OCONEE NUCLEAR STATION

KEOWEE PRA

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Severe Accident Analysis Section
Nuclear Engineering Division

DUKE POWER COMPANY

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LIST OF ACRONYMS AND ABBREVIATIONS

A	amperes
ac	alternating current
AC	alternating current
ACB	Air Circuit Breaker
AG	Governor Air System
ART	Air Receiver Tank
CHE	Commission Human Error
CT	Combustion Turbine
dc	direct current
DC	direct current
DHE	Dynamic Human Error
EPRI	Electric Power Research Institute
ES	Emergency Start
ESG	Engineered Safeguards
GBO	Turbine Guide Bearing Oil System
GOPT	Governor Oil Pressure Tank
HRA	Human Reliability Analysis
I&C	Instruments and Controls
I/O	Input / Output
IPE	Individual Plant Examination (Generic Letter 88-20)
KOT	Keowee Overhead Transformer
kV	kilovolts
LHE	Latent Human Error
LOCA	Loss of Coolant Accident
LOOP	Loss of Off-site Power
LOR	Lower Oil Reservoir (Guide Bearing Oil System)
MCC	Motor Control Center
MFB	Main Feeder Buses
NSM	Nuclear Station Modification
OG	Governor Oil System
PCB	Power Circuit Breaker
PMG	Permanent Magnet Generator
PRA	Probabilistic Risk Assessment
psi	pounds per square inch (gauge pressure)
RHE	Recovery Human Error
rpm	revolutions per minute
Swyd	Switchyard
TDEFW	Turbine-Driven Emergency Feedwater Pump
TS	Turbine Sump Pump System

UF	underfrequency
UOR	Upper Oil Reservoir (Guide Bearing Oil System)
UV	undervoltage
V	volts
WL	Generator Cooling Water System

ES EXECUTIVE SUMMARY

ES.1 BACKGROUND AND OBJECTIVES

This report presents a detailed analytical reliability study of the Keowee hydroelectric generating facility, which serves as the primary source of emergency ac power for the three-unit Oconee Nuclear Station. As part of the study, a complete analytical model (fault tree model) representing potential failure modes of Keowee, in the form of many distinct combinations of equipment failures, is developed. The model includes considerations of common cause equipment failures and human errors and responses. With a detailed analysis of the equipment performance experience, a plant-specific set of component failure data is created to facilitate a quantitative solution of the integrated Keowee reliability model.

The objectives of this study are:

1. to create an integrated reliability model of Keowee,

2. to obtain an analytical solution of the Keowee reliability model,

3. to compare the reliability results from Keowee operating experience with the analytical model, and

4. to derive insights on the adequacy and value of the various recent efforts to enhance Keowee performance.

The Keowee reliability model can be coupled with the existing model of the Oconee ac power system to provide information on the reliability of the overall Oconee ac power system and to make available new results of core damage sequences resulting from postulated loss of ac power events which degenerate to core damage scenarios.

ES.2 PLANT/SYSTEM FAMILIARIZATION

Oconee Nuclear Station is a three-reactor electric generating facility. Each reactor has a turbine-generator system that is used to produce 890 MW electric power at the generator-transformer output terminals. When the reactor is producing power, the electrical

equipment needed to operate the reactor is powered by the unit auxiliary transformer. The backup power source, relied upon when the unit is shutdown, is the off-site power from the grid through the start-up transformer of the unit.

When the normal and the backup power sources are lost, as could be the case during a loss-of-off-site-power event, emergency ac power must be available to continue operating the emergency shutdown equipment of the reactor. The two-unit Keowee Hydroelectric Station is the primary source of such emergency power for Oconee.

The Oconee ac power system also can be energized, through the 100/4 kV CT5 transformer, by a separate 100 kV transmission line powered by the Central switching station or by a dedicated alignment to the three-unit Lee combustion turbine station.

ES.3 METHODOLOGY

The overall methodology employed in this study consists of:

a. fault tree modeling of the systems which are essential for Keowee to support the emergency power function for Oconee,
b. analysis of equipment failure data to estimate the failure probabilities of components which appear in the system fault trees,
c. detailed common cause failure analysis,
d. human reliability analysis to represent the role of plant personnel to cause equipment unavailability or availability, and
e. solution and refinement of the model to obtain quantitative information on the system reliability.

The analytical model is built on the premise that potential failures of the system can be adequately characterized by the many possible combinations of failures of individual equipment comprising the system. Since Keowee is used almost on a daily basis to augment the grid generation, the substantial system level experience available offers a unique opportunity to test this assumption. Although not every component involved in the emergency start of the Keowee is demanded during the daily grid operation, the differences can be accounted for by the analytical model. Thus, the analytical model can be used to make comparisons of Keowee reliability from operational experience and model prediction.

ES.4 RESULTS AND CONCLUSIONS

ES.4.1 KEOWEE RELIABILITY

The overall reliability of Keowee is expressed as the failure probability of Keowee to provide emergency ac power to Oconee either through the underground path or the overhead path. The model predicted value for this probability is 0.0074. This value includes the beneficial effect of operator action to recover failed functions using available equipment (for example, using the overhead unit for the underground path if the underground unit fails to start and the overhead path is unavailable). This value is also based on the component failure data derived from a synthesis of the plant specific data and generic data by means of the Bayesian update process. Table ES.4-1 contains the results using generic data and also the case without operator action.

For the overall Keowee unavailability (0.0074), the main cause of unavailability is the maintenance unavailability of both units (0.005).

The reliability of the Keowee underground power source is calculated to be 97.8% (0.022 failure probability), not including the effect of common cause failure and double maintenance. For the overhead path, the corresponding value is 93.5% (0.065 failure probability).

The analytically predicted failure probability of the Keowee unit to start is 0.0078 for the unit used for daily power generation and 0.0081 for the unit not used for daily power generation. The slight difference between the two results is due to the fact that the exposure time for component failure and detection is short for the unit used daily compared to the other unit which experiences less frequent testing. These results can be compared to 0.0045 from experience (average of 1984-93 experience base). The failure probability for the 24-hour run mission is 0.011 for the unit used for daily power generation and 0.012 for the standby unit, compared to 0.012 from experience. These results are in remarkable agreement.

ES.4.2 OCONEE AC POWER RELIABILITY

When the Keowee reliability model is coupled with the Oconee ac power model and then solved with the existing data base of loss-of-off-site-power initiating events and

component failures, the overall failure probability of ac power for the Oconee electrical equipment can be obtained. The result of this model solution is 6.4E-5. This value includes the frequency of losing off-site power, the probability of Keowee emergency power failure, and the failure probability of the backup emergency power from CT5. It does not include the recovery of off-site power. Thus, the annual probability of station blackout for an Oconee unit is estimated to be 6.4E-5.

ES.4.3 AC POWER CORE DAMAGE SEQUENCES

Should the plant experience a loss of all ac power event, continued core heat removal can be accomplished by the ac-independent turbine driven emergency feedwater pump, unless the reactor coolant pump seals fail as a consequence of loss of seal cooling/injection. The Safe Shutdown Facility (SSF) is capable of providing reactor coolant pump seal injection and steam generator cooling in a loss of all ac power condition. Also, recovery of off-site power can mitigate the event. Loss of all ac power events which subsequently involve SSF failure and failure to recover off-site power are assumed to lead to core damage conditions. Such core damage sequences are identified by integrating the ac power model with the SSF, turbine driven emergency feedwater, and off-site power recovery models. The result of solution of this core damage model is a new estimate for ac power core damage frequency of 1E-6 per reactor year. This value can be compared to the value of 3E-6, previously calculated as part of the individual plant examination (IPE) program.

ES.4.4 CONCLUSIONS

The following are the major conclusions derived from this study:

- Keowee is a reliable source of emergency power for Oconee for conditions involving the loss of on-site power and off-site power.

- As expected, Keowee power through the underground path is the more assured source of emergency power for Oconee.

- The failure probabilities of a Keowee unit to start and run for the mission time estimated from a detailed system model are in close agreement with those derived from the Keowee operational data.

- Overall, the probability of incurring a sustained loss of ac power for Oconee is very low. The Oconee ac power system is more vulnerable to a loss of ac power condition during damaging severe weather conditions compared to conditions involving a random loss of off-site power.

- The core damage risk of accidents involving the loss of ac power is very low, about one in a million.

The recommended plant action resulting from this study is the continued vigilance and operational/maintenance practices promoting high reliability, recognizing the vulnerability of the system during conditions of severe weather, optimizing maintenance unavailability of the underground power, and satisfactory cause-and-effect analysis of equipment failures.

Table ES.4-1

Keowee Emergency Power Failure Probability[1]

Model Configuration	Failure Probability
Base Case (Failure of Keowee power through the under ground path and the overhead path, Bayesian-updated data)	0.0074
Bayesian Updated Data Without Operator Recoveries	0.010
Generic Data Without Operator Recoveries	0.013

Note 1: This represents the failure probability of Keowee and its power paths to supply emergency power to Oconee.

1.0 INTRODUCTION

1.1 BACKGROUND

The Keowee Hydroelectric Station, consisting of two 87.5 MW_e hydro-turbine-generators (designated as Keowee 1 and Keowee 2), is the primary source of emergency power for Oconee Nuclear Station (Oconee 1, Oconee 2 and Oconee 3). In the early 1990s there appeared to be more than the normal rate of equipment problems at Keowee. In addition, a number of previously unrecognized failure modes of concern (called "single failures") were found in the Oconee-Keowee emergency power function by Duke engineering studies, as part of the ongoing effort to develop a set of design basis documents (DBDs) for the Oconee plant systems. These two developments, and perhaps a few others also, led to regulatory questions on the reliability of Keowee to provide the emergency power function for Oconee.

Quantitative analyses of the reliability of Keowee had been made by Duke earlier, as part of the Station Blackout issue and the individual plant examination for severe accident vulnerabilities (generally known as the IPE study -- Reference 1). These studies relied upon the data from the large number of Keowee generator starts for power generation occurring almost daily. This operational data is used to characterize the reliability of Keowee.

The occurrence of equipment failures and the reports of new single failure vulnerabilities at Keowee for design basis accidents prompted the regulatory interest in Duke conducting a detailed analytical study of Keowee reliability. Thus, in late 1993 Duke decided to undertake a full scale reliability analysis of Keowee (the Keowee Reliability Analysis) to analytically determine the reliability of Keowee to provide the emergency power function to Oconee. (The study utilizes the PRA methodology to calculate the Keowee reliability; therefore, it is also referred to as the Keowee PRA.) Duke informed the NRC of this decision by letter of November 10, 1993 (Reference 2). Subsequently, a project team was established to conduct the study.

1.2 OBJECTIVES AND SCOPE

The objectives of the Keowee PRA project are:

1. to develop an integrated reliability model of Keowee,

2. to obtain an analytical estimate of the reliability of Keowee to provide emergency power to Oconee,

3. to compare the reliability results from Keowee operational experience with the analytical reliability results, and

4. to derive insights on the adequacy and the value of the ongoing efforts to improve Keowee reliability.

The scope of the study was to include all major pieces of equipment, which can be reasonably characterized by reliability data, including the front line and support systems and the power paths from Keowee to Oconee (the underground path and the overhead path). The end points of the power paths are the transformers (transformer CT4 for the underground path and transformer CT3 for the overhead path) stepping down the Keowee power to the 4160 V power needed by the Oconee safety functions. To facilitate comparison with appropriate IPE results (Reference 1), Oconee 3 was selected for the Oconee interface.

1.3 METHODS AND COMPUTER CODES

The analytical method employed in this study is the traditional quantitative reliability analysis involving fault trees. In this approach, the top event of the fault tree is the event of interest (for example, failure of Keowee power through both the underground and the overhead paths). The conditions or equipment failures and the combination thereof necessary for this top event outcome are defined by conducting systems analysis and Boolean algebra formulation of the failure events involved. In actuality, several fault trees are constructed to represent the failures of the systems and subsystems involved in the power generation and transmission processes. The individual trees are integrated into a high level tree whose top event is the Keowee emergency power function failure of concern. The solution of the integrated model is a large set of individual combinations of

equipment failure events (called cut sets) which would cause the function failure in a unique way. To obtain the quantitative solution of the fault tree, reliability data of the failure events and the equipment failure modes appearing on the fault tree must be obtained.

For the Keowee Reliability Analysis both generic and plant-specific (Keowee) equipment failure data were compiled. To obtain the plant-specific reliability data, an extensive analysis of the Keowee operating history of the previous 10 years (1984-1993) is performed to identify equipment failures of interest. The generic reliability data is imported by reviewing available sources of generic data and selecting what appeared to be a suitable current vintage set. In addition to the plant-specific and generic equipment reliability data, a third set of data is compiled by the synthesis (by means of the Bayesian update process) of the generic and plant specific data.

In addition to random equipment failures described above, the systems analysis process includes consideration of common cause equipment failures and human errors. For the common cause analysis, the methodology employed closely matches the approach in NUREG-4780 (Reference 3). The role of plant personnel to influence the reliability of Keowee is modeled by considering two types of human errors -- human errors that render equipment in a failed condition, and human errors that result in improper or unsuccessful action following a Keowee demand.

The CAFTA computer code is employed to enable the fault tree construction and the model solution. The integrated model consists of approximately 700 gates and 1135 basic events.

1.4 DESCRIPTION OF TASKS

Task 1: Plant Familiarization

This task is comprised of gathering design and operational information (system descriptions, design basis documents, equipment manuals, and plant procedures) and reports, concerns, and problems regarding Keowee-Oconee power systems, and conducting a detailed walkdown of Keowee and Oconee ac power equipment.

Task 2: System Model Development

Tasks 2 and 3 form the essence of the reliability analysis process. In Task 2, the systems, subsystems, and major equipment necessary to enable, start, and control the power generation to supply Oconee emergency demands are identified. The primary mission of each of these devices and the manner in which the missions fail to be accomplished are determined. The equipment failures leading to the mission failure are identified by analyzing the failure modes and effects of the components. The failure models of each major equipment, subsystem and system are then developed by building individual fault trees.

Task 3: Reliability Data Development

In this task the probabilistic values of equipment failures and human errors are developed. For the equipment failure analysis, the operational records of Keowee for the past 10 years (1984-93) were collected and scrutinized to identify equipment failures of interest and to develop the plant specific reliability data. In addition, this task included the effort to compile applicable generic data, the analysis of common cause events, and the human reliability analysis.

Task 4: Model Integration and Solution

The individual trees, developed in Task 2, are integrated into an overall model (by means of a high-level tree) by coupling the individual system models together, as part of Task 4.

A data file is created to represent the basic events of the integrated model, by consolidating the random failure data, the common cause failure data, and the human error probabilities from Task 3.

The integrated model is solved at this stage to quantify the Keowee generators' overall reliability and to identify the cut sets responsible for the varied failure possibilities. The solution process also requires elimination of any invalid cut sets (if any), application of any recovery factors, and truncation of the solution to a numerical value of reliability significance.

Task 5: Analysis of Results

This task is to interpret the results of the analysis, perform sensitivity studies, and to draw insights and conclusions of the analytical effort. Comparisons to the Keowee reliability experience data are made to ascertain agreements, differences, and plausible explanations.

Task 6: Report Preparation

This task concerns the preparation of the Keowee Reliability Analysis Report, intended to present the summary of the study for use by internal and external interested parties. Included in this task is the compilation of supporting notebooks containing detailed notes on the systems analysis and data work.

Task 7: Peer Review

The analysis and the preliminary results and conclusions of the study are reviewed by the site engineering and operational personnel to verify that the assumptions are reasonable and the representation of equipment and human response and the logic structure are appropriate. This peer review supplements the many review sessions involving the project team during the model development and model solution phases.

Task 8: Recommendations

This final task is intended to formulate any recommendations found to be appropriate by the project team, as evident from the qualitative and quantitative insights drawn from the study as well as the results of the sensitivity studies.

1.5 PROJECT ORGANIZATION

The Keowee reliability study was performed by Duke personnel. A project team, consisting of personnel from the Severe Accident Analysis Section in the Nuclear GO/Nuclear Engineering Division, with expertise in reliability/PRA analysis was the core of the project organization. This team was supported by site personnel in the areas of engineering and Keowee operation and maintenance, on an as-needed basis. In addition to these in-house personnel, an outside reliability consultant (SAROS) was used on a limited basis for review and consultation.

In conducting the study, the team was given refresher training on systems analysis, software execution, and human reliability analysis.

The team held periodic meetings to review progress of the work, to discuss and resolve problem areas, to review models, data, and task results, and to disseminate pertinent information. In addition, several meetings were held with the consultant, site personnel, and the NRC/contractor personnel to present modeling approaches and task results. These proceedings enabled the identification of areas needing additional investigation, and facilitated a thorough scrutiny of the study tasks and end results.

1.6 OVERVIEW OF THE REPORT

Section 2 contains a brief description of the Oconee ac power system, while the Keowee generating system is described in Section 3.

The Keowee systems analysis is developed in Section 4, and the reliability data (random Keowee unit and component failure, common cause failure, and the human reliability) is presented in Section 5.

In Section 6, the Keowee reliability model is integrated with the Oconee ac power model and the pertinent other plant models to derive insights on the occurrence probability of a sustained loss of ac power event for an Oconee reactor and the resulting core damage probability.

Section 7 contains the results, conclusions and recommendations.

References are listed in Section 8.

The details of the systems analysis, data analysis, and sensitivity studies are presented in Appendices A-E. Appendices F and G, respectively, contain the integrated fault trees for the Keowee model and the Oconee ac power model.

2.0 DESCRIPTION OF OCONEE AC POWER SYSTEM

2.1 INTRODUCTION

The ac power system (auxiliary ac power) provides the ac power needed by the various electrical equipment in the plant. The essential ac power is the power used at 4 kV (used by the large pump motors), 600 V (used by fans, battery chargers, MCCs, etc.), and 208 V (used by most motor operated valves), and excludes the 7 kV power used by the reactor coolant pump motors. It is the essential power that is providing the plant safety functions and therefore of interest in this reliability analysis.

For each Oconee unit, the heart of the essential power system is the 4 kV redundant main feeder bus (MFB). Either MFB (MFB-1 or MFB-2) can power the three 4 kV switchgear centers (TC, TD and TE), from which the ac power loads at 4 kV, 600 V, and 208 V for the specific Oconee unit are supplied. This arrangement preserves the full complement of plant equipment in the event one of the two MFBs fails or is unavailable.

Normally, both MFBs are energized, and there are four different sources of power for the MFBs -- the normal source of unit auxiliary transformer, the start-up source from the off-site power system through the start-up transformer, the Keowee emergency power (either through the overhead path and the start-up transformer or the underground power through transformer CT4 and the standby buses), and the dedicated 100 kV line through transformer CT5 and the standby buses. Once de-energized, the MFBs can be re-energized either automatically or manually.

The standby buses serve all three Oconee units. They are normally de-energized, and become energized during accident conditions of interest (LOOP, LOCA, and LOCA with LOOP) automatically, by emergency start of the Keowee unit connected to the underground path and closure of the SK breakers, or manually by closing the SL breakers if the Keowee power is not available.

Not included in this discussion of the Oconee ac power system is the Standby Shutdown Facility (SSF), which is a separate facility, with its own ac power system, capable of maintaining the safe shutdown functions of Oconee during certain catastrophic events such as loss of all essential power.

Figure 2.1-1 presents a simplified diagram of the Oconee ac power system.

2.2 NORMAL POWER SOURCE

When an Oconee unit is operating, the main generator (through the 13.8 kV-7 kV / 4 kV auxiliary transformer) is the source of normal power for the main feeder buses. The main feeder buses are connected to the 4 kV tap of the auxiliary transformer by closing the N breakers (N1 and N2) and opening the other interfacing breakers of the MFBs (E and S breakers described below). The auxiliary transformer and the associated bus work have adequate capacity to supply the electrical loads of the given Oconee unit during normal operation and accident conditions. When the main generator is unavailable (as a result of a generator trip or the unit being in shutdown condition), another power source is needed to power the MFBs. When the generator trips, the N breakers open and a power transfer to the start-up source occurs with the closure of the E breakers, if power is available on the start-up transformer.

When the main generator is not producing power, as is the case when the reactor is shutdown, the main feeder buses can still be energized through the auxiliary transformer by back-charging the main generator by the grid. However, this mode of operation does require bypassing certain generator interlocks.

2.3 START-UP POWER SOURCE

The start-up source is the preferred source of power when power from the normal source (the auxiliary transformer) is not available. It consists of the start-up transformer (230 kV-7 kV/4 kV) and the 230 kV switchyard power, which is fed by the 230 kV Duke transmission system, the 230 kV Oconee 1 and Oconee 2 step-up transformers, and the 500 kV-230 kV auto transformer (fed by the 500 kV switchyard). Power from these sources normally energizes the red and yellow buses of the 230 kV switchyard, either of which can power the three start-up transformers. The red and yellow buses can also be powered by the Keowee overhead unit, through the Keowee step-up transformer and Power Circuit Breaker (PCB) 8 for the red bus or PCB-9 for the yellow bus. Figure 2.3-1 presents the simplified electrical schematics of the 230 kV switchyard.

For conditions involving LOOP or grid disturbance, the yellow bus and the start-up transformers are isolated from the rest of the switchyard by opening PCBs 8, 9, 12, 15,17,

21, 24, 26, 28, and 33 by the External Grid Trouble Protection System (EGTPS). This system monitors the voltage and frequency conditions in the 230 kV switchyard and initiates the switchyard isolation function and sends a Keowee emergency start signal. When the switchyard is isolated, the Keowee unit assigned to the overhead path closes onto the yellow bus by closing the associated air circuit breaker (ACB) to the Keowee step-up transformer and closing PCB-9.

The switchyard relaying and protective actions require dc power, provided by a two train switchyard battery system located in the switchyard relay house.

When the MFBs are energized by the start-up source, the E breakers are closed and the normal source breakers (N breakers) and the standby bus breakers (S breakers) are open.

For a loss of off-site power event, power is assumed to be lost initially to the start-up transformer from the transmission network. During the recovery phase, the off-site power is restored to the start-up transformer through either the yellow or red buses by one of the several 230 kV transmission lines or the 500/230 kV auto transformer.

2.4 KEOWEE EMERGENCY POWER

Keowee emergency power is the primary emergency power to each of the Oconee units when the normal source and the start-up sources of power fail to energize the main feeder buses. Keowee emergency power is made available to Oconee by starting the Keowee units and separating them from the grid (if either of them are feeding the grid) by the Keowee emergency start signal and making available one Keowee unit to power the underground path and the other unit to the overhead path.

The emergency start signal can originate from the EGTPS (indicative of a LOOP) or the MFB monitor panel (which senses a loss of voltage on the MFBs, indicative of a LOOP or other cause of loss of power on the MFBs). A Keowee emergency start signal is also generated as part of the Engineered Safeguards (ES) actuation, occurring on symptoms of a LOCA, steam line break, or high-energy line break inside containment.

When the ES condition is not accompanied by a loss of off-site power (as could be the case for a LOCA), the start-up source continues to be available and the MFBs are re-energized by the start-up source almost instantaneously (within about a second) following

the expected reactor-generator trip and the resulting opening to the N breakers. In this case, although the Keowee generators will emergency start, they remain in a standby mode (with the underground unit energizing the underground bus through transformer CT4 to the standby buses and the overhead unit idling with the breaker to the Keowee step-up transformer open).

For the loss of off-site power event, the EGTPS would signal for an emergency start and separate the 230 kV switchyard yellow bus from the transmission network and the rest of the switchyard. The yellow bus then can receive the Keowee overhead path power and deliver it to the start-up transformer. The sequence of events, involving the Keowee emergency start, switchyard isolation, and re-energization of the start-up transformer(s) by Keowee overhead unit through the yellow bus, is such that the start-up transformer can be energized in 23 seconds. This time interval includes the time for the Keowee unit to start and load (or to separate from the grid if operating on the grid, go to no-load condition, and then load), trip the 6.9 kV reactor coolant pump motor buses from the start-up transformer, and energize the overhead path. The underground path is energized as soon as the Keowee unit starts, allowing the SK breakers to close and energize the standby buses (within 23 seconds).

During LOOP events, the start-up source is the preferred source because of the larger capacity of the start-up transformer compared to the CT4 transformer. The MFBs are energized by the E breakers as soon as the start-up transformer is energized. In the event of power failure through the start-up source, the MFBs are energized automatically by the standby buses at about 31 seconds (20 seconds MFB delay time + 1 second delay for load shed of non-essential MFB loads +10 second delay to transfer to standby bus) by closure of the S breakers.

For a LOOP event coincident with an ES condition, the 20 second MFB delay is bypassed and transfer to the standby source could occur as early as 11 seconds

In the event the start-up source is not energized before the MFBs transfer to the standby buses and if the standby buses are unavailable, a retransfer to the start-up source would occur after an additional 10 seconds if the start-up source becomes available by that time.

In the analysis of loss of off-site power events, the Keowee overhead path is assumed unavailable for those LOOP events categorized as initiated by switchyard failures and those initiated by severe weather.

2.5 CT5 POWER

Power through the CT5 transformer is the alternate power supply to the standby buses. (The primary power source for the standby bus is the Keowee underground source through transformer CT4 and the SK breakers.) It consists of the 100/4 kV transformer located on the west side of the Oconee site (the 230 kV and the 500 kV switchyards are located on the east side), the SL breakers interfacing the 4 kV CT5 buses with the standby buses, and the 100 kV transmission line. The 100 kV transmission line is normally powered by the Central switchyard (located some 8 miles from the site) and can be dedicated to Oconee's sole use by separating the line from the Central switchyard and energizing by one of three 44 MVA combustion turbine generating units of the Lee Steam Station, located some 20 miles away.

CT5 is normally in an energized state and can be used to energize the main feeder buses if all other sources of power (the normal source, the start-up source, and the Keowee sources) are unavailable. This is done by manually closing the SL breakers from the control room. If the normal 100 kV power is not available, the Oconee operator can request Lee station to start and energize the 100 kV line and dedicate it to Oconee. This action requires some 30 to 60 minutes.

Whenever both Keowee units are in a planned maintenance, or one of the Keowee units or the Keowee power paths is unavailable for an extended time period (greater than 72 hours), CT5 is energized by a Lee unit and the 100 kV line separated from the grid system. Further, the standby buses are kept energized by closing the SL breakers at this time to enhance the readiness and availability of the standby source power in this period of reduced redundancy in the emergency power sources.

The CT5 power source constitutes a viable source of emergency power during LOOP events involving switchyard failures and independent failures of the Keowee underground path and during reduced availability of Keowee emergency power. Since CT5 and the associated 100 kV line are not rugged against severe weather, planned maintenance of the Keowee emergency power system which involves substantial reduction in Keowee

availability is done during periods of favorable weather conditions, by making use of weather forecast information.

2.6 EMERGENCY POWER SWITCHING LOGIC

The emergency power switching logic (EPSL) is the automatic means by which the breakers associated with dead buses of a power source are tripped, breakers associated with live buses are closed in a certain preferential manner (as described in Sections 2.2 and 2.3), and non-essential loads are stripped so as to enable the MFBs to power essential equipment during accident conditions of interest. It causes load shed of the non-essential loads off the MFBs whenever there is sustained undervoltage condition on the MFBs. This allows the standby source power to energize the MFBs of all affected Oconee units.

Normally, the breakers interfacing the MFBs (N, E, and S) are in the automatic mode. When the normal source of power (the unit generator) to the MFBs is lost, the N breakers must open and allow the preferred source of power (the start-up source) to re-energize the MFBs. This is accomplished by interlocking the N and E breaker position such that the E breakers will close when the N breakers trip and if power is available on the start-up transformer. If there is no power on the start-up source, the EPSL counts 20 seconds for the non-ES condition, initiates a load shed in the next second, and counts another 10 seconds before closing the S breakers to energize the MFB by the standby buses. The standby buses should have already been energized by the Keowee underground unit through the underground path by the automatic closing of the SK breakers. If the start-up transformer is energized before the last 10 seconds of the above sequence have expired (as would be the case with the Keowee overhead path energizing the start-up transformer by this time), the E breakers would close instead since the start-up source is the preferred source.

If power is not available at the standby buses when the EPSL seeks out the standby source, a retransfer to the start-up source would occur after an additional 10 seconds if the start-up source becomes energized later.

The LOCA-LOOP sequence proceeds directly to load shed and N and E or S breakers re-alignment without the 20 second MFB time delay.

Redundant devices (trip coils, relays, etc.) are utilized to accomplish breaker trip and close actions.

The control power needed by the breakers and protective relaying for each Oconee unit is provided by its respective dc buses and associated batteries. The dc power needed by the common standby bus components is supplied by Oconee 1 DC power system.

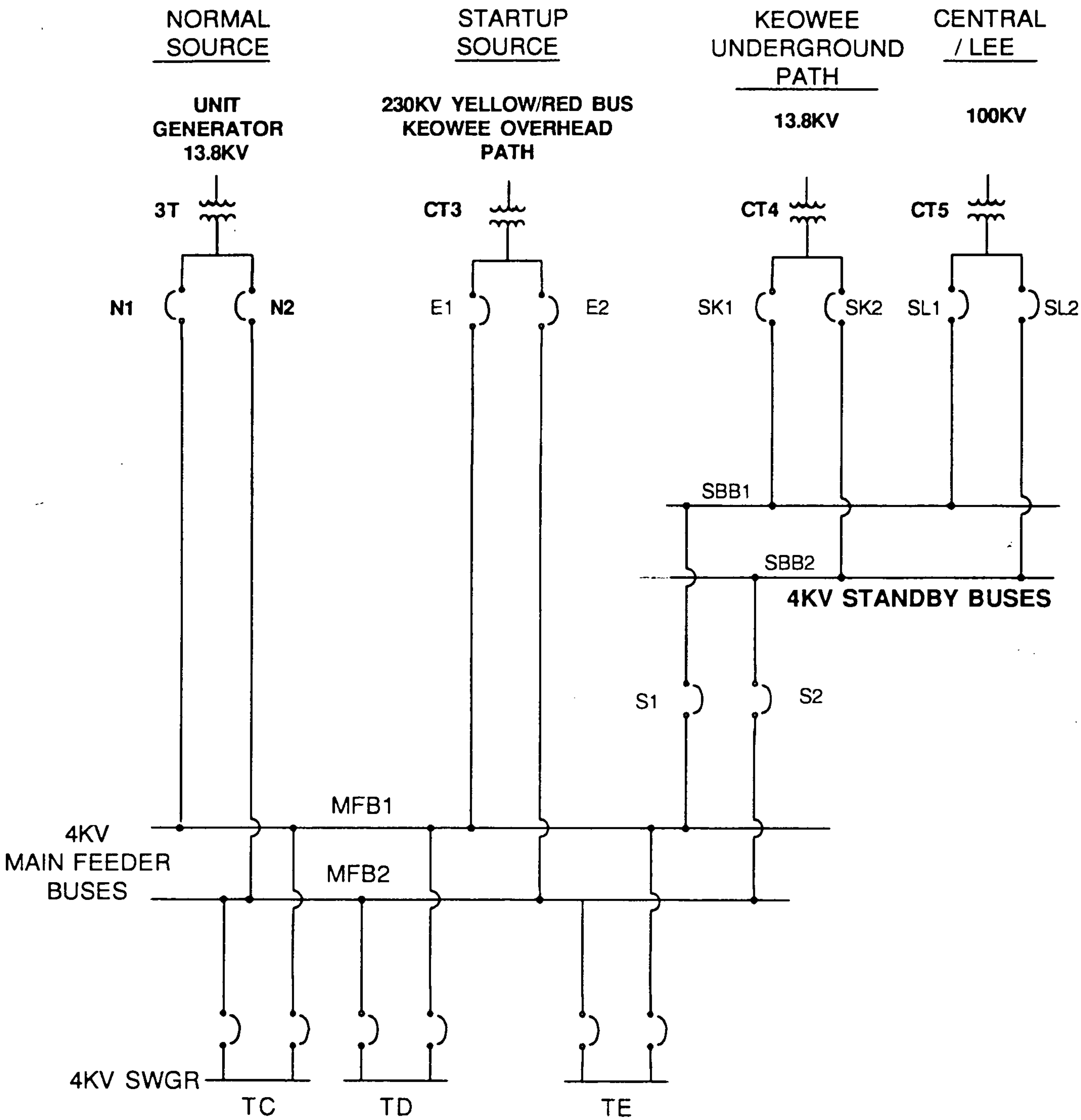


Figure 2.1-1 Oconee AC Power System

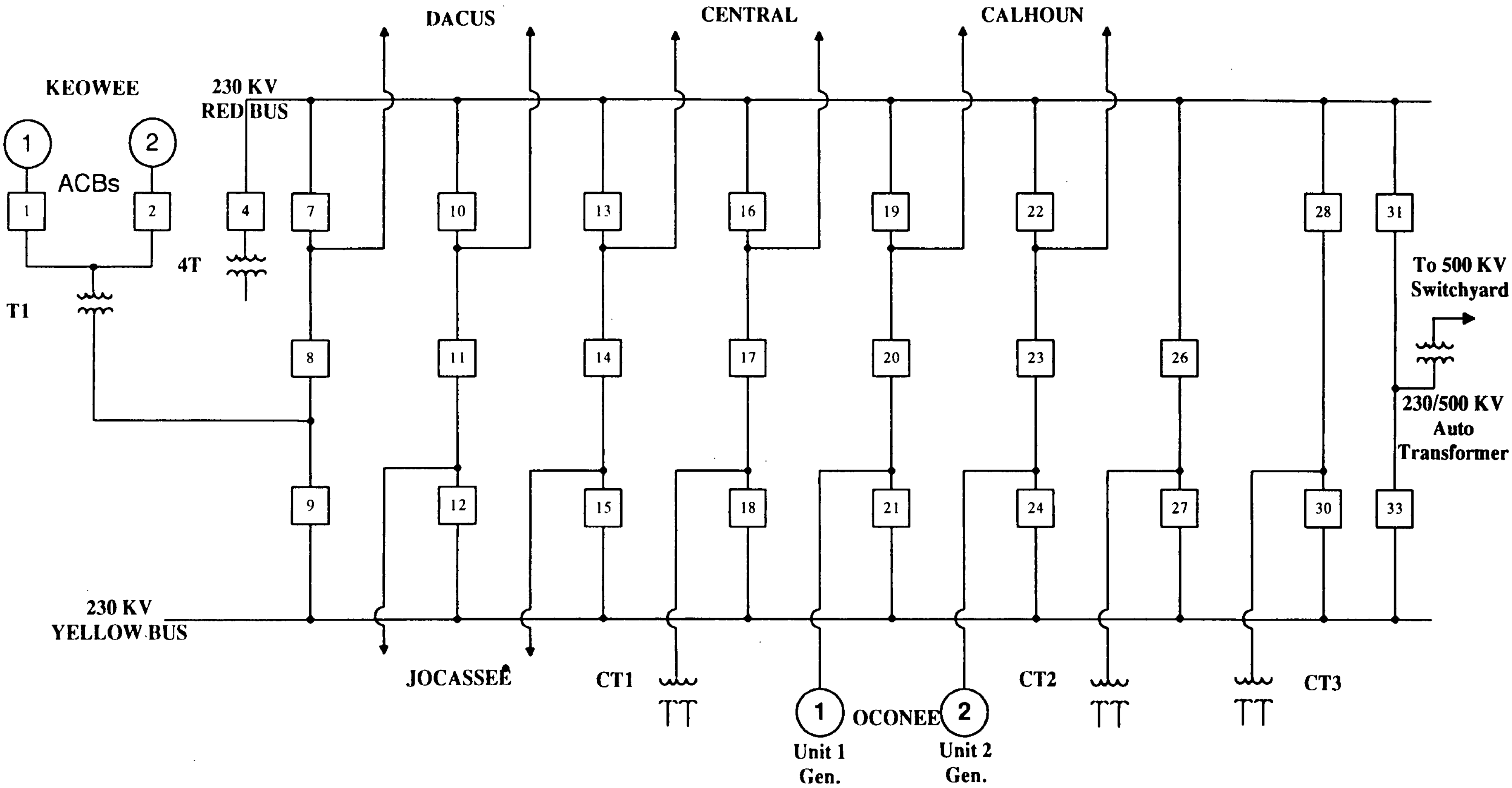


Figure 2.3-1 Oconee 230 kV Switchyard Arrangement

3.0 DESCRIPTION OF KEOWEE GENERATING STATION

3.1 INTRODUCTION

The Keowee generating station is a two unit hydroelectric generating facility, located approximately two-thirds of a mile east-northeast of the Oconee nuclear station. It utilizes water from the 18,000 acre Keowee reservoir through a common penstock to drive the two 96 khp, 128.6 rpm, 87.5 MW_e turbine-generators. Except for the 13.2 kV/230 kV step-up transformer and the penstock, the equipment needed for the power generation and distribution is located inside the Powerhouse.

Keowee is designed to supply the emergency power for Oconee during conditions involving the loss of the normal (Oconee generator) and off-site power for any or all three of the Oconee units. Keowee is also designed to supply power to the Duke 230 kV electrical grid when such grid generation is needed and if there is no emergency power demand for Oconee. When used as the emergency power system, Keowee functions as the on-site power source for Oconee via two separate and independent paths (the overhead path and the underground path). Except for the common penstock and some cooling water piping, each unit is independent of the other. There are interlocks to prevent both units feeding the underground path. Both units can feed the overhead path through the single Keowee step-up transformer, except when the Keowee emergency start signal is present.

Figure 3.1-1 shows a simplified flow path for ac power from the Keowee hydroelectric generators to the Oconee ac power system.

Although Keowee is designed to be operated semi-attended, the station is staffed by an operator at all times.

To generate electric power, each Keowee generator consists of the turbine, the governor, the generator, the exciter/voltage regulator, synchronizing equipment (needed for grid generation only), generator output breakers, control circuitry (for manual and automatic control), protective relaying, and auxiliary power (ac and dc power). The following sections describe these systems in detail. Additional details are provided in Section 4 and Appendix A concerning the reliability modeling of these systems. Figure 3.1-2 presents a simplified functional arrangement of these subsystems to illustrate the Keowee operation.

3.2 TURBINE

The turbine system consists of (1) the rotating elements (turbine runner and the main turbine shaft), (2) the wicket gate assembly, (3) the packing and bearing assembly, (4) the draft tube assembly, and (5) the sump. (See Figure 3.1-2.)

The main turbine shaft is bolted to the generator shaft, and the turbine runner and shaft assembly transform the fluid motion energy into the rotational energy of the turbine as water flows from the penstock through the wicket gate and down through the draft tube.

The wicket gate assembly controls the amount of water flow into the turbine, and thereby the turbine speed and load. This is accomplished by a set of servomotors that move the gate opening and closing arms to achieve the desired speed and load rather rapidly and finely. The servomotors respond to the governor commands for unit start, unit shutdown, load control, and no load operation.

Lubrication and heat removal of the turbine bearings are accomplished by the Turbine Guide Bearing Oil (GBO) system. It is a closed oil system, with an upper and lower oil reservoir. Oil is continuously circulated within the system by pumping the oil from the lower reservoir to the upper reservoir through an oil cooler by an ac pump and a standby dc pump. Water from the Keowee Cooling Water System flows by gravity through the oil cooler and the turbine packing to achieve bearing oil and packing cooling.

The draft tube assembly enables the discharge of the turbine water into the tailrace and creates a low-pressure region to assist the turbine rotation.

Each Keowee unit has a small area known as the wheel pit, located between the generator and turbine. The lower portion of the turbine wheel pit is the sump, which accumulates water leakage from the turbine packing. A set of ac and dc sump pumps is provided to pump the sump water into the sump drain line.

Power (ac and dc) needed by the turbine equipment (bearing oil cooler and sump pumps) is supplied by the Keowee auxiliary power system.

3.3 GOVERNOR

The governor is an electro-mechanical device used to control the position of the wicket gates to allow the turbine speed to match the nominal speed of 128.6 rpm for the full range of load conditions, from no load to full load. The mechanical portion (consisting of springs, pulleys, weights, linkages, and valves) controls oil pressure for the wicket gate servomotor. The electronic portion comprises the solenoids (shutdown solenoid and emergency load solenoid), relays, and switches which interface with the control and protective devices to accomplish the normal operation, emergency power operation, and shutdown.

Supporting the governor are the Governor Oil System and the Governor Air System. The governor oil system supplies oil at 300-350 psi to the governor to control the servomotors. As the oil is used up in the continuous governor operation, it drains into a large oil sump from which it is pumped to the oil pressure tank by three ac powered oil pumps. The air pressure in this oil tank enables a constant circulation of the oil in the governor system. The governor air system simply is a large air receiver which maintains a blanket of pressurized air in the oil tank.

The ac power needed by the oil pumps is supplied by the Keowee auxiliary power system. The normal pressure and oil level in the oil tank are such that the Keowee unit can start and supply loads for some period of time even if all the oil pumps are unavailable. However, as the oil level drops in the tank, the oil volume may not be sufficient to operate the servomotors unless the pumps become operable (within about an hour).

3.4 GENERATOR

The generator assembly is connected to the turbine by the common shaft, bolted at the turbine generator interface. Each generator is a 3-phase, 60 Hertz machine generating power at 13.8 kV, with a rated capacity of 87.5 MVA. It is located immediately below the operating floor of the Powerhouse. It consists of the shaft, the bearing (contained in an oil bath), the generator rotor(field) and stator, and the generator output bus.

Eight oil coolers, with cooling water from the Keowee cooling water system, cool the generator bearing system.

The generator stator is cooled by six air-to-water heat exchangers. Water for these heat exchangers also comes from the Cooling Water System.

An air brake system is used to stop the generator when shutting down. However, it is not needed for the power generation function.

There is a self-contained CO2 fire protection system provided in the generator assembly, and a generator lockout would occur if it actuates. Other protective relaying measures are also used for the generator as described in Section 3.7.

At the top of the generator assembly, a mechanical overspeed trip mechanism is installed to trip the turbine-generator system when the speed approaches unsafe conditions. When the generator trips (mechanical trip setpoint is 180 rpm), it takes several minutes (for the machinery to coast down) and operator action (to reset the overspeed trip) to restart the unit.

The generator excitation and regulation of the output voltage to the set 13.8 kV values are accomplished by the excitation and voltage regulator system.

3.5 EXCITATION/VOLTAGE REGULATION

To transform the mechanical energy of the turbine to electrical energy in the generator, a magnetic field must be supplied. Initially, the electrical input for the excitation field is supplied by the dc auxiliary power system through the field flashing breaker into the field breaker. The field, field flashing, and supply breakers would close on a Keowee start signal. As the generator begins to produce electrical energy, part of it is fed back to the exciter through the field supply breaker to sustain the field. The field flashing breaker opens after a time delay since the external source of field is no longer needed.

The voltage regulator modulates the field density within the generator in such a manner that the voltage of the generator electrical output matches the design value of 13.8 kV, within acceptable tolerances.

3.6 GENERATOR OUTPUT BREAKERS

The generator output breakers provide the interface between the generator and the power transmission line or bus. There are two output breakers for each unit: Air Circuit Breakers (ACBs) 1 and 3 for Unit 1 and ACBs 2 and 4 for Unit 2. ACBs 1 and 2 connect the generators to the Keowee 13.2 kV/230 kV step-up transformer, from which the Keowee power can feed the grid through PCB-8 or it can energize the Keowee overhead path to Oconee through PCB-9, the 230 kV switchyard yellow bus, and the Oconee start-up transformer(s).

ACBs 3 and 4 connect the Keowee units to the Keowee underground emergency power path to Oconee. Normally, one of the Keowee units is pre-assigned to the underground path, and its underground path breaker is kept closed while the other unit's breaker is left open. These breakers are interlocked to prevent both breakers being simultaneously closed onto the underground path.

When the Keowee units are started for grid generation, ACBs 1 and 2 close automatically. If a Keowee emergency power demand occurs at this time, these breakers will open, the turbine generators are controlled in the no-load mode, and then will energize the underground path up to CT4. If necessary (only if the event involves a loss of off-site power), the overhead path is energized by closing the overhead path breakers. The ACB (and PCB-9) closing logic contains a feature to confirm the yellow bus isolation is complete (PCBs 8, 12, 15, 17, 21, 24, 26, 28, and 33 are open). The ACB close is also controlled by delay times to prevent the units' energizing the Keowee transformer out of phase.

At the time of this study, the Keowee unit dedicated to the underground path is not allowed to feed the grid on an interim basis until certain single failure issues are resolved. Thus, when the unit starts up on an emergency demand, it energizes the underground path to allow loading in about 12 seconds. The other unit remains in a standby mode unless the normal switchyard power is lost, in which case the overhead path ACB closes after a time delay (~4 seconds for ACB-2 and ~6.5 seconds for ACB-1) to allow the affected Oconee unit's start-up bus to trip the non-essential 6.9 kV buses.

3.7 KEOWEE EMERGENCY START AND CONTROL

The start-up equipment for Keowee is located in the Keowee Control and Battery Rooms. The signals for automatic emergency start of the units originate from each Oconee unit (engineered safeguards actuation or loss of MFB power) and also from the Oconee 230 kV switchyard (EGTPS) through the Oconee electrical equipment room. The units can also be started manually in the emergency mode from the Oconee Control Rooms, or the Oconee cable rooms. The Oconee signals and control cables pass through the underground trench. Keowee station alarms are annunciated in the Keowee Control Room, while the critical alarms and controls are also provided in the Oconee Control Rooms.

For each Keowee unit, there are redundant channels (Channels A and B) and diverse means to detect a loss of power condition, process the signals, and initiate the emergency start function. Upon actuation, the emergency start auxiliary relays, located at Keowee, allow the field supply breakers to close and energize two master relays, one of which energizes the governor shutdown solenoid relays, and the other starts the equipment needed for lubrication and cooling.

3.8 PROTECTIVE RELAYING

Fault conditions of the power equipment and the power circuits are monitored and the faults are isolated by a variety of protective relays. Fault protection is provided for the generators, the transformers, and the bus work by means of the zone protection scheme.

The lockouts generated by these protection features could prevent the unit start. During an emergency start condition, only an emergency lockout can prevent the unit start, since the normal lockouts are bypassed under this condition. The reliability model includes failure modes of the relays whose spurious operation can create a Keowee failure due to spurious fault indications.

3.9 AUXILIARY POWER

The Keowee auxiliary power system comprises the 125 V dc power system and the 600 V and 208 V ac power system which are needed to operate the equipment needed for the Keowee start and power operation.

Each unit has a dc power system, consisting of a battery, battery charger and dc distribution bus. It enables the unit to start under a loss of all ac power condition, providing instrumentation and control power and dc power needed by the dc motors. The dc distribution system can be cross-connected between the units to facilitate battery maintenance. A standby charger is also available should one of the two normal chargers be out of service.

The ac portion of the auxiliary power system is also unit-specific, with the capability to cross-connect should the normal ac power bus for a Keowee unit be unavailable. AC power is needed for extended operation (more than an hour) of Keowee to charge the batteries, to operate the oil pumps, etc.

There are three transformers which can power the 600 V ac auxiliary power switchgear centers 1X and 2X of Keowee 1 and Keowee 2:

- the 4160/600 V CX transformer powered by the 1TC Oconee switchgear,
- the 13.8 kV/600 V 1X transformer powered by the Keowee main transformer, or
- the other 13.8 kV/600 V transformer (2X) powered by the Keowee main transformer.

Transformer CX is the primary source of auxiliary power for the Keowee unit assigned to the underground path. If this power source fails, the load center automatically transfers to the backup source, the auxiliary transformer off the Keowee transformer.

For the unit being used for the overhead path, the primary auxiliary power source is the auxiliary transformer off the Keowee transformer. If this source is unavailable, an automatic transfer to Transformer CX would occur.

Transformers 1X and 2X are normally energized by the grid through the 230 kV switchyard and the Keowee main transformer. With a loss of off-site power, the Keowee unit not operating on the underground path would energize these transformers with its overhead path ACB closed to the Keowee main transformer.

The 600 V ac auxiliary power switchgear centers can also be manually energized by opening and closing certain auxiliary power ACBs. Each units' motor control center can be cross-connected to the other unit's switchgear.

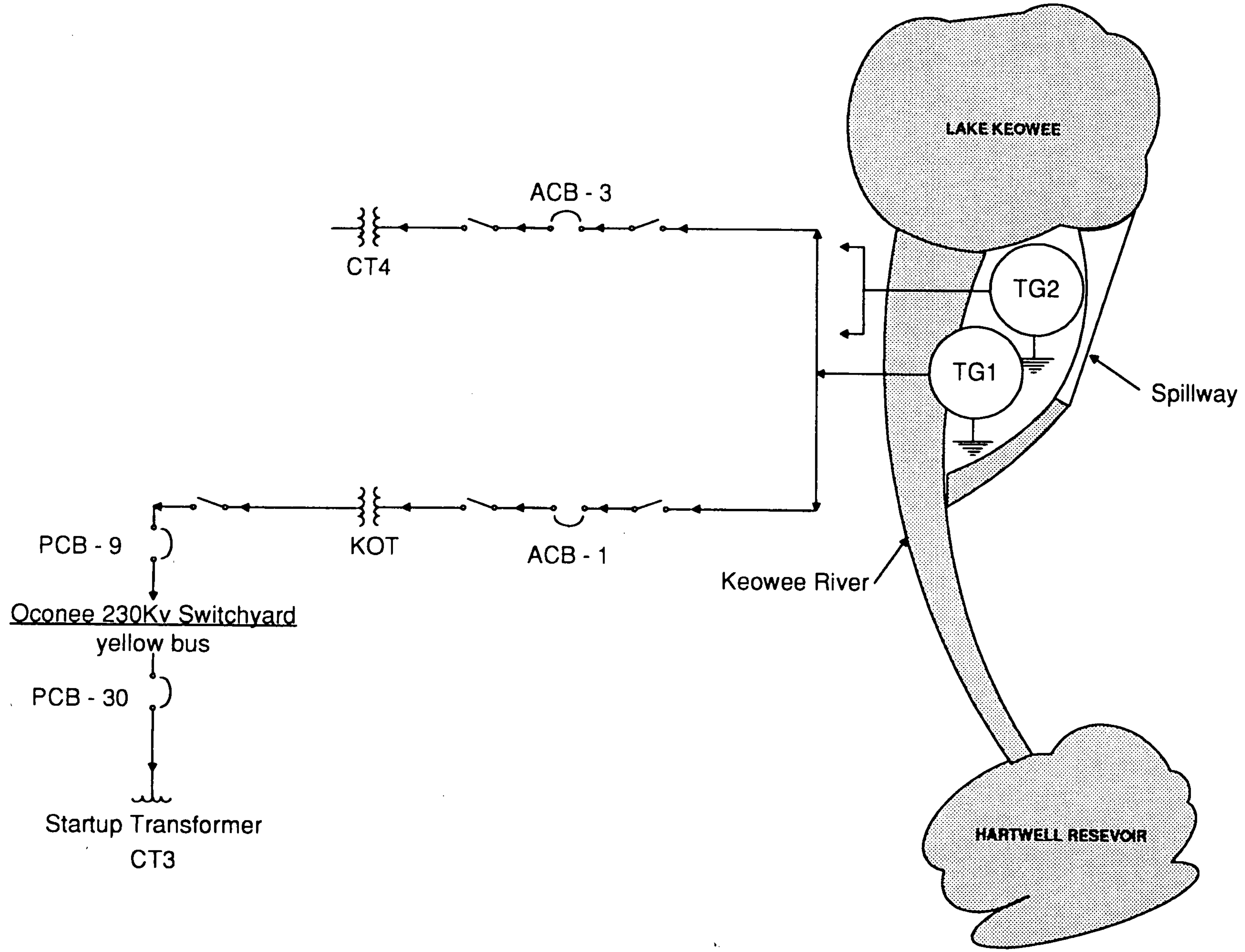


Figure 3.1-1 Keowee - Oconee AC Power Flowpath

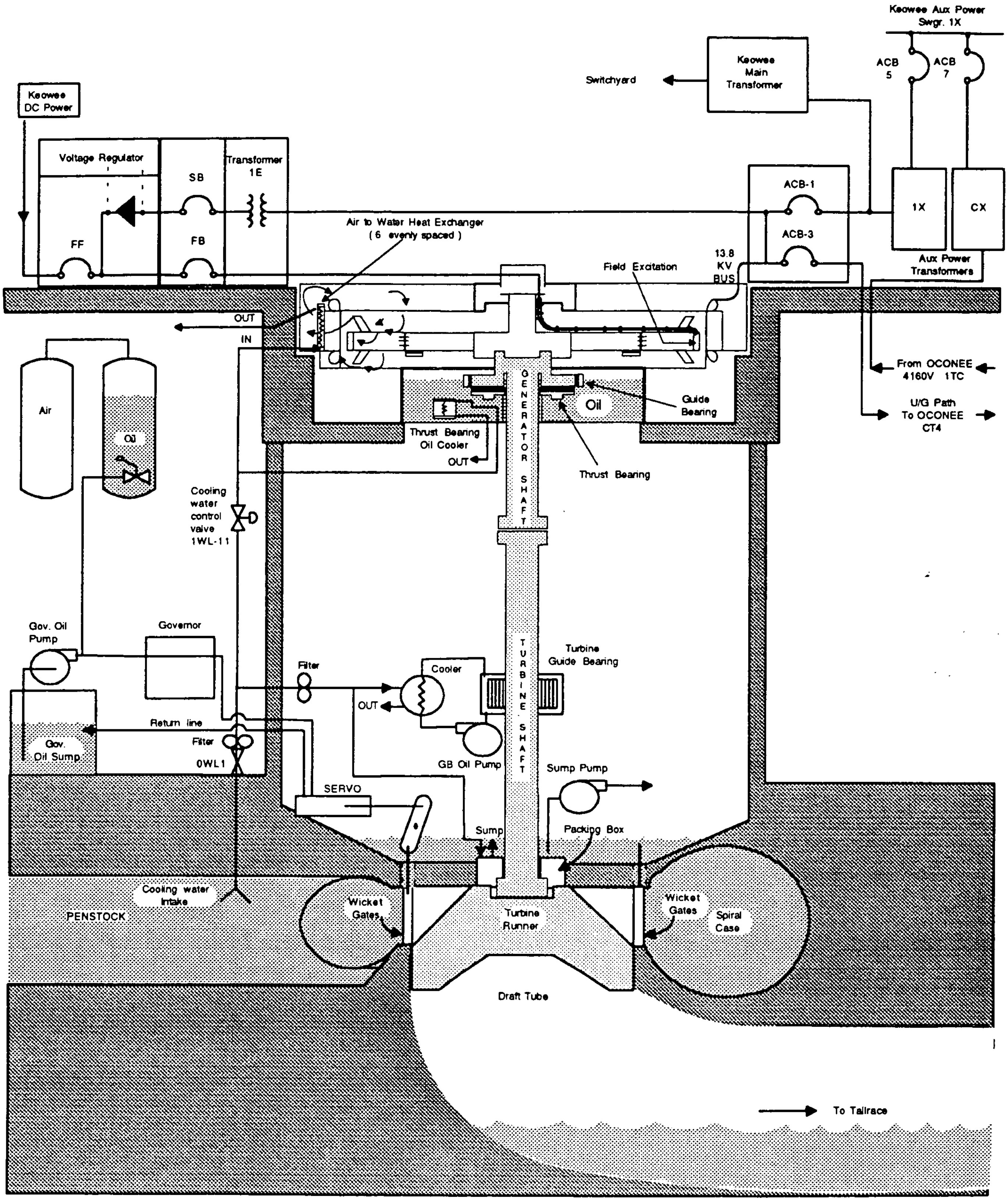


Figure 3.1-2 Keowee Subsystems Needed For Oconee AC Power

4.0 KEOWEE SYSTEMS ANALYSIS

4.1 OBJECTIVE

The systems analysis task of the Keowee PRA has as its primary objective to develop an analytical model for the analysis of the reliability of the Keowee Hydroelectric Generating Station to supply power to the Oconee Nuclear Station. In support of this objective, the analytical model should possess the following attributes:

- the ability to address the potential operating modes of Keowee,
- include all of the components necessary for the emergency operation of the Keowee units, and
- include important failure modes identified in the operating history of the Keowee units.

The base case result of the analysis is the failure probability of Keowee to supply power to Oconee either through CT3 or CT4.

4.2 SCOPE

The analysis is intended to determine the reliability of the Keowee units to supply emergency power to the Oconee Nuclear Site without duplicating models already developed in the existing Oconee Probabilistic Risk Assessment. Consistent with the objectives of the study, the analysis includes within the model consideration of the following:

- all systems and equipment at Keowee needed to successfully deliver emergency power to Oconee for the required mission time,
- the 230 kV switchyard at Oconee (including the External Grid Trouble Protection System),
- transformer CT3,
- the underground power path, and
- transformer CT4.

Since Oconee Unit 3 is the focus of the detailed analysis in the Oconee Probabilistic Risk Assessment (OPRA), transformer CT3 (the Unit 3 start-up transformer) has been selected

as the termination point for the Keowee overhead power in this analysis. This facilitates comparisons of the Keowee Reliability Assessment results with the OPRA data and possibly the integration of the Keowee model with the OPRA model. The reliability of Keowee to supply power to the other Oconee units would not be expected to be different than the results calculated in this analysis.

Some models do have interfaces with Oconee systems or components. Where an interface to an existing Oconee model is needed, the gate probability from the appropriate Oconee model is used as a basic event input value for the Keowee analysis.

The Keowee systems and components identified as needed to successfully deliver emergency power to Oconee are:

- Generator
- Turbine
- Governor
- Air Circuit Breakers (ACBs) 1 through 8
- AC & DC Auxiliary Power Systems
- Governor Air System
- Governor Oil System
- High Pressure Oil System
- Turbine Generator Cooling Water System
- Turbine Guide Bearing Oil System
- Turbine Sump Pump System
- Emergency Start Controls

During the course of this study, the Keowee Generator ACB Air System was determined to be important for Keowee operation. Failure of this system is included in the analysis as a basic event.

The scope of the system model task is to take the fault tree model to the lowest level of detail practical. The level of detail in the fault tree models is dictated typically by the availability of reliability data for the component. Equipment controls and components are usually taken down to the relay level. Some components, the governor for example, do not lend themselves readily to decomposition into a fault tree and are therefore treated as a single component.

4.3 METHODS

The reliability analysis is performed using fault tree methodology similar to the one described in NUREG-2300 (Reference 4). Figure 4.3-1 presents a diagram of the systems analysis process.

4.3.1 PLANT WALKDOWN

Plant walkdowns are conducted by the analysis team as part of the systems analysis effort. The objective of the walkdowns are to familiarize the team with the configuration, arrangement, and operation of Keowee and its systems. The walkdowns included the Keowee powerhouse as well as the Oconee 230 kV switchyard, and transformers CT3 and CT4.

Issues of particular interest such as location accessibility, susceptibility to particular failure modes, etc., are considered and discussed during the walkdowns. Table 4.3-1 presents the walkdown checklist.

Both a photographic and video record of the walkdown have been retained for reference by the analysts.

4.3.2 COMPUTER CODES

Fault trees are developed for each system modeled in the analysis. These fault trees are developed using the CAFTA fault tree analysis software as described in the CAFTA User's Manual. CAFTA provides a family of software products for the construction, viewing, and solution of fault trees, and the development of the required data bases.

4.3.3 BASIC COMPONENTS

The lowest level in a fault tree is the basic event. Each basic event represents the failure of some component with a specific failure mode of interest (e.g., valve fails to open). A basic component is a component whose failure is described by a basic event. The selection of basic components is also dictated by the level at which data is available. For fluid systems this typically means modeling down to the individual pumps and valves. Controls for pumps, valves, breakers, etc., are taken down to the relay level.

4.3.4 FAILURE MODES

A component usually can fail in more than one way. All relevant failure modes for a component are considered in the development of the fault trees. Typical failure modes are: fail to open, fail to close, fail to start, fail to run, and spuriously transfers position. The important failure mode for any particular analysis depends upon the application of the component and the system failure mode of interest (e.g., system fails to start or system fails to run).

Failures due to random events, common cause events, and human errors are also considered in the development of the trees.

4.4 MODEL DEVELOPMENT

Both Keowee units are designed, constructed, and maintained in the same manner. For the analysis purpose, it does not matter which unit is aligned to the underground or the overhead path. One unit can be assumed to be aligned to the underground path and the other to the overhead path without any loss of accuracy in the calculated unreliability number. As identified in the modeling assumptions below, Unit 1 is assumed to be in standby and aligned to the underground path while Unit 2 is assumed to be aligned to the overhead path and available for generation to the grid.

4.4.1 FAULT TREES

All of the system and component fault trees are presented in Appendices A.2 through A.14. The models are linked together for determining the overall Keowee reliability through a high-level logic tree contained in Appendix A.1. Major components and systems are shown transferring directly into the high-level logic tree. Some systems provide a support function and their models transfer into the fault trees of other systems or components.

Many of the system fault trees have top events and intermediate gates reflecting the reliability of the individual system or subsystem. Because both Keowee units are modeled, the Keowee system fault trees have individual top events for the unit 1 and unit 2 system.

The following table is a list of the fault tree models developed.

Appendix	Fault Tree
A.1	High-Level Logic Model
A.2	Emergency Power Paths
A.3	External Grid Trouble Protection
A.4	Air Circuit Breakers
A.5	Keowee Start Logic
A.6	Generator Excitation
A.7	Generator
A.8	Auxiliary AC and DC Power Systems
A.9	Switchyard DC Power System
A.10	Governor and Turbine
A.11	Governor Oil and Air Systems
A.12	Turbine Guide Bearing Oil System
A.13	Turbine Sump Pump System
A.14	Turbine-Generator Cooling Water System

Figure 4.3-2 shows the interconnections among the various fault trees.

4.4.2 KEOWEE OPERATING CONFIGURATION

Historically, both Keowee units have been available for generation to the Duke system. During the past couple of years, generation has been restricted to just one unit as a result of some potential failures, affecting the single-failure criteria, identified in engineering studies. The base case model for this analysis assumes that Keowee is being operated under the current operating restrictions. Operation is currently restricted such that only one unit is allowed to be generating to the grid. This unit is aligned to the overhead path through the generator output Air Circuit Breaker (ACB) on an emergency start. The other unit is in standby and is aligned to the underground path with its ACB (either ACB-3 or ACB-4) closed and the disconnects for the overhead ACB (either ACB-1 or ACB-2) open. The standby and operating units are swapped on a monthly basis. The overhead unit is assumed to be operated daily while the underground unit is assumed not to have operated in the previous 7 days.

4.4.3 GENERAL MODELING ASSUMPTIONS

The following modeling assumptions apply to all of the system and component fault trees. Modeling assumptions specific to a particular system are further identified in the appropriate system appendix.

1. Keowee Unit 1 is assumed to be the standby unit aligned to the underground path and Keowee Unit 2 is the operating unit aligned to the overhead. (This is consistent with the assumed alignment in the Oconee PRA.)

2. When a Keowee unit requires maintenance that will make the unit unavailable, the available unit is aligned to the underground path. Therefore, all single unit-related maintenance unavailability occurs on the unit aligned to the overhead path. The total unavailability of the two Keowee units is summed and applied to Unit 2 in the fault trees.

3. The Keowee units are rotated between the underground and overhead alignment every 30 days. Keowee Unit 1 has been aligned to the underground path and has not operated in the previous 7 days.

4. The unit aligned to the overhead path (Keowee Unit 2) is available for grid operation and is operated on a daily basis. Keowee Unit 2 was last operated 24 hours earlier.

5. Exposure times for components are assumed to be 1/2 of the time period since the last operation which would verify proper functioning of the device. For many components the exposure times are 7/2 days (84 hours) and 24/2 hours (12 hours).

6. Contacts of relays, switches, breakers, and disconnects are assumed to transfer position only when the primary device transfers position. That is, contact failures are assumed to be subsumed in the device failures.

7. Failures that would be alarmed and result in a unit being declared unavailable are not included in the models as start failures. These failures are assumed to be included in the unit unavailability data. These same failure modes would normally result in run failures and are included there.

4.4.4 DATA

The data base for the Keowee analysis has been developed from generic data sources as well as plant-specific information. The base case solution uses a Bayesian-update, based on Keowee-specific data and the generic data base. Refer to Section 5.0 for detailed information regarding the data development.

4.5 HIGH-LEVEL LOGIC MODEL

The integrated Keowee failure probability is arrived at through the use of a high-level logic model. Through this model the various system fault trees are combined into a single tree for use in the solution process.

The objectives of the high-level logic model are to:

- provide a top gate representing the overall failure probability of Keowee to supply power,
- provide a means for integration of the system models,
- provide a means for introducing the various operating modes of the station into the analysis, including generation to the grid and maintenance,
- provide a convenient location for development of dependent failures,
- provide a pictorial "story" of how the major systems/components influence the Keowee supply,
- provide intermediate gates at appropriate places for analysis of reliability at the unit and power path levels,
- provide intermediate gates at appropriate places for analysis of unit start and run reliability, and
- eliminate to the extent practical all invalid cut sets in the top gate solution as well as the intermediate gate solutions.

In order to satisfy these objectives, the model has been developed with the following attributes.

The top gate for the High-level Logic Model "Oconee Transformers CT3 And CT4 Fail To Receive Power From Keowee" represents the failure probability of interest in this analysis.

The high-level logic model tree separates the solution into the overhead and underground supplies. Additionally, the unit-related failures are on a different branch of the tree than the path-related failures. Furthermore, start and run failures of the two units are evaluated on different branches of the tree. These features allow the evaluation of the reliability at these lower levels. Events representing the probability of various operating conditions are included in the model (such as Unit 1 generating to the grid alone or with unit two, Unit 2 in maintenance, or both Keowee units in maintenance).

An effort is made to eliminate invalid cut sets from occurring in the solutions. This often requires the use of NOT gates in the high-level logic model. It is recognized that this often complicates the tree and the cut sets, but the benefit is in the overall reproducibility of the results by not relying on the analyst's judgment on deleting invalid results.

Refer to Appendix A.1 for further details on the High-Level Logic Model tree.

4.6 MODEL SOLUTION

4.6.1 MODEL INTEGRATION

Model integration is accomplished by creating an empty fault tree file and then loading in the individual trees one at a time. When the 14 individual trees are combined into a single tree, the resultant tree has but one top gate. This is the top gate from the High-level Logic Model identified above. All other top gates from the individual trees are captured as inputs into one or more of the other trees and all transfers identified in the individual trees have been replaced with the appropriate gate.

In some cases the integrated tree may contain circular logic; that is, a gate whose value is dependent on itself. Circular logic must be removed from the tree before a solution is possible. When a circular logic is detected, one or more of the input trees must be modified so that the circle is broken without losing the impact of the failures on the top gate. An often encountered situation of circular logic that is applicable to this study follows.

The auxiliary ac power system relies on the availability of the dc power system to provide power for the operation of various circuit breakers in the ac power system. The dc power system relies on batteries and battery chargers to provide a continuous and long term supply of dc power. If the ac power supply to the chargers is included in the model for the dc power system, a circular logic develops -- ac relies on dc which relies on ac. This circle is broken by not including the transfer to the auxiliary ac power tree in the dc power system logic. Because the ac power system failures result in the unit failing through other system transfers, the loss of this input into the dc power system tree does not cause the solution to "miss" failures and under-predict the failure probability.

4.6.2 CUT SET GENERATION

With the appropriate data file as input, the CAFTA software is used to generate as output a cut set listing. These cut sets are combinations of failures which result in the top gate of the tree being evaluated as true. All cut sets with a probability greater than the truncation limit (1.0E-08), are included in the output. The output also includes the calculated probability for the top gate.

The base case solution is arrived at through the following steps.

1. Solve the integrated tree using the Bayesian-updated data base. In this data base, any recoveries modeled in the trees are set to fail with a probability of 1.0.

2. Apply recoveries to the cut sets as described in Section 4.6.4.

3. Load the data base with the recovery values included into the cut set file, thus obtaining the final result.

4.6.3 MODEL VALIDATION

The initial cut set solution is scrutinized carefully to identify any inappropriate cut sets, missing cut sets, or cut sets suitable for recovery treatment. This effort occasionally leads to refinement of the model either at the system level or in the high level logic. Following adjustment of the model and application of recoveries, the final model and model solution are produced.

4.6.4 RECOVERIES

Recovery events are operator action to mitigate the consequences of failures that have occurred. These actions would require an operator to recognize an off-normal condition and formulate the appropriate response. Operator actions that are a normal response to an event (e.g., a step in a procedure that the operators are expected to be using) is not a recovery.

This analysis takes credit for the Keowee operators recovering certain failures resulting mostly from latent human errors or control system failures where the need for recovery is apparent and the capability exists to achieve rapid recovery. Only a few of the recoveries were identified early in the process and included in the fault trees. Most of the recoveries are applied to the individual cut sets that result from the fault tree solve. Recoveries could be applied manually; however, this study has taken advantage of a software feature that allows recoveries to be applied automatically.

This is done by creating a rule file that identifies the basic events to be recovered and the recovery to be applied to the cut sets containing the event. Some recoveries are applicable to more than one basic event. The software then searches the cut sets for these basic events and applies the appropriate recovery. Only one recovery is allowed to be applied to each cut set. The result is a new cut set file with the recoveries included as part of the cut sets. When the appropriate data is loaded into the cut sets, a new failure probability including the impact of the recoveries is calculated. Table 4.6-1 provides the list of recoveries applied to the cut sets and the basic event(s) that the recovery event is recovering.

Refer to Section 5.5 for further discussion on the quantification of the recovery events.

4.7 <u>BASE CASE ANALYSIS</u>

The base case analysis represents the reliability of Keowee for the current operating configuration (one unit allowed to operate on the grid and one unit in standby mode). The reliability data used in the base case is the Bayesian updated data. The base case analysis also takes credit for operator action (the recovery events).

The analysis computes the failure probability for Keowee to supply power to Oconee (through both the overhead and underground paths) following an emergency start demand from Oconee. Solutions are also obtained at the individual path level, unit level, and the start and run functions. The results are provided in Section 7.2.

4.8 SENSITIVITY STUDIES

Several sensitivity studies are performed to assess the impact on reliability of various changes in data or in the operating configuration. The sensitivity studies are described below and the results presented in Section 7.5. Additional detail and data files are included in Appendix E.

4.8.1 GENERIC VERSUS BAYESIAN UPDATED DATA

In a few instances the Bayesian-updated data changed significantly from the generic value. It is desirable to evaluate the sensitivity of the Keowee results to the plant-specific data used in the Bayesian-update process. The top and intermediate level gates are evaluated using both the generic and the Bayesian-updated data. The impact of the plant-specific data on the results is assessed in this manner.

This study is performed by first solving the tree with the Bayesian-updated data with no credit for recoveries to obtain the cut sets and then loading the generic data into the cut set file to get the new gate probabilities. Results are presented in Section 7.5.

4.8.2 GRID-CYCLED VERSUS STANDBY UNIT RELIABILITY

The reliabilities of the grid-cycled unit and the standby unit are expected to be different. Evaluating this difference is important in understanding the overall Keowee reliability results. By comparing the Keowee Unit 1 and Keowee Unit 2 reliabilities at various stages, an understanding of the contributors to unreliability of the two units is obtained. The probabilities of several of the intermediate gates from the underground and overhead branches of the tree are calculated and comparisons made.

In this study a number of intermediate gate values are solved for using the unrecovered data, included as Table E-1. Results are presented in Section 7.5.

4.8.3 RECOVERED VERSUS UNRECOVERED RESULTS

The base case analysis takes credit for operator action to recover from some failures. It is desirable to know the level of improvement in the Keowee failure probability that results from these recovery actions. The unrecovered result is an intermediate result in the process of obtaining the base case solution. This is the result following step 1 of the process described in Section 4.6.2. Comparison of this result to that of the base case provides information on the improvement in reliability obtained by considering operator actions.

As described in Section 4.6.2, the tree solution is accomplished using the Bayesian-updated data with no credit for recoveries, included as Table E-1.

4.8.4 HUMAN ERROR SENSITIVITY STUDIES

4.8.4.1 Latent Human Errors

The importance of the Latent Human Errors (LHEs) in the calculated failure probability is evaluated by setting these failure probabilities to 0.0 and comparing the result to the base case analysis.

4.8.4.2 Human Error Probabilities Prior To The 10/92 Loss Of Offsite Power

Following the 10/92 event, a number of procedural and administrative changes were made at Keowee. This sensitivity study evaluates the changes in Keowee reliability when human error probabilities based on the conditions that existed prior to 10/92 are used in the analysis. The RHEs, DHEs and LHEs are set to the pre-92 levels. The pre-92 values are compared to the base case values for the human error events in Table 4.8-1.

These changes are made in the Bayesian-updated data with credit for recoveries, the base case data file in Table D-1.

4.8.5 INFREQUENTLY TESTED/DEMANDED COMPONENTS CHALLENGED DURING EMERGENCY STARTS

Many Keowee components are challenged every time the unit is operated. However, some components are challenged only during emergency starts or during testing. It is desirable to estimate the sensitivity of the Keowee reliability result to the failure rate of these infrequently challenged components. This study is divided into three parts. Each part assesses the sensitivity of the Keowee results to a change that increases the likelihood of failure for components which are not frequently challenged.

1. Revise component exposure times to reflect quarterly rather than monthly swapping of the units.

2. Increase by an order of magnitude the failure probability of components not challenged during normal start and power operation but that are needed for emergency operation.

3. Increase by an order of magnitude the failure probability of all components needed for emergency operation.

Refer to Appendix E for further detail on the method and the input values used in this sensitivity study. The results are presented in Section 7.5.

4.8.6 MG-6 RELAY FAILURE RATE

A small number of MG-6 relay failures have occurred at Keowee. However, all of these failures occurred during a three year period rather than distributed evenly over the 10 year data collection period. It is desirable to estimate the sensitivity of the Keowee reliability result to the failure rate of these relays.

For this study, the MG-6 relay applications have been identified and specifically modeled in the Keowee analysis. The MG-6 failure rate is increased by a factor of 10 to assess the impact on the Keowee final result. The selection of the factor of 10 is arbitrary but is large enough to permit detection of any unusual sensitivity of the results to this failure rate.

Refer to Appendix E for further detail on the method and the input values used in this sensitivity study. The results are presented in Section 7.5.

4.8.7 UNCERTAINTY ANALYSIS

Risk assessment can provide useful insight into the relative strengths and weaknesses of plant design and operation. However, in performing risk assessment studies, the process by which the frequency of rare events is estimated is subject to varying degrees of uncertainty. Uncertainties result from the accuracy of basic event failure rates, the correctness and completeness of system models, and accuracy of modeling assumptions. The Keowee uncertainty analysis sensitivity study is an attempt to compute the probability distribution for the model's top gate, KEOWTOP.

The objective of this sensitivity study is to determine the probability distribution for the Keowee PRA top gate KEOWTOP. This is accomplished by the following method.

1. Add error factor and distribution type information to the type code and basic event databases. A categorization method is employed as follows:
   a) Component failure type codes for which generic failure rates are available are assigned the error factor calculated by the Bayesian-update spreadsheet.
   b) Basic events representing scheduled maintenance are assigned an error factor of 3.
   c) Human errors are assigned error factors of 5 or 10, depending on their failure probability value as follows:

Failure Probability	Error Factor
< 0.001	10
0.001 - 0.01	5

   (Events AB0SWGRREC and Y0STARTREC are assigned error factors of 2 due to their relatively high failure probability of 0.5)
   d) Due to higher uncertainty, common cause events, developed events, and plant-specific type code failure rates are assigned an error factor of 10.

2. Load the base case cut sets (Bayesian-updated, recoveries added) into CAFTA.

3. Use the CAFTA Uncertainty Analysis utility to evaluate the cut sets.

4.8.8 ONE VERSUS TWO UNITS GENERATING TO THE GRID

In order for Keowee to again use two units when generating to the grid, certain single failures identified in engineering studies must be corrected. These single failures are being addressed through the implementation of NSM-ON-52966. The Keowee reliability model has been developed with the implementation of this NSM as a consideration. An event is included in the model to turn on and off those parts of the model affected by this NSM. The results of the sensitivity study where two units are allowed to generate to the grid assumes that the NSM is in service, as this is an expected requirement to return to this mode of operation.

In the base case analysis the exposure times on the standby unit are much longer than those on the grid-cycled unit. As a result, the standby unit is calculated to have a higher failure rate. This sensitivity study is performed by modifying the data base to reflect the change in operating modes, and the implementation of NSM-ON-52966. These changes include the basic events reflecting the probability that unit 1 is generating to the grid and revising the exposure times on the unit 1 components to reflect the daily operation of the unit. The implementation of the NSM is specified by setting event ACB4MOD to 0. The tree is solved with the new data to obtain the failure probability.

This study is performed only with the Bayesian-updated data. The data bases used in this sensitivity study are included as Tables E-5 and E-6. Refer to Appendix E for further information on NSM-ON-52966.

4.8.9 SENSITIVITY TO FRACTION OF TIME THAT 2 UNITS GENERATE TO THE GRID

Based on the operating history of Keowee, the 2 units are operating simultaneously to the grid 3% to 4% of the time. This sensitivity study is performed to determine if the reliability estimate developed in this study is overly sensitive to this value. Though no changes in the modes of generation of Keowee are anticipated, this assures that the conclusions of the analysis remain valid should some change occur.

Basic event KK1BOTHDEX is increased to a maximum value of 30% (0.30). This value is nearly a factor of ten greater than the base case value, and is greater than the supply of water to Keowee should permit.

This study is performed using the data base identified in Section 4.8.8 for the dual generation study. The fault tree is solved with basic event KK1BOTHDEX set to 0.30 in order to be sure that an adequate number of cut sets with the event included are available in the cut set file since this is a large percentage increase in the basic event value. The recovered and unrecovered results are investigated for the impact of the change.

Table 4.3-1

Keowee Walkdown Checklist

Walkdown Item[1]	Function	Examined
Operating Floor		
Generator Field Breaker	Closed to energize Generator Field	✓
Voltage Regulator	Regulates Generator output voltage	✓
Power Drawers	Supply Field Current (dc) to Generator	✓
Field Flashing Breaker	Closed to energize Field Breaker from 125 Vdc bus 1DA (2DA) {For Generator start}	✓
Supply Breaker	Supplies current from 1E (2E) transformer to thyristor {Generator running}	✓
Thyristor	Converts ac to dc prior to supplying Field Breaker	✓
Field Breaker	Supplies dc current to Generator field winding	✓
Excitation Transformers 1E (2E)	Step Generator voltage down prior to supplying Field	✓
M/O Disconnects	Used to isolate ACBs 3 and 4 from the Generator	✓
Aux. Disconnects		✓
CT's, POT's and Surge Protection	Monitor and protect power equipment	✓
Transformers 1X (2X), CX	Step voltage down to supply 1X, 2X Switchgear	✓
Air Circuit Breakers (ACB) 1,2	Connect Generators to Main Step-up Transformer (to Overhead path) and to 1X,2X transformers to supply Keowee loads	✓
ACB-3,4	Connect Keowee with Underground path to CT-4	✓

Table 4.3-1

Keewee Walkdown Checklist

Walkdown Item[1]	Function	Examined
ACB-5	Connect 1X Switchgear with 1X Transformer	✓
ACB-6	Connect 2X Switchgear with 2X Transformer	✓
ACB-7	Connect 1X Switchgear with CX Transformer	✓
ACB-8	Connect 2X Switchgear with CX Transformer	✓
Generator Fire Suppression CO_2 cylinders	Inject CO_2 into Generator Housing	✓
Computer Equipment Room		
Static Inverter (later moved to Battery Room)	Converts dc to ac power to supply Station Computer, Statalarms, alarm typers	✓
Regulator and Power Supply	Supplies Inverter	✓
Computer Cabinets	Monitor plant status	✓
Logic Cabinets	House Keowee Controlling Devices	✓
Control Room		
Keowee Controls		
Exciter M.O. Base Volt Adjust	Provides coarse adjustment to raise	✓
Raise/Lower Switch	or lower Generator Field voltage to match bus voltage during a manual startup	✓
Auto Voltage Adjuster	Provides fine adjustment of Generator	✓
Raise/Lower Switch	Field voltage	✓
Speed Changer Motor Switch	Signals Governor to open or close wicket gates	✓
Generator ACB-1/2 Switch	Close, trip, or lock-out breaker	✓

Table 4.3-1

Keowee Walkdown Checklist

Walkdown Item[1]	Function	Examined
Gate Limit Motor Raise/Lower Sw.	Limits open position of the wicket gates	✓
Local Master Start/Norm/Stop Sw.	Energizes relays to start or shut down Generator	✓
Master Selector Auto/Man Switch	Sets logic for either an automatic or manual start	✓
Unit Sync 230 kV Man/Auto Sw.	Selects for either automatic or manual sync. to the grid	✓
Motor/Generator Switch	Selects operation mode	✓
Generator Voltage Regulator TEST/ON Switch	TEST mode selected to allow for manual control using the Auto Voltage Adjuster; ON mode provides auto Generator voltage regulation	✓ ✓
Keowee Instrumentation		
Condenser Operate Light	In motor mode, ON indicates runner is uncovered	✓
Draft Tube Depress Start	In motor mode, ON indicates runner depression of water	✓
Permissive Auto Start	ON indicates Unit is available for startup	✓
Generator Operation Complete	ON indicates adequate output voltage for Unit to be in generator mode	✓
Speed Adjust Meter	Indicates signal being sent from the Motor Speed Changer to the Governor	✓

Table 4.3-1

Keowee Walkdown Checklist

Walkdown Item[1]		Function	Examined
Forebay Elevation	(60-105 ft)	Indicates level of Lake Keowee above 700' ref. level	✓
Tailrace Elevation	(-5 to -45 ft)	Indicates level of Lake Hartwell, referenced to 700'	✓
Keowee Load Recorder			✓
Critical Keowee Statalarms			
Normal Lockout		Unit tripped and/or blocked from normal start	✓
Emergency Lockout		Unit tripped and/or blocked from emerg. start	✓
Alarm Lockout		Unit startup is blocked	✓
Startup Inhibit		Unit startup is blocked from any source	✓
Mechanical Equipment Gallery			
Governor Actuator Cabinet:		Houses the listed systems/components	✓
Hydraulic Power System		Positions wicket gates	✓
Distributing valve mechanism		Supplies oil to servomotors	✓
Auxiliary valve (used during maint.)		- same as distributing valve -	✓
Restoring mechanism between wicket gates and valve system		Stops gates at desired position	✓
Governor Head		Provides speed sensing	✓
Compensating dashpot		Provides for smoother gate movement	✓
Transfer Valve		Selects distributing valve or aux. valve; or both valves closed	✓

Table 4.3-1

Keowee Walkdown Checklist

Walkdown Item[1]	Function	Examined
Tachometer (for info only)		✓
Speed Changer Knob	Manually change operating speed	✓
Brake valve		
Manual Operating Handle		✓
Override switch	Overrides electrical interlocks to allow manual brake application	✓
Governor Oil System		
Pump Control Valve Case Assembly	Houses pump controls	✓
Relief valve		✓
Pressure Shutoff valve	Permits removal of pump w/o loss of system pressure	✓
Pilot valve	Senses system pressure and directs oil to servomotors or accumulator tank	✓
Pressure switch	Starts and stops pump motor to maintain adequate system pressure	
Echelon Control Knob	Selects loading and unloading pressure of the pumps relative to the operating pump	✓
Governor Oil Pump A	Pumps oil to the Gov. Oil Accumulator Tank	✓
Governor Oil Pump B		✓
Governor Oil Pump C		✓
Governor Oil Sump		✓
Governor Oil Accumulator Tank	Supplies Governor with pressurized oil	✓
Governor Air System	Supplies 350 psig pressure to the Governor Oil Accumulator Tank	

Table 4.3-1

Keowee Walkdown Checklist

Walkdown Item[1]	Function	Examined
Air Compressors		✓
Air Receiver Tank		✓
Turbine Grease Pump System	Lubricates wicket gates and gate operating mechanism	✓
Pumping station		✓
Control panel with timers		✓
Station Air	Supplies Generator Air Brakes	
Receiver Tank		✓
Compressor		✓
ACB Air Compressor		✓
Lube Oil Storage Tanks	Supply oil to Generator and Turbine oil pots	✓
Lube Oil Purifiers		✓
Depressing Air Compressors	Depress Water from Draft Tube	✓
600 V MCCs 1XA, 1XS, 2XA, 2XS	Supply 600 Vac Station loads	✓
Turbine Pit		
Open and Close Servomotors	Move the operating ring	✓
Wicket Gates (20)	Control flow rate through turbine	✓
Gate Operating Mechanism		✓
Bottom Ring		✓
Outer Head Cover		
Inner Head Cover		
Packing Box	Seals turbine shaft	

Table 4.3-1

Keowee Walkdown Checklist

Walkdown Item[1]	Function	Examined
Runner	Converts kinetic energy of water to mechanical energy of shaft	
Runner Support Brace		
Turbine Shaft		✓
Turbine Sump Pumps (Turbine Wheel Pit)		
AC Pump		✓
AC Pump (spare)		✓
DC Pump		✓
Turbine Guide Bearing Oil System		
Turbine Guide Bearing	Provides lateral shaft support	✓
Turbine Guide Bearing Oil Cooler		✓
AC Pump	Operates continuously to lubricate guide bearing	✓
DC Pump (back up)	Operates on AC pump failure or low oil level	✓
Upper Oil Reservoir	Holds emergency oil supply	
Lower Oil Reservoir	Provides suction to oil pump(s)	
Overflow Lines	Provides flowpath from upper to lower oil reservoir	
High Pressure Oil System		
Generator Thrust & Guide Bearings	Provide lateral and axial shaft support	
AC Generator High Pressure Oil Pump	Supply oil under bearing to lift shaft	✓
DC Generator High Pressure Oil Pump	from 0 - 37 rpm	✓

Table 4.3-1

Keowee Walkdown Checklist

Walkdown Item[1]	Function	Examined
Embedded Parts		
Draft Tube Liner	Collects water leaving runner	
Spiral Case	Channels water to turbine	
Generator Housing		
Generator Ventilation System	Cools stator, rotor	
Paddle-type blowers	Circulate air through generator housing and air coolers	
Air Coolers		
Spiral Case Gallery		
Spiral Case Access Main Door		
Gravity Oil Tank	Collects drainage from Generator and Turbine oil reservoirs	✓
Transfer Oil Pump	Transfers oil from Gravity Oil tank to Lube Oil Storage Tanks	✓
Recirculating Oil Pump	Transfers oil from Gravity Oil tank to Generator or Turbine oil reservoirs	✓
Battery Room		
Batteries 1 and 2	Supply DC Distr. Centers 1DA, 2DA	✓
DC Distr. Center 1DA, 2DA	Supply 125 Vdc Station loads	✓
Battery Chargers 1, 2 and Stand-by	Charge Batteries 1 and 2	✓
Miscellaneous Terminal Cabinets	House Keowee Controlling Devices	✓

Table 4.3-1

Keeowee Walkdown Checklist

Walkdown Item[1]	Function	Examined
Draft Tube Access Gallery		
Draft Tube Unwatering Pumps		✓
Station Unwatering Pumps	Remove water from Station Unwatering Sump	✓
Spiral Case Unwatering Valve	Opened to drain water from Spiral Case to Draft Tube	✓
Draft Tube Access Main Door		✓
General		
Generator Cooling Water System	Cools the listed safety-related loads	
Turbine Packing Box		
Generator Thrust Bearing Coolers (8)		✓
Generator Air Coolers (6)		
Brake and Jack System		
Automatic Brake Timer	Permits intermittent, then continuous brake application	
Control Switch	Select Man. or Auto; remove from service	✓
Speed Switch	Starts the braking cycle after unit has decelerated to the predetermined speed	
Position Switch	Prevents application of brakes with gates open	
Air Brakes	Decelerate Generator shaft	
Generator Jacking Pump	Supplies oil to the brake shoes to lift the generator shaft (used during maintenance)	✓

Table 4.3-1

Keowee Walkdown Checklist

Walkdown Item[1]	Function	Examined
Outside		
Main Step-up Transformer		✓
Depressing Air Tanks (6)		✓
Structures		
Keowee Dam		✓
Keowee Spillway		✓
Little River Dam and Dikes		
Oconee Intake Canal Dike		
Keowee Intake Structure		✓
Keowee Power and Penstock Tunnels		
Keowee Powerhouse		✓
Keowee Breaker Vault		✓
Keowee Service Bldg. Substructure		✓
Switchyard Relay House		✓
125 V Switchyard Batteries, Relays		✓
Main Electrical Paths		**All Examined**

ACB-1--> 1X Transformer --> ACB-5 --> 600 V 1X Switchgear --> 600 V MCC 1XA, 1XS, (2XA, 2XS)

--> Main Transformer --> Overhead path --> PCB-9 --> Yellow Bus --> PCB-18,27,30 --> CT-1,2,3 --> Oconee Main Feeder Buses

Table 4.3-1

Keowee Walkdown Checklist

Walkdown Item[1]	Function	Examined
ACB-2--> 2X Transformer --> ACB-6 --> 600 V 2X Switchgear --> 600 V MCC 2XA, 2XS, (1XA, 1XS) --> Main Transformer --> Overhead path --> PCB-9 --> Yellow Bus --> PCB-18,27,30 --> CT-1,2,3 --> Oconee Main Feeder Buses		
1TC --> CX Transformer --> ACB-7 --> 600 V 1X Switchgear --> ACB-8 --> 600 V 2X Switchgear		
ACB-3,4--> Underground path --> CT-4 (Unit 1/2 Blockhouse) --> Standby Buses --> Oconee Main Feeder Buses		

[1]Not all of the listed items were accessible, but are included for completeness.

Notes:

1. While performing the walkdown, the team took photographs, which are collected in the PRA Walkdown Photo Album, and also took some video footage.

2. General Walkdown Observations:
   - Many of the station components are clearly labeled. However, labeling is not yet as comprehensive as at Oconee. An effort is underway to expand labeling of station equipment.
   - Station equipment appeared to be in good material condition.
   - Station housekeeping is good. Everything appeared to be in its proper place.

Table 4.3-1

Keowee Walkdown Checklist

- Station equipment throughout the plant is protected from fire by fire detectors and spray nozzles, portable CO_2 extinguishers, and in the case of the generator, an automatic CO_2 fire suppression system. An evaluation of Keowee fire concerns will be done by an IPEEE study.

- No design deficiencies were identified.

Table 4.6-1

Recovery Events Applied To Cut Sets

	Event Name	Recovery Event - Failure Event Pair
1)	EK0BASERHE	Failure To Recover From Improper Base Adjust Setting
	EK1BASELHE	Keowee Unit 1 Base Adjust Is Set Incorrectly
2)	EK0BASERHE	Failure To Recover From Improper Base Adjust Setting
	EK2BASELHE	Keowee Unit 2 Base Adjust Is Set Incorrectly
3)	FK0FISHDHE	Failure To Recover Flow Through Clogged Main Strainer
	FK0FISHCOM	Common Cause Failure Of Both Unit's WL Filters Due To Intake Debris
4)	FK0FISHDHE	Failure To Recover Flow Through Clogged Main Strainer
	FK2FL01FRF	Filter 2WLFL-1 Becomes Clogged
5)	FK0FISHDHE	Failure To Recover Flow Through Clogged Main Strainer
	FK1FL01FRF	Filter 1WLFL-1 Becomes Clogged
6)	GK0BRGVRHE	Failure To Recover Thrust Bearing Cooling
	GK2BRGVLHE	Keowee 2 Gen. Brng Oil Cooling Flow Path Vlvs Mispositioned After Maintenance
7)	GK0BRGVRHE	Failure To Recover Thrust Bearing Cooling
	GK1BRGVLHE	Keowee 1 Gen. Brng Oil Cooling Flow Path Vlvs Mispositioned After Maint
8)	Y0STARTRHE	Operators Fail To Manually Start Keowee
	Y0STARTCOM	Common Cause Failure Of Emergency Start Signal
9)	Y0STARTRHE	Operators Fail To Manually Start Keowee
	L0EGTPSCOM	Common Cause Failure of UV And UF Detection Circuits
10)	AB0SWGRRHE	Failure To Recover Keowee Auxiliary Power Breakers
	XA1BKRSCOM	CCF of 1X Aux. Power Breakers ACB-5 & -7
11)	AB0SWGRRHE	Failure To Recover Keowee Auxiliary Power Breakers
	XA2BKRSCOM	CCF of Aux. Power Breakers ACB-6 & -8
12)	AB0SWGRRHE	Failure To Recover Keowee Auxiliary Power Breakers
	XA56BKRCOM	Common Cause Failure Of ACB-5 And ACB-6 To Close
13)	AB0SWGRRHE	Failure To Recover Keowee Auxiliary Power Breakers
	XA78BKRCOM	Common Cause Failure Of ACB-7 And ACB-8 To Close

Table 4.6-1

Recovery Events Applied To Cut Sets

	Event Name	Recovery Event - Failure Event Pair
14)	AB0SWGRRHE	Failure To Recover Keowee Auxiliary Power Breakers
	AB0SWGRCOM	Common Cause Failure Of All Keowee Auxiliary Power Breakers
15)	XD0KBATRHE	Failure To Recover DC Power By Cross-connecting The DC Distr. Center
	XD2KBATBYF	Keowee Battery No. 2 Fails during Discharge
16)	XD0KBATRHE	Failure To Recover DC Power By Cross-connecting The DC Distr. Center
	XD1KBATBYF	Keowee Battery No. 1 Fails During Discharge
17)	Y0STARTRHE	Operators Fail To Manually Start Keowee
	Y0STARTCOM	Common Cause Failure Of Emergency Start Signal
18)	Y0STARTRHE	Operators Fail To Manually Start Keowee
	L0EGTPSCOM	Common Cause Failure of UV And UF Detection Circuits

Table 4.8-1

Human Error Probabilities
Pre-1992 and Base Case

Event	Pre-92 Value	Base Case Value	Description
ABEOPRCDHE	1.00E-01	9.00E-03	Operators Faill To Close Air Circuit Breaker 2
EK1BASELHE	1.00E-02	3.20E-03	Keowee Unit 1 Base Adjust Is Set Incorrectly
EK2BASELHE	1.00E-02	3.20E-03	Keowee Unit 2 Base Adjust Is Set Incorrectly
FK0FL00DHE	2.0E-01	6.3E-02	Failure To Recover From Turbine Guide Bearing or Packing WL Filter Clogging
PK1TSDCLHE	1.00E-02	3.20E-03	Latent Human Error Fails Turbine No. 1 DC Sump Pump
PK2TSDCLHE	1.00E-02	3.20E-03	Latent Human Error Fails Turbine No. 2 DC Sump Pump
XD1KB1XDHE	2.0E-01	9.3E-02	Keowee Standby Battery Charger SBC Not Lined Up in 1 Hour
XD2KB2XDHE	2.0E-01	9.3E-02	Keowee Standby Battery Charger SBC Not Lined Up in 1 Hour

Note: Only the revised events are listed.

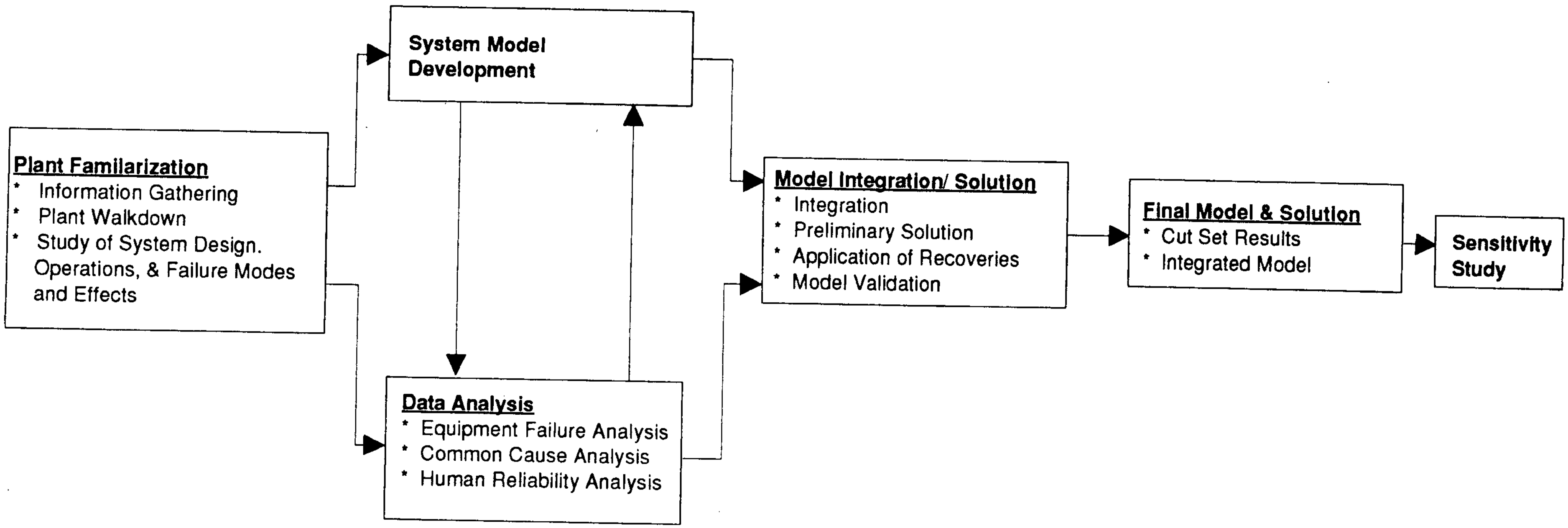


Figure 4.3-1 Systems Analysis Process Diagram

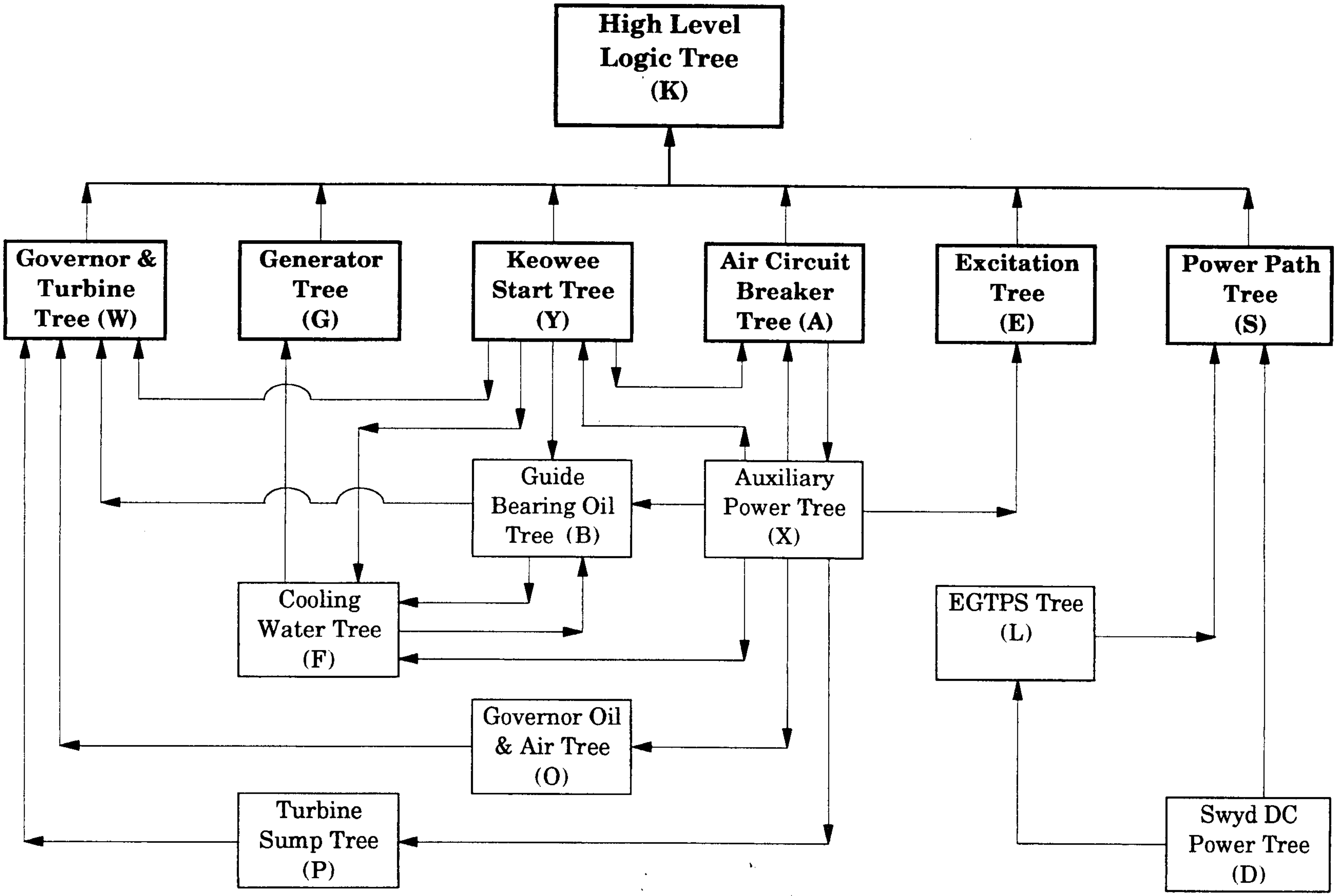


Figure 4.3-2 Keowee Fault Tree Overview

5.0 KEOWEE DATA ANALYSIS

5.1 INTRODUCTION

The objective of the data analysis is to generate the values of the basic events of the fault trees and other events needed to quantify the Keowee reliability. Specifically, the data analysis provides the quantitative information on (1) Keowee plant data, (2) Keowee common cause failure data, and (3) Keowee human reliability.

The Keowee plant data comprise the Keowee unit level reliability data (failure to start, failure to run, and maintenance unavailability), derived from Keowee-specific operating experience, and the equipment reliability data derived from the analysis of plant-specific component level experience data and consideration of generic data. The equipment reliability data are used to calculate the basic event probabilities of the random failure type.

The common cause analysis, presented in Section 5.4, investigates the potential for simultaneous failure of both Keowee units due to some indirectly shared influence (for example, identical design, spatial coupling, etc.,) and estimates the common cause failure probabilities.

Section 5.5 summarizes the analysis of the human element for its potential to cause Keowee failures or, occasionally, to overcome the equipment failures and achieve desired emergency response.

Together, the basic events from random equipment failures, common cause failures, human errors, equipment maintenance unavailabilities, and any defined operational mode fractions comprise the data base needed for the Keowee PRA model solution. Appendix D contains the data base resulting from the data analysis.

5.2 KEOWEE PLANT DATA ANALYSIS

5.2.1 DATA ANALYSIS PROCESS

An extensive amount of data was collected and analyzed in support of the Keowee PRA. Keowee unit level and equipment level operating data were collected for the period covering January 1, 1984 to December 31, 1993.

The process utilized for the plant-specific data collection and analysis effort comprised:

- selection of the type of data needed as determined by the systems analysts,
- selection of data sources,
- review of data reports and compilation of data of interest,
- validation of the data by cross-checking the different data sources, interviewing Keowee personnel for clarification and confirmation, and Keowee PRA team reviews,
- generation of event data tables with the information organized in the desired format,
- generation of data on number of demands and operating hours,
- calculation of failure rates and unavailability values, and
- preparation of data reports.

5.2.2 DATA SOURCES

A number of data sources were relied on to compile the Keowee-specific data, as follows:

Keowee Operator Logs

This source is considered to be a complete and thorough record of plant operations and events of interest. This was the primary source of information for unit/component failures, unavailability, and unit run times. Event descriptions from this source could often be cross-checked with other sources such as the Oconee work request data base and the plant incident report data base (PIR & PIP) for completeness. These logbooks are controlled documents, maintained by the Keowee Hydro Station operators and reviewed by the Keowee plant supervisor while in active use. The inactive logbooks are maintained in permanent storage by Oconee Document Control.

Keowee Switchboard Log

This is a computer printout containing unit operating data--start/stop times and hourly power output values. This was the primary source for the number of unit demands.

PIP/PIR/IIR Data Base

These are the Duke Power nuclear station incident report data base. These reports contain information (such as nature of the failure and cause of the failure) on component failures or problems in systems addressed in Technical Specifications.

INPO LER Data Base

This is a computer database maintained by INPO. It was referenced for completeness.

Work Request Data Base

A work request (WR) is written whenever maintenance is required on any piece of equipment. It contains the information on the nature and cause of the problem that required the maintenance work, who performed the work, and the dates of origination and completion of the WR and the work. As such, WRs constitute the most complete source of component failure histories. Along with the Keowee operators logbook, WRs served as a primary source of component failures and unit unavailability data.

Oconee Reactor Operator Logbook

The RO logbook contains information on Keowee and switchyard operations affecting Oconee, equipment removal and restoration entries, and completion of periodic tests.

Jocassee Hydroelectric Station Data

The Keowee data team met with Jocassee personnel to compare the operating experience and failure history of similar equipment. Jocassee personnel provided a listing of failure events for those Jocassee systems and equipment which perform similar functions at Keowee. This data enabled a qualitative benchmark of the Keowee data. The review of the Jocassee data indicated that, in general, equipment failures at Jocassee are similar to

those found at Keowee and that it did not suggest the need to consider any new failure modes at Keowee.

5.2.3 KEOWEE GENERATOR RELIABILITY DATA

The Keowee generator reliability data include the unit start failure probability, the unit run failure probability, and the maintenance unavailabilities of one or both units. The start and run failure probabilities derived from the operating experience are not used in this Keowee reliability model calculation but are used to compare the model prediction with the operational data. The unit maintenance unavailability data, however, are used explicitly in the model calculation.

Table 5.2-1 provides a listing of the Keowee unit start and run failure events during the data period 1984-1993, and Table 5.2-2 contains the summary information on the number of start failures and run failures, the total number of start demands, the total unit load run hours, and the unit unavailability hours.

The start failure probability of interest is the failure applicable for an emergency start situation (ES failures). This probability is determined by first determining the number start failures applicable for the emergency start condition during the observation period and dividing by the number of applicable start demands. The ES failures include any actual failures during an emergency start (test or actuation) and any failure during normal automatic starts where the failure was caused by equipment response which would not have been bypassed during an emergency start condition. From the data in Table 5.2-2, there are 29 applicable failures in 6488 applicable start demands, resulting in an emergency start failure probability of 4.5E-3/demand.

Similarly, the run failure probability of interest is the probability that the unit will fail during the load run, after a successful start. It is determined by dividing the number of load run failures applicable for the emergency load condition by the total number of successful load run hours during the observation period. From Table 5.2-2, there are 5 run failures applicable to the emergency load run situation and 9713 total load run hours, giving a run failure probability of 5.1E-4/hour.

The maintenance unavailabilities calculated from the data in Table 5.2-2 amount to 3.8E-2 for one unit in maintenance and 5.2 for both units in concurrent maintenance.

5.2.4 KEOWEE COMPONENT FAILURE DATA

Keowee component failure data are extracted from the body of data comprising the Keowee plant and equipment data. The component failures of interest are those events where a component appearing in one of the system models failed or was taken out of service for repair. Following the event identification, the event listing is sorted by the system or subsystem (for example ACB or generator) to correlate to appropriate type codes. Table C.1-1 in Appendix C provides the component failure data sorted by type code. The number of failures and information on number of demands or service hours are used to calculate the plant-specific component failure rates, as discussed in Section 5.3.

As part of the Keowee component failure analysis, the trend in the occurrence of failures was investigated to identify any temporal behavior of concern. Figure 5.2-1 presents the trend in the occurrence of equipment failure and problems during this observation period. It suggests an increased activity of equipment failures in the 1991-92 period. Examination of equipment type, revealed that MG-6 relays and the X-relays are the principal contributors to this trend. Figure 5.2-2 presents the failure history of these relays compared to the Keowee start failures.

All the X relays and many of the MG-6 relays have now been replaced, and the undesirable trend appears to have been corrected.

5.3 KEOWEE COMPONENT RELIABILITY DATA

The objective of the Keowee component data analysis is to develop the basic event data base representing the random failure probabilities of the components, with their specific failure modes, represented in the system fault trees. It is this data base; along with the data representing the human error events, common cause failure events, maintenance unavailability events, and operational state conditioning events; that is used to solve the system models and the integrated Keowee model to obtain the numerical reliability solutions of interest.

To establish the component reliability data base for the Keowee PRA study, three options were considered:

1. use of generic data,

2. use of Keowee-specific data, and
3. use the combined generic and Keowee-specific data by means of the Bayesian update technique.

The option to use generic data as the sole basis for the Keowee component reliability data base was rejected because of the availability of substantial Keowee-specific data. On the other hand, for some Keowee components with few or no failures and limited number of demands in the data period, the Keowee data alone was not considered adequate for statistical significance. Thus, it was decided to use Option 3 (Bayesian-updated generic plus Keowee data) for the base case solutions, and to perform a sensitivity study using the generic data to infer any strong dependence of the results on the type of the data. It turns out that because the Keowee data base was fairly extensive, the Bayesian-updated generic-plus-Keowee data followed the Keowee-specific data characteristics. Thus, the base case data base is primarily the Keowee-specific data base.

Generic Failure Rates

As part of the data analysis task, the availability and usability of various data sources were investigated. Generic data sources considered in this investigation included (1) NUREG-1150 data sources, (2) EPRI ALWR data base, (3) INEL data base, and (4) generic data in published PRAs. The availability of data pertaining to hydroelectric equipment from the Duke system was also investigated; however, it was determined not to be available in the level of detail needed for the Keowee PRA effort. The generic data in the Davis-Besse PRA (Reference 5) seems to be an amalgamation of several data sources and, in general, the data values in this reference appeared to be consistent with the values found in other data sources. Therefore, the generic failure rate data reported in the Davis-Besse PRA was selected as the primary generic data source. The INEL report, "Generic Component Failure Data Base for Light Water and Liquid Sodium Reactor PRAs" (Reference 6), and IEEE Std. 500 (Reference 7) were also utilized where the data on the equipment type was not available in the Davis-Besse PRA.

The generic component failure rates used in the Keowee PRA study are shown in Table 5.3-1.

Plant-Specific Failure Rates

The plant-specific component failure rates/probabilities are calculated by dividing the number of component failures, as derived in Section 5.2.4, by the number of component challenges or service hours, as appropriate. For example, to compute the pump start failure probability, the number of start failures for the ten pumps included in the Keowee PRA model is ascertained. This number is then divided by the aggregate number of pump starts to obtain the pump start failure probability.

The Chi-Squared variate at the 50% cumulative probability level is used estimate plant-specific failure rates for components that have not experienced a failure. The Advanced Light Water Reactor Utility Requirements Document (Reference 8) utilizes the following equation to estimate failure rates where no failures have occurred (such as for large-break LOCAs):

$$\phi(A) = \frac{X^2_{50}(2n+1)}{2T}$$

where $\phi(A)$ = the failure rate of interest
$X^2_{50}(2n+1)$ = the chi-squared quantile at the 50% cumulative probability level, with $2n + 1$ degrees of freedom
n = the number of failures observed
T = exposure time or number of demands.

(The 50% quantile is the median point of a data set: half of the values occur below this value and half above.)

For the case where no failures have been observed, $n = 0$, and $X^2_{50}(1) = 0.455$. Thus the equation simplifies to:

$$\phi(A) = \frac{0.2275}{T}$$

Bayesian-Updated Failure Rates

The final step in the analysis of data for use in the Keowee PRA model involves the Bayesian update process. In this exercise, the generic failure rates are "updated" with the plant-specific evidence on the number of failures, challenges, and service hours.

Results of Component Data Analysis

Table 5.3-1 contains data bases for the three types of component failure rates -- generic failure rates, plant-specific failure rates, and the Bayesian-updated failure rates. As stated earlier, it is the Bayesian-updated failure rates data that was used in the base case solution of the Keowee systems and the integrated models.

As seen from this table, most of the plant-specific failure rates are lower than their generic counter parts. The service environment and operating stresses of the components in Keowee are relatively mild compared to the typical nuclear power plant environment. Also, some components (for example, the oil pumps) are relatively simple devices and appear to be very rugged for the Keowee applications. These differences could possibly account for some of the large differences between the generic failure rates and the Keowee failure rates in the few component types. Nevertheless, when viewed as an aggregate the Keowee component data is consistent with the generic data.

Additional details of the Keowee component reliability analysis may be found in Appendix C.1.

5.4 KEOWEE COMMON CAUSE FAILURE ANALYSIS

5.4.1 OVERVIEW

Common cause failure mechanisms are an important aspect of a probabilistic safety study that have been recognized in many PRA studies to be major contributors to plant risk and system unavailability. A common cause failure event is an event resulting in multiple failures of a specified set of (usually similar) components due to a shared cause. Thus, these failures effectively defeat the redundancy employed to ensure the reliability of plant safety systems. For this reason a detailed assessment of potential common cause failure modes was performed for the Keowee systems and equipment.

5.4.2 PROCESS

The process used to assess common cause failure is based heavily on the guidance of NUREG/CR-4780 (Reference 3). This assessment included an operating history review,

qualitative analysis, Keowee specific data analysis, and event quantification. A detailed description of the process used to identify and quantify common cause events is provided in Appendix C.2.

The operating history review includes examination of Keowee operator logs, LERs, and Problem Investigation Reports (IIR/PIR/PIP) for the years 1980-1993. The review period spans 14 years, instead of 10 years, as is used for the equipment random failure data, to capture the operating experience events for common cause failure analysis. Industry experience is also examined by reviewing EPRI Report TR-100382 (Reference 9) which provides information on actual events in recent years.

A detailed qualitative analysis of the Keowee systems and components is performed using a modified procedure based on the generic cause approach described in NUREG/CR-4780, Volume 2, Appendix B (Reference 10). A full description of the qualitative procedure used is presented in Appendix C.2 of this report.

Unlike previous Oconee risk studies, Keowee common cause events are modeled and quantified on a "component-level" rather than on a "train-level." Component-level modeling provides a better understanding of the common cause contribution to Keowee unavailability by examining root causes of equipment failures, common cause defense mechanisms, and potential recovery actions for certain failure modes.

Using the system fault trees, the results of the operating history review, and the qualitative analysis, a list of common cause basic events is developed and incorporated into the fault trees. Candidate events are chosen to represent those components in the qualitative analysis that were found to have tangible coupling mechanisms between the units or between redundant components on the same unit. Common cause failures that have occurred previously at Keowee are also modeled. The system fault trees are also reviewed for dependencies or redundancies that could affect common cause modeling and to determine the best location for each common cause basic event. Most events are placed in the high level logic tree unless they affect a single unit only.

To the greatest extent possible, both industry data and Keowee operating data are used to quantify common cause basic events instead of using strictly generic common cause parameters. Industry common cause events are reviewed and screened according to their applicability to similar Keowee components. Industry data is found on circuit breakers,

batteries, and air-operated valves.

The Multiple Greek Letter (MGL) model is used to calculate common cause multipliers. Basic events for which no common cause data is available, are quantified using generic MGL parameters taken from NUREG/CR-5801 (Reference 11). The common cause multipliers are in turn multiplied by the random failure probability for the component group represented by the common cause basic event. The random failure probability is the "independent" failure probability for the modeled component. For components which were modeled down to the subcomponent level, the random failure probability was taken as the intermediate gate solution from the system fault tree for that specific component group.

Credit is taken, when deemed appropriate, for Keowee defensive mechanisms that are considered substantially stronger than typical industry defensive strategies. For example, the use of at least one Keowee unit for daily grid generation provides a strong defense against common cause failure. Unit operation in this mode provides a full functional check of the most important systems needed for emergency operation. By providing a frequent test, the exposure time of the units to a common failure mode is greatly reduced. The additional design margin provided for higher system generating loads is another important defense mechanism for the generator and generator cooling water systems. Basic events that are considered "strongly defended" are given a "Beta-factor" that is a factor of two lower than the generic "Beta-factor" for that system.

5.4.3 COMMON CAUSE ANALYSIS RESULTS

The results of the common cause quantification are presented in Table 5.4-1. A sensitivity study is performed by summing the common cause component run failures and start failures and comparing the total probability with the run and start common cause failure probability calculated using a "system-level" analysis approach. Details of this sensitivity study are provided in Appendix C.2, Section C.2.5.2.

The results of this comparison are shown in Figure 5.4-1. This comparison shows good agreement between the component-level analysis and a system-level analysis. However, the additional effort of the component-level analysis provides additional insight into the common cause contribution to specific system unreliability and the importance of operator

recovery of equipment failures such as generator cooling or auxiliary power breakers.

The overall impact of common cause failures on Keowee reliability is discussed in Section 7.6 and in Appendix C.2 of this report.

5.5 KEOWEE HUMAN RELIABILITY ANALYSIS

5.5.1 OVERVIEW

The objective of the Keowee human reliability analysis (HRA) effort is to identify, assess, and quantify potential human errors which can lead to the failure of Keowee for the Oconee emergency power function. The human error events of interest are either modeled in the affected individual system fault trees or considered as part of the integrated solution of the Keowee reliability model.

Human reliability events in the Keowee PRA account for potential human errors which would result in:

a. failed initial equipment configurations (called pre-event errors or latent human errors),
b. unsuccessful response in dealing with failed equipment (called recovery errors), and
c. a worsening situation (called commission errors).

This section summarizes the Keowee PRA HRA process and the quantitative results. Appendix C.3 contains additional details.

5.5.2 PROCESS

The HRA process utilized in the Keowee PRA is consistent with the process outlined in the EPRI report "SHARP 1 -- A Revised Systematic Human Action Reliability Procedure" (Reference 12).

Briefly, the process consists of the following steps:

1. walkdown of Keowee,

2. review of Keowee and industry operating events,
3. review of plant procedures,
4. event identification and integration,
5. interview of plant personnel,
6. quantification,
7. recovery analysis, and
8. internal review.

Appendix C.3 elaborates on these steps, and the following subsections provide a brief description of some of these steps.

5.5.3 WALKDOWN

The initial walkdown of the plant was performed at an early stage of the project, and it involved the entire Keowee PRA team. During this walkdown, the Keowee operators were briefly interviewed, focusing on such considerations as procedure use and staffing.

The plant walkdown enabled the team to develop the understanding on the physical arrangement of systems, locations of controls and indications of equipment of interest, and factors affecting equipment recovery. Further, the walkdown proceedings facilitated the interface for subsequent dialogue between the HRA team and the Keowee personnel.

5.5.4 PLANT INTERVIEWS

Numerous interviews and phone conversations were conducted as part of the HRA process. Personnel contacted included:

- a Keowee "on call" operator,
- the Keowee electrical systems engineer,
- the Keowee mechanical systems engineer, and
- the Oconee Switchyard Superintendent.

These interviews were utilized to gather HRA information such as:

- plant policy on post-maintenance functional testing, on tag-out and key control, and on use of procedures,

- control boards labeling conventions,
- indications on improperly aligned equipment,
- extent of training and practice on specific procedures,
- feasibility of operator action upon equipment failure, and
- time estimates.

5.5.5 SCREENING

The intent of the screening step suggested by the SHARP methodology (Reference 12) was followed by performing a review of the plant procedures, documenting the resulting insights, and providing the results to the system analysts for inclusion in the system models.

At a later stage of the HRA process, a more detailed review of the procedures was conducted to ensure that no important human error events were overlooked.

5.5.6 TYPES OF EVENTS CONSIDERED

For the Keowee PRA, the assumed initiating event is a loss of off-site power at Oconee for which emergency power from Keowee is needed.

Human error events often considered in PRA studies are classified as pre-initiator errors (also designated as latent human errors) or post-initiator errors, on the basis as to whether the error is assumed to occur prior to the initiating event or after the initiating event.

The post-initiator errors are further distinguished into three types:

- Dynamic Human Error (DHE) -- This is a post initiator human error for a situation where the correct response is proceduralized.

- Recovery Human Error (RHE) -- This is a post initiator human error for a situation where the correct response is not proceduralized.

- Commission Human Error (CHE) -- This is an error in which the operator takes a wrong action in response to the event and thereby makes the event more serious.

In general, commission errors are not analyzed in typical PRA studies. For the Keowee PRA, however, an attempt is made to look for the opportunities for these types of errors and to quantify selected errors for the pre-1992 configuration where the error potential was more apparent.

Thus, the Keowee PRA human error analysis includes the analysis of latent human errors (LHEs), post initiator events (DHE and RHE), and commission errors.

5.5.7 METHODOLOGY

Latent Human Errors

The latent human errors identified for the Keowee systems are classified and assigned probability values using the event tree and probability values found in NUREG/CR-1278 (Reference 13), as follows:

	Error Classification	Error Probability
1.	Post maintenance errors for components which are not functionally tested and not checked on the daily rounds.	3.2E-3
2.	Post maintenance errors for components which are not functionally tested but are checked on the daily rounds.	3.2E-4
3.	Post maintenance errors for components which are functionally tested.	2.6E-4
4.	Post maintenance errors for components which are functionally tested and red-tagged.	5.2E-5

Post Initiator (DHE and RHE) Events

The correlation used to quantify most post initiator events for the Keowee PRA is the decision tree model of EPRI TR-100259 (Reference 14). This method relies on the details of procedures as a way of assigning probabilities of the human responses. For the non-proceduralized event involving the manual starting of Keowee, however, the value of 0.5 is assigned based on engineering judgment.

Errors of Commission

Errors of commission were considered for the Keowee PRA HRA because errors of this type were identified during the review of the operating experience. These events were quantified to perform a sensitivity study related to the pre-10/92 versus post-10/92 configuration of Keowee human factors (control room indications, personnel training, procedures, and management interface).

The quantification method used for the errors of commission is entitled "INTENT: A Method for Estimating Human Error Probabilities of Errors of Intention" (Reference 15). This method involves classifying the errors into various types and using performance shaping factors to calculate the probability values based on an assumed distribution.

5.5.8 KEOWEE HUMAN RELIABILITY RESULTS

The results of the Keowee PRA human reliability analysis are shown in Table 5.5-1, with the error events and their estimated probabilities. These events and their probabilities are used in the Keowee fault tree models to calculate the overall probability of Keowee failure following an emergency start demand from Oconee.

5.5.9 INSIGHTS AND RECOMMENDATIONS

Although there are several opportunities for latent human errors, these error probabilities are calculated to be low. This result is consistent with the low occurrence of human error events found in the operating experience review. Sensitivity studies (Section 7.5) involving recovery events indicate that, collectively, the operator recovery of equipment failures reduces the Keowee overall failure probability by approximately 26%. Individual recovery events have only a small impact on the calculated overall Keowee failure probability, however.

Some enhancement of the alarm response procedure and the Keowee emergency start procedure are recommended as indicated below:

a. The Keowee procedure group should review MP/0/A/2005/1 to determine if additional details (such as valve names, sign-off spaces and verification spaces) are needed.

b. The alarm response procedure for generator cooling water flow (SA2-28) should have sign-off spaces ("place-keeping aids").

c. The Keowee procedure for emergency start should include guidance to close the auxiliary power breakers locally if they can not be closed from the control room.

d. The alarm response procedure for the battery trouble alarm (SA1-44) should include the steps necessary to align the standby charger.

Table 5.2-1 Keowee PRA Unit Emergency Start / Run Failures (1984-1993)

DATE	SOURCE	UNIT	COMPONENT	EVENT DESCRIPTION	EFFECT ON UNIT OPERATION
5-7-84	K Log U1 RO Log U2 RO Log WR 58285B	2 **EMERG. START FAILURE**	Voltage Regulator (No Component Failure)	Unit 2 started for system generation but received a Normal Lockout. The voltage regulator would not come on in auto (unit would run in manual). The cause of the problem was determined to be due to the **Base Adjuster** having a preset position (S3-S4) which gave a low no-load machine voltage (12.8kV instead of rated 13.8kV) which did not match the Volts Adjust setting of 13.8kV setting when the voltage reg. came on in auto. The mismatch caused a time delay greater than the Volts-Hertz time delay relay setting which shut down the unit. The Base Adjust was reset to 13.8kV and the unit started several times successfully.	This is being counted as an ES failure due to the fact that the Base Adjust was set for only 12.8 kV instead of the 13.8kV required to supply Oconee's emergency loads.
11-20-84	K Log Unit 2 RO Log WR 58309B	2 **EMERG. START FAILURE**	#2 Supply Breaker **X Relay Coil**	Oconee started Unit 2 for operability test to take Unit 1 out of service for annual PMG inspection but the #2 Supply Breaker failed to close. The breaker was removed and inspected but the cause of the **problem was not found.** Unit 2 was run several times successfully with no re-occurrence of the problem.	Unit 2 was not available for Emergency Start during this occurrence.
12-4-84	K Log U2 RO Log WR 58312B	2 **EMERG. START FAILURE**	#2 Supply Breaker **X Relay Coil**	Oconee attempted an auto start of Unit 2 but the Supply Breaker failed to close. Replaced **X-relay coil and adjusted mechanical linkage to relay.** Tested breaker successfully 15 times.	Unit 2 was not available for Emergency Start during this occurrence.

Table 5.2-1 Keowee PRA Unit Emergency Start / Run Failures (1984-1993)

DATE	SOURCE	UNIT	COMPONENT	EVENT DESCRIPTION	EFFECT ON UNIT OPERATION
11-19-85	K Log PIR O85-46-4 WR 58369B	2 **EMERG. RUN FAILURE**	**#2 Generator**	Unit 2 was generating to the grid when it received a Normal Lockout due to a Generator Field Ground. The problem was due to the electrical connection between two generator rotor field poles having burned out. The root cause of the burned out connection was believed to be due to vibration.	Unit 2 was unavailable for Emerg. Start for 181 hours to repair the generator.
4-23-86	K Log WR 58420B U2 RO Log	2 **EMERG. START FAILURE**	Voltage Regulator **#2 Supply Breaker**	At 1540 Oconee started Unit 2 to check operability, but ACB-2 failed to close. Started the unit from Keowee and observed that the **Supply Breaker** did not close.Upon inspection, the breaker did not appear to be jacked all the way in. The breaker had moved back in its slot enough to break contact. The breaker was jacked in and tested satisfactorily.	Unit 2 unavailable or Emergency Start.
4-24-86	K Log WR 58421B U2 RO Log	2 **EMERG. START FAILURE**	Voltage Regulator **#2 Supply Breaker (latch release plunger)**	At 0649 Oconee attempted to start Unit 2 for system generation, but the **Supply Breaker** did not close. The unit was then started from Keowee. The Field breaker closed but the Supply Breaker failed to close. The next start attempt from Keowee was successful but the following attempt from Oconee was not. The problem was determined to be due to a corroded **latch release plunger** in the Generator Supply Breaker. This latch release plunger prevented the breaker from operating as expected.	Unit 2 unavailable for Emergency Start.
5-28-86	K Log WR 58446B U2 RO Log	1 **EMERG. START FAILURE**	Voltage Regulator **Field Breaker**	Oconee started Unit 1 for system generation but the Field Breaker did not close. The unit was started and ran in local / manual satisfactorily. Oconee performed an operability test on unit 1 and it worked fine. No problem was identified.	Unit 1 unavailable for Emergency Start.

Table 5.2-1 Keowee PRA Unit Emergency Start / Run Failures (1984-1993)

DATE	SOURCE	UNIT	COMPONENT	EVENT DESCRIPTION	EFFECT ON UNIT OPERATION
2-6-88	K Log	1 **EMERG. START FAILURE**	Voltage Regulator **Field Breaker**	Started Unit 1 for system generation. The unit rolled off but excitation did not close. Aborted start on #1. Started Unit 1 again and everything worked okay.	Whenever the generator excitation doesn't close in, the unit will not start in any mode.
3-15-88	K Log	1 **EMERG. START FAILURE**	Voltage Regulator **Field Breaker**	Started Unit 1 for system generation but the Excitation Breakers failed to close. Aborted start. Started, paralleled, placed Unit 1 on LFC. Unit started fine this start.	Whenever the generator excitation doesn't close in, the unit will not start in any mode.
5-23-88	K Log	1 **EMERG. START FAILURE**	Voltage Regulator **Field Breaker**	When doing retest on Unit 1 the unit came on but the excitation supply did not close. The unit shut down due to an incomplete sequence. Did another start and the unit worked okay.	Whenever the generator excitation doesn't close in, the unit will not start in any mode.
2-9-89	K Log WR 58647B	1 **EMERG. START FAILURE**	#1 Field Supply Breaker **X Relay**	Oconee started Unit 1 to test the Overhead Path, but the Supply Breaker did not close. Problem was determined to be due to the X Relay sticking. Replaced relay and the worked fine.	Unit 1 unavailable for Emergency Start.
2-12-90	K Log WR 58720B	1 **EMERG. START FAILURE**	#1 Field Breaker **X Relay**	Started Unit 1 for system generation but excitation breakers did not close. Problem was found to be due to X Relay coil sticking. Replaced X Relay unit tested satisfactorily.	Failure of the generator excitation to close in would have prevented an Emergency Start had it been required.

Table 5.2-1 Keowee PRA Unit Emergency Start / Run Failures (1984-1993)

DATE	SOURCE	UNIT	COMPONENT	EVENT DESCRIPTION	EFFECT ON UNIT OPERATION
3-27-90	K Log WR 58732B	1 **EMERG. START FAILURE**	Voltage Regulator **Base Adjust (70B Cam Switch)**	Started Unit 2 for system generation but unit would not start. Found problem to be due to the 70B cam switch not resetting to its preset position. This caused the 70BX relay to drop out. Cleaned contacts and unit started.	This is being counted as an ES failure since we don't know what the Base Adjust setting was when the unit was started. It may have been positioned at a setting which provided voltage less than 13.8kV.
12-26-90	K Log	1 **EMERG. START FAILURE**	Voltage Regulator **Field Breaker** (X-Relay)	Started Unit 1 for system generation but Generator Excitation Breakers did not close in. A 2nd start attempt was successful. **This is one of a series of phantom Unit 1 start failures which resulted in the replacement of all excitation breaker X relays.**	Failure of the generator excitation to close in would have prevented an Emergency Start had it been required.
1-16-91	K Log	1 **EMERG. START FAILURE**	Voltage Regulator **Field Breaker** (X-Relay)	Started Unit 1 for weekly preventative maintenance but Generator Excitation Breakers did not close in. A 2nd start attempt was successful. **This is one of a series of phantom Unit 1 start failures which resulted in the replacement of all excitation breaker X relays.**	Failure of the generator excitation to close in would have prevented an Emergency Start had it been required.
1-21-91	K Log	1 **EMERG. START FAILURE**	Voltage Regulator **Field Breaker** (X-Relay)	Oconee started Unit 1 for test but Generator Excitation Breakers did not close in. A 2nd start attempt was successful. **This is one of a series of phantom Unit 1 start failures which resulted in the replacement of all excitation breaker X relays.**	Failure of the generator excitation to close in would have prevented an Emergency Start had it been required.

Table 5.2-1 Keowee PRA Unit Emergency Start / Run Failures (1984-1993)

DATE	SOURCE	UNIT	COMPONENT	EVENT DESCRIPTION	EFFECT ON UNIT OPERATION
2-1-91	K Log	1 **EMERG. START FAILURE**	Voltage Regulator **Field Breaker** (X-Relay)	Started Unit 1 for system generation but Generator Excitation Breakers did not close in. A 2nd start attempt was successful. **This is one of a series of phantom Unit 1 start failures which resulted in the replacement of all excitation breaker X relays.**	Failure of the generator excitation to close in would have prevented an Emergency Start had it been required.
3-31-91	K Log	1 **EMERG. START FAILURE**	Voltage Regulator **Field Breaker** (X-Relay)	Started Unit 1 for system generation but Generator Excitation Breakers did not close in. A 2nd start attempt was successful. **This is one of a series of phantom Unit 1 start failures which resulted in the replacement of all excitation breaker X relays.**	Failure of the generator excitation to close in would have prevented an Emergency Start had it been required.
4-7-91	K Log WR 58771B	1 **EMERG. START FAILURE**	Voltage Regulator **Field Breaker** (X-Relay)	Started Unit 1 for system generation. The Field Supply Breaker did not close in. A 2nd start attempt was successful. Supply Breaker was replaced with spare breaker and both tested satisfactorily. Cause of problem unknown. **This is one of a series of phantom Unit 1 start failures which resulted in the replacement of all excitation breaker X relays.**	Failure of the generator excitation to close in would have prevented an Emergency Start had it been required.
5-31-91	K Log	1 **EMERG. START FAILURE**	Voltage Regulator **Field Breaker** (X-Relay)	Unit 1 started for system generation. Unit rolled off but the Supply, Field, and Field Flashing Breakers failed to close. **This is one of a series of phantom Unit 1 start failures which resulted in the replacement of all excitation breaker X relays.**	Failure of the generator excitation to close in would have prevented an Emergency Start had it been required.

Table 5.2-1 Keowee PRA Unit Emergency Start / Run Failures (1984-1993)

DATE	SOURCE	UNIT	COMPONENT	EVENT DESCRIPTION	EFFECT ON UNIT OPERATION
6-7-91	K Log	1 **EMERG. START FAILURE**	Voltage Regulator **Field Breaker** (X-Relay)	Started Unit 1 for system generation but excitation didn't close in. Immediately attempted another start and unit started and closed in satisfactorily. **This is one of a series of phantom Unit 1 start failures which resulted in the replacement of all excitation breaker X relays.**	Failure of the generator excitation to close in would have prevented an Emergency Start had it been required.
6-11-91	K Log PIP 4-O91-0063	1 **EMERG. START FAILURE**	#1 Field Supply Breaker **X Relay**	Oconee started Unit 1 for PT. The Field Supply Breaker failed to close. The problem was found to be due to the X Relay not resetting after the last shutdown. Relay was reset and Unit 1 ran satisfactorily.	Unit 1 unavailable for Emergency Start.
9-6-91	K Log WR 59667	2 **EMERG. START FAILURE**	Voltage Regulator Field Breaker **99SY Relay**	Started Unit 2 for system generation. Field Breaker failed to close. Problem was due to the 99SY relay being open. Replaced relay and tested unit satisfactorily. The 99SY relay is an auxiliary relay off of the Shutdown Solenoid Auxiliary Relay circuit. the 99SX relay energizes the governor and the 99SY relay to close the Field Breaker.	Unit 2 unavailable for Emergency Start.
1-29-92	K Log PIR 4-O92-0020 LER 269/92-02	1 **EMERG. START FAILURE**	Voltage Regulator **Field Supply Breaker** (X -Relay)	Started Unit 1 for system generation but the generator excitation did not close in. Checked circuitry with no problems found. Restarted unit and everything worked as designed. Keowee operators to check that X-Coil has reset after each Unit 1 and Unit 2 shutdown. **This is one of a series of phantom Unit 1 start failures which resulted in the replacement of all excitation breaker X relays.**	Unit 1 was not available for Emergency Start during this occurrence.

Table 5.2-1 Keowee PRA Unit Emergency Start / Run Failures (1984-1993)

DATE	SOURCE	UNIT	COMPONENT	EVENT DESCRIPTION	EFFECT ON UNIT OPERATION
10-19-92	K Log PIP 2-O92-0563 LER 270/92-04	2 **EMERG. RUN FAILURE**	No Component Failure.	**Oconee LOOP Event** - With the Main Transformer still locked out and both units spinning, the K Operator reset the Transformer lockout which allowed ACB-1 to close and re-energize the Transformer. ACB-6 was closed to restore Aux. Power to Unit 2. He then reset the 1X and ACB-7 lockouts and closed ACB-7 by hand to re-energize 1X. ONS Operator reset the ES signal and K Unit 1 is shut down. **The K Unit 1 shut down results in Unit 2** being tripped which causes the 2nd loss of power to ONS-2. K Unit 2 was tripped by protective logic which monitors voltage on the Main S/U Transf. (which was de-energized).	Unit 2 Run Failure. **Note: This was not an equipment failure. the unit operated as designed.**
10-19-92	K Log PIP 2-O92-0563 LER 270/92-04	2 **EMERG. START FAILURE**	No Component Failure.	**Oconee LOOP Event -** When the Main Feeder Buses became de-energ., a 2nd ES Signal was initiated to start both K units, but ACB-1 did not close due absence of Swyd. Isol. Complete Permissive Signal. K Unit 2 had started to slow down when the 2nd ES signal was received, but the ES Signal caused it to restart before the speed switch in the Field Breaker anti-pump circuit could reset which prevented the field from flashing.	Unit 2 unavailable for Emergency Start until speed switch in Field Breaker is allowed to reset. **Note: This was not an equipment failure. the unit operated as designed.**
11-5-92	K Log WR 59746C	2 **EMERG. RUN FAILURE**	**63TA/2X-C2**	Unit 2 was generating to the grid. A unit 2 Trip was received, followed by the closure of #2 Governor Main Valve. The trip was initiated when a **wire lug was broken on 63TA/2X-C2 relay** during a wiring inspection in cabinet 2LC2.	**Human Error.** Unit 2 was out of operation and the Overhead path was out of service while the lug was being replaced.

Table 5.2-1 Keowee PRA Unit Emergency Start / Run Failures (1984-1993)

DATE	SOURCE	UNIT	COMPONENT	EVENT DESCRIPTION	EFFECT ON UNIT OPERATION
11-28-92	K Log WR 59752C PIP 0-O92-0663 PIP 0-O92-0675	2 **EMERG. START FAILURE**	ACB-2 **Exhaust Valve Connection Rod**	Keowee Unit 2 was started for system generation but ACB-2 would not close either automatically or manually. The operator found a smoking relay in the ACB-2 cabinet. The problem was caused by a broken **exhaust valve connection rod** which caused the x-relay (52X/MG-6 relay) to remain energized until it overheated and burned up.	This is being counted as an Emerg. Start failure due to the fact that this unit was aligned to the overhead Emergency Power Path.
12-1-92	K Log WR 59753C LER 269/92-18	1 **EMERG. RUN FAILURE**	Voltage Regulator **Voltage Error Card** **Voltage Adjuster**	While generating to the grid Unit 1 received a statalarm on Generator #1 Excitation Low and Static Inverter AC Frequency Out of Tolerance. The output voltage was also swinging. The unit was shut down. Troubleshooting the problem revealed that the **Voltage Regulator Error Detector in the logic drawer was bad.** While testing the voltage error detector it was necessary to run the Voltage Adjuster to its maximum and minimum positions. Due to age and wear the cam follower on the cam switchs #2 and #9 were bent backwards making it necessary to replace the **Voltage Adjuster.** Replaced with a used component from stock.	Unit 1 out of service for ES.
12-2-92	K Log WR 59754C	2 **EMERG. START FAILURE**	**#2 Generator** Y Phase PT Circuit	Unit 2 started for operability test. The unit tripped by emergency lockout on #2 generator ground fault overcurrent (59GN2). Found nicked wire (53) between 290-1X and 290-4X with a nick in the insulation from a screw used to attach the cover plate of the Voltage Regulator . Problem was caused by I & E technicians as they were completing a Configuration Control Inspection of Safety Related cabinet wiring.	**Human Error.** Unit 2 unavailable for Emergency Start.

Table 5.2-1 Keowee PRA Unit Emergency Start / Run Failures (1984-1993)

DATE	SOURCE	UNIT	COMPONENT	EVENT DESCRIPTION	EFFECT ON UNIT OPERATION
4-5-93	K Log WR 59790C PIP 0-O93-0322 PIP 0-O93-0319	2 **EMERG. START FAILURE**	Voltage Regulator Field Flash Breaker **DC Control Power Fuse (NON-15)**	Unit 2 started for system generation but Field Flash Breaker failed to close. Problem was due to a blown fuse in the DC control circuitry for the breaker. Fuse was replaced and the unit tested successfully.	Unit 2 unavailable for Emergency Start.
4-12-93	K Log WR 59797C WR 59799C PIP 0-O93-0332 PIP 0-O93-0357	2 **EMERG. START FAILURE**	Voltage Regulator #2 Field Flash Breaker **Closing Coil**	Unit 2 Keowee Alarm lockout due to Field Flash Breaker failure during startup for system generation. Closing coil had burned. Replaced closing coil and plunger assembly.	Unit 2 unavailable for Emergency Start.
5-4-93	K Log WR 74354B 0-O93-0374	1 **EMERG. RUN FAILURE**	Voltage Regulator **Volts-Hertz Limiter Card**	Keowee unit 1 Voltage Regulator OOS. Unit 1 was shut down while generating to the grid due to VARs going in the hole. The unit did not respond to the Voltage Adjust or the Base Adjust controls. Entered 72 Hr. LCO.	Unit 1 unavailable for emergency start.
9-16-93	K Log WR 93067874-01 PIP 0-O93-0739	1 **EMERG. START FAILURE**	Voltage Regulator #1 Field Supply Breaker **Breaker Mechanism Cotter Pin**	Keowee unit 1 failed to emergency start per PT/0A/0620/16 due to the Field Supply and Field Flashing breakers failing to close. The supply breaker did not close due to a 'trip free' operation caused by a missing cotter pin in the pin that connects the close solenoid armature to the breaker toggle mechanism. As a result, the closing coil remained energized because the auxiliary contacts did not function to energize the y-relay to drop out the x-relay which de-energizes the close coil.	Loss of a required Emergency Power Source. This is a valid Emergency start failure and it occurred during an ES test.

Table 5.2-2 Keowee Operation Summary Data (1984 - 1993)

	Year :	1993	1992	1991	1990	1989	1988	1987	1986	1985	1984	**TOTAL**
ES Failures Counted for KRA:		3	4	9	3	1	3	0	3	0	3	**29**
ES Failures (Actual):		1	1	0	0	0	0	0	0	0	0	2
Number of Automatic Start Failures:		3	6	2	2	1	3	1	0	1	0	19
Number of Manual Start Failures:		1	1	0	0	1	0	0	0	0	1	4
Number of Unit Demands:	Unit 1	418	294	339	419	294	331	331	327	288	349	3390
	Unit 2	224	293	332	405	364	327	300	257	248	348	3098
	Subtotals	642	587	671	824	658	658	631	584	536	697	**6488**
Number of ES Demands:	(HOT)	2	4	0	0	0	0	1	0	0	0	7
	(COLD)	11	17	5	10	16	9	15	10	9	4	106
Emerg. Run Failures Counted For KRA:		1	3	0	0	0	0	0	0	1	0	**5**
Automatic Run Failures:		0	0	0	0	0	2	0	0	0	0	2
Number of Unit Run Hours:	Unit 1	925.7	710.4	562.0	636.1	312.1	271.4	459.6	383.8	411.8	612.1	5285.0
	Unit 2	331.3	733.1	547.7	554.3	428.6	296.2	429.1	281.9	311.9	513.9	4428.0
	Subtotals	1257.0	1443.5	1109.7	1190.4	740.7	567.6	888.7	665.7	723.7	1126.0	**9713.0**
Unit Unavailability For ES:	Unit 1	195.40	180.30	108.38	83.90	129.23	86.42	484.90	115.70	246.00	215.21	1845.44
	Unit 2	219.04	166.57	130.82	48.37	108.48	72.67	129.40	130.65	388.18	548.43	1942.61
	Subtotals	414.44	346.87	239.20	132.27	237.71	159.09	614.30	246.35	634.18	763.64	**3788.05**
Station Unavailability For ES:		84.85	19.58	65.37	1.30	40.37	1.50	62.40	0	109.40	73.80	458.57

Table 5.2-2 Keowee Operation Summary Data (1984 - 1993)

	Year :	1993	1992	1991	1990	1989	1988	1987	1986	1985	1984	**TOTAL**
Period Hours:	Unit 1	87600										
(Total No. Hrs. For Review Period)	Unit 2	87600										
Unit Availability:	Unit 1	85754.56										
(Period Hrs. - Unavailable Hrs.)	Unit 2	85657.39										**171412**

Table 5.3-1: Keowee Component Failure Rates

Component	Failure Mode	Type Code	Generic Failure Rate		Error Factor	Source	No. of Failures	Denominator	Plant-Specific Failure Rate	Bayesian-Updated Failure Rate	Error Factor
Air Operated Valve	Fails to Open on Demand	**AVO**	**2.20E-03**	/d	2.8	Davis-Besse IPE	0	6488	**3.51E-05**	**2.8E-04**	2.8
Air Operated Valve	Transfers Closed	**AVT**	**2.70E-06**	/hr	10	Davis-Besse IPE	0	9713	**2.34E-05**	**2.3E-06**	10.0
Battery Charger	Fails to Maintain Output	**BCF**	**1.10E-05**	/hr	4.9	Davis-Besse IPE	6	171412	**3.50E-05**	**2.9E-05**	1.9
Electric Bus (DC)	Fails	**BDF**	**6.10E-07**	/hr	5.2	Davis-Besse IPE	0	872212	**2.61E-07**	**3.2E-07**	5.2
Electric Bus (4 Kv or Higher AC)	Fails	**BHF**	**5.30E-07**	/hr	5.1	Davis-Besse IPE	0	350400	**6.49E-07**	**4.0E-07**	5.1
Electric Bus (600 Vac or Lower)	Fails	**BLF**	**3.60E-07**	/hr	6.4	Davis-Besse IPE	0	342824	**6.64E-07**	**2.7E-07**	6.4
Battery	Fails to Provide Output	**BYF**	**1.18E-03**	/d	7.8	Composite	0	60	**3.79E-03**	**9.3E-04**	7.8
Circuit Breaker (4 or 6.9 Kv AC)	Fails to Remain Closed	**C4T**	**1.90E-06**	/hr	5.7	Davis-Besse IPE	0	262800	**8.66E-07**	**9.4E-07**	5.7
Circuit Breaker (DC)	Spurious Operation	**CDT**	**1.90E-06**	/hr	5.7	Davis-Besse IPE	0	6250420	**3.64E-08**	**7.5E-08**	5.7
Circuit Breaker (PCB)	Fails to Close on Demand	**CHC**	**7.20E-05**	/d	10	IEEE 500, p. 115	1	2263	**4.42E-04**	**2.6E-04**	3.7
Human Error	Error of Commision	**CHE**	**N/A**	N/A	N/A	N/A	N/A		**N/A**	**N/A**	N/A
Circuit Breaker (PCB)	Fails to Open on Demand	**CHO**	**4.00E-05**	/d	10	IEEE 500, p. 115	0	2263	**1.01E-04**	**2.6E-05**	10.0
Circuit Breaker (PCB)	Spurious Operation	**CHT**	**3.00E-07**	/hr	10	IEEE 500, p. 115	2	615432	**3.25E-06**	**1.9E-06**	2.8
Circuit Breaker (Low Voltage AC)	Spurious Operation	**CLT**	**1.90E-06**	/hr	5.7	Davis-Besse IPE	1	1371296	**7.29E-07**	**9.1E-07**	3.3

Table 5.3-1: Keowee Component Failure Rates

Component	Failure Mode	Type Code	Generic Failure Rate		Error Factor	Source	No. of Failures	Denominator	Plant-Specific Failure Rate	Bayesian-Updated Failure Rate	Error Factor
Common Cause		**COM**	**N/A**	N/A	N/A	N/A	N/A		**N/A**	**N/A**	N/A
Check Valve	Fails to Close on Demand	**CVC**	**9.70E-04**	/d	5.2	Davis-Besse IPE	0	1040	**2.19E-04**	**3.5E-04**	5.2
Check Valve	Fails to Open on Demand	**CVO**	**1.90E-04**	/d	8.9	Davis-Besse IPE	0	87832	**2.59E-06**	**2.3E-06**	8.9
Check Valve	Fails to Remain Open	**CVT**	**4.50E-07**	/hr	20	Davis-Besse IPE	0	197774	**1.15E-06**	**1.3E-07**	20.0
Undeveloped Event		**DEX**	**N/A**	N/A	N/A	N/A	N/A		**N/A**	**N/A**	N/A
Human Error	Dynamic Human Error	**DHE**	**N/A**	N/A	N/A	N/A	N/A		**N/A**	**N/A**	N/A
Diode	Fails to Operate	**DIF**	**1.22E-06**	/hr	10	IEEE 500	1	175200	**5.71E-06**	**3.8E-06**	3.7
Battery	Unavailable Due to Maintenance or Testing	**DYM**	**N/A**	N/A	N/A	N/A	N/A		**N/A**	**N/A**	N/A
Filter or Strainer (Raw Water)	Plugs/fails to Deliver Flow	**FRF**	**1.20E-05**	/hr	6.6	Davis-Besse IPE	0	342824	**6.64E-07**	**9.8E-07**	6.6
Filter or Strainer (Oil)	Plugs/fails to Deliver Flow	**FTC**	**1.20E-05**	/hr	6.6	Davis-Besse IPE	0	171412	**1.33E-06**	**1.8E-06**	6.6
Electrical Fuse	Fails to Remain Closed	**FUF**	**6.30E-07**	/hr	9.4	Davis-Besse IPE	4	857060	**4.67E-06**	**3.6E-06**	2.1
Float Valve	Fails to Remain Open	**FVT**	**Unavailable**	/hr	N/A	N/A	1	171412	**5.83E-06**	N/A	N/A
Pump	Fails to Run	**GPR**	**2.40E-05**	/hr	3.2	Davis-Besse IPE	2	195632	**1.02E-05**	**1.4E-05**	2.3
Pump	Fails to Start on Demand	**GPS**	**3.10E-03**	/d	3.2	Davis-Besse IPE	7	87784	**7.97E-05**	**9.7E-05**	1.7

Table 5.3-1: Keowee Component Failure Rates

Component	Failure Mode	Type Code	Generic Failure Rate		Error Factor	Source	No. of Failures	Denominator	Plant-Specific Failure Rate	Bayesian-Updated Failure Rate	Error Factor
Hydro-Electric Generator	Fails to Run	**HGR**	**N/A**	/hr	N/A	N/A	1	10570	**9.46E-05**	**N/A**	N/A
Hydro-Electric Generator	Fails to Start	**HGS**	**N/A**	/d	N/A	N/A	1	6488	**1.54E-04**	**N/A**	N/A
Heat Exchanger	Fails to Transfer Heat	**HXF**	**3.40E-06**	/hr	8.2	Davis-Besse IPE	0	307394	**7.40E-07**	**6.4E-07**	8.2
Heat Exchanger	External Leak	**HXL**	**3.00E-07**	/hr	10	EGG-SRE-8875	0	1028472	**2.21E-07**	**1.0E-07**	10
Keowee Station	Out of Service for Maintenance or Testing	**HYM**	**N/A**	N/A	N/A	N/A	N/A		**N/A**	**N/A**	N/A
Human Error	Latent (Pre-initiator) Human Error	**LHE**	**N/A**	N/A	N/A	N/A	N/A		**N/A**	**N/A**	N/A
Switch (Level)	Fails to Operate on Demand	**LSD**	**1.60E-03**	/d	4.3	Davis-Besse IPE	0		**Inadequate Info.**	**N/A**	N/A
Switch (Level)	Spurious Operation	**LST**	**2.30E-06**	/hr	8	Davis-Besse IPE	0	707552	**3.22E-07**	**3.1E-07**	8.0
Switch (Push Button)	Spurious Operation	**PBT**	**1.00E-06**	/hr	10	EGG-SRE-8875	0	518664	**4.39E-07**	**2.4E-07**	10.0
Switch (Pressure)	Fails to Close on Demand	**PSC**	**2.60E-04**	/d	8.1	Davis-Besse IPE	0	85722	**2.65E-06**	**2.9E-06**	8.1
Switch (Pressure)	Spurious Operation	**PST**	**8.50E-07**	/hr	4.6	Davis-Besse IPE	0	857060	**2.65E-07**	**4.3E-07**	4.6
Relay (MG6)	Fails to Operate on Demand	**R6D**	**N/A**	/d	N/A	N/A	5	20089	**2.49E-04**	**N/A**	N/A
Relay (MG6)	Spurious Operation	**R6T**	**N/A**	/hr	N/A	N/A	0	1378774	**1.65E-07**	**N/A**	N/A

Table 5.3-1: Keowee Component Failure Rates

Component	Failure Mode	Type Code	Generic Failure Rate		Error Factor	Source	No. of Failures	Denominator	Plant-Specific Failure Rate	Bayesian-Updated Failure Rate	Error Factor
Human Error	Failure to Recover	**RHE**	**N/A**	N/A	N/A	N/A	N/A		**N/A**	**N/A**	N/A
Relief Valve	Spurious Operation	**RVT**	**1.70E-06**	/hr	4.2	Davis-Besse IPE	3	177124	**1.69E-05**	**5.6E-06**	2.2
Relay	Fails to Operate on Demand	**RYD**	**1.90E-04**	/d	9	Davis-Besse IPE	4	126969	**3.15E-05**	**3.3E-05**	2.1
Relay	Spurious Operation	**RYT**	**1.00E-06**	/hr	5	Davis-Besse IPE	3	9354504	**3.21E-07**	**3.6E-07**	2.3
Switch (Speed)	Fails on Demand	**SSD**	**2.50E-04**	/d	6.4	Davis-Besse IPE	0	19464	**1.17E-05**	**1.8E-05**	6.4
Switch (Speed)	Spurious Operation	**SST**	**1.00E-06**	/hr	10	EGG-SRE-8875	1	114796	**8.71E-06**	**4.2E-06**	3.7
Solenoid Valve	Fails to Open on Demand	**SVO**	**2.80E-03**	/d	7.5	Davis-Besse IPE	0	9769	**2.33E-05**	**2.9E-05**	7.5
Solenoid Valve	Spurious Operation	**SVT**	**4.10E-07**	/hr	3	Davis-Besse IPE	0	257069	**8.85E-07**	**3.9E-07**	3.0
Switch	Fails to Close on Demand	**SWC**	**1.00E-05**	/d	5	EGG-SRE-8875	0	61	**3.73E-03**	**1.0E-05**	5.0
Switch	Spurious Operation	**SWT**	**1.00E-06**	/hr	10	EGG-SRE-8875	0	2166121	**1.05E-07**	**7.0E-08**	10.0
Transformer(Excitation)	Fails to Maintain Power	**TGF**	**2.00E-06**	/hr	7	Davis-Besse IPE	0	171412	**1.33E-06**	**9.8E-07**	7.0
Transformer (High Voltage)	Fails to Maintain Power	**THF**	**2.00E-06**	/hr	7	Davis-Besse IPE	1	262800	**3.81E-06**	**3.1E-06**	3.4
Transformer (High Voltage)	Unavailable Due to Maintenance or Testing	**THM**	**N/A**	N/A	N/A	N/A	N/A		**N/A**	**N/A**	N/A
Tank	Fails to Maintain Pressure	**TKF**	**7.50E-07**	/hr	6.3	Davis-Besse IPE	0	342824	**6.64E-07**	**4.6E-07**	6.3

Table 5.3-1: Keowee Component Failure Rates

Component	Failure Mode	Type Code	Generic Failure Rate		Error Factor	Source	No. of Failures	Denominator	Plant-Specific Failure Rate	Bayesian-Updated Failure Rate	Error Factor
Transformer (Low Voltage)	Fails to Maintain Power	**TLF**	**2.00E-06**	/hr	7	Davis-Besse IPE	0	272513	**8.35E-07**	**7.5E-07**	7.0
System Train	Unavailable Due to Maintenance or Testing	**TRM**	**N/A**	N/A	N/A	N/A	N/A		**N/A**	**N/A**	N/A
Manual Valve	Transfers Position	**VVT**	**8.00E-08**	/hr	7.3	Davis-Besse IPE	0	14484363	**1.57E-08**	**1.7E-08**	7.3

Table 5.4-1

List of Common Cause Basic Events

Event Name	*Description*	*Strong Defense*	*Combination Event*	*MGL Parameter Source*	*Multiplier*	*Independent* Failure Prob.*	*Basic Event Probability*
AB0SWGRCOM	CCF of All Keowee Auxiliary Power Breakers			CCDAT	0.084	7.96E-03	6.69E-04
AB23BKRCOM†	CCF of Keowee Generator Breakers ACB-2 & -3	✓		CCDAT	0.095	1.17E-03	1.12E-04
AB24BKRCOM	CCF of Unit 2 Generator Breakers ACB-2 & -4	✓		CCDAT	0.095	1.17E-03	1.12E-04
ACBXFERCOM	ACB-2 and ACB-3 Transfer Open			App. C.2 Table C.2-6	0.05	2.55E-05	1.28E-06
AK1OFRQCOM†	CCF of KU1 Overfrequency Relays to Reset			App. C.2 Table C.2-6	0.1	3.30E-05	3.30E-06
AK2OFRQCOM†	CCF of KU2 Overfrequency Relays to Reset			App. C.2 Table C.2-6	0.1	3.30E-05	3.30E-06
BKGBOILCOM	CCF of Turbine Guide Bearing Oil System			App. C.2 Table C.2-6	0.02	9.70E-05	1.94E-06
DDCBATTCOM	CCF of Swyd Batteries SY-1 and SY-2			ALWR Util. Req. Doc	0.029	9.30E-04	2.70E-05
E12EXCTCOM	CCF of Excitation Breakers	✓	Field Bkr.	CCDAT	0.033	2.19E-04	5.31E-05
		✓	F. Supply Bkr.	CCDAT	0.033	8.17E-04	
		✓	F. Flashing Close	App. C.2 Table C.2-7	0.05	2.03E-04	
		✓	F. Flashing Open	App. C.2 Table C.2-7	0.05	1.76E-04	
EK00RUNCOM	CCF of Voltage Regulators to Continue			App. C.2 Table C.2-6	0.05	2.47E-03	1.24E-04
EKSTARTCOM	CCF of Voltage Regulators on Start			App. C.2 Table C.2-6	0.1	6.17E-04	6.17E-05
FK0FISHCOM	Common Mode Failure of Strainers Due to Debris			Explicitly Calculated	N/A	N/A	2.55E-03
FKVALVECOM	CCF of WL Cooling Water Control Valves			ALWR Util. Req. Doc	.088	2.80E-04	2.46E-05
GK0COOLCOM	CCF of Keowee Generator Air Cooling	✓		App. C.2 Table C.2-7	0.03	1.54E-05	4.61E-07
GK0LOCKCOM	Common Cause Actuation of Gen. Lockouts			App. C.2 Table C.2-6	0.05	8.11E-05	4.06E-06
GKHPOILCOM	CCF of Generator Thrust Bearings	✓		App. C.2 Table C.2-7	0.03	1.54E-05	4.61E-07

Table 5.4-1

List of Common Cause Basic Events

Event Name	*Description*	*Strong Defense*	*Combination Event*	*MGL Parameter Source*	*Multiplier*	*Independent* Failure Prob.*	*Basic Event Probability*
L0EGTPSCOM	CCF of Swyd UV and UF Detection Circuitry		(3 sets of at least 4 or more relays)	App. C.2 Table C.2-6	0.018	9.90E-05	1.78E-06
OK0PRUNCOM	CCF of Both Governor Oil Systems Fail to Run	✓	Pump fails (start)	App. C.2 Table C.2-7	0.01	1.46E-03	1.46E-05
		✓	Pump fails (run)	App. C.2 Table C.2-7	0.005	1.40E-05	
OK1PRUNCOM	CCF of Unit 1 Governor Oil Pumps Fail to Run	✓		App. C.2 Table C.2-7	0.008	1.40E-05	1.12E-07
OK1PSTRCOM	CCF of Unit 1 Governor Oil Pumps Fail to Start	✓		App. C.2 Table C.2-7	0.014	1.46E-03	2.04E-05
OK2PRUNCOM	CCF of Unit 2 Governor Oil Pumps Fail to Run	✓		App. C.2 Table C.2-7	0.008	1.40E-05	1.12E-07
OK2PSTRCOM	CCF of Unit 2 Governor Oil Pumps Fail to Start	✓		App. C.2 Table C.2-7	0.014	1.46E-03	2.04E-05
PK0SUMPCOM	CCF of Both Turbine Sump Pump Systems	✓	Pumps/Valves	App. C.2 Table C.2-7	0.005	3.47E-04	2.44E-06
		✓	Suction Line	App. C.2 Table C.2-7	0.03	2.35E-05	
PK1ACDCCOM	CCF of Keowee 1 AC & DC Sump Pumps	✓	Pumps/Valves	App. C.2 Table C.2-7	0.012	3.47E-04	2.77E-05
			Suction Line	(multiplier is assumed)	1.0	1.61E-05	
PK2ACDCCOM	CCF of Keowee 2 AC & DC Sump Pumps	✓	Pumps/Valves	App. C.2 Table C.2-7	0.012	3.47E-04	2.77E-05
			Suction Line	(multiplier is assumed)	1.0	1.61E-05	
SU127UVCOM	CCF of Oconee Unit 1 Standby Bus UV Relays			App. C.2 Table C.2-7	0.05	2.37E-03	1.18E-04
SU227UVCOM	CCF of Oconee Unit 2 Standby Bus UV Relays			App. C.2 Table C.2-7	0.05	2.37E-03	1.18E-04
SU327UVCOM	CCF of Oconee Unit 3 Standby Bus UV Relays			App. C.2 Table C.2-7	0.05	2.37E-03	1.18E-04
WK00RUNCOM	CCF of Keowee Governors to Run	✓		App. C.2 Table C.2-7	0.03	6.97E-04	2.09E-05
WKCSTRTCOM	CCF of Keowee Governors to Cold Start	✓		App. C.2 Table C.2-7	0.05	2.24E-04	1.12E-05
WKHSTRTCOM†	CCF of Keowee Governors to Hot Start	✓		App. C.2 Table C.2-7	0.05	7.00E-05	3.50E-06

Table 5.4-1

List of Common Cause Basic Events

Event Name	*Description*	*Strong Defense*	*Combination Event*	*MGL Parameter Source*	*Multiplier*	*Independent* Failure Prob.*	*Basic Event Probability*
XA0SWGRCOM	CCF of Transformers 1X, 2X, & CX			App. C.2 Table C.2-6	0.05	2.45E-05	1.22E-06
XA1BKRSCOM	CCF of 1X Aux Power Breakers ACB-5 & -7			CCDAT	0.039	7.96E-03	3.10E-04
XA2BKRSCOM	CCF of 2X Aux Power Breakers ACB-6 & -8			CCDAT	0.039	7.96E-03	3.10E-04
XA56BKRCOM	CCF of Aux Power Breakers ACB-5 & -6			CCDAT	0.039	7.96E-03	3.10E-04
XA78BKRCOM	CCF of Aux Power Breakers ACB-7 & -8			CCDAT	0.039	7.96E-03	3.10E-04
XD0BATTCOM	CCF of Keowee Station Batteries (Start)			ALWR Util. Req. Doc	0.029	9.30E-04	2.70E-05
XD0CHRGCOM	CCF of Keowee Battery Chargers (Run)			App. C.2 Table C.2-6	0.05	6.96E-04	3.48E-05
Y0STARTCOM	CCF of Emergency Start Signal		27X relays	App. C.2 Table C.2-6	0.1	3.30E-05	7.26E-06
			KA/KB relays	App. C.2 Table C.2-6	0.1	3.30E-05	
			ESRX relays	App. C.2 Table C.2-6	0.02	3.30E-05	

* Note: Probability based on bayesian updated independent component failure rates.

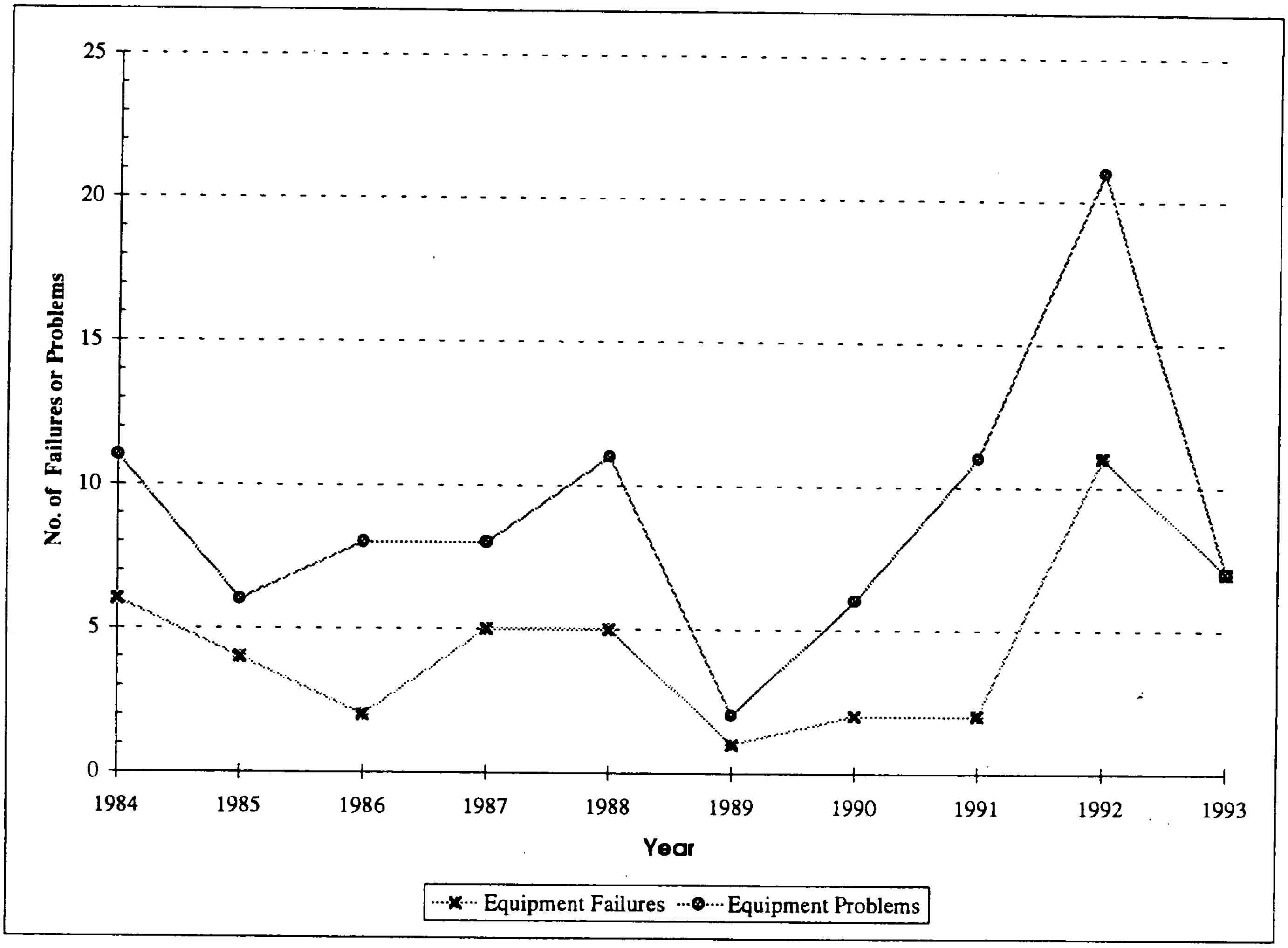
† Note: These events only apply to a sensitivity case and are not included in the base case solution.

Table 5.5-1 Keowee Human Reliability Analysis Results

Event	Description	Value
AB2CLOSLHE	Air Circuit Breaker 2 Fails To Close Due To A Latent Human Error	2.60E-04
AB2OPENLHE	Air Circuit Breaker 2 Fails To Open Due To A Latent Human Error	2.60E-04
AB4CLOSLHE	Air Circuit Breaker 4 Fails To Close Due To A Latent Human Error	2.60E-04
AB51431LHE	Manual/Auto Control Switch 143/1 Left In Manual	3.20E-04
AB5CLOSLHE	Air Circuit Breaker 5 Fails To Close Due To A Latent Human Error	2.60E-04
AB5OPENLHE	Air Circuit Breaker 5 Fails To Open Due To A Latent Human Error	3.20E-03
AB61432LHE	Manual/Auto Control Switch 143/2 Left In Manual	3.20E-04
AB6CLOSLHE	Air Circuit Breaker 6 Fails To Close Due To A Latent Human Error	2.60E-04
AB6OPENLHE	Air Circuit Breaker 6 Fails To Open Due To A Latent Human Error	3.20E-03
AB7CLOSLHE	Air Circuit Breaker 7 Fails To Close Due To A Latent Human rror	2.60E-04
AB7OPENLHE	Air Circuit Breaker 7 Fails To Open Due To A Latent Human Error	3.20E-03
BK1GBDCLHE	Latent Human Error Fails Unit 1 DC Guide Bearing Oil Pump Discharge Path	3.20E-03
BK2GBDCLHE	Latent Human Error Fails Unit 2 DC Guide Bearing Oil Pump Discharge Path	3.20E-03
EK1BASELHE	Keowee Unit 1 Base Adjust Is Set Incorrectly	3.20E-03
EK1FLDCLHE	Keowee Unit 1 Field Breaker Fails to Close Due to Latent Human Error	2.60E-04
EK1FLSCLHE	Keowee Unit 1 Field Flashing Breaker Fails to Close Due to Latent Human Error	2.60E-04
EK1FLSOLHE	Keowee Unit 1 Field Flashing Breaker Fails to Open Due to Latent Human Error	2.60E-04
EK1SPYCLHE	Keowee Unit 1 Supply Breaker Fails to Close Due to Latent Human Error	2.60E-04
EK2BASELHE	Keowee Unit 2 Base Adjust Is Set Incorrectly	3.20E-03
EK2FLDCLHE	Keowee Unit 2 Field Breaker Fails to Close Due to Latent Human Error	2.60E-04
EK2FLSCLHE	Keowee Unit 2 Field Flashing Breaker Fails to Close Due to Latent Human Error	2.60E-04
EK2FLSOLHE	Keowee Unit 2 Field Flashing Breaker Fails to Open Due to Latent Human Error	2.60E-04
EK2SPYCLHE	Keowee Unit 2 Supply Breaker Fails to Close Due to Latent Human Error	2.60E-04
FK1120GLHE	Control Switch S120G Not in "Auto" Position	3.20E-03
FK2120GLHE	Control Switch S120G Not in "Auto" Position	2.60E-04
GK1BRGVLHE	KHU1 BNG Oil Cooling Path Valves Misaligned	2.60E-04
GK1COOLLHE	KHU1 Generator Air Cooler WL Flow Path Valves Mispositioned	2.60E-04
GK1NGDCLHE	Failure to Close the Unit 1 Neutral Ground Disconnect Following Maintenance	5.20E-05

Table 5.5-1 Keowee Human Reliability Analysis Results

Event	Description	Value
GK2BRGVLHE	KHU2 BNG OIL Cooling Path Valves Misaligned	2.60E-04
GK2COOLLHE	KHU2 Generator Air Cooler WL Flow Path Valves Mispositioned	2.60E-04
GK2NGDCLHE	Failure to Close the Unit 1 Neutral Ground Disconnect Following Maintenance	5.20E-05
OK1001BLHE	Latent Human Error Fails OG Pump 1B	3.20E-03
OK1001CLHE	Latent Human Error Fails OG Pump 1C	3.20E-03
OK2002BLHE	Latent Human Error Fails OG Pump 2B	3.20E-03
OK2002CLHE	Latent Human Error Fails OG Pump 2C	3.20E-03
PK1TSDCLHE	Latent Human Error Fails Turbine No. 1 DC Sump Pump	3.20E-03
PK2TSDCLHE	Latent Human Error Fails Turbine No. 2 DC Sump Pump	3.20E-03
SXFRCT4LHE	Latent Human Error Fails Transformer CT-4	6.40E-05
AB0SWGRRHE	Recovery of Keowee Aux. Power Breakers by Manual Control	5.0E-01
ABEOPRCDHE	Operators Faill To Close Air Circuit Breaker 2	9.00E-03
ABPOPRCDHE	Operators Fail To Close Air Circuit Breaker 4	9.00E-03
EK0BASEDHE	Recovery of Keowee Base Adjust LHE.	1.9E-02
FK0FISHDHE	Recovery of Main WL Strainer Clogging	6.3E-02
FK0FL00DHE	Recovery of Turbine Guide Bearing or Packing WL Filter Clogging	6.3E-02
FK0GBHXDHE	Recovery of Turbine Guide Bearing HX WL Valves	6.3E-02
GK0BRGVRHE	Recovery of Keowee Generator Thrust Bearing Oil Cooling Flow Path WL Valves	1.0E-01
XD0KBATDHE	Cross Connect of Keowee DC Distribution Centers	1.0E00
XD1KB1XDHE	Keowee Standby Battery Charger SBC Not Lined Up in 1 Hour	9.3E-02
XD2KB2XDHE	Keowee Standby Battery Charger SBC Not Lined Up in 1 Hour	9.3E-02
WK1GVDCLHE	Latent Human Error Fails Keowee Governor 1 During a Cold Start	2.6E-04
WK2GVDCLHE	Latent Human Error Fails Keowee Governor 2 During a Cold Start	2.6E-04
Y0STARTRHE	Recovery of Keowee Auto-Start Failures	5.0E-01
ACBTRIPCHE	Operators Trip Air Circuit Breaker 2	2.80E-02
YKEMSTRCHE	Operator Incorrectly Resets Keowee Emergency Start	5.66E-03



DATA SUMMARY

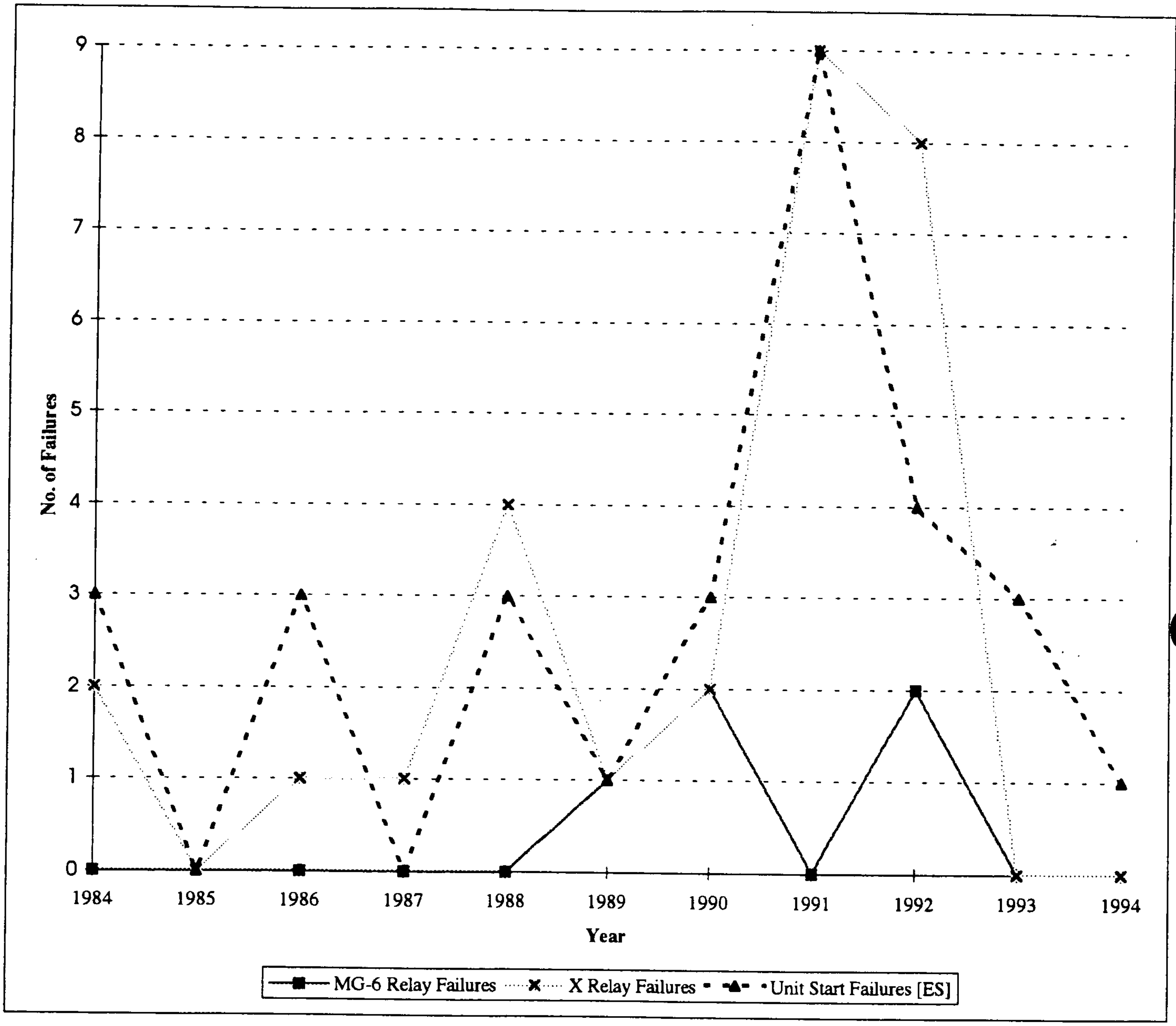
	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	TOTAL
Equipment Failures	6	4	2	5	5	1	2	2	11	7	**45**
Equipment Problems	11	6	8	8	11	2	6	11	21	7	**91**

Definitions:

Equipment Failures - **Includes only events where failed components were replaced during corrective action**

Equipment Problems - **Includes all events, whether problem equipment was replaced or not**

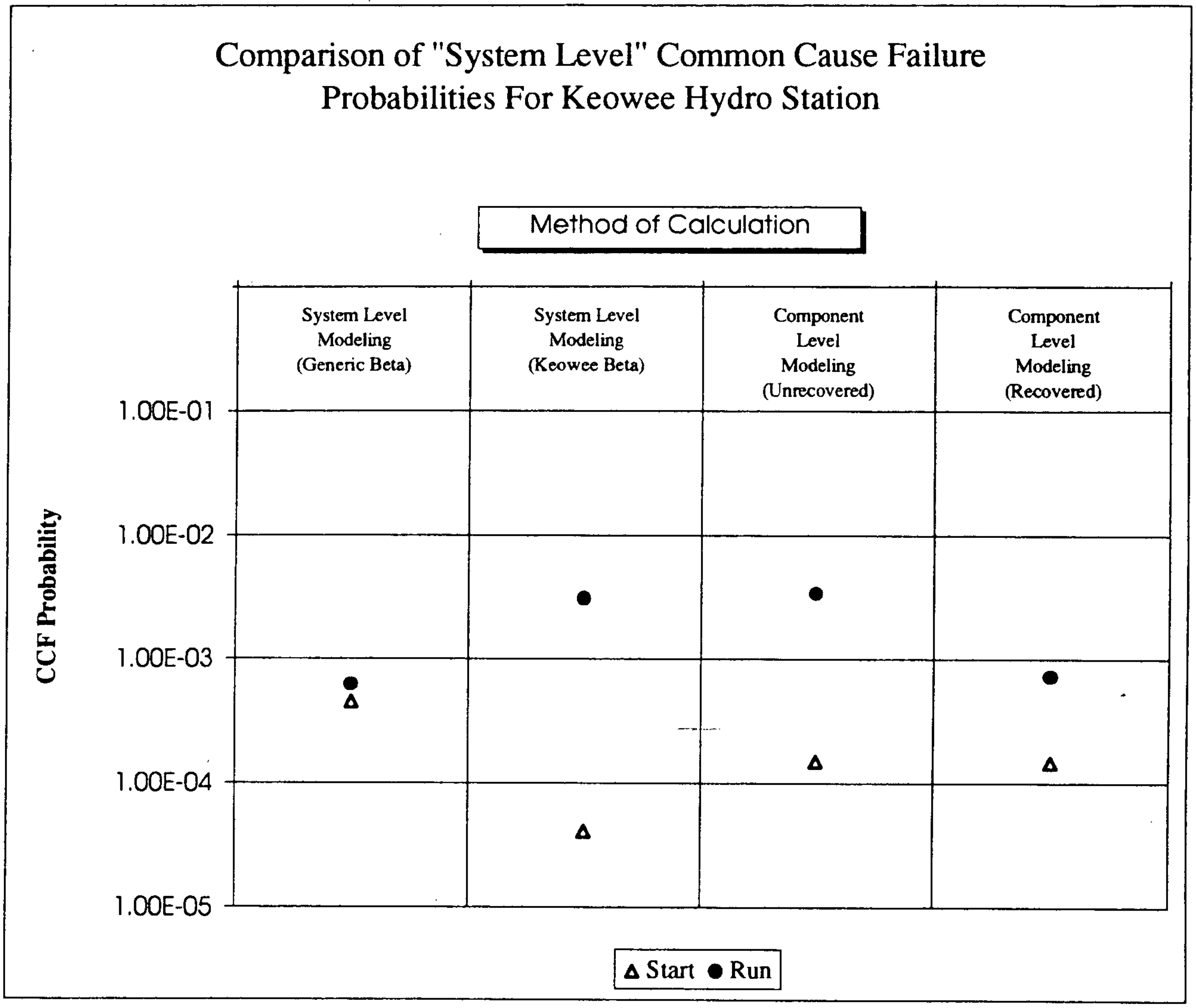
Figure 5.2-1 Keowee Equipment Failures and Problems



DATA SUMMARY

	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1st half 1994	TOTAL
MG-6 Relay Failures	0	0	0	0	0	1	2	0	2	0	0	**5**
X Relay Failures	2	0	1	1	4	1	2	9	8	0	0	**28**
Unit Start Failures [ES]	3	0	3	0	3	1	3	9	4	3	1	**30**

Figure 5.2-2 Keowee Relay Failures and Unit Emergency Start Failures



"System Level" and "Component Level" Comparison Values*

	Start	Run
System Level Modeling (Generic Beta)	4.50E-04	6.20E-04
System Level Modeling (Keowee Beta)	4.05E-05	3.05E-03
Component Level Modeling (Unrecovered)	1.50E-04	3.36E-03
Component Level Modeling (Recovered)	1.46E-04	7.23E-04

*Note: System Level Independent Failure Rate was based on actual operating data. (Refer to Figure 7.2-2 and Table 7.2-6)

Figure 5.4-1

6.0 INTEGRATION OF KEOWEE MODEL WITH OCONEE AC POWER MODEL

6.1 INTRODUCTION

The existing Oconee probabilistic risk assessment (PRA) model contains a detailed model of the Oconee ac power system. This model is built with Oconee 3 as the representative system. It consists of the many fault trees representing the loss of power to the various load centers (208 V and 600 V motor control centers and the three 4160 V engineered safeguards switchgear centers) which power the electrical equipment supporting the safety functions of the reactor. Normally, power from both the 4160 V MFBs energizes the three engineered safeguards (ES) switchgear centers, and from there to the 600 V and 208 V motor control centers in a cascaded arrangement. Therefore, a loss of power to both MFBs will result in a loss of all ac power for the reactor. (There is a separate auxiliary 4160 V switchgear directly off transformer CT4 which can power a small set of reactor heat removal equipment in the event of a loss of the three ES switchgear centers; however, this auxiliary switchgear is not considered in this analysis.)

This existing model of the MFBs utilizes certain high level failure modes of Keowee (common cause failure, maintenance unavailability, and the individual Keowee unit failures) to represent the Keowee reliability. The detailed Keowee reliability model developed as part of the Keowee reliability study can be coupled with the MFB model to provide an integrated Keowee-Oconee ac power model, in lieu of the existing high level representation of the Keowee failure modes. Section 6.2 presents this integration of the Keowee model with the Oconee ac power model.

A sustained loss of all ac power event can lead to a core damage condition if steam generator cooling and reactor coolant pumps seal cooling are not provided by systems not dependent on the ac power system (namely, the turbine driven emergency feedwater pump and the SSF). Section 6.3 discusses the interfacing of the ac power model solution with the turbine driven EFW pump and SSF models to produce core damage sequences resulting from loss of ac power events. These results can provide the quantitative risk perspectives of such events.

6.2 OCONEE AC POWER MODEL

The Oconee ac power model is the logic model representing the set of conditions that produce the loss of ac power to both the main feeder buses. It includes the initiating events which cause an interruption of power on the MFBs, the failures of the various backup power sources for the MFBs, MFB maintenance unavailabilities, and potential faults within the MFBs.

Normally, the MFBs are powered by the auxiliary transformer (3T) when the generator is on line. If the generator trips, a fast transfer to the start-up source occurs if the start-uptransformer (CT3) is energized (normally by the 230 kV switchyard and the grid). If the start-up source also fails, power is lost to the MFBs, and emergency power is made available from Keowee through the overhead path through transformer CT3 and the underground path through the standby buses. If power from Keowee is unavailable, then the CT5 power is relied on to energize the MFBs through the standby buses.

The initiating event of interest is a loss-of-off-site-power (LOOP) which is assumed to lead to a reactor/generator trip. Power to the start-up transformer (CT3) is also assumed to be lost because of the LOOP event, preventing the fast transfer of the MFBs to the start-up source. An automatic Keowee emergency start signal is generated, establishing Keowee power to CT3 (the Keowee overhead power) and to the standby buses (the Keowee underground power). The energizing of CT3 by the Keowee overhead path power enables the emergency power switching logic (EPSL) to connect the MFBs to CT3, while the Keowee underground power at the standby buses remains in a standby mode. If CT3 is not energized within 31 seconds of the loss of voltage of the MFBs, the MFBs are connected to the standby buses instead.

The LOOP events are classified into three different types--T5G, T5S, and T5W-- on the basis of how the initiating event affects the availability of the Keowee overhead power source and the CT5 power. T5G is a LOOP event involving the loss of the grid connected to the Oconee reactor of interest (Oconee 3). For this event, the Keowee overhead power is not affected; however, the normal power for CT5 from the Central switchyard is assumed to be lost as part of the initiating event. T5S is a LOOP event involving some failure in the switchyard. Consequently, the Keowee overhead path is assumed not to be available, while the normally energized CT5 is considered available to energize the standby

buses if needed. The last category, T5W, is a weather related LOOP event for which both the Keowee overhead path and the 100 kV line for CT5 are assumed to be unsuitable.

It is to be noted for Oconee 3, the switchyard event would have to affect both the 525 kV and the Oconee 1-2 230 kV switchyard to cause a LOOP and the unavailability of the Keowee overhead power. However, this independence is neglected in this analysis.

Whenever both sources of Keowee power are unavailable because of maintenance, the 100 kV line associated with CT5 is energized by a dedicated Lee generator and the standby buses are energized. This operational mode is explicitly modeled in the ac power fault tree. For other situations involving Keowee power failure, operator action to close the SL breakers is necessary, and CT5 failure is applied as a recovery event in the cut set solution if the failure mode represented by the cut set permits use of CT5 power.

Two different CT5 recovery events are used in this analysis. One event (PACLEE1REC) represents the failure probability of CT5 power energizing the standby buses during a LOOP event involving the switchyard failure. In this case, the 100 kV power of CT5 is not affected. A value of 0.01 is assigned to this event, and it includes the human error probability to close the SL breakers and the hardware failures and maintenance unavailability of CT5 and the associated 100 kV line. The other event (PACLEE2REC) represents the failure probability of CT5 power energizing the standby buses during a LOOP event involving failure of the grid. For this situation power to the 100 kV line is not initially available, and a Lee generator has to energize the line by manual actions. A value of 0.05 is used for this event to represent the hardware and human failures.

The ac power model is built on the existing Oconee PRA/IPE model of the ac power system by replacing the high level Keowee failures with a detailed model of the Keowee underground power and the Keowee overhead power. Figure 6.2-1 presents the ac power fault tree, with the Keowee interface shown as transfer gates to the corresponding gates in the Keowee integrated fault tree (Appendix F). The complete integrated Oconee ac power-Keowee tree is shown in Appendix G.

The ac power model can be solved with the data for the Keowee equipment and the data for the Oconee equipment in the Oconee PRA data base. Since Oconee dc power is a support system for the ac power, the existing dc power model is also called during the solution process. The cut set solution, after application of any appropriate CT5 recovery

events, represents the probability of a loss of all ac power event, but not including the recovery of off-site power. The results are presented in Section 7.3.

6.3 AC POWER CORE DAMAGE SEQUENCES

If off-site power is not recovered, the ac power event can lead to a sustained loss of all ac power event, with the potential for core damage. Each Oconee reactor has a turbine driven emergency feedwater (EFW) pump, which works without the need for ac power and can provide reactor decay heat removal through the steam generators (SGs). Nevertheless, a sustained loss of ac power condition can cause failure of the reactor coolant pump (RCP) seals, due to lack of cooling, and thereby lead to an unmitigated loss of coolant condition. The safe shutdown facility (SSF) at Oconee is capable of providing RCP seal cooling and SG cooling under conditions involving the loss of the plant ac power.

To determine the core damage risk of a loss of all ac power event, the failure probability of the turbine driven EFW pump, the SSF and off-site power recovery must be considered, in addition to the probability of the loss of all ac power event. This is accomplished by defining the logic models for the failure of the turbine driven EFW pump and the SSF and combining with the ac power model. The coupled solution of this ac power core damage model is modified by application of the off-site power recovery factors to obtain the core damage frequency for ac power events.

Figure 6.3-1 presents the logic model of the ac power core damage event, with the transfer gates to the ac power model described in Section 6.2. The SSF logic utilizes the PRA solution of the SSF ASW pump and the SSF RCM pump (Appendix A.13 of Reference 1) since it is a totally independent system.

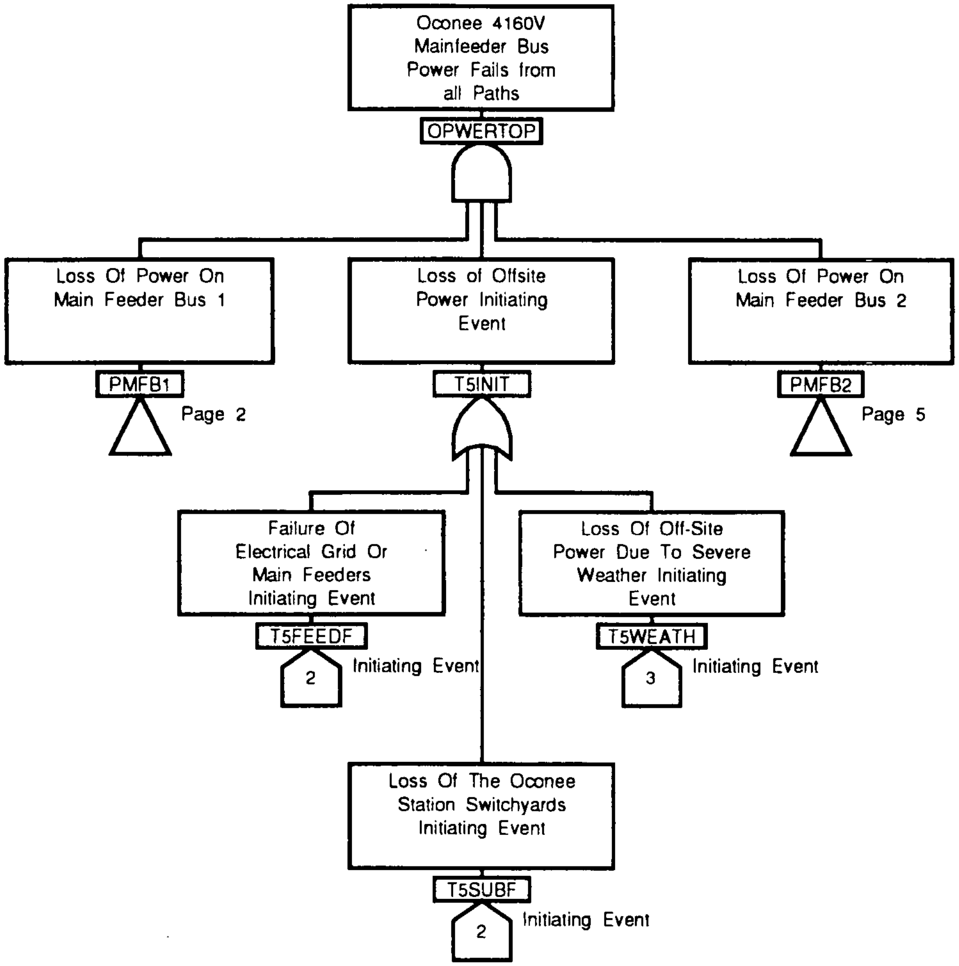
The probability of recovering off-site power varies with the time following the event, the longer the available time the more likely the power recovery. The time available for recovering off-site power depends on the nature of the equipment failures which cause the failure of the emergency power. Equipment failures which cause initial failure (for example, start failure of both Keowee units) make the available time for power recovery short compared to those equipment failures occurring later (for example, failure of the Keowee unit to run for the assumed 24-hour mission time). Also, the availability of secondary side (SG) cooling extends these times further. These considerations lead to the

formulation of six off-site power recovery events. Their values are selected by analyzing the time of recovery of off-site power for the weather related events, as reported in Reference 1.

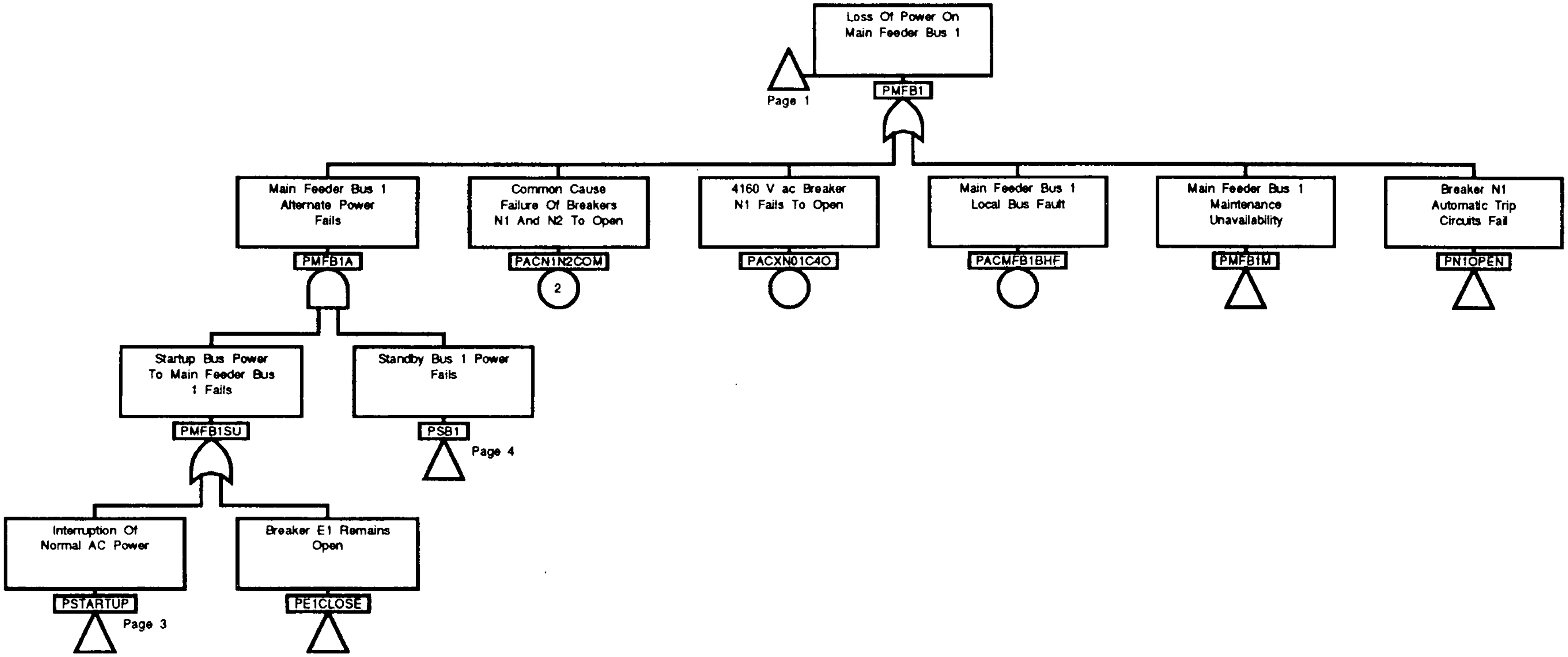
The six off-site power recovery events and their probabilities are as follows:

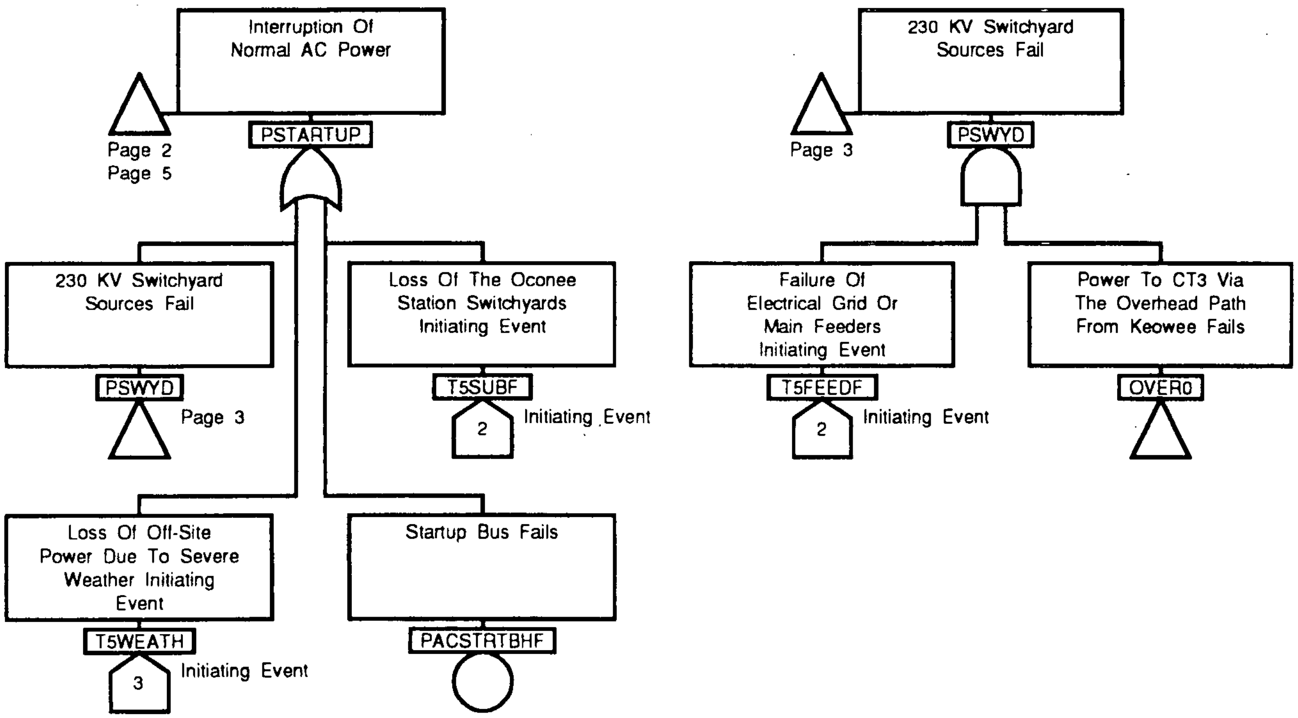
RECOVERY EVENT	FAILURE MODE	SG COOLING	PROB.
TACOFF1REC	start-start	NO	0.67
TACOFF2REC	start-start	YES	0.22
TACOFF3REC	start-run	YES	0.065
TACOFF4REC	run-run	YES	0.051
TACOFF5REC	start-run	NO	0.14
TACOFF6REC	run-run	NO	0.073

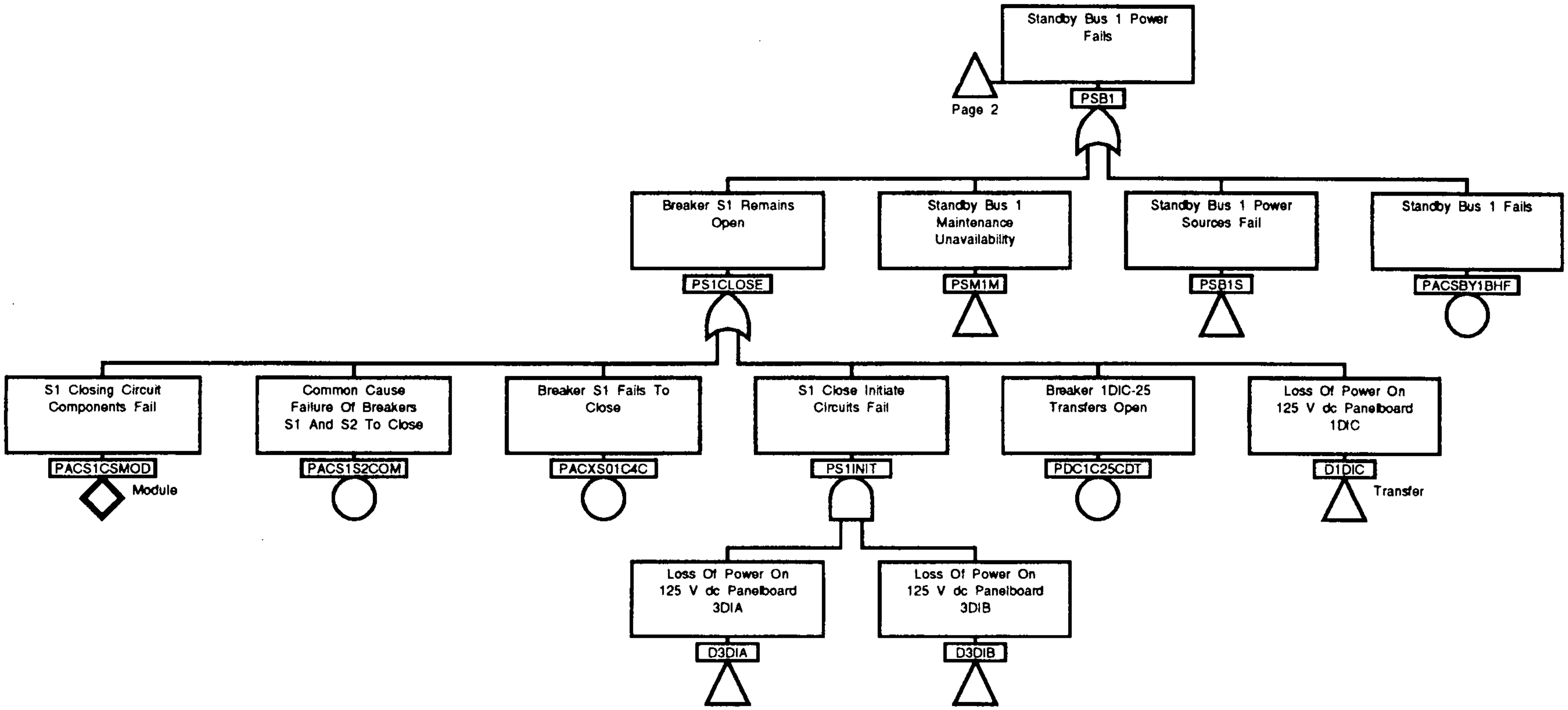
The ac power core damage model is solved by utilizing the new Keowee model, the Keowee data base, and the Oconee PRA data base. The cut set solution is modified by applying the off-site power recovery factors appropriate for the individual cut sets. The results are presented in Section 7.4.

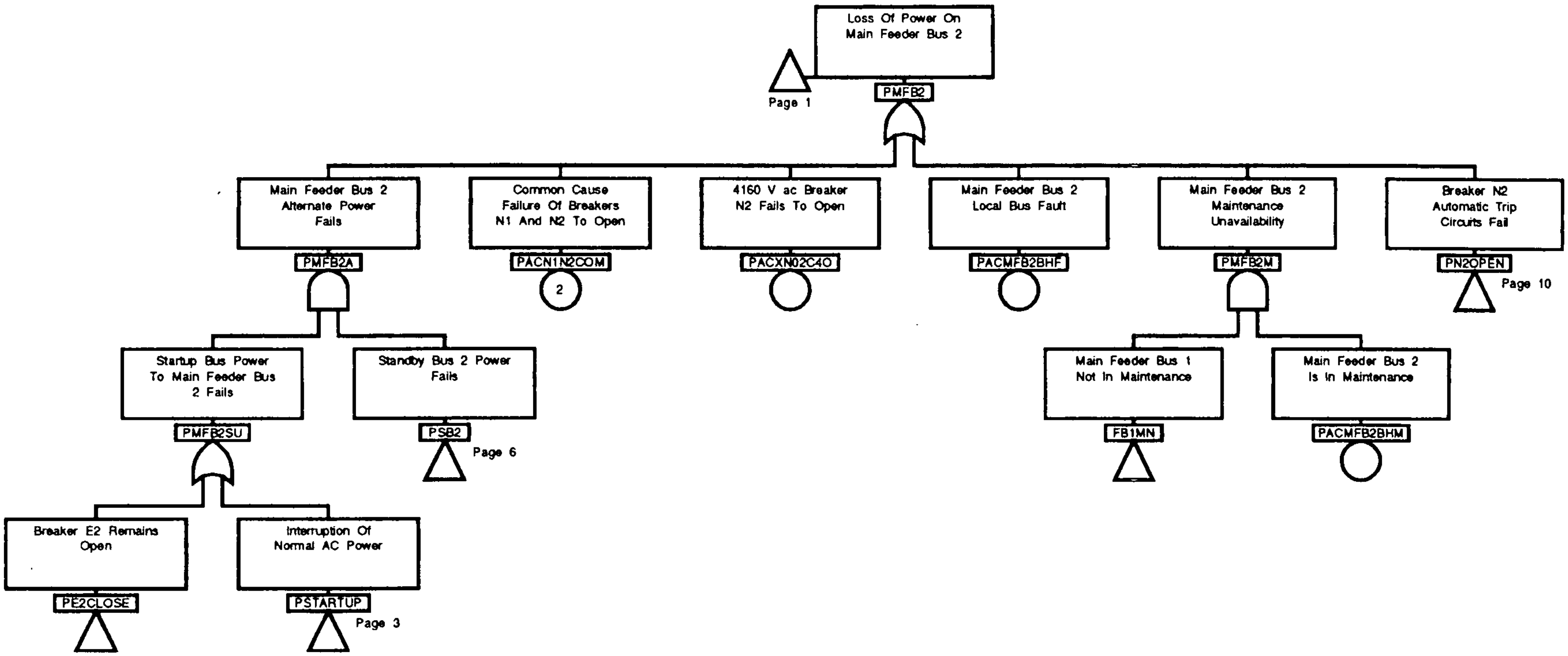


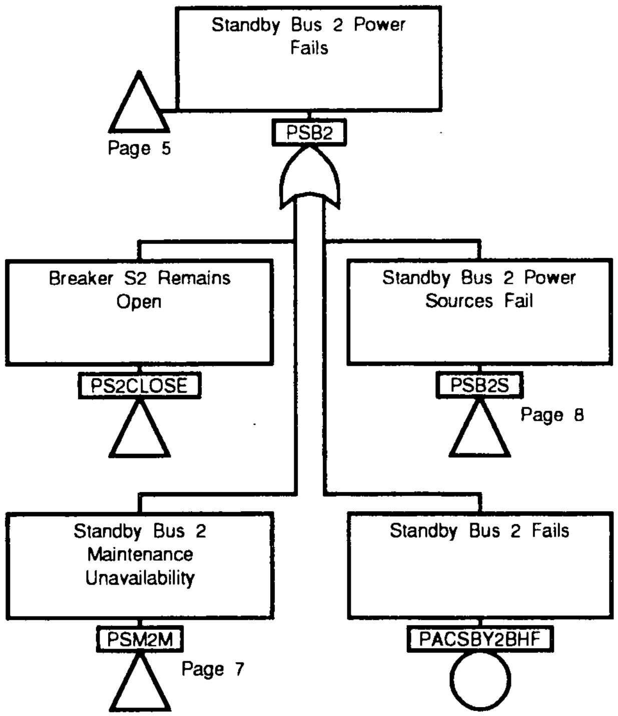
ONS-Keowee AC Power Integrated Model	FIGURE 6.2-1	Page 1


Loss Of Power On
Main Feeder Bus 1
Page 1
PMFB1
Main Feeder Bus 1
Alternate Power
Fails
PMFB1A
Common Cause
Failure Of Breakers
N1 And N2 To Open
PACN1N2COM
2
4160 V ac Breaker
N1 Fails To Open
PACXN01C4O
Main Feeder Bus 1
Local Bus Fault
PACMFB1BHF
Main Feeder Bus 1
Maintenance
Unavailability
PMFB1M
Breaker N1
Automatic Trip
Circuits Fail
PN1OPEN
Startup Bus Power
To Main Feeder Bus
1 Fails
PMFB1SU
Standby Bus 1 Power
Fails
PSB1
Page 4
Interruption Of
Normal AC Power
PSTARTUP
Page 3
Breaker E1 Remains
Open
PE1CLOSE

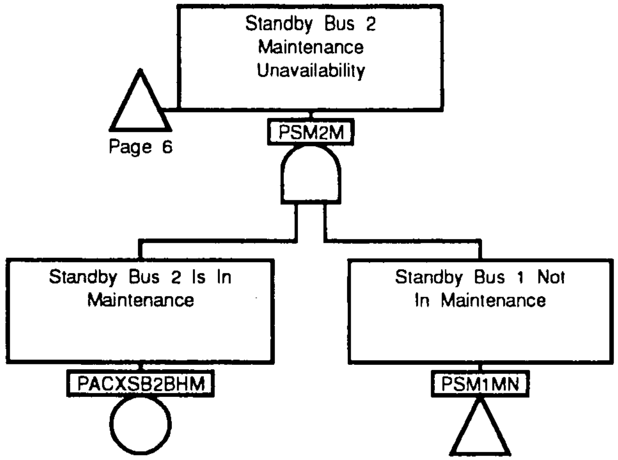

Interruption Of
Normal AC Power
Page 2
Page 5
PSTARTUP
230 KV Switchyard
Sources Fail
PSWYD
Page 3
Loss Of The Oconee
Station Switchyards
Initiating Event
T5SUBF
2
Initiating Event
Loss Of Off-Site
Power Due To Severe
Weather Initiating
Event
T5WEATH
3
Initiating Event
Startup Bus Fails
PACSTRTBHF
230 KV Switchyard
Sources Fail
Page 3
PSWYD
Failure Of
Electrical Grid Or
Main Feeders
Initiating Event
T5FEEDF
2
Initiating Event
Power To CT3 Via
The Overhead Path
From Keowee Fails
OVER0

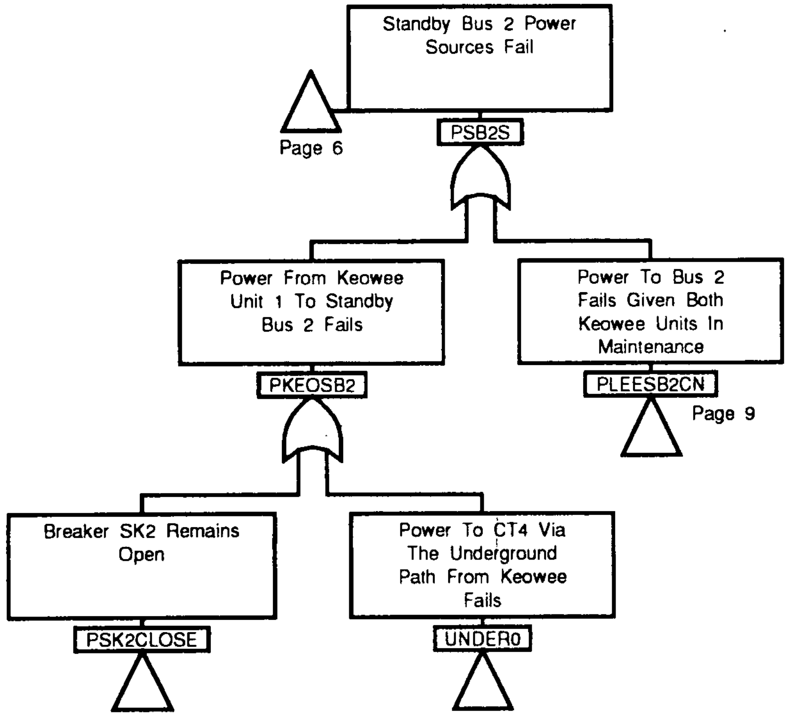

Standby Bus 1 Power Fails
PSB1
Page 2
Breaker S1 Remains Open
PS1CLOSE
Standby Bus 1 Maintenance Unavailability
PSM1M
Standby Bus 1 Power Sources Fail
PSB1S
Standby Bus 1 Fails
PACSBY1BHF
S1 Closing Circuit Components Fail
PACS1CSMOD
Module
Common Cause Failure Of Breakers S1 And S2 To Close
PACS1S2COM
Breaker S1 Fails To Close
PACXS01C4C
S1 Close Initiate Circuits Fail
PS1INIT
Breaker 1DIC-25 Transfers Open
PDC1C25CDT
Loss Of Power On 125 V dc Panelboard 1DIC
D1DIC
Transfer
Loss Of Power On 125 V dc Panelboard 3DIA
D3DIA
Loss Of Power On 125 V dc Panelboard 3DIB
D3DIB


Loss Of Power On Main Feeder Bus 2
PMFB2
Page 1
Main Feeder Bus 2 Alternate Power Fails
PMFB2A
Common Cause Failure Of Breakers N1 And N2 To Open
PACN1N2COM
2
4160 V ac Breaker N2 Fails To Open
PACXN02C4O
Main Feeder Bus 2 Local Bus Fault
PACMFB2BHF
Main Feeder Bus 2 Maintenance Unavailability
PMFB2M
Breaker N2 Automatic Trip Circuits Fail
PN2OPEN
Page 10
Startup Bus Power To Main Feeder Bus 2 Fails
PMFB2SU
Standby Bus 2 Power Fails
PSB2
Page 6
Main Feeder Bus 1 Not In Maintenance
FB1MN
Main Feeder Bus 2 Is In Maintenance
PACMFB2BHM
Breaker E2 Remains Open
PE2CLOSE
Interruption Of Normal AC Power
PSTARTUP
Page 3

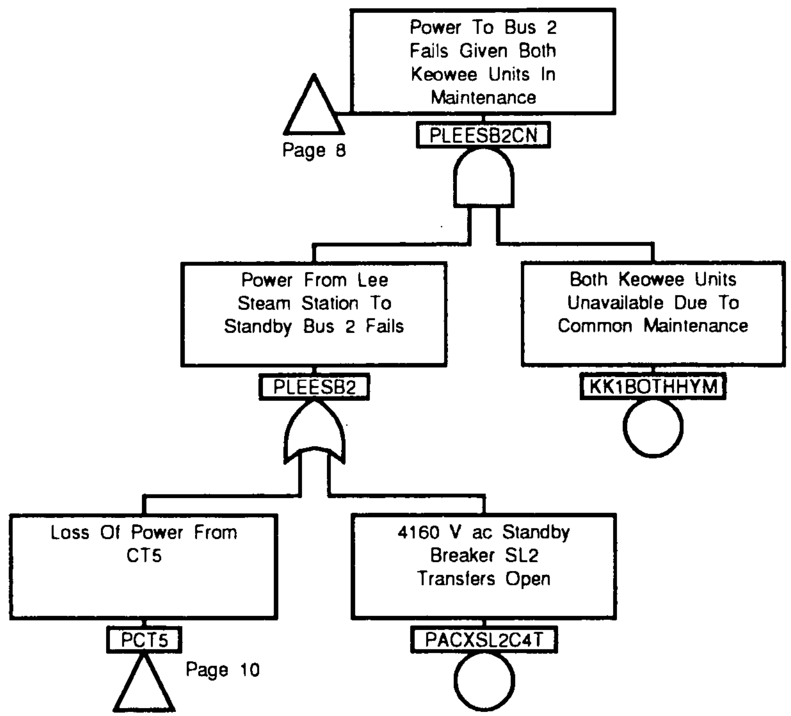


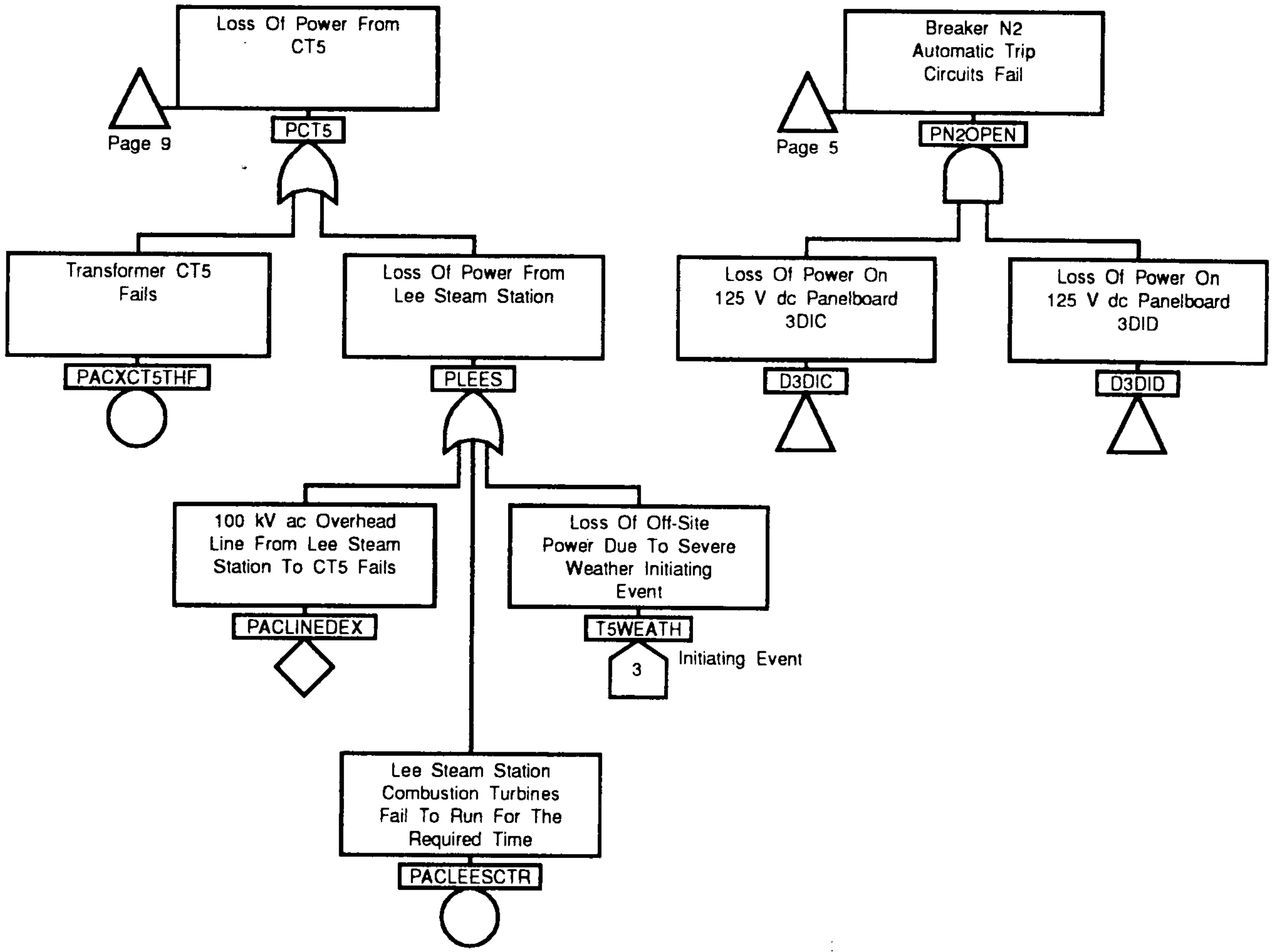
Standby Bus 2 Power Fails
PSB2
Page 5
Breaker S2 Remains Open
PS2CLOSE
Standby Bus 2 Power Sources Fail
PSB2S
Page 8
Standby Bus 2 Maintenance Unavailability
PSM2M
Page 7
Standby Bus 2 Fails
PACSBY2BHF


Standby Bus 2 Maintenance Unavailability
Page 6
PSM2M
Standby Bus 2 Is In Maintenance
PACXSB2BHM
Standby Bus 1 Not In Maintenance
PSM1MN

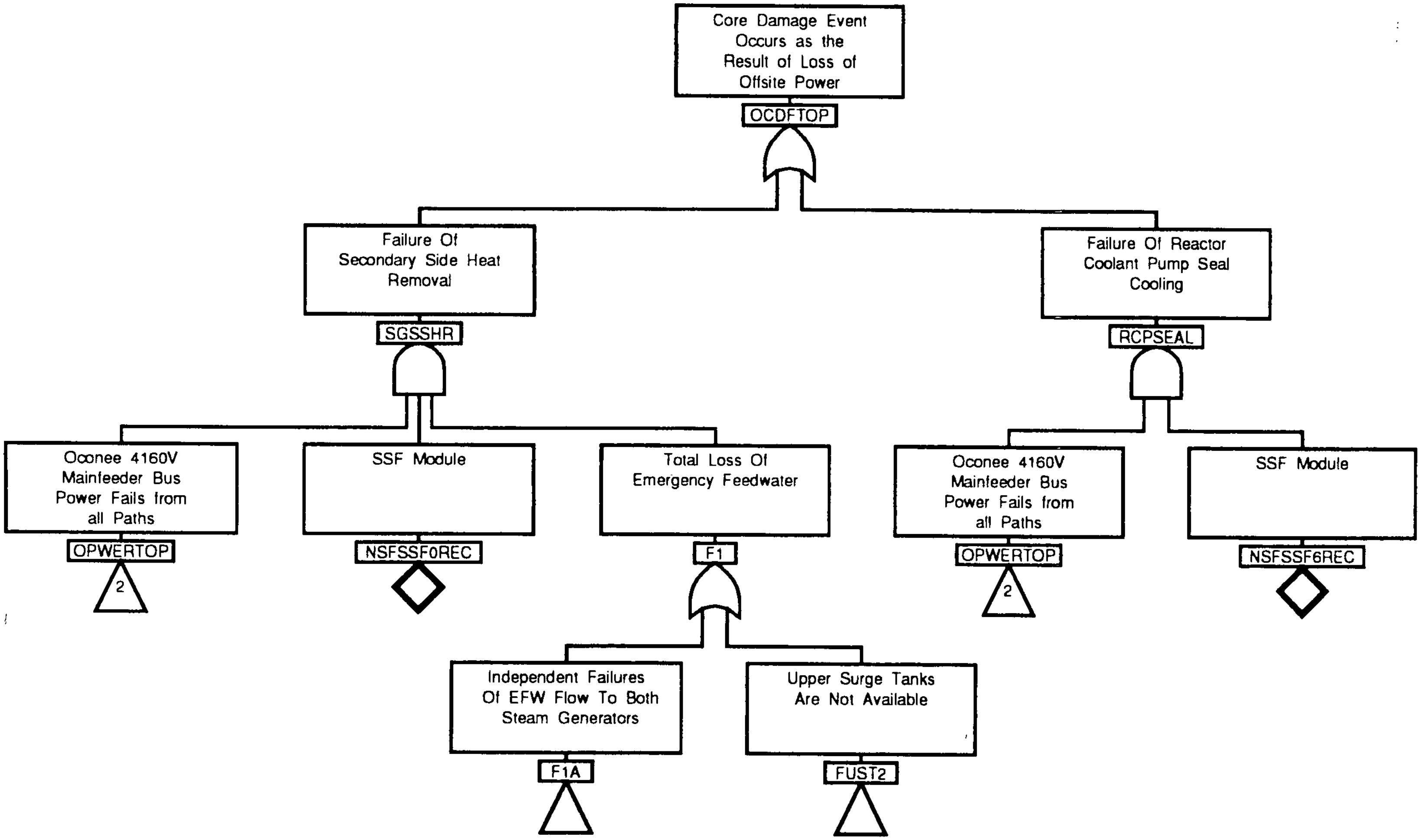


Standby Bus 2 Power Sources Fail
Page 6
PSB2S
Power From Keowee Unit 1 To Standby Bus 2 Fails
PKEOSB2
Power To Bus 2 Fails Given Both Keowee Units In Maintenance
PLEESB2CN
Page 9
Breaker SK2 Remains Open
PSK2CLOSE
Power To CT4 Via The Underground Path From Keowee Fails
UNDER0


Power To Bus 2 Fails Given Both Keowee Units In Maintenance
PLEESB2CN
Page 8
Power From Lee Steam Station To Standby Bus 2 Fails
PLEESB2
Both Keowee Units Unavailable Due To Common Maintenance
KK1BOTHHYM
Loss Of Power From CT5
PCT5
Page 10
4160 V ac Standby Breaker SL2 Transfers Open
PACXSL2C4T



Loss Of Power From CT5
PCT5
Page 9
Transformer CT5 Fails
PACXCT5THF
Loss Of Power From Lee Steam Station
PLEES
100 kV ac Overhead Line From Lee Steam Station To CT5 Fails
PACLINEDEX
Loss Of Off-Site Power Due To Severe Weather Initiating Event
T5WEATH
3
Initiating Event
Lee Steam Station Combustion Turbines Fail To Run For The Required Time
PACLEESCTR
Breaker N2 Automatic Trip Circuits Fail
PN2OPEN
Page 5
Loss Of Power On 125 V dc Panelboard 3DIC
D3DIC
Loss Of Power On 125 V dc Panelboard 3DID
D3DID



ONS-Keowee Core Damage Fault Tree	FIGURE 6.3-1	Page 1

7.0 RESULTS, CONCLUSIONS, AND RECOMMENDATIONS

7.1 INTRODUCTION

The Keowee reliability model, described in Section 4, is solved using the database consisting of component failure basic events, common cause failure events, and HRA events (Section 5). The solution is obtained for the overall Keowee function representing the failure of both the Keowee power through the underground path and that through the overhead path. The solution is obtained both with generic data and the Bayesian updated data and also by not considering the operator recovery actions. Solutions are also obtained at the path level and Keowee unit level to provide perspectives on the relative path reliability and to enable comparisons with the Keowee unit reliability data.

Integration of the Keowee reliability model with the existing Oconee ac power system model permits analysis of the reliability of the Oconee ac power model. This part of the result provides quantitative information on the likelihood of a loss of off-site power event progressing into a loss of all ac power event.

Finally, the new ac power model is coupled with the SSF, TDEFW pump, and the LOOP recovery models to provide the risk perspectives on ac power related core damage accident sequences.

The results of a number of sensitivity studies are used to draw conclusions on the relative importance of various Keowee subsystems, failure modes, operational modes, and plant enhancements.

7.2 KEOWEE RELIABILITY

Table 7.2-1 presents the results of the Keowee fault tree model solution. The base case result, 0.0074, is for the Bayesian updated database and includes the effect of operator recovery. If recovery potential by operator action is ignored, the failure probability becomes 0.01. Operator recovery potential comes into play for a limited number of important failure modes, such as failure of the Keowee unit assigned to the underground path and failure of the overhead path (for example, due to switchyard isolation failure) or common cause failure of both units to run due to clogging of the cooling water filters.

These actions are in the plant procedures, and there appears to be adequate operator familiarity with these actions.

Use of the generic data instead of the Bayesian updated data (which is highly influenced by the plant-specific evidence) is found to change the result only by a modest value (0.013 for generic versus 0.01 with the Bayesian updated set).

Figure 7.2-1 presents the breakdown of the share of Keowee failure probability for the important causes. It is to be noted that whenever both Keowee units are taken out of service (this accounts for some 75% of the base case failure probabilities), the standby buses are energized by CT5 and the 100 kV line energized by starting a Lee combustion turbine unit, thus improving the reliability of the backup emergency power source.

A listing of the top 100 cut sets for the base case calculation is presented in Table 7.2-2.

Table 7.2-3 contains the results of the solution at the individual path level. It is seen that the underground path power is more reliable than the overhead path power (0.027 failure probability versus 0.070), due to the overhead unit taking up all the single unit maintenance unavailability (0.038). Tables 7.2-4 and 7.2-5 contain the dominant cut sets for the underground supply and the overhead supply, respectively.

Figure 7.2-2 contains the comparison of the fault tree model predicted Keowee start failure probabilities with the reliability from actual experience for the last 10 years (1984-93). As seen, the analytical reliability is in remarkable agreement with the system level experience. The small difference for the predicted cold start reliability for the standby unit (0.0081) and the unit used for grid generation (0.0078) is due to the different exposure times for component failure and detection when the standby unit assigned to the underground is not used for grid generation (daily demand versus weekly testing).

Table 7.2-6 presents the comparison of the Keowee run failure probability (for the assumed 24-hour mission time) predicted by the model versus the operating experience. In this case also the numbers are nearly identical.

Figures 7.2-3 and 7.2-4 identify the Keowee systems with the most influence on start and run failures, respectively. The excitation system is the predominant source of start

failures, as seen from the Keowee start failure data as well as from the model prediction. For the run failure, no single system stands out as being the major source of failure.

The Keowee reliability study included a substantial effort to investigate potential common cause failure modes at the component level in lieu of the simplified system level estimate. Table 7.2-7 contains the comparison of the system level common cause failure probabilities with that obtained from a rigorous analysis at the component level. The two estimates are in close agreement.

7.3 OCONEE AC POWER RELIABILITY

Table 7.3-1 presents the results of the ac power model that incorporates the new Keowee reliability model. The model is solved with the existing database of Oconee electrical equipment and Bayesian updated Keowee equipment database. The frequencies of the loss-of-off-site power initiating events are those used in the IPE model (T5S=0.049, T5F=0.027, and T5W=0.014).

The probability of losing all ac power for an Oconee unit is calculated to be 6.4E-5 in a year. This value does not include the recovery of off-site power nor the mitigation capability of the SSF.

Table 7.3-2 presents the relative importance of various events that affect the loss of all ac power probability. The occurrence of a severe weather event has the most influence, since it is assumed that the Keowee overhead power and the CT5 power would be lost during such an event. Other events of importance are CT4 maintenance unavailability, both Keowee units in maintenance, and the maintenance unavailability of a single Keowee unit.

7.4 AC POWER CORE DAMAGE SEQUENCES

Table 7.4-1 presents the results of ac power core damage sequence analysis. The core melt frequency due to loss of ac power events is calculated to be 1E-6 per reactor year. The corresponding value in the previous IPE calculation is approximately 3E-6 per reactor year.

The reduction in the loss of ac power core damage frequency in the new analysis is attributed primarily to two factors:

- the decrease in the fraction of time that both units are in common maintenance (0.00532 in the new analysis vs. 0.0193 in the IPE analysis), and
- the reduced importance of the common cause Keowee run failure in the new analysis, because of the credit for recovery of the cooling water filter assembly failure mode.

For this calculation also, the occurrence of the severe weather event has the greatest impact on the calculated core damage frequency. Other events of influence are the recovery of off-site power, inability to deploy the SSF within the necessary time, and CT4 failure. Table 7.4-2 shows the relative importance of key events affecting the ac power core damage frequency.

7.5 SENSITIVITY STUDIES

The results of the various sensitivity studies are discussed in the following sections. Appendix E contains a more detailed discussion of the data modifications required for each of the sensitivity studies.

7.5.1 GENERIC VERSUS BAYESIAN UPDATED DATA

Table 7.5-1 contains the results for a number of gates for the Bayesian updated versus generic reliability data comparison.

In general, the more a particular gate value is dominated by the plant specific data (e.g., the DEX events) the smaller the change when the generic data is used. An increase of about 50% is observed in most of the gate values when the generic data is used. Because the KEOWTOP gate is largely dominated by the Keowee unit maintenance unavailability, the impact is not large in the overall result.

7.5.2 GRID CYCLED VERSUS STANDBY UNIT RELIABILITY

Table 7.5-2 shows the calculated failure probabilities for Keowee Unit 1 (standby unit) and Keowee Unit 2 (the grid cycled unit).

It is observed that the failure probabilities for the standby unit are about the same as those for the grid cycled unit.

7.5.3 RECOVERED VERSUS UNRECOVERED RESULTS

The results for these two cases are available in Table 7.2-1.

It is seen that the application of the recoveries results in approximately a 26% reduction in the failure probability for Keowee. The most important recovery is the recovery from the common cause failure of the Auxiliary Power Breakers, AB0SWGRRHE.

7.5.4 HUMAN ERROR SENSITIVITY STUDIES

7.5.4.1 Latent Human Errors

The potential Keowee reliability improvement from the Latent Human Errors (LHEs) is evaluated by setting these failure probabilities to 0.0 and comparing the result to the base case analysis. The result of the analysis when the LHEs are set to 0.0 is 7.2E-03. This is less than a 3% reduction from the base case value of 7.4E-03.

7.5.4.2 Human Error Probabilities Prior To 10/92 Event

Table 7.5-3 shows the comparison of the calculated Keowee failure probability using the pre-92 human error probabilities with the base case result.

7.5.5 INFREQUENTLY TESTED/DEMANDED COMPONENTS

Table 7.5-4 presents the results of sensitivity studies that assess the impact on the Keowee reliability results from a change that increases the likelihood of failure for components which are not frequently challenged. The three parts of the study are summarized as follows.

1. Revise component exposure times to reflect quarterly rather than monthly swapping of the units.

2. Increase by an order of magnitude the failure probability of components not challenged during normal start and power operation but that are needed for emergency operation.

3. Increase by an order of magnitude the failure probability of *all* components demanded during emergency operation.

It is seen that decreasing the unit swap frequency from monthly to quarterly results in only a negligible, 0.5%, increase in the Keowee failure probability.

When those components needed for emergency operation but not challenged during normal start and power operation are assumed to fail at ten times the base case rate, the start failure probability of the unit increases by a factor of approximately 2. The unit run failure probability is negligibly impacted and the overall failure probability of Keowee to supply emergency power to Oconee is increased by about 15% .

When all components demanded for emergency operation are assumed to fail at ten times the base case rate, the overall failure probability of Keowee is increased by about 30% over the base case value.

7.5.6 MG-6 RELAY FAILURE RATE

Increasing the plant specific failure rate for the MG-6 relays by an order of magnitude caused the Keowee failure probability to increase from 7.4E-5 to 7.7E-3, a change of about 4%. Thus, the impact of a large increase in the MG-6 relay failure rate has only a modest impact on Keowee reliability.

7.5.7 UNCERTAINTY ANALYSIS

Figure 7.5-1 provides the probability distribution for the calculated Keowee failure probability, taking into account the estimates in the uncertainty in the individual equipment and other event probabilities. The point estimate value (considering no uncertainty) is 7.4E-3. Using a 5000 sample simulation, the sensitivity study produced an estimated mean value of 7.3E-3.

The fifth and 95th percentiles have an estimated value of 2.9E-3 and 1.5E-2.

7.5.8 ONE VERSUS TWO UNITS GENERATING TO THE GRID

Table 7.5-5 contains the calculated overall Keowee failure probability for the two cases.

It is observed that there is no deterioration in the calculated reliability when both units are allowed to be used on the grid.

7.5.9 SENSITIVITY TO FRACTION OF TIME THAT 2 UNITS GENERATE TO THE GRID

The results of this study for both the recovered and unrecovered comparisons are included in Table 7.5-5. The recovered failure probability falls from 0.00736 to 0.00732 when the fraction of the time that the units generate together is increased from 0.034 to 0.3 The reduction in the unrecovered case is from 0.0104 to 0.0103.

These changes are considered to be insignificant changes in the failure probability over the range investigated.

7.6 CONCLUSIONS

Keowee Reliability

1. The failure probability of Keowee and its power paths to provide emergency power when needed by an Oconee unit is low (0.0071). Therefore, Keowee is a very reliable source of emergency power for Oconee.

2. Simultaneous failure of both Keowee units, due to concurrent maintenance unavailability or common cause failure of both units, is the principal cause of Keowee failure.

Keowee Power Path Reliability

1. Keowee power through the underground path is more reliable than the power through the overhead path (failure probability of 0.027 for the underground power versus 0.070 for the power through the overhead path), mainly due to the fact that single Keowee unit maintenance is not performed on the unit assigned to the underground path.

2. Simply looking at the power path (that is, not including the Keowee unit), the underground path is still more reliable than the overhead path since the overhead path is dependent upon the switchyard isolation function.

Keowee Analytical Reliability Versus System Experience

1. The reliability of the Keowee unit calculated from the fault tree model is in remarkable agreement with that derived from the substantial grid generation experience. There is substantial reliability experience at the system level as well as at the component level. Either way of quantifying the reliability is valid.

2. Although some of the components of the Keowee system needed for the emergency power function are not called upon to operate during the daily grid generation function, the failure modes represented by these components comprise only about 15% of the failure modes contained in the Keowee mode. The functional status of these components is verified by the existing periodic tests.

3. The Keowee reliability data from the grid generation experience is vast compared to the database from the periodic tests and emergency demands (29 failures in 6488 starts versus 2 failures in 113 starts during 1984-93) and the resulting reliability results have much higher statistical accuracy than that generated from the limited test and emergency demand experience.

Keowee Unit Reliability

1. The overall failure probability (including the start and run failure) of a Keowee unit not including the maintenance unavailability is approximately 0.02, indicating a very reliable source of emergency power for Oconee.

2. For the overhead unit, the maintenance unavailability (0.038) is an additional large contributor for the failure of the emergency power function.

3. For the start failure, the generator excitation system is the main source of unit failure, as seen from the operational experience and the analytical results.

Keowee Equipment Reliability

1. The detailed analysis of the component failure history at Keowee and comparison with component generic failure rates do not indicate any unacceptable equipment performance. For the most part, Keowee component failure rates seem to be consistent with or better than the generic failure rates. In general, the equipment service environment (temperature, moisture, vibration, dust, and radiation) is better at Keowee compared to that in typical nuclear power plant buildings.

2. There are more equipment problems or failures reported in the period 1991-92. These failures adversely affect the Keowee reliability in the same period. The trend for the subsequent years shows improved equipment performance (fewer failures).

Use of Keowee for Grid Generation

1. Use of the Keowee unit(s) to generate power to the grid does not adversely affect the reliability of Keowee for the Oconee emergency power function, as shown by the comparison between the reliability between Keowee Unit 2, assumed to be operating on the grid when needed, and Keowee Unit 1, assumed to be in a standby mode. With both units allowed to operate on the grid, the overall Keowee failure probability is calculated to be 0.0073, compared to the probability of 0.0074 with only one unit permitted for grid use.

2. Overall, the grid generation mode occurs only a small fraction of the time (about 6%) even though a unit may be started for grid generation almost daily.

Common Cause Failure

1. Common cause failure of Keowee is an important failure mode, both in the new analysis as well as in the previous (IPE) analysis.

2. The more elaborate investigation of common cause failure potential at the component level produced results generally consistent with the results obtained from the simplified system level analysis. However, the component level analysis led to the identification of failure modes which could be rectified by operator

actions. With the operator action, the common cause failure probability of Keowee was estimated to be approximately 10% of the total Keowee failure probability.

Role of Human Element

The plant staff has a positive and negative role in influencing the Keowee reliability. On the positive side, the operators can overcome certain equipment failures (such as failure of the Keowee underground unit or common cause failure of Keowee cooling water filters) and restore Keowee power to Oconee. On the other hand, latent human errors, during equipment maintenance and testing, can render equipment in an unavailable state. Collectively, the effect of operator action is the change from 0.01 to 0.0074 for the Keowee failure probability. No single event stands out as having a significant impact. On the other hand, some latent human error events can totally fail a unit. Thus, good human performance and adequate administrative controls are important to keep the error probability at low values. The human reliability analysis; which took into consideration the operating experience, the plant procedures and operating characteristics; produced low error rates for the latent human error events of concern.

Plant Enhancements

1. The recent improvement in the Keowee administration and management (including personnel training, development of operating and emergency procedures, etc.) is considered to have a positive impact on the Keowee reliability

2. Analysis of the Keowee reliability with both units assumed to be available for grid generation after implementation of the modification, shows that the Keowee failure probability is not increased (0.0073 versus the base case failure probability of 0.0074).

Oconee AC Power Reliability

1. Overall, the Oconee ac power system is highly reliable (failure probability of 6.4E-5 per reactor year). The redundancy in the main feeder bus and the many ways of supplying power to the main feeder bus make a sustained loss of ac power quite unlikely.

2. The system is most vulnerable for conditions of severe weather when the off-site power, the Keowee overhead power, and the CT5 power all might be lost. The relatively high reliability of Keowee underground path and the ability to make use of the overhead unit through the underground path, should the underground unit fail, make the probability of losing all ac power small. Thus, the Keowee underground path and its power supply are very important elements of the Oconee ac power system.

3. The backup ac power supplied by CT5 helps to reduce the risk of power failure to the MFBs, particularly during LOOP disturbances originating at the switchyard and those from the grid. Without this backup capability, the frequency of a loss of all ac power event would have been approximately a factor of 8 higher.

AC Power Core Damage Risk

1. The risk of core damage from loss of ac power events at Oconee is small (1.E-6 per reactor year) because of the low probability of a loss of all ac power event and the mitigation capability of the SSF. The new result, which comes from the existing plant models of the SSF, the turbine driven emergency feedwater pump, and the ac power system coupled with the new Keowee reliability model, is consistent with the previous result from the IPE program.

2. Failures of Keowee which are of the type "failure-to-run" are less important to the core damage risk than start failures. For the run failures, there is increased chance of recovery of off-site power prior to core damage than the start failures.

3. The SSF plays a major role in reducing the core damage risk from loss of ac power events (approximately a factor of six reduction). Therefore, it is beneficial to schedule SSF outages to periods when CT4 or both Keowee units are not out of service.

Achievement of Objectives

1. The Keowee PRA effort has produced a detailed reliability model of Keowee to facilitate reliability studies of Keowee equipment performance and operational issues.

2. An analytically derived set of Keowee reliability values has been obtained, providing useful information to address important questions involving mode of operation, equipment performance, and component testing.

3. The analytical tools, databases, sensitivity studies, and coupled results have provided important tools and insights. These should improve confidence on Keowee capability and the reliability of the Oconee ac power system.

4. Thus, all the objectives initially established for this study have been successfully achieved.

7.7 RECOMMENDATIONS

Although this re-analysis of the Oconee ac power system (with a detailed, integrated model of Keowee) confirmed the high reliability of the system, some recommendations are made. The objectives of these recommendations are to assure continued, visible high reliability of the system and to maintain the necessary sensitivity of the importance of the system for the overall nuclear safety of the Oconee units.

1. Enhancement of some of the Keowee procedures to keep the probability of latent human errors low and to improve the likelihood of recovery action is recommended for certain Keowee alarm response procedures, maintenance procedures and emergency procedures. Appendix C.3 provides the specifics on these recommended procedure enhancements.

2. A formal review of severe weather potential should be instituted as part of the consideration for scheduling outages of the Keowee underground path and also for the Keowee outages affecting both units, particularly outages lasting more than a shift.

3. Planning of the SSF outages should consider the availability of CT4, CT5, and a Keowee unit. Simultaneous unavailability of the SSF and one or more of these key Oconee ac power equipment should be avoided, to the extent practical.

4. A systematic monitoring of the Oconee ac power equipment should be performed, analyzing the root cause of equipment failures and their full implications. This can be achieved as part of the Maintenance Rule program.

5. The Oconee ac power system should be treated with care and sensitivity because of its importance for all three Oconee units, interconnections, and dependencies. When equipment failures occur, the root cause of the failure should be fully analyzed and the implications of the failure fully understood and resolved. Planning of equipment outages should consider the severe weather vulnerability and the SSF availability, as discussed in Items 3 and 4 above.

Table 7.2-1

Keowee Emergency Power Failure Probability

Model Configuration	Failure Probability
Base Case (Failure of Keowee through both the underground path and the overhead path (Bayesian-updated data)	7.4E-03
Bayesian Updated Data Without Operator Recoveries	1.0E-02
Generic Data Without Operator Recoveries	1.3E-02

Table 7.2-2

Top 100 Cut Sets From The Keowee Emergency Power Model

Module/Event	Description	Rate	Exposure	Prob.	Cs Prob.
1) KEOWTOP					*7.35E-03
1) KK1BOTHHYM	Both Keowee Units Unavailable Due To Common Maintenance		5.23E-3	5.23E-03	5.23E-03
2)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	3.22E-04
AB0SWGRCOM	Common Cause Failure Of All Keowee Auxiliary Power Breakers		6.69E-04	6.69E-04	
AB0SWGRRHE	Recovery of Keowee Aux Power Breakers by Manual Control		5.0E-01	5.00E-01	
3)-XA1XAALBLM	MCC 1XA Is Connected to Its Alternate Source of Power		2.74E-03	2.74E-03	2.66E-04
-AD1B4ALCDT	Breaker 4AL In 125 V dc Distribution Center 1DA Transfers Open	7.5E-08	30	2.25E-06	
-AB7OPENLHE	Air Circuit Breaker 7 Fails To Open Due To A Latent Human Error		3.20E-3	3.20E-03	
-AB7MECHDEX	Air Circuit Breaker 7 Fails To Open Due To Mechanical Failure		8.01E-04	8.01E-04	
-AB752TCRYD	Air Circuit Breaker 7 Trip Coil TC Fails On Demand	3.3E-05	1	3.30E-05	
-AB710AFFUF	One Or More Air Circuit Breaker 7 Control Power Fuses Fail	3.6E-06	6	2.16E-05	
-AB51431SWT	Manual/Auto Control Switch 143/1 Spuriously Transfers Into Manual	7.0E-08	360	2.52E-05	
-AB51431LHE	Manual/Auto Control Switch 143/1 Left In Manual		3.20E-4	3.20E-04	
-AA227X2RYD	Auxiliary Relay 27X/2X Fails To Operate On Demand	3.3E-05	1	3.30E-05	
-AA127X2R6D	Transformer CX Undervoltage Relay 27/CX1 Fails To Drop Out	2.49E-04	1	2.49E-04	
AB7MCH2DEX	Air Circuit Breaker 7 Fails To Close Due To Mechanical Failure		7.04E-03	7.04E-03	
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
4)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	1.55E-04
FK0FISHCOM	Common Cause Failure Of Both Unit s WL Filters Due To Intake Debris		2.55E-3	2.55E-03	
FK0FISHDHE	Recovery of Main WL Strainer Clogging		6.3E-02	6.30E-02	
5)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	1.19E-04
EK00RUNCOM	Common Cause Failure Of Both Units Voltage Regulators To Run		1.24E-4	1.24E-04	
6) EK1VREGDEX	KHU-1 Voltage Adjust Failure Drives Generator Output Too High/Low		2.47E-3	2.47E-03	9.39E-05
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
7) GK10001HGR	Keowee Unit 1 Generator Fault While the Unit Runs	9.46E-05	24	2.27E-03	8.63E-05
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
8)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	5.58E-05
-KK2RUNSDEX	Keowee Unit 2 Only Is Supplying The Grid		0.06	6.00E-02	
-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	
-KK1BOTHDEX	Keowee Units 1 And 2 Are Supplying The Grid		0.0	0.00E+00	
EKSTARTCOM	Common Cause Failure Of Both Units Voltage Regulators To Start		6.17E-5	6.17E-05	
9)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	4.80E-05
-KK2RUNSDEX	Keowee Unit 2 Only Is Supplying The Grid		0.06	6.00E-02	
-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	
-KK1BOTHDEX	Keowee Units 1 And 2 Are Supplying The Grid		0.0	0.00E+00	
E12EXCTCOM	Units 1 & 2 Excit Fail Due To Common Cause Failure Of The Breakers		5.31E-05	5.31E-05	
10) EK1BAS2DEX	KHU-1 Base Adjust Fails To Maintain Generator Output Within Acceptable R		1.24E-3	1.24E-03	4.71E-05
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	

Table 7.2-2

Top 100 Cut Sets From The Keowee Emergency Power Model

Module/Event	Description	Rate	Exposure	Prob.	Cs Prob.
11)-XD1DALTBYM	Normal Power To Dist. Center 1DA Is In Test or Maintenance		5.48E-03	5.48E-03	3.51E-05
-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
XD1KBATBYF	Keowee Battery No. 1 Fails During Discharge	9.30E-04	1	9.30E-04	
XD0KBATRHE			1.00E+00	1.00E+00	
12)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	3.35E-05
XD0CHRGCOM	Common Cause Failure Of Keowee Battery Chargers		3.48E-05	3.48E-05	
13)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	2.60E-05
XD0BATTCOM	Common Cause Failure Of Keowee I&C Power Batteries		2.70E-05	2.70E-05	
14)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	2.37E-05
FKVALVECOM	Common Cause Failure Of Cooling Water Control Valves		2.46E-5	2.46E-05	
15)-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	2.34E-05
EK1BASEDEX	Keowee Unit 1 Base Adjust Fails To Establish Correct Unit Voltage		6.17E-4	6.17E-04	
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
16) KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	2.13E-05
WK1GVRNDEX	Keowee Unit 1 Gov. Fails to Position Wicket Gates With Unit Running		5.6E-4	5.60E-04	
17) KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	2.13E-05
WK1TBRNDEX	Keowee Unit 1 Turbine Fails With the Unit Running		5.6e-4	5.60E-04	
18)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	2.01E-05
WK00RUNCOM	Common Cause Failure of Keowee Governors to Run		2.09E-05	2.09E-05	
19)-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	1.76E-05
EK1SPYMDEX	Keowee Unit 1 Supply Breaker Fails To Close Due To Mehanical Failure		4.62E-4	4.62E-04	
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
20)-XA1XAALBLM	MCC 1XA Is Connected to Its Alternate Source of Power		2.74E-03	2.74E-03	1.73E-05
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
XA1XCXXTHM	4160/600 Vac Transformer CX Is in Maintenance		4.57E-4	4.57E-04	
21)-XA1XAALBLM	MCC 1XA Is Connected to Its Alternate Source of Power		2.74E-03	2.74E-03	1.73E-05
-AD1B4ALCDT	Breaker 4AL In 125 V dc Distribution Center 1DA Transfers Open	7.5E-08	30	2.25E-06	
-AB7OPENLHE	Air Circuit Breaker 7 Fails To Open Due To A Latent Human Error		3.20E-3	3.20E-03	
-AB7MECHDEX	Air Circuit Breaker 7 Fails To Open Due To Mechanical Failure		8.01E-04	8.01E-04	
-AB752TCRYD	Air Circuit Breaker 7 Trip Coil TC Fails On Demand	3.3E-05	1	3.30E-05	
-AB710AFFUF	One Or More Air Circuit Breaker 7 Control Power Fuses Fail	3.6E-06	6	2.16E-05	
-AB51431SWT	Manual/Auto Control Switch 143/1 Spuriously Transfers Into Manual	7.0E-08	360	2.52E-05	
-AB51431LHE	Manual/Auto Control Switch 143/1 Left In Manual		3.20E-4	3.20E-04	
-AA227X2RYD	Auxiliary Relay 27X/2X Fails To Operate On Demand	3.3E-05	1	3.30E-05	
-AA127X2R6D	Transformer CX Undervoltage Relay 27/CX1 Fails To Drop Out	2.49E-04	1	2.49E-04	
AB7MCH2DEX	Air Circuit Breaker 7 Fails To Close Due To Mechanical Failure		7.04E-03	7.04E-03	
EK2VREGDEX	KHU-2 Voltage Adjust Failure Drives Generator Output Too High/Low		2.47E-3	2.47E-03	

Table 7.2-2

Top 100 Cut Sets From The Keowee Emergency Power Model

Module/Event	Description	Rate	Exposure	Prob.	Cs Prob.
22)-XA1XAALBLM	MCC 1XA Is Connected to Its Alternate Source of Power		2.74E-03	2.74E-03	1.59E-05
-AD1B4ALCDT	Breaker 4AL In 125 V dc Distribution Center 1DA Transfers Open	7.5E-08	30	2.25E-06	
-AB7OPENLHE	Air Circuit Breaker 7 Fails To Open Due To A Latent Human Error		3.20E-3	3.20E-03	
-AB7MECHDEX	Air Circuit Breaker 7 Fails To Open Due To Mechanical Failure		8.01E-04	8.01E-04	
-AB752TCRYD	Air Circuit Breaker 7 Trip Coil TC Fails On Demand	3.3E-05	1	3.30E-05	
-AB710AFFUF	One Or More Air Circuit Breaker 7 Control Power Fuses Fail	3.6E-06	6	2.16E-05	
-AB51431SWT	Manual/Auto Control Switch 143/1 Spuriously Transfers Into Manual	7.0E-08	360	2.52E-05	
-AB51431LHE	Manual/Auto Control Switch 143/1 Left In Manual		3.20E-4	3.20E-04	
-AA227X2RYD	Auxiliary Relay 27X/2X Fails To Operate On Demand	3.3E-05	1	3.30E-05	
-AA127X2R6D	Transformer CX Undervoltage Relay 27/CX1 Fails To Drop Out	2.49E-04	1	2.49E-04	
AB7MCH2DEX	Air Circuit Breaker 7 Fails To Close Due To Mechanical Failure		7.04E-03	7.04E-03	
GK20001HGR	Keowee Unit 2 Generator Fault While the Unit Runs	9.46E-05	24	2.27E-03	
23)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	1.40E-05
OKOPRUNCOM	Common Cause Failure Of Both Governor Oil Systems To Run		1.46E-05	1.46E-05	
24)-XA1XAALBLM	MCC 1XA Is Connected to Its Alternate Source of Power		2.74E-03	2.74E-03	1.40E-05
-AD1B4ALCDT	Breaker 4AL In 125 V dc Distribution Center 1DA Transfers Open	7.5E-08	30	2.25E-06	
-AB7OPENLHE	Air Circuit Breaker 7 Fails To Open Due To A Latent Human Error		3.20E-3	3.20E-03	
-AB7MECHDEX	Air Circuit Breaker 7 Fails To Open Due To Mechanical Failure		8.01E-04	8.01E-04	
-AB752TCRYD	Air Circuit Breaker 7 Trip Coil TC Fails On Demand	3.3E-05	1	3.30E-05	
-AB710AFFUF	One Or More Air Circuit Breaker 7 Control Power Fuses Fail	3.6E-06	6	2.16E-05	
-AB51431SWT	Manual/Auto Control Switch 143/1 Spuriously Transfers Into Manual	7.0E-08	360	2.52E-05	
-AB51431LHE	Manual/Auto Control Switch 143/1 Left In Manual		3.20E-4	3.20E-04	
-AA227X2RYD	Auxiliary Relay 27X/2X Fails To Operate On Demand	3.3E-05	1	3.30E-05	
-AA127X2R6D	Transformer CX Undervoltage Relay 27/CX1 Fails To Drop Out	2.49E-04	1	2.49E-04	
AB7MCH2DEX	Air Circuit Breaker 7 Fails To Close Due To Mechanical Failure		7.04E-03	7.04E-03	
ACB4MOD	NSM-ON-52966 Is Not In Service		1	1.00E+00	
ACBAIRPDEX	ACB Air Supply Fails Causing Low Pressure In All ACB Accumulators		2.00E-03	2.00E-03	
25) EK1DIODDEX	Keowee Unit 1 Exciter Fan Supply Diode Bridge Fails		2.88E-4	2.88E-04	1.09E-05
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
26) FK1WL11AVO	Cooling Water Control Valve 1WL-11 Fails To Open On Demand	2.80E-04	1	2.80E-04	1.06E-05
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
27)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	1.01E-05
-KK2RUNSDEX	Keowee Unit 2 Only Is Supplying The Grid		0.06	6.00E-02	
-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	
-KK1BOTHDEX	Keowee Units 1 And 2 Are Supplying The Grid		0.0	0.00E+00	
WKCSTRTCOM	Common Cause Failure of Keowee Governors to Cold Start		1.12E-05	1.12E-05	
28)-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	9.88E-06
EK1SPYCLHE	Keowee Unit 1 Supply Breaker Fails To Close Due To Latent Human Error		2.60E-4	2.60E-04	
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
29)-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	9.88E-06
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
WK1GVCDLHE	Latent Human Error Fails Keowee 1 Governor During Cold Start		2.6E-4	2.60E-04	

Table 7.2-2

Top 100 Cut Sets From The Keowee Emergency Power Model

Module/Event	Description	Rate	Exposure	Prob.	Cs Prob.
30) GK1COOLLHE	Keowee 1 Gen. Air Cooler WL Flow Path Vlvs Mispositioned After Maint		2.60E-04	2.60E-04	9.88E-06
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
31)-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	9.88E-06
EK1FLDCLHE	Keowee Unit 1 Field Breaker Fails To Close Due To Latent Human Error		2.60E-4	2.60E-04	
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
32)-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	9.88E-06
EK1FLSCLHE	Keowee Unit 1 Field Flashing Breaker Fails To Close Due To Latent Human		2.60E-4	2.60E-04	
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
33)-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	9.88E-06
EK1FLSOLHE	Keowee Unit 1 Field Flashing Breaker Fails To Open Due To Latent Human E		2.60E-4	2.60E-04	
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
34)-XA1XAALBLM	MCC 1XA Is Connected to Its Alternate Source of Power		2.74E-03	2.74E-03	9.81E-06
-AD1B4ALCDT	Breaker 4AL In 125 V dc Distribution Center 1DA Transfers Open	7.5E-08	30	2.25E-06	
-AB7OPENLHE	Air Circuit Breaker 7 Fails To Open Due To A Latent Human Error		3.20E-3	3.20E-03	
-AB7MECHDEX	Air Circuit Breaker 7 Fails To Open Due To Mechanical Failure		8.01E-04	8.01E-04	
-AB752TCRYD	Air Circuit Breaker 7 Trip Coil TC Fails On Demand	3.3E-05	1	3.30E-05	
-AB710AFFUF	One Or More Air Circuit Breaker 7 Control Power Fuses Fail	3.6E-06	6	2.16E-05	
-AB51431SWT	Manual/Auto Control Switch 143/1 Spuriously Transfers Into Manual	7.0E-08	360	2.52E-05	
-AB51431LHE	Manual/Auto Control Switch 143/1 Left In Manual		3.20E-4	3.20E-04	
-AA227X2RYD	Auxiliary Relay 27X/2X Fails To Operate On Demand	3.3E-05	1	3.30E-05	
-AA127X2R6D	Transformer CX Undervoltage Relay 27/CX1 Fails To Drop Out	2.49E-04	1	2.49E-04	
AB7CLOSLHE	Air Circuit Breaker 7 Fails To Close Due To A Latent Human Error		2.60E-4	2.60E-04	
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
35) EK141AXR6D	Keowee Unit 1 Relay 41/AX Fails To Pick-up And Latch	2.49E-04	1	2.49E-04	9.46E-06
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
36)-XA1XAALBLM	MCC 1XA Is Connected to Its Alternate Source of Power		2.74E-03	2.74E-03	9.39E-06
-AD1B4ALCDT	Breaker 4AL In 125 V dc Distribution Center 1DA Transfers Open	7.5E-08	30	2.25E-06	
-AB7OPENLHE	Air Circuit Breaker 7 Fails To Open Due To A Latent Human Error		3.20E-3	3.20E-03	
-AB7MECHDEX	Air Circuit Breaker 7 Fails To Open Due To Mechanical Failure		8.01E-04	8.01E-04	
-AB752TCRYD	Air Circuit Breaker 7 Trip Coil TC Fails On Demand	3.3E-05	1	3.30E-05	
-AB710AFFUF	One Or More Air Circuit Breaker 7 Control Power Fuses Fail	3.6E-06	6	2.16E-05	
-AB51431SWT	Manual/Auto Control Switch 143/1 Spuriously Transfers Into Manual	7.0E-08	360	2.52E-05	
-AB51431LHE	Manual/Auto Control Switch 143/1 Left In Manual		3.20E-4	3.20E-04	
-AA227X2RYD	Auxiliary Relay 27X/2X Fails To Operate On Demand	3.3E-05	1	3.30E-05	
-AA127X2R6D	Transformer CX Undervoltage Relay 27/CX1 Fails To Drop Out	2.49E-04	1	2.49E-04	
AA127CPR6D	Transformer CX Undervoltage Relay 27/CX1 Fails To Pick Up	2.49E-04	1	2.49E-04	
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	

Table 7.2-2

Top 100 Cut Sets From The Keowee Emergency Power Model

Module/Event	Description	Rate	Exposure	Prob.	Cs Prob.
37)-XA1XAALBLM	MCC 1XA Is Connected to Its Alternate Source of Power		2.74E-03	2.74E-03	8.66E-06
-AD1B4ALCDT	Breaker 4AL In 125 V dc Distribution Center 1DA Transfers Open	7.5E-08	30	2.25E-06	
-AB7OPENLHE	Air Circuit Breaker 7 Fails To Open Due To A Latent Human Error		3.20E-3	3.20E-03	
-AB7MECHDEX	Air Circuit Breaker 7 Fails To Open Due To Mechanical Failure		8.01E-04	8.01E-04	
-AB752TCRYD	Air Circuit Breaker 7 Trip Coil TC Fails On Demand	3.3E-05	1	3.30E-05	
-AB710AFFUF	One Or More Air Circuit Breaker 7 Control Power Fuses Fail	3.6E-06	6	2.16E-05	
-AB51431SWT	Manual/Auto Control Switch 143/1 Spuriously Transfers Into Manual	7.0E-08	360	2.52E-05	
-AB51431LHE	Manual/Auto Control Switch 143/1 Left In Manual		3.20E-4	3.20E-04	
-AA227X2RYD	Auxiliary Relay 27X/2X Fails To Operate On Demand	3.3E-05	1	3.30E-05	
-AA127X2R6D	Transformer CX Undervoltage Relay 27/CX1 Fails To Drop Out	2.49E-04	1	2.49E-04	
AB7MCH2DEX	Air Circuit Breaker 7 Fails To Close Due To Mechanical Failure		7.04E-03	7.04E-03	
EK2BAS2DEX	KHU-2 Base Adjust Fails To Maintain Generator Output Within Acceptable R		1.24E-3	1.24E-03	
38) YOSTARTCOM	Common Cause Failure Of Emergency Start Signal		7.26E-06	7.26E-06	7.26E-06
YOSTARTRHE			1.00E+00	1.00E+00	
39)-XD2DALTBYM	Normal Power To Dist Cntr 2DA Is In Test or Maintenance		5.48E-03	5.48E-03	6.46E-06
-XA1XAALBLM	MCC 1XA Is Connected to Its Alternate Source of Power		2.74E-03	2.74E-03	
-AD1B4ALCDT	Breaker 4AL In 125 V dc Distribution Center 1DA Transfers Open	7.5E-08	30	2.25E-06	
-AB7OPENLHE	Air Circuit Breaker 7 Fails To Open Due To A Latent Human Error		3.20E-3	3.20E-03	
-AB7MECHDEX	Air Circuit Breaker 7 Fails To Open Due To Mechanical Failure		8.01E-04	8.01E-04	
-AB752TCRYD	Air Circuit Breaker 7 Trip Coil TC Fails On Demand	3.3E-05	1	3.30E-05	
-AB710AFFUF	One Or More Air Circuit Breaker 7 Control Power Fuses Fail	3.6E-06	6	2.16E-05	
-AB51431SWT	Manual/Auto Control Switch 143/1 Spuriously Transfers Into Manual	7.0E-08	360	2.52E-05	
-AB51431LHE	Manual/Auto Control Switch 143/1 Left In Manual		3.20E-4	3.20E-04	
-AA227X2RYD	Auxiliary Relay 27X/2X Fails To Operate On Demand	3.3E-05	1	3.30E-05	
-AA127X2R6D	Transformer CX Undervoltage Relay 27/CX1 Fails To Drop Out	2.49E-04	1	2.49E-04	
AB7MCH2DEX	Air Circuit Breaker 7 Fails To Close Due To Mechanical Failure		7.04E-03	7.04E-03	
XD2KBATBYF	Keowee Battery No. 2 Fails during Discharge	9.30E-04	1	9.30E-04	
40) EK1VREGDEX	KHU-1 Voltage Adjust Failure Drives Generator Output Too High/Low		2.47E-3	2.47E-03	6.10E-06
EK2VREGDEX	KHU-2 Voltage Adjust Failure Drives Generator Output Too High/Low		2.47E-3	2.47E-03	
41)-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	5.85E-06
GK10001HGS	Keowee Unit 1 Generator Fault Causes Unit Start Failure	1.54E-04	1	1.54E-04	
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	

Table 7.2-2

Top 100 Cut Sets From The Keowee Emergency Power Model

Module/Event	Description	Rate	Exposure	Prob.	Cs Prob.
42)-XA1XAALBLM	MCC 1XA Is Connected to Its Alternate Source of Power		2.74E-03	2.74E-03	5.85E-06
-AD1B4ALCDT	Breaker 4AL In 125 V dc Distribution Center 1DA Transfers Open	7.5E-08	30	2.25E-06	
-AB7OPENLHE	Air Circuit Breaker 7 Fails To Open Due To A Latent Human Error		3.20E-3	3.20E-03	
-AB7MECHDEX	Air Circuit Breaker 7 Fails To Open Due To Mechanical Failure		8.01E-04	8.01E-04	
-AB752TCRYD	Air Circuit Breaker 7 Trip Coil TC Fails On Demand	3.3E-05	1	3.30E-05	
-AB710AFFUF	One Or More Air Circuit Breaker 7 Control Power Fuses Fail	3.6E-06	6	2.16E-05	
-AB51431SWT	Manual/Auto Control Switch 143/1 Spuriously Transfers Into Manual	7.0E-08	360	2.52E-05	
-AB51431LHE	Manual/Auto Control Switch 143/1 Left In Manual		3.20E-4	3.20E-04	
-AA227X2RYD	Auxiliary Relay 27X/2X Fails To Operate On Demand	3.3E-05	1	3.30E-05	
-AA127X2R6D	Transformer CX Undervoltage Relay 27/CX1 Fails To Drop Out	2.49E-04	1	2.49E-04	
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
XA1BKRSCOM	CCF of 1X Aux Power Breakers ACB-5 & -7		3.10E-04	3.10E-04	
AB0SWGRRHE	Recovery of Keowee Aux Power Breakers by Manual Control		5.0E-01	5.00E-01	
43)-XA1XAALBLM	MCC 1XA Is Connected to Its Alternate Source of Power		2.74E-03	2.74E-03	5.85E-06
-AD1B4ALCDT	Breaker 4AL In 125 V dc Distribution Center 1DA Transfers Open	7.5E-08	30	2.25E-06	
-AB7OPENLHE	Air Circuit Breaker 7 Fails To Open Due To A Latent Human Error		3.20E-3	3.20E-03	
-AB7MECHDEX	Air Circuit Breaker 7 Fails To Open Due To Mechanical Failure		8.01E-04	8.01E-04	
-AB752TCRYD	Air Circuit Breaker 7 Trip Coil TC Fails On Demand	3.3E-05	1	3.30E-05	
-AB710AFFUF	One Or More Air Circuit Breaker 7 Control Power Fuses Fail	3.6E-06	6	2.16E-05	
-AB51431SWT	Manual/Auto Control Switch 143/1 Spuriously Transfers Into Manual	7.0E-08	360	2.52E-05	
-AB51431LHE	Manual/Auto Control Switch 143/1 Left In Manual		3.20E-4	3.20E-04	
-AA227X2RYD	Auxiliary Relay 27X/2X Fails To Operate On Demand	3.3E-05	1	3.30E-05	
-AA127X2R6D	Transformer CX Undervoltage Relay 27/CX1 Fails To Drop Out	2.49E-04	1	2.49E-04	
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
XA78BKRCOM	Common Cause Failure Of ACB-7 And ACB-8 To Close		3.10E-04	3.10E-04	
AB0SWGRRHE	Recovery of Keowee Aux Power Breakers by Manual Control		5.0E-01	5.00E-01	
44) EK1VREGDEX	KHU-1 Voltage Adjust Failure Drives Generator Output Too High/Low		2.47E-3	2.47E-03	5.61E-06
GK20001HGR	Keowee Unit 2 Generator Fault While the Unit Runs	9.46E-05	24	2.27E-03	
45) EK2VREGDEX	KHU-2 Voltage Adjust Failure Drives Generator Output Too High/Low		2.47E-3	2.47E-03	5.61E-06
GK10001HGR	Keowee Unit 1 Generator Fault While the Unit Runs	9.46E-05	24	2.27E-03	
46) GK10001HGR	Keowee Unit 1 Generator Fault While the Unit Runs	9.46E-05	24	2.27E-03	5.15E-06
GK20001HGR	Keowee Unit 2 Generator Fault While the Unit Runs	9.46E-05	24	2.27E-03	
47) KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	5.11E-06
OK1AG04RVT	Safety Relief Valve 1AG-4 Spurious Operation	5.60E-06	24	1.34E-04	
48) KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	5.11E-06
OK10003RVT	Safety Relief Valve 1OG-3 Spurious Operation	5.60E-06	24	1.34E-04	
49)-XD1DALTBYM	Normal Power To Dist. Center 1DA Is In Test or Maintenance		5.48E-03	5.48E-03	5.07E-06
-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	
-KK1BOTHDEX	Keowee Units 1 And 2 Are Supplying The Grid		0.0	0.00E+00	
XD1KBATBYF	Keowee Battery No. 1 Fails During Discharge	9.30E-04	1	9.30E-04	
XD2DALTBYM	Normal Power To Dist Cntr 2DA Is In Test or Maintenance		5.48E-03	5.48E-03	

Table 7.2-2

Top 100 Cut Sets From The Keowee Emergency Power Model

Module/Event	Description	Rate	Exposure	Prob.	Cs Prob.
50)-XD2DALTBYM	Normal Power To Dist Cntr 2DA Is In Test or Maintenance		5.48E-03	5.48E-03	5.07E-06
-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	
-KK1BOTHDEX	Keowee Units 1 And 2 Are Supplying The Grid		0.0	0.00E+00	
XD1DALTBYM	Normal Power To Dist. Center 1DA Is In Test or Maintenance		5.48E-03	5.48E-03	
XD2KBATBYF	Keowee Battery No. 2 Fails during Discharge	9.30E-04	1	9.30E-04	
51) ACB4MOD	NSM-ON-52966 Is Not In Service		1	1.00E+00	4.94E-06
ACBAIRPDEX	ACB Air Supply Fails Causing Low Pressure In All ACB Accumulators		2.00E-03	2.00E-03	
EK1VREGDEX	KHU-1 Voltage Adjust Failure Drives Generator Output Too High/Low		2.47E-3	2.47E-03	
52)-XA1XAALBLM	MCC 1XA Is Connected to Its Alternate Source of Power		2.74E-03	2.74E-03	4.89E-06
-AD1B4ALCDT	Breaker 4AL In 125 V dc Distribution Center 1DA Transfers Open	7.5E-08	30	2.25E-06	
-AB7OPENLHE	Air Circuit Breaker 7 Fails To Open Due To A Latent Human Error		3.20E-3	3.20E-03	
-AB7MECHDEX	Air Circuit Breaker 7 Fails To Open Due To Mechanical Failure		8.01E-04	8.01E-04	
-AB752TCRYD	Air Circuit Breaker 7 Trip Coil TC Fails On Demand	3.3E-05	1	3.30E-05	
-AB710AFFUF	One Or More Air Circuit Breaker 7 Control Power Fuses Fail	3.6E-06	6	2.16E-05	
-AB51431SWT	Manual/Auto Control Switch 143/1 Spuriously Transfers Into Manual	7.0E-08	360	2.52E-05	
-AB51431LHE	Manual/Auto Control Switch 143/1 Left In Manual		3.20E-4	3.20E-04	
-AA227X2RYD	Auxiliary Relay 27X/2X Fails To Operate On Demand	3.3E-05	1	3.30E-05	
-AA127X2R6D	Transformer CX Undervoltage Relay 27/CX1 Fails To Drop Out	2.49E-04	1	2.49E-04	
AB752Y2RYT	Air Circuit Breaker 7 Y-relay Spurious Operation	3.6E-07	360	1.30E-04	
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
53) ACB4MOD	NSM-ON-52966 Is Not In Service		1	1.00E+00	4.54E-06
ACBAIRPDEX	ACB Air Supply Fails Causing Low Pressure In All ACB Accumulators		2.00E-03	2.00E-03	
GK10001HGR	Keowee Unit 1 Generator Fault While the Unit Runs	9.46E-05	24	2.27E-03	
54)-XA1XAALBLM	MCC 1XA Is Connected to Its Alternate Source of Power		2.74E-03	2.74E-03	4.05E-06
-KK2RUNSDEX	Keowee Unit 2 Only Is Supplying The Grid		0.06	6.00E-02	
-KK1BOTHDEX	Keowee Units 1 And 2 Are Supplying The Grid		0.0	0.00E+00	
-AD1B4ALCDT	Breaker 4AL In 125 V dc Distribution Center 1DA Transfers Open	7.5E-08	30	2.25E-06	
-AB7OPENLHE	Air Circuit Breaker 7 Fails To Open Due To A Latent Human Error		3.20E-3	3.20E-03	
-AB7MECHDEX	Air Circuit Breaker 7 Fails To Open Due To Mechanical Failure		8.01E-04	8.01E-04	
-AB752TCRYD	Air Circuit Breaker 7 Trip Coil TC Fails On Demand	3.3E-05	1	3.30E-05	
-AB710AFFUF	One Or More Air Circuit Breaker 7 Control Power Fuses Fail	3.6E-06	6	2.16E-05	
-AB51431SWT	Manual/Auto Control Switch 143/1 Spuriously Transfers Into Manual	7.0E-08	360	2.52E-05	
-AB51431LHE	Manual/Auto Control Switch 143/1 Left In Manual		3.20E-4	3.20E-04	
-AA227X2RYD	Auxiliary Relay 27X/2X Fails To Operate On Demand	3.3E-05	1	3.30E-05	
-AA127X2R6D	Transformer CX Undervoltage Relay 27/CX1 Fails To Drop Out	2.49E-04	1	2.49E-04	
AB7MCH2DEX	Air Circuit Breaker 7 Fails To Close Due To Mechanical Failure		7.04E-03	7.04E-03	
EK2BASEDEX	Keowee Unit 2 Base Adjust Fails To Establish Correct Unit Voltage		6.17E-4	6.17E-04	

Table 7.2-2

Top 100 Cut Sets From The Keowee Emergency Power Model

Module/Event	Description	Rate	Exposure	Prob.	Cs Prob.
55)-XA1XAALBLM	MCC 1XA Is Connected to Its Alternate Source of Power		2.74E-03	2.74E-03	3.91E-06
-AD1B4ALCDT	Breaker 4AL In 125 V dc Distribution Center 1DA Transfers Open	7.5E-08	30	2.25E-06	
-AB7OPENLHE	Air Circuit Breaker 7 Fails To Open Due To A Latent Human Error		3.20E-3	3.20E-03	
-AB7MECHDEX	Air Circuit Breaker 7 Fails To Open Due To Mechanical Failure		8.01E-04	8.01E-04	
-AB752TCRYD	Air Circuit Breaker 7 Trip Coil TC Fails On Demand	3.3E-05	1	3.30E-05	
-AB710AFFUF	One Or More Air Circuit Breaker 7 Control Power Fuses Fail	3.6E-06	6	2.16E-05	
-AB51431SWT	Manual/Auto Control Switch 143/1 Spuriously Transfers Into Manual	7.0E-08	360	2.52E-05	
-AB51431LHE	Manual/Auto Control Switch 143/1 Left In Manual		3.20E-4	3.20E-04	
-AA227X2RYD	Auxiliary Relay 27X/2X Fails To Operate On Demand	3.3E-05	1	3.30E-05	
-AA127X2R6D	Transformer CX Undervoltage Relay 27/CX1 Fails To Drop Out	2.49E-04	1	2.49E-04	
AB7MCH2DEX	Air Circuit Breaker 7 Fails To Close Due To Mechanical Failure		7.04E-03	7.04E-03	
WK2GVRNDEX	Keowee Unit 2 Gov. Fails to Position Wicket Gates With Unit Running		5.6E-4	5.60E-04	
56)-XA1XAALBLM	MCC 1XA Is Connected to Its Alternate Source of Power		2.74E-03	2.74E-03	3.91E-06
-AD1B4ALCDT	Breaker 4AL In 125 V dc Distribution Center 1DA Transfers Open	7.5E-08	30	2.25E-06	
-AB7OPENLHE	Air Circuit Breaker 7 Fails To Open Due To A Latent Human Error		3.20E-3	3.20E-03	
-AB7MECHDEX	Air Circuit Breaker 7 Fails To Open Due To Mechanical Failure		8.01E-04	8.01E-04	
-AB752TCRYD	Air Circuit Breaker 7 Trip Coil TC Fails On Demand	3.3E-05	1	3.30E-05	
-AB710AFFUF	One Or More Air Circuit Breaker 7 Control Power Fuses Fail	3.6E-06	6	2.16E-05	
-AB51431SWT	Manual/Auto Control Switch 143/1 Spuriously Transfers Into Manual	7.0E-08	360	2.52E-05	
-AB51431LHE	Manual/Auto Control Switch 143/1 Left In Manual		3.20E-4	3.20E-04	
-AA227X2RYD	Auxiliary Relay 27X/2X Fails To Operate On Demand	3.3E-05	1	3.30E-05	
-AA127X2R6D	Transformer CX Undervoltage Relay 27/CX1 Fails To Drop Out	2.49E-04	1	2.49E-04	
AB7MCH2DEX	Air Circuit Breaker 7 Fails To Close Due To Mechanical Failure		7.04E-03	7.04E-03	
WK2TBRNDEX	Keowee Unit 2 Turbine Fails With the Unit Running		5.6E-4	5.60E-04	
57)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	3.91E-06
GK0LOCKCOM	Common Cause Actuation of Generator Lockouts		4.06E-06	4.06E-06	
58) KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	3.83E-06
YK1SS12SST	Keowee 1 Overspeed Switch 12 Spuriously Picks Up KEE-111	4.2E-06	24	1.01E-04	
59) EK1F30AFUF	Keowee Unit 1 Excitation Cabinet Fan Fuses Fail	3.6E-06	24	8.64E-05	3.28E-06
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	

Table 7.2-2

Top 100 Cut Sets From The Keowee Emergency Power Model

Module/Event	Description	Rate	Exposure	Prob.	Cs Prob.
60)-XA2XAALBLM	MCC 2XA Is Connected to Its Alternate Power Source		2.74E-03	2.74E-03	3.18E-06
-XA1XAALBLM	MCC 1XA Is Connected to Its Alternate Source of Power		2.74E-03	2.74E-03	
-AD2B2ALCDT	Breaker 2AL In 125V dc Distribution Center 2DA Transfers Open	7.5E-08	30	2.25E-06	
-AB6OPENLHE	Air Circuit Breaker 6 Fails To Open Due To A Latent Human Error		3.20E-3	3.20E-03	
-AB6MECHDEX	Air Circuit Breaker 6 Fails To Open Due To Mechanical Failure		8.01E-04	8.01E-04	
-AB652TCRYD	Air Circuit Breaker 6 Trip Coil 52TC Fails Fails To Operate	3.3E-05	1	3.30E-05	
-AB61432SWT	Manual/Auto Control Switch 143/2 Spuriously Transfers Into Manual	7.0E-08	360	2.52E-05	
-AB61432LHE	Manual/Auto Control Switch 143/2 Left In Manual		3.20E-4	3.20E-04	
-AB610AFFUF	One Or More Control Power Fuses For Relay 27X/2X Fail	3.6E-06	6	2.16E-05	
-AA227X2RYD	Auxiliary Relay 27X/2X Fails To Operate On Demand	3.3E-05	1	3.30E-05	
-AA2272XR6D	Transformer 2X Undervoltage Relay 27/2X Fails To Drop Out	2.49E-04	1	2.49E-04	
AB6MCH2DEX	Air Circuit Breaker 6 Fails To Close Due To Mechanical Failure		7.04E-03	7.04E-03	
XA1XCXXTHM	4160/600 Vac Transformer CX Is in Maintenance		4.57E-4	4.57E-04	
61)-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	3.13E-06
EK1EXC1TGF	Keowee Unit 1 Gen Excitation Transformer Is Failed	9.8E-07	84	8.23E-05	
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
62) EK1BAS2DEX	KHU-1 Base Adjust Fails To Maintain Generator Output Within Acceptable R		1.24E-3	1.24E-03	3.06E-06
EK2VREGDEX	KHU-2 Voltage Adjust Failure Drives Generator Output Too High/Low		2.47E-3	2.47E-03	
63) EK1VREGDEX	KHU-1 Voltage Adjust Failure Drives Generator Output Too High/Low		2.47E-3	2.47E-03	3.06E-06
EK2BAS2DEX	KHU-2 Base Adjust Fails To Maintain Generator Output Within Acceptable R		1.24E-3	1.24E-03	
64)-XA1XAALBLM	MCC 1XA Is Connected to Its Alternate Source of Power		2.74E-03	2.74E-03	3.03E-06
-KK2RUNSDEX	Keowee Unit 2 Only Is Supplying The Grid		0.06	6.00E-02	
-KK1BOTHDEX	Keowee Units 1 And 2 Are Supplying The Grid		0.0	0.00E+00	
-AD1B4ALCDT	Breaker 4AL In 125 V dc Distribution Center 1DA Transfers Open	7.5E-08	30	2.25E-06	
-AB7OPENLHE	Air Circuit Breaker 7 Fails To Open Due To A Latent Human Error		3.20E-3	3.20E-03	
-AB7MECHDEX	Air Circuit Breaker 7 Fails To Open Due To Mechanical Failure		8.01E-04	8.01E-04	
-AB752TCRYD	Air Circuit Breaker 7 Trip Coil TC Fails On Demand	3.3E-05	1	3.30E-05	
-AB710AFFUF	One Or More Air Circuit Breaker 7 Control Power Fuses Fail	3.6E-06	6	2.16E-05	
-AB51431SWT	Manual/Auto Control Switch 143/1 Spuriously Transfers Into Manual	7.0E-08	360	2.52E-05	
-AB51431LHE	Manual/Auto Control Switch 143/1 Left In Manual		3.20E-4	3.20E-04	
-AA227X2RYD	Auxiliary Relay 27X/2X Fails To Operate On Demand	3.3E-05	1	3.30E-05	
-AA127X2R6D	Transformer CX Undervoltage Relay 27/CX1 Fails To Drop Out	2.49E-04	1	2.49E-04	
AB7MCH2DEX	Air Circuit Breaker 7 Fails To Close Due To Mechanical Failure		7.04E-03	7.04E-03	
EK2SPYMDEX	Keowee Unit 2 Supply Breaker Fails To Close Due To Mehanical Failure		4.62E-4	4.62E-04	
65)-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	2.93E-06
EK1FLSMDEX	Keowee Unit 1 Field Flashing Breaker Fails To Close Due To Mechanical Fa		7.71E-5	7.71E-05	
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
66)-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	2.93E-06
EK1FLDMDEX	Keowee Unit 1 Field Breaker Fails To Close Due To Mechanical Failure		7.71E-5	7.71E-05	
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
67) KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	2.83E-06
UACXCT4THF	Transformer CT4 Failed	3.1E-06	24	7.44E-05	

Table 7.2-2

Top 100 Cut Sets From The Keowee Emergency Power Model

Module/Event	Description	Rate	Exposure	Prob.	Cs Prob.
68) EK1BAS2DEX	KHU-1 Base Adjust Fails To Maintain Generator Output Within Acceptable R		1.24E-3	1.24E-03	2.82E-06
GK20001HGR	Keowee Unit 2 Generator Fault While the Unit Runs	9.46E-05	24	2.27E-03	
69) EK2BAS2DEX	KHU-2 Base Adjust Fails To Maintain Generator Output Within Acceptable R		1.24E-3	1.24E-03	2.82E-06
GK10001HGR	Keowee Unit 1 Generator Fault While the Unit Runs	9.46E-05	24	2.27E-03	
70) ACB4MOD	NSM-ON-52966 Is Not In Service		1	1.00E+00	2.48E-06
ACBAIRPDEX	ACB Air Supply Fails Causing Low Pressure In All ACB Accumulators		2.00E-03	2.00E-03	
EK1BAS2DEX	KHU-1 Base Adjust Fails To Maintain Generator Output Within Acceptable R		1.24E-3	1.24E-03	
71)-XD1DALTBYM	Normal Power To Dist. Center 1DA Is In Test or Maintenance		5.48E-03	5.48E-03	2.45E-06
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
XD1CKC1BCF	Battery Charger KC1 Fails	2.9E-05	24	6.96E-04	
XD1KB1XRHE	Keowee Standby Battery Charger SBC Not Lined Up in 1 Hour		9.3e-02	9.30E-02	
72)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	2.35E-06
PK0SUMPCOM	Common Cause Failure Of Turbine Sump Pump System		2.44E-06	2.44E-06	
73)-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	2.31E-06
EK1BASELHE	Keowee Unit 1 Base Adjust Is Set Incorrectly		3.20E-3	3.20E-03	
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
EK0BASERHE	Recovery of Keowee Base Adjust LHE		1.9E-02	1.90E-02	
74)-XD1DALTBYM	Normal Power To Dist. Center 1DA Is In Test or Maintenance		5.48E-03	5.48E-03	2.28E-06
-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	
-KK1BOTHDEX	Keowee Units 1 And 2 Are Supplying The Grid		0.0	0.00E+00	
EK2VREGDEX	KHU-2 Voltage Adjust Failure Drives Generator Output Too High/Low		2.47E-3	2.47E-03	
XD1KBATBYF	Keowee Battery No. 1 Fails During Discharge	9.30E-04	1	9.30E-04	
XD0KBATRHE			1.00E+00	1.00E+00	
75)-XD2DALTBYM	Normal Power To Dist Cntr 2DA Is In Test or Maintenance		5.48E-03	5.48E-03	2.28E-06
EK1VREGDEX	KHU-1 Voltage Adjust Failure Drives Generator Output Too High/Low		2.47E-3	2.47E-03	
XD2KBATBYF	Keowee Battery No. 2 Fails during Discharge	9.30E-04	1	9.30E-04	
76)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	2.17E-06
EK2VREGDEX	KHU-2 Voltage Adjust Failure Drives Generator Output Too High/Low		2.47E-3	2.47E-03	
SXFRCT4THM	Transformer CT4 Is In Maintenance		9.13E-04	9.13E-04	
77) KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	2.13E-06
WK1SPD2DEX	Keowee Unit 1 Governor Failure Creates Overspeed Condition		5.6E-05	5.60E-05	
78)-XD1DALTBYM	Normal Power To Dist. Center 1DA Is In Test or Maintenance		5.48E-03	5.48E-03	2.10E-06
-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	
-KK1BOTHDEX	Keowee Units 1 And 2 Are Supplying The Grid		0.0	0.00E+00	
GK20001HGR	Keowee Unit 2 Generator Fault While the Unit Runs	9.46E-05	24	2.27E-03	
XD1KBATBYF	Keowee Battery No. 1 Fails During Discharge	9.30E-04	1	9.30E-04	
XD0KBATRHE			1.00E+00	1.00E+00	
79)-XD2DALTBYM	Normal Power To Dist Cntr 2DA Is In Test or Maintenance		5.48E-03	5.48E-03	2.10E-06
GK10001HGR	Keowee Unit 1 Generator Fault While the Unit Runs	9.46E-05	24	2.27E-03	
XD2KBATBYF	Keowee Battery No. 2 Fails during Discharge	9.30E-04	1	9.30E-04	
80) FK1WL11AVT	Cooling Water Control Valve 1WL-11 Transfers Closed	2.30E-06	24	5.52E-05	2.10E-06
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	

Table 7.2-2

Top 100 Cut Sets From The Keowee Emergency Power Model

Module/Event	Description	Rate	Exposure	Prob.	Cs Prob.
81)-OMOD	Startup Bus UV Sensing Mod Is In Service		0	0.00E+00	2.05E-06
-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
OFACTORDEX	Overload Susceptibility Factor		1.0	1.00E+00	
S227EUVRYT	Unit 2 Startup Bus Undervoltage Relay 27E Fails	3.6E-07	9	2.33E-03	
SXFRCT4THM	Transformer CT4 Is In Maintenance		9.13E-04	9.13E-04	
82)-OMOD	Startup Bus UV Sensing Mod Is In Service		0	0.00E+00	2.05E-06
-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
OFACTORDEX	Overload Susceptibility Factor		1.0	1.00E+00	
S127EUVRYT	Unit 1 Startup Bus Undervoltage Relay 27E Fails	3.6E-07	9	2.33E-03	
SXFRCT4THM	Transformer CT4 Is In Maintenance		9.13E-04	9.13E-04	
83)-XA1XAALBLM	MCC 1XA Is Connected to Its Alternate Source of Power		2.74E-03	2.74E-03	2.01E-06
-AD1B4ALCDT	Breaker 4AL In 125 V dc Distribution Center 1DA Transfers Open	7.5E-08	30	2.25E-06	
-AB7OPENLHE	Air Circuit Breaker 7 Fails To Open Due To A Latent Human Error		3.20E-3	3.20E-03	
-AB7MECHDEX	Air Circuit Breaker 7 Fails To Open Due To Mechanical Failure		8.01E-04	8.01E-04	
-AB752TCRYD	Air Circuit Breaker 7 Trip Coil TC Fails On Demand	3.3E-05	1	3.30E-05	
-AB710AFFUF	One Or More Air Circuit Breaker 7 Control Power Fuses Fail	3.6E-06	6	2.16E-05	
-AB51431SWT	Manual/Auto Control Switch 143/1 Spuriously Transfers Into Manual	7.0E-08	360	2.52E-05	
-AB51431LHE	Manual/Auto Control Switch 143/1 Left In Manual		3.20E-4	3.20E-04	
-AA227X2RYD	Auxiliary Relay 27X/2X Fails To Operate On Demand	3.3E-05	1	3.30E-05	
-AA127X2R6D	Transformer CX Undervoltage Relay 27/CX1 Fails To Drop Out	2.49E-04	1	2.49E-04	
AB7MCH2DEX	Air Circuit Breaker 7 Fails To Close Due To Mechanical Failure		7.04E-03	7.04E-03	
EK2DIODDEX	Keowee Unit 2 Exciter Fan Supply Diode Bridge Fails		2.88E-4	2.88E-04	
84)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	1.99E-06
GK20001HGR	Keowee Unit 2 Generator Fault While the Unit Runs	9.46E-05	24	2.27E-03	
SXFRCT4THM	Transformer CT4 Is In Maintenance		9.13E-04	9.13E-04	
85)-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	1.98E-06
GK1NGDCLHE	Failure to Close the Unit 1 Neutral Ground Disconnect Following Maintena		5.20E-05	5.20E-05	
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
86)-XA1XAALBLM	MCC 1XA Is Connected to Its Alternate Source of Power		2.74E-03	2.74E-03	1.96E-06
-AD1B4ALCDT	Breaker 4AL In 125 V dc Distribution Center 1DA Transfers Open	7.5E-08	30	2.25E-06	
-AB7OPENLHE	Air Circuit Breaker 7 Fails To Open Due To A Latent Human Error		3.20E-3	3.20E-03	
-AB7MECHDEX	Air Circuit Breaker 7 Fails To Open Due To Mechanical Failure		8.01E-04	8.01E-04	
-AB752TCRYD	Air Circuit Breaker 7 Trip Coil TC Fails On Demand	3.3E-05	1	3.30E-05	
-AB710AFFUF	One Or More Air Circuit Breaker 7 Control Power Fuses Fail	3.6E-06	6	2.16E-05	
-AB51431SWT	Manual/Auto Control Switch 143/1 Spuriously Transfers Into Manual	7.0E-08	360	2.52E-05	
-AB51431LHE	Manual/Auto Control Switch 143/1 Left In Manual		3.20E-4	3.20E-04	
-AA227X2RYD	Auxiliary Relay 27X/2X Fails To Operate On Demand	3.3E-05	1	3.30E-05	
-AA127X2R6D	Transformer CX Undervoltage Relay 27/CX1 Fails To Drop Out	2.49E-04	1	2.49E-04	
AB7MCH2DEX	Air Circuit Breaker 7 Fails To Close Due To Mechanical Failure		7.04E-03	7.04E-03	
FK2WL11AVO	Cooling Water Control Valve 2WL-11 Fails To Open On Demand	2.80E-04	1	2.80E-04	
87)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	1.87E-06
BKGBOILCOM	Common Cause Failure Of Turbine Guide Bearing Oil System		1.94E-06	1.94E-06	

Table 7.2-2

Top 100 Cut Sets From The Keowee Emergency Power Model

Module/Event	Description	Rate	Exposure	Prob.	Cs Prob.
88)-XD1DALTBYM	Normal Power To Dist. Center 1DA Is In Test or Maintenance		5.48E-03	5.48E-03	1.85E-06
-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	
-KK1BOTHDEX	Keowee Units 1 And 2 Are Supplying The Grid		0.0	0.00E+00	
ACB4MOD	NSM-ON-52966 Is Not In Service		1	1.00E+00	
ACBAIRPDEX	ACB Air Supply Fails Causing Low Pressure In All ACB Accumulators		2.00E-03	2.00E-03	
XD1KBATBYF	Keowee Battery No. 1 Fails During Discharge	9.30E-04	1	9.30E-04	
XD0KBATRHE			1.00E+00	1.00E+00	
89)-XA1XAALBLM	MCC 1XA Is Connected to Its Alternate Source of Power		2.74E-03	2.74E-03	1.82E-06
-AD1B4ALCDT	Breaker 4AL In 125 V dc Distribution Center 1DA Transfers Open	7.5E-08	30	2.25E-06	
-AB7OPENLHE	Air Circuit Breaker 7 Fails To Open Due To A Latent Human Error		3.20E-3	3.20E-03	
-AB7MECHDEX	Air Circuit Breaker 7 Fails To Open Due To Mechanical Failure		8.01E-04	8.01E-04	
-AB752TCRYD	Air Circuit Breaker 7 Trip Coil TC Fails On Demand	3.3E-05	1	3.30E-05	
-AB710AFFUF	One Or More Air Circuit Breaker 7 Control Power Fuses Fail	3.6E-06	6	2.16E-05	
-AB51431SWT	Manual/Auto Control Switch 143/1 Spuriously Transfers Into Manual	7.0E-08	360	2.52E-05	
-AB51431LHE	Manual/Auto Control Switch 143/1 Left In Manual		3.20E-4	3.20E-04	
-AA227X2RYD	Auxiliary Relay 27X/2X Fails To Operate On Demand	3.3E-05	1	3.30E-05	
-AA127X2R6D	Transformer CX Undervoltage Relay 27/CX1 Fails To Drop Out	2.49E-04	1	2.49E-04	
AB7MCH2DEX	Air Circuit Breaker 7 Fails To Close Due To Mechanical Failure		7.04E-03	7.04E-03	
GK2COOLLHE	Keowee 2 Gen. Air Cooler WL Flow Path Vlvs Mispositioned After Maint		2.60E-04	2.60E-04	
90)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	1.76E-06
ACB4MOD	NSM-ON-52966 Is Not In Service		1	1.00E+00	
ACBAIRPDEX	ACB Air Supply Fails Causing Low Pressure In All ACB Accumulators		2.00E-03	2.00E-03	
SXFRCT4THM	Transformer CT4 Is In Maintenance		9.13E-04	9.13E-04	
91)-XA1XAALBLM	MCC 1XA Is Connected to Its Alternate Source of Power		2.74E-03	2.74E-03	1.74E-06
-AD1B4ALCDT	Breaker 4AL In 125 V dc Distribution Center 1DA Transfers Open	7.5E-08	30	2.25E-06	
-AB7OPENLHE	Air Circuit Breaker 7 Fails To Open Due To A Latent Human Error		3.20E-3	3.20E-03	
-AB7MECHDEX	Air Circuit Breaker 7 Fails To Open Due To Mechanical Failure		8.01E-04	8.01E-04	
-AB752TCRYD	Air Circuit Breaker 7 Trip Coil TC Fails On Demand	3.3E-05	1	3.30E-05	
-AB710AFFUF	One Or More Air Circuit Breaker 7 Control Power Fuses Fail	3.6E-06	6	2.16E-05	
-AB51431SWT	Manual/Auto Control Switch 143/1 Spuriously Transfers Into Manual	7.0E-08	360	2.52E-05	
-AB51431LHE	Manual/Auto Control Switch 143/1 Left In Manual		3.20E-4	3.20E-04	
-AA227X2RYD	Auxiliary Relay 27X/2X Fails To Operate On Demand	3.3E-05	1	3.30E-05	
-AA127X2R6D	Transformer CX Undervoltage Relay 27/CX1 Fails To Drop Out	2.49E-04	1	2.49E-04	
AB7MCH2DEX	Air Circuit Breaker 7 Fails To Close Due To Mechanical Failure		7.04E-03	7.04E-03	
EK241AXR6D	Keowee Unit 2 Relay 41/AX Fails To Pick-up And Latch	2.49E-04	1	2.49E-04	

Table 7.2-2

Top 100 Cut Sets From The Keowee Emergency Power Model

Module/Event	Description	Rate	Exposure	Prob.	Cs Prob.
92)-XA1XAALBLM	MCC 1XA Is Connected to Its Alternate Source of Power		2.74E-03	2.74E-03	1.71E-06
-KK2RUNSDEX	Keowee Unit 2 Only Is Supplying The Grid		0.06	6.00E-02	
-KK1BOTHDEX	Keowee Units 1 And 2 Are Supplying The Grid		0.0	0.00E+00	
-AD1B4ALCDT	Breaker 4AL In 125 V dc Distribution Center 1DA Transfers Open	7.5E-08	30	2.25E-06	
-AB7OPENLHE	Air Circuit Breaker 7 Fails To Open Due To A Latent Human Error		3.20E-3	3.20E-03	
-AB7MECHDEX	Air Circuit Breaker 7 Fails To Open Due To Mechanical Failure		8.01E-04	8.01E-04	
-AB752TCRYD	Air Circuit Breaker 7 Trip Coil TC Fails On Demand	3.3E-05	1	3.30E-05	
-AB710AFFUF	One Or More Air Circuit Breaker 7 Control Power Fuses Fail	3.6E-06	6	2.16E-05	
-AB51431SWT	Manual/Auto Control Switch 143/1 Spuriously Transfers Into Manual	7.0E-08	360	2.52E-05	
-AB51431LHE	Manual/Auto Control Switch 143/1 Left In Manual		3.20E-4	3.20E-04	
-AA227X2RYD	Auxiliary Relay 27X/2X Fails To Operate On Demand	3.3E-05	1	3.30E-05	
-AA127X2R6D	Transformer CX Undervoltage Relay 27/CX1 Fails To Drop Out	2.49E-04	1	2.49E-04	
AB7MCH2DEX	Air Circuit Breaker 7 Fails To Close Due To Mechanical Failure		7.04E-03	7.04E-03	
EK2FLDCLHE	Keowee Unit 2 Field Breaker Fails To Close Due To Latent Human Error		2.60E-4	2.60E-04	
93)-XA1XAALBLM	MCC 1XA Is Connected to Its Alternate Source of Power		2.74E-03	2.74E-03	1.71E-06
-KK2RUNSDEX	Keowee Unit 2 Only Is Supplying The Grid		0.06	6.00E-02	
-KK1BOTHDEX	Keowee Units 1 And 2 Are Supplying The Grid		0.0	0.00E+00	
-AD1B4ALCDT	Breaker 4AL In 125 V dc Distribution Center 1DA Transfers Open	7.5E-08	30	2.25E-06	
-AB7OPENLHE	Air Circuit Breaker 7 Fails To Open Due To A Latent Human Error		3.20E-3	3.20E-03	
-AB7MECHDEX	Air Circuit Breaker 7 Fails To Open Due To Mechanical Failure		8.01E-04	8.01E-04	
-AB752TCRYD	Air Circuit Breaker 7 Trip Coil TC Fails On Demand	3.3E-05	1	3.30E-05	
-AB710AFFUF	One Or More Air Circuit Breaker 7 Control Power Fuses Fail	3.6E-06	6	2.16E-05	
-AB51431SWT	Manual/Auto Control Switch 143/1 Spuriously Transfers Into Manual	7.0E-08	360	2.52E-05	
-AB51431LHE	Manual/Auto Control Switch 143/1 Left In Manual		3.20E-4	3.20E-04	
-AA227X2RYD	Auxiliary Relay 27X/2X Fails To Operate On Demand	3.3E-05	1	3.30E-05	
-AA127X2R6D	Transformer CX Undervoltage Relay 27/CX1 Fails To Drop Out	2.49E-04	1	2.49E-04	
AB7MCH2DEX	Air Circuit Breaker 7 Fails To Close Due To Mechanical Failure		7.04E-03	7.04E-03	
EK2FLSCLHE	Keowee Unit 2 Field Flashing Breaker Fails To Close Due To Latent Human		2.60E-4	2.60E-04	
94)-XA1XAALBLM	MCC 1XA Is Connected to Its Alternate Source of Power		2.74E-03	2.74E-03	1.71E-06
-KK2RUNSDEX	Keowee Unit 2 Only Is Supplying The Grid		0.06	6.00E-02	
-KK1BOTHDEX	Keowee Units 1 And 2 Are Supplying The Grid		0.0	0.00E+00	
-AD1B4ALCDT	Breaker 4AL In 125 V dc Distribution Center 1DA Transfers Open	7.5E-08	30	2.25E-06	
-AB7OPENLHE	Air Circuit Breaker 7 Fails To Open Due To A Latent Human Error		3.20E-3	3.20E-03	
-AB7MECHDEX	Air Circuit Breaker 7 Fails To Open Due To Mechanical Failure		8.01E-04	8.01E-04	
-AB752TCRYD	Air Circuit Breaker 7 Trip Coil TC Fails On Demand	3.3E-05	1	3.30E-05	
-AB710AFFUF	One Or More Air Circuit Breaker 7 Control Power Fuses Fail	3.6E-06	6	2.16E-05	
-AB51431SWT	Manual/Auto Control Switch 143/1 Spuriously Transfers Into Manual	7.0E-08	360	2.52E-05	
-AB51431LHE	Manual/Auto Control Switch 143/1 Left In Manual		3.20E-4	3.20E-04	
-AA227X2RYD	Auxiliary Relay 27X/2X Fails To Operate On Demand	3.3E-05	1	3.30E-05	
-AA127X2R6D	Transformer CX Undervoltage Relay 27/CX1 Fails To Drop Out	2.49E-04	1	2.49E-04	
AB7MCH2DEX	Air Circuit Breaker 7 Fails To Close Due To Mechanical Failure		7.04E-03	7.04E-03	
EK2SPYCLHE	Keowee Unit 2 Supply Breaker Fails To Close Due To Latent Human Error		2.60E-4	2.60E-04	

Table 7.2-2

Top 100 Cut Sets From The Keowee Emergency Power Model

Module/Event	Description	Rate	Exposure	Prob.	Cs Prob.
95)-XA1XAALBLM	MCC 1XA Is Connected to Its Alternate Source of Power		2.74E-03	2.74E-03	1.71E-06
-KK2RUNSDEX	Keowee Unit 2 Only Is Supplying The Grid		0.06	6.00E-02	
-KK1BOTHDEX	Keowee Units 1 And 2 Are Supplying The Grid		0.0	0.00E+00	
-AD1B4ALCDT	Breaker 4AL In 125 V dc Distribution Center 1DA Transfers Open	7.5E-08	30	2.25E-06	
-AB7OPENLHE	Air Circuit Breaker 7 Fails To Open Due To A Latent Human Error		3.20E-3	3.20E-03	
-AB7MECHDEX	Air Circuit Breaker 7 Fails To Open Due To Mechanical Failure		8.01E-04	8.01E-04	
-AB752TCRYD	Air Circuit Breaker 7 Trip Coil TC Fails On Demand	3.3E-05	1	3.30E-05	
-AB710AFFUF	One Or More Air Circuit Breaker 7 Control Power Fuses Fail	3.6E-06	6	2.16E-05	
-AB51431SWT	Manual/Auto Control Switch 143/1 Spuriously Transfers Into Manual	7.0E-08	360	2.52E-05	
-AB51431LHE	Manual/Auto Control Switch 143/1 Left In Manual		3.20E-4	3.20E-04	
-AA227X2RYD	Auxiliary Relay 27X/2X Fails To Operate On Demand	3.3E-05	1	3.30E-05	
-AA127X2R6D	Transformer CX Undervoltage Relay 27/CX1 Fails To Drop Out	2.49E-04	1	2.49E-04	
AB7MCH2DEX	Air Circuit Breaker 7 Fails To Close Due To Mechanical Failure		7.04E-03	7.04E-03	
WK2GVCDLHE	Latent Human Error Fails Keowee 2 Governor During Cold Start		2.6E-4	2.60E-04	
96)-XA1XAALBLM	MCC 1XA Is Connected to Its Alternate Source of Power		2.74E-03	2.74E-03	1.71E-06
-KK2RUNSDEX	Keowee Unit 2 Only Is Supplying The Grid		0.06	6.00E-02	
-KK1BOTHDEX	Keowee Units 1 And 2 Are Supplying The Grid		0.0	0.00E+00	
-AD1B4ALCDT	Breaker 4AL In 125 V dc Distribution Center 1DA Transfers Open	7.5E-08	30	2.25E-06	
-AB7OPENLHE	Air Circuit Breaker 7 Fails To Open Due To A Latent Human Error		3.20E-3	3.20E-03	
-AB7MECHDEX	Air Circuit Breaker 7 Fails To Open Due To Mechanical Failure		8.01E-04	8.01E-04	
-AB752TCRYD	Air Circuit Breaker 7 Trip Coil TC Fails On Demand	3.3E-05	1	3.30E-05	
-AB710AFFUF	One Or More Air Circuit Breaker 7 Control Power Fuses Fail	3.6E-06	6	2.16E-05	
-AB51431SWT	Manual/Auto Control Switch 143/1 Spuriously Transfers Into Manual	7.0E-08	360	2.52E-05	
-AB51431LHE	Manual/Auto Control Switch 143/1 Left In Manual		3.20E-4	3.20E-04	
-AA227X2RYD	Auxiliary Relay 27X/2X Fails To Operate On Demand	3.3E-05	1	3.30E-05	
-AA127X2R6D	Transformer CX Undervoltage Relay 27/CX1 Fails To Drop Out	2.49E-04	1	2.49E-04	
AB7MCH2DEX	Air Circuit Breaker 7 Fails To Close Due To Mechanical Failure		7.04E-03	7.04E-03	
EK2FLSOLHE	Keowee Unit 2 Field Flashing Breaker Fails To Open Due To Latent Human E		2.60E-4	2.60E-04	
97) BK1GBO1FTC	Filter 1GBOFL-1 Becomes Clogged	1.80E-06	24	4.32E-05	1.64E-06
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
98) EK1BAS2DEX	KHU-1 Base Adjust Fails To Maintain Generator Output Within Acceptable R		1.24E-3	1.24E-03	1.54E-06
EK2BAS2DEX	KHU-2 Base Adjust Fails To Maintain Generator Output Within Acceptable R		1.24E-3	1.24E-03	
99)-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	1.52E-06
-KK1BOTHDEX	Keowee Units 1 And 2 Are Supplying The Grid		0.0	0.00E+00	
EK1BASEDEX	Keowee Unit 1 Base Adjust Fails To Establish Correct Unit Voltage		6.17E-4	6.17E-04	
EK2VREGDEX	KHU-2 Voltage Adjust Failure Drives Generator Output Too High/Low		2.47E-3	2.47E-03	
100) EK188SVRYT	Keowee Unit 1 Fan Control Relay 88SV Prior To Or During The Run	3.6E-07	108	3.89E-05	1.48E-06
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	

Table 7.2-3

Failure Probability of Keowee Power Source/Path [1]

	Underground Power	Overhead Power
Power Source [2]	2.0E-02	2.2E-02
Power Path [3]	1.1E-03	8.2E-03
Total	2.2E-02	2.8E-02
Total [4]	2.7E-02	7.0E-02

[1] These results do not include the impact of common cause failures.
[2] Power source in this case includes the Keowee unit through the generator output breaker.
[3] Power path includes components downstream of the generator output breaker through the Oconee transformer.
[4] These results include the impact of the unit maintenance unavailability.

Table 7.2-4

Top 50 Cut Sets From The Keowee Emergency Power Model
Underground Unit- Gate UNDER0

Module/Event	Description	Rate	Exposure	Prob.	Cs Prob.
1) UNDER0					*3.01E-02
1) KK1BOTHHYM	Both Keowee Units Unavailable Due To Common Maintenance		5.23E-3	5.23E-03	5.23E-03
2)-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	3.20E-03
-KK1BOTHDEX	Keowee Units 1 And 2 Are Supplying The Grid		0.0	0.00E+00	
ABPOPRCRHE	Operators Fail To Close Air Circuit Breaker 4		1.0	1.00E+00	
ACB4MOD	NSM-ON-52966 Is Not In Service		1	1.00E+00	
EK1BASELHE	Keowee Unit 1 Base Adjust Is Set Incorrectly		3.20E-3	3.20E-03	
3) ABPOPRCRHE	Operators Fail To Close Air Circuit Breaker 4		1.0	1.00E+00	2.47E-03
ACB4MOD	NSM-ON-52966 Is Not In Service		1	1.00E+00	
EK1VREGDEX	KHU-1 Voltage Adjust Failure Drives Generator Output Too High/Low		2.47E-3	2.47E-03	
4)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	2.45E-03
FK0FISHCOM	Common Cause Failure Of Both Unit s WL Filters Due To Intake Debris		2.55E-3	2.55E-03	
5) ABPOPRCRHE	Operators Fail To Close Air Circuit Breaker 4		1.0	1.00E+00	2.27E-03
ACB4MOD	NSM-ON-52966 Is Not In Service		1	1.00E+00	
GK10001HGR	Keowee Unit 1 Generator Fault While the Unit Runs	9.46E-05	24	2.27E-03	
6) ABPOPRCRHE	Operators Fail To Close Air Circuit Breaker 4		1.0	1.00E+00	1.24E-03
ACB4MOD	NSM-ON-52966 Is Not In Service		1	1.00E+00	
EK1BAS2DEX	KHU-1 Base Adjust Fails To Maintain Generator Output Within Acceptable R		1.24E-3	1.24E-03	
7)-XD1DALTBYM	Normal Power To Dist. Center 1DA Is In Test or Maintenance		5.48E-03	5.48E-03	9.25E-04
-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	
-KK1BOTHDEX	Keowee Units 1 And 2 Are Supplying The Grid		0.0	0.00E+00	
ABPOPRCRHE	Operators Fail To Close Air Circuit Breaker 4		1.0	1.00E+00	
ACB4MOD	NSM-ON-52966 Is Not In Service		1	1.00E+00	
XD1KBATBYF	Keowee Battery No. 1 Fails During Discharge	9.30E-04	1	9.30E-04	
8)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	8.78E-04
SXFRCT4THM	Transformer CT4 Is In Maintenance		9.13E-04	9.13E-04	
9)-XD1DALTBYM	Normal Power To Dist. Center 1DA Is In Test or Maintenance		5.48E-03	5.48E-03	6.92E-04
ABPOPRCRHE	Operators Fail To Close Air Circuit Breaker 4		1.0	1.00E+00	
ACB4MOD	NSM-ON-52966 Is Not In Service		1	1.00E+00	
XD1CKC1BCF	Battery Charger KC1 Fails	2.9E-05	24	6.96E-04	
XD1KB1XRHE	Keowee Standby Battery Charger SBC Not Lined Up in 1 Hour		1	1.00E+00	
10)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	6.44E-04
AB0SWGRCOM	Common Cause Failure Of All Keowee Auxiliary Power Breakers		6.69E-04	6.69E-04	
11)-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	6.17E-04
-KK1BOTHDEX	Keowee Units 1 And 2 Are Supplying The Grid		0.0	0.00E+00	
ABPOPRCRHE	Operators Fail To Close Air Circuit Breaker 4		1.0	1.00E+00	
ACB4MOD	NSM-ON-52966 Is Not In Service		1	1.00E+00	
EK1BASEDEX	Keowee Unit 1 Base Adjust Fails To Establish Correct Unit Voltage		6.17E-4	6.17E-04	

Table 7.2-4

Top 50 Cut Sets From The Keowee Emergency Power Model
Underground Unit- Gate UNDER0

Module/Event	Description	Rate	Exposure	Prob.	Cs Prob.
12) ABPOPRCRHE	Operators Fail To Close Air Circuit Breaker 4		1.0	1.00E+00	5.60E-04
ACB4MOD	NSM-ON-52966 Is Not In Service		1	1.00E+00	
WK1GVRNDEX	Keowee Unit 1 Gov. Fails to Position Wicket Gates With Unit Running		5.6E-4	5.60E-04	
13) ABPOPRCRHE	Operators Fail To Close Air Circuit Breaker 4		1.0	1.00E+00	5.60E-04
ACB4MOD	NSM-ON-52966 Is Not In Service		1	1.00E+00	
WK1TBRNDEX	Keowee Unit 1 Turbine Fails With the Unit Running		5.6e-4	5.60E-04	
14)-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	4.62E-04
-KK1BOTHDEX	Keowee Units 1 And 2 Are Supplying The Grid		0.0	0.00E+00	
ABPOPRCRHE	Operators Fail To Close Air Circuit Breaker 4		1.0	1.00E+00	
ACB4MOD	NSM-ON-52966 Is Not In Service		1	1.00E+00	
EK1SPYMDEX	Keowee Unit 1 Supply Breaker Fails To Close Due To Mehanical Failure		4.62E-4	4.62E-04	
15)-XA1XAALBLM	MCC 1XA Is Connected to Its Alternate Source of Power		2.74E-03	2.74E-03	3.08E-04
-AD1B4ALCDT	Breaker 4AL In 125 V dc Distribution Center 1DA Transfers Open	7.5E-08	30	2.25E-06	
-AB7OPENLHE	Air Circuit Breaker 7 Fails To Open Due To A Latent Human Error		3.20E-3	3.20E-03	
-AB7MECHDEX	Air Circuit Breaker 7 Fails To Open Due To Mechanical Failure		8.01E-04	8.01E-04	
-AB752TCRYD	Air Circuit Breaker 7 Trip Coil TC Fails On Demand	3.3E-05	1	3.30E-05	
-AB710AFFUF	One Or More Air Circuit Breaker 7 Control Power Fuses Fail	3.6E-06	6	2.16E-05	
-AB51431SWT	Manual/Auto Control Switch 143/1 Spuriously Transfers Into Manual	7.0E-08	360	2.52E-05	
-AB51431LHE	Manual/Auto Control Switch 143/1 Left In Manual		3.20E-4	3.20E-04	
-AA227X2RYD	Auxiliary Relay 27X/2X Fails To Operate On Demand	3.3E-05	1	3.30E-05	
-AA127X2R6D	Transformer CX Undervoltage Relay 27/CX1 Fails To Drop Out	2.49E-04	1	2.49E-04	
ABPOPRCRHE	Operators Fail To Close Air Circuit Breaker 4		1.0	1.00E+00	
ACB4MOD	NSM-ON-52966 Is Not In Service		1	1.00E+00	
XA1BKRSCOM	CCF of 1X Aux Power Breakers ACB-5 & -7		3.10E-04	3.10E-04	
16) ABPOPRCRHE	Operators Fail To Close Air Circuit Breaker 4		1.0	1.00E+00	2.88E-04
ACB4MOD	NSM-ON-52966 Is Not In Service		1	1.00E+00	
EK1DIODDEX	Keowee Unit 1 Exciter Fan Supply Diode Bridge Fails		2.88E-4	2.88E-04	
17) ABPOPRCRHE	Operators Fail To Close Air Circuit Breaker 4		1.0	1.00E+00	2.80E-04
ACB4MOD	NSM-ON-52966 Is Not In Service		1	1.00E+00	
FK1WL11AVO	Cooling Water Control Valve 1WL-11 Fails To Open On Demand	2.80E-04	1	2.80E-04	

Table 7.2-4

Top 50 Cut Sets From The Keowee Emergency Power Model
Underground Unit- Gate UNDER0

Module/Event	Description	Rate	Exposure	Prob.	Cs Prob.
18)-XA1XAALBLM	MCC 1XA Is Connected to Its Alternate Source of Power		2.74E-03	2.74E-03	2.66E-04
-AD1B4ALCDT	Breaker 4AL In 125 V dc Distribution Center 1DA Transfers Open	7.5E-08	30	2.25E-06	
-AB7OPENLHE	Air Circuit Breaker 7 Fails To Open Due To A Latent Human Error		3.20E-3	3.20E-03	
-AB7MECHDEX	Air Circuit Breaker 7 Fails To Open Due To Mechanical Failure		8.01E-04	8.01E-04	
-AB752TCRYD	Air Circuit Breaker 7 Trip Coil TC Fails On Demand	3.3E-05	1	3.30E-05	
-AB710AFFUF	One Or More Air Circuit Breaker 7 Control Power Fuses Fail	3.6E-06	6	2.16E-05	
-AB51431SWT	Manual/Auto Control Switch 143/1 Spuriously Transfers Into Manual	7.0E-08	360	2.52E-05	
-AB51431LHE	Manual/Auto Control Switch 143/1 Left In Manual		3.20E-4	3.20E-04	
-AA227X2RYD	Auxiliary Relay 27X/2X Fails To Operate On Demand	3.3E-05	1	3.30E-05	
-AA127X2R6D	Transformer CX Undervoltage Relay 27/CX1 Fails To Drop Out	2.49E-04	1	2.49E-04	
AB7MCH2DEX	Air Circuit Breaker 7 Fails To Close Due To Mechanical Failure		7.04E-03	7.04E-03	
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
19) ABPOPRCRHE	Operators Fail To Close Air Circuit Breaker 4		1.0	1.00E+00	2.60E-04
ACB4MOD	NSM-ON-52966 Is Not In Service		1	1.00E+00	
GK1COOLLHE	Keowee 1 Gen. Air Cooler WL Flow Path Vlvs Mispositioned After Maint		2.60E-04	2.60E-04	
20) ABPOPRCRHE	Operators Fail To Close Air Circuit Breaker 4		1.0	1.00E+00	2.60E-04
ACB4MOD	NSM-ON-52966 Is Not In Service		1	1.00E+00	
GK1BRGVLHE	Keowee 1 Gen. Brng Oil Cooling Flow Path Vlvs Mispositioned After Maint		2.60E-04	2.60E-04	
21)-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	2.60E-04
-KK1BOTHDEX	Keowee Units 1 And 2 Are Supplying The Grid		0.0	0.00E+00	
ABPOPRCRHE	Operators Fail To Close Air Circuit Breaker 4		1.0	1.00E+00	
ACB4MOD	NSM-ON-52966 Is Not In Service		1	1.00E+00	
WK1GVCDLHE	Latent Human Error Fails Keowee 1 Governor During Cold Start		2.6E-4	2.60E-04	
22)-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	2.60E-04
-KK1BOTHDEX	Keowee Units 1 And 2 Are Supplying The Grid		0.0	0.00E+00	
ABPOPRCRHE	Operators Fail To Close Air Circuit Breaker 4		1.0	1.00E+00	
ACB4MOD	NSM-ON-52966 Is Not In Service		1	1.00E+00	
EK1FLSOLHE	Keowee Unit 1 Field Flashing Breaker Fails To Open Due To Latent Human E		2.60E-4	2.60E-04	
23)-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	2.60E-04
-KK1BOTHDEX	Keowee Units 1 And 2 Are Supplying The Grid		0.0	0.00E+00	
ABPOPRCRHE	Operators Fail To Close Air Circuit Breaker 4		1.0	1.00E+00	
ACB4MOD	NSM-ON-52966 Is Not In Service		1	1.00E+00	
EK1SPYCLHE	Keowee Unit 1 Supply Breaker Fails To Close Due To Latent Human Error		2.60E-4	2.60E-04	
24)-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	2.60E-04
-KK1BOTHDEX	Keowee Units 1 And 2 Are Supplying The Grid		0.0	0.00E+00	
ABPOPRCRHE	Operators Fail To Close Air Circuit Breaker 4		1.0	1.00E+00	
ACB4MOD	NSM-ON-52966 Is Not In Service		1	1.00E+00	
EK1FLDCLHE	Keowee Unit 1 Field Breaker Fails To Close Due To Latent Human Error		2.60E-4	2.60E-04	

Table 7.2-4

Top 50 Cut Sets From The Keowee Emergency Power Model
Underground Unit- Gate UNDER0

Module/Event	Description	Rate	Exposure	Prob.	Cs Prob.
25)-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	2.60E-04
-KK1BOTHDEX	Keowee Units 1 And 2 Are Supplying The Grid		0.0	0.00E+00	
ABPOPRCRHE	Operators Fail To Close Air Circuit Breaker 4		1.0	1.00E+00	
ACB4MOD	NSM-ON-52966 Is Not In Service		1	1.00E+00	
EK1FLSCLHE	Keowee Unit 1 Field Flashing Breaker Fails To Close Due To Latent Human		2.60E-4	2.60E-04	
26) ABPOPRCRHE	Operators Fail To Close Air Circuit Breaker 4		1.0	1.00E+00	2.49E-04
ACB4MOD	NSM-ON-52966 Is Not In Service		1	1.00E+00	
EK141AXR6D	Keowee Unit 1 Relay 41/AX Fails To Pick-up And Latch	2.49E-04	1	2.49E-04	
27)-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	1.54E-04
-KK1BOTHDEX	Keowee Units 1 And 2 Are Supplying The Grid		0.0	0.00E+00	
ABPOPRCRHE	Operators Fail To Close Air Circuit Breaker 4		1.0	1.00E+00	
ACB4MOD	NSM-ON-52966 Is Not In Service		1	1.00E+00	
GK10001HGS	Keowee Unit 1 Generator Fault Causes Unit Start Failure	1.54E-04	1	1.54E-04	
28) ABPOPRCRHE	Operators Fail To Close Air Circuit Breaker 4		1.0	1.00E+00	1.34E-04
ACB4MOD	NSM-ON-52966 Is Not In Service		1	1.00E+00	
OK1AG04RVT	Safety Relief Valve 1AG-4 Spurious Operation	5.60E-06	24	1.34E-04	
29) ABPOPRCRHE	Operators Fail To Close Air Circuit Breaker 4		1.0	1.00E+00	1.34E-04
ACB4MOD	NSM-ON-52966 Is Not In Service		1	1.00E+00	
OK10003RVT	Safety Relief Valve 1OG-3 Spurious Operation	5.60E-06	24	1.34E-04	
30)-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	1.22E-04
EK1BASELHE	Keowee Unit 1 Base Adjust Is Set Incorrectly		3.20E-3	3.20E-03	
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
31)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	1.19E-04
EK00RUNCOM	Common Cause Failure Of Both Units Voltage Regulators To Run		1.24E-4	1.24E-04	
32) ABPOPRCRHE	Operators Fail To Close Air Circuit Breaker 4		1.0	1.00E+00	1.01E-04
ACB4MOD	NSM-ON-52966 Is Not In Service		1	1.00E+00	
YK1SS12SST	Keowee 1 Overspeed Switch 12 Spuriously Picks Up KEE-111	4.2E-06	24	1.01E-04	
33) EK1VREGDEX	KHU-1 Voltage Adjust Failure Drives Generator Output Too High/Low		2.47E-3	2.47E-03	9.39E-05
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
34) ABPOPRCRHE	Operators Fail To Close Air Circuit Breaker 4		1.0	1.00E+00	8.64E-05
ACB4MOD	NSM-ON-52966 Is Not In Service		1	1.00E+00	
EK1F30AFUF	Keowee Unit 1 Excitation Cabinet Fan Fuses Fail	3.6E-06	24	8.64E-05	
35) GK10001HGR	Keowee Unit 1 Generator Fault While the Unit Runs	9.46E-05	24	2.27E-03	8.63E-05
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
36)-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	8.23E-05
-KK1BOTHDEX	Keowee Units 1 And 2 Are Supplying The Grid		0.0	0.00E+00	
ABPOPRCRHE	Operators Fail To Close Air Circuit Breaker 4		1.0	1.00E+00	
ACB4MOD	NSM-ON-52966 Is Not In Service		1	1.00E+00	
EK1EXC1TGF	Keowee Unit 1 Gen Excitation Transformer Is Failed	9.8E-07	84	8.23E-05	

Table 7.2-4

Top 50 Cut Sets From The Keowee Emergency Power Model
Underground Unit- Gate UNDER0

Module/Event	Description	Rate	Exposure	Prob.	Cs Prob.
37)-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	7.71E-05
-KK1BOTHDEX	Keowee Units 1 And 2 Are Supplying The Grid		0.0	0.00E+00	
ABPOPRCRHE	Operators Fail To Close Air Circuit Breaker 4		1.0	1.00E+00	
ACB4MOD	NSM-ON-52966 Is Not In Service		1	1.00E+00	
EK1FLDMDEX	Keowee Unit 1 Field Breaker Fails To Close Due To Mechanical Failure		7.71E-5	7.71E-05	
38)-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	7.71E-05
-KK1BOTHDEX	Keowee Units 1 And 2 Are Supplying The Grid		0.0	0.00E+00	
ABPOPRCRHE	Operators Fail To Close Air Circuit Breaker 4		1.0	1.00E+00	
ACB4MOD	NSM-ON-52966 Is Not In Service		1	1.00E+00	
EK1FLSMDEX	Keowee Unit 1 Field Flashing Breaker Fails To Close Due To Mechanical Fa		7.71E-5	7.71E-05	
39) UACXCT4THF	Transformer CT4 Failed	3.1E-06	24	7.44E-05	7.44E-05
40) SXFRCT4LHE	Latent Human Error on CT4 Maintenance		6.40E-05	6.40E-05	6.40E-05
41) ABPOPRCRHE	Operators Fail To Close Air Circuit Breaker 4		1.0	1.00E+00	5.60E-05
ACB4MOD	NSM-ON-52966 Is Not In Service		1	1.00E+00	
WK1SPD2DEX	Keowee Unit 1 Governor Failure Creates Overspeed Condition		5.6E-05	5.60E-05	
42)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	5.58E-05
-KK2RUNSDEX	Keowee Unit 2 Only Is Supplying The Grid		0.06	6.00E-02	
-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	
-KK1BOTHDEX	Keowee Units 1 And 2 Are Supplying The Grid		0.0	0.00E+00	
EKSTARTCOM	Common Cause Failure Of Both Units Voltage Regulators To Start		6.17E-5	6.17E-05	
43) ABPOPRCRHE	Operators Fail To Close Air Circuit Breaker 4		1.0	1.00E+00	5.52E-05
ACB4MOD	NSM-ON-52966 Is Not In Service		1	1.00E+00	
FK1WL11AVT	Cooling Water Control Valve 1WL-11 Transfers Closed	2.30E-06	24	5.52E-05	
44)-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	5.20E-05
-KK1BOTHDEX	Keowee Units 1 And 2 Are Supplying The Grid		0.0	0.00E+00	
ABPOPRCRHE	Operators Fail To Close Air Circuit Breaker 4		1.0	1.00E+00	
ACB4MOD	NSM-ON-52966 Is Not In Service		1	1.00E+00	
GK1NGDCLHE	Failure to Close the Unit 1 Neutral Ground Disconnect Following Maintena		5.20E-05	5.20E-05	

Table 7.2-4

Top 50 Cut Sets From The Keowee Emergency Power Model
Underground Unit- Gate UNDER0

Module/Event	Description	Rate	Exposure	Prob.	Cs Prob.
45)-XA1XAALBLM	MCC 1XA Is Connected to Its Alternate Source of Power		2.74E-03	2.74E-03	4.92E-05
-AD1B4ALCDT	Breaker 4AL In 125 V dc Distribution Center 1DA Transfers Open	7.5E-08	30	2.25E-06	
-AB7OPENLHE	Air Circuit Breaker 7 Fails To Open Due To A Latent Human Error		3.20E-3	3.20E-03	
-AB7MECHDEX	Air Circuit Breaker 7 Fails To Open Due To Mechanical Failure		8.01E-04	8.01E-04	
-AB752TCRYD	Air Circuit Breaker 7 Trip Coil TC Fails On Demand	3.3E-05	1	3.30E-05	
-AB710AFFUF	One Or More Air Circuit Breaker 7 Control Power Fuses Fail	3.6E-06	6	2.16E-05	
-AB51431SWT	Manual/Auto Control Switch 143/1 Spuriously Transfers Into Manual	7.0E-08	360	2.52E-05	
-AB51431LHE	Manual/Auto Control Switch 143/1 Left In Manual		3.20E-4	3.20E-04	
-AA227X2RYD	Auxiliary Relay 27X/2X Fails To Operate On Demand	3.3E-05	1	3.30E-05	
-AA127X2R6D	Transformer CX Undervoltage Relay 27/CX1 Fails To Drop Out	2.49E-04	1	2.49E-04	
AB5MCH2DEX	Air Circuit Breaker 5 Fails To Close Due To Mechanical Failure		7.04E-03	7.04E-03	
AB7MCH2DEX	Air Circuit Breaker 7 Fails To Close Due To Mechanical Failure		7.04E-03	7.04E-03	
ABPOPRCRHE	Operators Fail To Close Air Circuit Breaker 4		1.0	1.00E+00	
ACB4MOD	NSM-ON-52966 Is Not In Service		1	1.00E+00	
46)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	4.80E-05
-KK2RUNSDEX	Keowee Unit 2 Only Is Supplying The Grid		0.06	6.00E-02	
-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	
-KK1BOTHDEX	Keowee Units 1 And 2 Are Supplying The Grid		0.0	0.00E+00	
E12EXCTCOM	Units 1 & 2 Excit Fail Due To Common Cause Failure Of The Breakers		5.31E-05	5.31E-05	
47) EK1BAS2DEX	KHU-1 Base Adjust Fails To Maintain Generator Output Within Acceptable R		1.24E-3	1.24E-03	4.71E-05
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
48) ABPOPRCRHE	Operators Fail To Close Air Circuit Breaker 4		1.0	1.00E+00	4.32E-05
ACB4MOD	NSM-ON-52966 Is Not In Service		1	1.00E+00	
BK1GBO1FTC	Filter 1GBOFL-1 Becomes Clogged	1.80E-06	24	4.32E-05	
49) ABPOPRCRHE	Operators Fail To Close Air Circuit Breaker 4		1.0	1.00E+00	3.89E-05
ACB4MOD	NSM-ON-52966 Is Not In Service		1	1.00E+00	
EK188SVRYT	Keowee Unit 1 Fan Control Relay 88SV Prior To Or During The Run	3.6E-07	108	3.89E-05	
50)-XD1DALTBYM	Normal Power To Dist. Center 1DA Is In Test or Maintenance		5.48E-03	5.48E-03	3.51E-05
-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
XD1KBATBYF	Keowee Battery No. 1 Fails During Discharge	9.30E-04	1	9.30E-04	

Table 7.2-5

Top 50 Cut Sets From The Keowee Emergency Power Model
Overhead Unit- Gate OVER0

Module/Event	Description	Rate	Exposure	Prob.	Cs Prob.
1) OVERO					*7.27E-02
1) KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	3.80E-02
2) KK1BOTHHYM	Both Keowee Units Unavailable Due To Common Maintenance		5.23E-3	5.23E-03	5.23E-03
3)-KK2RUNSDEX	Keowee Unit 2 Only Is Supplying The Grid		0.06	6.00E-02	3.01E-03
-KK1BOTHDEX	Keowee Units 1 And 2 Are Supplying The Grid		0.0	0.00E+00	
EK2BASELHE	Keowee Unit 2 Base Adjust Is Set Incorrectly		3.20E-3	3.20E-03	
4) EK2VREGDEX	KHU-2 Voltage Adjust Failure Drives Generator Output Too High/Low		2.47E-3	2.47E-03	2.47E-03
5)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	2.45E-03
FK0FISHCOM	Common Cause Failure Of Both Unit s WL Filters Due To Intake Debris		2.55E-3	2.55E-03	
6)-OMOD	Startup Bus UV Sensing Mod Is In Service		0.0	0.00E+00	2.33E-03
OFACTORDEX	Overload Susceptibility Factor		1.0	1.00E+00	
S227EUVRYT	Unit 2 Startup Bus Undervoltage Relay 27E Fails	3.6E-07	9	2.33E-03	
7)-OMOD	Startup Bus UV Sensing Mod Is In Service		0.0	0.00E+00	2.33E-03
OFACTORDEX	Overload Susceptibility Factor		1.0	1.00E+00	
S127EUVRYT	Unit 1 Startup Bus Undervoltage Relay 27E Fails	3.6E-07	9	2.33E-03	
8) GK20001HGR	Keowee Unit 2 Generator Fault While the Unit Runs	9.46E-05	24	2.27E-03	2.27E-03
9) ACB4MOD	NSM-ON-52966 Is Not In Service		1	1.00E+00	2.00E-03
ACBAIRPDEX	ACB Air Supply Fails Causing Low Pressure In All ACB Accumulators		2.00E-03	2.00E-03	
10) EK2BAS2DEX	KHU-2 Base Adjust Fails To Maintain Generator Output Within Acceptable R		1.24E-3	1.24E-03	1.24E-03
11)-XD2DALTBYM	Normal Power To Dist Cntr 2DA Is In Test or Maintenance		5.48E-03	5.48E-03	9.25E-04
XD2KBATBYF	Keowee Battery No. 2 Fails during Discharge	9.30E-04	1	9.30E-04	
12)-XD2DALTBYM	Normal Power To Dist Cntr 2DA Is In Test or Maintenance		5.48E-03	5.48E-03	6.92E-04
XD2CKC2BCF	Battery Charger KC2 Fails	2.9E-05	24	6.96E-04	
XD2KB2XRHE	Keowee Standby Battery Charger SBC Not Lined Up in 1 Hour		1	1.00E+00	
13)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	6.44E-04
AB0SWGRCOM	Common Cause Failure Of All Keowee Auxiliary Power Breakers		6.69E-04	6.69E-04	
14)-KK2RUNSDEX	Keowee Unit 2 Only Is Supplying The Grid		0.06	6.00E-02	5.80E-04
-KK1BOTHDEX	Keowee Units 1 And 2 Are Supplying The Grid		0.0	0.00E+00	
EK2BASEDEX	Keowee Unit 2 Base Adjust Fails To Establish Correct Unit Voltage		6.17E-4	6.17E-04	
15) WK2TBRNDEX	Keowee Unit 2 Turbine Fails With the Unit Running		5.6E-4	5.60E-04	5.60E-04
16) WK2GVRNDEX	Keowee Unit 2 Gov. Fails to Position Wicket Gates With Unit Running		5.6E-4	5.60E-04	5.60E-04
17)-KK2RUNSDEX	Keowee Unit 2 Only Is Supplying The Grid		0.06	6.00E-02	4.34E-04
-KK1BOTHDEX	Keowee Units 1 And 2 Are Supplying The Grid		0.0	0.00E+00	
EK2SPYMDEX	Keowee Unit 2 Supply Breaker Fails To Close Due To Mehanical Failure		4.62E-4	4.62E-04	

Table 7.2-5

Top 50 Cut Sets From The Keowee Emergency Power Model
Overhead Unit- Gate OVER0

Module/Event	Description	Rate	Exposure	Prob.	Cs Prob.
18)-XA2XAALBLM	MCC 2XA Is Connected to Its Alternate Power Source		2.74E-03	2.74E-03	3.08E-04
-AD2B2ALCDT	Breaker 2AL In 125V dc Distribution Center 2DA Transfers Open	7.5E-08	30	2.25E-06	
-AB6OPENLHE	Air Circuit Breaker 6 Fails To Open Due To A Latent Human Error		3.20E-3	3.20E-03	
-AB6MECHDEX	Air Circuit Breaker 6 Fails To Open Due To Mechanical Failure		8.01E-04	8.01E-04	
-AB652TCRYD	Air Circuit Breaker 6 Trip Coil 52TC Fails Fails To Operate	3.3E-05	1	3.30E-05	
-AB61432SWT	Manual/Auto Control Switch 143/2 Spuriously Transfers Into Manual	7.0E-08	360	2.52E-05	
-AB61432LHE	Manual/Auto Control Switch 143/2 Left In Manual		3.20E-4	3.20E-04	
-AB610AFFUF	One Or More Control Power Fuses For Relay 27X/2X Fail	3.6E-06	6	2.16E-05	
-AA227X2RYD	Auxiliary Relay 27X/2X Fails To Operate On Demand	3.3E-05	1	3.30E-05	
-AA2272XR6D	Transformer 2X Undervoltage Relay 27/2X Fails To Drop Out	2.49E-04	1	2.49E-04	
XA2BKRSCOM	CCF of Aux Power Breakers ACB-6 & -8		3.10E-04	3.10E-04	
19) AB2MCH2DEX	Air Circuit Breaker 2 Fails To Close Due To Mechanical Failure		3.02E-4	3.02E-04	3.02E-04
20) EK2DIODDEX	Keowee Unit 2 Exciter Fan Supply Diode Bridge Fails		2.88E-4	2.88E-04	2.88E-04
21) FK2WL11AVO	Cooling Water Control Valve 2WL-11 Fails To Open On Demand	2.80E-04	1	2.80E-04	2.80E-04
22) GK2BRGVLHE	Keowee 2 Gen. Brng Oil Cooling Flow Path Vlvs Mispositioned After Mainte		2.60E-04	2.60E-04	2.60E-04
23) GK2COOLLHE	Keowee 2 Gen. Air Cooler WL Flow Path Vlvs Mispositioned After Maint		2.60E-04	2.60E-04	2.60E-04
24) SPCB009CHC	SWYD PCB-9 Fails To Close On Demand	2.6E-04	1	2.60E-04	2.60E-04
25) AA227T2R6D	Transformer #1 Undervoltage Relay (27T/2X) Fails To Drop Out	2.49E-04	1	2.49E-04	2.49E-04
ABEOPRCRHE	Operators Fail To Close Air Circuit Breaker 2		1	1.00E+00	
26) AB252Y2R6D	Air Circuit Breaker 2 Relay 52Y Failed To Drop Out Following Last Demand	2.49E-04	1	2.49E-04	2.49E-04
27) AB2R52XR6D	Air Circuit Breaker 2 Relay 52X Fails To Operate	2.49E-04	1	2.49E-04	2.49E-04
28) EK241AXR6D	Keowee Unit 2 Relay 41/AX Fails To Pick-up And Latch	2.49E-04	1	2.49E-04	2.49E-04
29)-KK2RUNSDEX	Keowee Unit 2 Only Is Supplying The Grid		0.06	6.00E-02	2.44E-04
-KK1BOTHDEX	Keowee Units 1 And 2 Are Supplying The Grid		0.0	0.00E+00	
EK2SPYCLHE	Keowee Unit 2 Supply Breaker Fails To Close Due To Latent Human Error		2.60E-4	2.60E-04	
30)-KK2RUNSDEX	Keowee Unit 2 Only Is Supplying The Grid		0.06	6.00E-02	2.44E-04
-KK1BOTHDEX	Keowee Units 1 And 2 Are Supplying The Grid		0.0	0.00E+00	
EK2FLSCLHE	Keowee Unit 2 Field Flashing Breaker Fails To Close Due To Latent Human		2.60E-4	2.60E-04	
31)-KK2RUNSDEX	Keowee Unit 2 Only Is Supplying The Grid		0.06	6.00E-02	2.44E-04
-KK1BOTHDEX	Keowee Units 1 And 2 Are Supplying The Grid		0.0	0.00E+00	
WK2GVCDLHE	Latent Human Error Fails Keowee 2 Governor During Cold Start		2.6E-4	2.60E-04	
32)-KK2RUNSDEX	Keowee Unit 2 Only Is Supplying The Grid		0.06	6.00E-02	2.44E-04
-KK1BOTHDEX	Keowee Units 1 And 2 Are Supplying The Grid		0.0	0.00E+00	
AB2CLOSLHE	Air Circuit Breaker 2 Fails To Close Due To A Latent Human Error		2.60E-4	2.60E-04	
33)-KK2RUNSDEX	Keowee Unit 2 Only Is Supplying The Grid		0.06	6.00E-02	2.44E-04
-KK1BOTHDEX	Keowee Units 1 And 2 Are Supplying The Grid		0.0	0.00E+00	
EK2FLSOLHE	Keowee Unit 2 Field Flashing Breaker Fails To Open Due To Latent Human E		2.60E-4	2.60E-04	

Table 7.2-5

Top 50 Cut Sets From The Keowee Emergency Power Model
Overhead Unit- Gate OVER0

Module/Event	Description	Rate	Exposure	Prob.	Cs Prob.
34)-KK2RUNSDEX	Keowee Unit 2 Only Is Supplying The Grid		0.06	6.00E-02	2.44E-04
-KK1BOTHDEX	Keowee Units 1 And 2 Are Supplying The Grid		0.0	0.00E+00	
EK2FLDCLHE	Keowee Unit 2 Field Breaker Fails To Close Due To Latent Human Error		2.60E-4	2.60E-04	
35) SXFRCT3THM	Transformer CT3 Is In Maintenance		1.74E-04	1.74E-04	1.74E-04
36)-KK2RUNSDEX	Keowee Unit 2 Only Is Supplying The Grid		0.06	6.00E-02	1.45E-04
-KK1BOTHDEX	Keowee Units 1 And 2 Are Supplying The Grid		0.0	0.00E+00	
GK20002HGS	Keowee Unit 2 Generator Fault Causes Unit Start Failure	1.54E-04	1	1.54E-04	
37) OK20003RVT	Safety Relief Valve 20G-3 Spurious Operation	5.60E-06	24	1.34E-04	1.34E-04
38) OK2AG04RVT	Safety Relief Valve 2AG-4 Spurious Operation	5.60E-06	24	1.34E-04	1.34E-04
39)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	1.19E-04
EK00RUNCOM	Common Cause Failure Of Both Units Voltage Regulators To Run		1.24E-4	1.24E-04	
40)-OMOD	Startup Bus UV Sensing Mod Is In Service		0.0	0.00E+00	1.18E-04
OFACTORDEX	Overload Susceptibility Factor		1.0	1.00E+00	
SU327UVCOM	Common Cause Failure of Unit 3 SU Bus Undervoltage Relays		1.18E-04	1.18E-04	
41)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	1.08E-04
AB24BKRCOM	Common Cause Failure Of Air Circuit Breakers 2 And 4 To Close		1.12E-04	1.12E-04	
42) YK2SS12SST	Keowee 2 Overspeed Switch 12 Spuriously Picks Up KEE-211	4.2E-06	24	1.01E-04	1.01E-04
43) EK2F30AFUF	Keowee Unit 2 Excitation Cabinet Fan Fuses Fail	3.6E-06	24	8.64E-05	8.64E-05
44) SXFRCT3THF	Transformer CT3 Faulted	3.1E-06	24	7.44E-05	7.44E-05
45)-KK2RUNSDEX	Keowee Unit 2 Only Is Supplying The Grid		0.06	6.00E-02	7.25E-05
-KK1BOTHDEX	Keowee Units 1 And 2 Are Supplying The Grid		0.0	0.00E+00	
EK2FLDMDEX	Keowee Unit 2 Field Breaker Fails To Close Due To Mechanical Failure		7.71E-5	7.71E-05	
46)-KK2RUNSDEX	Keowee Unit 2 Only Is Supplying The Grid		0.06	6.00E-02	7.25E-05
-KK1BOTHDEX	Keowee Units 1 And 2 Are Supplying The Grid		0.0	0.00E+00	
EK2FLSMDEX	Keowee Unit 2 Field Flashing Breaker Fails To Close Due To Mechanical Fa		7.71E-5	7.71E-05	
47) GK2FIREDEX	Spurious Actuation of Unit 2 Gen. CO2 Fire Supression System		7.00E-05	7.00E-05	7.00E-05
48) WK2SPD2DEX	Keowee Unit 2 Governor Failure Creates Overspeed Condition		5.6E-05	5.60E-05	5.60E-05
49)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	5.58E-05
-KK2RUNSDEX	Keowee Unit 2 Only Is Supplying The Grid		0.06	6.00E-02	
-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	
-KK1BOTHDEX	Keowee Units 1 And 2 Are Supplying The Grid		0.0	0.00E+00	
EKSTARTCOM	Common Cause Failure Of Both Units Voltage Regulators To Start		6.17E-5	6.17E-05	
50) FK2WL11AVT	Cooling Water Control Valve 2WL-11 Transfers Closed	2.30E-06	24	5.52E-05	5.52E-05

Table 7.2-6

Keowee Run Failure Probability - Base Case

	Failure Probability
Reliability Model Prediction - - Standby Unit	0.012
Reliability Model Prediction - - Grid-cycled Unit	0.011
Overall Experience (1984-1993)	0.012

Table 7.2-7

Comparison of System Level Versus Component Level
Common Cause Failure Probability

	Start Failure Prob.	Run Failure prob.	Total CCF Prob.
System Level:			
A. Generic Beta factor	4.50E-4	6.20E-4	1.07E-3
B. Keowee Beta factor	4.05E-5	3.05E-3	3.09E-3
Component Level:	1.50E-4	3.36E-3	3.51E-3

Table 7.3-1

Top 100 Cut Sets From The ONS-Keowee AC Power Integrated Model

Module/Event	Description	Rate	Exposure	Prob.	Cs Prob.
1) OPWERTOP					*6.35E-05
1)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	1.26E-05
-KK1BOTHHYM	Both Keowee Units Unavailable Due To Common Maintenance		5.23E-3	5.23E-03	
SXFRCT4THM	Transformer CT4 Is In Maintenance		9.13E-04	9.13E-04	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
2) KK1BOTHHYM	Both Keowee Units Unavailable Due To Common Maintenance		5.23E-3	5.23E-03	7.53E-06
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
PACOT5WDEX	Modifier Since Keowee Maintenance Is Scheduled For Mild Weather Periods		1.00E-01	1.00E-01	
3)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	4.63E-06
AB0SWGRCOM	Common Cause Failure Of All Keowee Auxiliary Power Breakers		6.69E-04	6.69E-04	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
AB0SWGRRHE	Recovery of Keowee Aux Power Breakers by Manual Control		5.0E-01	5.00E-01	
4)-XA1XAALBLM	MCC 1XA Is Connected to Its Alternate Source of Power		2.74E-03	2.74E-03	3.82E-06
-AD1B4ALCDT	Breaker 4AL In 125 V dc Distribution Center 1DA Transfers Open	7.5E-08	30	2.25E-06	
-AB7OPENLHE	Air Circuit Breaker 7 Fails To Open Due To A Latent Human Error		3.20E-3	3.20E-03	
-AB7MECHDEX	Air Circuit Breaker 7 Fails To Open Due To Mechanical Failure		8.01E-04	8.01E-04	
-AB752TCRYD	Air Circuit Breaker 7 Trip Coil TC Fails On Demand	3.3E-05	1	3.30E-05	
-AB710AFFUF	One Or More Air Circuit Breaker 7 Control Power Fuses Fail	3.6E-06	6	2.16E-05	
-AB51431SWT	Manual/Auto Control Switch 143/1 Spuriously Transfers Into Manual	7.0E-08	360	2.52E-05	
-AB51431LHE	Manual/Auto Control Switch 143/1 Left In Manual		3.20E-4	3.20E-04	
-AA227X2RYD	Auxiliary Relay 27X/2X Fails To Operate On Demand	3.3E-05	1	3.30E-05	
-AA127X2R6D	Transformer CX Undervoltage Relay 27/CX1 Fails To Drop Out	2.49E-04	1	2.49E-04	
AB7MCH2DEX	Air Circuit Breaker 7 Fails To Close Due To Mechanical Failure		7.04E-03	7.04E-03	
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
5)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	2.23E-06
FK0FISHCOM	Common Cause Failure Of Both Unit s WL Filters Due To Intake Debris		2.55E-3	2.55E-03	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
FK0FISHDHE	Recovery of Main WL Strainer Clogging		6.3E-02	6.30E-02	
6) KK1BOTHHYM	Both Keowee Units Unavailable Due To Common Maintenance		5.23E-3	5.23E-03	1.98E-06
PACLINEDEX	100 kV ac Overhead Line From Lee Steam Station To CT5 Fails		7.800E-03	7.80E-03	
T5SUBF	Loss Of The Oconee Station Switchyards Initiating Event		4.86E-02	4.86E-02	
7)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	1.72E-06
EK0ORUNCOM	Common Cause Failure Of Both Units Voltage Regulators To Run		1.24E-4	1.24E-04	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
8) EK1VREGDEX	KHU-1 Voltage Adjust Failure Drives Generator Output Too High/Low		2.47E-3	2.47E-03	1.35E-06
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
9) GK10001HGR	Keowee Unit 1 Generator Fault While the Unit Runs	9.46E-05	24	2.27E-03	1.24E-06
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
10) KK1BOTHHYM	Both Keowee Units Unavailable Due To Common Maintenance		5.23E-3	5.23E-03	1.11E-06
PACLINEDEX	100 kV ac Overhead Line From Lee Steam Station To CT5 Fails		7.800E-03	7.80E-03	
T5FEEDF	Failure Of Electrical Grid Or Main Feeders Initiating Event		2.730E-02	2.73E-02	
11) T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	1.07E-06
UACXCT4THF	Transformer CT4 Failed	3.1E-06	24	7.44E-05	

Table 7.3-1

Top 100 Cut Sets From The ONS-Keowee AC Power Integrated Model

Module/Event	Description	Rate	Exposure	Prob.	Cs Prob.
12) SXFRCT4LHE	Latent Human Error on CT4 Maintenance		6.40E-05	6.40E-05	9.22E-07
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
13)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	8.03E-07
-KK2RUNSDEX	Keowee Unit 2 Only Is Supplying The Grid		0.06	6.00E-02	
-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	
-KK1BOTHDEX	Keowee Units 1 And 2 Are Supplying The Grid		0.0	0.00E+00	
EKSTARTCOM	Common Cause Failure Of Both Units Voltage Regulators To Start		6.17E-5	6.17E-05	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
14)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	6.91E-07
-KK2RUNSDEX	Keowee Unit 2 Only Is Supplying The Grid		0.06	6.00E-02	
-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	
-KK1BOTHDEX	Keowee Units 1 And 2 Are Supplying The Grid		0.0	0.00E+00	
E12EXCTCOM	Units 1 & 2 Excit Fail Due To Common Cause Failure Of The Breakers		5.31E-05	5.31E-05	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
15) EK1BAS2DEX	KHU-1 Base Adjust Fails To Maintain Generator Output Within Acceptable R		1.24E-3	1.24E-03	6.79E-07
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
16) KK1BOTHHYM	Both Keowee Units Unavailable Due To Common Maintenance		5.23E-3	5.23E-03	5.67E-07
PACLEESCTR	Lee Steam Station Combustion Turbines Fail To Run For The Required Time	9.30E-05	24	2.23E-03	
T5SUBF	Loss Of The Oconee Station Switchyards Initiating Event		4.86E-02	4.86E-02	
17)-XD1DALTBYM	Normal Power To Dist. Center 1DA Is In Test or Maintenance		5.48E-03	5.48E-03	5.06E-07
-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
XD1KBATBYF	Keowee Battery No. 1 Fails During Discharge	9.30E-04	1	9.30E-04	
XD0KBATRHE	Failure To Recover DC By Cross Connecting The Distribution Centers		1.00E+00	1.00E+00	
18)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	4.82E-07
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
XD0CHRGCOM	Common Cause Failure Of Keowee Battery Chargers		3.48E-05	3.48E-05	
19)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	4.39E-07
AB0SWGRCOM	Common Cause Failure Of All Keowee Auxiliary Power Breakers		6.69E-04	6.69E-04	
T5FEEDF	Failure Of Electrical Grid Or Main Feeders Initiating Event		2.730E-02	2.73E-02	
AB0SWGRRHE	Recovery of Keowee Aux Power Breakers by Manual Control		5.0E-01	5.00E-01	
PACLEE2REC	Operators Fail To Align Power From Lee Steam Station To Standby Buses		5.0e-02	5.00E-02	
20)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	4.25E-07
-KK1BOTHHYM	Both Keowee Units Unavailable Due To Common Maintenance		5.23E-3	5.23E-03	
SXFRCT4THM	Transformer CT4 Is In Maintenance		9.13E-04	9.13E-04	
T5SUBF	Loss Of The Oconee Station Switchyards Initiating Event		4.86E-02	4.86E-02	
PACLEE1REC	Operators Fail To Align Power From Lee Steam Station To Standby Buses		1.0e-02	1.00E-02	
21)-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	4.15E-07
-KK1BOTHDEX	Keowee Units 1 And 2 Are Supplying The Grid		0.0	0.00E+00	
ABPOPRCRHE	Operators Fail To Close Air Circuit Breaker 4		9.0E-03	9.00E-03	
ACB4MOD	NSM-ON-52966 Is Not In Service		1	1.00E+00	
EK1BASELHE	Keowee Unit 1 Base Adjust Is Set Incorrectly		3.20E-3	3.20E-03	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	

Table 7.3-1

Top 100 Cut Sets From The ONS-Keowee AC Power Integrated Model

Module/Event	Description	Rate	Exposure	Prob.	Cs Prob.
22)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	3.74E-07
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
XDOBATTCOM	Common Cause Failure Of Keowee I&C Power Batteries		2.70E-05	2.70E-05	
23)-XA1XAALBLM	MCC 1XA Is Connected to Its Alternate Source of Power		2.74E-03	2.74E-03	3.62E-07
-AD1B4ALCDT	Breaker 4AL In 125 V dc Distribution Center 1DA Transfers Open	7.5E-08	30	2.25E-06	
-AB7OPENLHE	Air Circuit Breaker 7 Fails To Open Due To A Latent Human Error		3.20E-3	3.20E-03	
-AB7MECHDEX	Air Circuit Breaker 7 Fails To Open Due To Mechanical Failure		8.01E-04	8.01E-04	
-AB752TCRYD	Air Circuit Breaker 7 Trip Coil TC Fails On Demand	3.3E-05	1	3.30E-05	
-AB710AFFUF	One Or More Air Circuit Breaker 7 Control Power Fuses Fail	3.6E-06	6	2.16E-05	
-AB51431SWT	Manual/Auto Control Switch 143/1 Spuriously Transfers Into Manual	7.0E-08	360	2.52E-05	
-AB51431LHE	Manual/Auto Control Switch 143/1 Left In Manual		3.20E-4	3.20E-04	
-AA227X2RYD	Auxiliary Relay 27X/2X Fails To Operate On Demand	3.3E-05	1	3.30E-05	
-AA127X2R6D	Transformer CX Undervoltage Relay 27/CX1 Fails To Drop Out	2.49E-04	1	2.49E-04	
AB7MCH2DEX	Air Circuit Breaker 7 Fails To Close Due To Mechanical Failure		7.04E-03	7.04E-03	
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
T5FEEDF	Failure Of Electrical Grid Or Main Feeders Initiating Event		2.730E-02	2.73E-02	
PACLEE2REC	Operators Fail To Align Power From Lee Steam Station To Standby Buses		5.0e-02	5.00E-02	
24)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	3.41E-07
FKVALVECOM	Common Cause Failure Of Cooling Water Control Valves		2.46E-5	2.46E-05	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
25)-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	3.38E-07
EK1BASEDEX	Keowee Unit 1 Base Adjust Fails To Establish Correct Unit Voltage		6.17E-4	6.17E-04	
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
26) ABPOPRCRHE	Operators Fail To Close Air Circuit Breaker 4		9.0E-03	9.00E-03	3.20E-07
ACB4MOD	NSM-ON-52966 Is Not In Service		1	1.00E+00	
EK1VREGDEX	KHU-1 Voltage Adjust Failure Drives Generator Output Too High/Low		2.47E-3	2.47E-03	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
27) KK1BOTHHYM	Both Keowee Units Unavailable Due To Common Maintenance		5.23E-3	5.23E-03	3.19E-07
PACLEESCTR	Lee Steam Station Combustion Turbines Fail To Run For The Required Time	9.30E-05	24	2.23E-03	
T5FEEDF	Failure Of Electrical Grid Or Main Feeders Initiating Event		2.730E-02	2.73E-02	
28) KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	3.06E-07
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
WK1TBRNDEX	Keowee Unit 1 Turbine Fails With the Unit Running		5.6e-4	5.60E-04	
29) KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	3.06E-07
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
WK1GVRNDEX	Keowee Unit 1 Gov. Fails to Position Wicket Gates With Unit Running		5.6E-4	5.60E-04	
30) ABPOPRCRHE	Operators Fail To Close Air Circuit Breaker 4		9.0E-03	9.00E-03	2.94E-07
ACB4MOD	NSM-ON-52966 Is Not In Service		1	1.00E+00	
GK10001HGR	Keowee Unit 1 Generator Fault While the Unit Runs	9.46E-05	24	2.27E-03	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
31)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	2.90E-07
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
WK00RUNCOM	Common Cause Failure of Keowee Governors to Run		2.09E-05	2.09E-05	

Table 7.3-1

Top 100 Cut Sets From The ONS-Keowee AC Power Integrated Model

Module/Event	Description	Rate	Exposure	Prob.	Cs Prob.
32)-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	2.53E-07
EK1SPYMDEX	Keowee Unit 1 Supply Breaker Fails To Close Due To Mehanical Failure		4.62E-4	4.62E-04	
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
33)-XA1XAALBLM	MCC 1XA Is Connected to Its Alternate Source of Power		2.74E-03	2.74E-03	2.49E-07
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
XA1XCXXTHM	4160/600 Vac Transformer CX Is in Maintenance		4.57E-4	4.57E-04	
34)-XA1XAALBLM	MCC 1XA Is Connected to Its Alternate Source of Power		2.74E-03	2.74E-03	2.49E-07
-AD1B4ALCDT	Breaker 4AL In 125 V dc Distribution Center 1DA Transfers Open	7.5E-08	30	2.25E-06	
-AB7OPENLHE	Air Circuit Breaker 7 Fails To Open Due To A Latent Human Error		3.20E-3	3.20E-03	
-AB7MECHDEX	Air Circuit Breaker 7 Fails To Open Due To Mechanical Failure		8.01E-04	8.01E-04	
-AB752TCRYD	Air Circuit Breaker 7 Trip Coil TC Fails On Demand	3.3E-05	1	3.30E-05	
-AB710AFFUF	One Or More Air Circuit Breaker 7 Control Power Fuses Fail	3.6E-06	6	2.16E-05	
-AB51431SWT	Manual/Auto Control Switch 143/1 Spuriously Transfers Into Manual	7.0E-08	360	2.52E-05	
-AB51431LHE	Manual/Auto Control Switch 143/1 Left In Manual		3.20E-4	3.20E-04	
-AA227X2RYD	Auxiliary Relay 27X/2X Fails To Operate On Demand	3.3E-05	1	3.30E-05	
-AA127X2R6D	Transformer CX Undervoltage Relay 27/CX1 Fails To Drop Out	2.49E-04	1	2.49E-04	
AB7MCH2DEX	Air Circuit Breaker 7 Fails To Close Due To Mechanical Failure		7.04E-03	7.04E-03	
EK2VREGDEX	KHU-2 Voltage Adjust Failure Drives Generator Output Too High/Low		2.47E-3	2.47E-03	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
35)-XA1XAALBLM	MCC 1XA Is Connected to Its Alternate Source of Power		2.74E-03	2.74E-03	2.28E-07
-AD1B4ALCDT	Breaker 4AL In 125 V dc Distribution Center 1DA Transfers Open	7.5E-08	30	2.25E-06	
-AB7OPENLHE	Air Circuit Breaker 7 Fails To Open Due To A Latent Human Error		3.20E-3	3.20E-03	
-AB7MECHDEX	Air Circuit Breaker 7 Fails To Open Due To Mechanical Failure		8.01E-04	8.01E-04	
-AB752TCRYD	Air Circuit Breaker 7 Trip Coil TC Fails On Demand	3.3E-05	1	3.30E-05	
-AB710AFFUF	One Or More Air Circuit Breaker 7 Control Power Fuses Fail	3.6E-06	6	2.16E-05	
-AB51431SWT	Manual/Auto Control Switch 143/1 Spuriously Transfers Into Manual	7.0E-08	360	2.52E-05	
-AB51431LHE	Manual/Auto Control Switch 143/1 Left In Manual		3.20E-4	3.20E-04	
-AA227X2RYD	Auxiliary Relay 27X/2X Fails To Operate On Demand	3.3E-05	1	3.30E-05	
-AA127X2R6D	Transformer CX Undervoltage Relay 27/CX1 Fails To Drop Out	2.49E-04	1	2.49E-04	
AB7MCH2DEX	Air Circuit Breaker 7 Fails To Close Due To Mechanical Failure		7.04E-03	7.04E-03	
GK20001HGR	Keowee Unit 2 Generator Fault While the Unit Runs	9.46E-05	24	2.27E-03	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
36) PACS1S2COM	Common Cause Failure Of Breakers S1 And S2 To Close		8.900E-05	8.90E-05	2.16E-07
T5SUBF	Loss Of The Oconee Station Switchyards Initiating Event		4.86E-02	4.86E-02	
PACS1S2REC			5.0e-02	5.00E-02	
37)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	2.11E-07
FK0FISHCOM	Common Cause Failure Of Both Unit s WL Filters Due To Intake Debris		2.55E-3	2.55E-03	
T5FEEDF	Failure Of Electrical Grid Or Main Feeders Initiating Event		2.730E-02	2.73E-02	
FK0FISHDHE	Recovery of Main WL Strainer Clogging		6.3E-02	6.30E-02	
PACLEE2REC	Operators Fail To Align Power From Lee Steam Station To Standby Buses		5.0e-02	5.00E-02	
38)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	2.02E-07
OK0PRUNCOM	Common Cause Failure Of Both Governor Oil Systems To Run		1.46E-05	1.46E-05	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	

Table 7.3-1

Top 100 Cut Sets From The ONS-Keowee AC Power Integrated Model

Module/Event	Description	Rate	Exposure	Prob.	Cs Prob.
39)-XA1XAALBLM	MCC 1XA Is Connected to Its Alternate Source of Power		2.74E-03	2.74E-03	2.01E-07
-AD1B4ALCDT	Breaker 4AL In 125 V dc Distribution Center 1DA Transfers Open	7.5E-08	30	2.25E-06	
-AB7OPENLHE	Air Circuit Breaker 7 Fails To Open Due To A Latent Human Error		3.20E-3	3.20E-03	
-AB7MECHDEX	Air Circuit Breaker 7 Fails To Open Due To Mechanical Failure		8.01E-04	8.01E-04	
-AB752TCRYD	Air Circuit Breaker 7 Trip Coil TC Fails On Demand	3.3E-05	1	3.30E-05	
-AB710AFFUF	One Or More Air Circuit Breaker 7 Control Power Fuses Fail	3.6E-06	6	2.16E-05	
-AB51431SWT	Manual/Auto Control Switch 143/1 Spuriously Transfers Into Manual	7.0E-08	360	2.52E-05	
-AB51431LHE	Manual/Auto Control Switch 143/1 Left In Manual		3.20E-4	3.20E-04	
-AA227X2RYD	Auxiliary Relay 27X/2X Fails To Operate On Demand	3.3E-05	1	3.30E-05	
-AA127X2R6D	Transformer CX Undervoltage Relay 27/CX1 Fails To Drop Out	2.49E-04	1	2.49E-04	
AB7MCH2DEX	Air Circuit Breaker 7 Fails To Close Due To Mechanical Failure		7.04E-03	7.04E-03	
ACB4MOD	NSM-ON-52966 Is Not In Service		1	1.00E+00	
ACBAIRPDEX	ACB Air Supply Fails Causing Low Pressure In All ACB Accumulators		2.00E-03	2.00E-03	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
40)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	1.63E-07
EKOORUNCOM	Common Cause Failure Of Both Units Voltage Regulators To Run		1.24E-4	1.24E-04	
T5FEEDF	Failure Of Electrical Grid Or Main Feeders Initiating Event		2.730E-02	2.73E-02	
PACLEE2REC	Operators Fail To Align Power From Lee Steam Station To Standby Buses		5.0e-02	5.00E-02	
41) ABPOPRCRHE	Operators Fail To Close Air Circuit Breaker 4		9.0E-03	9.00E-03	1.61E-07
ACB4MOD	NSM-ON-52966 Is Not In Service		1	1.00E+00	
EK1BAS2DEX	KHU-1 Base Adjust Fails To Maintain Generator Output Within Acceptable R		1.24E-3	1.24E-03	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
42) EK1DIODDEX	Keowee Unit 1 Exciter Fan Supply Diode Bridge Fails		2.88E-4	2.88E-04	1.58E-07
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
43)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	1.56E-07
AB0SWGRCOM	Common Cause Failure Of All Keowee Auxiliary Power Breakers		6.69E-04	6.69E-04	
T5SUBF	Loss Of The Oconee Station Switchyards Initiating Event		4.86E-02	4.86E-02	
AB0SWGRRHE	Recovery of Keowee Aux Power Breakers by Manual Control		5.0E-01	5.00E-01	
PACLEE1REC	Operators Fail To Align Power From Lee Steam Station To Standby Buses		1.0e-02	1.00E-02	
44) FK1WL11AVO	Cooling Water Control Valve 1WL-11 Fails To Open On Demand	2.80E-04	1	2.80E-04	1.53E-07
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
45)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	1.46E-07
-KK2RUNSDEX	Keowee Unit 2 Only Is Supplying The Grid		0.06	6.00E-02	
-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	
-KK1BOTHDEX	Keowee Units 1 And 2 Are Supplying The Grid		0.0	0.00E+00	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
WKCSTRTCOM	Common Cause Failure of Keowee Governors to Cold Start		1.12E-05	1.12E-05	
46) GK1COOLLHE	Keowee 1 Gen. Air Cooler WL Flow Path Vlvs Mispositioned After Maint		2.60E-04	2.60E-04	1.42E-07
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
47)-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	1.42E-07
EK1FLDCLHE	Keowee Unit 1 Field Breaker Fails To Close Due To Latent Human Error		2.60E-4	2.60E-04	
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	

Table 7.3-1

Top 100 Cut Sets From The ONS-Keowee AC Power Integrated Model

Module/Event	Description	Rate	Exposure	Prob.	Cs Prob.
48)-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	1.42E-07
EK1SPYCLHE	Keowee Unit 1 Supply Breaker Fails To Close Due To Latent Human Error		2.60E-4	2.60E-04	
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
49)-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	1.42E-07
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
WK1GVCDLHE	Latent Human Error Fails Keowee 1 Governor During Cold Start		2.6E-4	2.60E-04	
50)-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	1.42E-07
EK1FLSCLHE	Keowee Unit 1 Field Flashing Breaker Fails To Close Due To Latent Human		2.60E-4	2.60E-04	
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
51)-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	1.42E-07
EK1FLSOLHE	Keowee Unit 1 Field Flashing Breaker Fails To Open Due To Latent Human E		2.60E-4	2.60E-04	
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
52)-XA1XAALBLM	MCC 1XA Is Connected to Its Alternate Source of Power		2.74E-03	2.74E-03	1.41E-07
-AD1B4ALCDT	Breaker 4AL In 125 V dc Distribution Center 1DA Transfers Open	7.5E-08	30	2.25E-06	
-AB7OPENLHE	Air Circuit Breaker 7 Fails To Open Due To A Latent Human Error		3.20E-3	3.20E-03	
-AB7MECHDEX	Air Circuit Breaker 7 Fails To Open Due To Mechanical Failure		8.01E-04	8.01E-04	
-AB752TCRYD	Air Circuit Breaker 7 Trip Coil TC Fails On Demand	3.3E-05	1	3.30E-05	
-AB710AFFUF	One Or More Air Circuit Breaker 7 Control Power Fuses Fail	3.6E-06	6	2.16E-05	
-AB51431SWT	Manual/Auto Control Switch 143/1 Spuriously Transfers Into Manual	7.0E-08	360	2.52E-05	
-AB51431LHE	Manual/Auto Control Switch 143/1 Left In Manual		3.20E-4	3.20E-04	
-AA227X2RYD	Auxiliary Relay 27X/2X Fails To Operate On Demand	3.3E-05	1	3.30E-05	
-AA127X2R6D	Transformer CX Undervoltage Relay 27/CX1 Fails To Drop Out	2.49E-04	1	2.49E-04	
AB7CLOSLHE	Air Circuit Breaker 7 Fails To Close Due To A Latent Human Error		2.60E-4	2.60E-04	
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
53) KK1UNDRBHF	Fault Occurs On The Underground Power Path	4.00E-07	24	9.60E-06	1.38E-07
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
54) EK141AXR6D	Keowee Unit 1 Relay 41/AX Fails To Pick-up And Latch	2.49E-04	1	2.49E-04	1.36E-07
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	

Table 7.3-1

Top 100 Cut Sets From The ONS-Keowee AC Power Integrated Model

Module/Event	Description	Rate	Exposure	Prob.	Cs Prob.
55)-XA1XAALBLM	MCC 1XA Is Connected to Its Alternate Source of Power		2.74E-03	2.74E-03	1.35E-07
-AD1B4ALCDT	Breaker 4AL In 125 V dc Distribution Center 1DA Transfers Open	7.5E-08	30	2.25E-06	
-AB7OPENLHE	Air Circuit Breaker 7 Fails To Open Due To A Latent Human Error		3.20E-3	3.20E-03	
-AB7MECHDEX	Air Circuit Breaker 7 Fails To Open Due To Mechanical Failure		8.01E-04	8.01E-04	
-AB752TCRYD	Air Circuit Breaker 7 Trip Coil TC Fails On Demand	3.3E-05	1	3.30E-05	
-AB710AFFUF	One Or More Air Circuit Breaker 7 Control Power Fuses Fail	3.6E-06	6	2.16E-05	
-AB51431SWT	Manual/Auto Control Switch 143/1 Spuriously Transfers Into Manual	7.0E-08	360	2.52E-05	
-AB51431LHE	Manual/Auto Control Switch 143/1 Left In Manual		3.20E-4	3.20E-04	
-AA227X2RYD	Auxiliary Relay 27X/2X Fails To Operate On Demand	3.3E-05	1	3.30E-05	
-AA127X2R6D	Transformer CX Undervoltage Relay 27/CX1 Fails To Drop Out	2.49E-04	1	2.49E-04	
AA127CPR6D	Transformer CX Undervoltage Relay 27/CX1 Fails To Pick Up	2.49E-04	1	2.49E-04	
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
56)-XA1XAALBLM	MCC 1XA Is Connected to Its Alternate Source of Power		2.74E-03	2.74E-03	1.29E-07
-AD1B4ALCDT	Breaker 4AL In 125 V dc Distribution Center 1DA Transfers Open	7.5E-08	30	2.25E-06	
-AB7OPENLHE	Air Circuit Breaker 7 Fails To Open Due To A Latent Human Error		3.20E-3	3.20E-03	
-AB7MECHDEX	Air Circuit Breaker 7 Fails To Open Due To Mechanical Failure		8.01E-04	8.01E-04	
-AB752TCRYD	Air Circuit Breaker 7 Trip Coil TC Fails On Demand	3.3E-05	1	3.30E-05	
-AB710AFFUF	One Or More Air Circuit Breaker 7 Control Power Fuses Fail	3.6E-06	6	2.16E-05	
-AB51431SWT	Manual/Auto Control Switch 143/1 Spuriously Transfers Into Manual	7.0E-08	360	2.52E-05	
-AB51431LHE	Manual/Auto Control Switch 143/1 Left In Manual		3.20E-4	3.20E-04	
-AA227X2RYD	Auxiliary Relay 27X/2X Fails To Operate On Demand	3.3E-05	1	3.30E-05	
-AA127X2R6D	Transformer CX Undervoltage Relay 27/CX1 Fails To Drop Out	2.49E-04	1	2.49E-04	
AB7MCH2DEX	Air Circuit Breaker 7 Fails To Close Due To Mechanical Failure		7.04E-03	7.04E-03	
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
T5SUBF	Loss Of The Oconee Station Switchyards Initiating Event		4.86E-02	4.86E-02	
PACLEE1REC	Operators Fail To Align Power From Lee Steam Station To Standby Buses		1.0e-02	1.00E-02	
57) EK1VREGDEX	KHU-1 Voltage Adjust Failure Drives Generator Output Too High/Low		2.47E-3	2.47E-03	1.28E-07
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
T5FEEDF	Failure Of Electrical Grid Or Main Feeders Initiating Event		2.730E-02	2.73E-02	
PACLEE2REC	Operators Fail To Align Power From Lee Steam Station To Standby Buses		5.0e-02	5.00E-02	
58)-XA1XAALBLM	MCC 1XA Is Connected to Its Alternate Source of Power		2.74E-03	2.74E-03	1.25E-07
-AD1B4ALCDT	Breaker 4AL In 125 V dc Distribution Center 1DA Transfers Open	7.5E-08	30	2.25E-06	
-AB7OPENLHE	Air Circuit Breaker 7 Fails To Open Due To A Latent Human Error		3.20E-3	3.20E-03	
-AB7MECHDEX	Air Circuit Breaker 7 Fails To Open Due To Mechanical Failure		8.01E-04	8.01E-04	
-AB752TCRYD	Air Circuit Breaker 7 Trip Coil TC Fails On Demand	3.3E-05	1	3.30E-05	
-AB710AFFUF	One Or More Air Circuit Breaker 7 Control Power Fuses Fail	3.6E-06	6	2.16E-05	
-AB51431SWT	Manual/Auto Control Switch 143/1 Spuriously Transfers Into Manual	7.0E-08	360	2.52E-05	
-AB51431LHE	Manual/Auto Control Switch 143/1 Left In Manual		3.20E-4	3.20E-04	
-AA227X2RYD	Auxiliary Relay 27X/2X Fails To Operate On Demand	3.3E-05	1	3.30E-05	
-AA127X2R6D	Transformer CX Undervoltage Relay 27/CX1 Fails To Drop Out	2.49E-04	1	2.49E-04	
AB7MCH2DEX	Air Circuit Breaker 7 Fails To Close Due To Mechanical Failure		7.04E-03	7.04E-03	
EK2BAS2DEX	KHU-2 Base Adjust Fails To Maintain Generator Output Within Acceptable R		1.24E-3	1.24E-03	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
59) T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	1.24E-07
U5186EFRYT	Time Delay Overcurrent Relay 51 Actuates Lockout Relay 86EF	3.6E-07	24	8.64E-06	

Table 7.3-1

Top 100 Cut Sets From The ONS-Keowee AC Power Integrated Model

Module/Event	Description	Rate	Exposure	Prob.	Cs Prob.
60) T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	1.24E-07
U62BSK1RYT	SK1 Breaker Failure Relay 62BXSK1 Spuriously Picks Up	3.6E-07	24	8.64E-06	
61) T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	1.24E-07
U87TCT4RYT	Spurious Op of CT4 Differential Rly 87T Actuates LOR 86EF	3.6E-07	24	8.64E-06	
62) T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	1.24E-07
U86TCT4RYT	CT4 Lockout Relay 86T/CT4 Spuriously Picks Up	3.6E-07	24	8.64E-06	
63) T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	1.24E-07
U51TNC4RYT	CT4 Neutral Ground Rly Actuates CT4 LOR 86T/CT4	3.6E-07	24	8.64E-06	
64) T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	1.24E-07
U5086EFRYT	Overcurrent Relay 50 Spuriously Actuates Lockout Rly 86EF	3.6E-07	24	8.64E-06	
65) T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	1.24E-07
U86CT4XRYT	Auxiliary Lockout Relay 86CT4X Spuriously Picks Up	3.6E-07	24	8.64E-06	
66) T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	1.24E-07
U62BSK2RYT	SK2 Breaker Failure Relay 62BXSK2 Spuriously Picks Up	3.6E-07	24	8.64E-06	
67) T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	1.24E-07
UXX86EFRYT	Lockout Relay 86EF Spuriously Picks Up	3.6E-07	24	8.64E-06	
68)-XD1DALTBYM	Normal Power To Dist. Center 1DA Is In Test or Maintenance		5.48E-03	5.48E-03	1.20E-07
-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	
-KK1BOTHDEX	Keowee Units 1 And 2 Are Supplying The Grid		0.0	0.00E+00	
ABPOPRCRHE	Operators Fail To Close Air Circuit Breaker 4		9.0E-03	9.00E-03	
ACB4MOD	NSM-ON-52966 Is Not In Service		1	1.00E+00	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
XD1KBATBYF	Keowee Battery No. 1 Fails During Discharge	9.30E-04	1	9.30E-04	
69) GK10001HGR	Keowee Unit 1 Generator Fault While the Unit Runs	9.46E-05	24	2.27E-03	1.18E-07
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
T5FEEDF	Failure Of Electrical Grid Or Main Feeders Initiating Event		2.730E-02	2.73E-02	
PACLEE2REC	Operators Fail To Align Power From Lee Steam Station To Standby Buses		5.0e-02	5.00E-02	
70) PACS1CSMOD	S1 Closing Circuit Components Fail		2.833E-03	2.83E-03	1.16E-07
PACS2CSMOD	S2 Closing Circuit Components Fail		2.833E-03	2.83E-03	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
71) T5FEEDF	Failure Of Electrical Grid Or Main Feeders Initiating Event		2.730E-02	2.73E-02	9.91E-08
Y0STARTCOM	Common Cause Failure Of Emergency Start Signal		7.26E-06	7.26E-06	
Y0STARTRHE	Operators Fail To Manually Start Keowee		0.5	5.00E-01	

Table 7.3-1

Top 100 Cut Sets From The ONS-Keowee AC Power Integrated Model

Module/Event	Description	Rate	Exposure	Prob.	Cs Prob.
72)-XD2DALTBYM	Normal Power To Dist Cntr 2DA Is In Test or Maintenance		5.48E-03	5.48E-03	9.31E-08
-XA1XAALBLM	MCC 1XA Is Connected to Its Alternate Source of Power		2.74E-03	2.74E-03	
-AD1B4ALCDT	Breaker 4AL In 125 V dc Distribution Center 1DA Transfers Open	7.5E-08	30	2.25E-06	
-AB7OPENLHE	Air Circuit Breaker 7 Fails To Open Due To A Latent Human Error		3.20E-3	3.20E-03	
-AB7MECHDEX	Air Circuit Breaker 7 Fails To Open Due To Mechanical Failure		8.01E-04	8.01E-04	
-AB752TCRYD	Air Circuit Breaker 7 Trip Coil TC Fails On Demand	3.3E-05	1	3.30E-05	
-AB710AFFUF	One Or More Air Circuit Breaker 7 Control Power Fuses Fail	3.6E-06	6	2.16E-05	
-AB51431SWT	Manual/Auto Control Switch 143/1 Spuriously Transfers Into Manual	7.0E-08	360	2.52E-05	
-AB51431LHE	Manual/Auto Control Switch 143/1 Left In Manual		3.20E-4	3.20E-04	
-AA227X2RYD	Auxiliary Relay 27X/2X Fails To Operate On Demand	3.3E-05	1	3.30E-05	
-AA127X2R6D	Transformer CX Undervoltage Relay 27/CX1 Fails To Drop Out	2.49E-04	1	2.49E-04	
AB7MCH2DEX	Air Circuit Breaker 7 Fails To Close Due To Mechanical Failure		7.04E-03	7.04E-03	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
XD2KBATBYF	Keowee Battery No. 2 Fails during Discharge	9.30E-04	1	9.30E-04	
73) EK1VREGDEX	KHU-1 Voltage Adjust Failure Drives Generator Output Too High/Low		2.47E-3	2.47E-03	8.79E-08
EK2VREGDEX	KHU-2 Voltage Adjust Failure Drives Generator Output Too High/Low		2.47E-3	2.47E-03	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
74)-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	8.43E-08
GK10001HGS	Keowee Unit 1 Generator Fault Causes Unit Start Failure	1.54E-04	1	1.54E-04	
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
75)-XA1XAALBLM	MCC 1XA Is Connected to Its Alternate Source of Power		2.74E-03	2.74E-03	8.42E-08
-AD1B4ALCDT	Breaker 4AL In 125 V dc Distribution Center 1DA Transfers Open	7.5E-08	30	2.25E-06	
-AB7OPENLHE	Air Circuit Breaker 7 Fails To Open Due To A Latent Human Error		3.20E-3	3.20E-03	
-AB7MECHDEX	Air Circuit Breaker 7 Fails To Open Due To Mechanical Failure		8.01E-04	8.01E-04	
-AB752TCRYD	Air Circuit Breaker 7 Trip Coil TC Fails On Demand	3.3E-05	1	3.30E-05	
-AB710AFFUF	One Or More Air Circuit Breaker 7 Control Power Fuses Fail	3.6E-06	6	2.16E-05	
-AB51431SWT	Manual/Auto Control Switch 143/1 Spuriously Transfers Into Manual	7.0E-08	360	2.52E-05	
-AB51431LHE	Manual/Auto Control Switch 143/1 Left In Manual		3.20E-4	3.20E-04	
-AA227X2RYD	Auxiliary Relay 27X/2X Fails To Operate On Demand	3.3E-05	1	3.30E-05	
-AA127X2R6D	Transformer CX Undervoltage Relay 27/CX1 Fails To Drop Out	2.49E-04	1	2.49E-04	
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
XA1BKRSCOM	CCF of 1X Aux Power Breakers ACB-5 & -7		3.10E-04	3.10E-04	
AB0SWGRRHE	Recovery of Keowee Aux Power Breakers by Manual Control		5.0E-01	5.00E-01	

Table 7.3-1

Top 100 Cut Sets From The ONS-Keowee AC Power Integrated Model

Module/Event	Description	Rate	Exposure	Prob.	Cs Prob.
76)-XA1XAALBLM	MCC 1XA Is Connected to Its Alternate Source of Power		2.74E-03	2.74E-03	8.42E-08
-AD1B4ALCDT	Breaker 4AL In 125 V dc Distribution Center 1DA Transfers Open	7.5E-08	30	2.25E-06	
-AB7OPENLHE	Air Circuit Breaker 7 Fails To Open Due To A Latent Human Error		3.20E-3	3.20E-03	
-AB7MECHDEX	Air Circuit Breaker 7 Fails To Open Due To Mechanical Failure		8.01E-04	8.01E-04	
-AB752TCRYD	Air Circuit Breaker 7 Trip Coil TC Fails On Demand	3.3E-05	1	3.30E-05	
-AB710AFFUF	One Or More Air Circuit Breaker 7 Control Power Fuses Fail	3.6E-06	6	2.16E-05	
-AB51431SWT	Manual/Auto Control Switch 143/1 Spuriously Transfers Into Manual	7.0E-08	360	2.52E-05	
-AB51431LHE	Manual/Auto Control Switch 143/1 Left In Manual		3.20E-4	3.20E-04	
-AA227X2RYD	Auxiliary Relay 27X/2X Fails To Operate On Demand	3.3E-05	1	3.30E-05	
-AA127X2R6D	Transformer CX Undervoltage Relay 27/CX1 Fails To Drop Out	2.49E-04	1	2.49E-04	
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
XA78BKRCOM	Common Cause Failure Of ACB-7 And ACB-8 To Close		3.10E-04	3.10E-04	
AB0SWGRRHE	Recovery of Keowee Aux Power Breakers by Manual Control		5.0E-01	5.00E-01	
77) EK1VREGDEX	KHU-1 Voltage Adjust Failure Drives Generator Output Too High/Low		2.47E-3	2.47E-03	8.08E-08
GK20001HGR	Keowee Unit 2 Generator Fault While the Unit Runs	9.46E-05	24	2.27E-03	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
78) EK2VREGDEX	KHU-2 Voltage Adjust Failure Drives Generator Output Too High/Low		2.47E-3	2.47E-03	8.08E-08
GK10001HGR	Keowee Unit 1 Generator Fault While the Unit Runs	9.46E-05	24	2.27E-03	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
79)-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	8.00E-08
-KK1BOTHDEX	Keowee Units 1 And 2 Are Supplying The Grid		0.0	0.00E+00	
ABPOPRCRHE	Operators Fail To Close Air Circuit Breaker 4		9.0E-03	9.00E-03	
ACB4MOD	NSM-ON-52966 Is Not In Service		1	1.00E+00	
EK1BASEDEX	Keowee Unit 1 Base Adjust Fails To Establish Correct Unit Voltage		6.17E-4	6.17E-04	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
80)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	7.62E-08
-KK2RUNSDEX	Keowee Unit 2 Only Is Supplying The Grid		0.06	6.00E-02	
-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	
-KK1BOTHDEX	Keowee Units 1 And 2 Are Supplying The Grid		0.0	0.00E+00	
EKSTARTCOM	Common Cause Failure Of Both Units Voltage Regulators To Start		6.17E-5	6.17E-05	
T5FEEDF	Failure Of Electrical Grid Or Main Feeders Initiating Event		2.730E-02	2.73E-02	
PACLEE2REC	Operators Fail To Align Power From Lee Steam Station To Standby Buses		5.0e-02	5.00E-02	
81)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	7.51E-08
FK0FISHCOM	Common Cause Failure Of Both Unit s WL Filters Due To Intake Debris		2.55E-3	2.55E-03	
T5SUBF	Loss Of The Oconee Station Switchyards Initiating Event		4.86E-02	4.86E-02	
FK0FISHDHE	Recovery of Main WL Strainer Clogging		6.3E-02	6.30E-02	
PACLEE1REC	Operators Fail To Align Power From Lee Steam Station To Standby Buses		1.0e-02	1.00E-02	
82) GK10001HGR	Keowee Unit 1 Generator Fault While the Unit Runs	9.46E-05	24	2.27E-03	7.42E-08
GK20001HGR	Keowee Unit 2 Generator Fault While the Unit Runs	9.46E-05	24	2.27E-03	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
83) KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	7.35E-08
OK1AG04RVT	Safety Relief Valve 1AG-4 Spurious Operation	5.60E-06	24	1.34E-04	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	

Table 7.3-1

Top 100 Cut Sets From The ONS-Keowee AC Power Integrated Model

Module/Event	Description	Rate	Exposure	Prob.	Cs Prob.
84) KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	7.35E-08
OK10003RVT	Safety Relief Valve 10G-3 Spurious Operation	5.60E-06	24	1.34E-04	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
85)-XD1DALTBYM	Normal Power To Dist. Center 1DA Is In Test or Maintenance		5.48E-03	5.48E-03	7.30E-08
-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	
-KK1BOTHDEX	Keowee Units 1 And 2 Are Supplying The Grid		0.0	0.00E+00	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
XD1KBATBYF	Keowee Battery No. 1 Fails During Discharge	9.30E-04	1	9.30E-04	
XD2DALTBYM	Normal Power To Dist Cntr 2DA Is In Test or Maintenance		5.48E-03	5.48E-03	
86)-XD2DALTBYM	Normal Power To Dist Cntr 2DA Is In Test or Maintenance		5.48E-03	5.48E-03	7.30E-08
-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	
-KK1BOTHDEX	Keowee Units 1 And 2 Are Supplying The Grid		0.0	0.00E+00	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
XD1DALTBYM	Normal Power To Dist. Center 1DA Is In Test or Maintenance		5.48E-03	5.48E-03	
XD2KBATBYF	Keowee Battery No. 2 Fails during Discharge	9.30E-04	1	9.30E-04	
87) PACN1N2COM	Common Cause Failure Of Breakers N1 And N2 To Open		3.000E-05	3.00E-05	7.29E-08
T5SUBF	Loss Of The Oconee Station Switchyards Initiating Event		4.86E-02	4.86E-02	
PACN1N2REC	Operators Fail To Open N1 and N2 Within 40 Minutes		5.0e-02	5.00E-02	
88) ABPOPRCRHE	Operators Fail To Close Air Circuit Breaker 4		9.0E-03	9.00E-03	7.26E-08
ACB4MOD	NSM-ON-52966 Is Not In Service		1	1.00E+00	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
WK1TBRNDEX	Keowee Unit 1 Turbine Fails With the Unit Running		5.6e-4	5.60E-04	
89) ABPOPRCRHE	Operators Fail To Close Air Circuit Breaker 4		9.0E-03	9.00E-03	7.26E-08
ACB4MOD	NSM-ON-52966 Is Not In Service		1	1.00E+00	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
WK1GVRNDEX	Keowee Unit 1 Gov. Fails to Position Wicket Gates With Unit Running		5.6E-4	5.60E-04	
90) ACBAIRPDEX	ACB Air Supply Fails Causing Low Pressure In All ACB Accumulators		2.00E-03	2.00E-03	7.11E-08
EK1VREGDEX	KHU-1 Voltage Adjust Failure Drives Generator Output Too High/Low		2.47E-3	2.47E-03	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
91)-XA1XAALBLM	MCC 1XA Is Connected to Its Alternate Source of Power		2.74E-03	2.74E-03	7.04E-08
-AD1B4ALCDT	Breaker 4AL In 125 V dc Distribution Center 1DA Transfers Open	7.5E-08	30	2.25E-06	
-AB7OPENLHE	Air Circuit Breaker 7 Fails To Open Due To A Latent Human Error		3.20E-3	3.20E-03	
-AB7MECHDEX	Air Circuit Breaker 7 Fails To Open Due To Mechanical Failure		8.01E-04	8.01E-04	
-AB752TCRYD	Air Circuit Breaker 7 Trip Coil TC Fails On Demand	3.3E-05	1	3.30E-05	
-AB710AFFUF	One Or More Air Circuit Breaker 7 Control Power Fuses Fail	3.6E-06	6	2.16E-05	
-AB51431SWT	Manual/Auto Control Switch 143/1 Spuriously Transfers Into Manual	7.0E-08	360	2.52E-05	
-AB51431LHE	Manual/Auto Control Switch 143/1 Left In Manual		3.20E-4	3.20E-04	
-AA227X2RYD	Auxiliary Relay 27X/2X Fails To Operate On Demand	3.3E-05	1	3.30E-05	
-AA127X2R6D	Transformer CX Undervoltage Relay 27/CX1 Fails To Drop Out	2.49E-04	1	2.49E-04	
AB752Y2RYT	Air Circuit Breaker 7 Y-relay Spurious Operation	3.6E-07	360	1.30E-04	
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	

Table 7.3-1

Top 100 Cut Sets From The ONS-Keowee AC Power Integrated Model

Module/Event	Description	Rate	Exposure	Prob.	Cs Prob.
92)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	6.55E-08
-KK2RUNSDEX	Keowee Unit 2 Only Is Supplying The Grid		0.06	6.00E-02	
-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	
-KK1BOTHDEX	Keowee Units 1 And 2 Are Supplying The Grid		0.0	0.00E+00	
E12EXCTCOM	Units 1 & 2 Excit Fail Due To Common Cause Failure Of The Breakers		5.31E-05	5.31E-05	
T5FEEDF	Failure Of Electrical Grid Or Main Feeders Initiating Event		2.730E-02	2.73E-02	
PACLEE2REC	Operators Fail To Align Power From Lee Steam Station To Standby Buses		5.0e-02	5.00E-02	
93) ACBAIRPDEX	ACB Air Supply Fails Causing Low Pressure In All ACB Accumulators		2.00E-03	2.00E-03	6.54E-08
GK10001HGR	Keowee Unit 1 Generator Fault While the Unit Runs	9.46E-05	24	2.27E-03	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
94) EK1BAS2DEX	KHU-1 Base Adjust Fails To Maintain Generator Output Within Acceptable R		1.24E-3	1.24E-03	6.43E-08
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
T5FEEDF	Failure Of Electrical Grid Or Main Feeders Initiating Event		2.730E-02	2.73E-02	
PACLEE2REC	Operators Fail To Align Power From Lee Steam Station To Standby Buses		5.0e-02	5.00E-02	
95) PACS1S2COM	Common Cause Failure Of Breakers S1 And S2 To Close		8.900E-05	8.90E-05	6.41E-08
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
PACS1S2REC	Failure To Manually Close Breakers S1 and S2		5.0e-02	5.00E-02	
96) PACSK12COM	Common Cause Failure Of Breakers SK1 And SK2 To Close		8.900E-05	8.90E-05	6.41E-08
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
PACSK12REC	Failure To Manually Close Breakers SK1 and SK2		5.0e-02	5.00E-02	
97)-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	5.99E-08
-KK1BOTHDEX	Keowee Units 1 And 2 Are Supplying The Grid		0.0	0.00E+00	
ABPOPRCRHE	Operators Fail To Close Air Circuit Breaker 4		9.0E-03	9.00E-03	
ACB4MOD	NSM-ON-52966 Is Not In Service		1	1.00E+00	
EK1SPYMDEX	Keowee Unit 1 Supply Breaker Fails To Close Due To Mehanical Failure		4.62E-4	4.62E-04	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
98)-XA1XAALBLM	MCC 1XA Is Connected to Its Alternate Source of Power		2.74E-03	2.74E-03	5.84E-08
-KK2RUNSDEX	Keowee Unit 2 Only Is Supplying The Grid		0.06	6.00E-02	
-KK1BOTHDEX	Keowee Units 1 And 2 Are Supplying The Grid		0.0	0.00E+00	
-AD1B4ALCDT	Breaker 4AL In 125 V dc Distribution Center 1DA Transfers Open	7.5E-08	30	2.25E-06	
-AB7OPENLHE	Air Circuit Breaker 7 Fails To Open Due To A Latent Human Error		3.20E-3	3.20E-03	
-AB7MECHDEX	Air Circuit Breaker 7 Fails To Open Due To Mechanical Failure		8.01E-04	8.01E-04	
-AB752TCRYD	Air Circuit Breaker 7 Trip Coil TC Fails On Demand	3.3E-05	1	3.30E-05	
-AB710AFFUF	One Or More Air Circuit Breaker 7 Control Power Fuses Fail	3.6E-06	6	2.16E-05	
-AB51431SWT	Manual/Auto Control Switch 143/1 Spuriously Transfers Into Manual	7.0E-08	360	2.52E-05	
-AB51431LHE	Manual/Auto Control Switch 143/1 Left In Manual		3.20E-4	3.20E-04	
-AA227X2RYD	Auxiliary Relay 27X/2X Fails To Operate On Demand	3.3E-05	1	3.30E-05	
-AA127X2R6D	Transformer CX Undervoltage Relay 27/CX1 Fails To Drop Out	2.49E-04	1	2.49E-04	
AB7MCH2DEX	Air Circuit Breaker 7 Fails To Close Due To Mechanical Failure		7.04E-03	7.04E-03	
EK2BASEDEX	Keowee Unit 2 Base Adjust Fails To Establish Correct Unit Voltage		6.17E-4	6.17E-04	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
99)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	5.80E-08
EK00RUNCOM	Common Cause Failure Of Both Units Voltage Regulators To Run		1.24E-4	1.24E-04	
T5SUBF	Loss Of The Oconee Station Switchyards Initiating Event		4.86E-02	4.86E-02	
PACLEE1REC	Operators Fail To Align Power From Lee Steam Station To Standby Buses		1.0e-02	1.00E-02	

Table 7.3-1

Top 100 Cut Sets From The ONS-Keowee AC Power Integrated Model

Module/Event	Description	Rate	Exposure	Prob.	Cs Prob.
100)-XA1XAALBLM	MCC 1XA Is Connected to Its Alternate Source of Power		2.74E-03	2.74E-03	5.64E-08
-AD1B4ALCDT	Breaker 4AL In 125 V dc Distribution Center 1DA Transfers Open	7.5E-08	30	2.25E-06	
-AB7OPENLHE	Air Circuit Breaker 7 Fails To Open Due To A Latent Human Error		3.20E-3	3.20E-03	
-AB7MECHDEX	Air Circuit Breaker 7 Fails To Open Due To Mechanical Failure		8.01E-04	8.01E-04	
-AB752TCRYD	Air Circuit Breaker 7 Trip Coil TC Fails On Demand	3.3E-05	1	3.30E-05	
-AB710AFFUF	One Or More Air Circuit Breaker 7 Control Power Fuses Fail	3.6E-06	6	2.16E-05	
-AB51431SWT	Manual/Auto Control Switch 143/1 Spuriously Transfers Into Manual	7.0E-08	360	2.52E-05	
-AB51431LHE	Manual/Auto Control Switch 143/1 Left In Manual		3.20E-4	3.20E-04	
-AA227X2RYD	Auxiliary Relay 27X/2X Fails To Operate On Demand	3.3E-05	1	3.30E-05	
-AA127X2R6D	Transformer CX Undervoltage Relay 27/CX1 Fails To Drop Out	2.49E-04	1	2.49E-04	
AB7MCH2DEX	Air Circuit Breaker 7 Fails To Close Due To Mechanical Failure		7.04E-03	7.04E-03	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
WK2GVRNDEX	Keowee Unit 2 Gov. Fails to Position Wicket Gates With Unit Running		5.6E-4	5.60E-04	

Table 7.3-2

Basic Event Importance Measures From The ONS-Keowee AC Power Integrated Model

Basic Event	Probability	Fus. Ves.	Critic	Birnbm	Red Wrth	Ach Wrth
T5WEATH	1.44E-02	8.46E-01	8.45E-01	3.79E-03	6.50E+00	5.88E+01
KK2UNITHYM	3.80E-02	2.06E-01	2.06E-01	3.50E-04	1.26E+00	6.22E+00
SXFRCT4THM	9.13E-04	2.03E-01	2.03E-01	1.43E-02	1.25E+00	2.23E+02
KK1BOTHHYM	5.23E-03	1.78E-01	1.78E-01	2.20E-03	1.22E+00	3.49E+01
PAC0T5WDEX	1.00E-01	1.17E-01	1.17E-01	7.53E-05	1.13E+00	2.05E+00
AB7MCH2DEX	7.04E-03	9.43E-02	9.42E-02	8.64E-04	1.10E+00	1.43E+01
AB0SWGRRHE	5.00E-01	9.02E-02	9.02E-02	1.16E-05	1.10E+00	1.09E+00
AB0SWGRCOM	6.69E-04	8.10E-02	8.10E-02	7.81E-03	1.09E+00	1.22E+02
T5SUBF	4.86E-02	7.92E-02	7.92E-02	1.05E-04	1.09E+00	2.55E+00
T5FEEDF	2.73E-02	7.47E-02	7.47E-02	1.76E-04	1.08E+00	3.66E+00
PACLINEDEX	7.80E-03	4.80E-02	4.80E-02	3.97E-04	1.05E+00	7.10E+00
ACB4MOD	1.00E+00	4.42E-02	4.42E-02	2.85E-06	1.05E+00	1.00E+00
PACLEE2REC	5.00E-02	4.27E-02	4.27E-02	5.51E-05	1.04E+00	1.81E+00
ABPOPRCRHE	9.00E-03	3.99E-02	3.99E-02	2.86E-04	1.04E+00	5.40E+00
FK0FISHDHE	6.30E-02	3.90E-02	3.90E-02	3.99E-05	1.04E+00	1.58E+00
FK0FISHCOM	2.55E-03	3.89E-02	3.89E-02	9.85E-04	1.04E+00	1.62E+01
EK1VREGDEX	2.47E-03	3.76E-02	3.76E-02	9.83E-04	1.04E+00	1.62E+01
GK10001HGR	2.27E-03	3.43E-02	3.43E-02	9.75E-04	1.04E+00	1.61E+01
EK00RUNCOM	1.24E-04	3.00E-02	3.00E-02	1.56E-02	1.03E+00	2.43E+02
PACLEE1REC	1.00E-02	2.61E-02	2.61E-02	1.68E-04	1.03E+00	3.58E+00
EK1BAS2DEX	1.24E-03	1.84E-02	1.84E-02	9.58E-04	1.02E+00	1.58E+01
XD1KBATBYF	9.30E-04	1.80E-02	1.80E-02	1.25E-03	1.02E+00	2.03E+01
UACXCT4THF	7.44E-05	1.74E-02	1.74E-02	1.51E-02	1.02E+00	2.35E+02
SXFRCT4LHE	6.40E-05	1.48E-02	1.48E-02	1.49E-02	1.01E+00	2.32E+02
XD0KBATRHE	1.00E+00	1.42E-02	1.42E-02	9.16E-07	1.01E+00	1.00E+00
EKSTARTCOM	6.17E-05	1.41E-02	1.40E-02	1.47E-02	1.01E+00	2.28E+02
PACLEESCTR	2.23E-03	1.37E-02	1.37E-02	3.97E-04	1.01E+00	7.14E+00
EK2VREGDEX	2.47E-03	1.27E-02	1.27E-02	3.32E-04	1.01E+00	6.13E+00
E12EXCTCOM	5.31E-05	1.21E-02	1.21E-02	1.47E-02	1.01E+00	2.28E+02
GK20001HGR	2.27E-03	1.15E-02	1.15E-02	3.27E-04	1.01E+00	6.06E+00
XD1KB1XRHE	1.00E+00	9.35E-03	9.35E-03	6.03E-07	1.01E+00	1.00E+00
XD1CKC1BCF	6.96E-04	9.34E-03	9.34E-03	8.66E-04	1.01E+00	1.44E+01
ACBAIRPDEX	2.00E-03	9.21E-03	9.20E-03	2.97E-04	1.01E+00	5.59E+00
EK1BASELHE	3.20E-03	8.92E-03	8.92E-03	1.80E-04	1.01E+00	3.78E+00
EK1BASEDEX	6.17E-04	8.52E-03	8.51E-03	8.90E-04	1.01E+00	1.48E+01
XD0CHRGCOM	3.48E-05	8.43E-03	8.42E-03	1.56E-02	1.01E+00	2.43E+02
WK1TBRNDEX	5.60E-04	7.73E-03	7.73E-03	8.90E-04	1.01E+00	1.48E+01
WK1GVRNDEX	5.60E-04	7.73E-03	7.73E-03	8.90E-04	1.01E+00	1.48E+01
XD0BATTCOM	2.70E-05	6.54E-03	6.53E-03	1.56E-02	1.01E+00	2.43E+02
EK1SPYMDEX	4.62E-04	6.25E-03	6.24E-03	8.72E-04	1.01E+00	1.45E+01
FKVALVECOM	2.46E-05	5.96E-03	5.95E-03	1.56E-02	1.01E+00	2.43E+02

Table 7.3-2

Basic Event Importance Measures From The ONS-Keowee AC Power Integrated Model

Basic Event	Probability	Fus. Ves.	Critic	Birnbm	Red Wrth	Ach Wrth
XA1XCXXTHM	4.57E-04	5.81E-03	5.81E-03	8.21E-04	1.01E+00	1.37E+01
EK2BAS2DEX	1.24E-03	5.78E-03	5.78E-03	3.01E-04	1.01E+00	5.66E+00
XD2KBATBYF	9.30E-04	5.11E-03	5.11E-03	3.54E-04	1.01E+00	6.49E+00
WK00RUNCOM	2.09E-05	5.06E-03	5.05E-03	1.56E-02	1.01E+00	2.43E+02
GK0BRGVRHE	1.00E+00	4.86E-03	4.86E-03	3.14E-07	1.00E+00	1.00E+00
Y0STARTCOM	7.26E-06	4.75E-03	4.70E-03	4.18E-02	1.00E+00	6.48E+02
Y0STARTRHE	1.00E+00	4.75E-03	4.75E-03	3.06E-07	1.00E+00	1.00E+00
PACS1S2COM	8.90E-05	4.43E-03	4.42E-03	3.21E-03	1.00E+00	5.07E+01
PACS1S2REC	5.00E-02	4.43E-03	4.43E-03	5.71E-06	1.00E+00	1.08E+00
XA1BKRSCOM	3.10E-04	4.29E-03	4.29E-03	8.94E-04	1.00E+00	1.48E+01
GK1BRGVLHE	2.60E-04	4.01E-03	4.01E-03	9.95E-04	1.00E+00	1.64E+01
EK0BASERHE	1.90E-02	3.96E-03	3.96E-03	1.35E-05	1.00E+00	1.20E+00
PACS2CSMOD	2.83E-03	3.96E-03	3.96E-03	9.01E-05	1.00E+00	2.39E+00
PACS1CSMOD	2.83E-03	3.96E-03	3.96E-03	9.01E-05	1.00E+00	2.39E+00
EK1DIODDEX	2.88E-04	3.59E-03	3.59E-03	8.04E-04	1.00E+00	1.35E+01
OK0PRUNCOM	1.46E-05	3.54E-03	3.53E-03	1.56E-02	1.00E+00	2.43E+02
XA78BKRCOM	3.10E-04	3.36E-03	3.35E-03	6.98E-04	1.00E+00	1.18E+01
FK1WL11AVO	2.80E-04	3.34E-03	3.33E-03	7.69E-04	1.00E+00	1.29E+01
WK1GVCDLHE	2.60E-04	3.10E-03	3.10E-03	7.69E-04	1.00E+00	1.29E+01
EK1FLSCLHE	2.60E-04	3.10E-03	3.10E-03	7.69E-04	1.00E+00	1.29E+01
EK1SPYCLHE	2.60E-04	3.10E-03	3.10E-03	7.69E-04	1.00E+00	1.29E+01
EK1FLDCLHE	2.60E-04	3.10E-03	3.10E-03	7.69E-04	1.00E+00	1.29E+01
EK1FLSOLHE	2.60E-04	3.10E-03	3.10E-03	7.69E-04	1.00E+00	1.29E+01
GK1COOLLHE	2.60E-04	3.10E-03	3.10E-03	7.69E-04	1.00E+00	1.29E+01
XD2CKC2BCF	6.96E-04	3.10E-03	3.10E-03	2.87E-04	1.00E+00	5.45E+00
XD2KB2XRHE	1.00E+00	3.10E-03	3.10E-03	2.00E-07	1.00E+00	1.00E+00
EK141AXR6D	2.49E-04	2.97E-03	2.97E-03	7.69E-04	1.00E+00	1.29E+01
WKCSTRTCOM	1.12E-05	2.55E-03	2.55E-03	1.47E-02	1.00E+00	2.28E+02
AB7CLOSLHE	2.60E-04	2.54E-03	2.54E-03	6.30E-04	1.00E+00	1.08E+01
AA127CPR6D	2.49E-04	2.43E-03	2.43E-03	6.30E-04	1.00E+00	1.08E+01
EK2BASEDEX	6.17E-04	2.40E-03	2.40E-03	2.51E-04	1.00E+00	4.89E+00
WK2GVRNDEX	5.60E-04	2.32E-03	2.32E-03	2.67E-04	1.00E+00	5.14E+00
WK2TBRNDEX	5.60E-04	2.32E-03	2.32E-03	2.67E-04	1.00E+00	5.14E+00
XA2BKRSCOM	3.10E-04	2.22E-03	2.22E-03	4.62E-04	1.00E+00	8.15E+00
KK1UNDRBHF	9.60E-06	2.21E-03	2.21E-03	1.49E-02	1.00E+00	2.32E+02
PACN1N2REC	5.00E-02	2.10E-03	2.10E-03	2.71E-06	1.00E+00	1.04E+00
PACN1N2COM	3.00E-05	2.10E-03	2.10E-03	4.51E-03	1.00E+00	7.09E+01
XD1DALTBYM	5.48E-03	2.09E-03	2.09E-03	2.46E-05	1.00E+00	1.38E+00
EK2BASELHE	3.20E-03	2.01E-03	2.01E-03	4.05E-05	1.00E+00	1.63E+00
U51TNC4RYT	8.64E-06	2.00E-03	2.00E-03	1.49E-02	1.00E+00	2.32E+02
U87TCT4RYT	8.64E-06	2.00E-03	2.00E-03	1.49E-02	1.00E+00	2.32E+02

Table 7.3-2

Basic Event Importance Measures From The ONS-Keowee AC Power Integrated Model

Basic Event	Probability	Fus. Ves.	Critic	Birnbm	Red Wrth	Ach Wrth
U86TCT4RYT	8.64E-06	2.00E-03	2.00E-03	1.49E-02	1.00E+00	2.32E+02
U5186EFRYT	8.64E-06	2.00E-03	2.00E-03	1.49E-02	1.00E+00	2.32E+02
UXX86EFRYT	8.64E-06	2.00E-03	2.00E-03	1.49E-02	1.00E+00	2.32E+02
U86CT4XRYT	8.64E-06	2.00E-03	2.00E-03	1.49E-02	1.00E+00	2.32E+02
U62BSK1RYT	8.64E-06	2.00E-03	2.00E-03	1.49E-02	1.00E+00	2.32E+02
U5086EFRYT	8.64E-06	2.00E-03	2.00E-03	1.49E-02	1.00E+00	2.32E+02
U62BSK2RYT	8.64E-06	2.00E-03	2.00E-03	1.49E-02	1.00E+00	2.32E+02
EK2SPYMDEX	4.62E-04	1.97E-03	1.97E-03	2.76E-04	1.00E+00	5.27E+00
GK10001HGS	1.54E-04	1.82E-03	1.82E-03	7.64E-04	1.00E+00	1.28E+01
PACSK12COM	8.90E-05	1.74E-03	1.74E-03	1.26E-03	1.00E+00	2.06E+01
OK1AG04RVT	1.34E-04	1.58E-03	1.58E-03	7.59E-04	1.00E+00	1.28E+01
OK10003RVT	1.34E-04	1.58E-03	1.58E-03	7.59E-04	1.00E+00	1.28E+01
PACSK2CMOD	1.30E-03	1.56E-03	1.56E-03	7.72E-05	1.00E+00	2.19E+00
PACSK1CMOD	1.30E-03	1.56E-03	1.56E-03	7.72E-05	1.00E+00	2.19E+00
GK2BRGVLHE	2.60E-04	1.43E-03	1.43E-03	3.56E-04	1.00E+00	6.51E+00
AB752Y2RYT	1.30E-04	1.24E-03	1.24E-03	6.20E-04	1.00E+00	1.06E+01
XD2DALTBYM	5.48E-03	1.23E-03	1.23E-03	1.45E-05	1.00E+00	1.22E+00
YK1SS12SST	1.01E-04	1.18E-03	1.18E-03	7.57E-04	1.00E+00	1.27E+01
AB6MCH2DEX	7.04E-03	1.08E-03	1.08E-03	9.86E-06	1.00E+00	1.15E+00
EK1F30AFUF	8.64E-05	1.01E-03	1.01E-03	7.51E-04	1.00E+00	1.26E+01
PACSK12REC	5.00E-02	1.00E-03	1.00E-03	1.29E-06	1.00E+00	1.02E+00
GK0LOCKCOM	4.06E-06	9.84E-04	9.82E-04	1.56E-02	1.00E+00	2.43E+02
PACXSB1BHM	1.02E-03	9.78E-04	9.78E-04	6.19E-05	1.00E+00	1.96E+00
PACXSB2BHM	1.02E-03	9.78E-04	9.78E-04	6.19E-05	1.00E+00	1.96E+00
EK1EXC1TGF	8.23E-05	9.62E-04	9.62E-04	7.54E-04	1.00E+00	1.27E+01
EK2DIODDEX	2.88E-04	9.32E-04	9.32E-04	2.09E-04	1.00E+00	4.24E+00
EK1FLSMDEX	7.71E-05	9.01E-04	9.01E-04	7.54E-04	1.00E+00	1.27E+01
EK1FLDMDEX	7.71E-05	9.01E-04	9.01E-04	7.54E-04	1.00E+00	1.27E+01
FK2WL11AVO	2.80E-04	7.52E-04	7.52E-04	1.73E-04	1.00E+00	3.69E+00
GK2COOLLHE	2.60E-04	6.99E-04	6.98E-04	1.73E-04	1.00E+00	3.69E+00
EK241AXR6D	2.49E-04	6.69E-04	6.69E-04	1.73E-04	1.00E+00	3.69E+00
WK1SPD2DEX	5.60E-05	6.57E-04	6.57E-04	7.57E-04	1.00E+00	1.27E+01
EK2SPYCLHE	2.60E-04	6.57E-04	6.57E-04	1.63E-04	1.00E+00	3.52E+00
EK2FLSOLHE	2.60E-04	6.57E-04	6.57E-04	1.63E-04	1.00E+00	3.52E+00
EK2FLSCLHE	2.60E-04	6.57E-04	6.57E-04	1.63E-04	1.00E+00	3.52E+00
EK2FLDCLHE	2.60E-04	6.57E-04	6.57E-04	1.63E-04	1.00E+00	3.52E+00
WK2GVCDLHE	2.60E-04	6.57E-04	6.57E-04	1.63E-04	1.00E+00	3.52E+00
FK1WL11AVT	5.52E-05	6.43E-04	6.43E-04	7.51E-04	1.00E+00	1.26E+01
GK1NGDCLHE	5.20E-05	6.06E-04	6.05E-04	7.51E-04	1.00E+00	1.26E+01
PK0SUMPCOM	2.44E-06	5.91E-04	5.90E-04	1.56E-02	1.00E+00	2.43E+02
XA2XAALBLM	2.74E-03	5.62E-04	5.62E-04	1.32E-05	1.00E+00	1.20E+00

Table 7.3-2

Basic Event Importance Measures From The ONS-Keowee AC Power Integrated Model

Basic Event	Probability	Fus. Ves.	Critic	Birnbm	Red Wrth	Ach Wrth
BK1GBO1FTC	4.32E-05	5.03E-04	5.03E-04	7.51E-04	1.00E+00	1.26E+01
BKGBOILCOM	1.94E-06	4.70E-04	4.69E-04	1.56E-02	1.00E+00	2.43E+02
PACXCT5THF	7.44E-05	4.58E-04	4.58E-04	3.97E-04	1.00E+00	7.15E+00
EK188SVRYT	3.89E-05	4.53E-04	4.53E-04	7.51E-04	1.00E+00	1.26E+01
AB4MCH2DEX	3.02E-04	4.08E-04	4.08E-04	8.72E-05	1.00E+00	2.35E+00
WK1GVCDDEX	3.50E-05	4.08E-04	4.08E-04	7.51E-04	1.00E+00	1.26E+01
WK1TBCDDEX	3.50E-05	4.08E-04	4.08E-04	7.51E-04	1.00E+00	1.26E+01
YK1MR4ARYD	3.30E-05	3.84E-04	3.84E-04	7.51E-04	1.00E+00	1.26E+01
YK199SXRYD	3.30E-05	3.84E-04	3.84E-04	7.51E-04	1.00E+00	1.26E+01
YK199SNRYD	3.30E-05	3.84E-04	3.84E-04	7.51E-04	1.00E+00	1.26E+01
YK199SDRYD	3.30E-05	3.84E-04	3.84E-04	7.51E-04	1.00E+00	1.26E+01
EK188SVRYD	3.30E-05	3.84E-04	3.84E-04	7.51E-04	1.00E+00	1.26E+01
EK1S41XRYD	3.30E-05	3.84E-04	3.84E-04	7.51E-04	1.00E+00	1.26E+01
EK1R31YRYD	3.30E-05	3.84E-04	3.84E-04	7.51E-04	1.00E+00	1.26E+01
EK1F31XRYD	3.30E-05	3.84E-04	3.84E-04	7.51E-04	1.00E+00	1.26E+01
EK141CFRYD	3.30E-05	3.84E-04	3.84E-04	7.51E-04	1.00E+00	1.26E+01
EK1415YRYD	3.30E-05	3.84E-04	3.84E-04	7.51E-04	1.00E+00	1.26E+01
EK199SYRYD	3.30E-05	3.84E-04	3.84E-04	7.51E-04	1.00E+00	1.26E+01
EK1S41CRYD	3.30E-05	3.84E-04	3.84E-04	7.51E-04	1.00E+00	1.26E+01
EK1R31TRYD	3.30E-05	3.84E-04	3.84E-04	7.51E-04	1.00E+00	1.26E+01
EK1R41YRYD	3.30E-05	3.84E-04	3.84E-04	7.51E-04	1.00E+00	1.26E+01
EK1F41CRYD	3.30E-05	3.84E-04	3.84E-04	7.51E-04	1.00E+00	1.26E+01
EK1R41XRYD	3.30E-05	3.84E-04	3.84E-04	7.51E-04	1.00E+00	1.26E+01
GK1FIREDEX	3.19E-05	3.71E-04	3.71E-04	7.51E-04	1.00E+00	1.26E+01
PK1PACKDEX	3.10E-05	3.61E-04	3.61E-04	7.51E-04	1.00E+00	1.26E+01
EK1R9C1R6T	3.05E-05	3.55E-04	3.55E-04	7.51E-04	1.00E+00	1.26E+01
EK1901ARYT	3.02E-05	3.52E-04	3.52E-04	7.51E-04	1.00E+00	1.26E+01
EK186EXRYT	3.02E-05	3.52E-04	3.52E-04	7.51E-04	1.00E+00	1.26E+01
EK1R9A1RYT	3.02E-05	3.52E-04	3.52E-04	7.51E-04	1.00E+00	1.26E+01
EK1415YRYT	3.02E-05	3.52E-04	3.52E-04	7.51E-04	1.00E+00	1.26E+01
EK1R41YRYT	3.02E-05	3.52E-04	3.52E-04	7.51E-04	1.00E+00	1.26E+01
EK131TDRYT	3.02E-05	3.52E-04	3.52E-04	7.51E-04	1.00E+00	1.26E+01
EK1R31YRYT	3.02E-05	3.52E-04	3.52E-04	7.51E-04	1.00E+00	1.26E+01
PK1ACDCCOM	2.77E-05	3.23E-04	3.23E-04	7.51E-04	1.00E+00	1.26E+01
AB7R52YRYD	3.30E-05	3.13E-04	3.13E-04	6.13E-04	1.00E+00	1.05E+01
AA127XCRYD	3.30E-05	3.13E-04	3.13E-04	6.13E-04	1.00E+00	1.05E+01
AB7R52XRYD	3.30E-05	3.13E-04	3.13E-04	6.13E-04	1.00E+00	1.05E+01
AB752CCRYD	3.30E-05	3.13E-04	3.13E-04	6.13E-04	1.00E+00	1.05E+01
ACBXFERCOM	1.28E-06	3.10E-04	3.10E-04	1.56E-02	1.00E+00	2.43E+02
XA0SWGRCOM	1.22E-06	2.96E-04	2.95E-04	1.56E-02	1.00E+00	2.43E+02
FK1FL02FRF	2.35E-05	2.74E-04	2.74E-04	7.51E-04	1.00E+00	1.26E+01

Table 7.3-2

Basic Event Importance Measures From The ONS-Keowee AC Power Integrated Model

Basic Event	Probability	Fus. Ves.	Critic	Birnbm	Red Wrth	Ach Wrth
EK1EXC2TGF	2.35E-05	2.74E-04	2.74E-04	7.51E-04	1.00E+00	1.26E+01
GK20002HGS	1.54E-04	2.70E-04	2.70E-04	1.13E-04	1.00E+00	2.75E+00
XA1XAALBLM	2.74E-03	2.52E-04	2.52E-04	5.94E-06	1.00E+00	1.09E+00
OK20003RVT	1.34E-04	2.51E-04	2.51E-04	1.20E-04	1.00E+00	2.87E+00
OK2AG04RVT	1.34E-04	2.51E-04	2.51E-04	1.20E-04	1.00E+00	2.87E+00
AB7KEYISWT	2.52E-05	2.39E-04	2.39E-04	6.13E-04	1.00E+00	1.05E+01
OK1PSTRCOM	2.04E-05	2.38E-04	2.38E-04	7.51E-04	1.00E+00	1.26E+01
PAC1TC4C4T	2.26E-05	2.15E-04	2.15E-04	6.16E-04	1.00E+00	1.05E+01
AB4CLOSLHE	2.60E-04	2.08E-04	2.08E-04	5.17E-05	1.00E+00	1.80E+00
PACXN02C4O	3.00E-04	2.01E-04	2.01E-04	4.33E-05	1.00E+00	1.67E+00
PACXSK2C4C	3.00E-04	2.01E-04	2.01E-04	4.33E-05	1.00E+00	1.67E+00
PACXS01C4C	3.00E-04	2.01E-04	2.01E-04	4.33E-05	1.00E+00	1.67E+00
PACXS02C4C	3.00E-04	2.01E-04	2.01E-04	4.33E-05	1.00E+00	1.67E+00
PACXN01C4O	3.00E-04	2.01E-04	2.01E-04	4.33E-05	1.00E+00	1.67E+00
PACXSK1C4C	3.00E-04	2.01E-04	2.01E-04	4.33E-05	1.00E+00	1.67E+00
AB4R52XR6D	2.49E-04	1.99E-04	1.99E-04	5.17E-05	1.00E+00	1.80E+00
AB452Y2R6D	2.49E-04	1.99E-04	1.99E-04	5.17E-05	1.00E+00	1.80E+00
AB24BKRCOM	1.12E-04	1.98E-04	1.98E-04	1.14E-04	1.00E+00	2.77E+00
YK2SS12SST	1.01E-04	1.86E-04	1.86E-04	1.19E-04	1.00E+00	2.84E+00
FK1FL01FRF	2.35E-05	1.28E-04	1.28E-04	3.50E-04	1.00E+00	6.43E+00
AB5MCH2DEX	7.04E-03	1.21E-04	1.21E-04	1.11E-06	1.00E+00	1.02E+00
WK2SPD2DEX	5.60E-05	1.05E-04	1.05E-04	1.20E-04	1.00E+00	2.87E+00
XA1X2CCCLT	2.18E-05	6.90E-05	6.90E-05	2.04E-04	1.00E+00	4.16E+00
YK114X3SSD	1.80E-05	5.70E-05	5.70E-05	2.04E-04	1.00E+00	4.17E+00
EK1FAN1TLF	1.80E-05	5.70E-05	5.70E-05	2.04E-04	1.00E+00	4.17E+00
YK1SS13SSD	1.80E-05	5.70E-05	5.70E-05	2.04E-04	1.00E+00	4.17E+00
GK1HPO3HXF	1.54E-05	4.86E-05	4.86E-05	2.04E-04	1.00E+00	4.17E+00
GK1GAC1HXF	1.54E-05	4.86E-05	4.86E-05	2.04E-04	1.00E+00	4.17E+00
GK1HPO2HXF	1.54E-05	4.86E-05	4.86E-05	2.04E-04	1.00E+00	4.17E+00
GK1GAC5HXF	1.54E-05	4.86E-05	4.86E-05	2.04E-04	1.00E+00	4.17E+00
GK1GAC4HXF	1.54E-05	4.86E-05	4.86E-05	2.04E-04	1.00E+00	4.17E+00
GK1HPO6HXF	1.54E-05	4.86E-05	4.86E-05	2.04E-04	1.00E+00	4.17E+00
GK1HPO1HXF	1.54E-05	4.86E-05	4.86E-05	2.04E-04	1.00E+00	4.17E+00
GK1HPO8HXF	1.54E-05	4.86E-05	4.86E-05	2.04E-04	1.00E+00	4.17E+00
GK1GAC3HXF	1.54E-05	4.86E-05	4.86E-05	2.04E-04	1.00E+00	4.17E+00
GK1GAC6HXF	1.54E-05	4.86E-05	4.86E-05	2.04E-04	1.00E+00	4.17E+00
GK1HPO4HXF	1.54E-05	4.86E-05	4.86E-05	2.04E-04	1.00E+00	4.17E+00
GK1HPO5HXF	1.54E-05	4.86E-05	4.86E-05	2.04E-04	1.00E+00	4.17E+00
FK1TRHXHXF	1.54E-05	4.86E-05	4.86E-05	2.04E-04	1.00E+00	4.17E+00
GK1HPO7HXF	1.54E-05	4.86E-05	4.86E-05	2.04E-04	1.00E+00	4.17E+00
GK1GAC2HXF	1.54E-05	4.86E-05	4.86E-05	2.04E-04	1.00E+00	4.17E+00

Table 7.3-2

Basic Event Importance Measures From The ONS-Keowee AC Power Integrated Model

Basic Event	Probability	Fus. Ves.	Critic	Birnbm	Red Wrth	Ach Wrth
OK10003TKF	1.10E-05	3.50E-05	3.50E-05	2.04E-04	1.00E+00	4.17E+00
OK1AG01TKF	1.10E-05	3.50E-05	3.50E-05	2.04E-04	1.00E+00	4.17E+00
GK1GAC5HXL	1.08E-05	3.42E-05	3.42E-05	2.04E-04	1.00E+00	4.17E+00
GK1GAC2HXL	1.08E-05	3.42E-05	3.42E-05	2.04E-04	1.00E+00	4.17E+00
GK1GAC3HXL	1.08E-05	3.42E-05	3.42E-05	2.04E-04	1.00E+00	4.17E+00
GK1GAC4HXL	1.08E-05	3.42E-05	3.42E-05	2.04E-04	1.00E+00	4.17E+00
GK1GAC1HXL	1.08E-05	3.42E-05	3.42E-05	2.04E-04	1.00E+00	4.17E+00
GK1GAC6HXL	1.08E-05	3.42E-05	3.42E-05	2.04E-04	1.00E+00	4.17E+00
GK1063FPST	1.03E-05	3.27E-05	3.27E-05	2.04E-04	1.00E+00	4.17E+00
EK141AXR6T	8.71E-06	2.76E-05	2.76E-05	2.04E-04	1.00E+00	4.17E+00
AB3R52ZR6T	8.71E-06	2.76E-05	2.76E-05	2.04E-04	1.00E+00	4.17E+00
YK163BLRYT	8.64E-06	2.74E-05	2.74E-05	2.04E-04	1.00E+00	4.17E+00
YK14AMRRYT	8.64E-06	2.74E-05	2.74E-05	2.04E-04	1.00E+00	4.17E+00
YK163TBRYT	8.64E-06	2.74E-05	2.74E-05	2.04E-04	1.00E+00	4.17E+00
YK163BHRYT	8.64E-06	2.74E-05	2.74E-05	2.04E-04	1.00E+00	4.17E+00
YK199SDRYT	8.64E-06	2.74E-05	2.74E-05	2.04E-04	1.00E+00	4.17E+00
YK199SXRYT	8.64E-06	2.74E-05	2.74E-05	2.04E-04	1.00E+00	4.17E+00
YK199SNRYT	8.64E-06	2.74E-05	2.74E-05	2.04E-04	1.00E+00	4.17E+00
GK187GBRYT	8.64E-06	2.74E-05	2.74E-05	2.04E-04	1.00E+00	4.17E+00
GK187TERYT	8.64E-06	2.74E-05	2.74E-05	2.04E-04	1.00E+00	4.17E+00
EK186X2RYT	8.64E-06	2.74E-05	2.74E-05	2.04E-04	1.00E+00	4.17E+00
GK186E1RYT	8.64E-06	2.74E-05	2.74E-05	2.04E-04	1.00E+00	4.17E+00
EK199SYRYT	8.64E-06	2.74E-05	2.74E-05	2.04E-04	1.00E+00	4.17E+00
GK13SUIRYT	8.64E-06	2.74E-05	2.74E-05	2.04E-04	1.00E+00	4.17E+00
GK187G1RYT	8.64E-06	2.74E-05	2.74E-05	2.04E-04	1.00E+00	4.17E+00
GK162TDRYT	8.64E-06	2.74E-05	2.74E-05	2.04E-04	1.00E+00	4.17E+00
GK159GNRYT	8.64E-06	2.74E-05	2.74E-05	2.04E-04	1.00E+00	4.17E+00
GK140G1RYT	8.64E-06	2.74E-05	2.74E-05	2.04E-04	1.00E+00	4.17E+00
GK163FXRYT	8.64E-06	2.74E-05	2.74E-05	2.04E-04	1.00E+00	4.17E+00
AA186S1RYT	8.64E-06	2.73E-05	2.73E-05	2.04E-04	1.00E+00	4.16E+00
AB710A1FUF	2.16E-05	2.34E-05	2.34E-05	6.98E-05	1.00E+00	2.08E+00
AB352TCSVT	9.36E-06	2.21E-05	2.21E-05	1.52E-04	1.00E+00	3.36E+00
XA1XCXXTLF	1.80E-05	1.96E-05	1.96E-05	7.01E-05	1.00E+00	2.09E+00
XD1DARXBDF	7.68E-06	1.81E-05	1.81E-05	1.52E-04	1.00E+00	3.36E+00
EK2FLSMDEX	7.71E-05	1.78E-05	1.78E-05	1.49E-05	1.00E+00	1.23E+00
EK2FLDMDEX	7.71E-05	1.78E-05	1.78E-05	1.49E-05	1.00E+00	1.23E+00
YK163BLLST	7.44E-06	1.76E-05	1.76E-05	1.52E-04	1.00E+00	3.36E+00
YK163TBLST	7.44E-06	1.76E-05	1.76E-05	1.52E-04	1.00E+00	3.36E+00
YK163BHLST	7.44E-06	1.76E-05	1.76E-05	1.52E-04	1.00E+00	3.36E+00
EK2F30AFUF	8.64E-05	1.73E-05	1.73E-05	1.29E-05	1.00E+00	1.20E+00
GK2FIREDEX	7.00E-05	1.72E-05	1.72E-05	1.59E-05	1.00E+00	1.25E+00

Table 7.3-2

Basic Event Importance Measures From The ONS-Keowee AC Power Integrated Model

Basic Event	Probability	Fus. Ves.	Critic	Birnbm	Red Wrth	Ach Wrth
GK1WL44VVT	6.53E-06	1.54E-05	1.54E-05	1.52E-04	1.00E+00	3.36E+00
GK1WL69VVT	6.53E-06	1.54E-05	1.54E-05	1.52E-04	1.00E+00	3.36E+00
GK1WL33VVT	6.53E-06	1.54E-05	1.54E-05	1.52E-04	1.00E+00	3.36E+00
GK1WL45VVT	6.53E-06	1.54E-05	1.54E-05	1.52E-04	1.00E+00	3.36E+00
GK1WL16VVT	6.53E-06	1.54E-05	1.54E-05	1.52E-04	1.00E+00	3.36E+00
GK1WL29VVT	6.53E-06	1.54E-05	1.54E-05	1.52E-04	1.00E+00	3.36E+00
GK1WL57VVT	6.53E-06	1.54E-05	1.54E-05	1.52E-04	1.00E+00	3.36E+00
GK1WL48VVT	6.53E-06	1.54E-05	1.54E-05	1.52E-04	1.00E+00	3.36E+00
GK1WL52VVT	6.53E-06	1.54E-05	1.54E-05	1.52E-04	1.00E+00	3.36E+00
GK1WL60VVT	6.53E-06	1.54E-05	1.54E-05	1.52E-04	1.00E+00	3.36E+00
GK1WL61VVT	6.53E-06	1.54E-05	1.54E-05	1.52E-04	1.00E+00	3.36E+00
GK1WL25VVT	6.53E-06	1.54E-05	1.54E-05	1.52E-04	1.00E+00	3.36E+00
GK1WL68VVT	6.53E-06	1.54E-05	1.54E-05	1.52E-04	1.00E+00	3.36E+00
GK1WL76VVT	6.53E-06	1.54E-05	1.54E-05	1.52E-04	1.00E+00	3.36E+00
GK1WL17VVT	6.53E-06	1.54E-05	1.54E-05	1.52E-04	1.00E+00	3.36E+00
GK1WL65VVT	6.53E-06	1.54E-05	1.54E-05	1.52E-04	1.00E+00	3.36E+00
GK1WL24VVT	6.53E-06	1.54E-05	1.54E-05	1.52E-04	1.00E+00	3.36E+00
GK1WL41VVT	6.53E-06	1.54E-05	1.54E-05	1.52E-04	1.00E+00	3.36E+00
GK1WL64VVT	6.53E-06	1.54E-05	1.54E-05	1.52E-04	1.00E+00	3.36E+00
GK1WL32VVT	6.53E-06	1.54E-05	1.54E-05	1.52E-04	1.00E+00	3.36E+00
GK1WL53VVT	6.53E-06	1.54E-05	1.54E-05	1.52E-04	1.00E+00	3.36E+00
GK1WL73VVT	6.53E-06	1.54E-05	1.54E-05	1.52E-04	1.00E+00	3.36E+00
GK1WL28VVT	6.53E-06	1.54E-05	1.54E-05	1.52E-04	1.00E+00	3.36E+00
GK1WL20VVT	6.53E-06	1.54E-05	1.54E-05	1.52E-04	1.00E+00	3.36E+00
GK1WL72VVT	6.53E-06	1.54E-05	1.54E-05	1.52E-04	1.00E+00	3.36E+00
GK1WL21VVT	6.53E-06	1.54E-05	1.54E-05	1.52E-04	1.00E+00	3.36E+00
GK1WL78VVT	6.53E-06	1.54E-05	1.54E-05	1.52E-04	1.00E+00	3.36E+00
GK1WL37VVT	6.53E-06	1.54E-05	1.54E-05	1.52E-04	1.00E+00	3.36E+00
GK1WL56VVT	6.53E-06	1.54E-05	1.54E-05	1.52E-04	1.00E+00	3.36E+00
GK1WL49VVT	6.53E-06	1.54E-05	1.54E-05	1.52E-04	1.00E+00	3.36E+00
GK1WL36VVT	6.53E-06	1.54E-05	1.54E-05	1.52E-04	1.00E+00	3.36E+00
XA1XAMCBLF	6.48E-06	1.53E-05	1.53E-05	1.52E-04	1.00E+00	3.36E+00
XA1XXXXBLF	6.48E-06	1.53E-05	1.53E-05	1.52E-04	1.00E+00	3.36E+00
ED11D3DCDT	6.30E-06	1.49E-05	1.49E-05	1.52E-04	1.00E+00	3.36E+00
AB4PS02PST	1.60E-04	1.45E-05	1.45E-05	5.86E-06	1.00E+00	1.09E+00
EK1S141SWT	5.88E-06	1.39E-05	1.39E-05	1.52E-04	1.00E+00	3.36E+00
EK14152SWT	5.88E-06	1.39E-05	1.39E-05	1.52E-04	1.00E+00	3.36E+00
EK1S31TSWT	5.88E-06	1.39E-05	1.39E-05	1.52E-04	1.00E+00	3.36E+00
AB3PUSHPBT	5.76E-06	1.36E-05	1.36E-05	1.52E-04	1.00E+00	3.36E+00
GKHPOILCOM	4.61E-07	1.27E-05	1.27E-05	1.78E-03	1.00E+00	2.86E+01
GK0COOLCOM	4.61E-07	1.27E-05	1.27E-05	1.78E-03	1.00E+00	2.86E+01

Table 7.3-2

Basic Event Importance Measures From The ONS-Keowee AC Power Integrated Model

Basic Event	Probability	Fus. Ves.	Critic	Birnbm	Red Wrth	Ach Wrth
FK0WL01VVT	4.08E-07	1.17E-05	1.17E-05	1.85E-03	1.00E+00	2.97E+01
FK2WL11AVT	5.52E-05	1.11E-05	1.11E-05	1.29E-05	1.00E+00	1.20E+00
AB452Y2R6T	1.35E-04	1.10E-05	1.10E-05	5.26E-06	1.00E+00	1.08E+00
SPCB033CHO	2.60E-05	1.01E-05	1.01E-05	2.52E-05	1.00E+00	1.39E+00
SPCB021CHO	2.60E-05	1.01E-05	1.01E-05	2.52E-05	1.00E+00	1.39E+00
SPCB028CHO	2.60E-05	1.01E-05	1.01E-05	2.52E-05	1.00E+00	1.39E+00
SPCB024CHO	2.60E-05	1.01E-05	1.01E-05	2.52E-05	1.00E+00	1.39E+00
SPCB026CHO	2.60E-05	1.01E-05	1.01E-05	2.52E-05	1.00E+00	1.39E+00
SPCB017CHO	2.60E-05	1.01E-05	1.01E-05	2.52E-05	1.00E+00	1.39E+00
SPCB015CHO	2.60E-05	1.01E-05	1.01E-05	2.52E-05	1.00E+00	1.39E+00
SPCB012CHO	2.60E-05	1.01E-05	1.01E-05	2.52E-05	1.00E+00	1.39E+00
SPCB008CHO	2.60E-05	1.01E-05	1.01E-05	2.52E-05	1.00E+00	1.39E+00
AA127C1R6T	8.71E-06	9.47E-06	9.47E-06	7.01E-05	1.00E+00	2.09E+00
AA127R1RYT	8.64E-06	9.39E-06	9.39E-06	7.01E-05	1.00E+00	2.09E+00
AA186CXRYT	8.64E-06	9.39E-06	9.39E-06	7.01E-05	1.00E+00	2.09E+00
AA187CXRYT	8.64E-06	9.39E-06	9.39E-06	7.01E-05	1.00E+00	2.09E+00
AB752TCRYT	8.64E-06	9.39E-06	9.39E-06	7.01E-05	1.00E+00	2.09E+00
ABEOPRCRHE	1.00E+00	8.60E-06	8.60E-06	5.55E-10	1.00E+00	1.00E+00
SPCB009CHC	2.60E-04	5.31E-06	5.31E-06	1.32E-06	1.00E+00	1.02E+00
AB2MCH2DEX	3.02E-04	5.11E-06	5.11E-06	1.09E-06	1.00E+00	1.02E+00
XA56BKRCOM	3.10E-04	4.50E-06	4.50E-06	9.36E-07	1.00E+00	1.01E+00
EK186E2RYT	2.16E-06	4.48E-06	4.48E-06	1.34E-04	1.00E+00	3.08E+00
AA227T2R6D	2.49E-04	4.10E-06	4.10E-06	1.06E-06	1.00E+00	1.02E+00
AB252Y2R6D	2.49E-04	4.10E-06	4.10E-06	1.06E-06	1.00E+00	1.02E+00
AB2R52XR6D	2.49E-04	4.10E-06	4.10E-06	1.06E-06	1.00E+00	1.02E+00
AB2CLOSLHE	2.60E-04	4.02E-06	4.02E-06	9.98E-07	1.00E+00	1.02E+00
GK1WL51VVT	1.84E-06	3.81E-06	3.81E-06	1.34E-04	1.00E+00	3.08E+00
GK1WL54VVT	1.84E-06	3.81E-06	3.81E-06	1.34E-04	1.00E+00	3.08E+00
FK1WL12VVT	1.84E-06	3.81E-06	3.81E-06	1.34E-04	1.00E+00	3.08E+00
GK1WL55VVT	1.84E-06	3.81E-06	3.81E-06	1.34E-04	1.00E+00	3.08E+00
GK1WL35VVT	1.84E-06	3.81E-06	3.81E-06	1.34E-04	1.00E+00	3.08E+00
GK1WL67VVT	1.84E-06	3.81E-06	3.81E-06	1.34E-04	1.00E+00	3.08E+00
GK1WL59VVT	1.84E-06	3.81E-06	3.81E-06	1.34E-04	1.00E+00	3.08E+00
FK1WL42VVT	1.84E-06	3.81E-06	3.81E-06	1.34E-04	1.00E+00	3.08E+00
GK1WL71VVT	1.84E-06	3.81E-06	3.81E-06	1.34E-04	1.00E+00	3.08E+00
FK1WL43VVT	1.84E-06	3.81E-06	3.81E-06	1.34E-04	1.00E+00	3.08E+00
GK1WL62VVT	1.84E-06	3.81E-06	3.81E-06	1.34E-04	1.00E+00	3.08E+00
GK1WL27VVT	1.84E-06	3.81E-06	3.81E-06	1.34E-04	1.00E+00	3.08E+00
FK1WL15VVT	1.84E-06	3.81E-06	3.81E-06	1.34E-04	1.00E+00	3.08E+00
GK1WL58VVT	1.84E-06	3.81E-06	3.81E-06	1.34E-04	1.00E+00	3.08E+00
GK1WL23VVT	1.84E-06	3.81E-06	3.81E-06	1.34E-04	1.00E+00	3.08E+00

Table 7.3-2

Basic Event Importance Measures From The ONS-Keowee AC Power Integrated Model

Basic Event	Probability	Fus. Ves.	Critic	Birnbm	Red Wrth	Ach Wrth
GK1WL63VVT	1.84E-06	3.81E-06	3.81E-06	1.34E-04	1.00E+00	3.08E+00
GK1WL22VVT	1.84E-06	3.81E-06	3.81E-06	1.34E-04	1.00E+00	3.08E+00
GK1WL47VVT	1.84E-06	3.81E-06	3.81E-06	1.34E-04	1.00E+00	3.08E+00
GK1WL18VVT	1.84E-06	3.81E-06	3.81E-06	1.34E-04	1.00E+00	3.08E+00
GK1WL31VVT	1.84E-06	3.81E-06	3.81E-06	1.34E-04	1.00E+00	3.08E+00
GK1WL19VVT	1.84E-06	3.81E-06	3.81E-06	1.34E-04	1.00E+00	3.08E+00
GK1WL70VVT	1.84E-06	3.81E-06	3.81E-06	1.34E-04	1.00E+00	3.08E+00
GK1WL30VVT	1.84E-06	3.81E-06	3.81E-06	1.34E-04	1.00E+00	3.08E+00
GK1WL46VVT	1.84E-06	3.81E-06	3.81E-06	1.34E-04	1.00E+00	3.08E+00
GK1WL38VVT	1.84E-06	3.81E-06	3.81E-06	1.34E-04	1.00E+00	3.08E+00
GK1WL50VVT	1.84E-06	3.81E-06	3.81E-06	1.34E-04	1.00E+00	3.08E+00
GK1WL34VVT	1.84E-06	3.81E-06	3.81E-06	1.34E-04	1.00E+00	3.08E+00
GK1WL75VVT	1.84E-06	3.81E-06	3.81E-06	1.34E-04	1.00E+00	3.08E+00
GK1WL26VVT	1.84E-06	3.81E-06	3.81E-06	1.34E-04	1.00E+00	3.08E+00
GK1WL74VVT	1.84E-06	3.81E-06	3.81E-06	1.34E-04	1.00E+00	3.08E+00
GK1WL39VVT	1.84E-06	3.81E-06	3.81E-06	1.34E-04	1.00E+00	3.08E+00
GK1WL66VVT	1.84E-06	3.81E-06	3.81E-06	1.34E-04	1.00E+00	3.08E+00
AB5CLOSLHE	2.60E-04	3.77E-06	3.77E-06	9.36E-07	1.00E+00	1.01E+00
XD104CCCDT	1.80E-06	3.74E-06	3.74E-06	1.34E-04	1.00E+00	3.08E+00
ED13BR2CDT	1.80E-06	3.74E-06	3.74E-06	1.34E-04	1.00E+00	3.08E+00
XA1A2BTCDT	1.80E-06	3.72E-06	3.72E-06	1.33E-04	1.00E+00	3.06E+00
XD1BK1ACDT	1.80E-06	3.72E-06	3.72E-06	1.33E-04	1.00E+00	3.06E+00
XD1DA1CCDT	1.80E-06	3.72E-06	3.72E-06	1.33E-04	1.00E+00	3.06E+00
DDCBATTDEX	1.00E+00	3.63E-06	3.63E-06	2.34E-10	1.00E+00	1.00E+00
DDCUN31DIM	6.93E-04	3.63E-06	3.63E-06	3.38E-07	1.00E+00	1.01E+00
DDCX3CABCF	6.96E-04	3.63E-06	3.63E-06	3.37E-07	1.00E+00	1.01E+00
AA1271PR6D	2.49E-04	3.61E-06	3.61E-06	9.36E-07	1.00E+00	1.01E+00
EK1415TSWT	1.68E-06	3.49E-06	3.49E-06	1.34E-04	1.00E+00	3.08E+00
AB31523SWT	1.68E-06	3.49E-06	3.49E-06	1.34E-04	1.00E+00	3.08E+00
GK13SUISWT	1.68E-06	3.49E-06	3.49E-06	1.34E-04	1.00E+00	3.08E+00
EK1S41TSWT	1.68E-06	3.49E-06	3.49E-06	1.34E-04	1.00E+00	3.08E+00
YK13SUISWT	1.68E-06	3.49E-06	3.49E-06	1.34E-04	1.00E+00	3.08E+00
PACX1TCBHF	9.60E-06	2.74E-06	2.74E-06	1.84E-05	1.00E+00	1.29E+00
AB8MCH2DEX	7.04E-03	2.59E-06	2.59E-06	2.37E-08	1.00E+00	1.00E+00
GK2NGDCLHE	5.20E-05	2.57E-06	2.57E-06	3.19E-06	1.00E+00	1.05E+00
BK2GBO1FTC	4.32E-05	2.27E-06	2.27E-06	3.40E-06	1.00E+00	1.05E+00
AB7PUSHPBT	7.20E-06	2.05E-06	2.05E-06	1.84E-05	1.00E+00	1.29E+00
WK2GVCDDEX	3.50E-05	1.73E-06	1.73E-06	3.19E-06	1.00E+00	1.05E+00
WK2TBCDDEX	3.50E-05	1.73E-06	1.73E-06	3.19E-06	1.00E+00	1.05E+00
PK2PACKDEX	3.10E-05	1.63E-06	1.63E-06	3.40E-06	1.00E+00	1.05E+00
PK1TSACGPR	4.20E-04	9.11E-08	9.11E-08	1.40E-08	1.00E+00	1.00E+00

Table 7.3-2

Basic Event Importance Measures From The ONS-Keowee AC Power Integrated Model

Basic Event	Probability	Fus. Ves.	Critic	Birnbm	Red Wrth	Ach Wrth
PK1TSDCLHE	3.20E-03	9.11E-08	9.11E-08	1.84E-09	1.00E+00	1.00E+00
BK1GOACGPR	3.36E-04	7.29E-08	7.29E-08	1.40E-08	1.00E+00	1.00E+00
BK1GBDCLHE	3.20E-03	7.29E-08	7.29E-08	1.47E-09	1.00E+00	1.00E+00
AA127X1RYT	1.38E-04	6.55E-08	6.55E-08	3.06E-08	1.00E+00	1.00E+00
AB552TCRYT	1.38E-04	6.55E-08	6.55E-08	3.06E-08	1.00E+00	1.00E+00
AB51431RYT	1.30E-04	6.14E-08	6.14E-08	3.06E-08	1.00E+00	1.00E+00
AB552Y2RYT	1.30E-04	6.14E-08	6.14E-08	3.06E-08	1.00E+00	1.00E+00
AB5PUSHPBT	9.22E-05	4.36E-08	4.36E-08	3.06E-08	1.00E+00	1.00E+00
SKXFMR1THF	7.44E-05	3.52E-08	3.52E-08	3.06E-08	1.00E+00	1.00E+00

Table 7.4-1

Top Cut Sets From The ONS-Keowee Core Damage Model

Module/Event	Description	Rate	Exposure	Prob.	Cs Prob.
1) CDFREQ					*1.04E-06
1)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	2.77E-07
-KK1BOTHHYM	Both Keowee Units Unavailable Due To Common Maintenance		5.23E-3	5.23E-03	
SXFRCT4THM	Transformer CT4 Is In Maintenance		9.13E-04	9.13E-04	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
NSFORCMDHE	Operators Fail To Align The SSF RCM System For Operation		1.000E-01	1.00E-01	
TACOFF2REC	Offsite power not recov. given start failures with SSHR		2.20E-01	2.20E-01	
2) KK1BOTHHYM	Both Keowee Units Unavailable Due To Common Maintenance		5.23E-3	5.23E-03	1.66E-07
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
NSFORCMDHE	Operators Fail To Align The SSF RCM System For Operation		1.000E-01	1.00E-01	
PACOT5WDEX	Modifier Since Keowee Maintenance Is Scheduled For Mild Weather Periods		1.00E-01	1.00E-01	
TACOFF2REC	Offsite power not recov. given start failures with SSHR		2.20E-01	2.20E-01	
3)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	9.69E-08
-KK1BOTHHYM	Both Keowee Units Unavailable Due To Common Maintenance		5.23E-3	5.23E-03	
SXFRCT4THM	Transformer CT4 Is In Maintenance		9.13E-04	9.13E-04	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
NACSFDGDGM	SSF Diesel Generator Is In Maintenance		3.500E-02	3.50E-02	
TACOFF2REC	Offsite power not recov. given start failures with SSHR		2.20E-01	2.20E-01	
4)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	5.89E-08
-KK1BOTHHYM	Both Keowee Units Unavailable Due To Common Maintenance		5.23E-3	5.23E-03	
SXFRCT4THM	Transformer CT4 Is In Maintenance		9.13E-04	9.13E-04	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
NACSFDGDGR	SSF Diesel Generator Fails To Run	3.00E-03	24	7.20E-02	
TACOFF3REC	Offsite power not recov. given 1 run failure with SSHR		6.50E-02	6.50E-02	
5) KK1BOTHHYM	Both Keowee Units Unavailable Due To Common Maintenance		5.23E-3	5.23E-03	5.80E-08
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
NACSFDGDGM	SSF Diesel Generator Is In Maintenance		3.500E-02	3.50E-02	
PACOT5WDEX	Modifier Since Keowee Maintenance Is Scheduled For Mild Weather Periods		1.00E-01	1.00E-01	
TACOFF2REC	Offsite power not recov. given start failures with SSHR		2.20E-01	2.20E-01	
6) KK1BOTHHYM	Both Keowee Units Unavailable Due To Common Maintenance		5.23E-3	5.23E-03	3.52E-08
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
NACSFDGDGR	SSF Diesel Generator Fails To Run	3.00E-03	24	7.20E-02	
PACOT5WDEX	Modifier Since Keowee Maintenance Is Scheduled For Mild Weather Periods		1.00E-01	1.00E-01	
TACOFF3REC	Offsite power not recov. given 1 run failure with SSHR		6.50E-02	6.50E-02	
7)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	3.32E-08
-KK1BOTHHYM	Both Keowee Units Unavailable Due To Common Maintenance		5.23E-3	5.23E-03	
SXFRCT4THM	Transformer CT4 Is In Maintenance		9.13E-04	9.13E-04	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
NACSFDGDGS	SSF Diesel Generator Fails To Start	1.20E-02	1	1.20E-02	
TACOFF2REC	Offsite power not recov. given start failures with SSHR		2.20E-01	2.20E-01	
8)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	3.01E-08
ABOSWGRCOM	Common Cause Failure Of All Keowee Auxiliary Power Breakers		6.69E-04	6.69E-04	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
NSFORCMDHE	Operators Fail To Align The SSF RCM System For Operation		1.000E-01	1.00E-01	
ABOSWGRRHE	Recovery of Keowee Aux Power Breakers by Manual Control		5.0E-01	5.00E-01	
TACOFF3REC	Offsite power not recov. given 1 run failure with SSHR		6.50E-02	6.50E-02	

Table 7.4-1

Top Cut Sets From The ONS-Keowee Core Damage Model

Module/Event	Description	Rate	Exposure	Prob.	Cs Prob.
9)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	2.77E-08
-KK1BOTHHYM	Both Keowee Units Unavailable Due To Common Maintenance		5.23E-3	5.23E-03	
SXFRCT4THM	Transformer CT4 Is In Maintenance		9.13E-04	9.13E-04	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
NSFTIMEDHE	Operators Fail To Deploy To The Standby Shutdown Facility In Time		1.00E-02	1.00E-02	
TACOFF2REC	Offsite power not recov. given start failures with SSHR		2.20E-01	2.20E-01	
10)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	2.77E-08
-KK1BOTHHYM	Both Keowee Units Unavailable Due To Common Maintenance		5.23E-3	5.23E-03	
SXFRCT4THM	Transformer CT4 Is In Maintenance		9.13E-04	9.13E-04	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
NSFCON2CMS	Train 2 Refrigerant Compressor Fails To Start	1.00E-02	1	1.00E-02	
TACOFF2REC	Offsite power not recov. given start failures with SSHR		2.20E-01	2.20E-01	
11)-XA1XAALBLM	MCC 1XA Is Connected to Its Alternate Source of Power		2.74E-03	2.74E-03	2.49E-08
-AD1B4ALCDT	Breaker 4AL In 125 V dc Distribution Center 1DA Transfers Open	7.5E-08	30	2.25E-06	
-AB7OPENLHE	Air Circuit Breaker 7 Fails To Open Due To A Latent Human Error		3.20E-3	3.20E-03	
-AB7MECHDEX	Air Circuit Breaker 7 Fails To Open Due To Mechanical Failure		8.01E-04	8.01E-04	
-AB752TCRYD	Air Circuit Breaker 7 Trip Coil TC Fails On Demand	3.3E-05	1	3.30E-05	
-AB710AFFUF	One Or More Air Circuit Breaker 7 Control Power Fuses Fail	3.6E-06	6	2.16E-05	
-AB51431SWT	Manual/Auto Control Switch 143/1 Spuriously Transfers Into Manual	7.0E-08	360	2.52E-05	
-AB51431LHE	Manual/Auto Control Switch 143/1 Left In Manual		3.20E-4	3.20E-04	
-AA227X2RYD	Auxiliary Relay 27X/2X Fails To Operate On Demand	3.3E-05	1	3.30E-05	
-AA127X2R6D	Transformer CX Undervoltage Relay 27/CX1 Fails To Drop Out	2.49E-04	1	2.49E-04	
AB7MCH2DEX	Air Circuit Breaker 7 Fails To Close Due To Mechanical Failure		7.04E-03	7.04E-03	
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
NSFORCMDHE	Operators Fail To Align The SSF RCM System For Operation		1.000E-01	1.00E-01	
TACOFF3REC	Offsite power not recov. given 1 run failure with SSHR		6.50E-02	6.50E-02	
12) KK1BOTHHYM	Both Keowee Units Unavailable Due To Common Maintenance		5.23E-3	5.23E-03	1.99E-08
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
NACSFDGDGS	SSF Diesel Generator Fails To Start	1.20E-02	1	1.20E-02	
PACOT5WDEX	Modifier Since Keowee Maintenance Is Scheduled For Mild Weather Periods		1.00E-01	1.00E-01	
TACOFF2REC	Offsite power not recov. given start failures with SSHR		2.20E-01	2.20E-01	
13)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	1.77E-08
-KK2RUNSDEX	Keowee Unit 2 Only Is Supplying The Grid		0.06	6.00E-02	
-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	
-KK1BOTHDEX	Keowee Units 1 And 2 Are Supplying The Grid		0.0	0.00E+00	
EKSTARTCOM	Common Cause Failure Of Both Units Voltage Regulators To Start		6.17E-5	6.17E-05	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
NSFORCMDHE	Operators Fail To Align The SSF RCM System For Operation		1.000E-01	1.00E-01	
TACOFF2REC	Offsite power not recov. given start failures with SSHR		2.20E-01	2.20E-01	
14)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	1.70E-08
AB0SWGRCOM	Common Cause Failure Of All Keowee Auxiliary Power Breakers		6.69E-04	6.69E-04	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
NACSFDGDGR	SSF Diesel Generator Fails To Run	3.00E-03	24	7.20E-02	
AB0SWGRRHE	Recovery of Keowee Aux Power Breakers by Manual Control		5.0E-01	5.00E-01	
TACOFF4REC	Offsite power not recov. given run failures with SSHR		5.10E-02	5.10E-02	

Table 7.4-1

Top Cut Sets From The ONS-Keowee Core Damage Model

Module/Event	Description	Rate	Exposure	Prob.	Cs Prob.
15) KK1BOTHHYM	Both Keowee Units Unavailable Due To Common Maintenance		5.23E-3	5.23E-03	1.66E-08
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
NSFCON2CMS	Train 2 Refrigerant Compressor Fails To Start	1.00E-02	1	1.00E-02	
PACOT5WDEX	Modifier Since Keowee Maintenance Is Scheduled For Mild Weather Periods		1.00E-01	1.00E-01	
TACOFF2REC	Offsite power not recov. given start failures with SSHR		2.20E-01	2.20E-01	
16) KK1BOTHHYM	Both Keowee Units Unavailable Due To Common Maintenance		5.23E-3	5.23E-03	1.66E-08
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
NSFTIMEDHE	Operators Fail To Deploy To The Standby Shutdown Facility In Time		1.00E-02	1.00E-02	
PACOT5WDEX	Modifier Since Keowee Maintenance Is Scheduled For Mild Weather Periods		1.00E-01	1.00E-01	
TACOFF2REC	Offsite power not recov. given start failures with SSHR		2.20E-01	2.20E-01	
17)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	1.52E-08
-KK2RUNSDEX	Keowee Unit 2 Only Is Supplying The Grid		0.06	6.00E-02	
-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	
-KK1BOTHDEX	Keowee Units 1 And 2 Are Supplying The Grid		0.0	0.00E+00	
E12EXCTCOM	Units 1 & 2 Excit Fail Due To Common Cause Failure Of The Breakers		5.31E-05	5.31E-05	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
NSFORCMDHE	Operators Fail To Align The SSF RCM System For Operation		1.000E-01	1.00E-01	
TACOFF2REC	Offsite power not recov. given start failures with SSHR		2.20E-01	2.20E-01	
18)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	1.45E-08
FKOFISHCOM	Common Cause Failure Of Both Unit s WL Filters Due To Intake Debris		2.55E-3	2.55E-03	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
NSFORCMDHE	Operators Fail To Align The SSF RCM System For Operation		1.000E-01	1.00E-01	
FKOFISHDHE	Recovery of Main WL Strainer Clogging		6.3E-02	6.30E-02	
TACOFF3REC	Offsite power not recov. given 1 run failure with SSHR		6.50E-02	6.50E-02	
19)-XA1XAALBLM	MCC 1XA Is Connected to Its Alternate Source of Power		2.74E-03	2.74E-03	1.40E-08
-AD1B4ALCDT	Breaker 4AL In 125 V dc Distribution Center 1DA Transfers Open	7.5E-08	30	2.25E-06	
-AB7OPENLHE	Air Circuit Breaker 7 Fails To Open Due To A Latent Human Error		3.20E-3	3.20E-03	
-AB7MECHDEX	Air Circuit Breaker 7 Fails To Open Due To Mechanical Failure		8.01E-04	8.01E-04	
-AB752TCRYD	Air Circuit Breaker 7 Trip Coil TC Fails On Demand	3.3E-05	1	3.30E-05	
-AB710AFFUF	One Or More Air Circuit Breaker 7 Control Power Fuses Fail	3.6E-06	6	2.16E-05	
-AB51431SWT	Manual/Auto Control Switch 143/1 Spuriously Transfers Into Manual	7.0E-08	360	2.52E-05	
-AB51431LHE	Manual/Auto Control Switch 143/1 Left In Manual		3.20E-4	3.20E-04	
-AA227X2RYD	Auxiliary Relay 27X/2X Fails To Operate On Demand	3.3E-05	1	3.30E-05	
-AA127X2R6D	Transformer CX Undervoltage Relay 27/CX1 Fails To Drop Out	2.49E-04	1	2.49E-04	
AB7MCH2DEX	Air Circuit Breaker 7 Fails To Close Due To Mechanical Failure		7.04E-03	7.04E-03	
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
NACSFDGDGR	SSF Diesel Generator Fails To Run	3.00E-03	24	7.20E-02	
TACOFF4REC	Offsite power not recov. given run failures with SSHR		5.10E-02	5.10E-02	
20) KK1BOTHHYM	Both Keowee Units Unavailable Due To Common Maintenance		5.23E-3	5.23E-03	1.29E-08
PACLINEDEX	100 kV ac Overhead Line From Lee Steam Station To CT5 Fails		7.800E-03	7.80E-03	
T5SUBF	Loss Of The Oconee Station Switchyards Initiating Event		4.86E-02	4.86E-02	
NSFORCMDHE	Operators Fail To Align The SSF RCM System For Operation		1.000E-01	1.00E-01	
TACOFF3REC	Offsite power not recov. given 1 run failure with SSHR		6.50E-02	6.50E-02	

Table 7.4-1

Top Cut Sets From The ONS-Keowee Core Damage Model

Module/Event	Description	Rate	Exposure	Prob.	Cs Prob.
21)-XD1DALTBYM	Normal Power To Dist. Center 1DA Is In Test or Maintenance		5.48E-03	5.48E-03	1.11E-08
-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
XD1KBATBYF	Keowee Battery No. 1 Fails During Discharge	9.30E-04	1	9.30E-04	
NSFORCMDHE	Operators Fail To Align The SSF RCM System For Operation		1.000E-01	1.00E-01	
XD0KBATRHE	Failure To Recover DC By Cross Connecting The Distribution Centers		1.00E+00	1.00E+00	
TACOFF2REC	Offsite power not recov. given start failures with SSHR		2.20E-01	2.20E-01	
22)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	1.05E-08
AB0SWGRCOM	Common Cause Failure Of All Keowee Auxiliary Power Breakers		6.69E-04	6.69E-04	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
NACSFDGDGM	SSF Diesel Generator Is In Maintenance		3.500E-02	3.50E-02	
AB0SWGRRHE	Recovery of Keowee Aux Power Breakers by Manual Control		5.0E-01	5.00E-01	
TACOFF3REC	Offsite power not recov. given 1 run failure with SSHR		6.50E-02	6.50E-02	
23)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	1.04E-08
-KK1BOTHHYM	Both Keowee Units Unavailable Due To Common Maintenance		5.23E-3	5.23E-03	
SXFRCT4THM	Transformer CT4 Is In Maintenance		9.13E-04	9.13E-04	
T5SUBF	Loss Of The Oconee Station Switchyards Initiating Event		4.86E-02	4.86E-02	
NACDJ01HXF	Diesel Jacket Heat Exchanger 1 Fails	6.4E-07	16	2.46E-04	
24)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	1.04E-08
-KK1BOTHHYM	Both Keowee Units Unavailable Due To Common Maintenance		5.23E-3	5.23E-03	
SXFRCT4THM	Transformer CT4 Is In Maintenance		9.13E-04	9.13E-04	
T5SUBF	Loss Of The Oconee Station Switchyards Initiating Event		4.86E-02	4.86E-02	
NACDJ02HXF	Diesel Jacket Heat Exchanger 2 Fails	6.4E-07	16	2.46E-04	
25)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	1.04E-08
FK0FISHCOM	Common Cause Failure Of Both Unit s WL Filters Due To Intake Debris		2.55E-3	2.55E-03	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
NACSFDGDGR	SSF Diesel Generator Fails To Run	3.00E-03	24	7.20E-02	
FK0FISHDHE	Recovery of Main WL Strainer Clogging		6.3E-02	6.30E-02	
TACOFF3REC	Offsite power not recov. given 1 run failure with SSHR		6.50E-02	6.50E-02	
26)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	1.03E-08
BK00RUNCOM	Common Cause Failure Of Both Units Voltage Regulators To Run		1.24E-4	1.24E-04	
FEFTDFPTPR	Turbine-Driven EFW Pump Fails To Run For The Required Time	2.50E-03	24	6.00E-02	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
NSF0ASWDHE	Operators Fail To Align The SSF ASW System For Operation		1.000E-01	1.00E-01	

Table 7.4-2

Basic Event Importance Measures From The ONS-Keowee Core Damage Model

Basic Event	Probability	Fus. Ves.	Critic	Birnbm	Red Wrth	Ach Wrth
T5WEATH	1.44E-02	9.68E-01	9.68E-01	7.01E-05	3.09E+01	6.72E+01
TACOFF2REC	2.20E-01	7.51E-01	7.51E-01	3.56E-06	4.02E+00	3.66E+00
NSF0RCMDHE	1.00E-01	5.46E-01	5.46E-01	5.69E-06	2.20E+00	5.91E+00
SXFRCT4THM	9.13E-04	5.20E-01	5.20E-01	5.94E-04	2.08E+00	5.70E+02
KK1BOTHHYM	5.23E-03	3.09E-01	3.09E-01	6.16E-05	1.45E+00	5.97E+01
PAC0T5WDEX	1.00E-01	2.99E-01	2.99E-01	3.12E-06	1.43E+00	3.69E+00
TACOFF3REC	6.50E-02	1.89E-01	1.89E-01	3.04E-06	1.23E+00	3.72E+00
NACSFDGDGM	3.50E-02	1.59E-01	1.59E-01	4.73E-06	1.19E+00	5.37E+00
NACSFDGDGR	7.20E-02	1.30E-01	1.30E-01	1.88E-06	1.15E+00	2.68E+00
AB0SWGRCOM	6.69E-04	5.53E-02	5.53E-02	8.62E-05	1.06E+00	8.36E+01
AB0SWGRRHE	5.00E-01	5.53E-02	5.53E-02	1.15E-07	1.06E+00	1.06E+00
NACSFDGDGS	1.20E-02	5.09E-02	5.09E-02	4.42E-06	1.05E+00	5.19E+00
NSFCON2CMS	1.00E-02	4.24E-02	4.24E-02	4.42E-06	1.04E+00	5.20E+00
NSFTIMEDHE	1.00E-02	4.24E-02	4.24E-02	4.42E-06	1.04E+00	5.20E+00
AB7MCH2DEX	7.04E-03	3.73E-02	3.73E-02	5.52E-06	1.04E+00	6.26E+00
T5SUBF	4.86E-02	3.24E-02	3.24E-02	6.95E-07	1.03E+00	1.63E+00
TACOFF4REC	5.10E-02	2.98E-02	2.98E-02	6.09E-07	1.03E+00	1.55E+00
FK0FISHDHE	6.30E-02	2.39E-02	2.39E-02	3.95E-07	1.02E+00	1.35E+00
FK0FISHCOM	2.55E-03	2.39E-02	2.39E-02	9.76E-06	1.02E+00	1.03E+01
KK2UNITHYM	3.80E-02	2.27E-02	2.27E-02	6.22E-07	1.02E+00	1.57E+00
EKSTARTCOM	6.17E-05	1.70E-02	1.70E-02	2.86E-04	1.02E+00	2.76E+02
E12EXCTCOM	5.31E-05	1.46E-02	1.46E-02	2.86E-04	1.01E+00	2.76E+02
PACLINEDEX	7.80E-03	1.24E-02	1.24E-02	1.65E-06	1.01E+00	2.57E+00
XD1KBATBYF	9.30E-04	1.07E-02	1.07E-02	1.20E-05	1.01E+00	1.25E+01
XD0KBATRHE	1.00E+00	1.07E-02	1.07E-02	1.11E-08	1.01E+00	1.00E+00
NACDJ02HXF	2.46E-04	1.00E-02	1.00E-02	4.25E-05	1.01E+00	4.17E+01
NACDJ01HXF	2.46E-04	1.00E-02	1.00E-02	4.25E-05	1.01E+00	4.17E+01
EK00RUNCOM	1.24E-04	9.89E-03	9.89E-03	8.31E-05	1.01E+00	8.07E+01
FEFTDFPTPR	6.00E-02	9.89E-03	9.89E-03	1.72E-07	1.01E+00	1.15E+00
NSF0ASWDHE	1.00E-01	9.89E-03	9.89E-03	1.03E-07	1.01E+00	1.09E+00

Table 7.5-1

Sensitivity Study Results
Generic Versus Bayesian Updated Data

Gate Name	Result - Bayesian Updated Data with no credit for recoveries	Result - Generic Data with no credit for recoveries	Percent Change
KEOWTOP	1.0E-02	1.3E-02	30.0%
KEOWCOM	3.5E-03	4.8E-03	37.1%
K12COM	3.6E-03	5.0E-03	38.9%
KCOMMODE	3.6E-06	4.4E-06	22.2%
KCOMRUN	3.5E-03	4.3E-03	22.9%
KU1GVTBHOT	1.6E-03	1.9E-03	18.8%
KU1RUN	1.2E-02	1.8E-02	50.0%
KU1START0	8.4E-03	1.3E-02	54.8%
KU1STARTF	8.1E-03	1.2E-02	48.1%
KU1UNDER	2.0E-02	3.0E-02	50.0%
KU1UNDER0	2.0E-02	3.0E-02	50.0%
KU2GVTBHOT	1.6E-03	1.9E-03	18.8%
KU2OVER	1.8E-02	2.6E-02	44.4%
KU2OVER0	2.2E-02	3.4E-02	54.5%
KU2RUN	1.1E-02	1.6E-02	45.5%
KU2START0	7.5E-03	1.1E-02	46.7%
KU2STARTF	7.8E-03	1.1E-02	41.0%
OPATHTOP	8.2E-03	1.8E-02	119.5%
OVER0	7.3E-02	9.4E-02	28.8%
OVERTOP	6.5E-02	9.3E-02	43.1%
UNDER0	3.0E-02	4.2E-02	40.0%
UNDERTOP	2.2E-02	3.2E-02	45.5%
UPATHTOP	1.1E-03	1.2E-03	9.1%

Table 7.5-2

Sensitivity Study Results

Grid Cycled (Overhead) Versus Standby (Underground) Generator Reliability [1]

Failure Mode	Standby Generator Failure Probability	Grid Cycled Generator Failure Probability
Cold Start Failure	8.1E-03	7.8E-03
Hot Start Failure	1.6E-03 [2]	1.6E-03
Run Failure	1.2E-02	1.1E-02

[1] These failure probabilities are for the generators exclusively and do not include the failures of the paths or output breakers.

[2] Base Case analysis does not involve hot start failures of the underground unit.

Table 7.5-3

Sensitivity Study Results
Human Error Probabilities

Data Change	Failure Probability
RHEs, DHEs & LHEs @ pre-92	7.4E-03
Base Case	7.4E-03

Table 7.5-4

Sensitivity Study Results -- Infrequently Tested/Demanded Components

Gate	Description	Base Case Value	Case 1 Value	Percent Increase	Case 2 Value	Percent Increase	Case 3 Value	Percent Increase
KU2STARTF*	Keowee Unit 2 Fails To Start	7.84E-3	7.84E-3	0	1.62E-2	107	2.44E-2	211
KU2RUN*	Keowee Unit 2 Fails To Run	1.04E-2	1.04E-2	0	1.06E-2	1.9	1.57E-2	51
KEOWTOP	Oconee Emergency Power From Keowee Fails	7.35E-3 7.28E-3**	7.39E-3	0.5	8.40E-3**	15	9.49E-3*	30

* Cutsets for gates KU2STARTF and KU2RUN have not had recovery events added.

** These values are for KEOWTOP solved at a truncation limit of 1E-7. Attempting to solve for objectives 2 and 3 at the usual limit of 1E-8 exceeded CAFTA's limit on the number of cut sets.

Table 7.5-5

Sensitivity Study Results
One Versus Two Units Generating To The Grid

	One unit generation	Two unit generation (0.034)	Two unit generation (0.3)
Recovered	7.4E-03	7.3E-03	7.3E-03
Unrecovered	1.0E-02	1.0E-02	1.0E-02

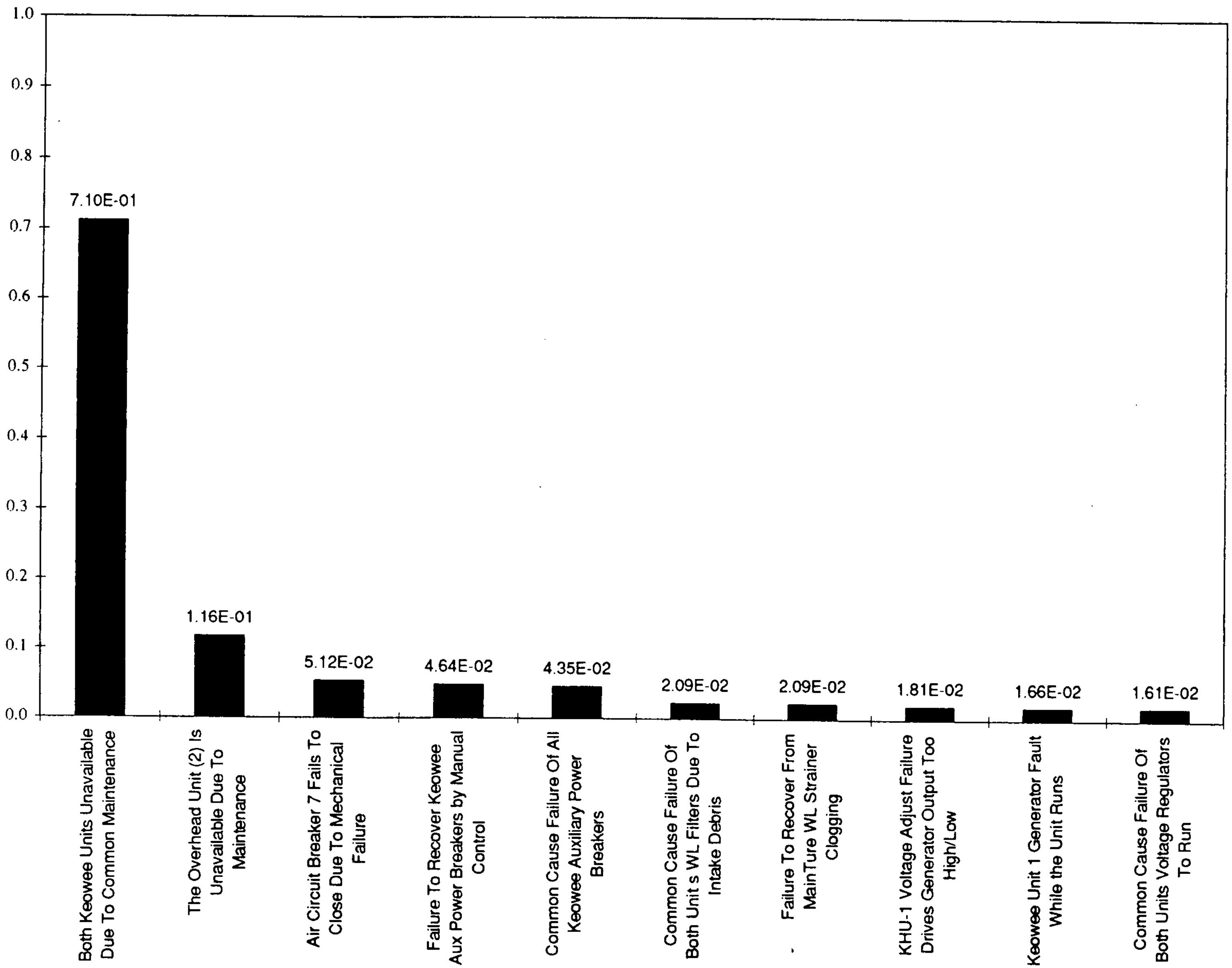
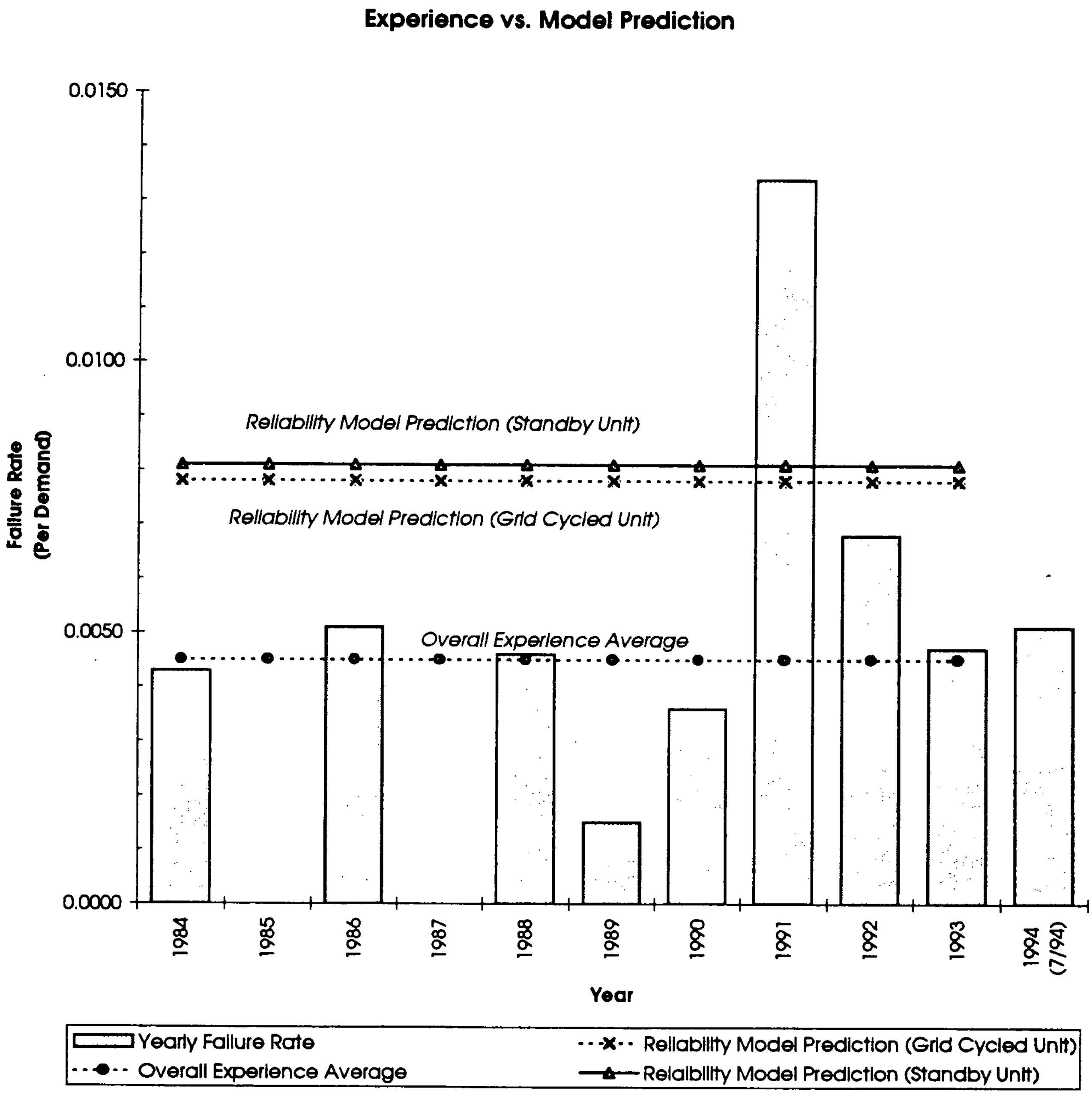


Figure 7.2-1 Dominant Contributors To Keowee Unavailability as Ranked by Importance Measure



DATA SUMMARY

	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994•(7/94)
Yearly Failure Rate	0.0043	0.0	0.0051	0.0	0.0046	0.0015	0.0036	0.0134	0.0068	0.0047	0.0051
Reliability Model Prediction (Grid Cycled Unit)											0.0078
Reliability Model Prediction (Standby Unit)											0.0081
Overall Experience Average (1984 - 93)											0.0045

Figure 7.2-2 Keowee Start Failure Probability

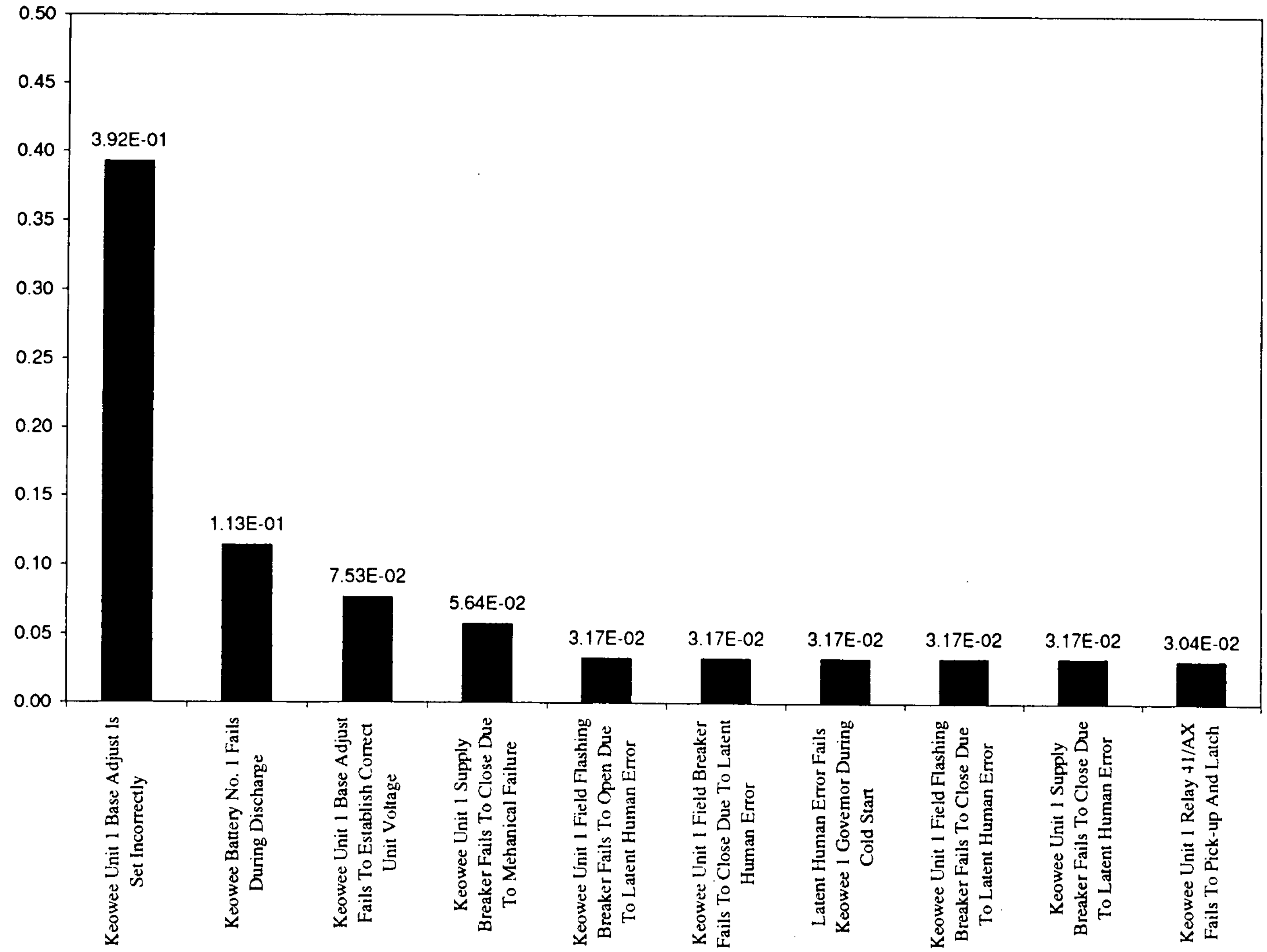


Figure 7.2-3 Dominant Contributors to Keowee Unit 1 Start Failure as Ranked by Importance Measure

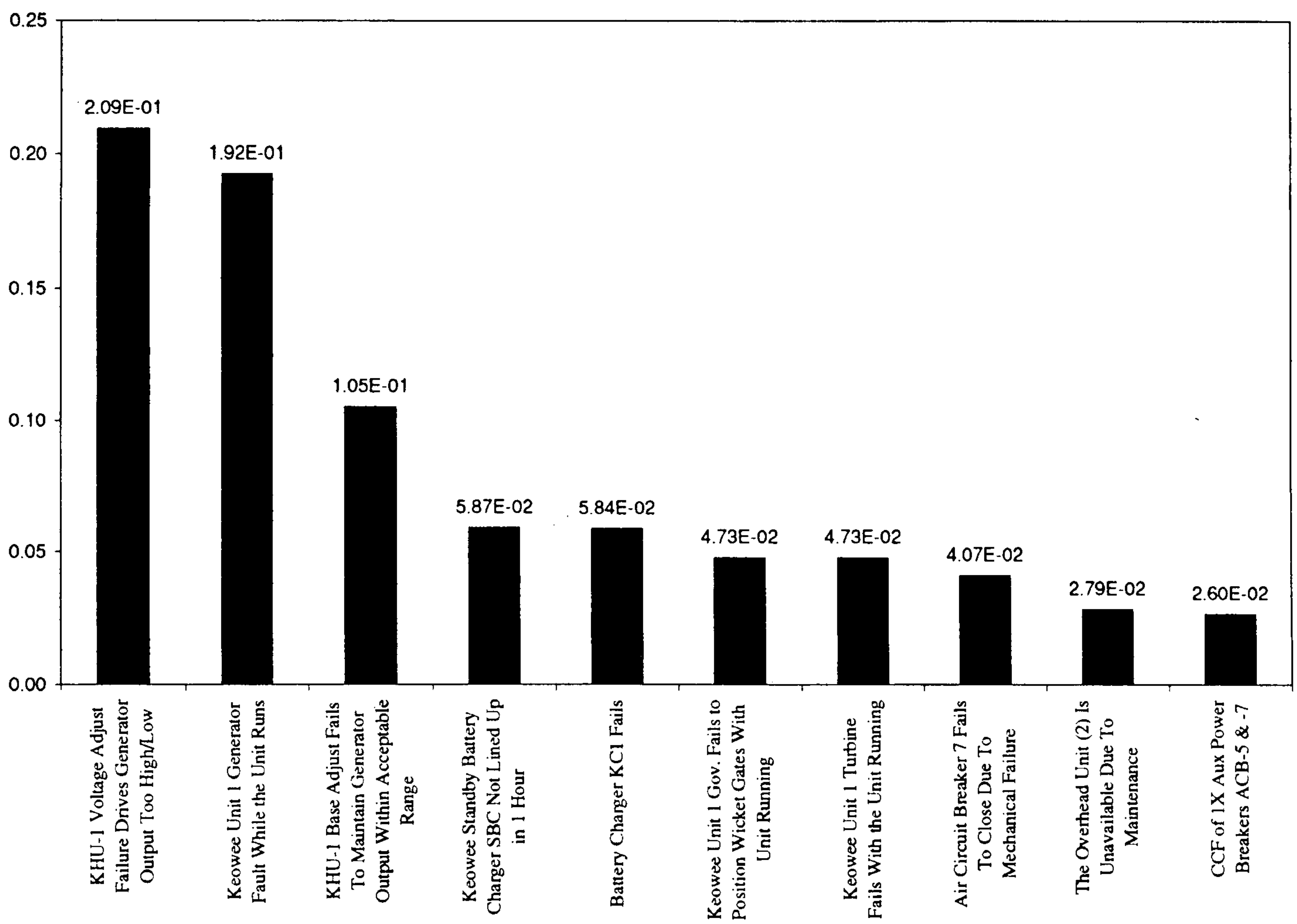


Figure 7.2-4 Dominant Contributors to Keowee Underground Unit (Unit 1) Run Failures as Ranked by Importance Measure

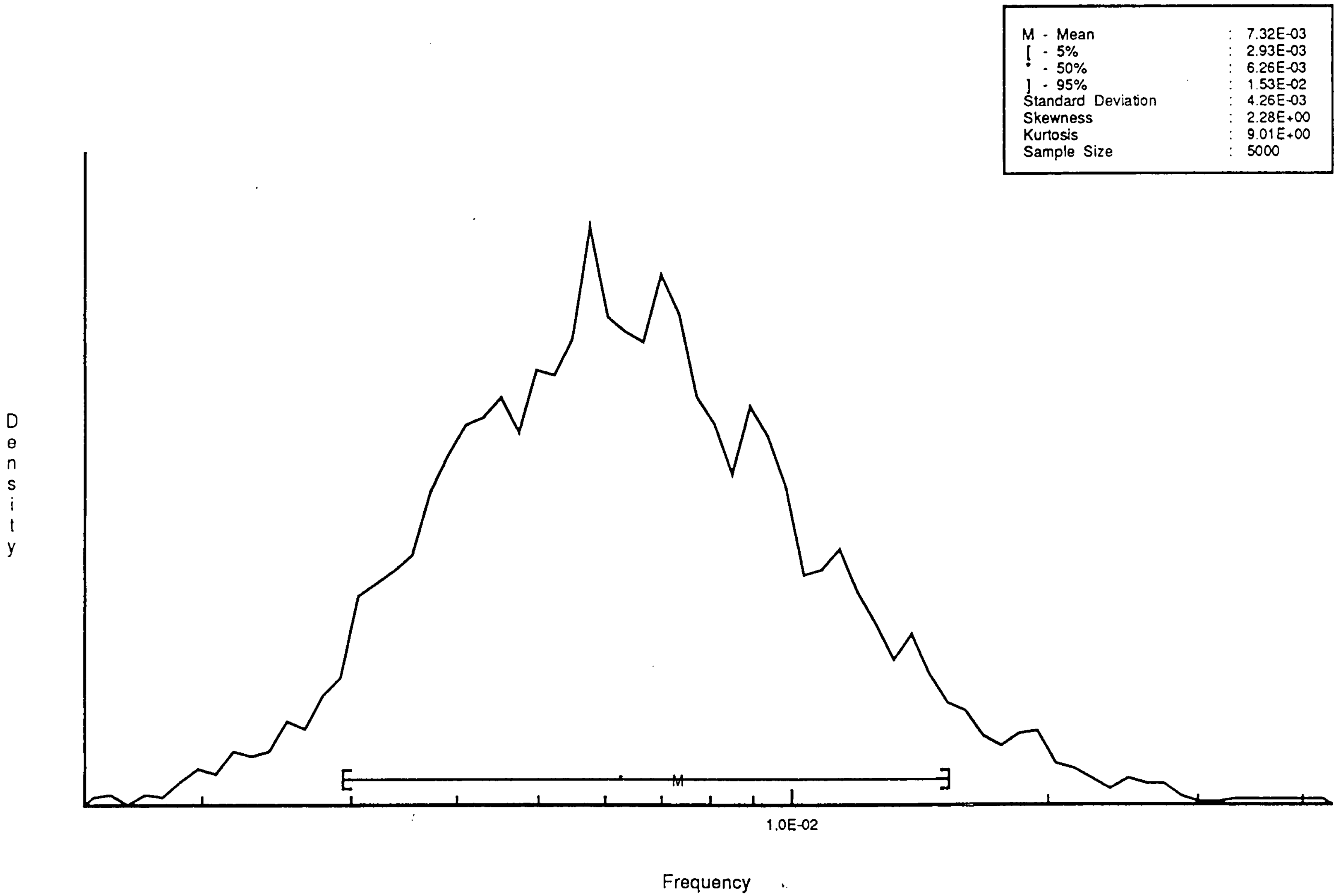


Figure 7.5-1: Probability Distribution For Model Top Gate KEOWTOP

8.0 REFERENCES

1. Oconee Nuclear Station Unit 3 Probabilistic Risk Assessment, Rev. 1, Duke Power Company, 1989.

2. Hampton, J. W., Letter to USNRC, "Detailed PRA Analysis of Keowee Concerning Its Role as an Emergency Supply," Duke Power Co., November 10, 1993.

3. Procedures for Treating Common Cause Failures in Safety and Reliability Studies, Vol. I: Procedural Framework and Examples, NUREG/CR- 4780, USNRC, 1988.

4. PRA Procedures Guide, NUREG/CR-2300, American Nuclear Society and the Institute Of Electrical And Electronic Engineers, Inc., 1983.

5. Individual Plant Examination For The Davis-Besse Nuclear Power Station, Toledo Edison Company, 1993.

6. Generic Component Failure Data Base For Light Water And Liquid Sodium Reactor PRAs, EGG-SSRE-8875, Idaho National Engineering Laboratory, 1990.

7. IEEE Guide To The Collection And Presentation Of Electrical, Electronic, Sensing Component, And Mechanical Equipment Reliability Data For Nuclear Power Generating Stations, IEEE Std 500-1984, Institute Of Electrical And Electronic Engineers, Inc., 1983.

8. EPRI, NP-6780-L, Rev. 4, Vol. 2, Ch. 1, App. A, PRA Key Assumptions And Groundrules, April, 1992.

9. Fleming, K. N., et. al., A Database of Common Cause Events for Risk and Reliability Applications, Electric Power Research Institute, EPRI-TR-100382, 1992.

10. Molesh, A., et. al., Procedures For Treating Common Cause Failures in Safety and Reliability Studies, Vol. II: Analytical Background and Techniques, NUREG/CR-4780 (EPRI NP-5613), USNRC, 1989.

11. Molesh, A., Procedures For Treating Common Cause Failures in Safety and Reliability Studies, NUREG/CR-5801, USNRC, 1993.

12. Wakefield, D. J., et. al., SHARP 1 -- A Revised Systematic Human Action Reliability Procedure, EPRI TR-101711, Electric Power Research Institute, 1992.

13. Swain, A. D., H. E. Guttmann, Handbook of Human Reliability Analysis with Emphasis on Nuclear Plant Applications Final Report, NUREG/CR-1278, USNRC, 1983.

14. Parry, G. W.,. Lydell, B, An Approach to the Analysis of Operator Actions in Probabilistic Risk Assessment, EPRI-TR-100259, Electric Power Research Institute, 1992.

15. Gertman, David I., et. al., INTENT: A Method For Estimating Human Error Probabilities for Errors of Intention, EGG-SRE-9178, Idaho National Engineering Laboratory, 1990.

16. Licensee Event Report (LER) 270/92-04, Loss of Offsite Power at Oconee Unit 2

APPENDIX A.1
HIGH LEVEL LOGIC MODEL

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A.1 HIGH LEVEL LOGIC MODEL

A.1.1 OBJECTIVES

The objectives of the high level logic model are to:

- provide a top gate representing the overall failure probability of Keowee to supply power,
- provide a means for integration of the system models,
- provide a means for introducing the various operating modes of the station into the analysis, including generation to the grid and maintenance,
- provide a convenient location for development of dependent failures,
- provide a pictorial "story" of how the major systems/components influence the Keowee supply
- provide intermediate gates at appropriate places for analysis of reliability at the unit and power path levels,
- provide intermediate gates at appropriate places for analysis of unit start and run reliability,
- eliminate to the extent practical all invalid cut sets in the top gate solution as well as the intermediate gate solutions.

A.1.2 DESCRIPTION OF HIGH LEVEL LOGIC MODEL TREE

A.1.2.1 TOP GATE

In order to satisfy the stated objectives the model has been developed with the following attributes.

The top gate for the high level logic model "KEOWTOP: Oconee Transformers CT3 And CT4 Fail To Receive Power From Keowee" represents the failure probability of interest in this analysis.

The high level logic model tree separates the solution into the overhead and underground supplies. Additionally, the unit related failures are on a different branch of the tree than the path related failures. Also, start and run failures of the two units are evaluated on different branches of the tree. These features allow the evaluation of the reliability at these lower levels. Events representing the probability of various operating conditions are included in the

model such as, Unit 1 generating to the grid alone or with Unit 2, Unit 2 in maintenance, and both Keowee units in maintenance.

The effort is made to eliminate invalid cut sets from occurring in the solutions. This often requires the use of NOT gates in the high level logic model. It is recognized that this often complicates the tree and the cut sets, but the benefit is in the overall reproducibility by not relying on the analyst's judgment on deleting invalid results.

The high level logic model tree has relatively few basic events. Many of the termination points for this tree are transfers to the individual system models. Refer to Table A.1-1 for a list of the fault tree transfers and to Table A.1-2 for the basic events.

The high level logic model is included as Figure A.1-1. Refer to section 4.0 for discussion of the systems analysis assumptions and the process.

A.1.2.2 UNDERGROUND POWER SUPPLY

The highest level gate for the evaluation of the underground supply reliability "UNDER0: Power To CT4 Via The Underground Path From Keowee Fails" includes all failure modes for the underground supply. The gate includes the common cause failures, double maintenance failure, as well as the unit and path failures. Progressively finer levels of detail about the underground supply are available at the lower gates in the tree. The following discussion provides a summary of the kind of information available at some of the lower gates of the underground branch of the tree.

UNDERTOP: Oconee Emergency Power Via The Underground Path Fails

The inputs to this gate consider the availability of a Keowee unit to supply the underground path and the proper function of the path itself. The availability of a Keowee unit to supply the underground path further considers that either unit may be available to supply the underground path. Keowee Unit 1 is the unit assumed to be normally aligned to the underground path. However, for combinations of overhead path failures and underground unit (Unit 1) failures it is possible to recover the emergency power supply by aligning the overhead unit (Unit 2) to the underground path. Refer to Section 4.0 for more information regarding the assumed alignment of the units.

KU1UNDER0: Keowee Unit 1 Fails To Supply The Underground Path

At this level of the tree, failures on the Unit 1 side of Keowee contribute to the failure probability. The inputs to this gate consider failures of the unit to function and the successful maintenance of the connection to the underground path via Air Circuit Breaker 3 (ACB-3). The unit failure further considers the failure of the unit to start or to run for the required mission time. Start failures are also further subdivided.

A Keowee unit that is available for its emergency power supply function may either be in standby or generating to the grid. Either of these conditions may exist at the time an emergency start signal is received. These two conditions place different demands on the Keowee units when the start signal is received. Both situations are included in the model as "start" failures event though in one case the unit is operating at the time the start signal is received. The unit start from standby is referred to as a "cold start" while the unit start from generating to the grid is referred to as a "hot start". Component failures contributing to these start failures are conditioned in the tree by the probability that the unit is in the applicable mode.

For the base case analysis, the unit aligned to the underground path (Unit 1) is assumed to not be generating to the grid. This is consistent with the current operating restrictions applied to the Keowee units. However, the ability to analyze the condition where both units may be allowed to generate to the grid has been built into the high level tree. Refer to section 4.0 for discussion of the systems analysis assumptions.

A.1.2.3 OVERHEAD POWER SUPPLY

The highest level gate for the evaluation of the overhead supply reliability "OVER0: Power To CT3 Via The Overhead Path From Keowee Fails" includes all failure modes for the overhead supply. The gate includes the common cause failures, double maintenance failure, as well as the unit and path failures. Progressively finer levels of detail about the overhead supply are available at the lower gates in the tree. The following discussion provides a summary of the kind of information available at some of the lower gates of the overhead branch of the tree.

OVERTOP: Oconee Emergency Power Via The Overhead Path Fails

The inputs to this gate consider the availability of Keowee Unit 2 to supply the overhead path, including maintenance unavailability, and the proper function of the path itself.

KU2OVER0: Keowee Unit 2 Fails To Supply The Overhead Power Path

At this level of the tree, failures on the Unit 2 side of Keowee contribute to the failure probability. The inputs to this gate consider failures of the unit to function and the successful maintenance of the connection to the overhead path via Air Circuit Breaker 2 (ACB-2). The unit failure further considers the failure of the unit to start or to run for the required mission time. Start failures are also further subdivided into the "hot start" and "cold start" failures described above. No restrictions on generating to the grid are in place on the unit aligned to the overhead path.

A.1.2.4 DOUBLE MAINTENANCE

Both Keowee units can be in maintenance simultaneously. This event automatically leads to failure of Keowee as an emergency power supply for Oconee. This basic event is included on both the underground and overhead branches of the tree.

Refer to Section 5.3 and Appendix C.1 for information on the quantification of this event.

A.1.2.5 DEPENDENT FAILURES

Common cause and other dependent failures affecting both Keowee units have been grouped under the gate "KEOWCOM: Keowee Failure Due To Common Mode Failures". Component common cause events and special situations that lead to failure of both units are included here. Special situations include the opportunity for both units to be connected to the same path inadvertently. Since no attempt is made to synchronize units with each other on an emergency start, both units are assumed to fail if they inadvertently close on the same path. Failures which would lead to this occurrence are included in the analysis.

Refer to Section 5.4 and Appendix C.2 for information on the quantification of common cause events.

A.1.3 DATA

The high level logic model uses basic events to condition the failures according to the various possible operating configurations of the Keowee units. These events identify the probability that a unit is generating to the grid and are based on the Keowee operating history. Other specific component failure probabilities are also required. These events are included in the model as undeveloped (DEX) events and the calculation of their values is presented here.

Unit Run Information

The unit run information is based on the data for the most recent years where both units were allowed to generate to the grid, 1989 through 1991. This data is presented in the following table.

	STATION RUN HOURS	TOTAL UNIT HOURS	UNIT 1	UNIT 2
1989	513.40	740.70	312.10	428.60
1990	865.60	1190.40	636.10	554.30
1991	773.70	1109.70	562.00	547.70
TOTALS	2152.70	3040.80	1510.20	1530.60
	UNITS 1 & 2 RUN TOGETHER	UNIT 1 ALONE	UNIT 2 ALONE	
HOURS	888.10	622.10	642.50	
YEARLY FRACTION	0.034	0.024	0.024	

In the above data the unit run hours are available, however, no information is available on whether the unit was aligned to the overhead or the underground path. It is assumed in the calculations that each unit's generation hours are equally divided between the overhead and underground alignment.

KK1RUNSDEX: Keowee Unit 1 Supplying The Grid

This event represents the probability that the unit aligned to the underground (Keowee Unit 1 in the model) is generating to the grid by itself.

In the current operating configuration, the underground unit is not used for generation to the grid. For the base case calculation, this DEX has the value 0.0.

The base case value of KK1RUNSDEX = 0.0

In sensitivity studies where both units can generate to the grid this DEX takes on the value based on the operating history given above. With the assumption that 50% of a unit's hours of generation come while aligned to the underground path, the DEX is calculated as shown below.

The sensitivity study value of KK1RUNSDEX = (622.1+642.5)/2/(3*8760) = 2.4E-2

<u>KK2RUNSDEX: Keowee Unit 2 Supplying The Grid</u>

This event represents the probability that the unit aligned to the overhead (Keowee Unit 2 in the model) is generating to the grid by itself. No restrictions are placed on generation to the grid by the unit aligned to the overhead path.

Historically, a unit generates approximately 6% of the time.

The value of KK2RUNSDEX = 6.0E-02

<u>KK1BOTHDEX: Keowee Units 1 & 2 Supplying The Grid</u>

In the current operating configuration, the underground unit is not used for generation to the grid. For the base case calculation, this DEX has the value 0.0.

The base case value of KK1BOTHDEX = 0.0

In sensitivity studies where both units can generate to the grid this DEX takes on the value based on the operating history given above.

The value of KK1BOTHDEX = 888.1/(3*8760) = 3.4E-2

KB4CONNDEX: Air Circuit Breaker 4 Connects Unit 2 To The Underground Path

This DEX represents the potential for ACB-4 to spuriously close and parallel the two units. No single failure exists that would cause the spurious closure of ACB-4. When ACB-3 is closed both the positive and negative sides of the ACB-4 close coil are separated from the power supply by open contacts. Spurious operation of the close coil should be far less likely for this design than might otherwise be the case. The value for this event is estimated as 1% of the RYT type code value of 4.7E-7/hour with a 24 hour mission time.

The value of KB4CONNDEX= 1.1E-7

K12COM1DEX: Grid Degradation Occurs And Causes Failure Of Both Keowee Units

No record of such an event occurring on the Duke system has been identified. A review of the industry events in NSAC-204 comprising more than 1000 reactor years of experience, leads to the conclusion that generator failure from an unisolated fault is a rare event. The Keowee generators, main step-up transformer, and the switchyard all have protective relaying. Calculation OSC-5096 specifically considers Keowee stability for various fault conditions. Therefore, a screening value of 1.00E-06 is selected for this event.

The value of K12COM1DEX is 1.00E-06

WK1SPD1DEX &WK2SPD1DEX: Potentially Damaging Overfrequency Occurs At Load Rejection

When Keowee is generating to the grid, an emergency start signal causes a load rejection to occur. The loss of load on the generator will result in a turbine speed transient. Until the governor closes the wicket gates to the no load setting an overspeed/overfrequency condition exists. Depending on unit load and the lake levels at the time of the emergency start, the overfrequency is potentially damaging to the Oconee loads. A damaging overfrequency condition is conservatively assumed to always occur.

The value of WK1SPD1DEX = WK2SPD1DEX = 1.0

A.1.4 RESULTS

The High Level Logic Model is not a system as such and, therefore, no system level results are determined. The results of the Keowee model solution are presented in Section 7.2.

A.1.5 REFERENCES

OSS-0254.00-00-2005, Keowee Emergency Power Design Basis Document

Table A.1-1

High Level Logic Model Fault Tree Transfers

Transfer Gate Name	Description
UPATHTOP	Underground Path Fails To Connect Keowee To Oconee
ACB3TRANS	Air Circuit Breaker 3 Transfers Open
KU1GVTBCLD	Keowee Unit 1 Governor Or Turbine Fails During A Cold Start
KU1GEXCLD	Keowee Unit 1 Generator Excitation Fails During A Cold Start
YK1CLDSTRT	Keowee Unit 1 Governor Control Fails During A Cold Start
KU1GENCLD	Keowee Unit 1 Generator Fails During A Cold Start
ACB1OPEN	Air Circuit Breaker 1 Fails To Open
ACB3CLOSE	Air Circuit Breaker 3 Fails To Close
ACB3OPEN	Air Circuit Breaker 3 Fails To Open
KU1GVTBRUN	Keowee Unit 1 Governor Or Turbine Fails While The Unit Runs

Table A.1-1

High Level Logic Model Fault Tree Transfers

Transfer Gate Name	Description
KU1GEXRUN	Keowee Unit 1 Generator Excitation Fails While The Unit Runs
KU1GENRUN	Keowee Unit 1 Generator Fails While The Unit Runs
ACB4CLOSE	Air Circuit Breaker 4 Fails To Connect Unit 2 To The Underground Path
ACB4TRANS	Air Circuit Breaker 4 Transfers Open
KU2GVTBCLD	Keowee Unit 2 Governor Or Turbine Fails During A Cold Start
KU2GEXCLD	Keowee Unit 2 Generator Excitation Fails During A Cold Start
YK2CLDSTRT	Keowee Unit 2 Governor Control Fails During A Cold Start
KU2GENCLD	Keowee Unit 2 Generator Fails During A Cold Start

Table A.1-1

High Level Logic Model Fault Tree Transfers

Transfer Gate Name	Description
KU2GVTBHOT	Keowee Unit 2 Governor Or Turbine Fails During A Hot Start
KU2GVTBRUN	Keowee Unit 2 Governor Or Turbine Fails While The Unit Runs
KU2GEXRUN	Keowee Unit 2 Generator Excitation Fails While The Unit Runs
KU2GENRUN	Keowee Unit 2 Generator Fails While The Unit Runs
ACB2CLOSE	Air Circuit Breaker 2 Fails Close
ACB2TRANS	Air Circuit Breaker 2 Transfers Open
OPATHTOP	Overhead Path Fails To Connect Keowee To Oconee

Table A.1-2

High Level Logic Model Reliability Data

Event Name	Description	Failure Rate[1]	Factor	Rational For Factor[2]	Failure Probability
AB0SWGRCOM	Common Cause Failure Of All Keowee Auxiliary Power Breakers		6.69E-04		6.69E-04
ACB4MOD	NSM-ON-52966 Is Not In Service		1		1.00E+00
ACBXFERCOM	Common Cause Failure That Results In ACBs 2 & 3 Transfering Open		1.28E-06		1.28E-06
BKGBOILCOM	Common Cause Failure Of Turbine Guide Bearing Oil System		1.94E-06		1.94E-06
E12EXCTCOM	Units 1 & 2 Excit Fail Due To Common Cause Failure Of The Breakers		5.31E-05		5.31E-05
EK00RUNCOM	Common Cause Failure Of Both Units Voltage Regulators To Run		1.24E-04		1.24E-04
EKSTARTCOM	Common Cause Failure Of Both Units Voltage Regulators To Start		6.17E-05		6.17E-05
FK0FISHCOM	Common Cause Failure Of Both Unit s WL Filters Due To Intake Debris		2.55E-03		2.55E-03
FKVALVECOM	Common Cause Failure Of Cooling Water Control Valves		2.46E-05		2.46E-05
GK0COOLCOM	Common Cause Failure of Generator Air Cooling		4.61E-07		4.61E-07
GK0LOCKCOM	Common Cause Actuation of Generator Lockouts		4.06E-06		4.06E-06
GKHPOILCOM	Common Cause Failure of Generator Thrust Bearings		4.61E-07		4.61E-07
K12COM1DEX	Grid Degradation Occurs And Causes Failure Of Both Keowee Units		1.00E-06		1.00E-06

[1] Demand, H=Hour
[2] es for assigning basic event factors are discussed in Table C.

Table A.1-2

High Level Logic Model Reliability Data

Event Name	Description	Failure Rate[1]	Factor	Rational For Factor[2]	Failure Probability
KA127T1R6D	Xfrmr 1X UV Relay 27T/1X Fails To Pick-up	2.49E-04 /D	1 D	1 demand per emergency start	2.49E-04
KA127T1R6T	Xfrmr 1X UV Relay 27T/1X Spuriously De-energizes	3.63E-07 /H	360 H	Rule 4:Indicated by computer point.	1.31E-04
KA227T2R6T	Xfmr 2X UV Relay 27T/2x Spuriously De-energizes	3.63E-07 /H	360 H	Rule 4:Indicated by computer point.	1.31E-04
KB4CONNDEX	Air Circuit Breaker 4 Connects Unit 2 To The Underground Path		1.10E-07		1.10E-07
KK1BOTHDEX	Keowee Units 1 And 2 Are Supplying The Grid		0		0.00E+00
KK1BOTHHYM	Both Keowee Units Unavailable Due To Common Maintenance		5.23E-03		5.23E-03
KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0		0.00E+00
KK2RUNSDEX	Keowee Unit 2 Only Is Supplying The Grid		0.06		6.00E-02
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-02		3.80E-02
OK0PRUNCOM	Common Cause Failure Of Both Governor Oil Systems To Run		1.46E-05		1.46E-05
PK0SUMPCOM	Common Cause Failure Of Turbine Sump Pump System		2.44E-06		2.44E-06
WK00RUNCOM	Common Cause Failure of Keowee Governors to Run		2.09E-05		2.09E-05
WK1SPD1DEX	Potentially Damaging Overspeed Condition Occures At Load Rejection		1		1.00E+00
WKCSTRTCOM	Common Cause Failure of Keowee Governors to Cold Start		1.12E-05		1.12E-05
WKHSTRTCOM	Common Cause Failure of Keowee Governors to Hot Start		3.50E-06		3.50E-06

[1] D=Demand, H=Hour

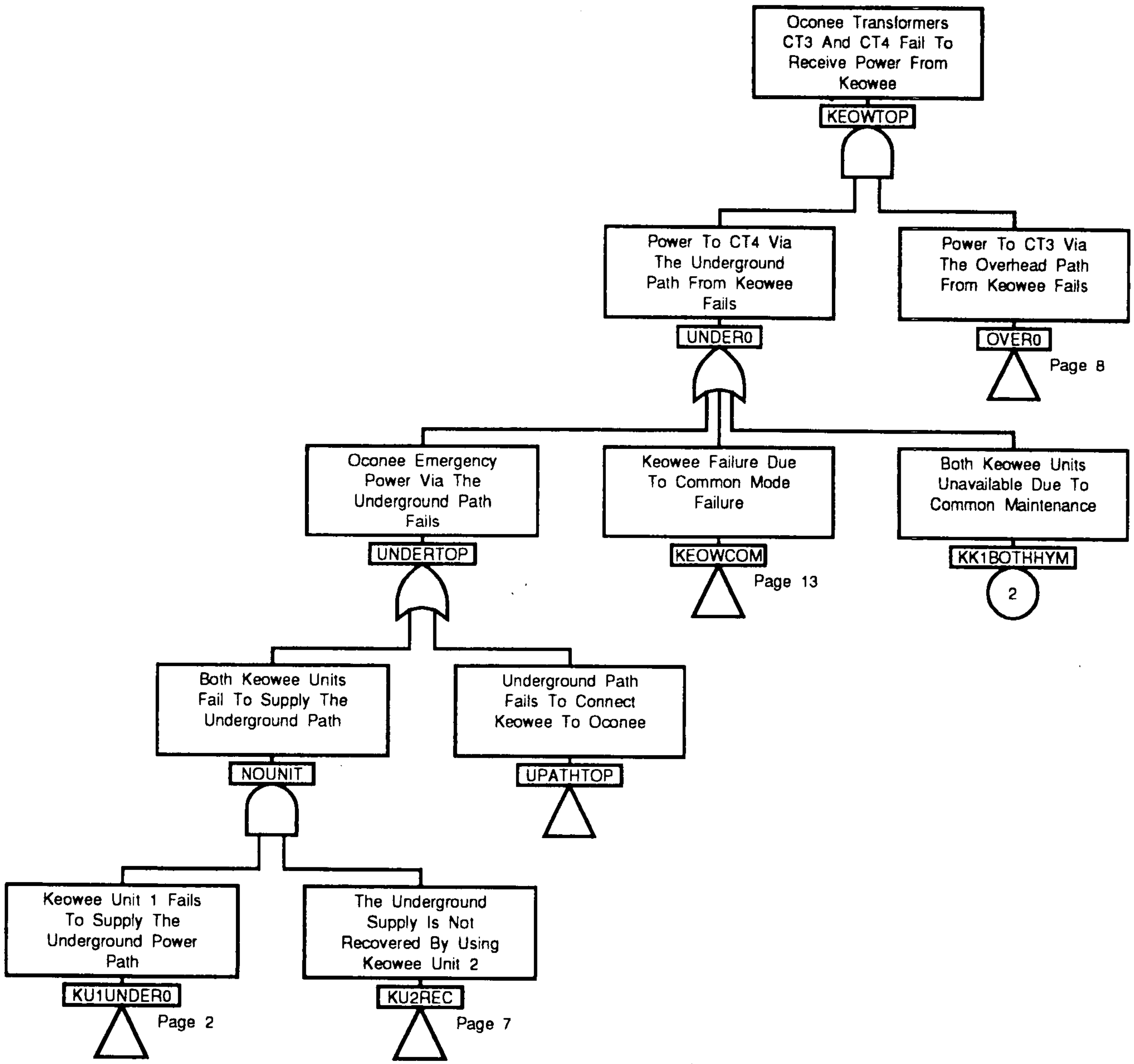
[2] Rules for assigning basic event factors are discussed in Table C.1-4

Table A.1-2

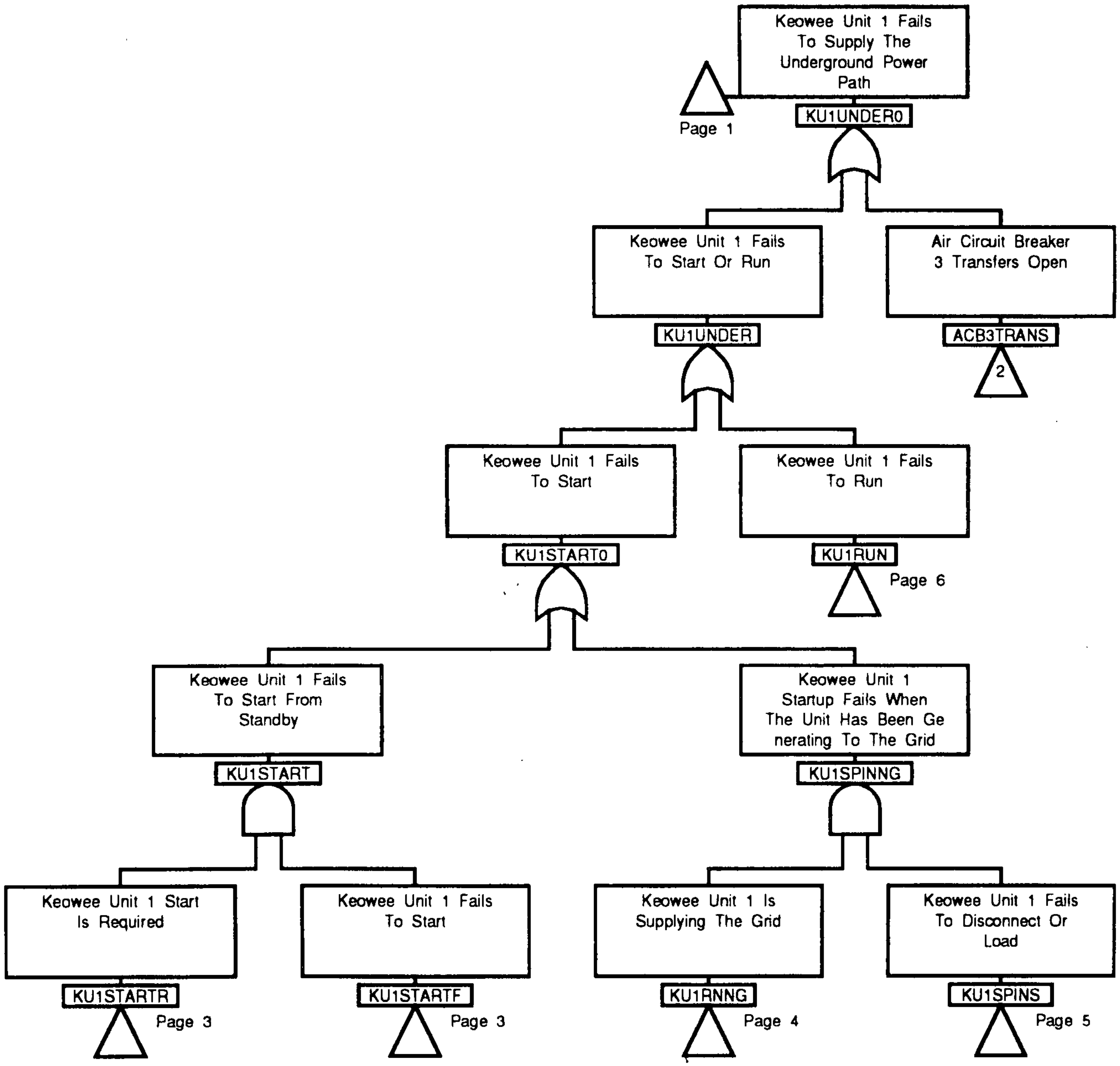
High Level Logic Model Reliability Data

Event Name	Description	Failure Rate[1]	Factor	Rational For Factor[2]	Failure Probability
XA0SWGRCOM	Common Cause Failure Of Transformers 1X, 2X, And CX		1.22E-06		1.22E-06
XA1XAALBLM	MCC 1XA Is Connected to Its Alternate Source of Power		2.74E-03		2.74E-03
XA2XAALBLM	MCC 2XA Is Connected to Its Alternate Power Source		2.74E-03		2.74E-03
XD0BATTCOM	Common Cause Failure Of Keowee I&C Power Batteries		2.70E-05		2.70E-05
XD0CHRGCOM	Common Cause Failure Of Keowee Battery Chargers		3.48E-05		3.48E-05
Y0STARTCOM	Common Cause Failure Of Emergency Start Signal		7.26E-06		7.26E-06

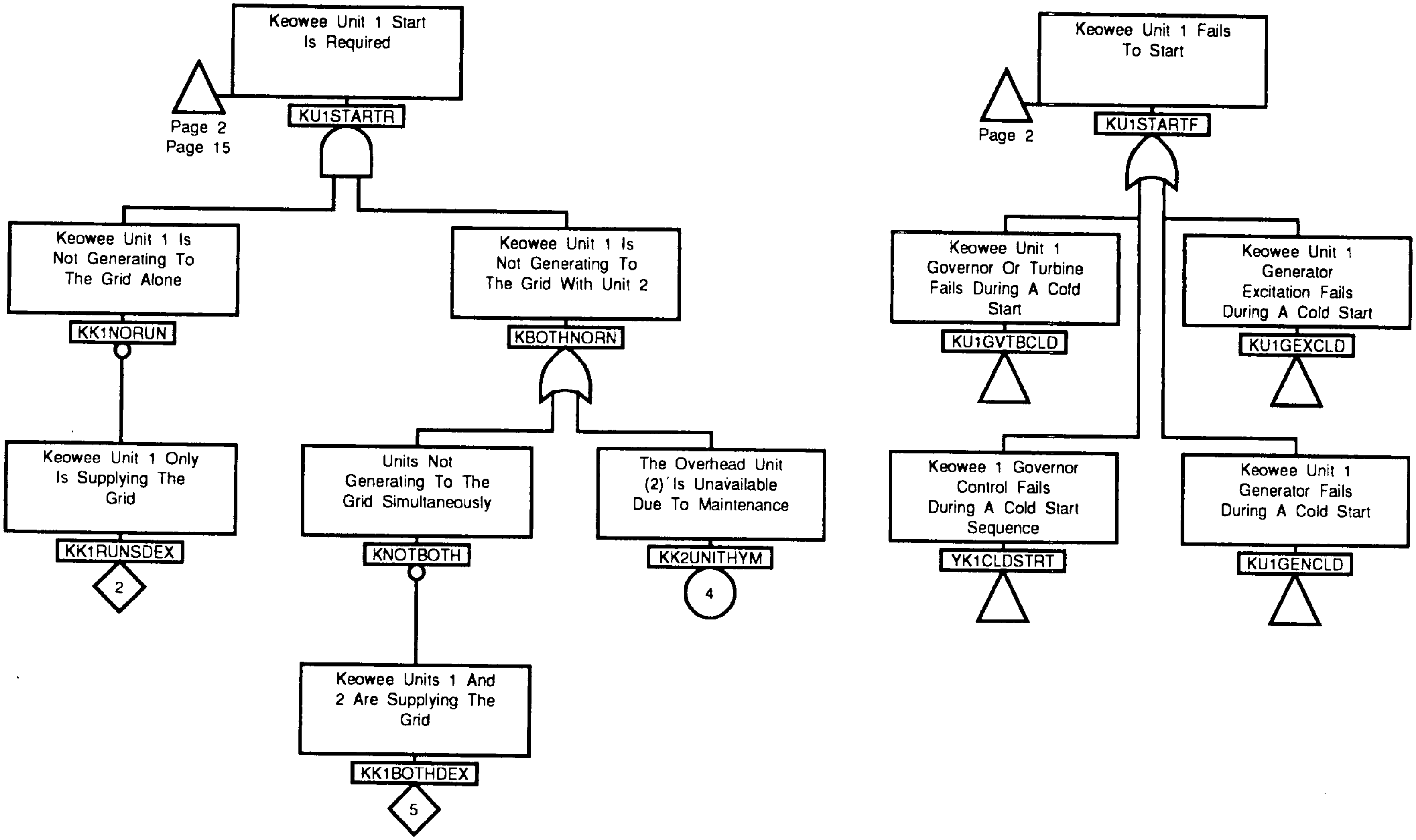
[1] D=Demand, H=Hour
[2] ...s for assigning basic event factors are discussed in Table C.



High Level Logic Model Tree | FIGURE A.1-1 | Page 1

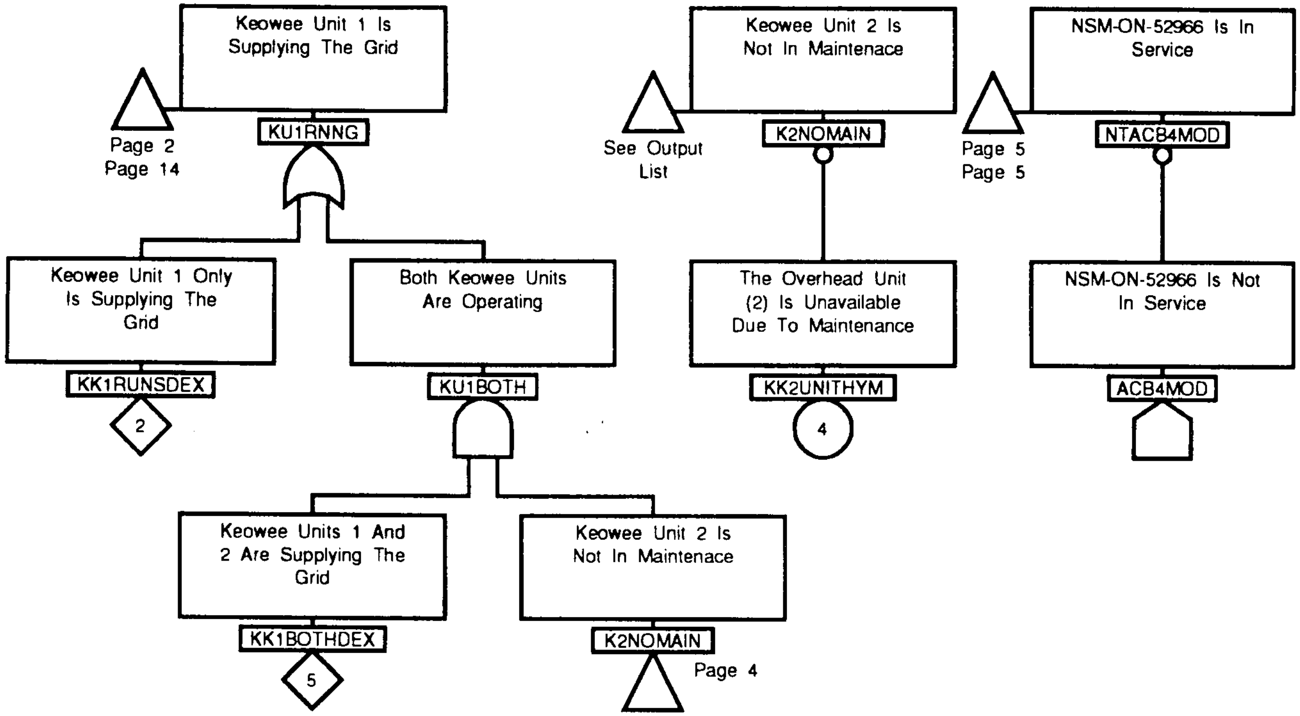


High Level Logic Model Tree | FIGURE A.1-1 | Page 2



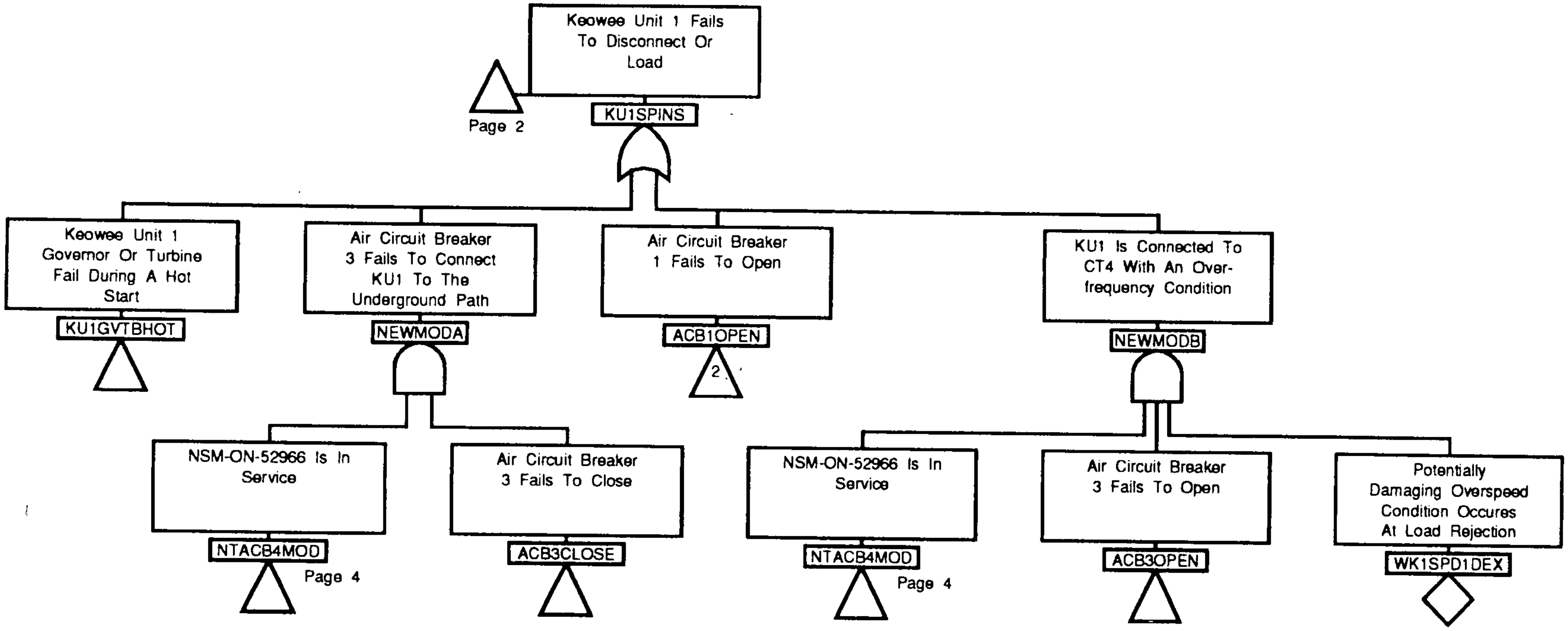
Keowee Unit 1 Start Is Required
KU1STARTR
Page 2
Page 15
Keowee Unit 1 Is Not Generating To The Grid Alone
KK1NORUN
Keowee Unit 1 Only Is Supplying The Grid
KK1RUNSDEX
2
Keowee Unit 1 Is Not Generating To The Grid With Unit 2
KBOTHNORN
Units Not Generating To The Grid Simultaneously
KNOTBOTH
Keowee Units 1 And 2 Are Supplying The Grid
KK1BOTHDEX
5
The Overhead Unit (2)´Is Unavailable Due To Maintenance
KK2UNITHYM
4
Keowee Unit 1 Fails To Start
KU1STARTF
Page 2
Keowee Unit 1 Governor Or Turbine Fails During A Cold Start
KU1GVTBCLD
Keowee Unit 1 Generator Excitation Fails During A Cold Start
KU1GEXCLD
Keowee 1 Governor Control Fails During A Cold Start Sequence
YK1CLDSTRT
Keowee Unit 1 Generator Fails During A Cold Start
KU1GENCLD

K2NOMAIN Outputs:
Page 13, Page 4, Page 16, Page 14, Page 19, Page 19

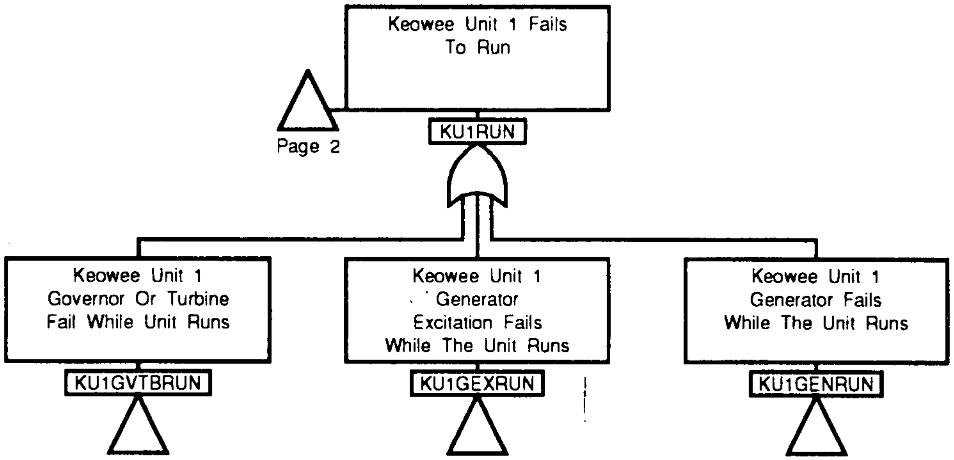


High Level Logic Model Tree

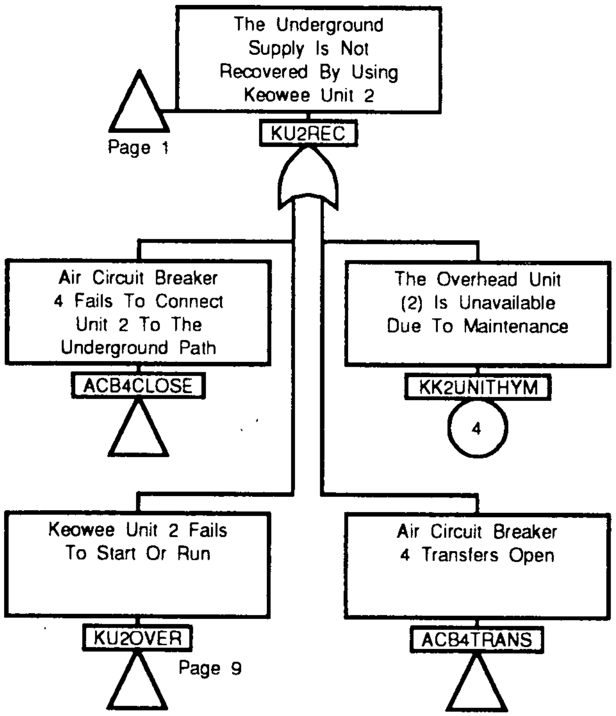
FIGURE A.1-1

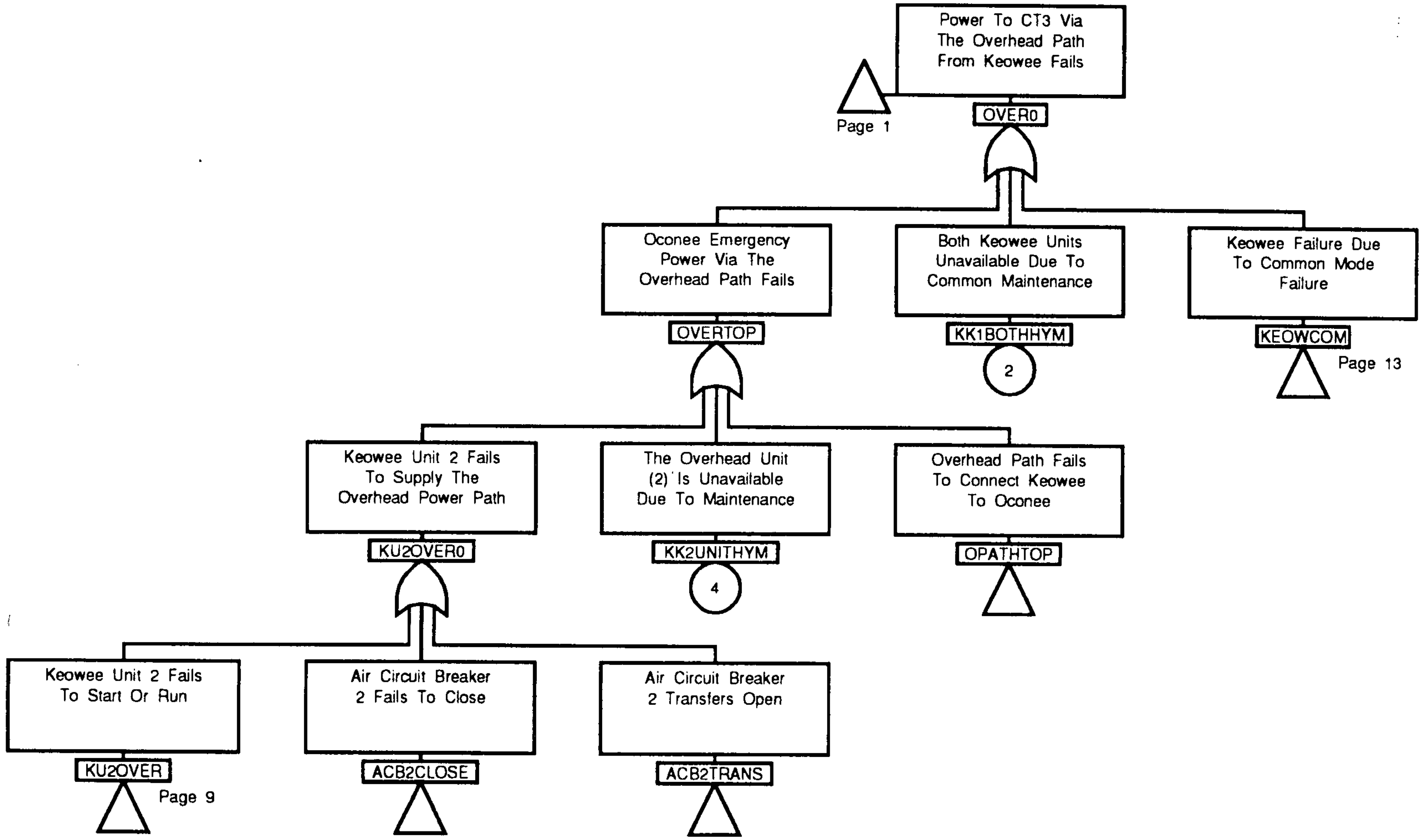


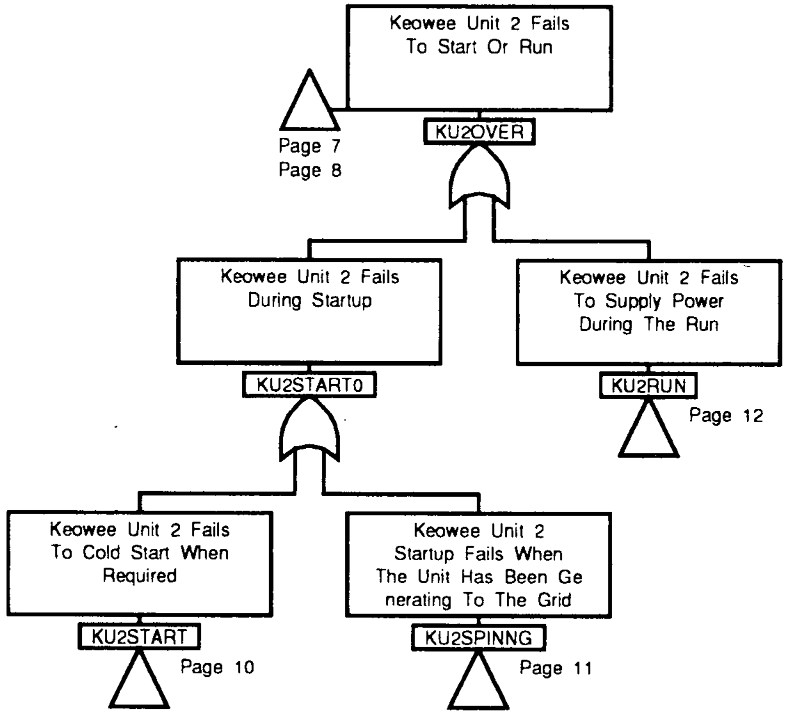
High Level Logic Model Tree | FIGURE A.1-1 |



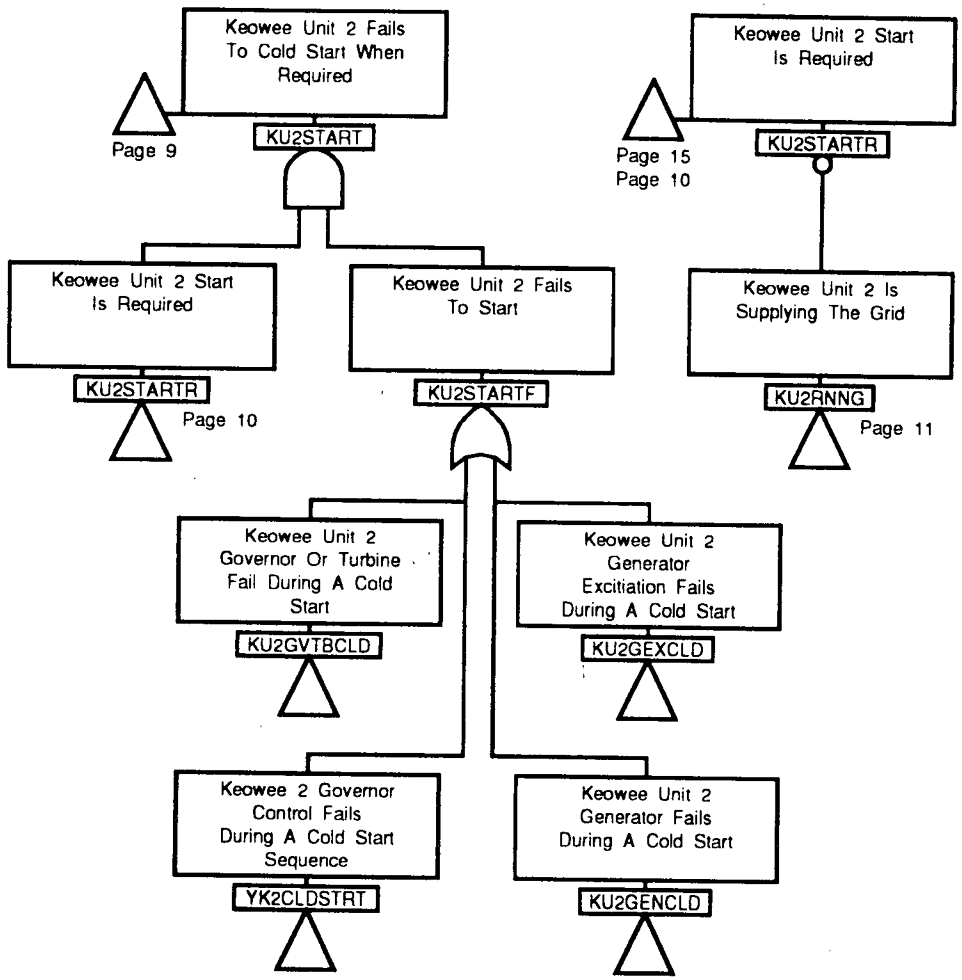
High Level Logic Model Tree	FIGURE A.1-1	Page 6

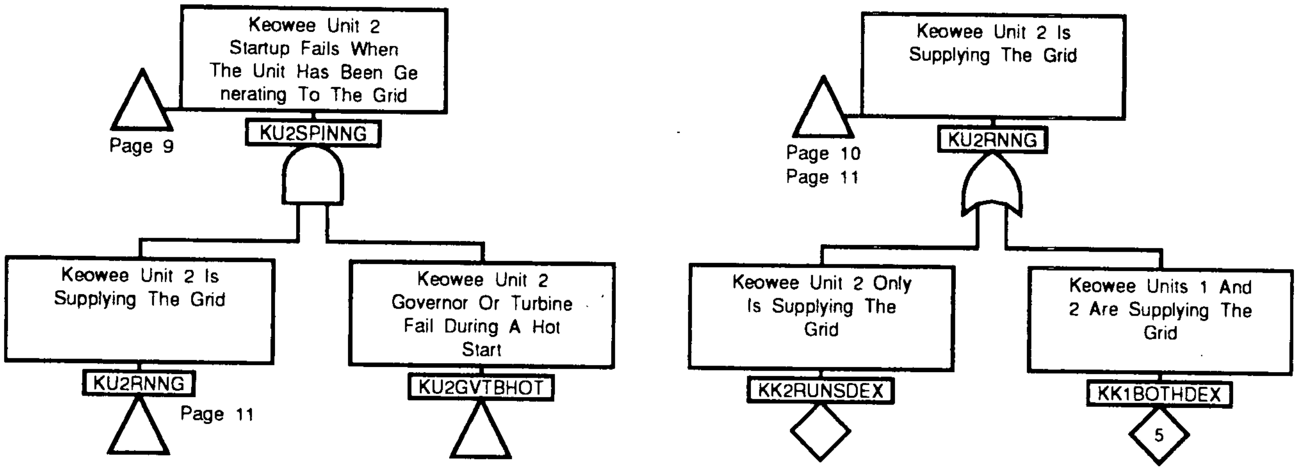

The Underground Supply Is Not Recovered By Using Keowee Unit 2
KU2REC
Page 1
Air Circuit Breaker 4 Fails To Connect Unit 2 To The Underground Path
ACB4CLOSE
The Overhead Unit (2) Is Unavailable Due To Maintenance
KK2UNITHYM
4
Keowee Unit 2 Fails To Start Or Run
KU2OVER
Page 9
Air Circuit Breaker 4 Transfers Open
ACB4TRANS


Power To CT3 Via The Overhead Path From Keowee Fails
Page 1
OVER0
Oconee Emergency Power Via The Overhead Path Fails
OVERTOP
Both Keowee Units Unavailable Due To Common Maintenance
KK1BOTHHYM
2
Keowee Failure Due To Common Mode Failure
KEOWCOM
Page 13
Keowee Unit 2 Fails To Supply The Overhead Power Path
KU2OVER0
The Overhead Unit (2) Is Unavailable Due To Maintenance
KK2UNITHYM
4
Overhead Path Fails To Connect Keowee To Oconee
OPATHTOP
Keowee Unit 2 Fails To Start Or Run
KU2OVER
Page 9
Air Circuit Breaker 2 Fails To Close
ACB2CLOSE
Air Circuit Breaker 2 Transfers Open
ACB2TRANS

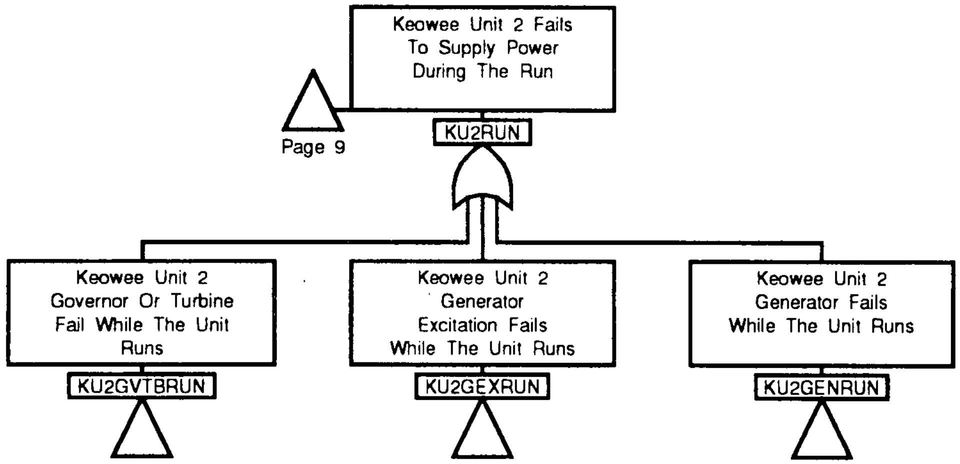


High Level Logic Model Tree	FIGURE A.1-1	Page 9

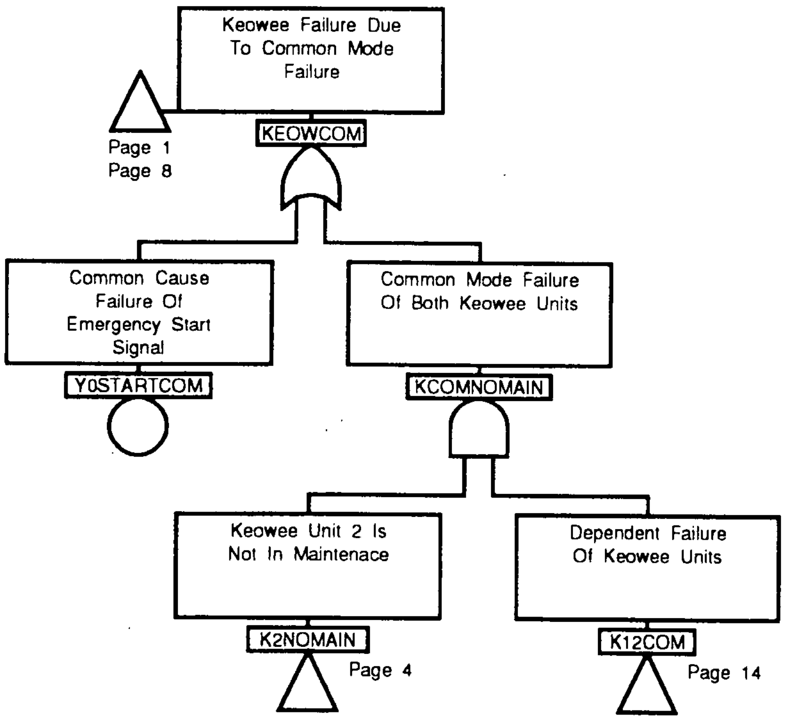

Keowee Unit 2 Fails To Cold Start When Required
KU2START
Page 9
Keowee Unit 2 Start Is Required
KU2STARTR
Page 15
Page 10
Keowee Unit 2 Start Is Required
KU2STARTR
Page 10
Keowee Unit 2 Fails To Start
KU2STARTF
Keowee Unit 2 Is Supplying The Grid
KU2RNNG
Page 11
Keowee Unit 2 Governor Or Turbine Fail During A Cold Start
KU2GVTBCLD
Keowee Unit 2 Generator Excitiation Fails During A Cold Start
KU2GEXCLD
Keowee 2 Governor Control Fails During A Cold Start Sequence
YK2CLDSTRT
Keowee Unit 2 Generator Fails During A Cold Start
KU2GENCLD



High Level Logic Model Tree	FIGURE A.1-1	Page 11

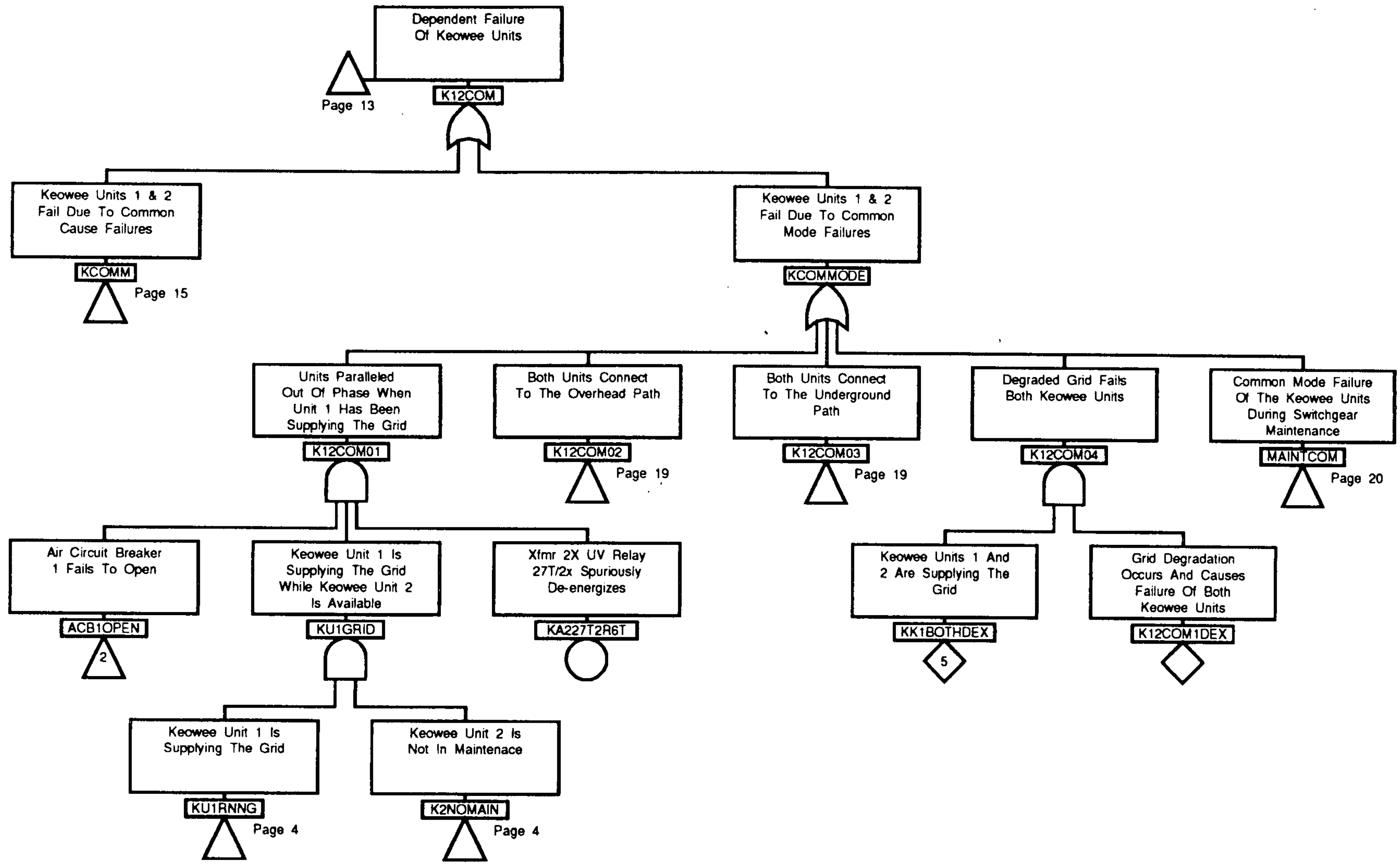


High Level Logic Model Tree | FIGURE A.1-1 |

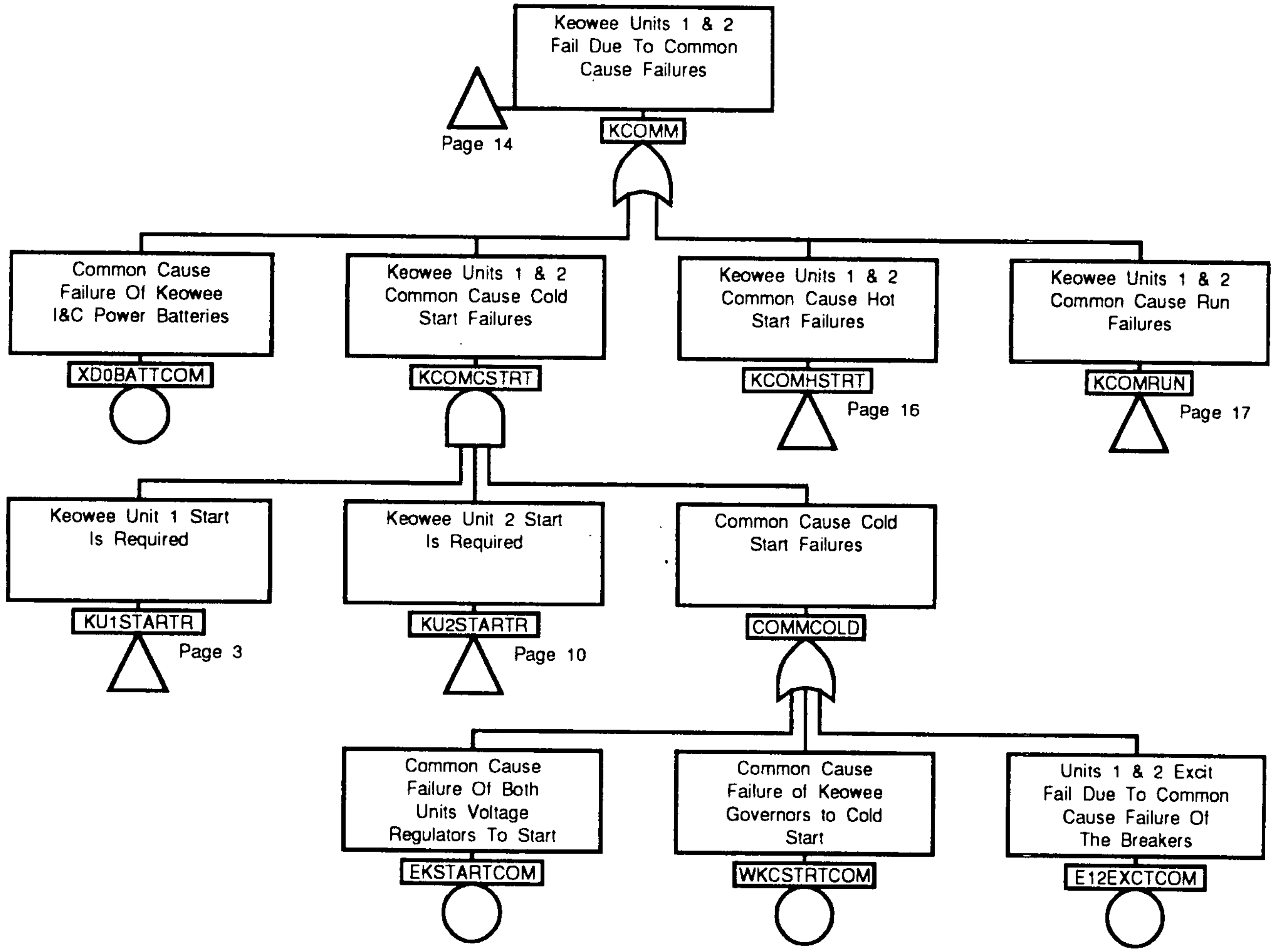


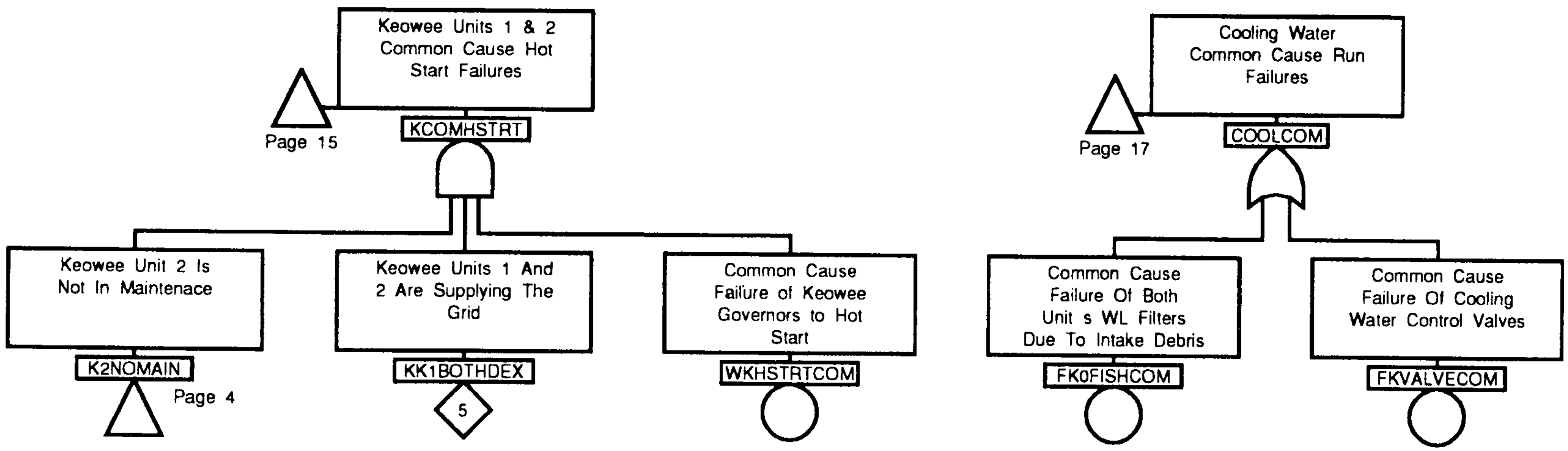
High Level Logic Model Tree

FIGURE A.1-1



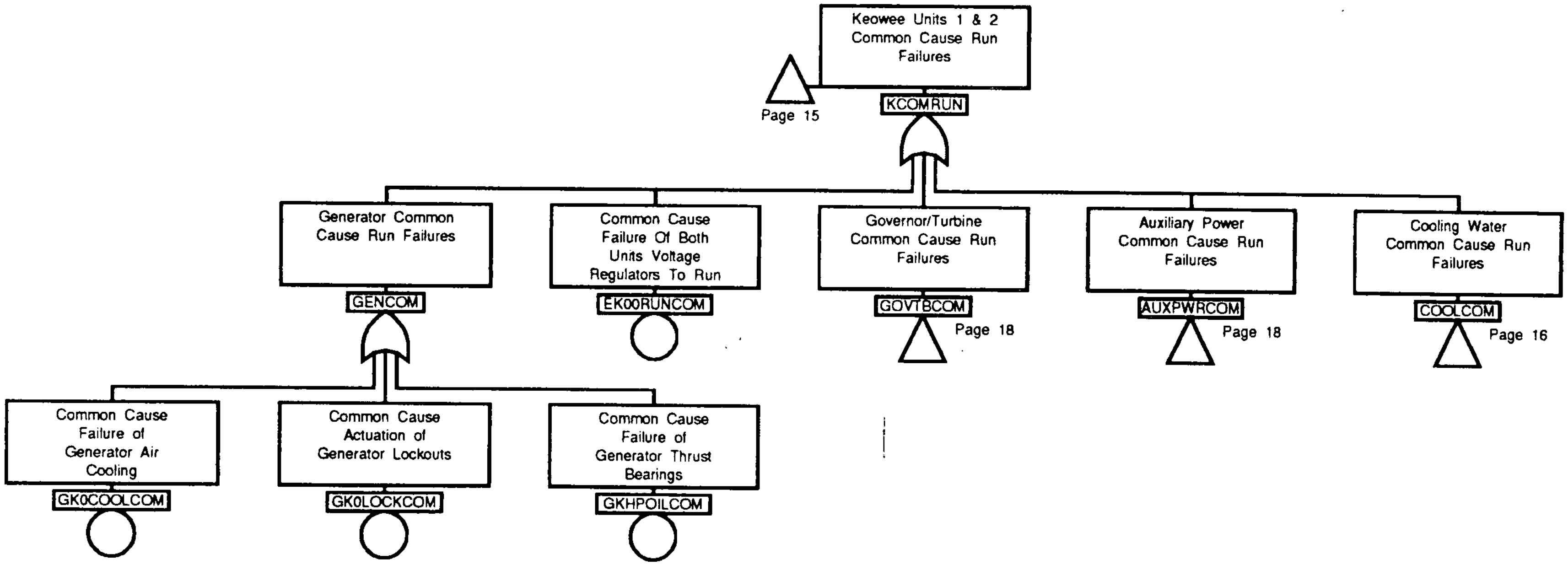
High Level Logic Model Tree | FIGURE A.1-1 |


Keewee Units 1 & 2 Fail Due To Common Cause Failures
KCOMM
Page 14
Common Cause Failure Of Keowee I&C Power Batteries
XD0BATTCOM
Keowee Units 1 & 2 Common Cause Cold Start Failures
KCOMCSTRT
Keowee Units 1 & 2 Common Cause Hot Start Failures
KCOMHSTRT
Page 16
Keowee Units 1 & 2 Common Cause Run Failures
KCOMRUN
Page 17
Keowee Unit 1 Start Is Required
KU1STARTR
Page 3
Keowee Unit 2 Start Is Required
KU2STARTR
Page 10
Common Cause Cold Start Failures
COMMCOLD
Common Cause Failure Of Both Units Voltage Regulators To Start
EKSTARTCOM
Common Cause Failure of Keowee Governors to Cold Start
WKCSTRTCOM
Units 1 & 2 Excit Fail Due To Common Cause Failure Of The Breakers
E12EXCTCOM



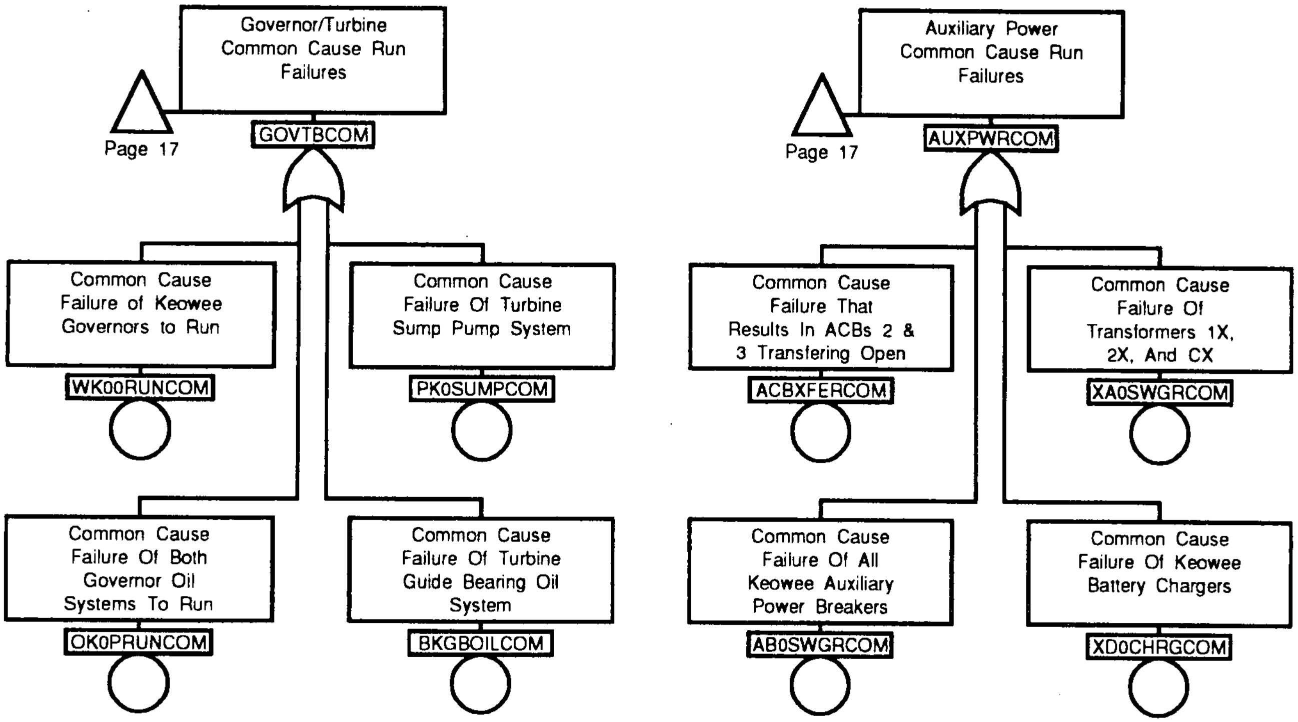
High Level Logic Model Tree

FIGURE A.1-1



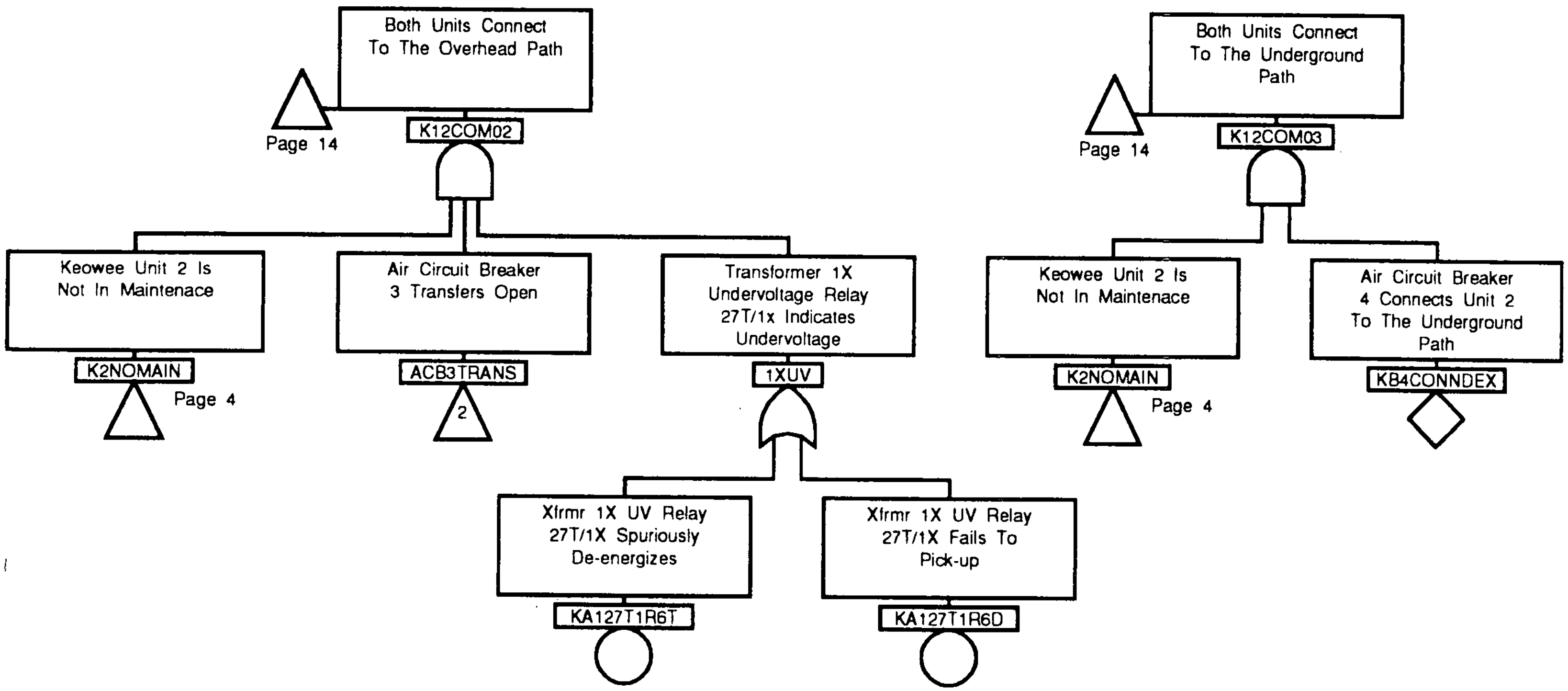
High Level Logic Model Tree

FIGURE A.1-1

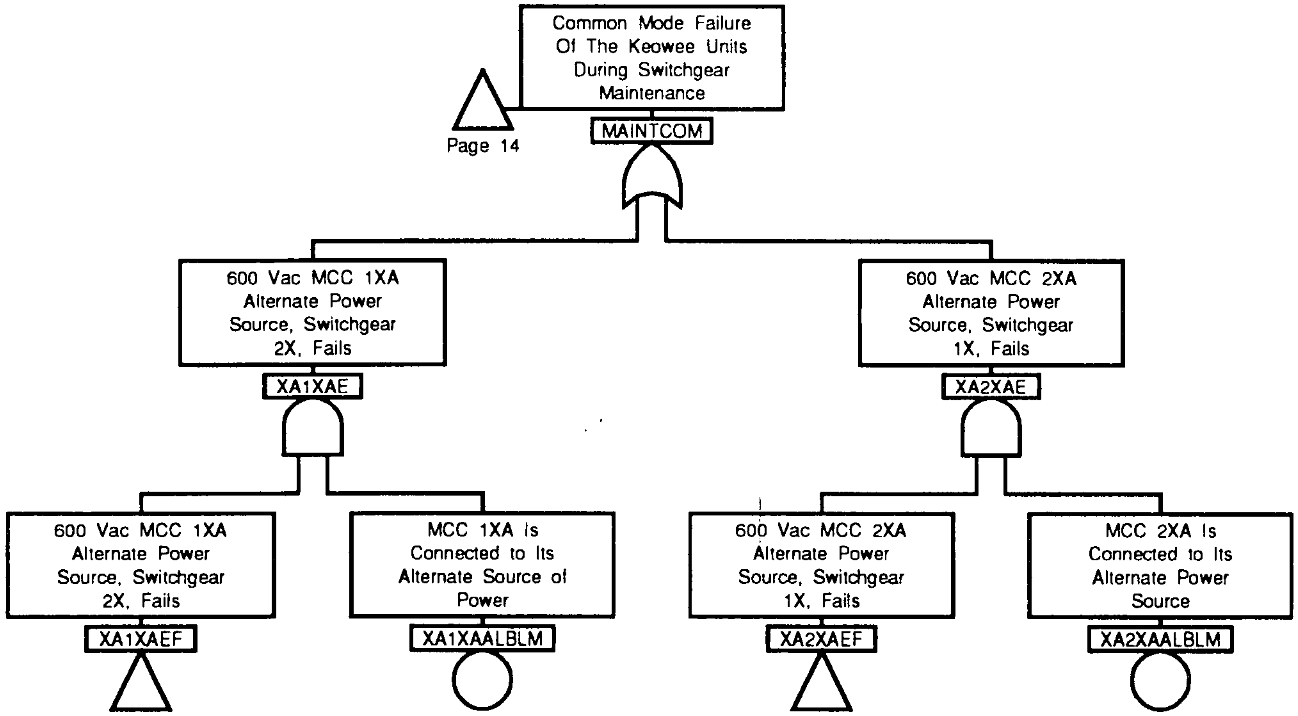


High Level Logic Model Tree

FIGURE A.1-1



High Level Logic Model Tree | FIGURE A.1-1



High Level Logic Model Tree | FIGURE A.1-1 |

Gate/Event Name	Page	Zone	Gate/Event Name	Page	Zone	Gate/Event Name	Page	Zone	Gate/Event Name	Page	Zone
1XUV	19		K12COM04	14		KK2UNITHYM	3		KU2GVTBRUN	12	
AB0SWGRCOM	18		K12COM1DEX	14		KK2UNITHYM	4		KU2OVER	7	
ACB1OPEN	5		K2NOMAIN	4		KK2UNITHYM	7		KU2OVER	8	
ACB1OPEN	14		K2NOMAIN	4		KK2UNITHYM	8		KU2OVER	9	
ACB2CLOSE	8		K2NOMAIN	13		KNOTBOTH	3		KU2OVER0	8	
ACB2TRANS	8		K2NOMAIN	14		KU1BOTH	4		KU2REC	1	
ACB3CLOSE	5		K2NOMAIN	16		KU1GENCLD	3		KU2REC	7	
ACB3OPEN	5		K2NOMAIN	19		KU1GENRUN	6		KU2RNNG	10	
ACB3TRANS	2		K2NOMAIN	19		KU1GEXCLD	3		KU2RNNG	11	
ACB3TRANS	19		KA127T1R6D	19		KU1GEXRUN	6		KU2RNNG	11	
ACB4CLOSE	7		KA127T1R6T	19		KU1GRID	14		KU2RUN	9	
ACB4MOD	4		KA227T2R6T	14		KU1GVTBCLD	3		KU2RUN	12	
ACB4TRANS	7		KB4CONNDEX	19		KU1GVTBHOT	5		KU2SPINNG	9	
ACBXFERCOM	18		KBOTHNORN	3		KU1GVTBRUN	6		KU2SPINNG	11	
AUXPWRCOM	17		KCOMCSTRT	15		KU1RNNG	2		KU2START	9	
AUXPWRCOM	18		KCOMHSTRT	15		KU1RNNG	4		KU2START	10	
BKGBOILCOM	18		KCOMHSTRT	16		KU1RNNG	14		KU2START0	9	
COMMCOLD	15		KCOMM	14		KU1RUN	2		KU2STARTF	10	
COOLCOM	16		KCOMM	15		KU1RUN	6		KU2STARTR	10	
COOLCOM	17		KCOMMODE	14		KU1SPINNG	2		KU2STARTR	10	
E12EXCTCOM	15		KCOMNOMAIN	13		KU1SPINS	2		KU2STARTR	15	
EK00RUNCOM	17		KCOMRUN	15		KU1SPINS	5		MAINTCOM	14	
EKSTARTCOM	15		KCOMRUN	17		KU1START	2		MAINTCOM	20	
FK0FISHCOM	16		KEOWCOM	1		KU1START0	2		NEWMODA	5	
FKVALVECOM	16		KEOWCOM	8		KU1STARTF	2		NEWMODB	5	
GENCOM	17		KEOWCOM	13		KU1STARTF	3		NOUNIT	1	
GK0COOLCOM	17		KEOWTOP	1		KU1STARTR	2		NTACB4MOD	4	
GK0LOCKCOM	17		KK1BOTHDEX	3		KU1STARTR	3		NTACB4MOD	5	
GKHPOILCOM	17		KK1BOTHDEX	4		KU1STARTR	15		NTACB4MOD	5	
GOVTBCOM	17		KK1BOTHDEX	11		KU1UNDER	2		OK0PRUNCOM	18	
GOVTBCOM	18		KK1BOTHDEX	14		KU1UNDER0	1		OPATHTOP	8	
K12COM	13		KK1BOTHDEX	16		KU1UNDER0	2		OVER0	1	
K12COM	14		KK1BOTHHYM	1		KU2GENCLD	10		OVER0	8	
K12COM01	14		KK1BOTHHYM	8		KU2GENRUN	12		OVERTOP	8	
K12COM02	14		KK1NORUN	3		KU2GEXCLD	10		PK0SUMPCOM	18	
K12COM02	19		KK1RUNSDEX	3		KU2GEXRUN	12		UNDER0	1	
K12COM03	14		KK1RUNSDEX	4		KU2GVTBCLD	10		UNDERTOP	1	
K12COM03	19		KK2RUNSDEX	11		KU2GVTBHOT	11		UPATHTOP	1	

APPENDIX A.2
KEOWEE EMERGENCY POWER PATHS

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

A.2 KEOWEE EMERGENCY POWER PATHS

A.2.1 OBJECTIVES

The main objective of this analysis is to develop logic models of the emergency power paths and the Switchyard Isolation function. This model is combined with the high level logic model and remaining system models to form an integrated model for assessing the reliability of Keowee. Other objectives are to identify major contributors to system unreliability, significant potential human errors and common-cause failure modes.

The scope of this analysis is limited to equipment required to support a Keowee emergency start and run under load following a loss of offsite power condition.

A.2.2 SYSTEM DESIGN

The Keowee underground power path connects a designated Keowee unit to the Oconee standby buses via transformer CT4. This path is dedicated for emergency power purposes and energizes whenever the designated Keowee unit is started. The overhead power path connects the remaining Keowee unit to the Oconee startup transformers through the 230 kV switchyard in loss of off-site power (LOOP) events. When a LOOP is detected by the External Grid Trouble Protection System (EGTPS), the EGTPS initiates a switchyard yellow bus isolation from the grid, and aligns emergency power from Keowee to the startup transformer of each Oconee unit.

Figure A.2-1 shows the overhead power path. Given an EGTPS actuation, the Keowee units are signaled to emergency start and a switchyard yellow bus isolation is initiated. The yellow bus isolation signal includes components which command power circuit breakers (PCBs) 8, 9, 12, 15, 17, 21, 24, 26, 28, and 33 to trip open and PCBs 9, 18, 27, and 30 to close. The PCB 9 close signal is not completed until the following is accomplished:

(1) a redundant switchyard isolated confirmed relay [27X/SC1 (27X/SC2)] signal is generated after the successful opening of PCBs 8, 12, 15, 17, 21, 24, 26, 28, and 33, and

(2) relay 27X/SC1 (27X/SC2) operates a time delay relay 27XTD/SC1 (27XTD/SC2), which [4 seconds after the operation of 27X/SC1 (27X/SC2)] disables the PCB 9 trip coil and enables the close coil.

The switchyard isolated confirmed relay [27X/SC1 (27X/SC2)] signal also actuates a switchyard isolation auxiliary relay SIA (SIB), which in turn actuates the Keowee Unit 1 and Unit 2 Switchyard Isolated Interposing Relays [1SIXA and 2SIXA (1SIXB and 2SIXB)]. The switchyard isolated interposing relays provide close permissive interlocks for the automatic closing circuits of ACB-1 and ACB-2.

A.2.3 SYSTEM BOUNDARIES

Overhead Path

The overhead path begins with the Keowee Main Step-Up Transformer and extends through the 230 kV Switchyard to the Oconee 3 startup breakers side of Transformer CT3. In the 230 kV Switchyard PCB 9 must be closed to complete the connection. Red Bus/Yellow Bus tie breakers PCBs 8, 17, and 26 as well as yellow bus isolation breakers PCBs 12, 15, 21, 24, and 33 must be open to isolate the emergency power path from switchyard connections.

Underground Path

The underground path begins at the 13.8 kV underground cable side of air circuit breaker (ACB)-3 and ACB-4 and continues to the standby bus feeder breakers side of CT4.

Electrical Power Supplies

The 230 kV Switchyard DC Power System provides the control power for the switchyard PCBs. Trip coils #1 for PCBs 8 through 17 are powered by Switchyard DC Panelboard DYA. Trip coils #1 for PCBs 21 through 33 are powered by Switchyard DC Panelboard DYB. Trip coils #2 for PCBs 8 through 17 are powered from Switchyard DC Panelboard DYE and trip coils #2 for PCBs 21 through 33 are powered by Switchyard DC Panelboard DYF. Closing coil power for each PCB is auctioneered between two

switchyard dc panelboards. For PCB 9, DYA and DYE are used, and for PCB 30, DYB and DYF are used. The Switchyard Isolate Complete Channel 1 logic uses control power from DYC and Channel 2 uses DYG.

External Control Systems

The automatic control signals that manipulate the 230 kV Switchyard PCBs are initiated by the EGTPS Channel 1 and Channel 2 (see Appendix A.3).

A.2.4 INSTRUMENTATION AND CONTROLS

The controls for the 230 kV Switchyard breakers are located in the Oconee 1 and 2 Control Room. All switchyard disconnects, both manual and motor-operated, have position indication in the control room. Synchronizing circuits and potential transformer inputs are selected by sync-scope selector switches. White indicating lights show which incoming lines or transformers are energized. Transducers as well as directly connected instrument transformers provide electrical measurements for the 230 kV Switchyard in the control room.

A.2.5 LOCATION WITHIN THE PLANT

The 230 kV Switchyard is located on the east side of the Turbine Building. It is the interface for Oconee Generator Units 1 and 2, Oconee Startup Transformers CT1, CT2, and CT3, the Oconee 525 kV Switchyard, the Keowee overhead line, and the 230 kV transmission lines (Dacus Black and White lines, Central Black and White lines, Calhoun Black and White lines, and Jocassee Black and White lines).

The CT4 Transformer is located in the Unit 1/2 Blockhouse adjacent to the east side of the Turbine Building.

A.2.6 NORMAL OPERATION

During the startup and shutdown of an Oconee unit, the 230 kV Switchyard provides power to the unit auxiliary loads through the respective unit startup transformer. When the unit generators are operating, the 230 kV Switchyard is the point where generated power from Oconee 1 and Oconee 2 is distributed to the 230 kV transmission system. The Keowee overhead path is normally energized by the switchyard through PCB 9 to provide auxiliary power to the Keowee unit assigned to the overhead power path.

The Keowee underground power path is normally not energized (unless the assigned Keowee unit is operating).

A.2.7 PERFORMANCE DURING KEOWEE EMERGENCY OPERATION

During Oconee emergency operation involving a loss of off-site power, the overhead power path through the isolated Yellow Bus of the 230 kV Switchyard provides emergency power from Keowee to the startup transformers of the Oconee units. The underground power path provides power through the CT4 Transformer to the Oconee 4160 V Standby Buses.

A.2.8 TEST AND MAINTENANCE

Testing

The Degraded Grid and Switchyard Isolation Functional Test is performed one channel at a time on a refueling frequency. The test includes the following:

(1) functional verification of the Keowee overhead ACB and PCB-9 operation during switchyard isolation,

(2) demonstration of the operability of the Degraded Grid Protection System (DGPS),

(3) demonstration of the ability of the overhead Keowee unit to energize the 230 kV Yellow Bus for all three Oconee units' Startup Transformers and carry the shutdown loads of Oconee Unit 1, and

(4) demonstration of the capability to realign the 230 kV Yellow Bus back to the system grid, while Oconee loads are being fed from the overhead Keowee unit.

A.2.9 OPERATING EXPERIENCE

A summary of significant operating events is provided in Table A.2-4.

A.2.10 ASSUMPTIONS

A.2.10.1 SYSTEM DESIGN ASSUMPTIONS

1. The switchyard PCBs are assumed to have adequate operating gas pressure prior to the actuating event.

2. The switchyard and emergency power paths are not operating in any kind of extreme environmental conditions prior to the actuating event.

A.2.10.2 OPERATIONAL ASSUMPTIONS

1. The switchyard is operating in a normal operational alignment with all switchyard breakers closed.

A.2.10.3 MODELING ASSUMPTIONS

1. The failure of any breaker to open or close in accordance with the switchyard isolation logic and overhead path alignment logic is a failure to establish the power path.

2. Operator action is not modeled.

3. The Unit 3 Startup Bus undervoltage detection function is provided by redundant circuits to ensure reactor coolant pumps are loadshed before the overhead path to the Unit 3 Startup Bus is completed. When reactor coolant pumps trip logic is not satisfied by a Startup Bus undervoltage signal, it is assumed that the reactor coolant pumps will overload the Startup Transformer when the pumps attempt to re-start. The modification which provides redundant Startup Bus undervoltage relays has been completed on Unit 3 and installation is planned for completion on Units 1 and 2.

A.2.11 FAULT TREE ANALYSIS

A.2.11.1 TOP EVENT SUCCESS CRITERIA

Success for either the underground power path or the overhead power path is that the path is established and maintained for 24 hours after the initiating event.

A.2.11.2 DETAILED FAILURE CRITERIA

1. Switchyard Yellow Bus isolation and closing of breakers necessary to establish the overhead power path to the startup transformers are the desired final actions and the top events in this section of the analysis. Lower levels of the fault tree involve breaker trip relays and closing coil operations that must occur to accomplish the top events.

A.2.11.3 DESCRIPTION OF FAULT TREE

The System fault tree is shown in Figure A.2-2. The Fault Tree Modeling Guidelines (Appendix B) were followed in developing the fault tree. A list of all fault tree transfers is presented in Table A.2-4.

A.2.11.4 HUMAN INTERACTIONS

Human reliability analysis was performed as described in Appendix C.3. One possible human action has been determined that could impact success of the underground power path.

SXFRCT4LHE

This basic event accounts for technician errors during CT4 maintenance that may not be detected during post maintenance testing.

A.2.11.5 RELIABILITY DATA

Appendix C.1 discusses development of the reliability data. System reliability data is listed in Table A.2-5.

A.2.11.6 COMMON CAUSE ASSESSMENT

Common cause analysis was performed as described in Appendix C.2.

SU327UVCOM This basic event accounts for the possibility that both Unit 3 Startup Bus undervoltage relays experience a common cause failure. The relays are of the same make and model, and common cause failures are assumed to exist.

A.2.12 RESULTS

Reliability of the system is defined as the probability that the system will succeed in supporting Keowee emergency operation (black start plus a 24 hour run). The system model yields a probability of approximately 1.14E-03 for failure to maintain the underground path for the mission time of the event. The failure of the overhead path is 8.08E-03. Thus the reliability of the underground path is 99.89% and the reliability of the overhead path is computed to be 99.19%. The relative importance of the various component failures is shown in Tables A.2-6 and -7.

A.2.13 REFERENCES

A.2.13.1 DOCUMENTS

1. OSS-0254-00-00-2004, 230 kV Switchyard Design Basis Document

A.2.13.2 DRAWINGS

1. OEE-38, Rev. 12, 230 kV Switchyard Control PCB No. 8 Trip Coil No. 1

2. OEE-38A, Rev. 7, 230 kV Switchyard Control PCB No. 8 Trip Coil No. 2

3. OEE-39, Rev. 11, 230 kV Switchyard Control PCB No. 9 Trip Coil No. 1

4. OEE-39A, Rev. 9, 230 kV Switchyard Control PCB No. 9 Trip Coil No. 2

5. OEE-39B, Rev. 1, 230 kV Switchyard Control PCB No. 9 Close Coil

6. OEE-42, Rev. 6, 230 kV Switchyard Control PCB No. 12 Trip Coil No. 1

7. OEE-42A, Rev. 6, 230 kV Switchyard Control PCB No. 12 Trip Coil No. 2

8. OEE-45, Rev. 6, 230 kV Switchyard Control PCB No. 15 Trip Coil No. 1

9. OEE-45A, Rev. 7, 230 kV Switchyard Control PCB No. 15 Trip Coil No. 2

10. OEE-47, Rev. 10, 230 kV Switchyard Control PCB No. 17 Trip Coil No. 1

11. OEE-47A, Rev. 7, 230 kV Switchyard Control PCB No. 17 Trip Coil No. 2

12. OEE-51, Rev. 11, 230 kV Switchyard Control PCB No. 21 Trip Coil No. 1

13. OEE-51A, Rev. 15, 230 kV Switchyard Control PCB No. 21 Trip Coil No. 2

14. OEE-54, Rev. 11, 230 kV Switchyard Control PCB No. 24 Trip Coil No. 1

15. OEE-54A, Rev. 14, 230 kV Switchyard Control PCB No. 24 Trip Coil No. 2

16. OEE-56, Rev. 12, 230 kV Switchyard Control PCB No. 26 Trip Coil No. 1

17. OEE-56A, Rev. 9, 230 kV Switchyard Control PCB No. 26 Trip Coil No. 2

18. OEE-58, Rev. 3, 230 kV Switchyard Control PCB No. 28 Trip Coil No. 1

19. OEE-58A, Rev. 2, 230 kV Switchyard Control PCB No. 28 Trip Coil No. 2

20. OEE-60B, Rev. 0, 230 kV Switchyard Control PCB No. 30 Close Coil

21. OEE-63, Rev. 5, 230 kV Switchyard Control PCB No. 33 Trip Coil No. 1

22. OEE-63A, Rev. 5, 230 kV Switchyard Control PCB No. 33 Trip Coil No. 2

23. OEE-71-2, & -3 series, Startup Transformer CT3 Diff. Lock Out

24. OEE-76 series, External Grid Trouble Protective System

25. OEE-78, Rev. 4, Transf. CT4 Diff. Lockout

26. OEE-317-56, Rev. 6, 6900V. Switchgear #3TA Breaker Throwover Circuit

27. KEE-17 series, Keowee Hydro Station Transformer Differential

Table A.2-1

Keeowee Emergency Power Paths Power Supplies

Component	Power Supply[1]	Compartment Number
PCB-9 Trip Coil #1	SDC Pnlbd DYA	Bkr 9
PCB-9 Trip Coil #2	SDC Pnlbd DYE	Bkr 9
PCB-9 Closing Coil	SDC Pnlbd DYE	Bkr 9
PCB-9 Closing Coil	SDC Pnlbd DYA	Bkr 9
PCB-30 Closing Coil	SDC Pnlbd DYB	Bkr 10
PCB-30 Closing Coil	SDC Pnlbd DYF	Bkr 10
PCB-8 Trip Coil #1	SDC Pnlbd DYA	Bkr 8
PCB-8 Trip Coil #2	SDC Pnlbd DYE	Bkr 8
PCB-12 Trip Coil #1	SDC Pnlbd DYA	Bkr 12
PCB-12 Trip Coil #2	SDC Pnlbd DYE	Bkr 12
PCB-15 Trip Coil #1	SDC Pnlbd DYA	Bkr 15
PCB-15 Trip Coil #2	SDC Pnlbd DYE	Bkr 15
PCB-17 Trip Coil #1	SDC Pnlbd DYA	Bkr 17
PCB-17 Trip Coil #2	SDC Pnlbd DYE	Bkr 17
PCB-21 Trip Coil #1	SDC Pnlbd DYB	Bkr 1
PCB-21 Trip Coil #2	SDC Pnlbd DYF	Bkr 1

[1] MCC = Motor Control Center
DC = Distribution Center

Table A.2-1

Keowee Emergency Power Paths Power Supplies

Component	Power Supply[1]	Compartment Number
PCB-24 Trip Coil #1	SDC Pnlbd DYB	Bkr 4
PCB-24 Trip Coil #2	SDC Pnlbd DYF	Bkr 4
PCB-26 Trip Coil #1	SDC Pnlbd DYB	Bkr 6
PCB-26 Trip Coil #2	SDC Pnlbd DYF	Bkr 6
PCB-28 Trip Coil #1	SDC Pnlbd DYB	Bkr 8
PCB-28 Trip Coil #2	SDC Pnlbd DYF	Bkr 8
PCB-33 Trip Coil #1	SDC Pnlbd DYB	Bkr 13
PCB-33 Trip Coil #2	SDC Pnlbd DYF	Bkr 13
Swyd Isolate Complete Ch 1	SDC Pnlbd DYC	Bkr 12
Swyd Isolate Complete Ch 2	SDC Pnlbd DYG	Bkr 16

[1] MCC = Motor Control Center
DC = Distribution Center

Table A.2-2

Keowee Emergency Power Paths Test Procedures

Procedure	Test Frequency	Description
PT/0/A/0610/22, Degraded Grid and Switchyard Isolation Functional Test	Unit 1 Refueling	Functional verification of overhead ACB and PCB-9 operation during Switchyard Isolation. Demonstration of Degraded Grid Protection System operability. Demonstration of Keowee units' "Black Start" capability. Demonstration of Overhead unit ability to energize the Startup Transformers and carry the shutdown loads of Unit 1. Demonstration of capability to realign Yellow Bus back to the grid while feeding the Oconee loads from the overhead unit.

Table A.2-3

Keowee Emergency Power Paths Significant Operating Events

Date	Unit	Component	Event Summary
11/20/86	1/2	94T/K Relay	Keowee main step-up transformer locked out and PCBs 8 and 9 tripped open, which isolated Oconee's overhead emergency power path as a result of relay 94T/K actuation caused by vibration due to drilling and grinding on a panel at Keowee. The 94T/K relay is known to be mechanically sensitive.
1/31/86	0	PCB-20	While troubleshooting PCBs in the 230 kV Swyd PCB-24 was manually closed without reseting the Generator Lockout relays. A yellow bus lockout occurred. When all the tie breakers opened, all of Generator #1 current passed through PCB-20 to the grid. The breaker exploded apparently due to degraded breaker contacts. A Unit 1 Reactor trip ensued.
3/27/86	2	Lightning Arrestors	While changing lightning arrestors a capacitor was not re-installed on the X-phase due to a stripped bolt. When Keowee 2 was started for an operational test an emergency lockout was received due to a Generator Ground fault Overvoltage (59GN2 Relay). The Y and Z-phase capacitors were removed and the the unit tested satisfactorily.

Table A.2-3

Keowee Emergency Power Paths Significant Operating Events

Date	Unit	Component	Event Summary
8/28/85	0	CT-3	Oconee 3 was in a refueling outage with auxiliary power being supplied through CT-3 when the transformer's Fault Pressure Relay actuated. A lockout occurred which cleared and de-energized CT-3 and the Unit 3 Main Feeder Buses resulting in a Unit 3 LOOP. The cause of the fault pressure could not be determined.
9/28/84	1/2	PCB-22	PCB-22 short circuited when being returned to service following maintenance. This caused a Red Bus differential lockout which opened PCB-8 and-9. The reason PCB-9 opened is unknown.
1/26/84	2	ACB-2	While Keowee 2 was out of service for annual ACB maintenance, the maintenance crew failed to lift the trip wires before servicing ACB-2. This caused PCB-8 and -9 to open.

Table A.2-4

Keeowee Emergency Power Paths Fault Tree Transfers

Transfer Gate Name	Description	Components Supplied
SDCDYA	Loss of Power on 125 Vdc Swyd DC Pnlbd DYA	PCB-9 Trip Coil #1 PCB-9 Clsng Ckt Source #1 PCB-8 Trip Coil #1 PCB-12 Trip Coil #1 PCB-15 Trip Coil #1 PCB-17 Trip Coil #1
SDCDYB	Loss of Power on 125 Vdc Swyd DC Pnlbd DYB	PCB-30 Clsng Ckt Source #1 PCB-21 Trip Coil #1 PCB-24 Trip Coil #1 PCB-26 Trip Coil #1 PCB-28 Trip Coil #1 PCB-33 Trip Coil #1
SDCDYC	Loss of Power on 125 Vdc Swyd DC Pnlbd DYC	Swyd Isolate Complete Ch 1
SDCDYE	Loss of Power on 125 Vdc Swyd DC Pnlbd DYE	PCB-9 Trip Coil #2 PCB-9 Clsng Ckt Source #2 PCB-8 Trip Coil #2 PCB-12 Trip Coil #2 PCB-15 Trip Coil #2 PCB-17 Trip Coil #2

Table A.2-4

Keeowee Emergency Power Paths Fault Tree Transfers

Transfer Gate Name	Description	Components Supplied
SDCDYF	Loss of Power on 125 Vdc Swyd DC Pnlbd DYF	PCB-30 Clsng Ckt Source #2 PCB-21 Trip Coil #2 PCB-24 Trip Coil #2 PCB-26 Trip Coil #2 PCB-28 Trip Coil #2 PCB-33 Trip Coil #2
SDCDYG	Loss of Power on 125 Vdc Swyd DC Pnlbd DYG	Swyd Isolate Complete Ch 2 PCB-9 Clsng Ckt Source #1
SDCDYC	Loss of Power on 125 Vdc Swyd DC Pnlbd DYC	Swyd Isolate Complete Ch 1
SEGTP1ANIT	EGTPS Ch 1A Initiators Fail	PCB-24 Trip Coil #1 PCB-26 Trip Coil #1 PCB-28 Trip Coil #1 PCB-33 Trip Coil #1
SEGTP2ANIT	EGTPS Ch 2A Initiators Fail	PCB-24 Trip Coil #2 PCB-26 Trip Coil #2 PCB-28 Trip Coil #2 PCB-33 Trip Coil #2

Table A.2-4

Keeowee Emergency Power Paths Fault Tree Transfers

Transfer Gate Name	Description	Components Supplied
SEGTP1BNIT	EGTPS Ch 1B Initiators Fail	Keowee Start Relay 27X/STA PCB-8 Trip Coil #1 PCB-12 Trip Coil #1 PCB-15 Trip Coil #1 PCB-17 Trip Coil #1
SEGTP2BNIT	EGTPS Ch 2B Initiators Fail	Keowee Start Relay 27X/STB PCB-8 Trip Coil #2 PCB-17 Trip Coil #2
SEG94V1AF	EGTPS UV Ch 1 Relay 94V1A Fails	EGTPS Ch 1A
SEG94V2AF	EGTPS UV Ch 2 Relay 94V2A Fails	PCB-12 Trip Coil #2 EGTPS Ch 2A
SEG94F1AF	EGTPS UF Ch 1 Relay 94F1A Fails	EGTPS Ch 1A
SEG94F2AF	EGTPS UF Ch 2 Relay 94 F2A Fails	PCB-12 Trip Coil #2 EGTPS Ch 2A

Table A.2-4

Keeowee Emergency Power Paths Fault Tree Transfers

Transfer Gate Name	Description	Components Supplied
SEG94V1DF	EGTPS UV Ch 1 Relay 94 V1D Fails	Swyd Isolate Signal EGTPS Ch 1D
SEG94F1DF	EGTPS UF Ch1 Relay 94 F1D Fails	Swyd Isolate Signal EGTPS Ch 1D
SEG94V2BF	EGTPS UV Ch 2 Relay 94 V2B Fails	PCB-12 Trip Coil #2 PCB-15 Trip Coil #2
SEG94F2BF	EGTPS UF Ch 2 Relay 94 F2B Fails	PCB-12 Trip Coil #2 PCB-15 Trip Coil #2
SEG94V2CF	EGTPS UV Ch 2 Relay 94V2C Fails	PCB-15 Trip Coil #2
SEG94F2CF	EGTPS UF Ch 2 Relay 94F2C Fails	PCB-15 Trip Coil #2
SEG94V2DF	EGTPS UV Ch 2 Relay 94V2D Fails	Swyd Isolate Signal PCB-21 Trip Coil #2
SEG94F2DF	EGTPS UF Ch 2 Relay 94F2D Fails	Swyd Isolate Signal PCB-21 Trip Coil #2

Table A.2-5

Keowee Emergency Power Paths Reliability Data

Event Name	Description	Failure Rate[1]	Factor	Rationale For Factor[2]	Failure Probability
AB1FALTDEX	Fault Occurs at ACB 1				0.00E+00
AB1PSWTPST	Air Circuit Breaker 1 Accumulator Pressure Switch Fails Low	4.30E-07 /H	24 H	Rule 5: Last demanded at unit start	1.03E-05
AB2PSWTPST	Air Circuit Breaker 2 Accumulator Pressure Switch Fails Low	4.30E-07 /H	24 H	Rule 5: Last demanded at unit start	1.03E-05
AB3PSWTPST	Air Circuit Breaker 3 Accumulator Pressure Switch Fails Low	4.30E-07 /H	24 H	Assumed ACB-3 would have to open half way through the mission to allow recovery by closing ACB-4.	1.03E-05
AB4PSWTPST	Air Circuit Breaker 4 Accumulator Pressure Switch Indicates Low Air Pressure	4.30E-07 /H	12 H	Half the time since the last operation and assume ACB-4 is needed half way through the mission (360+12)	5.16E-06
ACBAIRPDEX	ACB Air Supply Fails Causing Low Pressure In All ACB Accumulators	2.00E-03			2.00E-03
AD1C3CCCDT	Breaker 3CC In 125V dc Distribution Center 1DA Transfers Position	7.50E-08 /H	24 H	Rule 1: Loss of power is alarmed	1.80E-06
AD1C3CLCDT	Breaker 3CL In 125V dc Distribution Center 1DA Transfers Position	7.50E-08 /H	24 H	Rule 1: Loss of power is alarmed	1.80E-06
AD2C3CCCDT	Breaker 3CC In 125V dc Distribution Center 2DA Transfers Position	7.50E-08 /H	24 H	Rule 1: Loss of power is alarmed	1.80E-06
AD2C3CLCDT	Breaker 3CL In 125V dc Distribution Center 2DA Transfers Position	7.50E-08 /H	24 H	Rule 1: Loss of power is alarmed	1.80E-06
KK1OVERBHF	Fault Occurs On The Overhead Power Path	4.00E-07 /H	24 H		9.60E-06
KK1UNDRBHF	Fault Occurs On The Underground Power Path	4.00E-07 /H	24 H		9.60E-06

Table A.2-5

Keowee Emergency Power Paths Reliability Data

Event Name	Description	Failure Rate[1]	Factor	Rationale For Factor[2]	Failure Probability
S27XSC1RYD	Channel 1 Swyd Isolated Rly, 27X/SC1, Fails to Pick Up	3.30E-05 /D	1 D	1 demand per swyd isolation event	3.30E-05
S27XSC2RYD	Channel 2 Swyd Isolated Rly, 27X/SC2, Fails to Pick Up	3.30E-05 /D	1 D	1 demand per swyd isolation event	3.30E-05
S27XTD1RYD	Channel 1 Swyd Isolated Time Delay Rly, 27XTD/SC1, Fails	3.30E-05 /D	1 D	1 demand per swyd isolation event	3.30E-05
S27XTD2RYD	Channel 2 Swyd Isolated Time Delay Rly, 27XTD/SC2, Fails	3.30E-05 /D	1 D	1 demand per swyd isolation event	3.30E-05
SB18UX1RYT	Auxiliary Relay 8UX-1 Spurious Operation	3.60E-06 /H	24 H		8.64E-06
SB28UX2RYT	Auxiliary Relay 8UX-2 Spurious Operation	3.60E-06 /H	24 H		8.64E-06
SB38UX3RYT	Auxiliary Relay 8UX-3 Spurious Operation	3.60E-06 /H	24 H		8.64E-06
SB48UX4RYT	Auxiliary Relay 8UX-4 Spurious Operation	3.60E-06 /H	24 H		8.64E-06
SDCAIDDDIF	Control Power From DYA To PCB 9 Isolating Diode Fails	3.80E-06 /H	24 H		9.12E-05
SDCBIDXDIF	Control Power From DYB To PCB-30 Isolating Diode Fails (2 Diodes)	3.80E-06 /H	24 H		9.12E-05
SDCDA12CDT	125 Vdc Swyd Control Power Pnlbd DYA Bkr 12 Xfrs Open	7.50E-08 /H	24 H	Rule 1: Loss of power is alarmed	1.80E-06
SDCDA15CDT	125 Vdc Swyd Control Power Pnlbd DYA Bkr 15 Xfrs Open	7.50E-08 /H	24 H	Rule 1: Loss of power is alarmed	1.80E-06
SDCDA17CDT	125 Vdc Swyd Control Power Pnlbd DYA Bkr 17 Xfrs Open	7.50E-08 /H	24 H	Rule 1: Loss of power is alarmed	1.80E-06

Table A.2-5

Keowee Emergency Power Paths Reliability Data

Event Name	Description	Failure Rate[1]	Factor	Rationale For Factor[2]	Failure Probability
SDCDB01CDT	125 Vdc Swyd Control Power Pnlbd DYB Bkr 1 Xfrs Open	7.50E-08 /H	24 H	Rule 1: Loss of power is alarmed	1.80E-06
SDCDB13CDT	125 Vdc Swyd Control Power Pnlbd DYB Bkr 13 Xfrs Open	7.50E-08 /H	24 H	Rule 1: Loss of power is alarmed	1.80E-06
SDCDC12CDT	125 Vdc Swyd Control Power Pnlbd DYC Bkr 12 Xfrs Open	7.50E-08 /H	24 H	Rule 1: Loss of power is alarmed	1.80E-06
SDCDE12CDT	125 Vdc Swyd Control Power Pnlbd DYE Bkr 12 Xfrs Open	7.50E-08 /H	24 H	Rule 1: Loss of power is alarmed	1.80E-06
SDCDE15CDT	125 Vdc Swyd Control Power Pnlbd DYE Bkr 15 Xfrs Open	7.50E-08 /H	24 H	Rule 1: Loss of power is alarmed	1.80E-06
SDCDE17CDT	125 Vdc Swyd Control Power Pnlbd DYE Bkr 17 Xfrs Open	7.50E-08 /H	24 H	Rule 1: Loss of power is alarmed	1.80E-06
SDCDF01CDT	125 Vdc Swyd Control Power Pnlbd DYF Bkr 1 Xfrs Open	7.50E-08 /H	24 H	Rule 1: Loss of power is alarmed	1.80E-06
SDCDF13CDT	125 Vdc Swyd Control Power Pnlbd DYF Bkr 13 Xfrs Open	7.50E-08 /H	24 H	Rule 1: Loss of power is alarmed	1.80E-06
SDCDG16CDT	125 Vdc Swyd Control Power Pnlbd DYG Bkr 16 Xfrs Open	7.50E-08 /H	24 H	Rule 1: Loss of power is alarmed	1.80E-06
SDCDY10CDT	125 Vdc Swyd Control Power Pnlbd DYB Bkr 10 Xfrs Open	7.50E-08 /H	24 H	Rule 1: Loss of power is alarmed	1.80E-06
SDCDYA8CDT	125 Vdc Swyd Control Power Pnlbd DYA Bkr 8 Xfrs Open	7.50E-08 /H	24 H	Rule 1: Loss of power is alarmed	1.80E-06
SDCDYA9CDT	125 Vdc Swyd Control Power Pnlbd DYA Bkr 9 Xfrs Open	7.50E-08 /H	24 H	Rule 1: Loss of power is alarmed	1.80E-06
SDCDYB4CDT	125 Vdc Swyd Control Power Pnlbd DYB Bkr 4 Xfrs Open	7.50E-08 /H	24 H	Rule 1: Loss of power is alarmed	1.80E-06

Table A.2-5

Keowee Emergency Power Paths Reliability Data

Event Name	Description	Failure Rate[1]	Factor	Rationale For Factor[2]	Failure Probability
SDCDYB6CDT	125 Vdc Swyd Control Power Pnlbd DYB Bkr 6 Xfrs Open	7.50E-08 /H	24 H	Rule 1: Loss of power is alarmed	1.80E-06
SDCDYB8CDT	125 Vdc Swyd Control Power Pnlbd DYB Bkr 8 Xfrs Open	7.50E-08 /H	24 H	Rule 1: Loss of power is alarmed	1.80E-06
SDCDYE8CDT	125 Vdc Swyd Control Power Pnlbd DYE Bkr 8 Xfrs Open	7.50E-08 /H	24 H	Rule 1: Loss of power is alarmed	1.80E-06
SDCDYE9CDT	125 Vdc Swyd Control Power Pnlbd DYE Bkr 9 Xfrs Open	7.50E-08 /H	24 H	Rule 1: Loss of power is alarmed	1.80E-06
SDCDYF4CDT	125 Vdc Swyd Control Power Pnlbd DYF Bkr 4 Xfrs Open	7.50E-08 /H	24 H	Rule 1: Loss of power is alarmed	1.80E-06
SDCDYF6CDT	125 Vdc Swyd Control Power Pnlbd DYF Bkr 6 Xfrs Open	7.50E-08 /H	24 H	Rule 1: Loss of power is alarmed	1.80E-06
SDCDYF8CDT	125 Vdc Swyd Control Power Pnlbd DYF Bkr 8 Xfrs Open	7.50E-08 /H	24 H	Rule 1: Loss of power is alarmed	1.80E-06
SDCDYY0CDT	125 Vdc Swyd Control Power Pnlbd DYF Bkr 10 Xfrs Open	7.50E-08 /H	24 H	Rule 1: Loss of power is alarmed	1.80E-06
SDCEIDDDIF	Control Power From DYE To PCB-9 Isolating Diode Fails	3.80E-06 /H	24 H	Rule 1: Loss of power is alarmed	9.12E-05
SDCFIDXDIF	Control Power From DYF To PCB-30 Isolating Diode Fails (2 diodes)	3.80E-06 /H	24 H	Rule 1: Loss of power is alarmed	9.12E-05
SK194GBRYT	Keowee Unit 1 94GB Auxiliary Relay Spurious Operation	3.60E-06 /H	24 H		8.64E-06
SK294GBRYT	Keowee Unit 2 94GB Auxiliary Relay Spurious Operation	3.60E-06 /H	24 H		8.64E-06
SPC14KVBHF	13.8 kV Bus Faulted	4.00E-07 /H	24 H		9.60E-06

Table A.2-5

Keowee Emergency Power Paths Reliability Data

Event Name	Description	Failure Rate[1]	Factor	Rationale For Factor[2]	Failure Probability
SPC51TNRYT	Main Step Up Transformer Neutral Ground Relay 51TN Spurious Operation	3.60E-06 /H	24 H		8.64E-06
SPC62ABRYT	ACB Back-up Trip Timer 62AB Spurious Operation	3.60E-06 /H	24 H		8.64E-06
SPC631XRYT	Auxiliary Relay 63H1X Spurious Operation	3.60E-06 /H	24 H		8.64E-06
SPC871XRYT	Transformer 1X Differential Relay 87T-1X Spurious Operation	3.60E-06 /H	72 H		2.59E-05
SPC872XRYT	Transformer 2X Differential Relay 87T-2X Spurious Operation	3.60E-06 /H	72 H		2.59E-05
SPC87T1RYT	Main Step Up Transformer Differential Relay 87T Spurious Operation	3.60E-06 /H	72 H		2.59E-05
SPC94TKRYT	Auxiliary Relay 94T/K Spurious Operation	3.60E-06 /H	24 H		8.64E-06
SPCB008CHO	SWYD PCB-8 Fails to Trip	2.60E-05 /D	1 D	1 demand per swyd isolation event	2.60E-05
SPCB009CHC	SWYD PCB-9 Fails To Close On Demand	2.60E-04 /D	1 D	1 demand per swyd isolation event	9.40E-04
SPCB009CHO	SWYD PCB-9 Fails To Trip	2.60E-05 /D	1 D	1 demand per swyd isolation event	2.60E-04
SPCB012CHO	SWYD PCB-12 Fails To Trip	2.60E-05 /D	1 D	1 demand per swyd isolation event	2.60E-05
SPCB015CHO	SWYD PCB-15 Fails To Trip On Demand	2.60E-05 /D	1 D	1 demand per swyd isolation event	2.60E-05
SPCB017CHO	SWYD PCB-17 Fails To Trip On Demand	2.60E-05 /D	1 D	1 demand per swyd isolation event	2.60E-05
SPCB021CHO	SWYD PCB-21 Fails To Trip On Demand	2.60E-05 /D	1 D	1 demand per swyd isolation event	2.60E-05
SPCB024CHO	SWYD PCB-24 Fails To Trip On Demand	2.60E-05 /D	1 D	1 demand per swyd isolation event	2.60E-05
SPCB026CHO	SWYD PCB-26 Fails To Trip On Demand	2.60E-05 /D	1 D	1 demand per swyd isolation event	2.60E-05

Table A.2-5

Keewee Emergency Power Paths Reliability Data

Event Name	Description	Failure Rate[1]	Factor	Rationale For Factor[2]	Failure Probability
SPCB028CHO	SWYD PCB-28 Fails To Trip On Demand	2.60E-05 /D	1 D	1 demand per swyd isolation event	2.60E-05
SPCB030CHC	SWYD PCB-30 Fails To Close On Demand	2.60E-04 /D	1 D	1 demand per swyd isolation event	2.60E-04
SPCB033CHO	SWYD PCB-33 Fails To Open On Demand	2.60E-05 /D	1 D	1 demand per swyd isolation event	2.60E-05
SPCD87LRYT	Line Differential Relay 87L Spurious Operation	3.60E-06 /H	24 H		8.64E-06
SPCGLASSWT	Break Glass Switch Spurious Operation	7.00E-08 /H	24 H		1.75E-06
SPCR86TRYT	Lock Out Relay 86T Spurious Operation	3.60E-06 /H	24 H		8.64E-06
SXFRCT3THF	Transformer CT3 Faulted	3.10E-06 /H	24 H		7.44E-05
SXFRCT3THM	Transformer CT3 Is In Maintenance				1.74E-04
SXFRCT4LHE	Latent Human Error On CT4 Maintenance				6.40E-05
SXFRCT4THM	Transformer CT4 Is In Maintenance				9.13E-04
SY30R94RYT	PCB 30 Relay 94 Spuriously Picks Up	3.60E-06 /H	24 H		8.64E-06
SY51TN2RYT	230kV Neutral Ground Relay Spuriously Picks Up	3.60E-06 /H	24 H		8.64E-06
SY51TN4RYT	4.16kV Neutral Ground Relay Spuriously Picks Up	3.60E-06 /H	24 H		8.64E-06
SY51TN6RYT	6.9kV Neutral Ground Relay 51TN Spuriously Picks Up	3.60E-06 /H	24 H		8.64E-06
SY62X1FRYT	Breaker Failure Relay 62X1 Spuriously Picks Up	3.60E-06 /H	24 H		8.64E-06
SY62X2FRYT	Breaker Failure Relay 62X2 Spuriously Picks Up	3.60E-06 /H	24 H		8.64E-06

Table A.2-5

Keowee Emergency Power Paths Reliability Data

Event Name	Description	Failure Rate[1]	Factor	Rationale For Factor[2]	Failure Probability
SY62XXFRYT	Breaker Failure Relay 62X Spuriously Picks Up	3.60E-06 /H	24 H		8.64E-06
SY86BUIRYT	CT3 6.9kV Start Up Bus Lockout Relay Spuriously Picks Up	3.60E-06 /H	24 H		8.64E-06
SY86CT3RYT	Transformer CT3 Lockout Relay Spuriously Picks Up	3.60E-06 /H	24 H		8.64E-06
SY86YA9RYT	Yellow Bus Lockout Auxiliary Relay 86YA9 Spuriously Picks Up	3.60E-06 /H	24 H		8.64E-06
SY86YJ3RYT	Yellow Bus Lockout Auxiliary Relay 86YJ30 Spuriously Picks Up	3.60E-06 /H	24 H		8.64E-06
SY87BYXRYT	Yellow Bus X Phase Differential Relay 87BYX Spuriously Picks Up	3.60E-06 /H	24 H		8.64E-06
SY87BYYRYT	Yellow Bus Y Phase Differential Relay 87BYY Spuriously Picks Up	3.60E-06 /H	24 H		8.64E-06
SY87BYZRYT	Yellow Bus Z Phase Differential Relay 86BYZ Spuriously Picks Up	3.60E-06 /H	24 H		8.64E-06
SY87LXXRYT	Differential Auxiliary Relay 87LX Spuriously Picks Up	3.60E-06 /H	24 H		8.64E-06
SY94L1XRYT	Protective Relay 94L Spuriously Picks Up	3.60E-06 /H	24 H		8.64E-06
SYE1362RYT	E13 Bkr Failure Relay 62B Spuriously Picks Up	3.60E-06 /H	24 H		8.64E-06
SYE2362RYT	E23 Bkr Failure Relay 62B Spuriously Picks Up	3.60E-06 /H	24 H		8.64E-06
SYP2862RYT	PCB 28 Breaker Failure Relay 62B Spuriously Picks Up	3.60E-06 /H	24 H		8.64E-06

Table A.2-5

Keowee Emergency Power Paths Reliability Data

Event Name	Description	Failure Rate[1]	Factor	Rationale For Factor[2]	Failure Probability
SYP3062RYT	PCB 30 Breaker Failure Relay 62B Spuriously Picks Up	3.60E-06 /H	24 H		8.64E-06
SYP86TXRYT	PCB 30 LOR 86TX Spuriously Picks Up	3.60E-06 /H	24 H		8.64E-06
SYPCB09CHT	Switchyard Power Circuit Breaker 9 Transfers Open	1.90E-06 /H	24 H		4.56E-05
SYPCB30CHT	Switchyard Power Circuit Breaker 30 Transfers Open	1.90E-06 /H	24 H		4.56E-05
SYPL86TRYT	PCB 30 LOR 86T Spuriously Picks Up	3.60E-06 /H	24 H		8.64E-06
SYPL87LRYT	Differential Relay 87L Spuriously Picks Up	3.60E-06 /H	24 H		8.64E-06
SYR86BYRYT	Yellow Bus Lockout Relay 86BY Spuriously Picks Up	3.60E-06 /H	24 H		8.64E-06
SYS63FPRYT	Fault Pressure Relay 63FP Spuriously Picks Up	3.60E-06 /H	24 H		8.64E-06
SYSX50BRYT	Transformer CT3 Fault Detector Relay 50B Spuriously Picks Up	3.60E-06 /H	24 H		8.64E-06
SYX87TBRYT	Differential Relay 87B Spuriously Picks Up	3.60E-06 /H	24 H		8.64E-06
SYXX87TRYT	Differential Relay 87T Spuriously Picks Up	3.60E-06 /H	24 H		8.64E-06
U5086EFRYT	Overcurrent Relay 50 Spuriously Actuates Lockout Rly 86EF	3.60E-06 /H	24 H		8.64E-06
U5186EFRYT	Time Delay Overcurrent Relay 51 Actuates Lockout Relay 86EF	3.60E-06 /H	24 H		8.64E-06
U51TNC4RYT	CT4 Neutral Ground Rly Actuates CT4 LOR 86T/CT4	3.60E-06 /H	24 H		8.64E-06

Table A.2-5

Keewee Emergency Power Paths Reliability Data

Event Name	Description	Failure Rate[1]	Factor	Rationale For Factor[2]	Failure Probability
U62BSK1RYT	SK1 Breaker Failure Relay 62BXSK1 Spuriously Picks Up	3.60E-06 /H	24 H		8.64E-06
U62BSK2RYT	SK2 Breaker Failure Relay 62BXSK2 Spuriously Picks Up	3.60E-06 /H	24 H		8.64E-06
U86CT4XRYT	Auxiliary Lockout Relay 86CT4X Spuriously Picks Up	3.60E-06 /H	24 H		8.64E-06
U86TCT4RYT	CT4 Lockout Relay 86T/CT4 Spuriously Picks Up	3.60E-06 /H	24 H		8.64E-06
U87TCT4RYT	Spurious Op of CT4 Differential Rly 87T Actuates LOR 86EF	3.60E-06 /H	24 H		8.64E-06
UACXCT4THF	Transformer CT4 Failed	3.10E-06 /H	24 H		7.44E-05
UXX86EFRYT	Lockout Relay 86EF Spuriously Picks Up	3.60E-06 /H	24 H		8.64E-06

1 D = Demand, H = Hour

2 Rules for assigning basic event factors are discussed in Table C.1-4.

Table A.2-6

Keeowee Emergency Power Paths Dominant Minimal Cut Sets

Cut Sets For Gate UPATHTOP: Underground Path Fails To Connect Keowee To Oconee

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
1)	9.13E-04	80.1	SXFRCT4THM	9.13E-04	Transformer CT4 Is In Maintenance
			K2NOMAIN	1.00E+00	Keowee Unit 2 Is Not In Maintenance
2)	7.44E-05	6.5	UACXCT4THF	7.44E-05	Transformer CT4 Failed
3)	6.40E-05	5.6	SXFRCT4LHE	6.40E-05	Latent Human Error On CT4 Maintenance
4)	9.60E-06	0.8	KK1UNDRBHF	9.60E-06	Fault Occurs On The Underground Power Path
5)	8.64E-06	0.8	U62BSK2RYT	8.64E-06	SK2 Breaker Failure Relay 62BXSK2 Spuriously Picks Up
6)	8.64E-06	0.8	U87TCT4RYT	8.64E-06	Spurious Op of CT4 Differential Rly 87T Actuates LOR 86EF
7)	8.64E-06	0.8	U62BSK1RYT	8.64E-06	SK1 Breaker Failure Relay 62BXSK1 Spuriously Picks Up
8)	8.64E-06	0.8	U86TCT4RYT	8.64E-06	CT4 Lockout Relay 86T/CT4 Spuriously Picks Up
9)	8.64E-06	0.8	U5086EFRYT	8.64E-06	Overcurrent Relay 50 Spuriously Actuates Lockout Rly 86EF
10)	8.64E-06	0.8	UXX86EFRYT	8.64E-06	Lockout Relay 86EF Spuriously Picks Up

Table A.2-6

Keowee Emergency Power Paths Dominant Minimal Cut Sets

Cut Sets For Gate UPATHTOP: Underground Path Fails To Connect Keowee To Oconee

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
11)	8.64E-06	0.8	U5186EFRYT	8.64E-06	Time Delay Overcurrent Relay 51 Actuates Lockout Relay 86EF
12)	8.64E-06	0.8	U51TNC4RYT	8.64E-06	CT4 Neutral Ground Rly Actuates CT4 LOR 86T/CT4
13)	8.64E-06	0.8	U86CT4XRYT	8.64E-06	Auxiliary Lockout Relay 86CT4X Spuriously Picks Up
Total:	1.14E-03				

Table A.2-7

Keowee Emergency Power Paths Dominant Minimal Cut Sets

Cut Sets For Gate OPATHTOP: Overhead Path Fails To Connect Keowee To Oconee

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
1)	2.33E-03		-OMOD	1.00E+00	Startup Bus UV Sensing Mod Is In Service
			FACTORDEX	1.00E+00	Overload Susceptibility Factor
		28.8	S227EUVRYT	2.33E-03	Unit 2 Startup Bus Undervoltage Relay 27E Fails
2)	2.33E-03		-OMOD	1.00E+00	Startup Bus UV Sensing Mod Is In Service
			FACTORDEX	1.00E+00	Overload Susceptibility Factor
		28.8	S127EUVRYT	2.33E-03	Unit 1 Startup Bus Undervoltage Relay 27E Fails
3)	2.00E-03	24.8	ACBAIRPDEX	2.00E-03	ACB Air Supply Fails Causing Low Pressure In All ACB Accumulators
			ACB4MOD	1.00E+00	NSM-ON-52966 Is Not In Service
4)	2.60E-04	3.2	SPCB009CHC	2.60E-04	SWYD PCB-9 Fails To Close On Demand
5)	1.74E-04	2.2	SXFRCT3THM	1.74E-04	Transformer CT4 Is In Maintenance
6)	1.18E-04		OMOD	1.00E+00	Startup Bus UV Sensing Mod Is In Service
			FACTORDEX	1.00E+00	Overload Susceptibility Factor
		1.5	SU327UVCOM	1.18E-04	Common Cause Failure Of Startup Bus Undervoltage Relay
7)	7.44E-05	0.9	SXFRCT3THF	7.44E-05	Transformer CT3 Faulted

Table A.2-7

Keeowee Emergency Power Paths Dominant Minimal Cut Sets

Cut Sets For Gate OPATHTOP: Overhead Path Fails To Connect Keowee To Oconee

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
8)	4.56E-05	0.6	SYPCB09CHT	4.56E-5	Switchyard Power Circuit Breaker 9 Transfers Open
9)	4.56E-05	0.6	SYPCB30CHT	4.56E-5	Switchyard Power Circuit Breaker 30 Transfers Open
10)	2.60E-05	0.3	SPCB008CHO	2.60E-05	SWYD PCB-8 Fails to Trip On Demand
11)	2.60E-05	0.3	SPCB012CHO	2.60E-05	SWYD PCB-12 Fails To Trip On Demand
12)	2.60E-05	0.3	SPCB015CHO	2.60E-05	SWYD PCB-15 Fails To Trip On Demand
13)	2.60E-05	0.3	SPCB017CHO	2.60E-05	SWYD PCB-17 Fails To Trip On Demand
14)	2.60E-05	0.3	SPCB021CHO	2.60E-05	SWYD PCB-21 Fails To Trip On Demand
15)	2.60E-05	0.3	SPCB024CHO	2.60E-05	SWYD PCB-24 Fails To Trip On Demand
16)	2.60E-05	0.3	SPCB026CHO	2.60E-05	SWYD PCB-26 Fails To Trip On Demand
17)	2.60E-05	0.3	SPCB028CHO	2.60E-05	SWYD PCB-28 Fails To Trip On Demand

Table A.2-7

Keeowee Emergency Power Paths Dominant Minimal Cut Sets

Cut Sets For Gate OPATHTOP: Overhead Path Fails To Connect Keowee To Oconee

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
18)	2.60E-05	0.3	SPCB033CHO	2.60E-05	SWYD PCB-33 Fails To Trip On Demand
19)	2.59E-05	0.3	SPC87T1RYT	2.59E-05	Main Step Up Transformer Differential Relay 87T Spurious Open
20)	2.59E-05	0.3	SPC871XRYT	2.59E-05	Transformer 1X Differential Relay 87T-1X Spurious Operation
21)	2.59E-05	0.3	SPC872XRYT	2.59E-05	Transformer 2X Differential Relay 87T-2X Spurious Operation
22)	1.03E-05	0.1	AB1PSWTPST	1.03E-05	Air Circuit Breaker 1 Accumulator Pressure Switch Fails Low
			ACB4MOD	1.00E+00	NSM-ON-52966 Is Not In Service
23)	1.03E-05	0.1	AB2PSWTPST	1.03E-05	Air Circuit Breaker 2 Accumulator Pressure Switch Fails Low
			ACB4MOD	1.00E+00	NSM-ON-52966 Is Not In Service
24)	1.03E-05	0.1	AB3PSWTPST	1.03E-05	Air Circuit Breaker 3 Accumulator Pressure Switch Fails Low
			ACB4MOD	1.00E+00	NSM-ON-52966 Is Not In Service
25)	9.60E-06	0.1	SPC14KVBHF	9.60E-06	13.8 kV Bus Faulted
26)	9.60E-06	0.1	KK1OVERBHF	9.60E-06	Fault Occurs On The Overhead Power Path

Table A.2-7

Keewee Emergency Power Paths Dominant Minimal Cut Sets

Cut Sets For Gate OPATHTOP: Overhead Path Fails To Connect Keowee To Oconee

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
27)	8.64E-06		ACB4MOD	1.00E+00	NSM-ON-52966 Is Not In Service
		0.1	SB48UX4RYT	8.64E-06	Auxiliary Relay 8UX-4 Spurious Operation
28)	8.64E-06		ACB4MOD	1.00E+00	NSM-ON-52966 Is Not In Service
		0.1	SB28UX2RYT	8.64E-06	Auxiliary Relay 8UX-2 Spurious Operation
29)	8.64E-06		ACB4MOD	1.00E+00	NSM-ON-52966 Is Not In Service
		0.1	SB38UX3RYT	8.64E-06	Auxiliary Relay 8UX-3 Spurious Operation
30)	8.64E-06		ACB4MOD	1.00E+00	NSM-ON-52966 Is Not In Service
		0.1	SK294GBRYT	8.64E-06	Keowee Unit 2 94GB Auxiliary Relay Spurious Operation
31)	8.64E-06		ACB4MOD	1.00E+00	NSM-ON-52966 Is Not In Service
		0.1	SK194GBRYT	8.64E-06	Keowee Unit 1 94GB Auxiliary Relay Spurious Operation
32)	8.64E-06		ACB4MOD	1.00E+00	NSM-ON-52966 Is Not In Service
		0.1	SB18UX1RYT	8.64E-06	Auxiliary Relay 8UX-1 Spurious Operation
33)	8.64E-06	0.1	SPCD87LRYT	8.64E-06	Line Differential Relay 87L Spurious Operation

Table A.2-7

Keeowee Emergency Power Paths Dominant Minimal Cut Sets

Cut Sets For Gate OPATHTOP: Overhead Path Fails To Connect Keowee To Oconee

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
34)	8.64E-06	0.1	SY86YA9RYT	8.64E-06	Yellow Bus Lockout Auxiliary Relay 86YA9 Spuriously Picks Up
35)	8.64E-06	0.1	SYR86BYRYT	8.64E-06	Yellow Bus Lockout Relay 86BY Spuriously Picks Up
36)	8.64E-06	0.1	SY62XXFRYT	8.64E-06	Breaker Failure Relay 62X Spuriously Picks Up
37)	8.64E-06	0.1	SY62X1FRYT	8.64E-06	Breaker Failure Relay 62X1 Spuriously Picks Up
38)	8.64E-06	0.1	SYPL86TRYT	8.64E-06	PCB 30 LOR 86T Spuriously Picks Up
39)	8.64E-06	0.1	SY87LXXRYT	8.64E-06	Differential Auxiliary Relay 87LX Spuriously Picks Up
40)	8.64E-06	0.1	SYPL87LRYT	8.64E-06	Differential Relay 87L Spuriously Picks Up
41)	8.64E-06	0.1	SYXX87TRYT	8.64E-06	Differential Relay 87T Spuriously Picks Up
42)	8.64E-06	0.1	SPC62ABRYT	8.64E-06	ACB Back-up Trip Timer 62AB Spurious Operation
43)	8.64E-06	0.1	SPC631XRYT	8.64E-06	Auxiliary Relay 63H1X Spurious Operation

Table A.2-7

Keewee Emergency Power Paths Dominant Minimal Cut Sets

Cut Sets For Gate OPATHTOP: Overhead Path Fails To Connect Keowee To Oconee

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
44)	8.64E-06	0.1	SY51TN2RYT	8.64E-06	230kV Neutral Ground Relay Spuriously Picks Up
45)	8.64E-06	0.1	SPC94TKRYT	8.64E-06	Auxiliary Relay 94T/K Spurious Operation
46)	8.64E-06	0.1	SYS63FPRYT	8.64E-06	Fault Pressure Relay 63FP Spuriously Picks Up
47)	8.64E-06	0.1	SYSX50BRYT	8.64E-06	Transformer CT3 Fault Detector Relay 50B Spuriously Picks Up
48)	8.64E-06	0.1	SY30R94RYT	8.64E-06	PCB 30 Relay 94 Spuriously Picks Up
49)	8.64E-06	0.1	SY51TN4RYT	8.64E-06	4.16kV Neutral Ground Relay Spuriously Picks Up
50)	8.64E-06	0.1	SYE2362RYT	8.64E-06	E23 Bkr Failure Relay 62B Spuriously Picks Up
51)	8.64E-06	0.1	SPC51TNRYT	8.64E-06	Main Step Up Transformer Neutral Ground Relay 51TN Spurious
52)	8.64E-06	0.1	SPCR86TRYT	8.64E-06	Lock Out Relay 86T Spurious Operation
53)	8.64E-06	0.1	SY51TN6RYT	8.64E-06	6.9kV Neutral Ground Relay 51TN Spuriously Picks Up

Table A.2-7

Keeowee Emergency Power Paths Dominant Minimal Cut Sets

Cut Sets For Gate OPATHTOP: Overhead Path Fails To Connect Keowee To Oconee

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
54)	8.64E-06	0.1	SY94L1XRYT	8.64E-06	Protective Relay 94L Spuriously Picks Up
55)	8.64E-06	0.1	SYP86TXRYT	8.64E-06	PCB 30 LOR 86TX Spuriously Picks Up
56)	8.64E-06	0.1	SY86YJ3RYT	8.64E-06	Yellow Bus Lockout Aux Relay 86YJ30 Spuriously Picks UP
57)	8.64E-06	0.1	SY86BUIRYT	8.64E-06	CT3 6.9kV Start Up Bus Lockout Relay Spuriously Picks Up
58)	8.64E-06	0.1	SY86CT3RYT	8.64E-06	Transformer CT3 Lockout Relay Spuriously Picks Up
59)	8.64E-06	0.1	SYE1362RYT	8.64E-06	E13 Bkr Failure Relay 62B Spuriously Picks Up
60)	8.64E-06	0.1	SY87BYXRYT	8.64E-06	Yellow Bus X Phase Differential Relay 87BYX Spuriously Picks
61)	8.64E-06	0.1	SYP3062RYT	8.64E-06	PCB 30 Breaker Failure Relay 62B Spuriously Picks Up
62)	8.64E-06	0.1	SY62X2FRYT	8.64E-06	Breaker Failure Relay 62X2 Spuriously Picks Up
63)	8.64E-06	0.1	SYX87TBRYT	8.64E-06	Differential Relay 87B Spuriously Picks Up

Table A.2-7

Keeowee Emergency Power Paths Dominant Minimal Cut Sets

Cut Sets For Gate OPATHTOP: Overhead Path Fails To Connect Keowee To Oconee

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
64)	8.64E-06	0.1	SY87BYYRYT	8.64E-06	Yellow Bus Y Phase Differential Relay 87BYY Spuriously Picks
65)	8.64E-06	0.1	SY87BYZRYT	8.64E-06	Yellow Bus Z Phase Differential Relay 86BYZ Spuriously Picks
66)	8.64E-06	0.1	SYP2862RYT	8.64E-06	PCB 28 Breaker Failure Relay 62B Spuriously Picks Up
67)	5.44E-06		-OMOD	1.00E+00	Startup Bus UV Sensing Mod Is In Service
			OFACTORDEX	1.00E+00	Overload Susceptibility Factor
		<0.1	S327E1VRYT	2.33E-03	Unit 3 Startup Bus Undervoltage Trip Relay 27E1 Fails
		<0.1	S327EUVRYT	2.33E-03	Unit 3 Startup Bus Undervoltage Trip Relay 27E Fails
68)	5.16E-06	0.1	AB4PSWTPST	5.16E-06	Air Circuit Breaker 4 Accumulator Pressure Switch Indicates
			ACB4MOD	1.00E+00	NSM-ON-52966 Is Not In Service
69)	1.80E-06		ACB4MOD	1.00E+00	NSM-ON-52966 Is Not In Service
		<0.1	AD1C3CCCDT	1.80E-06	Bkr 3CC In 125V dc Distribution Center 1DA Transfers Position
70)	1.80E-06		ACB4MOD	1.00E+00	NSM-ON-52966 Is Not In Service
		<0.1	AD1C3CLCDT	1.80E-06	Bkr 3CL In 125V dc Distribution Center 1DA Transfers Position

Table A.2-7

Keeowee Emergency Power Paths Dominant Minimal Cut Sets

Cut Sets For Gate OPATHTOP: Overhead Path Fails To Connect Keowee To Oconee

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
71)	1.80E-06		ACB4MOD	1.00E+00	NSM-ON-52966 Is Not In Service
		<0.1	AD2C3CCCDT	1.80E-06	Bkr 3CC In 125V dc Distribution Center 2DA Transfers Position
72)	1.80E-06		ACB4MOD	1.00E+00	NSM-ON-52966 Is Not In Service
		<0.1	AD2C3CLCDT	1.80E-06	Bkr 3CL In 125V dc Distribution Center 2DA Transfers Position
73)	1.68E-06	<0.1	SPCGLASSWT	1.86E-06	Break Glass Switch Spurious Operation
Total:	8.08E-03				

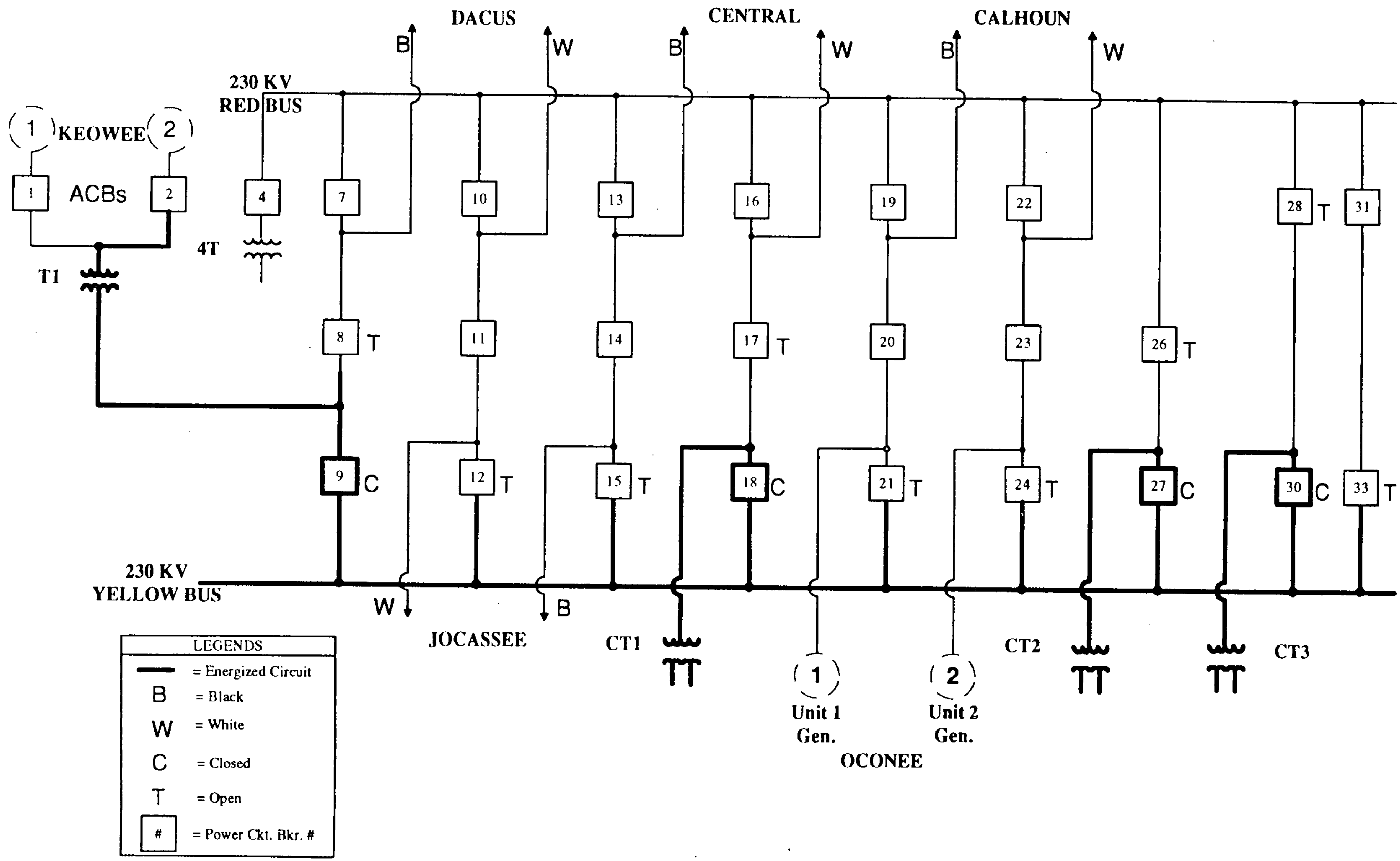
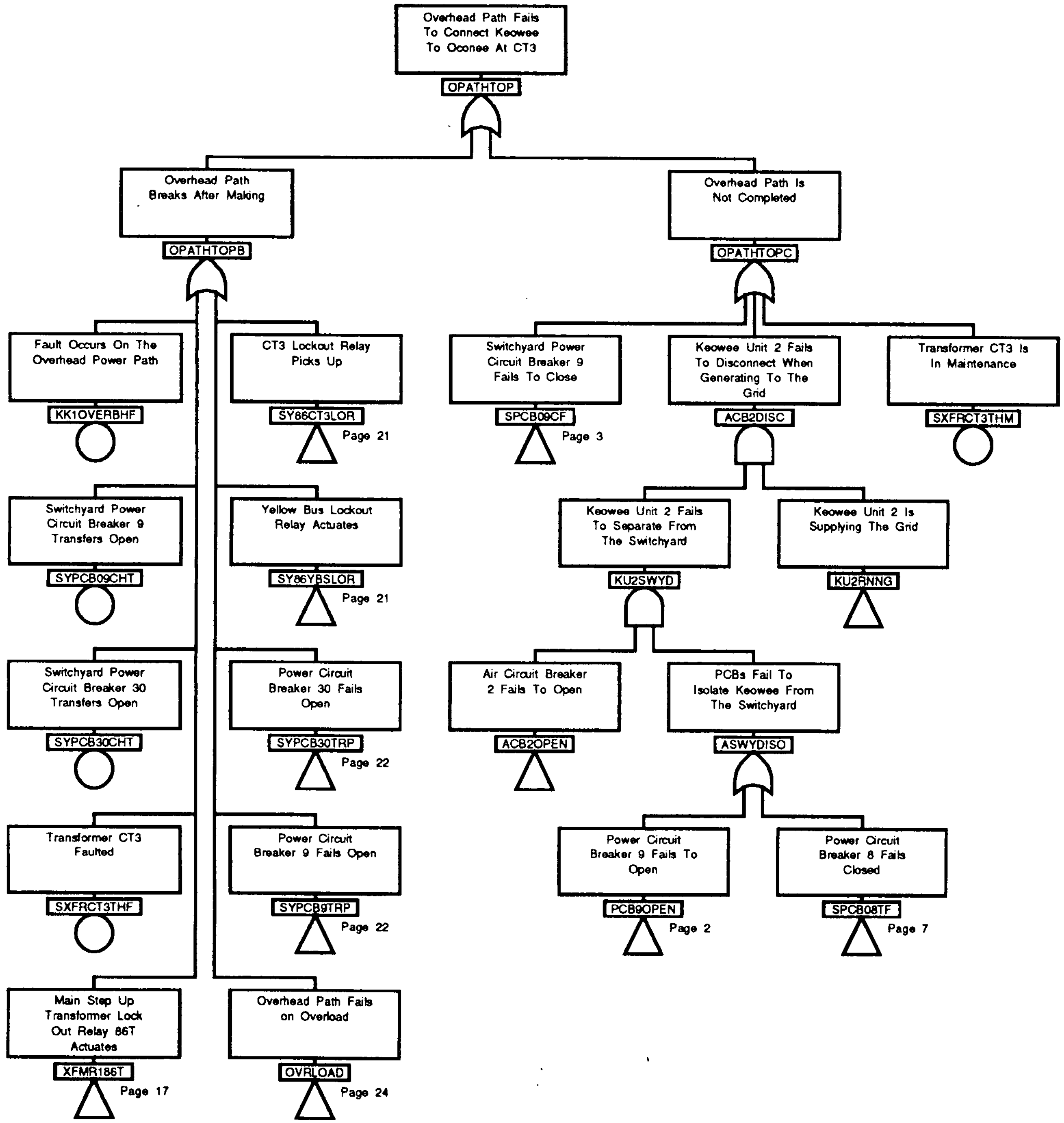
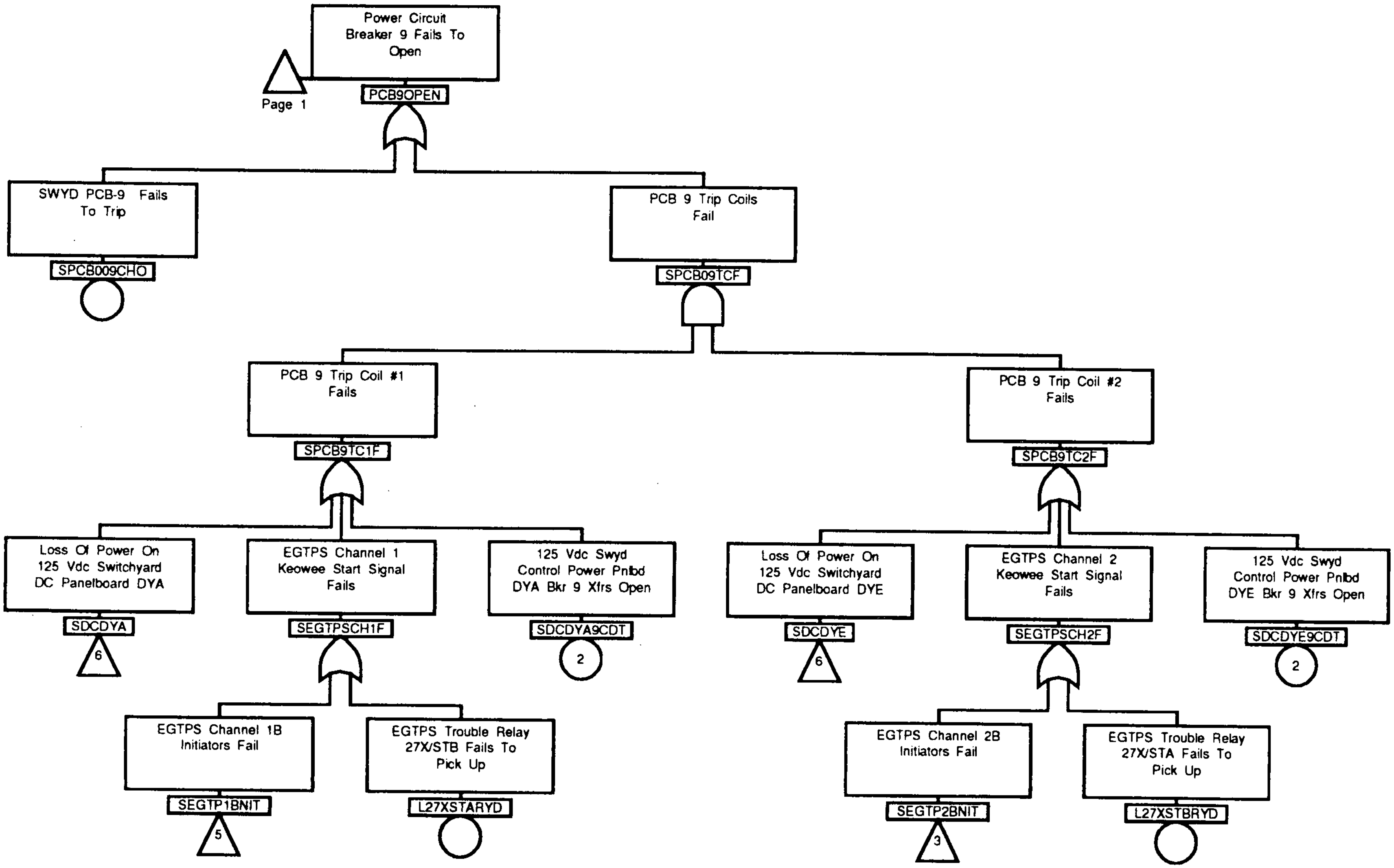


Figure A.2-1 Overhead Power Path

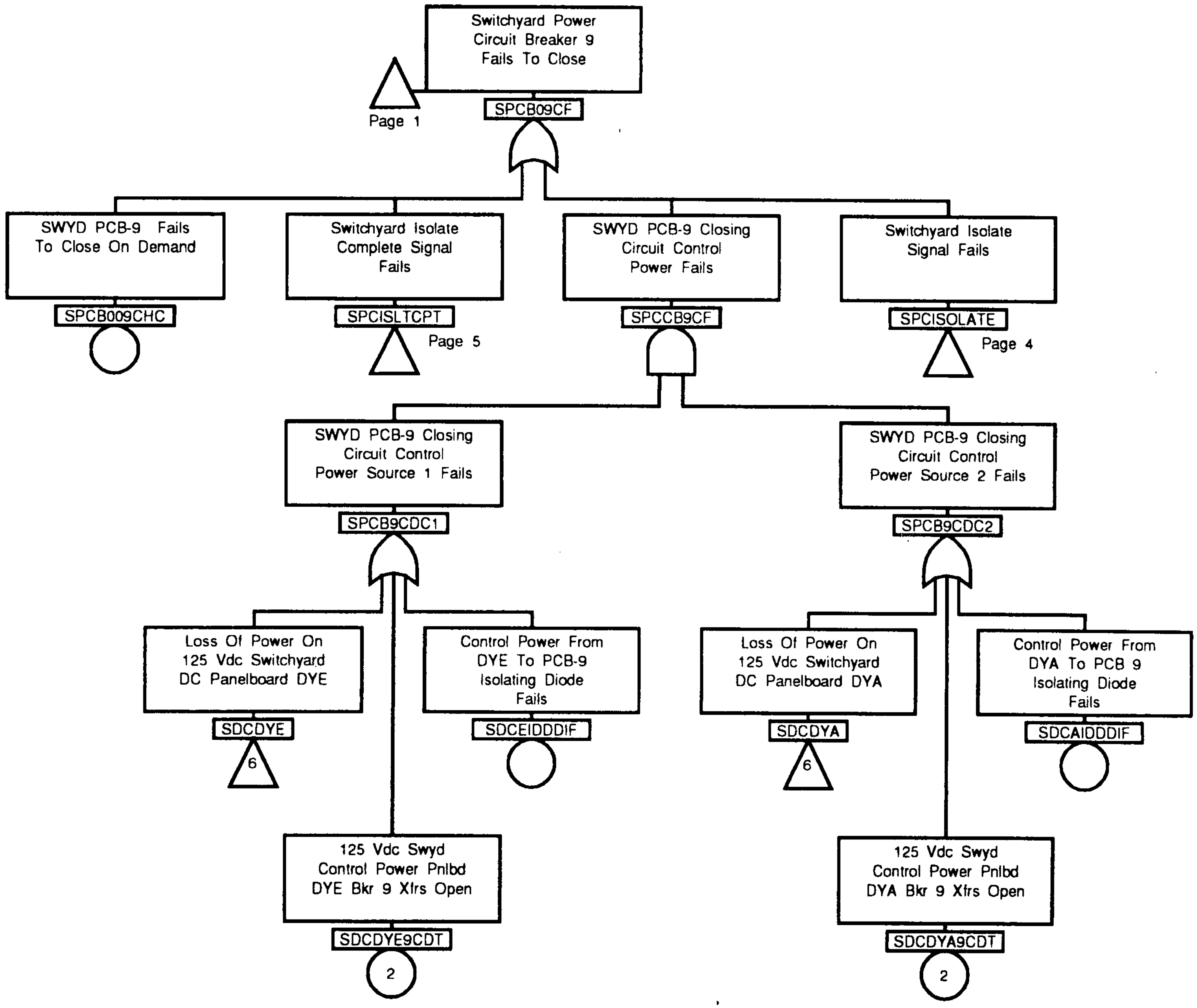


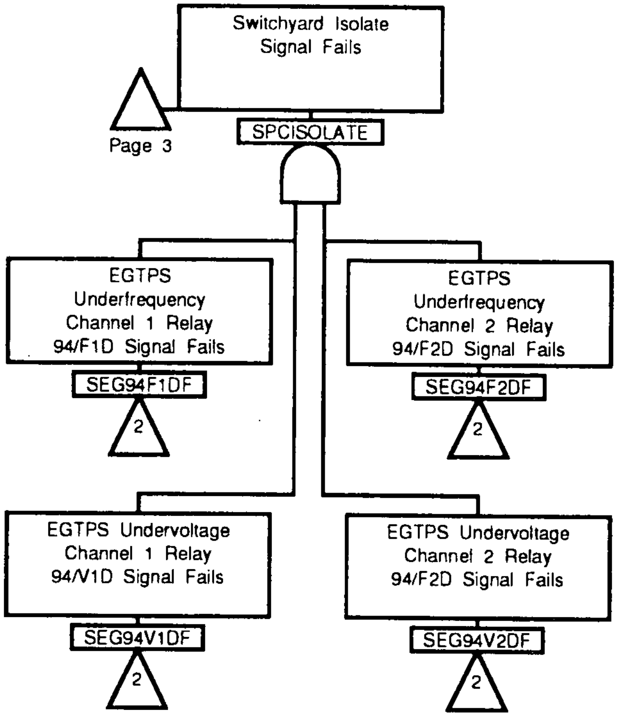
Keowee Emergency Power Paths Fault Tree

FIGURE A.2-2

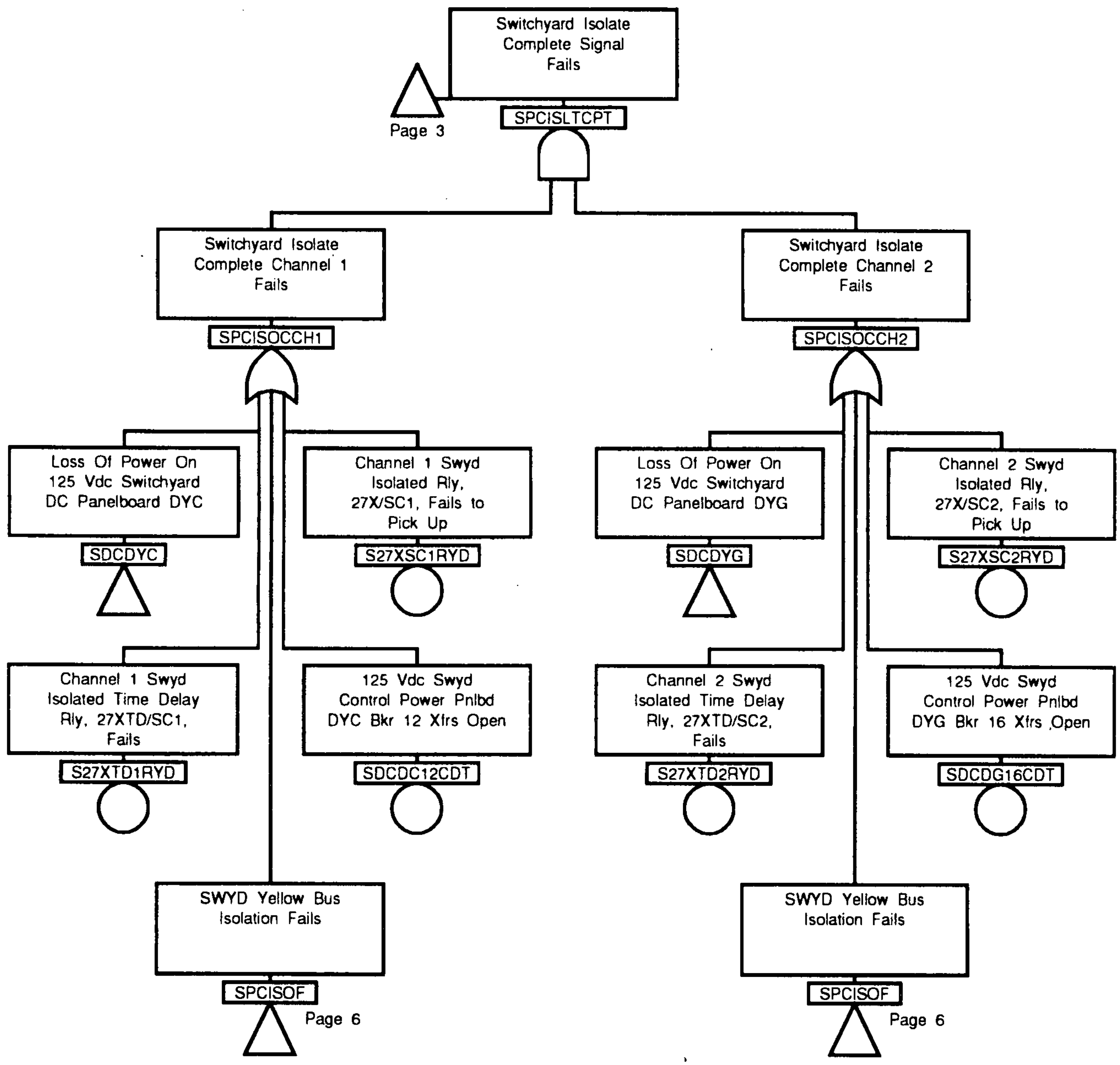


Keowee Emergency Power Paths Fault Tree | FIGURE A.2-2 | Page 2

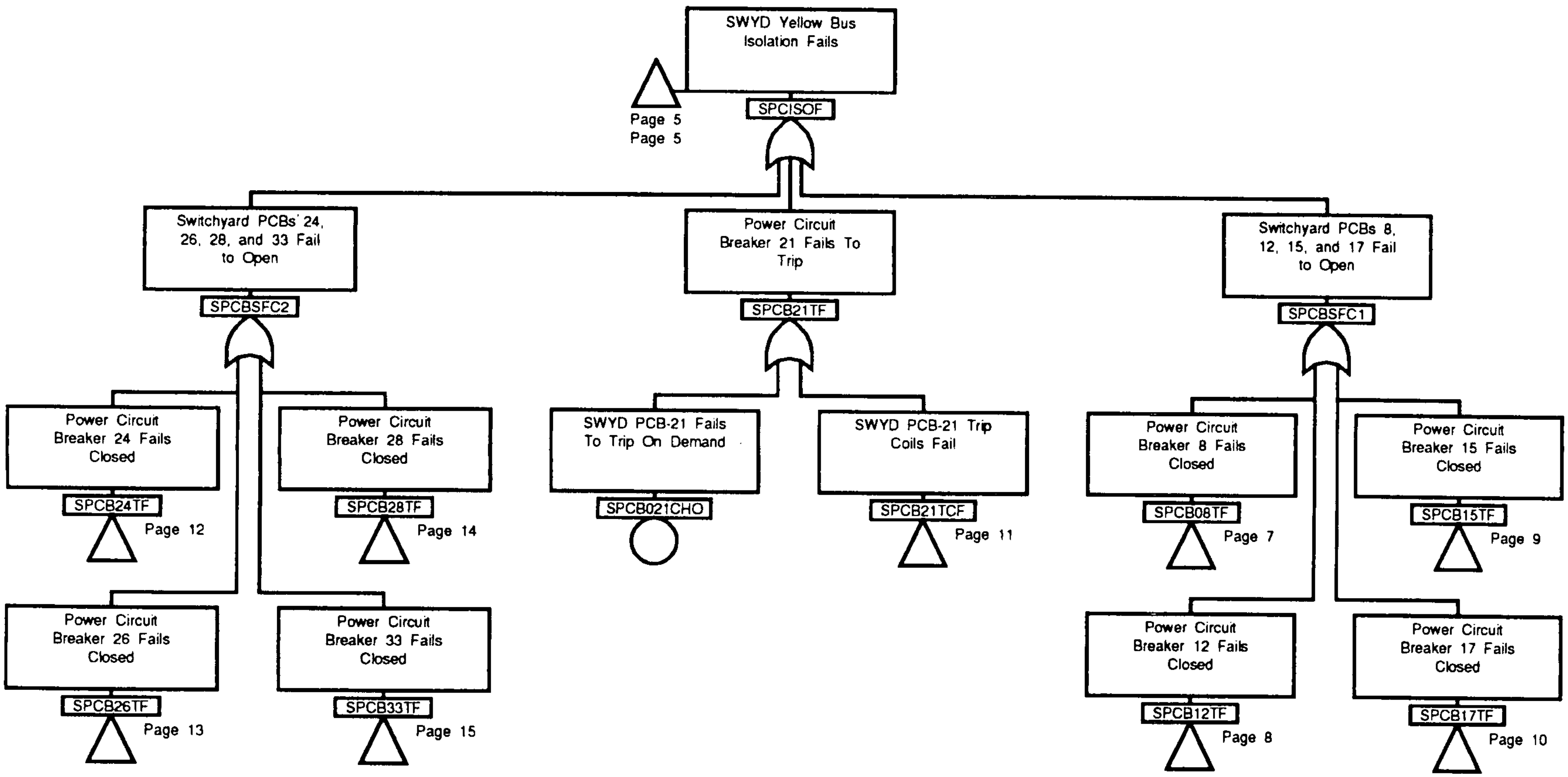

Switchyard Power Circuit Breaker 9 Fails To Close
SPCB09CF
Page 1
SWYD PCB-9 Fails To Close On Demand
SPCB009CHC
Switchyard Isolate Complete Signal Fails
SPCISLTCPT
Page 5
SWYD PCB-9 Closing Circuit Control Power Fails
SPCCB9CF
Switchyard Isolate Signal Fails
SPCISOLATE
Page 4
SWYD PCB-9 Closing Circuit Control Power Source 1 Fails
SPCB9CDC1
SWYD PCB-9 Closing Circuit Control Power Source 2 Fails
SPCB9CDC2
Loss Of Power On 125 Vdc Switchyard DC Panelboard DYE
SDCDYE
6
Control Power From DYE To PCB-9 Isolating Diode Fails
SDCEIDDDIF
Loss Of Power On 125 Vdc Switchyard DC Panelboard DYA
SDCDYA
6
Control Power From DYA To PCB 9 Isolating Diode Fails
SDCAIDDDIF
125 Vdc Swyd Control Power Pnlbd DYE Bkr 9 Xfrs Open
SDCDYE9CDT
2
125 Vdc Swyd Control Power Pnlbd DYA Bkr 9 Xfrs Open
SDCDYA9CDT
2



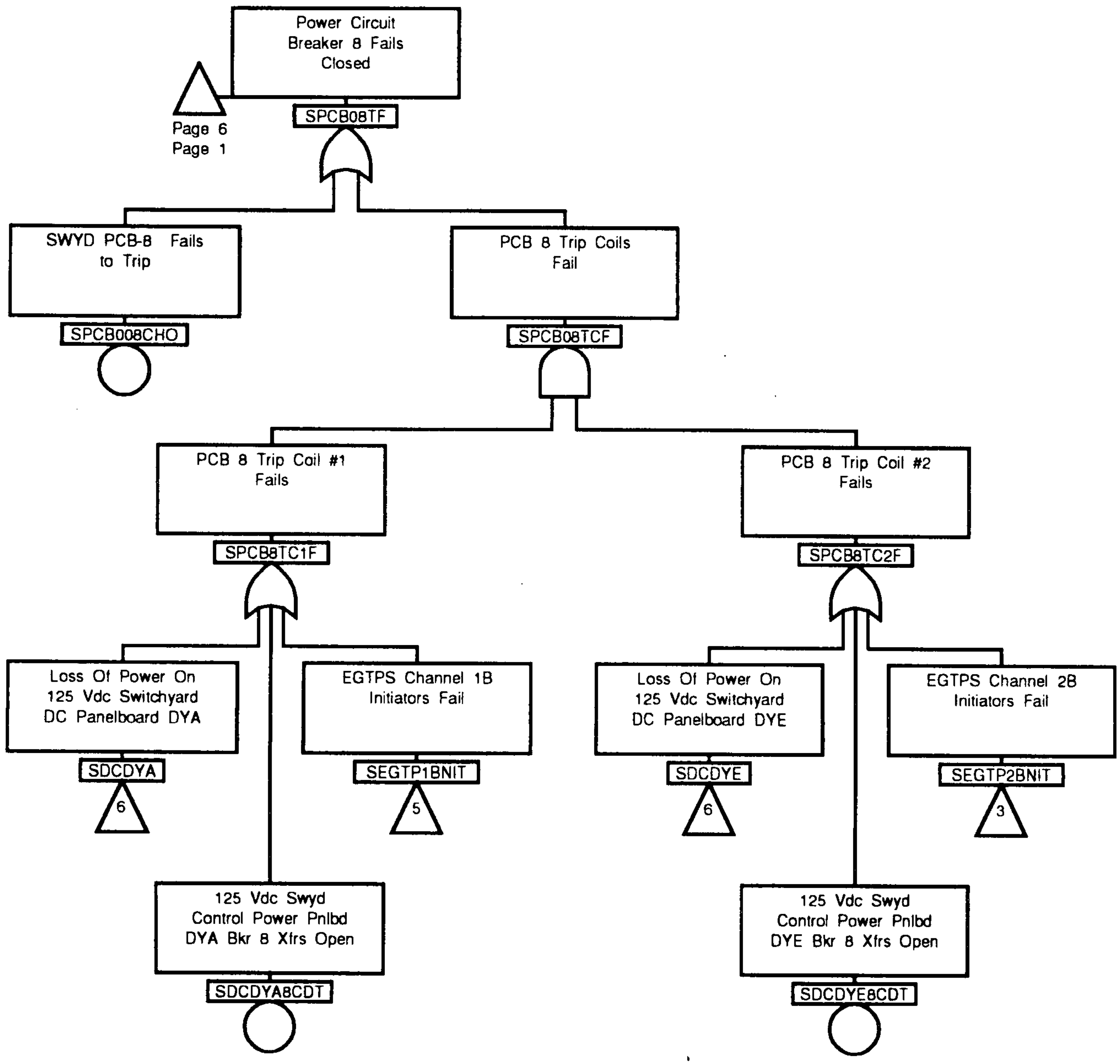
Keowee Emergency Power Paths Fault Tree | FIGURE A.2-2 |



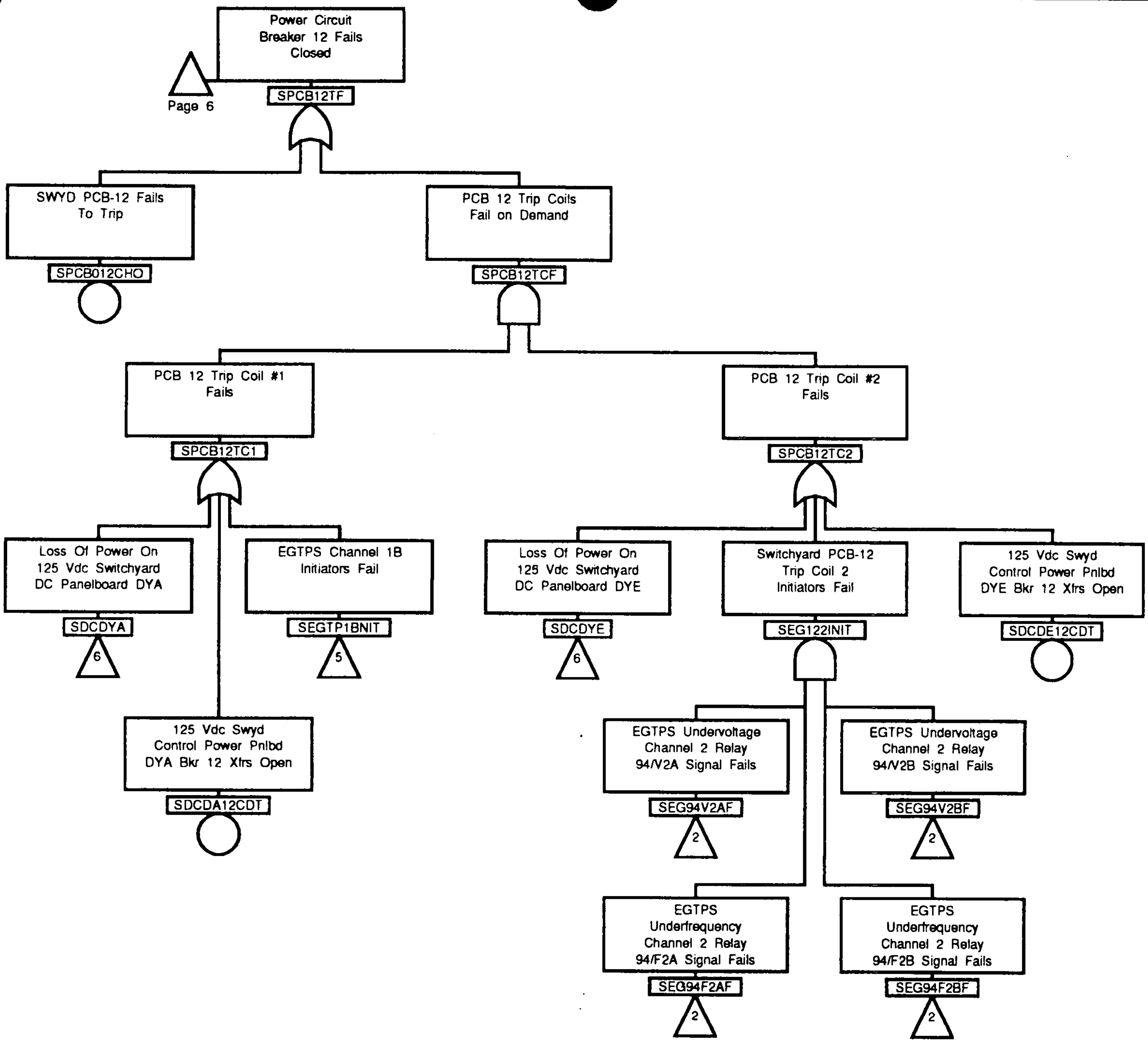
Keowee Emergency Power Paths Fault Tree | FIGURE A.2-2 |



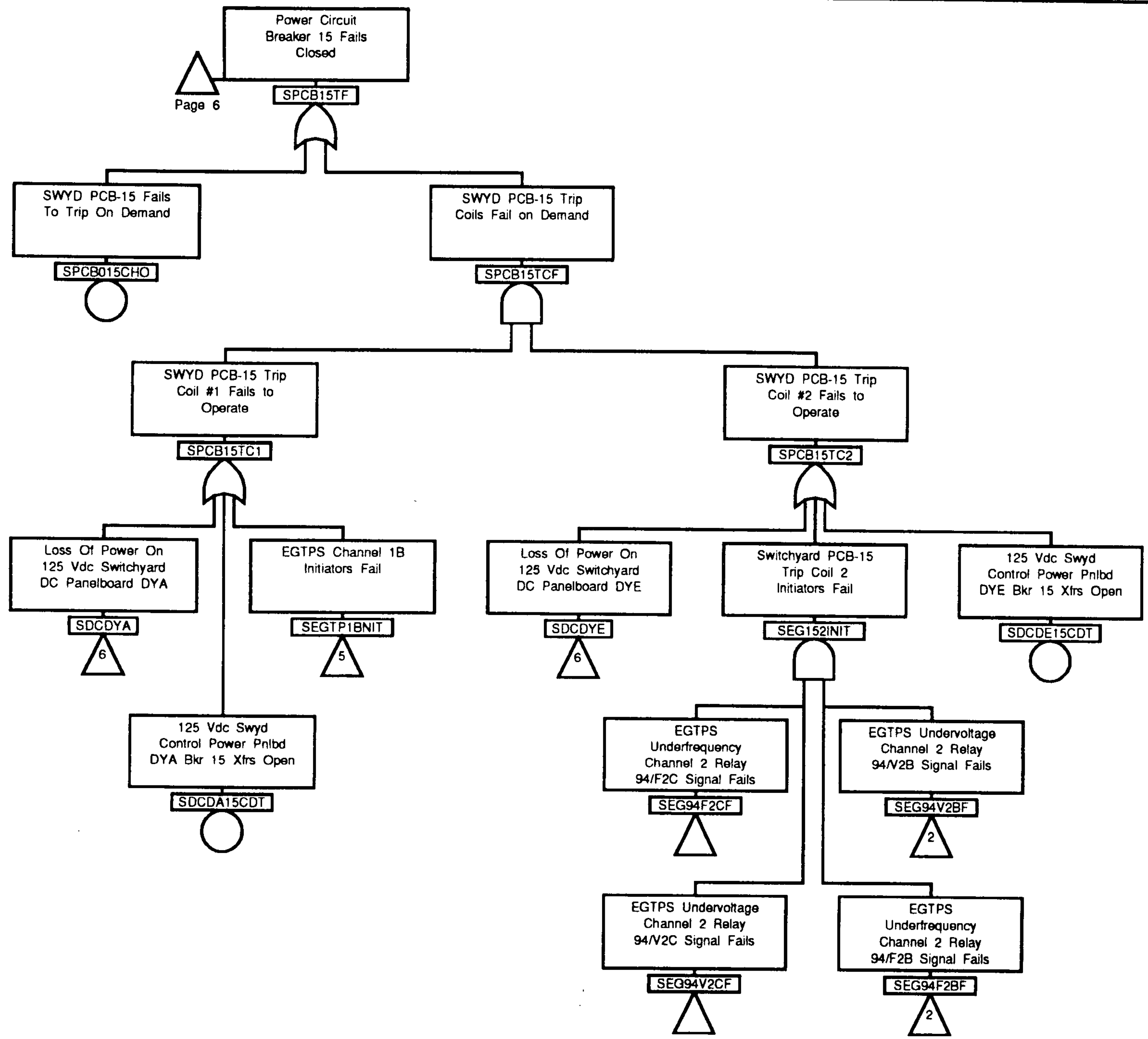
Keeowee Emergency Power Paths Fault Tree | FIGURE A.2-2 |



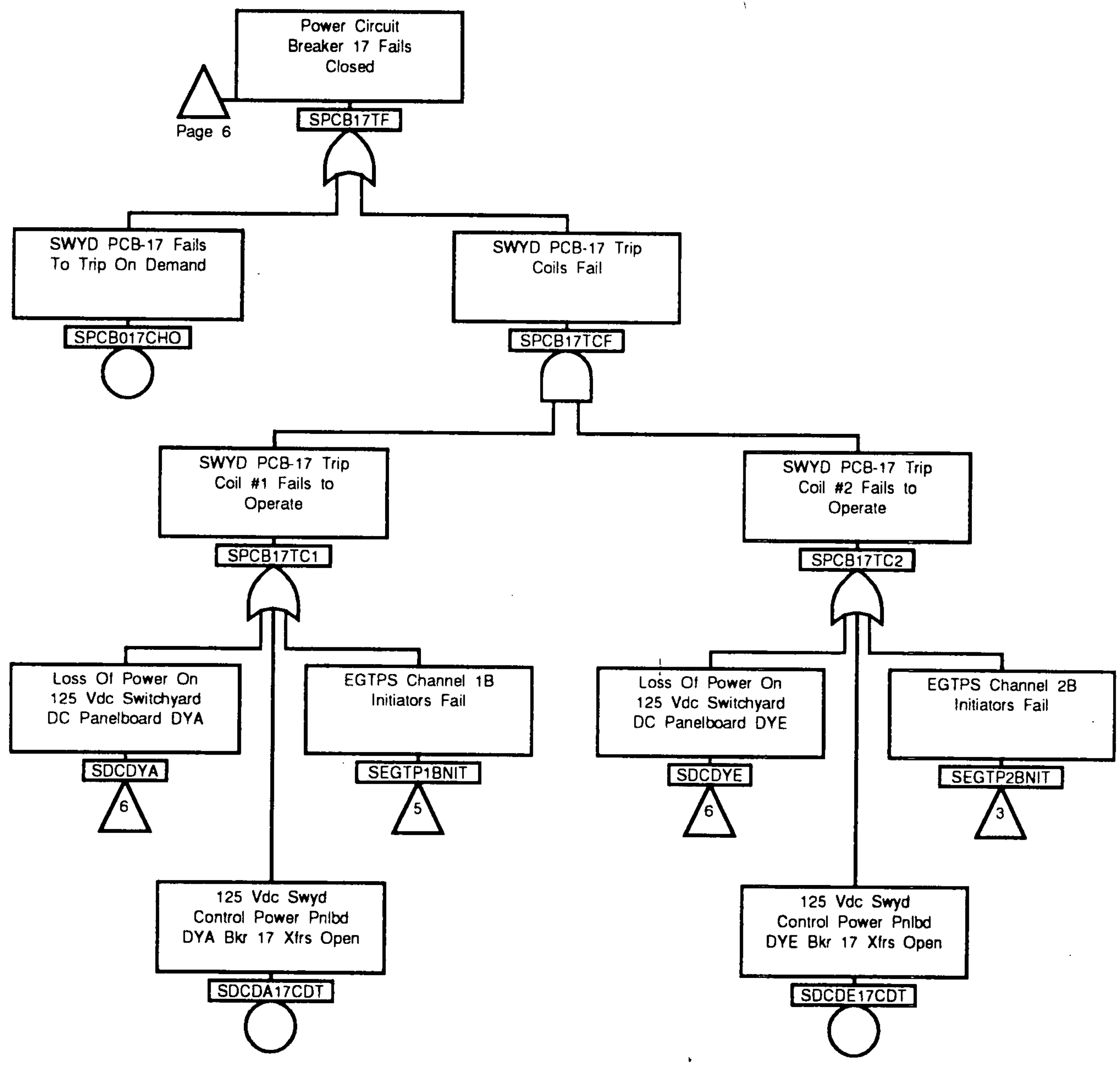
Keowee Emergency Power Paths Fau[illegible] Tree	FIGURE A.2-2	Pa[illegible] 7



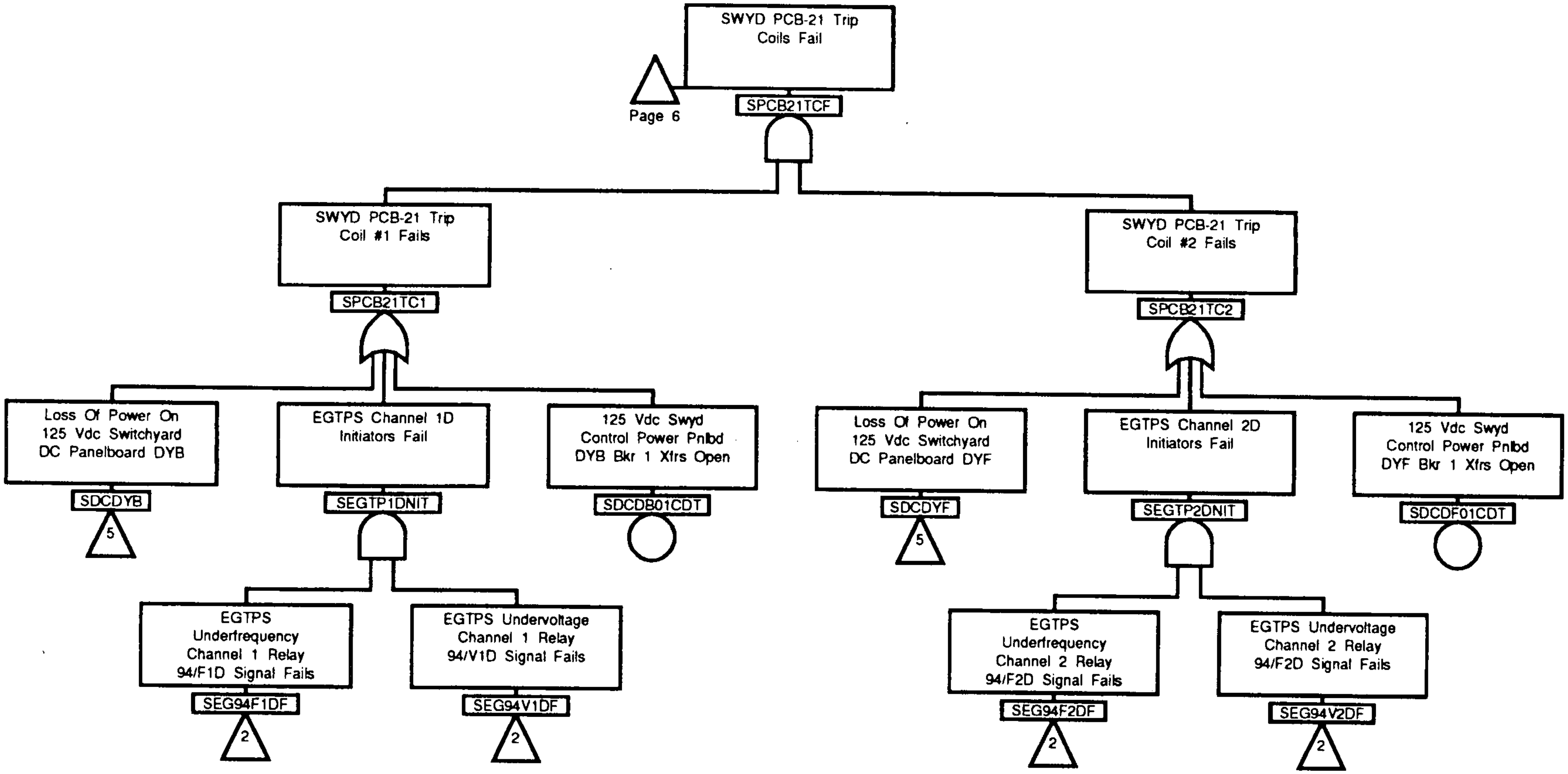
Keowee Emergency Power Paths Fault Tree | FIGURE A.2-2 |

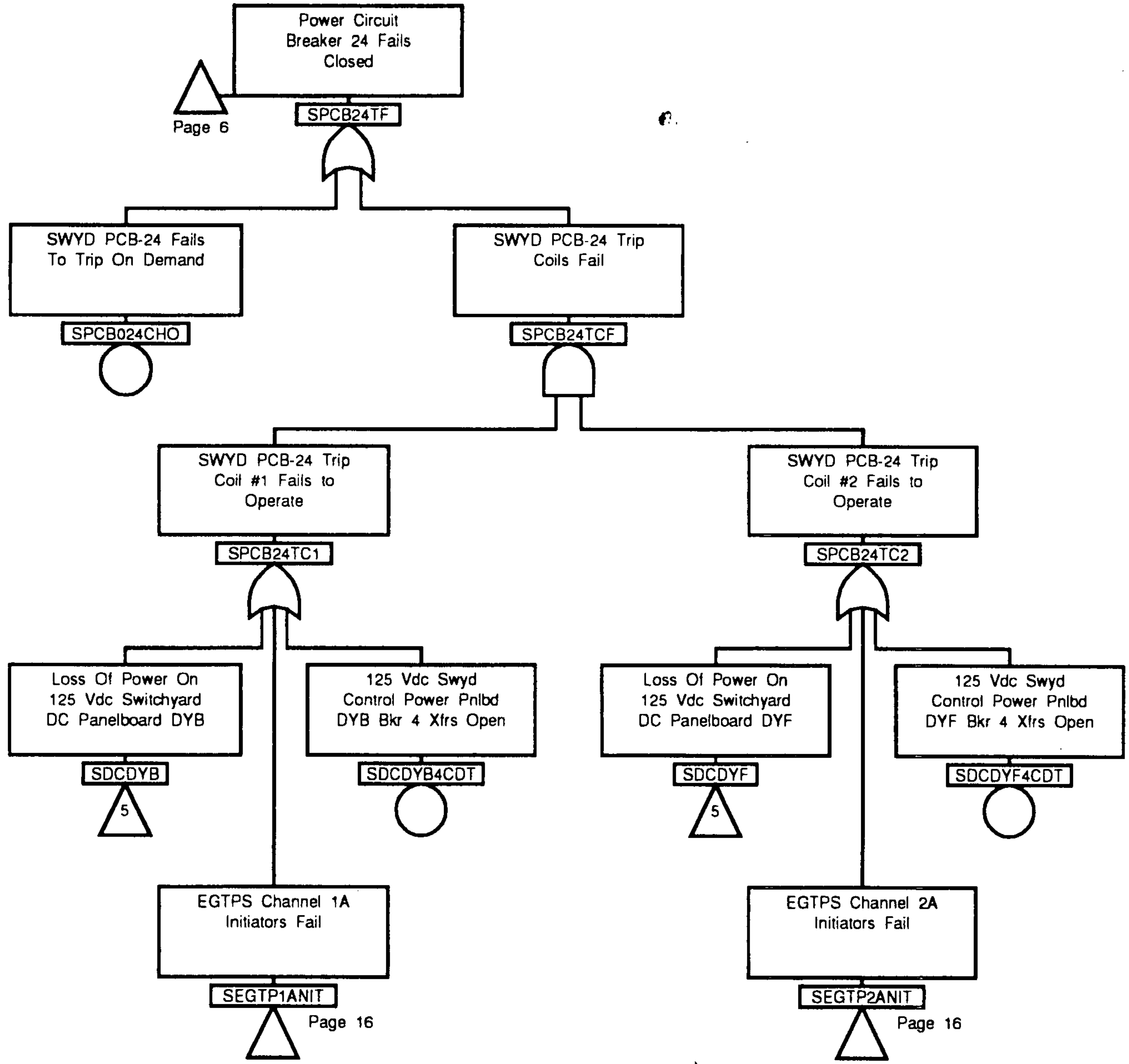


Keowee Emergency Power Paths Fault Tree | FIGURE A.2-2 |

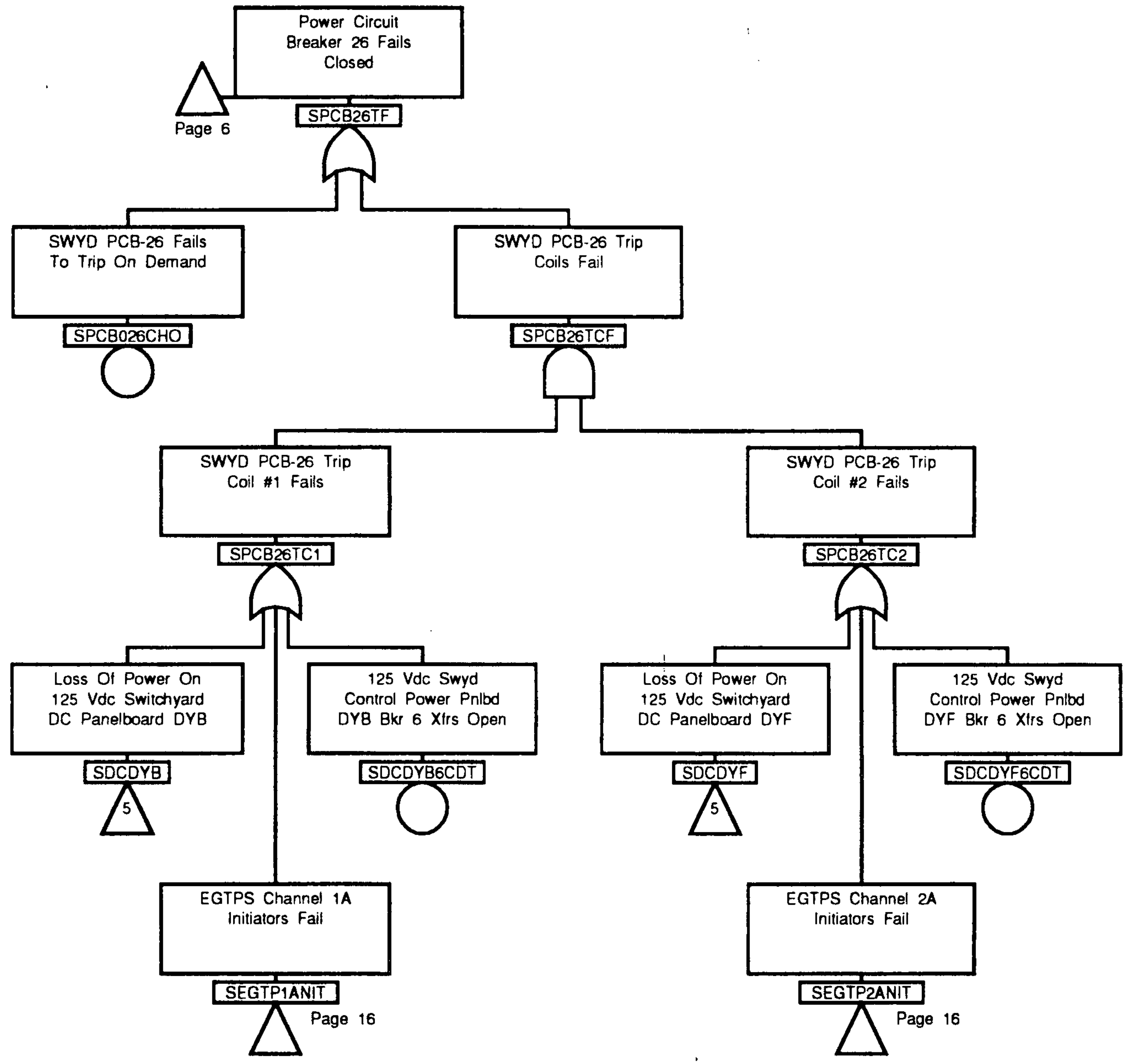


Keowee Emergency Power Paths Fault Tree	FIGURE A.2-2	Page 10

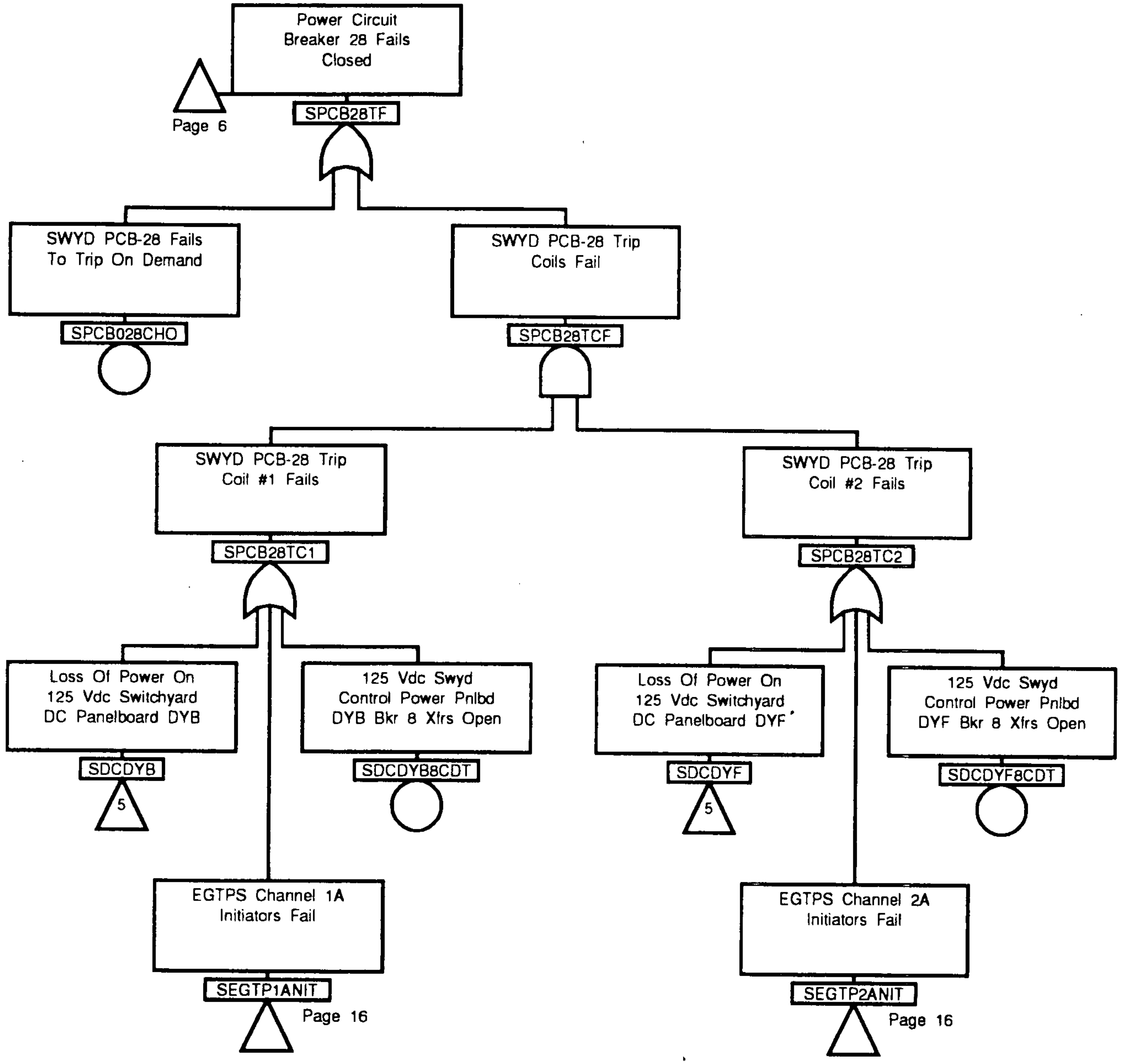

SWYD PCB-21 Trip Coils Fail
SPCB21TCF
Page 6
SWYD PCB-21 Trip Coil #1 Fails
SPCB21TC1
SWYD PCB-21 Trip Coil #2 Fails
SPCB21TC2
Loss Of Power On 125 Vdc Switchyard DC Panelboard DYB
SDCDYB
5
EGTPS Channel 1D Initiators Fail
SEGTP1DNIT
125 Vdc Swyd Control Power Pnlbd DYB Bkr 1 Xfrs Open
SDCDB01CDT
Loss Of Power On 125 Vdc Switchyard DC Panelboard DYF
SDCDYF
5
EGTPS Channel 2D Initiators Fail
SEGTP2DNIT
125 Vdc Swyd Control Power Pnlbd DYF Bkr 1 Xfrs Open
SDCDF01CDT
EGTPS Underfrequency Channel 1 Relay 94/F1D Signal Fails
SEG94F1DF
2
EGTPS Undervoltage Channel 1 Relay 94/V1D Signal Fails
SEG94V1DF
2
EGTPS Underfrequency Channel 2 Relay 94/F2D Signal Fails
SEG94F2DF
2
EGTPS Undervoltage Channel 2 Relay 94/F2D Signal Fails
SEG94V2DF
2



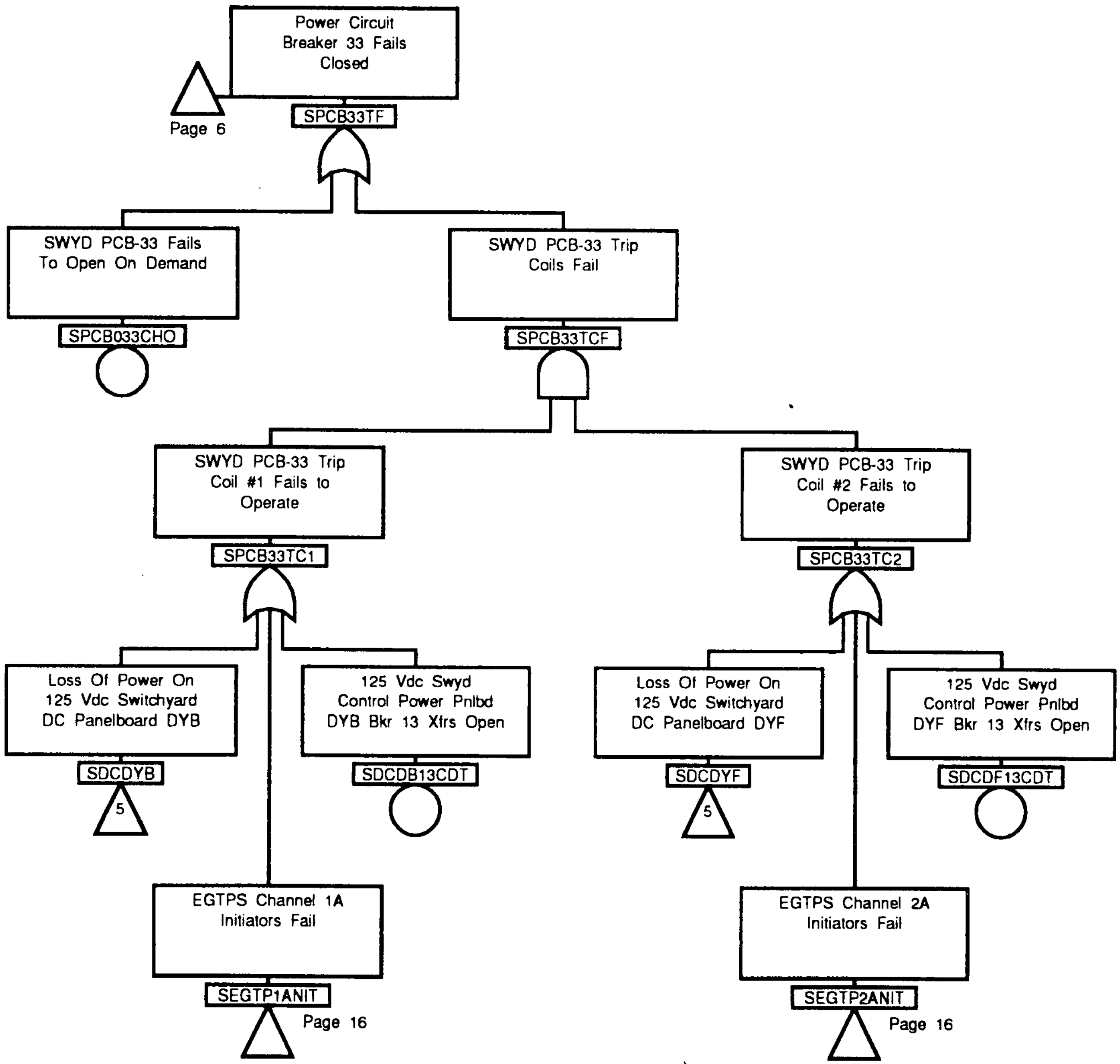
Keeowee Emergency Power Paths Fault Tree | FIGURE A.2-2 |



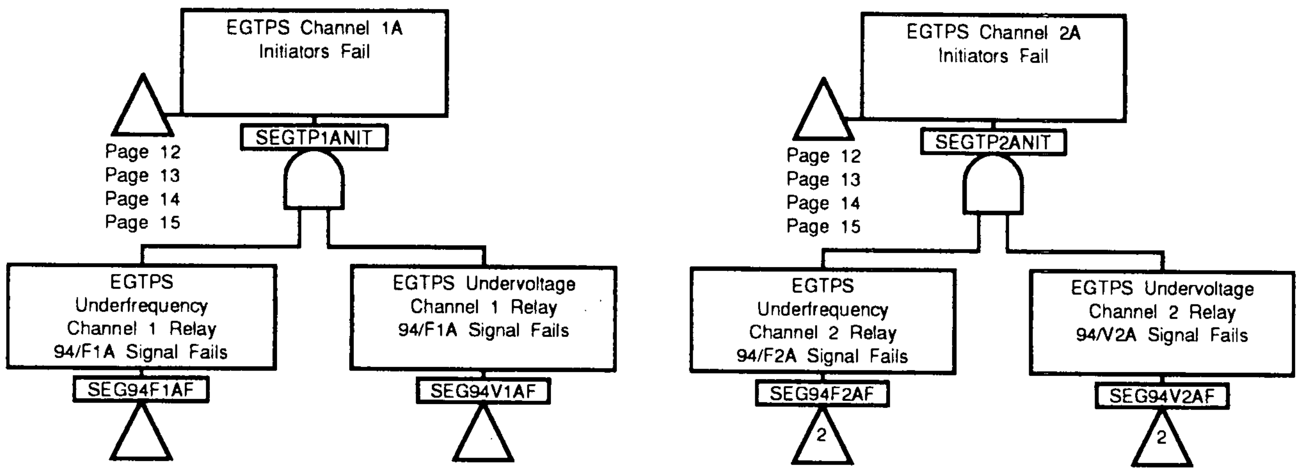
Keowee Emergency Power Paths Fault Tree	FIGURE A.2-2	Page 13

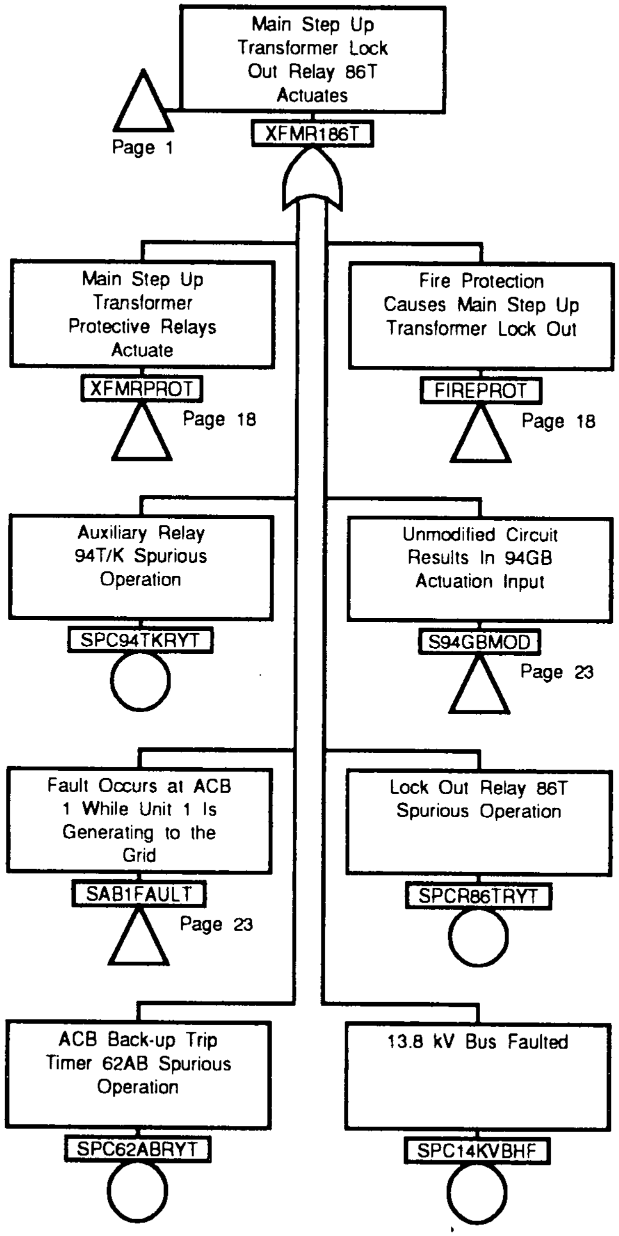


Keewee Emergency Power Paths Fault Tree | FIGURE A.2-2 |

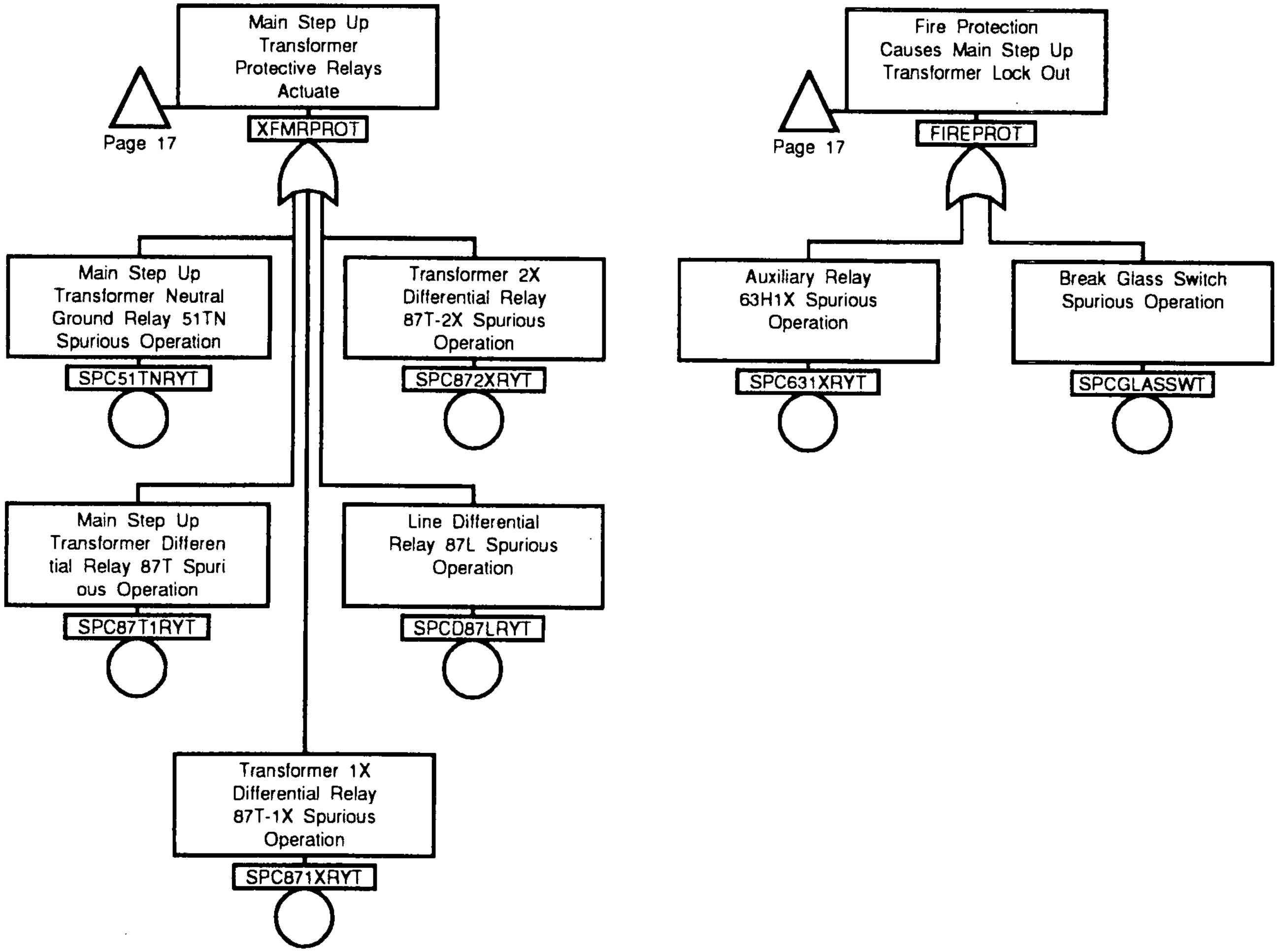


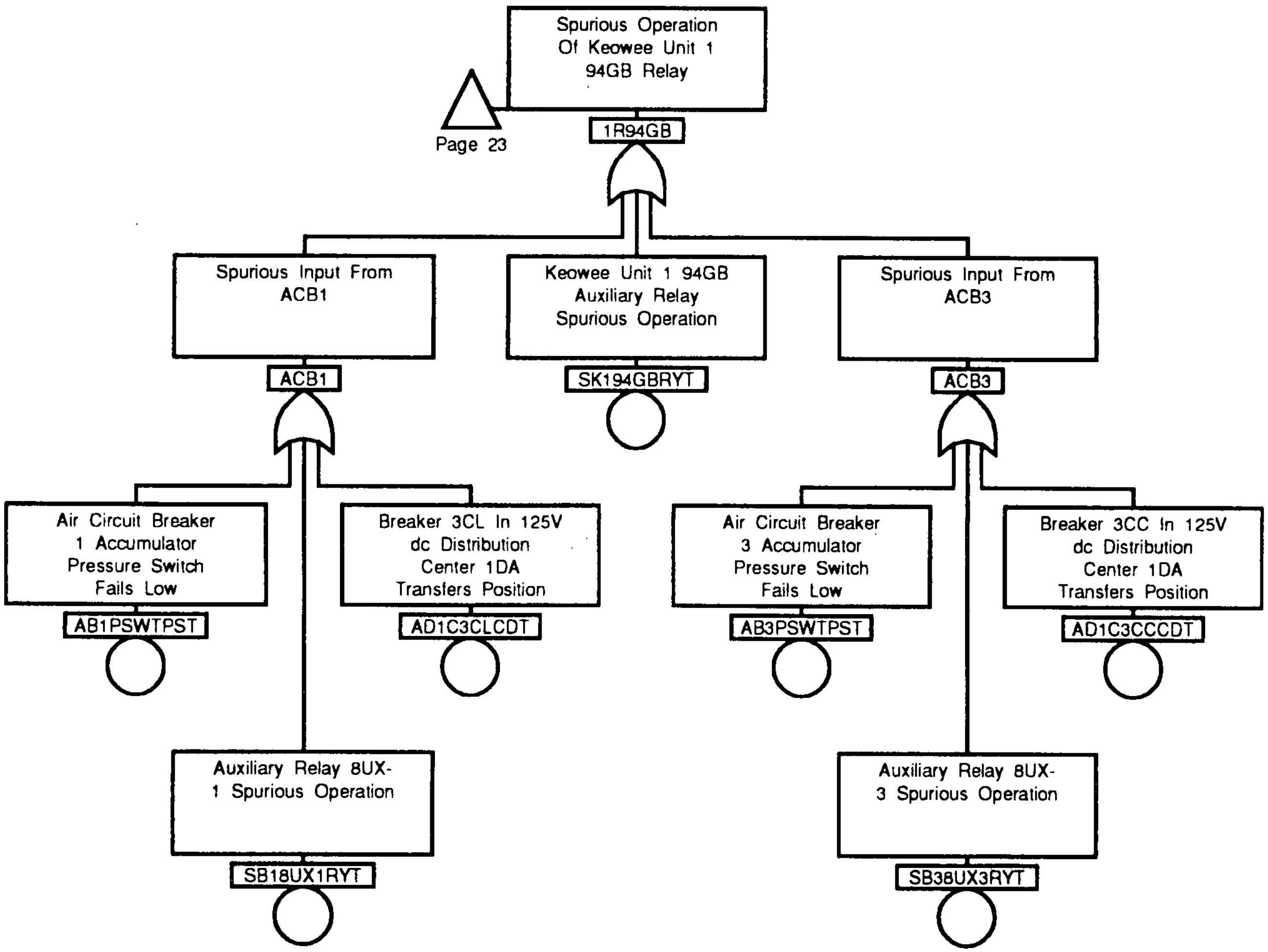
Keowee Emergency Power Paths Fault Tree	FIGURE A.2-2	Page 15

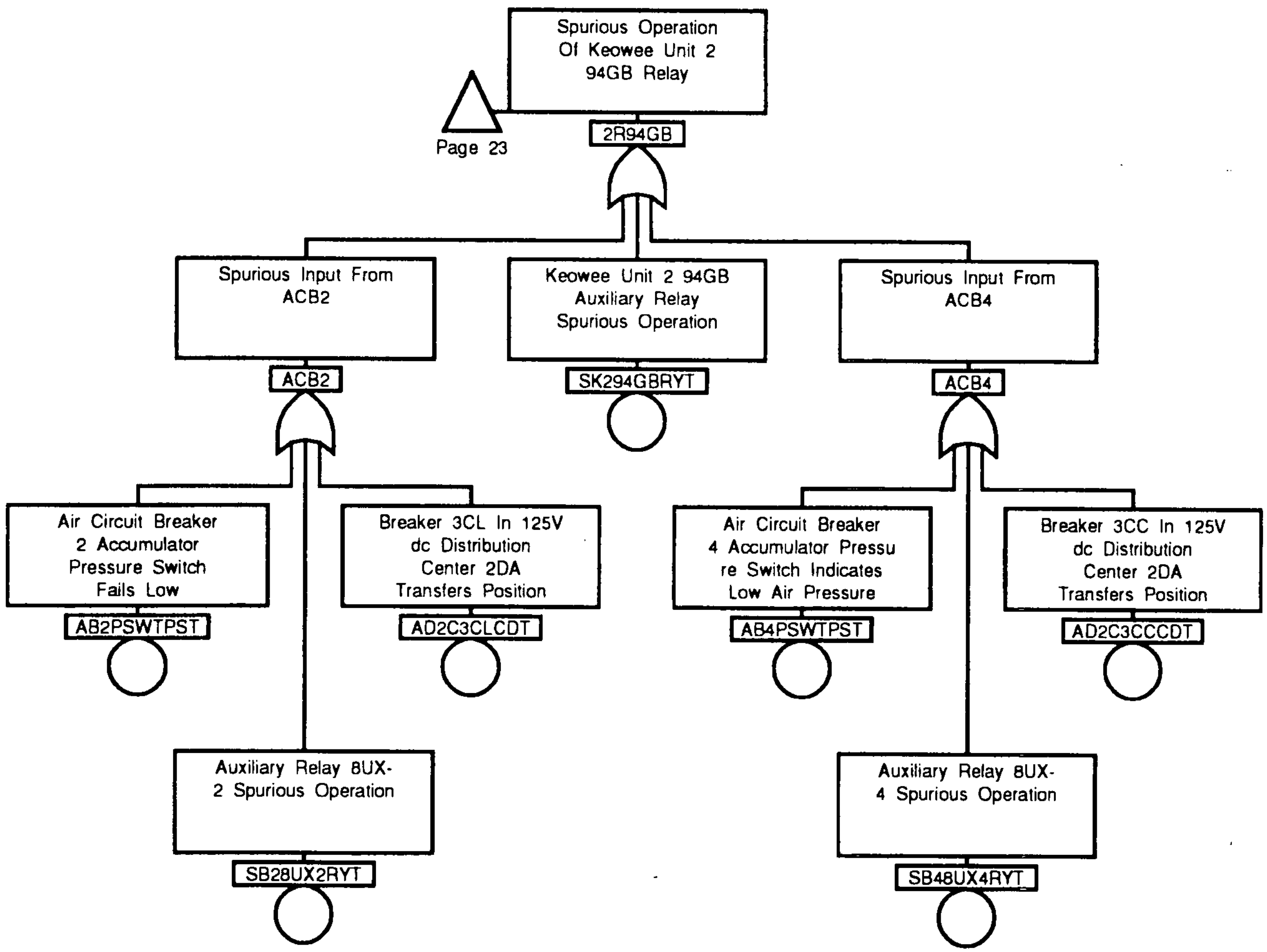

EGTPS Channel 1A Initiators Fail
SEGTP1ANIT
Page 12
Page 13
Page 14
Page 15
EGTPS Underfrequency Channel 1 Relay 94/F1A Signal Fails
SEG94F1AF
EGTPS Undervoltage Channel 1 Relay 94/F1A Signal Fails
SEG94V1AF
EGTPS Channel 2A Initiators Fail
SEGTP2ANIT
Page 12
Page 13
Page 14
Page 15
EGTPS Underfrequency Channel 2 Relay 94/F2A Signal Fails
SEG94F2AF
2
EGTPS Undervoltage Channel 2 Relay 94/V2A Signal Fails
SEG94V2AF
2



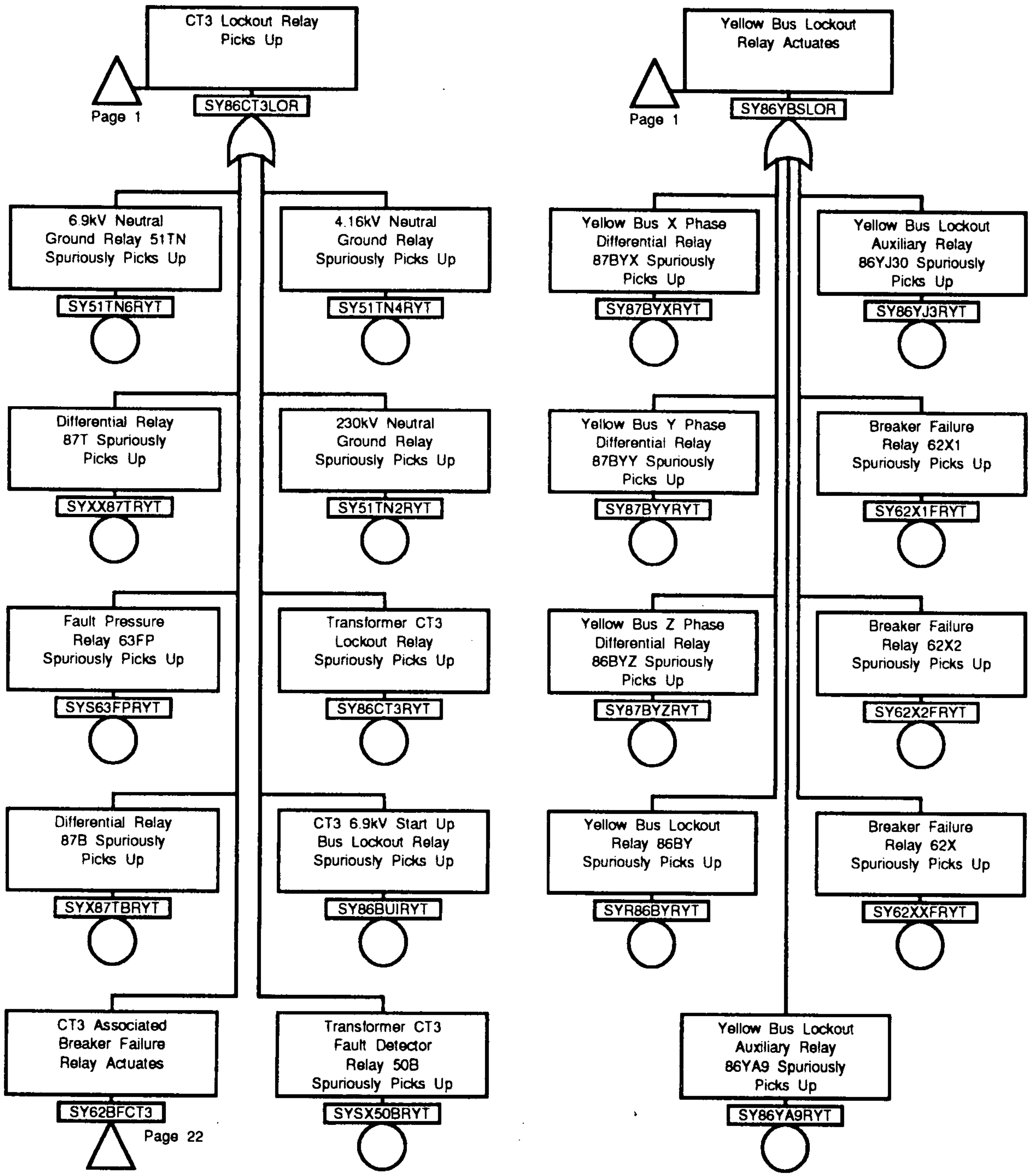
Keowee Emergency Power Paths Fault Tree | FIGURE A.2-2 |


Main Step Up Transformer Protective Relays Actuate
XFMRPROT
Page 17
Main Step Up Transformer Neutral Ground Relay 51TN Spurious Operation
SPC51TNRYT
Transformer 2X Differential Relay 87T-2X Spurious Operation
SPC872XRYT
Main Step Up Transformer Differen tial Relay 87T Spuri ous Operation
SPC87T1RYT
Line Differential Relay 87L Spurious Operation
SPCD87LRYT
Transformer 1X Differential Relay 87T-1X Spurious Operation
SPC871XRYT
Fire Protection Causes Main Step Up Transformer Lock Out
FIREPROT
Page 17
Auxiliary Relay 63H1X Spurious Operation
SPC631XRYT
Break Glass Switch Spurious Operation
SPCGLASSWT

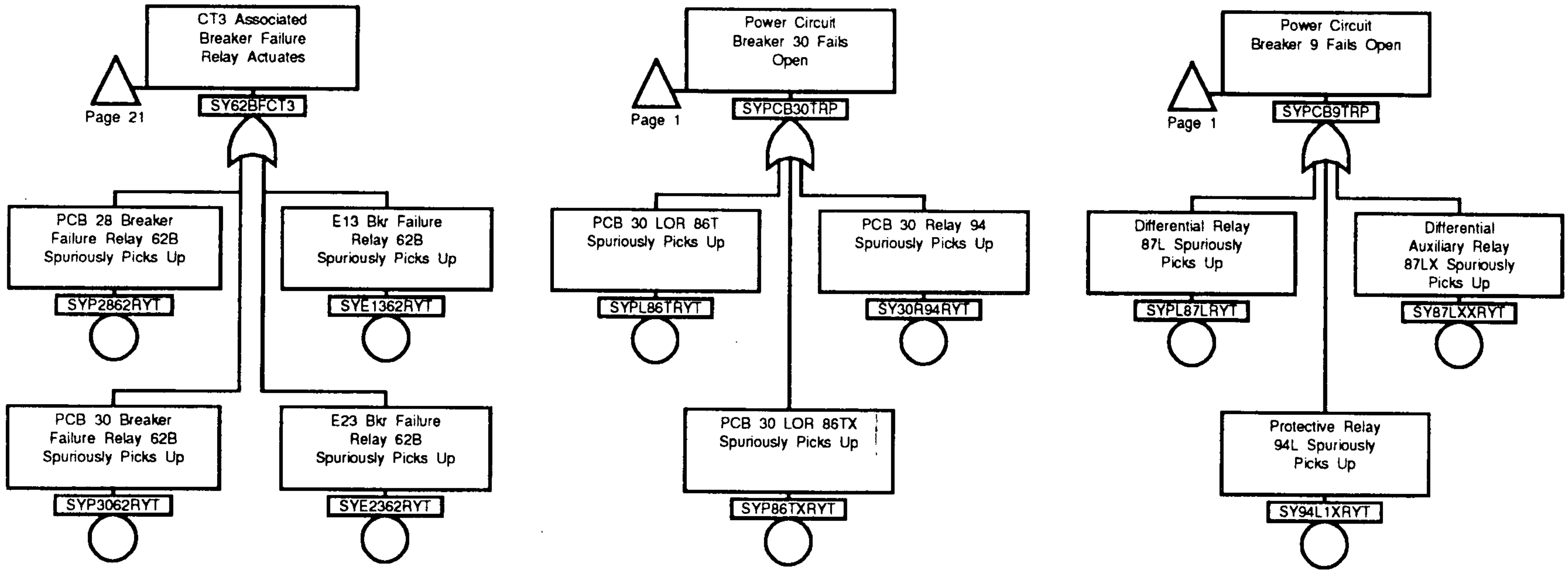

Spurious Operation Of Keowee Unit 1 94GB Relay
Page 23
1R94GB
Spurious Input From ACB1
ACB1
Keowee Unit 1 94GB Auxiliary Relay Spurious Operation
SK194GBRYT
Spurious Input From ACB3
ACB3
Air Circuit Breaker 1 Accumulator Pressure Switch Fails Low
AB1PSWTPST
Breaker 3CL In 125V dc Distribution Center 1DA Transfers Position
AD1C3CLCDT
Air Circuit Breaker 3 Accumulator Pressure Switch Fails Low
AB3PSWTPST
Breaker 3CC In 125V dc Distribution Center 1DA Transfers Position
AD1C3CCCDT
Auxiliary Relay 8UX-1 Spurious Operation
SB18UX1RYT
Auxiliary Relay 8UX-3 Spurious Operation
SB38UX3RYT



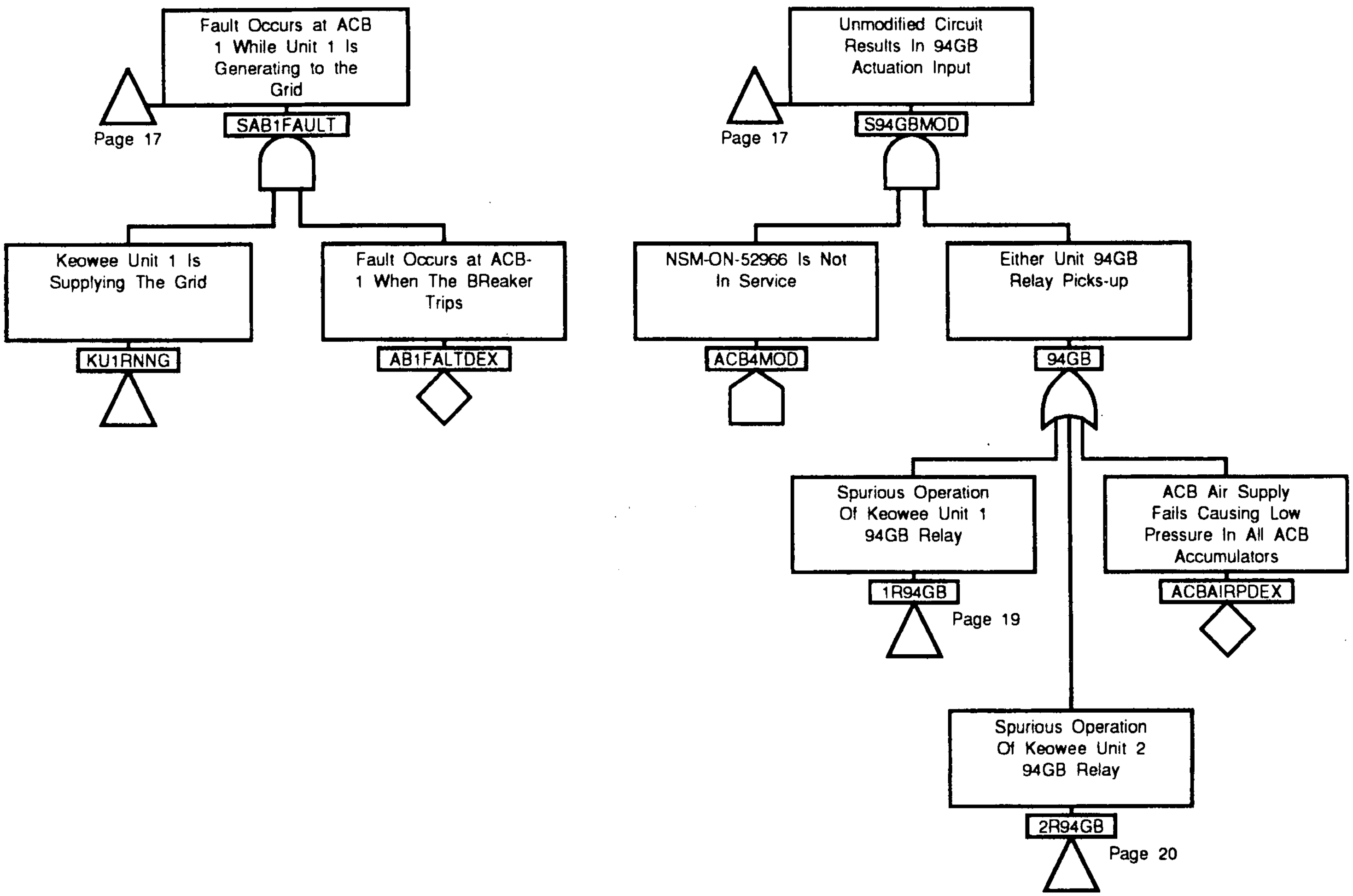
Keowee Emergency Power Paths Fault Tree | FIGURE A.2-2



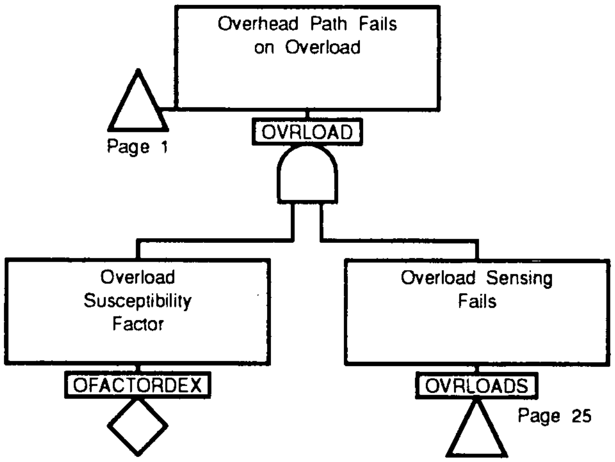
Keowee Emergency Power Paths Fault Tree	FIGURE A.2-2	Page 21



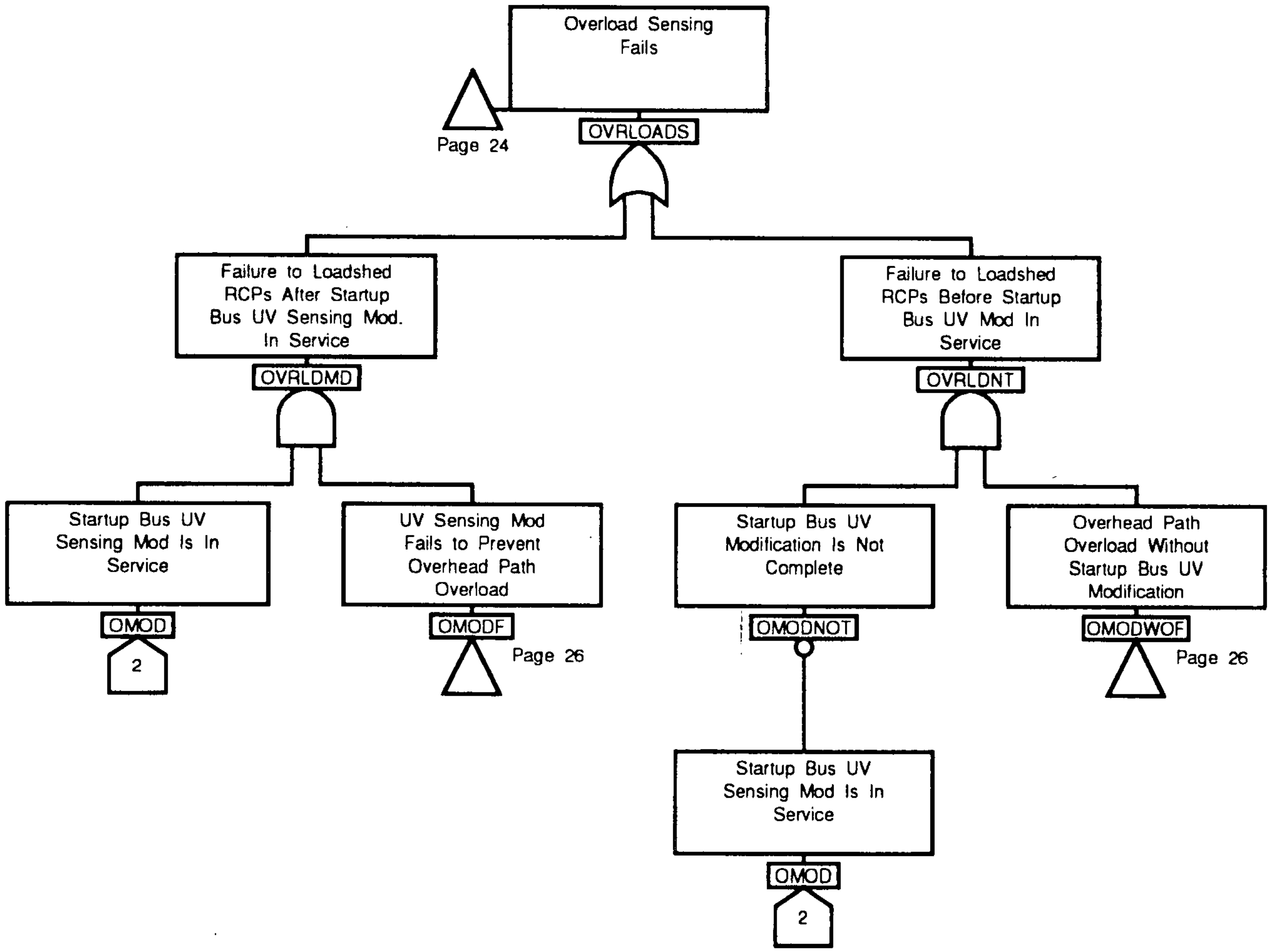
Keowee Emergency Power Paths Fault Tree	FIGURE A.2-2	Page 22



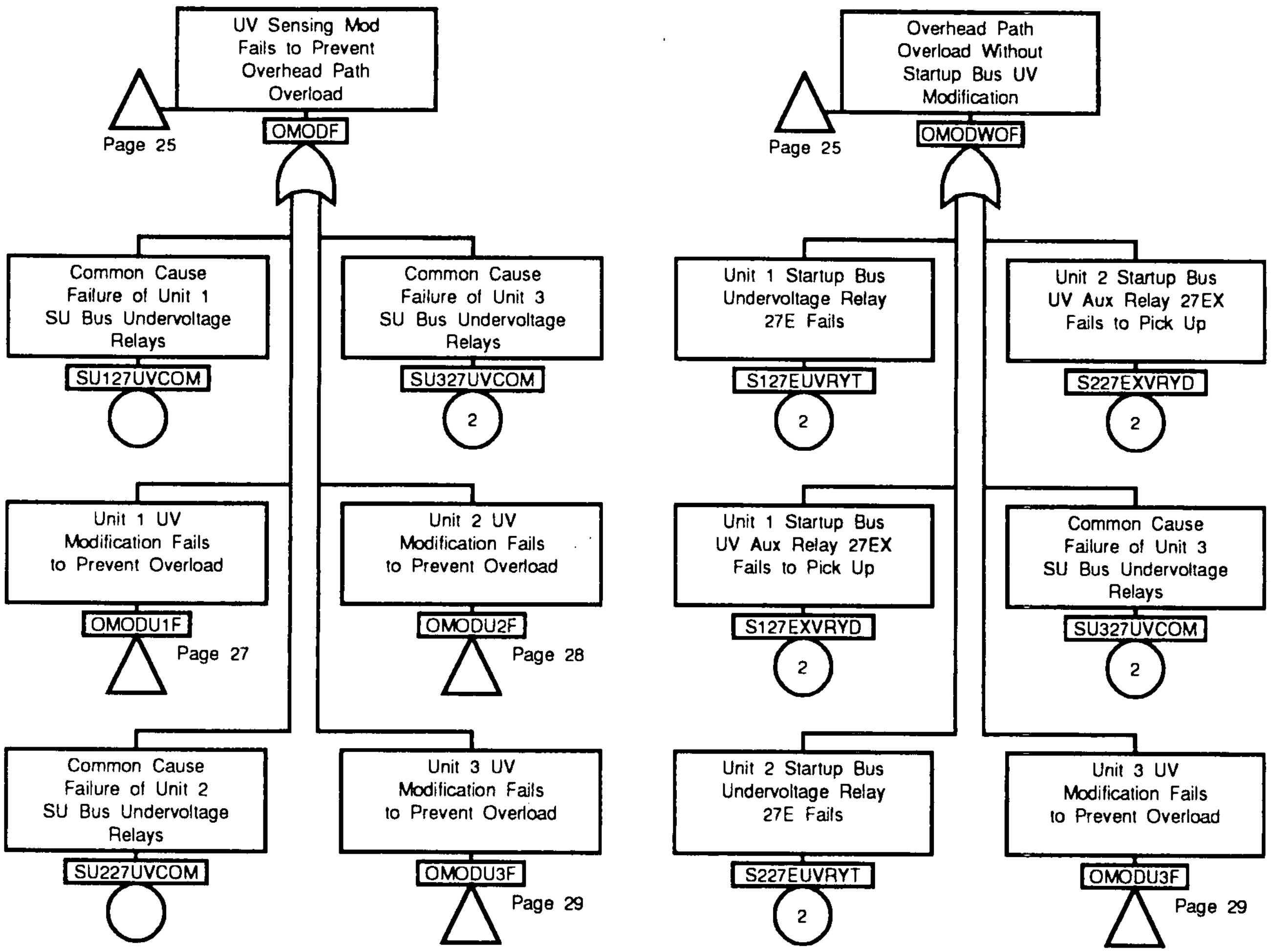
Keowee Emergency Power Paths Fault Tree	FIGURE A.2-2	



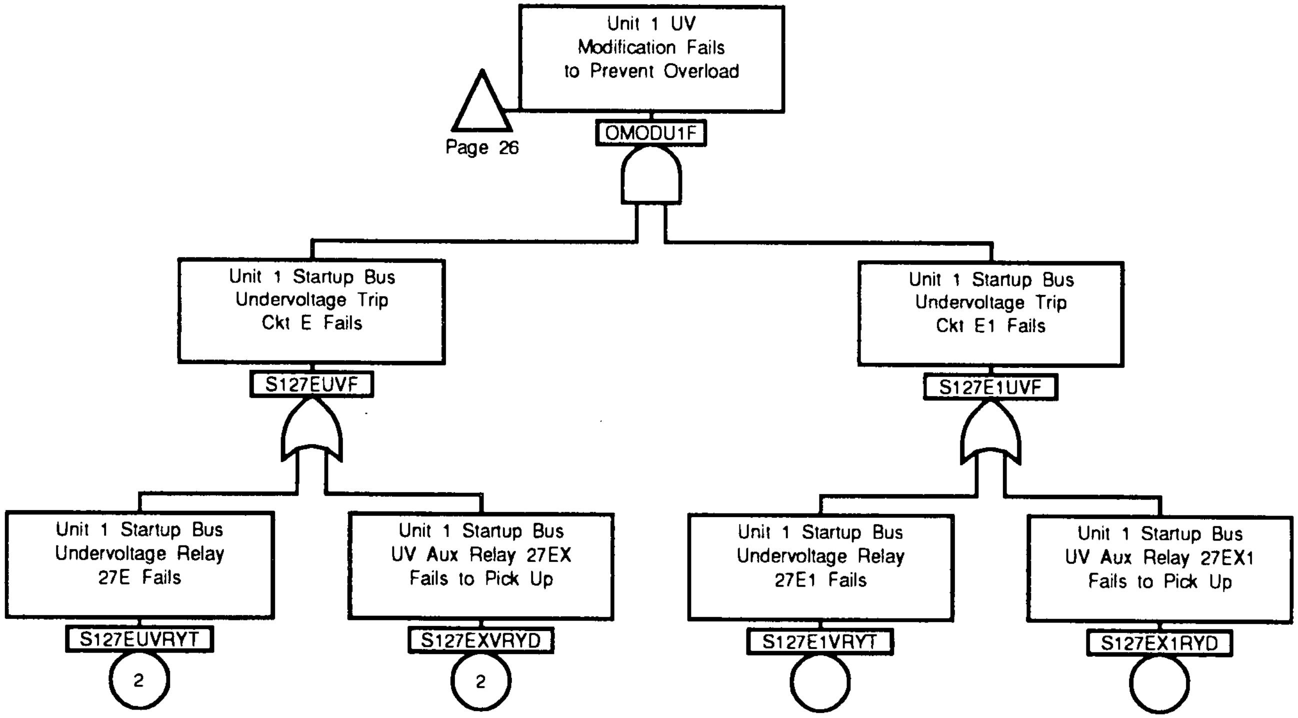
Keeowee Emergency Power Paths Fault Tree | FIGURE A.2-2 |



Keowee Emergency Power Paths Fault Tree	FIGURE A.2-2	Page 25

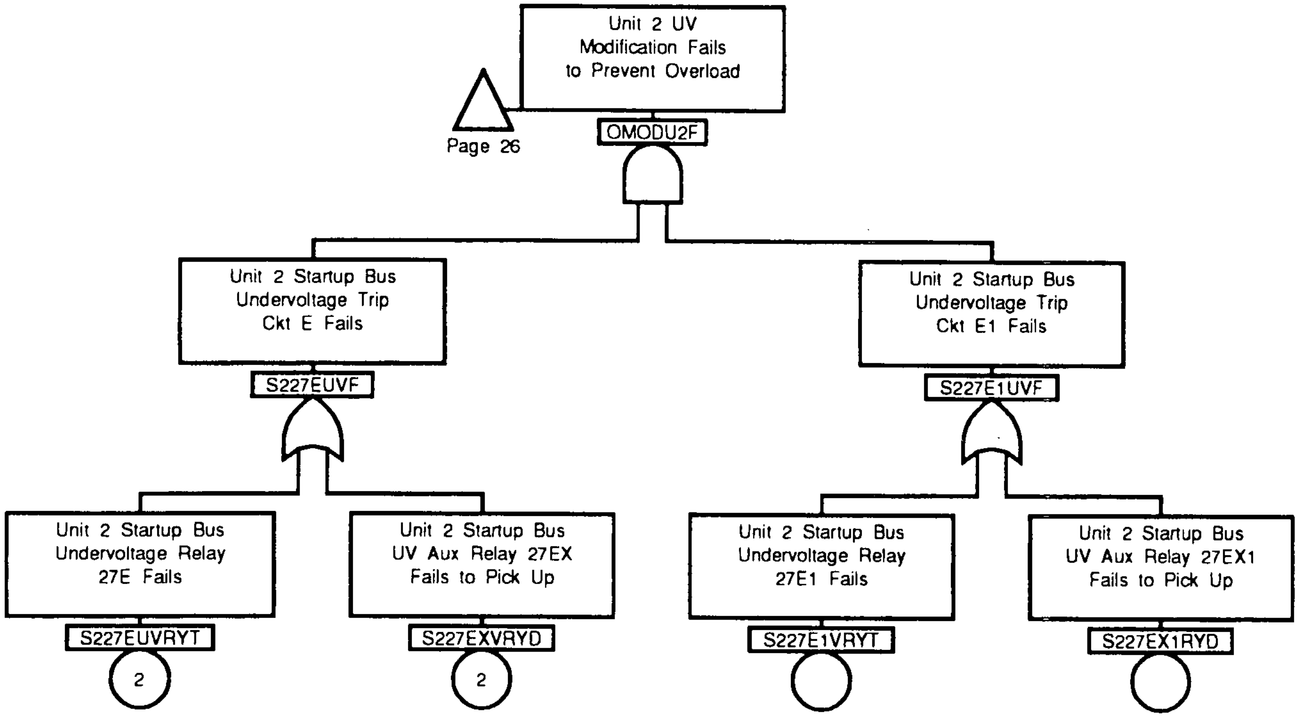


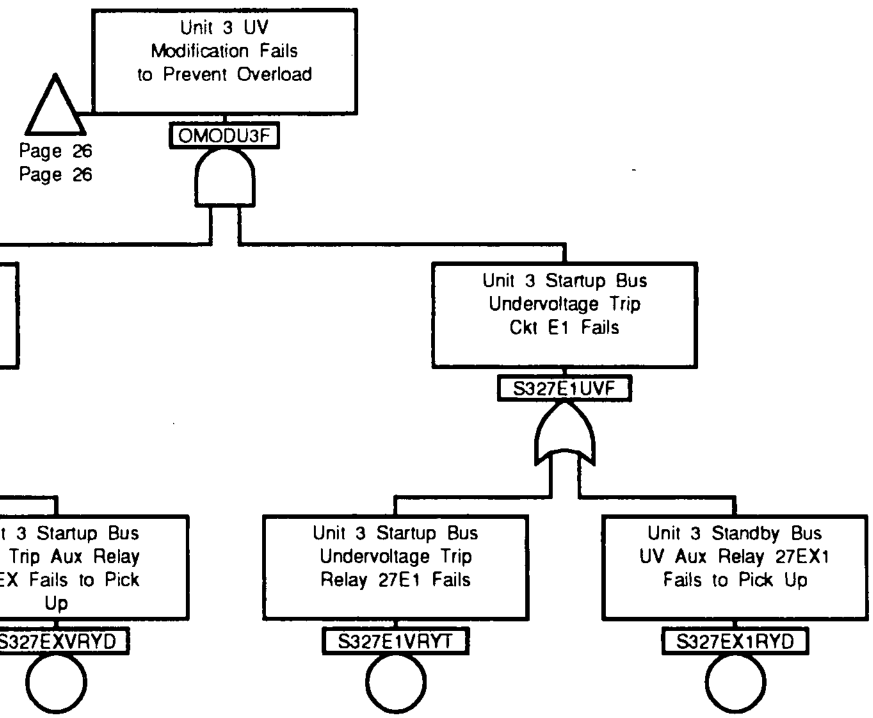
Keowee Emergency Power Paths Fault Tree | FIGURE A.2-2 |

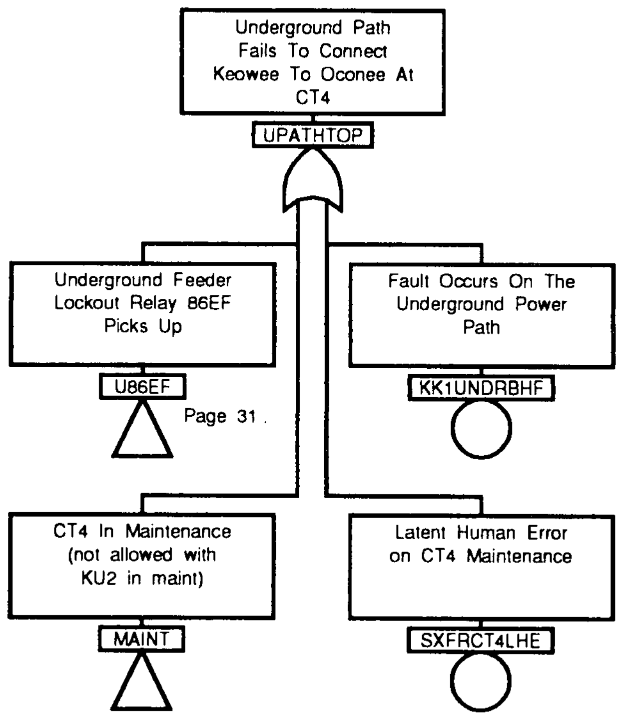


Keowee Emergency Power Paths Fault Tree

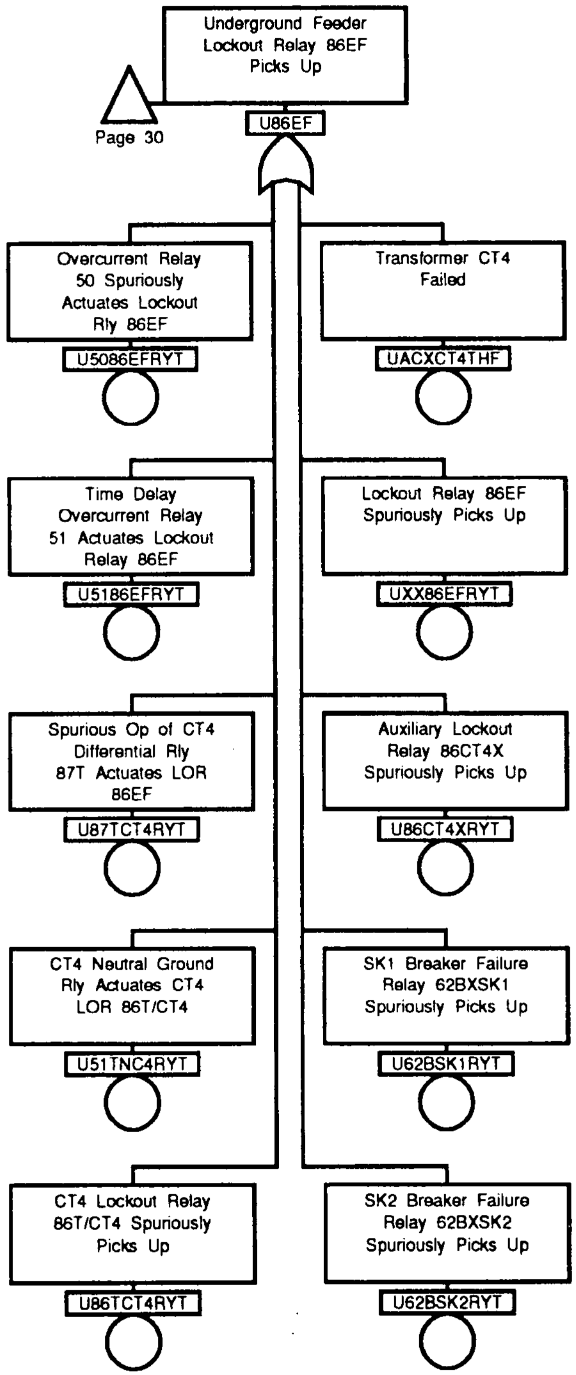
FIGURE A.2-2


Unit 2 UV Modification Fails to Prevent Overload
OMODU2F
Page 26
Unit 2 Startup Bus Undervoltage Trip Ckt E Fails
S227EUVF
Unit 2 Startup Bus Undervoltage Trip Ckt E1 Fails
S227E1UVF
Unit 2 Startup Bus Undervoltage Relay 27E Fails
S227EUVRYT
2
Unit 2 Startup Bus UV Aux Relay 27EX Fails to Pick Up
S227EXVRYD
2
Unit 2 Startup Bus Undervoltage Relay 27E1 Fails
S227E1VRYT
Unit 2 Startup Bus UV Aux Relay 27EX1 Fails to Pick Up
S227EX1RYD


Unit 3 UV
Modification Fails
to Prevent Overload
OMODU3F
Page 26
Page 26
Unit 3 Startup Bus
Undervoltage Trip
Ckt E Fails
S327EUVF
Unit 3 Startup Bus
Undervoltage Trip
Ckt E1 Fails
S327E1UVF
Unit 3 Startup Bus
Undervoltage Trip
Relay 27E Fails
S327EUVRYT
Unit 3 Startup Bus
UV Trip Aux Relay
27EX Fails to Pick
Up
S327EXVRYD
Unit 3 Startup Bus
Undervoltage Trip
Relay 27E1 Fails
S327E1VRYT
Unit 3 Standby Bus
UV Aux Relay 27EX1
Fails to Pick Up
S327EX1RYD



Underground Path Fails To Connect Keowee To Oconee At CT4
UPATHTOP
Underground Feeder Lockout Relay 86EF Picks Up
U86EF
Page 31
Fault Occurs On The Underground Power Path
KK1UNDRBHF
CT4 In Maintenance (not allowed with KU2 in maint)
MAINT
Latent Human Error on CT4 Maintenance
SXFRCT4LHE


Underground Feeder Lockout Relay 86EF Picks Up
Page 30
U86EF
Overcurrent Relay 50 Spuriously Actuates Lockout Rly 86EF
U5086EFRYT
Transformer CT4 Failed
UACXCT4THF
Time Delay Overcurrent Relay 51 Actuates Lockout Relay 86EF
U5186EFRYT
Lockout Relay 86EF Spuriously Picks Up
UXX86EFRYT
Spurious Op of CT4 Differential Rly 87T Actuates LOR 86EF
U87TCT4RYT
Auxiliary Lockout Relay 86CT4X Spuriously Picks Up
U86CT4XRYT
CT4 Neutral Ground Rly Actuates CT4 LOR 86T/CT4
U51TNC4RYT
SK1 Breaker Failure Relay 62BXSK1 Spuriously Picks Up
U62BSK1RYT
CT4 Lockout Relay 86T/CT4 Spuriously Picks Up
U86TCT4RYT
SK2 Breaker Failure Relay 62BXSK2 Spuriously Picks Up
U62BSK2RYT

Gate/Event Name	Page	Zone	Gate/Event Name	Page	Zone	Gate/Event Name	Page	Zone	Gate/Event Name	Page	Zone
1R94GB	19		OMODNOT	25		S27XSC2RYD	5		SDCDYA9CDT	3	
1R94GB	23		OMODU1F	26		S27XTD1RYD	5		SDCDYB	11	
2R94GB	20		OMODU1F	27		S27XTD2RYD	5		SDCDYB	12	
2R94GB	23		OMODU2F	26		S327E1UVF	29		SDCDYB	13	
94GB	23		OMODU2F	28		S327E1VRYT	29		SDCDYB	14	
AB1FALTDEX	23		OMODU3F	26		S327EUVF	29		SDCDYB	15	
AB1PSWTPST	19		OMODU3F	26		S327EUVRYT	29		SDCDYB4CDT	12	
AB2PSWTPST	20		OMODU3F	29		S327EX1RYD	29		SDCDYB6CDT	13	
AB3PSWTPST	19		OMODWOF	25		S327EXVRYD	29		SDCDYB8CDT	14	
AB4PSWTPST	20		OMODWOF	26		S94GBMOD	17		SDCDYC	5	
ACB1	19		OPATHTOP	1		S94GBMOD	23		SDCDYE	2	
ACB2	20		OPATHTOPB	1		SAB1FAULT	17		SDCDYE	3	
ACB2DISC	1		OPATHTOPC	1		SAB1FAULT	23		SDCDYE	7	
ACB2OPEN	1		OVRLDMD	25		SB18UX1RYT	19		SDCDYE	8	
ACB3	19		OVRLDNT	25		SB28UX2RYT	20		SDCDYE	9	
ACB4	20		OVRLOAD	1		SB38UX3RYT	19		SDCDYE	10	
ACB4MOD	23		OVRLOAD	24		SB48UX4RYT	20		SDCDYE8CDT	7	
ACBAIRPDEX	23		OVRLOADS	24		SDCAIDDDIF	3		SDCDYE9CDT	2	
AD1C3CCCDT	19		OVRLOADS	25		SDCDA12CDT	8		SDCDYE9CDT	3	
AD1C3CLCDT	19		PCB9OPEN	1		SDCDA15CDT	9		SDCDYF	11	
AD2C3CCCDT	20		PCB9OPEN	2		SDCDA17CDT	10		SDCDYF	12	
AD2C3CLCDT	20		S127E1UVF	27		SDCDB01CDT	11		SDCDYF	13	
ASWYDISO	1		S127E1VRYT	27		SDCDB13CDT	15		SDCDYF	14	
FIREPROT	17		S127EUVF	27		SDCDC12CDT	5		SDCDYF	15	
FIREPROT	18		S127EUVRYT	26		SDCDE12CDT	8		SDCDYF4CDT	12	
KK1OVERBHF	1		S127EUVRYT	27		SDCDE15CDT	9		SDCDYF6CDT	13	
KK1UNDRBHF	30		S127EX1RYD	27		SDCDE17CDT	10		SDCDYF8CDT	14	
KU1RNNG	23		S127EXVRYD	26		SDCDF01CDT	11		SDCDYG	5	
KU2RNNG	1		S127EXVRYD	27		SDCDF13CDT	15		SDCEIDDDIF	3	
KU2SWYD	1		S227E1UVF	28		SDCDG16CDT	5		SEG122INIT	8	
L27XSTARYD	2		S227E1VRYT	28		SDCDYA	2		SEG152INIT	9	
L27XSTBRYD	2		S227EUVF	28		SDCDYA	3		SEG94F1AF	16	
MAINT	30		S227EUVRYT	26		SDCDYA	7		SEG94F1DF	4	
OFACTORDEX	24		S227EUVRYT	28		SDCDYA	8		SEG94F1DF	11	
OMOD	25		S227EX1RYD	28		SDCDYA	9		SEG94F2AF	8	
OMOD	25		S227EXVRYD	26		SDCDYA	10		SEG94F2AF	16	
OMODF	25		S227EXVRYD	28		SDCDYA8CDT	7		SEG94F2BF	8	
OMODF	26		S27XSC1RYD	5		SDCDYA9CDT	2		SEG94F2BF	9	

Gate/Event Name	Page	Zone	Gate/Event Name	Page	Zone	Gate/Event Name	Page	Zone	Gate/Event Name	Page	Zone
SEG94F2CF	9		SPC51TNRYT	18		SPCB17TF	6		SPCISLTCPT	3	
SEG94F2DF	4		SPC62ABRYT	17		SPCB17TF	10		SPCISLTCPT	5	
SEG94F2DF	11		SPC631XRYT	18		SPCB21TC1	11		SPCISOCCH1	5	
SEG94V1AF	16		SPC871XRYT	18		SPCB21TC2	11		SPCISOCCH2	5	
SEG94V1DF	4		SPC872XRYT	18		SPCB21TCF	6		SPCISOF	5	
SEG94V1DF	11		SPC87T1RYT	18		SPCB21TCF	11		SPCISOF	5	
SEG94V2AF	8		SPC94TKRYT	17		SPCB21TF	6		SPCISOF	6	
SEG94V2AF	16		SPCB008CHO	7		SPCB24TC1	12		SPCISOLATE	3	
SEG94V2BF	8		SPCB009CHC	3		SPCB24TC2	12		SPCISOLATE	4	
SEG94V2BF	9		SPCB009CHO	2		SPCB24TCF	12		SPCR86TRYT	17	
SEG94V2CF	9		SPCB012CHO	8		SPCB24TF	6		SU127UVCOM	26	
SEG94V2DF	4		SPCB015CHO	9		SPCB24TF	12		SU227UVCOM	26	
SEG94V2DF	11		SPCB017CHO	10		SPCB26TC1	13		SU327UVCOM	26	
SEGTP1ANIT	12		SPCB021CHO	6		SPCB26TC2	13		SU327UVCOM	26	
SEGTP1ANIT	13		SPCB024CHO	12		SPCB26TCF	13		SXFRCT3THF	1	
SEGTP1ANIT	14		SPCB026CHO	13		SPCB26TF	6		SXFRCT3THM	1	
SEGTP1ANIT	15		SPCB028CHO	14		SPCB26TF	13		SY30R94RYT	22	
SEGTP1ANIT	16		SPCB033CHO	15		SPCB28TC1	14		SY51TN2RYT	21	
SEGTP1BNIT	2		SPCB08TCF	7		SPCB28TC2	14		SY51TN4RYT	21	
SEGTP1BNIT	7		SPCB08TF	1		SPCB28TCF	14		SY51TN6RYT	21	
SEGTP1BNIT	8		SPCB08TF	6		SPCB28TF	6		SY62BFCT3	21	
SEGTP1BNIT	9		SPCB08TF	7		SPCB28TF	14		SY62BFCT3	22	
SEGTP1BNIT	10		SPCB09CF	1		SPCB33TC1	15		SY62X1FRYT	21	
SEGTP1DNIT	11		SPCB09CF	3		SPCB33TC2	15		SY62X2FRYT	21	
SEGTP2ANIT	12		SPCB09TCF	2		SPCB33TCF	15		SY62XXFRYT	21	
SEGTP2ANIT	13		SPCB12TC1	8		SPCB33TF	6		SY86BUIRYT	21	
SEGTP2ANIT	14		SPCB12TC2	8		SPCB33TF	15		SY86CT3LOR	1	
SEGTP2ANIT	15		SPCB12TCF	8		SPCB8TC1F	7		SY86CT3LOR	21	
SEGTP2ANIT	16		SPCB12TF	6		SPCB8TC2F	7		SY86CT3RYT	21	
SEGTP2BNIT	2		SPCB12TF	8		SPCB9CDC1	3		SY86YA9RYT	21	
SEGTP2BNIT	7		SPCB15TC1	9		SPCB9CDC2	3		SY86YBSLOR	1	
SEGTP2BNIT	10		SPCB15TC2	9		SPCB9TC1F	2		SY86YBSLOR	21	
SEGTP2DNIT	11		SPCB15TCF	9		SPCB9TC2F	2		SY86YJ3RYT	21	
SEGTPSCH1F	2		SPCB15TF	6		SPCBSFC1	6		SY87BYXRYT	21	
SEGTPSCH2F	2		SPCB15TF	9		SPCBSFC2	6		SY87BYYRYT	21	
SK194GBRYT	19		SPCB17TC1	10		SPCCB9CF	3		SY87BYZRYT	21	
SK294GBRYT	20		SPCB17TC2	10		SPCD87LRYT	18		SY87LXXRYT	22	
SPC14KVBHF	17		SPCB17TCF	10		SPCGLASSWT	18		SY94L1XRYT	22	

Gate/Event Name	Page	Zone	Gate/Event Name	Page	Zone	Gate/Event Name	Page	Zone	Gate/Event Name	Page	Zone
SYE1362RYT	22										
SYE2362RYT	22										
SYP2862RYT	22										
SYP3062RYT	22										
SYP86TXRYT	22										
SYPCB09CHT	1										
SYPCB30CHT	1										
SYPCB30TRP	1										
SYPCB30TRP	22										
SYPCB9TRP	1										
SYPCB9TRP	22										
SYPL86TRYT	22										
SYPL87LRYT	22										
SYR86BYRYT	21										
SYS63FPRYT	21										
SYSX50BRYT	21										
SYX87TBRYT	21										
SYXX87TRYT	21										
U5086EFRYT	31										
U5186EFRYT	31										
U51TNC4RYT	31										
U62BSK1RYT	31										
U62BSK2RYT	31										
U86CT4XRYT	31										
U86EF	30										
U86EF	31										
U86TCT4RYT	31										
U87TCT4RYT	31										
UACXCT4THF	31										
UPATHTOP	30										
UXX86EFRYT	31										
XFMR186T	1										
XFMR186T	17										
XFMRPROT	17										
XFMRPROT	18										

APPENDIX A.3

EXTERNAL GRID TROUBLE PROTECTION SYSTEM

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A.3 EXTERNAL GRID TROUBLE PROTECTION SYSTEM

A.3.1 OBJECTIVES

The main objective of this analysis is to develop a logic model of the External Grid Trouble Protection System (EGTPS). This model is combined with the high-level model and remaining system models to form an integrated model for assessing the reliability of Keowee. Other objectives are to identify major contributors to system unreliability, significant potential human errors and common-cause failure modes.

The scope of this analysis is limited to EGTPS equipment required to support a Keowee emergency start and run under load following a loss of off-site power condition.

A.3.2 SYSTEM DESIGN

The EGTPS provides detection of impending collapse or degraded voltage on the 230 kV grid or the 230 kV Switchyard when voltage and/or frequency on the 230 kV red and yellow buses deteriorates to system actuation set points. When the system actuates, it provides Emergency Start (ES) signals to the Keowee hydro units. The system then provides the breaker manipulation logic to isolate the 230 kV switchyard yellow bus and establish the overhead power path from the Keowee unit aligned to the overhead power path through the isolated switchyard yellow bus to the startup transformers of all three Oconee units.

The EGTPS contains two undervoltage and two underfrequency initiation channels consisting of networks of undervoltage relays and underfrequency relays. A channel is actuated when two out of three phases of both switchyard yellow bus and switchyard red bus sensing relays detect undervoltage or underfrequency conditions. When a channel is actuated, four tripping relays ("94" relays) carry out the EGTPS function.

Figure A.3-1 is a logic diagram of the EGTPS Channel 1. When channel 1 is actuated:

1. Relays 94/V1A or 94/F1A actuate trip coil #1 of Power Circuit Breakers (PCBs) 24, 26, 28, and 33.

2. Relays 94/V1B or 94/F1B actuate trip coil #1 of PCBs 8, 12, 15, and 17; they also actuate EGTPS Trouble Relay 27X/STA which in turn provides the Channel 1 Keowee Emergency Start signal and actuates PCB 9 trip coil #1.

3. Relays 94/V1C or 94/F1C actuate statalarms and event recorders.

4. Relays 94/V1D or 94/F1D actuate trip coil #1 of PCB 21 and the close coils of PCBs 9, 18, 27, and 30.

For channel 2:

1. Relays 94/V2A or 94/F2A actuate the trip coil #2 of PCBs 12, 24, 26, 28, and 33.

2. Relays 94/V2B or 94/F2B actuate the trip coil #2 of PCBs 8, 12, 15, and 17; they actuate EGTPS Trouble Relay 27X/STB which provides the Channel 2 Keowee Emergency Start signal and actuates PCB 9 trip coil #2.

3. Relays 94/V2C or 94/F2C actuate the trip coil #2 of PCB 15 and statalarms and event recorders.

4. Relays 94/V2D or 94/F2D actuate trip coil #2 of PCB 21 and the close coils of PCBs 9, 18, 27 and 30.

Other system outputs are switchyard isolation confirmed signals which are generated when all of the following PCBs are opened to isolate the switchyard:

1.	PCB 8	4.	PCB 17	7.	PCB 26
2.	PCB 12	5.	PCB 21	8.	PCB 28
3.	PCB 15	6.	PCB 24	9.	PCB 33

The switchyard isolation confirmed relay 27X/SC1(2) operates the switchyard isolation auxiliary relay SIA(B), which in turn operates the Keowee Unit 1 and Keowee Unit 2 Switchyard Isolated Interposing Relays [1SIXA(B) and 2SIXA(B)]. The switchyard isolated interposing relays provide the close permissive in the automatic close circuits of ACB-1 and ACB-2. Also, the PCB 9 automatic close circuit requires operation of a

switchyard isolation complete time delay relay, 27XTD/SC1 or 27XTD/SC2. The time delay provides adequate time (about 4 seconds) for Reactor Coolant Pump Switchgear breakers to open before PCB 9 closes re-energizing the switchyard and the main feeder buses through the yellow bus and the startup transformers. This portion of the EGTPS is modeled in the switchyard isolation model (Appendix A.2).

Undervoltage Channel 1 is composed of six undervoltage relays (27B), each connected to a phase of the yellow and red buses. When a 27B ac relay detects undervoltage and drops out, an associated auxiliary dc relay (27X) is picked up. When two auxiliary relays of the same phase (one on the yellow bus and one on the red bus) are picked up concurrently, a phase undervoltage auxiliary relay (27X/RY) picks up. When two out of three 27X/RY relays (X,Y,and Z phases) are picked up, the Channel 1 tripping relays (the 94 relays) are picked up.

Underfrequency Channel 1 is composed of six underfrequency relays (81B), connected to the phases of the yellow and red buses in a configuration similar to that of the undervoltage relays. When an 81B ac relay detects underfrequency and drops out, an associated auxiliary dc relay (81X) picks up. A phase underfrequency auxiliary relay picks up when yellow bus and red bus same phase relays pick up. When two out of three 81X/RY relays (X,Y, and Z phases) pick up, the Channel 1 tripping relays again pick up.

The Channel 2 undervoltage and underfrequency components of the EGTPS are configured similarly, but different manufacturer components are used to minimize common mode failures.

A.3.3 SYSTEM BOUNDARIES

Electrical Power Supplies

The 230 kV Switchyard DC Power System (Appendix A.9) provides control power to both channels of the EGTPS.

External Control Systems

The EGTPS interfaces with the Oconee Unit 1 Keowee Emergency Start System. It does not require any external controls for its operation.

A.3.4 INSTRUMENTATION AND CONTROLS

The EGTPS panels are located in the 230 kV switchyard relay house. There are six green lights on the EGTPS undervoltage Channel 1 panel. Each light indicates the trip status of the red and yellow bus phase undervoltage relays. The lights turn on for an undervoltage condition. Three red indicating lights per channel indicate when both red and yellow buses are experiencing undervoltage on one particular phase. Six green lights on the EGTPS underfrequency Channel 1 panel similarly indicate the trip status of the red and yellow bus phase underfrequency relays. Three red lamps indicate simultaneous underfrequency conditions on like phases of the red and yellow bus. A pair of blue lamps for each channel. are connected in two out of three logic to indicate whenever one of the three logic inputs are satisfied. A single, normally on, lamp on each channel related panel of undervoltage and underfrequency indicates the presence of 125 Vdc control power. The EGTPS panels and their associated channels are identified as follows:

Panel	SBR-17	Undervoltage Channel 1
Panel	SRF-17	Underfrequency Channel 1
Panel	RF-17	Undervoltage Channel 2
Panel	RB-17	Underfrequency Channel 2

A Switchyard Isolation Confirmed signal is generated when the switchyard PCB auxiliary contacts show that the switchyard yellow bus has been isolated from the grid and the switchyard PCBs are aligned to supply power to the unit startup transformers via the overhead power path. The "SWYD ISOLATED SIGNAL" indicating lights are located on the Switchyard Isolated Signal test panels. Both channels' test panels are in the switchyard relay house.

Statalarms pertaining to the EGTPS are located in the Oconee Unit 1/2 Control Room on Annunciator Alarm Panels SA15 and SA16. These alarms are listed in Table A.3-4.

A.3.5 LOCATION WITHIN THE PLANT

The External Grid Trouble Protection System is physically located in the Switchyard Relay House. The undervoltage and underfrequency sensor relays are on each phase of the switchyard red and yellow buses in the 230 kV switchyard.

A.3.6 NORMAL OPERATION

The system is normally operating, monitoring the voltage and frequency of the grid at the 230 kV Switchyard. Routine testing of both voltage and frequency channels assures their operability.

A.3.7 PERFORMANCE DURING KEOWEE EMERGENCY OPERATION

The EGTPS is designed to initiate the emergency response necessary to recover from a LOOP event. The system is battery powered in order to be capable of performing its function if ac power is lost. The system (1) provides signals to start the Keowee emergency generators; (2) provides signals to isolate the switchyard from the grid; and (3) establish a power path from the Keowee unit (connected to the overhead) to the startup transformers after a time delay (4-5 seconds) to assure necessary load shed is accomplished.

A Keowee emergency start and energizing of Transformer CT4 can also be accomplished by the Main Feeder Bus Monitors and the Engineered Safeguards Actuation System associated with each Oconee unit. For the overhead power path, however, operation of the EGTPS is necessary to isolate the switchyard and establish the connection between Keowee and the startup transformers of the Oconee units.

A.3.8 TEST AND MAINTENANCE

Testing

The EGTPS Logic And Switchyard Isolation Logic Test is performed quarterly to verify operation of system logic associated with the EGTPS and Switchyard Isolation, and to verify the actuation set-point of time delay relays for PCB-9 close permissive. Since system actuation requires 2 out of 3 logic, the individual voltage and frequency channels can be tested without disabling the system or disabling a single channel.

Installed test circuitry is used to verify that each channel's red and yellow bus, X, Y, and Z phases undervoltage and underfrequency conditions can be detected. Logic operation is verified by observing statalarms, switchyard event recorder printouts, and indicating lights.

Nine pushbuttons (one per breaker) are provided in the switchyard relay house to simulate the response of each PCB affected by a switchyard isolation signal.

The Degraded Grid and Switchyard Isolation Functional Test is performed one channel at a time on a refueling frequency. The test includes (1) functional verification of overhead ACB and PCB-9 operation during switchyard isolation, (2) demonstration of the operability of the Degraded Grid Protection System (DGPS), (3) demonstration of the ability of the overhead Keowee unit to energize the 230 kV Yellow Bus for all three Oconee units' Startup Transformers and carry the shutdown loads of Oconee Unit 1, and (4) demonstration of the capability to realign the 230 kV Yellow Bus back to the system grid while Oconee loads are being fed from the Overhead Keowee unit. The test is directly associated with the switchyard isolation model (Appendix A.2) and the Keowee emergency start model (Appendix A.5), but is mentioned here since it requires de-energizing the EGTPS while the DGPS logic is verified. The verification of DGPS operability is estimated to require about three hours to complete. Following the DGPS verification, the EGTPS is enabled. Prior to the test, a Lee Gas Turbine is aligned to energize CT-5.

The EGTPS testing requirements are listed in Table A.3-2.

A.3.9 OPERATING EXPERIENCE

There have been no reported instances of EGTPS failures.

A.3.10 ASSUMPTIONS

A.3.10.1 SYSTEM DESIGN ASSUMPTIONS

1. Undervoltage Channel 2 is similar in operation and redundant to undervoltage Channel 1. (The major difference between the two channels is that each channel uses different manufacturer components to minimize common mode failures.)

2. Underfrequency Channel 2 is similar in operation and redundant to underfrequency Channel 1. (The major difference between the two channels is that each channel uses different manufacturer components to minimize common mode failure.)

A.3.10.2 OPERATIONAL ASSUMPTIONS

1. Both Channels of undervoltage detection and underfrequency detection are assumed operational.

A.3.10.3 MODELING ASSUMPTIONS

1. Only the undervoltage and underfrequency detection functions of the EGTPS are modeled in this section of the analysis. The Switchyard Isolation Complete function is covered in Appendix A.2.

A.3.11 FAULT TREE ANALYSIS

A.3.11.1 TOP EVENT SUCCESS CRITERIA

Success of the EGTPS System requires that the initiating event (LOOP) is detected, the output tripping relays provide signals to their output functions and at least one channelized EGTPS Trouble Relay (27X/STA or 27X/STB) actuates.

A.3.11.2 DETAILED FAILURE CRITERIA

1. Start relay operations are the desired final actions of the EGTPS channels in this section of the analysis and their failures are top events of the fault tree. Progressively lower levels of the fault tree involve the circuit components necessary to generate the final actions in reverse order. Thus, the circuit components which sense the initiator for which they are designed are at the bottom of the fault trees.

A.3.11.3 DESCRIPTION OF FAULT TREE

The EGTPS System fault tree is shown in Figure A.3-2. The Fault Tree Modeling Guidelines (Appendix B) were followed in developing the fault tree. A list of all fault tree transfers is presented in Table A.3-3.

A.3.11.4 HUMAN INTERACTIONS

There are no human reliability events in the EGTPS fault tree, since the human interactions are very few in this system and immediate feedback of inappropriate action is expected.

A.3.11.5 RELIABILITY DATA

Section 5.3 discusses development of the reliability data. For the base case solution, the plant-specific failure rate data and generic failure rate data were combined using a Bayesian update.

As discussed in Section 5.3, consideration of relevant statalarms is part of the process of determining each basic event factor. EGTPS statalarms are listed in Table A.3-4.

System reliability data is listed in Table A.3-5.

A.3.11.6 COMMON CAUSE ASSESSMENT

Common cause failure of electromagnetic relays may result in the failure of the Channel 1 detection circuits. This may include both undervoltage detection and underfrequency detection. Similarly for the Channel 2 detectors common cause failure of solid state relays may involve the solid state undervoltage devices and the solid state frequency devices. Thus, a common cause failure probability is included for the same channel undervoltage and underfrequency components. The common-cause events are quantified in Appendix C.2.

A.3.12 RESULTS

Reliability of the EGTPS is defined as the probability that the system will succeed in providing Keowee Emergency Start signals when a LOOP occurs. The system model yields a probability of approximately 3E-05 for a channel [up to and including the EGTPS Trouble Relay 27X/STA(B)] to fail to provide a Keowee Emergency Start signal.

Table A.3-6 lists the dominant minimal cut sets for the External Grid Trouble Protection System. The dominant contributor to failure is "EGTPS Trouble Relay 27X/STA(B) Fails To Pick Up". "Common Cause Failure Of The UV and UF Detection Circuits" are the next highest contributors to channel unreliability.

A.3.13 REFERENCES

A.3.13.1 DOCUMENTS

1. OSS-0254.00-00-2005, Rev. 2, Keowee Emergency Power Design Basis Document.

2. OSS-0254.00-00-2004, Rev. 1, 230 kV Switchyard Design Basis Document.

A.3.13.2 PROCEDURES

1. PT/0/A/0610/02, Change 14, External Grid Trouble Protective System Logic And Switchyard Isolation Logic Test.

Table A.3-1

EGTPS Power Supplies

Component	Power Supply[1]	Panelboard Number
EGTPS		
Undervoltage Ch. 1	230 kV Switchyard 125 Vdc Control Power System DC 1DA	DYC-13
Underfrequency Ch. 1	DC 1DA	DYC-14
Undervoltage Ch. 2	DC 2DA	DYG-12
Underfrequency Ch. 2	DC 2DA	DYG-18
External Grid Trouble Switchyard Isolated System		
SWYD Isolate Complete Ch. 1	DC 1DA	DYC-12
SWYD Isolate Complete Ch. 2	DC 2DA	DYG-16

[1] MCC = Motor Control Center
DC = Distribution Center

Table A.3-2

EGTPS Test Procedures

Procedure	Test Frequency	Description
PT/0/A/0610/02, EGTPS Logic And Switchyard Isolation Logic Test.	Quarterly	Verify operation of system logic associated with EGTPS and switchyard isolation circuits.

Table A.3-3

EGTPS Fault Tree Transfers

Transfer Gate Name	Description	Components Supplied
SDCDYC	Loss of Power on 125 V dc SWYD DC Panelboard DYC	EGTPS Channel 1
SDCDYG	Loss of Power on 125 V dc SWYD DC Panelboard DYG	EGTPS Channel 2

Table A.3-4

EGTPS Statalarms

Point No.	Alarm	Actuator
SA15-1	CHANNEL #1 TEST	Test Pushbuttons
SA15-2	CHANNEL #1 UNDERFREQUENCY	94/F1C
SA15-3	CHANNEL #2 TEST	Test Pushbuttons
SA15-4	CHANNEL #2 UNDERFREQUENCY	94/F2C
SA15-5	CHANNEL #1 DC SUPPLY FAILURE	74B/V1 & 74B/F1
SA15-6	CHAN. #1 UNDERVOLTAGE INITIATED	27X
SA15-7	CHAN #2 UNDERVOLTAGE INITIATED	27X
SA15-9	CHANNEL #1 UNDERVOLTAGE	94/V1C
SA15-10	CHAN. #1 UNDERFREQUENCY INITIATED	81X
SA15-11	CHANNEL #2 UNDERVOLTAGE	94/V2C
SA15-12	CHAN #2 UNDERFREQUENCY INITIATED	81X
SA16-1	EGTPS CHAN. #1 VOLTAGE RELAY COIL TROUBLE	74M
SA16-2	EGTPS CHAN.#1 FREQ. RELAY COIL TROUBLE	74M
SA16-3	EGTPS CHAN.#2 VOLTAGE RELAY COIL TROUBLE	74M
SA16-4	EGTPS CHAN.#2 FREQ. RELAY COIL TROUBLE	74M
SA16-5	CHAN. #1 SWYD ISOLATED TEST	Test Pushbuttons
SA16-6	CHAN. #2 SWYD ISOLATED TEST	Test Pushbuttons

Table A.3-5

EGTPS Reliability Data

Event Name	Description	Failure Rate[1]	Factor	Failure Probability
L0EGTPSCOM	Common Cause Failure of UV And UF Detection Circuits			1.78E-06
L27BRX1RYD	Snsng Rly 27B/RX1 Fails to Drop Out on Undervoltage	3.30E-05	1 D	3.30E-05
L27BRX2RYD	Snsng Rly 27B/RX2 Fails to Drop Out on Undervoltage	3.30E-05	1 D	3.30E-05
L27BRY1RYD	Snsng Rly 27B/RY1 Fails to Drop Out on Undervoltage	3.30E-05	1 D	3.30E-05
L27BRY2RYD	Snsng Rly 27B/RY2 Fails to Drop Out on Undervoltage	3.30E-05	1 D	3.30E-05
L27BRZ1RYD	Snsng Rly 27B/RZ1 Fails to Drop Out on Undervoltage	3.30E-05	1 D	3.30E-05
L27BRZ2RYD	Snsng Rly 27B/RZ2 Fails to Drop Out on Undervoltage	3.30E-05	1 D	3.30E-05
L27BYX1RYD	Snsng Rly 27B/YX1 Fails to Drop Out on Undervoltage	3.30E-05	1 D	3.30E-05
L27BYX2RYD	Snsng Rly 27B/YX2 Fails to Drop Out on Undervoltage	3.30E-05	1 D	3.30E-05
L27BYY1RYD	Snsng Rly 27B/YY1 Fails to Drop Out on Undervoltage	3.30E-05	1 D	3.30E-05
L27BYY2RYD	Snsng Rly 27B/YY2 Fails to Drop Out on Undervoltage	3.30E-05	1 D	3.30E-05
L27BYZ1RYD	Snsng Rly 27B/YZ1 Fails to Drop Out on Undervoltage	3.30E-05	1 D	3.30E-05
L27BYZ2RYD	Snsng Rly 27B/YZ2 Fails to Drop Out on Undervoltage	3.30E-05	1 D	3.30E-05
L27XPX1RYD	Ch 1 Phase X UV Aux. Relay Fails To Pick Up	3.30E-05	1 D	3.30E-05
L27XPX2RYD	Ch 2 Phase X UV Aux. Relay Fails To Pick Up	3.30E-05	1 D	3.30E-05
L27XPY1RYD	Ch 1 Phase Y UV Aux. Relay Fails to Pick Up	3.30E-05	1 D	3.30E-05
L27XPY2RYD	Ch 2 Phase Y UV Aux. Relay Fails to Pick Up	3.30E-05	1 D	3.30E-05
L27XPZ1RYD	Ch 1 Phase Z UV Aux. Relay Fails To Pick Up	3.30E-05	1 D	3.30E-05
L27XPZ2RYD	Ch 2 Phase Z UV Aux. Relay Fails To Pick Up	3.30E-05	1 D	3.30E-05
L27XRX1RYD	Red Bus Phase X1 UV Aux. Relay Fails To Pick Up	3.30E-05	1 D	3.30E-05
L27XRX2RYD	Red Bus Phase X2 UV Aux. Relay Fails To Pick Up	3.30E-05	1 D	3.30E-05
L27XRY1RYD	Red Bus Phase Y1 UV Aux. Relay Fails To Pick Up	3.30E-05	1 D	3.30E-05
L27XRY2RYD	Red Bus Phase Y2 UV Aux. Relay Fails To Pick Up	3.30E-05	1 D	3.30E-05
L27XRZ1RYD	Red Bus Phase Z1 UV Aux. Relay Fails To Pick Up	3.30E-05	1 D	3.30E-05
L27XRZ2RYD	Red Bus Phase Z2 UV Aux. Relay Fails To Pick Up	3.30E-05	1 D	3.30E-05
L27XSTARYD	Ch 1 EGTPS Trouble Relay 27X/STA Fails To Pick Up	3.30E-05	1 D	3.30E-05
L27XSTBRYD	Ch 2 EGTPS Trouble Relay 27X/STB Fails To Pick Up	3.30E-05	1 D	3.30E-05
L27XYX1RYD	Yellow Bus Phase X1 UV Aux. Relay Fails To Pick Up	3.30E-05	1 D	3.30E-05
L27XYX2RYD	Yellow Bus Phase X2 UV Aux. Relay Fails To Pick Up	3.30E-05	1 D	3.30E-05
L27XYY1RYD	Yellow Bus Phase Y1 UV Aux. Relay Fails To Pick Up	3.30E-05	1 D	3.30E-05
L27XYY2RYD	Yellow Bus Phase Y2 UV Aux. Relay Fails To Pick Up	3.30E-05	1 D	3.30E-05
L27XYZ1RYD	Yellow Bus Phase Z1 UV Aux. Relay Fails To Pick Up	3.30E-05	1 D	3.30E-05
L27XYZ2RYD	Yellow Bus Phase Z2 UV Aux. Relay Fails To Pick Up	3.30E-05	1 D	3.30E-05

Table A.3-5

EGTPS Reliability Data

Event Name	Description	Failure Rate[1]	Factor	Failure Probability
L81BRX1RYD	Sensing Rly 81BL/RX1 Fails To Drop Out On Underfreq.	3.30E-05	1 D	3.30E-05
L81BRX2RYD	Sensing Rly 81BL/RX2 Fails To Drop Out On Underfreq.	3.30E-05	1 D	3.30E-05
L81BRY1RYD	Sensing Rly 81BL/RY1 Fails To Drop Out On Underfreq.	3.30E-05	1 D	3.30E-05
L81BRY2RYD	Sensing Rly 81BL/RY2 Fails To Drop Out On Underfreq.	3.30E-05	1 D	3.30E-05
L81BRZ1RYD	Sensing Rly 81BL/RZ1 Fails To Drop Out On Underfreq.	3.30E-05	1 D	3.30E-05
L81BRZ2RYD	Sensing Rly 81BL/RZ2 Fails To Drop Out On Underfreq.	3.30E-05	1 D	3.30E-05
L81BYX1RYD	Sensing Rly 81BL/YX1 Fails To Drop Out On Underfreq.	3.30E-05	1 D	3.30E-05
L81BYX2RYD	Sensing Rly 81BL/YX2 Fails To Drop Out On Underfreq.	3.30E-05	1 D	3.30E-05
L81BYY1RYD	Sensing Rly 81BL/YY1 Fails To Drop Out On Underfreq.	3.30E-05	1 D	3.30E-05
L81BYY2RYD	Sensing Rly 81BL/YY2 Fails To Drop Out On Underfreq.	3.30E-05	1 D	3.30E-05
L81BYZ1RYD	Sensing Rly 81BL/YZ1 Fails To Drop Out On Underfreq.	3.30E-05	1 D	3.30E-05
L81BYZ2RYD	Sensing Rly 81BL/YZ2 Fails To Drop Out On Underfreq.	3.30E-05	1 D	3.30E-05
L81XPX1RYD	Ch 1 Phase X Underfreq. Aux. Relay Fails To Pick Up	3.30E-05	1 D	3.30E-05
L81XPX2RYD	Ch 2 Phase X Underfreq. Aux. Relay Fails To Pick Up	3.30E-05	1 D	3.30E-05
L81XPY1RYD	Ch 1 Phase Y Underfreq. Aux. Relay Fails To Pick Up	3.30E-05	1 D	3.30E-05
L81XPY2RYD	Ch 2 Phase Y Underfreq. Aux. Relay Fails To Pick Up	3.30E-05	1 D	3.30E-05
L81XPZ1RYD	Ch 1 Phase Z Underfreq. Aux. Relay Fails To Pick Up	3.30E-05	1 D	3.30E-05
L81XPZ2RYD	Ch 2 Phase Z Underfreq. Aux. Relay Fails To Pick Up	3.30E-05	1 D	3.30E-05
L81XRX1RYD	Red Bus Phase X1 Underfreq. Aux. Rly Fails To Pick Up	3.30E-05	1 D	3.30E-05
L81XRX2RYD	Red Bus Phase X2 Underfreq. Aux. Rly Fails To Pick Up	3.30E-05	1 D	3.30E-05
L81XRY1RYD	Red Bus Phase Y1 Underfreq. Aux. Rly Fails To Pick Up	3.30E-05	1 D	3.30E-05
L81XRY2RYD	Red Bus Phase Y2 Underfreq. Aux. Rly Fails To Pick Up	3.30E-05	1 D	3.30E-05
L81XRZ1RYD	Red Bus Phase Z1 Underfreq. Aux. Rly Fails To Pick Up	3.30E-05	1 D	3.30E-05
L81XRZ2RYD	Red Bus Phase Z2 Underfreq. Aux. Rly Fails To Pick Up	3.30E-05	1 D	3.30E-05
L81XYX1RYD	Yellow Bus Phase X1 UF Aux. Rly Fails To Pick Up	3.30E-05	1 D	3.30E-05
L81XYX2RYD	Yellow Bus Phase X2 UF Aux. Rly Fails To Pick Up	3.30E-05	1 D	3.30E-05
L81XYY1RYD	Yellow Bus Phase Y1 UF Aux. Rly Fails To Pick Up	3.30E-05	1 D	3.30E-05
L81XYY2RYD	Yellow Bus Phase Y2 UF Aux. Rly Fails To Pick Up	3.30E-05	1 D	3.30E-05
L81XYZ1RYD	Yellow Bus Phase Z1 UF Aux. Rly Fails To Pick Up	3.30E-05	1 D	3.30E-05
L81XYZ2RYD	Yellow Bus Phase Z2 UF Aux. Rly Fails To Pick Up	3.30E-05	1 D	3.30E-05
LC94F1ARYD	EGTPS Underfrequency Relay 94/F1A Fails To Pick Up	3.30E-05	1 D	3.30E-05
LC94F1BRYD	EGTPS Underfrequency Relay 94/F1B Fails To Pick Up	3.30E-05	1 D	3.30E-05

Table A.3-5

EGTPS Reliability Data

Event Name	Description	Failure Rate[1]	Factor	Failure Probability
LC94F1DRYD	EGTPS Underfrequency Relay 94/F1D Fails To Pick Up	3.30E-05	1 D	3.30E-05
LC94F2ARYD	EGTPS Underfrequency Relay 94/F2A Fails To Pick Up	3.30E-05	1 D	3.30E-05
LC94F2BRYD	EGTPS Underfrequency Relay 94/F2B Fails To Pick Up	3.30E-05	1 D	3.30E-05
LC94F2CRYD	EGTPS Underfrequency Relay 94/F2C Fails To Pick Up	3.30E-05	1 D	3.30E-05
LC94F2DRYD	EGTPS Underfrequency Relay 94/F2D Fails To Pick Up	3.30E-05	1 D	3.30E-05
LC94V1ARYD	EGTPS Undervoltage Relay 94/V1A Fails To Pick Up	3.30E-05	1 D	3.30E-05
LC94V1BRYD	EGTPS Undervoltage Relay 94/V1B Fails To Pick Up	3.30E-05	1 D	3.30E-05
LC94V1DRYD	EGTPS Undervoltage Relay 94/V1D Fails To Pick Up	3.30E-05	1 D	3.30E-05
LC94V2ARYD	EGTPS Undervoltage Relay 94/V2A Fails To Pick Up	3.30E-05	1 D	3.30E-05
LC94V2BRYD	EGTPS Undervoltage Relay 94/V2B Fails To Pick Up	3.30E-05	1 D	3.30E-05
LC94V2CRYD	EGTPS Undervoltage Relay 94/V2C Fails To Pick Up	3.30E-05	1 D	3.30E-05
LDCYC13CDT	Switchyard 125 Vdc Panelboard DYC Bkr 13 Xfrs Open	7.50E-08	24 H	1.80E-06
LDCYC14CDT	Switchyard 125 Vdc Panelboard DYC Bkr 14 Xfrs Open	7.50E-08	24 H	1.80E-06
LDCYG12CDT	Switchyard 125 Vdc Panelboard DYG Bkr 12 Xfrs Open	7.50E-08	24 H	1.80E-06
LDCYG18CDT	Switchyard 125 Vdc Panelboard DYG Bkr 18 Xfrs Open	7.50E-08	24 H	1.80E-06

[1] D = Demand, H=Hour

[2] Rules for assigning basic event factors are discussed in Table C.1-4.

Table A.3-6

EGTPS Dominant Minimal Cutsets

Cutsets For Gate SEG94F1AF: EGTPS Channel 1 Relay 94/F1A Signal Fails

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
1)	3.30E-05	90.0	LC94F1ARYD	3.30E-05	EGTPS Relay 94/F1A Fails to Pick Up
2)	1.80E-06	4.9	LDCYC14CDT	1.80E-06	Switchyard 125 Vdc Panelboard DYC Breaker 14 Transfers Open
3)	1.78E-06	4.9	L0EGTPSCOM	1.78E-06	Common Cause Failure of UV and UF Detection Circuits
Total:	3.66E-05				

Table A.3-6

EGTPS Dominant Minimal Cutsets

Cutsets For Gate SEG94F1DF: EGTPS Channel 1 Relay 94/F1D Signal Fails

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
1)	3.30E-05	90.0	LC94F1DRYD	3.30E-05	EGTPS Relay 94/F1D Fails to Pick Up
2)	1.80E-06	4.9	LDCYC14CDT	1.80E-06	Switchyard 125 Vdc Panelboard DYC Breaker 14 Transfers Open
3)	1.78E-06	4.9	L0EGTPSCOM	1.78E-06	Common Cause Failure of UV and UF Detection Circuits
Total:	3.66E-05				

Table A.3-6

EGTPS Dominant Minimal Cutsets

Cutsets For Gate SEG94F2AF: EGTPS Channel 2 Relay 94/F2A Signal Fails

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
1)	3.30E-05	90.0	LC94F2ARYD	3.30E-05	EGTPS Relay 94/F2A Fails to Pick Up
2)	1.80E-06	4.9	LDCYG18CDT	1.80E-06	Switchyard 125 Vdc Panelboard DYG Breaker 18 Transfers Open
3)	1.78E-06	4.9	L0EGTPSCOM	1.78E-06	Common Cause Failure of UV and UF Detection Circuits
Total:	3.66E-05				

Table A.3-6

EGTPS Dominant Minimal Cutsets

Cutsets For Gate SEG94F2CF: EGTPS Channel 2 Relay 94/F2C Signal Fails

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
1)	3.30E-05	90.0	LC94F2CRYD	3.30E-05	EGTPS Relay 94/F2C Fails to Pick Up
2)	1.80E-06	4.9	LDCYG18CDT	1.80E-06	Switchyard 125 Vdc Panelboard DYG Breaker 18 Transfers Open
3)	1.78E-06	4.9	L0EGTPSCOM	1.78E-06	Common Cause Failure of UV and UF Detection Circuits
Total:	3.66E-05				

Table A.3-6

EGTPS Dominant Minimal Cutsets

Cutsets For Gate SEG94F2DF: EGTPS Channel 2 Relay 94/F2D Signal Fails

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
1)	3.30E-05	90.0	LC94F2DRYD	3.30E-05	EGTPS Relay 94/F2D Fails to Pick Up
2)	1.80E-06	4.9	LDCYG18CDT	1.80E-06	Switchyard 125 Vdc Panelboard DYG Breaker 18 Transfers Open
3)	1.78E-06	4.9	L0EGTPSCOM	1.78E-06	Common Cause Failure of UV and UF Detection Circuits
Total:	3.66E-05				

Table A.3-6

EGTPS Dominant Minimal Cutsets

Cutsets For Gate SEG94V1AF: EGTPS Channel 1 Relay 94/V1A Signal Fails

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
1)	3.30E-05	90.0	LC94V1ARYD	3.30E-05	EGTPS Relay 94/V1A Fails to Pick Up
2)	1.80E-06	4.9	LDCYC13CDT	1.80E-06	Switchyard 125 Vdc Panelboard DYC Breaker 13 Transfers Open
3)	1.78E-06	4.9	L0EGTPSCOM	1.78E-06	Common Cause Failure of UV and UF Detection Circuits
Total:	3.66E-05				

Table A.3-6

EGTPS Dominant Minimal Cutsets

Cutsets For Gate SEG94V1DF: EGTPS Channel 1 Relay 94/V1D Signal Fails

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
1)	3.30E-05	90.0	LC94V1DRYD	3.30E-05	EGTPS Relay 94/V1D Fails to Pick Up
2)	1.80E-06	4.9	LDCYC13CDT	1.80E-06	Switchyard 125 Vdc Panelboard DYC Breaker 13 Transfers Open
3)	1.78E-06	4.9	L0EGTPSCOM	1.78E-06	Common Cause Failure of UV and UF Detection Circuits
Total:	3.66E-05				

Table A.3-6

EGTPS Dominant Minimal Cutsets

Cutsets For Gate SEG94V2AF: EGTPS Channel 2 Relay 94/V2A Signal Fails

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
1).	3.30E-05	90.0	LC94V2ARYD	3.30E-05	EGTPS Relay 94/V2A Fails to Pick Up
2)	1.80E-06	4.9	LDCYG12CDT	1.80E-06	Switchyard 125 Vdc Panelboard DYG Breaker 12 Transfers Open
3)	1.78E-06	4.9	L0EGTPSCOM	1.78E-06	Common Cause Failure of UV and UF Detection Circuits
Total:	3.66E-05				

Table A.3-6

EGTPS Dominant Minimal Cutsets

Cutsets For Gate SEG94V2CF: EGTPS Channel 2 Relay 94/V2C Signal Fails

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
1)	3.30E-05	90.0	LC94V2CRYD	3.30E-05	EGTPS Relay 94/V2C Fails to Pick Up
2)	1.80E-06	4.9	LDCYG12CDT	1.80E-06	Switchyard 125 Vdc Panelboard DYG Breaker 12 Transfers Open
3)	1.78E-06	4.9	L0EGTPSCOM	1.78E-06	Common Cause Failure of UV and UF Detection Circuits
Total:	3.66E-05				

Table A.3-6

EGTPS Dominant Minimal Cutsets

Cutsets For Gate SEG94V2DF: EGTPS Channel 2 Relay 94/V2D Signal Fails

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
1)	3.30E-05	90.0	LC94V2DRYD	3.30E-05	EGTPS Relay 94/V2D Fails to Pick Up
2)	1.80E-06	4.9	LDCYG12CDT	1.80E-06	Switchyard 125 Vdc Panelboard DYG Breaker 12 Transfers Open
3)	1.78E-06	4.9	L0EGTPSCOM	1.78E-06	Common Cause Failure of UV and UF Detection Circuits
Total:	3.66E-05				

Table A.3-6

EGTPS Dominant Minimal Cutsets

Cutsets For Gate SEGTPSCH1F: EGTPS Channel 1 Keowee Start Signal Fails

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
1)	3.30E-05	94.8	L27XSTARYD	3.30E-05	Ch 1 EGTPS Trouble Relay 27X/STA Fails to Pick Up
2)	1.78E-06	5.1	L0EGTPSCOM	1.78E-06	Common Cause Failure of UV and UF Detection Circuits
Total:	3.48E-05				

Table A.3-6

EGTPS Dominant Minimal Cutsets

Cutsets For Gate SEGTPSCH2F: EGTPS Channel 2 Keowee Start Signal Fails

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
1)	3.30E-05	94.8	L27XSTBRYD	3.30E-05	Ch 2 EGTPS Trouble Relay 27X/STB Fails to Pick Up
2)	1.78E-06	5.1	L0EGTPSCOM	1.78E-06	Common Cause Failure of UV and UF Detection Circuits
Total:	3.48E-05				

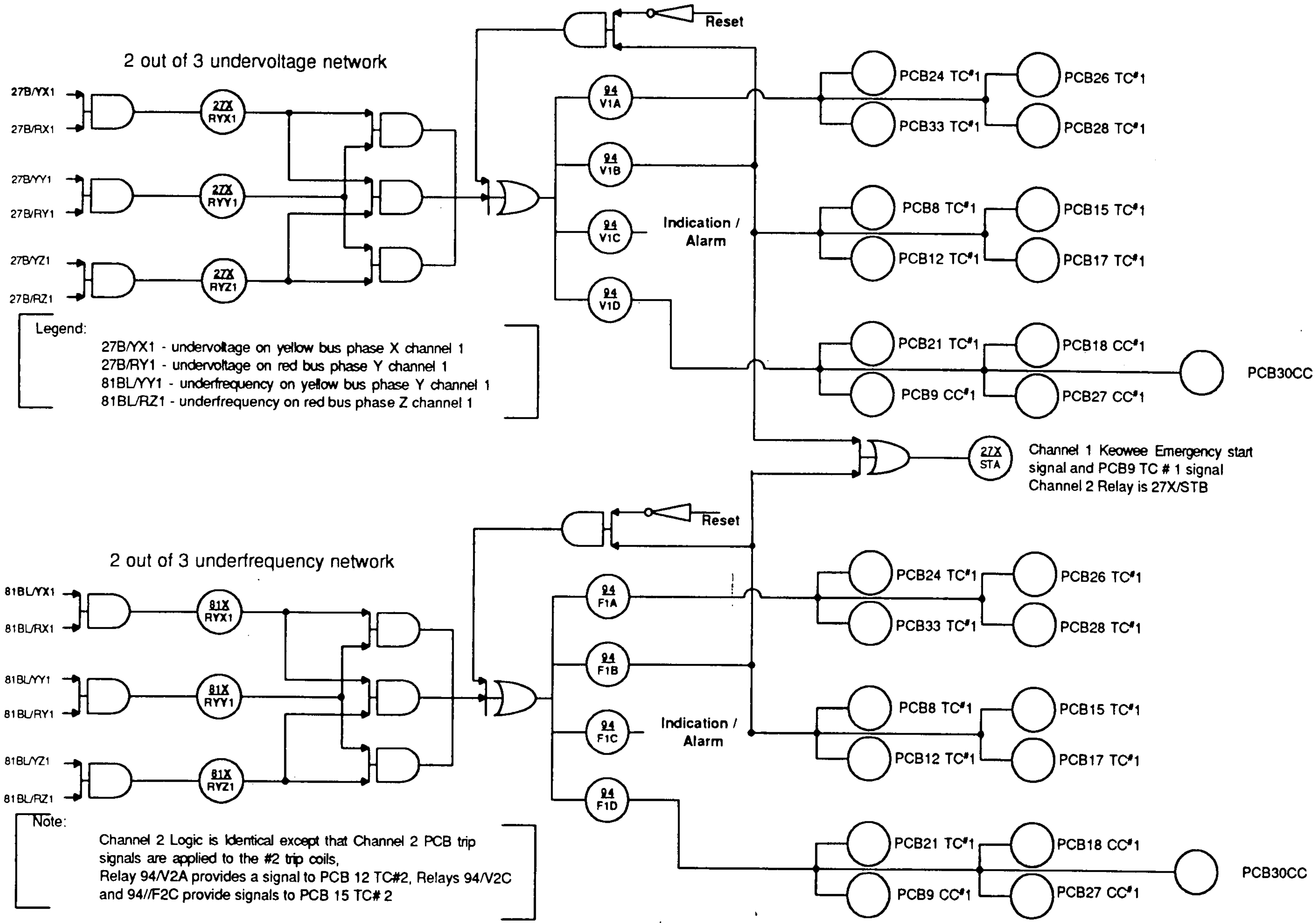
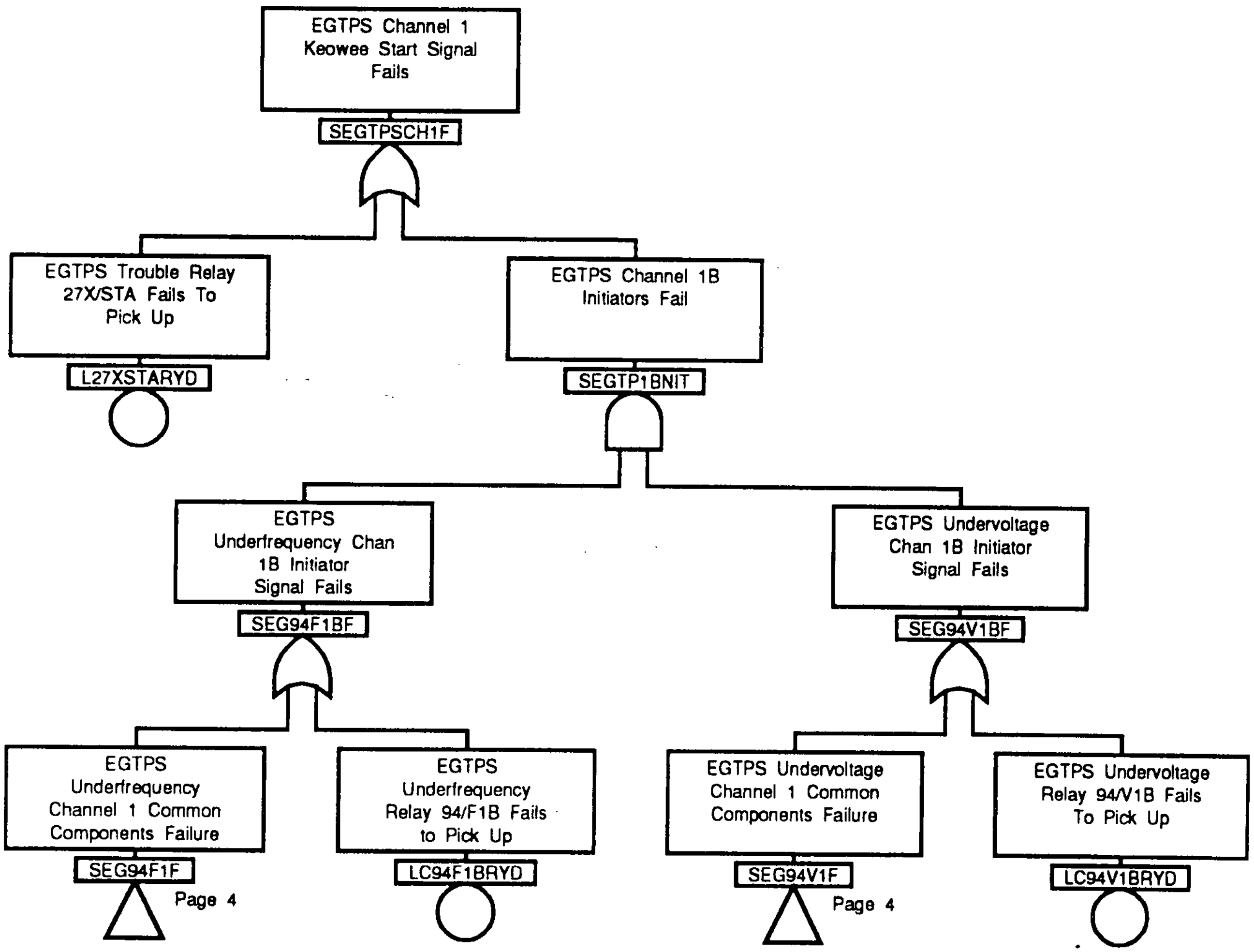
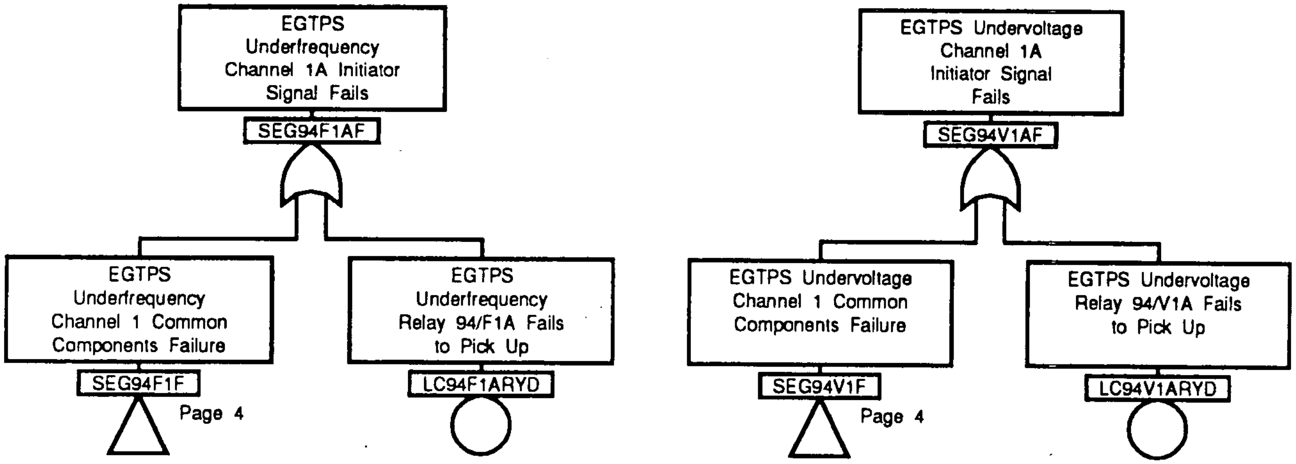


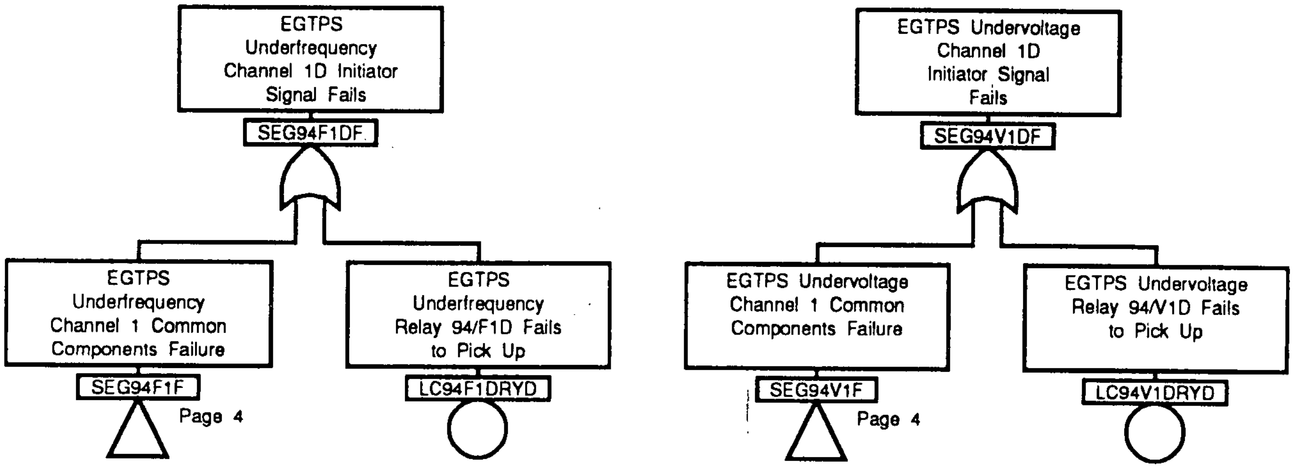
Figure A.3-1 Logic Diagram External Grid Trouble Protection System Channel 1

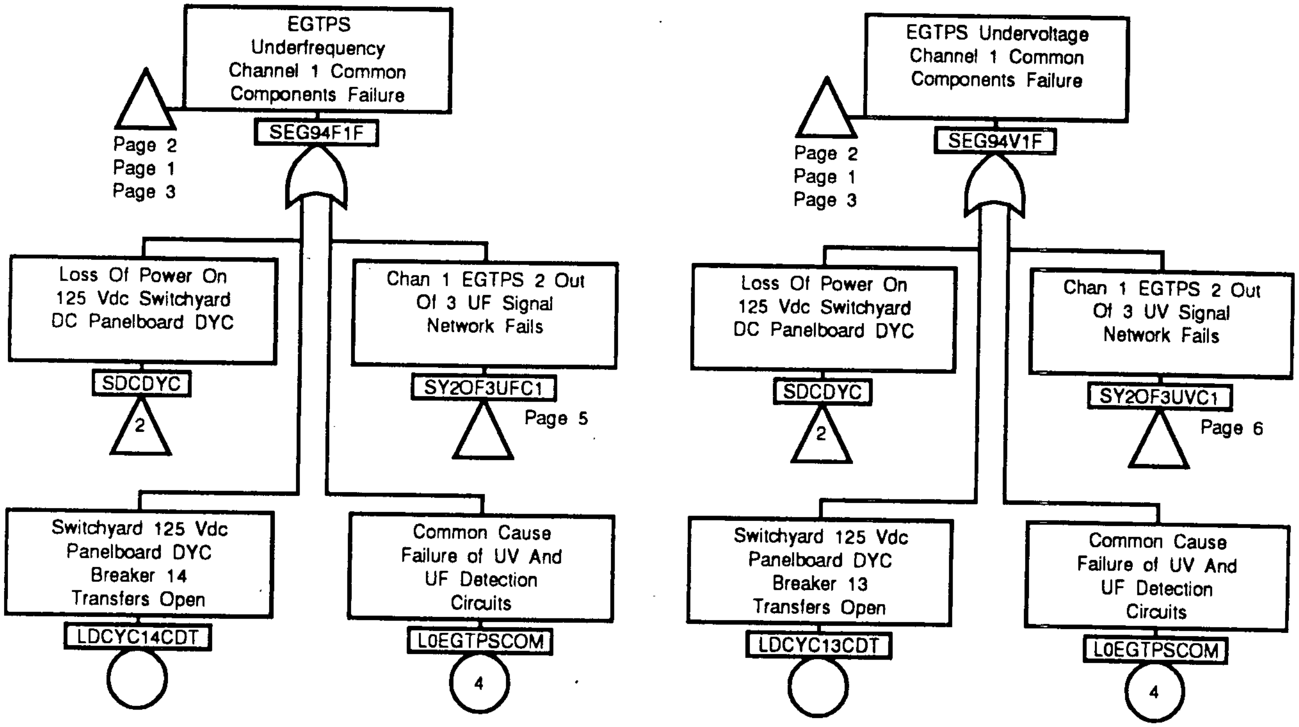


External Grid Trouble Protection System | FIGURE A.3-2 | Page 1

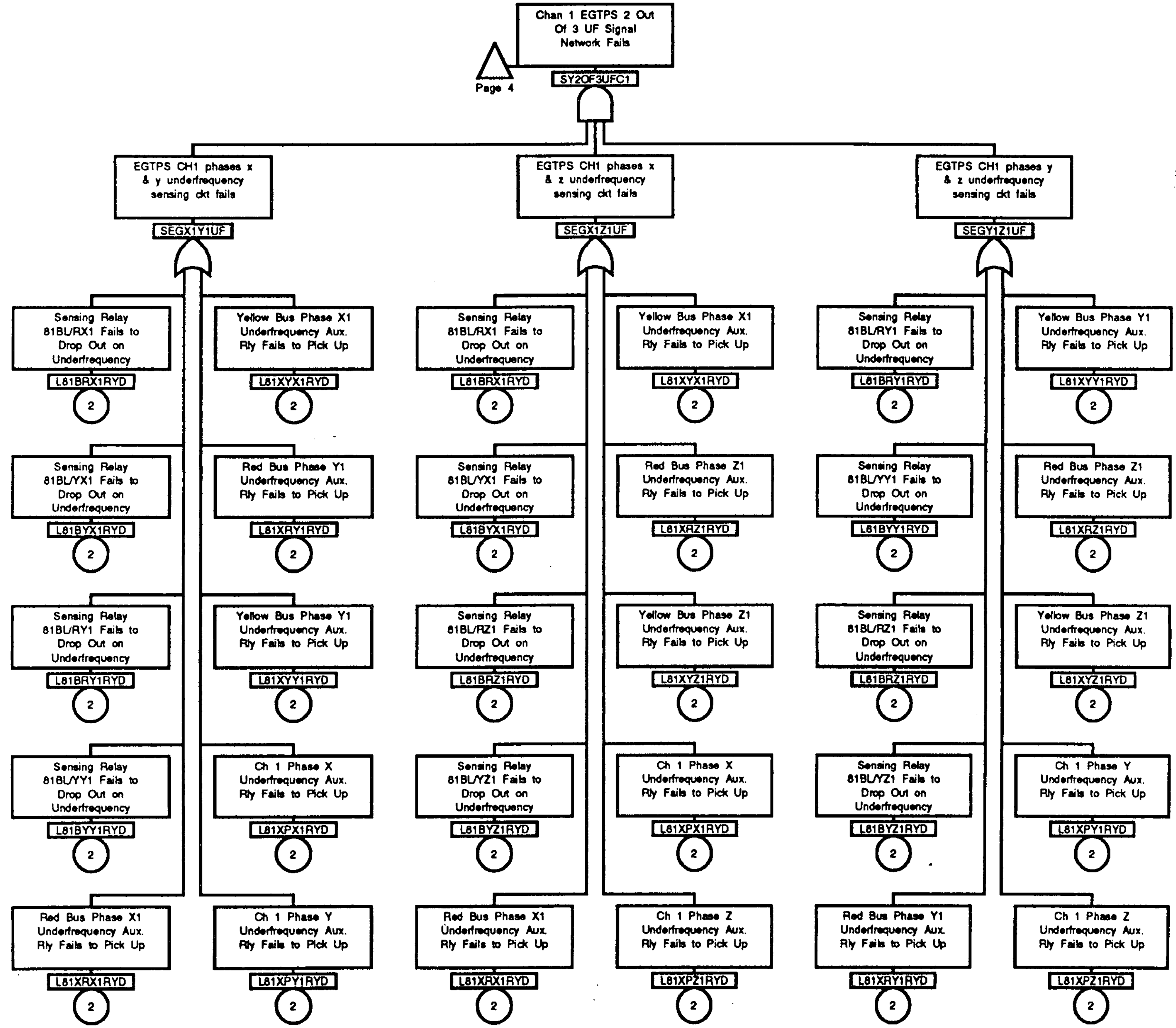


External Grid Trouble Protection System | FIGURE A.3-2 |

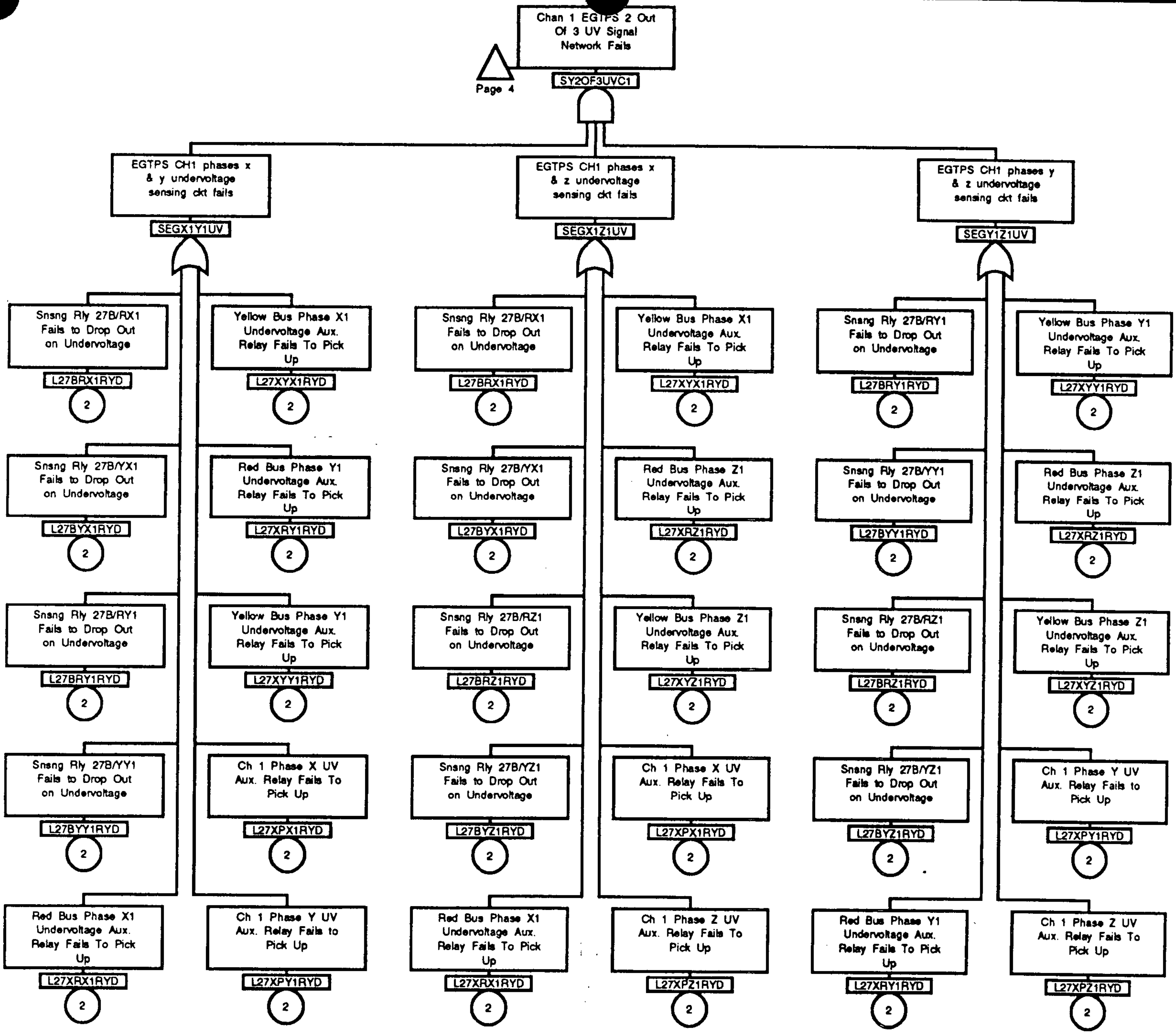

EGTPS Underfrequency Channel 1D Initiator Signal Fails
SEG94F1DF
EGTPS Underfrequency Channel 1 Common Components Failure
SEG94F1F
Page 4
EGTPS Underfrequency Relay 94/F1D Fails to Pick Up
LC94F1DRYD
EGTPS Undervoltage Channel 1D Initiator Signal Fails
SEG94V1DF
EGTPS Undervoltage Channel 1 Common Components Failure
SEG94V1F
Page 4
EGTPS Undervoltage Relay 94/V1D Fails to Pick Up
LC94V1DRYD



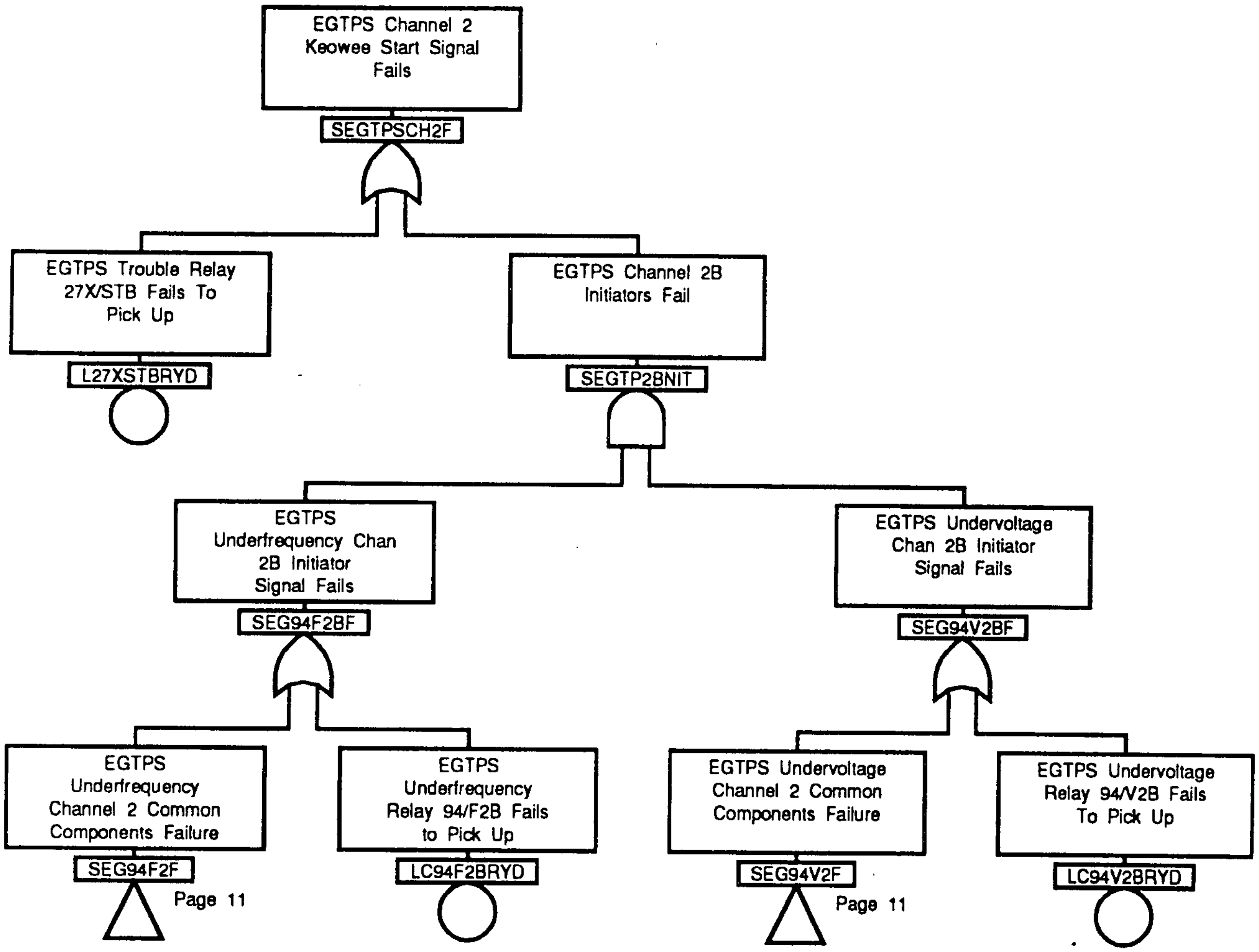
EGTPS Underfrequency Channel 1 Common Components Failure
SEG94F1F
Page 2
Page 1
Page 3
Loss Of Power On 125 Vdc Switchyard DC Panelboard DYC
SDCDYC
2
Chan 1 EGTPS 2 Out Of 3 UF Signal Network Fails
SY2OF3UFC1
Page 5
Switchyard 125 Vdc Panelboard DYC Breaker 14 Transfers Open
LDCYC14CDT
Common Cause Failure of UV And UF Detection Circuits
L0EGTPSCOM
4
EGTPS Undervoltage Channel 1 Common Components Failure
SEG94V1F
Page 2
Page 1
Page 3
Loss Of Power On 125 Vdc Switchyard DC Panelboard DYC
SDCDYC
2
Chan 1 EGTPS 2 Out Of 3 UV Signal Network Fails
SY2OF3UVC1
Page 6
Switchyard 125 Vdc Panelboard DYC Breaker 13 Transfers Open
LDCYC13CDT
Common Cause Failure of UV And UF Detection Circuits
L0EGTPSCOM
4



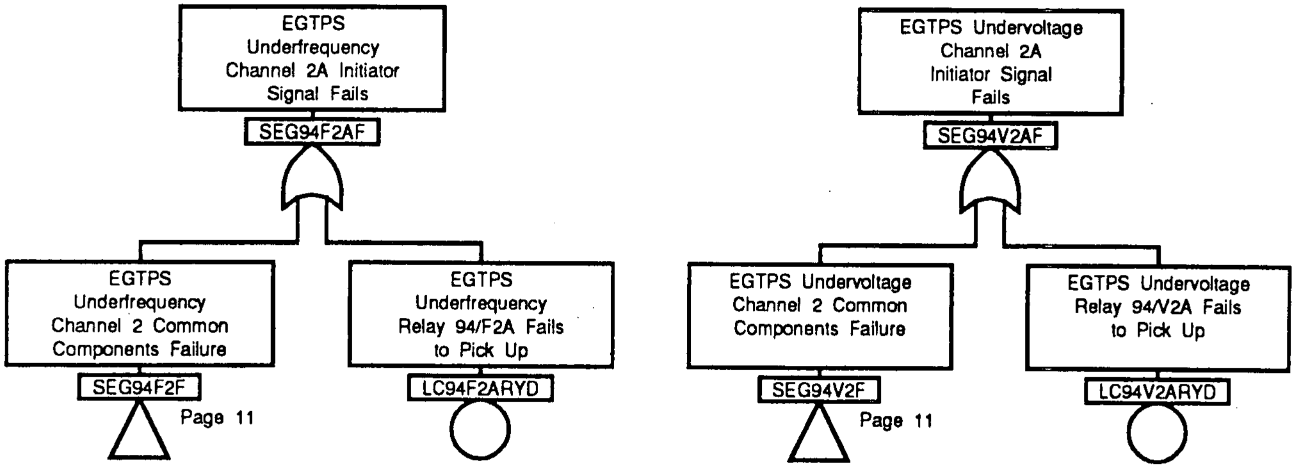
Chan 1 EGTPS 2 Out Of 3 UF Signal Network Fails
Page 4
SY2OF3UFC1
EGTPS CH1 phases x & y underfrequency sensing ckt fails
SEGX1Y1UF
EGTPS CH1 phases x & z underfrequency sensing ckt fails
SEGX1Z1UF
EGTPS CH1 phases y & z underfrequency sensing ckt fails
SEGY1Z1UF
Sensing Relay 81BL/RX1 Fails to Drop Out on Underfrequency
L81BRX1RYD
Yellow Bus Phase X1 Underfrequency Aux. Rly Fails to Pick Up
L81XYX1RYD
Sensing Relay 81BL/YX1 Fails to Drop Out on Underfrequency
L81BYX1RYD
Red Bus Phase Y1 Underfrequency Aux. Rly Fails to Pick Up
L81XRY1RYD
Sensing Relay 81BL/RY1 Fails to Drop Out on Underfrequency
L81BRY1RYD
Yellow Bus Phase Y1 Underfrequency Aux. Rly Fails to Pick Up
L81XYY1RYD
Sensing Relay 81BL/YY1 Fails to Drop Out on Underfrequency
L81BYY1RYD
Ch 1 Phase X Underfrequency Aux. Rly Fails to Pick Up
L81XPX1RYD
Red Bus Phase X1 Underfrequency Aux. Rly Fails to Pick Up
L81XRX1RYD
Ch 1 Phase Y Underfrequency Aux. Rly Fails to Pick Up
L81XPY1RYD
Red Bus Phase Z1 Underfrequency Aux. Rly Fails to Pick Up
L81XRZ1RYD
Sensing Relay 81BL/RZ1 Fails to Drop Out on Underfrequency
L81BRZ1RYD
Yellow Bus Phase Z1 Underfrequency Aux. Rly Fails to Pick Up
L81XYZ1RYD
Sensing Relay 81BL/YZ1 Fails to Drop Out on Underfrequency
L81BYZ1RYD
Ch 1 Phase Z Underfrequency Aux. Rly Fails to Pick Up
L81XPZ1RYD
Red Bus Phase Y1 Underfrequency Aux. Rly Fails to Pick Up
L81XRY1RYD
2

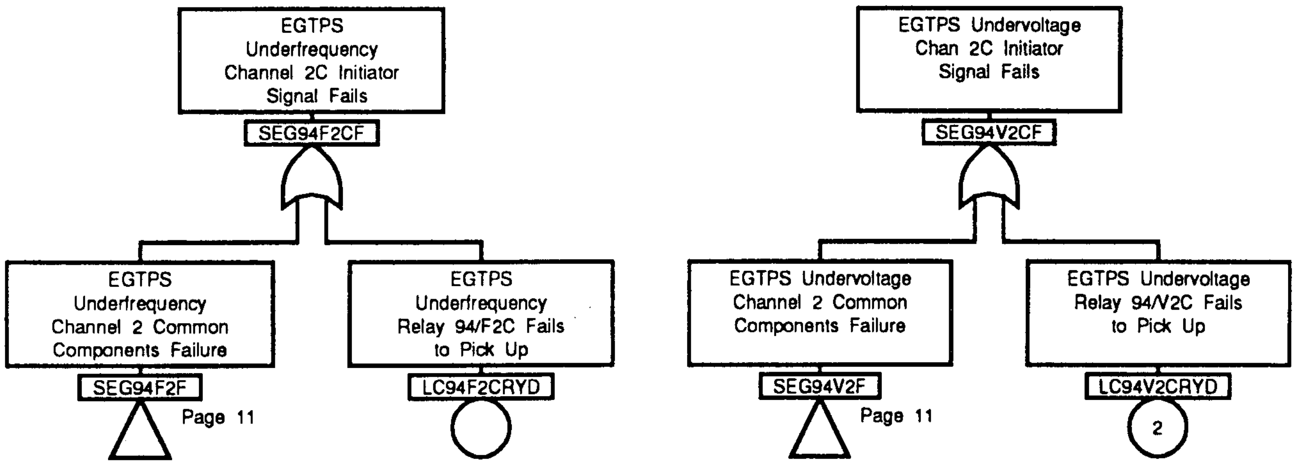


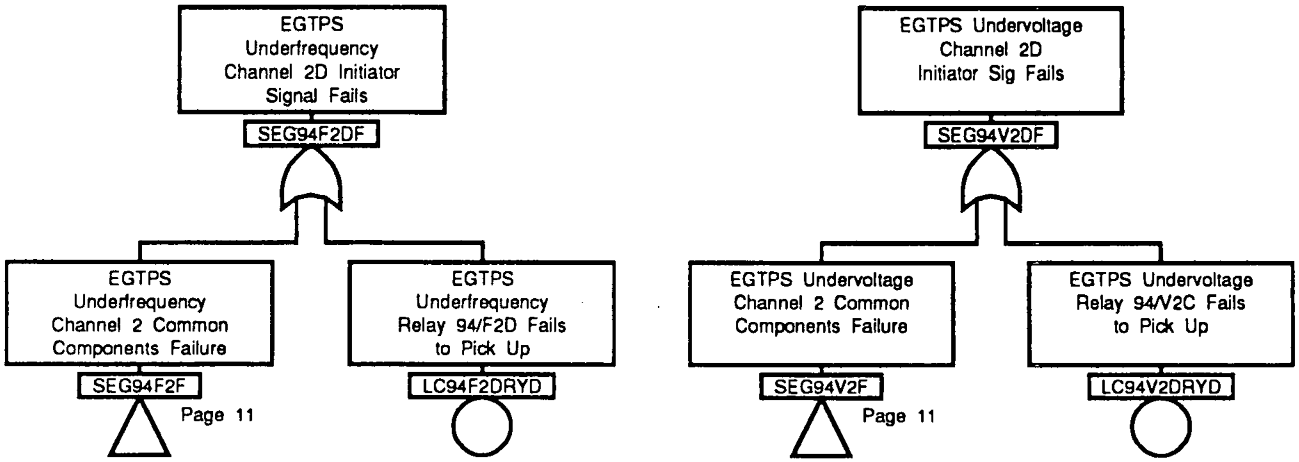
External Grid Trouble Protection System | FIGURE A.3-2 | Page 6

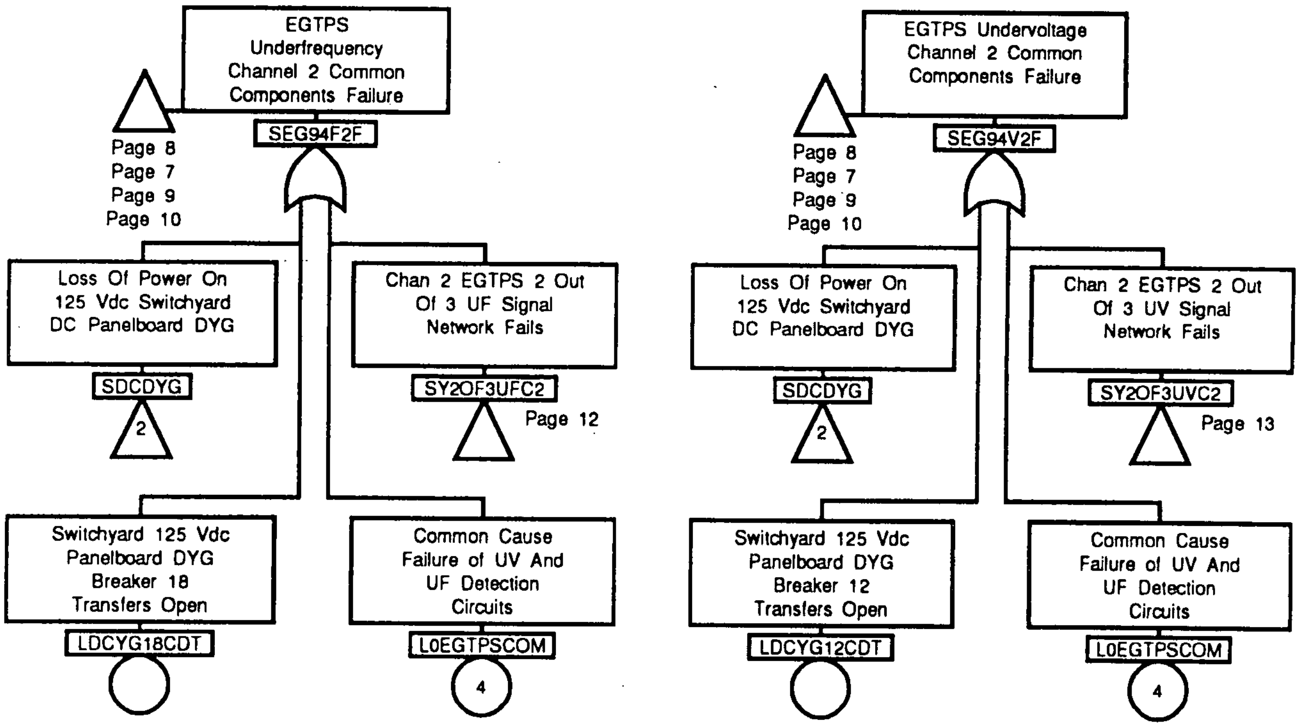


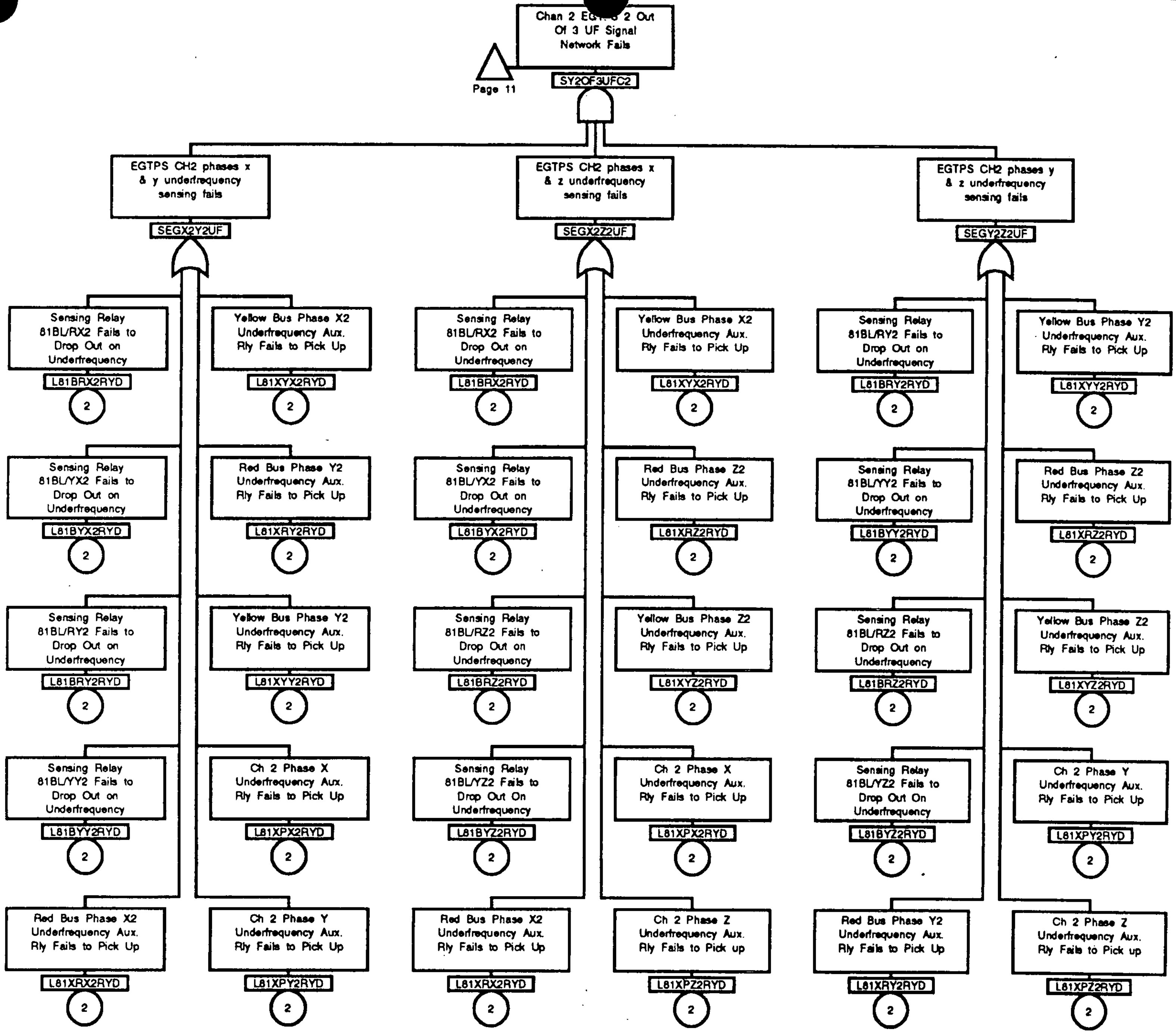
EGTPS Channel 2 Keowee Start Signal Fails
SEGTPSCH2F
EGTPS Trouble Relay 27X/STB Fails To Pick Up
L27XSTBRYD
EGTPS Channel 2B Initiators Fail
SEGTP2BNIT
EGTPS Underfrequency Chan 2B Initiator Signal Fails
SEG94F2BF
EGTPS Undervoltage Chan 2B Initiator Signal Fails
SEG94V2BF
EGTPS Underfrequency Channel 2 Common Components Failure
SEG94F2F
Page 11
EGTPS Underfrequency Relay 94/F2B Fails to Pick Up
LC94F2BRYD
EGTPS Undervoltage Channel 2 Common Components Failure
SEG94V2F
Page 11
EGTPS Undervoltage Relay 94/V2B Fails To Pick Up
LC94V2BRYD


EGTPS Underfrequency Channel 2A Initiator Signal Fails
SEG94F2AF
EGTPS Underfrequency Channel 2 Common Components Failure
SEG94F2F
Page 11
EGTPS Underfrequency Relay 94/F2A Fails to Pick Up
LC94F2ARYD
EGTPS Undervoltage Channel 2A Initiator Signal Fails
SEG94V2AF
EGTPS Undervoltage Channel 2 Common Components Failure
SEG94V2F
Page 11
EGTPS Undervoltage Relay 94/V2A Fails to Pick Up
LC94V2ARYD

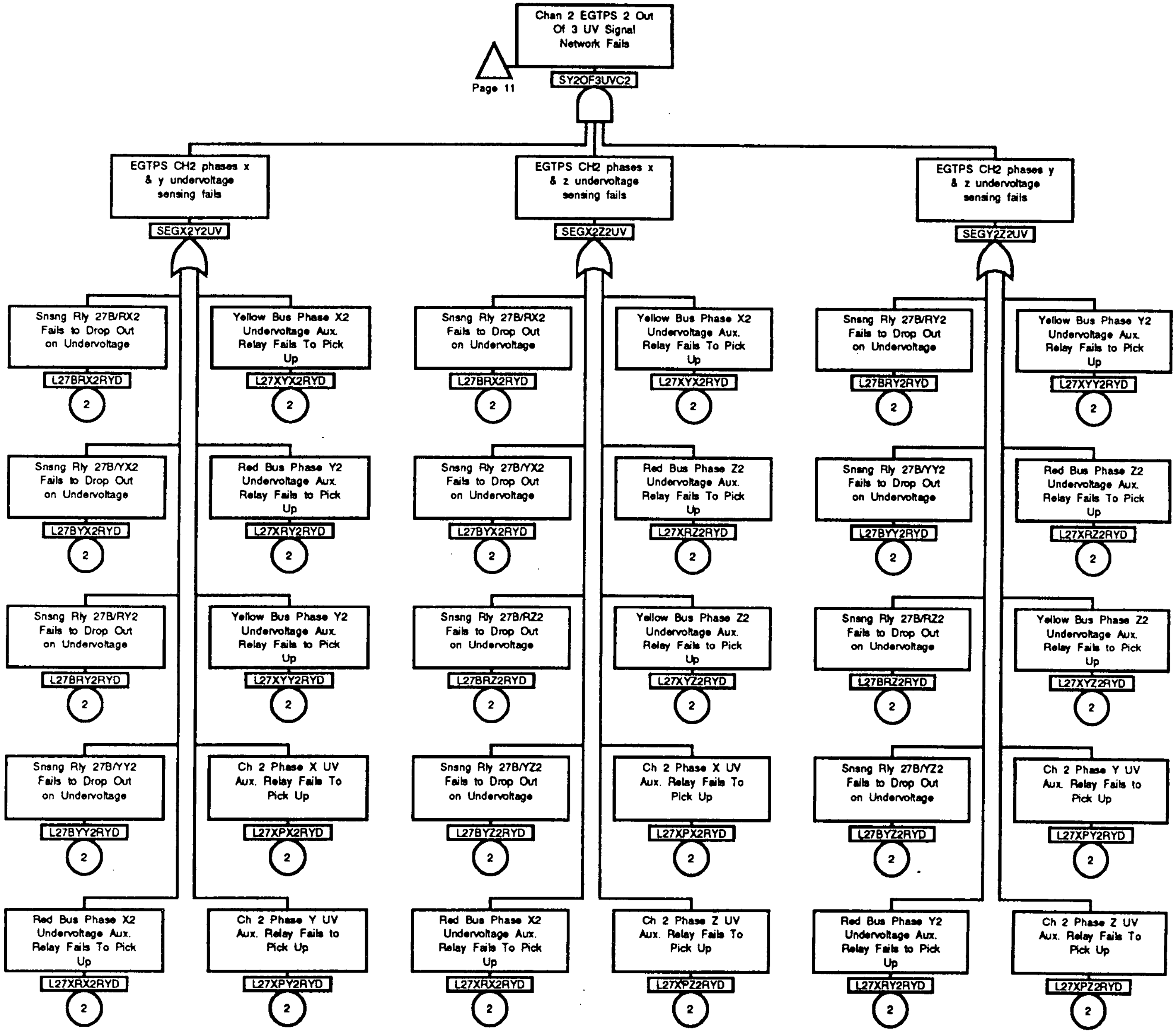

EGTPS
Underfrequency
Channel 2C Initiator
Signal Fails
SEG94F2CF
EGTPS
Underfrequency
Channel 2 Common
Components Failure
SEG94F2F
Page 11
EGTPS
Underfrequency
Relay 94/F2C Fails
to Pick Up
LC94F2CRYD
EGTPS Undervoltage
Chan 2C Initiator
Signal Fails
SEG94V2CF
EGTPS Undervoltage
Channel 2 Common
Components Failure
SEG94V2F
Page 11
EGTPS Undervoltage
Relay 94/V2C Fails
to Pick Up
LC94V2CRYD
2


EGTPS Underfrequency Channel 2D Initiator Signal Fails
SEG94F2DF
EGTPS Underfrequency Channel 2 Common Components Failure
SEG94F2F
Page 11
EGTPS Underfrequency Relay 94/F2D Fails to Pick Up
LC94F2DRYD
EGTPS Undervoltage Channel 2D Initiator Sig Fails
SEG94V2DF
EGTPS Undervoltage Channel 2 Common Components Failure
SEG94V2F
Page 11
EGTPS Undervoltage Relay 94/V2C Fails to Pick Up
LC94V2DRYD


EGTPS
Underfrequency
Channel 2 Common
Components Failure
SEG94F2F
Page 8
Page 7
Page 9
Page 10
Loss Of Power On
125 Vdc Switchyard
DC Panelboard DYG
SDCDYG
2
Chan 2 EGTPS 2 Out
Of 3 UF Signal
Network Fails
SY2OF3UFC2
Page 12
Switchyard 125 Vdc
Panelboard DYG
Breaker 18
Transfers Open
LDCYG18CDT
Common Cause
Failure of UV And
UF Detection
Circuits
L0EGTPSCOM
4
EGTPS Undervoltage
Channel 2 Common
Components Failure
SEG94V2F
Page 8
Page 7
Page 9
Page 10
Loss Of Power On
125 Vdc Switchyard
DC Panelboard DYG
SDCDYG
2
Chan 2 EGTPS 2 Out
Of 3 UV Signal
Network Fails
SY2OF3UVC2
Page 13
Switchyard 125 Vdc
Panelboard DYG
Breaker 12
Transfers Open
LDCYG12CDT
Common Cause
Failure of UV And
UF Detection
Circuits
L0EGTPSCOM
4



External Grid Trouble Protection System | FIGURE A.3-2 | Page 12



External Grid Trouble Protection System | FIGURE A.3-2 | Page 13

Gate/Event Name	Page	Zone	Gate/Event Name	Page	Zone	Gate/Event Name	Page	Zone	Gate/Event Name	Page	Zone
L0EGTPSCOM	4		L27XPZ2RYD	13		L81BRZ2RYD	12		L81XYX1RYD	5	
L0EGTPSCOM	4		L27XPZ2RYD	13		L81BRZ2RYD	12		L81XYX1RYD	5	
L0EGTPSCOM	11		L27XRX1RYD	6		L81BYX1RYD	5		L81XYX2RYD	12	
L0EGTPSCOM	11		L27XRX1RYD	6		L81BYX1RYD	5		L81XYX2RYD	12	
L27BRX1RYD	6		L27XRX2RYD	13		L81BYX2RYD	12		L81XYY1RYD	5	
L27BRX1RYD	6		L27XRX2RYD	13		L81BYX2RYD	12		L81XYY1RYD	5	
L27BRX2RYD	13		L27XRY1RYD	6		L81BYY1RYD	5		L81XYY2RYD	12	
L27BRX2RYD	13		L27XRY1RYD	6		L81BYY1RYD	5		L81XYY2RYD	12	
L27BRY1RYD	6		L27XRY2RYD	13		L81BYY2RYD	12		L81XYZ1RYD	5	
L27BRY1RYD	6		L27XRY2RYD	13		L81BYY2RYD	12		L81XYZ1RYD	5	
L27BRY2RYD	13		L27XRZ1RYD	6		L81BYZ1RYD	5		L81XYZ2RYD	12	
L27BRY2RYD	13		L27XRZ1RYD	6		L81BYZ1RYD	5		L81XYZ2RYD	12	
L27BRZ1RYD	6		L27XRZ2RYD	13		L81BYZ2RYD	12		LC94F1ARYD	2	
L27BRZ1RYD	6		L27XRZ2RYD	13		L81BYZ2RYD	12		LC94F1BRYD	1	
L27BRZ2RYD	13		L27XSTARYD	1		L81XPX1RYD	5		LC94F1DRYD	3	
L27BRZ2RYD	13		L27XSTBRYD	7		L81XPX1RYD	5		LC94F2ARYD	8	
L27BYX1RYD	6		L27XYX1RYD	6		L81XPX2RYD	12		LC94F2BRYD	7	
L27BYX1RYD	6		L27XYX1RYD	6		L81XPX2RYD	12		LC94F2CRYD	9	
L27BYX2RYD	13		L27XYX2RYD	13		L81XPY1RYD	5		LC94F2DRYD	10	
L27BYX2RYD	13		L27XYX2RYD	13		L81XPY1RYD	5		LC94V1ARYD	2	
L27BYY1RYD	6		L27XYY1RYD	6		L81XPY2RYD	12		LC94V1BRYD	1	
L27BYY1RYD	6		L27XYY1RYD	6		L81XPY2RYD	12		LC94V1DRYD	3	
L27BYY2RYD	13		L27XYY2RYD	13		L81XPZ1RYD	5		LC94V2ARYD	8	
L27BYY2RYD	13		L27XYY2RYD	13		L81XPZ1RYD	5		LC94V2BRYD	7	
L27BYZ1RYD	6		L27XYZ1RYD	6		L81XPZ2RYD	12		LC94V2CRYD	9	
L27BYZ1RYD	6		L27XYZ1RYD	6		L81XPZ2RYD	12		LC94V2CRYD	10	
L27BYZ2RYD	13		L27XYZ2RYD	13		L81XRX1RYD	5		LDCYC13CDT	4	
L27BYZ2RYD	13		L27XYZ2RYD	13		L81XRX1RYD	5		LDCYC14CDT	4	
L27XPX1RYD	6		L81BRX1RYD	5		L81XRX2RYD	12		LDCYG12CDT	11	
L27XPX1RYD	6		L81BRX1RYD	5		L81XRX2RYD	12		LDCYG18CDT	11	
L27XPX2RYD	13		L81BRX2RYD	12		L81XRY1RYD	5		SDCDYC	4	
L27XPX2RYD	13		L81BRX2RYD	12		L81XRY1RYD	5		SDCDYC	4	
L27XPY1RYD	6		L81BRY1RYD	5		L81XRY2RYD	12		SDCDYG	11	
L27XPY1RYD	6		L81BRY1RYD	5		L81XRY2RYD	12		SDCDYG	11	
L27XPY2RYD	13		L81BRY2RYD	12		L81XRZ1RYD	5		SEG94F1AF	2	
L27XPY2RYD	13		L81BRY2RYD	12		L81XRZ1RYD	5		SEG94F1BF	1	
L27XPZ1RYD	6		L81BRZ1RYD	5		L81XRZ2RYD	12		SEG94F1DF	3	
L27XPZ1RYD	6		L81BRZ1RYD	5		L81XRZ2RYD	12		SEG94F1F	1	

Gate/Event Name	Page	Zone	Gate/Event Name	Page	Zone	Gate/Event Name	Page	Zone	Gate/Event Name	Page	Zone
SEG94F1F	2		SEGX2Z2UF	12							
SEG94F1F	3		SEGX2Z2UV	13							
SEG94F1F	4		SEGY1Z1UF	5							
SEG94F2AF	8		SEGY1Z1UV	6							
SEG94F2BF	7		SEGY2Z2UF	12							
SEG94F2CF	9		SEGY2Z2UV	13							
SEG94F2DF	10		SY2OF3UFC1	4							
SEG94F2F	7		SY2OF3UFC1	5							
SEG94F2F	8		SY2OF3UFC2	11							
SEG94F2F	9		SY2OF3UFC2	12							
SEG94F2F	10		SY2OF3UVC1	4							
SEG94F2F	11		SY2OF3UVC1	6							
SEG94V1AF	2		SY2OF3UVC2	11							
SEG94V1BF	1		SY2OF3UVC2	13							
SEG94V1DF	3										
SEG94V1F	1										
SEG94V1F	2										
SEG94V1F	3										
SEG94V1F	4										
SEG94V2AF	8										
SEG94V2BF	7										
SEG94V2CF	9										
SEG94V2DF	10										
SEG94V2F	7										
SEG94V2F	8										
SEG94V2F	9										
SEG94V2F	10										
SEG94V2F	11										
SEGTP1BNIT	1										
SEGTP2BNIT	7										
SEGTPSCH1F	1										
SEGTPSCH2F	7										
SEGX1Y1UF	5										
SEGX1Y1UV	6										
SEGX1Z1UF	5										
SEGX1Z1UV	6										
SEGX2Y2UF	12										
SEGX2Y2UV	13										

APPENDIX A.4
AIR CIRCUIT BREAKERS

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A.4 AIR CIRCUIT BREAKERS

A.4.1 OBJECTIVES

The main objective of this analysis is to develop a logic model of the Air Circuit Breakers (ACBs). This model is combined with the high-level model and remaining system models to form an integrated model for assessing the reliability of Keowee. Other objectives are to identify major contributors to component unreliability, significant potential human errors and common-cause failure modes.

The scope of this analysis is limited to ACB equipment required to support a Keowee emergency start and run under load following a loss of offsite power.

A.4.2 SYSTEM DESIGN

A.4.2.1 AIR CIRCUIT BREAKER 1

ACB-1 provides the electrical connection for Keowee Unit 1 to the Keowee main step-up transformer. This breaker must be closed for Keowee Unit 1 to provide power to the grid or to supply Oconee emergency power through the overhead path. Air is used both to provide motive force for opening and closing the breaker as well as the insulating medium for extinguishing the arc when opening the breaker. This breaker is rated for 15 kV and 4000 A.

ACB-1 contains an air accumulator normally charged to 150 psig. This accumulator stores enough air at the nominal operating pressure for three to four operations of the breaker. Typical pressure drops during operation are 25 psig during the opening operation and 2 psig during the closing operation.

ACB-1 is provided with disconnect switches on either side of the breaker that can be used to isolate the breaker at both ends from the 13.8 kV electrical bus.

A simplified elementary diagram for ACB-1 is included as Figure A.4-1.

A.4.2.2 AIR CIRCUIT BREAKER 2

ACB-2 provides the electrical connection for Keowee Unit 2 to the main step-up transformer. This breaker must be closed for Keowee Unit 2 to provide power to the grid or to supply Oconee emergency power through the overhead path. Air is used both to provide motive force for opening and closing the breaker as well as the insulating medium for extinguishing the arc when opening the breaker. This breaker is rated for 15 kV and 4000 A.

ACB-2 contains an air accumulator normally charged to 150 psig. This accumulator stores enough air at the nominal operating pressure for three to four operations of the breaker. Typical pressure drops during operation are 25 psig during the opening operation and 2 psig during the closing operation.

ACB-2 is provided with disconnect switches on either side of the breaker that can be used to isolate the breaker at both ends from the 13.8 kV electrical bus.

A simplified elementary diagram for ACB-2 is included as Figure A.4-2.

A.4.2.3 AIR CIRCUIT BREAKER 3

ACB-3 provides the electrical connection for Keowee Unit 1 to transformer CT4 at Oconee through the underground path. This breaker must be closed for Keowee Unit 1 to provide emergency power through the underground path. Air is used both to provide motive force for opening and closing the breaker as well as the insulating medium for extinguishing the arc when opening the breaker. This breaker is rated for 15 kV and 2000 A.

ACB-3 contains an air accumulator normally charged to 150 psig. This accumulator stores enough air at the nominal operating pressure for three to four operations of the breaker. Typical pressure drops during operation are 25 psig during the opening operation and 2 psig during the closing operation.

ACB-3 is provided with disconnect switches on either side of the breaker that can be used to isolate the breaker at both ends from the 13.8 kV electrical bus. A motor operated

disconnect switch is provided between ACB-3 and the Keowee Unit 1 generator for isolation purposes (this disconnect has been disabled).

A simplified elementary diagram for ACB-3 is included as Figure A.4-3.

A.4.2.4 AIR CIRCUIT BREAKER 4

ACB-4 provides the electrical connection for Keowee Unit 2 to transformer CT4 at Oconee through the underground path. This breaker must be closed for Keowee Unit 2 to provide emergency power through the underground path. Air is used both to provide motive force for opening and closing the breaker as well as the insulating medium for extinguishing the arc when opening the breaker. This breaker is rated for 15 kV and 2000 A.

ACB-4 contains an air accumulator normally charged to 150 psig. This accumulator stores enough air at the nominal operating pressure for three to four operations of the breaker. Typical pressure drops during operation are 25 psig during the opening operation and 2 psig during the closing operation.

ACB-4 is provided with disconnect switches on either side of the breaker that can be used to isolate the breaker at both ends from the 13.8 kV electrical bus. A motor operated disconnect switch is provided between ACB-4 and the Keowee Unit 2 generator for isolation purposes (this disconnect has been disabled).

A simplified elementary diagram for ACB-4 is included as Figure A.4-4.

A.4.2.5 AIR CIRCUIT BREAKER 5

ACB-5 provides the electrical connection for transformer 1X at Keowee to 600 V ac load center 1X. This breaker must be closed for load center 1X to receive power from the 13.8 kV bus through transformer 1X. Air is used as the insulating medium for extinguishing the arc when opening the breaker. Operation of the breaker is electromechanical, air pressure is not required for breaker operation.

A simplified elementary diagram for ACB-5 is included as Figure A.4-5.

A.4.2.6 AIR CIRCUIT BREAKER 6

ACB-6 provides the electrical connection for transformer 2X at Keowee to 600 V ac load center 2X. This breaker must be closed for load center 2X to receive power from the 13.8 kV bus through transformer 2X. Air is used as the insulating medium for extinguishing the arc when opening the breaker. Operation of the breaker is electromechanical, air pressure is not required for breaker operation.

A simplified elementary diagram for ACB-6 is included as Figure A.4-6.

A.4.2.7 AIR CIRCUIT BREAKER 7

ACB-7 provides the electrical connection for transformer CX at Keowee to 600 V ac load center 1X. This breaker must be closed for load center 1X to receive power from the 4160 V ac underground supply from Oconee Unit 1, switchgear 1TC-4, through transformer CX. Air is used as the insulating medium for extinguishing the arc when opening the breaker. Operation of the breaker is electromechanical, air pressure is not required for breaker operation.

A simplified elementary diagram for ACB-7 is included as Figure A.4-7.

A.4.2.8 AIR CIRCUIT BREAKER 8

ACB-8 provides the electrical connection for transformer CX at Keowee to 600 V ac load center 2X. This breaker must be closed for load center 2X to receive power from the 4160 V ac underground supply from Oconee Unit 1, switchgear 1TC-4, through transformer CX. Air is used as the insulating medium for extinguishing the arc when opening the breaker. Operation of the breaker is electromechanical, air pressure is not required for breaker operation.

A simplified elementary diagram for ACB-8 is included as Figure A.4-8.

A.4.3 SYSTEM BOUNDARIES

Air Systems

ACBs 1, 2, 3, and 4 receive air from the Generator ACB Air System. A check valve located at the ACB provides isolation on loss of the air supply. Leakage of air on loss of the supply is limited to 5 psi/hr, however, the nominal rate is 2 to 3 psi/hr. The Generator ACB Air System is required for long term operability of ACBs 1 through 4.

Electrical Power Supplies

Control power is furnished from 125 V dc distribution centers 1DA (ACBs 1, 3, 5, and 7) and 2DA (ACBs 2, 4, 6, and 8). The power supplies for the modeled components are listed in Table A.4-1.

External Control Systems

Various ACBs receive Keowee emergency start signals, under-voltage relay inputs, generator lockout relay signals, or transformer lockout signals. The effect of these signals on breaker function is further described in Section A.4.4, Instrumentation and Controls.

Other System Boundaries

N/A

A.4.4 INSTRUMENTATION AND CONTROLS

A.4.4.1 EMERGENCY START RELAYS

ACBs 1 and 2 receive emergency start signals to trip. This isolates the Keowee units from the switchyard while the Oconee loads are load shed. The emergency start signal also begins a timing sequence for both breakers. After 6.5 seconds, ACB-1 receives a permissive to close if required. ACB-2 receives a similar permissive in 4 seconds. The stagger on the timing assures that both breakers would not attempt to close simultaneously, possibly tying the two units together when not synchronized.

A.4.4.2 UNDER-VOLTAGE RELAYS

27T/1X and 27T/2X

UV relays 27T/1X and 27T/2X (which are model MG-6 relays) monitor voltage on the 13.8 kV bus. They provide a permissive to close to ACB-1 (27T/1X) and ACB-2 (27T/2X). These permissives prevent automatic closure of the ACB if the 13.8 kV bus happens to be energized from some other source, e.g. the other unit or from the grid, when the unit may not be synchronized with the other source.

27/1X , 27/2X, 27/CX1, and 27CX2

UV relays 27/1X, 27/2X, and 27/CX1 and 27/CX2 (which are model MG-6 relays) monitor voltage on the 600 V ac side of transformers 1X, 2X, and CX respectively. These relays incorporate a 4 second time delay so that a momentary loss of voltage does not result in a control action. Through auxiliary relays, these UV relays provide control functions for ACBs 5, 6, 7, and 8.

- ACB-5 receives a signal from 27/1X to trip if voltage is lost at transformer 1X and a permissive to close if voltage is available from transformer 1X.

- ACB-6 receives a signal from 27/2X to trip if voltage is lost at transformer 2X and a permissive to close if voltage is available from transformer 2X.

- ACB-7 receives a signal from 27/CX1 to trip if voltage is lost at transformer CX and a permissive to close if voltage is available from transformer CX.

- ACB-8 receives a signal from 27/CX2 to trip if voltage is lost at transformer CX and a permissive to close if voltage is available from transformer CX.

A.4.4.3 LOCKOUT RELAYS

Generator lockout relays 86E-1 (Unit 1) and 86E-2 (Unit 2) provide trip signals to their respective output breakers, ACBs 1 and 3, and ACBs 2 and 4.

Main step-up transformer lockout relay 86T provides control to prevent closure of, or to trip, those ACBs which are required to isolate the overhead transformer, ACBs 1, 2, 5, and 7.

CT4 lockout relay 86EF provides a trip signal to those breakers which are required to isolate the underground feeder bus, ACBs 3 and 4.

Transformer CX lockout relay provides a trip signal to those breakers which are required to isolate the transformer, ACBs 6 and 8.

Load center lockout relays 86S/1X, load center 1X, and 86S/2X, load center 2X, provide a trip signal to those breakers which are required to isolate their respective load centers, ACBs 5 and 7, and ACBs 6 and 8.

A.4.4.4 INTERLOCKS BETWEEN ACBS

On each Keowee unit the underground and overhead breakers are interlocked such that the overhead breaker (ACB-1 or ACB-2) can not close automatically if its respective underground breaker (ACB-3 or ACB-4) is aligned to the underground path. Alignment to the underground path is indicated when both the breaker and its associated disconnect are closed.

The underground supply breakers (ACB-3 and ACB-4) are interlocked with each other such that ACB-3(4) can not be closed from the control room if ACB-4(3) is aligned to the underground path. Alignment to the underground path is indicated when both the breaker and its associated disconnect are closed.

The auxiliary power breakers are interlocked with each other so that a 600 V ac load center can be fed from only one source at a time. ACB-5 and ACB-7 are interlocked such that ACB-5(7) can not close automatically or manually from the control room if ACB-7(5) is closed.

A.4.4.5 INTERLOCKS WITH OTHER KEOWEE SYSTEMS/COMPONENTS

The overhead supply breakers (ACB-1 and ACB-2) are interlocked with the generator field breaker of its respective unit such that the ACB can not close unless the generator field breaker is closed.

ACBs 5, 6, 7, and 8 have automatic or manual control as selected on switchgear 1X and 2X. This feature is further described in Section A.4.7.3.

A.4.5 LOCATION WITHIN THE PLANT

The ACBs are located within the Keowee powerhouse on the operating floor, elevation 702'. Additionally, ACBs 3 and 4 are located within a missile protected vault.

A.4.6 NORMAL OPERATION

ACB-1 or ACB-2 is closed when its respective Keowee unit is being used to generate to the grid. When the unit is not generating to the grid, the breaker is open.

The underground supply breaker (ACB-3 or ACB-4) on the Keowee unit dedicated to the underground path is closed at all times. If that unit is generating to the grid, the underground path is energized all the way through transformer CT4 at Oconee.

Current operating restrictions do not allow the Keowee unit dedicated to the underground to generate to the grid.

The Keowee unit dedicated to the underground path receives auxiliary ac power from transformer CX by closing its respective load center feeder breaker from transformer CX, ACB-7 (Unit 1) or ACB-8 (Unit 2). For the underground unit, the supply from transformer CX becomes the preferred source of ac power in an emergency start situation. This is further described in Section A.4.7.3.

The Keowee unit dedicated to the overhead path receives auxiliary ac power through its respective transformer on the 13.8 kV bus (1X or 2X) This is accomplished by closing the appropriate load center feeder breaker, ACB-5 (Unit 1) or ACB-6 (Unit 2). For the overhead unit, the 13.8 kV bus transformer becomes the preferred source of auxiliary ac power in an emergency start situation. This is further described in Section A.4.7.3.

At least every 30 days the unit assigned to the underground supply is swapped to the overhead and vice versa.

A.4.7 PERFORMANCE DURING KEOWEE EMERGENCY OPERATION

A.4.7.1 ACB-1 AND ACB-2

If ACB-1 or ACB-2 is closed when an emergency start signal is received, the breaker is tripped. After a time delay of 6.5 seconds on Unit 1 and 4 seconds on Unit 2, the trip signal is removed and a permissive is present to allow the breaker to close as required. For the unit not aligned to the underground path, the overhead ACB will close if the following conditions are met:

- there is no main step-up transformer lockout
- the 13.8 kV bus is de-energized
- the unit's generator field breaker is racked in and closed
- the ACB's disconnect is closed
- the main step-up transformer disconnect is closed
- the unit's underground supply ACB is open or the disconnect is open
- a train A or B switchyard isolate complete signal is present
- air pressure in the ACB accumulator is above the block setpoint

A.4.7.2 ACB-3 AND ACB-4

Normally, either ACB-3 or ACB-4 is closed. No breaker operation is required if the unit designated to the underground path starts successfully.

When NSM-ON-52966 is placed in service, the operation of ACBs 3 and 4 will be altered. If the unit aligned to the underground path is generating to the grid when an emergency start signal is received, the corresponding underground supply breaker will open and then close in order to connect the unit to the underground path. The opening operation is intended to protect the Oconee loads from the potential over-frequency condition.

A.4.7.3 ACBS 5, 6, 7, AND 8

As noted in Section A.4.6, each unit's auxiliary ac power system has a preferred source of power depending on whether the unit is designated for the underground or the overhead path. ACBs 5 and 7 are controlled and interlocked to provide power to Unit 1 from any available source. ACBs 6 and 8 are similarly controlled for Unit 2. The following description of breaker operation is applicable to these pairs of breakers.

If voltage is lost to the preferred source of auxiliary ac power, a 4 second time delay begins. If voltage is not restored within this interval, the ACB closed on the preferred source is tripped. At this time, a 30 second timing sequence begins. During this interval, the ACB to the preferred source will re-close if voltage is available from this source even if voltage is available at the alternate source as well. If voltage is available only on the alternate source, then the ACB to the alternate supply will close. This ACB will remain closed as long as voltage is available on this supply even if the preferred source is re-energized. Under-voltage relays at the transformers provide the voltage sensing for control of the ACBs.

A.4.8 TEST AND MAINTENANCE

Testing

The test procedures applicable to the ACBs are detailed in Table A.4-3.

Maintenance

The maintenance procedures applicable to the ACBs are detailed in Table A.4-4.

A.4.9 OPERATING EXPERIENCE

A summary of significant operating events is provided in Table A.4-5.

A.4.10 ASSUMPTIONS

A.4.10.1 SYSTEM DESIGN ASSUMPTIONS

Adequate air pressure is available for ACB operations as long as the pressure is above the alarm setpoint.

A.4.10.2 OPERATIONAL ASSUMPTIONS

1. The underground and overhead unit assignments are swapped at least every 30 days.

2. One channel of the under-voltage relays 27T/1X and 27T/2X are tested every refueling outage.

3. Under-voltage relays 27/1X, 27/2X, 27/CX1, and 27/CX2 are tested on an annual basis.

4. The time delay relays 52-1TD and 52-2TD are tested annually.

A.4.10.3 MODELING ASSUMPTIONS

The following assumptions have been made in the development of the fault trees for the Air Circuit Breakers.

1. The breaker failure type codes (CHO, CHT, CHC) are not included as they would be redundant to modeling the failures of the breaker component parts.

2. ACB-1, 2, 3, 4 trip and closing coils are adequately modeled as solenoid valves.

3. Passive failures of air piping and check valve failures which could go undetected by the low pressure alarm and result in breaker failure are not probabilistically significant.

4. Mis-positioning of valves on the breaker air plumbing is considered in the quantification of the latent human error.

5. Breaker, disconnect, and relay contacts are not modeled as moving independently of the primary device. That is, the contacts fail only when the primary device fails.

6. ACBs 1 and 2 control power fuses blown or control power disconnects left open would be alarmed. These failures are not modeled due to the low probability of going undetected.

7. The presence of a main step-up transformer lock-out (86T) or a switchgear lockout (86S/1X or 86S/2X) prior to a LOOP would be indicated on the statalarm panel and therefore these failures are not included in the ACB-5, 6, 7, 8 fail to

close gates. Failures of these relays are included as run failures in the breaker transfers open logic.

8. Relays 83S1X and 83S2X identify the primary and alternate supplies for switchgear centers 1X and 2X respectively. Transfer of the relay out of the correct position does not contribute to failure since the auto-throwover logic always causes the switchgear to connect to which ever source is available regardless of whether it is the primary or alternate.

9. Leaving the control power disconnects in the open position is considered in the quantification of the open and close latent human errors for ACBs 5, 6, 7, 8.

Failure (transfers position) of under-voltage relay (27/1X, 27/2X, 27CX1, or 27CX2) prior to the LOOP could result in a plant configuration different than that assumed for the analysis. Since this transfer of ACBs 5, 6, 7, or 8 would be expected to be detected early, the exposure to this failure is small and would not contribute to the breaker failure probability. Failure of these relays <u>prior</u> to the mission is not included in the tree.

A.4.11 FAULT TREE ANALYSIS

A.4.11.1 TOP EVENT SUCCESS CRITERIA

Air circuit breaker operation is successful if the breaker moves to the required position and remains in that position for the required 24 hour mission .

A.4.11.2 DETAILED FAILURE CRITERIA

N/A

A.4.11.3 DESCRIPTION OF FAULT TREE

The ACBs fault tree is shown in Figure A.4-9. The Fault Tree Modeling Guidelines (Appendix B) were followed in developing the fault tree. A list of all fault tree top events (19 events in all) is presented in Table A.4-8. A list of all fault tree transfers is presented in Table A.4-6.

The specific failure of a breaker (failure to open or failure to close) that is required for the Keowee analysis is explicitly included as a top event (e.g., Air Circuit Breaker 2 Fails To Close, and Air Circuit Breaker 7 Fails To Open). In some cases the operation of one of the ACBs is dependent on operation of one of the other ACBs and these intra-model transfers are included.

Failure events considered in the trees include breaker failures due to either mechanical or electrical problems. In general, adequate generic data bases are available for electrical components, relays, switches, fuses, and solenoids. These failures are modeled explicitly through the basic events involving failures of these components. The mechanical failures have been developed from the plant specific data collected on the Keowee breakers. These generally are modeled as undeveloped events in the fault trees.

The tree structure allows the analysis of the Keowee reliability with the features of NSM-ON-52966, described in Appendix E. The branches of the tree that incorporate this NSM have an impact on the solution only when the event defining the inclusion of this modification is set appropriately.

Human events impacting the model are described in Section A.4.11.4.

Common-cause events impacting the model are described in Section A.4.11.6.

A.4.11.4 HUMAN INTERACTIONS

The success or failure of the Air Circuit Breakers to perform their function is impacted by several human actions. Those events explicitly included in the system fault tree are discussed below. Refer to Section 5.5 and Appendix C.3 for information on the quantification of human error events.

<u>ACBxOPENLHE, ACBxCLOSLHE</u>
(x = 1 through 8 as appropriate)

These basic events account for the potential of the plant personnel to fail to properly restore the ACBs. Post-maintenance testing is expected to detect the majority of errors. However, some errors may escape detection and fail the breaker at some future time.

ABEOPRCREC, ABPOPRCREC

These events consider the opportunity for the operators to close ACBs 2 and 4 respectively in order to complete the power path alignment. The fault tree includes these possible operator actions to recover from potential failures, mostly control system failures.

A.4.11.5 RELIABILITY DATA

Reliability data used in the Air Circuit Breaker analysis are listed in Table A.4-9.

Section 5.3 discusses development of the reliability data. For the base case solution, the plant-specific failure rate data and generic failure rate data were combined using a Bayesian update.

A.4.11.5.1 Exposure Times

Time dependent failures require an exposure time for determination of the failure probability. Failure times have been established based on the consideration of the time since the last test or operation of the component. Table A.4-9 contains a brief explanation of the rational used in determining the exposure time for each time dependent failure.

A.4.11.5.2 Undeveloped Events

The following undeveloped events (DEX) are included in the ACB fault tree. Refer to Table A.4-9 for descriptions of these events. In quantifying these events, Air Circuit Breakers 1,2,3 and 4 are considered in the same component population. Even though the current carrying capacity of ACBs 3 and 4 is different than that of ACBs 1 and 2, they are identical in the construction of the openning and closing mechanisms. Including all four breakers in the same component population is appropriate. ACBs 5, 6, 7, and 8 are considered together as a component population.

AB1MECHDEX (AB[2,3]MECHDEX): Air Circuit Breaker 1(2,3) Fails To Open Due To Mechanical Failure.

The 2/28/90 event, from Table A.4-5, involving a bad blast valve is considered a failure of ACB-2 to open since the blast valve functions to extinguish the arc when the breaker opens.

AB1MECHDEX, AB2MECHDEX, and AB3MECHDEX are quantified by considering the one component failure to open in the population over the total demands to open for the population.

1/(Unit 1 starts + Unit 2 starts +(2 x (61+10)) = 1.51E-04/demand

With one breaker demand for the emergency operation of Keowee, AB1MECHDEX = AB2MECHDEX = AB3MECHDEX = 1.51E-04

AB2MCH2DEX AB[3,4]MCH2DEX: Air Circuit Breaker 2 (3,4) Fails To Close Due To Mechanical Failure.

The 8/21/87 and 11/28/92 events, from Table A.4-5, are failures of ACB-2 and ACB-3 to close

AB2MCH2DEX, AB3MCH2DEX and AB4MCH2DEX are quantified by considering the two component failures to close over the total demands of the four breakers to close.

2/(Unit 1 starts + Unit 2 starts +(2 x (61+10)) = 3.02E-04/demand

With one breaker demand for the emergency operation of Keowee, AB2MCH2DEX = AB3MCH2DEX = AB4MCH2DEX = 3.02E-04

ACBAIRPDEX: ACB Air Supply Fails Causing Low Pressure In All ACB Accumulators

Failure of the ACB Air System may lead to loss of air pressure. All of the ACBs leak to varying degrees, therefore, loss of the compressors eventually leads to loss of air pressure in all of the ACB accumulators.

This event is developed on the assumption that the loss of air supply is dominated by a common cause failure of the air compressors to start during a black start of the Keowee

units. From the Catawba PRA data, the air compressor fails to start value is 1.00E-02. Using a generic Beta factor of 0.1 the common cause failure to start is calculated to be 1.00E-03. This value is then doubled to provide some allowance for failure modes not explicitly considered.

The value of ACBAIRPDEX = 2.00E-03

This failure is included in the ACB4CLOSE gate logic. The demand for ACB-4 to close is a recovery action and may come late enough in the mission for the air pressure to decay to a low value due to leakage.

AB6MECHDEX (AB7MECHDEX): Air Circuit Breaker 6(7) Fails To Open Due To Mechanical Failure.

There are no failure to open events for ACBs 5, 6, 7, or 8 in the event data base.

These breakers are manipulated during the monthly swap of the unit alignments. Additionally, they are tested annually.

AB5MECHDEX, AB6MECHDEX, AB7MECHDEX, and AB8MECHDEX are quantified by using the chi-squared distribution as discussed in Section 5.3.

$$0.455/(2x4x(61+10)) = 8.01E\text{-}04/demand$$

With one breaker demand for the emergency operation of Keowee, AB5MECHDEX = AB6MECHDEX = AB7MECHDEX = AB8MECHDEX = 8.01E-04

AB5MCH2DEX (AB[6, 7, 8]MCH2DEX): Air Circuit Breaker 5([6, 7, 8]) Fails To Close Due To Mechanical Failure.

The failure to close events on 10/19/92 for ACBs 5 and 7 resulted from impact spring failures. Other failure to close events for ACBs 5, 6, 7, and 8 contained in Table A.4-5 are all due to the X-relay failures or to the slow relay pick-up experienced when the X-relays were first replaced. The X-relays have all been replaced and timers installed to correct the pick-up problem, therefore, these events are not included in the failure computation for these basic events.

Since the breaker controls are modeled explicitly, failures of these components, if they were still part of the breaker construction, would have been modeled in the control component failures and not included in the DEX calculation. The DEX calculation includes those failures that are mechanical in nature and not explicitly modeled elsewhere. Two failure to close events, applicable to the current breaker construction, are found in Table A.4-5.

AB5MCH2DEX, AB6MCH2DEX, AB7MCH2DEX, and AB8MCH2DEX are quantified by using the chi-squared distribution as discussed in Section 5.3.

2/(4x(61+10)) = 7.04E-03/demand

With one breaker demand for the emergency operation of Keowee, AB5MCH2DEX = AB6MCH2DEX = AB7MCH2DEX = AB8MCH2DEX = 7.04E-03

<u>AB1ACCUDEX (AB[3, 4, 5] ACCUDEX): Air Circuit Breaker 1([2, 3, 4]) Accumulator Air Pressure Low.</u>

The different current carrying capacities of ACBs 1 and 2, and 3 and 4 are not believed to affect the availability of adequate air pressure in the accumulators. They are considered a single population for the calculation of these basic events. The accumulator pressure DEX for a breaker is applied to both the failure to open and failure to close gates for the respective breaker.

No ACB failures due to low air pressure are identified in Table A.4-5.

AB1ACCUDEX, AB2ACCUDEX, AB3ACCUDEX, and AB4ACCUDEX are quantified by using the chi-squared distribution as discussed in Section 5.3. The number of unit starts is much larger than the ACB 3 and 4 operations and is assumed to dominate the total demands.

0.455/(2x(Unit 1 starts + Unit 2 starts)) = 3.51E-05/demand

With one breaker demand for the emergency operation of Keowee, AB1ACCUDEX = AB2ACCUDEX = AB3ACCUDEX = AB4ACCUDEX = 3.51E-05.

AK2GATEDEX: Wicket Gate Limit Switch Indicates Gate Position Is Below No-load Setting

This event is having the gate position limit switch falsely indicate that the gate position is below no load. There are no reported failures of this device in the Keowee operational data.

This failure is quantified as a spurious operation of a limit switch over the 24 hour mission. From the McGuire PRA, the spurious operation of a limit switch occurs with the failure rate of 8.80E-07/hour.

For the 24 hour mission, AK2GATEDEX = 2.11E-05.

YK1(2)86N2DEX: Keowee Unit 1(2) Normal Lock-out Actuates

The events on 8/1/88, 8/18/88, and 5/10/84, from Table C.1-1 of Appendix C, are actuations of the normal lockout relay.

YK186N2DEX and YK286N2DEX are quantified by considering the 3 failures over the total run hours of the Keowee units.

3/(Unit 1 run hours+Unit 2 run hours) = 3.09E-4/hour

For the 24 hour mission, YK186N2DEX = YK286N2DEX = 7.41E-03.

A.4.11.6 COMMON-CAUSE ASSESSMENT

AB23BKRCOM, AB24BKRCOM

These events consider the potential for the breakers that are required to close (either 2 &3 or 2 & 4) failing to do so due to a common cause. These ACBs share many common elements in their design and construction. The potential for common cause failures of the breakers is assumed to exist.

Quantification of these events is discussed in the common cause failure analysis, described in Section 5.4 and Appendix C.2.

A.4.12 RESULTS

Tables A.4-10 through A.4 -28 lists the dominant minimal cut sets (failure sequences) for the Air Circuit Breaker top events. A list of dominant contributors to unavailability is given in Tables A.4-29 through A.4-47.

The dominant contributors to the unavailability of the Air Circuit Breakers tend to be the control relay failures, latent human errors and breaker mechanical failures.

A.4.13 REFERENCES

A.4.13.1 DOCUMENTS

1. OSS-0254.00-00-2005, Keowee Emergency Power Design Basis Document

A.4.13.2 PROCEDURES

1. MP/0/A/2000/053, Monthly Surveillance Test of ACB No. 3 and No. 4 Interlock

2. PT/0/A/0620/016, Keowee Hydro Emergency Start Test

3. MP/0/A/2000/068, Monthly Surveillance Test Of Overhead Emergency Feed Path "B" Finger

4. OP/1/A/2000/50, Unit No. 1 Electromechanical Relay ACB Trip Test

5. OP/0/A/2000/044, Keowee Emergency Power Path And Auxiliary Alignment

6. OP/0/A/2000/045, Auxiliary Power Transfer Test

7. MP/0/A/2001/02, ACB Inspection and Maintenance

8. OP/0/A/2000/005, ACB No. 1

9. OP/0/A/2000/007, ACB No. 3

10. OP/0/A/2000/009, ACB No. 5

11. AP/0/A/2000/002, Keowee Hydro Station Emergency Start

12. OP/0/A/2000/049, Auxiliary Power Transfer Test

A.4.13.3 DRAWINGS

1. K-700, Rev. 9, One Line Diagram, Relays and Meters 13.8-230kV.

2. KEE-27-1, Rev. 4, Keowee Hydro Station Units No. 1 & 2, Elementary Diagram, 600V Switchgear No. 1X ACB-5 and ACB-7.

3. KEE-27-2, Rev. 4, Keowee Hydro Station Units No. 1 & 2, Elementary Diagram, 600V Switchgear No. 2X ACB-6 and ACB-8.

4. KEE-27-3, Rev. 4, Keowee Hydro Station Units No. 1 & 2, Elementary Diagram, 600V Switchgear No. 1X Auto Thrower Relaying.

5. KEE-27-3-1, Rev. 1, Keowee Hydro Station Units No. 1 & 2, Elementary Diagram, 600V Switchgear No. 2X Auto Thrower Relaying.

6. KEE-112-2, Rev. 9, Keowee Hydro Station Unit No. 1, Elementary Diagram, Excitation System Generator Field Breaker.

7. KEE-212-2, Rev. 9, Keowee Hydro Station Unit No. 2, Elementary Diagram, Excitation System Generator Field Breaker.

8. KEE-113, Rev. 8, Keowee Hydro Station Unit No. 1, Elementary Diagram, Master Control System Start-up Controls.

9. KEE-213, Rev. 8, Keowee Hydro Station Unit No. 2, Elementary Diagram, Master Control System Start-up Controls.

10. KEE-113-5, Rev. 8, Keowee Hydro Station Unit No. 1, Elementary Diagram, Master Control System Turbine Miscellaneous Relaying.

11. KEE-213-5, Rev. 5, Keowee Hydro Station Unit No. 2, Elementary Diagram, Master Control System Turbine Miscellaneous Relaying.

12. KEE-114, Rev. 12, Keowee Hydro Station Unit No. 1, Elementary Diagram, Generator Control ACB-1 Control Circuit.

13. KEE-214, Rev. 9, Keowee Hydro Station Unit No. 2, Elementary Diagram, Generator Control ACB-2 Control Circuit.

14. KEE-114-1, Rev. 13, Keowee Hydro Station Unit No. 1, Elementary Diagram, Generator Control ACB-3 Control Circuit.

15. KEE-214-1, Rev. 10, Keowee Hydro Station Unit No. 2, Elementary Diagram, Generator Control ACB-4 Control Circuit.

16. KEE-114-3, Rev. 11, Keowee Hydro Station Unit No. 1, Elementary Diagram, Generator Control Normal and Emergency Lockout.

17. KEE-214-3, Rev. 8, Keowee Hydro Station Unit No. 2, Elementary Diagram, Generator Control Normal and Emergency Lockout.

Table A.4-1

Air Circuit Breaker Power Supplies

Component	Power Supply[1]	Compartment Number
ACB-1	125 V dc DC 1DA	3CL
ACB-2	125 V dc DC 2DA	3CL
ACB-3	125 V dc DC 1DA	3CC
ACB-4	125 V dc DC 2DA	3CC
ACB-5	125 V dc DC 1DA	4AL
ACB-6	125 V dc DC 2DA	2AL
ACB-7	125 V dc DC 1DA	4AL
ACB-8	125 V dc DC 2DA	2AL

[1] DC = Distribution Center

Table A.4-2

Air Circuit Breaker External Controls

Component	Signal
ACB-1	Emergency Start Relays 1ESRX/1A and 1ESRX/1B to Open
ACB-2	Emergency Start Relays 2ESRX/1A and 2ESRX/1B to Open
	Switchyard Isolate Complete Signal to Close
	Generator Field Breaker Is Closed Permissive to Close
	Overhead Transformer Lock-out Permissive (no lock-out)
ACB-3	None (pre-modification)
	1ESRX/1A and 1ESRX/1B to Open (post-modification)
	Overfrequency Relays Signal to Close (post-modification)

Table A.4-2

Air Circuit Breaker External Controls

Component	Signal
ACB-4	Close on Indication of Main Transformer Lock-out and Unit 1 Generator Emergency Lock-out (post-modification)
ACB-5	None
ACB-6	None
ACB-7	None
ACB-8	None

Table A.4-3

Air Circuit Breaker Test Procedures

Procedure	Test Frequency	Description
MP/0/A/2000/053 Monthly Surveillance Test of ACB No. 3 and No. 4 Interlock	Monthly	Functional test of interlock circuitry between ACB No. 3 and ACB No. 4.
PT/0/A/0620/016 Keowee Hydro Emergency Start Test	Periodic	Demonstrate the operability of each Keowee unit's emergency start circuitry from each control room.
MP/0/A/2000/068 Monthly Surveillance Test Of Overhead Emergency Feed Path "B" Finger Circuitry.	Monthly	Test of interlock circuitry between ACB No. 1 and ACB No. 3, and between ACB No. 2 and ACB No. 4.
OP/0/A/2000/049 Auxiliary Power Transfer Test	Annually	Verifies proper operation of the auto throwover circuits on ACBs 5 through 8.

Table A.4-3

Air Circuit Breaker Test Procedures

Procedure	Test Frequency	Description
OP/1/A/2000/50 Unit No. 1 Electro-Mechanical Relay ACB Trip Test	Quarterly	Verify tripping of ACB No. 1 and ACB No. 3 on actuation of the GENERATOR GROUND FAULT OVERVOLTAGE relay 59GN-1
OP/0/A/2000/044 Keowee Emergency Power Path And Auxiliary Alignment	Monthly	Change the alignment of the Keowee units and the auxiliary power source.
OP/0/A/2000/044 Auxiliary Power Transfer Test	Periodic	Demonstrate the ability of the 600 V ac load center to close its auxiliary and normal feeder breakers with the appropriate time delays.

Table A.4-4

Air Circuit Breaker Maintenance Procedures

Procedure	Maintenance Frequency	Description
MP/0/A/2001/02 ACB Inspection and Maintenance	Annual	Establishes the requirements for the inspection and maintenance of the ACBs.
OP/0/A/2000/005 ACB No. 1	As needed	Removal from service and restoration to service of ACB No. 1
OP/0/A/2000/007 ACB No. 3	As needed	Removal from service and restoration to service of ACB No. 3
OP/0/A/2000/009 ACB No. 5	As needed	Removal from service and restoration to service of ACB No. 5

Table A.4-5

Air Circuit Breaker Significant Operating Events

Date	Unit	Component	Event Summary
1-31-87	1	ACB-5	Oconee was performing a test on PCB 8 and 9 when ACB-5 tripped. Would not re-close.
8-21-87	1	ACB-3	Oconee attempted to line unit 1 up to the underground but they could not get ACB-3 to close due to a loose terminal.
2-28-90	2	ACB-2	ACB-2 out of service to replace a bad Blast Valve Pin in ACB-2.
3-1-92	1	ACB-5	After Oconee had completed the performance of a Switchyard test and had closed PCB's 8 & 9, ACB-5 failed to close automatically.
7-17-92	2	ACB-8	Keowee Operator found blown fuse in ACB-8 closing circuit during a time when Unit 1 was out of service and Unit 2 was lined up to feed CT4 and the standby busses with Unit 2 auxiliaries being fed through ACB-6. This made Unit 2 technically inoperable.
9-29-92	2	ACB-2	During the performance of post-mod. testing, it was discovered that ACB-2 did not close immediately after opening ACB-1 as the procedure required.
10-19-92	1	ACB-5, ACB-7	Oconee LOOP Event - Initially Unit 1 was generating to the grid and Unit 2 was lined up to the underground path. When the Swyd Isolation and the 1st ES actuation occurred, ACB-1 tripped and then re-closed. Unit 2 started and was supplying CT4. The K Operator tripped ACB-1 which de-energized all of Keowee's auxiliaries. ACB-5 and ACB-7 failed to transfer as designed to re-energize the 1X Swgr.

Table A.4-5

Air Circuit Breaker Significant Operating Events

Date	Unit	Component	Event Summary
10-19-92	2	ACB-8	Oconee LOOP Event - Following the Keowee Operator tripping ACB-1 and relay operation in the Oconee 230 KV switchyard causing a Main Transformer lockout, ACB-8 failed to close to re-energize 2X.
10-20-92	1	ACB-5	While testing the ACB5/ACB7 swap-over function, ACB 5 failed to close when ACB 7 was tripped.
10-22-92	1	ACB-1	Unit 1 had just been shut down and a cabinet inspection team was performing a cabinet inspection in Cabinet 1LC1 at Keowee when they discovered a broken lug on Emergency Start Timer 52-1TD (contact 4A) which trips ACB-1 on receipt of an ES signal.
11-24-92	2	ACB-6, ACB-8	While attempting to tie Keowee Unit 2 to the overhead after a successful Emergency Start Test of both units, feeder breakers for load center 2X, ACB-6 and ACB-8, would not close manually, which left Keowee Unit-2 without power.
11-28-92	2	ACB-2	Keowee Unit 2 was started for system generation but ACB-2 would not close either automatically or manually. The operator found a smoking relay in the ACB-2 cabinet.

Table A.4-6

Air Circuit Breaker Fault Tree Transfers

Transfer Gate Name	Description	Components Supplied
YK1STRTINT	Keowee 1 Emergency Start Aux Relays 1ESRX/1A & 1ESRX/1B Fail	ACB-1
YK2STRTINT	Keowee 2 Emergency Start Aux Relays 2ESRX/1A & 2ESRX/1B Fail	ACB-2, ACB-4
XD1DASRCES	Loss of Power to 125 V dc Distribution Center 1DA During Start	ACB-1, ACB-4
XD2DASRCES	Loss of Power to 125 V dc Distribution Center 2DA During Start	ACB-2
XFMR186T	Main Step-up Transformer Lock Out Relay 86T Actuates	ACB-2, ACB-5, ACB-6
KU2STARTR	Keowee Unit 2 Start Is Required	ACB-2
SPCISLTCPT	Switchyard Isolate Complete Signal Fails	ACB-2
KU2RNNG	Keowee Unit 2 Is Supplying The Grid	ACB-2
K2NOMAIN	Keowee Unit 2 Is Not In Maintenance	ACB-2

Table A.4-6

Air Circuit Breaker Fault Tree Transfers

Transfer Gate Name	Description	Components Supplied
KU1RNNG	Keowee Unit 1 Is Supplying The Grid	ACB-2, ACB-3
NTACB4MOD	NSM-ON-52966 Is In Service	ACB-2, ACB-3, ACB-4
FLDTRANS2	Keowee Unit 2 Field Breaker Transfers Open	ACB-2
GK286E2	Keowee Unit 2 Emergency Lock Out Due To Spurious Actuation Of Generator Protective Relay	ACB-2, ACB-4
U86EF	Underground Feeder Lock Out Relay 86EF Picks UP	ACB-3, ACB-4
GK186E1	Keowee Unit 1 Emergency Lock Out Due To Spurious Actuation Of Generator Protective Relay	ACB-3
GK186E1X	Keowee Unit 1 Emergency Lock Out Due To Spurious Actuation Of Generator Protective Relay	ACB-3

Table A.4-6

Air Circuit Breaker Fault Tree Transfers

Transfer Gate Name	Description	Components Supplied
XD1DAR	Loss Of Power On Keowee 1 125 V dc Distribution Center 1DA During Run	ACB-3, ACB-4
XD2DAR	Loss Of Power On Keowee 2 125 V dc Distribution Center 2DA During Run	ACB-4
YK2STR2INT	Keowee 2 Emergency Start Aux Relays 2ESRX/2A & 2ESRX/2B Fail	ACB-4

Table A.4-7

Air Circuit Breaker Statalarms

Point No.	Alarm	Actuator
1SA1-21	ACB-1 AIR PRESS LOW	63TX1
1SA1-22	ACB-3 AIR PRESS LOW	63TX3
1SA2-41	EMERG. START ACB 1 CLOSED	52-1/b
1SA2-42	EMERG. START ACB 3 CLOSED	52-3/b
1SA1-50	UNIT 1 DC SUPPLY FAILURE	"8" series relay
2SA1-21	ACB-2 AIR PRESS LOW	63TX2
2SA1-22	ACB-4 AIR PRESS LOW	63TX4
2SA2-41	EMERG. START ACB 2 CLOSED	52-2/b
2SA2-42	EMERG. START ACB 4 CLOSED	52-4/b
2SA1-50	UNIT 2 DC SUPPLY FAILURE	"8" series relay

Table A.4-8

Air Circuit Breaker Fault Tree Top Events

Gate Name	Description
ACB1OPEN	Air Circuit Breaker 1 Fails To Open
ACB2CLOSE	Air Circuit Breaker 2 Fails To Close
ACB2OPEN	Air Circuit Breaker 2 Fails To Open
ACB2TRANS	Air Circuit Breaker 2 Transfers Open
ACB3CLOSE	Air Circuit Breaker 3 Fails To Close
ACB3OPEN	Air Circuit Breaker 3 Fails To Open
ACB3TRANS	Air Circuit Breaker 3 Transfers Open
ACB4CLOSE	Air Circuit Breaker 4 Fails To Close
ACB4TRANS	Air Circuit Breaker 4 Transfers Open
ACB5CLOSE	Air Circuit Breaker 5 Fails To Close
ACB5TRANS	Air Circuit Breaker 5 Transfers Open
ACB6CLOSE	Air Circuit Breaker 6 Fails To Close
ACB6OPEN	Air Circuit Breaker 6 Fails To Open
ACB6TRANS	Air Circuit Breaker 6 Transfers Open
ACB7CLOSE	Air Circuit Breaker 7 Fails To Close
ACB7OPEN	Air Circuit Breaker 7 Fails To Open
ACB7TRANS	Air Circuit Breaker 7 Transfers Open
ACB8CLOSE	Air Circuit Breaker 8 Fails To Close
ACB8TRANS	Air Circuit Breaker 8 Transfers Open

Table A.4-9

Air Circuit Breaker Reliability Data

Event Name	Description	Failure Rate[1]	Factor	Rational For Factor[2]	Failure Probability
AA1271PR6D	Transformer 1X Undervoltage Relay 27/1X Fails To Pick Up	2.49E-04 /D	1 D	1 demand per emergency start required.	2.49E-04
AA1271XR6T	Transformer 1X Undervoltage Relay 27/1X Spuriously De-energizes	3.63E-07 /H	30 H	Rule 4: Indicated by computer point.	1.09E-05
AA127C1R6T	Transformer CX Undervoltage Relay 27/CX1 Spuriously De-energizes	3.63E-07 /H	24 H	Rule 3: Would align the unit 1 auxiliaries to transformer 1X. This is not the assumed initial condition for the KPRA. Indicated by computer point.	8.71E-06
AA127CPR6D	Transformer CX Undervoltage Relay 27/CX1 Fails To Pick Up	2.49E-04 /D	1 D	1 demand per emergency start required.	2.49E-04
AA127R1RYT	Auxiliary Relay 27X/CX1 Spurious Operation	3.60E-07 /H	24 H	Rule 3: Would align the unit 1 auxiliaries to transformer 1X. This is not the assumed initial condition for the KPRA. Indicated by computer point.	8.64E-06
AA127X1RYD	Auxiliary Relay 27X/1X Fails To Operate On Demand	3.30E-05 /D	1 D	1 demand per emergency start required.	3.30E-05
AA127X1RYT	Auxiliary Relay 27X/1X Spurious Operation	3.60E-07 /H	384 H	Rule 6:Spurious operation of the relay would be detected during the monthly swap by the trip of ACB-5.	1.38E-04
AA127X2R6D	Transformer CX Undervoltage Relay 27/CX1 Fails To Drop Out	2.49E-04 /D	1 D	1 demand per emergency start required.	2.49E-04
AA127XCRYD	Auxiliary Relay 27/CX1 Fails To Operate On Demand	3.30E-05 /D	1 D	1 demand per emergency start required.	3.30E-05
AA186CXRYT	Transformer CX Differential Lock Out Relay 86CX Spurious Operation	3.60E-07 /H	24 H	Rule 3: Indicated, and would place Keowee in a different condition than assumed for the analysis.	8.64E-06
AA186S1RYT	Switchgear 1X Lockout Relay 86S/1X Spurious Operation	3.60E-07 /H	24 H	Rule 3: Would put switchgear 1X in maintenance.	8.64E-06

[1]D=Demand, H=Hour

[2]Rules for assigning basic event factors are discussed in Table C.1-4

Table A.4-9

Air Circuit Breaker Reliability Data

Event Name	Description	Failure Rate[1]	Factor	Rational For Factor[2]	Failure Probability
AA187CXRYT	Transformer CX Differential Relay 87CX Spurious Operation	3.60E-07 /H	24 H	Rule 3: Would align the unit 1 auxiliaries to transformer 1X. This is not the assumed initial condition for the KPRA. Indicated by computer point.	8.64E-06
AA2272PR6D	Transformer 2X Undervoltage Relay 27/2X Fails To Pick Up	2.49E-04 /D	1 D	1 demand per emergency start required.	2.49E-04
AA2272XR6D	Transformer 2X Undervoltage Relay 27/2X Fails To Drop Out	2.49E-04 /D	1 D	1 demand per emergency start required.	2.49E-04
AA2272XR6T	Transformer 2X Undervoltage Relay 27/2X Spuriously De-energizes	3.63E-07 /H	24 H	Rule 3: Would align the unit 2 auxiliaries to transformer CX. This is not the assumed condition for the KPRA. Indicated by computer point.	8.71E-06
AA227C2R6T	Transformer CX Undervoltage Relay 27/CX2 Spuriously De-energizes	3.63E-07 /H	30 H	Rule 4: Indicated by computer point.	1.09E-05
AA227C2RYD	Auxiliary Relay 27X/CX2 Fails To Operate On Demand	3.30E-05 /D	1 D	1 demand per emergency start required.	3.30E-05
AA227CPR6D	Transformer CX Undervoltage Relay 27/CX2 Fails To Pick Up	2.49E-04 /D	1 D	1 demand per emergency start required.	2.49E-04
AA227R2RYT	Auxiliary Relay 27X/CX2 Spurious Operation	3.60E-07 /H	384 H	Rule 6:Spurious operation of the relay would be detected during the monthly swap by the trip of ACB-8.	1.38E-04
AA227T2R6D	Transformer #1 Undervoltage Relay (27T/2X) Fails To Drop Out	2.49E-04 /D	1 D	1 demand per emergency start required.	2.49E-04
AA227X2RYD	Auxiliary Relay 27X/2X Fails To Operate On Demand	3.30E-05 /D	1 D	1 demand per emergency start required.	3.30E-05
AA227X2RYT	Auxiliary Relay 27X/2X Spurious Operation	3.60E-07 /H	24 H	Rule 3: Would align the unit 2 auxiliaries to transformer CX. This is not the assumed	8.64E-06

[1]D=Demand, H=Hour

[2]Rules for assigning basic event factors are discussed in Table C.1-4

Table A.4-9

Air Circuit Breaker Reliability Data

Event Name	Description	Failure Rate[1]	Factor	Rational For Factor[2]	Failure Probability
				condition for the KPRA. Indicated by computer point.	
AA286S2RYT	Switchgear 2X Lockout Relay 86S/2X Spurious Operation	3.60E-07 /H	24 H	Rule 3: Would put switchgear 2X in maintenance.	8.64E-06
AB004ECCDT	DC Circuit Breaker 1DA-4EC Transfers Position	7.50E-08 /H	30 H	Rule 4: Indicated by rounds.	2.25E-06
AB0086TRYD	Keowee Main Tx Lock Out Relay 86T Fails To Operate On Demand	3.30E-05 /D	1 D	1 demand per emergency start required.	3.30E-05
AB0624CRYD	Time Delay Relay 62-4c Fails To Operate On Demand	3.30E-05 /D	1 D	1 demand per emergency start required.	3.30E-05
AB086E1RYD	Emergency Lock Out Relay 86E-1 Fails To Operate On Demand	3.30E-05 /D	1 D	1 demand per emergency start required.	3.30E-05
AB086TGRYD	General Keowee Main Tx Lock Out Sensing Relay Fails To Operate	3.30E-05 /D	1 D	1 demand per emergency start required.	3.30E-05
AB152TCSVO	Air Circuit Breaker 1 Trip Coil Fails To Operate	2.90E-05 /D	1 D	1 demand per emergency start required.	2.90E-05
AB1ACCUDEX	Air Circuit Breaker 1 Accumulator Air Pressure Low		3.51E-05		3.51E-05
AB1FALTDEX	Fault Occurs at ACB-1 When The BReaker Trips		0		0.00E+00
AB1MECHDEX	Air Circuit Breaker 1 Fails To Open Due To Mechanical Failure		1.51E-04		1.51E-04
AB1OPENLHE	Air Circuit Breaker 1 Fails To Open Due To A Latent Human Error		2.60E-04		2.60E-04
AB1PS02PST	Air Circuit Breaker 1 Accumulator Pressure Switch PS2 Fails Low	4.30E-07 /H	12 H	Rule 5: Last demanded at unit start.	5.16E-06

[1]D=Demand, H=Hour

[2]Rules for assigning basic event factors are discussed in Table C.1-4

Table A.4-9

Air Circuit Breaker Reliability Data

Event Name	Description	Failure Rate[1]	Factor	Rational For Factor[2]	Failure Probability
AB1R52ZR6D	Air Circuit Breaker 1 Relay 52Z Fails To Operate	2.49E-04 /D	1 D	1 demand per emergency start required.	2.49E-04
AB21521SWT	Control Switch 152-2 Spurious Operation	7.00E-08 /H	30 H	Causes trip of ACB-2. Half time between rounds plus the mission.	2.10E-06
AB22BV1RYT	Backup Undervoltage Relay 2BV1 Spurious Operation	3.60E-07 /H	24 H	Rule 3: Results in emergency lock-out.	8.64E-06
AB23BKRCOM	Common Cause Failure Of Air Circuit Breakers 2 And 3 To Close		1.12E-04		1.12E-04
AB24BKRCOM	Common Cause Failure Of Air Circuit Breakers 2 And 4 To Close		1.12E-04		1.12E-04
AB251G2RYT	Air Circuit Breaker 2 Overcurrent Ground Relay 51G-2 Spurious Operation	3.60E-07 /H	24 H	Rule 3: Indicated by event recorder.	8.64E-06
AB252CCSVO	Air Circuit Breaker 2 Close Coil Fails To Operate	2.90E-05 /D	1 D	1 demand per emergency start required.	2.90E-05
AB252TCSVO	Air Circuit Breaker 2 Trip Coil Fails To Operate	2.90E-05 /D	1 D	1 demand per emergency start required.	2.90E-05
AB252TCSVT	Air Circuit Breaker 2 Trip Coil Spurious Operation	3.90E-07 /H	36 H	Rule 6 method. Causes trip of ACB-2.	1.40E-05
AB252Y2R6D	Air Circuit Breaker 2 Relay 52Y Failed To Drop Out Following Last Demand	2.49E-04 /D	1 D	1 demand per emergency start required.	2.49E-04
AB252Y2R6T	Air Circuit Breaker 2 Y-relay Spurious Operation	3.63E-07 /H	12 H	Rule 6 method. Causes trip of ACB-2.	4.36E-06
AB2ACCUDEX	Air Circuit Breaker 2 Accumulator Air Pressure Low		3.51E-05		3.51E-05
AB2CLOSLHE	Air Circuit Breaker 2 Fails To Close Due To A Latent Human Error		2.60E-04		2.60E-04

[1]D=Demand, H=Hour

[2]Rules for assigning basic event factors are discussed in Table C.1-4

Table A.4-9

Air Circuit Breaker Reliability Data

Event Name	Description	Failure Rate[1]	Factor	Rational For Factor[2]	Failure Probability
AB2KEYISWT	Air Circuit Breaker 2 Key Interlock Switch Transfers Open	7.00E-08 /H	12 H	Rule 6 method. Causes trip of ACB-2.	8.40E-07
AB2MCH2DEX	Air Circuit Breaker 2 Fails To Close Due To Mechanical Failure		3.02E-04		3.02E-04
AB2MECHDEX	Air Circuit Breaker 2 Fails To Open Due To Mechanical Failure		1.51E-04		1.51E-04
AB2OPENLHE	Air Circuit Breaker 2 Fails To Open Due To A Latent Human Error		2.60E-04		2.60E-04
AB2PS02PST	Air Circuit Breaker 2 Accumulator Pressure Switch PS2 Fails Low	4.30E-07 /H	12 H	Half of the time since the last start. Causes failure of ACB-2 to close.	5.16E-06
AB2PUSHPBT	Trip Pushbutton On ACB2 Spurious Operation	2.40E-07 /H	36 H	Rule 6 method. Causes trip of ACB-2.	8.64E-06
AB2R462RYT	Air Circuit Breaker 2 Negative Sequence Relay 46-2 Spurious Operation	3.60E-07 /H	24 H	Rule 3: Indicated by event recorder.	8.64E-06
AB2R52XR6D	Air Circuit Breaker 2 Relay 52X Fails To Operate	2.49E-04 /D	1 D	1 demand per emergency start required.	2.49E-04
AB2R52ZR6D	Air Circuit Breaker 2 Relay 52Z Fails To Operate	2.49E-04 /D	1 D	1 demand per emergency start required.	2.49E-04
AB2R52ZR6T	Air Circuit Breaker 2 Relay 52Z Spurious Operation	3.63E-07 /H	36 H	Rule 6 method. Causes trip of ACB-2.	1.31E-05
AB31523SWT	Control Switch 152-3 Spurious Operation	7.00E-08 /H	24 H	Trips ACB-3.	1.68E-06
AB352CCSVO	Air Circuit Breaker 3 Close Coil Fails To Operate	2.90E-05 /D	1 D	1 demand per emergency start required.	2.90E-05
AB352TCSVO	Air Circuit Breaker 3 Trip Coil Fails To Operate	2.90E-05 /D	1 D	1 demand per emergency start required.	2.90E-05
AB352TCSVT	Air Circuit Breaker 3 Trip Coil Spurious Operation	3.90E-07 /H	24 H	Trips ACB-3.	9.36E-06

[1]D=Demand, H=Hour

[2]Rules for assigning basic event factors are discussed in Table C.1-4

Table A.4-9

Air Circuit Breaker Reliability Data

Event Name	Description	Failure Rate[1]	Factor	Rational For Factor[2]	Failure Probability
AB352Y2R6D	Air Circuit Breaker 3 Relay 52Y Failed To Drop Out Following Last Demand	2.49E-04 /D	1 D	1 demand per emergency start required.	2.49E-04
AB352Y2R6T	Air Circuit Breaker 3 Y-relay Spurious Operation	3.63E-07 /H	360 H	Rule 5.ACB-3 would not close.	1.31E-04
AB3ACCUDEX	Air Circuit Breaker 3 Accumulator Air Pressure Low		3.51E-05		3.51E-05
AB3CLOSLHE	Air Circuit Breaker 3 Fails To Close Due To Latent Human Error		2.60E-04		2.60E-04
AB3MCH2DEX	Air Circuit Breaker 3 Fails To Close Due To Mechanical Failure		3.02E-04		3.02E-04
AB3MECHDEX	Air Circuit Breaker 3 Fails To Open Due To Mechanical Failure		1.51E-04		1.51E-04
AB3PS02PST	Air Circuit Breaker 3 Accumulator Pressure Switch PS2 Fails Low	4.30E-07 /H	372 H	Assumed ACB-3 would have to open half way through the mission to allow recovery by closing ACB-4.	1.60E-04
AB3PUSHPBT	Trip Pushbutton On ACB3 Spurious Operation	2.40E-07 /H	24 H	Trips ACB-3.	5.76E-06
AB3R52XR6D	Air Circuit Breaker 3 Relay 52X Fails To Operate	2.49E-04 /D	1 D	1 demand per emergency start required.	2.49E-04
AB3R52ZR6D	Air Circuit Breaker 3 Relay 52Z Fails To Operate	2.49E-04 /D	1 D	1 demand per emergency start required.	2.49E-04
AB3R52ZR6T	Air Circuit Breaker 3 Relay 52Z Spurious Operation	3.63E-07 /H	24 H	Trips ACB-3.	8.71E-06
AB41523SWT	Control Switch 152-4 Spurious Operation	7.00E-08 /H	24 H	Assumed that recovery via ACB-4 was needed at the beginning of the mission.	1.68E-06
AB452CCSVO	Air Circuit Breaker 4 Close Coil Fails To Operate	2.90E-05 /D	1 D	1 demand per emergency start required.	2.90E-05

[1]D=Demand, H=Hour

[2]Rules for assigning basic event factors are discussed in Table C.1-4

Table A.4-9

Air Circuit Breaker Reliability Data

Event Name	Description	Failure Rate[1]	Factor	Rational For Factor[2]	Failure Probability
AB452TCSVT	Air Circuit Breaker 4 Trip Coil Spurious Operation	3.90E-07 /H	24 H	Assumed that recovery via ACB-4 was needed at the beginning of the mission.	9.36E-06
AB452Y2R6D	Air Circuit Breaker 4 Relay 52Y Failed To Drop Out Following Last Demand	2.49E-04 /D	1 D	1 demand per emergency start required.	2.49E-04
AB452Y2R6T	Air Circuit Breaker 4 Y-relay Spurious Operation	3.63E-07 /H	372 H	Half the time since the last operation and assume ACB-4 is needed half way through the mission (360+12)	1.35E-04
AB4ACCUDEX	Air Circuit Breaker 4 Accumulator Air Pressure Low		3.51E-05		3.51E-05
AB4CLOSLHE	Air Circuit Breaker 4 Fails To Close Due To A Latent Human Error		2.60E-04		2.60E-04
AB4CLSESWC	Air Circuit Breaker 4 Close Switch Fails To Close On Demand	1.00E-05 /D	1 D	1 demand per emergency start required.	1.00E-05
AB4KEYISWT	Air Circuit Breaker 4 Key Interlock Switch Transfers Open	7.00E-08 /H	372 H	Half the time since the last operation and assume ACB-4 is needed half way through the mission (360+12)	2.60E-05
AB4LORESWT	Air Circuit Breaker 4 Local/Remote Switch Contact Transfers Position	7.00E-08 /H	372 H	Half the time since the last operation and assume ACB-4 is needed half way through the mission (360+12)	2.60E-05
AB4MCH2DEX	Air Circuit Breaker 4 Fails To Close Due To Mechanical Failure		3.02E-04		3.02E-04
AB4PS02PST	Air Circuit Breaker 4 Accumulator Pressure Switch PS2 Indicates Low Pressure	4.30E-07 /H	372 H	Half the time since the last operation and assume ACB-4 is needed half way through the mission (360+12)	1.60E-04
AB4PUSHPBT	Trip Pushbutton On ACB-4 Spurious Operation	2.40E-07 /H	24 H	Assumed that recovery via ACB-4 was needed at the beginning of the mission.	5.76E-06

[1]D=Demand, H=Hour

[2]Rules for assigning basic event factors are discussed in Table C.1-4

Table A.4-9

Air Circuit Breaker Reliability Data

Event Name	Description	Failure Rate[1]	Factor	Rational For Factor[2]	Failure Probability
AB4R52XR6D	Air Circuit Breaker 4 Relay 52X Fails To Operate	2.49E-04 /D	1 D	1 demand per emergency start required.	2.49E-04
AB4R52ZR6T	Air Circuit Breaker 4 Relay 52Z Spurious Operation	3.63E-07 /H	24 H	Assumed that recovery via ACB-4 was needed at the beginning of the mission.	8.71E-06
AB510A1FUF	One Or More Control Power Fuses For X, Y And CC Fail	3.60E-06 /H	6 H	Rule 2: Indicated by loss of position indication.	2.16E-05
AB51431LHE	Manual/Auto Control Switch 143/1 Left In Manual		3.20E-04		3.20E-04
AB51431RYT	Auxiliary Relay 143X/1 Spuriously Energizes	3.60E-07 /H	360 H	Half the time since the unit alignment was swapped. ACB 5 would fail to close.	1.30E-04
AB51431SWT	Manual/Auto Control Switch 143/1 Spuriously Transfers Into Manual	7.00E-08 /H	360 H	Half the time since the unit alignment was swapped. ACB 5 would fail to close.	2.52E-05
AB552CCRYD	Air Circuit Breaker 5 Close Coil CC Fails On Demand	3.30E-05 /D	1 D	1 demand per emergency start required.	3.30E-05
AB552TCRYT	Air Circuit Breaker 5 Trip Coil 52TC Spurious Operation	3.60E-07 /H	384 H	Rule 6:Half the time since the unit alignment was swapped plus the mission. ACB 5 would fail to close or remain closed.	1.38E-04
AB552Y2RYT	Air Circuit Breaker 5 Y-relay Spurious Operation	3.60E-07 /H	360 H	Half the time since the unit alignment was swapped. ACB 5 would fail to close.	1.30E-04
AB583S5RYD	Time Delay Relay 83S5 Fails To Pick Up	3.30E-05 /D	1 D	1 demand per emergency start required.	3.30E-05
AB5CLOSLHE	Air Circuit Breaker 5 Fails To Close Due To A Latent Human Error		2.60E-04		2.60E-04
AB5KEYISWT	Air Circuit Breaker 5 Key Interlock Switch Transfers Open	7.00E-08 /H	360 H	Half the time since the unit alignment was swapped. ACB 5 would fail to close.	2.52E-05

[1] D=Demand, H=Hour

[2] Rules for assigning basic event factors are discussed in Table C.1-4

Table A.4-9

Air Circuit Breaker Reliability Data

Event Name	Description	Failure Rate[1]	Factor	Rational For Factor[2]	Failure Probability
AB5MCH2DEX	Air Circuit Breaker 5 Fails To Close Due To Mechanical Failure		7.04E-03		7.04E-03
AB5PUSHPBT	Trip Pushbutton On ACB5 Spurious Operation	2.40E-07 /H	384 H	Rule 6: Contributes to unit run failure by preventing closure of ACB 5.	9.22E-05
AB5R52XRYD	Air Circuit Breaker 5 Relay 52X Fails To Operate	3.30E-05 /D	1 D	1 demand per emergency start required.	3.30E-05
AB5R52YRYD	Air Circuit Breaker 5 Relay 52Y Failed To Drop Out At Last Demand	3.30E-05 /D	1 D	1 demand per emergency start required.	3.30E-05
AB610A1FUF	One Or More Control Power Fuses For X, Y And CC Fail	3.60E-06 /H	6 H	Rule 2: Indicated by loss of position indication.	2.16E-05
AB610AFFUF	One Or More Control Power Fuses For Relay 27X/2X Fail	3.60E-06 /H	6 H	Rule 2: Indicated by loss of position indication.	2.16E-05
AB61432LHE	Manual/Auto Control Switch 143/2 Left In Manual		3.20E-04		3.20E-04
AB61432SWT	Manual/Auto Control Switch 143/2 Spuriously Transfers Into Manual	7.00E-08 /H	360 H	Half the time since the unit alignment was swapped. ACB 6 would fail to close.	2.52E-05
AB652CCRYD	Air Circuit Breaker 6 Close Coil CC Fails On Demand	3.30E-05 /D	1 D	1 demand per emergency start required.	3.30E-05
AB652TCRYD	Air Circuit Breaker 6 Trip Coil 52TC Fails Fails To Operate	3.30E-05 /D	1 D	1 demand per emergency start required.	3.30E-05
AB652TCRYT	Air Circuit Breaker 6 Trip Coil 52TC Spurious Operation	3.60E-07 /H	24 H	Rule 1: Actuation prior to the emergency start would place the units in a configuration that is abnormal and not consistent with the modeling assumptions.	8.64E-06
AB652Y2RYT	Air Circuit Breaker 6 Y-relay Spurious Operation	3.60E-07 /H	360 H	Half the time since the unit alignment was swapped. Would prevent ACB 6 from closing.	1.30E-04

[1]D=Demand, H=Hour

[2]Rules for assigning basic event factors are discussed in Table C.1-4

Table A.4-9

Air Circuit Breaker Reliability Data

Event Name	Description	Failure Rate[1]	Factor	Rational For Factor[2]	Failure Probability
AB6CLOSLHE	Air Circuit Breaker 6 Fails To Close Due To A Latent Human Error		2.60E-04		2.60E-04
AB6KEYISWT	Air Circuit Breaker 6 Key Interlock Switch Transfers Open	7.00E-08 /H	360 H	Half the time since the unit alignment was swapped. Would prevent ACB 6 from closing.	2.52E-05
AB6MCH2DEX	Air Circuit Breaker 6 Fails To Close Due To Mechanical Failure		7.04E-03		7.04E-03
AB6MECHDEX	Air Circuit Breaker 6 Fails To Open Due To Mechanical Failure		8.01E-04		8.01E-04
AB6OPENLHE	Air Circuit Breaker 6 Fails To Open Due To A Latent Human Error		3.20E-03		3.20E-03
AB6PUSHPBT	Trip Pushbutton On ACB6 Spurious Operation	2.40E-07 /H	24 H	Rule 1: Actuation prior to the emergency start would place the units in a configuration that is abnormal and not consistent with the modeling assumptions.	5.76E-06
AB6R52XRYD	Air Circuit Breaker 6 Relay 52X Fails To Operate	3.30E-05 /D	1 D	1 demand per emergency start required.	3.30E-05
AB6R52YRYD	Air Circuit Breaker 6 Relay 52Y Failed To Drop Out At Last Demand	3.30E-05 /D	1 D	1 demand per emergency start required.	3.30E-05
AB710A1FUF	One Or More Control Power Fuses For X, Y And CC Fail	3.60E-06 /H	6 H	Rule 2: Indicated by loss of position indication.	2.16E-05
AB710AFFUF	One Or More Air Circuit Breaker 7 Control Power Fuses Fail	3.60E-06 /H	6 H	Rule 2: Indicated by loss of monitoring lights.	2.16E-05
AB752CCRYD	Air Circuit Breaker 7 Close Coil CC Fails On Demand	3.30E-05 /D	1 D	1 demand per emergency start required.	3.30E-05
AB752TCRYD	Air Circuit Breaker 7 Trip Coil TC Fails On Demand	3.30E-05 /D	1 D	1 demand per emergency start required.	3.30E-05

[1] D=Demand, H=Hour

[2] Rules for assigning basic event factors are discussed in Table C.1-4

Table A.4-9

Air Circuit Breaker Reliability Data

Event Name	Description	Failure Rate[1]	Factor	Rational For Factor[2]	Failure Probability
AB752TCRYT	Air Circuit Breaker 7 Trip Coil 52TC Spurious Operation	3.60E-07 /H	24 H	Rule 1: Actuation prior to the emergency start would place the units in a configuration that is abnormal and not consistent with the modeling assumptions.	8.64E-06
AB752Y2RYT	Air Circuit Breaker 7 Y-relay Spurious Operation	3.60E-07 /H	360 H	Half the time since the unit alignment was swapped. Would prevent ACB 7 from closing.	1.30E-04
AB7CLOSLHE	Air Circuit Breaker 7 Fails To Close Due To A Latent Human Error		2.60E-04		2.60E-04
AB7KEYISWT	Air Circuit Breaker 7 Key Interlock Switch Transfers Open	7.00E-08 /H	360 H	Half the time since the unit alignment was swapped. Would prevent ACB 7 from closing.	2.52E-05
AB7MCH2DEX	Air Circuit Breaker 7 Fails To Close Due To Mechanical Failure		7.04E-03		7.04E-03
AB7MECHDEX	Air Circuit Breaker 7 Fails To Open Due To Mechanical Failure		8.01E-04		8.01E-04
AB7OPENLHE	Air Circuit Breaker 7 Fails To Open Due To A Latent Human Error		3.20E-03		3.20E-03
AB7PUSHPBT	Trip Pushbutton On ACB7 Spurious Operation	2.40E-07 /H	30 H	Rule 1: Actuation prior to the emergency start would place the units in a configuration that is abnormal and not consistent with the modeling assumptions.	7.20E-06
AB7R52XRYD	Air Circuit Breaker 7 Relay 52X Fails To Operate	3.30E-05 /D	1 D	1 demand per emergency start required.	3.30E-05
AB7R52YRYD	Air Circuit Breaker 7 Relay 52Y Failed To Drop Out At Last Demand	3.30E-05 /D	1 D	1 demand per emergency start required.	3.30E-05
AB810A1FUF	One Or More Control Power Fuses For X, Y And CC Fail	3.60E-06 /H	6 H	Rule 2: Indicated by loss of position indication.	2.16E-05

[1]D=Demand, H=Hour

[2]Rules for assigning basic event factors are discussed in Table C.1-4

Table A.4-9

Air Circuit Breaker Reliability Data

Event Name	Description	Failure Rate[1]	Factor	Rational For Factor[2]	Failure Probability
AB81432RYT	Auxiliary Relay 143X/2 Spuriously Energizes	3.60E-07 /H	360 H	Half the time since the unit alignment was swapped. ACB 8 would fail to close.	1.30E-04
AB852CCRYD	Air Circuit Breaker 8 Close Coil CC Fails On Demand	3.30E-05 /D	1 D	1 demand per emergency start required.	3.30E-05
AB852TCRYT	Air Circuit Breaker 8 Trip Coil 52TC Spurious Operation	3.60E-07 /H	384 H	Rule 6: Would prevent ACB 8 from closing or remaining closed.	1.38E-04
AB852Y2RYT	Air Circuit Breaker 8 Y-relay Spurious Operation	3.60E-07 /H	360 H	Half the time since the unit alignment was swapped. ACB 8 would fail to close.	1.30E-04
AB86E1ARYD	Emergency Lock Out Aux. Relay 86E-1a Fails To Operate On Demand	3.30E-05 /D	1 D	1 demand per emergency start required.	3.30E-05
AB86E1GRYD	Keowee Unit 1 Emergency Lock Out Sensing Relay Fails To Operate	3.30E-05 /D	1 D	1 demand per emergency start required.	3.30E-05
AB883S8RYD	Time Delay Relay 83S8 Fails To Pick Up	3.30E-05 /D	1 D	1 demand per emergency start required.	3.30E-05
AB8KEYISWT	Air Circuit Breaker 8 Key Interlock Switch Transfers Open	7.00E-08 /H	360 H	Half the time since the unit alignment was swapped. ACB 8 would fail to close.	2.52E-05
AB8MCH2DEX	Air Circuit Breaker 8 Fails To Close Due To Mechanical Failure		7.04E-03		7.04E-03
AB8PUSHPBT	Trip Pushbutton On ACB8 Spurious Operation	2.40E-07 /H	384 H	Rule 6: Would prevent ACB 8 from closing or remaining closed.	9.22E-05
AB8R52XRYD	Air Circuit Breaker 8 Relay 52X Fails To Operate	3.30E-05 /D	1 D	1 demand per emergency start required.	3.30E-05
AB8R52YRYD	Air Circuit Breaker 8 Relay 52Y Failed To Drop Out At Last Demand	3.30E-05 /D	1 D	1 demand per emergency start required.	3.30E-05
ABEOPRCRHE	Operators Fail To Close Air Circuit Breaker 2		1		1.00E+00

[1]D=Demand, H=Hour

[2]Rules for assigning basic event factors are discussed in Table C.1-4

Table A.4-9

Air Circuit Breaker Reliability Data

Event Name	Description	Failure Rate[1]	Factor	Rational For Factor[2]	Failure Probability
ABPOPRCRHE	Operators Fail To Close Air Circuit Breaker 4		9.00E-03		9.00E-03
ACB4MOD	NSM-ON-52966 Is Not In Service		1		1.00E+00
ACBAIRPDEX	ACB Air Supply Fails Causing Low Pressure In All ACB Accumulators		2.00E-03		2.00E-03
ACBTRIPCHE	Operators Trip Gènerator Output ACBs		0		0.00E+00
AD1B4ALCDT	Breaker 4AL In 125 V dc Distribution Center 1DA Transfers Open	7.50E-08 /H	30 H	Breaker position change would be discovered by loss of lights during rounds. It is assumed that the demand for ACB 5 could come at any time during the mission.	2.25E-06
AD1C3CCCDT	Breaker 3CC In 125V dc Distribution Center 1DA Transfers Position	7.50E-08 /H	24 H	Rule 1: Loss of power is alarmed.	1.80E-06
AD1C3CLCDT	Breaker 3CL In 125V dc Distribution Center 1DA Transfers Position	7.50E-08 /H	24 H	Rule 1: Loss of power is alarmed.	1.80E-06
AD1SCLRCDT	Breaker 3CL In 125V dc Distribution Center 1DA Transfers Position (Rec)	7.50E-08 /H	12 H	The need for the recovery is assumed to occur half way through the mission.	9.00E-07
AD2B2ALCDT	Breaker 2AL In 125V dc Distribution Center 2DA Transfers Open	7.50E-08 /H	30 H	Breaker position change would be discovered by loss of lights during rounds. It is assumed that the demand for ACB 6 could come at any time during the mission.	2.25E-06
AD2B3CCCDT	Breaker 3CC In 125V dc Distribution Center 2DA Transfers Position	7.50E-08 /H	12 H	The need for ACB 4 is assumed to occur half way through the mission.	9.00E-07
AD2C3CLCDT	Breaker 3CL In 125V dc Distribution Center 2DA Transfers Position	7.50E-08 /H	24 H	Rule 1: Breaker transferring open would result in overhead transformer lock-out.	1.80E-06

[1]D=Demand, H=Hour

[2]Rules for assigning basic event factors are discussed in Table C.1-4

Table A.4-9

Air Circuit Breaker Reliability Data

Event Name	Description	Failure Rate[1]	Factor	Rational For Factor[2]	Failure Probability
AK1141XRYD	Auxiliary Relay 14GOV/1X Fails To Pick-up	3.30E-05 /D	1 D	1 demand per emergency start required.	3.30E-05
AK114GVDEX	KU1 Magnetic Speed Switch System Fails		1.00E-04		1.00E-04
AK121TDRYD	Time Delay Relay 2-1TD Fails To Pick-up	3.30E-05 /D	1 D	1 demand per emergency start required.	3.30E-05
AK152TDRYD	Time Delay Relay 52-1TD Fails To Pick-up	3.30E-05 /D	1 D	1 demand per emergency start required.	3.30E-05
AK152TDRYT	Time Delay Relay 52-1TD Spurious Operation	3.60E-07 /H	4380 H	Tested annually.	1.58E-03
AK152XGRYD	Relay 52XG/1 Fails To Pick Up When The Unit Is Started	3.30E-05 /D	1 D	1 demand per emergency start required.	3.30E-05
AK152XGRYT	Relay 52XG/1 Spuriously Drops Out While The Unit Is Running	3.60E-07 /H	2 H	Relay used to indicate that unit 1 is generating to the grid. Assumed that the unit generates 4 hours per day and used half of that time as the exposure time.	7.20E-07
AK1AX34RYT	Relay 52AX/34 Spuriously Drops-out	3.60E-07 /H	6 H	Rule 2: Failure would be indicated during the rounds by loss of indicating light.	2.16E-06
AK1GV1XRYD	Relay 14GOV/1X Fails To Pick-up	3.30E-05 /D	1 D	1 demand per emergency start required.	3.30E-05
AK1OFRQCOM	KU1 CCF Of 2/3 Overfrequency Relays To Reset When Frequency Drops		3.30E-06		3.30E-06
AK1X34XRYT	Relay 52AX/34X Spuriously Drops-out	3.60E-07 /H	6 H	Rule 2: Failure would be indicated during the rounds by loss of indicating light.	2.16E-06
AK212OSSST	Turbine Overspeed Switch Indicates Overspeed	4.20E-06 /H	36 H	Rule 6: With other events could result in trip of ACB 2.	1.51E-04
AK2142XRYD	Auxiliary Relay 14GOV/2X Fails To Pick-up	3.30E-05 /D	1 D	1 demand per emergency start required.	3.30E-05
AK214GVDEX	KU2 Magnetic Speed Switch System Fails		1.00E-04		1.00E-04

[1] D=Demand, H=Hour

[2] Rules for assigning basic event factors are discussed in Table C.1-4

Table A.4-9

Air Circuit Breaker Reliability Data

Event Name	Description	Failure Rate[1]	Factor	Rational For Factor[2]	Failure Probability
AK222TDRYD	Time Delay Relay 2-2TD Fails To Pick-up	3.30E-05 /D	1 D	1 demand per emergency start required.	3.30E-05
AK252TDRYD	Time Delay Relay 52-2TD Fails To Operate	3.30E-05 /D	1 D	1 demand per emergency start required.	3.30E-05
AK252TDRYT	Time Delay Relay 52-2TD Spurious Operation	3.60E-07 /H	4380 H	Tested annually.	1.58E-03
AK252W0RYD	KU2 Relay 52W Fails To Pick-up	3.30E-05 /D	1 D	1 demand per emergency start required.	3.30E-05
AK252XGRYD	Auxiliary Relay 52XG/2 Fails To Pick-up	3.30E-05 /D	1 D	1 demand per emergency start required.	3.30E-05
AK2GATEDEX	Wicket Gate Limit Switch Indicates Gate Position Is Below No-load Setting		2.11E-05		2.11E-05
AK2GV2XRYD	Relay 14GOV/2X Fails To Pick-up	3.30E-05 /D	1 D	1 demand per emergency start required.	3.30E-05
AK2OFRQCOM	KU2 CCF Of 2/3 Overfrequency Relays To Reset When Frequency Drops		3.30E-06		3.30E-06
KU2RNNG	Keowee Unit 2 Is Generating To The Grid		1.00E+00		1.00E+00
WK1SPD2DEX	Keowee Unit 1 Governor Failure Creates Overspeed Condition		1.20E-04		1.20E-04
WK2SPD2DEX	Keowee Unit 2 Governor Failure Creates Overspeed Condition		1.20E-04		1.20E-04
XA1BKRSCOM	CCF of 1X Aux Power Breakers ACB-5 & -7		3.10E-04		3.10E-04
XA2BKRSCOM	CCF of Aux Power Breakers ACB-6 & -8		3.10E-04		3.10E-04
XA56BKRCOM	Common Cause Failure Of ACB-5 And ACB-6 To Close		3.10E-04		3.10E-04
XA78BKRCOM	Common Cause Failure Of ACB-7 And ACB-8 To Close		3.10E-04		3.10E-04
YK286N2DEX	Keowee Unit 2 Normal Lockout Activates		7.41E-03		7.41E-03

[1]D=Demand, H=Hour

[2]Rules for assigning basic event factors are discussed in Table C.1-4

Table A.4-9

Air Circuit Breaker Reliability Data

Event Name	Description	Failure Rate[1]	Factor	Rational For Factor[2]	Failure Probability
YK299SXRYT	Shutdown Auxiliary Relay 99SX Spuriously Drops Out	3.60E-07 /H	24 H	Rule 1	8.64E-06
YKEMSRTCHE	Operator Incorrectly Resets Keowee Emergency Start Signals		0		0.00E+00

[1]D=Demand, H=Hour

[2]Rules for assigning basic event factors are discussed in Table C.1-4

Table A.4-10

Air Circuit Breaker Dominant Minimal Cut Sets

Cut Sets for Gate ACB1OPEN: ACB-1 Fails To Open

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
1)	1.58E-03	68.4%	AK152TDRYT	1.58E-03	Time Delay Relay 52-1TD Spurious Operation
2)	2.60E-04	11.3%	AB1OPENLHE	2.60E-04	Air Circuit Breaker 1 Fails To Open Due To A Latent Human Error
3)	2.49E-04	10.8%	AB1R52ZR6D	2.49E-04	Air Circuit Breaker 1 Relay 52Z Fails To Operate
4)	1.51E-04	6.5%	AB1MECHDEX	1.51E-04	Air Circuit Breaker 1 Fails To Open Due To Mechanical Failure
5)	3.51E-05	1.5%	AB1ACCUDEX	3.51E-05	Air Circuit Breaker 1 Accumulator Air Pressure Low
6)	2.90E-05	1.3%	AB152TCSVO	2.90E-05	Air Circuit Breaker 1 Trip Coil Fails To Operate
7)	5.16E-06	0.2%	AB1PS02PST	5.16E-06	Air Circuit Breaker 1 Accumulator Pressure Switch PS2 Fails Low
8)	1.80E-06	0.1%	AD1C3CLCDT	1.80E-06	Breaker 3CL In 125V dc Distribution Center 1DA Transfers Position

Total Event Probability = 2.31E-03

Table A.4-11

Air Circuit Breaker Dominant Minimal Cut Sets

Cut Sets for Gate ACB2CLOSE: ACB-2 Fails To Close

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
1)	3.02E-04	26.0%	AB2MCH2DEX	3.02E-04	Air Circuit Breaker 2 Fails To Close Due To Mechanical Failure
2)	2.49E-04	21.5%	AA227T2R6D	2.49E-04	Transformer #1 Undervoltage Relay (27T/2X) Fails To Drop Out
			ABEOPRCRHE	1.00E+00	Operators Fail To Close Air Circuit Breaker 2
3)	2.49E-04	21.5%	AB2R52XR6D	2.49E-04	Air Circuit Breaker 2 Relay 52X Fails To Operate
4)	2.49E-04	21.5%	AB252Y2R6D	2.49E-04	Air Circuit Breaker 2 Relay 52Y Failed To Drop Out Following Last Demand
5)	3.51E-05	3.0%	AB2ACCUDEX	3.51E-05	Air Circuit Breaker 2 Accumulator Air Pressure Low
6)	3.30E-05	2.8%	ABEOPRCRHE	1.00E+00	Operators Fail To Close Air Circuit Breaker 2
			AK252TDRYD	3.30E-05	Time Delay Relay 52-2TD Fails To Operate
7)	2.90E-05	2.5%	AB252CCSVO	2.90E-05	Air Circuit Breaker 2 Close Coil Fails To Operate

Total Event Probability = 1.16E-03

Table A.4-12

Air Circuit Breaker Dominant Minimal Cut Sets

Cut Sets for Gate ACB2OPEN: ACB-2 Fails To Open

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
1)	1.58E-03	68.4%	AK252TDRYT	1.58E-03	Time Delay Relay 52-2TD Spurious Operation
			KU2RNNG	1.00E+00	Keowee Unit 2 Is Supplying The Grid
2)	2.60E-04	11.3%	AB2OPENLHE	2.60E-04	Air Circuit Breaker 2 Fails To Open Due To A Latent Human Error
3)	2.49E-04	10.8%	AB2R52ZR6D	2.49E-04	Air Circuit Breaker 2 Relay 52Z Fails To Operate
4)	1.51E-04	6.5%	AB2MECHDEX	1.51E-04	Air Circuit Breaker 2 Fails To Open Due To Mechanical Failure
5)	3.51E-05	1.5%	AB2ACCUDEX	3.51E-05	Air Circuit Breaker 2 Accumulator Air Pressure Low
6)	2.90E-05	1.3%	AB252TCSVO	2.90E-05	Air Circuit Breaker 2 Trip Coil Fails To Operate
7)	5.16E-06	0.2%	AB2PS02PST	5.16E-06	Air Circuit Breaker 2 Accumulator Pressure Switch PS2 Fails Low
8)	1.80E-06	0.1%	AD2C3CLCDT	1.80E-06	Breaker 3CL In 125V dc Distribution Center 2DA Transfers Position
9)	1.20E-08	0.0%	AK214GVDEX	1.00E-04	KU2 Magnetic Speed Switch System Fails
			WK2SPD2DEX	1.20E-04	Keowee Unit 2 Governor Failure Creates Overspeed Condition
10)	3.96E-09	0.0%	AK252TDRYD	3.30E-05	Time Delay Relay 52-2TD Fails To Operate
			WK2SPD2DEX	1.20E-04	Keowee Unit 2 Governor Failure Creates Overspeed Condition
11)	3.96E-09	0.0%	AK2GV2XRYD	3.30E-05	Relay 14GOV/2X Fails To Pick-up
			WK2SPD2DEX	1.20E-04	Keowee Unit 2 Governor Failure Creates Overspeed Condition

Total Event Probability = 2.31E-03

Table A.4-13

Air Circuit Breaker Dominant Minimal Cut Sets

Cut Sets for Gate ACB2TRANS: ACB-2 Transfers Open

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
1)	1.40E-05	21.9%	AB252TCSVT	1.40E-05	Air Circuit Breaker 2 Trip Coil Spurious Operation
2)	1.31E-05	20.5%	AB2R52ZR6T	1.31E-05	Air Circuit Breaker 2 Relay 52Z Spurious Operation
3)	8.64E-06	13.5%	AB2R462RYT	8.64E-06	Air Circuit Breaker 2 Negative Sequence Relay 46-2 Spurious Operation
4)	8.64E-06	13.5%	AB2PUSHPBT	8.64E-06	Trip Pushbutton On ACB2 Spurious Operation
5)	8.64E-06	13.5%	AB251G2RYT	8.64E-06	Air Circuit Breaker 2 Overcurrent Ground Relay 51G-2 Spurious Operation
6)	8.64E-06	13.5%	AB22BV1RYT	8.64E-06	Backup Undervoltage Relay 2BV1 Spurious Operation
7)	2.10E-06	3.3%	AB21521SWT	2.10E-06	Control Switch 152-2 Spurious Operation

Total Event Probability = 6.38E-05

Table A.4-14

Air Circuit Breaker Dominant Minimal Cut Sets

Cut Sets for Gate ACB3CLOSE: ACB-3 Fails To Close

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
1)	3.02E-04	20.8%	AB3MCH2DEX	3.02E-04	Air Circuit Breaker 3 Fails To Close Due To Mechanical Failure
2)	2.60E-04	17.9%	AB3CLOSLHE	2.60E-04	Air Circuit Breaker 3 Fails To Close Due To Latent Human Error
3)	2.49E-04	17.2%	AB3R52XR6D	2.49E-04	Air Circuit Breaker 3 Relay 52X Fails To Operate
4)	2.49E-04	17.2%	AB352Y2R6D	2.49E-04	Air Circuit Breaker 3 Relay 52Y Failed To Drop Out Following Last Demand
5)	1.60E-04	11.0%	AB3PS02PST	1.60E-04	Air Circuit Breaker 3 Accumulator Pressure Switch PS2 Fails Low
6)	1.31E-04	9.0%	AB352Y2R6T	1.31E-04	Air Circuit Breaker 3 Y-relay Spurious Operation
7)	3.51E-05	2.4%	AB3ACCUDEX	3.51E-05	Air Circuit Breaker 3 Accumulator Air Pressure Low
8)	3.30E-05	2.3%	AK121TDRYD	3.30E-05	Time Delay Relay 2-1TD Fails To Pick-up
9)	2.90E-05	2.0%	AB352CCSVO	2.90E-05	Air Circuit Breaker 3 Close Coil Fails To Operate

Total Event Probability = 1.45E-03

Table A.4-15

Air Circuit Breaker Dominant Minimal Cut Sets

Cut Sets for Gate ACB3OPEN: ACB-3 Fails To Open

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
1)	2.49E-04	39.8%	AB3R52ZR6D	2.49E-04	Air Circuit Breaker 3 Relay 52Z Fails To Operate
2)	1.60E-04	25.6%	AB3PS02PST	1.60E-04	Air Circuit Breaker 3 Accumulator Pressure Switch PS2 Fails Low
3)	1.51E-04	24.1%	AB3MECHDEX	1.51E-04	Air Circuit Breaker 3 Fails To Open Due To Mechanical Failure
4)	3.51E-05	5.6%	AB3ACCUDEX	3.51E-05	Air Circuit Breaker 3 Accumulator Air Pressure Low
5)	2.90E-05	4.6%	AB352TCSVO	2.90E-05	Air Circuit Breaker 3 Trip Coil Fails To Operate

Total Event Probability = 6.26E-04

Table A.4-16

Air Circuit Breaker Dominant Minimal Cut Sets

Cut Sets for Gate ACB3TRANS: ACB-3 Transfers Open

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
1)	9.36E-06	36.7%	AB352TCSVT	9.36E-06	Air Circuit Breaker 3 Trip Coil Spurious Operation
2)	8.71E-06	34.2%	AB3R52ZR6T	8.71E-06	Air Circuit Breaker 3 Relay 52Z Spurious Operation
3)	5.76E-06	22.6%	AB3PUSHPBT	5.76E-06	Trip Pushbutton On ACB3 Spurious Operation
4)	1.68E-06	6.6%	AB31523SWT	1.68E-06	Control Switch 152-3 Spurious Operation

Total Event Probability = 2.55E-05

Table A.4-17

Air Circuit Breaker Dominant Minimal Cut Sets

Cut Sets for Gate ACB4CLOSE: ACB-4 Fails To Close

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
1)	9.00E-03	72.6%	ABPOPRCRHE	9.00E-03	Operators Fail To Close Air Circuit Breaker 4
			ACB4MOD	1.00E+00	NSM-ON-52966 Is Not In Service
2)	2.00E-03	16.1%	ACBAIRPDEX	2.00E-03	ACB Air Supply Fails Causing Low Pressure In All ACB Accumulators
3)	3.02E-04	2.4%	AB4MCH2DEX	3.02E-04	Air Circuit Breaker 4 Fails To Close Due To Mechanical Failure
4)	2.60E-04	2.1%	AB4CLOSLHE	2.60E-04	Air Circuit Breaker 4 Fails To Close Due To A Latent Human Error
5)	2.49E-04	2.0%	AB452Y2R6D	2.49E-04	Air Circuit Breaker 4 Relay 52Y Failed To Drop Out Following Last Demand
6)	2.49E-04	2.0%	AB4R52XR6D	2.49E-04	Air Circuit Breaker 4 Relay 52X Fails To Operate
7)	1.60E-04	1.3%	AB4PS02PST	1.60E-04	Air Circuit Breaker 4 Accumulator Pressure Switch PS2 Indicates Low Pres
8)	1.35E-04	1.1%	AB452Y2R6T	1.35E-04	Air Circuit Breaker 4 Y-relay Spurious Operation

Total Event Probability = 1.24E-02

Table A.4-18

Air Circuit Breaker Dominant Minimal Cut Sets

Cut Sets for Gate ACB4TRANS: ACB-4 Transfers Open

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
1)	9.36E-06	36.7%	AB452TCSVT	9.36E-06	Air Circuit Breaker 4 Trip Coil Spurious Operation
2)	8.71E-06	34.2%	AB4R52ZR6T	8.71E-06	Air Circuit Breaker 4 Relay 52Z Spurious Operation
3)	5.76E-06	22.6%	AB4PUSHPBT	5.76E-06	Trip Pushbutton On ACB-4 Spurious Operation
4)	1.68E-06	6.6%	AB41523SWT	1.68E-06	Control Switch 152-4 Spurious Operation

Total Event Probability = 2.55E-05

Table A.4-19

Air Circuit Breaker Dominant Minimal Cut Sets

Cut Sets for Gate ACB5CLOSE: ACB-5 Fails To Close

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
1)	7.04E-03	52.9%	AB5MCH2DEX	7.04E-03	Air Circuit Breaker 5 Fails To Close Due To Mechanical Failure
2)	3.20E-03	24.1%	AB7OPENLHE	3.20E-03	Air Circuit Breaker 7 Fails To Open Due To A Latent Human Error
3)	8.01E-04	6.0%	AB7MECHDEX	8.01E-04	Air Circuit Breaker 7 Fails To Open Due To Mechanical Failure
4)	3.20E-04	2.4%	AB51431LHE	3.20E-04	Manual/Auto Control Switch 143/1 Left In Manual
5)	3.10E-04	2.3%	XA1BKRSCOM	3.10E-04	CCF of 1X Aux Power Breakers ACB-5 & -7
6)	3.10E-04	2.3%	XA56BKRCOM	3.10E-04	Common Cause Failure Of ACB-5 And ACB-6 To Close
7)	2.60E-04	2.0%	AB5CLOSLHE	2.60E-04	Air Circuit Breaker 5 Fails To Close Due To A Latent Human Error
8)	2.49E-04	1.9%	AA1271PR6D	2.49E-04	Transformer 1X Undervoltage Relay 27/1X Fails To Pick Up
9)	2.49E-04	1.9%	AA127X2R6D	2.49E-04	Transformer CX Undervoltage Relay 27/CX1 Fails To Drop Out
10)	1.30E-04	1.0%	AB51431RYT	1.30E-04	Auxiliary Relay 143X/1 Spuriously Energizes
11)	1.30E-04	1.0%	AB552Y2RYT	1.30E-04	Air Circuit Breaker 5 Y-relay Spurious Operation

Total Event Probability = 1.33E-02

Table A.4-20

Air Circuit Breaker Dominant Minimal Cut Sets

Cut Sets for Gate ACB5TRANS: ACB-5 Transfers Open

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
1)	1.38E-04	35.6%	AA127X1RYT	1.38E-04	Auxiliary Relay 27X/1X Spurious Operation
2)	1.38E-04	35.6%	AB552TCRYT	1.38E-04	Air Circuit Breaker 5 Trip Coil 52TC Spurious Operation
3)	9.22E-05	23.8%	AB5PUSHPBT	9.22E-05	Trip Pushbutton On ACB5 Spurious Operation
4)	1.09E-05	2.8%	AA1271XR6T	1.09E-05	Transformer 1X Undervoltage Relay 27/1X Spuriously De-energizes
5)	8.64E-06	2.2%	AA186S1RYT	8.64E-06	Switchgear 1X Lockout Relay 86S/1X Spurious Operation

Total Event Probability = 3.88E-04

Table A.4-21

Air Circuit Breaker Dominant Minimal Cut Sets

Cut Sets for Gate ACB6CLOSE: ACB-6 Fails To Close

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
1)	7.04E-03	79.9%	AB6MCH2DEX	7.04E-03	Air Circuit Breaker 6 Fails To Close Due To Mechanical Failure
2)	3.20E-04	3.6%	AB61432LHE	3.20E-04	Manual/Auto Control Switch 143/2 Left In Manual
3)	3.10E-04	3.5%	XA56BKRCOM	3.10E-04	Common Cause Failure Of ACB-5 And ACB-6 To Close
4)	3.10E-04	3.5%	XA2BKRSCOM	3.10E-04	CCF of Aux Power Breakers ACB-6 & -8
5)	2.60E-04	3.0%	AB6CLOSLHE	2.60E-04	Air Circuit Breaker 6 Fails To Close Due To A Latent Human Error
6)	2.49E-04	2.8%	AA2272PR6D	2.49E-04	Transformer 2X Undervoltage Relay 27/2X Fails To Pick Up
7)	1.30E-04	1.5%	AB652Y2RYT	1.30E-04	Air Circuit Breaker 6 Y-relay Spurious Operation

Total Event Probability = 8.81E-03

Table A.4-22

Air Circuit Breaker Dominant Minimal Cut Sets

Cut Sets for Gate ACB6OPEN: ACB-6 Fails To Open

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
1)	3.20E-03	68.4%	AB6OPENLHE	3.20E-03	Air Circuit Breaker 6 Fails To Open Due To A Latent Human Error
2)	8.01E-04	17.1%	AB6MECHDEX	8.01E-04	Air Circuit Breaker 6 Fails To Open Due To Mechanical Failure
3)	3.20E-04	6.8%	AB61432LHE	3.20E-04	Manual/Auto Control Switch 143/2 Left In Manual
4)	2.49E-04	5.3%	AA2272XR6D	2.49E-04	Transformer 2X Undervoltage Relay 27/2X Fails To Drop Out

Total Event Probability = 4.68E-03

Table A.4-23

Air Circuit Breaker Dominant Minimal Cut Sets

Cut Sets for Gate ACB6TRANS: ACB-6 Transfers Open

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
1)	8.71E-06	21.6%	AA2272XR6T	8.71E-06	Transformer 2X Undervoltage Relay 27/2X Spuriously De-energizes
2)	8.64E-06	21.4%	AA227X2RYT	8.64E-06	Auxiliary Relay 27X/2X Spurious Operation
3)	8.64E-06	21.4%	AB652TCRYT	8.64E-06	Air Circuit Breaker 6 Trip Coil 52TC Spurious Operation
4)	8.64E-06	21.4%	AA286S2RYT	8.64E-06	Switchgear 2X Lockout Relay 86S/2X Spurious Operation
5)	5.76E-06	14.3%	AB6PUSHPBT	5.76E-06	Trip Pushbutton On ACB6 Spurious Operation

Total Event Probability = 4.04E-05

Table A.4-24

Air Circuit Breaker Dominant Minimal Cut Sets

Cut Sets for Gate ACB7CLOSE: ACB-7 Fails To Close

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
1)	7.04E-03	79.9%	AB7MCH2DEX	7.04E-03	Air Circuit Breaker 7 Fails To Close Due To Mechanical Failure
2)	3.20E-04	3.6%	AB51431LHE	3.20E-04	Manual/Auto Control Switch 143/1 Left In Manual
3)	3.10E-04	3.5%	XA78BKRCOM	3.10E-04	Common Cause Failure Of ACB-7 And ACB-8 To Close
4)	3.10E-04	3.5%	XA1BKRSCOM	3.10E-04	CCF of 1X Aux Power Breakers ACB-5 & -7
5)	2.60E-04	3.0%	AB7CLOSLHE	2.60E-04	Air Circuit Breaker 7 Fails To Close Due To A Latent Human Error
6)	2.49E-04	2.8%	AA127CPR6D	2.49E-04	Transformer CX Undervoltage Relay 27/CX1 Fails To Pick Up
7)	1.30E-04	1.5%	AB752Y2RYT	1.30E-04	Air Circuit Breaker 7 Y-relay Spurious Operation

Total Event Probability = 8.81E-03

Table A.4-25

Air Circuit Breaker Dominant Minimal Cut Sets

Cut Sets for Gate ACB7OPEN: ACB-7 Fails To Open

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
1)	3.20E-03	68.4%	AB7OPENLHE	3.20E-03	Air Circuit Breaker 7 Fails To Open Due To A Latent Human Error
2)	8.01E-04	17.1%	AB7MECHDEX	8.01E-04	Air Circuit Breaker 7 Fails To Open Due To Mechanical Failure
3)	3.20E-04	6.8%	AB51431LHE	3.20E-04	Manual/Auto Control Switch 143/1 Left In Manual
4)	2.49E-04	5.3%	AA127X2R6D	2.49E-04	Transformer CX Undervoltage Relay 27/CX1 Fails To Drop Out

Total Event Probability = 4.68E-03

Table A.4-26

Air Circuit Breaker Dominant Minimal Cut Sets

Cut Sets for Gate ACB7TRANS: ACB-7 Transfers Open

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
1)	8.71E-06	14.7%	AA127C1R6T	8.71E-06	Transformer CX Undervoltage Relay 27/CX1 Spuriously De-energizes
2)	8.64E-06	14.6%	AA127R1RYT	8.64E-06	Auxiliary Relay 27X/CX1 Spurious Operation
3)	8.64E-06	14.6%	AB752TCRYT	8.64E-06	Air Circuit Breaker 7 Trip Coil 52TC Spurious Operation
4)	8.64E-06	14.6%	AA187CXRYT	8.64E-06	Transformer CX Differential Relay 87CX Spurious Operation
5)	8.64E-06	14.6%	AA186S1RYT	8.64E-06	Switchgear 1X Lockout Relay 86S/1X Spurious Operation
6)	8.64E-06	14.6%	AA186CXRYT	8.64E-06	Transformer CX Differential Lock Out Relay 86CX Spurious Operation
7)	7.20E-06	12.2%	AB7PUSHPBT	7.20E-06	Trip Pushbutton On ACB7 Spurious Operation

Total Event Probability = 5.91E-05

Table A.4-27

Air Circuit Breaker Dominant Minimal Cut Sets

Cut Sets for Gate ACB8CLOSE: ACB-8 Fails To Close

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
1)	7.04E-03	54.2%	AB8MCH2DEX	7.04E-03	Air Circuit Breaker 8 Fails To Close Due To Mechanical Failure
2)	3.20E-03	24.6%	AB6OPENLHE	3.20E-03	Air Circuit Breaker 6 Fails To Open Due To A Latent Human Error
3)	8.01E-04	6.2%	AB6MECHDEX	8.01E-04	Air Circuit Breaker 6 Fails To Open Due To Mechanical Failure
4)	3.20E-04	2.5%	AB61432LHE	3.20E-04	Manual/Auto Control Switch 143/2 Left In Manual
5)	3.10E-04	2.4%	XA2BKRSCOM	3.10E-04	CCF of Aux Power Breakers ACB-6 & -8
6)	3.10E-04	2.4%	XA78BKRCOM	3.10E-04	Common Cause Failure Of ACB-7 And ACB-8 To Close
7)	2.49E-04	1.9%	AA227CPR6D	2.49E-04	Transformer CX Undervoltage Relay 27/CX2 Fails To Pick Up
8)	2.49E-04	1.9%	AA2272XR6D	2.49E-04	Transformer 2X Undervoltage Relay 27/2X Fails To Drop Out
9)	1.30E-04	1.0%	AB81432RYT	1.30E-04	Auxiliary Relay 143X/2 Spuriously Energizes
10)	1.30E-04	1.0%	AB852Y2RYT	1.30E-04	Air Circuit Breaker 8 Y-relay Spurious Operation

Total Event Probability = 1.30E-02

Table A.4-28

Air Circuit Breaker Dominant Minimal Cut Sets

Cut Sets for Gate ACB8TRANS: ACB-8 Transfers Open

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
1)	1.38E-04	34.1%	AA227R2RYT	1.38E-04	Auxiliary Relay 27X/CX2 Spurious Operation
2)	1.38E-04	34.1%	AB852TCRYT	1.38E-04	Air Circuit Breaker 8 Trip Coil 52TC Spurious Operation
3)	9.22E-05	22.8%	AB8PUSHPBT	9.22E-05	Trip Pushbutton On ACB8 Spurious Operation
4)	1.09E-05	2.7%	AA227C2R6T	1.09E-05	Transformer CX Undervoltage Relay 27/CX2 Spuriously De-energizes
5)	8.64E-06	2.1%	AA286S2RYT	8.64E-06	Switchgear 2X Lockout Relay 86S/2X Spurious Operation
6)	8.64E-06	2.1%	AA187CXRYT	8.64E-06	Transformer CX Differential Relay 87CX Spurious Operation
7)	8.64E-06	2.1%	AA186CXRYT	8.64E-06	Transformer CX Differential Lock Out Relay 86CX Spurious Operation

Total Event Probability=4.05E-04

Table A.4-29

Air Circuit Breaker Dominant Contributors To Unavailability

Rank	Event Description	Mean Unavailability[1]	Approximate Unavailability Contribution[2]
Air Circuit Breaker 1 Fails To Open			
1	AK152TDRYT Time Delay Relay 52-1TD Spurious Operation	1.58E-03	68.3%
2	AB1OPENLHE Air Circuit Breaker 1 Fails To Open Due To A Latent Human Error	2.59E-04	11.2%
3	AB1R52ZR6D Air Circuit Breaker 1 Relay 52Z Fails To Operate	2.49E-04	10.8%
4	AB1MECHDEX Air Circuit Breaker 1 Fails To Open Due To Mechanical Failure	1.51E-04	6.5%
5	AB1ACCUDEX Air Circuit Breaker 1 Accumulator Air Pressure Low	3.51E-05	1.5%
6	AB152TCSVO Air Circuit Breaker 1 Trip Coil Fails To Operate	2.89E-05	1.3%

[1] The mean unavailability is the summation of the values of all cut sets in which the event appears

[2] The contribution to unavailability is calculated by dividing the mean unavailability by the overall system unavailability and then multiplying by 100 percent

Table A.4-30

Air Circuit Breaker Dominant Contributors To Unavailability

Rank	Event Description	Mean Unavailability[1]	Approximate Unavailability Contribution[2]
	Air Circuit Breaker 2 Fails To Close		
1	AB2MCH2DEX Air Circuit Breaker 2 Fails To Close Due To Mechanical Failure	2.82E-04	26.1%
2	ABEOPRCRHE Operators Fail To Close Air Circuit Breaker 2	2.49E-04	24.3%
3	AB252Y2R6D Air Circuit Breaker 2 Relay 52Y Failed To Drop Out Following Last Demand	2.49E-04	21.5%
4	AB2R52XR6D Air Circuit Breaker 2 Relay 52X Fails To Operate	2.49E-04	21.5%
5	AA227T2R6D Transformer #1 Undervoltage Relay (27T/2X) Fails To Drop Out	3.51E-05	21.5%
6	AB2ACCUDEX Air Circuit Breaker 2 Accumulator Air Pressure Low	3.31E-05	3.0%
7	AK252TDRYD Time Delay Relay 52-2TD Fails To Operate	2.90E-05	2.9%

[1] The mean unavailability is the summation of the values of all cut sets in which the event appears

[2] The contribution to unavailability is calculated by dividing the mean unavailability by the overall system unavailability and then multiplying by 100 percent

Table A.4-31

Air Circuit Breaker Dominant Contributors To Unavailability

Rank	Event Description	Mean Unavailability[1]	Approximate Unavailability Contribution[2]
	Air Circuit Breaker 2 Fails To Open		
1	AK252TDRYT Time Delay Relay 52-2TD Spurious Operation	1.58E-03	68.3%
2	AB2OPENLHE Air Circuit Breaker 2 Fails To Open Due To A Latent Human Error	2.59E-04	11.2%
3	AB2R52ZR6D Air Circuit Breaker 2 Relay 52Z Fails To Operate	2.49E-04	10.8%
4	AB2MECHDEX Air Circuit Breaker 2 Fails To Open Due To Mechanical Failure	1.51E-04	6.5%
5	AB2ACCUDEX Air Circuit Breaker 2 Accumulator Air Pressure Low	3.51E-05	1.5%
6	AB252TCSVO Air Circuit Breaker 2 Trip Coil Fails To Operate	2.89E-05	1.3%

[1] The mean unavailability is the summation of the values of all cut sets in which the event appears

[2] The contribution to unavailability is calculated by dividing the mean unavailability by the overall system unavailability and then multiplying by 100 percent

Table A.4-32

Air Circuit Breaker Dominant Contributors To Unavailability

Rank	Event Description	Mean Unavailability[1]	Approximate Unavailability Contribution[2]
	Air Circuit Breaker 2 Transfers Open		
1	AB252TCSVT Air Circuit Breaker 2 Trip Coil Spurious Operation	1.40E-05	22.0%
2	AB2R52ZR6T Air Circuit Breaker 2 Relay 52Z Spurious Operation	1.31E-05	20.5%
3	AB2PUSHPBT Trip Pushbutton On ACB2 Spurious Operation	8.61E-06	13.5%
4	AB22BV1RYT Backup Undervoltage Relay 2BV1 Spurious Operation	8.61E-06	13.5%
5	AB2R462RYT Air Circuit Breaker 2 Negative Sequence Relay 46-2 Spurious Operation	8.61E-06	13.5%
6	AB251G2RYT Air Circuit Breaker 2 Overcurrent Ground Relay 51G-2 Spurious Operation	8.61E-06	13.5%
7	AB21521SWT Control Switch 152-2 Spurious Operation	2.10E-06	3.3%

[1] The mean unavailability is the summation of the values of all cut sets in which the event appears

[2] The contribution to unavailability is calculated by dividing the mean unavailability by the overall system unavailability and then multiplying by 100 percent

Table A.4-33

Air Circuit Breaker Dominant Contributors To Unavailability

Rank	Event Description	Mean Unavailability[1]	Approximate Unavailability Contribution[2]
	Air Circuit Breaker 3 Fails To Close		
1	AB3MCH2DEX Air Circuit Breaker 3 Fails To Close Due To Mechanical Failure	3.00E-04	21%
2	AB3CLOSLHE Air Circuit Breaker 3 Fails To Close Due To Latent Human Error	2.60E-04	18%
3	AB352Y2R6D Air Circuit Breaker 3 Relay 52Y Failed To Drop Out Following Last Demand	2.48E-04	17%
4	AB3R52XR6D Air Circuit Breaker 3 Relay 52X Fails To Operate	2.48E-04	17%
5	AB3PS02PST Air Circuit Breaker 3 Accumulator Pressure Switch PS2 Fails Low	1.60E-04	11%
6	AB352Y2R6T Air Circuit Breaker 3 Y-relay Spurious Operation	1.30E-04	9%
7	AB3ACCUDEX Air Circuit Breaker 3 Accumulator Air Pressure Low	3.49E-05	2%
8	AK121TDRYD Time Delay Relay 2-1TD Fails To Pick-up	3.29E-05	2%
9	AB352CCSVO Air Circuit Breaker 3 Close Coil Fails To Operate	2.89E-05	2%

[1] The mean unavailability is the summation of the values of all cut sets in which the event appears

[2] The contribution to unavailability is calculated by dividing the mean unavailability by the overall system unavailability and then multiplying by 100 percent

Table A.4-34

Air Circuit Breaker Dominant Contributors To Unavailability

Rank	Event Description	Mean Unavailability[1]	Approximate Unavailability Contribution[2]
Air Circuit Breaker 3 Fails To Open			
1	AB3R52ZR6D Air Circuit Breaker 3 Relay 52Z Fails To Operate	2.49E-04	39.8%
2	AB3PS02PST Air Circuit Breaker 3 Accumulator Pressure Switch PS2 Fails Low	1.60E-04	25.6%
3	AB3MECHDEX Air Circuit Breaker 3 Fails To Open Due To Mechanical Failure	1.51E-04	24.1%
4	AB3ACCUDEX Air Circuit Breaker 3 Accumulator Air Pressure Low	3.51E-05	5.6%
5	AB352TCSVO Air Circuit Breaker 3 Trip Coil Fails To Operate	2.90E-05	4.6%

[1] The mean unavailability is the summation of the values of all cut sets in which the event appears

[2] The contribution to unavailability is calculated by dividing the mean unavailability by the overall system unavailability and then multiplying by 100 percent

Table A.4-35

Air Circuit Breaker Dominant Contributors To Unavailability

Rank	Event Description	Mean Unavailability[1]	Approximate Unavailability Contribution[2]
Air Circuit Breaker 3 Transfers Open			
1	AB352TCSVT Air Circuit Breaker 3 Trip Coil Spurious Operation	9.36E-06	36.7%
2	AB3R52ZR6T Air Circuit Breaker 3 Relay 52Z Spurious Operation	8.7E-06	34.1%
3	AB3PUSHPBT Trip Pushbutton On ACB3 Spurious Operation	5.76E-06	22.6%
4	AB31523SWT Control Switch 152-3 Spurious Operation	1.68E-06	6.6%

[1] The mean unavailability is the summation of the values of all cut sets in which the event appears

[2] The contribution to unavailability is calculated by dividing the mean unavailability by the overall system unavailability and then multiplying by 100 percent

Table A.4-36

Air Circuit Breaker Dominant Contributors To Unavailability

Rank	Event Description	Mean Unavailability[1]	Approximate Unavailability Contribution[2]
	Air Circuit Breaker 4 Fails To Close		
1	ACB4MOD NSM-ON-52966 Is Not In Service	8.97E-03	72.3%
2	ABPOPRCRHE Operators Fail To Close Air Circuit Breaker 4	8.94E-03	72.1%
3	ACBAIRPDEX ACB Air Supply Fails Causing Low Pressure In All ACB Accumulators	1.97E-03	15.9%
4	AB4MCH2DEX Air Circuit Breaker 4 Fails To Close Due To Mechanical Failure	2.98E-04	2.4%
5	AB4CLOSLHE Air Circuit Breaker 4 Fails To Close Due To A Latent Human Error	2.55E-04	2.1%
6	AB452Y2R6D Air Circuit Breaker 4 Relay 52Y Failed To Drop Out Following Last Demand	2.46E-04	2.0%
7	AB4R52XR6D Air Circuit Breaker 4 Relay 52X Fails To Operate	2.46E-04	2.0%
8	AB4PS02PST Air Circuit Breaker 4 Accumulator Pressure Switch PS2 Indicates Low Pres	1.57E-04	1.3%
9	AB452Y2R6T Air Circuit Breaker 4 Y-relay Spurious Operation	1.33E-04	1.1%

[1] The mean unavailability is the summation of the values of all cut sets in which the event appears

[2] The contribution to unavailability is calculated by dividing the mean unavailability by the overall system unavailability and then multiplying by 100 percent

Table A.4-37

Air Circuit Breaker Dominant Contributors To Unavailability

Rank	Event Description	Mean Unavailability[1]	Approximate Unavailability Contribution[2]
	Air Circuit Breaker 4 Transfers Open		
1	AB452TCSVT Air Circuit Breaker 4 Trip Coil Spurious Operation	9.36E-06	36.7%
2	AB4R52ZR6T Air Circuit Breaker 4 Relay 52Z Spurious Operation	8.7E-06	34.1%
3	AB4PUSHPBT Trip Pushbutton On ACB-4 Spurious Operation	5.76E-06	22.6%
4	AB41523SWT Control Switch 152-4 Spurious Operation	1.68E-06	6.6%

[1] The mean unavailability is the summation of the values of all cut sets in which the event appears

[2] The contribution to unavailability is calculated by dividing the mean unavailability by the overall system unavailability and then multiplying by 100 percent

Table A.4-38

Air Circuit Breaker Dominant Contributors To Unavailability

Rank	Event Description	Mean Unavailability[1]	Approximate Unavailability Contribution[2]
Air Circuit Breaker 5 Fails To Close			
1	AB5MCH2DEX Air Circuit Breaker 5 Fails To Close Due To Mechanical Failure	7.01E-03	52.7%
2	AB7OPENLHE Air Circuit Breaker 7 Fails To Open Due To A Latent Human Error	3.18E-03	23.9%
3	AB7MECHDEX Air Circuit Breaker 7 Fails To Open Due To Mechanical Failure	7.93E-04	6.0%
4	AB51431LHE Manual/Auto Control Switch 143/1 Left In Manual	3.17E-04	2.4%
5	XA1BKRSCOM CCF of 1X Aux Power Breakers ACB-5 & -7	3.07E-04	2.3%
6	XA56BKRCOM Common Cause Failure Of ACB-5 And ACB-6 To Close	3.07E-04	2.3%
7	AB5CLOSLHE Air Circuit Breaker 5 Fails To Close Due To A Latent Human Error	2.57E-04	1.9%
8	AA127X2R6D Transformer CX Undervoltage Relay 27/CX1 Fails To Drop Out	2.46E-04	1.9%
9	AA1271PR6D Transformer 1X Undervoltage Relay 27/1X Fails To Pick Up	2.46E-04	1.9%

[1] The mean unavailability is the summation of the values of all cut sets in which the event appears

[2] The contribution to unavailability is calculated by dividing the mean unavailability by the overall system unavailability and then multiplying by 100 percent

Table A.4-39

Air Circuit Breaker Dominant Contributors To Unavailability

Rank	Event Description	Mean Unavailability[1]	Approximate Unavailability Contribution[2]
Air Circuit Breaker 5 Transfers Open			
1	AB552TCRYT Air Circuit Breaker 5 Trip Coil 52TC Spurious Operation	1.38E-04	35.6%
2	AA127X1RYT Auxiliary Relay 27X/1X Spurious Operation	1.38E-04	35.6%
3	AB5PUSHPBT Trip Pushbutton On ACB5 Spurious Operation	9.20E-05	23.7%
4	AA1271XR6T Transformer 1X Undervoltage Relay 27/1X Spuriously De-energizes	1.09E-05	2.8%
5	AA186S1RYT Switchgear 1X Lockout Relay 86S/1X Spurious Operation	8.65E-06	2.2%

1 The mean unavailability is the summation of the values of all cut sets in which the event appears

2 The contribution to unavailability is calculated by dividing the mean unavailability by the overall system unavailability and then multiplying by 100 percent

Table A.4-40

Air Circuit Breaker Dominant Contributors To Unavailability

Rank	Event Description	Mean Unavailability[1]	Approximate Unavailability Contribution[2]
	Air Circuit Breaker 6 Fails To Close		
1	AB6MCH2DEX Air Circuit Breaker 6 Fails To Close Due To Mechanical Failure	7.03E-03	79.8%
2	AB61432LHE Manual/Auto Control Switch 143/2 Left In Manual	3.17E-04	3.6%
3	XA2BKRSCOM CCF of Aux Power Breakers ACB-6 & -8	3.07E-04	3.5%
4	XA56BKRCOM Common Cause Failure Of ACB-5 And ACB-6 To Close	3.07E-04	3.5%
5	AB6CLOSLHE Air Circuit Breaker 6 Fails To Close Due To A Latent Human Error	2.58E-04	2.9%
6	AA2272PR6D Transformer 2X Undervoltage Relay 27/2X Fails To Pick Up	2.47E-04	2.8%
7	AB652Y2RYT Air Circuit Breaker 6 Y-relay Spurious Operation	1.29E-04	1.5%

[1] The mean unavailability is the summation of the values of all cut sets in which the event appears

[2] The contribution to unavailability is calculated by dividing the mean unavailability by the overall system unavailability and then multiplying by 100 percent

Table A.4-41

Air Circuit Breaker Dominant Contributors To Unavailability

Rank	Event Description	Mean Unavailability[1]	Approximate Unavailability Contribution[2]
Air Circuit Breaker 6 Fails To Open			
1	AB6OPENLHE Air Circuit Breaker 6 Fails To Open Due To A Latent Human Error	3.20E-03	68.3%
2	AB6MECHDEX Air Circuit Breaker 6 Fails To Open Due To Mechanical Failure	8.00E-04	17.1%
3	AB61432LHE Manual/Auto Control Switch 143/2 Left In Manual	3.19E-04	6.8%
4	AA2272XR6D Transformer 2X Undervoltage Relay 27/2X Fails To Drop Out	2.48E-04	5.3%

[1] The mean unavailability is the summation of the values of all cut sets in which the event appears

[2] The contribution to unavailability is calculated by dividing the mean unavailability by the overall system unavailability and then multiplying by 100 percent

Table A.4-42

Air Circuit Breaker Dominant Contributors To Unavailability

Rank	Event Description	Mean Unavailability[1]	Approximate Unavailability Contribution[2]
Air Circuit Breaker 6 Transfers Open			
1	AA2272XR6T Transformer 2X Undervoltage Relay 27/2X Spuriously De-energizes	8.73E-06	21.6%
2	AB652TCRYT Air Circuit Breaker 6 Trip Coil 52TC Spurious Operation	8.65E-06	21.4%
3	AA227X2RYT Auxiliary Relay 27X/2X Spurious Operation	8.65E-06	21.4%
4	AA286S2RYT Switchgear 2X Lockout Relay 86S/2X Spurious Operation	8.65E-06	21.4%
5	AB6PUSHPBT Trip Pushbutton On ACB6 Spurious Operation	5.78E-06	14.3%

[1] The mean unavailability is the summation of the values of all cut sets in which the event appears

[2] The contribution to unavailability is calculated by dividing the mean unavailability by the overall system unavailability and then multiplying by 100 percent

Table A.4-43

Air Circuit Breaker Dominant Contributors To Unavailability

Rank	Event Description	Mean Unavailability[1]	Approximate Unavailability Contribution[2]
	Air Circuit Breaker 7 Fails To Close		
1	AB7MCH2DEX Air Circuit Breaker 7 Fails To Close Due To Mechanical Failure	7.03E-03	79.8%
2	AB51431LHE Manual/Auto Control Switch 143/1 Left In Manual	3.17E-04	3.6%
3	XA1BKRSCOM CCF of 1X Aux Power Breakers ACB-5 & -7	3.07E-04	3.5%
4	XA78BKRCOM Common Cause Failure Of ACB-7 And ACB-8 To Close	3.07E-04	3.5%
5	AB7CLOSLHE Air Circuit Breaker 7 Fails To Close Due To A Latent Human Error	2.58E-04	2.9%
6	AA127CPR6D Transformer CX Undervoltage Relay 27/CX1 Fails To Pick Up	2.47E-04	2.8%
7	AB752Y2RYT Air Circuit Breaker 7 Y-relay Spurious Operation	1.29E-04	1.5%

[1] The mean unavailability is the summation of the values of all cut sets in which the event appears

[2] The contribution to unavailability is calculated by dividing the mean unavailability by the overall system unavailability and then multiplying by 100 percent

Table A.4-44

Air Circuit Breaker Dominant Contributors To Unavailability

Rank	Event Description	Mean Unavailability[1]	Approximate Unavailability Contribution[2]
	Air Circuit Breaker 7 Fails To Open		
1	AB7OPENLHE Air Circuit Breaker 7 Fails To Open Due To A Latent Human Error	3.20E-03	68.3%
2	AB7MECHDEX Air Circuit Breaker 7 Fails To Open Due To Mechanical Failure	8.00E-04	17.1%
3	AB51431LHE Manual/Auto Control Switch 143/1 Left In Manual	3.19E-04	6.8%
4	AA127X2R6D Transformer CX Undervoltage Relay 27/CX1 Fails To Drop Out	2.48E-04	5.3%

[1] The mean unavailability is the summation of the values of all cut sets in which the event appears

[2] The contribution to unavailability is calculated by dividing the mean unavailability by the overall system unavailability and then multiplying by 100 percent

Table A.4-45

Air Circuit Breaker Dominant Contributors To Unavailability

Rank	Event Description	Mean Unavailability[1]	Approximate Unavailability Contribution[2]
	Air Circuit Breaker 7 Transfers Open		
1	AA127C1R6T Transformer CX Undervoltage Relay 27/CX1 Spuriously De-energizes	8.69E-06	14.7%
2	AB752TCRYT Air Circuit Breaker 7 Trip Coil 52TC Spurious Operation	8.63E-06	14.6%
3	AA127R1RYT Auxiliary Relay 27X/CX1 Spurious Operation	8.63E-06	14.6%
4	AA186S1RYT Switchgear 1X Lockout Relay 86S/1X Spurious Operation	8.63E-06	14.6%
5	AA186CXRYT Transformer CX Differential Lock Out Relay 86CX Spurious Operation	8.63E-06	14.6%
6	AA187CXRYT Transformer CX Differential Relay 87CX Spurious Operation	8.63E-06	14.6%
7	AB7PUSHPBT Trip Pushbutton On ACB7 Spurious Operation	7.21E-06	12.2%

[1] The mean unavailability is the summation of the values of all cut sets in which the event appears

[2] The contribution to unavailability is calculated by dividing the mean unavailability by the overall system unavailability and then multiplying by 100 percent

Table A.4-46

Air Circuit Breaker Dominant Contributors To Unavailability

Rank	Event Description	Mean Unavailability[1]	Approximate Unavailability Contribution[2]
	Air Circuit Breaker 8 Fails To Close		
1	AB8MCH2DEX Air Circuit Breaker 8 Fails To Close Due To Mechanical Failure	6.99E-03	53.8%
2	AB6OPENLHE Air Circuit Breaker 6 Fails To Open Due To A Latent Human Error	3.17E-03	24.4%
3	AB6MECHDEX Air Circuit Breaker 6 Fails To Open Due To Mechanical Failure	7.90E-04	6.1%
4	AB61432LHE Manual/Auto Control Switch 143/2 Left In Manual	3.16E-04	2.4%
5	XA2BKRSCOM CCF of Aux Power Breakers ACB-6 & -8	3.06E-04	2.4%
6	XA78BKRCOM Common Cause Failure Of ACB-7 And ACB-8 To Close	3.06E-04	2.4%
7	AA227CPR6D Transformer CX Undervoltage Relay 27/CX2 Fails To Pick Up	2.46E-04	1.9%
8	AA2272XR6D Transformer 2X Undervoltage Relay 27/2X Fails To Drop Out	2.46E-04	1.9%

1 The mean unavailability is the summation of the values of all cut sets in which the event appears

2 The contribution to unavailability is calculated by dividing the mean unavailability by the overall system unavailability and then multiplying by 100 percent

Table A.4-47

Air Circuit Breaker Dominant Contributors To Unavailability

Rank	Event Description	Mean Unavailability[1]	Approximate Unavailability Contribution[2]
	Air Circuit Breaker 8 Transfers Open		
1	AA227R2RYT Auxiliary Relay 27X/CX2 Spurious Operation	1.38E-04	34.1%
2	AB852TCRYT Air Circuit Breaker 8 Trip Coil 52TC Spurious Operation	1.38E-04	34.1%
3	AB8PUSHPBT Trip Pushbutton On ACB8 Spurious Operation	9.19E-05	22.7%
4	AA227C2R6T Transformer CX Undervoltage Relay 27/CX2 Spuriously De-energizes	1.09E-05	2.7%
5	AA286S2RYT Switchgear 2X Lockout Relay 86S/2X Spurious Operation	8.63E-06	2.1%
6	AA187CXRYT Transformer CX Differential Relay 87CX Spurious Operation	8.63E-06	2.1%
7	AA186CXRYT Transformer CX Differential Lock Out Relay 86CX Spurious Operation	8.63E-06	2.1%

[1] The mean unavailability is the summation of the values of all cut sets in which the event appears

[2] The contribution to unavailability is calculated by dividing the mean unavailability by the overall system unavailability and then multiplying by 100 percent

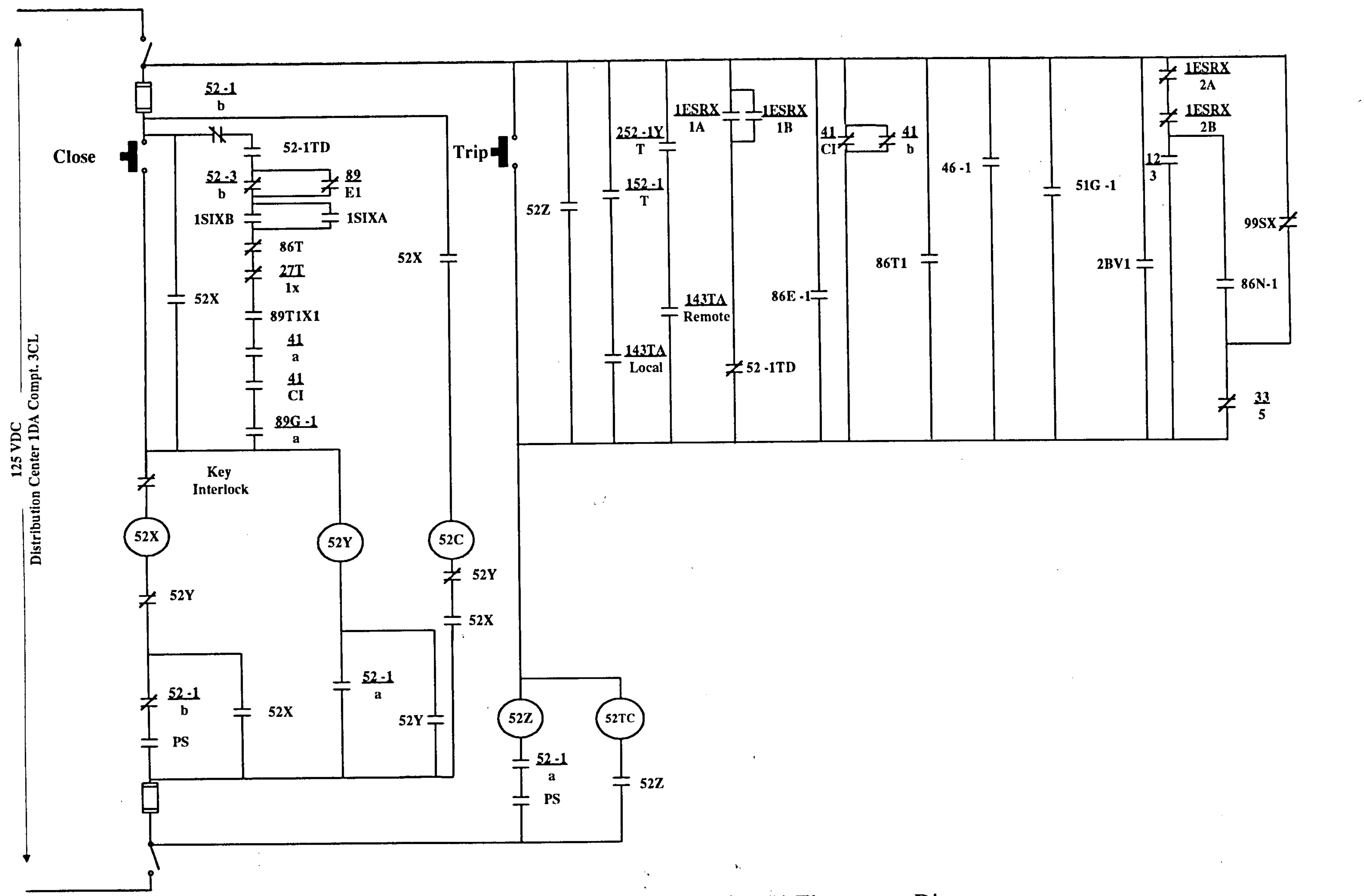


Figure A.4-1 Simplified Air Circuit Breaker #1 Elementary Diagram

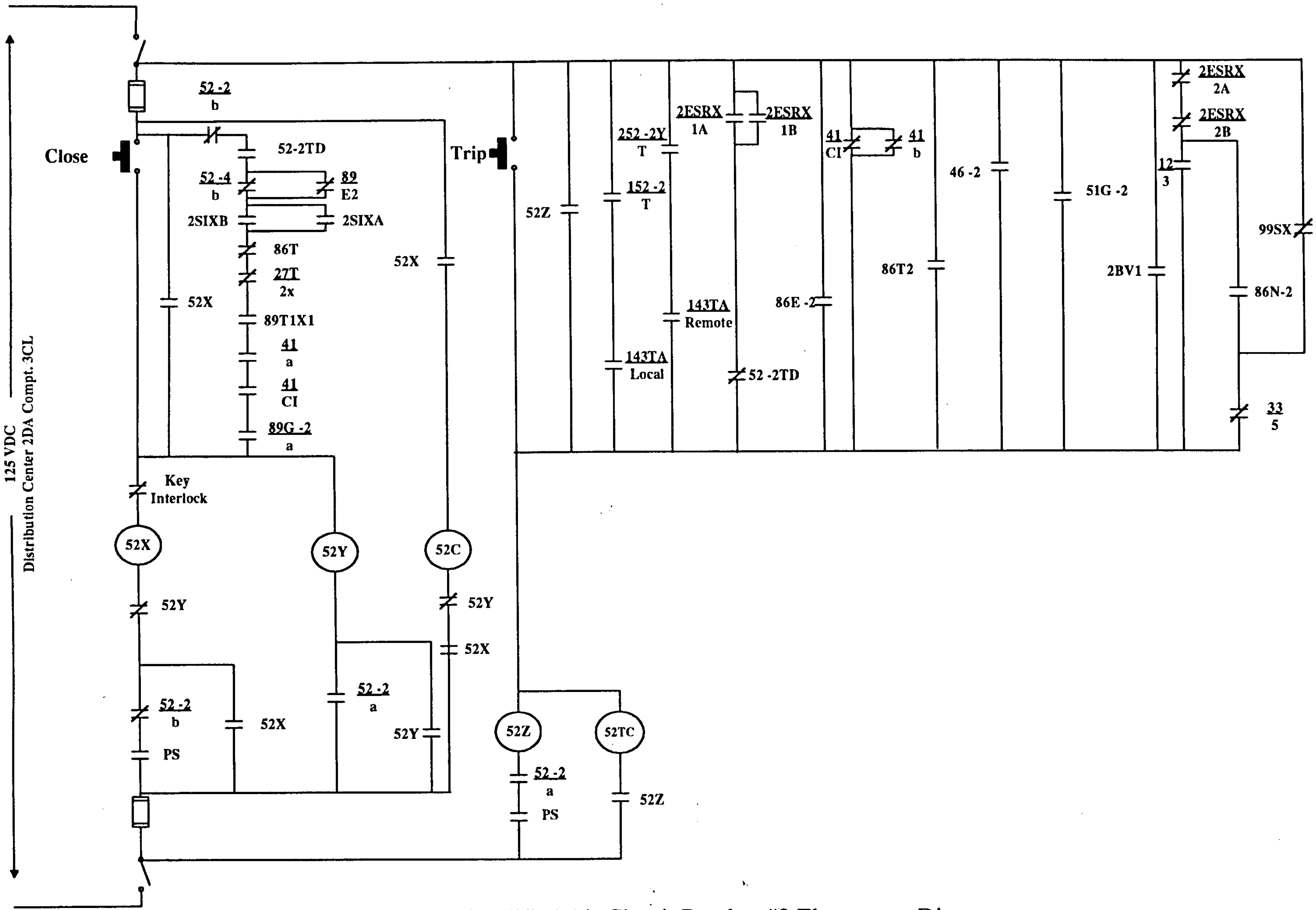


Figure A.4-2 Simplified Air Circuit Breaker #2 Elementary Diagram

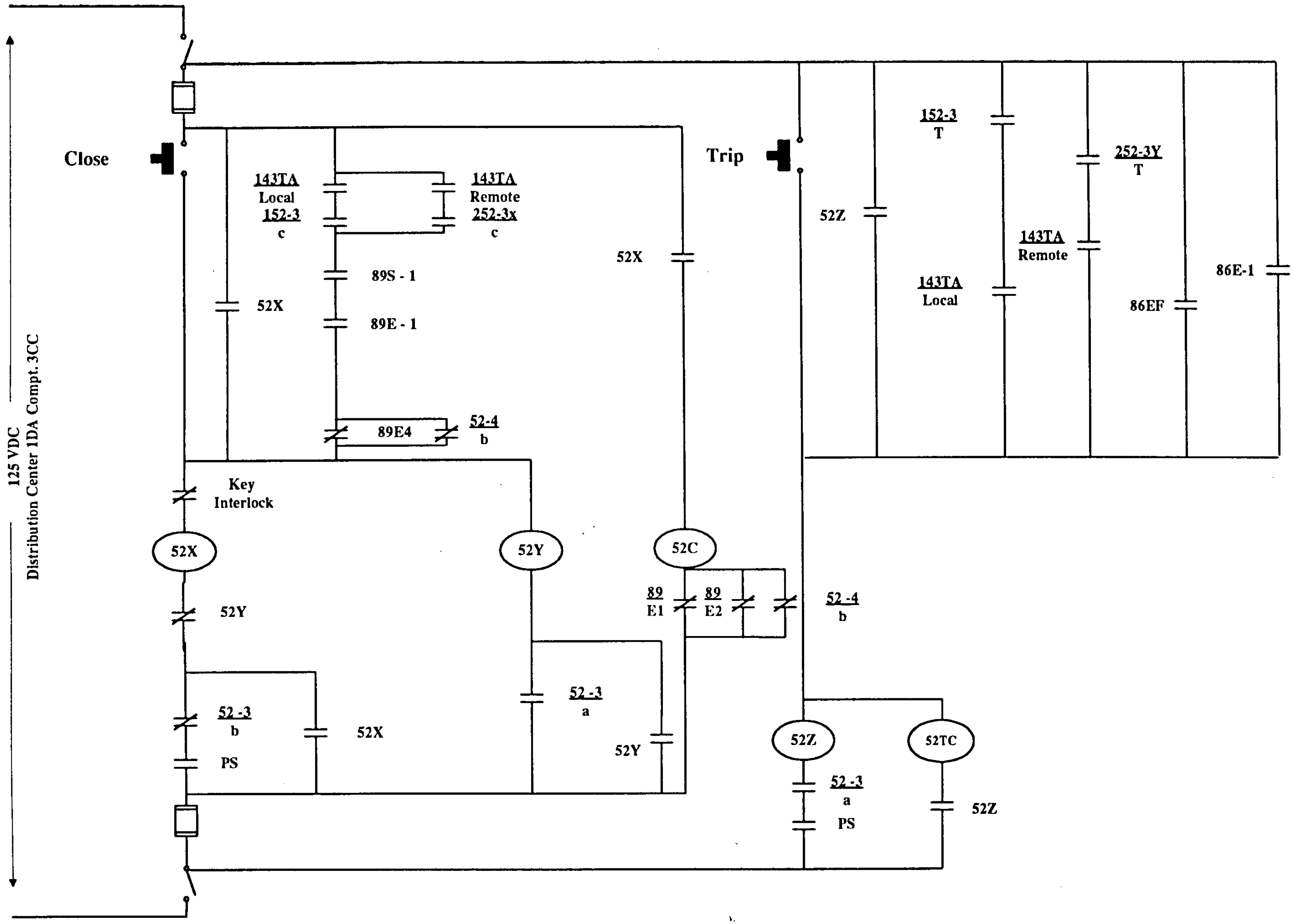


Figure A.4-3 Simplified Air Circuit Breaker #3 Elementary Diagram

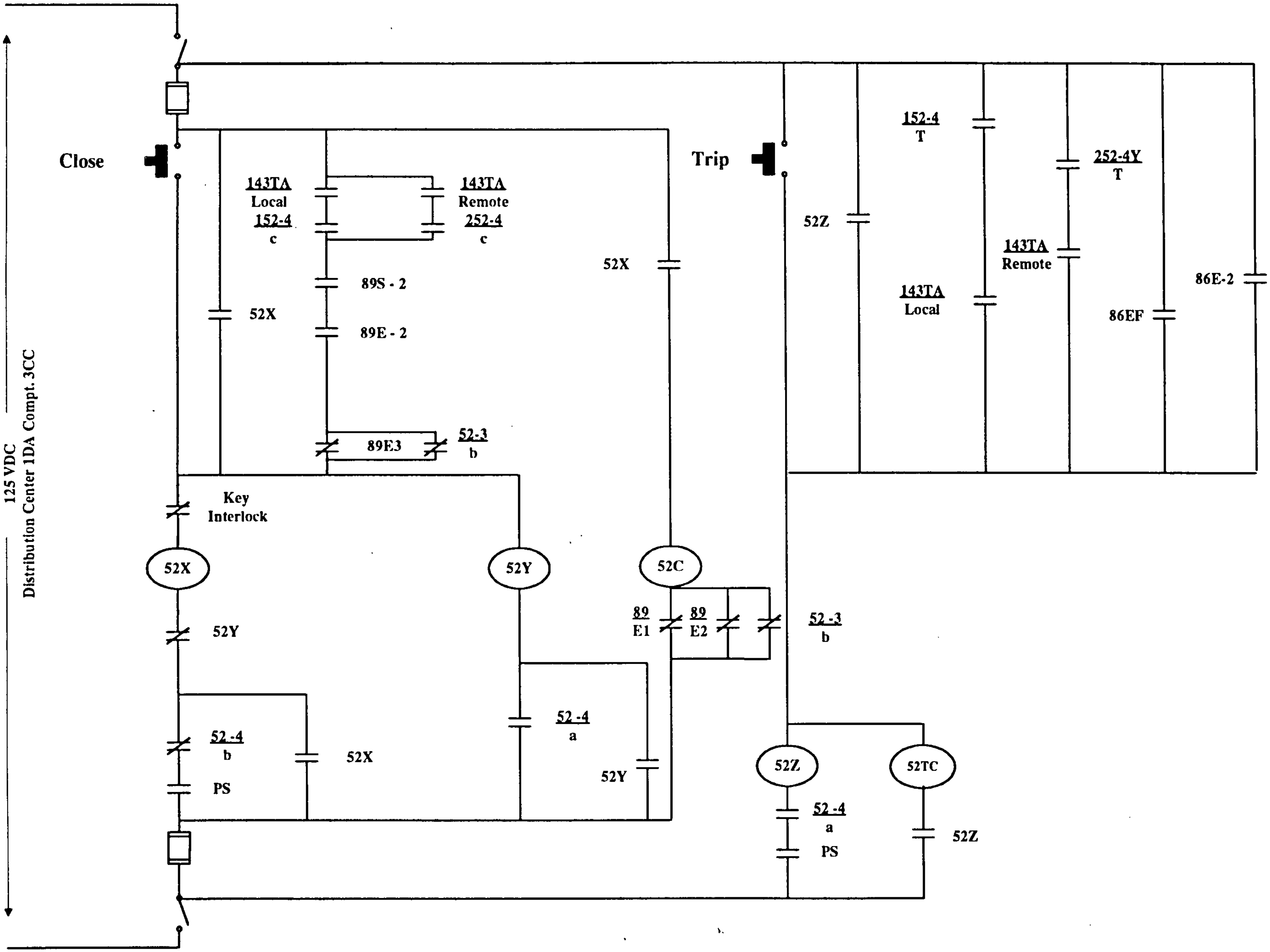


Figure A.4-4 Simplified Air Circuit Breaker #4 Elementary Diagram

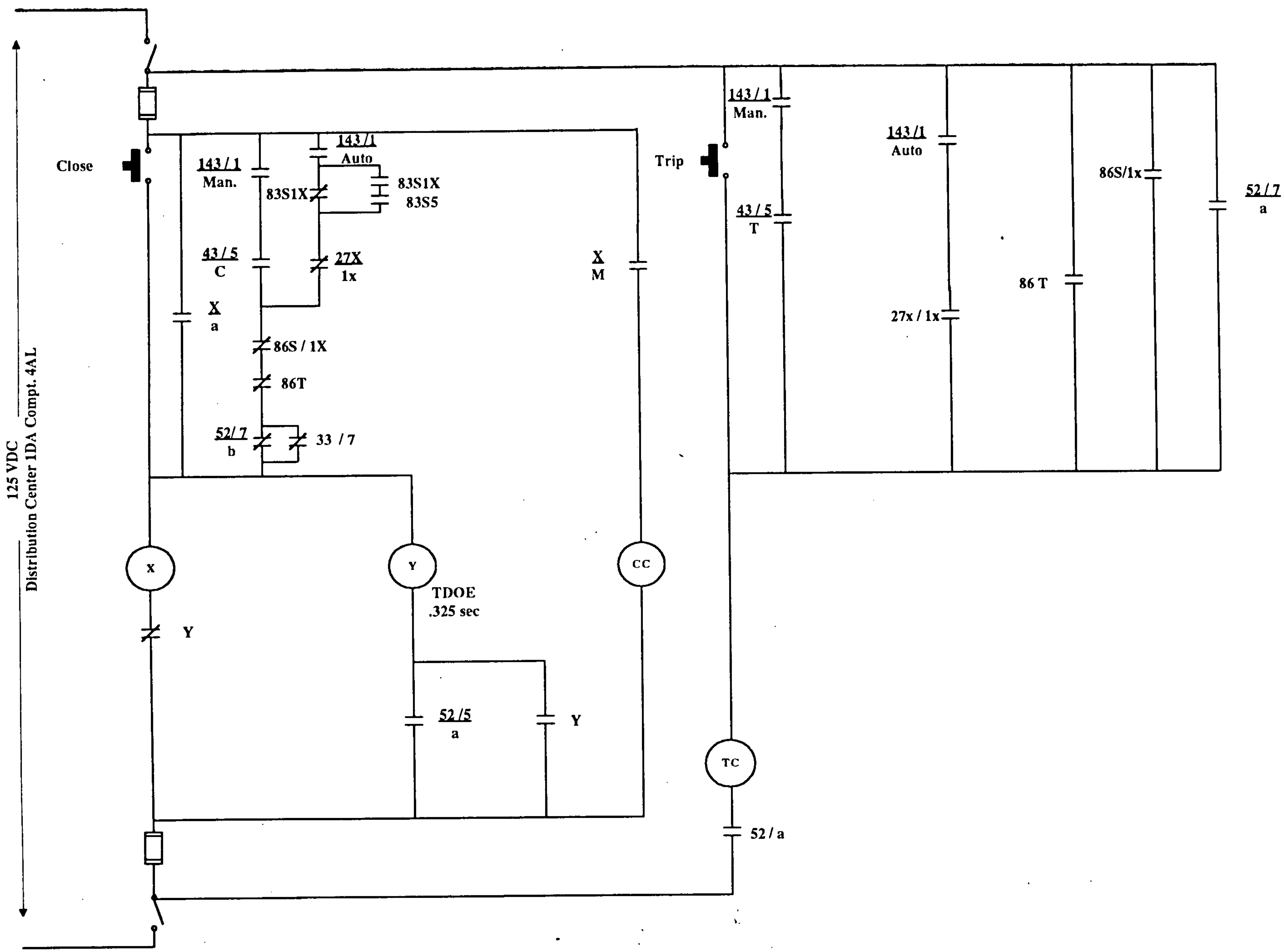


Figure A.4-5 Simplified Air Circuit Breaker #5 Elementary Diagram

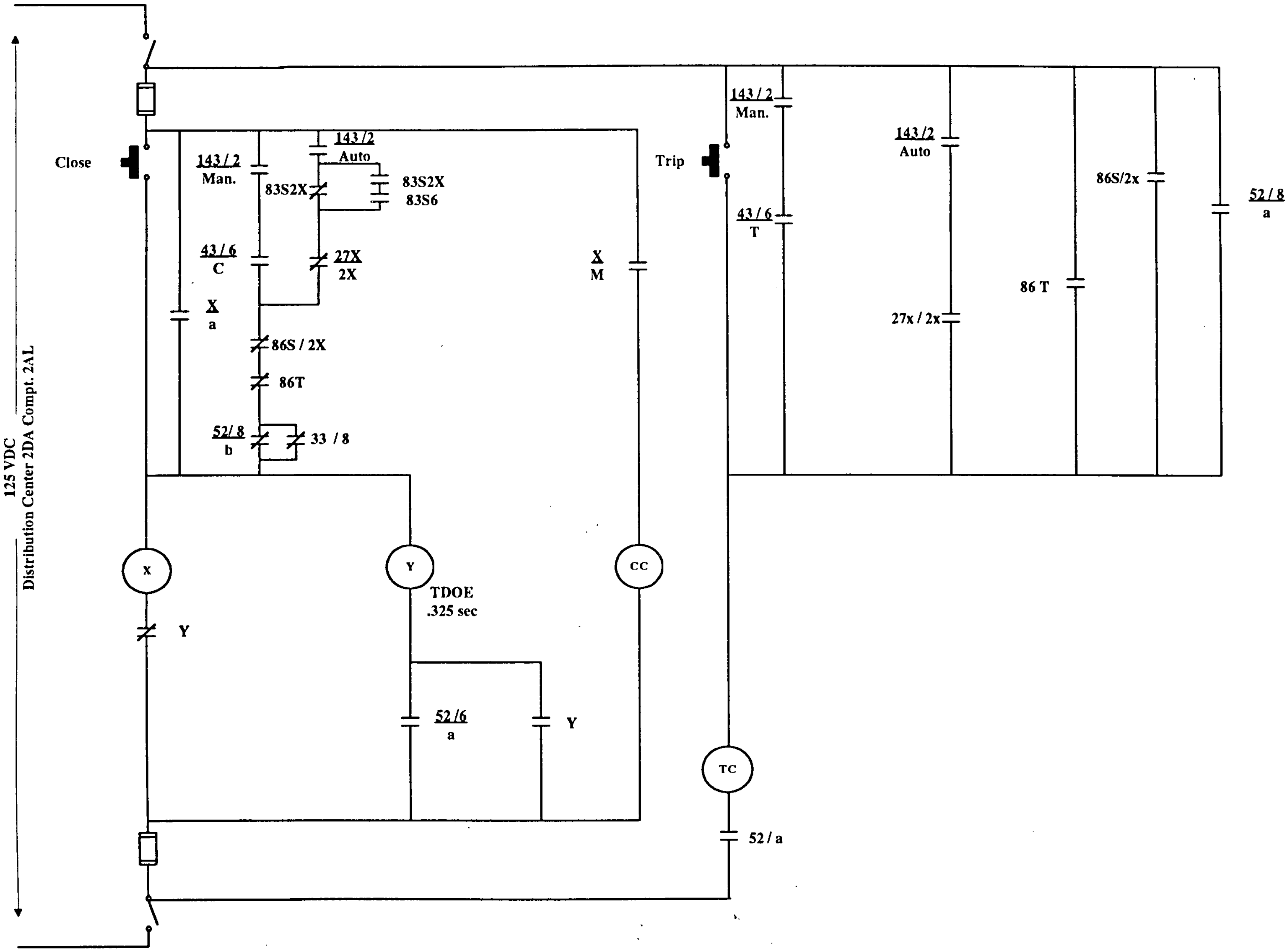


Figure A.4-6 Simplified Air Circuit Breaker #6 Elementary Diagram

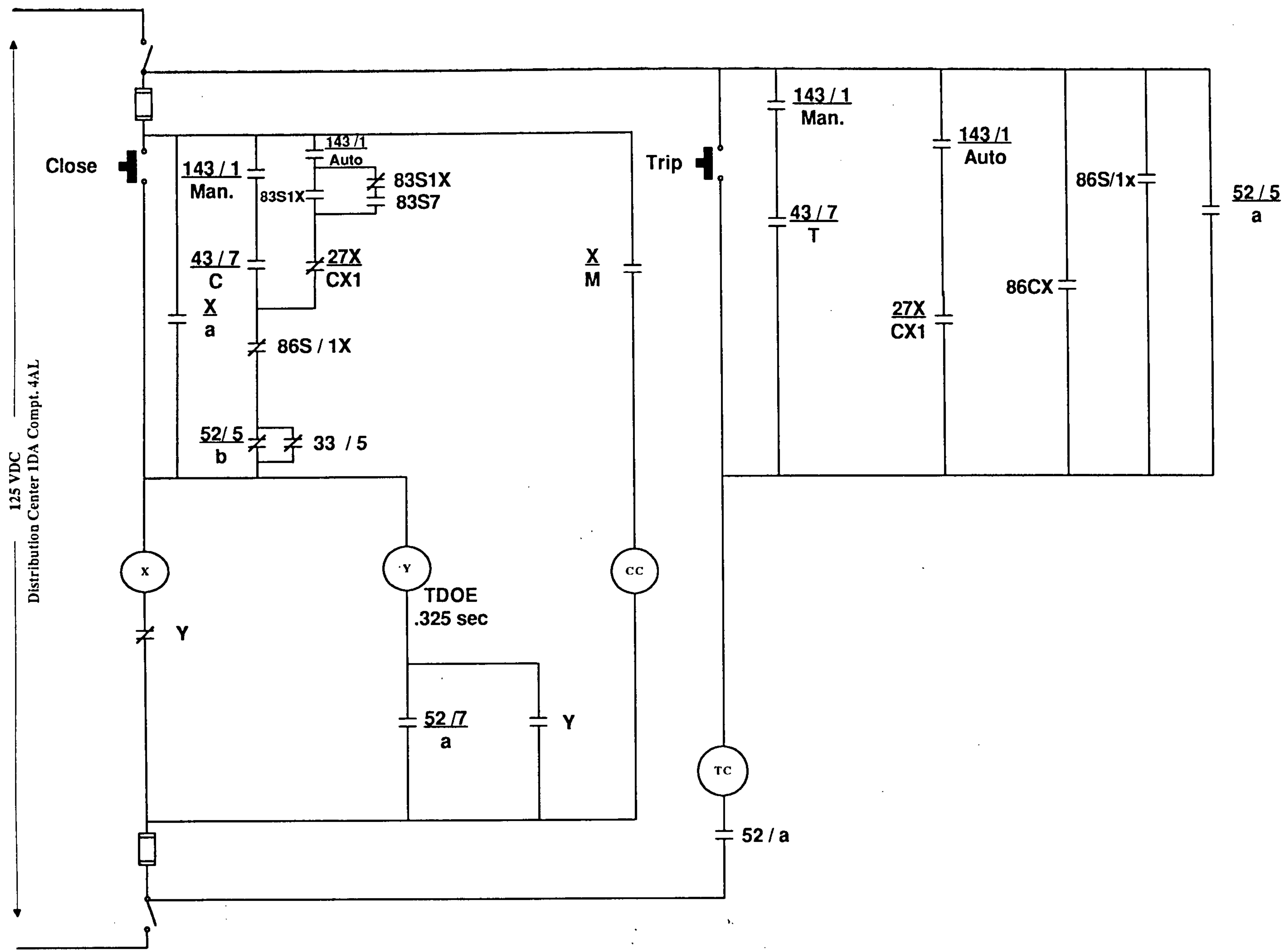


Figure A.4-7 Simplified Air Circuit Breaker #7 Elementary Diagram

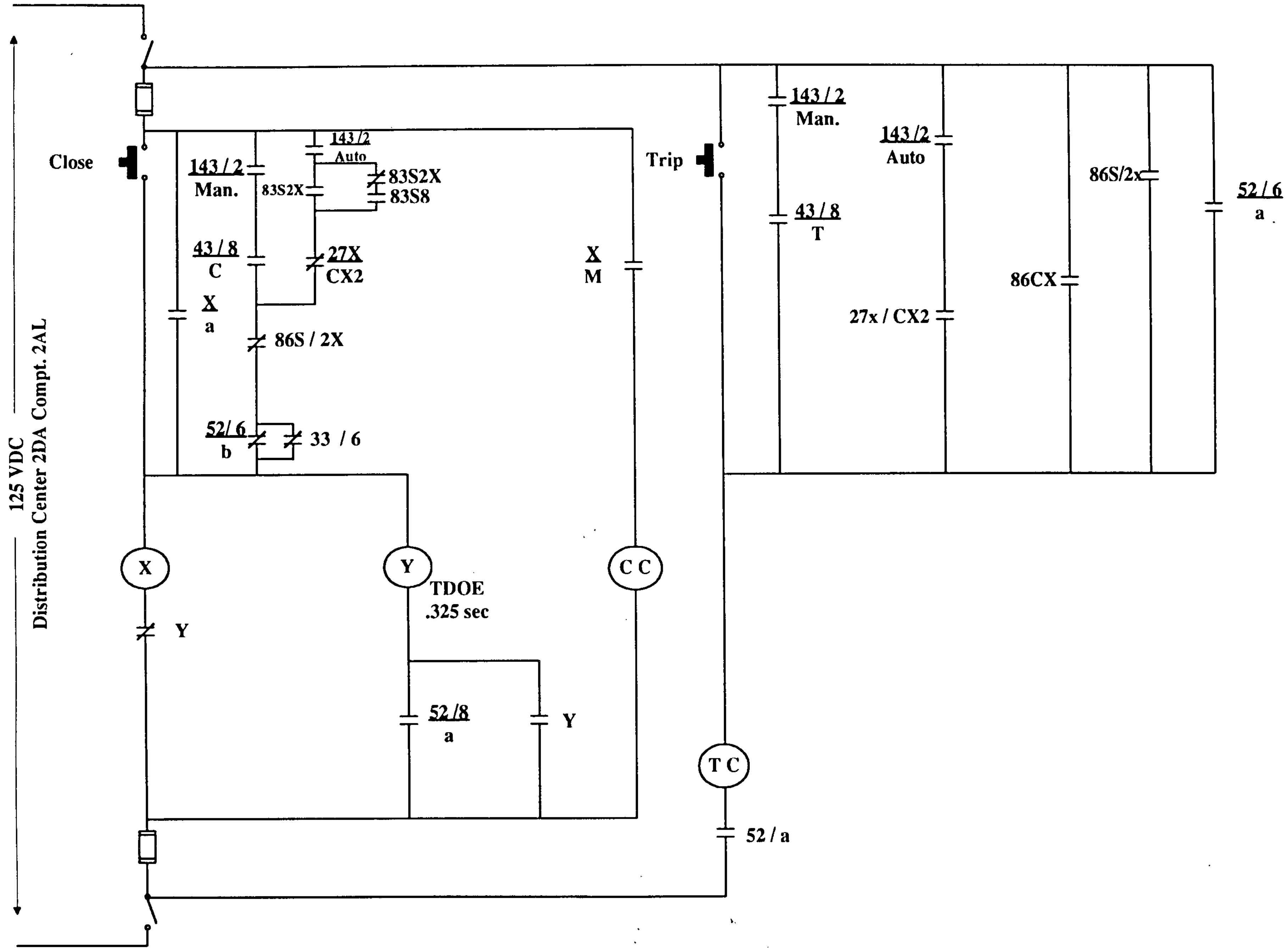
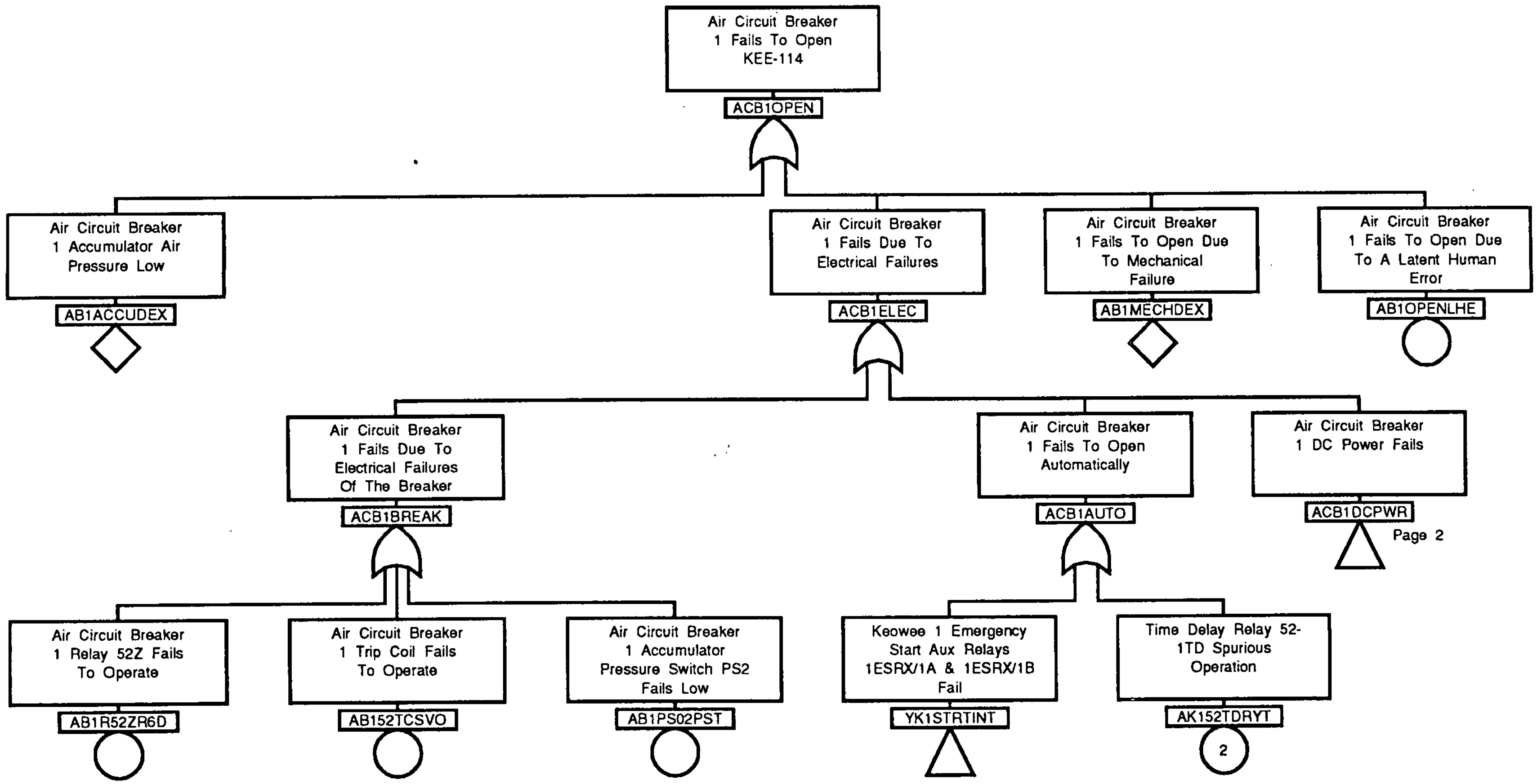
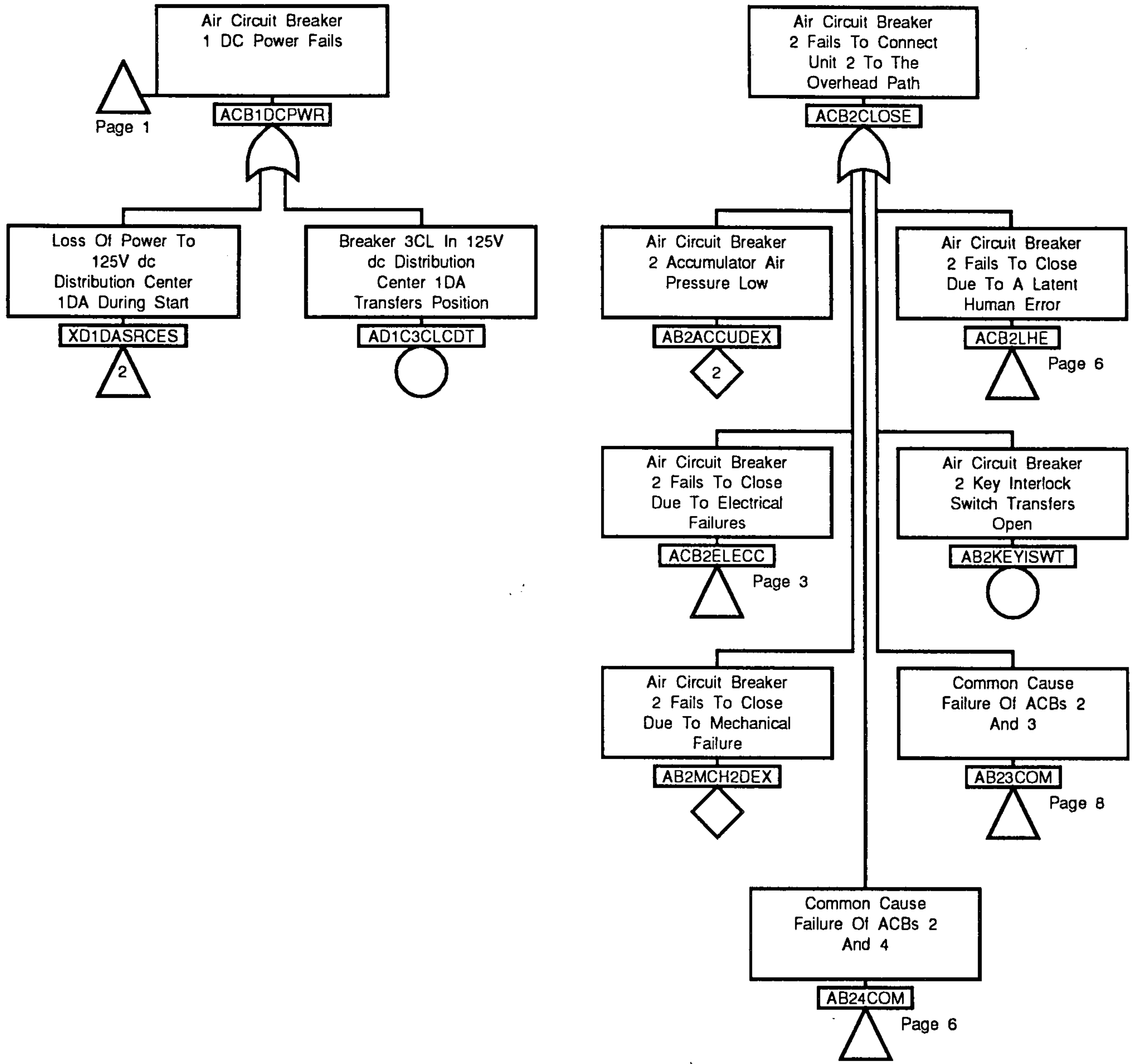


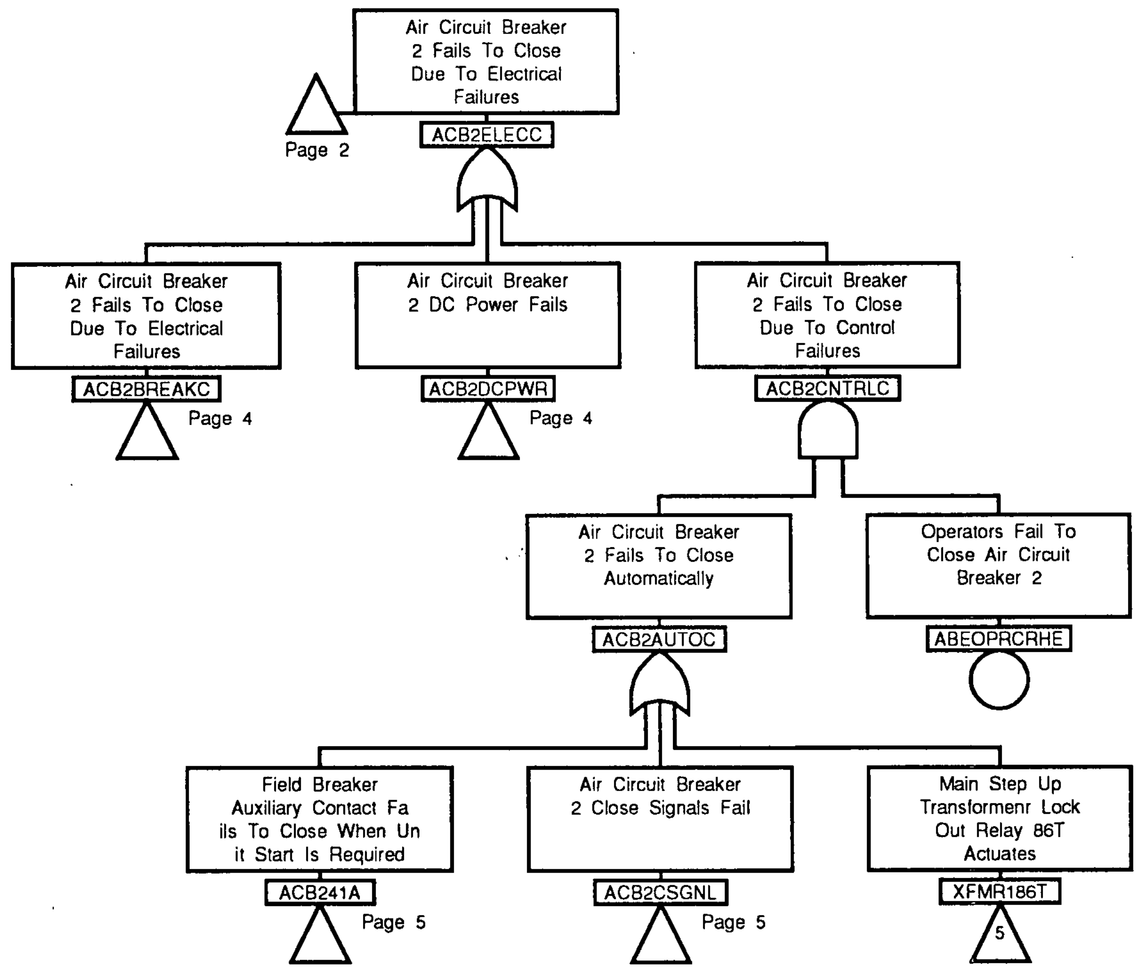
Figure A.4-8 Simplified Air Circuit Breaker #8 Elementary Diagram

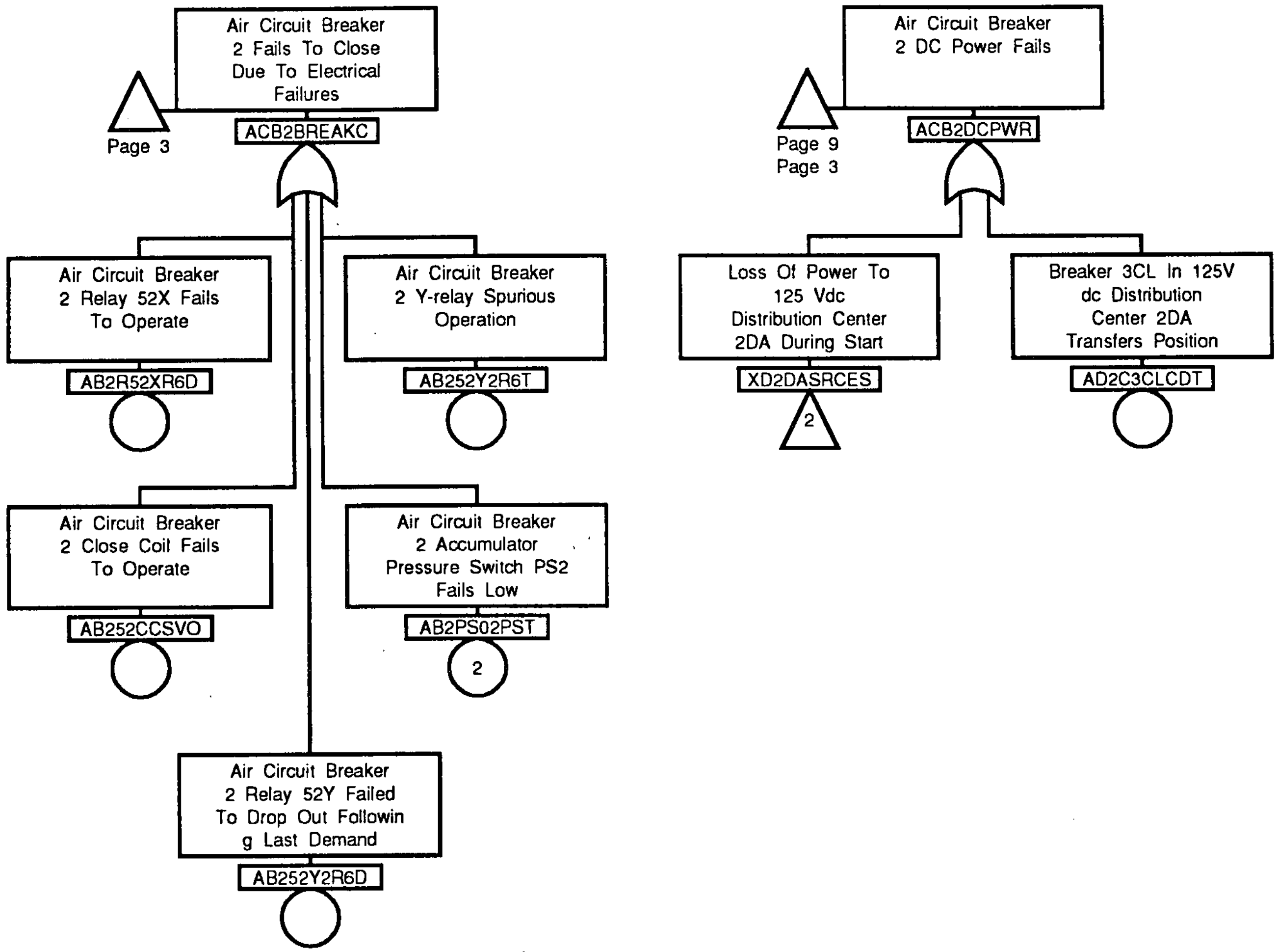


Air Circuit Breaker Fault Trees | FIGURE A.4-9 |

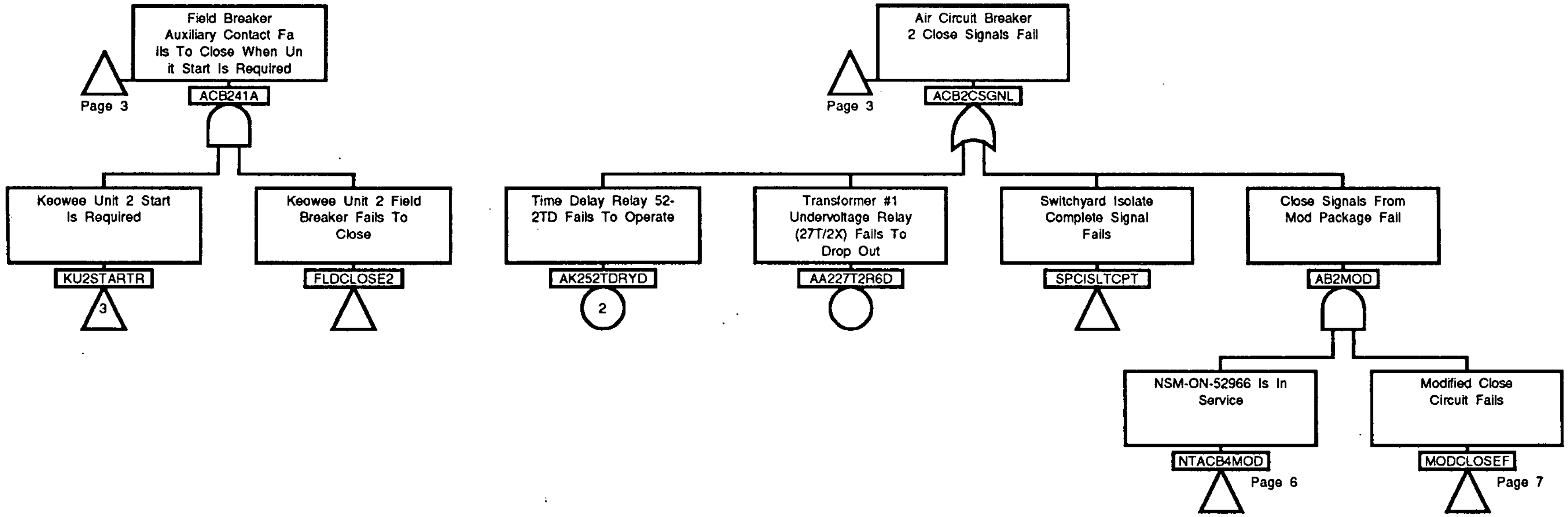


Air Circuit Breaker Fault Trees	FIGURE A.4-9	Page 2


Air Circuit Breaker 2 Fails To Close Due To Electrical Failures
ACB2ELECC
Page 2
Air Circuit Breaker 2 Fails To Close Due To Electrical Failures
ACB2BREAKC
Page 4
Air Circuit Breaker 2 DC Power Fails
ACB2DCPWR
Page 4
Air Circuit Breaker 2 Fails To Close Due To Control Failures
ACB2CNTRLC
Air Circuit Breaker 2 Fails To Close Automatically
ACB2AUTOC
Operators Fail To Close Air Circuit Breaker 2
ABEOPRCRHE
Field Breaker Auxiliary Contact Fa ils To Close When Un it Start Is Required
ACB241A
Page 5
Air Circuit Breaker 2 Close Signals Fail
ACB2CSGNL
Page 5
Main Step Up Transformenr Lock Out Relay 86T Actuates
XFMR186T
5

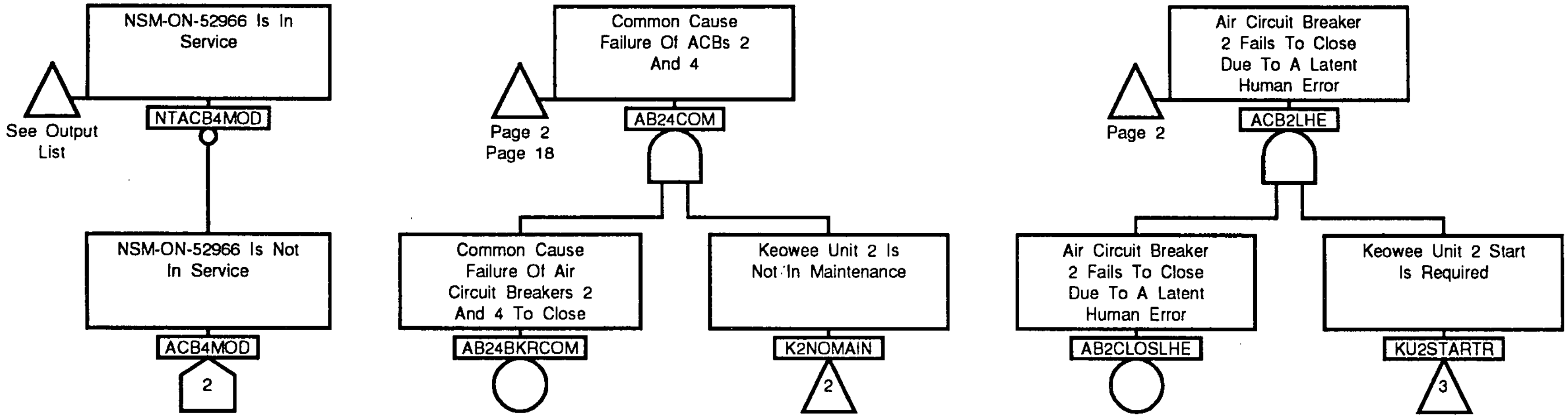


Air Circuit Breaker Fault Trees	FIGURE A.4-9	Page 4

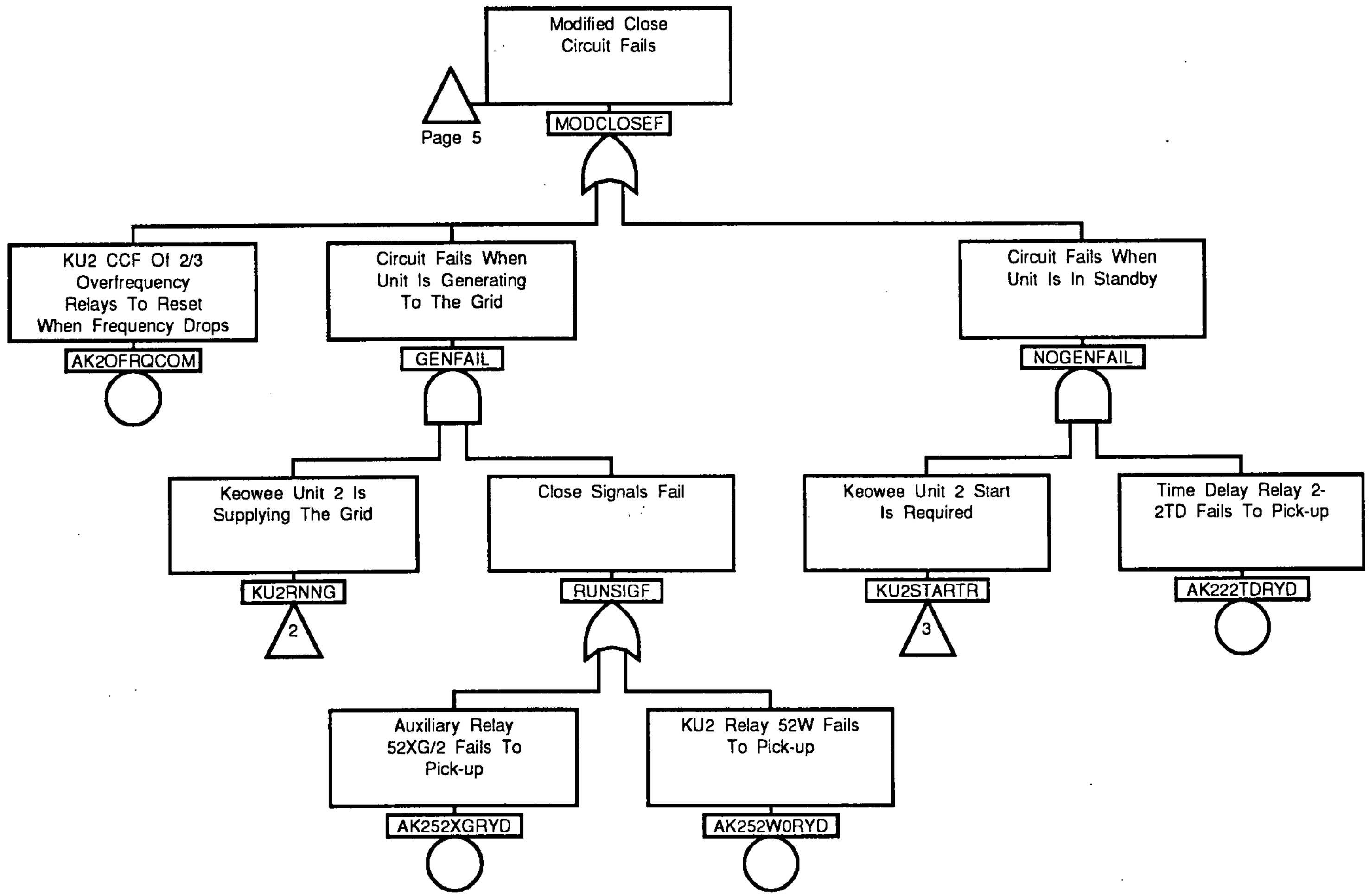


Field Breaker Auxiliary Contact Fa ils To Close When Un it Start Is Required
ACB241A
Page 3
Keowee Unit 2 Start Is Required
KU2STARTR
3
Keowee Unit 2 Field Breaker Fails To Close
FLDCLOSE2
Air Circuit Breaker 2 Close Signals Fail
ACB2CSGNL
Page 3
Time Delay Relay 52-2TD Fails To Operate
AK252TDRYD
2
Transformer #1 Undervoltage Relay (27T/2X) Fails To Drop Out
AA227T2R6D
Switchyard Isolate Complete Signal Fails
SPCISLTCPT
Close Signals From Mod Package Fail
AB2MOD
NSM-ON-52966 Is In Service
NTACB4MOD
Page 6
Modified Close Circuit Fails
MODCLOSEF
Page 7

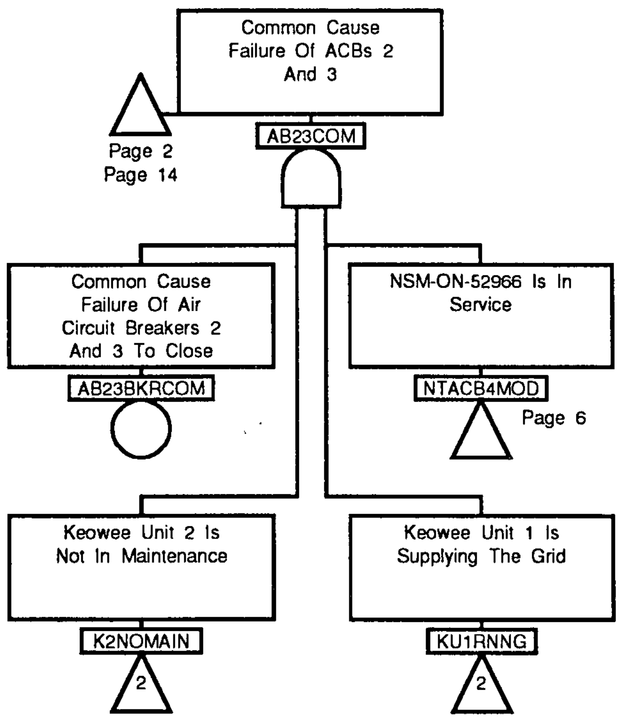
NTACB4MOD Outputs:
Page 8, Page 5, Page 16, Page 13, Page 28



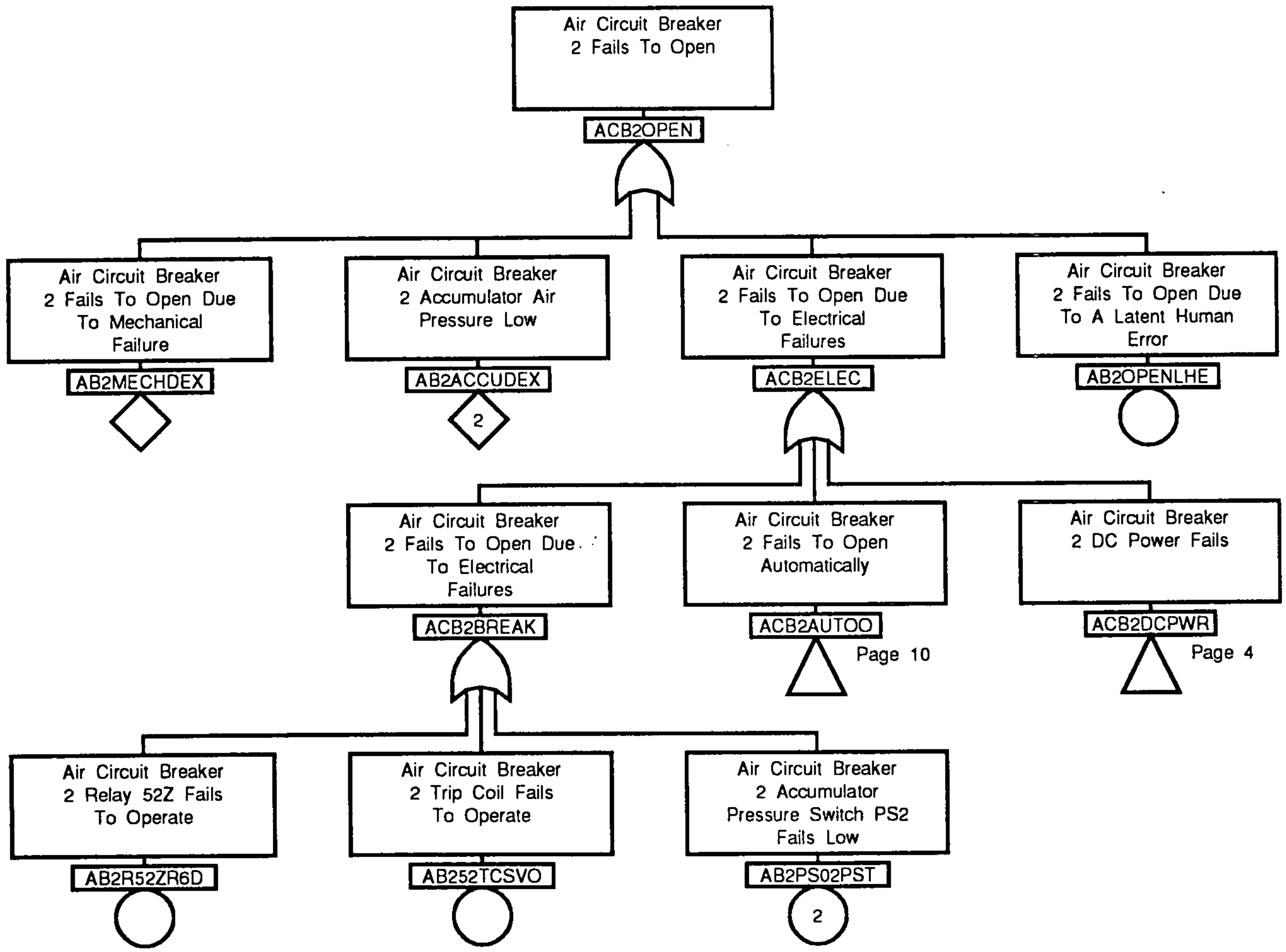
Air Circuit Breaker Fault Trees	FIGURE A.4-9	Page 6

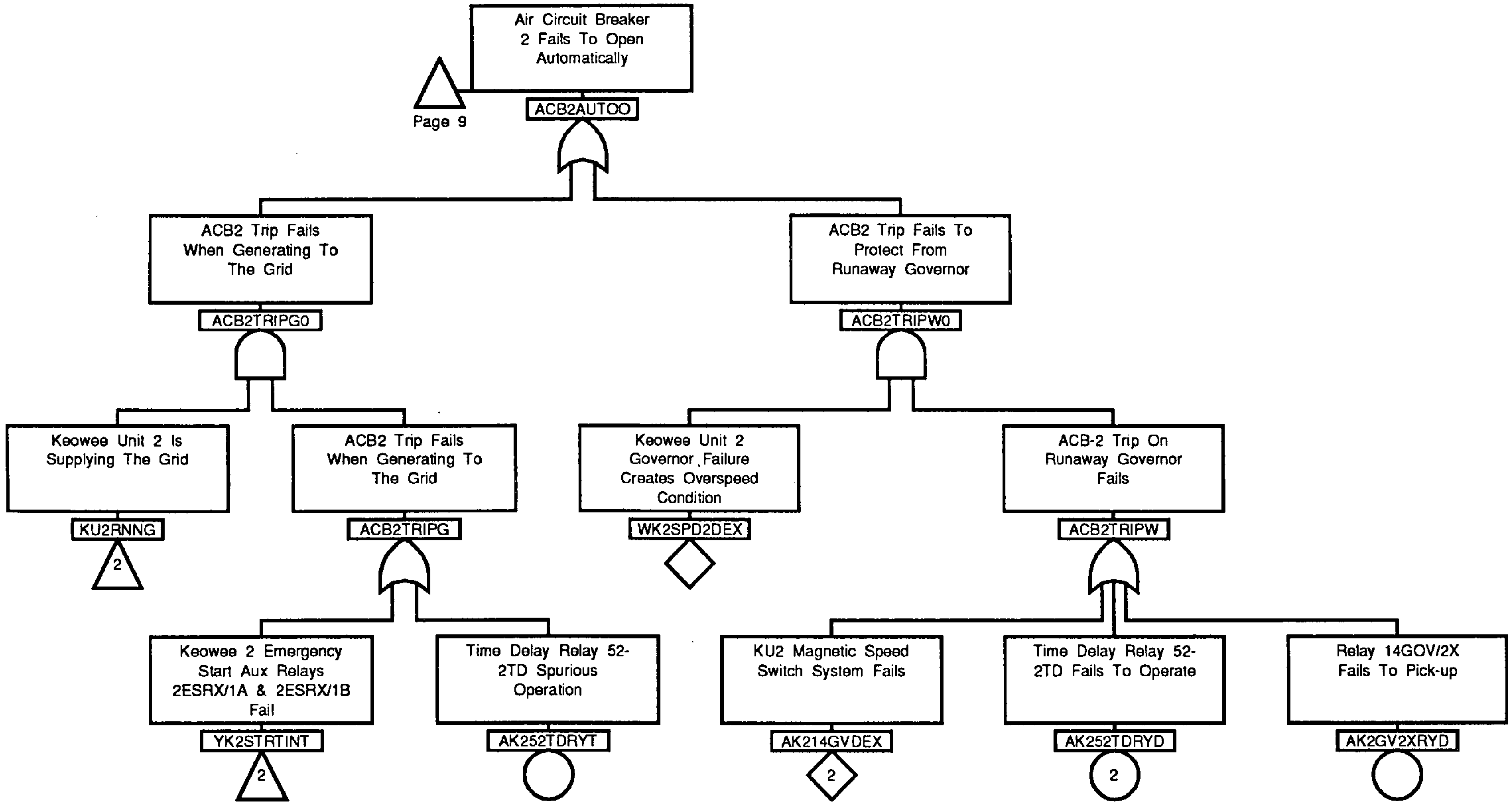


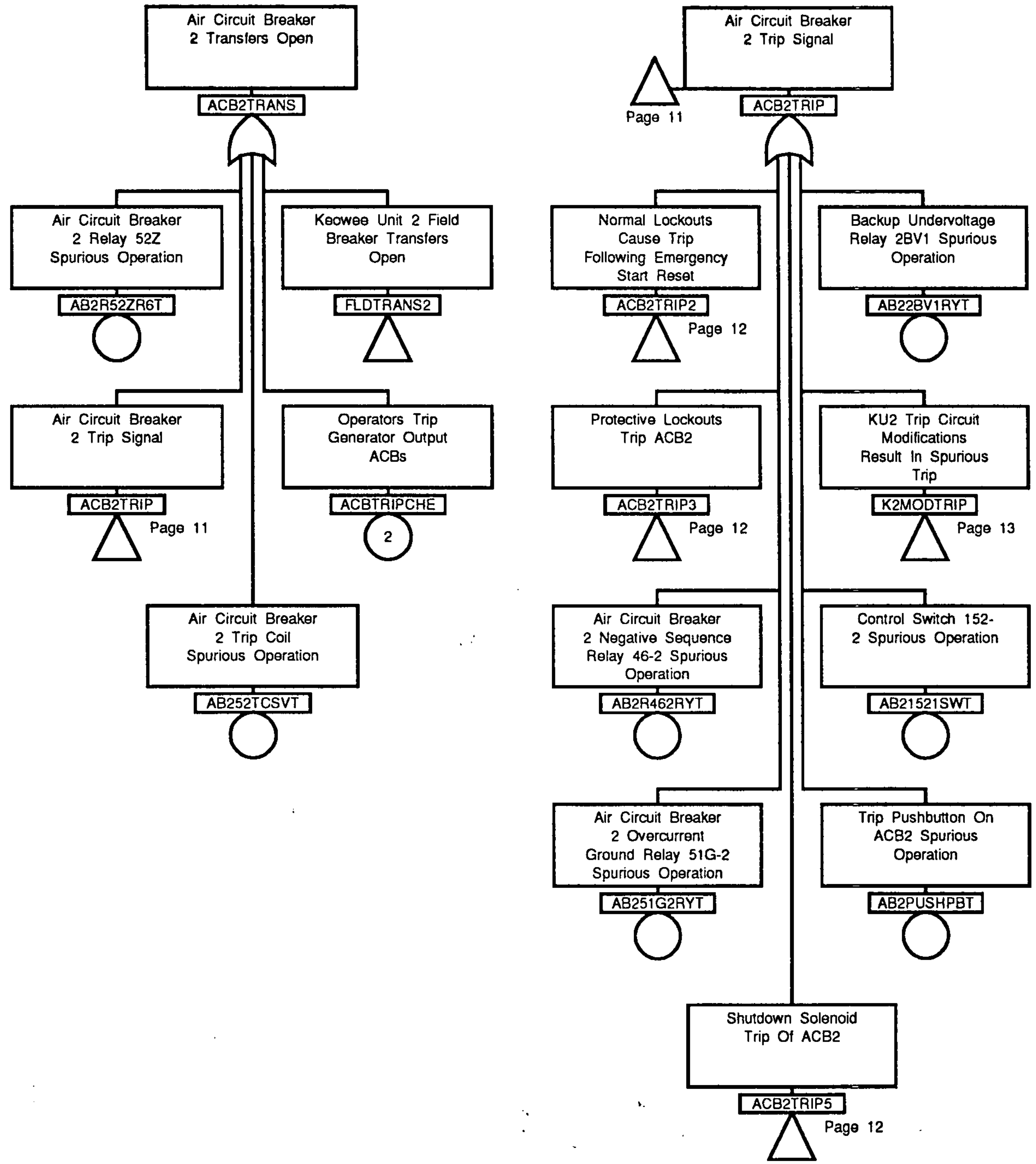
Air Circuit Breaker Fault Trees | FIGURE A.4-9 |



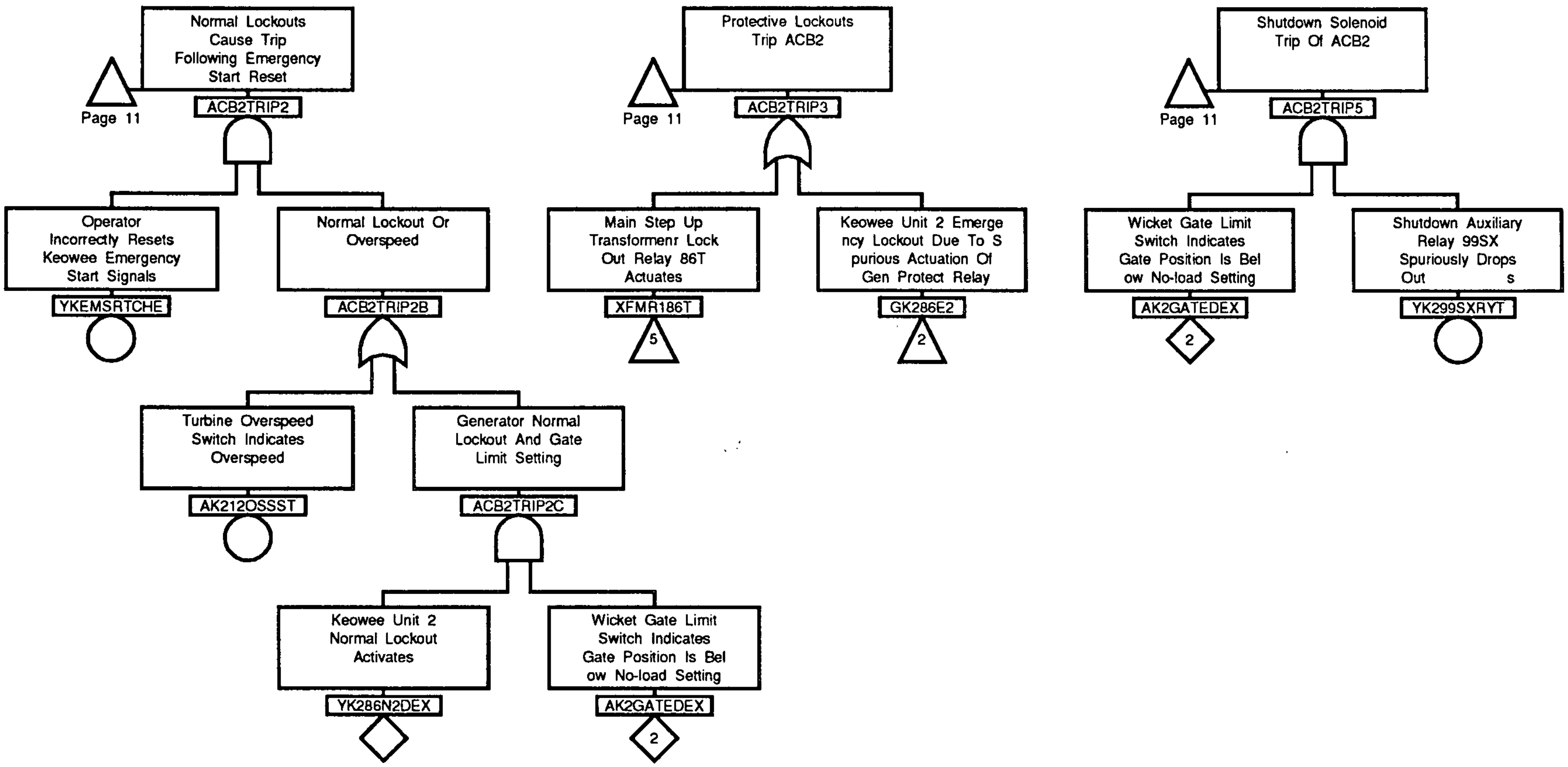
Common Cause
Failure Of ACBs 2
And 3
AB23COM
Page 2
Page 14
Common Cause
Failure Of Air
Circuit Breakers 2
And 3 To Close
AB23BKRCOM
NSM-ON-52966 Is In
Service
NTACB4MOD
Page 6
Keowee Unit 2 Is
Not In Maintenance
K2NOMAIN
2
Keowee Unit 1 Is
Supplying The Grid
KU1RNNG
2


Air Circuit Breaker 2 Fails To Open
ACB2OPEN
Air Circuit Breaker 2 Fails To Open Due To Mechanical Failure
AB2MECHDEX
Air Circuit Breaker 2 Accumulator Air Pressure Low
AB2ACCUDEX
2
Air Circuit Breaker 2 Fails To Open Due To Electrical Failures
ACB2ELEC
Air Circuit Breaker 2 Fails To Open Due To A Latent Human Error
AB2OPENLHE
Air Circuit Breaker 2 Fails To Open Due To Electrical Failures
ACB2BREAK
Air Circuit Breaker 2 Fails To Open Automatically
ACB2AUTOO
Page 10
Air Circuit Breaker 2 DC Power Fails
ACB2DCPWR
Page 4
Air Circuit Breaker 2 Relay 52Z Fails To Operate
AB2R52ZR6D
Air Circuit Breaker 2 Trip Coil Fails To Operate
AB252TCSVO
Air Circuit Breaker 2 Accumulator Pressure Switch PS2 Fails Low
AB2PS02PST
2

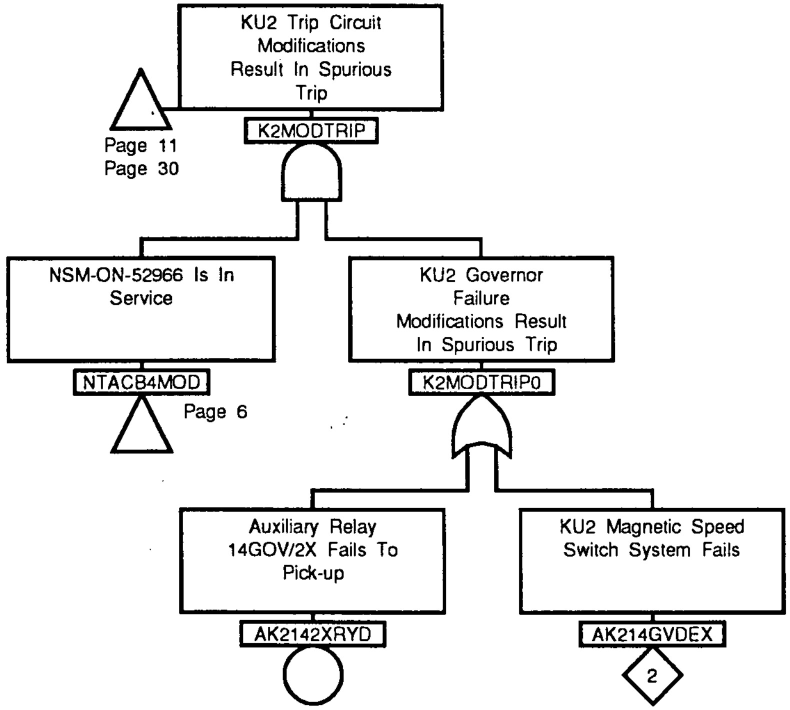

Air Circuit Breaker 2 Fails To Open Automatically
Page 9
ACB2AUTOO
ACB2 Trip Fails When Generating To The Grid
ACB2TRIPG0
ACB2 Trip Fails To Protect From Runaway Governor
ACB2TRIPW0
Keowee Unit 2 Is Supplying The Grid
KU2RNNG
2
ACB2 Trip Fails When Generating To The Grid
ACB2TRIPG
Keowee Unit 2 Governor Failure Creates Overspeed Condition
WK2SPD2DEX
ACB-2 Trip On Runaway Governor Fails
ACB2TRIPW
Keowee 2 Emergency Start Aux Relays 2ESRX/1A & 2ESRX/1B Fail
YK2STRTINT
2
Time Delay Relay 52-2TD Spurious Operation
AK252TDRYT
KU2 Magnetic Speed Switch System Fails
AK214GVDEX
2
Time Delay Relay 52-2TD Fails To Operate
AK252TDRYD
2
Relay 14GOV/2X Fails To Pick-up
AK2GV2XRYD

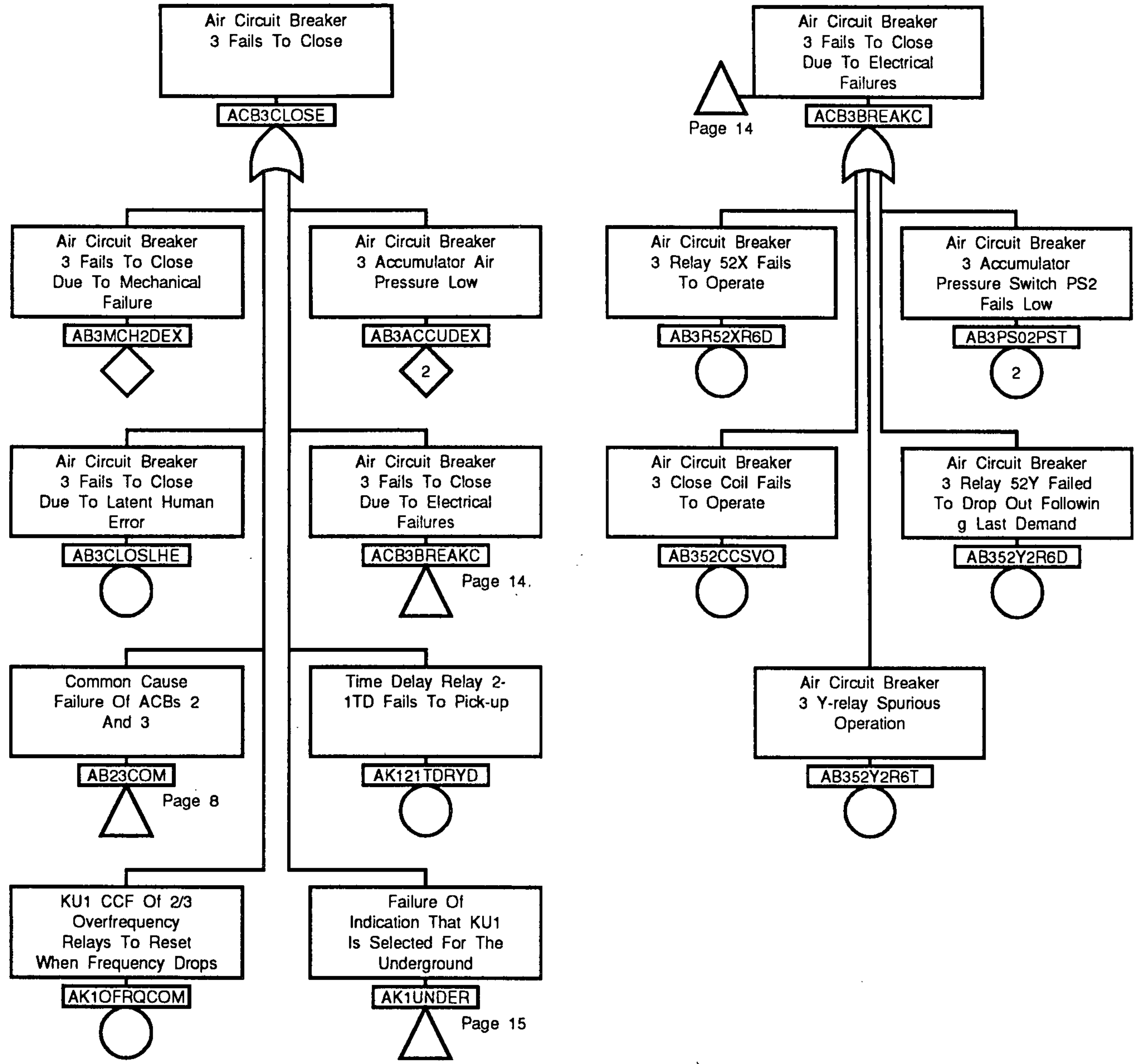


Air Circuit Breaker Fault Trees	FIGURE A.4-9	Page 11

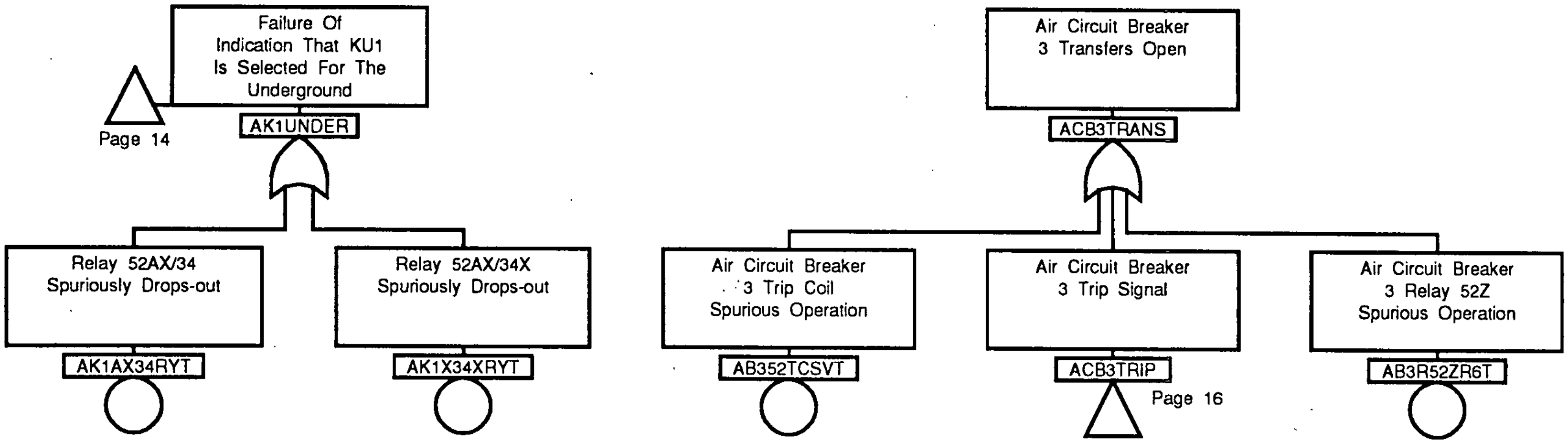


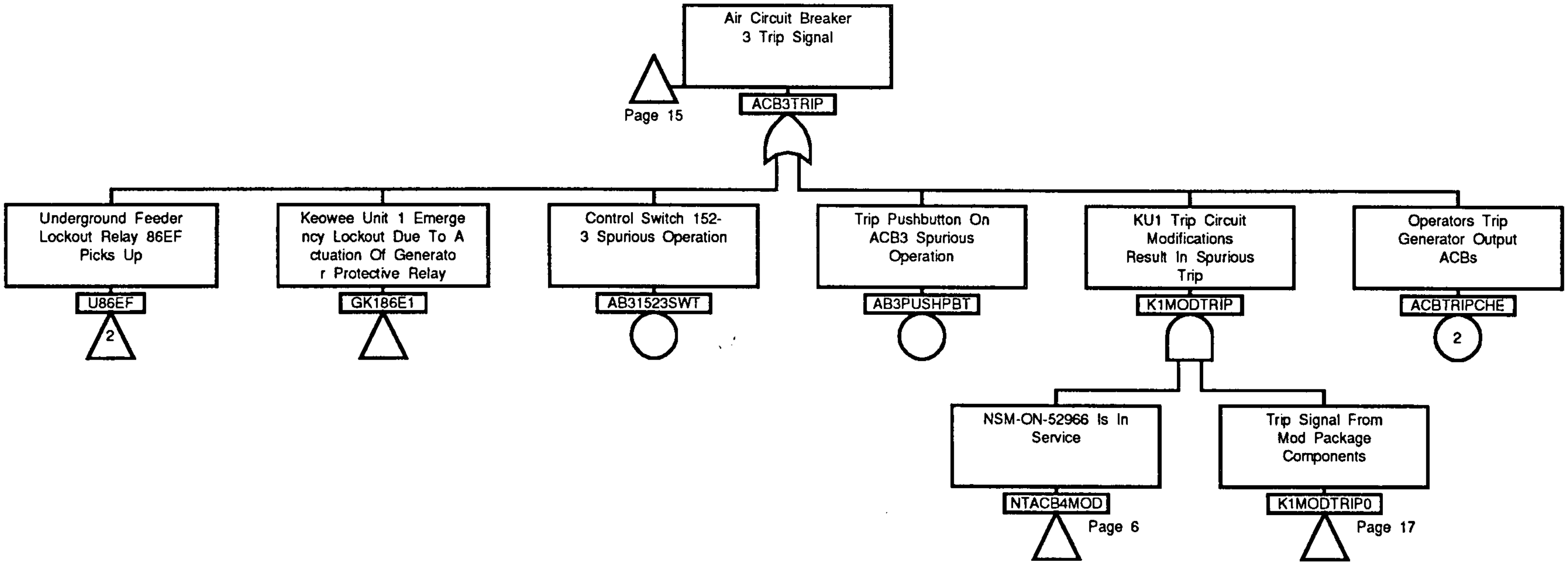
Air Circuit Breaker Fault Trees | FIGURE A.4-9 |

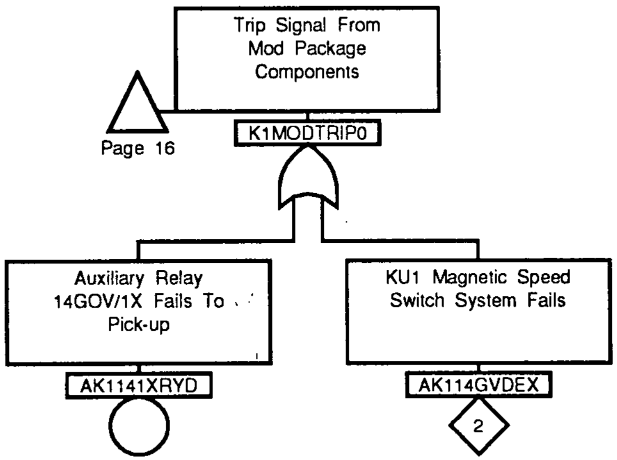

KU2 Trip Circuit Modifications Result In Spurious Trip
K2MODTRIP
Page 11
Page 30
NSM-ON-52966 Is In Service
NTACB4MOD
Page 6
KU2 Governor Failure Modifications Result In Spurious Trip
K2MODTRIP0
Auxiliary Relay 14GOV/2X Fails To Pick-up
AK2142XRYD
KU2 Magnetic Speed Switch System Fails
AK214GVDEX
2

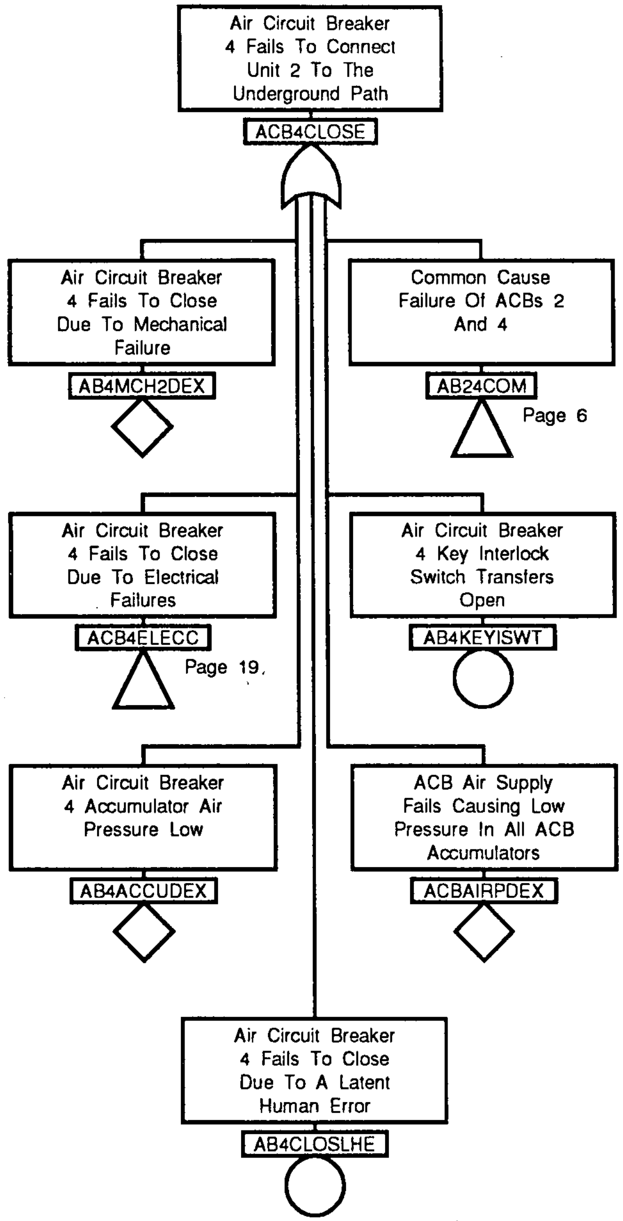


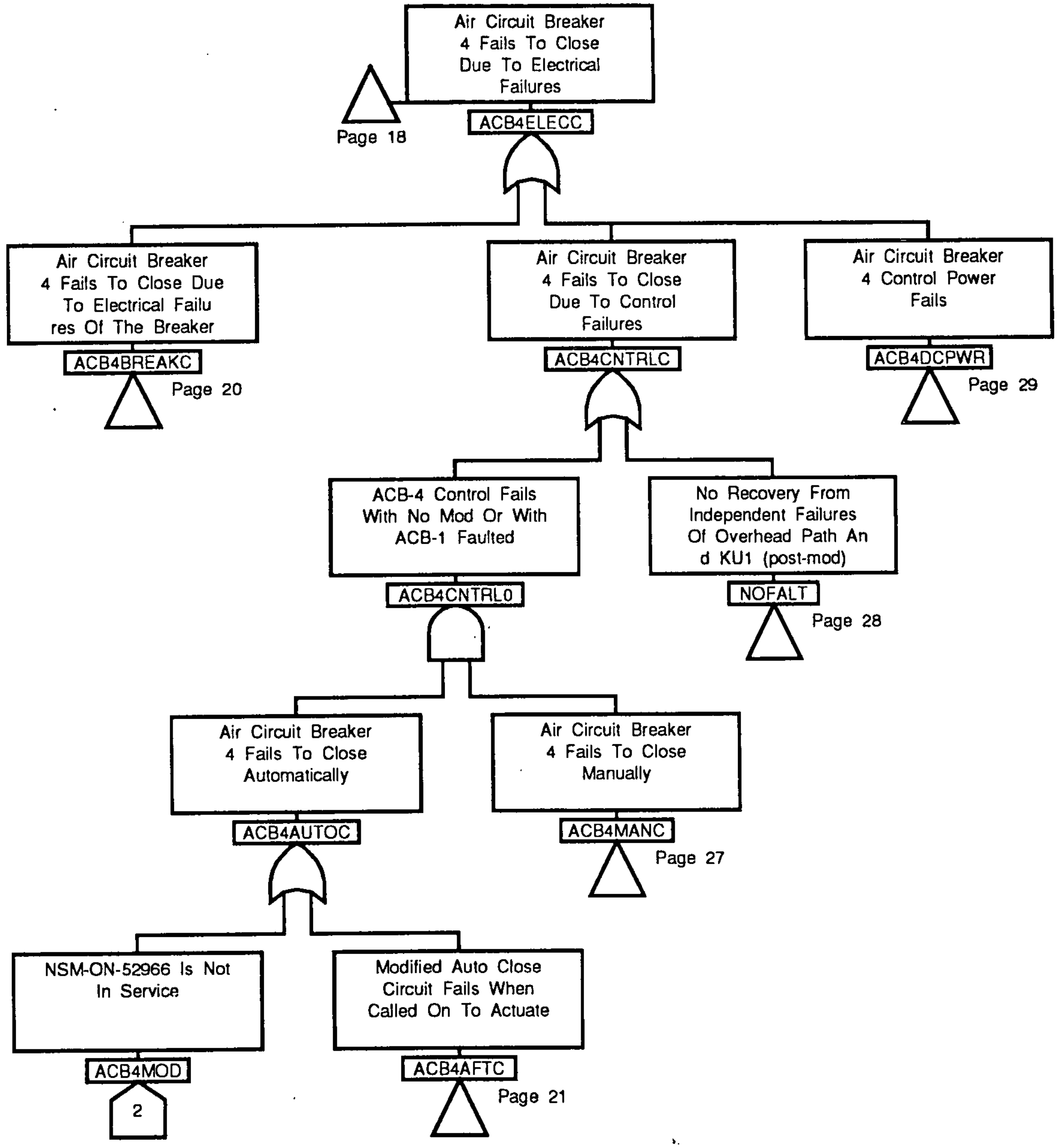
Air Circuit Breaker 3 Fails To Close
ACB3CLOSE
Air Circuit Breaker 3 Fails To Close Due To Mechanical Failure
AB3MCH2DEX
Air Circuit Breaker 3 Accumulator Air Pressure Low
AB3ACCUDEX
2
Air Circuit Breaker 3 Fails To Close Due To Latent Human Error
AB3CLOSLHE
Air Circuit Breaker 3 Fails To Close Due To Electrical Failures
ACB3BREAKC
Page 14
Common Cause Failure Of ACBs 2 And 3
AB23COM
Page 8
Time Delay Relay 2-1TD Fails To Pick-up
AK121TDRYD
KU1 CCF Of 2/3 Overfrequency Relays To Reset When Frequency Drops
AK1OFRQCOM
Failure Of Indication That KU1 Is Selected For The Underground
AK1UNDER
Page 15
Air Circuit Breaker 3 Fails To Close Due To Electrical Failures
Page 14
ACB3BREAKC
Air Circuit Breaker 3 Relay 52X Fails To Operate
AB3R52XR6D
Air Circuit Breaker 3 Accumulator Pressure Switch PS2 Fails Low
AB3PS02PST
2
Air Circuit Breaker 3 Close Coil Fails To Operate
AB352CCSVO
Air Circuit Breaker 3 Relay 52Y Failed To Drop Out Followin g Last Demand
AB352Y2R6D
Air Circuit Breaker 3 Y-relay Spurious Operation
AB352Y2R6T


Failure Of Indication That KU1 Is Selected For The Underground
AK1UNDER
Page 14
Relay 52AX/34 Spuriously Drops-out
AK1AX34RYT
Relay 52AX/34X Spuriously Drops-out
AK1X34XRYT
Air Circuit Breaker 3 Transfers Open
ACB3TRANS
Air Circuit Breaker 3 Trip Coil Spurious Operation
AB352TCSVT
Air Circuit Breaker 3 Trip Signal
ACB3TRIP
Page 16
Air Circuit Breaker 3 Relay 52Z Spurious Operation
AB3R52ZR6T

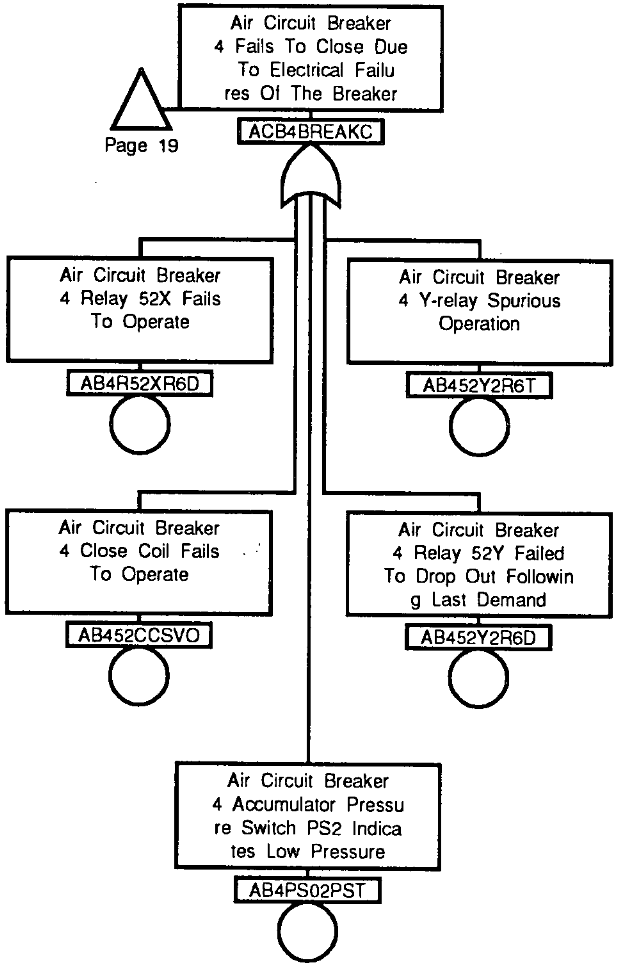

Air Circuit Breaker 3 Trip Signal
ACB3TRIP
Page 15
Underground Feeder Lockout Relay 86EF Picks Up
U86EF
2
Keewee Unit 1 Emergency Lockout Due To Actuation Of Generator Protective Relay
GK186E1
Control Switch 152-3 Spurious Operation
AB31523SWT
Trip Pushbutton On ACB3 Spurious Operation
AB3PUSHPBT
KU1 Trip Circuit Modifications Result In Spurious Trip
K1MODTRIP
Operators Trip Generator Output ACBs
ACBTRIPCHE
2
NSM-ON-52966 Is In Service
NTACB4MOD
Page 6
Trip Signal From Mod Package Components
K1MODTRIP0
Page 17

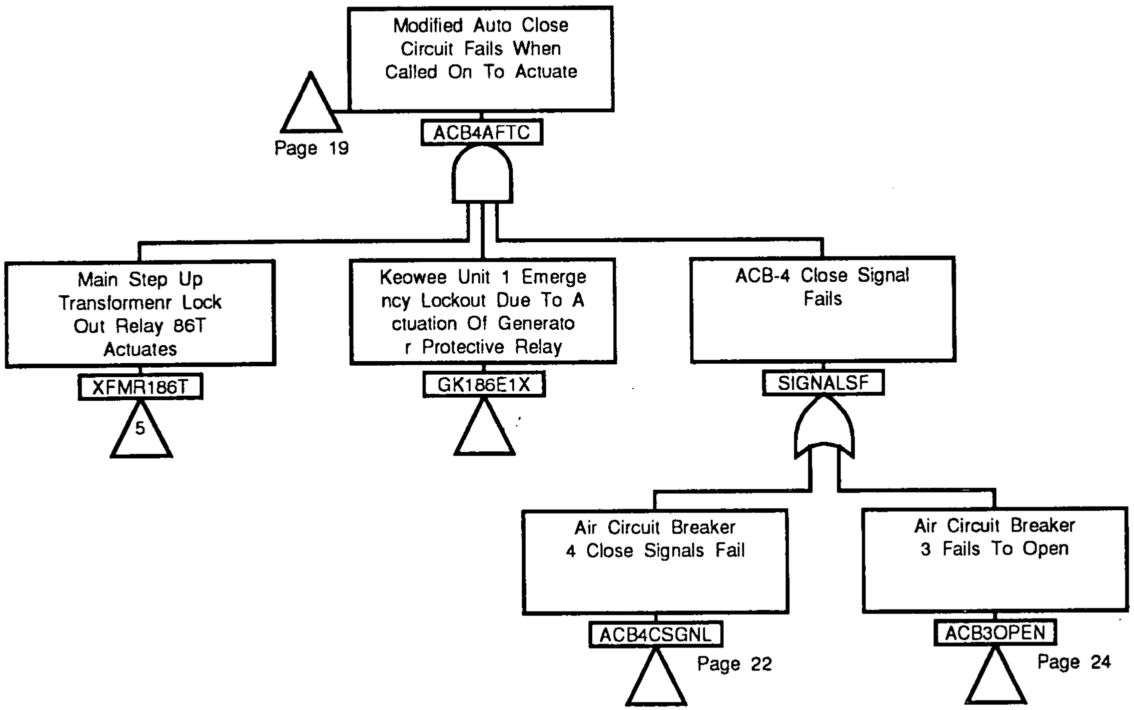

Trip Signal From Mod Package Components
K1MODTRIP0
Page 16
Auxiliary Relay 14GOV/1X Fails To Pick-up
AK1141XRYD
KU1 Magnetic Speed Switch System Fails
AK114GVDEX
2

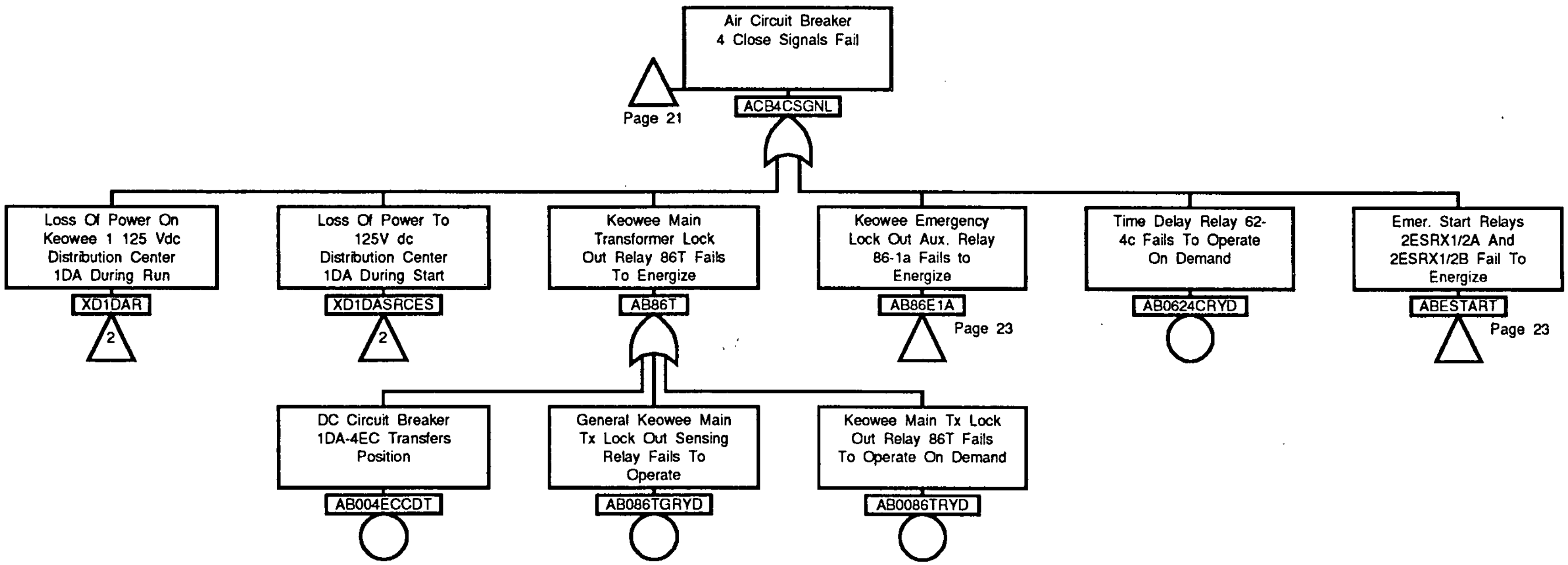

Air Circuit Breaker 4 Fails To Connect Unit 2 To The Underground Path
ACB4CLOSE
Air Circuit Breaker 4 Fails To Close Due To Mechanical Failure
AB4MCH2DEX
Common Cause Failure Of ACBs 2 And 4
AB24COM
Page 6
Air Circuit Breaker 4 Fails To Close Due To Electrical Failures
ACB4ELECC
Page 19
Air Circuit Breaker 4 Key Interlock Switch Transfers Open
AB4KEYISWT
Air Circuit Breaker 4 Accumulator Air Pressure Low
AB4ACCUDEX
ACB Air Supply Fails Causing Low Pressure In All ACB Accumulators
ACBAIRPDEX
Air Circuit Breaker 4 Fails To Close Due To A Latent Human Error
AB4CLOSLHE



Air Circuit Breaker Fault Trees | FIGURE A.4-9 |

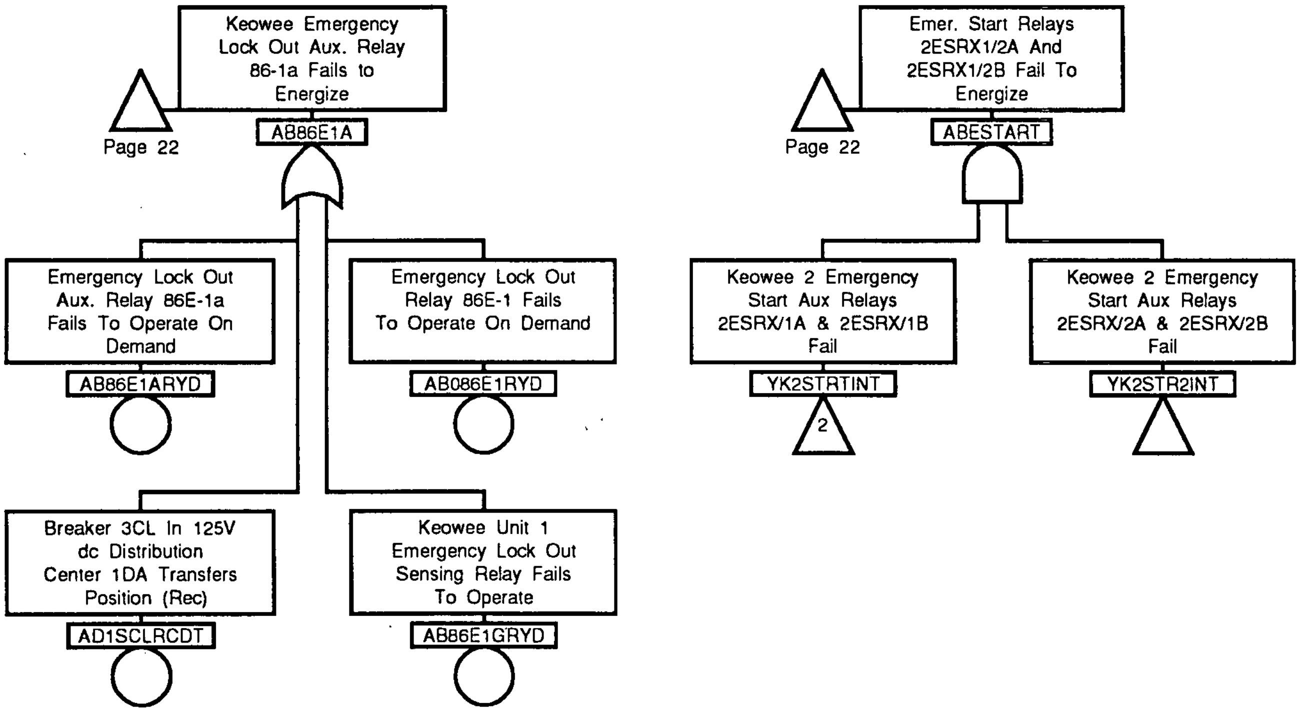

Air Circuit Breaker 4 Fails To Close Due To Electrical Failu res Of The Breaker
ACB4BREAKC
Page 19
Air Circuit Breaker 4 Relay 52X Fails To Operate
AB4R52XR6D
Air Circuit Breaker 4 Y-relay Spurious Operation
AB452Y2R6T
Air Circuit Breaker 4 Close Coil Fails To Operate
AB452CCSVO
Air Circuit Breaker 4 Relay 52Y Failed To Drop Out Followin g Last Demand
AB452Y2R6D
Air Circuit Breaker 4 Accumulator Pressu re Switch PS2 Indica tes Low Pressure
AB4PS02PST

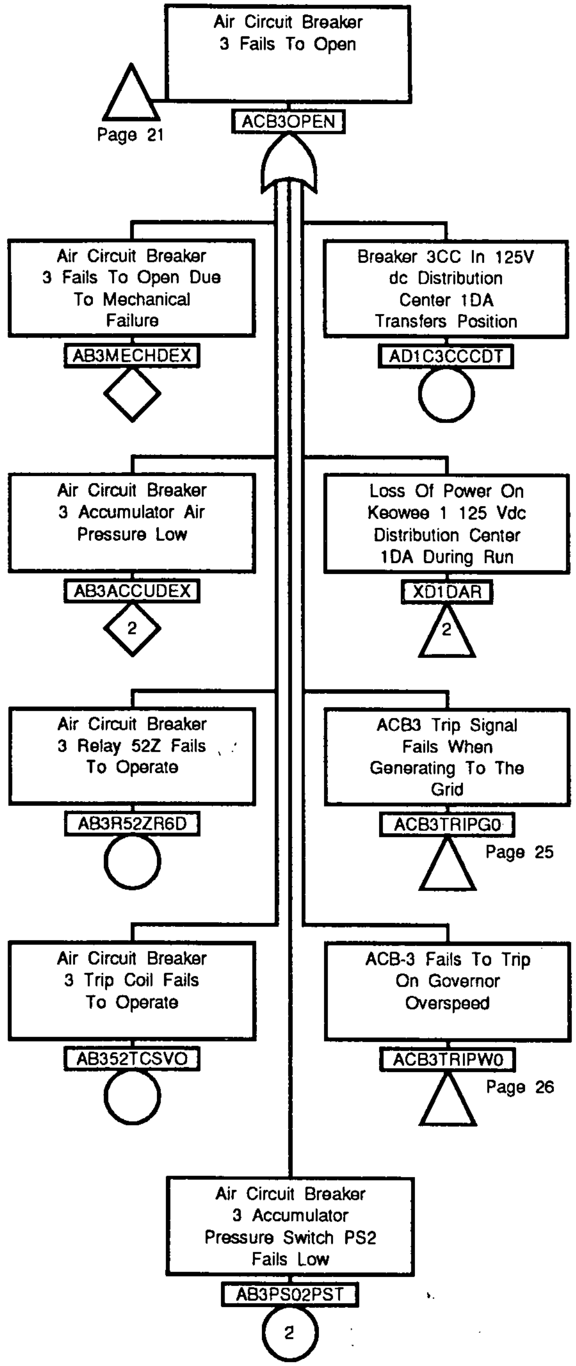

Modified Auto Close Circuit Fails When Called On To Actuate
ACB4AFTC
Page 19
Main Step Up Transformenr Lock Out Relay 86T Actuates
XFMR186T
5
Keowee Unit 1 Emerge ncy Lockout Due To A ctuation Of Generato r Protective Relay
GK186E1X
ACB-4 Close Signal Fails
SIGNALSF
Air Circuit Breaker 4 Close Signals Fail
ACB4CSGNL
Page 22
Air Circuit Breaker 3 Fails To Open
ACB3OPEN
Page 24



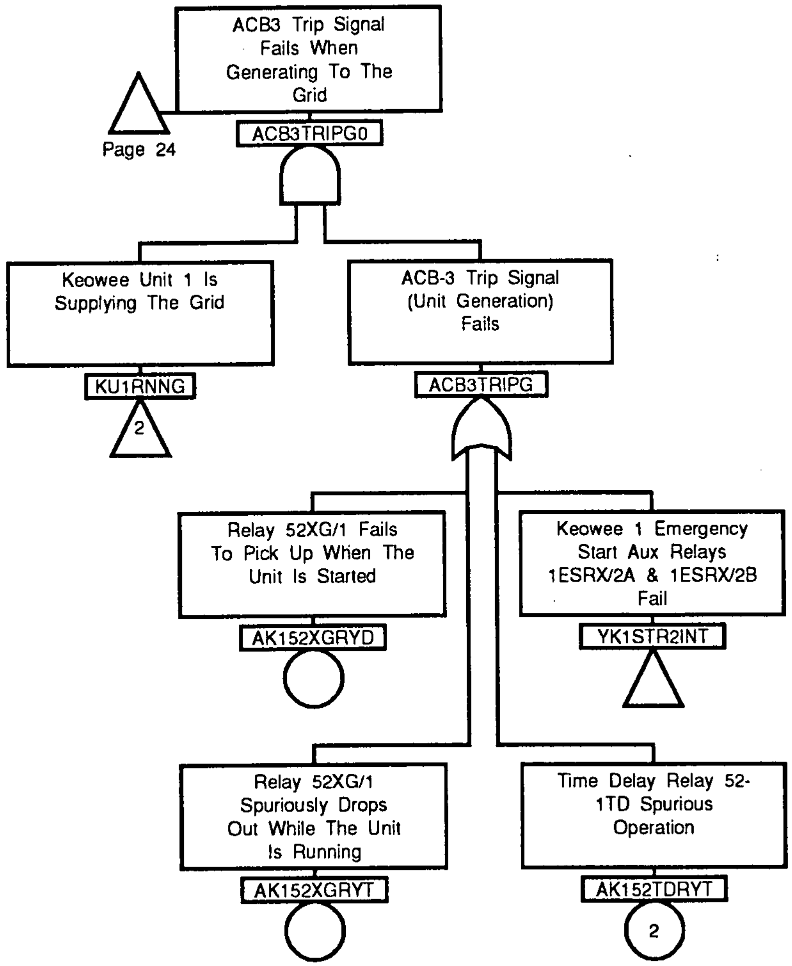
Air Circuit Breaker Fault Trees

FIGURE A.4-9

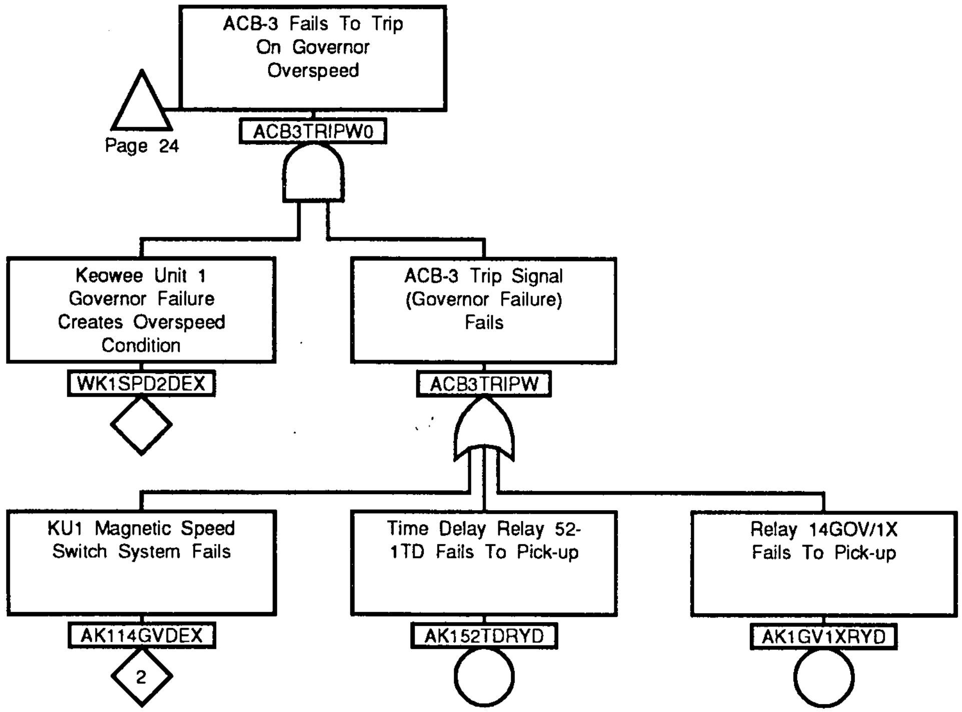

Keowee Emergency Lock Out Aux. Relay 86-1a Fails to Energize
AB86E1A
Page 22
Emergency Lock Out Aux. Relay 86E-1a Fails To Operate On Demand
AB86E1ARYD
Emergency Lock Out Relay 86E-1 Fails To Operate On Demand
AB086E1RYD
Breaker 3CL In 125V dc Distribution Center 1DA Transfers Position (Rec)
AD1SCLRCDT
Keowee Unit 1 Emergency Lock Out Sensing Relay Fails To Operate
AB86E1GRYD
Emer. Start Relays 2ESRX1/2A And 2ESRX1/2B Fail To Energize
ABESTART
Page 22
Keowee 2 Emergency Start Aux Relays 2ESRX/1A & 2ESRX/1B Fail
YK2STRTINT
2
Keowee 2 Emergency Start Aux Relays 2ESRX/2A & 2ESRX/2B Fail
YK2STR2INT



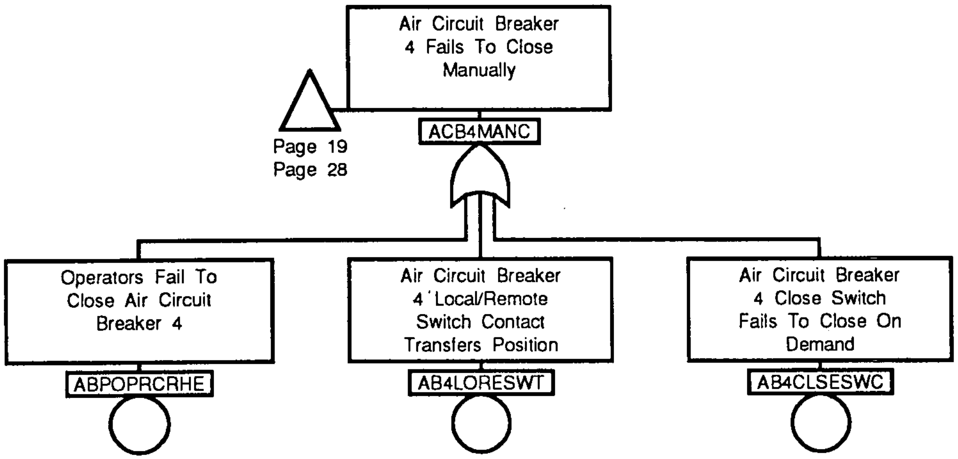
Air Circuit Breaker Fault Trees	FIGURE A.4-9	Page 24

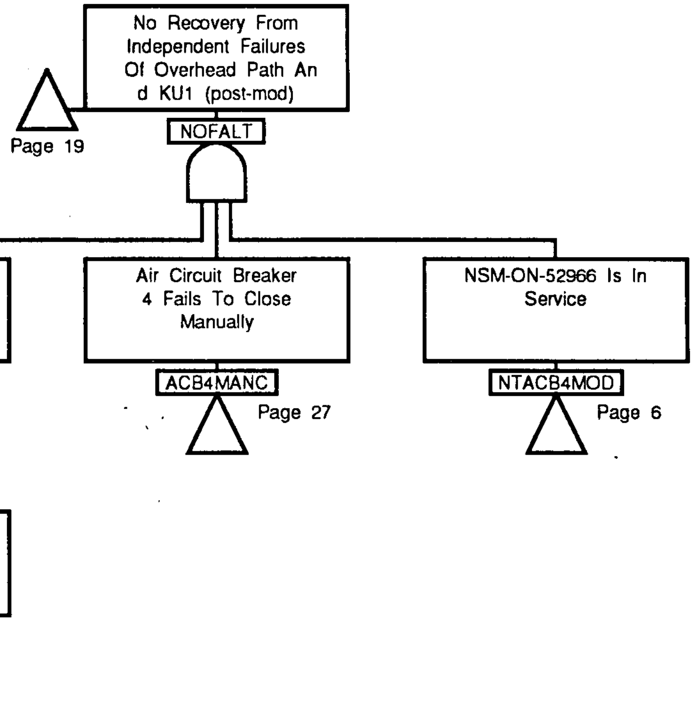


ACB3 Trip Signal Fails When Generating To The Grid
ACB3TRIPG0
Page 24
Keowee Unit 1 Is Supplying The Grid
KU1RNNG
2
ACB-3 Trip Signal (Unit Generation) Fails
ACB3TRIPG
Relay 52XG/1 Fails To Pick Up When The Unit Is Started
AK152XGRYD
Keowee 1 Emergency Start Aux Relays 1ESRX/2A & 1ESRX/2B Fail
YK1STR2INT
Relay 52XG/1 Spuriously Drops Out While The Unit Is Running
AK152XGRYT
Time Delay Relay 52-1TD Spurious Operation
AK152TDRYT
2

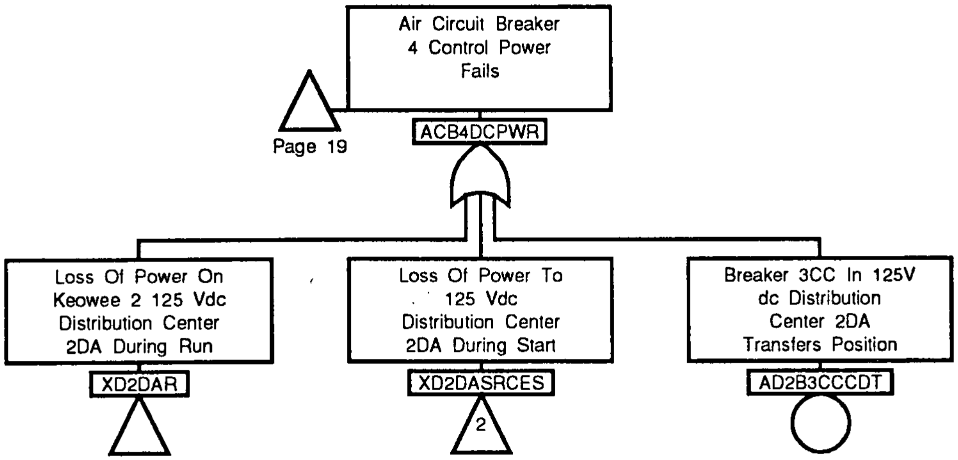


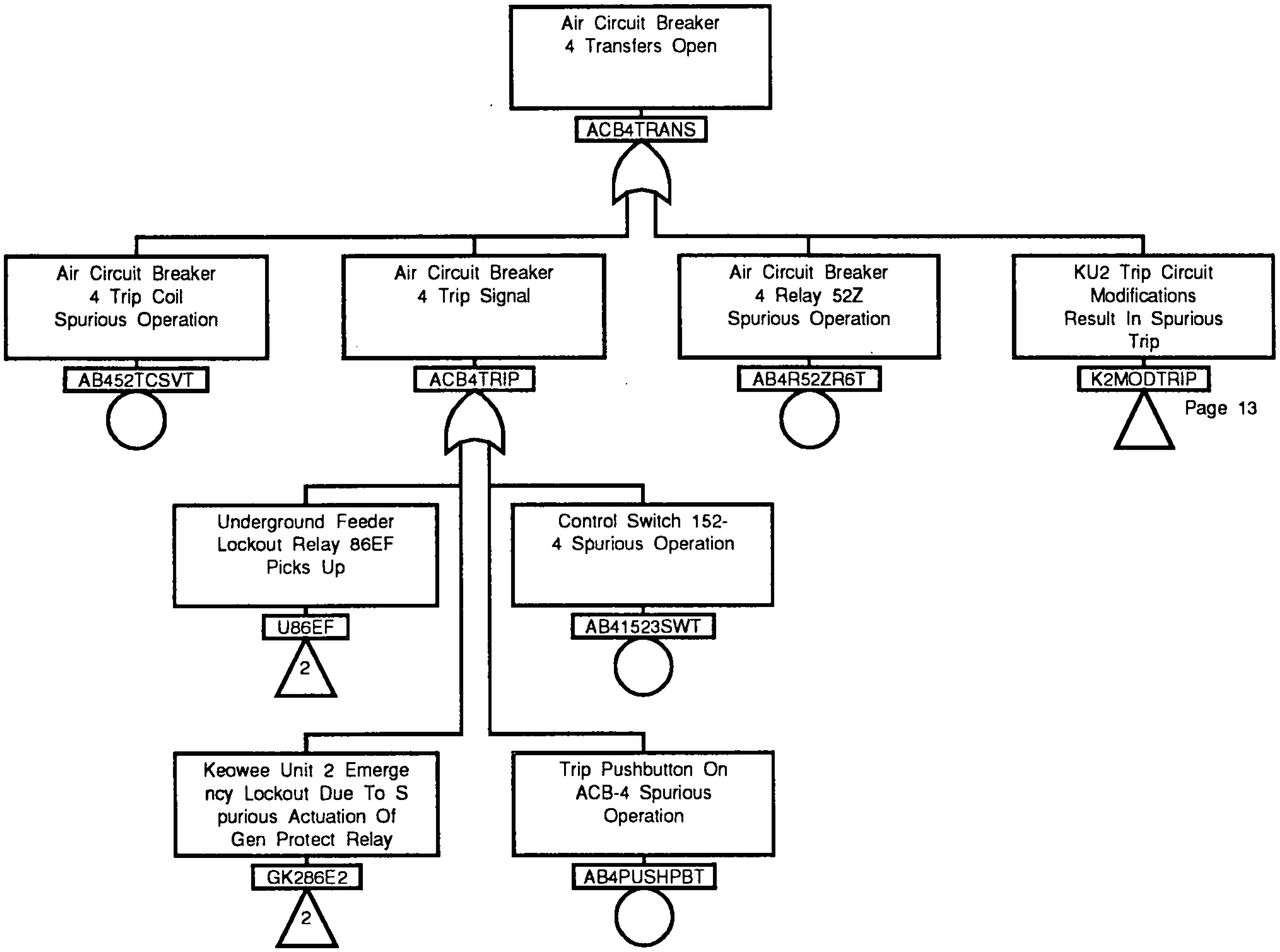
Air Circuit Breaker Fault Trees | FIGURE A.4-9 |


Air Circuit Breaker 4 Fails To Close Manually
ACB4MANC
Page 19
Page 28
Operators Fail To Close Air Circuit Breaker 4
ABPOPRCRHE
Air Circuit Breaker 4 Local/Remote Switch Contact Transfers Position
AB4LORESWT
Air Circuit Breaker 4 Close Switch Fails To Close On Demand
AB4CLSESWC

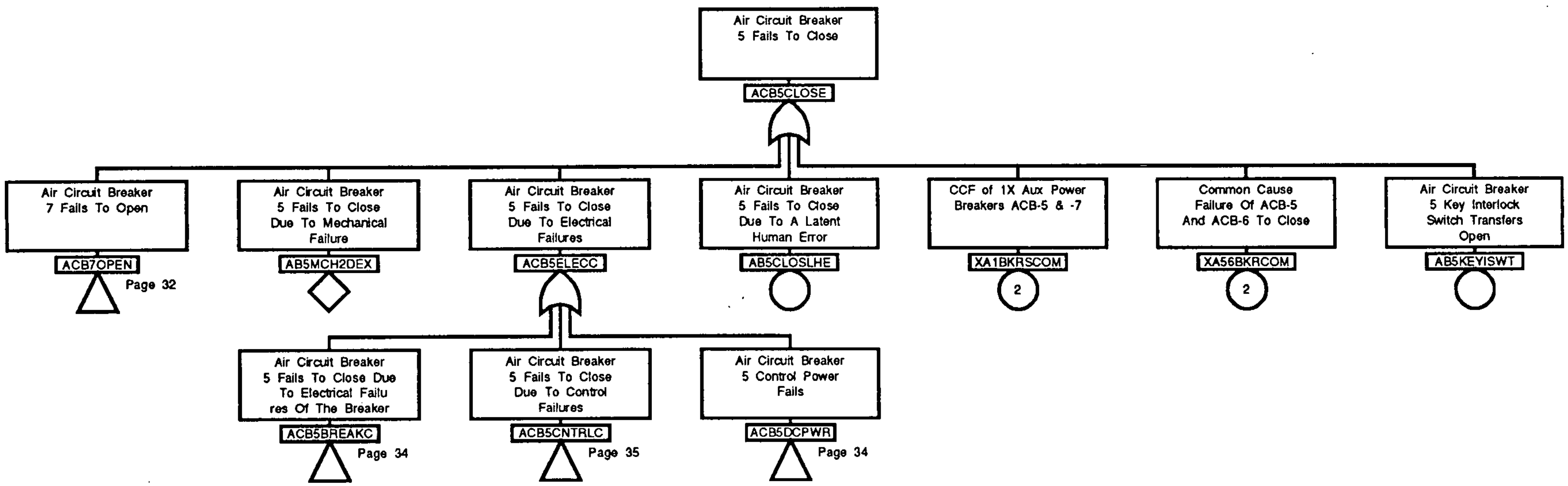


No Recovery From Independent Failures Of Overhead Path An d KU1 (post-mod)
NOFALT
Page 19
Air Circuit Breaker 1 Is Not Faulted
NOAB1FALT
Air Circuit Breaker 4 Fails To Close Manually
ACB4MANC
Page 27
NSM-ON-52966 Is In Service
NTACB4MOD
Page 6
Fault Occurs at ACB-1 When The BReaker Trips
AB1FALTDEX

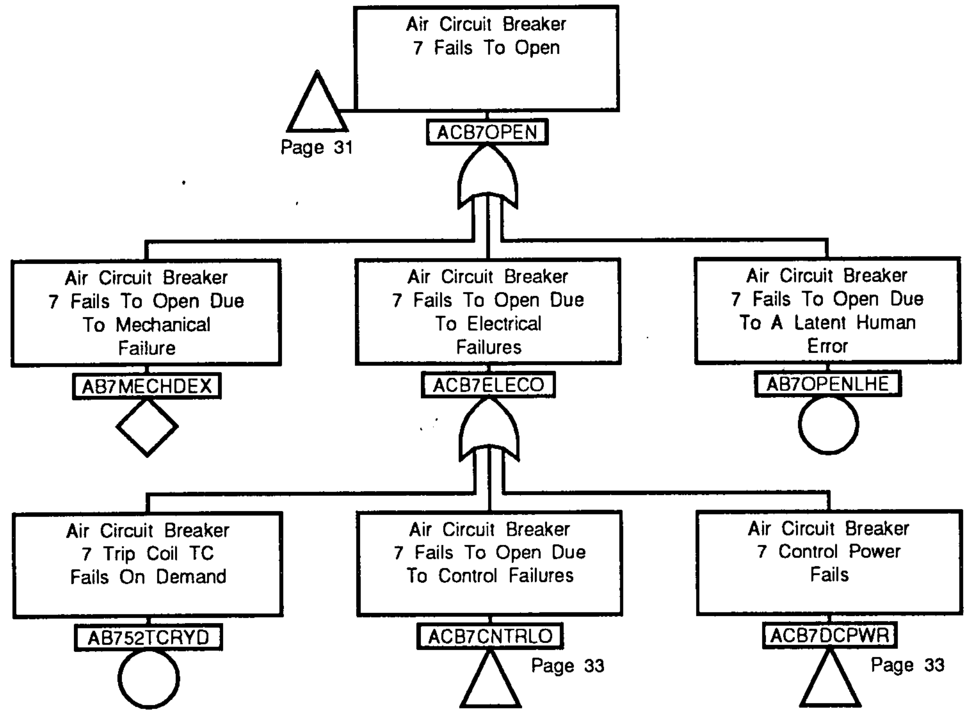

Air Circuit Breaker 4 Control Power Fails
ACB4DCPWR
Page 19
Loss Of Power On Keowee 2 125 Vdc Distribution Center 2DA During Run
XD2DAR
Loss Of Power To 125 Vdc Distribution Center 2DA During Start
XD2DASRCES
2
Breaker 3CC In 125V dc Distribution Center 2DA Transfers Position
AD2B3CCCDT

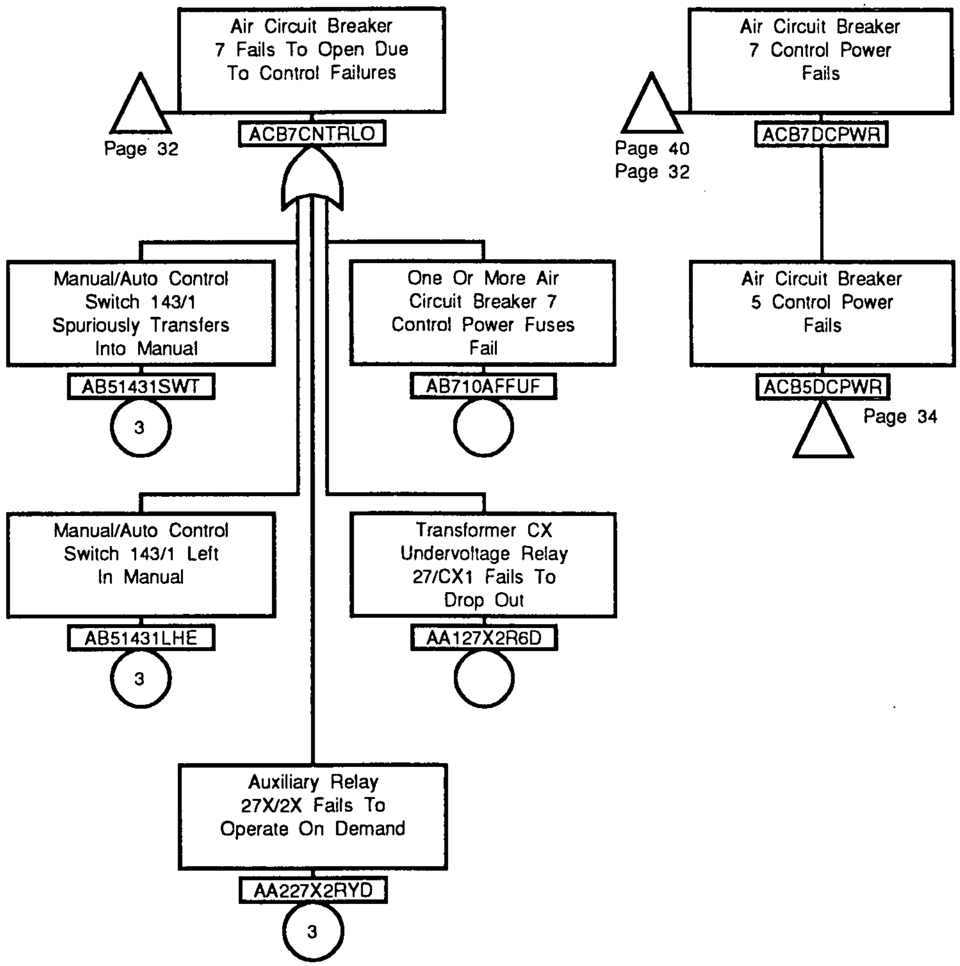


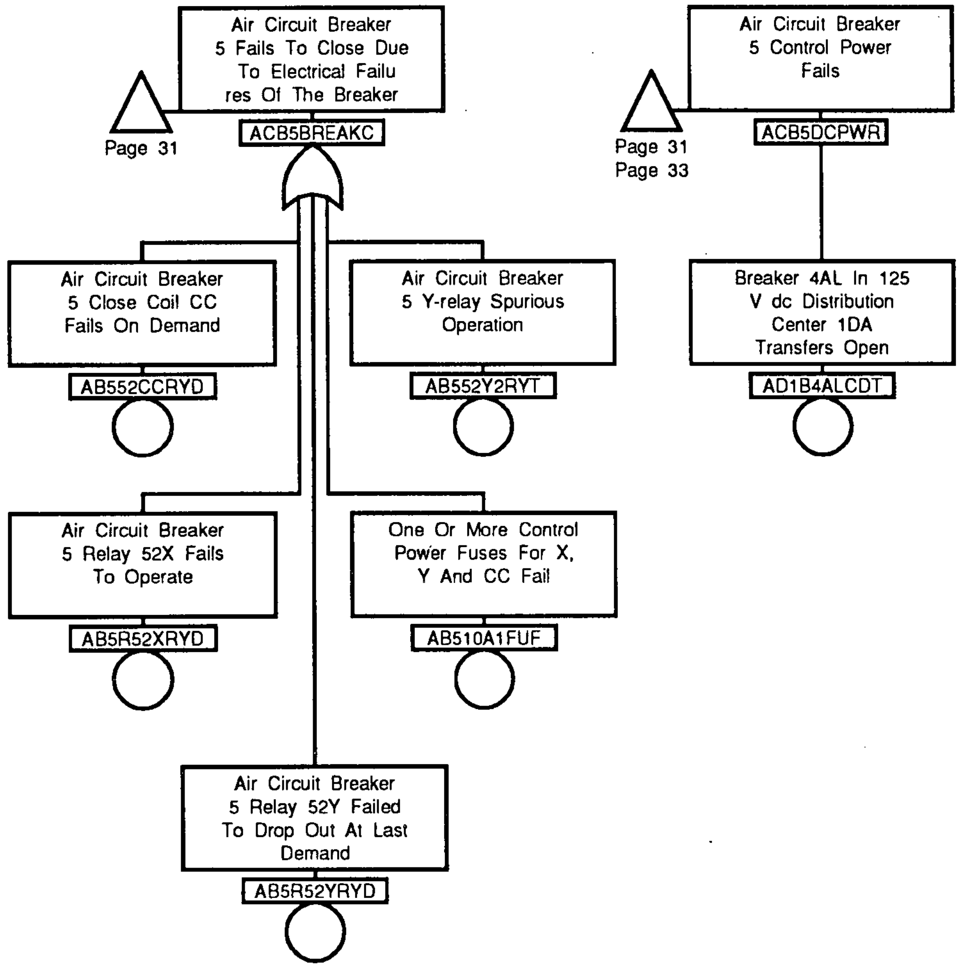
Air Circuit Breaker 4 Transfers Open
ACB4TRANS
Air Circuit Breaker 4 Trip Coil Spurious Operation
AB452TCSVT
Air Circuit Breaker 4 Trip Signal
ACB4TRIP
Air Circuit Breaker 4 Relay 52Z Spurious Operation
AB4R52ZR6T
KU2 Trip Circuit Modifications Result In Spurious Trip
K2MODTRIP
Page 13
Underground Feeder Lockout Relay 86EF Picks Up
U86EF
2
Control Switch 152-4 Spurious Operation
AB41523SWT
Keowee Unit 2 Emergency Lockout Due To Spurious Actuation Of Gen Protect Relay
GK286E2
2
Trip Pushbutton On ACB-4 Spurious Operation
AB4PUSHPBT



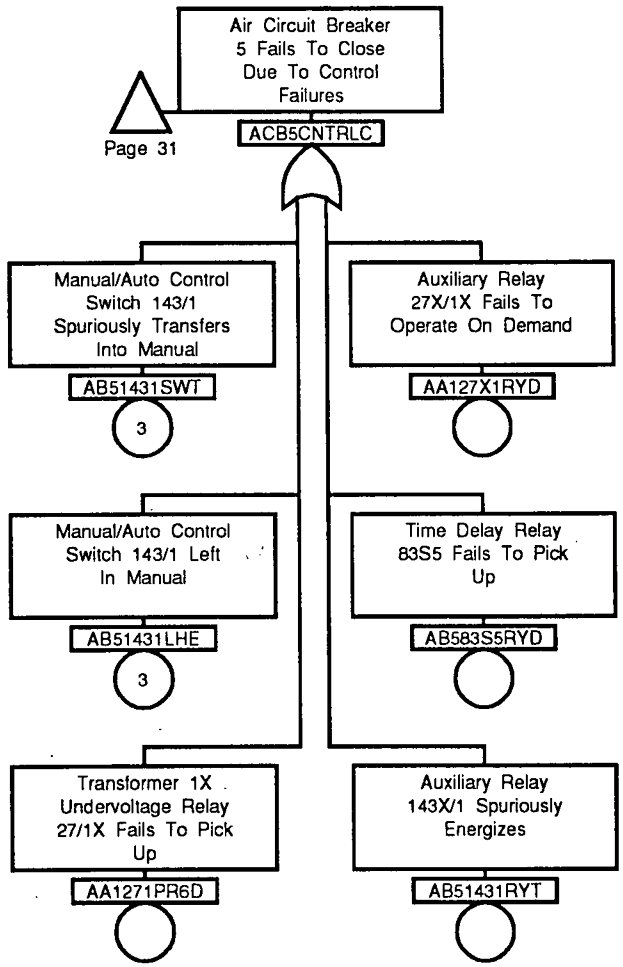
Air Circuit Breaker 5 Fails To Close
ACB5CLOSE
Air Circuit Breaker 7 Fails To Open
ACB7OPEN
Page 32
Air Circuit Breaker 5 Fails To Close Due To Mechanical Failure
AB5MCH2DEX
Air Circuit Breaker 5 Fails To Close Due To Electrical Failures
ACB5ELECC
Air Circuit Breaker 5 Fails To Close Due To A Latent Human Error
AB5CLOSLHE
CCF of 1X Aux Power Breakers ACB-5 & -7
XA1BKRSCOM
2
Common Cause Failure Of ACB-5 And ACB-6 To Close
XA56BKRCOM
2
Air Circuit Breaker 5 Key Interlock Switch Transfers Open
AB5KEYISWT
Air Circuit Breaker 5 Fails To Close Due To Electrical Failu res Of The Breaker
ACB5BREAKC
Page 34
Air Circuit Breaker 5 Fails To Close Due To Control Failures
ACB5CNTRLC
Page 35
Air Circuit Breaker 5 Control Power Fails
ACB5DCPWR
Page 34

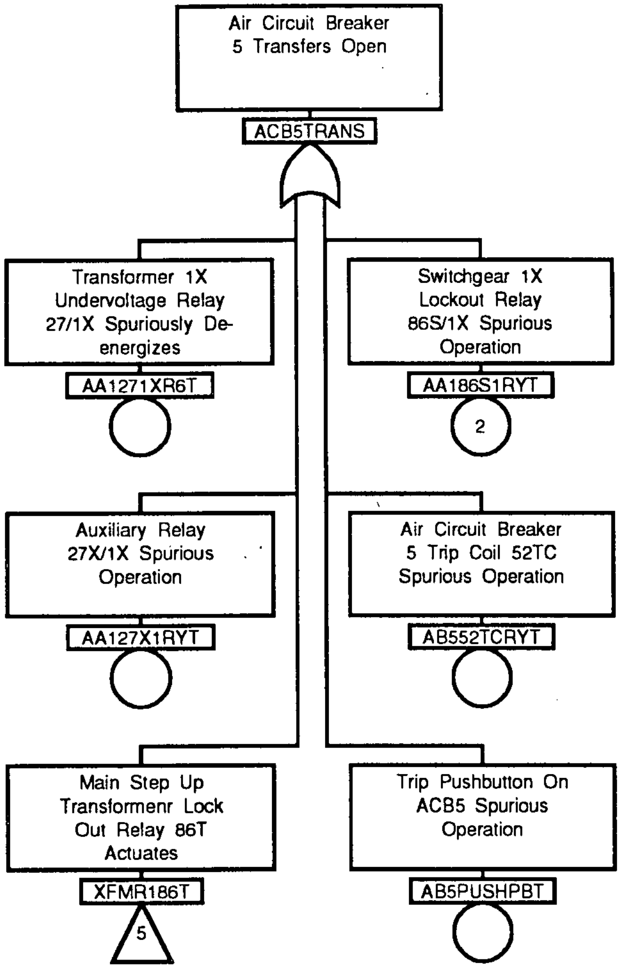

Air Circuit Breaker 7 Fails To Open
Page 31
ACB7OPEN
Air Circuit Breaker 7 Fails To Open Due To Mechanical Failure
AB7MECHDEX
Air Circuit Breaker 7 Fails To Open Due To Electrical Failures
ACB7ELECO
Air Circuit Breaker 7 Fails To Open Due To A Latent Human Error
AB7OPENLHE
Air Circuit Breaker 7 Trip Coil TC Fails On Demand
AB752TCRYD
Air Circuit Breaker 7 Fails To Open Due To Control Failures
ACB7CNTRLO
Page 33
Air Circuit Breaker 7 Control Power Fails
ACB7DCPWR
Page 33

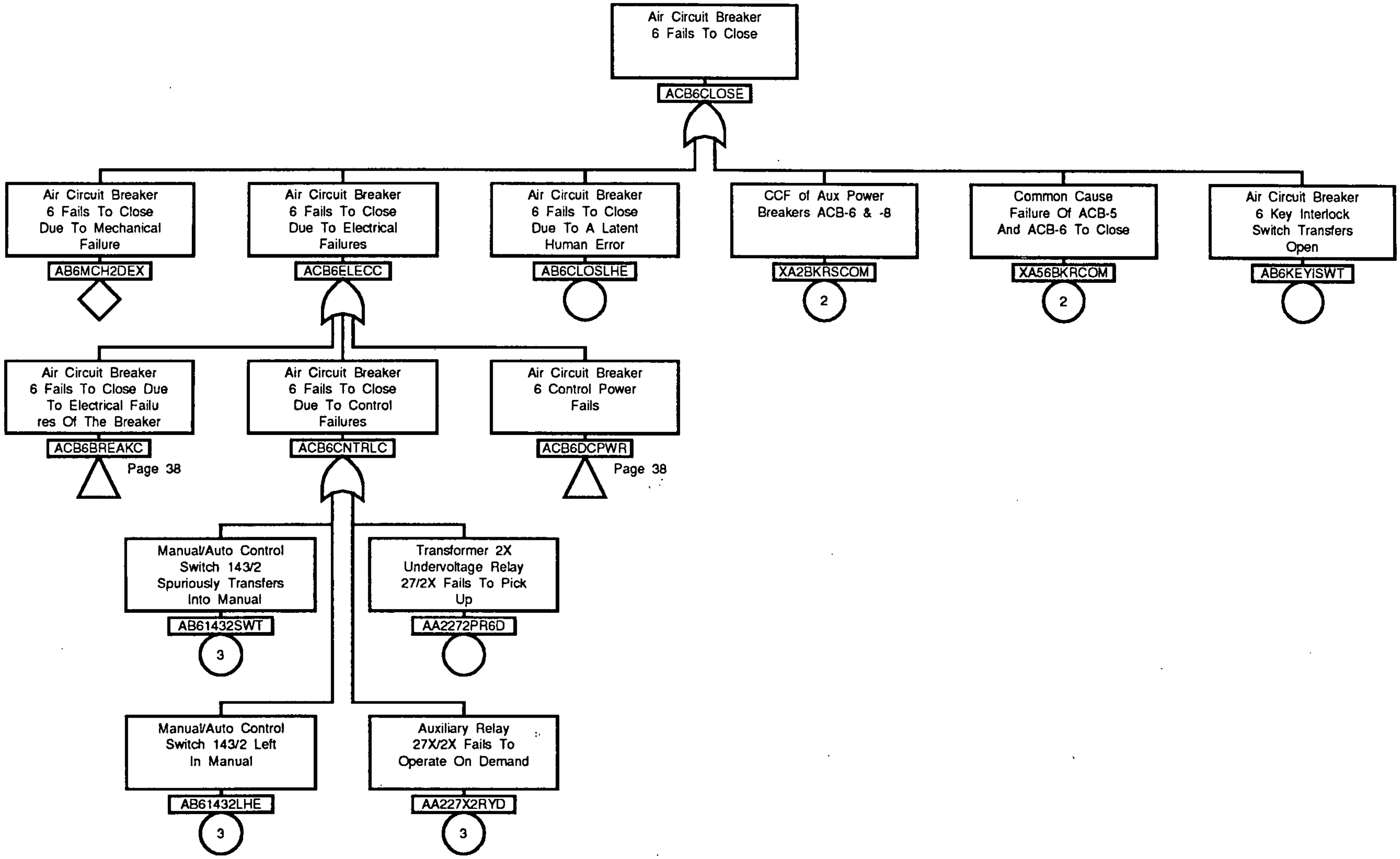

Air Circuit Breaker 7 Fails To Open Due To Control Failures
ACB7CNTRLO
Page 32
Manual/Auto Control Switch 143/1 Spuriously Transfers Into Manual
AB51431SWT
3
One Or More Air Circuit Breaker 7 Control Power Fuses Fail
AB710AFFUF
Manual/Auto Control Switch 143/1 Left In Manual
AB51431LHE
3
Transformer CX Undervoltage Relay 27/CX1 Fails To Drop Out
AA127X2R6D
Auxiliary Relay 27X/2X Fails To Operate On Demand
AA227X2RYD
3
Air Circuit Breaker 7 Control Power Fails
ACB7DCPWR
Page 40
Page 32
Air Circuit Breaker 5 Control Power Fails
ACB5DCPWR
Page 34



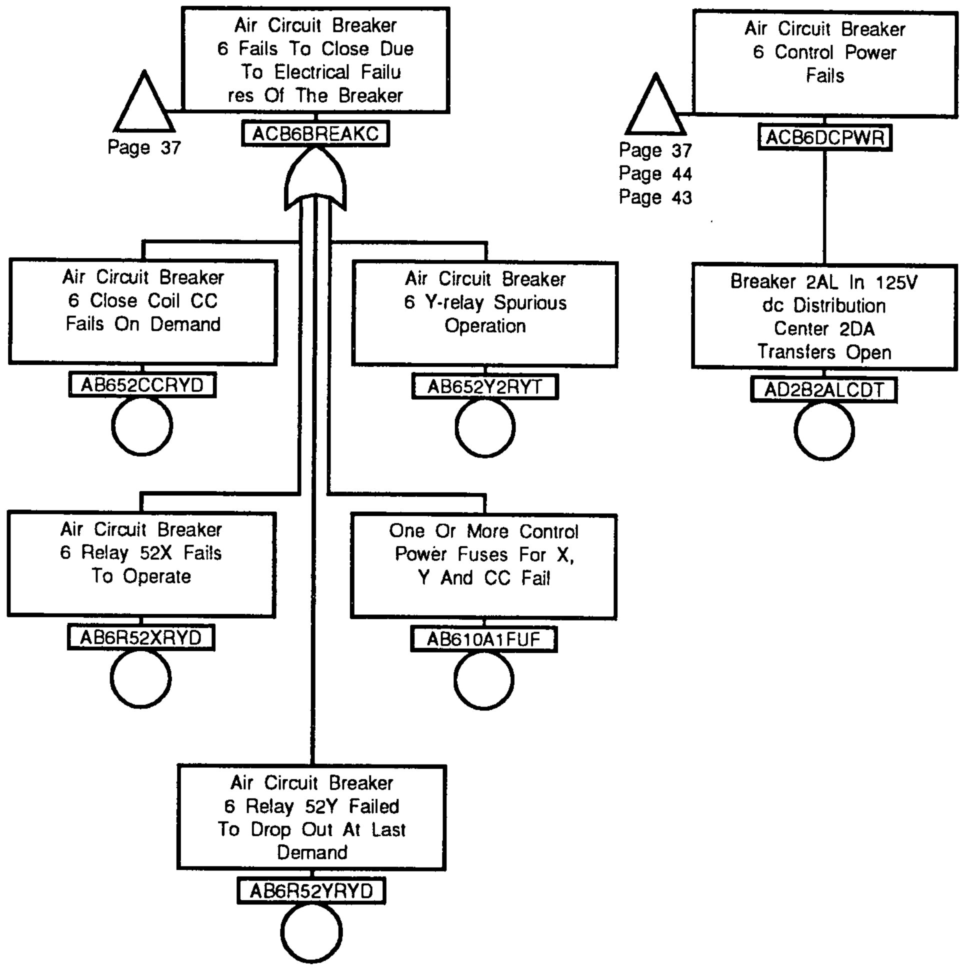
Air Circuit Breaker Fault Trees | FIGURE A.4-9 |

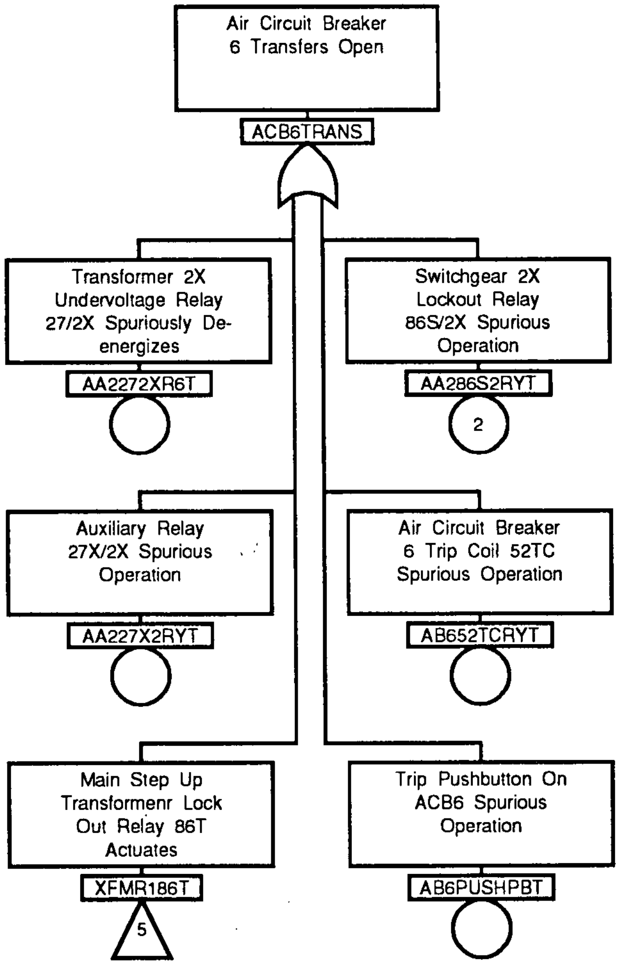

Air Circuit Breaker 5 Fails To Close Due To Control Failures
ACB5CNTRLC
Page 31
Manual/Auto Control Switch 143/1 Spuriously Transfers Into Manual
AB51431SWT
3
Auxiliary Relay 27X/1X Fails To Operate On Demand
AA127X1RYD
Manual/Auto Control Switch 143/1 Left In Manual
AB51431LHE
3
Time Delay Relay 83S5 Fails To Pick Up
AB583S5RYD
Transformer 1X Undervoltage Relay 27/1X Fails To Pick Up
AA1271PR6D
Auxiliary Relay 143X/1 Spuriously Energizes
AB51431RYT

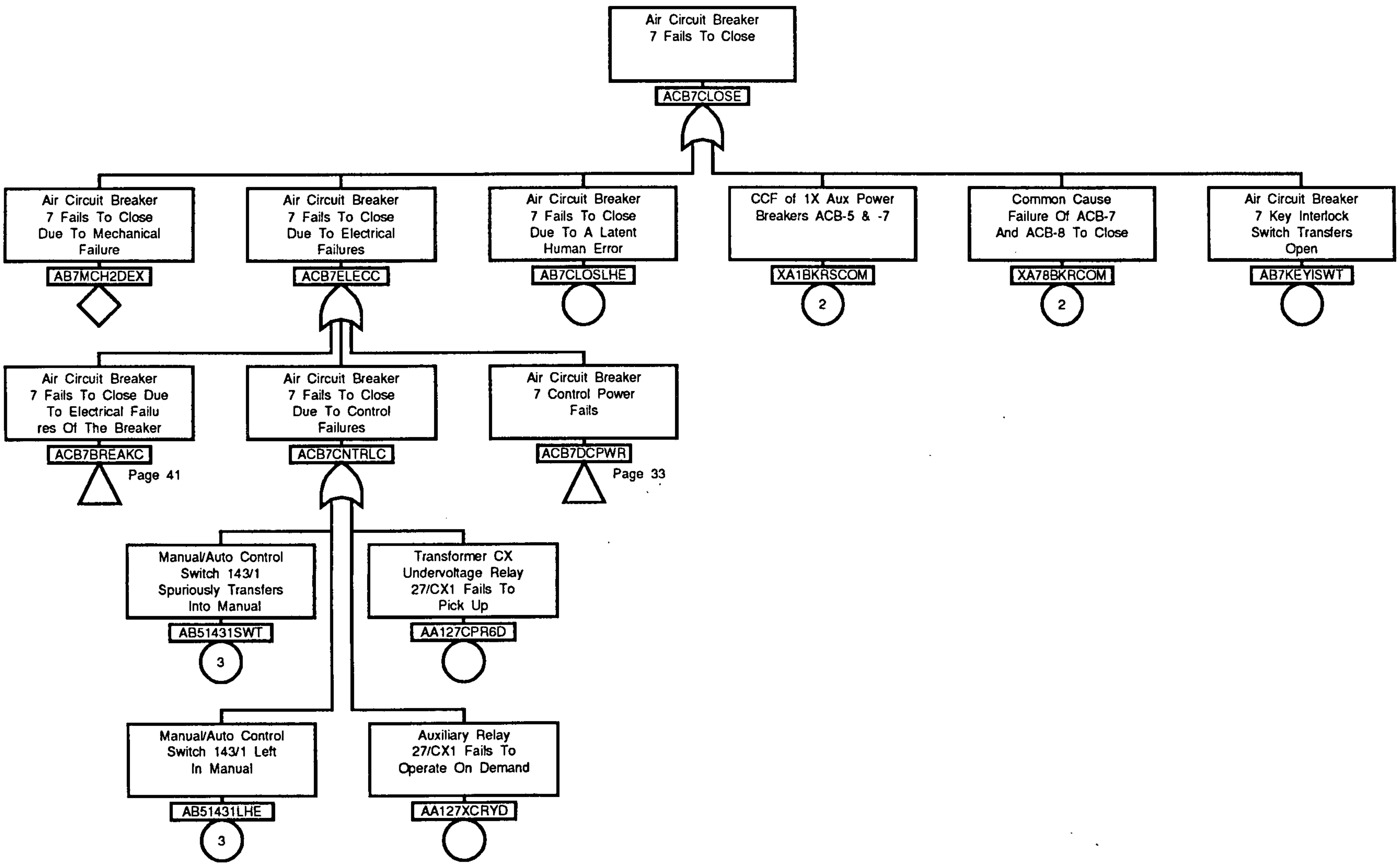

Air Circuit Breaker 5 Transfers Open
ACB5TRANS
Transformer 1X Undervoltage Relay 27/1X Spuriously De-energizes
AA1271XR6T
Switchgear 1X Lockout Relay 86S/1X Spurious Operation
AA186S1RYT
2
Auxiliary Relay 27X/1X Spurious Operation
AA127X1RYT
Air Circuit Breaker 5 Trip Coil 52TC Spurious Operation
AB552TCRYT
Main Step Up Transformenr Lock Out Relay 86T Actuates
XFMR186T
5
Trip Pushbutton On ACB5 Spurious Operation
AB5PUSHPBT

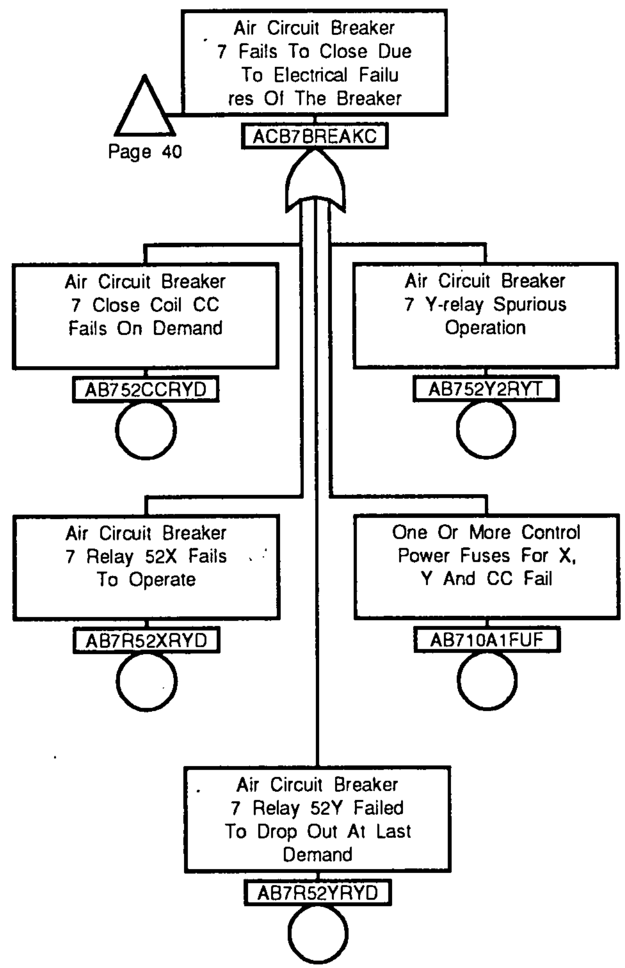


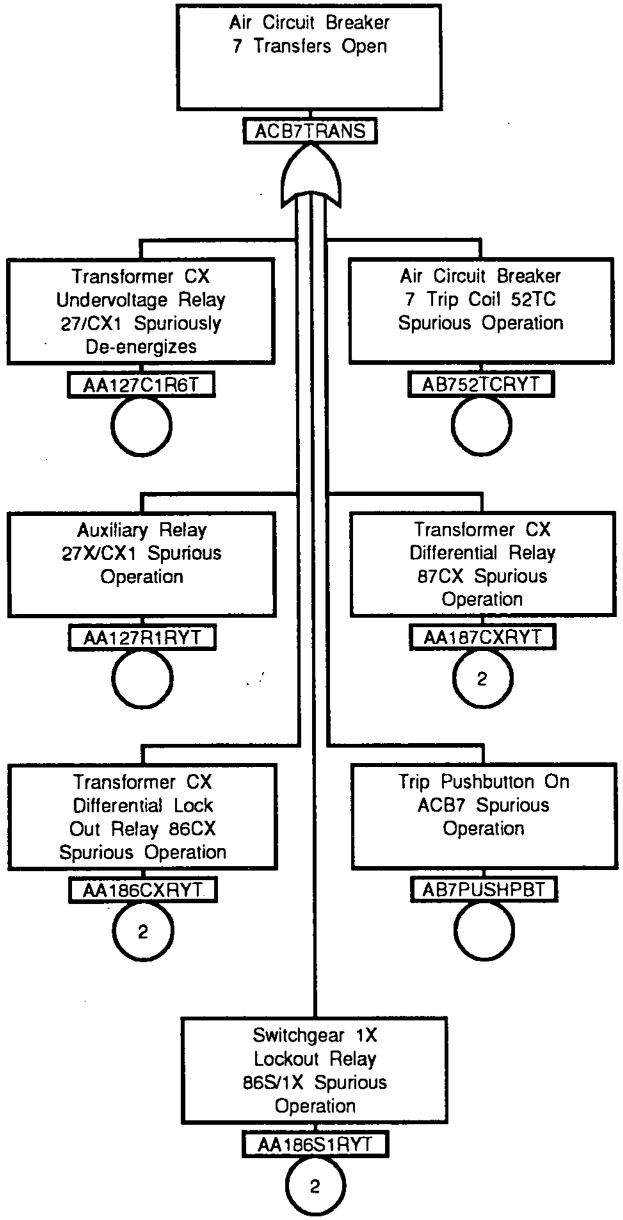
Air Circuit Breaker Fault Trees	FIGURE A.4-9	Page 37

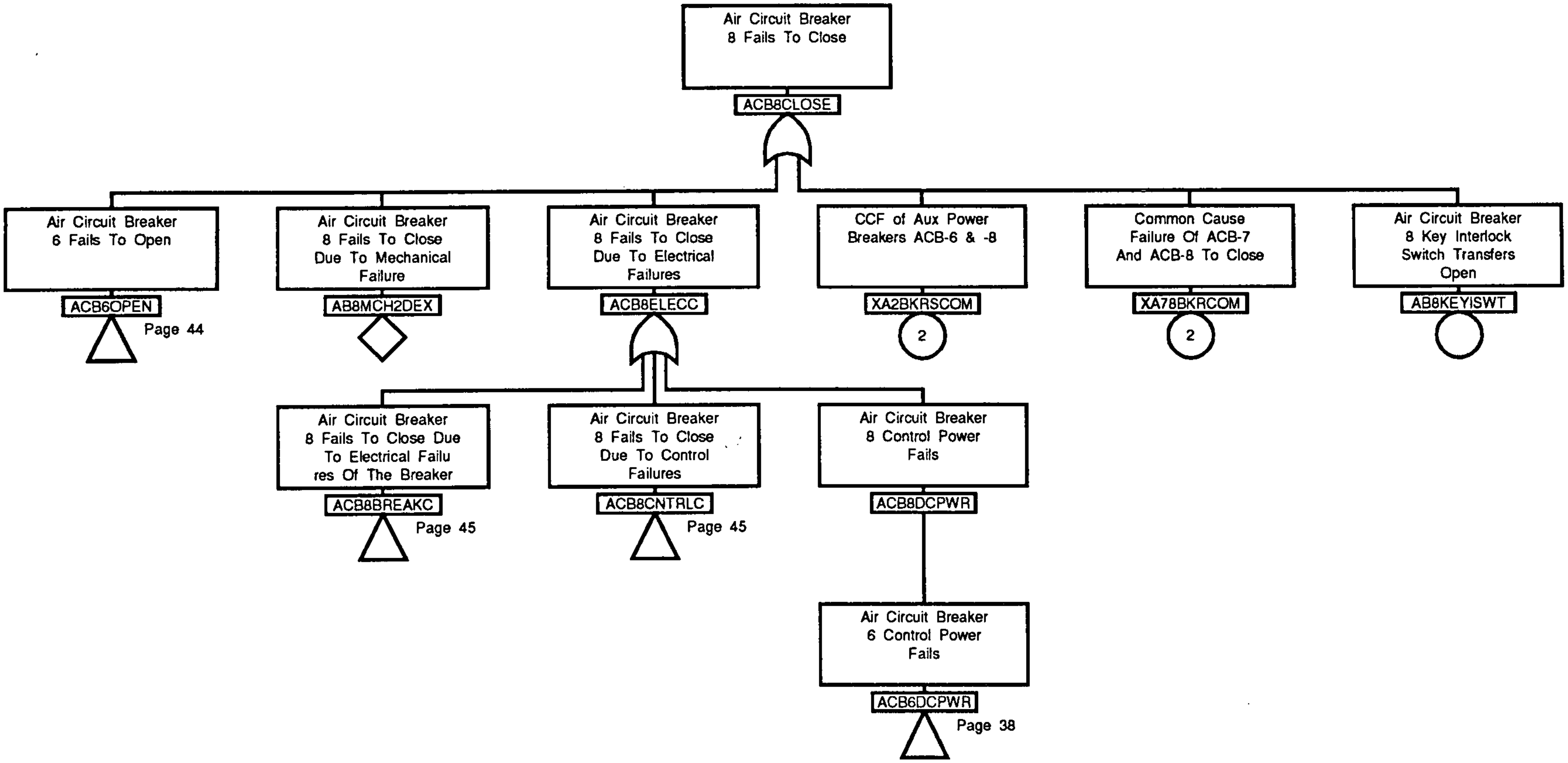

Air Circuit Breaker 6 Fails To Close Due To Electrical Failu res Of The Breaker
ACB6BREAKC
Page 37
Air Circuit Breaker 6 Close Coil CC Fails On Demand
AB652CCRYD
Air Circuit Breaker 6 Y-relay Spurious Operation
AB652Y2RYT
Air Circuit Breaker 6 Relay 52X Fails To Operate
AB6R52XRYD
One Or More Control Power Fuses For X, Y And CC Fail
AB610A1FUF
Air Circuit Breaker 6 Relay 52Y Failed To Drop Out At Last Demand
AB6R52YRYD
Air Circuit Breaker 6 Control Power Fails
ACB6DCPWR
Page 37
Page 44
Page 43
Breaker 2AL In 125V dc Distribution Center 2DA Transfers Open
AD2B2ALCDT


Air Circuit Breaker 6 Transfers Open
ACB6TRANS
Transformer 2X Undervoltage Relay 27/2X Spuriously De-energizes
AA2272XR6T
Switchgear 2X Lockout Relay 86S/2X Spurious Operation
AA286S2RYT
2
Auxiliary Relay 27X/2X Spurious Operation
AA227X2RYT
Air Circuit Breaker 6 Trip Coil 52TC Spurious Operation
AB652TCRYT
Main Step Up Transformenr Lock Out Relay 86T Actuates
XFMR186T
5
Trip Pushbutton On ACB6 Spurious Operation
AB6PUSHPBT


Air Circuit Breaker 7 Fails To Close
ACB7CLOSE
Air Circuit Breaker 7 Fails To Close Due To Mechanical Failure
AB7MCH2DEX
Air Circuit Breaker 7 Fails To Close Due To Electrical Failures
ACB7ELECC
Air Circuit Breaker 7 Fails To Close Due To A Latent Human Error
AB7CLOSLHE
CCF of 1X Aux Power Breakers ACB-5 & -7
XA1BKRSCOM
2
Common Cause Failure Of ACB-7 And ACB-8 To Close
XA78BKRCOM
2
Air Circuit Breaker 7 Key Interlock Switch Transfers Open
AB7KEYISWT
Air Circuit Breaker 7 Fails To Close Due To Electrical Failu res Of The Breaker
ACB7BREAKC
Page 41
Air Circuit Breaker 7 Fails To Close Due To Control Failures
ACB7CNTRLC
Air Circuit Breaker 7 Control Power Fails
ACB7DCPWR
Page 33
Manual/Auto Control Switch 143/1 Spuriously Transfers Into Manual
AB51431SWT
3
Transformer CX Undervoltage Relay 27/CX1 Fails To Pick Up
AA127CPR6D
Manual/Auto Control Switch 143/1 Left In Manual
AB51431LHE
3
Auxiliary Relay 27/CX1 Fails To Operate On Demand
AA127XCRYD


Air Circuit Breaker 7 Fails To Close Due To Electrical Failu res Of The Breaker
ACB7BREAKC
Page 40
Air Circuit Breaker 7 Close Coil CC Fails On Demand
AB752CCRYD
Air Circuit Breaker 7 Y-relay Spurious Operation
AB752Y2RYT
Air Circuit Breaker 7 Relay 52X Fails To Operate
AB7R52XRYD
One Or More Control Power Fuses For X, Y And CC Fail
AB710A1FUF
Air Circuit Breaker 7 Relay 52Y Failed To Drop Out At Last Demand
AB7R52YRYD


Air Circuit Breaker 7 Transfers Open
ACB7TRANS
Transformer CX Undervoltage Relay 27/CX1 Spuriously De-energizes
AA127C1R6T
Air Circuit Breaker 7 Trip Coil 52TC Spurious Operation
AB752TCRYT
Auxiliary Relay 27X/CX1 Spurious Operation
AA127R1RYT
Transformer CX Differential Relay 87CX Spurious Operation
AA187CXRYT
2
Transformer CX Differential Lock Out Relay 86CX Spurious Operation
AA186CXRYT
2
Trip Pushbutton On ACB7 Spurious Operation
AB7PUSHPBT
Switchgear 1X Lockout Relay 86S/1X Spurious Operation
AA186S1RYT
2



Air Circuit Breaker 8 Fails To Close
ACB8CLOSE
Air Circuit Breaker 6 Fails To Open
ACB6OPEN
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Air Circuit Breaker 8 Fails To Close Due To Mechanical Failure
AB8MCH2DEX
Air Circuit Breaker 8 Fails To Close Due To Electrical Failures
ACB8ELECC
CCF of Aux Power Breakers ACB-6 & -8
XA2BKRSCOM
2
Common Cause Failure Of ACB-7 And ACB-8 To Close
XA78BKRCOM
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Air Circuit Breaker 8 Key Interlock Switch Transfers Open
AB8KEYISWT
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ACB8BREAKC
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Air Circuit Breaker 8 Fails To Close Due To Control Failures
ACB8CNTRLC
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Air Circuit Breaker 8 Control Power Fails
ACB8DCPWR
Air Circuit Breaker 6 Control Power Fails
ACB6DCPWR
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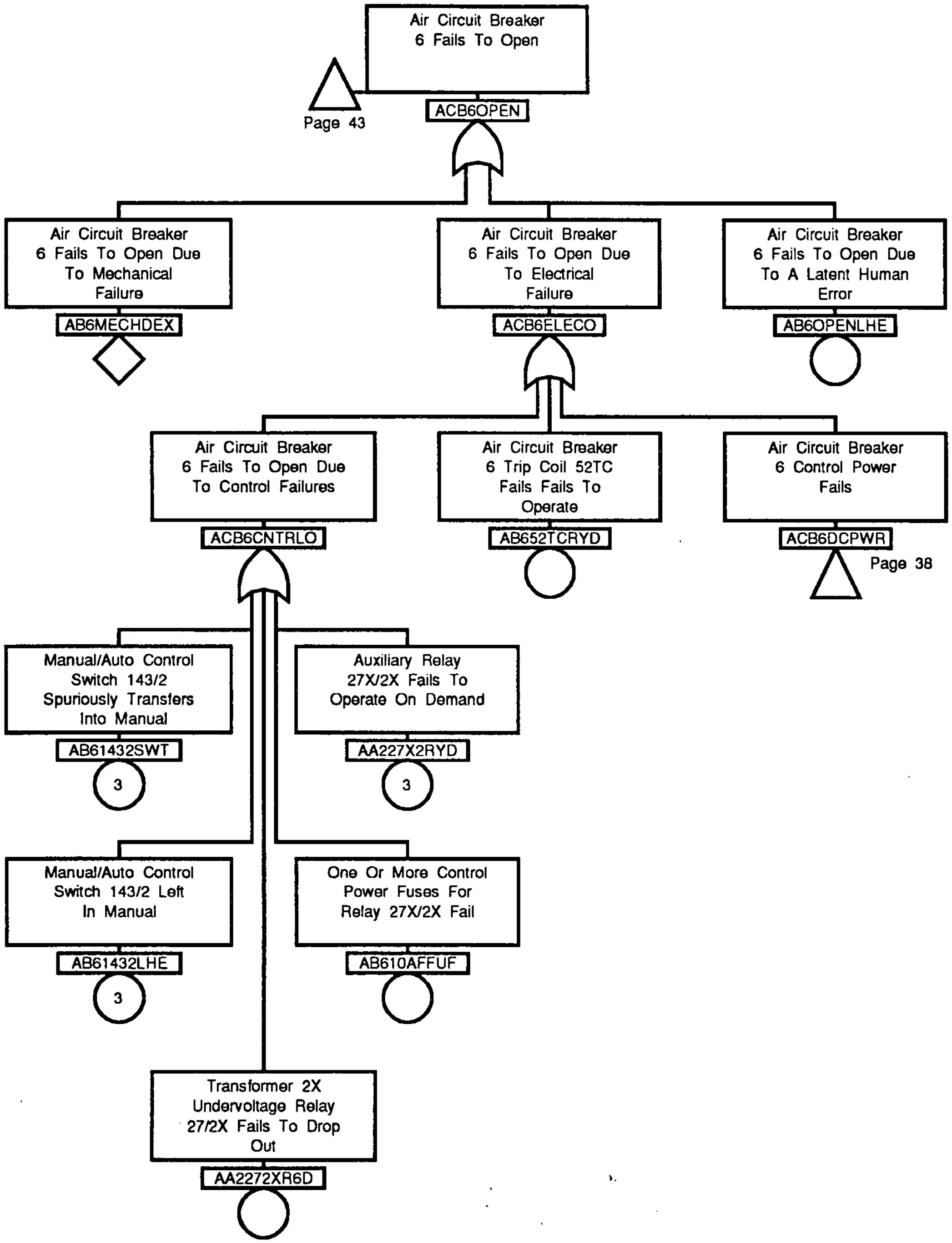
Air Circuit Breaker 6 Fails To Open
ACB6OPEN
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Air Circuit Breaker 6 Fails To Open Due To Mechanical Failure
AB6MECHDEX
Air Circuit Breaker 6 Fails To Open Due To Electrical Failure
ACB6ELECO
Air Circuit Breaker 6 Fails To Open Due To A Latent Human Error
AB6OPENLHE
Air Circuit Breaker 6 Fails To Open Due To Control Failures
ACB6CNTRLO
Air Circuit Breaker 6 Trip Coil 52TC Fails Fails To Operate
AB652TCRYD
Air Circuit Breaker 6 Control Power Fails
ACB6DCPWR
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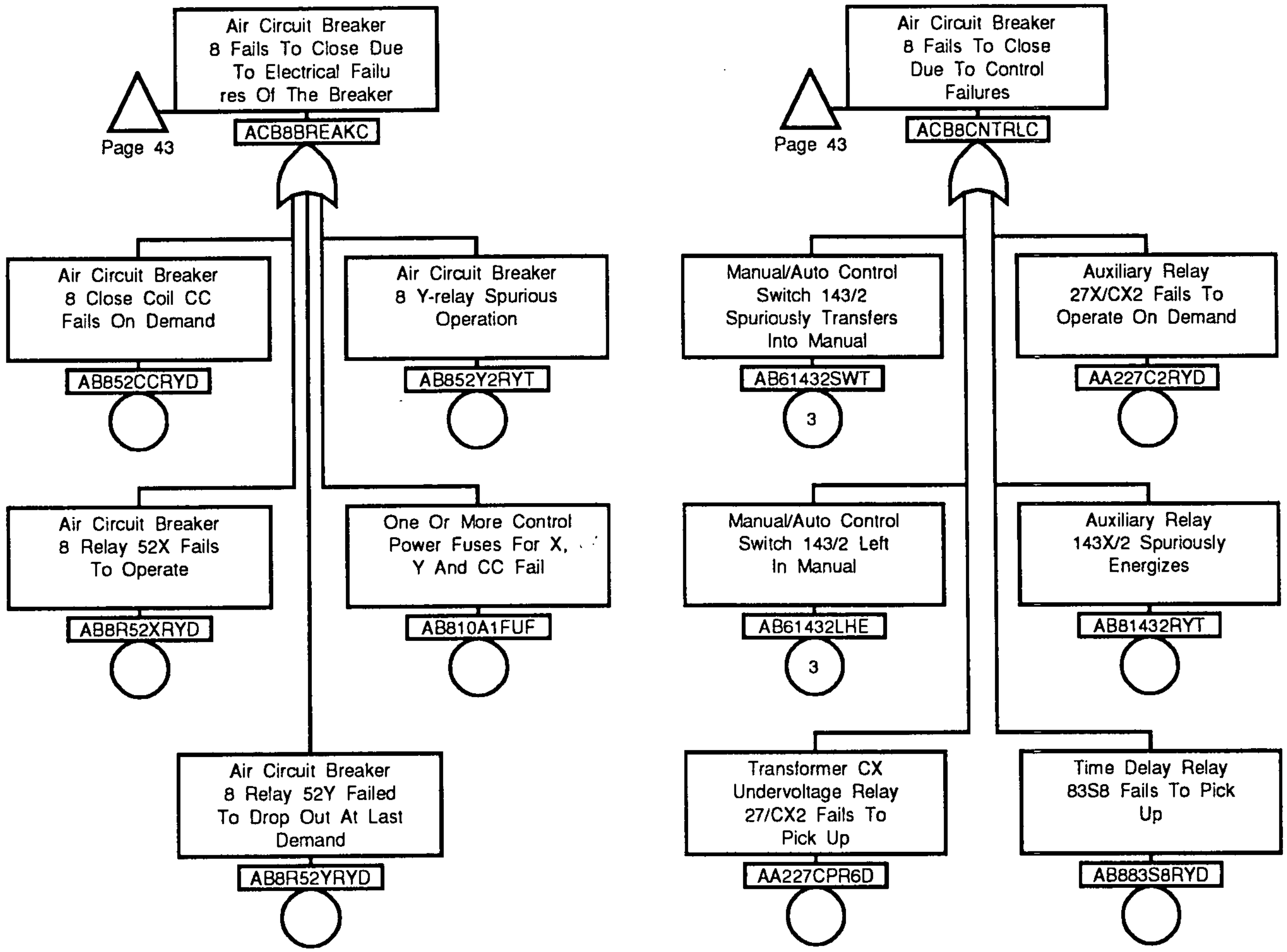
Manual/Auto Control Switch 143/2 Spuriously Transfers Into Manual
AB61432SWT
3
Auxiliary Relay 27X/2X Fails To Operate On Demand
AA227X2RYD
3
Manual/Auto Control Switch 143/2 Left In Manual
AB61432LHE
3
One Or More Control Power Fuses For Relay 27X/2X Fail
AB610AFFUF
Transformer 2X Undervoltage Relay 27/2X Fails To Drop Out
AA2272XR6D


Air Circuit Breaker 8 Fails To Close Due To Electrical Failu res Of The Breaker
ACB8BREAKC
Page 43
Air Circuit Breaker 8 Close Coil CC Fails On Demand
AB852CCRYD
Air Circuit Breaker 8 Y-relay Spurious Operation
AB852Y2RYT
Air Circuit Breaker 8 Relay 52X Fails To Operate
AB8R52XRYD
One Or More Control Power Fuses For X, Y And CC Fail
AB810A1FUF
Air Circuit Breaker 8 Relay 52Y Failed To Drop Out At Last Demand
AB8R52YRYD
Air Circuit Breaker 8 Fails To Close Due To Control Failures
ACB8CNTRLC
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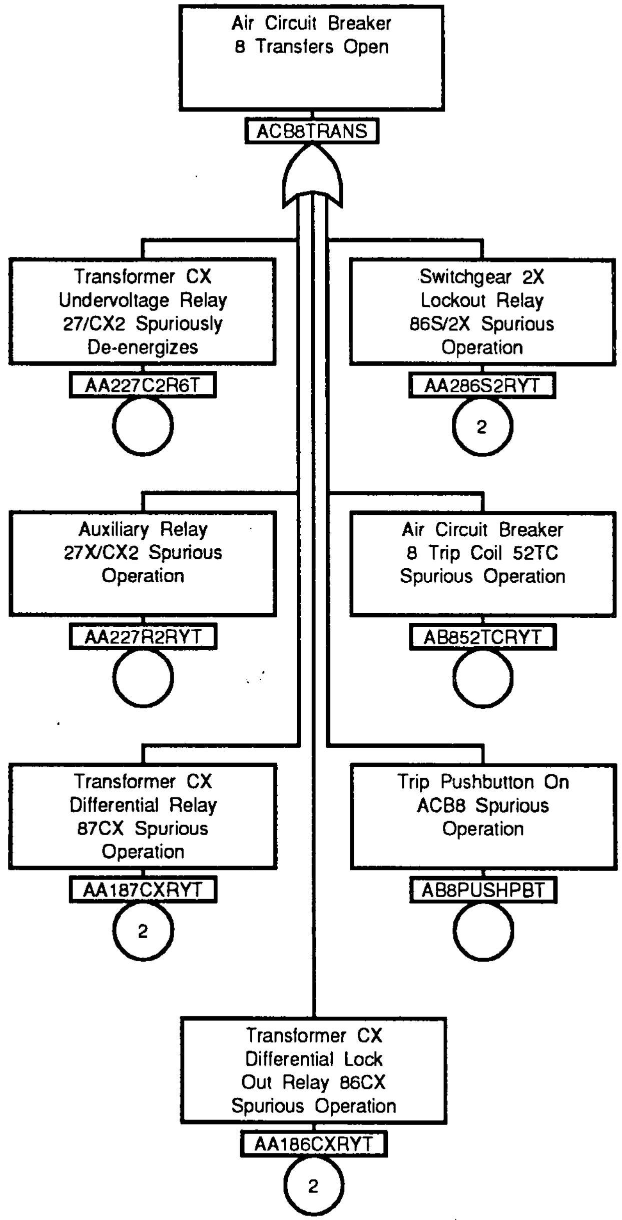
Manual/Auto Control Switch 143/2 Spuriously Transfers Into Manual
AB61432SWT
3
Auxiliary Relay 27X/CX2 Fails To Operate On Demand
AA227C2RYD
Manual/Auto Control Switch 143/2 Left In Manual
AB61432LHE
3
Auxiliary Relay 143X/2 Spuriously Energizes
AB81432RYT
Transformer CX Undervoltage Relay 27/CX2 Fails To Pick Up
AA227CPR6D
Time Delay Relay 83S8 Fails To Pick Up
AB883S8RYD


Air Circuit Breaker 8 Transfers Open
ACB8TRANS
Transformer CX Undervoltage Relay 27/CX2 Spuriously De-energizes
AA227C2R6T
Switchgear 2X Lockout Relay 86S/2X Spurious Operation
AA286S2RYT
2
Auxiliary Relay 27X/CX2 Spurious Operation
AA227R2RYT
Air Circuit Breaker 8 Trip Coil 52TC Spurious Operation
AB852TCRYT
Transformer CX Differential Relay 87CX Spurious Operation
AA187CXRYT
2
Trip Pushbutton On ACB8 Spurious Operation
AB8PUSHPBT
Transformer CX Differential Lock Out Relay 86CX Spurious Operation
AA186CXRYT
2

Gate/Event Name	Page	Zone
AA1271PR6D	35	
AA1271XR6T	36	
AA127C1R6T	42	
AA127CPR6D	40	
AA127R1RYT	42	
AA127X1RYD	35	
AA127X1RYT	36	
AA127X2R6D	33	
AA127XCRYD	40	
AA186CXRYT	42	
AA186CXRYT	46	
AA186S1RYT	36	
AA186S1RYT	42	
AA187CXRYT	42	
AA187CXRYT	46	
AA2272PR6D	37	
AA2272XR6D	44	
AA2272XR6T	39	
AA227C2R6T	46	
AA227C2RYD	45	
AA227CPR6D	45	
AA227R2RYT	46	
AA227T2R6D	5	
AA227X2RYD	33	
AA227X2RYD	37	
AA227X2RYD	44	
AA227X2RYT	39	
AA286S2RYT	39	
AA286S2RYT	46	
AB004ECCDT	22	
AB0086TRYD	22	
AB0624CRYD	22	
AB086E1RYD	23	
AB086TGRYD	22	
AB152TCSVO	1	
AB1ACCUDEX	1	
AB1FALTDEX	28	
AB1MECHDEX	1	

Gate/Event Name	Page	Zone
AB1OPENLHE	1	
AB1PS02PST	1	
AB1R52ZR6D	1	
AB21521SWT	11	
AB22BV1RYT	11	
AB23BKRCOM	8	
AB23COM	2	
AB23COM	8	
AB23COM	14	
AB24BKRCOM	6	
AB24COM	2	
AB24COM	6	
AB24COM	18	
AB251G2RYT	11	
AB252CCSVO	4	
AB252TCSVO	9	
AB252TCSVT	11	
AB252Y2R6D	4	
AB252Y2R6T	4	
AB2ACCUDEX	2	
AB2ACCUDEX	9	
AB2CLOSLHE	6	
AB2KEYISWT	2	
AB2MCH2DEX	2	
AB2MECHDEX	9	
AB2MOD	5	
AB2OPENLHE	9	
AB2PS02PST	4	
AB2PS02PST	9	
AB2PUSHPBT	11	
AB2R462RYT	11	
AB2R52XR6D	4	
AB2R52ZR6D	9	
AB2R52ZR6T	11	
AB31523SWT	16	
AB352CCSVO	14	
AB352TCSVO	24	
AB352TCSVT	15	

Gate/Event Name	Page	Zone
AB352Y2R6D	14	
AB352Y2R6T	14	
AB3ACCUDEX	14	
AB3ACCUDEX	24	
AB3CLOSLHE	14	
AB3MCH2DEX	14	
AB3MECHDEX	24	
AB3PS02PST	14	
AB3PS02PST	24	
AB3PUSHPBT	16	
AB3R52XR6D	14	
AB3R52ZR6D	24	
AB3R52ZR6T	15	
AB41523SWT	30	
AB452CCSVO	20	
AB452TCSVT	30	
AB452Y2R6D	20	
AB452Y2R6T	20	
AB4ACCUDEX	18	
AB4CLOSLHE	18	
AB4CLSESWC	27	
AB4KEYISWT	18	
AB4LORESWT	27	
AB4MCH2DEX	18	
AB4PS02PST	20	
AB4PUSHPBT	30	
AB4R52XR6D	20	
AB4R52ZR6T	30	
AB510A1FUF	34	
AB51431LHE	33	
AB51431LHE	35	
AB51431LHE	40	
AB51431RYT	35	
AB51431SWT	33	
AB51431SWT	35	
AB51431SWT	40	
AB552CCRYD	34	
AB552TCRYT	36	

Gate/Event Name	Page	Zone
AB552Y2RYT	34	
AB583S5RYD	35	
AB5CLOSLHE	31	
AB5KEYISWT	31	
AB5MCH2DEX	31	
AB5PUSHPBT	36	
AB5R52XRYD	34	
AB5R52YRYD	34	
AB610A1FUF	38	
AB610AFFUF	44	
AB61432LHE	37	
AB61432LHE	44	
AB61432LHE	45	
AB61432SWT	37	
AB61432SWT	44	
AB61432SWT	45	
AB652CCRYD	38	
AB652TCRYD	44	
AB652TCRYT	39	
AB652Y2RYT	38	
AB6CLOSLHE	37	
AB6KEYISWT	37	
AB6MCH2DEX	37	
AB6MECHDEX	44	
AB6OPENLHE	44	
AB6PUSHPBT	39	
AB6R52XRYD	38	
AB6R52YRYD	38	
AB710A1FUF	41	
AB710AFFUF	33	
AB752CCRYD	41	
AB752TCRYD	32	
AB752TCRYT	42	
AB752Y2RYT	41	
AB7CLOSLHE	40	
AB7KEYISWT	40	
AB7MCH2DEX	40	
AB7MECHDEX	32	

APPENDIX A.5
KEOWEE START AND RUN CONTROL

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A.5 KEOWEE EMERGENCY START

A.5.1 OBJECTIVES

The objective of this analysis is to develop a logic model of the Keowee Emergency Starting Sequences from the point that the individual Oconee units recognize the need for Keowee emergency start, to the positioning of electrical relays and solenoids that cause the Keowee turbine wicket gates to come under the control of their hydraulic governor units. This model is combined with the high-level model and remaining system models to form an integrated model for assessing the reliability of Keowee. Other objectives are to identify major contributors to system unreliability, significant potential human errors and common-cause failure modes.

The scope of this analysis is limited to instrumentation and control equipment required to support a Keowee emergency start and run under load following a loss of off-site power event for an Oconee unit.

A.5.2 EMERGENCY START DESIGN

Each Keowee unit has its own automatic startup equipment contained in separate cubicles within the Keowee control room. The initiation of emergency startup is accomplished by control signals from either Oconee control area. Normal startup is by operator action while emergency startup is automatic. On emergency automatic startup, both units are started simultaneously; the unit tied to the underground feeder supplies that feeder to Transformer CT4, and the other unit is available to supply the Oconee Startup Transformers through a 230 kV overhead transmission line and the Oconee 230 kV switchyard. Each unit is capable of accepting full emergency power load as it accelerates from zero to rated speed and voltage within 23 seconds of the receipt of the emergency start signal. If the units are operating when the emergency start signal occurs, they are separated from the network, the switchyard yellow bus is isolated, and the unit not tied to the underground power path will reconnect to the 230 kV overhead transmission line in about 6.5 seconds (Unit 1) or 4.0 seconds (Unit 2) after the switchyard isolate complete signal is received.

A diagram of the Keowee emergency start logic is provided as Figure A.5-1. The diagram shows the kinds of events or initiators that will actuate the Oconee 1, Channel A Keowee Emergency Start Relay KA. Not shown is the completely redundant Channel B that actuates Oconee 1, Keowee Emergency Start Relay KB. Each channel is sensitive to Engineered Safeguards (ESG) System initiators, Main Feeder Bus Monitor initiators, and External Grid Trouble Protection System (EGTPS) initiators, as well as a manual Emergency Start Pushbutton Switch in the Oconee 1 & 2 Control Room, and a manual Emergency Start Key-Switch in the Oconee 1 & 2 Cable Room. After a Keowee Emergency Start Relay has been picked up, it seals itself in until the signal is intentionally cleared by manual reset. The ESG System contact is also sealed in when the ESG System is actuated; therefore, when a Keowee Emergency Start Signal is initiated by an ESG signal, the ESG signal must be cleared before the Keowee Emergency Start signal can be cleared.

The Oconee 2 Keowee Emergency Start Relays, CR2A and CR2B, are similarly actuated by automatic signals from the Unit 2 ESG System, and the Unit 2 Main Feeder Bus Monitor System. The relays can be manually actuated by Unit 2 local locked selector switches, 2SSW'A' for Channel A, and 2SSW'B' for Channel B. The Channel A, Keowee Emergency Start Relay CR2A is shown in Figure A.5-1. It should be noted that there is no EGTPS input to the Oconee 2 Keowee Emergency Start Relays.

The Oconee 3, Keowee Emergency Start Relays, CR3A and CR3B, are actuated by automatic signals from the Unit 3 ESG System, and the Unit 3 Main Feeder Bus Monitoring System. The relays can be manually actuated by individual manual Emergency Start Pushbutton Switches in the Oconee 3 Control Room and manual Emergency Start Key-Switches in the Oconee 3 Cable Room. There is no EGTPS input to the Oconee 3 Keowee Emergency Start Relays.

The Keowee emergency start signal can be provided by any one of the Oconee units, but the EGTPS Keowee Emergency Start signal is applied to Oconee Unit 1 only. The EGTPS through relay STA provides a Keowee Start signal to Oconee Unit 1, Channel A Emergency Start Relay KA in the Oconee Unit 1 Control Room. The Channel B EGTPS, Keowee Emergency Start signal is applied through relay STB and actuates Emergency Start Relay KB in the Oconee 1 Control Room. The KA relay actuates four Emergency Start auxiliary relays at Keowee. Two of these are used in the Keowee Unit 1 Start Logic,

and the other two are used in the Unit 2 Start Logic. The four relays are described as follows:

1. Channel A Emergency Start Auxiliary Relay 1ESRX/2A or Channel B counterpart 1ESRX/2B must be picked up to complete one of several permissives that must be satisfied before the Keowee 1 Shutdown Auxiliary Relay (99SX) can be picked up, and 99SX must be picked up to start Keowee Unit 1.

2. Channel A Emergency Start Auxiliary Relay 1ESRX/1A or Channel B counterpart 1ESRX/1B must be picked up, or all of the Keowee 1 normal start permissives must be satisfied to satisfy one of three conditions needed to actuate the Keowee 1 Master Relays 4A and 4B. The other two necessary conditions are Emergency Lockout Relay 86E-1 "not tripped" and the Unit 1 Startup Inhibit Key Switch 3SUI "Uninhibited". 'Master Relay 4A picked up' is also one of the several permissives that must be satisfied to pick up 99SX in logic description 1 above.

3. Channel A Emergency Start Auxiliary Relay 2ESRX/2A or Channel B counterpart 2ESRX/2B must be picked up to complete one of the permissives necessary to pickup the Keowee 2 Shutdown Auxiliary Relay (99SX). The Keowee Unit 2 logic is similar to the Keowee Unit 1 logic.

4. Channel A Emergency Start Auxiliary Relay 2ESRX/1A or Channel B counterpart 2ESRX/1B must be picked up, or all of the Keowee 2 normal start permissives must be satisfied to satisfy one of three conditions needed to actuate the Keowee 2 Master Relays 4A and 4B. The other two necessary are Emergency Lockout Relay 86E-2 "not tripped" and the Unit 2 Startup Inhibit Key Switch 3SUI "Uninhibited".

In addition to energizing the Master Relays and the Shutdown Auxiliary Relays, the Emergency Start Auxiliary Relays have the following functions:

1. Energize the closing circuits of the Generator Field Breaker 41.

2. Energize the closing circuits of the Generator Excitation Supply Breaker 41-52.

3. Energize the closing circuits of the Field Flashing Breaker 31.

4. Energize the trip circuits of overhead breakers ACB-1 and ACB-2 to ensure the separation of Keowee Units from the 230kV Switchyard.

5. Energize the Partial Shutdown (Emergency Load) Solenoids 99SN.

6. Block the Dashpot Bypass Solenoid 99BP.

7. Block operation of the governor speed changer motor by the autosynchronizer.

8. Block operation of the Motor Generator Relay 83.

9. Block operation of the Lockout Auxiliary Relays 86EX-1 and 86EX-2 from any normal lockout relay actuation.

10. Inhibit load frequency control.

11. Block operation of the synchronizing relay.

12. Bypass the normal lockout relay functions.

After the Shutdown Auxiliary Relay 99SX is energized as part of the emergency start sequence, the following actions take place:

1. The Shutdown Solenoid 99SD and the Partial Shutdown (Emergency Load) Solenoid 99SN are energized, and then the wicket gates open toward the preset 50% position.

2. At 37 RPM the Emergency Load Solenoid 99SN automatically de-energizes and the wicket gates move to the no load setting.

3. At 122 RPM the Emergency Load Solenoid again energizes and the unit comes under governor control accelerating to 128.6 RPM.

The Keowee unit tied to the underground power path is now available to supply power to the Standby Bus via CT-4 and the SK breakers. The Keowee unit tied to the overhead

power path will automatically energize the 230kV Switchyard by closing the overhead path ACB (ACB-1 or ACB-2) if switchyard isolation has occurred (ACB-1 closes 6.5 seconds after switchyard isolation or ACB-2 closes 4 seconds after switchyard isolation).

When a Keowee Unit is operating in the Emergency Mode, actuation of any of the following devices will trip the unit:

1. The Startup Inhibited Key operated switch 3SUI in the "inhibit" position

2. Emergency Lockout Relay 86E

3. Turbine Guide Bearing Low Oil Level Relay 63TB/1X

4. Generator Bearing High Oil Level Relay 63BL/HX

5. Generator Bearing Low Oil Level Relay 63BL/LXTD

6. Generator Overspeed Switch (12) open, indicating the unit speed is greater than the trip setpoint.

A.5.3 SYSTEM BOUNDARIES

Electrical Power Supplies

Control power for Channel A Emergency Start Auxiliary Relays (for Keowee 1 and 2) is supplied by 125 Vdc Distribution Center 1DA, and control power for Channel B Emergency Start Auxiliary Relays (for Keowee 1 and 2) comes from 125 Vdc Distribution Center 2DA. The Keowee Unit 1 turbine and governor startup control power is from Distribution Center 1DA, and the Keowee Unit 2 turbine and governor startup control power is from Distribution Center 2DA.

Control power for Oconee Units 1, 2, and 3, Channel A Keowee Emergency Start logic and Relays KA, CR2A, and CR3A comes from 125 Vdc Panelboards 1DIA, 2DIA, and 3DIA respectively. Similarly, control power for the Channel B Keowee Emergency Start

logic and Relays KB, CR2B, and CR3B is from 125 Vdc Panelboards 1DIB, 2DIB, and 3DIB respectively.

External Control Systems

The EGTPS (Appendix A. 3) provides the Keowee emergency start signals when it senses a loss of power in the 230 kV switchyard. Automatic emergency start signals are also provided to Keowee by the Engineered Safeguards Actuation System in each unit and by the Main Feeder Bus Monitor System in each unit.

A.5.4 INSTRUMENTATION AND CONTROLS

Oconee 1

The Oconee 1&2 Control Room has all the alarms and controls for normal operation of the Keowee Units. All controls of importance located on the Keowee control boards are duplicated in the Oconee 1&2 Control Room.

When Oconee 1, Channel A(B) Keowee Emergency Start Relay KA (KB) is actuated the following indication is available:

A red light on Emergency Power Switching Logic Panel 3, EPSLP3.

A statalarm in the Control Room, 1SA15-28 (1SA14-28) Keowee Emergency Start Channel A (B) Logic Initiate.

The status of the emergency start relay KA (KB) is also monitored by computer.

An amber light is provided on EPSLP3 to indicate the availability of DC control power to the Channel A (B) Keowee emergency start logic.

A statalarm in the Control Room, 1SA15-29 (1SA14-29) Keowee Emergency Start Channel A (B) Logic DC Power Lost, indicates the loss of DC control power to the Channel A (B) emergency start logic.

A red coil monitor light is provided on EPSLP3 to monitor the circuit continuity through the Emergency Start Relay KA (KB). The light is lit when relay KA (KB) is de-energized. The status of the coil monitor relays is monitored by computer.

On 1EPSLP3 Channel A (B) one red coil monitoring light monitors the continuity through the four Keowee emergency start auxiliary relays. The light is lit when the relays are de-energized. The status of the coil monitor relay is monitored by the plant computer.
A red light on EPSLP3 and a statalarm, 1SA15-30 (1SA14-30) on 1VB2 Switchyard Isolation Confirmed Channel A (B) Logic, indicates when the switchyard isolation auxiliary relay SIA (SIB) is energized. The status of the switchyard isolation relays are also monitored by the plant computer.

Oconee 2

When Oconee 2 Channel A (B) Keowee Emergency Start Relay CR2A (CR2B) is actuated the following indication is available:

A red light on EPSLP3.

A statalarm in the Control Room, 2SA15-28 (2SA14-28) Keowee Emergency Start Channel A (B) Logic Initiate.

The status of the emergency start relay CR2A (CR2B) is also monitored by computer.

An amber light is provided on EPSLP3 to indicate the availability of DC control power to the Channel A (B) Keowee emergency start logic.

A statalarm in the Control Room, 2SA15-29 (2SA14-29) Keowee Emergency Start Channel A (B) Logic DC Power Lost, indicates the loss of DC control power to the Channel A (B) Keowee emergency start logic.

A red coil monitor light is provided on EPSLP3 to monitor the circuit continuity through the Emergency Start Relay CR2A (CR2B). The light is lit when relay CR2A (CR2B) is de-energized. The status of the coil monitor relays is monitored by computer.

Oconee 3

When Oconee 3 Channel A (B) Keowee Emergency Start Relay CR3A (CR3B) is actuated the following indication is available:

A red light on EPSLP3.

A statalarm in the Control Room, 3SA15-28 (3SA14-28) Keowee Emergency Start Channel A (B) Logic Initiate.

The status of the emergency start relay CR3A (CR3B) is monitored by computer.

An amber light is provided on EPSLP3 to indicate the availability of DC control power to the Channel A (B) Keowee emergency start logic.

A statalarm in the Control Room, 3SA15-29 (3SA14-29) Keowee Emergency Start Channel A (B) Logic DC Power Lost, indicates the loss of DC control power to the Channel A (B) Keowee emergency start logic.

A red coil monitor light is provided on EPSLP3 to monitor the circuit continuity through the Emergency Start Relay CR3A (CR3B). The light is lit when relay CR3A (CR3B) is de-energized. The status of the coil monitor relays is monitored by computer.

Keowee

The Keowee Control Room has sufficient controls, alarms, and indications to start, control, and run both units in manual or automatic control.

A.5.5 LOCATION WITHIN THE PLANT

The automatic startup circuitry for the Keowee units is in separate cubicles of the Keowee control room. The Oconee emergency power start signal circuitry is located in each Oconee control room and the cable rooms.

A.5.6 NORMAL OPERATION

This analysis concerns emergency startup of the Keowee hydro-electric generators. The generator and the governor itself work the same for normal starts as they do for emergency starts. The difference between a normal start and run operation and an emergency start and run operation is the much greater number of permissive interlocks that must be satisfied to keep the master relays picked up during the normal start and run operation.

A.5.7 PERFORMANCE DURING KEOWEE EMERGENCY OPERATION

The initiating event analyzed in this study is the LOOP. The LOOP initiates a dual channel EGTPS response and a dual channel Main Feeder Bus Monitor response in the affected Oconee unit(s). EGTPS Train A Output Relay STA or the Train B Output Relay STB actuates the Oconee 1 Keowee Emergency Start Relay KA or KB respectively. The unit 1 KA relay, the unit 2 CR2A relay, or the unit 3 CR3A relay will actuate the Keowee Channel A Emergency Start Auxiliary Relays, 1ESRX/1A, 1ESRX/2A, 2ESRX/1A, and 2ESRX/2A. The unit 1 KB relay, the unit 2 CR2B relay, or the unit 3 CR3B relay will actuate the Keowee Channel B Emergency Start Auxiliary Relays, 1ESRX/1B, 1ESRX/2B, 2ESRX/1B, and 2ESRX/2B. Keowee Unit 1(2) emergency start initiation is complete when any of the following emergency start auxiliary relay pairs are actuated:

1. 1ESRX/1A and 1ESRX/2A (2ESRX/1A and 2ESRX/2A)

2. 1ESRX/1A and 1ESRX/2B (2ESRX/1A and 2ESRX/2B)

3. 1ESRX/1B and 1ESRX/2A (2ESRX/1B and 2ESRX/2A)

4. 1ESRX/1B and 1ESRX/2B (2ESRX/1B and 2ESRX/2B)

A.5.8 TEST AND MAINTENANCE

Testing

The Degraded Grid and Switchyard Isolation Functional Test is performed during Oconee Unit 1 refueling. The test includes (1) functional verification of overhead ACB and PCB-9 operation during switchyard isolation, (2) demonstration of the operability of the Degraded Grid Protection System (DGPS), (3) demonstration of the ability of the overhead Keowee unit to energize the 230 kV Yellow Bus for all three Oconee Units' Startup Transformers, and (4) demonstration of the capability to realign the 230 kV Yellow Bus back to the system grid while Oconee loads are being fed from the overhead Keowee unit.

A.5.9 OPERATING EXPERIENCE

There have been no reported instances of Keowee Emergency Start signal failures.

A.5.10 ASSUMPTIONS

A.5.10.1 SYSTEM DESIGN ASSUMPTIONS

1. The Keowee Start/Run Model is comprised of the control circuitry that must be actuated to emergency start the Keowee turbine units through actuation of the governor control system. Keowee controls are assumed to be in their normal operating positions.

2. The EGTPS and Keowee support systems are assumed to be in their normal operating configurations.

A.5.10.2 OPERATIONAL ASSUMPTIONS

1. The hot start sequence is challenged when the Keowee unit is running on the grid at the time the emergency start signal occurs.

2. The cold start sequence is challenged when the unit is idle, standing by for emergency operation at the time the emergency start occurs.

A.5.10.3 MODELING ASSUMPTIONS

1. The Keowee Start/Run model is a support system for the Keowee Hydro Unit Governor and Turbine System. The top events provide the sequence control logic component failures to the Keowee Hydro Unit Governor and Turbine System as follows:

   a. The Keowee Start/Run model top gate YK1CLDSTRT (Keowee 1 Governor Control Fails During A Cold Start Sequence) is one of three OR gate inputs to the Keowee Hydro Unit Governor and Turbine top event, (Keowee Unit 1 Governor or Turbine Fails During a Cold Start).

   b. The Keowee Start/Run model top gate YK1HOTSTRT (Keowee 1 Governor Control Fails During A Hot Start Sequence) is one of three OR gate inputs to the Keowee Hydro Unit Governor and Turbine top event, (Keowee 1 Governor Control Fails During a Cold Start).

   c. YK1RUNCNTL (Keowee 1 Governor Control Fails During Run) is one of three OR gate inputs to Keowee Hydro Unit Governor and Turbine System gate Keowee Unit 1 Governor Fails With the Unit Running.

2. The Keowee Unit 2 model is symmetric to the Unit 1 model.

3. Conditioning logic is applied in the high level logic model.

A.5.11 <u>FAULT TREE ANALYSIS</u>

A.5.11.1 TOP EVENT SUCCESS CRITERIA

Success of the Keowee Start/Run function requires that the governor control successfully starts the Keowee Unit and governor control continues without failure for 24 hours.

A.5.11.2 DETAILED FAILURE CRITERIA

1. Failure of Keowee governor control during a cold start is the result of demand failures of the relays, solenoids, and a battery that must function during the Keowee emergency start sequence when the Keowee unit is initially in a standby state. This includes the transmittal of the start signal and proper operation of the turbine speed switches as the unit starts and approaches operating speed.

2. Failure of Keowee governor control during a hot start involves the same potential failures that are involved in cold start except for the speed switches. There is no noticeable difference between the history of hot start and the history of cold start failure rates.

3. Failure of Keowee governor control during run is influenced by time related failures of breakers, relays, solenoids, and switches over the 24 hr mission time of the emergency generator.

A.5.11.3 DESCRIPTION OF FAULT TREE

The Keowee Start/Run fault tree is shown in Figure A.5-2. The Fault Tree Modeling Guidelines (Appendix B) were followed in developing the fault tree. A list of all fault tree transfers is presented in Table A.5-4. Modules were not developed for the Keowee fault trees.

Human reliability analysis was performed as described in Appendix C.3. Human events impacting the model are described in Section A.5.11.4.

Common-cause analysis was performed as described in Appendix C.2. Common-cause events impacting the model are described in Section A.5.11.6.

A.5.11.4 HUMAN INTERACTIONS

Human actions by the operators or maintenance technicians can adversely affect Start/Run function circuit reliability. The normal Start/Run functions are initiated nearly every day and much more frequently than the emergency start functions. Any latent human error is expected to be discovered in the daily exercise of the function.

YKEMSRTCHE

This commission error event accounts for the potential of an operator to reset an emergency start signal.

A.5.11.5 RELIABILITY DATA

Section 5.3 discusses development of the reliability data. For the base case solution, the plant-specific failure rate data and generic failure rate data were combined using a Bayesian update.

As discussed in Section 5.3, consideration of relevant statalarms is part of the process of determining each basic event factor. Keowee Start/Run statalarms are listed in Table A.5-6.

System reliability data is listed in Table A.5-6.

A.5.11.6 COMMON-CAUSE ASSESSMENT

The common cause failures of the Keowee Start/Run control circuitry are included in the Keowee PRA high level logic tree.

A.5.12 RESULTS

Reliability of the Keowee Start/Run function is defined as the probability that the system will succeed in supporting Keowee emergency operation (black start plus a 24 hour run). The system model yields a governor control failure probability of approximately 1.7E-04 for a cold start, and 2.0E-04 for a 24-hr run. The model solution for failure of a hot start (unit running at the time the LOOP occurs) results in cut sets below the solve truncation limit of 1.0E-08. Thus, the reliability of each unit's governor control cold start is 99.98%, and the 24 hr run reliability is 99.98%.

Table A.5-7 and -8 lists the dominant minimal cut sets (failure sequences) for the Keowee Start/Run functions. The relative contribution to the total for each failure is shown in these tables.

A.5.13 REFERENCES

A.5.13.1 DOCUMENTS

1. OSS-0254.00-00-2005, Rev. 2, Keowee Emergency Power Design Basis Document.

2. Duke Power Company Oconee Nuclear Station Emergency Power Switching Logic Description Of Operation

A.5.13.2 DRAWINGS

1. OEE-120, Rev. 10, (Oconee Unit 1) Channel 'A' Keowee Emergency Start.

2. OEE-120-1, Rev. 12, (Oconee Unit 1) Channel 'B' Keowee Emergency Start.

3. OEE-220, Rev. 4, (Oconee Unit 2) Channel 'A' Keowee Emergency Start.

4. OEE-220-1, Rev. 4 (Oconee Unit 2) Channel 'B' Keowee Emergency Start.

5. KEE-111, Rev. 11, (Keowee Unit 1) Turbine and Governor Systems Startup Control.

6. KEE-113, Rev. 8, (Keowee Unit 1) Master Control System Startup Controls.

7. KEE-113-03, Rev. 9, (Keowee Unit 1) Master Control System Generator Miscellaneous Relaying.

8. KEE-113-04, Rev. 8, (Keowee Unit 1) Master Control System Turbine Miscellaneous Relaying.

9. KEE-113-05, Rev. 8, (Keowee Unit 1) Master Control System Turbine Miscellaneous Relaying.

10. KEE-114-3, Rev. 11, (Keowee Unit 1) Generator Control Normal and Emergency Lockout.

Table A.5-1

Keowee Start And Run Control Power Supplies

Component	Power Supply	Compartment Number
Keowee Emergency Start Channel A	Keowee #1, 125 Vdc Power Supply Distribution Center 1DA	1DA-4CR
Keowee Emergency Start Channel B	Keowee #2, 125 Vdc Power Supply Distribution Center 2DA	2DA-2CC
ONS1 Channel A, Keowee Emergency Start Relay, KA	ONS1 125 Vdc Vital I&C Power Distribution Center 1DIA	1DIA-2
ONS1 Channel B, Keowee Emergency Start Relay, KB	ONS1 125 Vdc Vital I&C Power Distribution Center 1DIB	1DIB-2
ONS2 Channel A, Keowee Emergency Start Relay CR2A	ONS2 125 Vdc Vital I&C Power Distribution Center 2DIA	2DIA-2
ONS2 Channel B, Keowee Emergency Start Relay CR2B	ONS2 125 Vdc Vital I&C Power Distribution Center 2DIB	2DIB-2
ONS3 Channel A, Keowee Emergency Start Relay CR3A	ONS3 125 Vdc Vital I&C Power Distribution Center 3DIA	3DIA-2
ONS3 Channel B, Keowee Emergency Start Relay CR3B	ONS3 125 Vdc Vital I&C Power Distribution Center 3DIB	3DIB-2

Table A.5-2

Keowee Start And Run Control Test Procedures

Procedure	Test Frequency	Description
PT/0/A0610/22	ONS1 Refueling	Degraded Grid and Switchyard Isolation Functional Test. ("Black Start" of both Keowee units is demonstrated in this test.)

Table A.5-3

Keowee Start And Run Control Significant Operating Events

Date	Unit	Component	Event Summary
5/30/85	1/2	Emergency Start Switch	Unit 1 was Emergency Started for test. The unit operated as designed, but the Emergency Start Switch would not reset. Further Emergency Start testing was postponed until the problem was resolved. Two broken wires and a loose connection were found in the circuitry.
4/23/86	1	Key Interlock Switch	At time 1520 an attempt to start Unit 1 for an operability check after maintenance failed. The problem was an out of adjustment Key Interlock Switch. At time 1824 Unit 1 was started successfully.

Table A.5-4

Keowee Start And Run Control Fault Tree Transfers

Transfer Gate Name	Description	Components Supplied
XD1DASRCES	Loss Of Power On Keowee 1 125 Vdc Distribution Center 1DA During Start	Keowee 1 Shtdwn Sol. 99SD, Keowee 1 Emer. Load Sol. 99SN
XD2DASRCES	Loss Of Power On Keowee 2 125 Vdc Distribution Center 2DA During Start	Keowee 2 Shtdwn Sol. 99SD, Keowee 2 Emer. Load Sol. 99SN
XD1DAR	Loss Of Power To Keowee 1 125 Vdc Dist. Cntr. 1DA During Run	Shutdown Aux. Rly. 99SX Keowee 1 Shtdwn. Solenoid Keowee 1 Emer. Load Sol.
XD2DAR	Loss Of Power To Keowee 2 125 Vdc Dist. Cntr. 2DA During Run	Shutdown Aux. Rly. 99SX Keowee 2 Shtdwn. Solenoid Keowee 2 Emer. Load Sol.
XD1DA	Loss Of Power On Keowee 1 125 Vdc Dist. Cntr. 1DA	Keowee 1 Emergency Start Aux. Rly 1ESRX/1A
XD2DA	Loss Of Power On Keowee 2 125 Vdc Dist. Cntr. 2DA	Keowee 2 Emergency Start Aux. Rly 1ESRX/1B
D1DIADEX	Loss Of Power On 125 Vdc Panelboard 1DIA	Oconee 1 Channel A Keowee Emergency Start Relay KA

Table A.5-4

Keowee Start And Run Control Fault Tree Transfers

Transfer Gate Name	Description	Components Supplied
D1DIBDEX	Loss Of Power On 125 Vdc Panelboard 1DIB	Oconee 1 Channel B Keowee Emergency Start Relay KB
D2DIA	Loss Of Power On 125 Vdc Panelboard 2DIA	Oconee 2 Channel A Keowee Emergency Start Relay CR2A
D2DIB	Loss Of Power On 125 Vdc Panelboard 2DIB	Oconee 2 Channel B Keowee Emergency Start Relay CR2B
D3DIA	Loss Of Power On 125 Vdc Panelboard 3DIA	Oconee 3 Channel A Keowee Emergency Start Relay CR3A
D3DIB	Loss Of Power On 125 Vdc Panelboard 3DIB	Oconee 3 Channel B Keowee Emergency Start Relay CR3B
SEGTPSCH1F	EGTPS Channel 1 Keowee Start Signal	Oconee 1 Channel A Keowee Emergency Start Relay KA
SEGTPSCH2F	EGTPS Channel 2 Keowee Start Signal	Oconee 1 Channel B Keowee Emergency Start Relay KB
YO1MFBMA	Oconee 1 MFB Monitor Chan. A Keowee Start Signal	Oconee 1 Channel A Keowee Emergency Start Relay KA

Table A.5-4

Keowee Start And Run Control Fault Tree Transfers

Transfer Gate Nane	Description	Components Supplied
YO1MFBMB	Oconee 1 MFB Monitor Chan. B Keowee Start Signal	Oconee 1 Channel B Keowee Emergency Start Relay KB
YO2MFBMA	Oconee 2 MFB Monitor Chan. A Keowee Start Signal	Oconee 2 Channel A Keowee Emergency Start Relay CR2A
YO2MFBMB	Oconee 2 MFB Monitor Chan. B Keowee Start Signal	Oconee 2 Channel B Keowee Emergency Start Relay CR2B
YO3MFBMA	Oconee 3 MFB Monitor Chan A Keowee Start Signal	Oconee 3 Channel A Keowee Emergency Start Relay CR3A
YO3MFBMB	Oconee 3 MFB Monitor Chan B Keowee Start Signal	Oconee 3 Channel B Keowee Emergency Start Relay CR3B

Table A.5-5

Keowee Start And Run Control Statalarms

Point No.	Alarm	Actuator
	ALARM PANELS ON 1VB2	
1SA14-28	KEO. EMERG. START CHNL. B LOGIC INITIATE	KB
1SA14-29	KEO. EMERG. START CHNL. B LOGIC DC PWR LOST	8ESB
1SA14-30	SWYD ISOLATION CONFIRMED CHNL. B LOGIC	SIB
1SA15-28	KEO. EMERG. START CHNL. A LOGIC INITIATE	KA
1SA15-29	KEO. EMERG. START CHNL. A LOGIC DC PWR LOST	8ESA
1SA15-30	SWYD ISOLATION CONFIRMED CHNL. A LOGIC	SIA
1SA16-19	13.8KV FEEDER DE-ENERGIZED	TDUVX

Table A.5-5

Keowee Start And Run Control Statalarms

Point No.	Alarm	Actuator
	ALARM PANELS ON 2VB2	
2SA14-28	KEO. EMERG. START CHNL. B LOGIC INITIATE	CR2B
2SA14-29	KEO. EMERG. START CHNL. B LOGIC DC PWR LOST	8ESB
2SA15-28	KEO. EMERG. START CHNL. A LOGIC INITIATE	CR2A
2SA15-29	KEO. EMERG. START CHNL. A LOGIC DC PWR LOST	8ESA

Table A.5-5

Keowee Start And Run Control Statalarms

Point No.	Alarm	Actuator
	ALARM PANELS ON 3VB2	
3SA14-28	KEO. EMERG. START CHNL B LOGIC INITIATE	CR3B
3SA14-29	KEO. EMERG. START CHNL B LOGIC DC PWR LOST	8ESB
3SA15-28	KEO. EMERG. START CHNL A LOGIC INITIATE	CR3A
3SA15-29	KEO. EMERG. START CHNL. A LOGIC DC PWR LOST	8ESA

Table A.5-6

Keowee Start and Run Control Reliability Data

Event Name	Description	Failure Rate[1]	Factor	Rationale For Factor[2]	Failure Probability
D1DIAXXDEX	Loss Of Power On 125 V dc Panelboard 1DIA				6.50E-06
D1DIBXXDEX	Loss Of Power On 125 V dc Panelboard 1DIB				6.50E-06
D2DIAXXDEX	Loss Of Power On 125 V dc Panelboard 2DIA				6.50E-06
D2DIBXXDEX	Loss of Power on 125 V dc Panelboard 2DIB				6.50E-06
D3DIAXXDEX	Loss Of Power On 125 V dc Panelboard 3DIA				6.50E-06
D3DIBXXDEX	Loss Of Power On 125 Vdc Panelboard 3DIB				6.50E-06
ED13BR2CDT	Breaker 3BR In 125V dc Distribution Center 1DA Transfers Open	7.50E-08 /H	24 H		1.80E-06
ED23BR2CDT	Breaker 3BR In 125V dc Distribution Center 2DA Transfers Open	7.50E-08 /H	24 H		1.80E-06
EU1C1RORYD	ONS1 ESG Chan. 1 Ro Relay Fails To Pick Up	3.30E-05 /D	1 D	(No credit taken for a start signal from Oconee Engineered Safeguards System.)	1.00E+00
EU1C2RORYD	ONS1 ESG Chan. 2 Ro Relay Fails to Pick Up	3.30E-05 /D	1 D	(No credit taken for a start signal from Oconee Engineered Safeguards System.)	1.00E+00
EU2C1RORYD	ONS2 ESG Chan. 1 Ro Relay Fails to Pick Up	3.30E-05 /D	1 D	(No credit taken for a start signal from Oconee Engineered Safeguards System.)	1.00E+00

Table A.5-6

Keowee Start and Run Control Reliability Data

Event Name	Description	Failure Rate[1]	Factor	Rationale For Factor[2]	Failure Probability
EU2C2RORYD	ONS2 ESG Chan. 2 Ro Relay Fails to Pick Up	3.30E-05 /D	1 D	(No credit taken for a start signal from Oconee Engineered Safeguards System.)	1.00E+00
EU3C1RORYD	ONS3 ESG Chan. 1 Ro Relay Fails to Pick Up	3.30E-05 /D	1 D	(No credit taken for a start signal from Oconee Engineered Safeguards System.)	1.00E+00
EU3C2RORYD	ONS3 ESG Chan. 2 Ro Relay Fails to Pick Up	3.30E-05 /D	1 D	(No credit taken for a start signal from Oconee Engineered Safeguards System.)	1.00E+00
GK186E1RYT	Keowee 1 Emergency Lockout Relay 86E-1 Spuriously Picks Up	3.60E-07 /H	24 H		8.64E-06
GK286E2RYT	Keowee 2 Emergency Lockout Relay 86E-2 Spuriously Picks Up	3.60E-07 /H	24 H		8.64E-06
XD104CCCDT	Breaker 1DA-4CC Transfers Open	7.50E-08 /H	24 H		1.80E-06
XD104CRCDT	Breaker 1DA-4CR Transfers Open	7.50E-08 /H	6 H		3.96E-07
XD202CCCDT	Breaker 2DA-2CC Transfers Open	7.50E-08 /H	24 H		1.80E-06
XD204CCCDT	Breaker 2DA-4CC Transfers Open	7.50E-08 /H	24 H		1.80E-06
YK114X3SSD	Keowee 1 Speed Switch 14-3 Fails to Open at 65 rpm	1.80E-05 /D	1 D		1.80E-05
YK13SUISWT	KHU#1 Startup Inhibit Sw 3SUI Xfrs to Inhibit	7.00E-08 /H	24 H		1.68E-06
YK14AMRRYT	Keowee 1 Master Relay 4A Spuriously Drops Out	3.60E-07 /H	24 H		8.64E-06
YK14BMRRYT	Keowee 1 Master Relay 4B Spuriously Drops Out	3.60E-07 /H	24 H		8.64E-06

Table A.5-6

Keowee Start and Run Control Reliability Data

Event Name	Description	Failure Rate[1]	Factor	Rationale For Factor[2]	Failure Probability
YK163BHLST	Keowee 1 Gen Thrst Brng Oil Lvl Hi Sw 63BL/H Sprsly Clsd	3.10E-07 /H	24 H		7.44E-06
YK163BHRYT	Keowee 1 Gen Thrst Brng Oil Lvl Hi Rly 63BL/HX Sprsly Picks Up	3.60E-07 /H	24 H		8.64E-06
YK163BLLST	Keowee 1 Gen Thrst Brng Oil Lvl Lo Sw 63BL/L Spuriously Operates	3.10E-07 /H	24 H		7.44E-06
YK163BLRYT	Keowee 1 Gen Thrst Brng Oil Lvl Lo Rly 63BL/LXTD Sprsly PIcks Up	3.60E-07 /H	24 H		8.64E-06
YK163TBLST	Keowee 1 Turb Guide Brng Lo Lvl Sensor Sw Spuriously Closes	3.10E-07 /H	24 H		7.44E-06
YK163TBRYT	Keowee 1 Turb Gd Brng Oil Lvl Lo Rly 63TB/1X Sprsly Picks Up	3.60E-07 /H	24 H		8.64E-06
YK186N1DEX	Keowee 1 Normal Lockout Actuates				9.89E-03
YK199SDRYD	Keowee 1 Shutdown Solenoid 99SD Fails To Pick Up	3.30E-05 /D	1 D		3.30E-05
YK199SDRYT	Keowee 1 Shutdown Solenoid Spuriously Drops Out	3.60E-07 /H	24 H		8.64E-06
YK199SNRYD	K1 Emergency Load Solenoid 99SN Fails To Pick Up/Drop Out	3.30E-05 /D	1 D		3.30E-05
YK199SNRYT	Emergency Load Solenoid 99SN Spuriously Drops Out	3.60E-07 /H	24 H		8.64E-06
YK199SXRYD	Keowee 1 Shutdown Solenoid Aux Relay 99SX Fails to Pick Up	3.30E-05 /D	1 D		3.30E-05
YK199SXRYT	Shutdown Auxiliary Relay 99SX Spuriously Drops Out	3.60E-07 /H	24 H		8.64E-06
YK1D4CRFUF	Fuse 1DA-4CR Fails	3.60E-06 /H	6 H		2.16E-05

Table A.5-6

Keowee Start and Run Control Reliability Data

Event Name	Description	Failure Rate[1]	Factor	Rationale For Factor[2]	Failure Probability
YK1ES1ARYD	Keowee 1 Emergency Start Aux Relay 1ESRX/1A Fails To Pick Up	3.30E-05 /D	1 D		3.30E-05
YK1ES1BRYD	Keowee 1 Emergency Start Aux Relay 1ESRX/1B Fails To Pick Up	3.30E-05 /D	1 D		3.30E-05
YK1ES2ARYD	Keowee 1 Emergency Start Aux Relay 1ESRX/2A Fails To Pick Up	3.30E-05 /D	1 D		3.30E-05
YK1ES2BRYD	Keowee 1 Emergency Start Aux Relay 1ESRX/2B Fails To Pick Up	3.30E-05 /D	1 D		3.30E-05
YK1MR4ARYD	Keowee 1 Start Master Relay 4A Fails To Pick Up	3.30E-05 /D	1 D		3.30E-05
YK1MR4BRYD	Keowee 1 Start Master Relay 4B Fails To Pick Up	3.30E-05 /D	1 D		3.30E-05
YK1SS12SST	Keowee 1 Overspeed Switch 12 Spuriously Picks Up	4.21E-06 /H	24 H		1.01E-04
YK1SS13SSD	Keowee 1 Speed Switch 13 Fails to Close at 122 rpm	1.80E-05 /D	1 D		1.80E-05
YK214X3SSD	KHU#2 Speed Switch 14-3 Fails to Open at 65 rpm	1.80E-05 /D	1 D		1.80E-05
YK23SUISWT	KHU#2 Startup Inhbt Sw 3SUI Sprsly Xfrs to Inhibit	7.00E-08 /H	24 H		1.68E-06
YK24AMRRYT	Keowee 2 Master Relay 4A Spuriously Drops Out	3.60E-07 /H	24 H		8.64E-06
YK24BMRRYT	Keowee 2 Master Relay 4B Spuriously Drops Out	3.60E-07 /H	24 H		8.64E-06
YK263BHLST	Keowee 2 Gen Thrst Brng Oil Lvl Hi Sw 63BL/H Sprsly Clsd	3.10E-07 /H	24 H		7.44E-06

Table A.5-6

Keeowee Start and Run Control Reliability Data

Event Name	Description	Failure Rate[1]	Factor	Rationale For Factor[2]	Failure Probability
YK263BHRYT	Keowee 2 Gen Thrst Brng Oil Lvl Hi Rly 63BL/HX Sprsly Picks Up	3.60E-07 /H	24 H		8.64E-06
YK263BLLST	Keowee 2 Gen Thrst Brng Oil Lvl Lo Sw 63BL/L Sprsly Opens	3.10E-07 /H	24 H		7.44E-06
YK263BLRYT	Keowee 2 Gen Thrst Brng Oil Lvl Lo Rly 63BL/LXTD Sprsly Picks Up	3.60E-07 /H	24 H		8.64E-06
YK263TBLST	Keowee 2 Turb Guide Brng Lo Lvl Sensor Sw Sprsly Closes	3.10E-07 /H	24 H		7.44E-06
YK263TBRYT	Keowee 2 Turb Gd Brng Oil Lvl Lo Rly 63TB/1X Sprsly Picks Up	3.60E-07 /H	24 H		8.64E-06
YK286N2DEX	Keowee Unit 2 Normal Lockout Activates				7.41E-03
YK299SDRYD	Keowee 2 Shutdown Solenoid 99SD Fails To Pick Up	3.30E-05 /D	1 D		3.30E-05
YK299SDRYT	Keowee 2 Shutdown Solenoid Spuriously Drops Out	3.60E-07 /H	24 H		8.64E-06
YK299SNRYD	Keowee 2 Emergency Load Solenoid 99SN Fails To Operate	3.30E-05 /D	1 D		3.30E-05
YK299SNRYT	Emergency Load Solenoid 99SN Spuriously Drops Out	3.60E-07 /H	24 H		8.64E-06
YK299SXRYD	Keowee 2 Shutdown Solenoid Aux Relay 99SX Fails to Pick Up	3.30E-05 /D	1 D		3.30E-05
YK299SXRYT	Shutdown Auxiliary Relay 99SX Spuriously Drops Out	3.60E-07 /H	24 H		8.64E-06
YK2D2CCFUF	Fuse 2DA-2CC Fails	3.60E-06 /H	6 H		2.16E-05

Table A.5-6

Keowee Start and Run Control Reliability Data

Event Name	Description	Failure Rate[1]	Factor	Rationale For Factor[2]	Failure Probability
YK2ES1ARYD	Keowee 2 Emergency Start Aux Relay 2ESRX/1A Fails To Pick Up	3.30E-05 /D	1 D		3.30E-05
YK2ES1BRYD	Keowee 2 Emergency Start Aux Relay 2ESRX/1B Fails to Pick Up	3.30E-05 /D	1 D		3.30E-05
YK2ES2ARYD	Keowee 2 Emergency Start Aux Relay 2ESRX/2A Fails to Pick Up	3.30E-05 /D	1 D		3.30E-05
YK2ES2BRYD	Keowee 2 Emergency Start Aux Relay 2ESRX/2B Fails to Pick Up	3.30E-05 /D	1 D		3.30E-05
YK2MR4ARYD	Keowee 2 Start Master Relay 4A Fails To Pick Up	3.30E-05 /D	1 D		3.30E-05
YK2MR4BRYD	Keowee 2 Start Master Relay 4B Fails to Pick Up	3.30E-05 /D	1 D		3.30E-05
YK2SS12SST	Keowee 2 Overspeed Switch 12 Spuriously Picks Up	4.21E-06 /H	24 H		1.01E-04
YK2SS13SSD	Keowee 2 Speed Switch 13 Fails to Close at 122 rpm	1.80E-05	1 D		1.80E-05
YKEMSRTCHE	Operator Incorrectly Resets Keowee Emergency Start Signals			(Event included for sensitivity study only.)	0.00E+00
YO1DIA2CDT	DC Circuit Breaker 1DIA-2 Transfers Position	7.50E-08 /H	30 H		2.25E-06
YO1DIB2CDT	DC Circuit Breaker 1DIB-2 Transfers Position	7.50E-08 /H	30 H		2.25E-06
YO1OPSARHE	Operator fails to operate Keowee start switch S1A		1 D	(No credit taken for Oconee Operator action.)	1.00E+00
YO1OPSBRHE	Operator fails to operate Keowee start switch S1B		1 D	(No credit taken for Oconee Operator action.)	1.00E+00

Table A.5-6

Keowee Start and Run Control Reliability Data

Event Name	Description	Failure Rate[1]	Factor	Rationale For Factor[2]	Failure Probability
YO1S1AFSWC	Control Switch S1A Fails To Close On Demand	1.00E-05 /D	1 D		1.00E-05
YO1S1BFSWC	Control Switch S1B Fails To Close On Demand	1.00E-05 /D	1 D		1.00E-05
YO1XXKARYD	ONS1 Ch A Keowee Emergency Start Relay KA Fails to Pick Up	3.30E-05 /D	1 D		3.30E-05
YO1XXKBRYD	Oconee Unit 1 Chan. B Keowee Emergency Start Relay Fails	3.30E-05 /D	1 D		3.30E-05
YO2CR2ARYD	ONS2 Ch A Keowee Emergency Start Relay CR2A Fails to Pick Up	3.30E-05 /D	1 D		3.30E-05
YO2CR2BRYD	ONS2 Keowee Emergency Start Relay CR2B Fails to Pick Up	3.30E-05 /D	1 D		3.30E-05
YO2DIA2CDT	Breaker 2DIA-2 Transfers Position	7.50E-08 /H	30 H		2.25E-06
YO2DIB2CDT	Breaker 2DIB-2 Transfers Position	7.50E-08 /H	30 H		2.25E-06
YO2SSWARHE	Operator Fails to Operate Keowee Start Switch 2SSW'A'		1 D	(No credit taken for Oconee Operator action.)	1.00E+00
YO2SSWASWC	Control Switch 2SSW'A' Fails To Close On Demand	1.00E-05 /D	1 D		1.00E-05
YO2SSWBRHE	Operator Fails to Operate Keowee Start Switch 2SSW'B'		1 D	(No credit taken for Oconee Operator action.)	1.00E+00
YO2SSWBSWC	Control Switch 2SSW'B' Fails To Close On Demand	1.00E-05 /D	1 D		1.00E-05
YO3CR3ARYD	ONS3 Ch A Keowee Emergency Start Relay CR3A Fails To Pick Up	3.30E-05 /D	1 D		3.30E-05
YO3CR3BRYD	ONS3 Keowee Emer Start Relay CR3B Fails to Pick Up	3.30E-05 /D	1 D		3.30E-05

Table A.5-6

Keowee Start and Run Control Reliability Data

Event Name	Description	Failure Rate[1]	Factor	Rationale For Factor[2]	Failure Probability
YO3DIA2CDT	Breaker 3DIA-2 Transfers Open	7.50E-08 /H	30 H		2.25E-06
YO3DIB2CDT	Breaker 3DIB-2 Transfers Open	7.50E-08 /H	30 H		2.25E-06
YO3OPFARHE	Operator fails to operate Keowee Start Switch 3S1A		1 D	(No credit taken for Oconee Operator action.)	1.00E+00
YO3OPFBRHE	Operator Fails to Operate Keowee Start Switch 3S1B		1 D	(No credit taken for Oconee Operator action.)	1.00E+00
YO3S1AFSWC	Control Switch S1A Fails To Close On Demand	1.00E-05 /D	1 D		1.00E-05
YO3S1BFSWC	Control Switch S1B Fails To Close On Demand	1.00E-05 /D	1 D		1.00E-05
YO3SSWARHE	Operator fails to operate Keowee Start Switch 3SSW'A'		1 D	(No credit taken for Oconee Operator action.)	1.00E+00
YO3SSWASWC	Control Switch 3SSW'A' Fails To Close On Demand	1.00E-05 /D	1 D		1.00E-05
YO3SSWBRHE	Operator Fails to Operate Keowee Start Switch 3SSW'B'		1 D	(No credit taken for Oconee Operator action.)	1.00E+00
YO3SSWBSWC	Control Switch 3SSW'B' Fails To Close On Demand	1.00E-05 /D	1 D		1.00E-05

1 D = Demand, H = Hour

2 Rules for assigning basic event factors are discussed in Table C.1-4.

Table A.5-7

Keeowee Start and Run Control Dominant Minimal Cut Sets

Cut Sets For Gate YK1CLDSTRT: Keowee 1 Governor Control Fails During A Cold Start Sequence

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
1)	3.30E-05	19.6	YK199SDRYD	3.30E-05	Keowee 1 Shutdown Solenoid 99SD Fails To Pick Up
2)	3.30E-05	19.6	YK199SNRYD	3.30E-05	K1 Emergency Load Solenoid 99SN Fails To Pick Up/Drop Out
3)	3.30E-05	19.6	YK199SXRYD	3.30E-05	Keowee 1 Shutdown Solenoid Aux Relay 99SX Fails to Pick Up
4)	3.30E-05	19.6	YK1MR4ARYD	3.30E-05	Keowee 1 Start Master Relay 4A Fails To Pick Up
5)	1.80E-05	10.7	YK1SS13SSD	1.80E-05	Keowee 1 Speed Switch 13 Fails to Close at 122 rpm
6)	1.80E-05	10.7	YK114X3SSD	1.80E-05	Keowee 1 Speed Switch 14-3 Fails to Open at 65 rpm
Total:	1.68E-04				

Table A.5-8

Keowee Start and Run Control Dominant Minimal Cut Sets

Cut Sets For Gate YK1RUNCNTL: Keowee 1 Governor Control Fails During Run

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
1)	1.01E-04	51.0	YK1SS12SST	1.01E-04	Keowee 1 Overspeed Switch 12 Spuriously Picks Up
2)	8.64E-06	4.4	YK163BHRYT	8.64E-06	Keowee 1 Gen Thrst Brng Oil Lvl Hi Rly 63BL/HX Sprsly Picks
3)	8.64E-06	4.4	YK163BLRYT	8.64E-06	Keowee 1 Gen Thrst Brng Oil Lvl Lo Rly 63BL/LXTD Sprsly Pcks
4)	8.64E-06	4.4	YK163TBRYT	8.64E-06	Keowee 1 Turb Gd Brng Oil Lvl Lo Rly 63TB/1X Sprsly Picks Up
5)	8.64E-06	4.4	YK14AMRRYT	8.64E-06	Keowee 1 Master Relay 4A Spuriously Drops Out
6)	8.64E-06	4.4	GK186E1RYT	8.64E-06	Keowee 1 Emergency Lockout Relay 86E-1 Spuriously Picks Up
7)	8.64E-06	4.4	YK199SDRYT	8.64E-06	Keowee 1 Shutdown Solenoid Spuriously Drops Out
8)	8.64E-06	4.4	YK199SXRYT	8.64E-06	Shutdown Auxiliary Relay 99SX Spuriously Drops Out
9)	8.64E-06	4.4	YK199SNRYT	8.64E-06	Emergency Load Solenoid 99SN Spuriously Drops Out
10)	7.44E-06	3.8	YK163TBLST	7.44E-06	Keowee 1 Turb Guide Brng Lo Lvl Sensor Sw Spuriously Closes

Table A.5-8

Keeowee Start and Run Control Dominant Minimal Cut Sets

Cut Sets For Gate YK1RUNCNTL: Keowee 1 Governor Control Fails During Run

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
11)	7.44E-06	3.8	YK163BLLST	7.44E-06	Keowee 1 Gen Thrst Brng Oil Lvl Lo Sw 63BL/L Spuriously Oper
12)	7.44E-06	3.8	YK163BHLST	7.44E-06	Keowee 1 Gen Thrst Brng Oil Lvl Hi Sw 63BL/H Sprsly Clsd
13)	1.80E-06	0.9	ED13BR2CDT	1.80E-06	Breaker 3BR In 125V dc Distribution Center 1DA Transfers Ope
14)	1.80E-06	0.9	XD104CCCDT	1.80E-06	Breaker 1DA-4CC Transfers Open
15)	1.68E-06	0.8	YK13SUISWT	1.68E-06	KHU#1 Startup Inhibit Sw 3SUI Xfrs to Inhibit
Total:	1.98E-04				

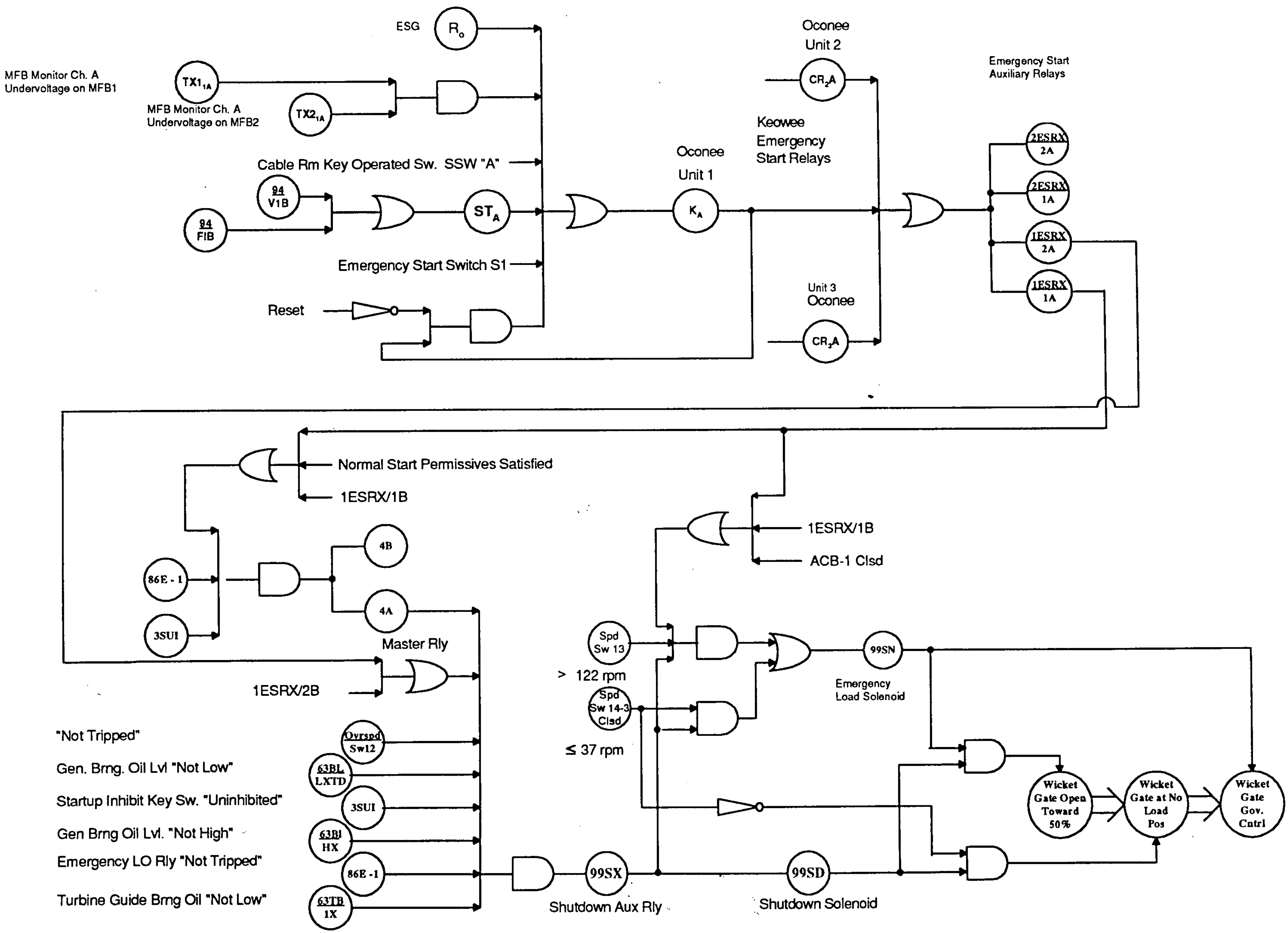
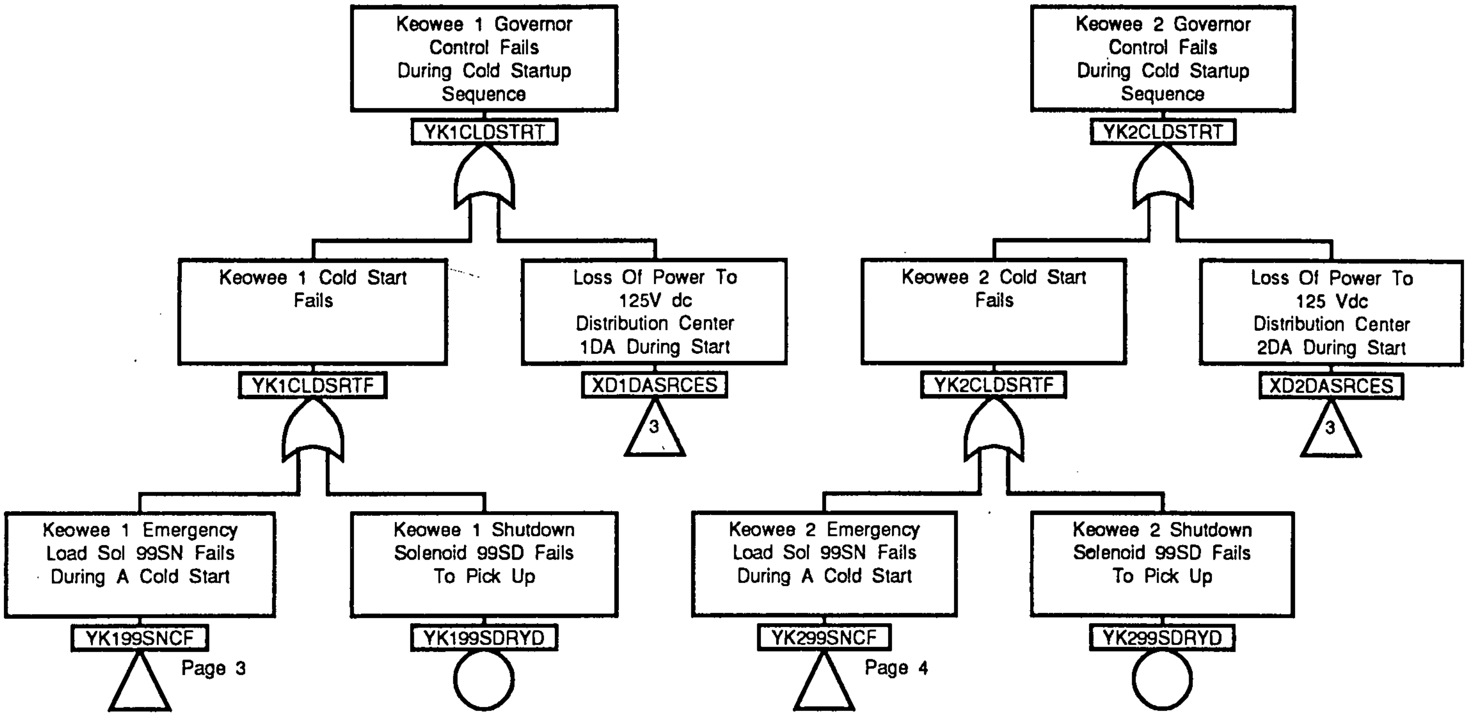
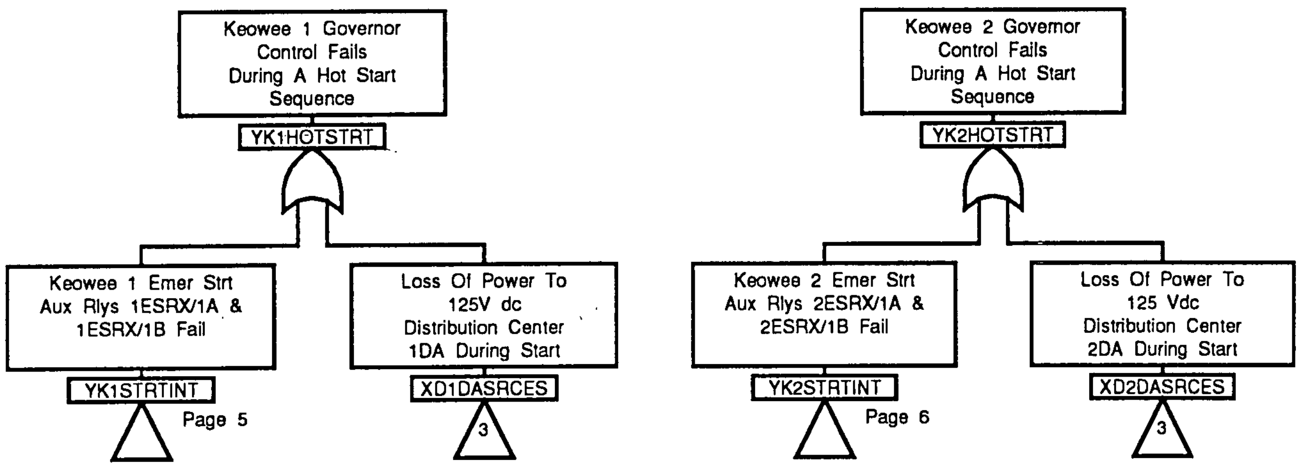


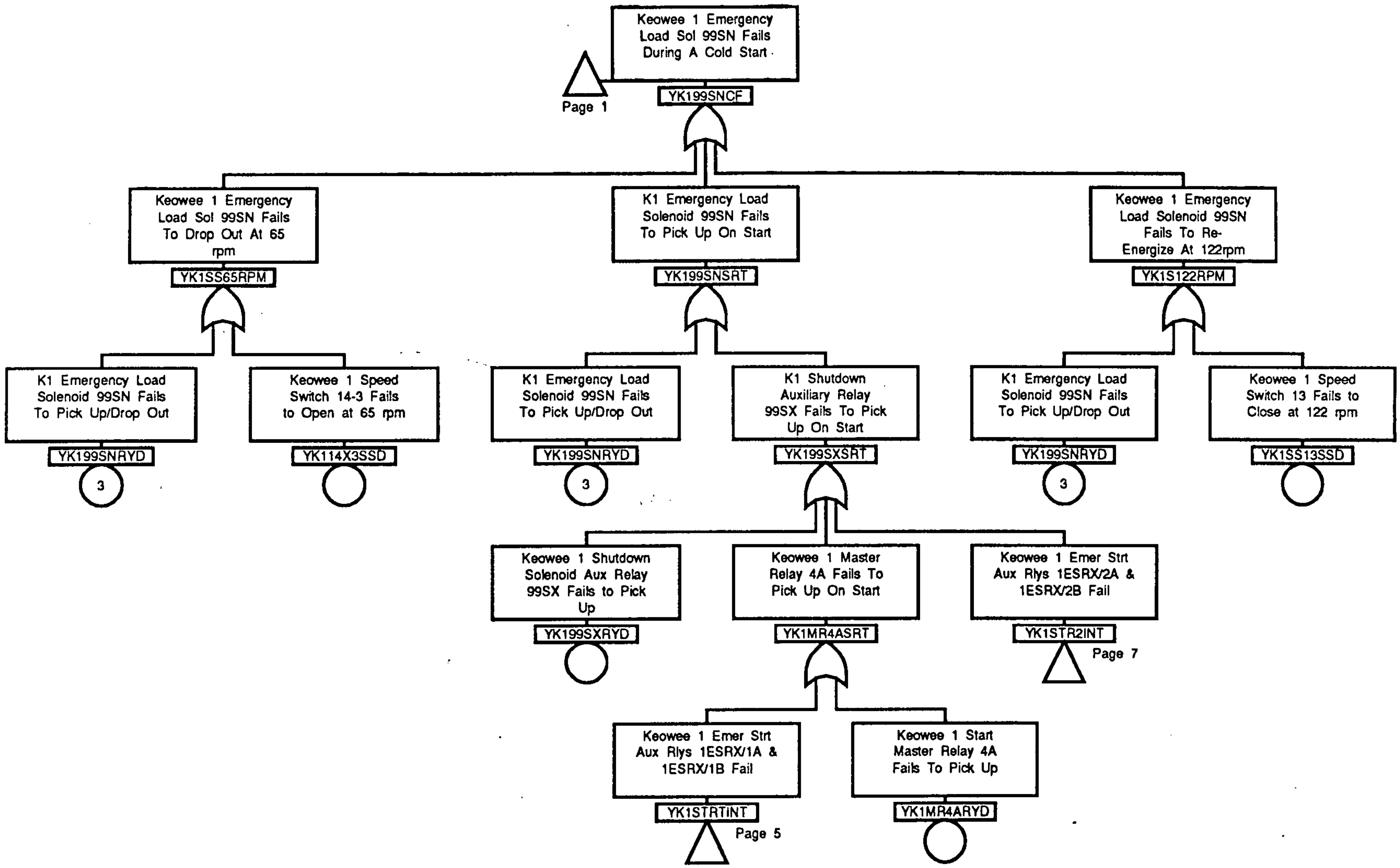
Figure A.5-1 Keowee Unit 1 Emergency Start Logic



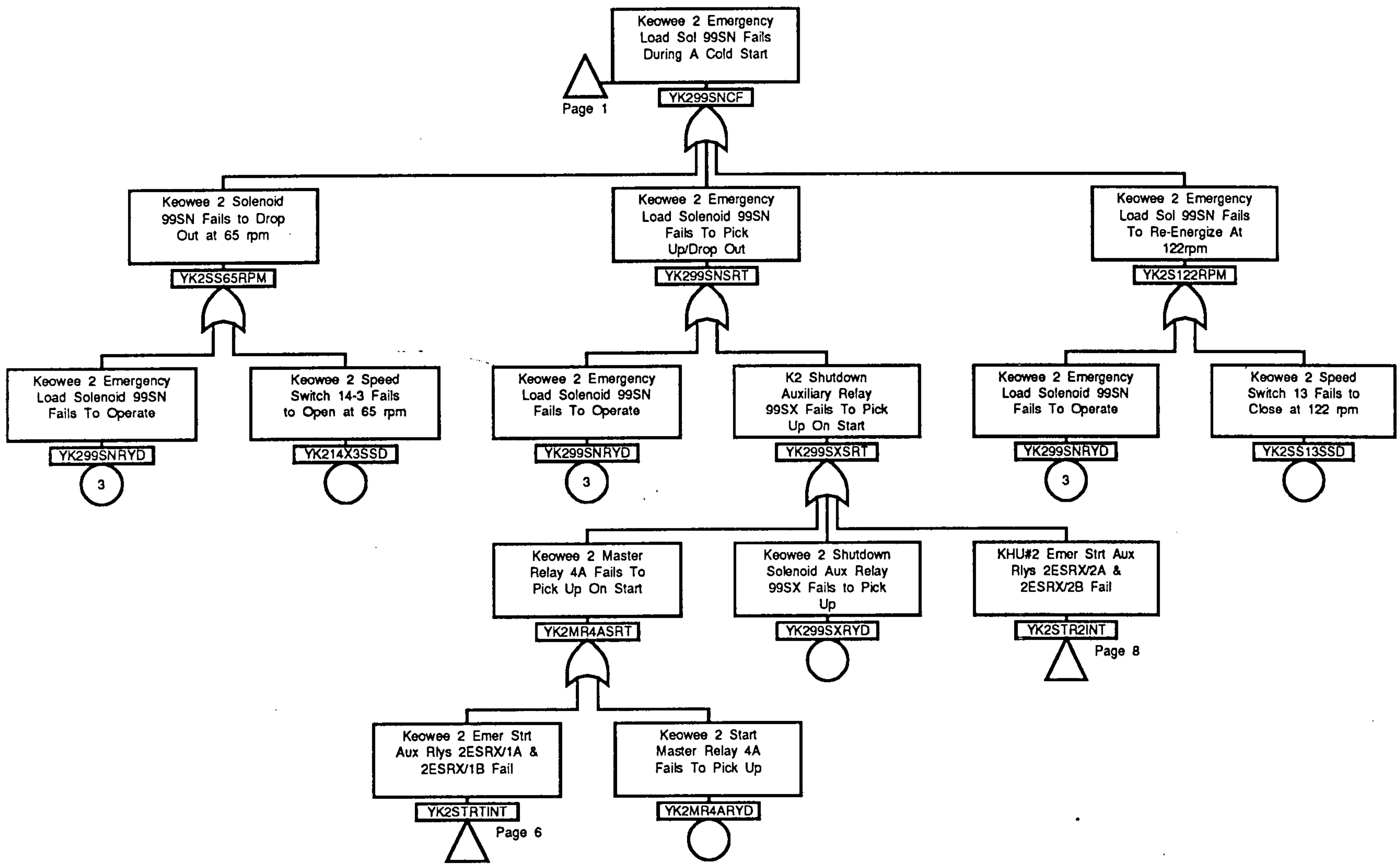
Keowee (Emergency) Start/Run Fault Tree	FIGURE A.5-2	Page 1



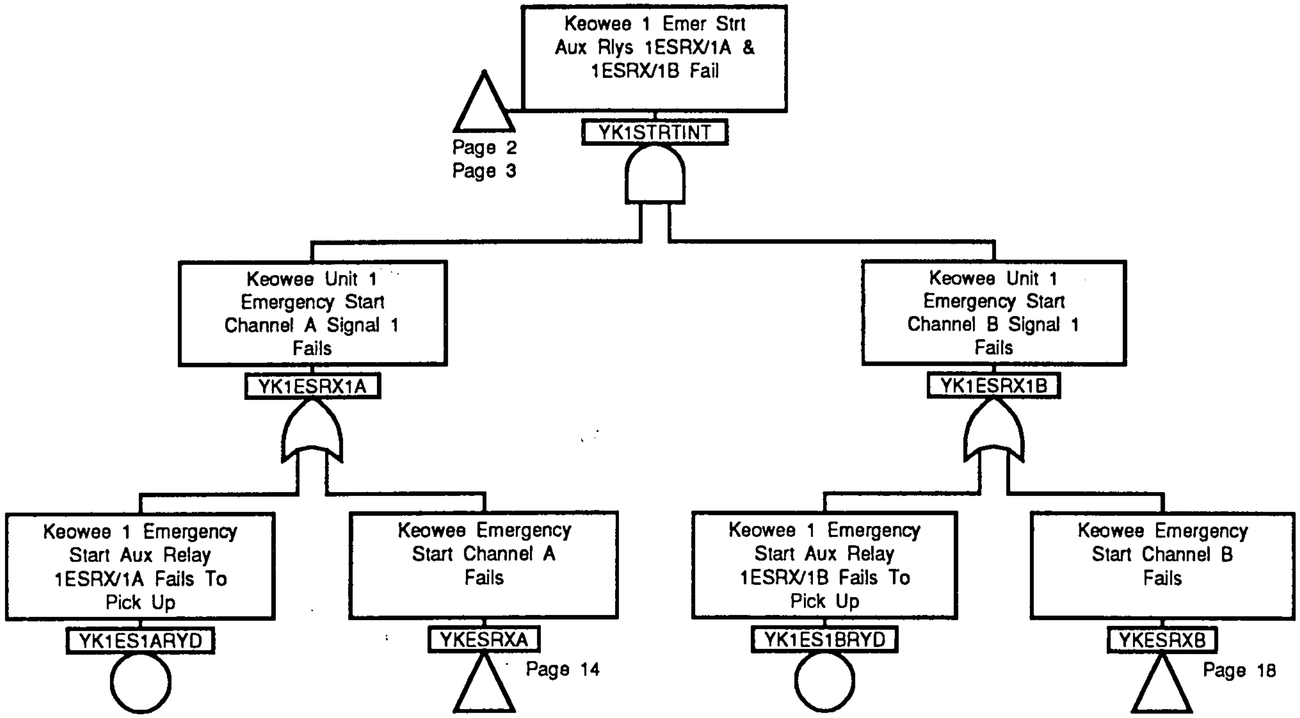
Keowee (Emergency) Start/Run Fault Tree | FIGURE A.5-2 |



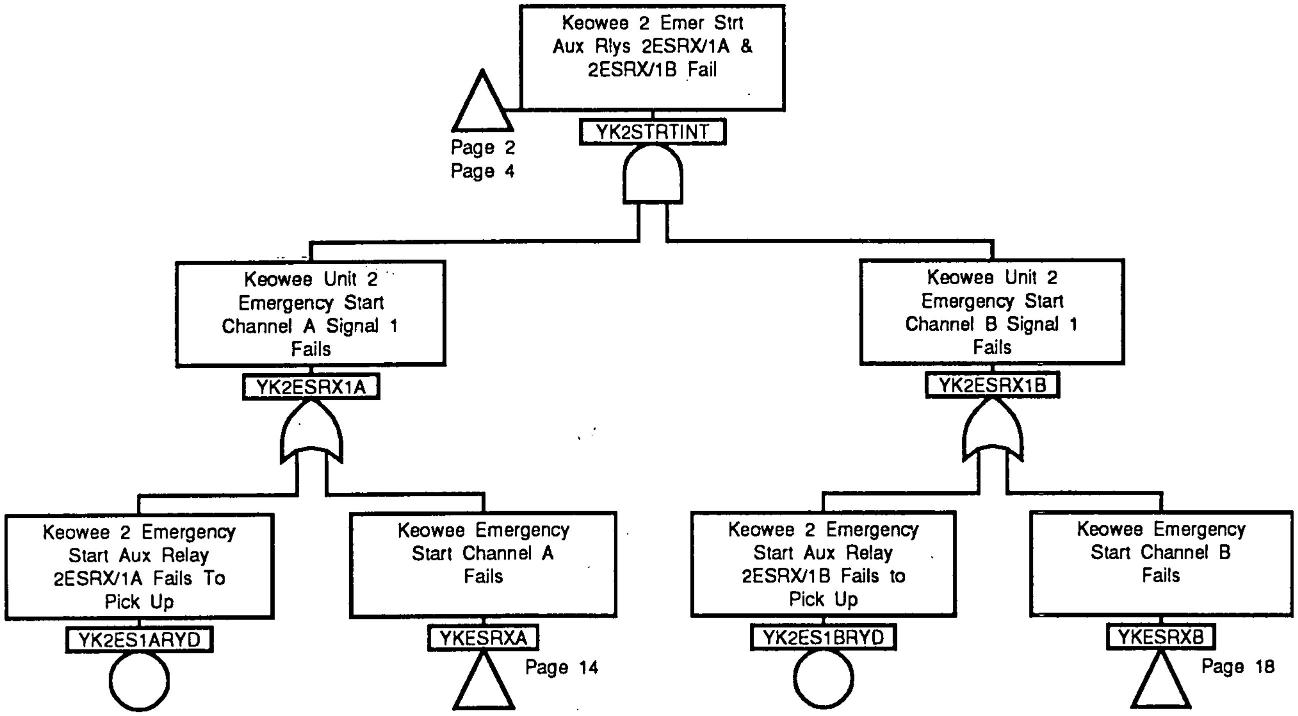
Keowee (Emergency) Start/Run Fault Tree	FIGURE A.5-2	Page 3



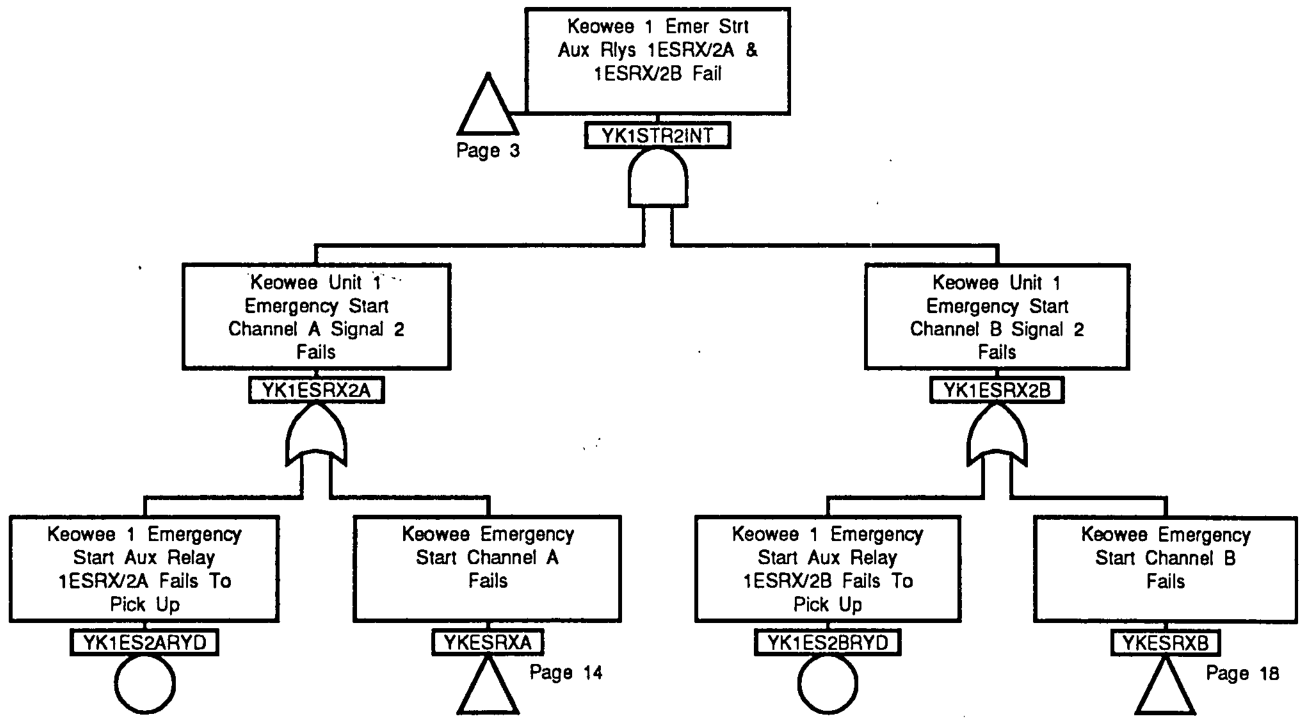
Keowee 2 Emergency Load Sol 99SN Fails During A Cold Start
YK299SNCF
Page 1
Keowee 2 Solenoid 99SN Fails to Drop Out at 65 rpm
YK2SS65RPM
Keowee 2 Emergency Load Solenoid 99SN Fails To Pick Up/Drop Out
YK299SNSRT
Keowee 2 Emergency Load Sol 99SN Fails To Re-Energize At 122rpm
YK2S122RPM
Keowee 2 Emergency Load Solenoid 99SN Fails To Operate
YK299SNRYD
3
Keowee 2 Speed Switch 14-3 Fails to Open at 65 rpm
YK214X3SSD
Keowee 2 Emergency Load Solenoid 99SN Fails To Operate
YK299SNRYD
3
K2 Shutdown Auxiliary Relay 99SX Fails To Pick Up On Start
YK299SXSRT
Keowee 2 Emergency Load Solenoid 99SN Fails To Operate
YK299SNRYD
3
Keowee 2 Speed Switch 13 Fails to Close at 122 rpm
YK2SS13SSD
Keowee 2 Master Relay 4A Fails To Pick Up On Start
YK2MR4ASRT
Keowee 2 Shutdown Solenoid Aux Relay 99SX Fails to Pick Up
YK299SXRYD
KHU#2 Emer Strt Aux Rlys 2ESRX/2A & 2ESRX/2B Fail
YK2STR2INT
Page 8
Keowee 2 Emer Strt Aux Rlys 2ESRX/1A & 2ESRX/1B Fail
YK2STRTINT
Page 6
Keowee 2 Start Master Relay 4A Fails To Pick Up
YK2MR4ARYD

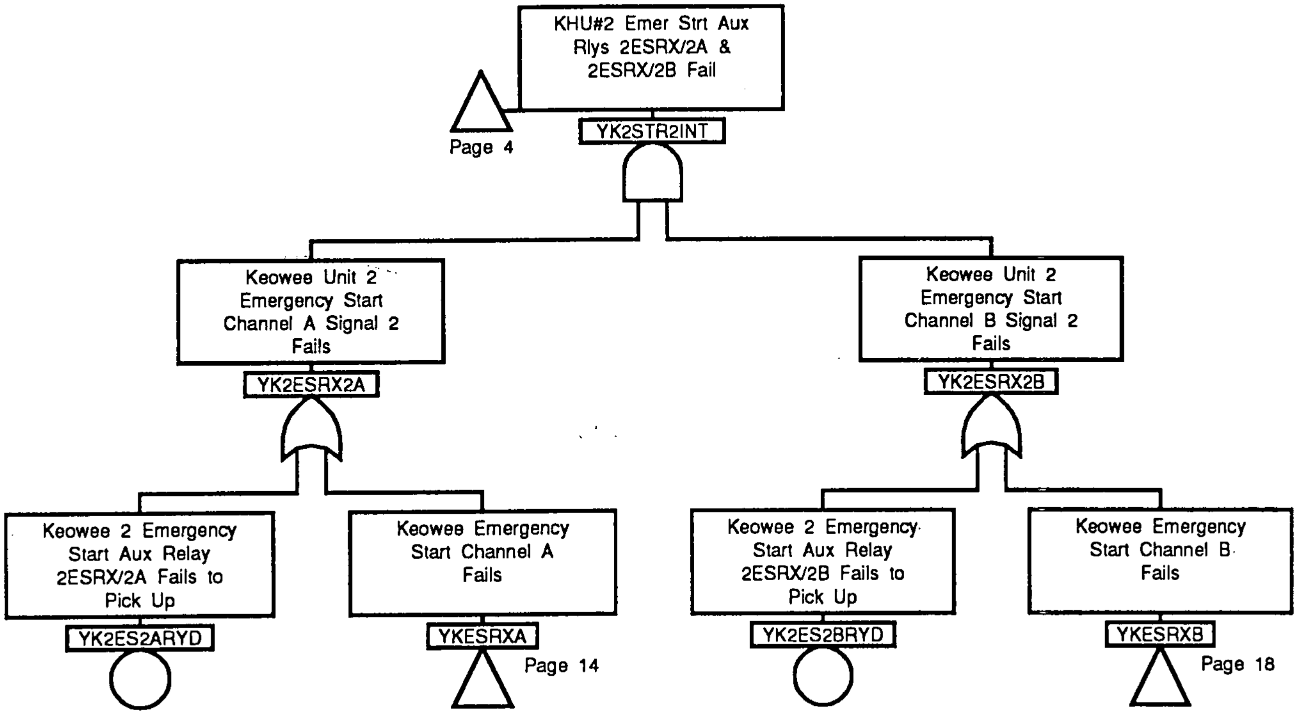


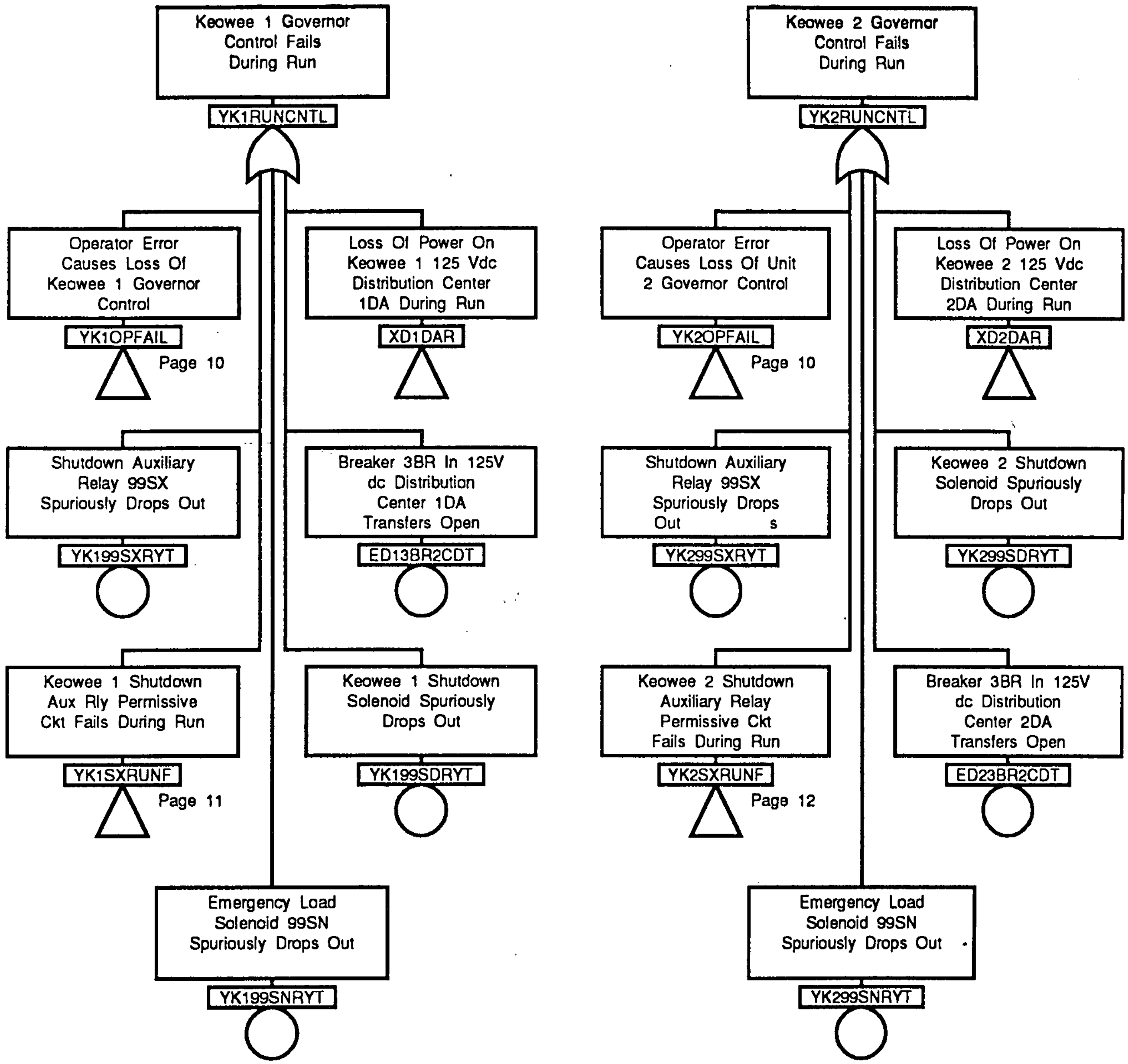
Keowee (Emergency) Start/Run Fault Tree	FIGURE A.5-2	Page 5



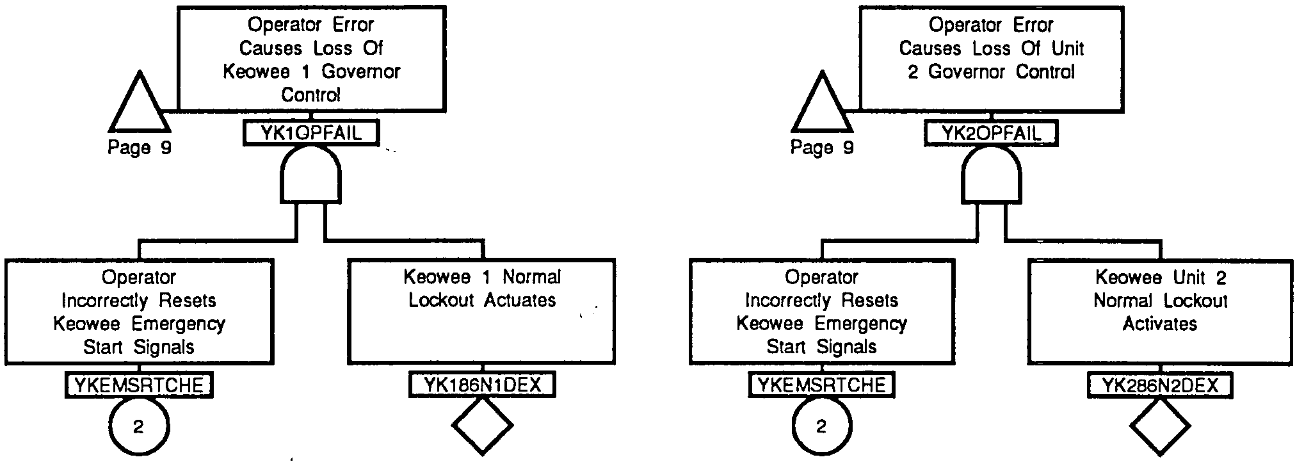
Keowee (Emergency) Start/Run Fault Tree | FIGURE A.5-2 |

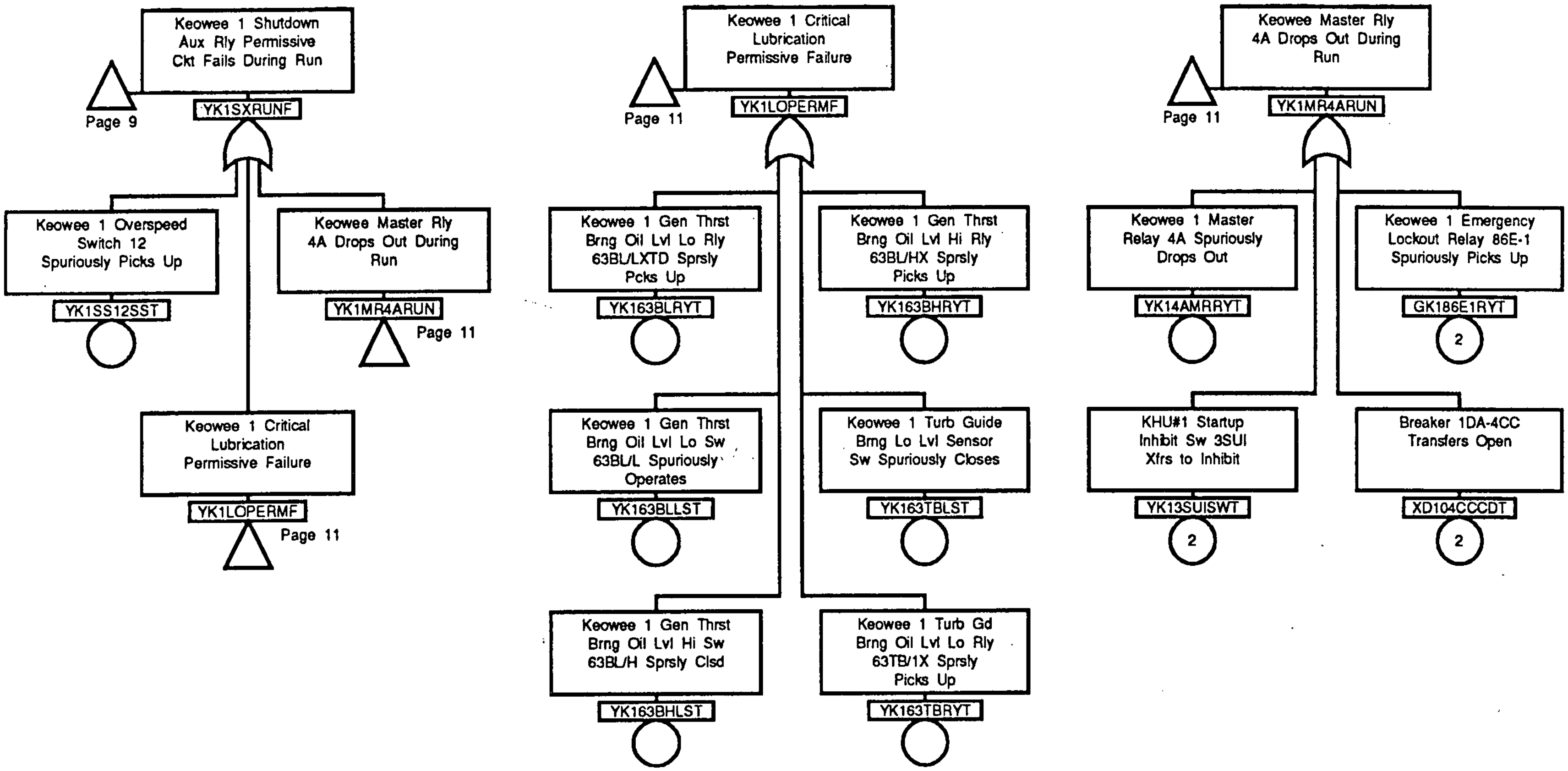

Keowee 1 Emer Strt Aux Rlys 1ESRX/2A & 1ESRX/2B Fail
YK1STR2INT
Page 3
Keowee Unit 1 Emergency Start Channel A Signal 2 Fails
YK1ESRX2A
Keowee Unit 1 Emergency Start Channel B Signal 2 Fails
YK1ESRX2B
Keowee 1 Emergency Start Aux Relay 1ESRX/2A Fails To Pick Up
YK1ES2ARYD
Keowee Emergency Start Channel A Fails
YKESRXA
Page 14
Keowee 1 Emergency Start Aux Relay 1ESRX/2B Fails To Pick Up
YK1ES2BRYD
Keowee Emergency Start Channel B Fails
YKESRXB
Page 18


KHU#2 Emer Strt Aux Rlys 2ESRX/2A & 2ESRX/2B Fail
YK2STR2INT
Page 4
Keowee Unit 2 Emergency Start Channel A Signal 2 Fails
YK2ESRX2A
Keowee Unit 2 Emergency Start Channel B Signal 2 Fails
YK2ESRX2B
Keowee 2 Emergency Start Aux Relay 2ESRX/2A Fails to Pick Up
YK2ES2ARYD
Keowee Emergency Start Channel A Fails
YKESRXA
Page 14
Keowee 2 Emergency Start Aux Relay 2ESRX/2B Fails to Pick Up
YK2ES2BRYD
Keowee Emergency Start Channel B Fails
YKESRXB
Page 18

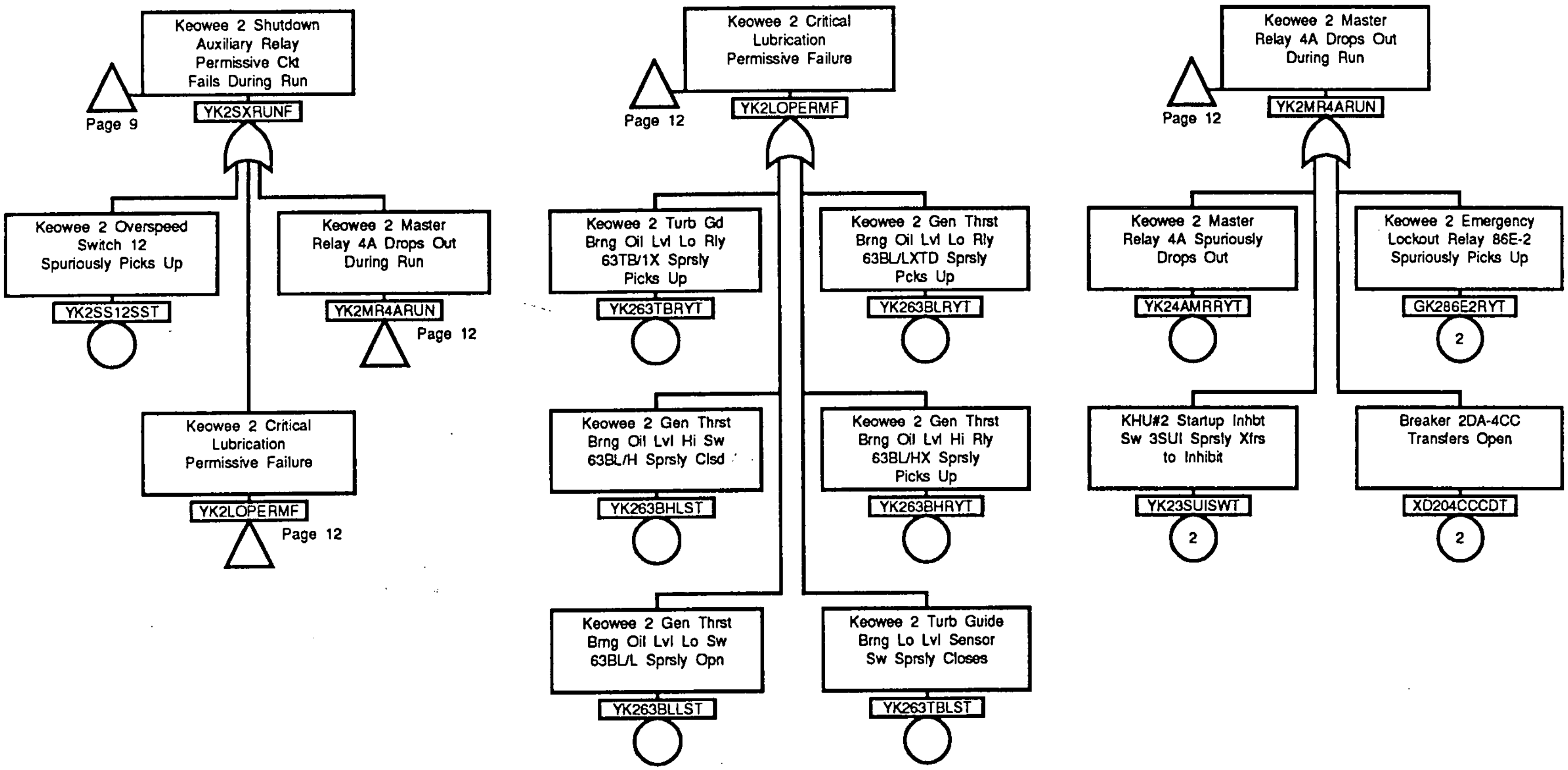


Keowee (Emergency) Start/Run Fault Tree	FIGURE A.5-2	Page 9

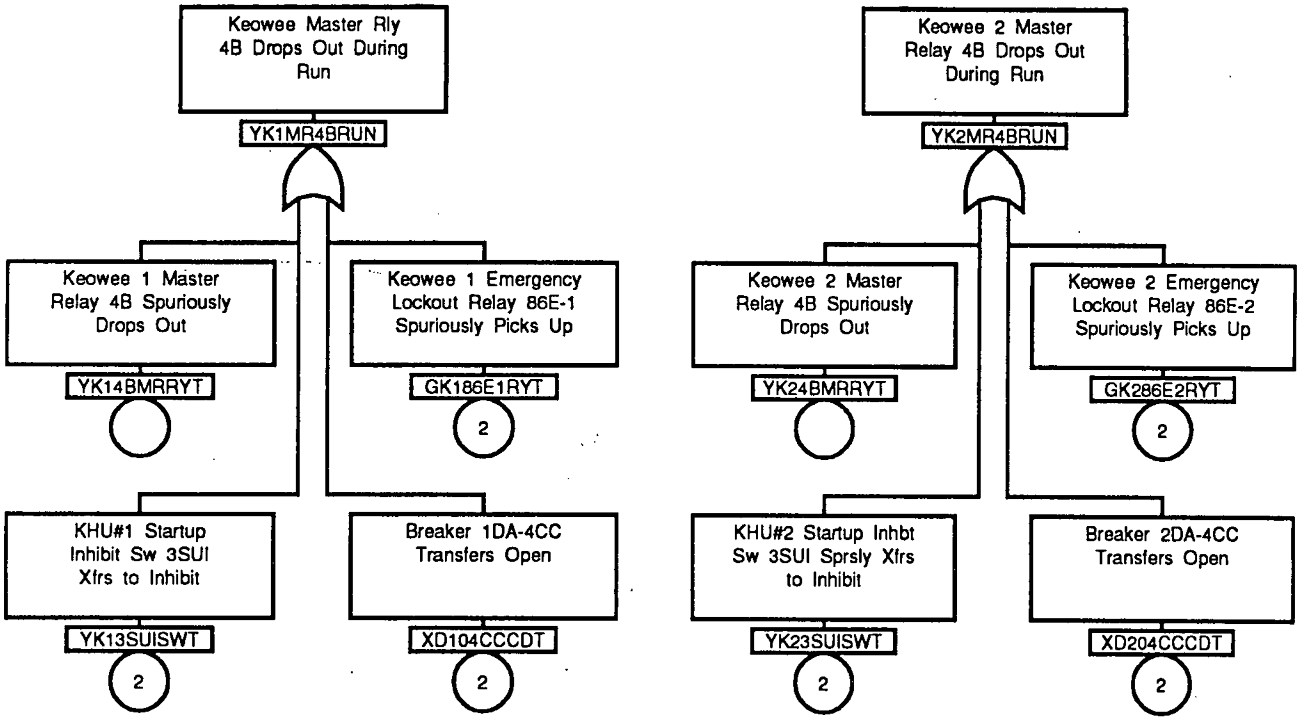

Operator Error Causes Loss Of Keowee 1 Governor Control
YK1OPFAIL
Page 9
Operator Incorrectly Resets Keowee Emergency Start Signals
YKEMSRTCHE
2
Keowee 1 Normal Lockout Actuates
YK186N1DEX
Operator Error Causes Loss Of Unit 2 Governor Control
YK2OPFAIL
Page 9
Operator Incorrectly Resets Keowee Emergency Start Signals
YKEMSRTCHE
2
Keowee Unit 2 Normal Lockout Activates
YK286N2DEX



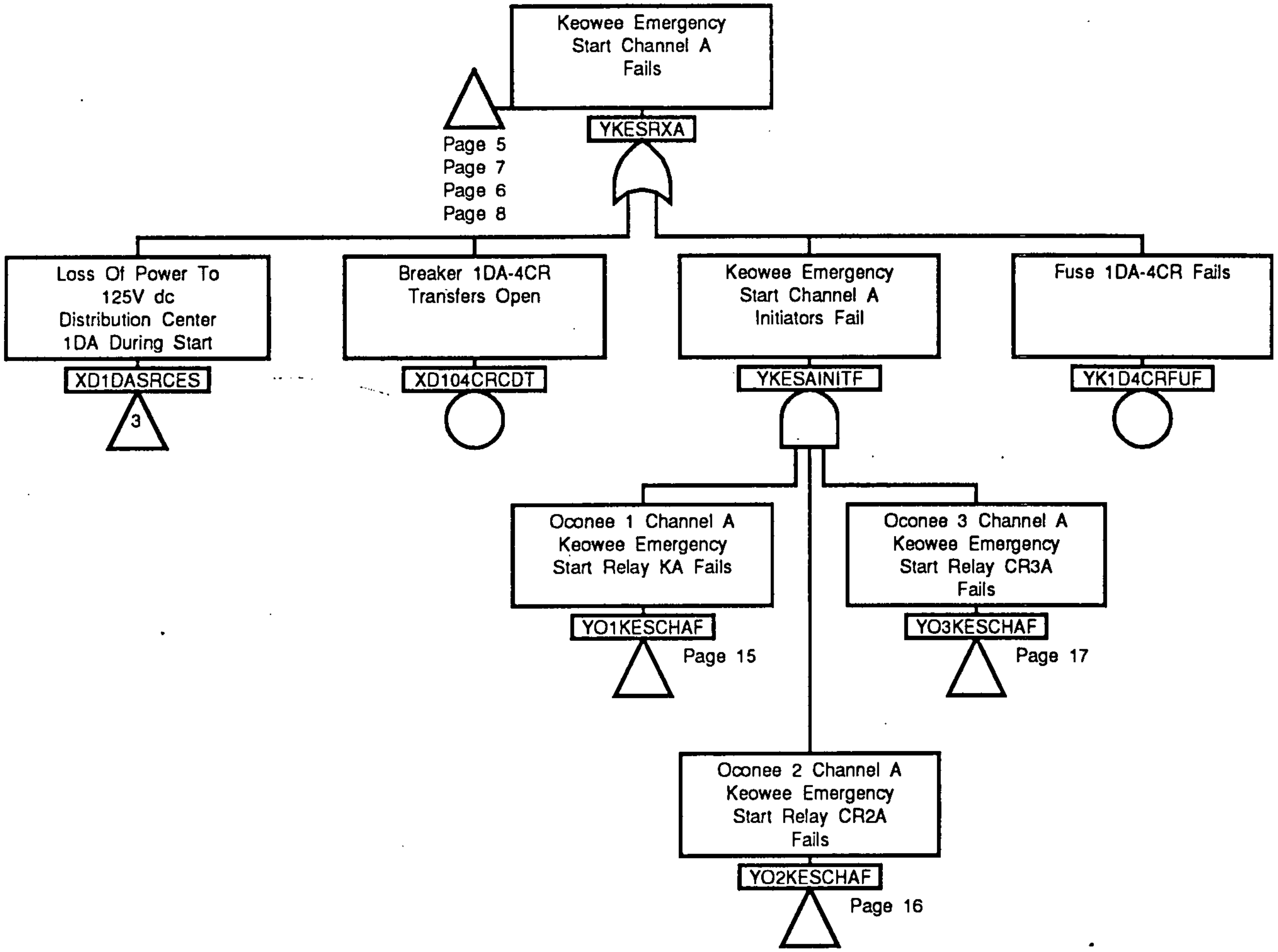
Keowee (Emergency) Start/Run Fault Tree | FIGURE A.5-2

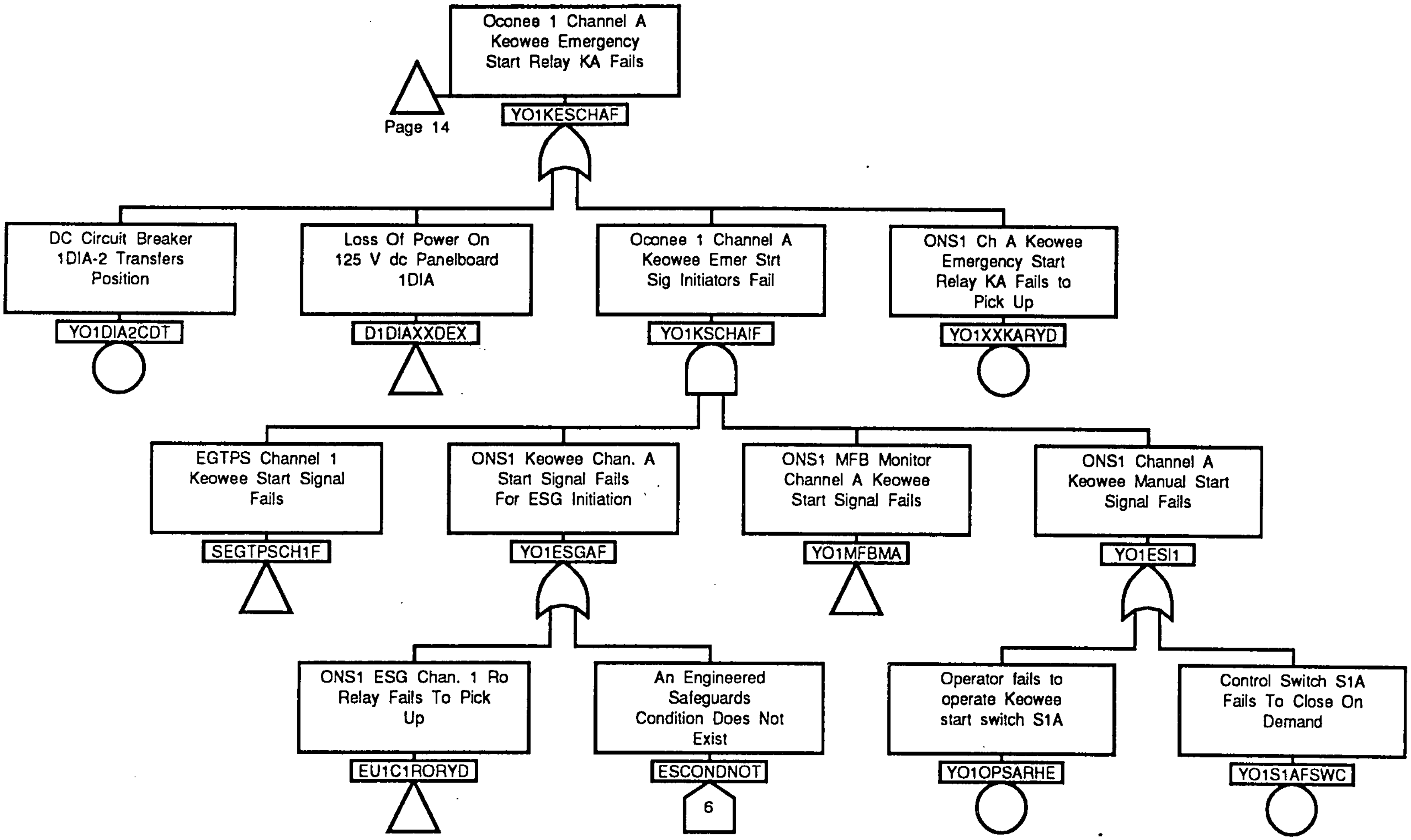


Keowee 2 Shutdown Auxiliary Relay Permissive Ckt Fails During Run
YK2SXRUNF
Page 9
Keowee 2 Overspeed Switch 12 Spuriously Picks Up
YK2SS12SST
Keowee 2 Master Relay 4A Drops Out During Run
YK2MR4ARUN
Page 12
Keowee 2 Critical Lubrication Permissive Failure
YK2LOPERMF
Page 12
Keowee 2 Critical Lubrication Permissive Failure
YK2LOPERMF
Page 12
Keowee 2 Turb Gd Brng Oil Lvl Lo Rly 63TB/1X Sprsly Picks Up
YK263TBRYT
Keowee 2 Gen Thrst Brng Oil Lvl Lo Rly 63BL/LXTD Sprsly Pcks Up
YK263BLRYT
Keowee 2 Gen Thrst Brng Oil Lvl Hi Sw 63BL/H Sprsly Clsd
YK263BHLST
Keowee 2 Gen Thrst Brng Oil Lvl Hi Rly 63BL/HX Sprsly Picks Up
YK263BHRYT
Keowee 2 Gen Thrst Brng Oil Lvl Lo Sw 63BL/L Sprsly Opn
YK263BLLST
Keowee 2 Turb Guide Brng Lo Lvl Sensor Sw Sprsly Closes
YK263TBLST
Keowee 2 Master Relay 4A Drops Out During Run
YK2MR4ARUN
Page 12
Keowee 2 Master Relay 4A Spuriously Drops Out
YK24AMRRYT
Keowee 2 Emergency Lockout Relay 86E-2 Spuriously Picks Up
GK286E2RYT
2
KHU#2 Startup Inhbt Sw 3SUI Sprsly Xfrs to Inhibit
YK23SUISWT
2
Breaker 2DA-4CC Transfers Open
XD204CCCDT
2



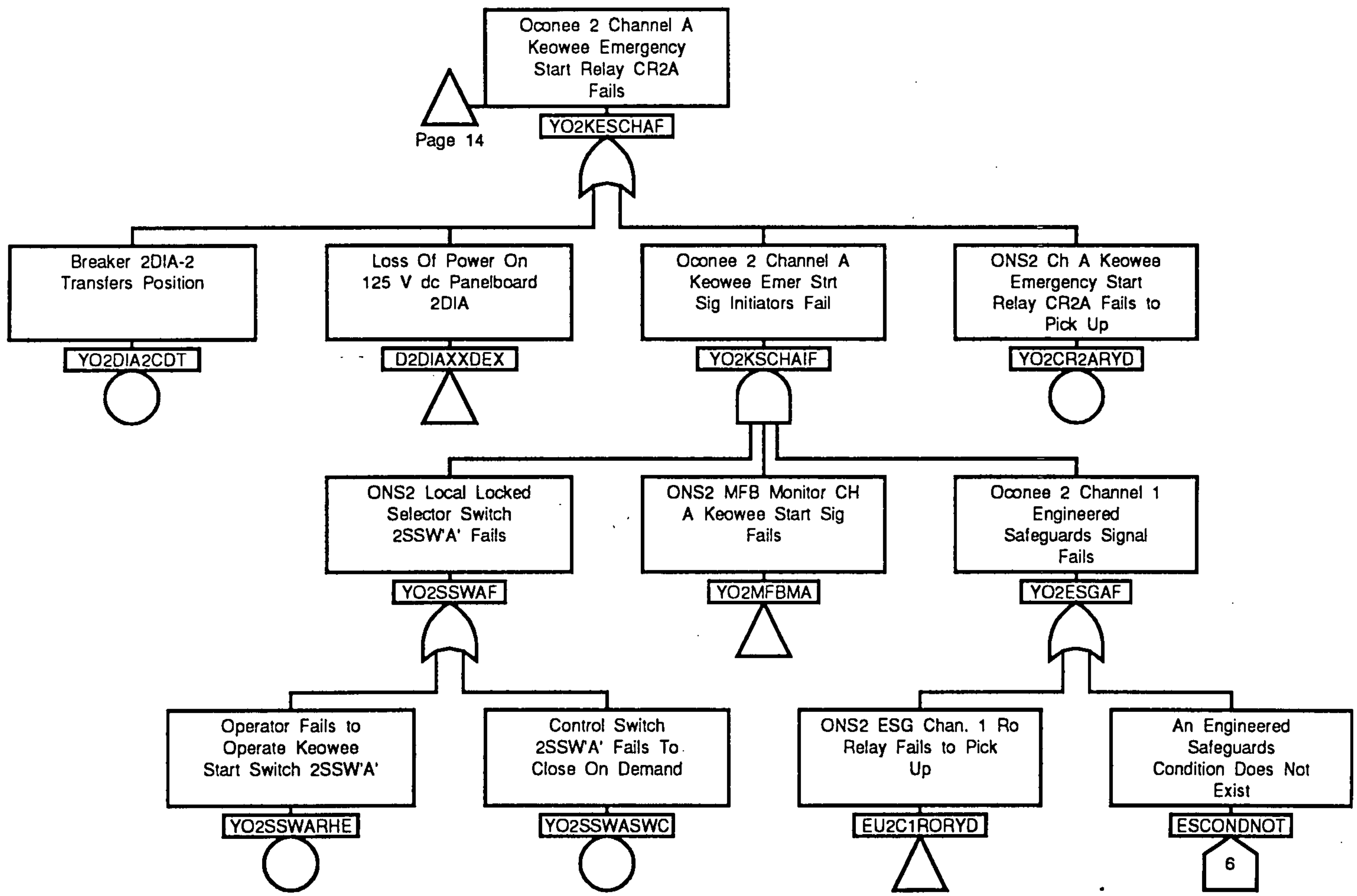
Keowee (Emergency) Start/Run Fault Tree	FIGURE A.5-2	


Keowee Emergency Start Channel A Fails
YKESRXA
Page 5
Page 7
Page 6
Page 8
Loss Of Power To 125V dc Distribution Center 1DA During Start
XD1DASRCES
3
Breaker 1DA-4CR Transfers Open
XD104CRCDT
Keowee Emergency Start Channel A Initiators Fail
YKESAINITF
Fuse 1DA-4CR Fails
YK1D4CRFUF
Oconee 1 Channel A Keowee Emergency Start Relay KA Fails
YO1KESCHAF
Page 15
Oconee 3 Channel A Keowee Emergency Start Relay CR3A Fails
YO3KESCHAF
Page 17
Oconee 2 Channel A Keowee Emergency Start Relay CR2A Fails
YO2KESCHAF
Page 16

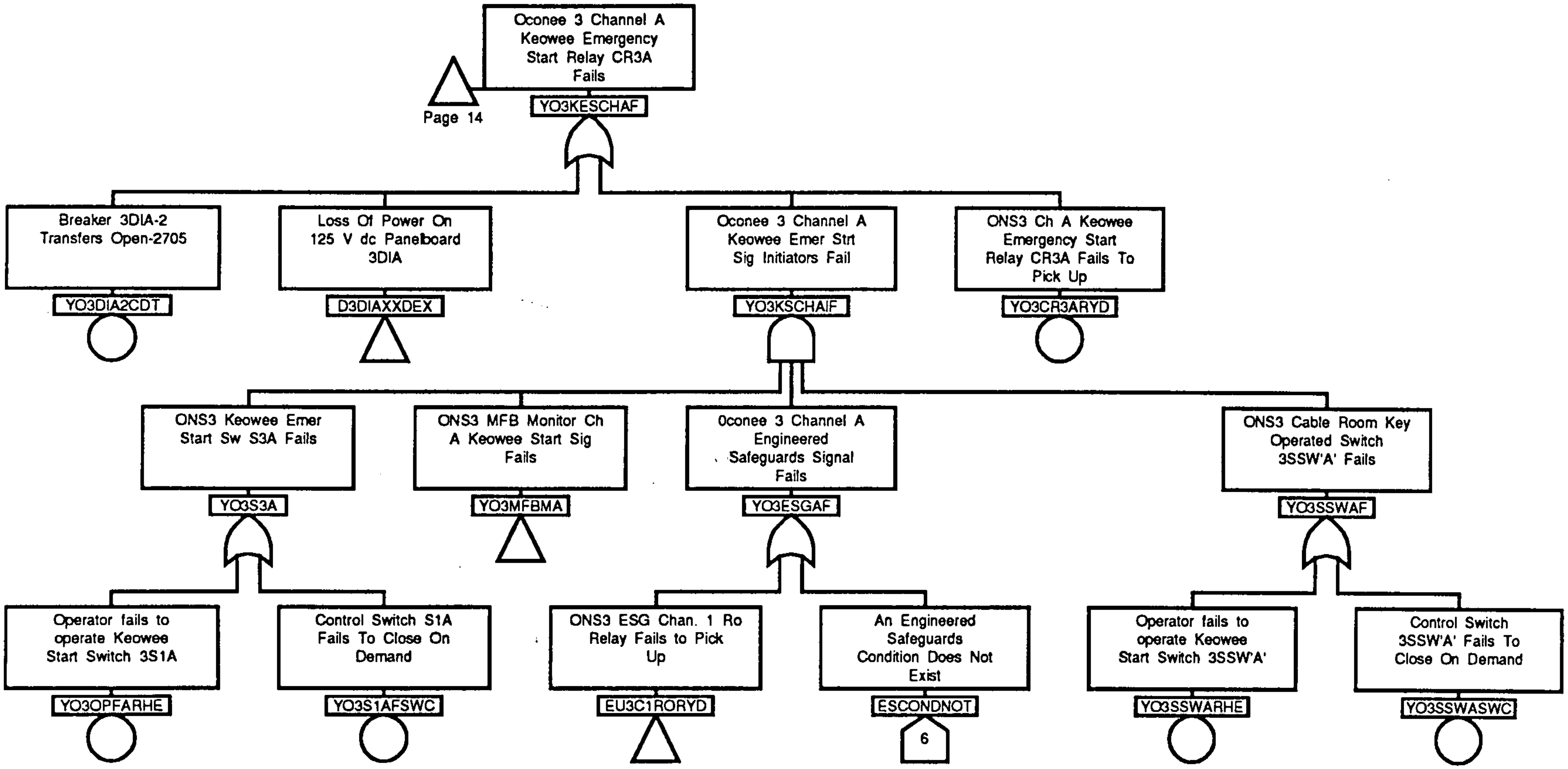


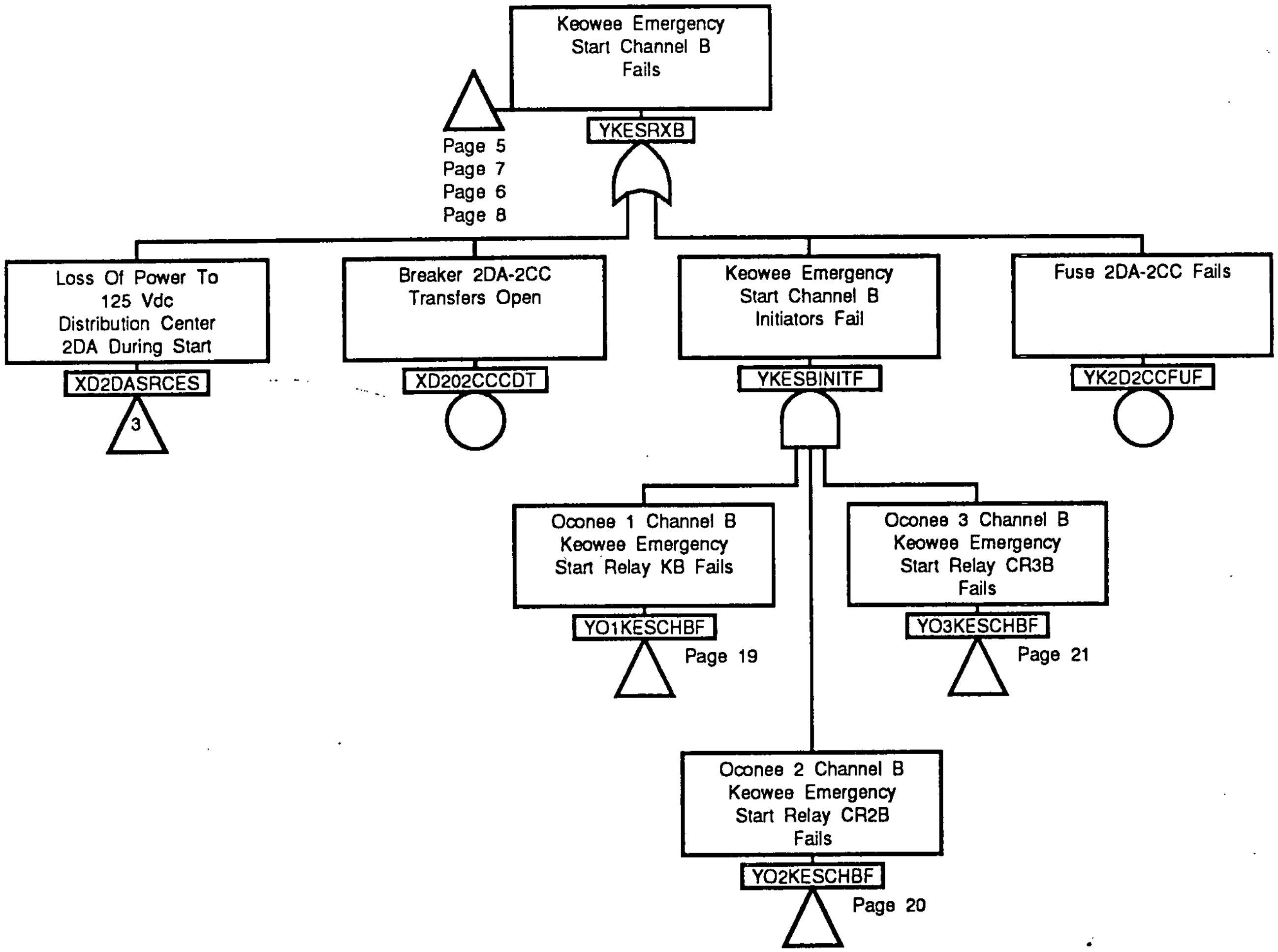
Keowee (Emergency) Start/Run Fault Tree

FIGURE A.5-2

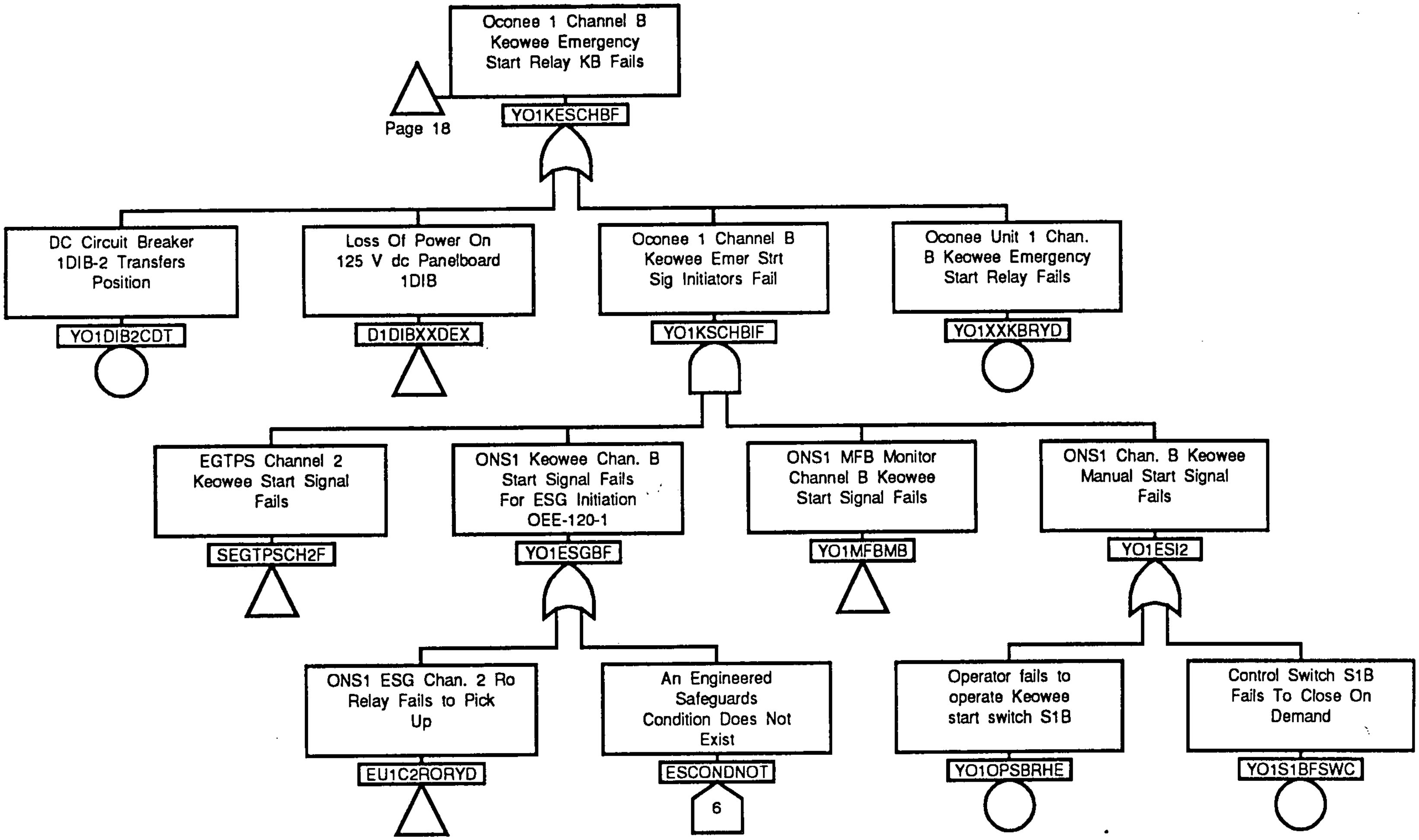


Oconee 2 Channel A Keowee Emergency Start Relay CR2A Fails
YO2KESCHAF
Page 14
Breaker 2DIA-2 Transfers Position
YO2DIA2CDT
Loss Of Power On 125 V dc Panelboard 2DIA
D2DIAXXDEX
Oconee 2 Channel A Keowee Emer Strt Sig Initiators Fail
YO2KSCHAIF
ONS2 Ch A Keowee Emergency Start Relay CR2A Fails to Pick Up
YO2CR2ARYD
ONS2 Local Locked Selector Switch 2SSW'A' Fails
YO2SSWAF
ONS2 MFB Monitor CH A Keowee Start Sig Fails
YO2MFBMA
Oconee 2 Channel 1 Engineered Safeguards Signal Fails
YO2ESGAF
Operator Fails to Operate Keowee Start Switch 2SSW'A'
YO2SSWARHE
Control Switch 2SSW'A' Fails To Close On Demand
YO2SSWASWC
ONS2 ESG Chan. 1 Ro Relay Fails to Pick Up
EU2C1RORYD
An Engineered Safeguards Condition Does Not Exist
ESCONDNOT
6

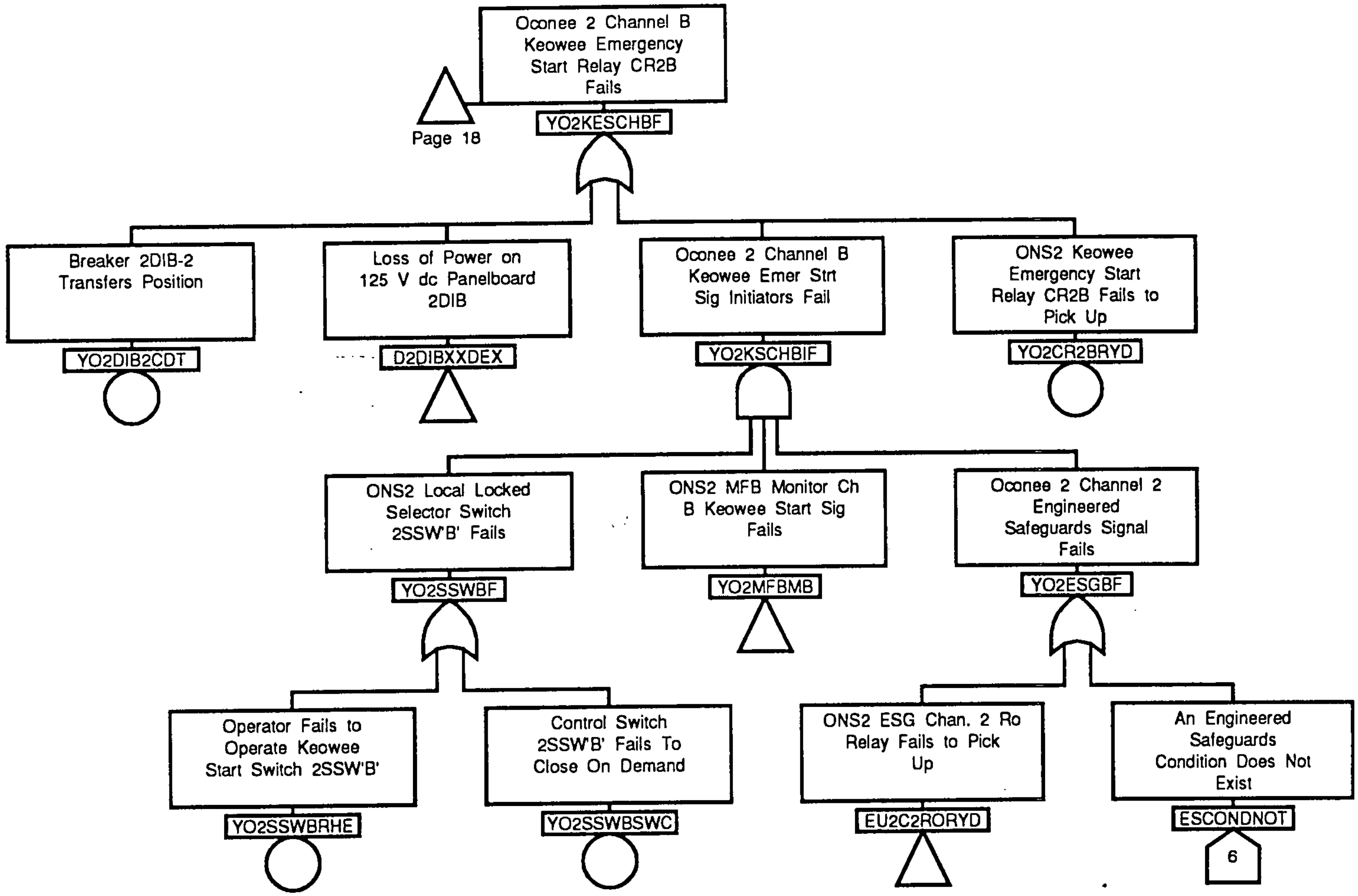

Oconee 3 Channel A Keowee Emergency Start Relay CR3A Fails
YO3KESCHAF
Page 14
Breaker 3DIA-2 Transfers Open-2705
YO3DIA2CDT
Loss Of Power On 125 V dc Panelboard 3DIA
D3DIAXXDEX
Oconee 3 Channel A Keowee Emer Strt Sig Initiators Fail
YO3KSCHAIF
ONS3 Ch A Keowee Emergency Start Relay CR3A Fails To Pick Up
YO3CR3ARYD
ONS3 Keowee Emer Start Sw S3A Fails
YO3S3A
ONS3 MFB Monitor Ch A Keowee Start Sig Fails
YO3MFBMA
Oconee 3 Channel A Engineered Safeguards Signal Fails
YO3ESGAF
ONS3 Cable Room Key Operated Switch 3SSW'A' Fails
YO3SSWAF
Operator fails to operate Keowee Start Switch 3S1A
YO3OPFARHE
Control Switch S1A Fails To Close On Demand
YO3S1AFSWC
ONS3 ESG Chan. 1 Ro Relay Fails to Pick Up
EU3C1RORYD
An Engineered Safeguards Condition Does Not Exist
ESCONDNOT
6
Operator fails to operate Keowee Start Switch 3SSW'A'
YO3SSWARHE
Control Switch 3SSW'A' Fails To Close On Demand
YO3SSWASWC



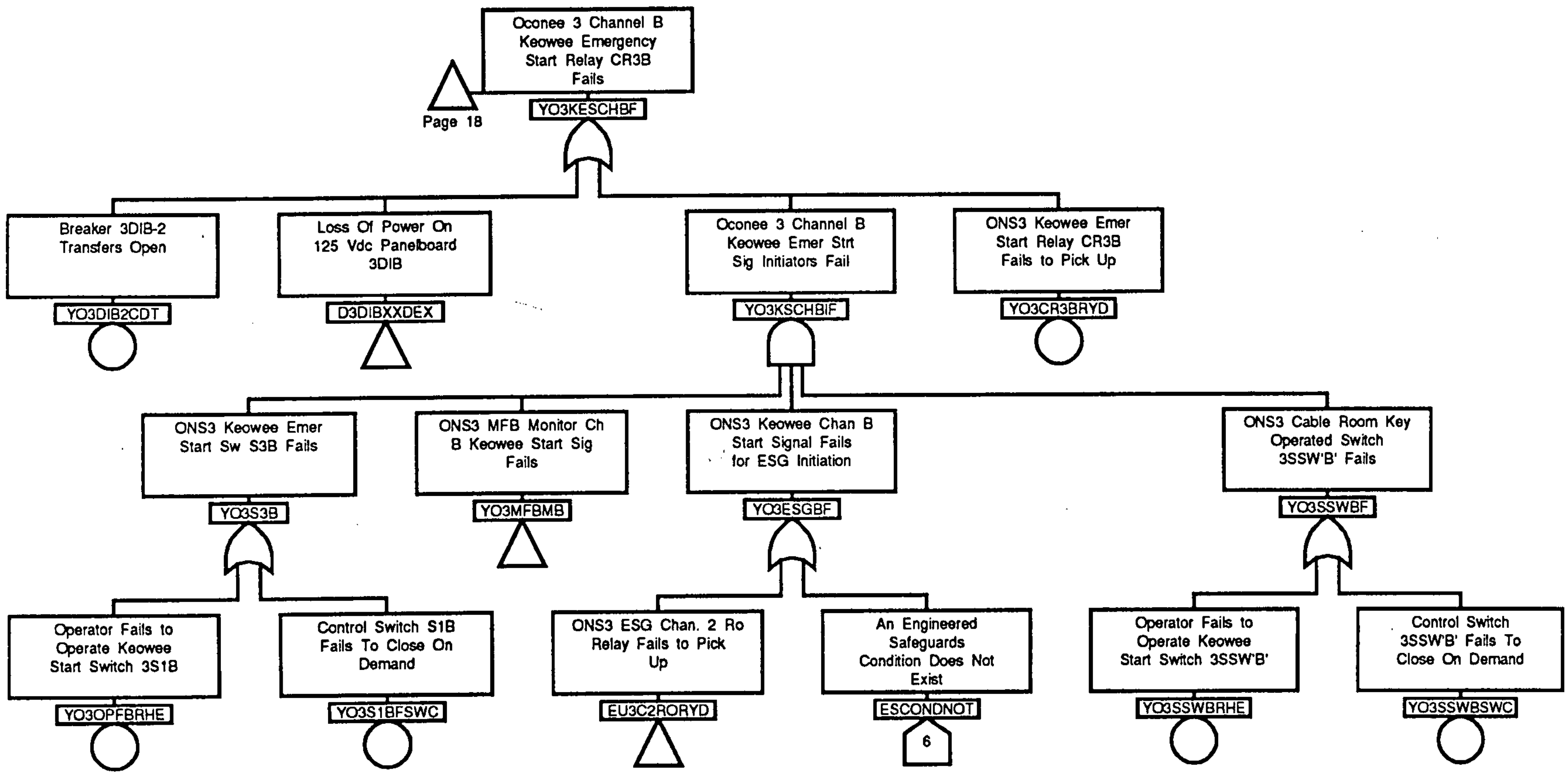
Keowee (Emergency) Start/Run Fault Tree | FIGURE A.5-2 |



Oconee 1 Channel B Keowee Emergency Start Relay KB Fails
YO1KESCHBF
Page 18
DC Circuit Breaker 1DIB-2 Transfers Position
YO1DIB2CDT
Loss Of Power On 125 V dc Panelboard 1DIB
D1DIBXXDEX
Oconee 1 Channel B Keowee Emer Strt Sig Initiators Fail
YO1KSCHBIF
Oconee Unit 1 Chan. B Keowee Emergency Start Relay Fails
YO1XXKBRYD
EGTPS Channel 2 Keowee Start Signal Fails
SEGTPSCH2F
ONS1 Keowee Chan. B Start Signal Fails For ESG Initiation OEE-120-1
YO1ESGBF
ONS1 MFB Monitor Channel B Keowee Start Signal Fails
YO1MFBMB
ONS1 Chan. B Keowee Manual Start Signal Fails
YO1ESI2
ONS1 ESG Chan. 2 Ro Relay Fails to Pick Up
EU1C2RORYD
An Engineered Safeguards Condition Does Not Exist
ESCONDNOT
6
Operator fails to operate Keowee start switch S1B
YO1OPSBRHE
Control Switch S1B Fails To Close On Demand
YO1S1BFSWC



Keowee (Emergency) Start/Run Fault Tree	FIGURE A.5-2	



Keowee (Emergency) Start/Run Fault Tree | FIGURE A.5-2 |

Gate/Event Name	Page	Zone	Gate/Event Name	Page	Zone	Gate/Event Name	Page	Zone	Gate/Event Name	Page	Zone
D1DIAXXDEX	15		XD2DASRCES	2		YK1LOPERMF	11		YK299SNRYD	4	
D1DIBXXDEX	19		XD2DASRCES	18		YK1LOPERMF	11		YK299SNRYD	4	
D2DIAXXDEX	16		YK114X3SSD	3		YK1MR4ARUN	11		YK299SNRYT	9	
D2DIBXXDEX	20		YK13SUISWT	11		YK1MR4ARUN	11		YK299SNSRT	4	
D3DIAXXDEX	17		YK13SUISWT	13		YK1MR4ARYD	3		YK299SXRYD	4	
D3DIBXXDEX	21		YK14AMRRYT	11		YK1MR4ASRT	3		YK299SXRYT	9	
ED13BR2CDT	9		YK14BMRRYT	13		YK1MR4BRUN	13		YK299SXSRT	4	
ED23BR2CDT	9		YK163BHLST	11		YK1OPFAIL	9		YK2CLDSRTF	1	
ESCONDNOT	15		YK163BHRYT	11		YK1OPFAIL	10		YK2CLDSTRT	1	
ESCONDNOT	16		YK163BLLST	11		YK1RUNCNTL	9		YK2D2CCFUF	18	
ESCONDNOT	17		YK163BLRYT	11		YK1S122RPM	3		YK2ES1ARYD	6	
ESCONDNOT	19		YK163TBLST	11		YK1SS12SST	11		YK2ES1BRYD	6	
ESCONDNOT	20		YK163TBRYT	11		YK1SS13SSD	3		YK2ES2ARYD	8	
ESCONDNOT	21		YK186N1DEX	10		YK1SS65RPM	3		YK2ES2BRYD	8	
EU1C1RORYD	15		YK199SDRYD	1		YK1STR2INT	3		YK2ESRX1A	6	
EU1C2RORYD	19		YK199SDRYT	9		YK1STR2INT	7		YK2ESRX1B	6	
EU2C1RORYD	16		YK199SNCF	1		YK1STRTINT	2		YK2ESRX2A	8	
EU2C2RORYD	20		YK199SNCF	3		YK1STRTINT	3		YK2ESRX2B	8	
EU3C1RORYD	17		YK199SNRYD	3		YK1STRTINT	5		YK2HOTSTRT	2	
EU3C2RORYD	21		YK199SNRYD	3		YK1SXRUNF	9		YK2LOPERMF	12	
GK186E1RYT	11		YK199SNRYD	3		YK1SXRUNF	11		YK2LOPERMF	12	
GK186E1RYT	13		YK199SNRYT	9		YK214X3SSD	4		YK2MR4ARUN	12	
GK286E2RYT	12		YK199SNSRT	3		YK23SUISWT	12		YK2MR4ARUN	12	
GK286E2RYT	13		YK199SXRYD	3		YK23SUISWT	13		YK2MR4ARYD	4	
SEGTPSCH1F	15		YK199SXRYT	9		YK24AMRRYT	12		YK2MR4ASRT	4	
SEGTPSCH2F	19		YK199SXSRT	3		YK24BMRRYT	13		YK2MR4BRUN	13	
XD104CCCDT	11		YK1CLDSRTF	1		YK263BHLST	12		YK2OPFAIL	9	
XD104CCCDT	13		YK1CLDSTRT	1		YK263BHRYT	12		YK2OPFAIL	10	
XD104CRCDT	14		YK1D4CRFUF	14		YK263BLLST	12		YK2RUNCNTL	9	
XD1DAR	9		YK1ES1ARYD	5		YK263BLRYT	12		YK2S122RPM	4	
XD1DASRCES	1		YK1ES1BRYD	5		YK263TBLST	12		YK2SS12SST	12	
XD1DASRCES	2		YK1ES2ARYD	7		YK263TBRYT	12		YK2SS13SSD	4	
XD1DASRCES	14		YK1ES2BRYD	7		YK286N2DEX	10		YK2SS65RPM	4	
XD202CCCDT	18		YK1ESRX1A	5		YK299SDRYD	1		YK2STR2INT	4	
XD204CCCDT	12		YK1ESRX1B	5		YK299SDRYT	9		YK2STR2INT	8	
XD204CCCDT	13		YK1ESRX2A	7		YK299SNCF	1		YK2STRTINT	2	
XD2DAR	9		YK1ESRX2B	7		YK299SNCF	4		YK2STRTINT	4	
XD2DASRCES	1		YK1HOTSTRT	2		YK299SNRYD	4		YK2STRTINT	6	

Gate/Event Name	Page	Zone
YK2SXRUNF	9	
YK2SXRUNF	12	
YKEMSRTCHE	10	
YKEMSRTCHE	10	
YKESAINITF	14	
YKESBINITF	18	
YKESRXA	5	
YKESRXA	6	
YKESRXA	7	
YKESRXA	8	
YKESRXA	14	
YKESRXB	5	
YKESRXB	6	
YKESRXB	7	
YKESRXB	8	
YKESRXB	18	
YO1DIA2CDT	15	
YO1DIB2CDT	19	
YO1ESGAF	15	
YO1ESGBF	19	
YO1ESI1	15	
YO1ESI2	19	
YO1KESCHAF	14	
YO1KESCHAF	15	
YO1KESCHBF	18	
YO1KESCHBF	19	
YO1KSCHAIF	15	
YO1KSCHBIF	19	
YO1MFBMA	15	
YO1MFBMB	19	
YO1OPSARHE	15	
YO1OPSBRHE	19	
YO1S1AFSWC	15	
YO1S1BFSWC	19	
YO1XXKARYD	15	
YO1XXKBRYD	19	
YO2CR2ARYD	16	
YO2CR2BRYD	20	
YO2DIA2CDT	16	
YO2DIB2CDT	20	
YO2ESGAF	16	
YO2ESGBF	20	
YO2KESCHAF	14	
YO2KESCHAF	16	
YO2KESCHBF	18	
YO2KESCHBF	20	
YO2KSCHAIF	16	
YO2KSCHBIF	20	
YO2MFBMA	16	
YO2MFBMB	20	
YO2SSWAF	16	
YO2SSWARHE	16	
YO2SSWASWC	16	
YO2SSWBF	20	
YO2SSWBRHE	20	
YO2SSWBSWC	20	
YO3CR3ARYD	17	
YO3CR3BRYD	21	
YO3DIA2CDT	17	
YO3DIB2CDT	21	
YO3ESGAF	17	
YO3ESGBF	21	
YO3KESCHAF	14	
YO3KESCHAF	17	
YO3KESCHBF	18	
YO3KESCHBF	21	
YO3KSCHAIF	17	
YO3KSCHBIF	21	
YO3MFBMA	17	
YO3MFBMB	21	
YO3OPFARHE	17	
YO3OPFBRHE	21	
YO3S1AFSWC	17	
YO3S1BFSWC	21	
YO3S3A	17	
YO3S3B	21	
YO3SSWAF	17	
YO3SSWARHE	17	
YO3SSWASWC	17	
YO3SSWBF	21	
YO3SSWBRHE	21	
YO3SSWBSWC	21	

Gate/Event Name Page Zone

APPENDIX A.6
GENERATOR EXCITATION

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A.6 GENERATOR EXCITATION

A.6.1 OBJECTIVES

The main objective of this analysis is to develop a logic model of the Generator Excitation system. This model is combined with the high-level model and remaining system models to form an integrated model for assessing the reliability of Keowee. Other objectives are to identify major contributors to component unreliability, significant potential human errors and common cause failure modes.

The scope of this analysis is limited to generator excitation equipment required to support a Keowee emergency start (no Keowee Auxiliary ac Power available) and run under load for the required mission.

A.6.2 SYSTEM DESIGN

A simplified diagram of the generator excitation subsystem is shown in Figure A.6-1. This subsystem consists primarily of three breakers (field, field flashing, and field supply) and the excitation cabinets containing the voltage and base adjust equipment.

Generator output voltage is regulated by applying a variable dc voltage to the generator field. Initial generator output is established by providing 125 V dc to the generator field from the station auxiliary dc power system. Once generator output is available, the generator output voltage is stepped down and rectified in order to maintain the required field necessary to assure proper generator output. The rectification and regulation is accomplished in the voltage regulator.

The voltage regulator consists of two primary subsystems, the base adjust and the voltage adjust. The base adjust provides a pre-set voltage to the field that is sufficient to establish the design output generator voltage, 13.8 kV. The voltage adjust provides the means to monitor the generator output and adjust the voltage applied to the field in order to maintain the design voltage over varying load conditions. The range of the voltage adjust is approximately ±10% of the rated output. The dc voltage to the field is controlled by varying the firing angle on the thyristors that rectify the output of the excitation transformer for use in generator excitation.

The setting of the base adjust is such that the Keowee output voltage is sufficient to supply power for the Oconee loads even if the voltage adjust subsystem fails to perform as designed.

A.6.2.1 GENERATOR FIELD BREAKER

The generator field breaker provides the connection to apply a dc voltage to the generator field. This dc voltage may be provided by one of two sources. The Keowee dc distribution center via the field flashing breaker, or from the voltage regulator cabinets. The field breaker closes on a start signal and remains closed as long as the generator is required.

A.6.2.2 GENERATOR FIELD FLASHING BREAKER

The generator field flashing breaker provides the connection to the excitation system from the Keowee auxiliary dc power system. The field flashing breaker closes on a generator start in order to provide the initial field voltage needed to establish generator output. Once the generator is able to supply itself, the field flashing breaker trips in order to prevent over-excitation of the generator or failure of the dc system.

A.6.2.3 GENERATOR FIELD SUPPLY BREAKER

The generator supply breaker provides the connection to the excitation system from the generator output. The generator output is supplied to the excitation transformer and from there to the regulator cabinets. This breaker closes on a generator start signal and remains closed as long as the generator is required.

A.6.2.4 BASE ADJUST

The base adjust provides a pre-set voltage to the field that is sufficient to establish the design output generator voltage, 13.8 kV. The setting of the base adjust is such that the Keowee output voltage is sufficient to supply power for the Oconee loads even if the voltage adjust subsystem fails to perform as designed.

A.6.2.5 VOLTAGE ADJUST

The voltage adjust provides the means to monitor the generator output and adjust the voltage applied to the field in order to maintain the design voltage over varying load conditions. The range of the voltage adjust is approximately ±10% of the rated output. The dc voltage to the field is controlled by varying the firing angle on the thyristors that rectify the output of the excitation transformer for use in generator excitation. Successful operation of the voltage adjust is not required in order to supply emergency power to Oconee.

A.6.3 SYSTEM BOUNDARIES

Electrical Power Supplies

Control and field flashing power is furnished from 125 V dc distribution centers 1DA (Unit 1) and 2DA (Unit 2). The power supplies for the modeled components are listed in Table A.6-1.

External Control Systems

All three (per unit) excitation breakers receive emergency start signals. The field breakers also receive a close permissive from the unit master relay 4A. The field and field flashing breakers also receive generator emergency lockout signals. The effect of these signals on breaker function is further described in Section A.6.4, Instrumentation and Controls. External controls are listed in Table A.6-2.

Other System Boundaries

The excitation transformer is connected to the generator output and thereby receives power for maintenance of the field voltage. The excitation system connects to the generator in order to supply the field voltage.

A.6.4 INSTRUMENTATION AND CONTROLS

A.6.4.1 EMERGENCY START RELAYS

The field, field flashing, and supply breakers all receive two trains of emergency start signals to close.

A.6.4.2 LOCKOUT RELAYS

Generator lockout auxiliary relay 86EX-1, one per unit, provides trip signals to the field and field flashing breakers on an emergency lockout following an emergency start. The normal lockout also trip the breakers on non-emergency starts.

A.6.4.3 INTERLOCKS WITH OTHER KEOWEE SYSTEMS/COMPONENTS

The generator field breaker is interlocked with of its respective overhead supply breaker, ACB-1 or ACB-2, such that the ACB can not close unless the generator field breaker is closed.

A.6.5 LOCATION WITHIN THE PLANT

The excitation system equipment is located within the Keowee powerhouse on the operating floor, elevation 702'.

A.6.6 NORMAL OPERATION

During a normal start, all three excitation breakers close. The field flashing breaker is controlled by a time delay relay and a voltage build-up relay which trip the breaker. The time delay is long enough for the system to establish generator output so that the field supply is self sustaining. Back-up is provided by the voltage adjust and by the voltage build-up relay to trip the breaker if trouble is sensed.

The supply and field breakers then remain closed as long as generator operation is required.

A.6.7 PERFORMANCE DURING KEOWEE EMERGENCY OPERATION

During an emergency start all three excitation breakers close on receipt of the emergency start signal. The field flashing breaker is controlled by a time delay relay which trips the breaker. This time delay is long enough for the system to establish generator output so that the field supply is self sustaining. Back-up is provided by the voltage adjust and by the voltage build-up relay to trip the breaker if trouble is sensed.

The supply and field breakers then remain closed as long as generator operation is required. The normal lockouts are bypassed during emergency operation.

A.6.8 TEST AND MAINTENANCE

Testing

The test procedures applicable to the generator excitation system are detailed in Table A.6-3.

Maintenance

The maintenance procedures applicable to the generator excitation system are detailed in Table A.6-4.

A.6.9 OPERATING EXPERIENCE

A summary of significant operating events is provided in Table A.6-5.

A.6.10 ASSUMPTIONS

A.6.10.1 SYSTEM DESIGN ASSUMPTIONS

1. The voltage adjust is not required to be operational for a successful emergency start and run. The base adjust portion of the voltage regulator is sufficient for the emergency load requirement.

2. The voltage build-up relay functions as a backup to the trip timer on the field flashing breaker. If the field flashing breaker fails to trip from the time delay, excessive volts at the generator output would be sensed for the corresponding frequency and result in actuation of the voltage build-up relay.

A.6.10.2 OPERATIONAL ASSUMPTIONS

1. The underground and overhead unit assignments are swapped at least every 30 days.

2. The overhead unit is operated daily and the underground unit is tested weekly.

A.6.10.3 MODELING ASSUMPTIONS

The following assumptions have been made in the development of the fault trees for the Excitation System.

1. The breaker failure type codes (CHO, CHT, CHC) are not included as they would be redundant to modeling the failures of the breaker component parts.

2. Having the Field Flashing Breaker remain closed at inappropriate times results in excitation failure.

3. The Voltage build-up Relay SV only has power available to it when the unit is generating. This should eliminate the potential for spurious operation prior to a unit start. This failure is not included in the field flashing breaker fails to close logic.

4. The Voltage build-up Relay SV provides a back-up to the 31/TD relay for tripping the Field Flashing Breaker (FFB). That is, should the 31/TD fail to trip the breaker, the generator voltage would exceed the allowed level at rated speed and an FFB trip signal would be generated by the SV relay.

5. Following generation from Keowee to the grid, a failure of the voltage adjust "as is" does not result in failure of that unit to supply Oconee. Voltages on the Oconee power system have been adequate prior to the loss of power and should continue to be adequate when power is restored from Keowee.

6. Transfer of the voltage adjust into auto is <u>not</u> required, since a base adjust setting of 13.8 kV provides adequate voltage to supply the Oconee loads.

7. The above assumptions preclude the need for a hot start failure of the excitation system.

8. The excitation cabinet fan failures are assumed to be dominated by the component failures that fail both the main and reserve fans. Independent failures of the main and reserve fans themselves to start or run are not included.

9. If a trip signal is present when a close signal is received a breaker will close and then trip immediately. This failure is included in the fail to close logic.

10. The excitation breakers have their dc control power monitored and alarmed. If the dc control power breaker were to transfer open this would be immediately known by the operators. Breaker spurious operation prior to the mission is not included in the fault tree.

A.6.11 FAULT TREE ANALYSIS

A.6.11.1 TOP EVENT SUCCESS CRITERIA

1. The Supply Breaker and Field Breaker should close and remain closed.

2. The Field Flashing Breaker should close, subsequently open and remain open.

A.6.11.2 DETAILED FAILURE CRITERIA

N/A

A.6.11.3 DESCRIPTION OF FAULT TREE

The Generator Excitation System fault tree is shown in Figure A.6-5. The Fault Tree Modeling Guidelines (Appendix B) were followed in developing the fault tree. A list of all fault tree top events is presented in Table A.6-8. A list of all fault tree transfers is presented in Table A.6-6.

There are four top events in the system fault tree. These are the failure to "cold start", and the failure to run, for each unit.

Failure events considered in the tree include breaker failures due to either mechanical or electrical problems. In general, data are available for electrical components, relays, switches, and fuses. These failures are modeled explicitly through the basic events involving failures of these components. The mechanical failures have been developed from the plant specific data collected on the Keowee breakers (Refer to Section A.6.11.5). These generally are modeled as undeveloped events in the fault trees.

The development of the tree provides for the analysis of the Keowee reliability following the implementation of NSM-ON-52966. Some branches of the tree only have an impact on the solution when the event defining the inclusion of this modification is set appropriately.

Human events impacting the model are described in Section A.6.11.4.

Common cause events impacting the model are described in Section A.6.11.6.

A.6.11.4 HUMAN INTERACTIONS

The success or failure of the Generator Excitation System to perform its function is impacted by several human actions. Those events explicitly included in the system fault tree are discussed below. Quantification of the human error events is presented in Section 5.5 and Appendix C.3.

<u>EKXYYYCLHE</u>
(X = unit number, YYY = breaker designator)

These basic events account for the potential for plant personnel to fail to properly restore the excitation breakers to a condition for proper closing. Post-maintenance testing is expected to detect the majority of errors. However, some errors may escape detection and fail the breaker.

EKXFLSOLHE
(X = unit number)

This basic event accounts for the potential for plant personnel to fail to properly restore the field flashing breaker to a condition for proper opening. Post-maintenance testing is expected to detect the majority of errors. However, some errors may escape detection and fail the breaker.

EKXBASELHE
(X = unit number)

This basic event accounts for the potential for the base adjust to be set incorrectly.

EKXBASEREC
(X = unit number)

The recovery events consider the potential for the operators to identify and correct an incorrect base adjust setting. Unit voltage is readily observable and the base adjust setting is changeable from the control room.. The recoveries are applied to the final cut sets and are not included in the tree.

A.6.11.5 RELIABILITY DATA

Reliability data used in the Generator Excitation System analysis are listed in Table A.6-9.

Section 5.3 and Appendix C.1 discuss development of the reliability data. For the base case solution, the plant-specific failure rate data and generic failure rate data are combined using a Bayesian update.

A.6.11.5.1 Exposure Times

Time dependent failures require an exposure time for determination of the failure probability. Failure times have been established based on the consideration of the time since the last test or operation of the component. Table A.6-9 contains a brief explanation of the rational used in determining the exposure time for each time dependent failure.

A.6.11.5.2 Undeveloped Events

The following undeveloped events are included in the generator excitation fault tree. Each of the three breakers (field, field flashing, and supply) are considered to be in a separate component population for quantifying the undeveloped events. The Unit 1 and Unit 2 breakers, performing the same function, are considered to be in the same population. The base and voltage adjust equipment are considered as separate component populations. As with the breakers the two units are combined within the population.

EK1SPYMDEX (EK2SPYMDEX): Keowee Unit 1(2) Supply Breaker Fails To Close Due To Mechanical Failure

The 9/16/93, 4/23/86, and 4/24/86 events, from Table A.6-5, are all failures of the supply breaker to close.

EK1SPYMDEX and EK2SPYMDEX are quantified by considering the three component failure to close in the population over the total demands for the population.

3/(Unit 1 starts + Unit 2 starts) = 4.62E-04/demand

With one breaker demand for the emergency operation of Keowee, EK1SPYMDEX = EK2SPYMDEX = 4.62E-04

EK1FLDMDEX (EK2FLDMDEX): Keowee Unit 1(2) Field Breaker Fails To Close Due To Mechanical Failure

No failures of the generator field breakers are found in the data of Table A.6-5.

EK1FLDMDEX and EK2FLDMDEX are quantified by considering one component failure to close in the population over twice the total demands for the population.

1/(2x(Unit 1 starts + Unit 2 starts)) = 7.71E-05/demand

With one breaker demand for the emergency operation of Keowee, EK1FLDMDEX = EK2FLDMDEX = 7.71E-05

EK1FLSMDEX (EK2FLSMDEX): Keowee Unit 1(2) Field Breaker Fails To Close Due To Mechanical Failure

No failures of the generator field flashing breakers are found in the data of Table A.6-5.

EK1FLSMDEX and EK2FLSMDEX are quantified by considering one component failure to close in the population over twice the total demands for the population.

1/(2x(Unit 1 starts + Unit 2 starts)) = 7.71E-05/demand

With one breaker demand for the emergency operation of Keowee, EK1FLSMDEX = EK2FLSMDEX = 7.71E-05

EK1BASEDEX (EK2BASEDEX): Keowee Unit 1(2) Base Adjust Fails To Establish Correct Unit Voltage

The 2/24/87, 3/27/90, 9/20/92, and 9/20/93 events, from Table A.6-5, are failures of the base adjust to set the correct voltage.

EK1BASEDEX and EK2BASEDEX are quantified by considering four component failure in the population over the total demands for the population.

4/(combined unit starts) = 6.17E-04/demand

With one demand for the emergency operation of Keowee, EK1BASEDEX = EK2BASEDEX = 6.17E-04

EK1BAS2DEX (EK2BAS2DEX): KHU-1(2) Base Adjust Fails To Maintain Generator Output Within Acceptable Range

There are no events, from Table A.6-5, that are failures of the base adjust to maintain correct voltage.

EK1BAS2DEX and EK2BAS2DEX are quantified by considering four component failure in the population over the total demands for the population.

1/(2x(combined unit run hours)) = 5.15E-05/hour

With a 24 hour mission for emergency operation of Keowee, EK1BAS2DEX = EK2BAS2DEX = 1.24E-03

EK1VREGDEX (EK2VREGDEX): KHU-1(2) Voltage Adjust Failure Drives Generator Output Too High/Low

The 5/4/93 event, from Table A.6-5, seem to be a failure where the voltage adjust drives the generator voltage outside the necessary range.

EK1VREGDEX and EK2VREGDEX are quantified by considering one component failure in the population over the total run hours for the population.

1/(2x(combined unit run hours)) = 1.03E-4/hour

With a 24 hour mission for emergency operation of Keowee, EK1VREGDEX = EK2VREGDEX = 2.47E-03

EK1DIODDEX (EK2DIODDEX): Keowee Unit 1(2) Exciter Fan Supply Diode Bridge Fails

The diode bridge is a group of 5 diodes. EK1DIODDEX and EK2DIODDEX are quantified by assuming a failure rate 5 times the diode failure rate from the data base.

5 x 2.4E-06/hour = 1.20E-05/hour

With a 24 hour mission for emergency operation of Keowee, EK1DIODDEX = EK2DIODDEX = 2.88E-04.

A.6.11.6 COMMON CAUSE ASSESSMENT

Refer to Section 5.4 and Appendix C.2 for detailed information on the quantification of the common cause events. All of the Excitation System common cause events are included in the high level logic model and not in the system fault tree.

E12EXCTCOM

This event considers the potential for both Keowee units to fail because the excitation breakers do not perform as required due to a common cause.

EKSTARTCOM

This event represents the potential for both Keowee units to fail to start due to common cause failure of the excitation systems.

EK00RUNCOM

This event represents the potential for both Keowee units to fail to run due to common cause failure of the excitation systems.

A.6.12 RESULTS

Tables A.6-10 through A.6 -13 lists the dominant minimal cut sets (failure sequences) for the Generator Excitation System top events. A list of dominant contributors to unavailability is given in Tables A.6-14 through A.6-17. The dominant contributors to the unavailability of the Generator Excitation System are the latent human errors and the undeveloped events.

A.6.13 REFERENCES

A.6.13.1 DOCUMENTS

1. OSS-0254.00-00-2005, Keowee Emergency Power Design Basis Document

2. EP-1020-19V, Westinghouse Instruction Manual - Vertical Waterwheel Generator

A.6.13.2 PROCEDURES

1. PT/0/A/0620/016, Keowee Hydro Emergency Start Test

2. PT/0/A/0620/016, Keowee Hydro Operation

3. OP/0/A/2000/013, Generator No. 1

4. OP/0/A/2000/041, Keowee Modes Of Operation

A.6.13.3 DRAWINGS

1. K-700 Rev. 9, One Line Diagram, Relays and Meters 13.8-230kV.

2. KEE-112, Rev. 7A, Keowee Hydro Station Unit No. 1, Elementary Diagram, Excitation System Generator Supply Breaker.

3. KEE-112-1, Rev. 6A, Keowee Hydro Station Unit No. 1, Elementary Diagram, Excitation System Generator Field Flashing Breaker.

4. KEE-112-2, Rev. 9, Keowee Hydro Station Unit No. 1, Elementary Diagram, Excitation System Generator Field Breaker.

5. KEE-112-3, Rev. 7, Keowee Hydro Station Unit No. 1, Elementary Diagram, Exciter Lockout And Fan Control.

6. KEE-112-4, Rev. 6, Keowee Hydro Station Unit No. 1, Elementary Diagram, Max. Excit. Pnl & M. O. Base Adj..

7. KEE-112-5, Rev. 6, Keowee Hydro Station Unit No. 1, Elementary Diagram, M. O. Auto Voltage Adjuster.

8. KEE-112-6, Rev. 6, Keowee Hydro Station Unit No. 1, Elementary Diagram, Regulator Controls.

9. KEE-112-7, Rev. 6, Keowee Hydro Station Unit No. 1, Elementary Diagram, Regulator Controls.

10. KEE-212, Rev. 6, Keowee Hydro Station Unit No. 1, Elementary Diagram, Excitation System Generator Supply Breaker.

11. KEE-212-1, Rev. 5, Keowee Hydro Station Unit No. 2, Elementary Diagram, Excitation System Generator Field Flashing Breaker.

12. KEE-212-2, Rev. 6, Keowee Hydro Station Unit No. 2, Elementary Diagram, Excitation System Generator Field Breaker.

13. KEE-212-3, Rev. 4, Keowee Hydro Station Unit No. 2, Elementary Diagram, Exciter Lockout And Fan Control.

14. KEE-212-4, Rev. 3, Keowee Hydro Station Unit No. 2, Elementary Diagram, Max. Excit. Pnl & M. O. Base Adj..

15. KEE-212-5, Rev. 4, Keowee Hydro Station Unit No. 2, Elementary Diagram, M. O. Auto Voltage Adjuster.

16. KEE-212-6, Rev. 4, Keowee Hydro Station Unit No. 2, Elementary Diagram, Regulator Controls.

17. KEE-212-7, Rev. 4, Keowee Hydro Station Unit No. 2, Elementary Diagram, Regulator Controls.

18. KEE-113, Rev. 8, Keowee Hydro Station Unit No. 1, Elementary Diagram, Master Control System Start-up Controls.

19. KEE-213, Rev. 8, Keowee Hydro Station Unit No. 2, Elementary Diagram, Master Control System Start-up Controls.

20. KEE-113-5, Rev. 8, Keowee Hydro Station Unit No. 1, Elementary Diagram, Master Control System Turbine Miscellaneous Relaying.

21. KEE-213,-5 Rev. 5, Keowee Hydro Station Unit No. 2, Elementary Diagram, Master Control System Turbine Miscellaneous Relaying.

22. KEE-114, Rev. 12, Keowee Hydro Station Unit No. 1, Elementary Diagram, Generator Control ACB-1 Control Circuit.

23. KEE-214, Rev. 9, Keowee Hydro Station Unit No. 2, Elementary Diagram, Generator Control ACB-2 Control Circuit.

24. KEE-114-3, Rev. 11, <u>Keowee Hydro Station Unit No. 1, Elementary Diagram, Generator Control Normal and Emergency Lockout</u>.

25. KEE-214-3, Rev. 8, <u>Keowee Hydro Station Unit No. 2, Elementary Diagram, Generator Control Normal and Emergency Lockout</u>.

Table A.6-1

Generator Excitation Power Supplies

Component	Power Supply[1]	Compartment Number
Generator Field Breaker (Unit 1)	125 V dc DC 1DA	4DR
Generator Field Flashing Breaker (Unit 1)	125 V dc DC 1DA	4DR
Generator Field Supply Breaker (Unit 1)	125 V dc DC 1DA	4DR
Generator Field Breaker (Unit 2)	125 V dc DC 2DA	
Generator Field Flashing Breaker (Unit 2)	125 V dc DC 2DA	
Generator Field Supply Breaker (Unit 2)	125 V dc DC 2DA	
Base Adjust (Unit 1)	125 V dc DC 1DA	4DR
Base Adjust (Unit 2)	125 V dc DC 2DA	
Field Flashing Supply (Unit 1)	125 V dc DC 1DA	3D
Field Flashing Supply (Unit 2)	125 V dc DC 2DA	2D

[1] DC = Distribution Center

Table A.6-2

Generator Excitation External Controls

Component	Signal
All Unit 1 Breakers	Emergency Start Relays 1ESRX/1A and 1ESRX/1B to Close
All Unit 2 Breakers	Emergency Start Relays 2ESRX/1A and 2ESRX/1B to Close
Unit 1 Master Relay 4A	Close Unit 1 Field Breaker
Unit 2 Master Relay 4A	Close Unit 2 Field Breaker

Table A.6-3

Generator Excitation Test Procedures

Procedure	Test Frequency	Description
PT/0/A/0620/016 Keowee Hydro Emergency Start Test	Periodic	Demonstrate the operability of each Keowee unit's emergency start circuitry from each control room.
PT/0/A/0620/016 Keowee Hydro Operation	Periodic	Periodically test the operation of the Keowee Hydro Units From The Oconee Control Room.

Table A.6-4

Generator Excitation Maintenance Procedures

Procedure	Maintenance Frequency	Description
OP/0/A/2000/013 Generator No. 1	As needed	Removal from service and restoration to service of Generator No. 1

Table A.6-5

Generator Excitation Significant Operating Events

Date	Unit	Component	Event Summary
2-24-87	2	Voltage Regulator	Unit 2 was started for system generation but it tripped due to no VARs. Keowee received a Hi Limit light on the Voltage Adjust. Found reset switch on the Base Adjust not running back to reset position.
3-27-90	1	Voltage Regulator	Started Unit 2 for system generation but unit would not start. Found problem to be due to the 70B cam switch not resetting to its preset position. This caused the 70BX relay to drop out.
9-20-92	2	Voltage Regulator	Unit 2 started from Keowee for system generation but voltage regulator did not come on. Unit 2 started in manual and paralled from Keowee. 70BX relay wasn't picked up so this stopped unit from starting.
9-20-93	1	Voltage Regulator	During Keowee Emer. Start test , unit 1 failed to reach rated voltage of 13.8 during test, only 13.3 KV. The base adjuster had failed and was replaced.
5-7-84	2	Voltage Regulator	Unit 2 started for system generation but received a Normal Lockout. The voltage regulator would not come on in auto (unit would run in manual). The cause of the problem was determined to be due to the Base Adjuster having a preset position (S3-S4) which gave a low no-load machine voltage (12.8kV instead of rated 13.8kV) which did not match the Volts Adjust setting of 13.8kV setting when the voltage reg. came on in auto. The mismatch caused a time delay greater than the Volts-Hertz time delay relay setting which shut down the unit. The Base Adjust was reset to 13.8kV and the unit started several times successfully.

Table A.6-5

Generator Excitation Significant Operating Events

Date	Unit	Component	Event Summary
5-22-89	2	Voltage Regulator	Started Unit 2 for system generation. After the unit paralled the operator could not get the VARs to come up. Received a #2 incomplete start statalarm and the unit tripped.
10-17-90	2	Voltage Regulator	Unit 2 started and paralleled but the Voltage Regulator did not come on.
10-18-90	2	Voltage Regulator	Started Unit 2 for system generation but the Voltage Regulator did not come on.
9-6-92	2	Voltage Regulator	Started Unit 2 for system generation but the Voltage Regulator failed to come on.
7-4-84	2	Voltage Regulator	Unit 2 started for system generation but received a Normal Lockout due to Regulator problems. The Voltage Regulator went into automatic before the generator was up to rated speed (ie. rated volts at less than rated frequency). This caused the V/Hz relay to operate which in time tripped the lockout after a time delay.
10-4-91	2	Voltage Regulator	Unit 2 started for system generation. Unit shut down by incomplete start.
4-12-93	2	Voltage Regulator #2 Field Flash Breaker	Unit 2 Keowee Alarm lockout due to Field Flash Breaker failure during startup for system generation. Closing coil had burned.
9-6-91	2	Voltage Regulator Field Breaker	Started Unit 2 for system generation. Field Breaker failed to close. Problem was due to the 99SY relay being open.

Table A.6-5

Generator Excitation Significant Operating Events

Date	Unit	Component	Event Summary
4-23-86	2	Voltage Regulator #2 Supply Breaker	At 1540 Oconee started Unit 2 to check operability, but ACB-2 failed to close. Started the unit from Keowee and observed that the Supply Breaker did not close.Upon inspection, the breaker did not appear to be jacked all the way in. The breaker had moved back in its slot enough to break contact.
4-24-86	2	Voltage Regulator #2 Supply Breaker	At 0649 Oconee attempted to start Unit 2 for system generation, but the Supply Breaker did not close. The unit was then started from Keowee. The Field breaker closed but the Supply Breaker failed to close. The next start attempt from Keowee was successful but the following attempt from Oconee was not. The problem was determined to be due to a corroded latch release plunger in the Generator Supply Breaker. This latch release plunger prevented the breaker from operating as expected.
9-16-93	1	Voltage Regulator #1 Field Supply Breaker	Keowee unit 1 failed to emergency start per PT/0A/0620/16 due to the Field Supply and Field Flashing breakers failing to close. The supply breaker did not close due to a'trip free' operation caused by a missing cotter pin in the pin that connects the close solenoid armature to the breaker toggle mechanism. As a result, the closing coil remained energized because the auxiliary contacts did not function to energize the y-relay to drop out the x-relay which de-energizes the close coil.

Table A.6-5

Generator Excitation Significant Operating Events

Date	Unit	Component	Event Summary
5-4-93	1	Voltage Regulator	Keowee unit 1 Voltage Regulator OOS. Unit 1 was shut down while generating to the grid due to VARs going in the hole. The unit did not respond to the Voltage Adjust or the Base Adjust controls.
5-28-86	1	Voltage Regulator Field Breaker	Oconee started Unit 1 for system generation but the Field Breaker did not close. The unit was started and ran in local / manual satisfactorily. Oconee performed an operability test on unit 1and it worked fine. No problem was identified.
2-6-88	1	Voltage Regulator Field Breaker	Started Unit 1 for system generation. The unitrolled off but excitation did not close. Abortedstart on #1. Started Unit 1 again and everythingworked okay.
3-15-88	1	Voltage Regulator Field Breaker	Started Unit 1 for system generation but theExcitation Breakers failed to close. Aborted start.Started, paralleled, placed Unit 1 on LFC. Unitstarted fine this start.
5-23-88	1	Voltage Regulator Field Breaker	When doing retest on Unit 1 the unit came on but the excitation supply did not close. The unit shutdown due to an incomplete sequence. Did anotherstart and the unit worked okay.
9-28-88	1	Voltage Regulator	Started Unit 1 for weekly PM. Unit would not start up. Shut down unit. Started unit and paralled. Shut down unit. Started Unit 1 but it did not parallel. Shut unit down. Unit 1 started, paralled, and on LFC.
6-3-91	2	Voltage Regulator	Unit 2 started for system generation but the Voltage Regulator failed to come on. Attempted a 2nd start and the regulator worked fine.

Table A.6-5

Generator Excitation Significant Operating Events

Date	Unit	Component	Event Summary
11-20-84	2	#2 Supply Breaker X Relay Coil	Oconee started Unit 2 for operability test to take Unit 1 out of service for annual PMG inspection but the #2 Supply Breaker failed to close. The breaker was removed and inspected but the cause of the problem was not found. Unit 2 was run several times successfully with no re-occurrence of the problem.
12-4-84	2	#2 Supply Breaker X Relay Coil	Oconee attempted an auto start of Unit 2 but the Supply Breaker failed to close. Replaced X-relay coil and adjusted mechanical linkage to relay. Tested breaker successfully 15 times.
7-28-87	1	#1 Supply Breaker X Relay	With both units shut down, the Keowee operator discovered that the unit 1 Supply Breaker closing coil was burning. Replaced closing coil and 41 AX relay (x relay).
2-9-89	1	#1 Field Supply Breaker X Relay	Oconee started Unit 1 to test the Overhead Path, but the Supply Breaker did not close. Problem was determined to be due to the X Relay sticking. Replaced relay and the worked fine.
2-12-90	1	#1 Field Breaker X Relay	Started Unit 1 for system generation but excitation breakers did not close. Problem was found to be due to X Relay coil sticking. Replaced X Relay unit tested satisfactorily.
12-26-90	1	Field Breaker (X-Relay)	Started Unit 1 for system generation but Generator Excitation Breakers did not close in. A 2nd start attempt was successful.
1-16-91	1	Field Breaker (X-Relay)	Started Unit 1 for weekly preventative maintenance but Generator Excitation Breakers did not close in. A 2nd start attempt was successful.
1-21-91	1	Field Breaker (X-Relay)	Oconee started Unit 1 for test but Generator Excitation Breakers did not close in. A 2nd start attempt was successful.

Table A.6-5

Generator Excitation Significant Operating Events

Date	Unit	Component	Event Summary
2-1-91	1	Field Breaker (X-Relay)	Started Unit 1 for system generation but Generator Excitation Breakers did not close in.A 2nd start attempt was successful.
3-31-91	1	Field Breaker (X-Relay)	Started Unit 1 for system generation but Generator Excitation Breakers did not close in.A 2nd start attempt was successful.
4-7-91	1	Field Breaker (X-Relay)	Started Unit 1 for system generation. The Field Supply Breaker did not close in. A 2nd startattempt was successful. Supply Breaker wasreplaced with spare breaker and both testedsatisfactorily. Cause of problem unknown.
5-31-91	1	Field Breaker (X-Relay)	Unit 1 started for system generation. Unit rolled off but the Supply, Field, and Field FlashingBreakers failed to close.
6-7-91	1	Field Breaker (X-Relay)	Started Unit 1 for system generation but excitation didn't close in. Immediately attemptedanother start and unit started and closed insatisfactorily.
6-11-91	1	#1 Field Supply Breaker X Relay	Oconee started Unit 1 for PT. The Field Supply Breaker failed to close. The problem was found to be due to the X Relay not resetting after thelast shutdown. Relay was reset and Unit 1 ran satisfactorily.
1-29-92	1	Field Supply Breaker (X -Relay)	Started Unit 1 for system generation but the generator excitation did not close in. Checked circuitry with no problems found. Restarted unitand everything worked as designed. Keowee operators to check that X-Coil has reset aftereach Unit 1 and Unit 2 shutdown.

Table A.6-5

Generator Excitation Significant Operating Events

Date	Unit	Component	Event Summary
2-13-92	1	Voltage Regulator Field Breaker X-Relay	After a normal shutdown of Unit 1 for system generation on 2/13/92, it was discovered that the Unit 1 Field Flashing Breaker X-Relay had not reset as designed. This made Unit 1 inoperable. Checking the X-Relay within 14 minutes after the occurrence revealed that the X-Relay coil had reset on its own. Unit 1 was operability tested satisfactorily.
2-20-92	1	Voltage Regulator Field Breaker X-Relay	After a normal shutdown of Unit 1 for system generation on 2/20/92, it was discovered that the Unit 1 Field Flashing Breaker X-Relay had not reset as designed. This made Unit 1 inoperable. Unit 1 was taken out of service to troubleshoot problem with X-Relay failing to reset. The Field Breaker was removed and cleaned and some burrs were removed from the X-Relay cylinder. Unit 1 was operability tested satisfactorily.
3-17-92	1	Voltage Regulator Field Breaker X-Relay	Replaced X-Relay on Unit 1 Field Breaker per procedure MP/0/A/2001/3 and per Gary Edens request. Relay installed failed during functional test. Failed relay was replaced by another relay and functionally tested satisfactorily.
5-1-92	1	Voltage Regulator Field Breaker X-Relay	After a normal shutdown of Unit 1 for system generation on 5/1/92, it was discovered that the Unit 1 Field Flashing Breaker X-Relay had not reset as designed. This made Unit 1 inoperable. Checking the X-Relay within 30 minutes after the occurrence revealed that the X-Relay coil had reset on its own. Unit 1 was operability tested satisfactorily.
6-12-92	1	Voltage Regulator Field Breaker X-Relay	After a normal shutdown of Unit 1 for system generation on 6/12/92, it was discovered that the Unit 1 Field Flashing Breaker X-Relay had not reset as designed. This made Unit 1 inoperable. The relay was manually reset and Unit 1 was operability tested satisfactorily.

Table A.6-6

Generator Excitation Fault Tree Transfers

Transfer Gate Name	Description	Components Supplied
YK1STRTINT	Keowee 1 Emergency Start Aux Relays 1ESRX/1A & 1ESRX/1B Fail	KU-1 Field Breaker
YK2STRTINT	Keowee 2 Emergency Start Aux Relays 2ESRX/1A & 2ESRX/1B Fail	KU-2 Field Breaker
XD1DASRCES	Loss of Power to 125 V dc Distribution Center 1DA During Start	All Unit 1 equipment
XD2DASRCES	Loss of Power to 125 V dc Distribution Center 2DA During Start	All Unit 2 equipment
GK186E1	Keowee Unit 1 Emergency Lock Out Due To Spurious Actuation Of Generator Protective Relay	KU-1 Field Breaker
GK286E2	Keowee Unit 2 Emergency Lock Out Due To Spurious Actuation Of Generator Protective Relay	KU-2 Field Breaker
YK1MR4ASRT	Keowee 1 Master Relay 4A Fails To Picks Up On Start	KU-1 Field Breaker
YK2MR4ASRT	Keowee 2 Master Relay 4A Fails To Picks Up On Start	KU-2 Field Breaker
NTACB4MOD	NSM-ON-52966 Is In Service	KU-1 and KU-2 Field Breakers

Table A.6-7

Generator Excitation Statalarms

Point No.	Alarm	Actuator
1SA2-31	GEN. #1 REGULATOR TRIP	94RB/1X
1SA2-33	GEN. #1 EXCITATION LOW	40X
1SA2-34	GEN. #1 MAX EXCITATION TIMING	76TX
1SA2-35	GEN. #1 MAX EXCITATION LIMITING	76LX
1SA2-36	GEN. #1 REG COOLING FAILURE	74F
1SA2-37	GEN. #1 VOLTS/CYCLE LIMITING	K1
1SA2-38	GEN. #1 REG. BLOWN FUSE ALARM	74B
1SA2-39	GEN. #1 EXCITATION RES FAN RUNNING	2BR
2SA2-31	GEN. #2 REGULATOR TRIP	94RB/1X
2SA2-33	GEN. #2 EXCITATION LOW	40X
2SA2-34	GEN. #2 MAX EXCITATION TIMING	76TX
2SA2-35	GEN. #2 MAX EXCITATION LIMITING	76LX
2SA2-36	GEN. #2 REG COOLING FAILURE	74F
2SA2-37	GEN. #2 VOLTS/CYCLE LIMITING	K1
2SA2-38	GEN. #2 REG. BLOWN FUSE ALARM	74B
2SA2-39	GEN. #2 EXCITATION RES FAN RUNNING	2BR

Table A.6-8

Generator Excitation Fault Tree Top Events

Gate Name	Description
KU1GEXCLD	Keowee Unit 1 Generator Excitation Fails During A Cold Start
KU1GEXRUN	Keowee Unit 1 Generator Excitation Fails While The Unit Runs
KU2GEXCLD	Keowee Unit 2 Generator Excitation Fails During A Cold Start
KU2GEXRUN	Keowee Unit 2 Generator Excitation Fails While The Unit Runs

Table A.6-9

Generator Excitation Reliability Data

Event Name	Description	Failure Rate [1]	Factor	Rational For Factor [2]	Failure Probability
ACB4MOD	NSM-ON-52966 Is Not In Service		0.5		5.00E-01
ED11D3DCDT	Breaker 3D In 125V dc Distribution Center 1DA Transfers Open	7.50E-08 /H	84 H	Rule 5: Would prevent field from flashing.	6.30E-06
ED13BR2CDT	Breaker 3BR In 125V dc Distribution Center 1DA Transfers Open	7.50E-08 /H	24 H	Rule 1 : Would result in field breaker trip.	1.80E-06
ED22D3DCDT	Breaker 2D In 125V dc Distribution Center 2DA Transfers Open	7.50E-08 /H	24 H	Rule 5: Would prevent field from flashing.	1.80E-06
ED23BR2CDT	Breaker 3BR In 125V dc Distribution Center 2DA Transfers Open	7.50E-08 /H	24 H	Rule 1 : Would result in field breaker trip.	1.80E-06
EK131TDRYD	Keowee Unit 1 Field Flashing Breaker Time Delay Relay 31/TD Fails To Operate	3.30E-05 /D	1 D	1 demand on unit start.	3.30E-05
EK131TDRYT	Keowee Unit 1 Field Flashing Breaker Time Delay Relay 31/TD Spurious Operation	3.60E-07 /H	84 H	Rule 5: Would prevent field flashing breaker from closing in and staying closed.	3.02E-05
EK14152SWT	KHU1 Generator Supply Breaker Trip Control Switch 141-52/T Spurious Operation	7.00E-08 /H	84 H	Rule 5: Failure prior to start would keep supply breaker from closing in and staying closed.	5.88E-06
EK1415TSWT	Spurious Operation Of The KHU1 Supply Breaker Trip Switch	7.00E-08 /H	24 H	Rule 1: Failure during mission fails run.	1.68E-06
EK1415YRYD	KHU1 Generator Supply Breaker Y-relay Failed To Drop-out At Last Operation	3.30E-05 /D	1 D	1 demand on unit start.	3.30E-05
EK1415YRYT	KHU1 Generator Supply Breaker Y-relay Spurious Operation	3.60E-07 /H	84 H	Rule 5: Failure prior to start would keep supply breaker from closing.	3.02E-05
EK141AXR6D	Keowee Unit 1 Relay 41/AX Fails To Pick-up And Latch	2.49E-04 /D	1 D	1 demand on unit start.	2.49E-04
EK141AXR6T	Keowee Unit 1 Relay 41/AX Spuriously Resets	3.63E-07 /H	24 H	Rule 1: Results in run failure.	8.71E-06
EK141CFRYD	Keowee Unit 1 Field Flashing Breaker Close Coil Fails To Operate On Demand	3.30E-05 /D	1 D	1 demand on unit start.	3.30E-05
EK186E2RYT	Keowee Unit 1 Lockout Auxiliary Relay 86EX-2 Is Picked-up	3.60E-07 /H	6 H	Rule 2: Indicated by computer point.	2.16E-06

1 D=Demand H=Hour

2 Rules for assigning basic event factors are discussed in Table C.1-4

Table A.6-9

Generator Excitation Reliability Data

Event Name	Description	Failure Rate [1]		Factor		Rational For Factor [2]	Failure Probability
EK186EXRYT	Keowee Unit 1 Gen Lockout Auxiliary Relay 86EX-1 Spurious Actuation	3.60E-07	/H	84	H	Rule 5: Would prevent field flashing breaker from closing in and staying closed.	3.02E-05
EK186X2RYT	Keowee Unit 1 Generator Lockout Auxiliary Relay 86EX-1 Spurious Actuation	3.60E-07	/H	24	H	Rule 1: Results in run failure.	8.64E-06
EK188SVRYD	Keowee Unit 1 Fan Control Relay 88SV Fails On Demand	3.30E-05	/D	1	D	1 demand on unit start.	3.30E-05
EK188SVRYT	Keowee Unit 1 Fan Control Relay 88SV Prior To Or During The Run	3.60E-07	/H	108	H	Rule 6: Excitation cabinet overheating fails run.	3.89E-05
EK1901ARYT	Keowee Unit 1 Relay 90X1A Spurious Operation	3.60E-07	/H	84	H	Rule 5: Failure prior to start would keep field flashing breaker from closing.	3.02E-05
EK199SXRYD	Auxiliary Relay 99SX1 Fails To Pick-up	3.30E-05	/D	1	D	1 demand on unit start.	3.30E-05
EK199SYRYD	Keowee Unit 1 Relay 99SY Fails To Pick-up	3.30E-05	/D	1	D	1 demand on unit start.	3.30E-05
EK199SYRYT	Keowee Unit 1 Relay 99SY Drops Out	3.60E-07	/H	24	H	Rule 1: Trips field breaker, fails unit run.	8.64E-06
EK1BAS2DEX	KHU-1 Base Adjust Fails To Maintain Generator Output Within Acceptable Range	1.24E-03					1.24E-03
EK1BASEDEX	Keowee Unit 1 Base Adjust Fails To Establish Correct Unit Voltage	6.17E-04					6.17E-04
EK1BASELHE	Keowee Unit 1 Base Adjust Is Set Incorrectly	3.20E-03					3.20E-03
EK1DIODDEX	Keowee Unit 1 Exciter Fan Supply Diode Bridge Fails	2.88E-04					2.88E-04
EK1EXC1TGF	Keowee Unit 1 Gen Excitation Transformer Is Failed	9.80E-07	/H	84	H	Rule 5: Failure prior to mission fails the unit start.	8.23E-05
EK1EXC2TGF	Keowee Unit 1 Generator Excitation Transformer Fails	9.80E-07	/H	24	H	Rule 1: Failure during the mission fails the unit run.	2.35E-05
EK1F30AFUF	Keowee Unit 1 Excitation Cabinet Fan Fuses Fail	3.60E-06	/H	24	H	Rule 1: Failure during the mission fails the unit run.	8.64E-05
EK1F31XRYD	Keowee Unit 1 Field Flashing Breaker Relay 31/X Fails To Pick-up On Demand	3.30E-05	/D	1	D	1 demand on unit start.	3.30E-05

1 D=Demand H=Hour

2 Rules for assigning basic event factors are discussed in Table C.1-4

Table A.6-9

Generator Excitation Reliability Data

Event Name	Description	Failure Rate [1]		Factor		Rational For Factor [2]	Failure Probability
EK1F41CRYD	Keowee Unit 1 Field Breaker Close Coil Fails To Operate On Demand	3.30E-05	/D	1	D	1 demand on unit start.	3.30E-05
EK1FAN1TLF	Keowee Unit 1 Generator Excitation Fan Power Transformer Fails	7.50E-07	/H	24	H	Rule 1: Fails the unit run due to overheating of the excitation cabinets.	1.80E-05
EK1FLDCLHE	Keowee Unit 1 Field Breaker Fails To Close Due To Latent Human Error			2.60E-04			2.60E-04
EK1FLDMDEX	Keowee Unit 1 Field Breaker Fails To Close Due To Mechanical Failure			7.71E-05			7.71E-05
EK1FLSCLHE	Keowee Unit 1 Field Flashing Breaker Fails To Close Due To Latent Human Error			2.60E-04			2.60E-04
EK1FLSMDEX	Keowee Unit 1 Field Flashing Breaker Fails To Close Due To Mechanical Failure			7.71E-05			7.71E-05
EK1FLSOLHE	Keowee Unit 1 Field Flashing Breaker Fails To Open Due To Latent Human Error			2.60E-04			2.60E-04
EK1R31TRYD	Keowee Unit 1 Field Flashing Breaker Trip Coil 31/T Fails To Operate	3.30E-05	/D	1	D	1 demand on unit start.	3.30E-05
EK1R31YRYD	KHU1 Gen Field Flashing Breaker Y-relay Failed To Drop Out At Last Operation	3.30E-05	/D	1	D	1 demand on unit start.	3.30E-05
EK1R31YRYT	KHU1 Generator Field Flashing Breaker Y-relay Spurious Operation	3.60E-07	/H	84	H	Rule 5: Fails unit start by preventing closure of the field flashing breaker.	3.02E-05
EK1R41XRYD	Keowee Unit 1 Field Breaker Relay 41/X Fails To Pick-up On Demand	3.30E-05	/D	1	D	1 demand on unit start.	3.30E-05
EK1R41YRYD	KHU1 Generator Field Breaker Y-relay Failed To Drop-out At Last Operation	3.30E-05	/D	1	D	1 demand on unit start.	3.30E-05
EK1R41YRYT	Keowee Unit 1 Generator Field Breaker Y-relay Spurious Operation	3.60E-07	/H	84	H	Rule 5: Fails unit start by preventing closure of the field breaker.	3.02E-05
EK1R9A1RYT	Keowee Unit 1 Relay 90X1A/TD	3.60E-07	/H	84	H	Rule 5: Fails unit start by	3.02E-05

1 D=Demand H=Hour

2 Rules for assigning basic event factors are discussed in Table C.1-4

Table A.6-9

Generator Excitation Reliability Data

Event Name	Description	Failure Rate [1]		Factor		Rational For Factor [2]	Failure Probability
	Spurious Operation					preventing closure of the field flashing breaker.	
EK1R9C1R6T	Keowee Unit 1 Relay 90X1C Spurious Operation	3.63E-07	/H	84	H	Rule 5: Fails unit start by preventing closure of the field flashing breaker.	3.05E-05
EK1S141SWT	KHU1 Field Breaker Trip Control Switch 141/T Spurious Operation	7.00E-08	/H	84	H	Rule 5: Fails unit start by preventing closure of the field breaker.	5.88E-06
EK1S31TSWT	KHU1 Field Flashing Breaker Trip Control Switch 131/T Spurious Operation	7.00E-08	/H	84	H	Rule 5: Fails unit start by preventing closure of the field flashing breaker.	5.88E-06
EK1S41CRYD	Keowee Unit 1 Supply Breaker Close Coil Fails To Operate On Demand	3.30E-05	/D	1	D	1 demand on unit start.	3.30E-05
EK1S41TSWT	Keowee Unit 1 Field Breaker Trip Control Switch Transfers Position	7.00E-08	/H	24	H	Rule 1: Causes field breaker to transfer open during the run.	1.68E-06
EK1S41XRYD	Keowee Unit 1 Supply Breaker Relay 41-52X Fails To Pick-up On Demand	3.30E-05	/D	1	D	1 demand on unit start.	3.30E-05
EK1SPYCLHE	Keowee Unit 1 Supply Breaker Fails To Close Due To Latent Human Error			2.60E-04			2.60E-04
EK1SPYMDEX	Keowee Unit 1 Supply Breaker Fails To Close Due To Mehanical Failure			4.62E-04			4.62E-04
EK1VHSVRYD	Keowee Unit 1 Voltage Build-up Relay Fails To Trip Field Flashing Breaker	3.30E-05	/D	1	D	1 demand on unit start.	3.30E-05
EK1VREGDEX	KHU-1 Voltage Adjust Failure Drives Generator Output Too High/Low			2.47E-03			2.47E-03
EK231TDRYD	Keowee Unit 2 Field Flashing Breaker Time Delay Relay 31/TD Fails To Operate	3.30E-05	/D	1	D	1 demand on unit start.	3.30E-05
EK231TDRYT	Keowee Unit 2 Field Flashing Breaker Time Delay Relay 31/TD Spurious Operation	3.60E-07	/H	12	H	Rule 5: Fails unit start by preventing closure of the field flashing breaker.	4.32E-06
EK24152SWT	KHU2 Generator Supply Breaker	7.00E-08	/H	12	H	Rule 5: Fails unit start by	8.40E-07

1 D=Demand H=Hour

2 Rules for assigning basic event factors are discussed in Table C.1-4

Table A.6-9

Generator Excitation Reliability Data

Event Name	Description	Failure Rate [1]		Factor		Rational For Factor [2]	Failure Probability
	Trip Control Switch Spurious Operation					preventing closure of the supply breaker.	
EK2415TSWT	Spurious Operation Of The KHU2 Supply Breaker Trip Switch	7.00E-08	/H	24	H	Rule 1: Fails unit run by causing the supply breaker to transfer open.	1.68E-06
EK2415YRYD	KHU2 Gen Supply Breaker Y-relay Failed To Drop-out At Last Operation	3.30E-05	/D	1	D	1 demand on unit start.	3.30E-05
EK2415YRYT	KHU2 Generator Supply Breaker Y-relay Spurious Operation	3.60E-07	/H	12	H	Rule 5: Fails unit start by preventing closure of the supply breaker.	4.32E-06
EK241AXR6D	Keowee Unit 2 Relay 41/AX Fails To Pick-up And Latch	2.49E-04	/D	1	D	1 demand on unit start.	2.49E-04
EK241AXR6T	Keowee Unit 2 Relay 41/AX Spuriously Resets	3.63E-07	/H	24	H	Rule 1: Fails unit run by causing the excitation cabinet fans to fail.	8.71E-06
EK241CFRYD	Keowee Unit 2 Field Flashing Breaker Close Coil Fails To Operat On Demand	3.30E-05	/D	1	D	1 demand on unit start.	3.30E-05
EK286E2RYT	Keowee Unit 2 Lockout Auxiliary Relay 86EX-2 Is Picked-up	3.60E-07	/H	6	H	Rule 2: Fails unit start by preventing closure of the supply breaker. Indicated by computer point.	2.16E-06
EK286EXRYT	Keowee Unit 2 Generator Lockout Auxiliary Relay 86EX-1 Spurious Actuation	3.60E-07	/H	12	H	Rule 5: Fails unit start by preventing closure of the field flashing breaker.	4.32E-06
EK286X2RYT	Keowee Unit 2 Generator Lockout Auxiliary Relay 86EX-1 Spurious Actuation	3.60E-07	/H	24	H	Rule 1: Fails the unit rin by tripping the supply breaker.	8.64E-06
EK288SVRYD	Keowee Unit 2 Fan Control Relay 88SV Fails On Demand	3.30E-05	/D	1	D	1 demand on unit start.	3.30E-05
EK288SVRYT	Keowee Unit 2 Fan Control Relay 88SV Prior To Or During The Run	3.60E-07	/H	36	H	Rule 6: Fails unit run by failing the excitation cabinet fans.	1.30E-05
EK2901ARYT	Keowee Unit 2 Relay 90X1A Spurious Operation	3.60E-07	/H	12	H	Rule 5: Fails unit start by preventing closure of the field flashing breaker.	4.32E-06
EK299SXRYD	Auxiliary Relay 99SX2 Fails To	3.30E-05	/D	1	D	1 demand on unit start.	3.30E-05

1 D=Demand H=Hour

2 Rules for assigning basic event factors are discussed in Table C.1-4

Table A.6-9

Generator Excitation Reliability Data

Event Name	Description	Failure Rate [1]		Factor		Rational For Factor [2]	Failure Probability
	Pick-up						
EK299SYRYD	Keowee Unit 2 Relay 99SY Fails To Pick-up	3.30E-05	/D	1	D	1 demand on unit start.	3.30E-05
EK299SYRYT	Keowee Unit 2 Relay 99SY Drops Out	3.60E-07	/H	24	H	Rule 1: Fails unit run by tripping the field breaker.	8.64E-06
EK2BAS2DEX	KHU-2 Base Adjust Fails To Maintain Generator Output Within Acceptable Range			1.24E-03			1.24E-03
EK2BASEDEX	Keowee Unit 2 Base Adjust Fails To Establish Correct Unit Voltage			6.17E-04			6.17E-04
EK2BASELHE	Keowee Unit 2 Base Adjust Is Set Incorrectly			3.20E-03			3.20E-03
EK2DIODDEX	Keowee Unit 2 Exciter Fan Supply Diode Bridge Fails			2.88E-04			2.88E-04
EK2EXC1TGF	Keowee Unit 2 Generator Excitation Transformer Is Failed	9.80E-07	/H	12	H	Rule 5: Fails the unit start by failing excitiation.	1.18E-05
EK2EXC2TGF	Keowee Unit 2 Generator Excitation Transformer Fails	9.80E-07	/H	24	H	Rule 5: Fails the unit run by failing excitiation.	2.35E-05
EK2F30AFUF	Keowee Unit 2 Excitation Cabinet Fan Fuses Fail	3.60E-06	/H	24	H	Rule 5: Fails the unit run by failing excitiation.	8.64E-05
EK2F31XRYD	Keowee Unit 2 Field Flashing Breaker Relay 31/X Fails To Pick-up On Demand	3.30E-05	/D	1	D	1 demand on unit start.	3.30E-05
EK2F41CRYD	Keowee Unit 2 Field Breaker Close Coil Fails To Operate On Demand	3.30E-05	/D	1	D	1 demand on unit start.	3.30E-05
EK2FAN1TLF	Keowee Unit 2 Generator Excitation Fan Power Transformer Fails	7.50E-07	/H	24	H	Rule 5: Fails the unit run by failing excitiation.	1.80E-05
EK2FLDCLHE	Keowee Unit 2 Field Breaker Fails To Close Due To Latent Human Error			2.60E-04			2.60E-04
EK2FLDMDEX	Keowee Unit 2 Field Breaker Fails To Close Due To Mechanical Failure			7.71E-05			7.71E-05
EK2FLSCLHE	Keowee Unit 2 Field Flashing Breaker Fails To Close Due To Latent Human Error			2.60E-04			2.60E-04

1 D=Demand H=Hour

2 Rules for assigning basic event factors are discussed in Table C.1-4

Table A.6-9

Generator Excitation Reliability Data

Event Name	Description	Failure Rate [1]	Factor	Rational For Factor [2]	Failure Probability
EK2FLSMDEX	Keowee Unit 2 Field Flashing Breaker Fails To Close Due To Mechanical Failure		7.71E-05		7.71E-05
EK2FLSOLHE	Keowee Unit 2 Field Flashing Breaker Fails To Open Due To Latent Human Error		2.60E-04		2.60E-04
EK2R31TRYD	Keowee Unit 2 Field Flashing Breaker Trip Coil 31/T Fails To Operate	3.30E-05 /D	1 D	1 demand on unit start.	3.30E-05
EK2R31YRYD	KHU2 Gen Field Flashing Breaker Y-relay Failed To Drop At Last Operation	3.30E-05 /D	1 D	1 demand on unit start.	3.30E-05
EK2R31YRYT	KHU2 Generator Field Flashing Breaker Y-relay Spurious Operation	3.60E-07 /H	12 H	Rule 5: Operation prior to start signal prevents closure of the field flashing breaker.	4.32E-06
EK2R41XRYD	Keowee Unit 2 Field Breaker Relay 41/X Fails To Pick-up On Demand	3.30E-05 /D	1 D	1 demand on unit start.	3.30E-05
EK2R41YRYD	KHU2 Generator Field Breaker Y-relay Failed To Drop-out At Last Operation	3.30E-05 /D	1 D	1 demand on unit start.	3.30E-05
EK2R41YRYT	KHU2 Generator Field Breaker Y-relay Spurious Operation	3.60E-07 /H	12 H	Rule 5: Operation prior to start signal prevents closure of the field breaker.	4.32E-06
EK2R9A2RYT	Keowee Unit 2 Relay 90X1A/TD Spurious Operation	3.60E-07 /H	12 H	Rule 5: Operation prior to start signal prevents closure of the field flashing breaker.	4.32E-06
EK2R9C2R6T	Keowee Unit 2 Relay 90X1C Spurious Operation	3.63E-07 /H	12 H	Rule 5: Operation prior to start signal prevents closure of the field flashing breaker.	4.36E-06
EK2S141SWT	KHU2 Field Breaker Trip Control Switch Spurious Operation	7.00E-08 /H	12 H	Rule 5: Operation prior to start signal prevents closure of the field breaker.	8.40E-07
EK2S31TSWT	KHU2 Field Flashing Breaker Trip Control Switch 131/T Spurious Operation	7.00E-08 /H	12 H	Rule 5: Operation prior to start signal prevents closure of the field flashing breaker.	8.40E-07
EK2S41CRYD	Keowee Unit 2 Supply Breaker Close Coil Fails To Operate On Demand	3.30E-05 /D	1 D	1 demand on unit start.	3.30E-05

1 D=Demand H=Hour

2 Rules for assigning basic event factors are discussed in Table C.1-4

Table A.6-9

Generator Excitation Reliability Data

Event Name	Description	Failure Rate [1]		Factor		Rational For Factor [2]	Failure Probability
EK2S41TSWT	Keowee Unit 2 Field Breaker Trip Control Switch Transfers Position	7.00E-08	/H	24	H	Rule 1: Fails unit by tripping the field breaker.	1.68E-06
EK2S41XRYD	Keowee Unit 2 Supply Breaker Relay 41-52X Fails To Pick-up On Demand	3.30E-05	/D	1	D	1 demand on unit start.	3.30E-05
EK2SPYCLHE	Keowee Unit 2 Supply Breaker Fails To Close Due To Latent Human Error			2.60E-04			2.60E-04
EK2SPYMDEX	Keowee Unit 2 Supply Breaker Fails To Close Due To Mehanical Failure			4.62E-04			4.62E-04
EK2VHSVRYD	Keowee Unit 2 Voltage Build-up Relay Fails To Trip Field Flashing Breaker	3.30E-05	/D	1	D		3.30E-05
EK2VREGDEX	KHU-2 Voltage Adjust Failure Drives Generator Output Too High/Low			2.47E-03			2.47E-03
GK186E1	Keowee Unit 1 Emergency Lockout Due To Actuation Of Generator Protective Relay			0			0.00E+00
GK286E2	Keowee Unit 2 Emergency Lockout Due To Spurious Actuation Of Gen Protect Relay			0			0.00E+00
XD1DASRCES	Loss Of Power To 125V dc Distribution Center 1DA During Start			0			0.00E+00
XD2DASRCES	Loss Of Power To 125 Vdc Distribution Center 2DA During Start			0			0.00E+00
YK1MR4ASRT	Keowee 1 Master Relay 4A Fails to Pick Up On Start			0			0.00E+00
YK1STR2INT	Keowee 1 Emergency Start Aux Relays 1ESRX/2A & 1ESRX/2B Fail			0			0.00E+00
YK1STRTINT	Keowee 1 Emergency Start Aux Relays 1ESRX/1A & 1ESRX/1B Fail			0			0.00E+00
YK2MR4ASRT	Keowee 2 Master Relay 4A Fails to Pick Up On Start			0			0.00E+00
YK2STR2INT	Keowee 2 Emergency Start Aux			0			0.00E+00

1 D=Demand H=Hour

2 Rules for assigning basic event factors are discussed in Table C.1-4

Table A.6-9

Generator Excitation Reliability Data

Event Name	Description	Failure Rate [1]	Factor	Rational For Factor [2]	Failure Probability
YK2STRTINT	Relays 2ESRX/2A & 2ESRX/2B Fail Keowee 2 Emergency Start Aux Relays 2ESRX/1A & 2ESRX/1B Fail		0		0.00E+00

1 D=Demand H=Hour

2 Rules for assigning basic event factors are discussed in Table C.1-4

Table A.6-10

Generator Excitation Dominant Minimal Cut Sets

Cut Sets for Gate KU1GEXRUN: Keowee Unit 1 Fails To Cold Start

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
1)	3.20E-03	49.8%	EK1BASELHE	3.20E-03	Keowee Unit 1 Base Adjust Is Set Incorrectly
2)	6.17E-04	9.6%	EK1BASEDEX	6.17E-04	Keowee Unit 1 Base Adjust Fails To Establish Correct Unit Voltage
3)	4.62E-04	7.2%	EK1SPYMDEX	4.62E-04	Keowee Unit 1 Supply Breaker Fails To Close Due To Mechanical Failure
4)	2.60E-04	4.0%	EK1FLDCLHE	2.60E-04	Keowee Unit 1 Field Breaker Fails To Close Due To Latent Human Error
5)	2.60E-04	4.0%	EK1FLSCLHE	2.60E-04	Keowee Unit 1 Field Flashing Breaker Fails To Close Due To Latent Human Error
6)	2.60E-04	4.0%	EK1FLSOLHE	2.60E-04	Keowee Unit 1 Field Flashing Breaker Fails To Open Due To Latent Human Error
7)	2.60E-04	4.0%	EK1SPYCLHE	2.60E-04	Keowee Unit 1 Supply Breaker Fails To Close Due To Latent Human Error
8)	2.49E-04	3.9%	EK141AXR6D	2.49E-04	Keowee Unit 1 Relay 41/AX Fails To Pick-up And Latch
9)	8.23E-05	1.3%	EK1EXC1TGF	8.23E-05	Keowee Unit 1 Gen Excitation Transformer Is Failed
10)	7.71E-05	1.2%	EK1FLDMDEX	7.71E-05	Keowee Unit 1 Field Breaker Fails To Close Due To Mechanical Failure
11)	7.71E-05	1.2%	EK1FLSMDEX	7.71E-05	Keowee Unit 1 Field Flashing Breaker Fails To Close Due To Mechanical Failure

Total Event Probability = 6.42E-03

Table A.6-11

Generator Excitation Dominant Minimal Cut Sets

Cut Sets for Gate KU1GEXRUN: Keowee Unit 1 Fails While Unit Runs

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
1)	2.47E-03	55.3%	EK1VREGDEX	2.47E-03	KHU-1 Voltage Adjust Failure Drives Generator Output Too High/Low
2)	1.24E-03	27.7%	EK1BAS2DEX	1.24E-03	KHU-1 Base Adjust Fails To Maintain Generator Output Within Acceptable Range
3)	2.88E-04	6.4%	EK1DIODDEX	2.88E-04	Keowee Unit 1 Exciter Fan Supply Diode Bridge Fails
4)	2.49E-04	5.6%	EK141AXR6D	2.49E-04	Keowee Unit 1 Relay 41/AX Fails To Pick-up And Latch
5)	8.64E-05	1.9%	EK1F30AFUF	8.64E-05	Keowee Unit 1 Excitation Cabinet Fan Fuses Fail
6)	3.89E-05	0.9%	EK188SVRYT	3.89E-05	Keowee Unit 1 Fan Control Relay 88SV Prior To Or During The Run
7)	3.30E-05	0.7%	EK188SVRYD	3.30E-05	Keowee Unit 1 Fan Control Relay 88SV Fails On Demand
8)	2.35E-05	0.5%	EK1EXC2TGF	2.35E-05	Keowee Unit 1 Generator Excitation Transformer Fails
9)	1.80E-05	0.4%	EK1FAN1TLF	1.80E-05	Keowee Unit 1 Generator Excitation Fan Power Transformer Fails
10)	8.71E-06	0.2%	EK141AXR6T	8.71E-06	Keowee Unit 1 Relay 41/AX Spuriously Resets
11)	8.64E-06	0.2%	EK186X2RYT	8.64E-06	Keowee Unit 1 Generator Lockout Auxiliary Relay 86EX-1 Spurious Actuation
12)	8.64E-06	0.2%	EK199SYRYT	8.64E-06	Keowee Unit 1 Relay 99SY Drops Out

Total Event Probability = 4.47E-03

Table A.6-12

Generator Excitation Dominant Minimal Cut Sets

Cut Sets for Gate KU2GEXCLD: Keowee Unit 2 Fails To Cold Start

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
1)	3.20E-03	52.3%	EK2BASELHE	3.20E-03	Keowee Unit 2 Base Adjust Is Set Incorrectly
2)	6.17E-04	10.1%	EK2BASEDEX	6.17E-04	Keowee Unit 2 Base Adjust Fails To Establish Correct Unit Voltage
3)	4.62E-04	7.5%	EK2SPYMDEX	4.62E-04	Keowee Unit 2 Supply Breaker Fails To Close Due To Mechanical Failure
4)	2.60E-04	4.2%	EK2FLDCLHE	2.60E-04	Keowee Unit 2 Field Breaker Fails To Close Due To Latent Human Error
5)	2.60E-04	4.2%	EK2FLSCLHE	2.60E-04	Keowee Unit 2 Field Flashing Breaker Fails To Close Due To Latent Human Error
6)	2.60E-04	4.2%	EK2FLSOLHE	2.60E-04	Keowee Unit 2 Field Flashing Breaker Fails To Open Due To Latent Human Error
7)	2.60E-04	4.2%	EK2SPYCLHE	2.60E-04	Keowee Unit 2 Supply Breaker Fails To Close Due To Latent Human Error
8)	2.49E-04	4.1%	EK241AXR6D	2.49E-04	Keowee Unit 2 Relay 41/AX Fails To Pick-up And Latch
9)	7.71E-05	1.3%	EK2FLDMDEX	7.71E-05	Keowee Unit 2 Field Breaker Fails To Close Due To Mechanical Failure
10)	7.71E-05	1.3%	EK2FLSMDEX	7.71E-05	Keowee Unit 2 Field Flashing Breaker Fails To Close Due To Mechanical Failure

Total Event Probability = 6.12E-03

Table A.6-13

Generator Excitation Dominant Minimal Cut Sets

Cut Sets for Gate KU2GEXRUN: Keowee Unit 2 Fails While Unit Runs

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
1)	2.47E-03	55.5%	EK2VREGDEX	2.47E-03	KHU-2 Voltage Adjust Failure Drives Generator Output Too High/Low
2)	1.24E-03	27.9%	EK2BAS2DEX	1.24E-03	KHU-2 Base Adjust Fails To Maintain Generator Output Within Acceptable
3)	2.88E-04	6.5%	EK2DIODDEX	2.88E-04	Keowee Unit 2 Exciter Fan Supply Diode Bridge Fails
4)	2.49E-04	5.6%	EK241AXR6D	2.49E-04	Keowee Unit 2 Relay 41/AX Fails To Pick-up And Latch
5)	8.64E-05	1.9%	EK2F30AFUF	8.64E-05	Keowee Unit 2 Excitation Cabinet Fan Fuses Fail
6)	3.30E-05	0.7%	EK288SVRYD	3.30E-05	Keowee Unit 2 Fan Control Relay 88SV Fails On Demand
7)	2.35E-05	0.5%	EK2EXC2TGF	2.35E-05	Keowee Unit 2 Generator Excitation Transformer Fails
8)	1.80E-05	0.4%	EK2FAN1TLF	1.80E-05	Keowee Unit 2 Generator Excitation Fan Power Transformer Fails
9)	1.30E-05	0.3%	EK288SVRYT	1.30E-05	Keowee Unit 2 Fan Control Relay 88SV Prior To Or During The Run
10)	8.71E-06	0.2%	EK241AXR6T	8.71E-06	Keowee Unit 2 Relay 41/AX Spuriously Resets
11)	8.64E-06	0.2%	EK286X2RYT	8.64E-06	Keowee Unit 2 Generator Lockout Auxiliary Relay 86EX-1 Spurious Actuation
12)	8.64E-06	0.2%	EK299SYRYT	8.64E-06	Keowee Unit 2 Relay 99SY Drops Out
13)	1.80E-06	0.0%	ED23BR2CDT	1.80E-06	Breaker 3BR In 125V dc Distribution Center 2DA Transfers Open
14)	1.68E-06	0.0%	EK2S41TSWT	1.68E-06	Keowee Unit 2 Field Breaker Trip Control Switch Transfers Position
15)	1.68E-06	0.0%	EK2415TSWT	1.68E-06	Spurious Operation Of The KHU2 Supply Breaker Trip Switch

Total Event Probability = 4.45E-04

Table A.6-14

Generator Excitation Dominant Contributors To Unavailability

Rank	Event Description	Mean Unavailability[1]	Approximate Unavailability Contribution[2]
	Keowee Unit 1 Generator Excitation Fails To Cold Start		
1	EK1BASELHE Keowee Unit 1 Base Adjust Is Set Incorrectly	3.19E-03	49.7%
2	EK1BASEDEX Keowee Unit 1 Base Adjust Fails To Establish Correct Unit Voltage	6.13E-04	9.6%
3	EK1SPYMDEX Keowee Unit 1 Supply Breaker Fails To Close Due To Mechanical Failure	4.59E-04	7.2%
4	EK1FLSOLHE Keowee Unit 1 Field Flashing Breaker Fails To Open Due To Latent Human Error	2.58E-04	4.0%
5	EK1FLSCLHE Keowee Unit 1 Field Flashing Breaker Fails To Close Due To Latent Human Error	2.58E-04	4.0%
6	EK1FLDCLHE Keowee Unit 1 Field Breaker Fails To Close Due To Latent Human Error	2.58E-04	4.0%
7	EK1SPYCLHE Keowee Unit 1 Supply Breaker Fails To Close Due To Latent Human Error	2.58E-04	4.0%
8	EK141AXR6D Keowee Unit 1 Relay 41/AX Fails To Pick-up And Latch	2.47E-04	3.9%

[1] The mean unavailability is the summation of the values of all cut sets in which the event appears

[2] The contribution to unavailability is calculated by dividing the mean unavailability by the overall system unavailability and then multiplying by 100 percent

Table A.6-15

Generator Excitation Dominant Contributors To Unavailability

Rank	Event Description	Mean Unavailability[1]	Approximate Unavailability Contribution[2]
	Keowee Unit 1 Generator Excitation Fails While Unit Runs		
1	EK1VREGDEX KHU-1 Voltage Adjust Failure Drives Generator Output Too High/Low	2.46E-03	55.1%
2	EK1BAS2DEX KHU-1 Base Adjust Fails To Maintain Generator Output Within Acceptable Range	1.23E-03	27.6%
3	EK1DIODDEX Keowee Unit 1 Exciter Fan Supply Diode Bridge Fails	2.87E-04	6.4%
4	EK141AXR6D Keowee Unit 1 Relay 41/AX Fails To Pick-up And Latch	2.48E-04	5.5%
5	EK1F30AFUF Keowee Unit 1 Excitation Cabinet Fan Fuses Fail	8.58E-05	1.9%

[1] The mean unavailability is the summation of the values of all cut sets in which the event appears

[2] The contribution to unavailability is calculated by dividing the mean unavailability by the overall system unavailability and then multiplying by 100 percent

Table A.6-16

Generator Excitation Dominant Contributors To Unavailability

Rank	Event Description	Mean Unavailability[1]	Approximate Unavailability Contribution[2]
Keowee Unit 2 Generator Excitation Fails To Cold Start			
1	EK2BASELHE Keowee Unit 2 Base Adjust Is Set Incorrectly	3.19E-03	52.1%
2	EK2BASEDEX Keowee Unit 2 Base Adjust Fails To Establish Correct Unit Voltage	6.12E-04	10.0%
3	EK2SPYMDEX Keowee Unit 2 Supply Breaker Fails To Close Due To Mechanical Failure	4.59E-04	7.5%
4	EK2FLDCLHE Keowee Unit 2 Field Breaker Fails To Close Due To Latent Human Error	2.58E-04	4.2%
5	EK2SPYCLHE Keowee Unit 2 Supply Breaker Fails To Close Due To Latent Human Error	2.58E-04	4.2%
6	EK2FLSOLHE Keowee Unit 2 Field Flashing Breaker Fails To Open Due To Latent Human E	2.58E-04	4.2%
7	EK2FLSCLHE Keowee Unit 2 Field Flashing Breaker Fails To Close Due To Latent Human	2.58E-04	4.2%
8	EK241AXR6D Keowee Unit 2 Relay 41/AX Fails To Pick-up And Latch	2.47E-04	4.0%
9	EK2FLSMDEX Keowee Unit 2 Field Flashing Breaker Fails To Close Due To Mechanical Failure	7.65E-05	1.3%
10	EK2FLDMDEX Keowee Unit 2 Field Breaker Fails To Close Due To Mechanical Failure	7.65E-05	1.3%

[1] The mean unavailability is the summation of the values of all cut sets in which the event appears

[2] The contribution to unavailability is calculated by dividing the mean unavailability by the overall system unavailability and then multiplying by 100 percent

Table A.6-17

Generator Excitation Dominant Contributors To Unavailability

Rank	Event Description	Mean Unavailability[1]	Approximate Unavailability Contribution[2]
Keowee Unit 2 Generator Excitation Fails While Unit Runs			
1	EK2VREGDEX KHU-2 Voltage Adjust Failure Drives Generator Output Too High/Low	2.47E-03	55.4%
2	EK2BAS2DEX KHU-2 Base Adjust Fails To Maintain Generator Output Within Acceptable	1.24E-03	27.8%
3	EK2DIODDEX Keowee Unit 2 Exciter Fan Supply Diode Bridge Fails	2.87E-04	6.5%
4	EK241AXR6D Keowee Unit 2 Relay 41/AX Fails To Pick-up And Latch	2.48E-04	5.6%
5	EK2F30AFUF Keowee Unit 2 Excitation Cabinet Fan Fuses Fail	8.59E-05	1.9%

[1] The mean unavailability is the summation of the values of all cut sets in which the event appears

[2] The contribution to unavailability is calculated by dividing the mean unavailability by the overall system unavailability and then multiplying by 100 percent

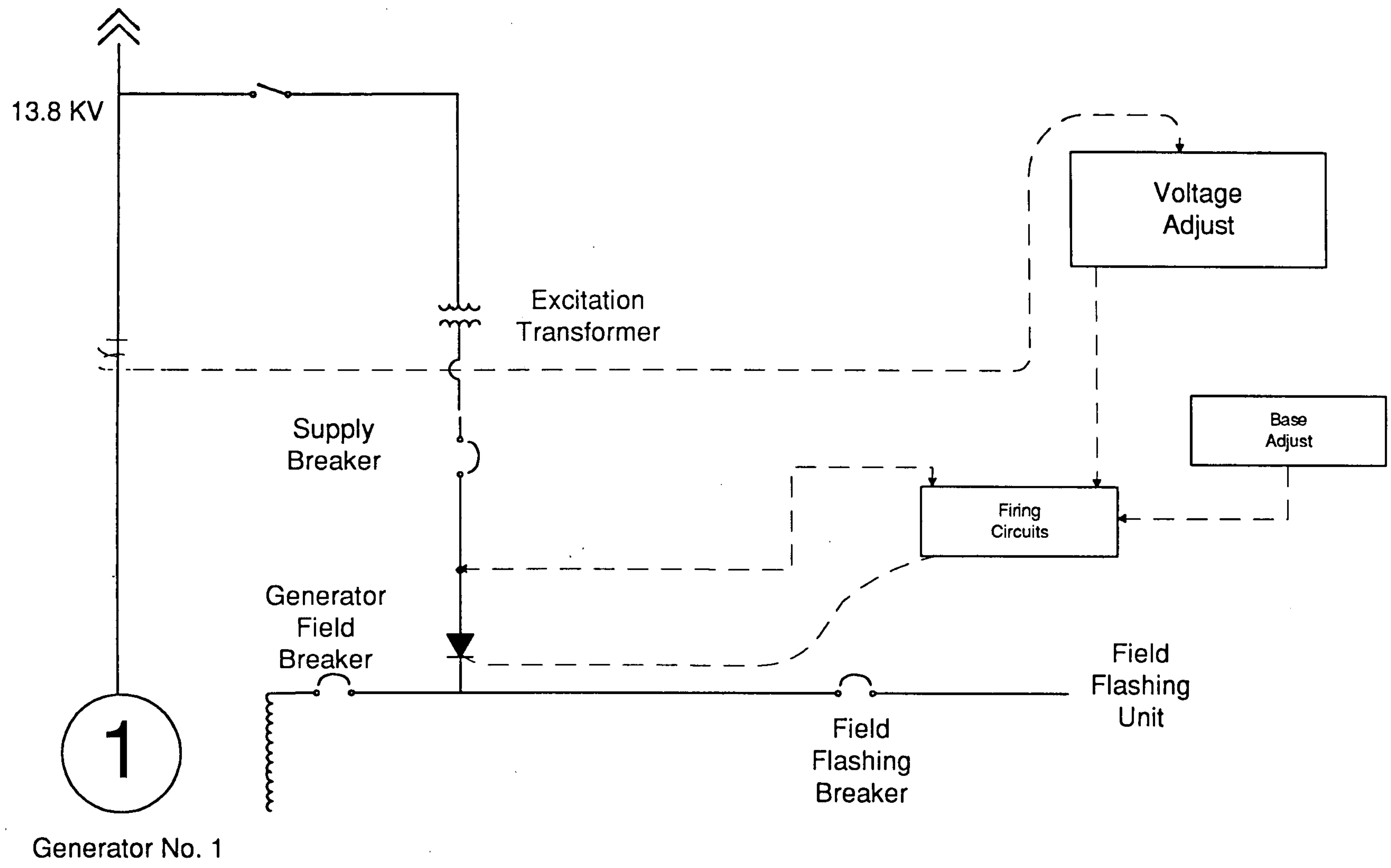


Figure A.6-1 Generator Excitation Simplified Diagram

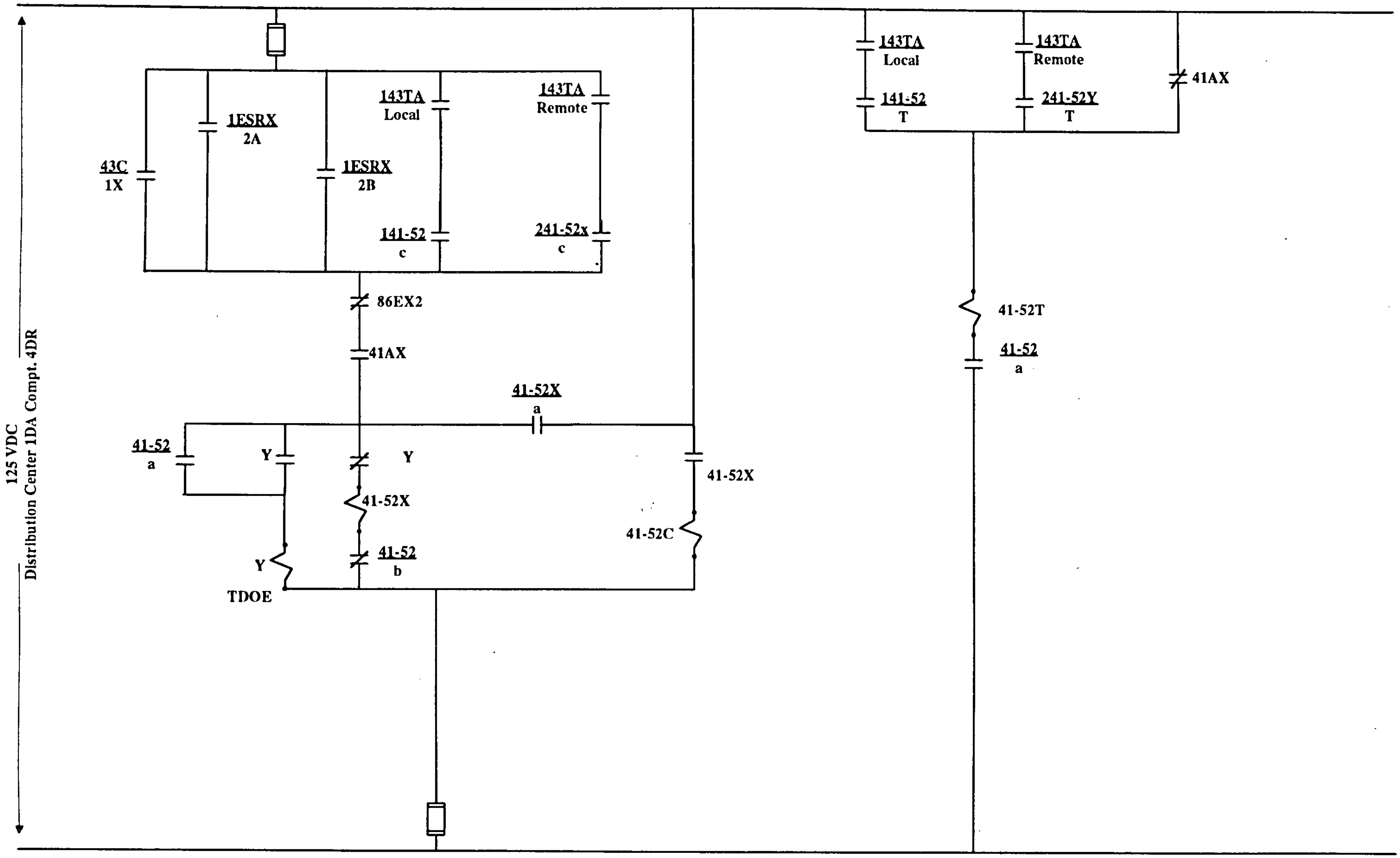


Figure A.6-2 Simplified Generator Supply Breaker Elementary Diagram

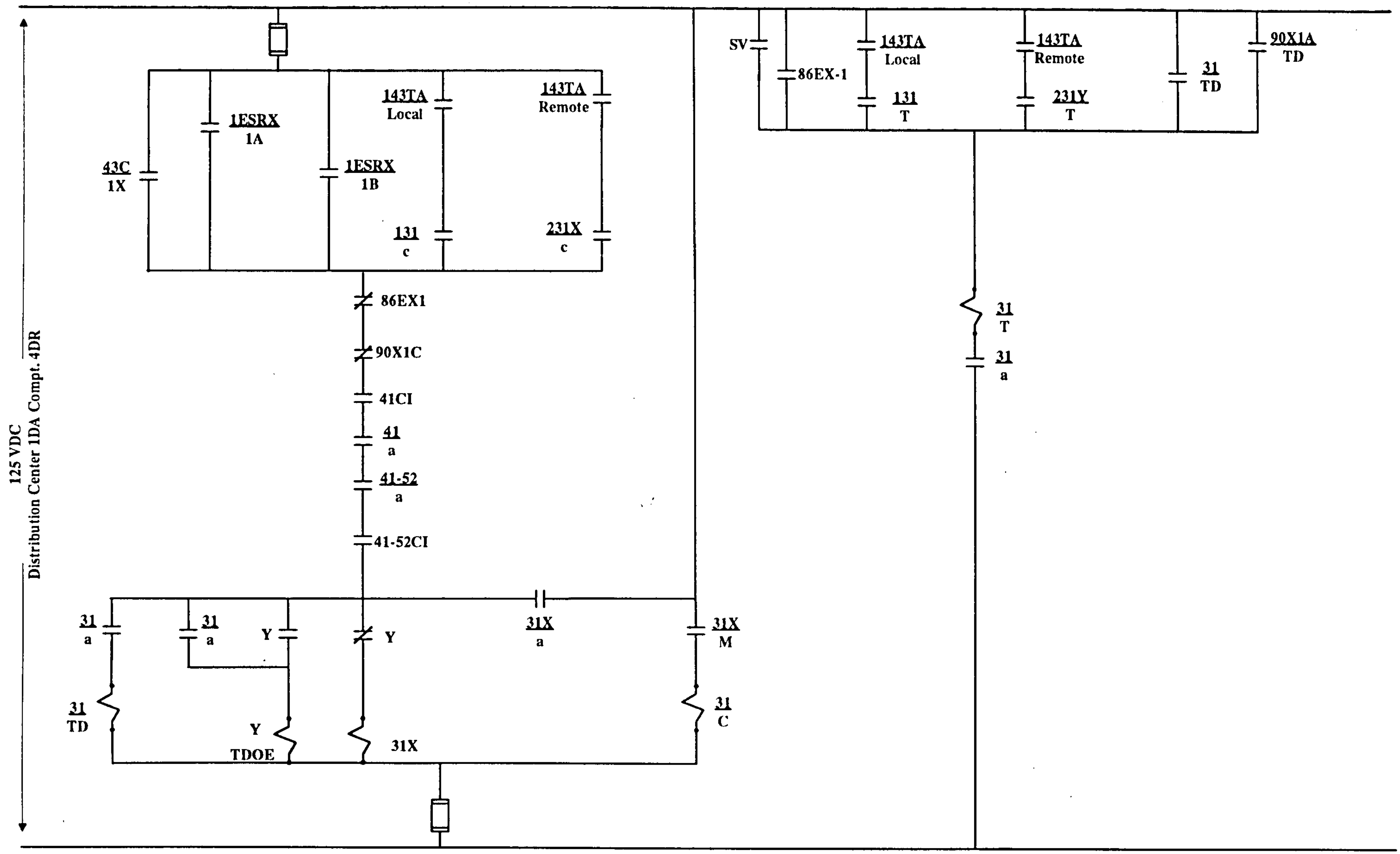


Figure A.6-3 Simplified Generator Field Flashing Breaker Elementary Diagram

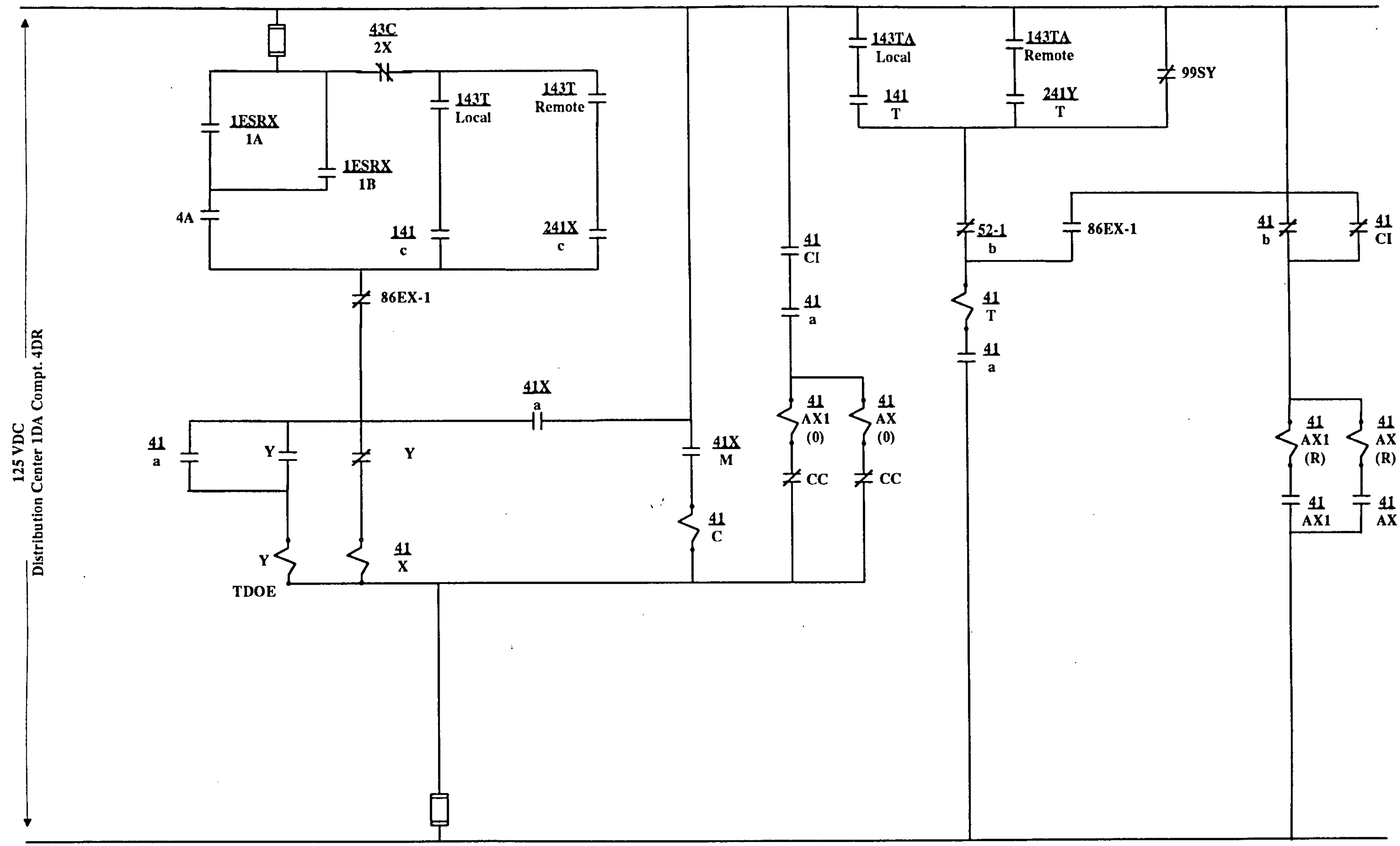
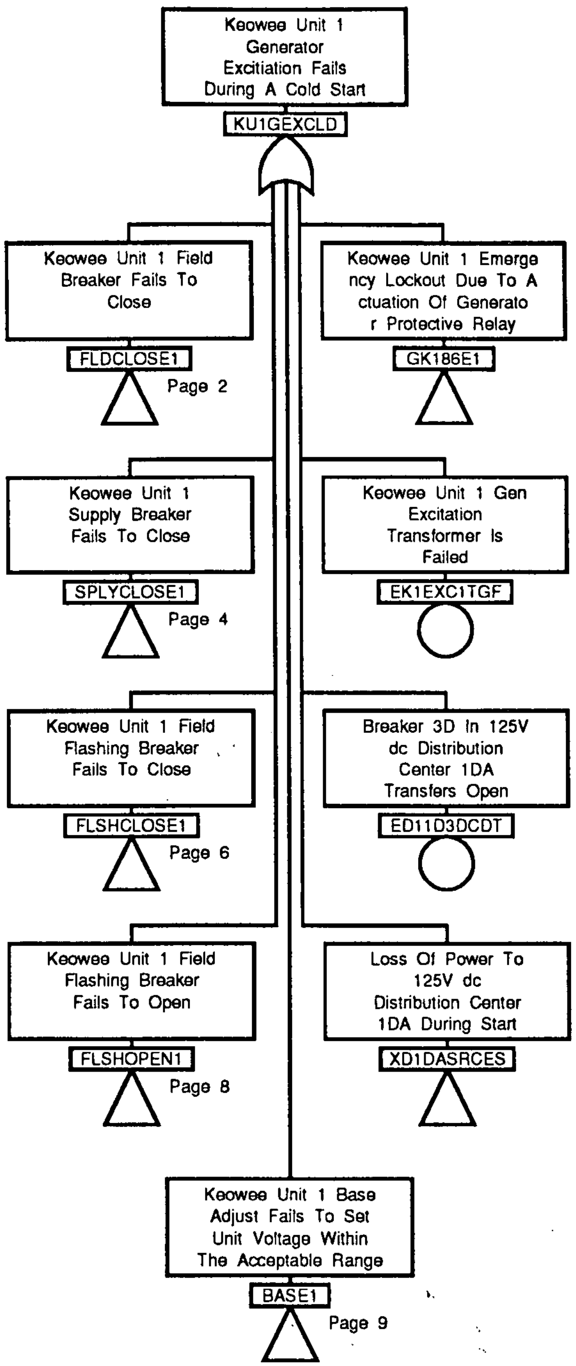
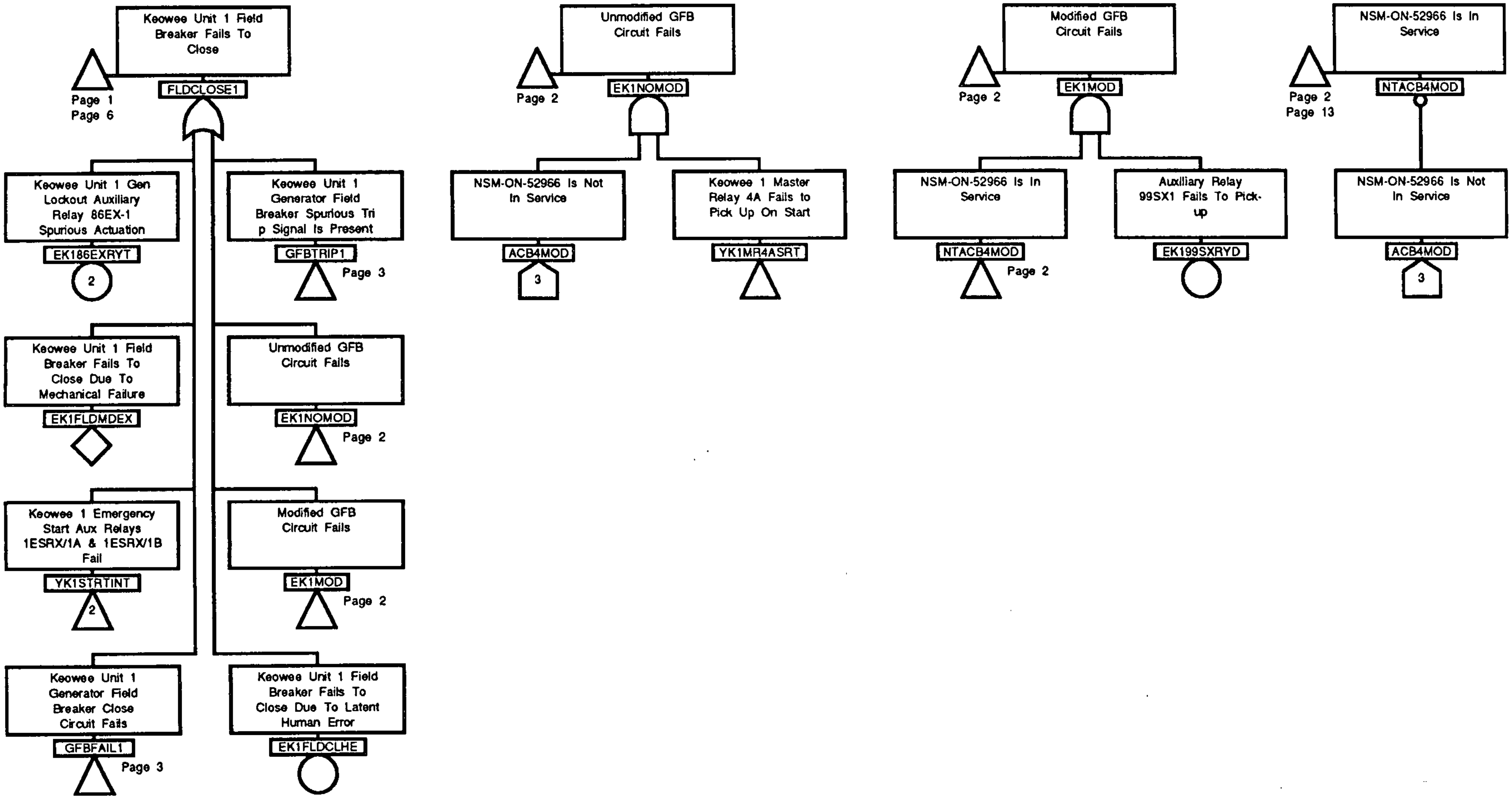


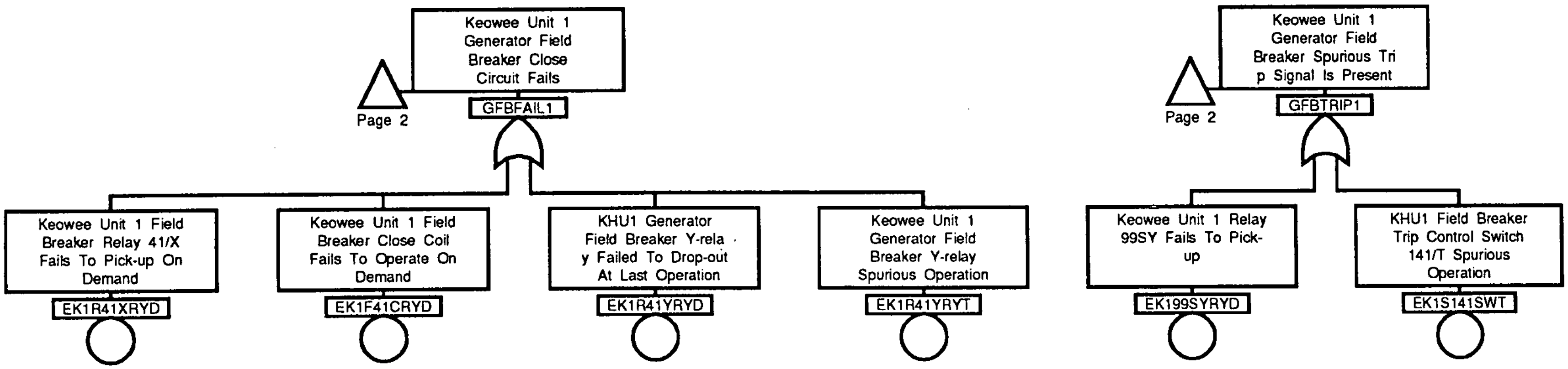
Figure A.6-4 Simplified Generator Field Breaker Elementary Diagram



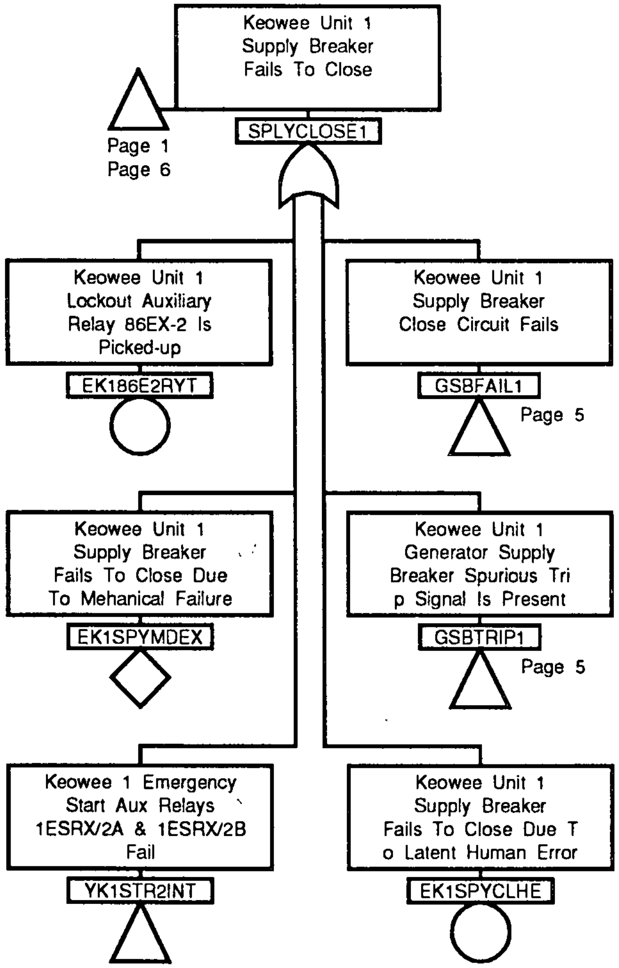
Keowee Units 1 & 2 Excitation Fault Tree | FIGURE A.6-5 |

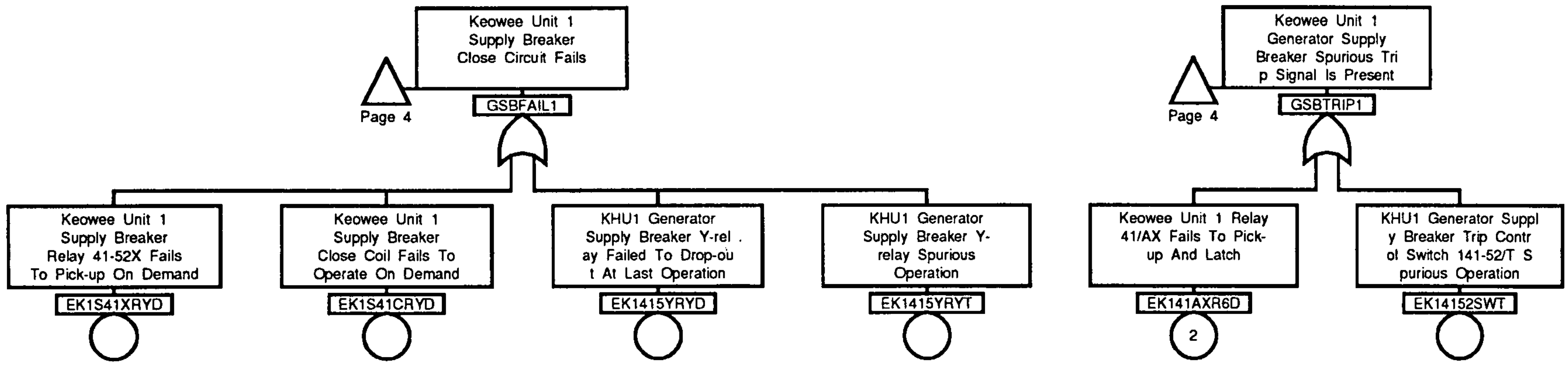


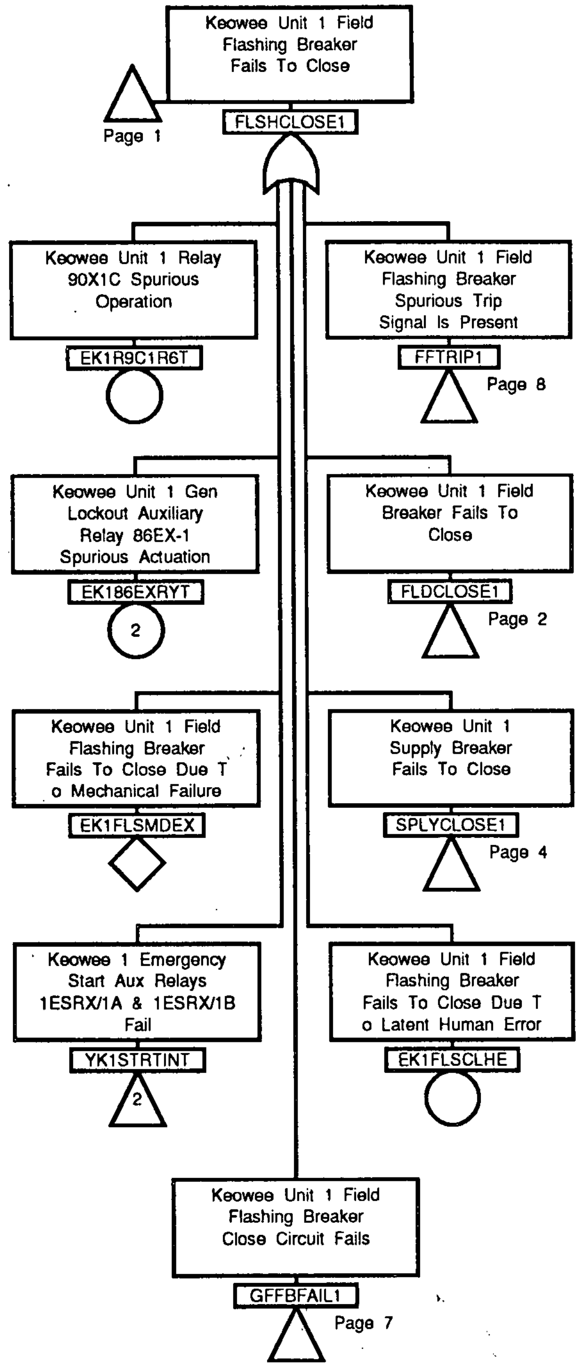
Keowee Units 1 & 2 Excitation Fault Tree | FIGURE A.6-5 | Page 2



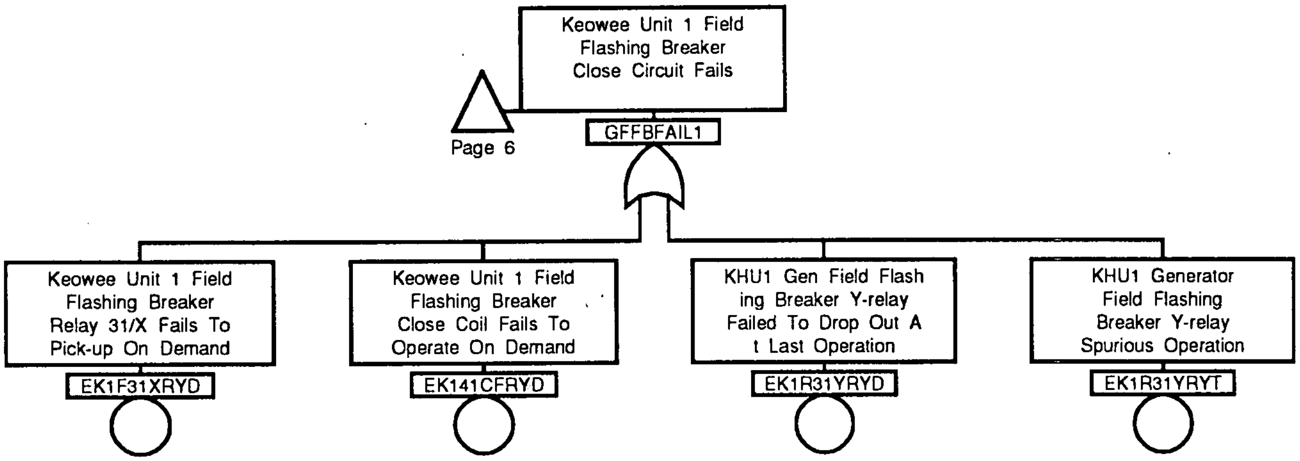
Keowee Units 1 & 2 Excitation Fault Tree	FIGURE A.6-5	Page 3

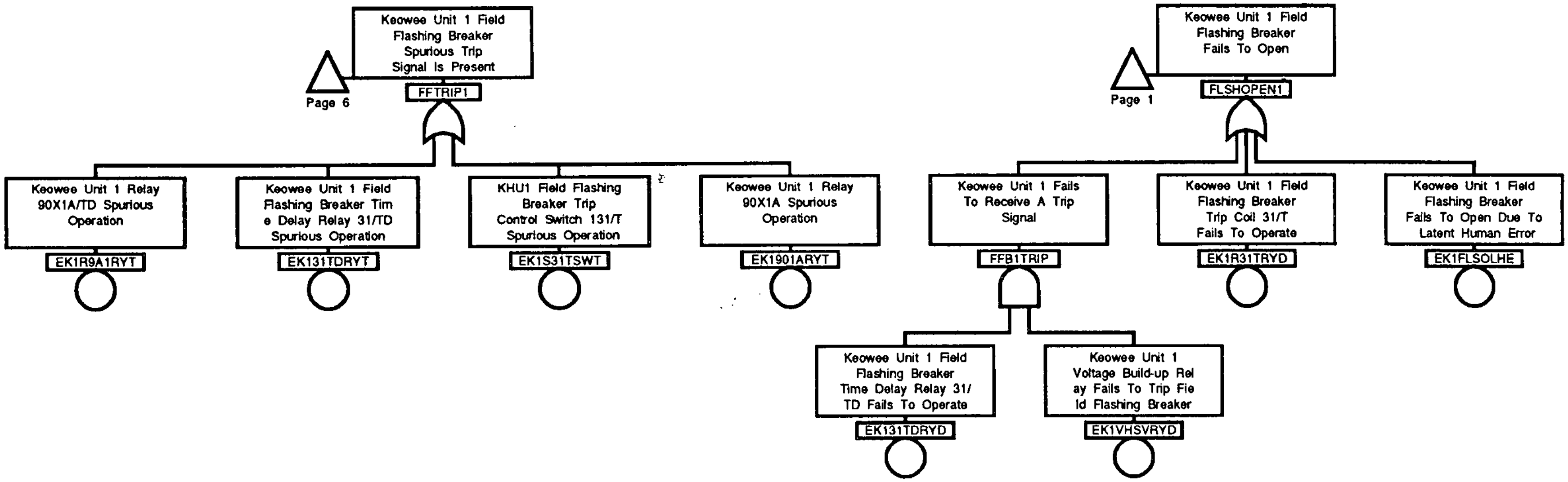

Keowee Unit 1 Supply Breaker Fails To Close
SPLYCLOSE1
Page 1
Page 6
Keowee Unit 1 Lockout Auxiliary Relay 86EX-2 Is Picked-up
EK186E2RYT
Keowee Unit 1 Supply Breaker Close Circuit Fails
GSBFAIL1
Page 5
Keowee Unit 1 Supply Breaker Fails To Close Due To Mehanical Failure
EK1SPYMDEX
Keowee Unit 1 Generator Supply Breaker Spurious Tri p Signal Is Present
GSBTRIP1
Page 5
Keowee 1 Emergency Start Aux Relays 1ESRX/2A & 1ESRX/2B Fail
YK1STR2INT
Keowee Unit 1 Supply Breaker Fails To Close Due T o Latent Human Error
EK1SPYCLHE


Keowee Unit 1 Supply Breaker Close Circuit Fails
GSBFAIL1
Page 4
Keowee Unit 1 Supply Breaker Relay 41-52X Fails To Pick-up On Demand
EK1S41XRYD
Keowee Unit 1 Supply Breaker Close Coil Fails To Operate On Demand
EK1S41CRYD
KHU1 Generator Supply Breaker Y-rel . ay Failed To Drop-ou t At Last Operation
EK1415YRYD
KHU1 Generator Supply Breaker Y-relay Spurious Operation
EK1415YRYT
Keowee Unit 1 Generator Supply Breaker Spurious Tri p Signal Is Present
GSBTRIP1
Page 4
Keowee Unit 1 Relay 41/AX Fails To Pick-up And Latch
EK141AXR6D
2
KHU1 Generator Suppl y Breaker Trip Contr ol Switch 141-52/T S purious Operation
EK14152SWT

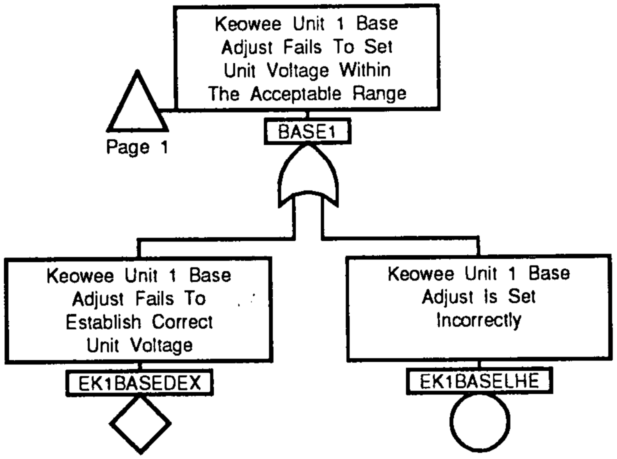


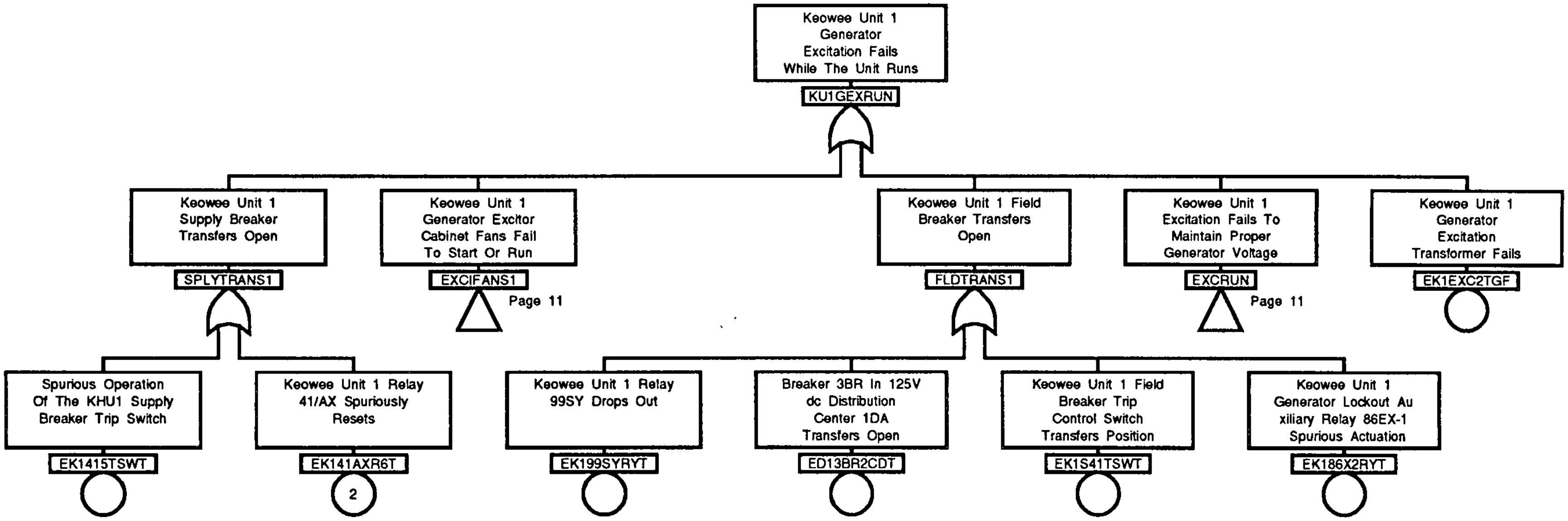
Keowee Units 1 & 2 Excitation Fault Tree	FIGURE A.6-5	Page 6


Keowee Unit 1 Field Flashing Breaker Close Circuit Fails
GFFBFAIL1
Page 6
Keowee Unit 1 Field Flashing Breaker Relay 31/X Fails To Pick-up On Demand
EK1F31XRYD
Keowee Unit 1 Field Flashing Breaker Close Coil Fails To Operate On Demand
EK141CFRYD
KHU1 Gen Field Flash ing Breaker Y-relay Failed To Drop Out A t Last Operation
EK1R31YRYD
KHU1 Generator Field Flashing Breaker Y-relay Spurious Operation
EK1R31YRYT



Keowee Units 1 & 2 Excitation Fault Tree	FIGURE A.6-5	Page 8


Keowee Unit 1 Base Adjust Fails To Set Unit Voltage Within The Acceptable Range
BASE1
Page 1
Keowee Unit 1 Base Adjust Fails To Establish Correct Unit Voltage
EK1BASEDEX
Keowee Unit 1 Base Adjust Is Set Incorrectly
EK1BASELHE


Keowee Unit 1 Generator Excitation Fails While The Unit Runs
KU1GEXRUN
Keowee Unit 1 Supply Breaker Transfers Open
SPLYTRANS1
Keowee Unit 1 Generator Excitor Cabinet Fans Fail To Start Or Run
EXCIFANS1
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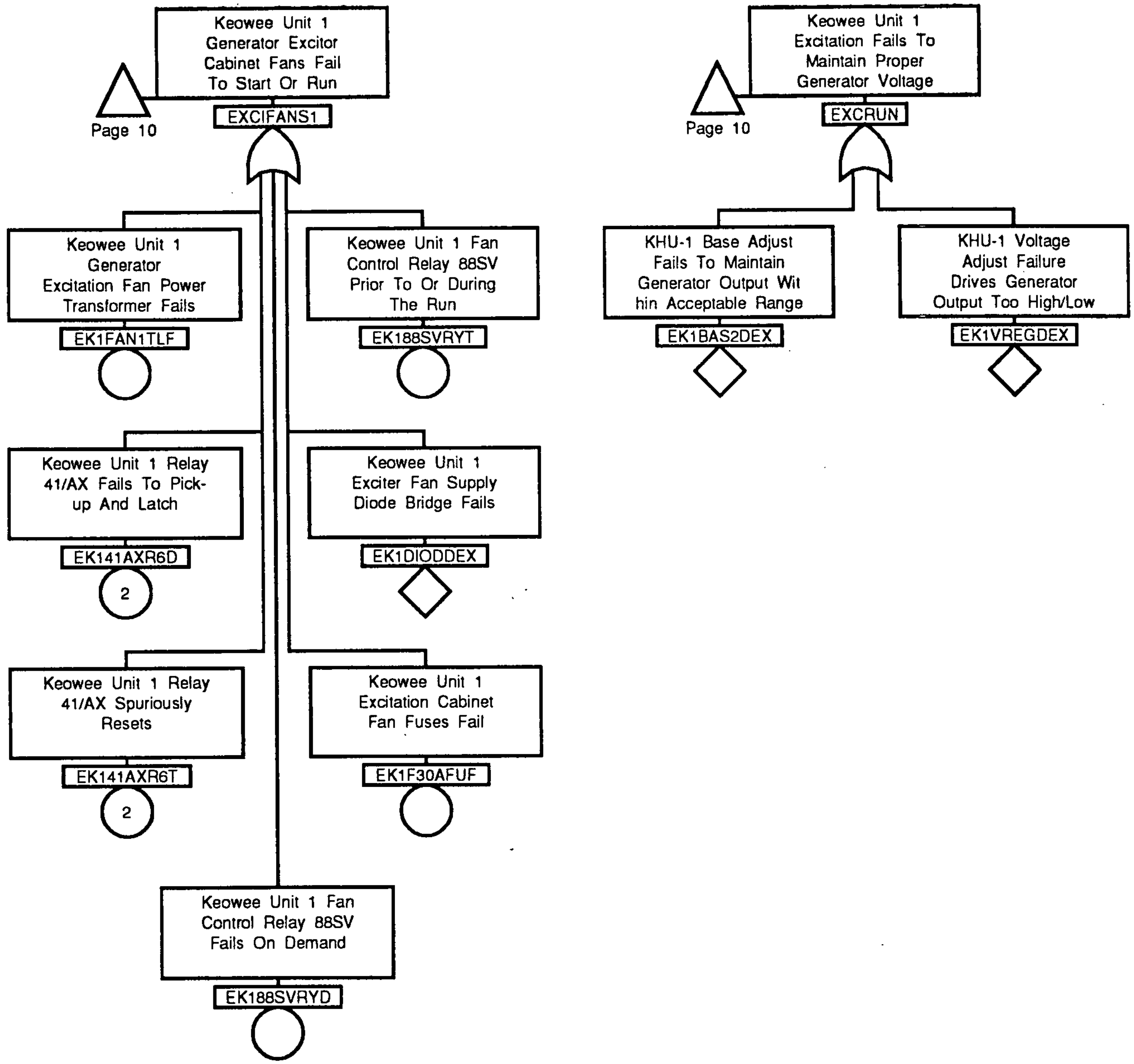
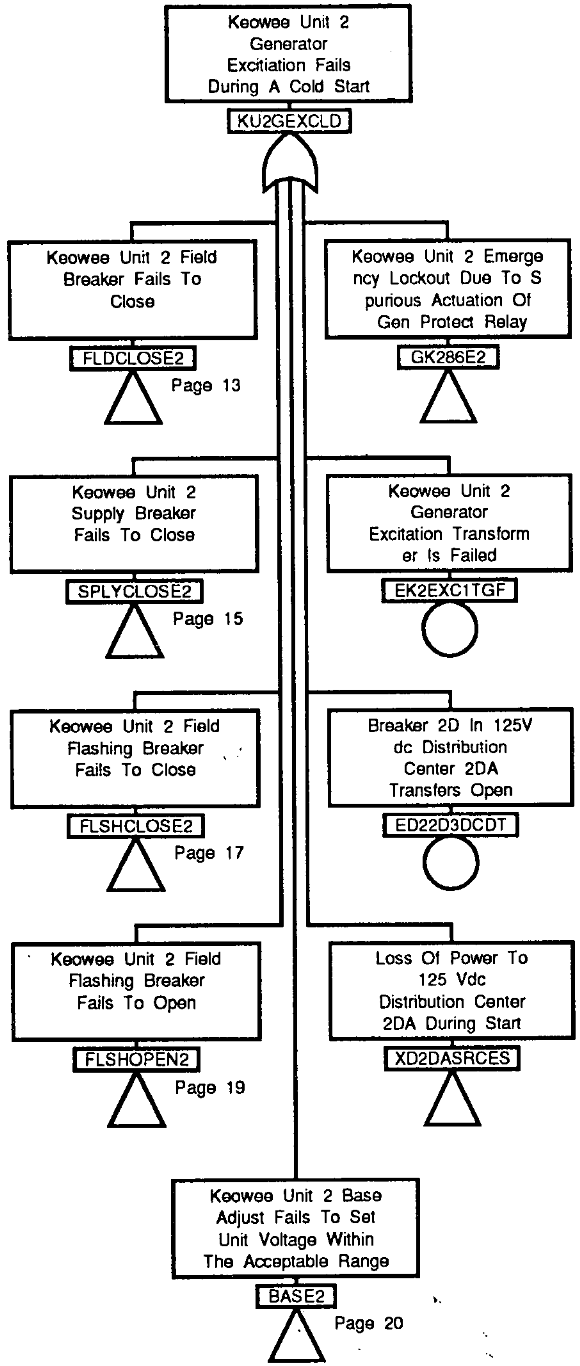
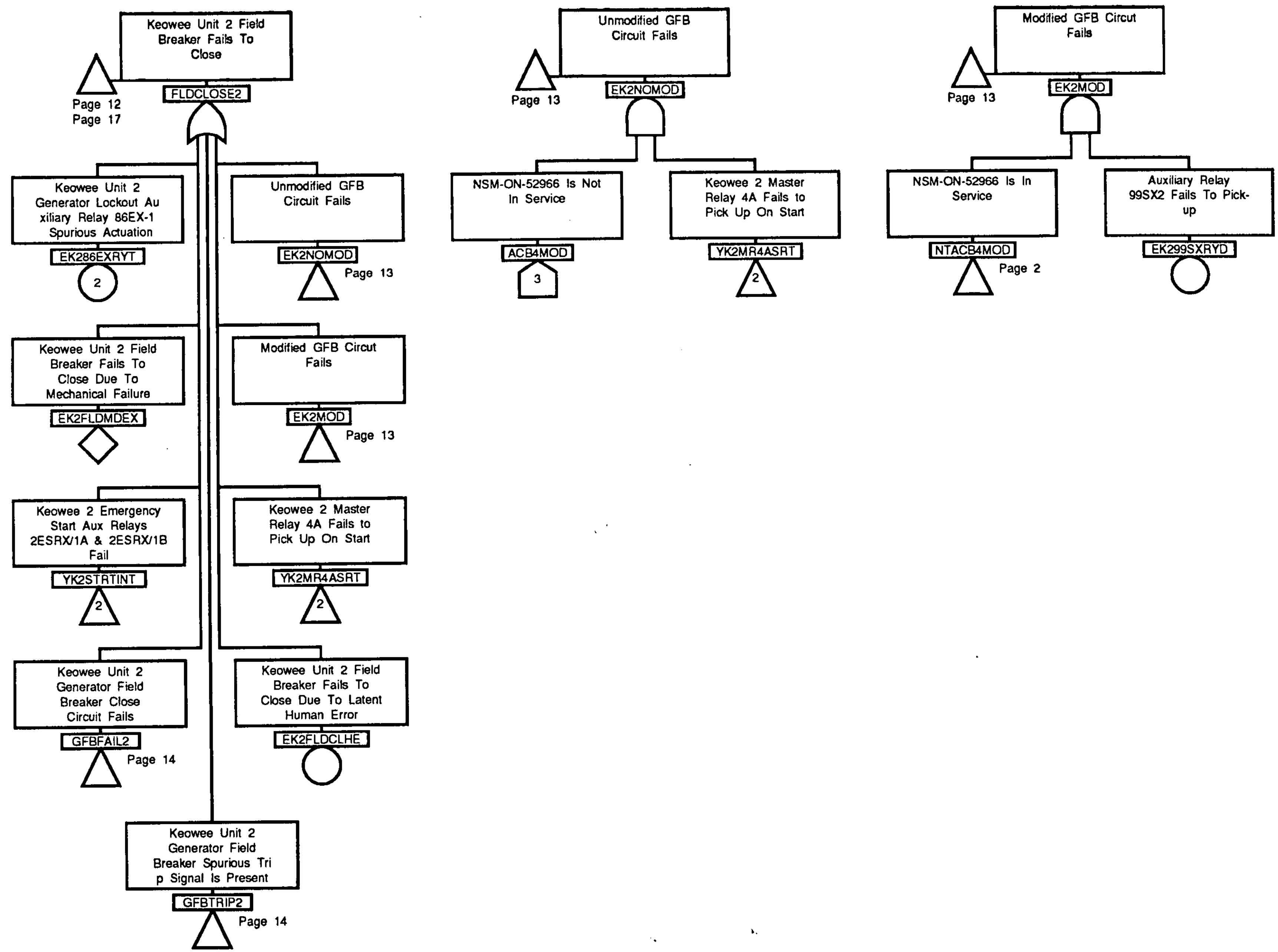
Keowee Unit 1 Field Breaker Transfers Open
FLDTRANS1
Keowee Unit 1 Excitation Fails To Maintain Proper Generator Voltage
EXCRUN
Page 11
Keowee Unit 1 Generator Excitation Transformer Fails
EK1EXC2TGF
Spurious Operation Of The KHU1 Supply Breaker Trip Switch
EK1415TSWT
Keowee Unit 1 Relay 41/AX Spuriously Resets
EK141AXR6T
2
Keowee Unit 1 Relay 99SY Drops Out
EK199SYRYT
Breaker 3BR In 125V dc Distribution Center 1DA Transfers Open
ED13BR2CDT
Keowee Unit 1 Field Breaker Trip Control Switch Transfers Position
EK1S41TSWT
Keowee Unit 1 Generator Lockout Au xiliary Relay 86EX-1 Spurious Actuation
EK186X2RYT



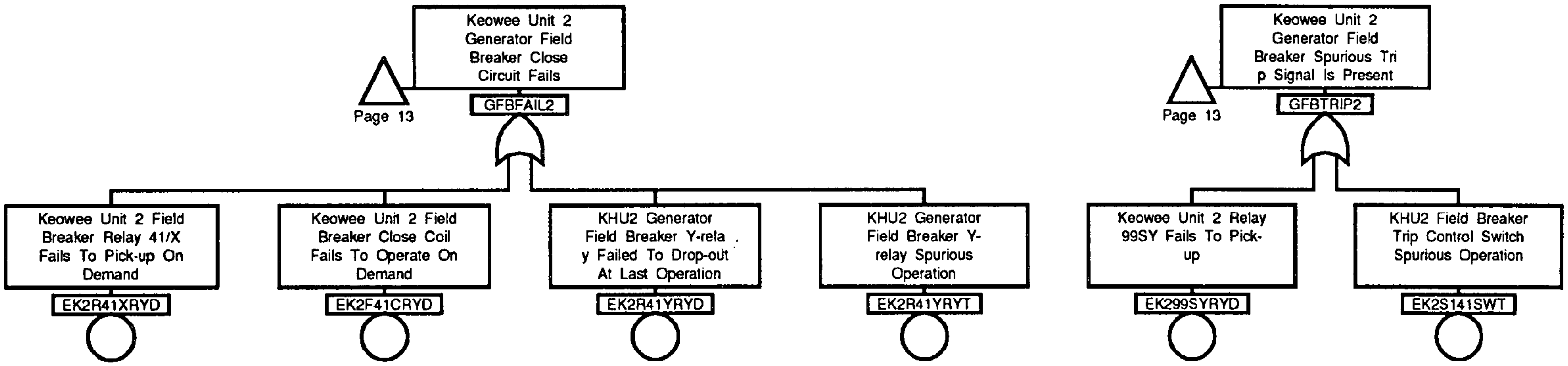
Keowee Units 1 & 2 Excitation Fault Tree | FIGURE A.6-5



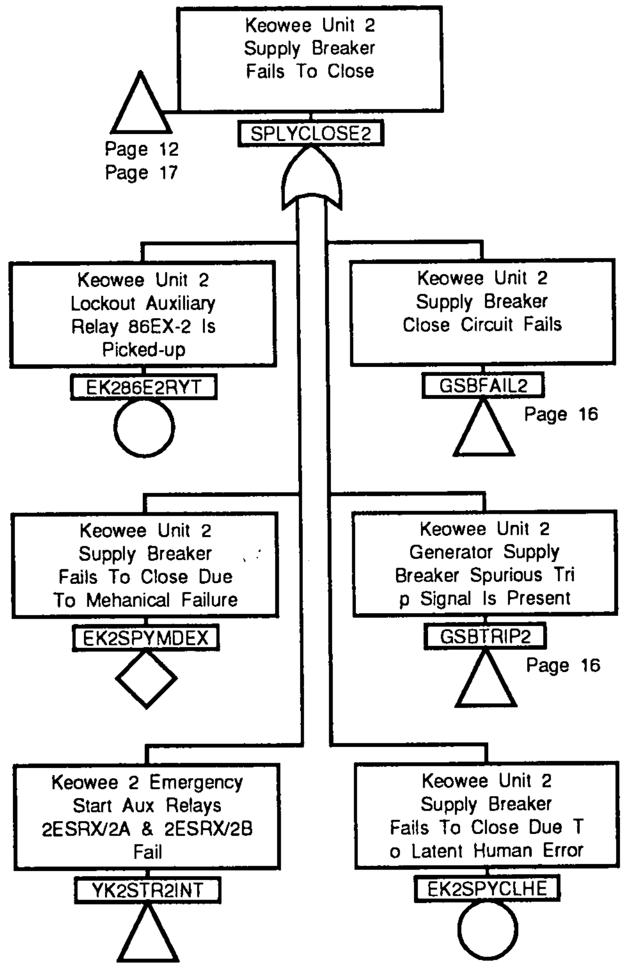
Keowee Units 1 & 2 Excitation Fault Tree | FIGURE A.6-5 |



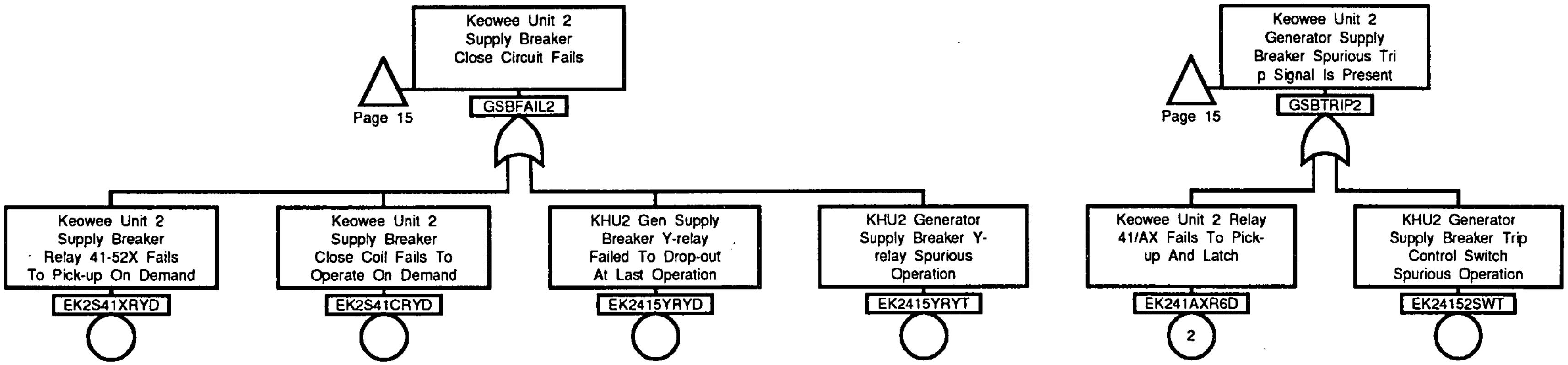
Keowee Unit 2 Field Breaker Fails To Close
Page 12
Page 17
FLDCLOSE2
Keowee Unit 2 Generator Lockout Au xiliary Relay 86EX-1 Spurious Actuation
EK286EXRYT
2
Unmodified GFB Circuit Fails
EK2NOMOD
Page 13
Keowee Unit 2 Field Breaker Fails To Close Due To Mechanical Failure
EK2FLDMDEX
Modified GFB Circut Fails
EK2MOD
Page 13
Keowee 2 Emergency Start Aux Relays 2ESRX/1A & 2ESRX/1B Fail
YK2STRTINT
2
Keowee 2 Master Relay 4A Fails to Pick Up On Start
YK2MR4ASRT
2
Keowee Unit 2 Generator Field Breaker Close Circuit Fails
GFBFAIL2
Page 14
Keowee Unit 2 Field Breaker Fails To Close Due To Latent Human Error
EK2FLDCLHE
Keowee Unit 2 Generator Field Breaker Spurious Tri p Signal Is Present
GFBTRIP2
Page 14
Unmodified GFB Circuit Fails
Page 13
EK2NOMOD
NSM-ON-52966 Is Not In Service
ACB4MOD
3
Keowee 2 Master Relay 4A Fails to Pick Up On Start
YK2MR4ASRT
2
Modified GFB Circut Fails
Page 13
EK2MOD
NSM-ON-52966 Is In Service
NTACB4MOD
Page 2
Auxiliary Relay 99SX2 Fails To Pick-up
EK299SXRYD



Keowee Units 1 & 2 Excitation Fault Tree	FIGURE A.6-5	Page 14



Keowee Units 1 & 2 Excitation Fault Tree | FIGURE A.6-5 |


Keowee Unit 2 Supply Breaker Close Circuit Fails
GSBFAIL2
Page 15
Keowee Unit 2 Supply Breaker Relay 41-52X Fails To Pick-up On Demand
EK2S41XRYD
Keowee Unit 2 Supply Breaker Close Coil Fails To Operate On Demand
EK2S41CRYD
KHU2 Gen Supply Breaker Y-relay Failed To Drop-out At Last Operation
EK2415YRYD
KHU2 Generator Supply Breaker Y-relay Spurious Operation
EK2415YRYT
Keowee Unit 2 Generator Supply Breaker Spurious Tri p Signal Is Present
GSBTRIP2
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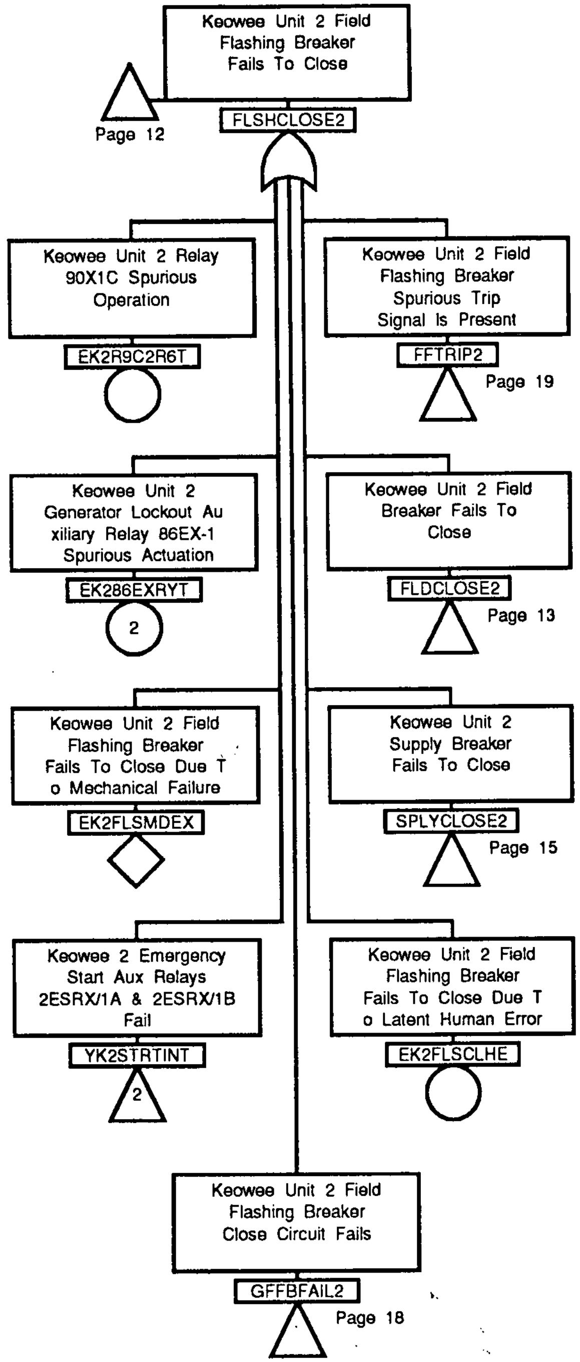
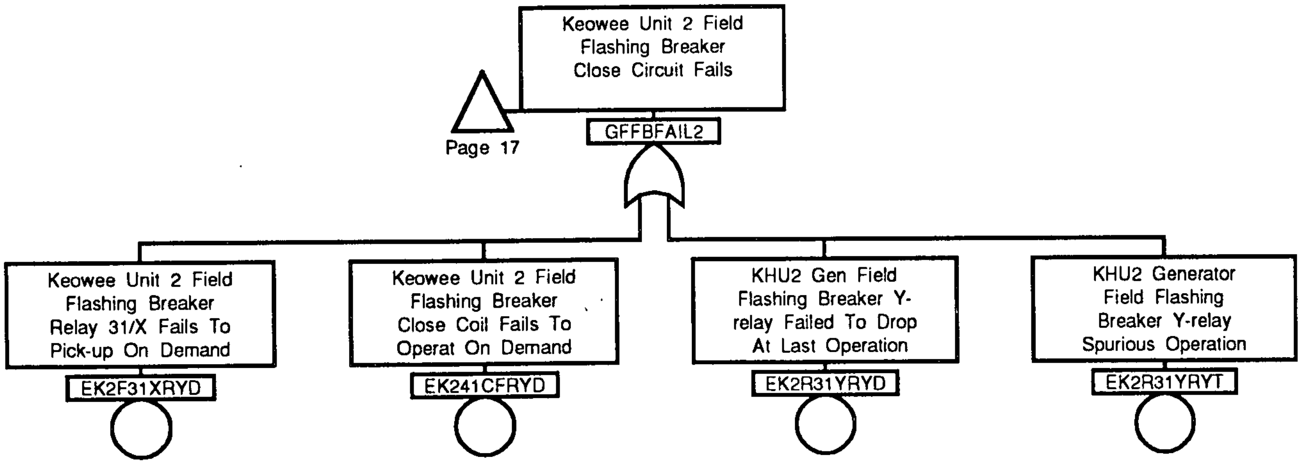
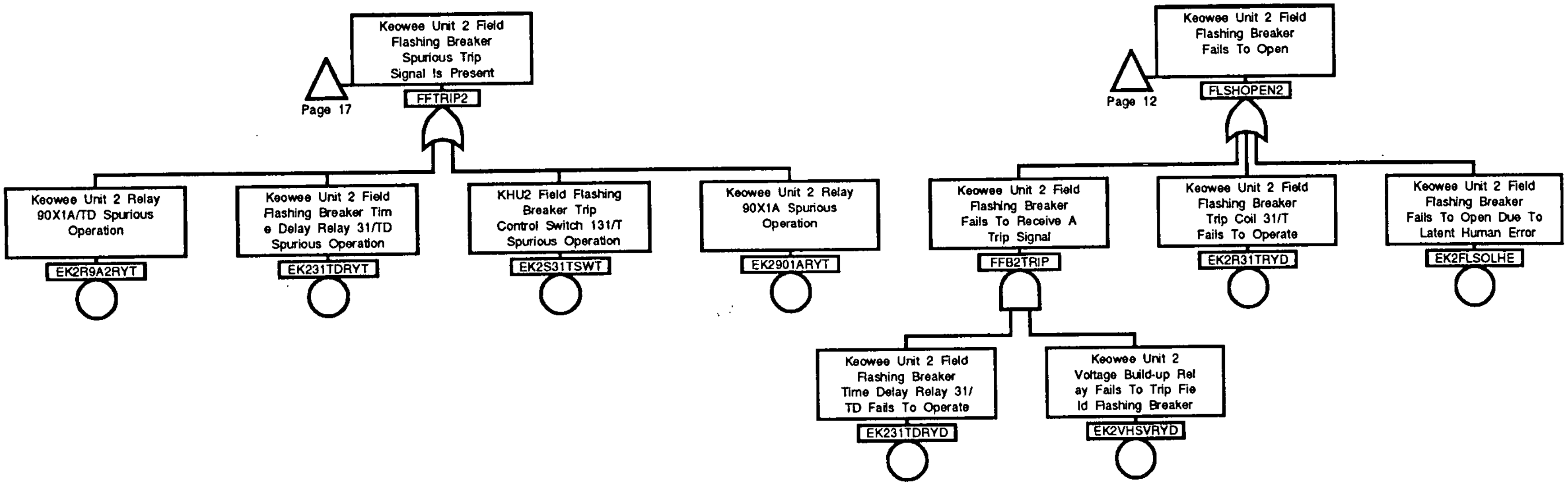
Keowee Unit 2 Relay 41/AX Fails To Pick-up And Latch
EK241AXR6D
2
KHU2 Generator Supply Breaker Trip Control Switch Spurious Operation
EK24152SWT



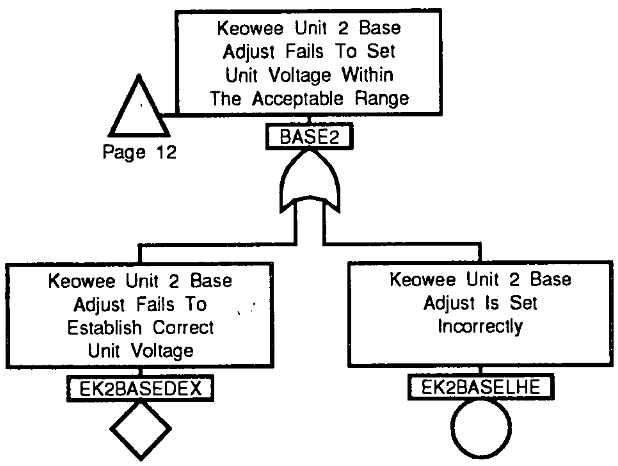
Keowee Units 1 & 2 Excitation Fault Tree	FIGURE A.6-5	Page 17



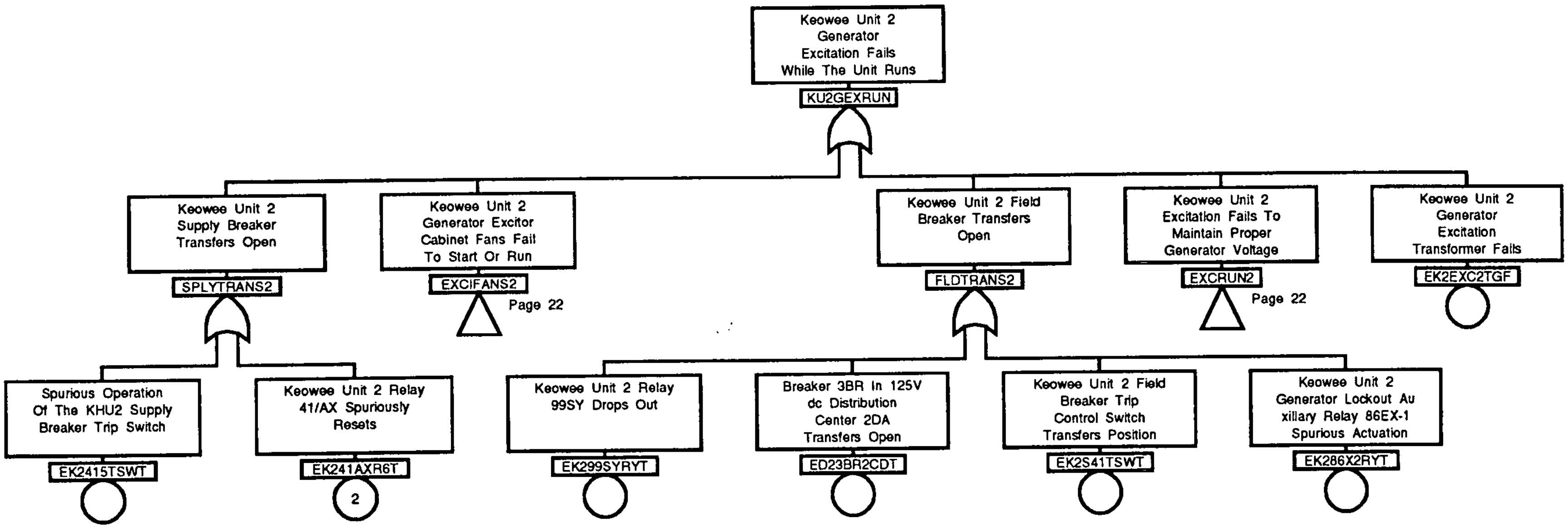
Keowee Units 1 & 2 Excitation Fault Tree | FIGURE A.6-5

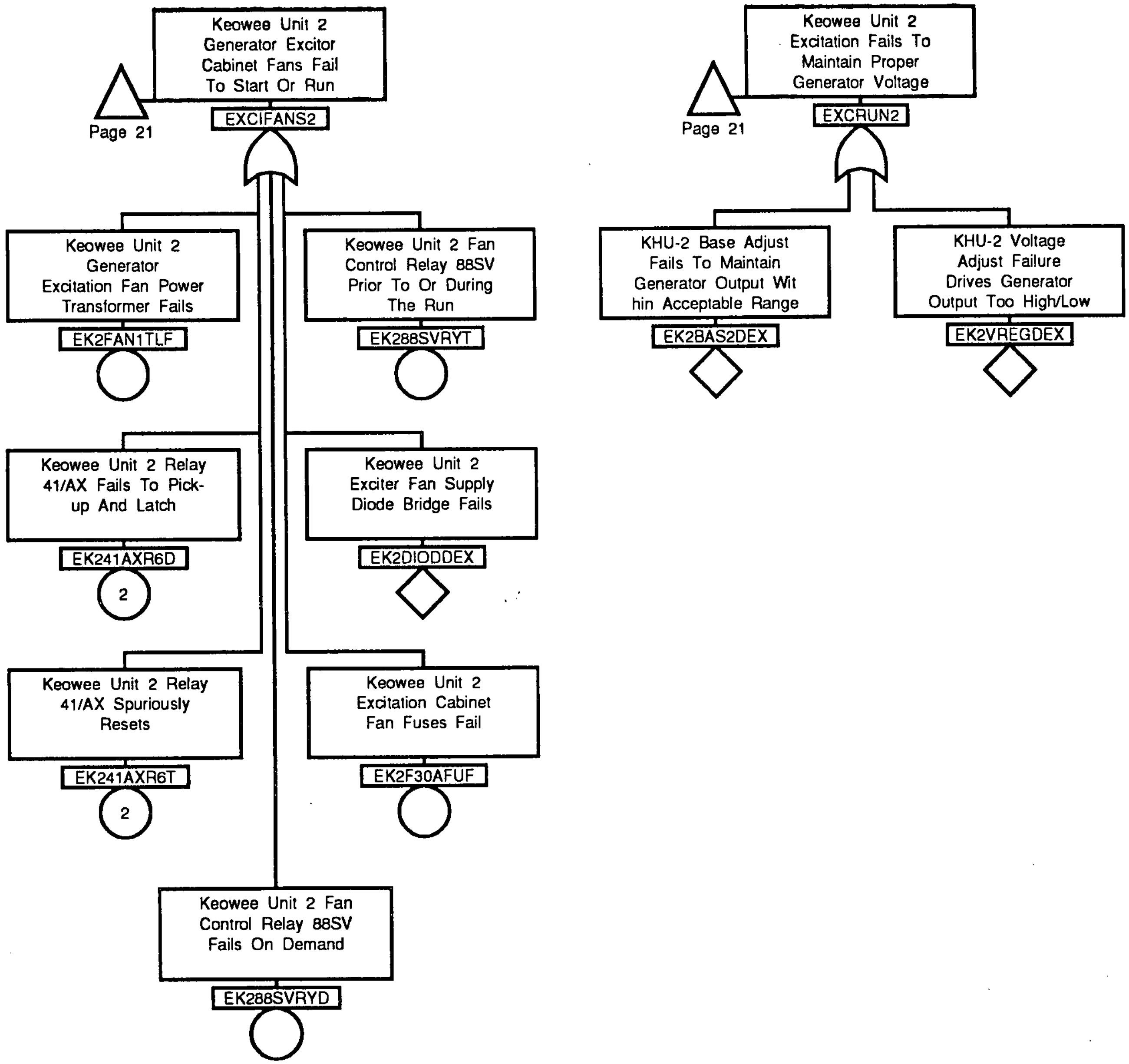


Keowee Units 1 & 2 Excitation Fault Tree | FIGURE A.6-5



Keowee Units 1 & 2 Excitation Fault Tree | FIGURE A.6-5 |


Keowee Unit 2 Generator Excitation Fails While The Unit Runs
KU2GEXRUN
Keowee Unit 2 Supply Breaker Transfers Open
SPLYTRANS2
Keowee Unit 2 Generator Excitor Cabinet Fans Fail To Start Or Run
EXCIFANS2
Page 22
Keowee Unit 2 Field Breaker Transfers Open
FLDTRANS2
Keowee Unit 2 Excitation Fails To Maintain Proper Generator Voltage
EXCRUN2
Page 22
Keowee Unit 2 Generator Excitation Transformer Fails
EK2EXC2TGF
Spurious Operation Of The KHU2 Supply Breaker Trip Switch
EK2415TSWT
Keowee Unit 2 Relay 41/AX Spuriously Resets
EK241AXR6T
2
Keowee Unit 2 Relay 99SY Drops Out
EK299SYRYT
Breaker 3BR In 125V dc Distribution Center 2DA Transfers Open
ED23BR2CDT
Keowee Unit 2 Field Breaker Trip Control Switch Transfers Position
EK2S41TSWT
Keowee Unit 2 Generator Lockout Au xillary Relay 86EX-1 Spurious Actuation
EK286X2RYT



Keowee Units 1 & 2 Excitation Fault Tree | FIGURE A.6-5 |

Gate/Event Name	Page	Zone	Gate/Event Name	Page	Zone	Gate/Event Name	Page	Zone	Gate/Event Name	Page	Zone
ACB4MOD	2		EK1F30AFUF	11		EK241AXR6T	21		EK2R9A2RYT	19	
ACB4MOD	2		EK1F31XRYD	7		EK241AXR6T	22		EK2R9C2R6T	17	
ACB4MOD	13		EK1F41CRYD	3		EK241CFRYD	18		EK2S141SWT	14	
BASE1	1		EK1FAN1TLF	11		EK286E2RYT	15		EK2S31TSWT	19	
BASE1	9		EK1FLDCLHE	2		EK286EXRYT	13		EK2S41CRYD	16	
BASE2	12		EK1FLDMDEX	2		EK286EXRYT	17		EK2S41TSWT	21	
BASE2	20		EK1FLSCLHE	6		EK286X2RYT	21		EK2S41XRYD	16	
ED11D3DCDT	1		EK1FLSMDEX	6		EK288SVRYD	22		EK2SPYCLHE	15	
ED13BR2CDT	10		EK1FLSOLHE	8		EK288SVRYT	22		EK2SPYMDEX	15	
ED22D3DCDT	12		EK1MOD	2		EK2901ARYT	19		EK2VHSVRYD	19	
ED23BR2CDT	21		EK1MOD	2		EK299SXRYD	13		EK2VREGDEX	22	
EK131TDRYD	8		EK1NOMOD	2		EK299SYRYD	14		EXCIFANS1	10	
EK131TDRYT	8		EK1NOMOD	2		EK299SYRYT	21		EXCIFANS1	11	
EK14152SWT	5		EK1R31TRYD	8		EK2BAS2DEX	22		EXCIFANS2	21	
EK1415TSWT	10		EK1R31YRYD	7		EK2BASEDEX	20		EXCIFANS2	22	
EK1415YRYD	5		EK1R31YRYT	7		EK2BASELHE	20		EXCRUN	10	
EK1415YRYT	5		EK1R41XRYD	3		EK2DIODDEX	22		EXCRUN	11	
EK141AXR6D	5		EK1R41YRYD	3		EK2EXC1TGF	12		EXCRUN2	21	
EK141AXR6D	11		EK1R41YRYT	3		EK2EXC2TGF	21		EXCRUN2	22	
EK141AXR6T	10		EK1R9A1RYT	8		EK2F30AFUF	22		FFB1TRIP	8	
EK141AXR6T	11		EK1R9C1R6T	6		EK2F31XRYD	18		FFB2TRIP	19	
EK141CFRYD	7		EK1S141SWT	3		EK2F41CRYD	14		FFTRIP1	6	
EK186E2RYT	4		EK1S31TSWT	8		EK2FAN1TLF	22		FFTRIP1	8	
EK186EXRYT	2		EK1S41CRYD	5		EK2FLDCLHE	13		FFTRIP2	17	
EK186EXRYT	6		EK1S41TSWT	10		EK2FLDMDEX	13		FFTRIP2	19	
EK186X2RYT	10		EK1S41XRYD	5		EK2FLSCLHE	17		FLDCLOSE1	1	
EK188SVRYD	11		EK1SPYCLHE	4		EK2FLSMDEX	17		FLDCLOSE1	2	
EK188SVRYT	11		EK1SPYMDEX	4		EK2FLSOLHE	19		FLDCLOSE1	6	
EK1901ARYT	8		EK1VHSVRYD	8		EK2MOD	13		FLDCLOSE2	12	
EK199SXRYD	2		EK1VREGDEX	11		EK2MOD	13		FLDCLOSE2	13	
EK199SYRYD	3		EK231TDRYD	19		EK2NOMOD	13		FLDCLOSE2	17	
EK199SYRYT	10		EK231TDRYT	19		EK2NOMOD	13		FLDTRANS1	10	
EK1BAS2DEX	11		EK24152SWT	16		EK2R31TRYD	19		FLDTRANS2	21	
EK1BASEDEX	9		EK2415TSWT	21		EK2R31YRYD	18		FLSHCLOSE1	1	
EK1BASELHE	9		EK2415YRYD	16		EK2R31YRYT	18		FLSHCLOSE1	6	
EK1DIODDEX	11		EK2415YRYT	16		EK2R41XRYD	14		FLSHCLOSE2	12	
EK1EXC1TGF	1		EK241AXR6D	16		EK2R41YRYD	14		FLSHCLOSE2	17	
EK1EXC2TGF	10		EK241AXR6D	22		EK2R41YRYT	14		FLSHOPEN1	1	

Gate/Event Name	Page	Zone	Gate/Event Name	Page	Zone	Gate/Event Name	Page	Zone	Gate/Event Name	Page	Zone
FLSHOPEN1	8		SPLYTRANS1	10							
FLSHOPEN2	12		SPLYTRANS2	21							
FLSHOPEN2	19		XD1DASRCES	1							
GFBFAIL1	2		XD2DASRCES	12							
GFBFAIL1	3		YK1MR4ASRT	2							
GFBFAIL2	13		YK1STR2INT	4							
GFBFAIL2	14		YK1STRTINT	2							
GFBTRIP1	2		YK1STRTINT	6							
GFBTRIP1	3		YK2MR4ASRT	13							
GFBTRIP2	13		YK2MR4ASRT	13							
GFBTRIP2	14		YK2STR2INT	15							
GFFBFAIL1	6		YK2STRTINT	13							
GFFBFAIL1	7		YK2STRTINT	17							
GFFBFAIL2	17										
GFFBFAIL2	18										
GK186E1	1										
GK286E2	12										
GSBFAIL1	4										
GSBFAIL1	5										
GSBFAIL2	15										
GSBFAIL2	16										
GSBTRIP1	4										
GSBTRIP1	5										
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GSBTRIP2	16										
KU1GEXCLD	1										
KU1GEXRUN	10										
KU2GEXCLD	12										
KU2GEXRUN	21										
NTACB4MOD	2										
NTACB4MOD	2										
NTACB4MOD	13										
SPLYCLOSE1	1										
SPLYCLOSE1	4										
SPLYCLOSE1	6										
SPLYCLOSE2	12										
SPLYCLOSE2	15										
SPLYCLOSE2	17										

APPENDIX A.7
KEOWEE GENERATOR

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A.7 KEOWEE GENERATOR

A.7.1 OBJECTIVES

The main objective of this analysis is to develop a logic model of the Keowee Generator. This model is combined with the high-level model and remaining system models to form an integrated model for assessing the reliability of Keowee. Other objectives are to identify major contributors to system unreliability, significant potential human errors and common-cause failure modes.

The scope of this analysis is limited to Generator equipment required to support a Keowee emergency start and run under load following a loss of offsite power event.

A.7.2 SYSTEM DESIGN

The Keowee Hydroelectric Station contains two vertical waterwheel driven electric generators rated at 87.5 MVA at a voltage of 13.8 kV. The generators are salient pole synchronous machines that operate at a speed of 128.6 rpm. A totally enclosed ventilation system with air to water heat exchangers removes the heat produced by the generator. The generators are of the "umbrella" design which utilizes a combined thrust and guide bearing located below the rotor. The bearings are completely submerged in an oil bath which both lubricates and cools the bearings. Heat is removed from the oil pot by water cooled heat exchangers.

A simplified diagram showing the generator with its major components is provided in Figure A.7-1. The following paragraphs briefly describe the major components of the generator.

High Pressure Oil Lift System

The generator is equipped with a high pressure oil lift system which provides a positive oil film between the thrust bearing shoes and the runner during starting and stopping. However, this oil lift function is not required during an emergency start of the unit and once the unit begins operation, the bearings are self lubricating. A simplified diagram of the high pressure oil lift system is shown in Figure A.7-2.

Ventilation System

The cooling air circulation pattern for the generator is shown in Figure A.7-1. The air discharged from the surface air coolers is drawn upward into the upper bracket area of the unit. The air circulation is achieved by paddle type blowers mounted on the top and bottom of the rotor. The air from the upper bracket passes directly into the main machine just behind the rotor rim from the top and bottom of the rotor. The entire air volume passes over the field copper of the rotor and into the vent ducts of the stator. To complete the ventilation cycle, the air discharges into the frame behind the stator core and again passes through the surface air coolers.

The generator is supplied with six water to air coolers evenly spaced about the generator enclosure which are capable of removing the heat due to machine losses to the air. The coolers are of the multipass type with air flow counter-current to the water flow. The cooling water is supplied by the Turbine Generator Cooling Water System (WL). The cooling water flow paths and valve arrangements are shown in Figure A.7-3.

Thrust and Guide Bearings

The generator has a flat pad, pivoted Kingsbury type bearing. The shoes of the bearing assembly are made of steel plate finished on the surface so that the babbit may be metallurgically bonded to the surface of the shoes. These shoes are capable of supporting the weight of the rotating parts of the unit and the external thrust created by the unit as it operates. Operating in conjunction with the thrust bearing is a segmental shoe type guide bearing. The guide bearing shoes are mounted on a shoe support ring and are properly positioned radially by means of individual jack screws.

Lubrication of the bearings is provided by completely submerging the thrust and guide bearing assemblies in an oil bath. The oil is kept at a safe operating temperature by means of cooling coils within the oil pot. Cooling water to the coils is provided by the WL system. The bearing oil cooling flow path and associated valves are shown in Figure A.7-4.

Fire Protection Equipment

The generator is protected from fires by a carbon dioxide fire protection system, which consists of initial and delayed discharge nozzles and thermostats located around the generator. In order to provide relief to prevent excessive pressure build-up within the air housing during CO2 discharge, two doors in the upper bracket top deck serve as weight loaded CO2 relief doors. The weight of each door is sufficient to maintain tight closure in normal operation. A pressure sensor in each CO2 discharge line will lockout the generator upon CO2 discharge. A simplified flow diagram of the generator fire protection system is shown in Figure A.7-5.

Brake and Jack System

The generator also has a combination air brake/oil jack system. The brakes have individually renewable wearing surfaces which operate against a segmental, renewable steel brake ring. Using compressed air, the brakes are used to slow and stop the unit during shutdown. The brake assemblies also serve as hydraulic jacks which can be used during maintenance to lift the entire rotor at least one inch.

Protective Relays

Keowee has three types of lockout relays. They are referred to as "emergency lockout," "normal lockout," and "alarm lockout" relays and are denoted by 86E, 86N and 30X respectively. The emergency lockout relay (86E) will prevent the Keowee unit from starting in either normal or emergency mode and trip the unit if it is running in either mode. The normal lockout relay (86N) will prevent the Keowee unit from starting in normal mode. It will not prevent an emergency start. This relay will also trip the unit if running in normal mode, not emergency mode. The alarm lockout relay (30X) will prevent the Keowee unit from starting in normal mode. It will not prevent an emergency start. This relay will not trip the unit if it is already running. Only the emergency lockout relay function and the relays that actuate it are modeled in the generator fault tree model.

A.7.3 SYSTEM BOUNDARIES

Turbine Generator Cooling Water System

Cooling water to the Generator air coolers and the Generator thrust bearing oil coolers is provided by the Turbine Generator Cooling Water (WL) System. A significant portion of the WL system supports the generator only, and has been incorporated into the "generator" model. This includes the air coolers, the oil coolers and their associated isolation and drain valves. Figure A.7-3 and A.7-4 show the WL components modeled in the generator model. The rest of the WL System is covered in the WL model and is described in Appendix A.14.

Generator Excitation

The Generator Excitation System supplies dc voltage to the generator field coils. The Generator Excitation System model is described in Appendix A.6.

Air Circuit Breakers

Output of the generator is supplied to the 13.8 kV bus through the Air Circuit Breakers. The Air Circuit Breaker model is described in Appendix A.4

A.7.4 INSTRUMENTATION AND CONTROLS

There are no control functions associated with the actual generator of the Keowee Hydro Station. All control functions are provided through other systems such as the governor, exciter and voltage regulator systems. Instrumentation associated with the generator primarily monitors temperature, cooling water flow, and thrust bearing oil level. Protective trips are provided for fire protection actuation, bus differential voltage, generator ground faults, and high or low bearing oil level. Control room statalarms associated with the generator are listed in Table A.7-5.

A.7.5 LOCATION WITHIN THE PLANT

The Keowee generators are located within the generator enclosures which are between the operating floor and the turbine pit.

A.7.6 NORMAL OPERATION

During normal operation, the Keowee generators are rated at 87.5 MVA at a voltage of 13.8 kV, and operate at a speed of 128.6 rpm. The totally enclosed ventilation system with air to water heat exchangers removes the heat produced by generating electricity. The generators are run on a combined thrust and guide bearing located below the rotor. The bearings are completely submerged in an oil bath which both lubricates and cools the bearings. Heat is removed from the oil pot by water cooled heat exchangers.

A.7.7 PERFORMANCE DURING KEOWEE EMERGENCY OPERATION

Keowee Generator operation is the same during normal and emergency operation. However, during an emergency start or run, the normal lockout relay will not prevent a start or trip a running unit.

A.7.8 TEST AND MAINTENANCE

Testing

The Keowee Generator testing requirements are detailed in Table A.7-1.

Maintenance

The Keowee Generator maintenance requirements are listed in Table A.7-2.

A.7.9 OPERATING EXPERIENCE

A summary of significant operating events is provided in Table A.7-3. Three of these events were considered to represent failures that would have resulted in failure of the generator during emergency operation. These were the Unit 2 generator fault that occurred on 11/19/85, the Unit 2 fault that occurred on 12/2/92, and the Unit 2 accidental actuation of the generator CO2 fire suppression system on 7/24/86.

A.7.10 ASSUMPTIONS

A.7.10.1 SYSTEM DESIGN ASSUMPTIONS

1. The High Pressure Oil System is not required during an emergency start. The generator bearings are self lubricating as long as adequate oil level is maintained.

2. To prevent generator failure due to over heating, all six generator air coolers are required to be functioning with full WL flow.

3. To prevent generator failure due to bearing lubrication failure, all eight bearing oil coolers are required to be functioning with full WL flow.

A.7.10.2 OPERATIONAL ASSUMPTIONS

1. It is assumed that the Unit 1 generator is assigned to the underground path, and the Unit 2 generator is assigned to the overhead path. It is also assumed that Unit 2 is operated daily. These assumptions are important when assigning exposure times for the calculation of failure probabilities.

2. Failures of components that would result in a control room alarm need not be modeled as a failure of the generator to start. Failures of this type would alert the operators of a problem and the unit would be declared inoperable.

A.7.10.3 MODELING ASSUMPTIONS

1. The High Pressure Oil System is not required during an emergency start. The generator bearings are self lubricating as long as adequate oil level is maintained. However, if the High Pressure Oil system were to leak, proper oil level could not be maintained and the generator would fail due to inadequate bearing lubrication. Therefore, the High Pressure Oil system must remain leak tight during the running of the Keowee generator.

2. The generator braking system is used to slow the generator following a unit shutdown. However, the braking system does not have adequate resistance to

prevent the starting or running of the generator. Therefore, spurious actuation of the braking system need not be modeled.

3. If the Generator CO2 Fire Protection system were to spuriously actuate, a generator emergency lockout would occur. Since the CO2 system is self contained, spurious actuation will be treated as an undeveloped event. The exception will be the pressure sensor and relay in the CO2 discharge line that generates the generator emergency lockout signal. These two components will be explicitly modeled.

4. Failures of components that would result in a control room alarm need not be modeled as a failure of the generator to start. Failures of this type would alert the operators of a problem and the unit would be declared inoperable. These type failures are already captured by the maintenance or testing basic event. However, these failures should be modeled as a cause of a generator run failure. Examples of this type of component are spurious or actual high generator bearing oil level, or spurious operation of any of the generator lockout relays.

5. If a generator air cooler should leak or if there is a failure of the cooler drain valves, water from the WL system could leak into the generator enclosure. It is assumed that this would result in failure of the generator.

6. It is possible that the generator enclosure space heaters may be spuriously actuated and overheat the generator and its enclosure . Since the generator coolers operate only while the unit is running, they would not remove the heat produced by the heaters. This could lead to actuation of the generator fire suppression system, which would cause a generator lockout and prevent an emergency start of the unit. However, the likelihood of the coincident spurious actuation of the heaters and the need for Keowee to emergency start is very low. Additionally, generator stator high temperature is alarmed and would alert the Keowee operator of problems prior to initiation of the CO2 fire suppression system. Therefore, spurious actuation of the generator enclosure space heaters will not be modeled as a failure mode for the generator failing to start.

7. It is not necessary to model the inadvertent actuation of the space heaters as a way to fail the generator while running. The generator enclosure space heaters produce

a small fraction of the heat produced by the generator while running. The generator coolers could easily remove the small amount of excess heat produced by the heaters.

8. It is assumed that the weekly test will uncover the failures that result in water leaking into the generator compartment (i.e. some valve transfers and heat exchanger leaks).

9. It is assumed that the weekly test is not of sufficient duration to detect those failure that would result in eventual generating overheating (e.g. cooling water valve transfers).

A.7.11 FAULT TREE ANALYSIS

A.7.11.1 TOP EVENT SUCCESS CRITERIA

Success of the Keowee Generator requires that:

- One of the two Keowee Generators starts and supplies adequate power to the Oconee station for twenty-four hours following a loss of offsite power.

- To prevent generator failure due to overheating, all six generator air coolers are required to be functioning with full WL flow. Therefore, failure of any one of the coolers, or failure of any one of the manual valves in the cooler flow path will result in inadequate cooling and failure of the generator.

- To prevent generator failure due to bearing lubrication failure, all eight bearing oil coolers are required to be functioning with full WL flow. Therefore, failure of any of the bearing oil coolers, or failure of any one of the manual valves in the cooler flow path will result in inadequate cooling of the bearing oil and failure of the generator.

A.7.11.2 DETAILED FAILURE CRITERIA

1. Actuation of any of the relays that cause "Emergency Lockout" will cause the generator to trip.

2. Spurious actuation of the generator fire suppression system will cause an "Emergency Lockout" and trip the operating unit.

3. Failure to cool the generator enclosure will result in overheating and either failure or trip of the unit.

4. Loss of the generator bearing oil will result in trip or failure of the generator. Also, failure to cool the generator bearing oil will result in failure of the generator.

5. A cooling water leak in the generator enclosure will result in failure of the generator.

6. The generator will not start if the neutral ground disconnect is open.

A.7.11.3 DESCRIPTION OF FAULT TREE

The Keowee Generator fault tree is shown in Figure A.7-6. The Keowee Generator fault tree contains four top events which serve as transfer points for the Keowee top logic model described in Appendix A.1. The top events of the generator fault tree are:

KU1GENCLD	Keowee Unit 1 Generator Fails During Cold Start
KU2GENCLD	Keowee Unit 2 Generator Fails During Cold Start
KU1GENRUN	Keowee Unit 1 Generator Fails While the Unit Runs
KU2GENRUN	Keowee Unit 2 Generator Fails While the Unit Runs

The Fault Tree Modeling Guidelines (Appendix B) were followed in developing the fault tree. A list of all fault tree transfers is presented in Table A.7-4. Modules were not developed for the Keowee fault trees.

Human reliability analysis was performed as described in Section 5.5 and Appendix C.3. Human events impacting the model are described in Section A.7.11.4.

Common-cause analysis was performed as described in Section 5.4 and Appendix C.2. Common-cause events impacting the model are described in Section A.7.11.6.

A.7.11.4 HUMAN INTERACTIONS

Human actions by the maintenance technicians and operators can adversely affect Keowee Generator reliability. Those events explicitly included in the system fault tree are discussed below.

GK1BRGVLHE, GK2BRGVLHE

These basic events account for the potential of the maintenance technicians to fail to properly restore the Generator Thrust Bearing Cooler isolation valves following maintenance. These valves are repositioned during maintenance on the thrust bearing heat exchangers. Post-maintenance testing is expected to detect the majority of errors. However, since the coolers would not be required until the generator is operating, there is a possibility that a latent human error could exist that will not be discovered until an emergency start is required.

These events were assigned a value of 2.6E-4 based on Figure C.3-1.

GK1COOLLHE, GK1COOLLHE

These basic events account for the potential of the maintenance technicians to fail to properly restore the generator air cooler isolation valves following maintenance or testing. These valves are repositioned during maintenance on the generator air cooler heat exchangers. Post-maintenance testing is expected to detect the majority of errors. However, since the generator coolers would not be required until the generator is operating, there is a possibility that a latent human error could exist that will not be discovered until an emergency start is required.

These events were assigned a value of 2.6E-4 based on Figure C.3-2.

GK1NGDCLHE, GK2NGDCLHE

These events represent a failure to close the neutral ground disconnects following maintenance or testing. These disconnects are opened and tagged per the procedures to remove the generators from service (OP/0/A/2000/13 and OP/0/A/2000/14 for Units 1 and 2 respectively). These procedures include independent verification, and include a post-maintenance operability verification.

During quantification of this event, credit was taken for the tag clearing being another level of verification.

These events were assigned a value of 5.2E-5 based on Figure C.3-3.

A.7.11.5 RELIABILITY DATA

Significant events associated with the Keowee Generators are listed in Table A.7-3. Two of these events were considered to represent failures that would have resulted in failure during emergency operation of the Keowee station. These were the Unit 2 generator fault that occurred on 11/19/85 and the Unit 2 fault that occurred on 12/2/92. An additional event, the Unit 2 accidental actuation of the generator CO2 fire suppression system on 7/24/86, would have resulted in a failure, but was associated with a human error rather than equipment failure. This event was considered as a potential error of commission but was screened out because of the low likelihood of allowing maintenance on the fire protection system during a loss of power event.

Section 5.3 of the main report discusses development of the reliability data. For the base case solution, the plant-specific failure rate data and generic failure rate data were combined using a Bayesian update.

There are three basic events in the generator model which do not represent failure of a component, but instead represent "undeveloped events." These are, AB1FALTDEX, GK1FIREDEX, and GK2FIREDEX.

AB1FALTDEX, Fault Occurs at ACB 1

This event represents the probability that a fault will occur on ACB1 when the unit has been operating on the grid. The probability of this event is set to zero for the

base case solution, since the underground unit is not allowed to generate to the grid. There have been no observed faults on any of the ACBs during the operating history of Keowee. Therefore, for sensitivity studies associated with operating the underground unit to the grid, the probability of AB1FALTDEX is calculated as follows;

AB1FALTDEX = .455/[2*(open and close demands)]
= .455/[2*(2*(Unit 1 Starts + Unit 2 Starts))]
= .455/[2*(2*(3390+3098))]
= 1.75E-5/demand

<u>GK1FIREDEX (GK2FIREDEX), Spurious Actuation of Unit 1 (Unit 2) Gen. CO2 Fire Suppression System</u>

This event represents the spurious action of the generator CO2 fire suppression system. It is intended to represent the combination of any failures that would cause discharge of the CO2 which would cause an Emergency Lockout. This would include instrumentation and control failures or valves which could transfer open. Not included are the pressure sensor in the CO2 discharge line or the generator fire relay, which are explicitly modeled. As described above, there has been one inadvertent actuation of the CO2 system, however this event was due to human error and was treated as a potential error of commission. Therefore, there have been no spurious actuations of the CO2 system during the operating history of Keowee and the probability of this undeveloped event is calculated as follows;

GK1FIREDEX = 24 Hours*.455/[2(Unit 1 Avail. Hrs + Unit 2 Avail. Hrs)]
= 24 * .455/[2(85,755 + 85,657)]
= 3.19E-5

As discussed in Section 5.3, consideration of relevant statalarms is part of the process of determining each basic event factor. Keowee Generator statalarms are listed in Table A.7-5.

System reliability data is listed in Table A.7-6.

A.7.11.6 COMMON-CAUSE ASSESSMENT

Common cause failures associated with the Keowee Generator are represented in the high-level fault tree by events :

GK0COOLCOM	Common Cause Failure of Generator Air Cooling
GK0LOCKCOM	Common Cause Actuation of Generator Lockouts
GKHPOILCOM	Common Cause Failure of Generator Thrust Bearings

Detailed descriptions of these events and their quantification are included in Appendix C.2.

A.7.12 RESULTS

Reliability of the Keowee Generator is defined as the probability that the system will succeed in supporting Keowee emergency operation (black start plus a 24 hour run). The Keowee Generator Unit 1 model yields a failure to start probability of approximately 2.06E-04 and a failure to run probability of approximately 4.09E-3. The Keowee Generator Unit 2 model yields a failure to start probability of approximately 2.06E-04 and a failure to run probability of approximately 3.22E-3. Thus the reliability of the Keowee Generators to start and run for the required mission time are computed to be :

Unit 1	99.57%
Unit 2	99.66%

Tables A.7-7 through A.7-9 list the dominant minimal cut sets (failure sequences) for the Keowee Generators. Lists of dominant contributors to unavailability are shown in Tables A.7-10 through A.7-12. The dominant contributors to the unavailability of the Keowee Generators are generator faults, followed by latent human errors associated with restoring the generator following maintenance or testing.

A.7.13 REFERENCES

A.7.13.1 DOCUMENTS

1. OP-OC-EL-KGH, Rev. 8, Operations Training Module, Keowee Hydro Generators, 11/1/93.

2. EP-1020-19V, Westinghouse Instruction Manual - Vertical Waterwheel Generator.

A.7.13.2 PROCEDURES

1. IP/1/B/0400/005, Change 2, Moore Model 33 Nullmatic Temperature Transmitter Calibration.

2. IP/1/A/0400/023, Change 1, Unit No. 1 CO2 Fire Protection Pressure Switch Calibration.

3. IP/1/B/0400/003, Change 2, Barton Model 258 Indicating Switch Calibration.

4. MP/0/A/2000/026, Change 8, Weighing CO2 Cylinders.

5. MP/0/A/2000/059, Change 7, Periodic Test of CO2 System Generator No. 1.

6. MP/1/A/2000/019, Change 5, Periodic Inspection of Generator No. 1.

7. MP/0/A/2000/030, Change 4, Generator - Fire Extinguishing System - CO2 Cylinders - Removal and Installation.

8. MP/1/A/2000/017, Change 5, Unit No. 1 Turbine, Governor, and Generator Weekly Preventative Maintenance.

9. MP/1/A/2000/054, Change 2, Cleaning of Generator No. 1.

10. MP/1/A/2200/007, Change 1, Unit No.1 Generator Brake Maintenance.

11. OP/0/A/2000/041, Keowee Modes Of Operation

12. AP/0/A/2000/002, Keowee Hydro Station - Emergency Start

A.7.13.3 DRAWINGS (Unit 1)

1. KEE-11, Rev 5, Elem. Diagram, Generator Controls, Gen #1 CO2 Fire Protection System.

2. KEE-32, Rev 2, Elem. Diagram, Fire Alarm System.

3. KFD-100A-1.1, Rev. 1, Flow Diagram of Turbine Generator Cooling Water System.

4. KFD-103A-1.1, Rev. 1, Flow Diagram of High Pressure Oil System.

5. KEE-106, Rev 3, Tabulation, Statalarm List #1SA1, T-G System Condition Alarm.

6. KEE-106-1, Rev 3, Tabulation, Statalarm List #1SA2, T-G System Running Alarm.

Table A.7-1

Keowee Generator Test Procedures

Procedure	Test Frequency	Description
IP/1/B/0400/005, Moore Model 33 Nullmatic Temperature Transmitter Calibration	Annual	Calibration of Generator Guide Bearing, Generator Thrust Bearing and Generator Bearing Oil Temperature Transmitters
IP/1/A/0400/023, Unit No. 1 CO2 Fire Protection Pressure Switch Calibration	18 Months	Calibration of the Generator CO2 Fire Protection System Pressure Switch
IP/1/B/0400/003, Barton Model 258 Indicating Switch Calibration	Annual	Calibration of Generator Cooling Water Flow Indicator and Generator Thrust Bearing Cooling Water Flow Indacator
MP/0/A/2000/026, Weighing CO2 Cylinders	Semi-Annual	Verify Adequacy of CO2 Weight for Generator CO2 Fire Protection System

Table A.7-1

Keowee Generator Test Procedures

Procedure	Test Frequency	Description
MP/0/A/2000/059, Periodic Test of CO2 System Generator No. 1	18 Months	Verify Operability of Generator CO2 Fire Protection System
MP/1/A/2000/019, Periodic Inspection of Generator No. 1	Quarterly	Inspection and Maintenance of Generator Collector Ring, Brushes, Braking System and Change HP Oil Filter

Table A.7-2

Keowee Generator Maintenance Procedures

Procedure	Test Frequency	Description
MP/0/A/2000/030, Generator - Fire Extinguishing System - CO2 Cylinders - Removal and Installation	As Required	Removal and Installation of Generator Fire Extinguishing System CO2 Cylinders
MP/1/A/2000/017, Unit No. 1 Turbine, Governor, and Generator Weekly Preventative Maintenance	Weekly	Preventive Maintenance and Inspection of the Turbine, Governor and Generator
MP/1/A/2000/054, Cleaning of Generator No. 1	As Required	Preventive Maintenance, Cleaning and Inspection of the Generator
MP/1/A/2200/007, Unit No.1 Generator Brake Maintenance	As Required	Preventive Maintenance and Inspection of the Generator Braking System

Table A.7-3

Keowee Generator Significant Operating Events

Date	Unit	Component	Event Summary
6-15-85	1	Generator Air Brake System. Speed Switch, 14/2.	Oconee received a #1 Generator Air Brake failure alarm. The unit was not running at the time. The problem was determined to be due to mercury speed switch, 14/2 not working properly. The switch was replaced.
11-19-85	2	Generator	Unit 2 was generating to the grid when it received a Normal Lockout due to a Generator Field Ground. The problem was due to the electrical connection between two generator rotor field poles having burned out. The root cause of the burned out connection was believed to be due to vibration.

Table A.7-3

Keowee Generator Significant Operating Events

Date	Unit	Component	Event Summary
7-24-86	2	Generator CO2 Fire Supression System	Received #2 Keowee Emergency Lockout due to CO2 actuation caused by electricians at Oconee performing NSM on Keowee Unit 1 CO2 switches. Event occurred when the wires were lifted for unit one but when testing the switch, the Unit 2 switch was depressed.
8-1-88	2	Generator Cooling Water Flow Indicator Swtich	Unit 2 tripped while generating to the grid due to Generator Cooling Water Alarm lockout. Operator readjusted cooling water flow which seemed to correct the problem.
8-18-88	2	Generator Cooling Water Alarm Circuit. Timer, 63GCAT	Unit 2 tripped while generating to the grid due to Generator Cooling Alarm lockout. Jumpered out 63CT Timer contacts and restarted unit. Replaced 63CT Timer because it had a bad coil.

Table A.7-3

Keowee Generator Significant Operating Events

Date	Unit	Component	Event Summary
12-2-92	2	Generator	Unit 2 started for operability test. The unit tripped by emergency lockout on #2 generator ground fault overcurrent (59GN2). Found nicked wire (53) between 290-1X and 290-4X with a nick in the insulation from a screw used to attach the cover plate of the Voltage Regulator. Problem was caused by I & E technicians as they were completing a Configuration Control Inspection of Safety Related cabinet wiring.

Table A.7-4

Keowee Generator Fault Tree Transfers

Transfer Gate Name	Description	Components Supplied
NTACB4MOD	NSM-ON-52966 Is In Service	Unit 1 Generator Protective Relays
FK1300	WL Fails To Supply Unit 1 Generator Thrust Bearing Cooling	Unit 1 Generator Thrust Bearing Oil Coolers
FK2300	WL Fails To Supply Unit 2 Generator Thrust Bearing Cooling	Unit 2 Generator Thrust Bearing Oil Coolers
FK1400	WL Fails To Supply Unit 1 Generator Air Coolers	Unit 1 Generator Air Coolers
FK2400	WL Fails To Supply Unit 2 Generator Air Coolers	Unit 2 Generator Air Coolers

Table A.7-5

Keowee Unit 1 Generator Statalarms
(Unit 2 Alarms are Similar)

Point No.	Alarm	Actuator
1SA1-31	GEN. #1 BRG OIL LEVEL HIGH	63PL/HX
1SA1-32	GEN. #1 BRG OIL LEVEL LOW	63BL/LX
1SA1-33	GEN. #1 AIR BRAKE PRESS. LOW	63AX
1SA1-34	GEN. #1 CO2 SYS. FAULT	63FTX1
1SA1-35	GEN. #1 FIRE CO2 RELEASE	63FX
1SA1-38	GEN. #1 CO2 ISOLATION VALVES OPEN	NA
1SA1-39	GEN. #1 CO2 ISOLATION VALVES CLOSED	NA
1SA1-40	GEN. NO. 1 FIRE	ZIU-2
1SA2-21	GEN. #1 BRG. OIL TEMP. HIGH	26GBX
1SA2-22	GEN. #1 THRUST BRG. TEMP. HIGH	38B2X
1SA2-23	GEN. #1 GUIDE BRG. TEMP. HIGH	38G2X
1SA2-25	GEN. #1 COOLER WTR. DISC. TEMP. HIGH	30GWX
1SA2-26	GEN. #1 COOLER AIR DISC. TEMP. HIGH	30GAX
1SA2-27	GEN. #1 COOLER WTR. DISC. TEMP. HIGH	63BC/ATX
1SA2-28	GEN. #1 COOLER WATER FLOW FAIL	63GC/ATX
1SA2-29	GEN. #1 GROUND	64FX
1SA2-30	GEN. #1 STATOR TEMP. HIGH	30SX
1SA2-43	GEN. #1 RELAY POTS. VOLTAGE FAIL.	60R
1SA2-44	GEN. #1 METER POTS. VOLTAGE FAIL.	60M
1SA2-2	UNIT NO. 1 NORMAL LOCKOUT	86N-1
1SA2-3	UNIT NO. 1 EMERGENCY LOCKOUT	86E-1

Table A.7-6

Keowee Generator Reliability Data

Event Name	Description	Failure Rate[1]		Factor		Rationale For Factor[2]	Failure Probability
AB1FALTDEX	Fault Occurs at ACB 1						0.0
GK10001HGR	Keowee Unit 1 Generator Fault While the Unit Runs	9.46E-05	/H	24	H	Rule 1: Generates Emergency Lockout Alarm	2.27E-03
GK10001HGS	Keowee Unit 1 Generator Fault Causes Unit Start Failure	1.54E-04	/D	1	D	Chalenged Each Time the Unit Starts	1.54E-04
GK1063FPST	Keowee 1 Gen CO2 Sys Press Switch 63F Spurious Operation	5.30E-07	/H	24	H	Rule 1: Generates Emergency Lockout Alarm and Fire CO2 Release Alarm	1.27E-05
GK112TDRYT	Time Delay Relay 12XTD/1 Spuriously Picks-up	5.20E-07	/H	24	H	Rule 1: Generates Emergency Lockout Alarm	1.25E-05
GK112X1RYT	Relay 12X/1 Spuriously Picks-up	5.20E-07	/H	24	H	Rule 1: Generates Emergency Lockout Alarm	1.25E-05
GK13SUIRYT	Keowee Unit 1 Startup Inhibit Switch Auxiliary Relay S3SUIX Spurious Actuation	5.20E-07	/H	24	H	Rule 1: Generates Emergency Lockout Alarm	1.25E-05
GK13SUISWT	Keowee Unit 1 Startup Inhibit Switch 3SUI Spurious Operation	7.30E-08	/H	24	H	Rule 1: Generates Emergency Lockout Alarm	1.75E-06
GK140G1RYT	Keowee Unit 1 Loss Of Generator Field Relay 40G1 Spurious Actuation	5.20E-07	/H	24	H	Rule 1: Generates Emergency Lockout Alarm	1.25E-05
GK159GNRYT	Keowee Unit 1 Generator Ground Fault Relay 59GN1 Spurious Actuation	5.20E-07	/H	24	H	Rule 1: Generates Emergency Lockout Alarm	1.25E-05
GK162TDRYT	Keowee Unit 1 Generator Backup Trip Timer 62-1TD Spurious Operation	5.20E-07	/H	24	H	Rule 1: Generates Emergency Lockout Alarm	1.25E-05
GK163FXRYT	Keowee Unit 1 Generator Fire Relay 63FX Spurious Actuation	5.20E-07	/H	24	H	Rule 1: Generates Emergency Lockout Alarm	1.25E-05
GK186E1RYT	Keowee 1 Emergency Lockout Relay 86E-1 Spuriously Picks Up	5.20E-07	/H	24	H	Rule 1: Generates Emergency Lockout Alarm	1.25E-05
GK187G1RYT	Keowee Unit 1 Generator Differential Relay 87G-1 Spurious Actuation	5.20E-07	/H	24	H	Rule 1: Generates Emergency Lockout Alarm	1.25E-05
GK187GBRYT	Keowee Unit 1 Generator Bus Differential Relay 87GB Spurious Actuation	5.20E-07	/H	24	H	Rule 1: Generates Emergency Lockout Alarm	1.25E-05

[1] D = Demand, H = Hour

[2] Rules for assigning basic event factors are discussed in Table C.1-4.

Table A.7-6

Keowee Generator Reliability Data

Event Name	Description	Failure Rate[1]		Factor		Rationale For Factor[2]	Failure Probability
GK187TERYT	Keowee Unit 1 Exitation Transformer Differential Relay 87T-1E Spur. Actuation	5.20E-07	/H	24	H	Rule 1: Generates Emergency Lockout Alarm	1.25E-05
GK1BRGVLHE	Keowee 1 Gen. Brng Oil Cooling Flow Path Vlvs Mispositioned After Maintenance						2.60E-04
GK1COOLLHE	Keowee 1 Gen. Air Cooler WL Flow Path Vlvs Mispositioned After Maintenance						2.60E-04
GK1FIREDEX	Spurious Actuation of Unit 1 Gen. CO2 Fire Supression System						7.00E-05
GK1GAC1HXF	Generator Air Cooler 1GAHW-1 Fails	4.40E-07	/H	24	H	Can Only Occur While the Unit is Running	1.06E-05
GK1GAC1HXL	Heat Exchanger 1GAC1 Leaks	2.60E-07	/H	108	H	Rule 6	9.98E-05
GK1GAC2HXF	Generator Air Cooler 1GAHW-2 Fails	4.40E-07	/H	24	H	Can Only Occur While the Unit is Running	1.06E-05
GK1GAC2HXL	Heat Exchanger 1GAC2 Leaks	2.60E-07	/H	108	H	Rule 6	9.98E-05
GK1GAC3HXF	Generator Air Cooler 1GAHW-3 Fails	4.40E-07	/H	24	H	Can Only Occur While the Unit is Running	1.06E-05
GK1GAC3HXL	Heat Exchanger 1GAC3 Leaks	2.60E-07	/H	108	H	Rule 6	9.98E-05
GK1GAC4HXF	Generator Air Cooler 1GAHW-4 Fails	4.40E-07	/H	24	H	Can Only Occur While the Unit is Running	1.06E-05
GK1GAC4HXL	Heat Exchanger 1GAC4 Leaks	2.60E-07	/H	108	H	Rule 6	9.98E-05
GK1GAC5HXF	Generator Air Cooler 1GAHW-5 Fails	4.40E-07	/H	24	H	Can Only Occur While the Unit is Running	1.06E-05
GK1GAC5HXL	Heat Exchanger 1GAC5 Leaks	2.60E-07	/H	108	H	Rule 6	9.98E-05
GK1GAC6HXF	Generator Air Cooler 1GAHW-6 Fails	4.40E-07	/H	24	H	Can Only Occur While the Unit is Running	1.06E-05

1 D = Demand, H = Hour
2 Rules for assigning basic event factors are discussed in Table C.1-4.

Table A.7-6

Keowee Generator Reliability Data

Event Name	Description	Failure Rate[1]		Factor		Rationale For Factor[2]	Failure Probability
GK1GAC6HXL	Heat Exchanger 1GAC6 Leaks	2.60E-07	/H	108	H	Rule 6	9.98E-05
GK1HPO1HXF	Generator Thrust Bearing Cooler 1HPOHX-1 Fails	4.40E-07	/H	24	H	Can Only Occur While the Unit is Running	1.06E-05
GK1HPO2HXF	Generator Thrust Bearing Cooler 1HPOHX-2 Fails	4.40E-07	/H	24	H	Can Only Occur While the Unit is Running	1.06E-05
GK1HPO3HXF	Generator Thrust Bearing Cooler 1HPOHX-3 Fails	4.40E-07	/H	24	H	Can Only Occur While the Unit is Running	1.06E-05
GK1HPO4HXF	Generator Thrust Bearing Cooler 1HPOHX-4 Fails	4.40E-07	/H	24	H	Can Only Occur While the Unit is Running	1.06E-05
GK1HPO5HXF	Generator Thrust Bearing Cooler 1HPOHX-5 Fails	4.40E-07	/H	24	H	Can Only Occur While the Unit is Running	1.06E-05
GK1HPO6HXF	Generator Thrust Bearing Cooler 1HPOHX-6 Fails	4.40E-07	/H	24	H	Can Only Occur While the Unit is Running	1.06E-05
GK1HPO6VVT	Genrator Bearing Oil Leak Because Manual Valve 1HPO-6 Transfers Position	1.60E-08	/H	24	H	Rule 1: Generates an Emergency Lockout Alrm and Brg. Oil Level Low Alarm	3.84E-07
GK1HPO7HXF	Generator Thrust Bearing Cooler 1HPOHX-7 Fails	4.40E-07	/H	24	H	Can Only Occur While the Unit is Running	1.06E-05
GK1HPO8HXF	Generator Thrust Bearing Cooler 1HPOHX-8 Fails	4.40E-07	/H	24	H	Can Only Occur While the Unit is Running	1.06E-05
GK1NGDCLHE	Failure to Close the Unit 1 Neutral Ground Disconnect Following Maintenance						5.20E-05
GK1O121SST	Speed Switch 12/1 Falsely Indicates High Speed	4.30E-06	/H	24	H	Rule 1: Generates Emergency Lockout Alarm	1.03E-04
GK1WL16VVT	Manual Valve 1WL-16 Transfers Position	1.60E-08	/H	384	H	Rule 6	6.14E-06
GK1WL17VVT	Manual Valve 1WL-17 Transfers Position	1.60E-08	/H	384	H	Rule 6	6.14E-06
GK1WL18VVT	Manual Valve 1WL18 Transfers Position	1.60E-08	/H	108	H	Rule 6	6.14E-06

[1] D = Demand, H = Hour
[2] Rules for assigning basic event factors are discussed in Table C.1-4.

Table A.7-6

Keowee Generator Reliability Data

Event Name	Description	Failure Rate[1]		Factor		Rationale For Factor[2]	Failure Probability
GK1WL19VVT	Manual Valve 1WL19 Transfers Position	1.60E-08	/H	108	H	Rule 6	6.14E-06
GK1WL20VVT	Manual Valve 1WL-20 Transfers Position	1.60E-08	/H	384	H	Rule 6	6.14E-06
GK1WL21VVT	Manual Valve 1WL-21 Transfers Position	1.60E-08	/H	384	H	Rule 6	6.14E-06
GK1WL22VVT	Manual Valve 1WL22 Transfers Position	1.60E-08	/H	108	H	Rule 6	6.14E-06
GK1WL23VVT	Manual Valve 1WL23 Transfers Position	1.60E-08	/H	108	H	Rule 6	6.14E-06
GK1WL24VVT	Manual Valve 1WL-24 Transfers Position	1.60E-08	/H	384	H	Rule 6	6.14E-06
GK1WL25VVT	Manual Valve 1WL-25 Transfers Position	1.60E-08	/H	384	H	Rule 6	6.14E-06
GK1WL26VVT	Manual Valve 1WL26 Transfers Position	1.60E-08	/H	108	H	Rule 6	6.14E-06
GK1WL27VVT	Manual Valve 1WL27 Transfers Position	1.60E-08	/H	108	H	Rule 6	6.14E-06
GK1WL28VVT	Manual Valve 1WL-28 Transfers Position	1.60E-08	/H	384	H	Rule 6	6.14E-06
GK1WL29VVT	Manual Valve 1WL-29 Transfers Position	1.60E-08	/H	384	H	Rule 6	6.14E-06
GK1WL30VVT	Manual Valve 1WL30 Transfers Position	1.60E-08	/H	108	H	Rule 6	6.14E-06
GK1WL31VVT	Manual Valve 1WL31 Transfers Position	1.60E-08	/H	108	H	Rule 6	6.14E-06
GK1WL32VVT	Manual Valve 1WL-32 Transfers Position	1.60E-08	/H	384	H	Rule 6	6.14E-06
GK1WL33VVT	Manual Valve 1WL-33 Transfers Position	1.60E-08	/H	384	H	Rule 6	6.14E-06
GK1WL34VVT	Manual Valve 1WL34 Transfers Position	1.60E-08	/H	108	H	Rule 6	6.14E-06
GK1WL35VVT	Manual Valve 1WL35 Transfers Position	1.60E-08	/H	108	H	Rule 6	6.14E-06
GK1WL36VVT	Manual Valve 1WL-36 Transfers Position	1.60E-08	/H	384	H	Rule 6	6.14E-06
GK1WL37VVT	Manual Valve 1WL-37 Transfers Position	1.60E-08	/H	384	H	Rule 6	6.14E-06

[1] D = Demand, H = Hour
[2] Rules for assigning basic event factors are discussed in Table C.1-4.

Table A.7-6

Keowee Generator Reliability Data

Event Name	Description	Failure Rate[1]		Factor		Rationale For Factor[2]	Failure Probability
GK1WL38VVT	Manual Valve 1WL38 Transfers Position	1.60E-08	/H	108	H	Rule 6	6.14E-06
GK1WL39VVT	Manual Valve 1WL39 Transfers Position	1.60E-08	/H	108	H	Rule 6	6.14E-06
GK1WL41VVT	Keowee 1 Manual Valve 1WL-41 Transfers Position to Block Discharge Path	1.60E-08	/H	384	H	Rule 6	6.14E-06
GK1WL44VVT	Manual Valve 1WL-44 Transfers Position	1.60E-08	/H	384	H	Rule 6	6.14E-06
GK1WL45VVT	Manual Valve 1WL-45 Transfers Position	1.60E-08	/H	384	H	Rule 6	6.14E-06
GK1WL46VVT	Manual Valve 1WL-46 Transfers Position	1.60E-08	/H	108	H	Rule 6	6.14E-06
GK1WL47VVT	Manual Valve 1WL-47 Transfers Position	1.60E-08	/H	108	H	Rule 6	6.14E-06
GK1WL48VVT	Manual Valve 1WL-48 Transfers Position	1.60E-08	/H	384	H	Rule 6	6.14E-06
GK1WL49VVT	Manual Valve 1WL-49 Transfers Position	1.60E-08	/H	384	H	Rule 6	6.14E-06
GK1WL50VVT	Manual Valve 1WL-50 Transfers Position	1.60E-08	/H	108	H	Rule 6	6.14E-06
GK1WL51VVT	Manual Valve 1WL-51 Transfers Position	1.60E-08	/H	108	H	Rule 6	6.14E-06
GK1WL52VVT	Manual Valve 1WL-52 Transfers Position	1.60E-08	/H	384	H	Rule 6	6.14E-06
GK1WL53VVT	Manual Valve 1WL-53 Transfers Position	1.60E-08	/H	384	H	Rule 6	6.14E-06
GK1WL54VVT	Manual Valve 1WL-54 Transfers Position	1.60E-08	/H	108	H	Rule 6	6.14E-06
GK1WL55VVT	Manual Valve 1WL-55 Transfers Position	1.60E-08	/H	108	H	Rule 6	6.14E-06
GK1WL56VVT	Manual Valve 1WL-56 Transfers Position	1.60E-08	/H	384	H	Rule 6	6.14E-06
GK1WL57VVT	Manual Valve 1WL-57 Transfers Position	1.60E-08	/H	384	H	Rule 6	6.14E-06
GK1WL58VVT	Manual Valve 1WL-58 Transfers Position	1.60E-08	/H	108	H	Rule 6	6.14E-06
GK1WL59VVT	Manual Valve 1WL-59 Transfers Position	1.60E-08	/H	108	H	Rule 6	6.14E-06

[1] D = Demand, H = Hour

[2] Rules for assigning basic event factors are discussed in Table C.1-4.

Table A.7-6

Keowee Generator Reliability Data

Event Name	Description	Failure Rate[1]		Factor		Rationale For Factor[2]	Failure Probability
GK1WL60VVT	Manual Valve 1WL-60 Transfers Position	1.60E-08	/H	384	H	Rule 6	6.14E-06
GK1WL61VVT	Manual Valve 1WL-61 Transfers Position	1.60E-08	/H	384	H	Rule 6	6.14E-06
GK1WL62VVT	Manual Valve 1WL-62 Transfers Position	1.60E-08	/H	108	H	Rule 6	6.14E-06
GK1WL63VVT	Manual Valve 1WL-63 Transfers Position	1.60E-08	/H	108	H	Rule 6	6.14E-06
GK1WL64VVT	Manual Valve 1WL-64 Transfers Position	1.60E-08	/H	384	H	Rule 6	6.14E-06
GK1WL65VVT	Manual Valve 1WL-65 Transfers Position	1.60E-08	/H	384	H	Rule 6	6.14E-06
GK1WL66VVT	Manual Valve 1WL-66 Transfers Position	1.60E-08	/H	108	H	Rule 6	6.14E-06
GK1WL67VVT	Manual Valve 1WL-67 Transfers Position	1.60E-08	/H	108	H	Rule 6	6.14E-06
GK1WL68VVT	Manual Valve 1WL-68 Transfers Position	1.60E-08	/H	384	H	Rule 6	6.14E-06
GK1WL69VVT	Manual Valve 1WL-69 Transfers Position	1.60E-08	/H	384	H	Rule 6	6.14E-06
GK1WL70VVT	Manual Valve 1WL-70 Transfers Position	1.60E-08	/H	108	H	Rule 6	6.14E-06
GK1WL71VVT	Manual Valve 1WL-71 Transfers Position	1.60E-08	/H	108	H	Rule 6	6.14E-06
GK1WL72VVT	Manual Valve 1WL-72 Transfers Position	1.60E-08	/H	384	H	Rule 6	6.14E-06
GK1WL73VVT	Manual Valve 1WL-73 Transfers Position	1.60E-08	/H	384	H	Rule 6	6.14E-06
GK1WL74VVT	Manual Valve 1WL-74 Transfers Position	1.60E-08	/H	108	H	Rule 6	6.14E-06
GK1WL75VVT	Manual Valve 1WL-75 Transfers Position	1.60E-08	/H	108	H	Rule 6	6.14E-06
GK1WL76VVT	Manual Valve 1WL76 Transfers Position and Blocks Discharge Path	1.60E-08	/H	384	H	Rule 6	6.14E-06
GK1WL78VVT	Manual Valve 1WL78 Transfers Position and Blocks Discharge Path	1.60E-08	/H	384	H	Rule 6	6.14E-06

1 D = Demand, H = Hour
2 Rules for assigning basic event factors are discussed in Table C.1-4.

Table A.7-6

Keowee Generator Reliability Data

Event Name	Description	Failure Rate[1]		Factor		Rationale For Factor[2]	Failure Probability
GK20001HGR	Keowee Unit 2 Generator Fault While the Unit Runs	9.46E-05	/H	24	H	Rule 1: Generates Emergency Lockout Alarm	2.27E-03
GK20002HGS	Keowee Unit 2 Generator Fault Causes Unit Start Failure	1.54E-04	/D	1	D	Chalenged Each Time the Unit Starts	1.54E-04
GK2063FPST	Keowee 2 Gen CO2 Sys Press Switch 63F Spurious Operation	5.30E-07	/H	24	H	Rule 1: Generates Emergency Lockout Alarm and Fire CO2 Release Alarm	1.27E-05
GK212TDRYT	Time Delay Relay 12XTD/2 Spuriously Picks-up	5.20E-07	/H	24	H	Rule 1: Generates Emergency Lockout Alarm	1.25E-05
GK212X2RYT	Relay 12X/2 Spuriously Picks-up	5.20E-07	/H	24	H	Rule 1: Generates Emergency Lockout Alarm	1.25E-05
GK23SUIRYT	Keowee Unit 2 Startup Inhibit Switch Auxiliary Relay S3SUIX Spurious Actuation	5.20E-07	/H	24	H	Rule 1: Generates Emergency Lockout Alarm	1.25E-05
GK23SUISWT	Keowee Unit 2 Startup Inhibit Swtich 3SUI Spurious Operation	7.30E-08	/H	24	H	Rule 1: Generates Emergency Lockout Alarm	1.75E-06
GK240G1RYT	Keowee Unit 2 Loss Of Generator Field Relay 40G1 Spurious Actuation	5.20E-07	/H	24	H	Rule 1: Generates Emergency Lockout Alarm	1.25E-05
GK259GNRYT	Keowee Unit 2 Generator Ground Fault Relay 59GN2 Spurious Actuation	5.20E-07	/H	24	H	Rule 1: Generates Emergency Lockout Alarm	1.25E-05
GK262TDRYT	Keowee Unit 2 Generator Backup Trip Timer 62-2TD Spurious Operation	5.20E-07	/H	24	H	Rule 1: Generates Emergency Lockout Alarm	1.25E-05
GK263FXRYT	Keowee Unit 2 Generator Fire Relay 63FX Spurious Actuation	5.20E-07	/H	24	H	Rule 1: Generates Emergency Lockout Alarm	1.25E-05
GK286E2RYT	Keowee 2 Emergency Lockout Relay 86E-2 Spuriously Picks Up	5.20E-07	/H	24	H	Rule 1: Generates Emergency Lockout Alarm	1.25E-05
GK287G2RYT	Keowee Unit 2 Generator Differential Relay 87G-2 Spurious Actuation	5.20E-07	/H	24	H	Rule 1: Generates Emergency Lockout Alarm	1.25E-05
GK287GBRYT	Keowee Unit 2 Generator Bus Differential Relay 87GB Spurious Actuation	5.20E-07	/H	24	H	Rule 1: Generates Emergency Lockout Alarm	1.25E-05
GK287TERYT	Keowee Unit 2 Excitation Transformer Differential Relay 87T-2E Spur. Actuation	5.20E-07	/H	24	H	Rule 1: Generates Emergency Lockout Alarm	1.25E-05

1 D = Demand, H = Hour
2 Rules for assigning basic event factors are discussed in Table C.1-4.

Table A.7-6

Keowee Generator Reliability Data

Event Name	Description	Failure Rate[1]		Factor		Rationale For Factor[2]	Failure Probability
GK2BRGVLHE	Keowee 2 Gen. Brng Oil Cooling Flow Path Vlvs Mispositioned After Maintenance						2.60E-04
GK2COOLLHE	Keowee 2 Gen. Air Cooler WL Flow Path Vlvs Mispositioned After Maintenance						2.60E-04
GK2FIREDEX	Spurious Actuation of Unit 2 Gen. CO2 Fire Supression System						7.00E-05
GK2GAC1HXF	Generator Air Cooler 2GAHW-1 Fails	4.40E-07	/H	24	H	Can Only Occur While the Unit is Running	1.06E-05
GK2GAC1HXL	Heat Exchanger 2GAC1 Leaks	2.60E-07	/H	36	H	Rule 6	9.36E-06
GK2GAC2HXF	Generator Air Cooler 2GAHW-2 Fails	4.40E-07	/H	24	H	Can Only Occur While the Unit is Running	1.06E-05
GK2GAC2HXL	Heat Exchanger 2GAC2 Leaks	2.60E-07	/H	36	H	Rule 6	9.36E-06
GK2GAC3HXF	Generator Air Cooler 2GAHW-3 Fails	4.40E-07	/H	24	H	Can Only Occur While the Unit is Running	1.06E-05
GK2GAC3HXL	Heat Exchanger 2GAC3 Leaks	2.60E-07	/H	36	H	Rule 6	9.36E-06
GK2GAC4HXF	Generator Air Cooler 2GAHW-4 Fails	4.40E-07	/H	24	H	Can Only Occur While the Unit is Running	1.06E-05
GK2GAC4HXL	Heat Exchanger 2GAC4 Leaks	2.60E-07	/H	36	H	Rule 6	9.36E-06
GK2GAC5HXF	Generator Air Cooler 2GAHW-5 Fails	4.40E-07	/H	24	H	Can Only Occur While the Unit is Running	1.06E-05
GK2GAC5HXL	Heat Exchanger 2GAC5 Leaks	2.60E-07	/H	36	H	Rule 6	9.36E-06
GK2GAC6HXF	Generator Air Cooler 2GAHW-6 Fails	4.40E-07	/H	24	H	Can Only Occur While the Unit is Running	1.06E-05
GK2GAC6HXL	Heat Exchanger 2GAC6 Leaks	2.60E-07	/H	36	H	Rule 6	9.36E-06

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2 Rules for assigning basic event factors are discussed in Table C.1-4.

Table A.7-6

Keewee Generator Reliability Data

Event Name	Description	Failure Rate[1]		Factor		Rationale For Factor[2]	Failure Probability
GK2HPO1HXF	Generator Thrust Bearing Cooler 2HPOHX-1 Fails	4.40E-07	/H	24	H	Can Only Occur While the Unit is Running	1.06E-05
GK2HPO2HXF	Generator Thrust Bearing Cooler 2HPOHX-2 Fails	4.40E-07	/H	24	H	Can Only Occur While the Unit is Running	1.06E-05
GK2HPO3HXF	Generator Thrust Bearing Cooler 2HPOHX-3 Fails	4.40E-07	/H	24	H	Can Only Occur While the Unit is Running	1.06E-05
GK2HPO4HXF	Generator Thrust Bearing Cooler 2HPOHX-4 Fails	4.40E-07	/H	24	H	Can Only Occur While the Unit is Running	1.06E-05
GK2HPO5HXF	Generator Thrust Bearing Cooler 2HPOHX-5 Fails	4.40E-07	/H	24	H	Can Only Occur While the Unit is Running	1.06E-05
GK2HPO6HXF	Generator Thrust Bearing Cooler 2HPOHX-6 Fails	4.40E-07	/H	24	H	Can Only Occur While the Unit is Running	1.06E-05
GK2HPO6VVT	Genrator Bearing Oil Leak Because Manual Valve 2HPO-6 Transfers Position	1.60E-08	/H	24	H	Rule 1: Generates an Emergency Lockout Alrm and Brg. Oil Level Low Alarm	3.84E-07
GK2HPO7HXF	Generator Thrust Bearing Cooler 2HPOHX-7 Fails	4.40E-07	/H	24	H	Can Only Occur While the Unit is Running	1.06E-05
GK2HPO8HXF	Generator Thrust Bearing Cooler 2HPOHX-8 Fails	4.40E-07	/H	24	H	Can Only Occur While the Unit is Running	1.06E-05
GK2NGDCLHE	Failure to Close the Unit 2 Neutral Ground Disconnect Following Maintenance						5.20E-05
GK2O121SST	Speed Switch 12/2 Falsely Indicates High Speed	4.30E-06	/H	24	H	Rule 1: Generates Emergency Lockout Alarm	1.03E-04
GK2WL16VVT	Manual Valve 2WL-16 Transfers Position	1.60E-08	/H	36	H	Rule 6	5.76E-07
GK2WL17VVT	Manual Valve 2WL-17 Transfers Position	1.60E-08	/H	36	H	Rule 6	5.76E-07
GK2WL18VVT	Manual Valve 2WL18 Transfers Position	1.60E-08	/H	36	H	Rule 6	5.76E-07
GK2WL19VVT	Manual Valve 2WL19 Transfers Position	1.60E-08	/H	36	H	Rule 6	5.76E-07

[1] D = Demand, H = Hour

[2] Rules for assigning basic event factors are discussed in Table C.1-4.

Table A.7-6

Keowee Generator Reliability Data

Event Name	Description	Failure Rate[1]		Factor		Rationale For Factor[2]	Failure Probability
GK2WL20VVT	Manual Valve 2WL-20 Transfers Position	1.60E-08	/H	36	H	Rule 6	5.76E-07
GK2WL21VVT	Manual Valve 2WL-21 Transfers Position	1.60E-08	/H	36	H	Rule 6	5.76E-07
GK2WL22VVT	Manual Valve 2WL22 Transfers Position	1.60E-08	/H	36	H	Rule 6	5.76E-07
GK2WL23VVT	Manual Valve 2WL23 Transfers Position	1.60E-08	/H	36	H	Rule 6	5.76E-07
GK2WL24VVT	Manual Valve 2WL-24 Transfers Position	1.60E-08	/H	36	H	Rule 6	5.76E-07
GK2WL25VVT	Manual Valve 2WL-25 Transfers Position	1.60E-08	/H	36	H	Rule 6	5.76E-07
GK2WL26VVT	Manual Valve 2WL26 Transfers Position	1.60E-08	/H	36	H	Rule 6	5.76E-07
GK2WL27VVT	Manual Valve 2WL27 Transfers Position	1.60E-08	/H	36	H	Rule 6	5.76E-07
GK2WL28VVT	Manual Valve 2WL-28 Transfers Position	1.60E-08	/H	36	H	Rule 6	5.76E-07
GK2WL29VVT	Manual Valve 2WL-29 Transfers Position	1.60E-08	/H	36	H	Rule 6	5.76E-07
GK2WL30VVT	Manual Valve 2WL30 Transfers Position	1.60E-08	/H	36	H	Rule 6	5.76E-07
GK2WL31VVT	Manual Valve 2WL31 Transfers Position	1.60E-08	/H	36	H	Rule 6	5.76E-07
GK2WL32VVT	Manual Valve 2WL-32 Transfers Position	1.60E-08	/H	36	H	Rule 6	5.76E-07
GK2WL33VVT	Manual Valve 2WL-33 Transfers Position	1.60E-08	/H	36	H	Rule 6	5.76E-07
GK2WL34VVT	Manual Valve 2WL34 Transfers Position	1.60E-08	/H	36	H	Rule 6	5.76E-07
GK2WL35VVT	Manual Valve 2WL35 Transfers Position	1.60E-08	/H	36	H	Rule 6	5.76E-07
GK2WL36VVT	Manual Valve 2WL-36 Transfers Position	1.60E-08	/H	36	H	Rule 6	5.76E-07
GK2WL37VVT	Manual Valve 2WL-37 Transfers Position	1.60E-08	/H	36	H	Rule 6	5.76E-07
GK2WL38VVT	Manual Valve 2WL38 Transfers Position	1.60E-08	/H	36	H	Rule 6	5.76E-07

[1] D = Demand, H = Hour
[2] Rules for assigning basic event factors are discussed in Table C.1-4.

Table A.7-6

Keowee Generator Reliability Data

Event Name	Description	Failure Rate[1]		Factor		Rationale For Factor[2]	Failure Probability
GK2WL39VVT	Manual Valve 2WL39 Transfers Position	1.60E-08	/H	36	H	Rule 6	5.76E-07
GK2WL41VVT	Keowee 2 Manual Valve 2WL-41 Transfers Position to Block Discharge Path	1.60E-08	/H	36	H	Rule 6	5.76E-07
GK2WL44VVT	Manual Valve 2WL-44 Transfers Position	1.60E-08	/H	36	H	Rule 6	5.76E-07
GK2WL45VVT	Manual Valve 2WL-45 Transfers Position	1.60E-08	/H	36	H	Rule 6	5.76E-07
GK2WL46VVT	Manual Valve 2WL-46 Transfers Position	1.60E-08	/H	36	H	Rule 6	5.76E-07
GK2WL47VVT	Manual Valve 2WL-47 Transfers Position	1.60E-08	/H	36	H	Rule 6	5.76E-07
GK2WL48VVT	Manual Valve 2WL-48 Transfers Position	1.60E-08	/H	36	H	Rule 6	5.76E-07
GK2WL49VVT	Manual Valve 2WL-49 Transfers Position	1.60E-08	/H	36	H	Rule 6	5.76E-07
GK2WL50VVT	Manual Valve 2WL-50 Transfers Position	1.60E-08	/H	36	H	Rule 6	5.76E-07
GK2WL51VVT	Manual Valve 2WL-51 Transfers Position	1.60E-08	/H	36	H	Rule 6	5.76E-07
GK2WL52VVT	Manual Valve 2WL-52 Transfers Position	1.60E-08	/H	36	H	Rule 6	5.76E-07
GK2WL53VVT	Manual Valve 2WL-53 Transfers Position	1.60E-08	/H	36	H	Rule 6	5.76E-07
GK2WL54VVT	Manual Valve 2WL-54 Transfers Position	1.60E-08	/H	36	H	Rule 6	5.76E-07
GK2WL55VVT	Manual Valve 2WL-55 Transfers Position	1.60E-08	/H	36	H	Rule 6	5.76E-07
GK2WL56VVT	Manual Valve 2WL-56 Transfers Position	1.60E-08	/H	36	H	Rule 6	5.76E-07
GK2WL57VVT	Manual Valve 2WL-57 Transfers Position	1.60E-08	/H	36	H	Rule 6	5.76E-07
GK2WL58VVT	Manual Valve 2WL-58 Transfers Position	1.60E-08	/H	36	H	Rule 6	5.76E-07
GK2WL59VVT	Manual Valve 2WL-59 Transfers Position	1.60E-08	/H	36	H	Rule 6	5.76E-07
GK2WL60VVT	Manual Valve 2WL-60 Transfers Position	1.60E-08	/H	36	H	Rule 6	5.76E-07

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2 Rules for assigning basic event factors are discussed in Table C.1-4.

Table A.7-6

Keowee Generator Reliability Data

Event Name	Description	Failure Rate[1]		Factor		Rationale For Factor[2]	Failure Probability
GK2WL61VVT	Manual Valve 2WL-61 Transfers Position	1.60E-08	/H	36	H	Rule 6	5.76E-07
GK2WL62VVT	Manual Valve 2WL-62 Transfers Position	1.60E-08	/H	36	H	Rule 6	5.76E-07
GK2WL63VVT	Manual Valve 2WL-63 Transfers Position	1.60E-08	/H	36	H	Rule 6	5.76E-07
GK2WL64VVT	Manual Valve 2WL-64 Transfers Position	1.60E-08	/H	36	H	Rule 6	5.76E-07
GK2WL65VVT	Manual Valve 2WL-65 Transfers Position	1.60E-08	/H	36	H	Rule 6	5.76E-07
GK2WL66VVT	Manual Valve 2WL-66 Transfers Position	1.60E-08	/H	36	H	Rule 6	5.76E-07
GK2WL67VVT	Manual Valve 2WL-67 Transfers Position	1.60E-08	/H	36	H	Rule 6	5.76E-07
GK2WL68VVT	Manual Valve 2WL-68 Transfers Position	1.60E-08	/H	36	H	Rule 6	5.76E-07
GK2WL69VVT	Manual Valve 2WL-69 Transfers Position	1.60E-08	/H	36	H	Rule 6	5.76E-07
GK2WL70VVT	Manual Valve 2WL-70 Transfers Position	1.60E-08	/H	36	H	Rule 6	5.76E-07
GK2WL71VVT	Manual Valve 2WL-71 Transfers Position	1.60E-08	/H	36	H	Rule 6	5.76E-07
GK2WL72VVT	Manual Valve 2WL-72 Transfers Position	1.60E-08	/H	36	H	Rule 6	5.76E-07
GK2WL73VVT	Manual Valve 2WL-73 Transfers Position	1.60E-08	/H	36	H	Rule 6	5.76E-07
GK2WL74VVT	Manual Valve 2WL-74 Transfers Position	1.60E-08	/H	36	H	Rule 6	5.76E-07
GK2WL75VVT	Manual Valve 2WL-75 Transfers Position	1.60E-08	/H	36	H	Rule 6	5.76E-07
GK2WL76VVT	Manual Valve 2WL76 Transfers Position and Blocks Discharge Path	1.60E-08	/H	36	H	Rule 6	5.76E-07
GK2WL78VVT	Manual Valve 2WL78 Transfers Position and Blocks Discharge Path	1.60E-08	/H	36	H	Rule 6	5.76E-07

1 D = Demand, H = Hour

2 Rules for assigning basic event factors are discussed in Table C.1-4.

Table A.7-7

Keeowee Generator Dominant Minimal Cut Sets

Cut Sets for Gates KU1GENCLD/KU2GENCLD - Keowee Unit 1/2 Generator Fails During Cold Start

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
KU1GENCLD - Keowee Unit 1 Generator Fails During A Cold Start					
1)	1.54E-04	74.8%	GK10001HGS	1.54E-04	Keowee Unit 1 Generator Fault Causes Unit Start Failure
2)	5.20E-05	25.2%	GK1NGDCLHE	5.20E-05	Failure to Close the Unit 1 Neutral Ground Disconnect Following
Total Event Probability = 2.06E-04					
KU2GENCLD - Keowee Unit 2 Generator Fails During A Cold Start					
1)	1.54E-04	74.8%	GK20002HGS	1.54E-04	Keowee Unit 2 Generator Fault Causes Unit Start Failure
2)	5.20E-05	25.2%	GK2NGDCLHE	5.20E-05	Failure to Close the Unit 2 Neutral Ground Disconnect Following Maintena
Total Event Probability = 2.06E-04					

Table A.7-8

Keewee Generator Dominant Minimal Cut Sets

Cut Sets for Gate KU1GENRUN - Keowee Unit 1 Generator Fails While the Unit Runs

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
1)	2.27E-03	66.0%	GK10001HGR	2.27E-03	Keowee Unit 1 Generator Fault While the Unit Run
2)	2.60E-04	7.6%	GK1BRGVLHE	2.60E-04	Keowee 1 Gen. Brng Oil Cooling Flow Path Vlvs Mi
3)	2.60E-04	7.6%	GK1COOLLHE	2.60E-04	Keowee 1 Gen. Air Cooler WL Flow Path Vlvs Mispo

Total Event Probability = 3.44E-03

Table A.7-9

Keowee Generator Dominant Minimal Cut Sets

Cut Sets for Gate KU2GENRUN - Keowee Unit 2 Generator Fails While the Unit Runs

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
1)	2.27E-03	70.5%	GK20001HGR	2.27E-03	Keowee Unit 2 Generator Fault While the Unit Runs
2)	2.60E-04	8.1%	GK2BRGVLHE	2.60E-04	Keowee 2 Gen. Brng Oil Cooling Flow Path Vlvs Mispositioned After Mainte
3)	2.60E-04	8.1%	GK2COOLLHE	2.60E-04	Keowee 2 Gen. Air Cooler WL Flow Path Vlvs Mispositioned After Maint
4)	7.00E-05	2.2%	GK2FIREDEX	7.00E-05	Spurious Actuation of Unit 2 Gen. CO2 Fire Supression System

Total Probability = 3.22E-03

Table A.7-10

Keeowee Generator Dominant Contributors To Unavailability
For Gates KU1GENCLD/KU2GENCLD - Keowee Unit 1/2 Generator Fails During Cold Start

Rank	Event Description	Mean Unavailability[1]	Approximate Unavailability Contribution[2]
1	GK10001HGS/ GK20002HGS Keowee Unit 1/2 Generator Fault Causes Unit Start Failure	1.54E-04	74.8%
2	GK1NGDCLHE/ GK2NGDCLHE Failure to Close the Unit 1/2 Neutral Ground Disconnect Following Maintenance	5.20E-05	25.2%

[1] Mean unavailability is defined as the summation of the values of all cut sets in which the event appears.

[2] The contribution to unavailability is calculated by dividing the mean unavailability by the overall system unavailability and then multiplying by 100 percent.

Table A.7-11

Keowee Generator Dominant Contributors To Unavailability
For Gate KU1GENRUN - Keowee Unit 1 Generator Fails While the Unit Runs

Rank	Event Description	Mean Unavailability[1]	Approximate Unavailability Contribution[2]
1	GK10001HGR Keowee Unit 1 Generator Fault While the Unit Run	2.27E-03	65.9%
2	GK1COOLLHE Keowee 1 Gen. Air Cooler WL Flow Path Vlvs Mispositioned	2.59E-04	7.5%
3	GK1BRGVLHE Keowee 1 Gen. Brng Oil Cooling Flow Path Vlvs Mispositioned	2.59E-04	7.5%

[1] Mean unavailability is defined as the summation of the values of all cut sets in which the event appears.

[2] The contribution to unavailability is calculated by dividing the mean unavailability by the overall system unavailability and then multiplying by 100 percent.

Table A.7-12

Keeowee Generator Dominant Contributors To Unavailability
For Gate KU2GENRUN - Keowee Unit 2 Generator Fails While the Unit Runs

Rank	Event Description	Mean Unavailability[1]	Approximate Unavailability Contribution[2]
1	GK20001HGR Keowee Unit 2 Generator Fault While the Unit Runs	2.27E-03	70.4%
2	GK2BRGVLHE Keowee 2 Gen. Brng Oil Cooling Flow Path Vlvs Mispositioned After Mainte	2.59E-04	8.1%
3	GK2COOLLHE Keowee 2 Gen. Air Cooler WL Flow Path Vlvs Mispositioned After Maint	2.59E-04	8.1%
4	GK2FIREDEX Spurious Actuation of Unit 2 Gen. CO2 Fire Supression System	6.99E-05	2.2%

[1] Mean unavailability is defined as the summation of the values of all cut sets in which the event appears.

[2] The contribution to unavailability is calculated by dividing the mean unavailability by the overall system unavailability and then multiplying by 100 percent.

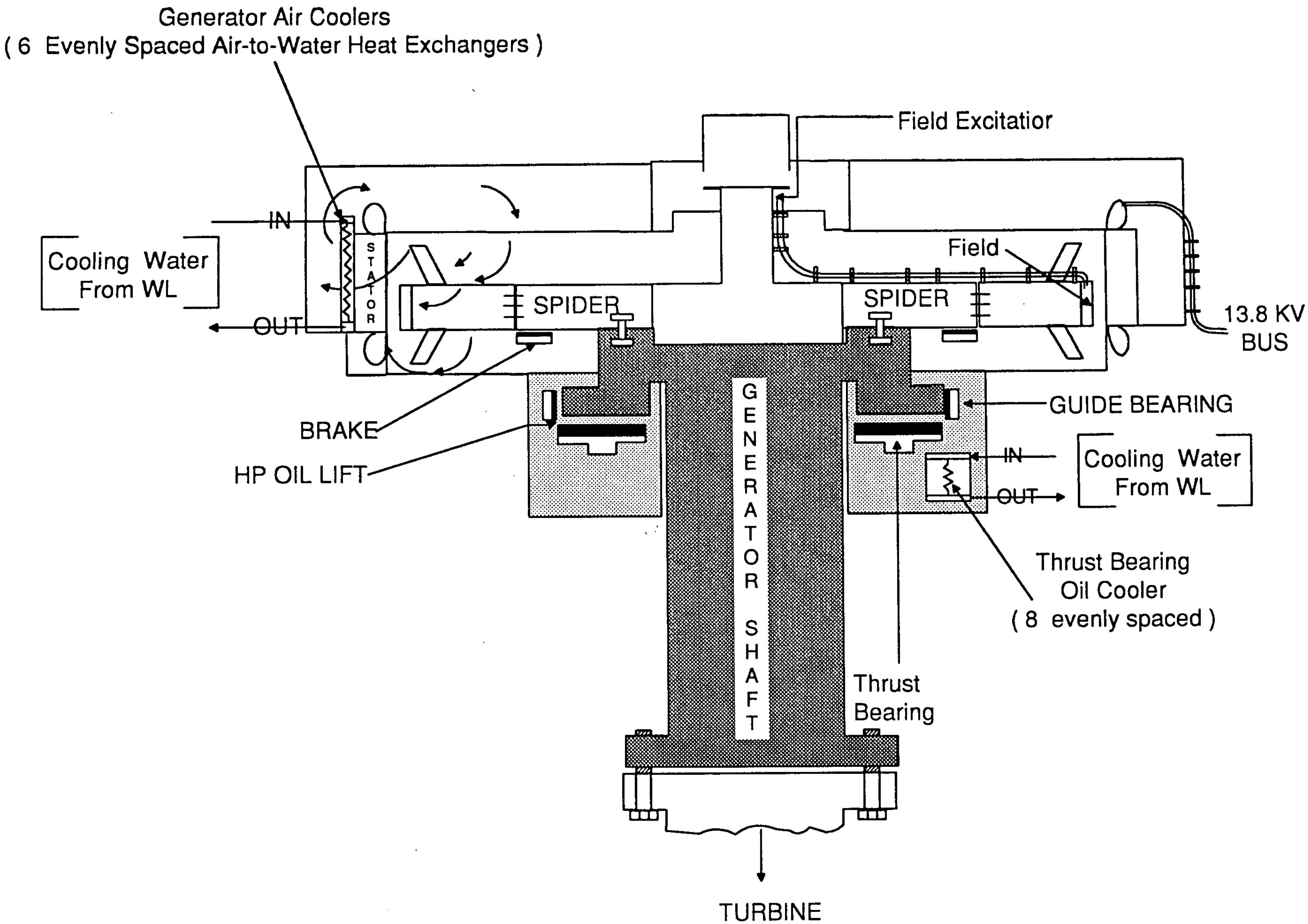


Figure A.7-1 Simplified Diagram of the Keowee Generator

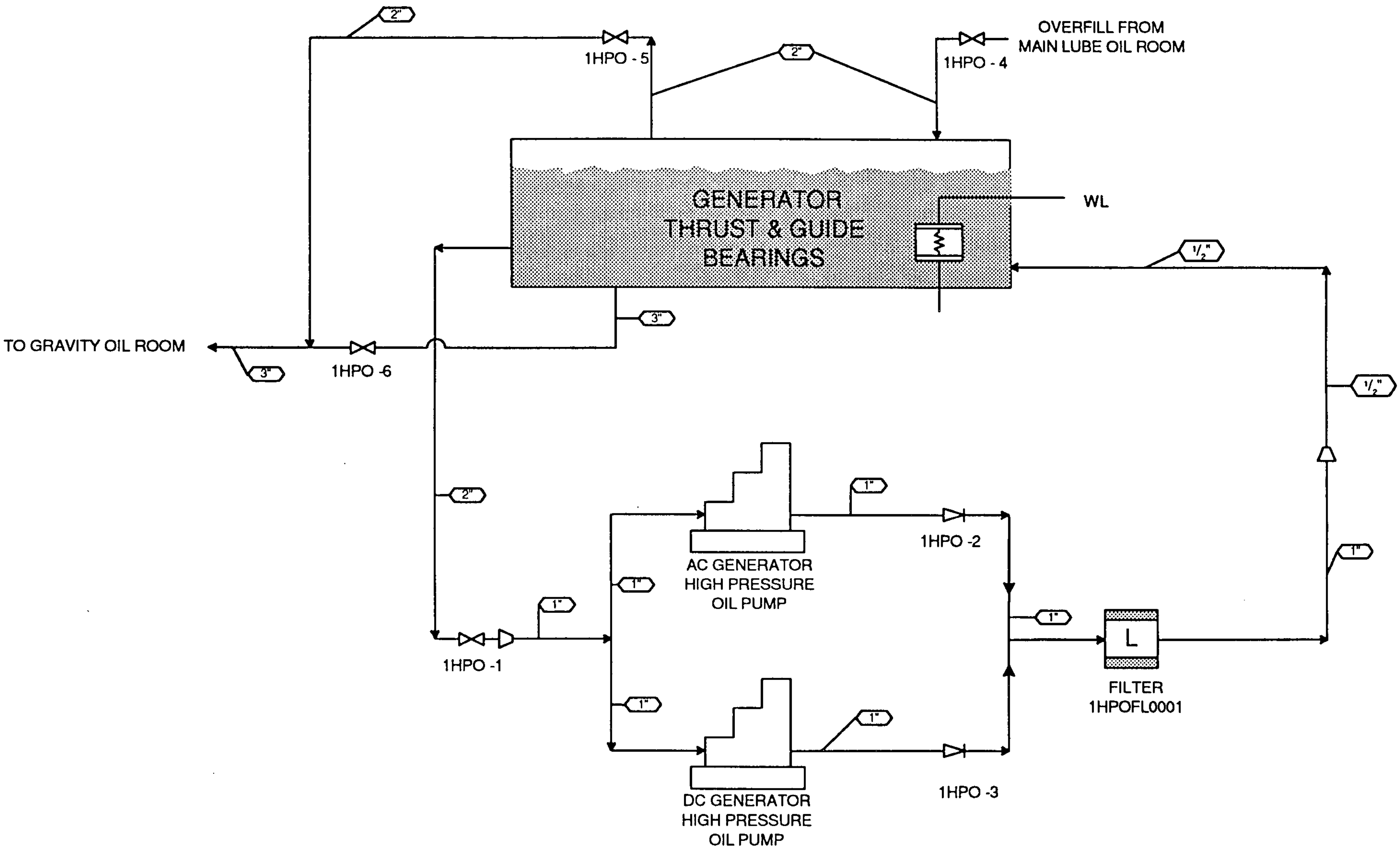


Figure A.7-2 Simplified Diagram of High Pressure Oil System

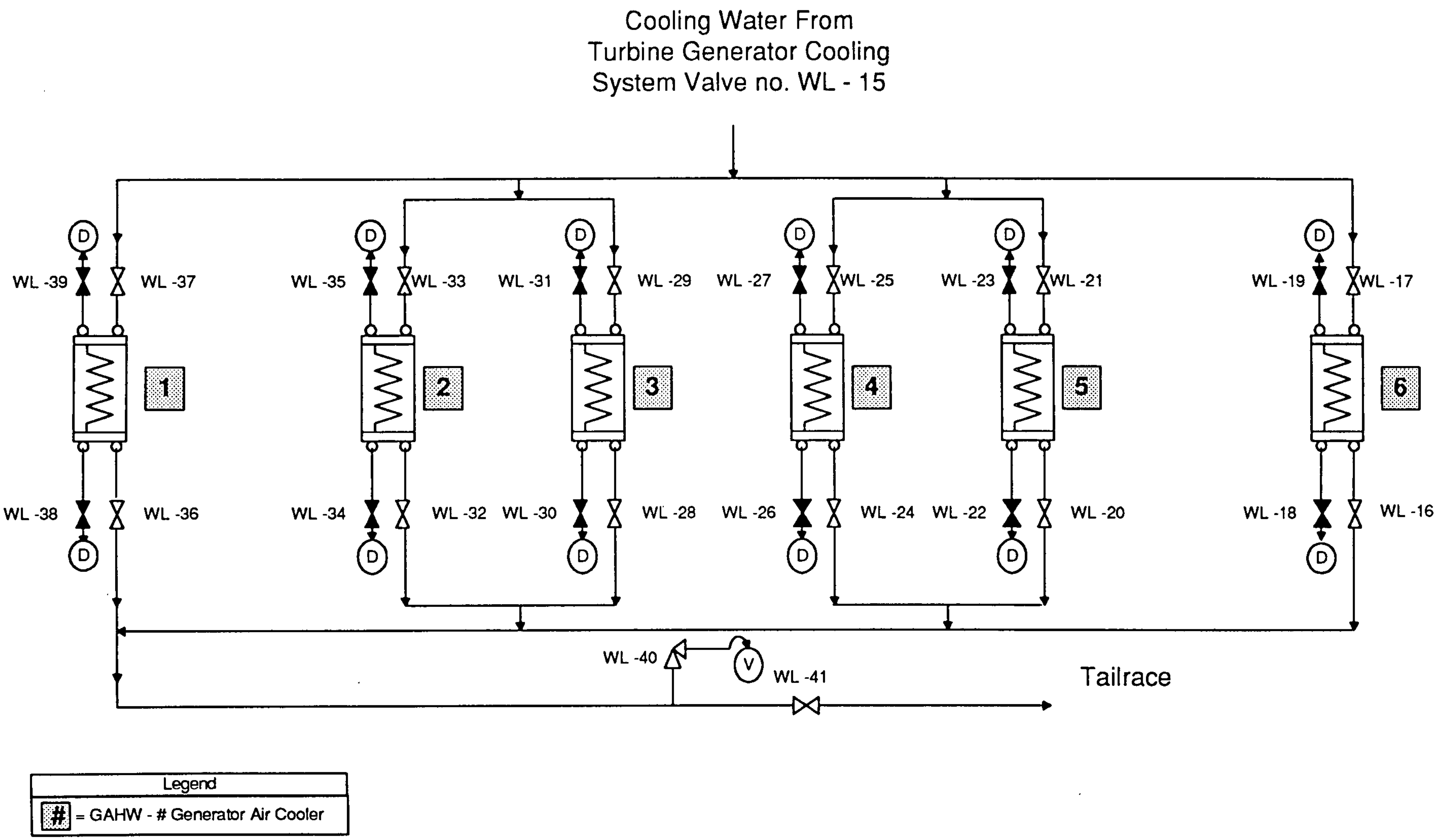


Figure A.7-3 Simplified Flow Diagram of the Keowee Generator Air Coolers

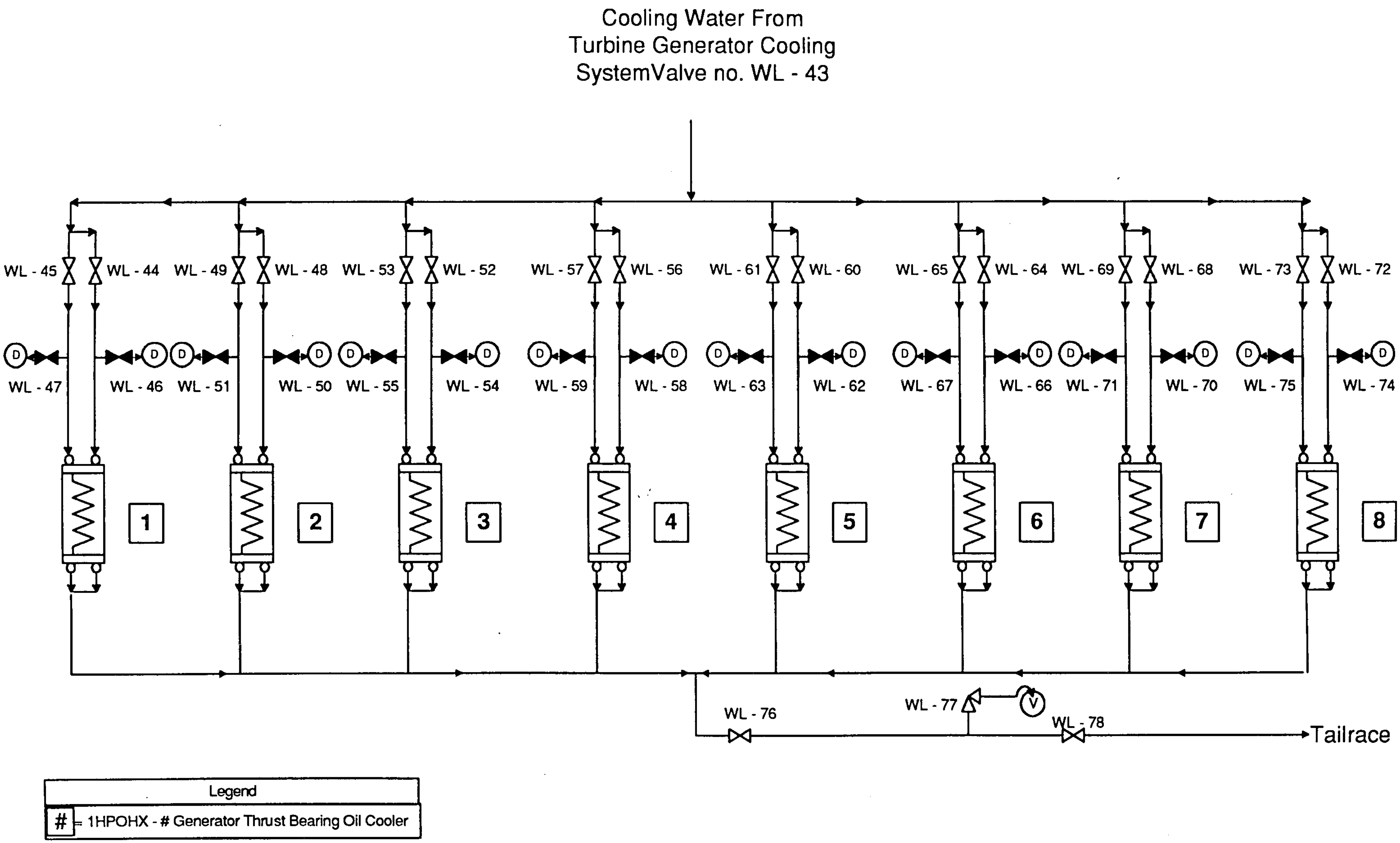


Figure A.7-4 Simplified Flow Diagram of the Keowee Generator Thrust Bearing Oil Coolers

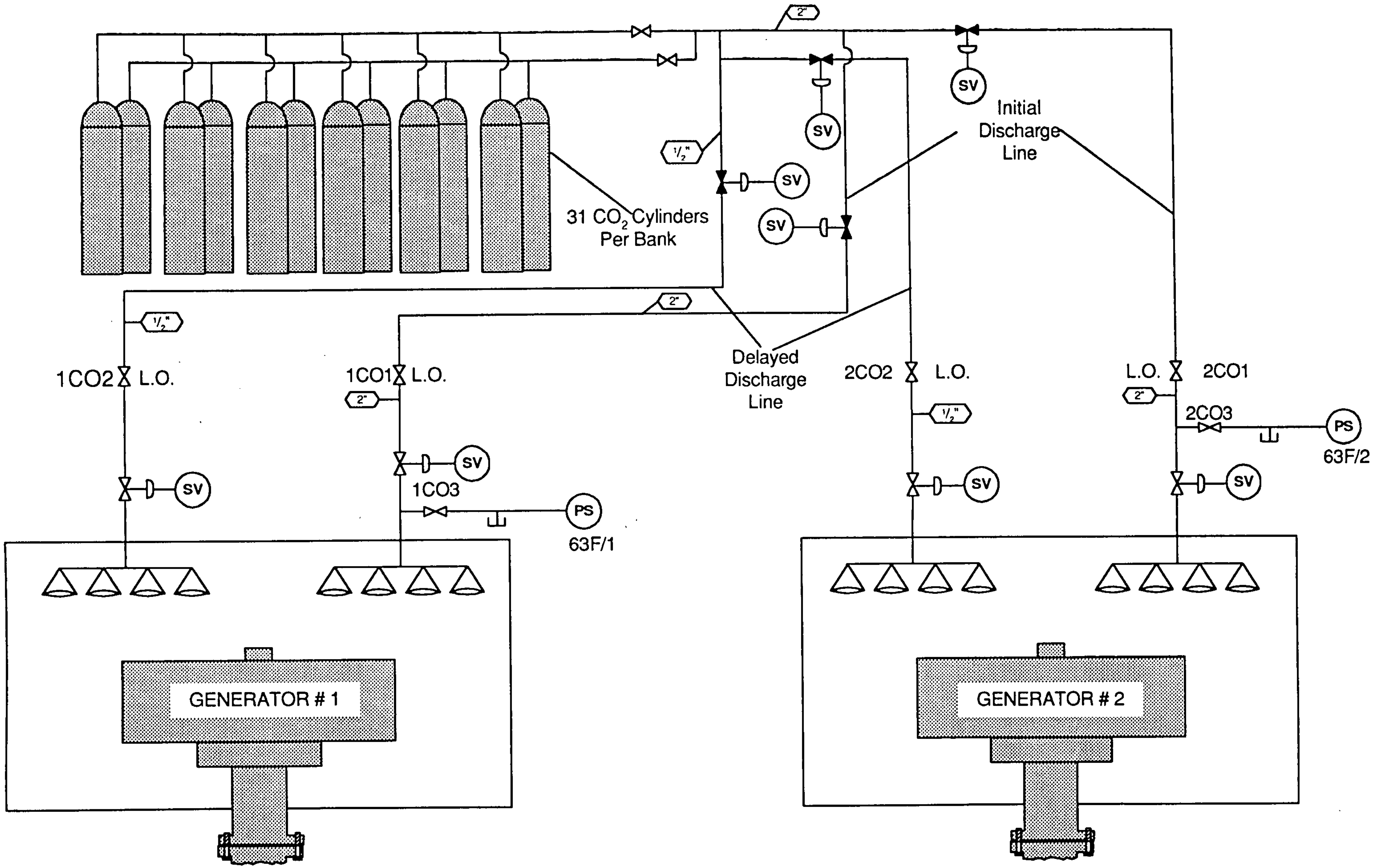
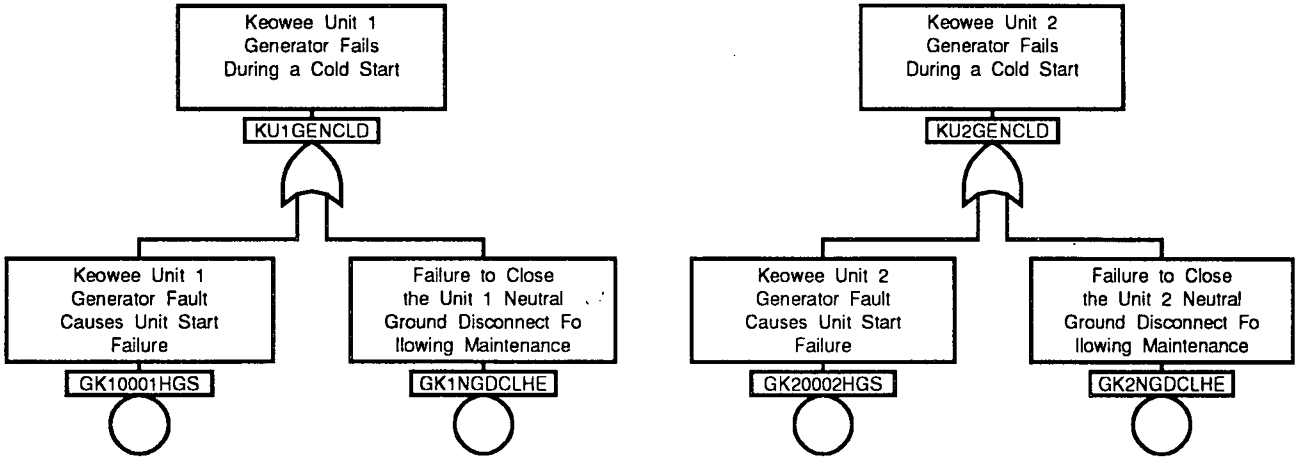
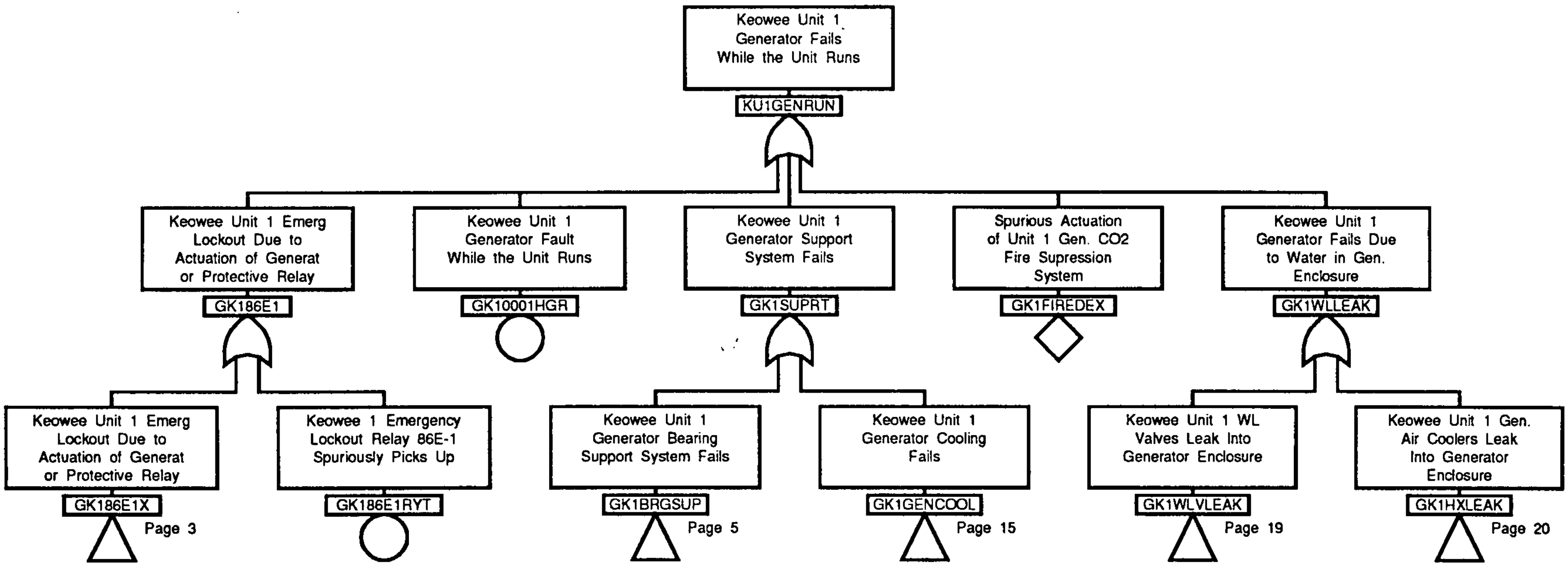


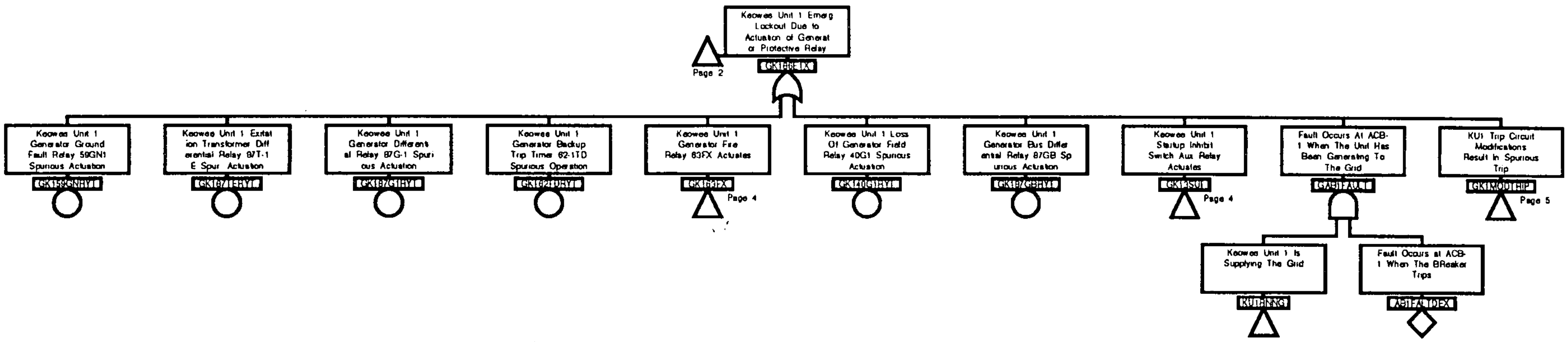
Figure A.7-5 Simplified Diagram of the Keowee Generator CO_2 Fire Supression System



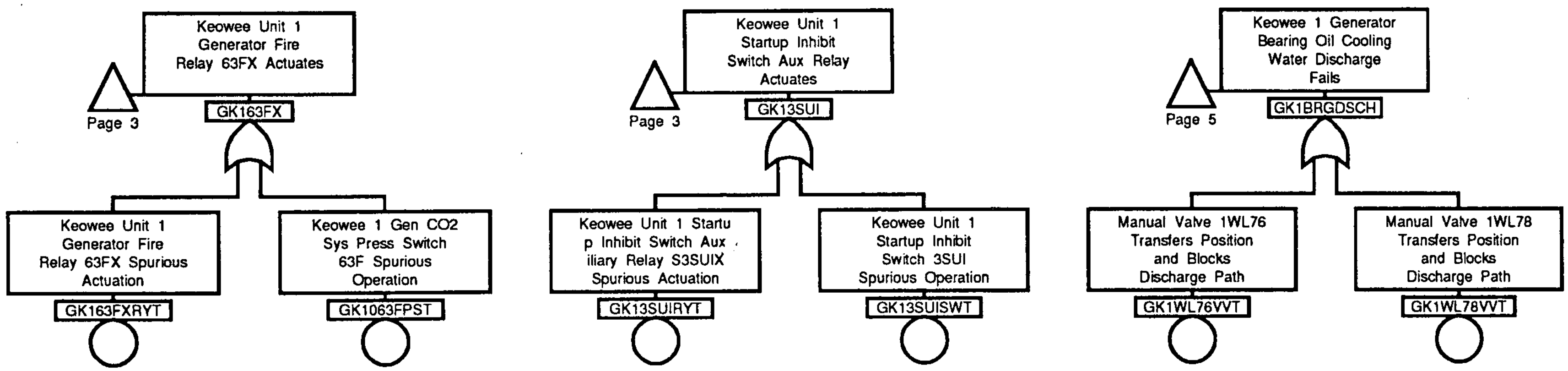
Keowee Generator Fault Tree | FIGURE A.7-6 |



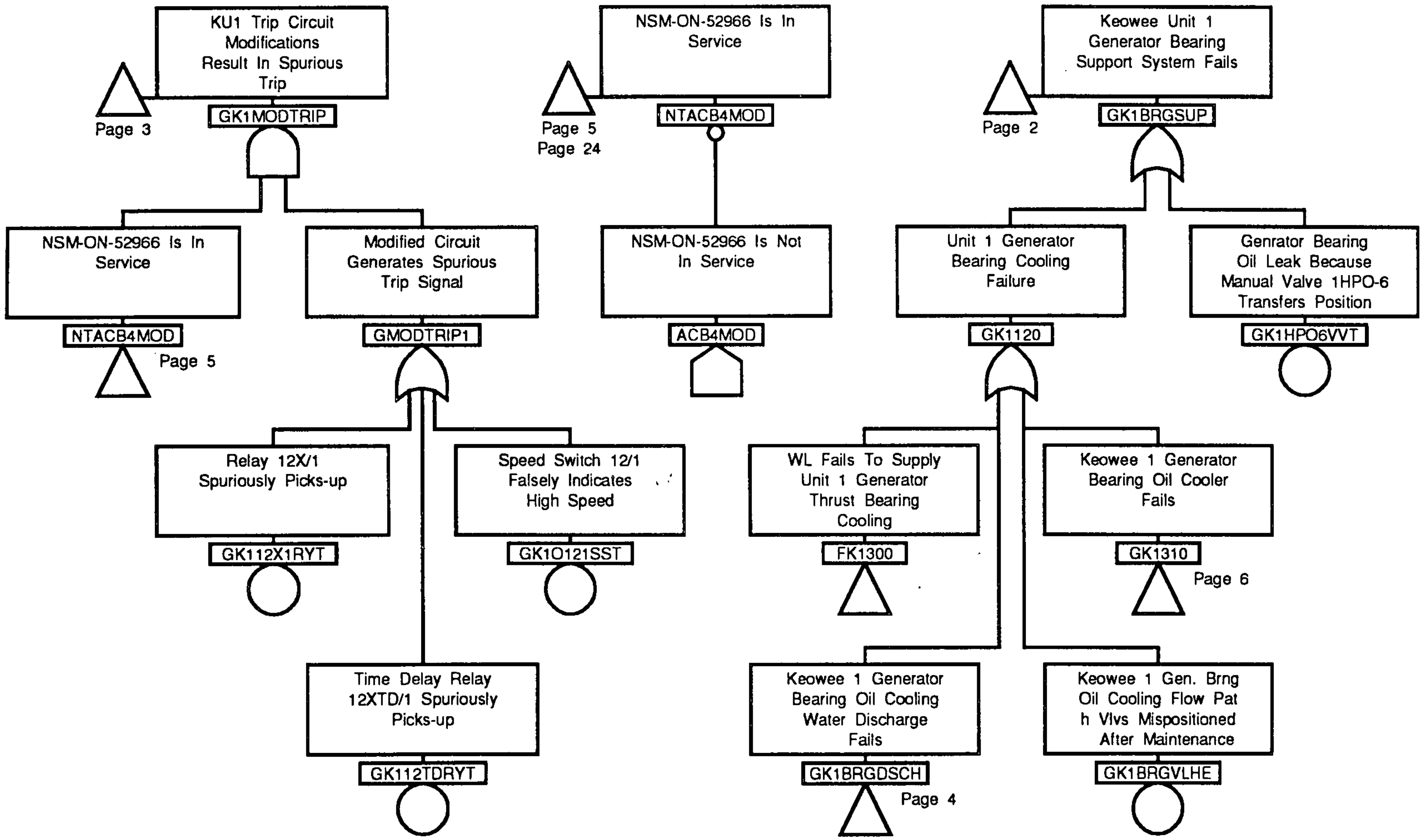
Keowee Generator Fault Tree	FIGURE A.7-6	Page 2



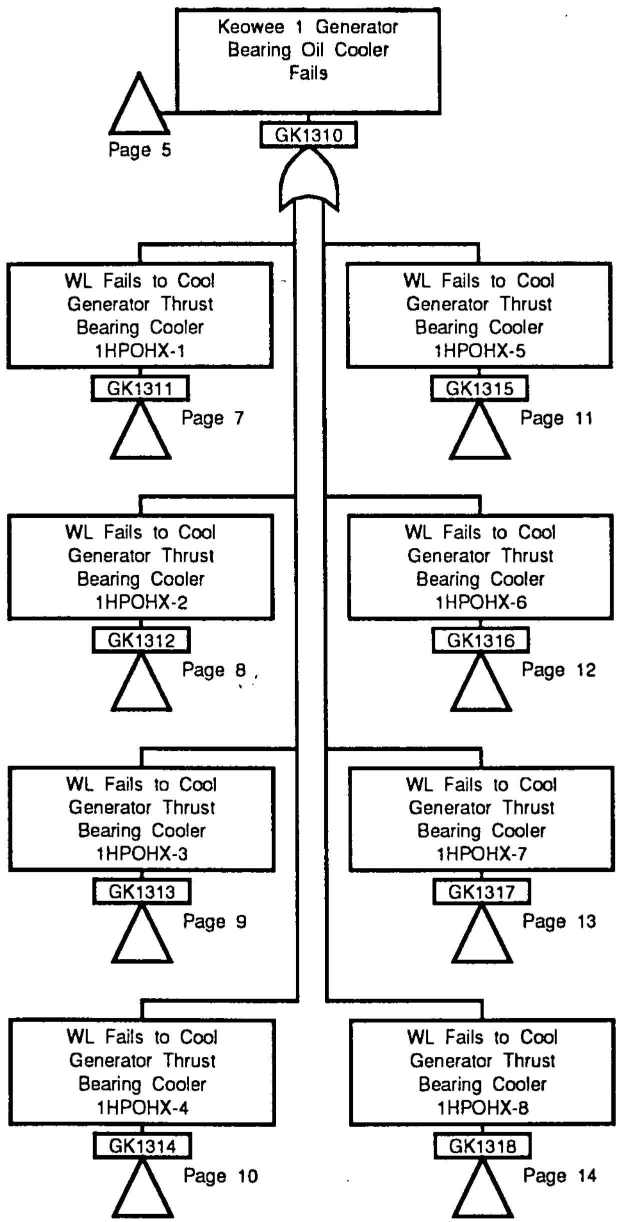
Keowee Unit 1 Emerg Lockout Due to Actuation of General or Protective Relay
Page 2
Keowee Unit 1 Generator Ground Fault Relay 59GN1 Spurious Actuation
Keowee Unit 1 Extation Transformer Differential Relay 87T-1E Spur Actuation
Keowee Unit 1 Generator Differential Relay 87G-1 Spurious Actuation
Keowee Unit 1 Generator Backup Trip Timer 62-1TD Spurious Operation
Keowee Unit 1 Generator Fire Relay 63FX Actuates
GK163FX
Page 4
Keowee Unit 1 Loss Of Generator Field Relay 40G1 Spurious Actuation
Keowee Unit 1 Generator Bus Differential Relay 87GB Spurious Actuation
Keowee Unit 1 Startup Inhibit Switch Aux Relay Actuates
Page 4
Fault Occurs At ACB-1 When The Unit Has Been Generating To The Grid
KU1 Trip Circuit Modifications Result In Spurious Trip
GK1MODTRIP
Page 5
Keowee Unit 1 Is Supplying The Grid
Fault Occurs at ACB-1 When The BReaker Trips



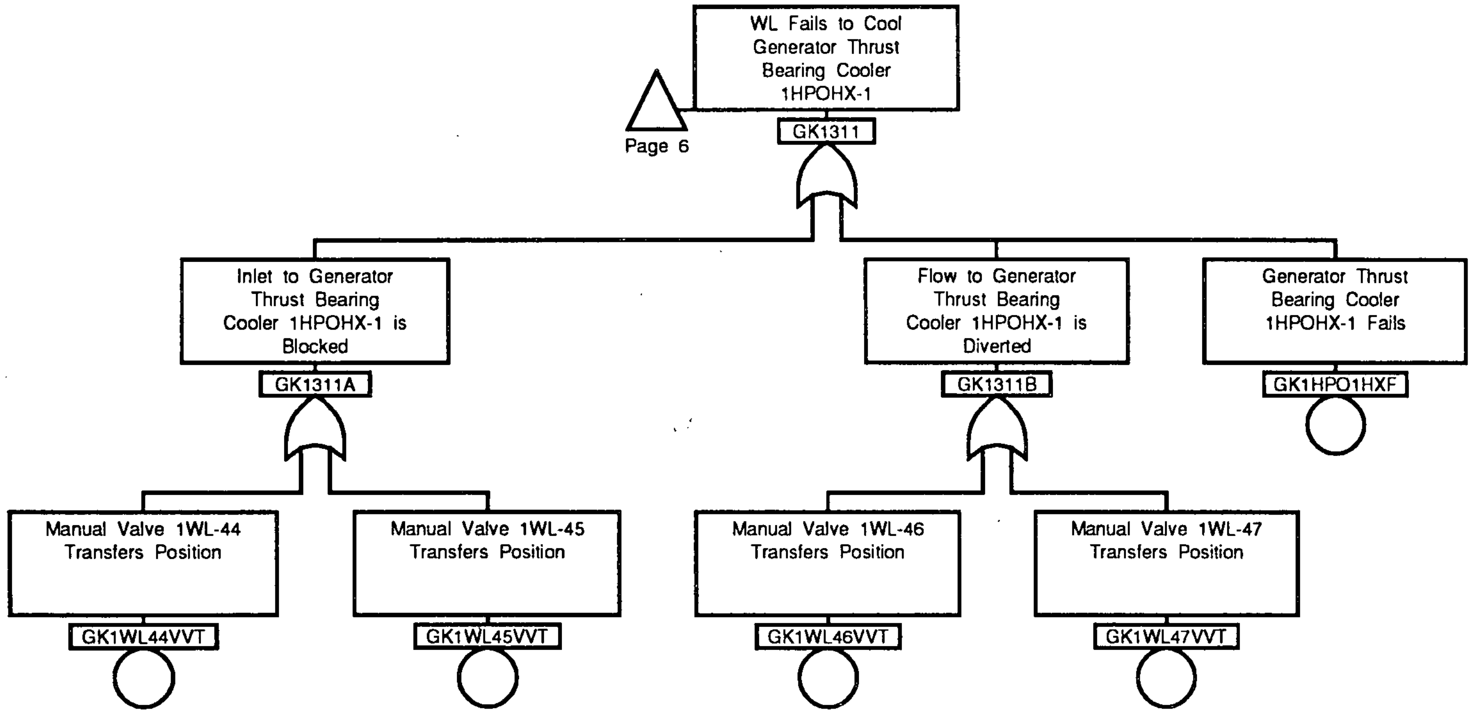
Keowee Generator Fault Tree	FIGURE A.7-6	Page 4



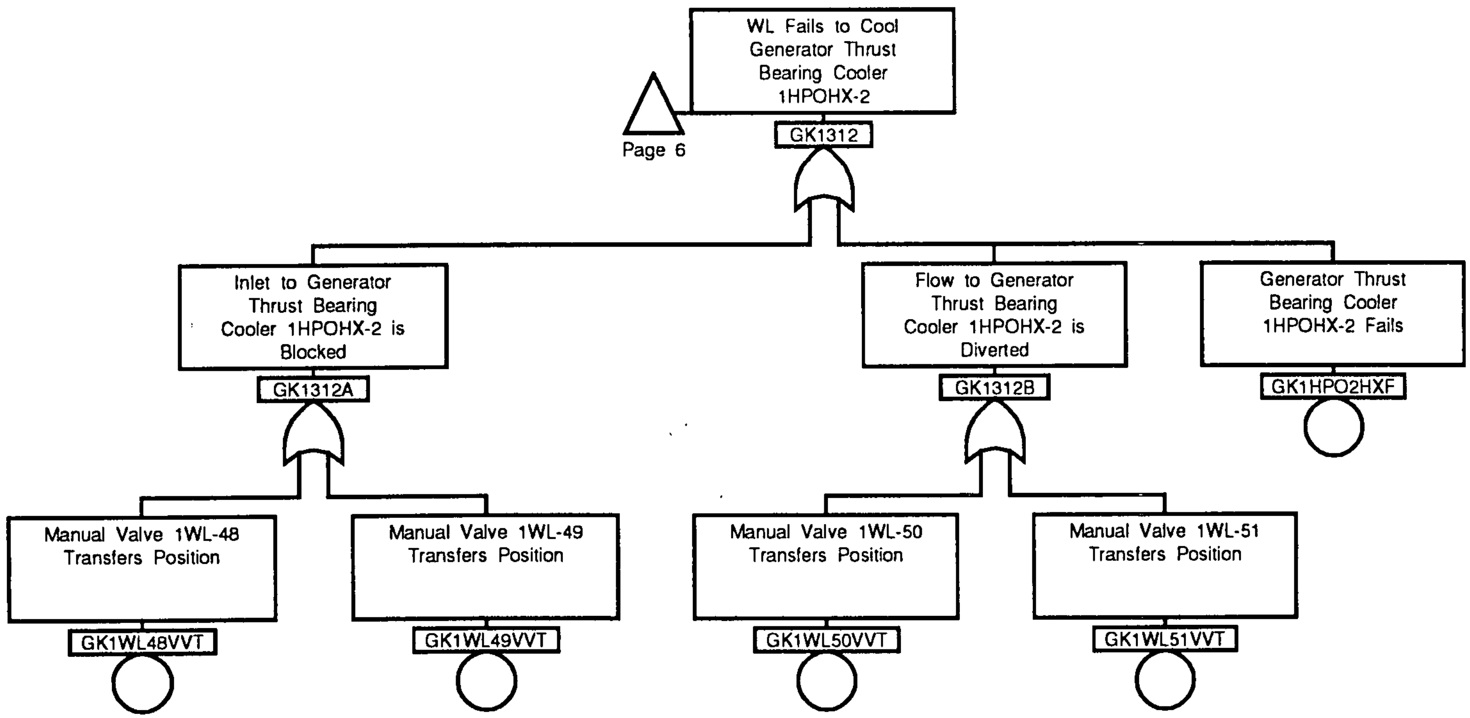
Keowee Generator Fault Tree | FIGURE A.7-6 |



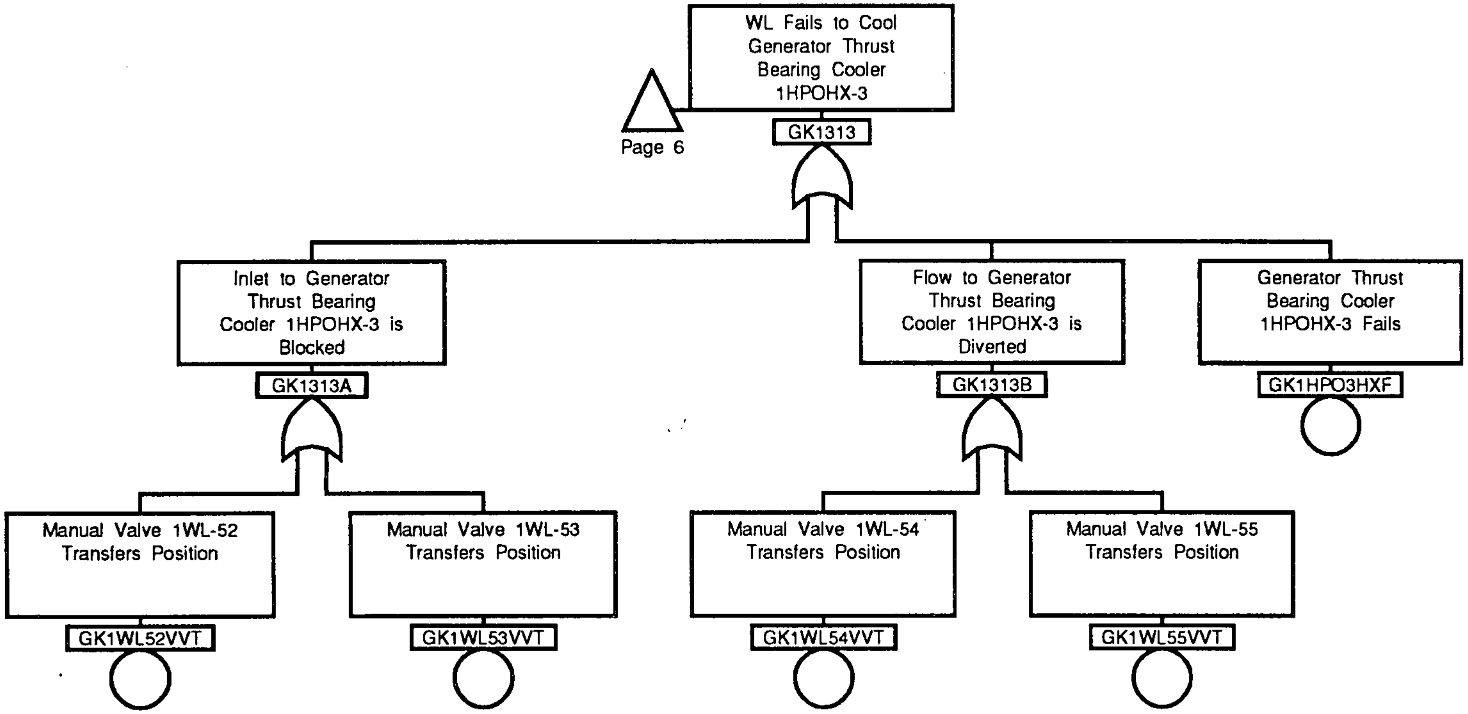
Keowee Generator Fault Tree	FIGURE A.7-6	Page 6

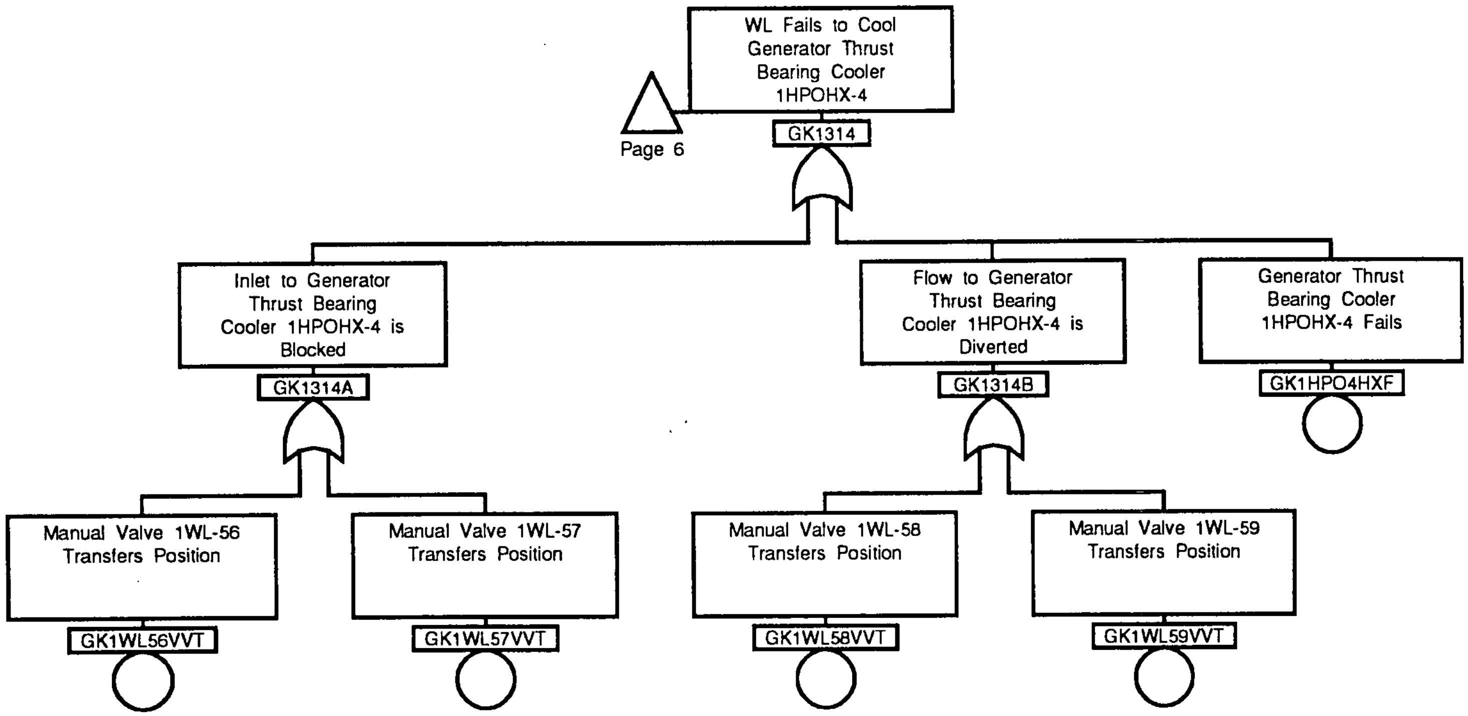


Keowee Generator Fault Tree | FIGURE A.7-6 |

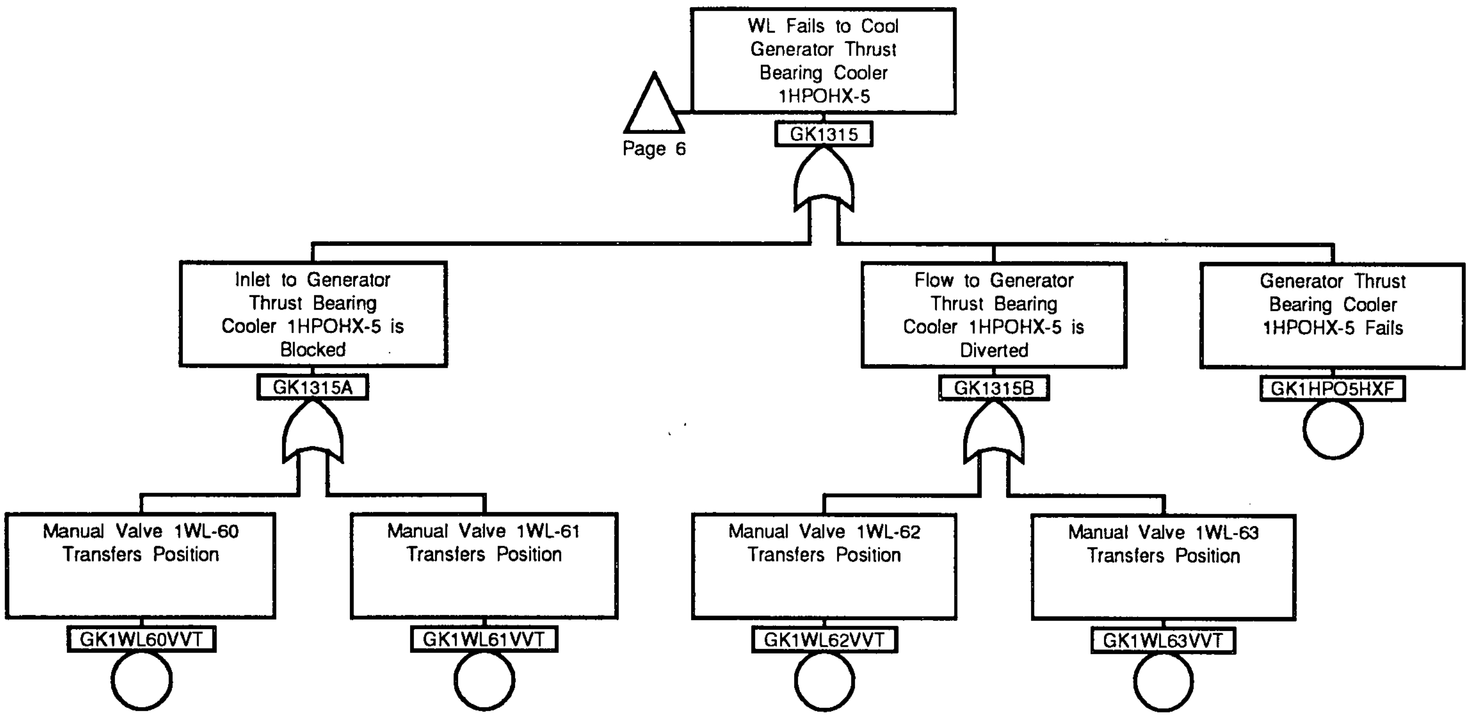


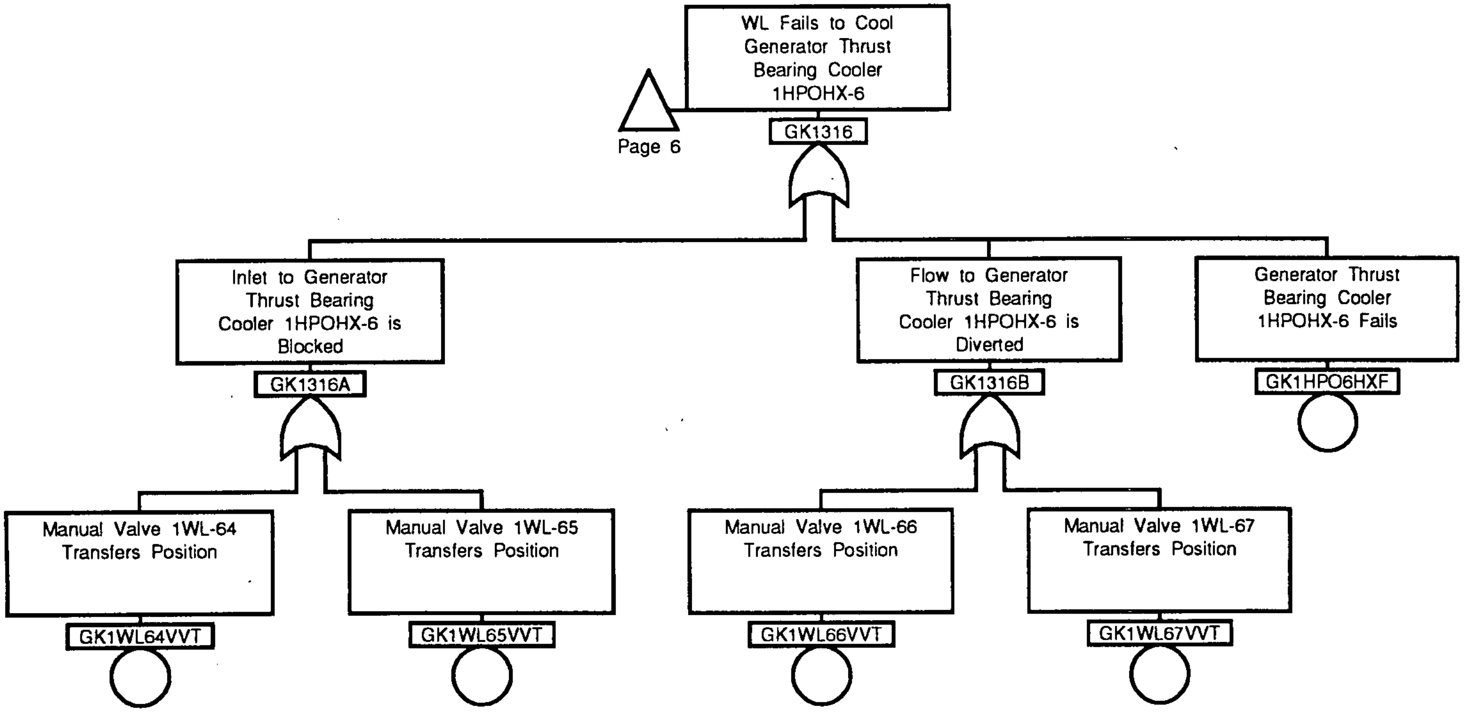
WL Fails to Cool Generator Thrust Bearing Cooler 1HPOHX-2
GK1312
Page 6
Inlet to Generator Thrust Bearing Cooler 1HPOHX-2 is Blocked
GK1312A
Flow to Generator Thrust Bearing Cooler 1HPOHX-2 is Diverted
GK1312B
Generator Thrust Bearing Cooler 1HPOHX-2 Fails
GK1HPO2HXF
Manual Valve 1WL-48 Transfers Position
GK1WL48VVT
Manual Valve 1WL-49 Transfers Position
GK1WL49VVT
Manual Valve 1WL-50 Transfers Position
GK1WL50VVT
Manual Valve 1WL-51 Transfers Position
GK1WL51VVT

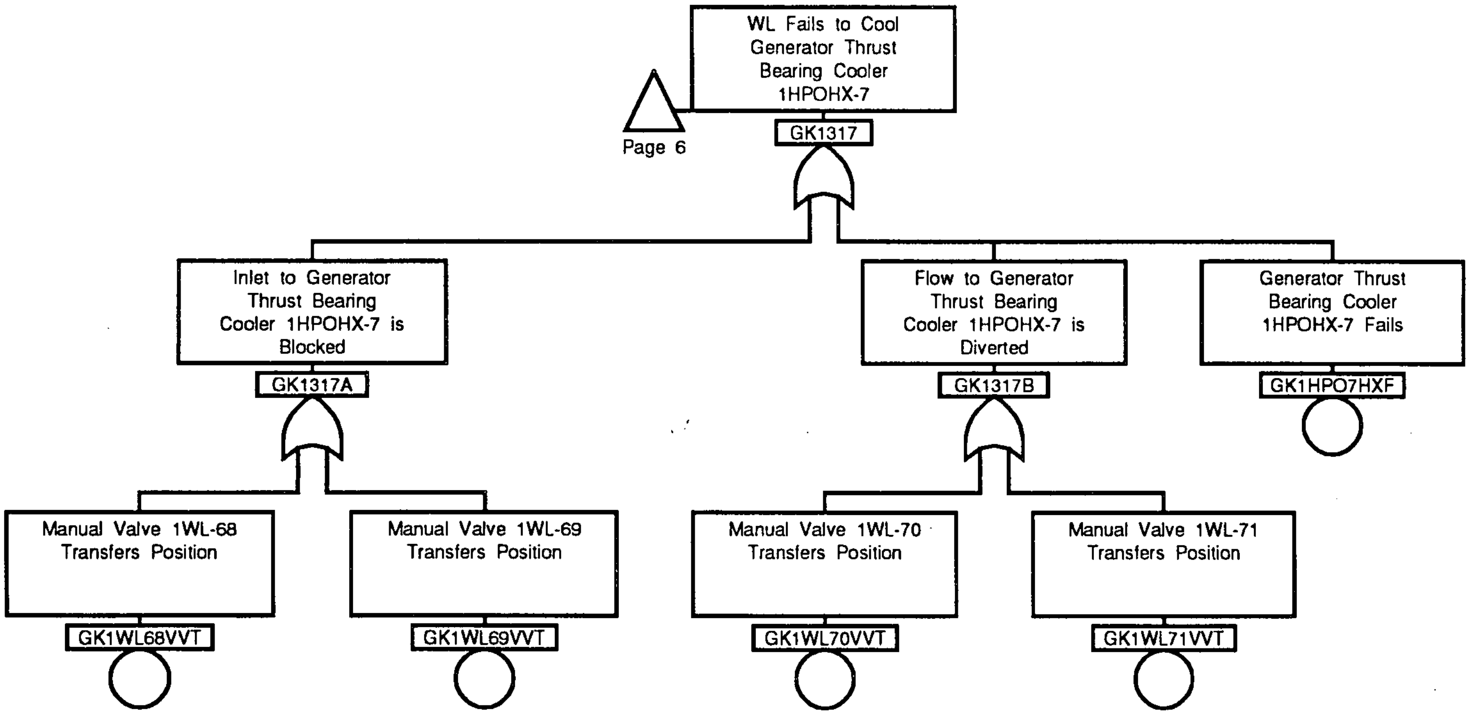

WL Fails to Cool Generator Thrust Bearing Cooler 1HPOHX-3
GK1313
Page 6
Inlet to Generator Thrust Bearing Cooler 1HPOHX-3 is Blocked
GK1313A
Flow to Generator Thrust Bearing Cooler 1HPOHX-3 is Diverted
GK1313B
Generator Thrust Bearing Cooler 1HPOHX-3 Fails
GK1HPO3HXF
Manual Valve 1WL-52 Transfers Position
GK1WL52VVT
Manual Valve 1WL-53 Transfers Position
GK1WL53VVT
Manual Valve 1WL-54 Transfers Position
GK1WL54VVT
Manual Valve 1WL-55 Transfers Position
GK1WL55VVT

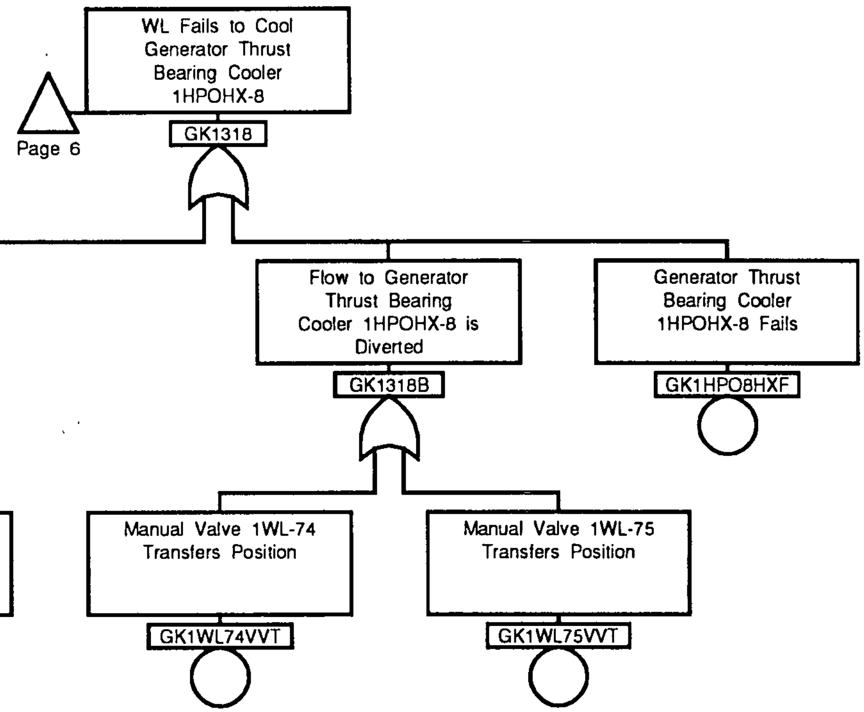


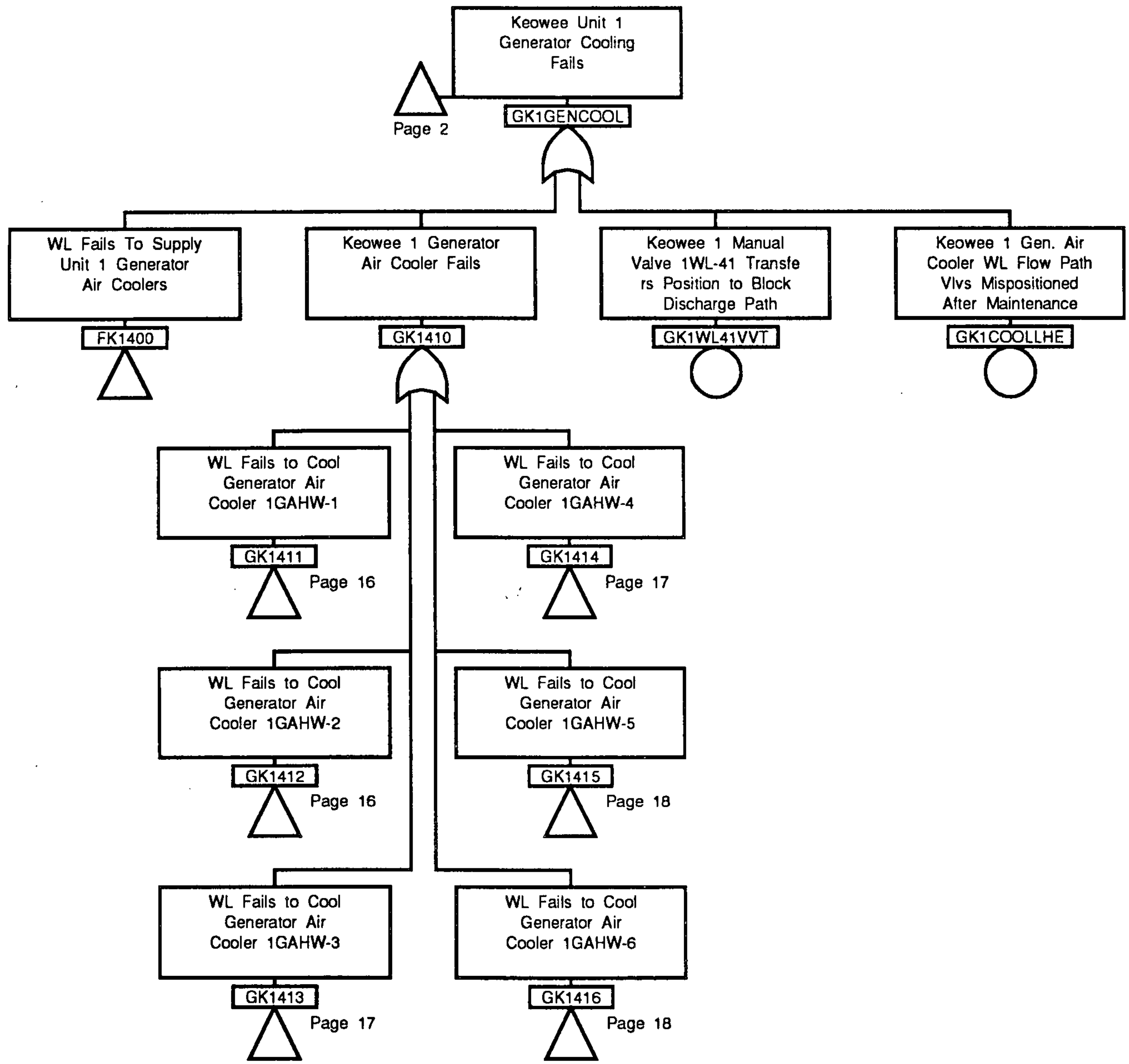
Keeowee Generator Fault Tree | FIGURE A.7-6 |


WL Fails to Cool Generator Thrust Bearing Cooler 1HPOHX-5
GK1315
Page 6
Inlet to Generator Thrust Bearing Cooler 1HPOHX-5 is Blocked
GK1315A
Flow to Generator Thrust Bearing Cooler 1HPOHX-5 is Diverted
GK1315B
Generator Thrust Bearing Cooler 1HPOHX-5 Fails
GK1HPO5HXF
Manual Valve 1WL-60 Transfers Position
GK1WL60VVT
Manual Valve 1WL-61 Transfers Position
GK1WL61VVT
Manual Valve 1WL-62 Transfers Position
GK1WL62VVT
Manual Valve 1WL-63 Transfers Position
GK1WL63VVT

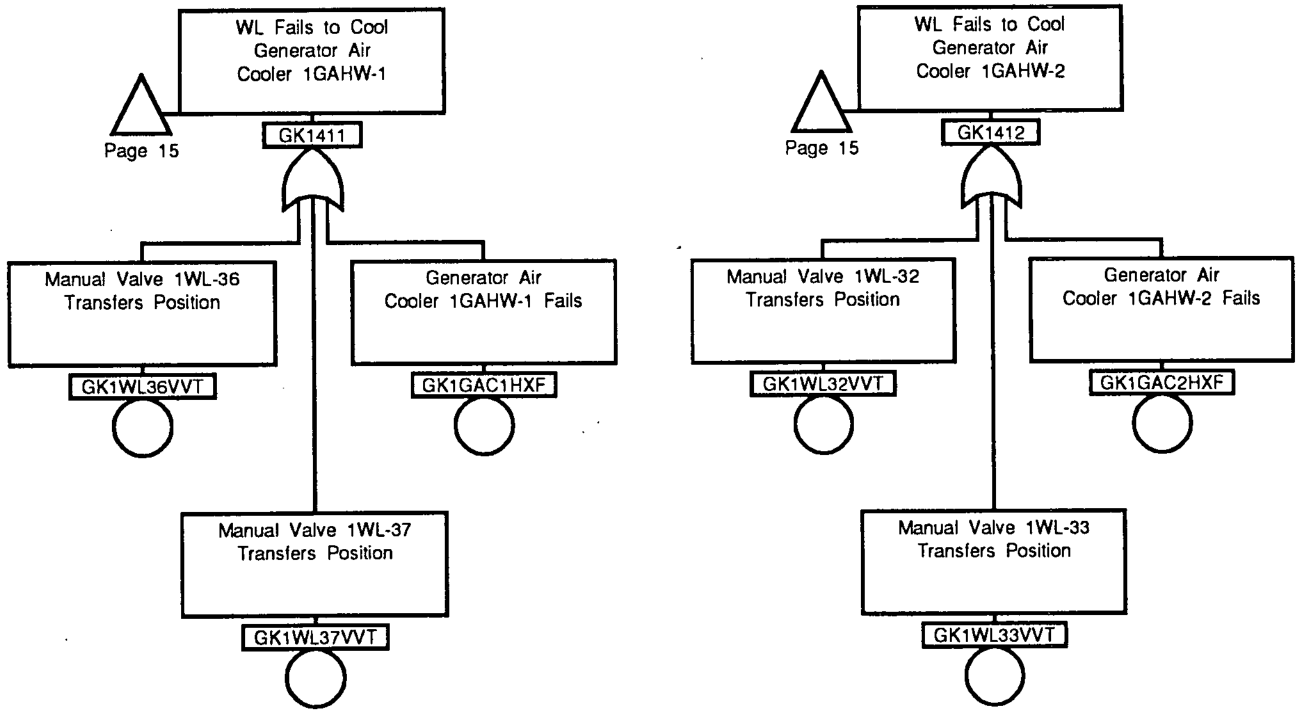

WL Fails to Cool Generator Thrust Bearing Cooler 1HPOHX-6
GK1316
Page 6
Inlet to Generator Thrust Bearing Cooler 1HPOHX-6 is Blocked
GK1316A
Flow to Generator Thrust Bearing Cooler 1HPOHX-6 is Diverted
GK1316B
Generator Thrust Bearing Cooler 1HPOHX-6 Fails
GK1HPO6HXF
Manual Valve 1WL-64 Transfers Position
GK1WL64VVT
Manual Valve 1WL-65 Transfers Position
GK1WL65VVT
Manual Valve 1WL-66 Transfers Position
GK1WL66VVT
Manual Valve 1WL-67 Transfers Position
GK1WL67VVT


WL Fails to Cool Generator Thrust Bearing Cooler 1HPOHX-7
GK1317
Page 6
Inlet to Generator Thrust Bearing Cooler 1HPOHX-7 is Blocked
GK1317A
Flow to Generator Thrust Bearing Cooler 1HPOHX-7 is Diverted
GK1317B
Generator Thrust Bearing Cooler 1HPOHX-7 Fails
GK1HPO7HXF
Manual Valve 1WL-68 Transfers Position
GK1WL68VVT
Manual Valve 1WL-69 Transfers Position
GK1WL69VVT
Manual Valve 1WL-70 Transfers Position
GK1WL70VVT
Manual Valve 1WL-71 Transfers Position
GK1WL71VVT

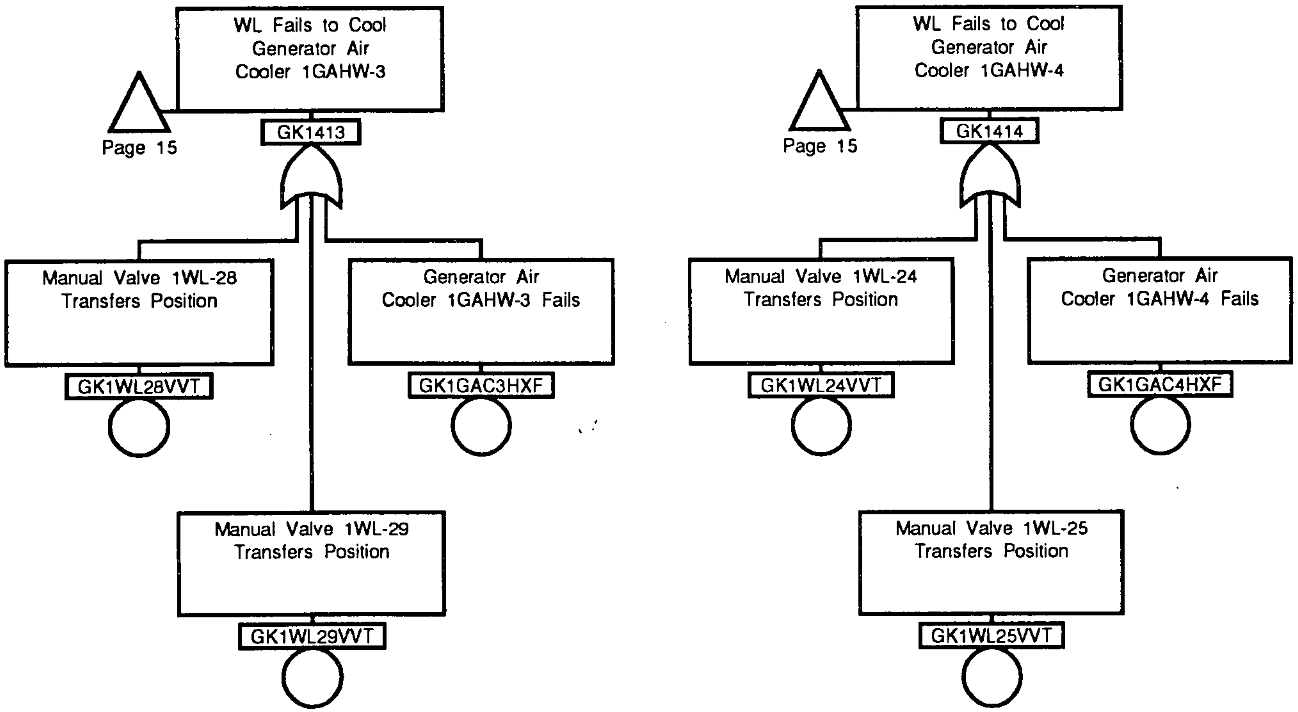

WL Fails to Cool Generator Thrust Bearing Cooler 1HPOHX-8
GK1318
Page 6
Inlet to Generator Thrust Bearing Cooler 1HPOHX-8 is Blocked
GK1318A
Flow to Generator Thrust Bearing Cooler 1HPOHX-8 is Diverted
GK1318B
Generator Thrust Bearing Cooler 1HPOHX-8 Fails
GK1HPO8HXF
Manual Valve 1WL-72 Transfers Position
GK1WL72VVT
Manual Valve 1WL-73 Transfers Position
GK1WL73VVT
Manual Valve 1WL-74 Transfers Position
GK1WL74VVT
Manual Valve 1WL-75 Transfers Position
GK1WL75VVT



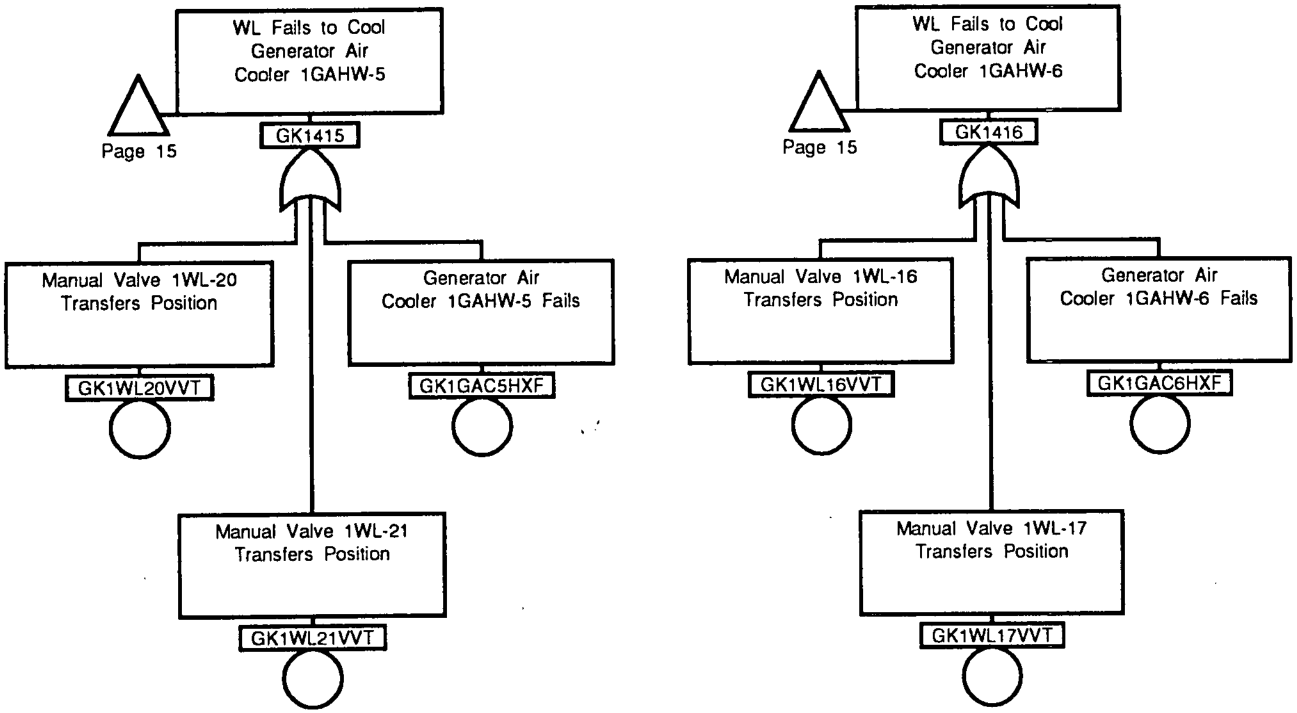
Keowee Generator Fault Tree | FIGURE A.7-6 |



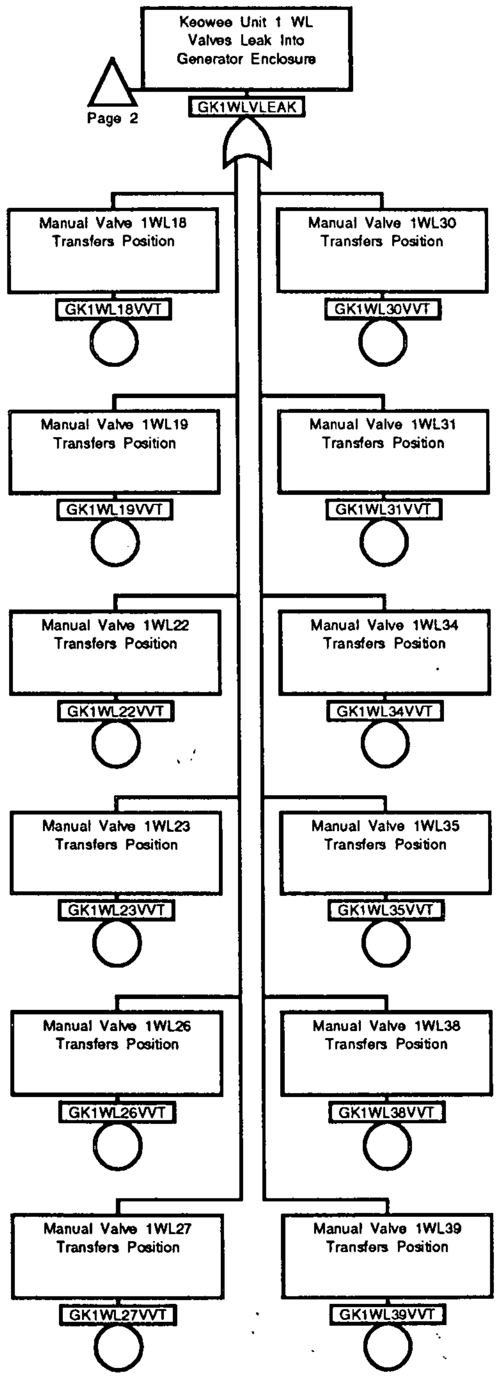
Keowee Generator Fault Tree | FIGURE A.7-6 |



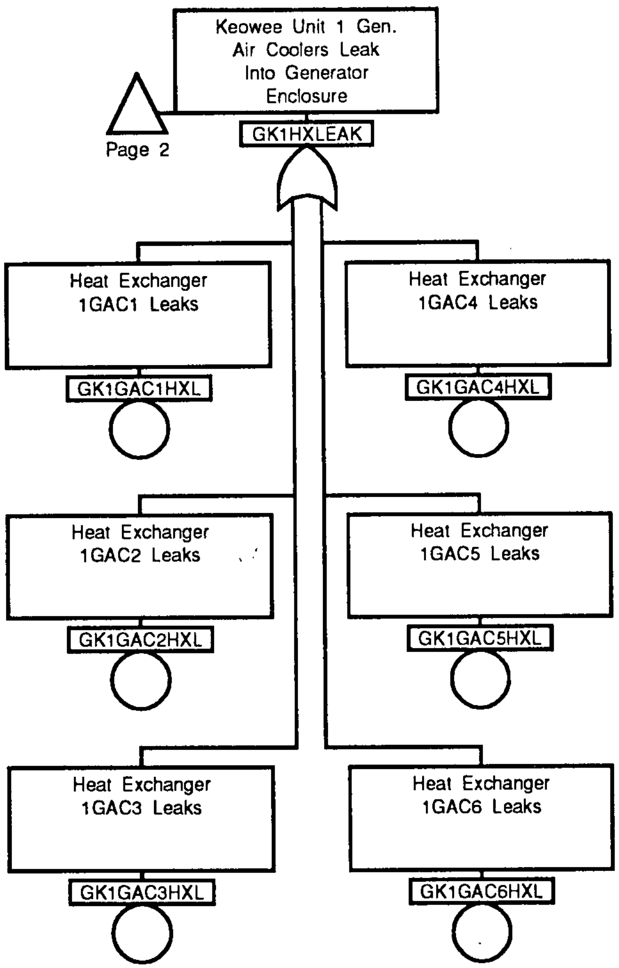
WL Fails to Cool
Generator Air
Cooler 1GAHW-3
Page 15
GK1413
Manual Valve 1WL-28
Transfers Position
GK1WL28VVT
Generator Air
Cooler 1GAHW-3 Fails
GK1GAC3HXF
Manual Valve 1WL-29
Transfers Position
GK1WL29VVT
WL Fails to Cool
Generator Air
Cooler 1GAHW-4
Page 15
GK1414
Manual Valve 1WL-24
Transfers Position
GK1WL24VVT
Generator Air
Cooler 1GAHW-4 Fails
GK1GAC4HXF
Manual Valve 1WL-25
Transfers Position
GK1WL25VVT



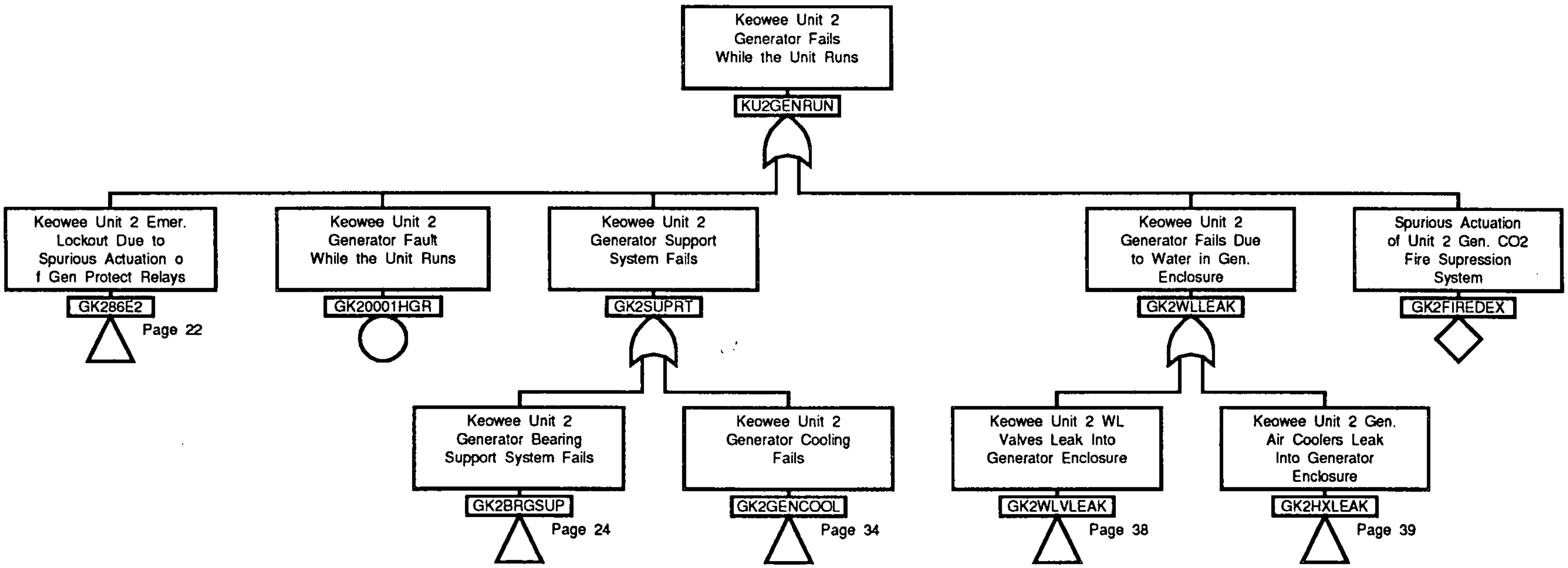
Keowee Generator Fault Tree | FIGURE A.7-6 |



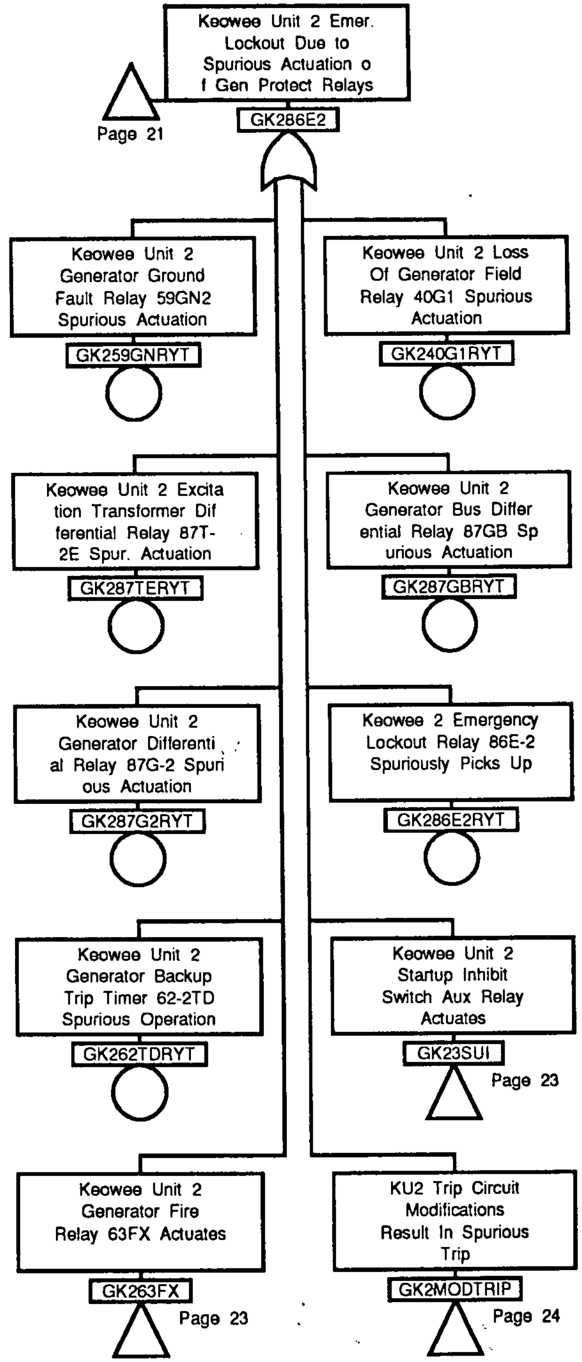
Keowee Unit 1 WL Valves Leak Into Generator Enclosure
Page 2
GK1WLVLEAK
Manual Valve 1WL18 Transfers Position
GK1WL18VVT
Manual Valve 1WL30 Transfers Position
GK1WL30VVT
Manual Valve 1WL19 Transfers Position
GK1WL19VVT
Manual Valve 1WL31 Transfers Position
GK1WL31VVT
Manual Valve 1WL22 Transfers Position
GK1WL22VVT
Manual Valve 1WL34 Transfers Position
GK1WL34VVT
Manual Valve 1WL23 Transfers Position
GK1WL23VVT
Manual Valve 1WL35 Transfers Position
GK1WL35VVT
Manual Valve 1WL26 Transfers Position
GK1WL26VVT
Manual Valve 1WL38 Transfers Position
GK1WL38VVT
Manual Valve 1WL27 Transfers Position
GK1WL27VVT
Manual Valve 1WL39 Transfers Position
GK1WL39VVT



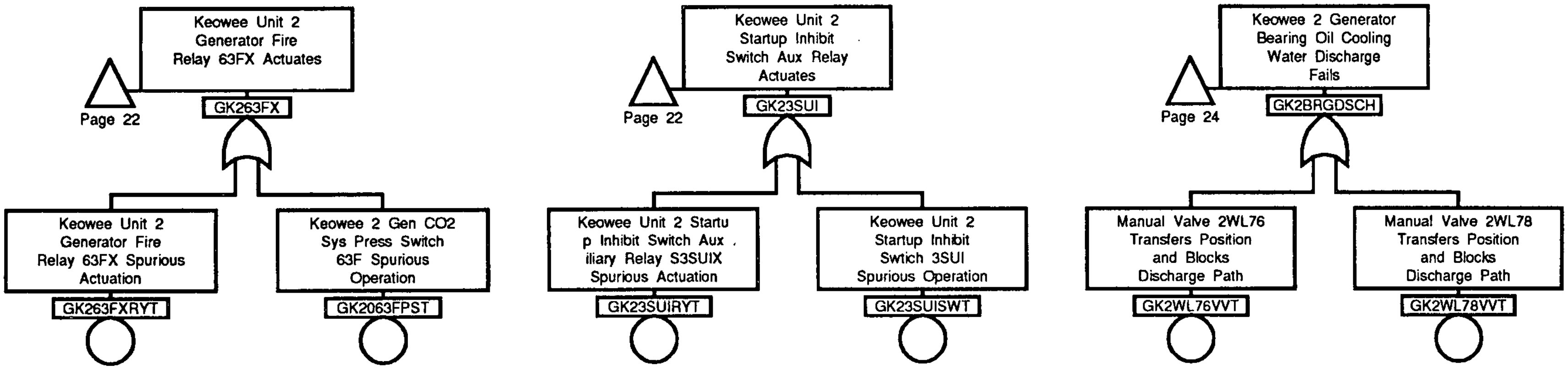
Keowee Generator Fault Tree | FIGURE A.7-6 |



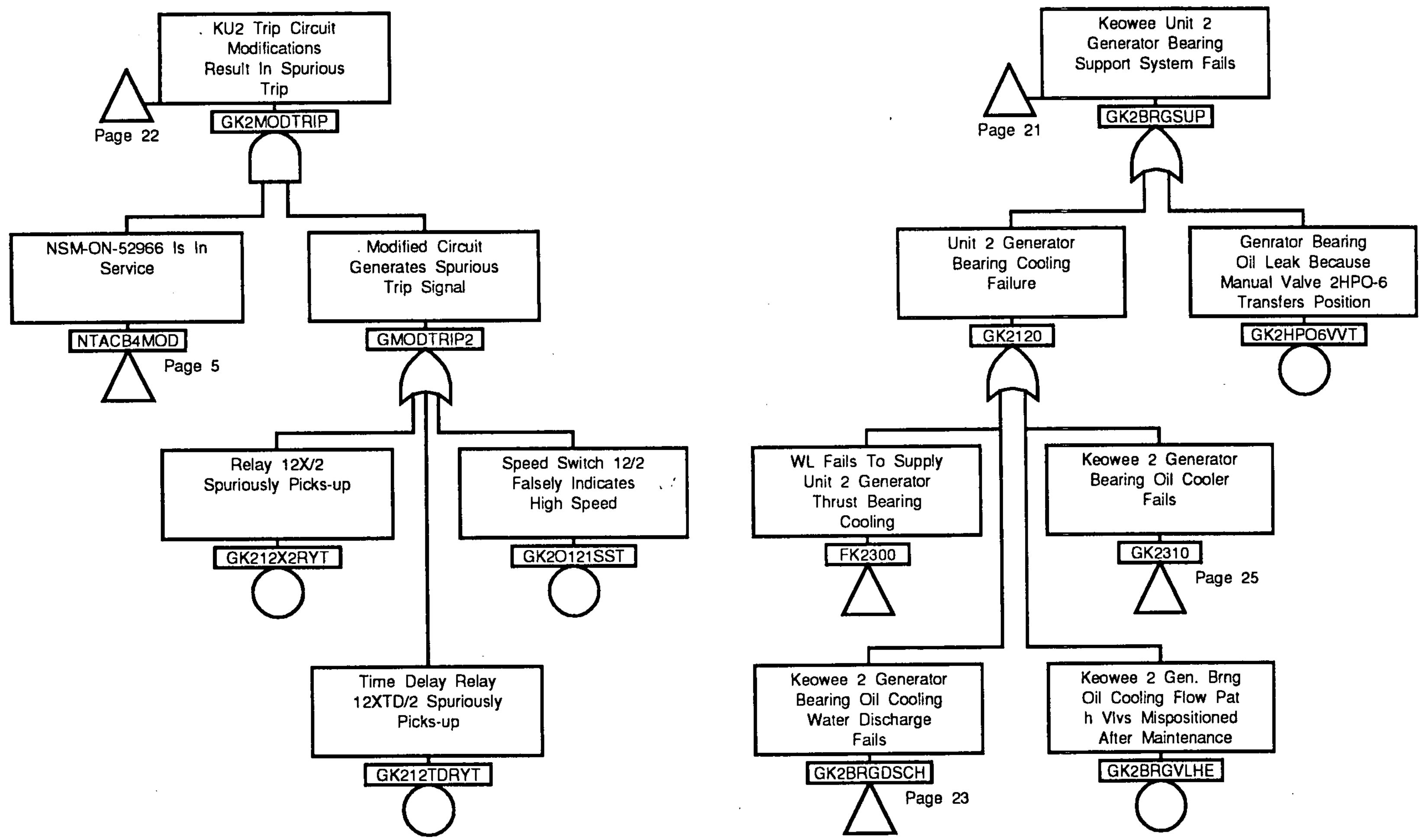
Keowee Generator Fault Tree | FIGURE A.7-6 |



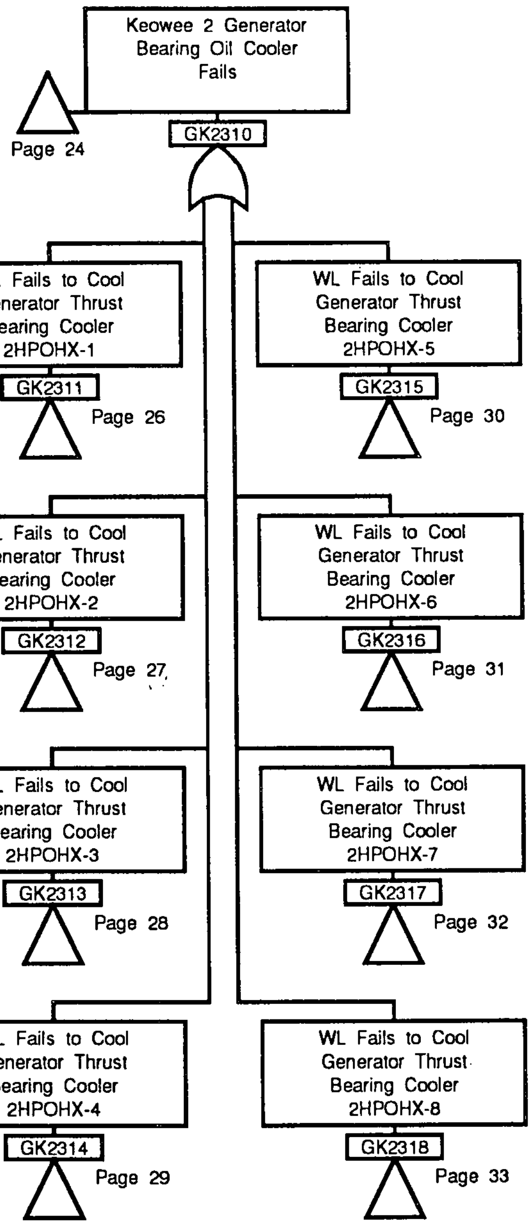
Keowee Generator Fault Tree	FIGURE A.7-6	Page 22

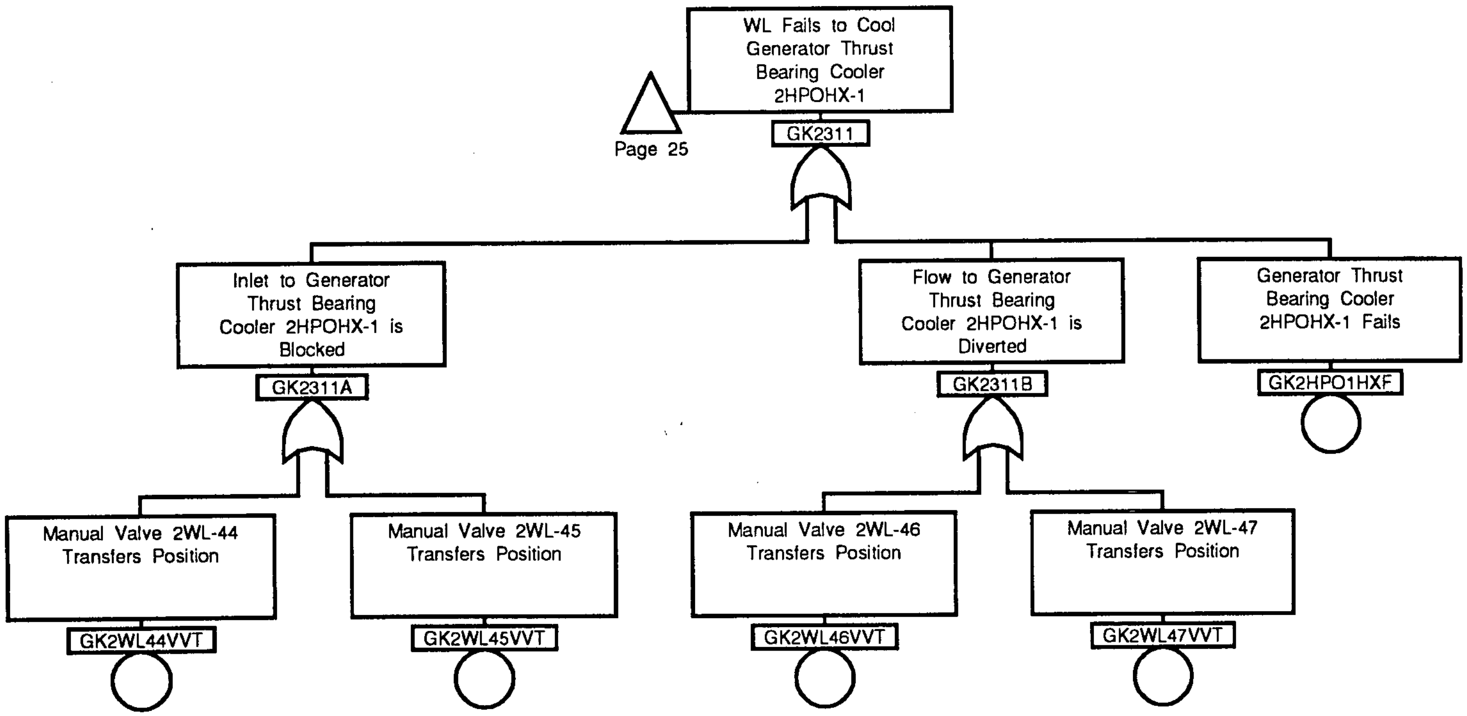


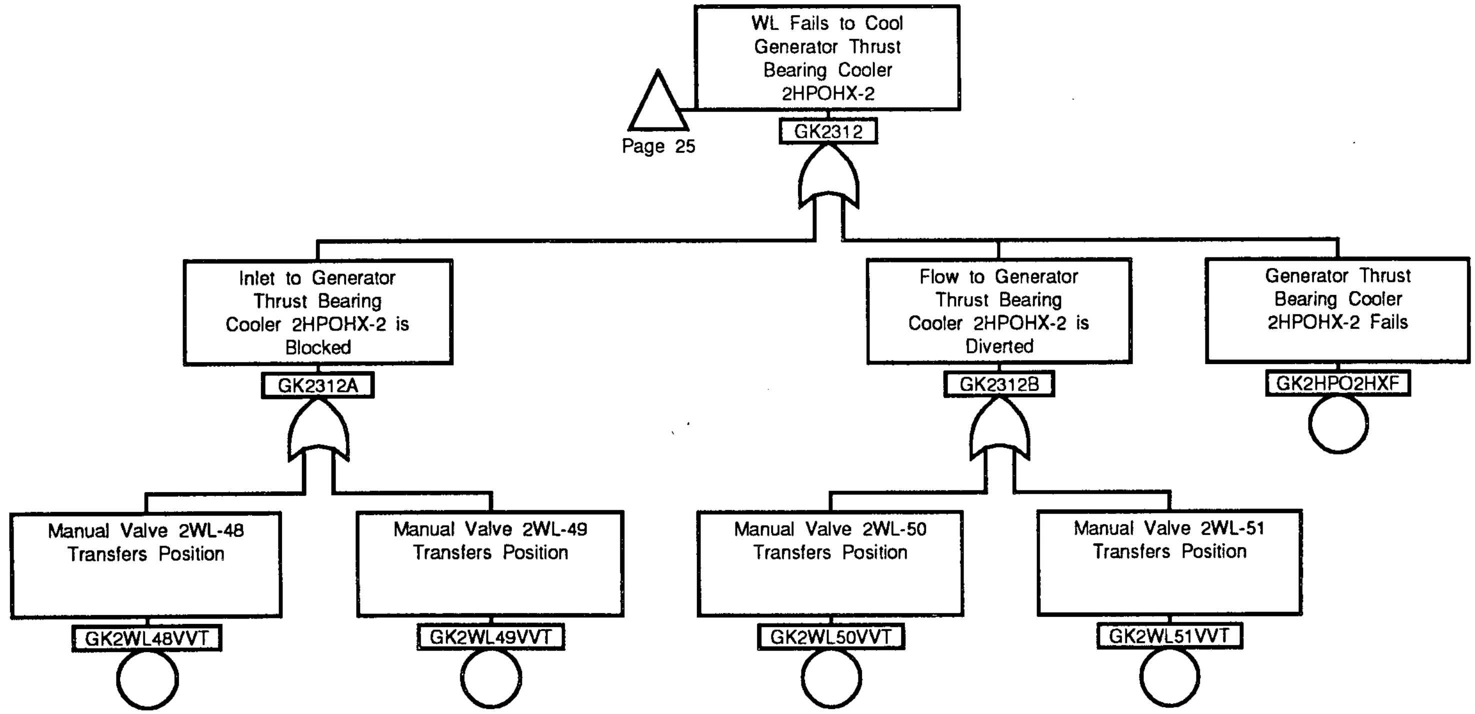
Keowee Generator Fault Tree	FIGURE A.7-6	Page 23

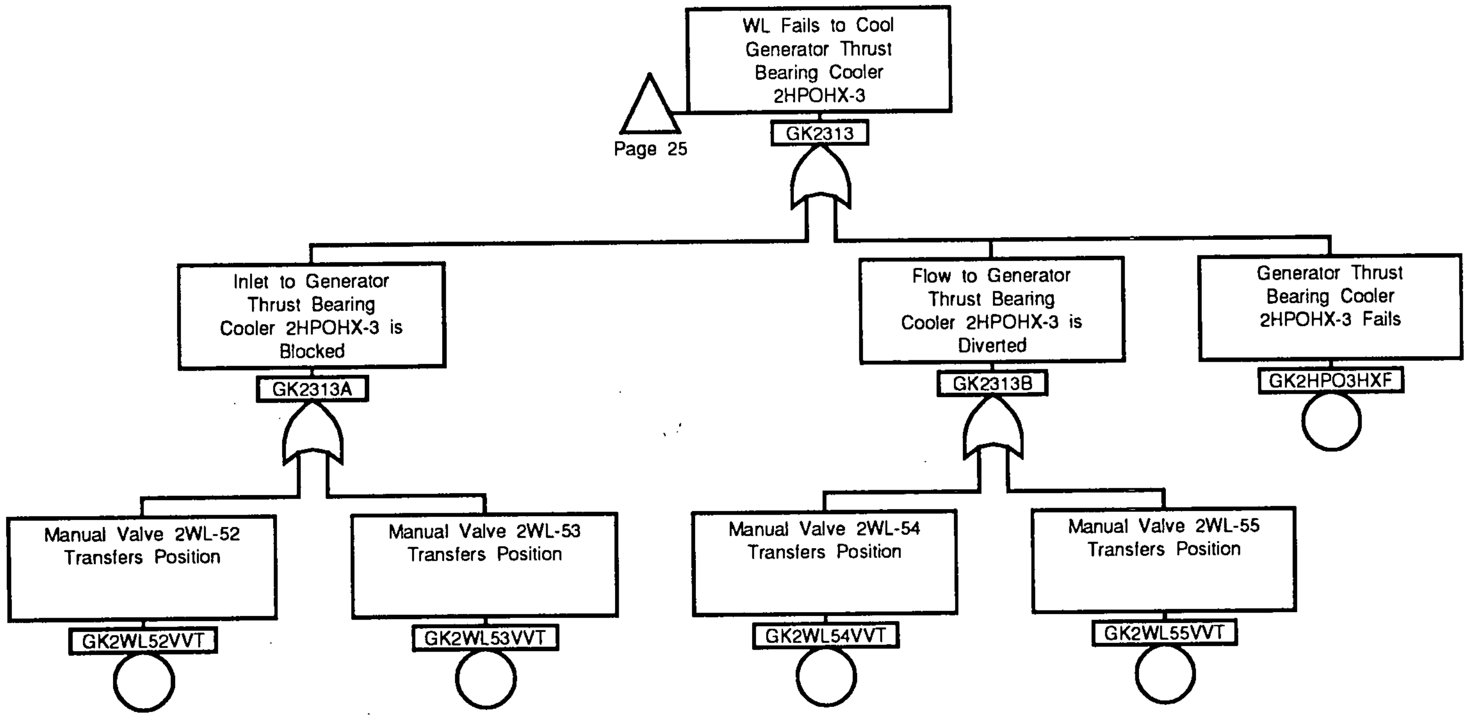


Keowee Generator Fault Tree | FIGURE A.7-6 |


Keowee 2 Generator Bearing Oil Cooler Fails
Page 24
GK2310
WL Fails to Cool Generator Thrust Bearing Cooler 2HPOHX-1
GK2311
Page 26
WL Fails to Cool Generator Thrust Bearing Cooler 2HPOHX-5
GK2315
Page 30
WL Fails to Cool Generator Thrust Bearing Cooler 2HPOHX-2
GK2312
Page 27
WL Fails to Cool Generator Thrust Bearing Cooler 2HPOHX-6
GK2316
Page 31
WL Fails to Cool Generator Thrust Bearing Cooler 2HPOHX-3
GK2313
Page 28
WL Fails to Cool Generator Thrust Bearing Cooler 2HPOHX-7
GK2317
Page 32
WL Fails to Cool Generator Thrust Bearing Cooler 2HPOHX-4
GK2314
Page 29
WL Fails to Cool Generator Thrust Bearing Cooler 2HPOHX-8
GK2318
Page 33


WL Fails to Cool Generator Thrust Bearing Cooler 2HPOHX-1
GK2311
Page 25
Inlet to Generator Thrust Bearing Cooler 2HPOHX-1 is Blocked
GK2311A
Flow to Generator Thrust Bearing Cooler 2HPOHX-1 is Diverted
GK2311B
Generator Thrust Bearing Cooler 2HPOHX-1 Fails
GK2HPO1HXF
Manual Valve 2WL-44 Transfers Position
GK2WL44VVT
Manual Valve 2WL-45 Transfers Position
GK2WL45VVT
Manual Valve 2WL-46 Transfers Position
GK2WL46VVT
Manual Valve 2WL-47 Transfers Position
GK2WL47VVT


WL Fails to Cool Generator Thrust Bearing Cooler 2HPOHX-2
Page 25
GK2312
Inlet to Generator Thrust Bearing Cooler 2HPOHX-2 is Blocked
GK2312A
Flow to Generator Thrust Bearing Cooler 2HPOHX-2 is Diverted
GK2312B
Generator Thrust Bearing Cooler 2HPOHX-2 Fails
GK2HPO2HXF
Manual Valve 2WL-48 Transfers Position
GK2WL48VVT
Manual Valve 2WL-49 Transfers Position
GK2WL49VVT
Manual Valve 2WL-50 Transfers Position
GK2WL50VVT
Manual Valve 2WL-51 Transfers Position
GK2WL51VVT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GK2313
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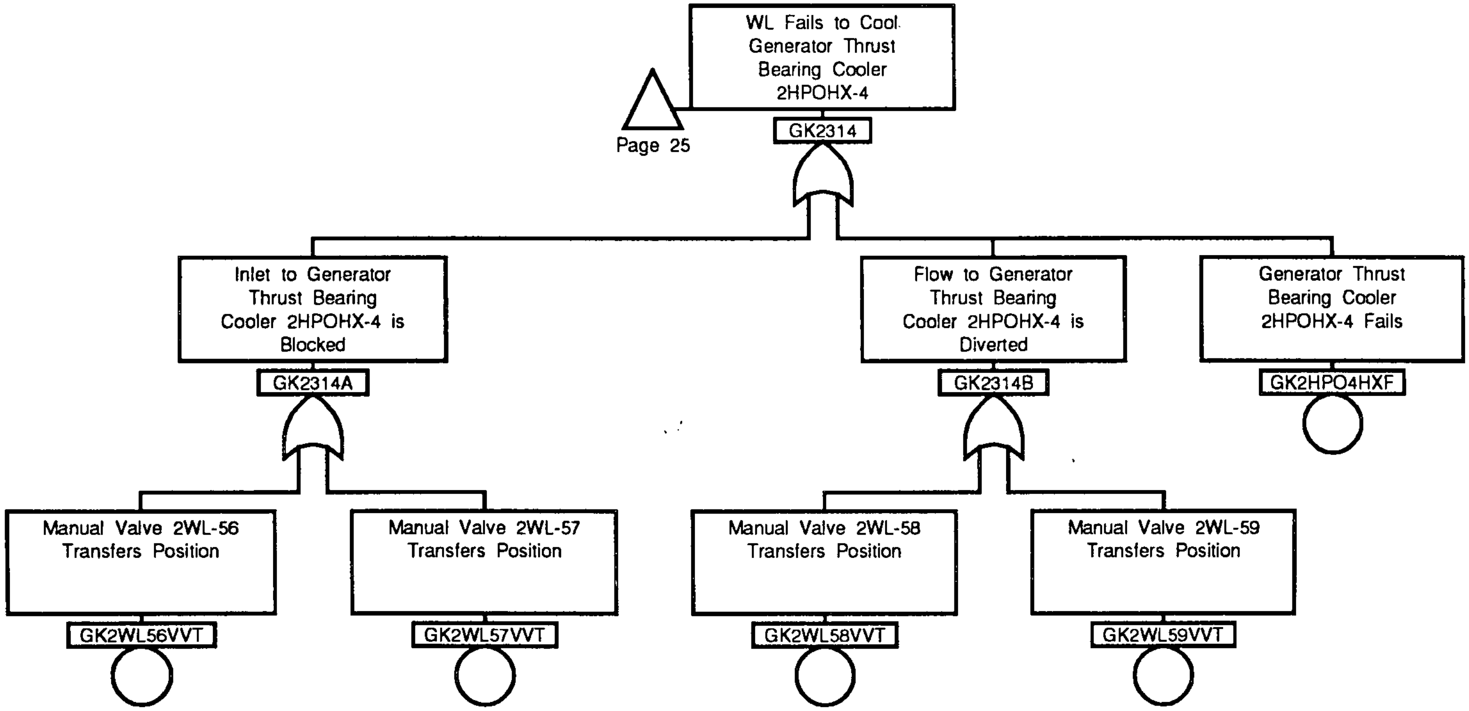
Inlet to Generator Thrust Bearing Cooler 2HPOHX-3 is Blocked
GK2313A
Flow to Generator Thrust Bearing Cooler 2HPOHX-3 is Diverted
GK2313B
Generator Thrust Bearing Cooler 2HPOHX-3 Fails
GK2HPO3HXF
Manual Valve 2WL-52 Transfers Position
GK2WL52VVT
Manual Valve 2WL-53 Transfers Position
GK2WL53VVT
Manual Valve 2WL-54 Transfers Position
GK2WL54VVT
Manual Valve 2WL-55 Transfers Position
GK2WL55VVT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GK2314
Page 25
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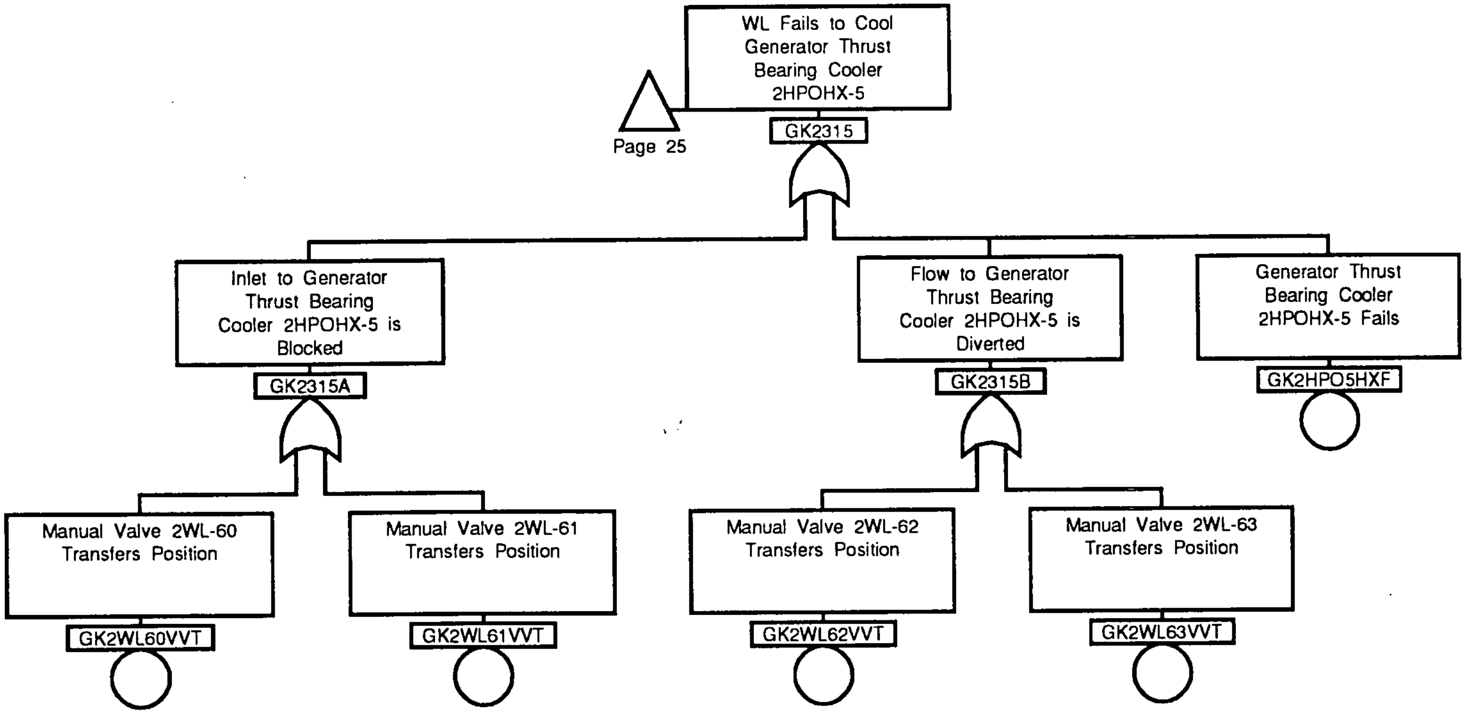
GK2314A
Flow to Generator Thrust Bearing Cooler 2HPOHX-4 is Diverted
GK2314B
Generator Thrust Bearing Cooler 2HPOHX-4 Fails
GK2HPO4HXF
Manual Valve 2WL-56 Transfers Position
GK2WL56VVT
Manual Valve 2WL-57 Transfers Position
GK2WL57VVT
Manual Valve 2WL-58 Transfers Position
GK2WL58VVT
Manual Valve 2WL-59 Transfers Position
GK2WL59VVT



WL Fails to Cool Generator Thrust Bearing Cooler 2HPOHX-5
GK2315
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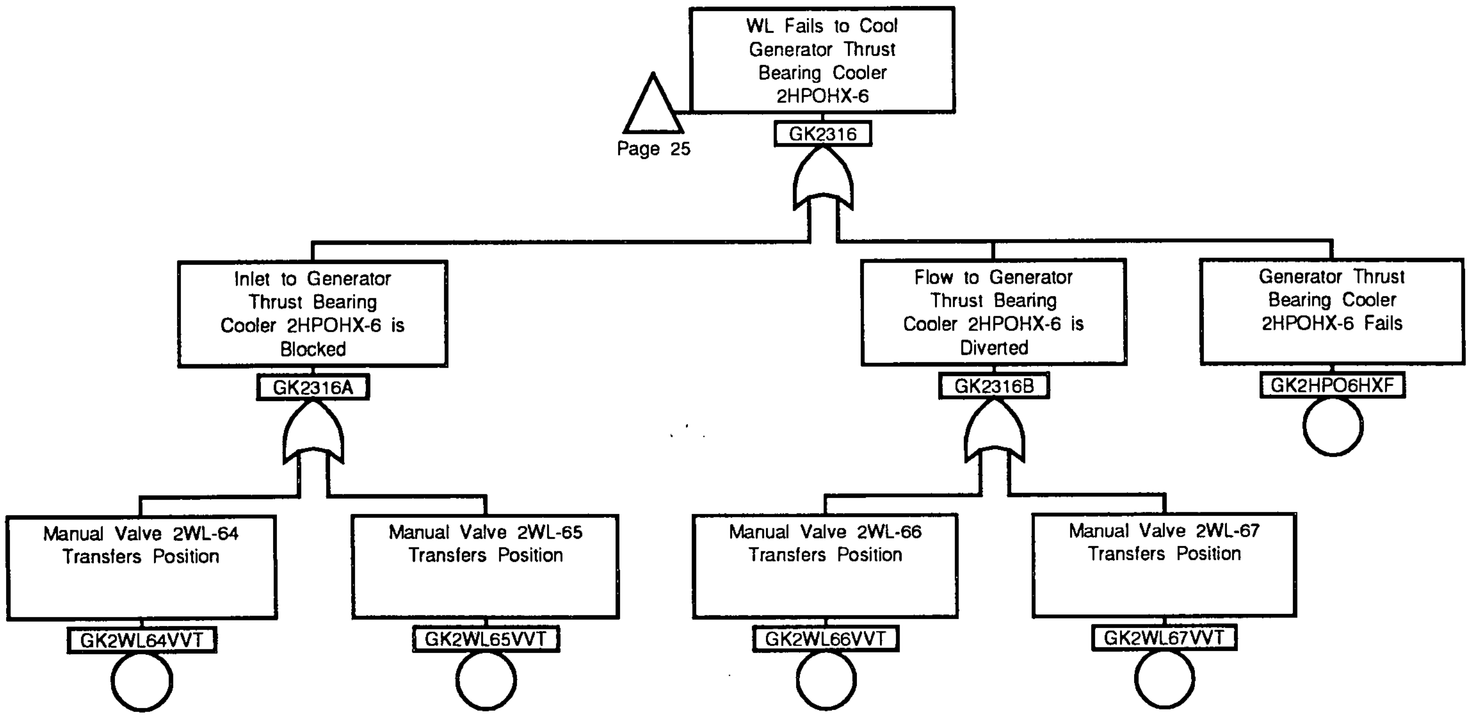
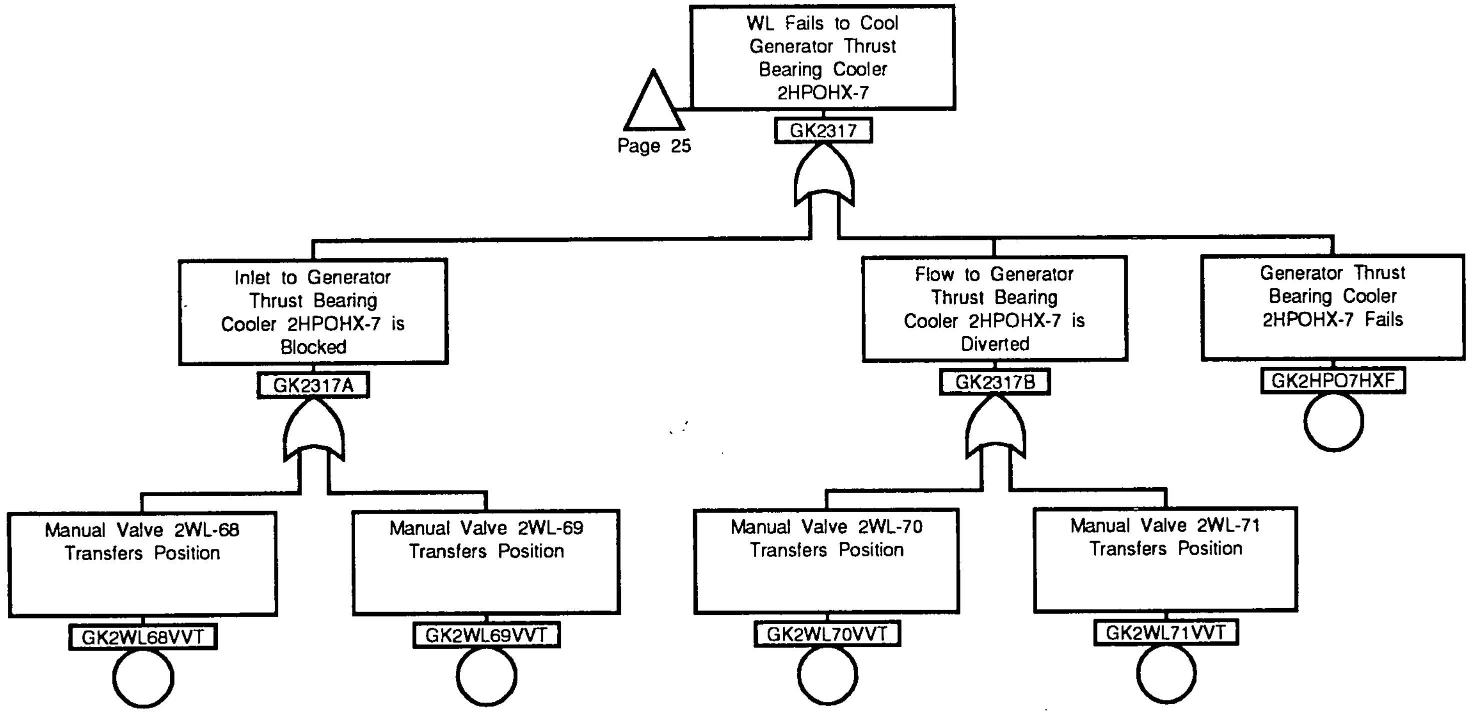
Inlet to Generator Thrust Bearing Cooler 2HPOHX-5 is Blocked
GK2315A
Flow to Generator Thrust Bearing Cooler 2HPOHX-5 is Diverted
GK2315B
Generator Thrust Bearing Cooler 2HPOHX-5 Fails
GK2HPO5HXF
Manual Valve 2WL-60 Transfers Position
GK2WL60VVT
Manual Valve 2WL-61 Transfers Position
GK2WL61VVT
Manual Valve 2WL-62 Transfers Position
GK2WL62VVT
Manual Valve 2WL-63 Transfers Position
GK2WL63VVT



Keowee Generator Fault Tree	FIGURE A.7-6	Page 31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GK2317
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GK2317A
Flow to Generator Thrust Bearing Cooler 2HPOHX-7 is Diverted
GK2317B
Generator Thrust Bearing Cooler 2HPOHX-7 Fails
GK2HPO7HXF
Manual Valve 2WL-68 Transfers Position
GK2WL68VVT
Manual Valve 2WL-69 Transfers Position
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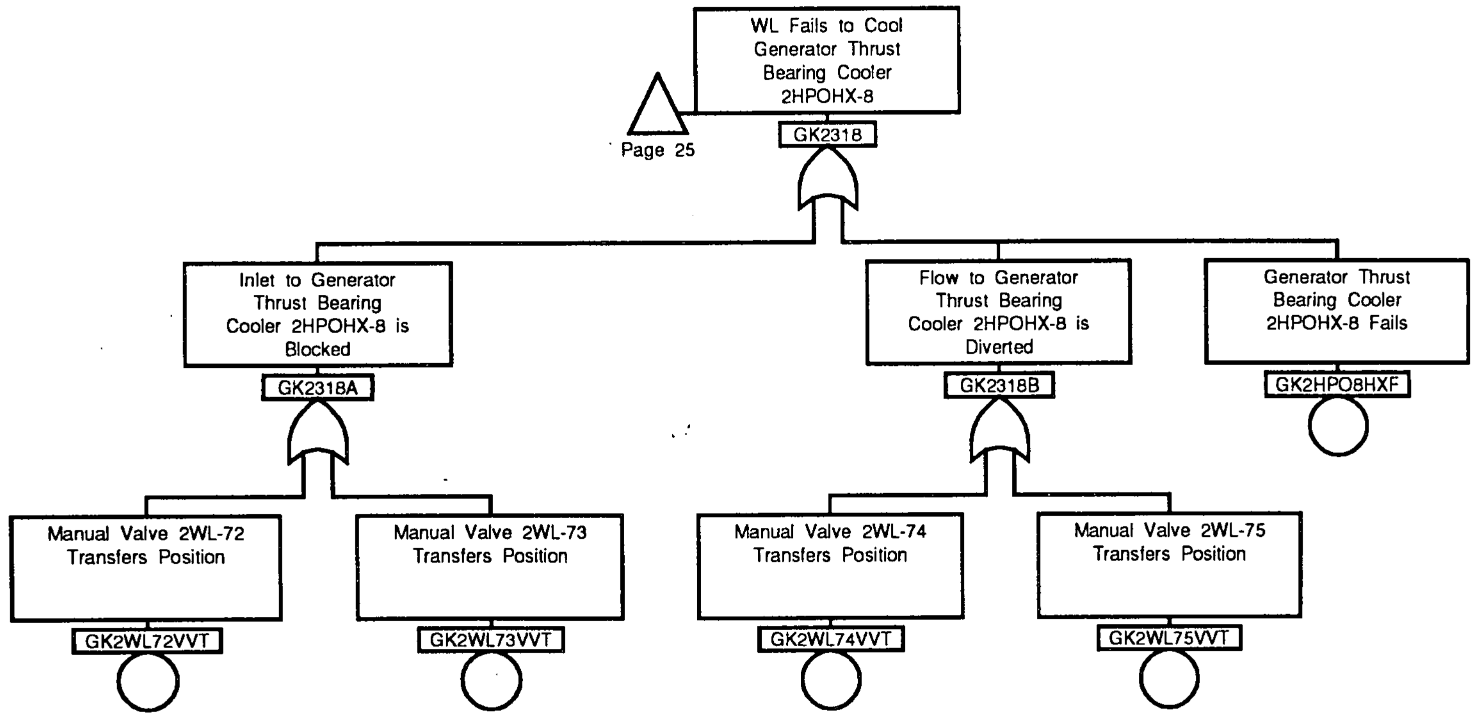
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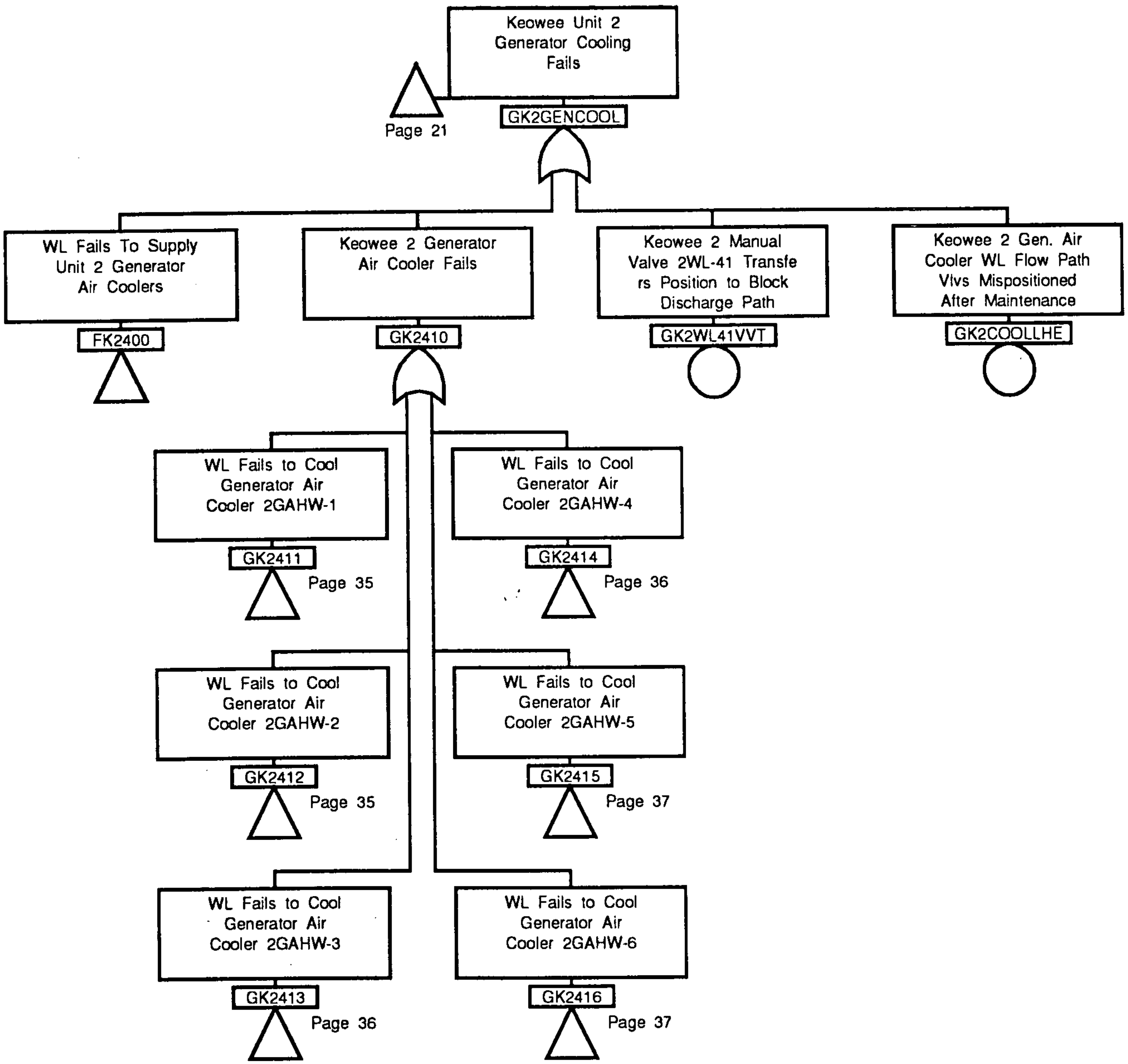
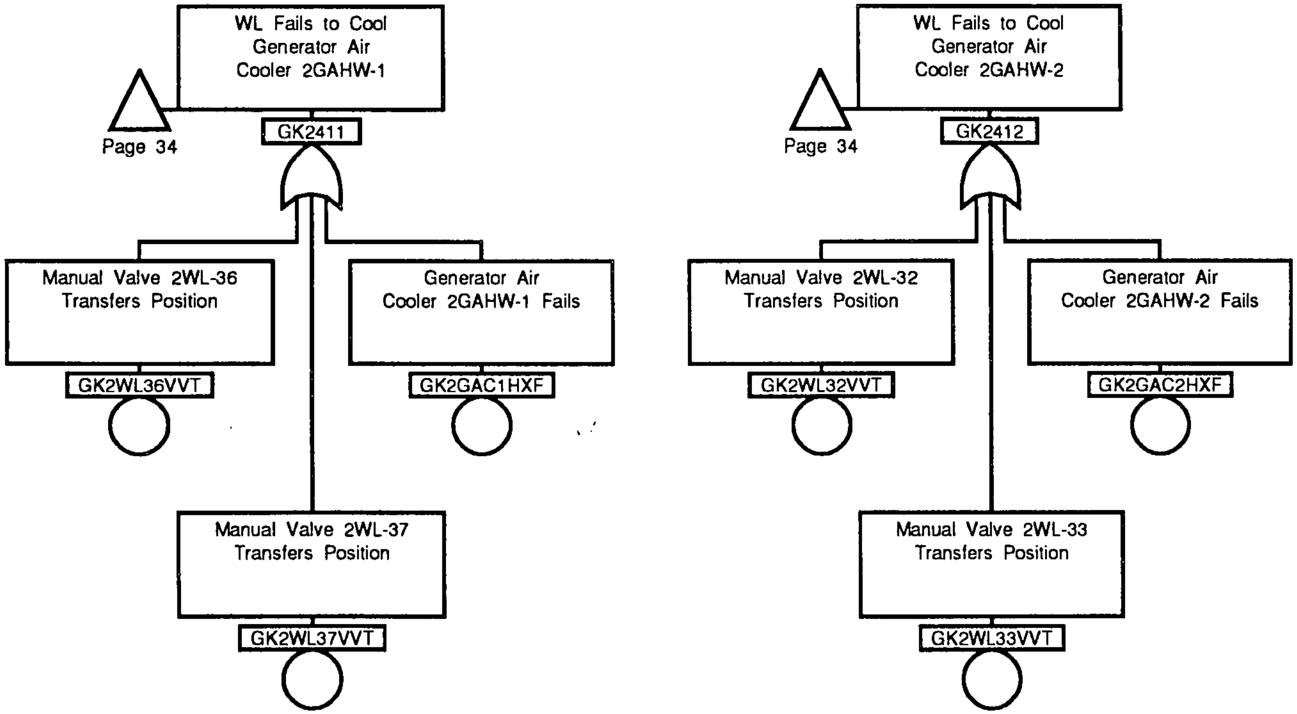
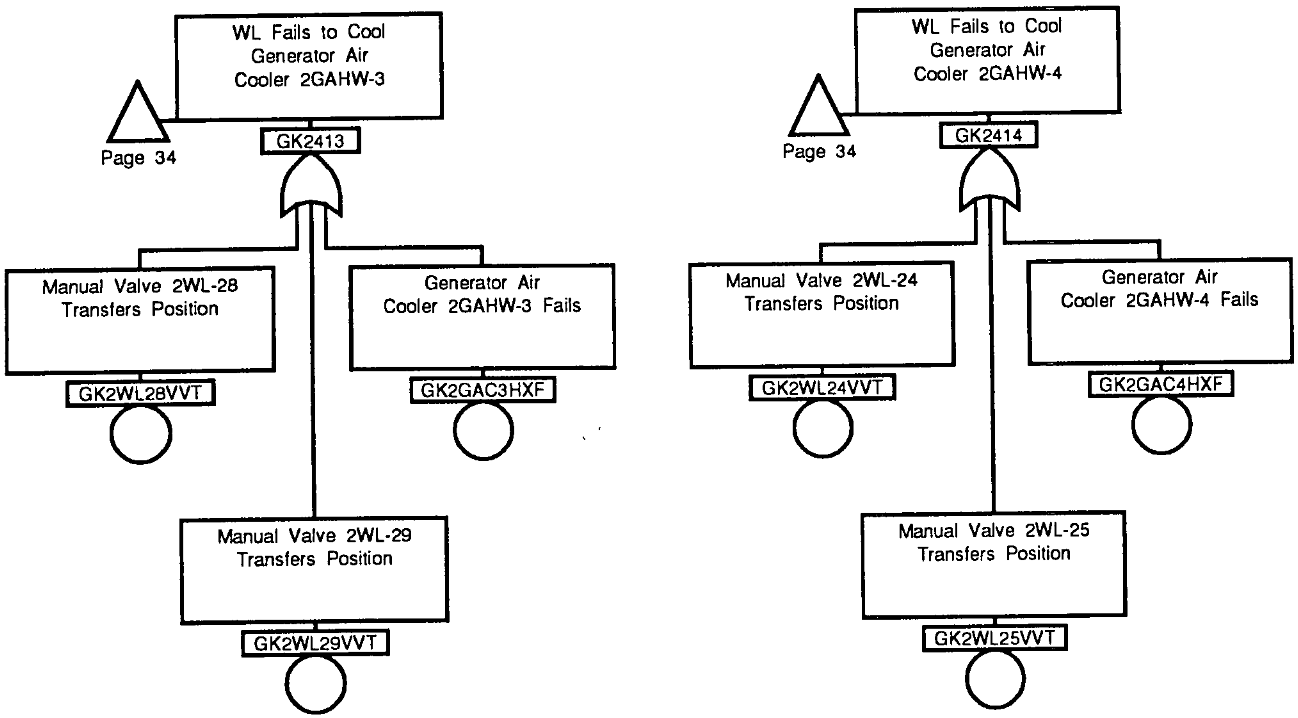
GK2318
Page 25
Inlet to Generator Thrust Bearing Cooler 2HPOHX-8 is Blocked
GK2318A
Flow to Generator Thrust Bearing Cooler 2HPOHX-8 is Diverted
GK2318B
Generator Thrust Bearing Cooler 2HPOHX-8 Fails
GK2HPO8HXF
Manual Valve 2WL-72 Transfers Position
GK2WL72VVT
Manual Valve 2WL-73 Transfers Position
GK2WL73VVT
Manual Valve 2WL-74 Transfers Position
GK2WL74VVT
Manual Valve 2WL-75 Transfers Position
GK2WL75VVT



Keowee Generator Fault Tree | FIGURE A.7-6 |



Keowee Generator Fault Tree | FIGURE A.7-6 |


WL Fails to Cool Generator Air Cooler 2GAHW-3
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GK2413
Manual Valve 2WL-28 Transfers Position
GK2WL28VVT
Generator Air Cooler 2GAHW-3 Fails
GK2GAC3HXF
Manual Valve 2WL-29 Transfers Position
GK2WL29VVT
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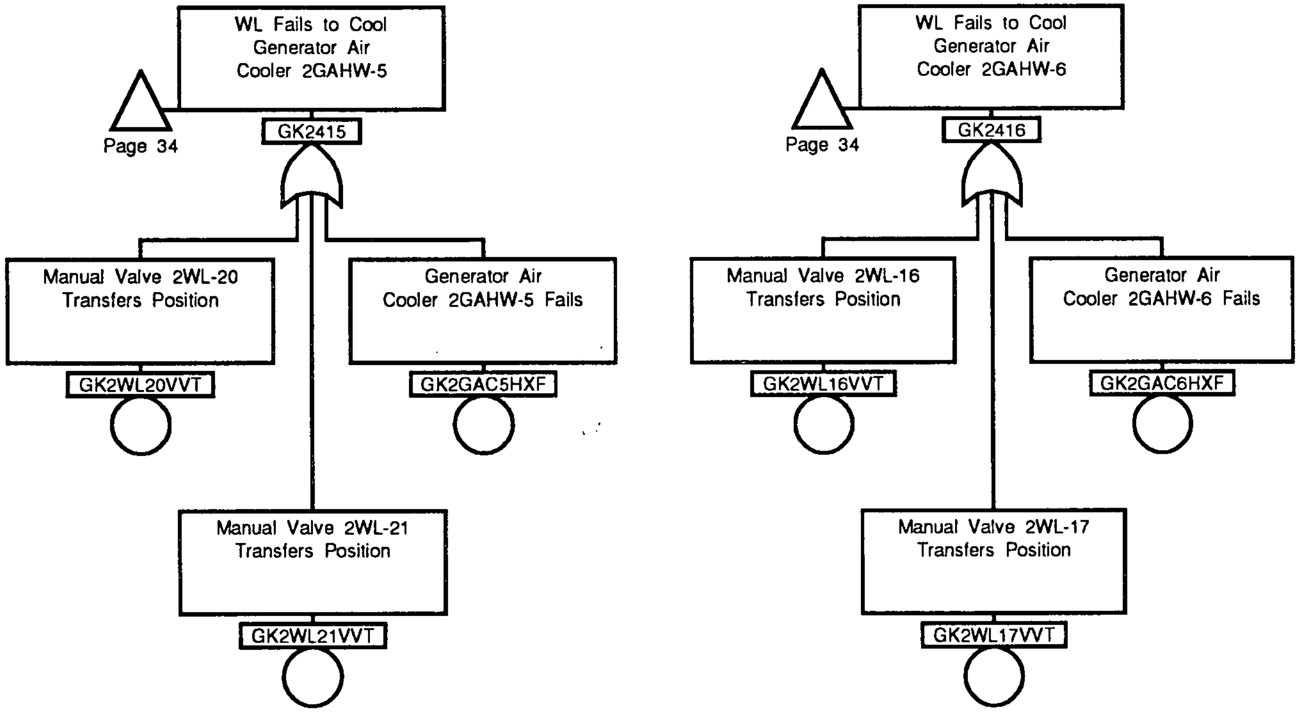
GK2WL24VVT
Generator Air Cooler 2GAHW-4 Fails
GK2GAC4HXF
Manual Valve 2WL-25 Transfers Position
GK2WL25VVT



WL Fails to Cool Generator Air Cooler 2GAHW-5
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GK2415
Manual Valve 2WL-20 Transfers Position
GK2WL20VVT
Generator Air Cooler 2GAHW-5 Fails
GK2GAC5HXF
Manual Valve 2WL-21 Transfers Position
GK2WL21VVT
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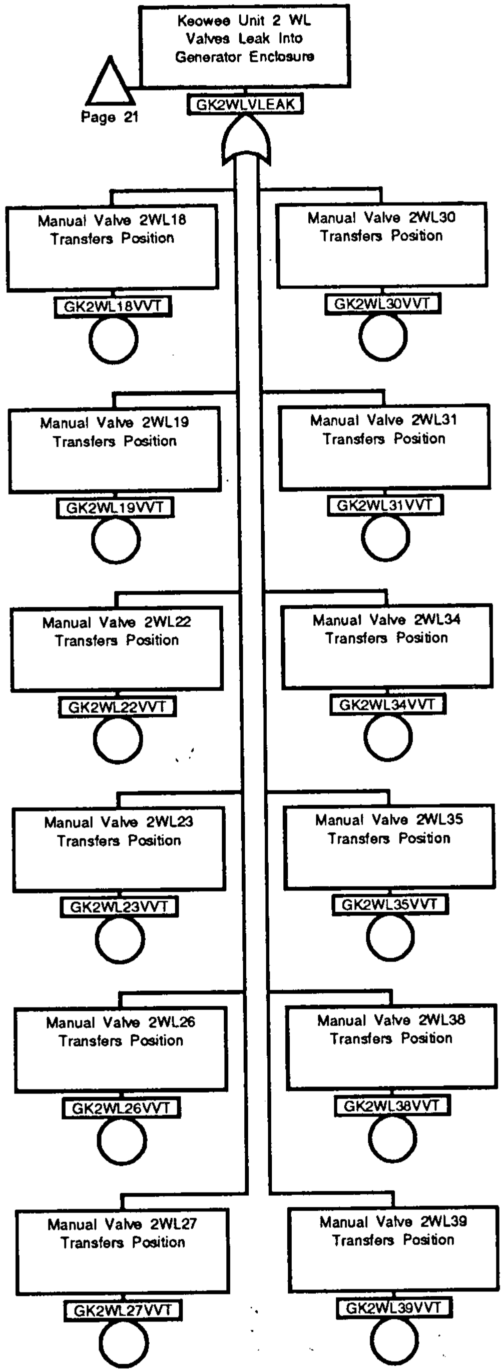
Manual Valve 2WL-16 Transfers Position
GK2WL16VVT
Generator Air Cooler 2GAHW-6 Fails
GK2GAC6HXF
Manual Valve 2WL-17 Transfers Position
GK2WL17VVT


Keowee Unit 2 WL Valves Leak Into Generator Enclosure
GK2WLVLEAK
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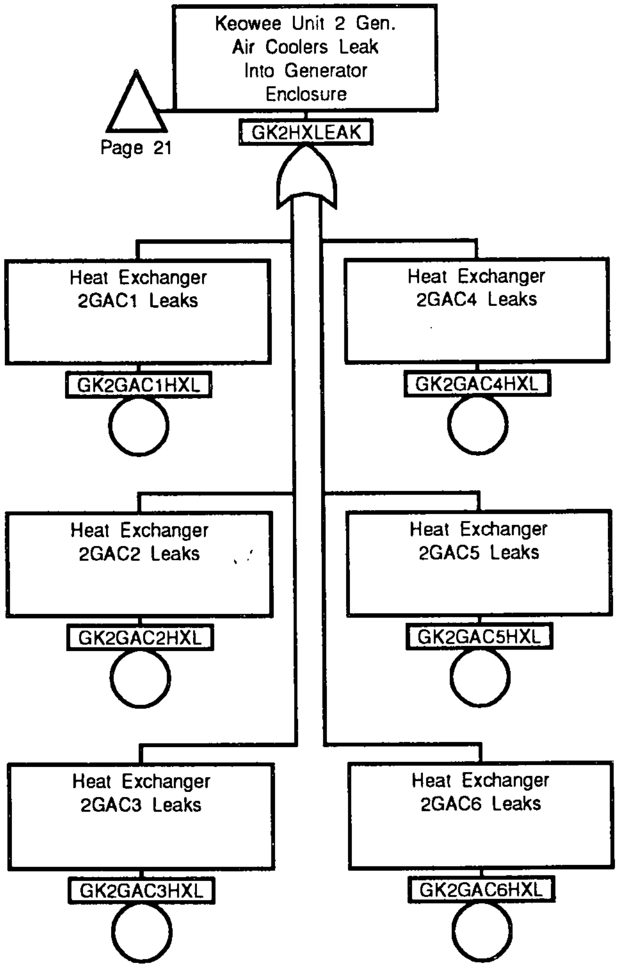
Manual Valve 2WL18 Transfers Position
GK2WL18VVT
Manual Valve 2WL30 Transfers Position
GK2WL30VVT
Manual Valve 2WL19 Transfers Position
GK2WL19VVT
Manual Valve 2WL31 Transfers Position
GK2WL31VVT
Manual Valve 2WL22 Transfers Position
GK2WL22VVT
Manual Valve 2WL34 Transfers Position
GK2WL34VVT
Manual Valve 2WL23 Transfers Position
GK2WL23VVT
Manual Valve 2WL35 Transfers Position
GK2WL35VVT
Manual Valve 2WL26 Transfers Position
GK2WL26VVT
Manual Valve 2WL38 Transfers Position
GK2WL38VVT
Manual Valve 2WL27 Transfers Position
GK2WL27VVT
Manual Valve 2WL39 Transfers Position
GK2WL39VVT



Keowee Generator Fault Tree | FIGURE A.7-6 |

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ACB4MOD	5		GK1317	6		GK1BRGDSCH	4		GK1WL17VVT	18	
FK1300	5		GK1317	13		GK1BRGDSCH	5		GK1WL18VVT	19	
FK1400	15		GK1317A	13		GK1BRGSUP	2		GK1WL19VVT	19	
FK2300	24		GK1317B	13		GK1BRGSUP	5		GK1WL20VVT	18	
FK2400	34		GK1318	6		GK1BRGVLHE	5		GK1WL21VVT	18	
GAB1FAULT	3		GK1318	14		GK1COOLLHE	15		GK1WL22VVT	19	
GK10001HGR	2		GK1318A	14		GK1FIREDEX	2		GK1WL23VVT	19	
GK10001HGS	1		GK1318B	14		GK1GAC1HXF	16		GK1WL24VVT	17	
GK1063FPST	4		GK13SUI	3		GK1GAC1HXL	20		GK1WL25VVT	17	
GK1120	5		GK13SUI	4		GK1GAC2HXF	16		GK1WL26VVT	19	
GK112TDRYT	5		GK13SUIRYT	4		GK1GAC2HXL	20		GK1WL27VVT	19	
GK112X1RYT	5		GK13SUISWT	4		GK1GAC3HXF	17		GK1WL28VVT	17	
GK1310	5		GK140G1RYT	3		GK1GAC3HXL	20		GK1WL29VVT	17	
GK1310	6		GK1410	15		GK1GAC4HXF	17		GK1WL30VVT	19	
GK1311	6		GK1411	15		GK1GAC4HXL	20		GK1WL31VVT	19	
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GK1311A	7		GK1412	15		GK1GAC5HXL	20		GK1WL33VVT	16	
GK1311B	7		GK1412	16		GK1GAC6HXF	18		GK1WL34VVT	19	
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GK1312B	8		GK1414	17		GK1HPO1HXF	7		GK1WL38VVT	19	
GK1313	6		GK1415	15		GK1HPO2HXF	8		GK1WL39VVT	19	
GK1313	9		GK1415	18		GK1HPO3HXF	9		GK1WL41VVT	15	
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GK1314B	10		GK163FX	4		GK1HPO8HXF	14		GK1WL49VVT	8	
GK1315	6		GK163FXRYT	4		GK1HXLEAK	2		GK1WL50VVT	8	
GK1315	11		GK186E1	2		GK1HXLEAK	20		GK1WL51VVT	8	
GK1315A	11		GK186E1RYT	2		GK1MODTRIP	3		GK1WL52VVT	9	
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GK1316	6		GK186E1X	3		GK1NGDCLHE	1		GK1WL54VVT	9	
GK1316	12		GK187G1RYT	3		GK1O121SST	5		GK1WL55VVT	9	
GK1316A	12		GK187GBRYT	3		GK1SUPRT	2		GK1WL56VVT	10	

Gate/Event Name	Page	Zone	Gate/Event Name	Page	Zone	Gate/Event Name	Page	Zone	Gate/Event Name	Page	Zone
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GK1WL64VVT	12		GK2314	29		GK262TDRYT	22		GK2HPO7HXF	32	
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GK1WL75VVT	14		GK2317	25		GK2BRGDSCH	24		GK2WL18VVT	38	
GK1WL76VVT	4		GK2317	32		GK2BRGSUP	21		GK2WL19VVT	38	
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Gate/Event Name	Page	Zone	Gate/Event Name	Page	Zone	Gate/Event Name	Page	Zone	Gate/Event Name	Page	Zone
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GK2WL44VVT	26		GMODTRIP2	24							
GK2WL45VVT	26		KU1GENCLD	1							
GK2WL46VVT	26		KU1GENRUN	2							
GK2WL47VVT	26		KU1RNNG	3							
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GK2WL49VVT	27		KU2GENRUN	21							
GK2WL50VVT	27		NTACB4MOD	5							
GK2WL51VVT	27		NTACB4MOD	5							
GK2WL52VVT	28		NTACB4MOD	24							
GK2WL53VVT	28										
GK2WL54VVT	28										
GK2WL55VVT	28										
GK2WL56VVT	29										
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GK2WL72VVT	33										
GK2WL73VVT	33										
GK2WL74VVT	33										
GK2WL75VVT	33										
GK2WL76VVT	23										
GK2WL78VVT	23										
GK2WLLEAK	21										

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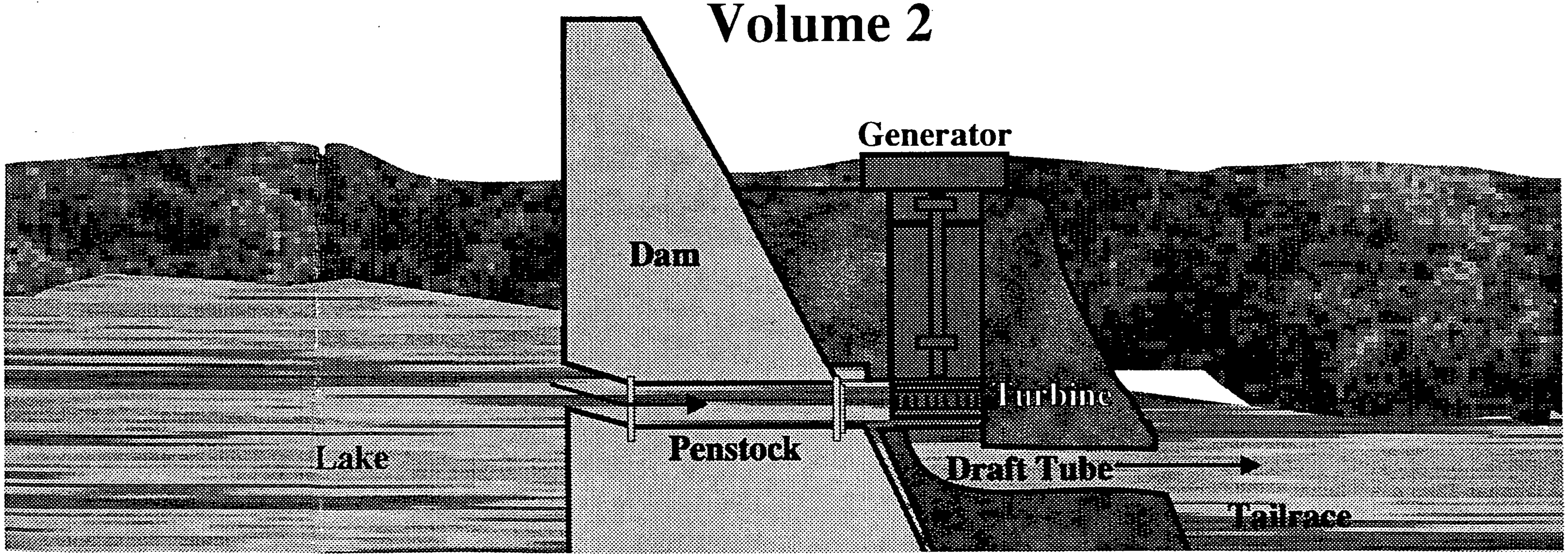
KEOWEE RELIABILITY ANALYSIS

DUKE POWER COMPANY

Volume 2



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APPENDIX A.8
KEOWEE AUXILIARY POWER SYSTEM

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A.8 KEOWEE AUXILIARY POWER SYSTEM

A.8.1 OBJECTIVES

The main objective of this analysis is to develop a logic model of the Keowee Auxiliary Power System. This model is combined with the high level logic model and remaining system models to form an integrated model for assessing the reliability of Keowee. Other objectives are to identify major contributors to system unreliability, significant potential human errors and common cause failure modes.

The scope of this analysis is limited to Keowee Auxiliary Power System equipment required to support a Keowee emergency start and run under load following a loss of offsite power condition.

A.8.2 SYSTEM DESIGN

The Keowee Auxiliary Power System consists of the 125 V dc power system and the 600 V ac system. The 125 V dc system supplies the unit auxiliary dc loads and the control power for Keowee emergency starting and breaker control switching logic. The system provides all electric power necessary to black start and operate the units in the event the ac auxiliary system is temporarily lost. Figure A.8-1 is the Keowee DC Auxiliary Power Simplified Diagram.

Figure A.8-2 is the Keowee AC Auxiliary Power Simplified Diagram. The Keowee 600 V ac Load Centers 1X and 2X with their normal and alternate feeder breakers will provide power to the Keowee ac auxiliary loads including battery chargers for the 125 V dc power systems. The load centers supply motor control centers (MCCs) from which power is further distributed to the electrical loads. Load Center 1X receives its power from the following sources:

1. Keowee Generator Unit 1 through transformer 1X and Air Circuit Breaker 5 (ACB-5).
2. The Oconee Switchgear 1TC through transformer CX and ACB-7.

3. The 230 kV switchyard through the Keowee step-up transformer, transformer 1X and ACB-5.

Similarly, Load Center 2X receives power from the following sources:

1. Keowee Generator Unit 2 through transformer 2X and ACB-6.
2. The Oconee switchgear 1TC through transformer CX and ACB-8.
3. The 230kV switchyard through the Keowee step-up transformer, transformer 2X and ACB-6.

The normal power to the auxiliaries of the Keowee unit lined up to the overhead power path comes from that unit when the Keowee unit is running or from the 230 kV switchyard when the Keowee unit is not generating power. The unit lined up to provide power through the underground power path normally receives its auxiliary power from source Transformer CX.

A.8.3 SYSTEM BOUNDARIES

Electrical Power Supplies

The Keowee 125 V dc Auxiliary Power System is dependent on the Keowee 600 V ac Auxiliary Power System to keep its batteries charged.

600 V ac auxiliary power for the Keowee unit tied to the underground power path is normally dependent on power supplied through transformer CX from the Oconee Unit 1, 4 kV Essential Auxiliary Power System Switchgear 1TC. The 600 V ac auxiliary power for the Keowee unit not tied to the underground feeder is normally supplied through its unit respective auxiliary transformer, 1X or 2X.

Keowee Auxiliary Automatic Switching

The 600 V Switchgear 1X and 2X have mode selector switches (143/A,M) which determine the power selection mode of the normal and alternate incoming power Air Circuit Breakers (ACBs). The breakers have manual control switches which are operable when the mode selector switches are in the "manual" position. When the mode selector

switches are in their normal "automatic" position the unit tied to the underground power path will receive its auxiliary power from transformer CX; therefore, ACB-7 or -8 will be the normally closed breaker for the unit tied to the underground path and ACB-5 or -6 will be the normally closed breaker for the other unit.

When the normal power to a switchgear is lost for 4 seconds, the normal breaker will trip. If power returns in less than 34 seconds, the normal breaker will re-close. Should the normal power not return in 34 seconds and alternate power is available, the alternate power breaker will automatically close. In the event that normal power returns, the normal breaker will not close again unless the alternate source is subsequently lost for longer than 4 seconds. The power seeking logic of the auxiliary power switchgear ACBs is more completely discussed in Appendix A.4.

Other System Boundaries

Individual load breakers are not included in the Auxiliary Power model. Load breakers are in the system models of the various loads.

A.8.4 INSTRUMENTATION AND CONTROLS

125 V dc Power System

The following devices are found on the control room electric boards (EB-2 for Unit 1 and EB-9 for Unit 2):

Battery DC Voltmeter
Battery Ground Leg P & N Indicating Lights
Battery Ground Detector Test Switch
Battery Undervoltage Relay 80-1 or 2.

The undervoltage relays have alarm functions only. Two voltmeters are provided on each Distribution Center to indicate the bus voltage on both 1DA and 2DA.

DC system trouble is indicated on Keowee control room statalarms. Table A.8-6 lists the Keowee Auxiliary Power System statalarms.

600 V ac System

The 1X and 2X switchgear automatic power seeking logic is described in Section A.8.3. If a load center is without power, its MCC can be manually aligned to receive power from the other load center. Breakers for the individual ac loads are located on the MCCs and are manually positioned. Load center breakers can be remote manually operated from the Keowee Control Room.

A.8.5 LOCATION WITHIN THE PLANT

All Keowee 125 V dc power system equipment is located within the Keowee Service Building substructure, below the slab located at 702'.

The Keowee electrical distribution system equipment is located inside the Powerhouse. Auxiliary Transformers No. 1X, 2X, and CX, and Load Centers 1X and 2X are located on the Operating Floor. Motor Control Centers are on the Mechanical Equipment Gallery, one floor below the Operating Floor.

A.8.6 NORMAL OPERATION

The Keowee 125 V dc Auxiliary Power System is electrically separated into 2 strings, each consisting of a battery charger, a battery bank, a distribution center and a deadlight panelboard. A standby battery charger is provided as a backup. Each string is connected to a 125 V dc isolating transfer diode, whose common output provides power to the Keowee static inverter for statalarm annunciators, computer I/O typers, etc.

In the event a unit's battery is out of service, the dc distribution centers may be tied together through the tie breakers, provided the operable battery has 59 operable cells. The ability to operate when called on to supply power in an emergency may be adversely affected if a battery is not in a fully charged condition. Thus, the standby charger should be connected as soon as possible after loss of the normal charger. Each battery has adequate capacity to ensure the emergency start and operation of both Keowee units for one hour.

The normal 600 V ac Auxiliary Power System configurations are described in Section A.8.2 above. One configuration that was not previously described is the line up when a load center is out of service for routine preventative maintenance. In this case its MCCs are lined up to the other Keowee unit's load center.

A.8.7 PERFORMANCE DURING KEOWEE EMERGENCY OPERATION

The loss of offsite power is a design basis event (DBE) for the Keowee 125 V dc Power System. For this emergency the power to the battery chargers is lost; however, either battery is capable of providing the control power necessary to black start the Keowee units. Following the unit startup, auxiliary power for the generator unit not connected to the underground path comes from the generator unit itself, through its auxiliary transformer and its normal ACB when it re-closes on sensing the return of power to its normal source. Auxiliary power for the unit connected to the underground is restored after power is restored to Oconee ESG Switchgear 1TC through CT4 and the standby bus.

A.8.8 TEST AND MAINTENANCE

Testing

The Keowee Auxiliary Power System testing requirements are detailed in Table A.8-2.

Maintenance

The Keowee Auxiliary Power System maintenance requirements are listed in Table A.8-3.

A.8.9 OPERATING EXPERIENCE

A summary of significant operating events is provided in Table A.8-4.

A.8.10 ASSUMPTIONS

A.8.10.1 SYSTEM DESIGN ASSUMPTIONS

1. It is assumed that the 125 V dc Power System is initially operable.

2. Even in the alternate alignment with the bus tie breakers closed, the 125 V dc power system is capable of providing black start power to the Keowee units up to one hour.

3. MCCs 1XS and 2XS are not modeled, since they provide power to none of the support equipment necessary for Keowee success. 1XS and 2XS provides power to the standby battery charger and can provide power to safety loads.

A.8.10.2 OPERATIONAL ASSUMPTIONS

1. The load center mode selector switches are assumed to be positioned for the automatic (power seeking) mode.

A.8.10.3 MODELING ASSUMPTIONS

125 V DC SYSTEM

1. The failure mode associated with Keowee start is the battery demand failure associated with the challenge of a black start. It is during the Keowee start up that the largest battery current is required. Consequently, the most probable time for failure occurs during start up. Time related failures are applied to the dc fault tree for the 24 hour Keowee run.

2. The battery charger input power supplies are only modeled to the MCC bus. The MCCs are modeled in the ac auxiliaries portion of the fault tree. Transfer to the ac tree would introduce circular logic, which has been avoided.

600 V AC AUXILIARY POWER SYSTEM

1. It is assumed that Keowee 1 is aligned to the underground power path and Keowee 2 is aligned to the overhead power path. Thus, Load Center 1X will be powered from transformer CX through ACB-7, and Load Center 2X will be powered from transformer 2X through ACB-6.

2. The 600 V ac MCCs are modeled for failure of their normal power supplies. The cross connection to the opposite train power supply (Load Center Switchgear) has not been included in order to avoid circular logic.

3. The normal and alternate power sources of the load centers are included in the 600 V ac fault tree. The selection logic is in the ACB fault trees which are transferred into the 600 V ac fault tree.

A.8.11 FAULT TREE ANALYSIS

A.8.11.1 TOP EVENT SUCCESS CRITERIA

Success of the Keowee Auxiliary Power System requires that the dc and ac power supplies remain functional for the duration of the event. If necessary, the functional power supplies can be manually cross connected to supply the opposite Keowee unit.

A.8.11.2 DETAILED FAILURE CRITERIA

1. The 125 V dc power supplies are modeled for failure to perform during the black start of the Keowee units, e.g., "Loss of Power to 125 V dc Dist. Cntr. 1DA during Start", and modeled for failure during the duration of the Keowee System performance run, "Loss of Power on Keowee 1 125 V dc Dist. Ctr. 1DA during Run". The alternate power to the distribution centers refers to short periods of preventative maintenance or test when the normal battery is isolated and the other battery is lined up to serve both units. This relatively small proportion of time with increased vulnerability is applied to both distribution centers for both start up and run functions.

2. After the assumed LOOP occurs and emergency power becomes available, power should be automatically restored to Load Center Switchgear 1X when ACB-7 re-

closes and automatically restored to Load Center Switchgear 2X after ACB-2 and ACB-6 close. These sequences and (should they fail) alternative power restoration sequences are modeled as demands (transfers to the ACB positioning fault trees) in the Keowee Auxiliary AC Power fault tree.

3. The power source for transformer CX is Oconee Unit 1 ESG Switchgear 1TC which is powered from Unit 1 Main Feeder Buses 1 and 2. Power for the main feeder buses can come from the Oconee 1 generator, the Oconee 1 startup source (230 kV switchyard or Keowee overhead power), or the standby bus (powered through the Keowee underground path or CT5).

A.8.11.3 DESCRIPTION OF FAULT TREE

The Keowee Auxiliary Power System fault tree is shown in Figure A.8-3. The Fault Tree Modeling Guidelines (Appendix B) were followed in developing the fault tree. A list of all fault tree transfers is presented in Table A.8-5.

In the dc section of the fault tree the alternate power line up to Distribution Center 1DA during Keowee run is Distribution Center 2DA and it is modeled as such. The alternate power line up to Distribution Center 2DA stops at the distribution center tie breakers to prevent circular logic in the model.

In the ac section each unit's MCCs have the capability of being powered from the other unit's load center. The model assumes that power from the cross connections is not available for the purpose of avoiding circular logic.

Human reliability analysis is performed as described in Appendix C.3. Human events impacting the model are described in Section A.8.12.6.

Common cause analysis is performed as described in Appendix C.2. Common cause events impacting the model are described in Section A.8.12.6.

A.8 .11.4 HUMAN INTERACTIONS

1. The Keowee Auxiliary Power System is monitored and challenged through test and Keowee generator operation such that latent failures are most unlikely.

2. The Standby Battery Charger at Keowee can be lined up to either battery in the event of a normal battery charger failure. This is modeled as a recovery for both Battery Charger #1 and Battery Charger #2.

A.8 .11.5 RELIABILITY DATA

Appendix C.1 discusses development of the reliability data.

Plant-specific data is used for maintenance events. The following maintenance events are included in the Keowee Auxiliary Power System model.

XD1DALTBYM, XD2DALTBYM, XA1XAALBM, XA2XAALBLM

These events account for maintenance and testing on the A and B trains. Each battery train is in maintenance or testing for approximately 3 days per year, and for 6 days every fifth year. Thus, the unavailability of a battery due to testing or maintenance is:

18(24) hr/5(8760) hr = 9.86E-3.

As discussed in Appendix C, consideration of relevant statalarms is part of the process of determining each basic event factor. System statalarms are listed in Table A.8 -6.

System reliability data is listed in Table A.8 -7.

A.8 .11.6 COMMON-CAUSE ASSESSMENT

XA1BKRSCOM, XA2BKRSCOM, XA56BKRCOM, XA78BKRCOM

The Auxiliary Power System power seeking breakers share the same design, maintenance procedures, operating conditions, environmental conditions, etc. A failure of both trains leads to a failure of the emergency power system to operate. Therefore, these common cause events are included in the fault tree to represent these coupling mechanisms.

A.8 .12 RESULTS

Reliability of the Keowee Auxiliary DC Power System is defined as the probability that the system will succeed in supporting Keowee emergency operation (black start plus a 24 hour run). The system model yields a probability of approximately 9.3E-04 that power on Distribution Center 1DA (or 2DA) will fail during an emergency start. Thus, the reliability of each unit's Auxiliary DC Power System during start is 99.91%. This is dominated by the generic demand failure rate of a battery. The Auxiliary DC Power System failure probability during a 24 hr mission time is 7.2E-04 (a system reliability of 99.93%). The Auxiliary AC Power System failure probability for the unit assigned to the underground for a 24 hr mission time is 3.7E-05 which converts to a 99.99% reliability. For the unit assigned to the overhead power path, the Auxiliary AC Power System failure probability is 3.5E-05; also a 99.99% reliability.

Tables A.8-8 through A.8-12 lists the dominant minimal cut sets (failure sequences) for the Auxiliary Power System. A list of dominant contributors to the unavailability of the dc Distribution Centers during the mission time is shown in Table A.8-13. The dominant contributor to the unavailability of an Auxiliary DC Power System train during run is failure of the train battery charger. The next highest contributors to system unreliability are faults on the train distribution centers. The dominant failure of the underground unit's Auxiliary AC Power System train ("Loss of power on MCC 1XA") is a spurious trip of the load center normal MCC feeder breaker 1X-2C during the 24 hr mission time. The next highest contributor is a fault on the MCC bus during the mission time. The dominant failures of the overhead unit's Auxiliary AC Power System are similar.

A.8 .13 REFERENCES

A.8 .13.1 DOCUMENTS

1. OSS-0254.00-00-2018, Rev. 0, Design Basis Specification for the Keowee 125 V DC Power System.

2. OSS-0254.00-00-2005, Rev. 2, Keowee Emergency Power Design Basis Document

A.8 .13.2 PROCEDURES

1. MP/0/A/2000/006, Change 2, Keowee Batteries and Chargers Inspection and Maintenance.

2. OP/0/A/2000/043, Change 6, Keowee Shift Turnover And Rounds.

A.8 .13.3 DRAWINGS

1. K-702, Rev. 17, Keowee One Line Diagram, 600 Volt Station Auxiliary Circuits.

2. K-704, Rev. 12, Keowee One Line Diagram, 125 Volt DC. Station Auxiliary Circuits.

3. KEE-6, Rev. 7, Keowee Development Unit 1 & 2, Tabulation Statalarm No. SA1 Station Alarms.

4. KEE-17-1, Rev. 15, Keowee Hydro Station Elementary Diagram, Transformer Differential.

5. KEE-27-1, Rev. 4, Keowee Elementary Diagram, 600V Switchgear No. 1X ACB-5 And ACB-7.

Table A.8-1

Keowee Auxiliary Power System Power Supplies

Component[1]	Power Source	Compartment Number / Comment
600 Vac Switchgear 1X (600 Vac Switchgear 2X)	ESG SWGR 1TC via Transformer CX	1TC-4 (when aligned to the underground)
600 Vac Switchgear 1X (600 Vac Switchgear 2X)	230 kV Switchyard via main step-up Xfmr and Xfmr 1X (2X)	When Keowee 1 (2) is idle and assigned to the ovhd. pwr. path.
600 Vac Switchgear 1X (600 Vac Swithgear 2X)	Keowee Unit 1 (2) via Xfmr 1X (2X)	When Keowee 1 (2) is on-line generating to the grid.
600 Vac MCC 1XA	600 Vac Switchgear 1X 600 Vac Switchgear 2X	2C (normal) 2D (alternate)
600 Vac MCC 2XA	600 Vac Switchgear 2X 600 Vac Switchgear 1X	2B (normal) 2A (alternate)
125 Vdc DC 1DA (2DA)	Battery 1 (2) and Battery Charger KC-1 (-2) Battery 2 (1) and Battery Charger KC-2 (-1)	(normal) (alternate)

[1] MCC = Motor Control Center
DC = Distribution Center

Table A.8-2

Keowee Auxiliary Power System Test Procedures

Procedure	Test Frequency	Description
IP/1(2)/A/0400/011	Annual	125 Vdc I&C Battery Bank No. 1 (2) Service Test and Annual Surveillance
IP/1(2)/A/0400/013	Daily	125 Vdc I&C Battery Bank No. 1 (2) Daily Surveillance
IP/1(2)/A/0400/014	Quarterly	125 Vdc I&C Battery Bank No. 1 (2) Quarterly Surveillance
IP/1(2)/A/0400/016	As Necessary	Instructions for Conducting Equilizing Charge on Battery Bank No. 1 (2)

Table A.8-3

<u>Keowee Auxiliary Power System Maintenance Procedures</u>

Procedure	Maintenance Frequency	Description
MP/0/A/2000/006,	Weekly	Keowee Batteries and Chargers Inspection and Maintenance

Table A.8-4

Keowee Auxiliary Power System Significant Operating Events

Date	Unit	Component	Event Summary
7/8/86	1/2	1TC-4	The Transformer CX supply breaker tripped. An attempt to close the breaker resulted in a DC Trouble alarm. The breaker had an internal ground and was replaced with a spare.
9/20/88	2	2X-2D	When clearing Load Center 1X for breaker inspection, the 1XA standby supply breaker, 2X-2D, failed to close. Replaced it with the spare breaker and closed the breaker from the Control Room.
12/16/92	2	KC-2	While Battery Bank #1 and Battery Charger #1 (KC-1) were removed from service for maint. KC-2 began erratic current swings. Attempts made to adjust voltage to stabilize KC-2 failed. Placed Battery Bank #1 on the Standby Charger (SBC) until Battery Bank #1 and KC-1 could be returned to service. Maint. personnel replaced the power supply, current control, voltage control, and the firing modules and returned KC-2 to service.
12/17/92	2	KC-2	During Emergency Start Testing KC-2 AC input switch tripped. Placed Battery Bank #2 on the SBC. Traced problem to a loose connection in the current limiter feedback circuit. Restored KC-2 to service.

Table A.8-4

Keowee Auxiliary Power System Significant Operating Events

Date	Unit	Component	Event Summary
12\21\92	2	KC-2	Smoke detector over KC-2 alarmed. Placed SBC in service on Battery Bank #2, and repaired KC-2. After repair KC-2 was placed back in service.

Table A.8-5

Keowee Auxiliary Power System Fault Tree Transfers

Transfer Gate Name	Description	Components Supplied
ACB2CLOSE	ACB 2 Fails To Close	Load Center 2X Load Center 1X
ACB2TRANS	ACB 2 Transfers Open	Load Center 2X Load Center 1X
ACB5CLOSE	ACB 5 Fails To Close	Load Center 1X
ACB5TRANS	ACB 5 Transfers Open	Load Center 1X
ACB6OPEN	ACB 6 Fails To Open	Load Center 2X
ACB6CLOSE	ACB 6 Fails To Close	Load Center 2X
ACB6TRANS	ACB 6 Transfers Open	Load Center 2X
ACB7OPEN	ACB 7 Fails To Open	Load Center 1X
ACB7CLOSE	ACB 7 Fails To Close	Load Center 1X
ACB7TRANS	ACB 7 Transfers Open	Load Center 1X
ACB8CLOSE	ACB 8 Fails To Close	Load Center 2X

Table A.8-5

Keowee Auxiliary Power System Fault Tree Transfers

Transfer Gate Name	Description	Components Supplied
ACB8TRANS	ACB 8 Transfers Open	Load Center 2X
KU2OVER	Keowee Unit 2 Fails To Supply The Overhead Path	Load Center 1X
PMFB1	Loss of Power on Main Feeder Bus 1	ESG Switchgear 1TC
PMFB2	Loss of Power on Main Feeder Bus 2	ESG Switchgear 1TC

Table A.8-6

Keowee Auxiliary Power System Statalarms

Point No.	Alarm	Actuator
	Keowee Statalarm Panel SA1	
SA1-31	Standby Battery Charger Trouble	30SBC
SA1-32	Battery #1 Tie Breaker Closed	30B1
SA1-33	Battery #2 Tie Breaker Closed	30B2
SA1-19	600 V Swgr. 1X Pwr. Supply Trouble	74T1 Timer
SA1-20	600 V Swgr. 2X Pwr. Supply Trouble	74T2 Timer
SA1-24	600 V Swgr. 1X Lockout Relay	86S/1X
SA1-25	600 V Swgr. 2X Lockout Relay	86S/2X
	Oconee Corresponding Alarms	
2SA17-38	600 V Swgr. 1X Pwr. Supply Trouble	
2SA18-38	600 V Swgr. 2X Pwr. Supply Trouble	
2SA17-50	Transformer 1X Trouble	
2SA18-50	Transformer 2X Trouble	
	Keowee Statalarm Panel 1SA1	
1SA1-44	Battery #1 Trouble	74BT/1
1SA1-45	Unit #1 Battery Ground	64PX/1, 64NX/1
1SA1-48	Unit #1 Battery Charger Trouble	30KC1
	Keowee Statalarm Panel 2SA1	
2SA1-44	Battery #2 Trouble	74BT/2
2SA1-45	Unit #2 Battery Ground	64PX/2, 64NX/2
2SA1-48	Unit #2 Battery Charger Trouble	30KC2

Table A.8-7

Keeowee Auxilliary Power System Reliability Data

Event Name	Description	Failure Rate[1]	Factor	Rationale For Factor[2]	Failure Probability
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance				3.80E-02
KU2CREDIT	Take Credit For Keowee Unit 2 Suppling Auxiliary ac Power To Unit 1				0.00E+00
PAC1TC4C4T	4160 Vac Breaker 1TC-4 Transfers Open	9.40E-07 /H	24 H		2.26E-05
PACTC01C4T	4160 Vac Breaker 1TC-1 Transfers Open	9.40E-07 /H	24 H		2.26E-05
PACTC14C4T	4160 Vac Breaker 1TC-14 Transfers Open	9.40E-07 /H	24 H		2.26E-05
PACX1TCBHF	4160 Vac Switchgear 1TC Fails	4.00E-07 /H	24 H		9.60E-06
SKXFMR1THF	Keowee Transformer 1 Fails	3.10E-06 /H	24 H		7.44E-05
XA1A2BTCDT	600 Vac Breaker 1XA-2BT Transfers Position	7.50E-08 /H	24 H		1.80E-06
XA1TR1XTLF	Keowee Transformer 1X Fails	7.50E-07 /H	24 H		1.80E-05
XA1X2AXCLT	600 Vac Breaker 1X-2A Transfers Position	9.08E-07 /H	24 H		2.18E-05
XA1X2CCCLT	600 Vac Breaker 1X-2C Transfers Position	9.08E-07 /H	24 H		2.18E-05
XA1XA1ACLT	600 Vac Breaker 1XA-1A Transfers Open	9.08E-07 /H	24 H		2.18E-05
XA1XAALBLM	MCC 1XA Is Connected to Its Alternate Source of Power				2.74E-03
XA1XAMCBLF	600 Vac MCC 1XA Fault	2.70E-07 /H	24 H		6.48E-06
XA1XCXXTHM	4160/600 Vac Xfrmr CX Is In Maint.				4.57E-04
XA1XCXXTLF	4160/600 Vac Transformer CX Fails	7.50E-07 /H	24 H		1.80E-05

Table A.8-7

Keowee Auxilliary Power System Reliability Data

Event Name	Description	Failure Rate[1]	Factor	Rationale For Factor[2]	Failure Probability
XA1XXXXBLF	600 Vac Switchgear 1X Fault	2.70E-07 /H	24 H		6.48E-06
XA2A2BTCDT	600 Vac Breaker 2XA-2BT Transfers Position	7.50E-08 /H	24 H		1.80E-06
XA2TR2XTLF	Keowee Transformer 2X Fails	7.50E-07 /H	24 H		1.80E-05
XA2X2BXCLT	600 Vac Breaker 2X-2B Transfers Position	9.08E-07 /H	24 H		2.18E-05
XA2X2DXCLT	600 Vac Breaker 2X-2D Transfers Open	9.08E-07 /H	24 H		2.18E-05
XA2X4AXCLT	600 Vac Breaker 2XA-4A Transfers Position	9.08E-07 /H	24 H		2.18E-05
XA2XAALBLM	MCC 2XA Is Connected to Its Alternate Power Source				2.74E-03
XA2XAMCBLF	600 Vac MCC-2XA Fault	2.70E-07 /H	24 H		6.48E-06
XA2XXXXBLF	600 Vac Switchgear 2X Fault	2.70E-07 /H	24 H		6.48E-06
XD1BK1ACDT	Battery No. 1 Breaker 1A Transfers Position run time dependent	7.50E-08 /H	24 H		1.80E-06
XD1CKC1BCF	Battery Charger KC1 Fails	2.90E-05 /H	24 H		6.96E-04
XD1DA1CCDT	125 Vdc Breaker 1C (from charger KC1) Transfers Position	7.50E-08 /H	24 H		1.80E-06
XD1DALTBYM	Normal Power To Dist. Center 1DA Is In Test or Maintenance				5.48E-03
XD1DALTBYM	Normal Power To Dist. Center 1DA Is In Test or Maintenance				5.48E-03
XD1DARXBDF	DC Distribution Center 1DA Faulted during Run	3.20E-07 /H	24 H		7.68E-06
XD1KB1XRHE	Keowee Standby Battery Charger SBC Not Lined Up in 1 Hour		1		1.00E+00

Table A.8-7

Keeowee Auxilliary Power System Reliability Data

Event Name	Description	Failure Rate[1]	Factor	Rationale For Factor[2]	Failure Probability
XD1KBATBYF	Keowee Battery No. 1 Fails During Discharge	9.30E-04 /D	1 D		9.30E-04
XD1TIE1CDT	Keowee 125V dc Dist Cntr 1DA Tie Breaker 1 Transfers Position	7.50E-08 /H	24 H		1.80E-06
XD2BK1ACDT	Battery No. 2 Breaker 1A Transfers Position	7.50E-08 /H	24 H		1.80E-06
XD2CKC2BCF	Battery Charger KC2 Fails	2.90E-05 /H	24 H		6.96E-04
XD2DA5CCDT	125 Vdc Breaker 2DA-5C (from Charger KC2) Transfers Open	7.50E-08 /H	24 H		1.80E-06
XD2DALTBYM	Normal Power To Dist Cntr 2DA Is In Test or Maintenance				5.48E-03
XD2DARXBDF	DC Distribution Center 2DA Faulted During Run	3.20E-07 /H	24 H		7.68E-06
XD2KB2XRHE	Keowee Standby Battery Charger SBC Not Lined Up in 1 Hour		1		1.00E+00
XD2KBATBYF	Keowee Battery No. 2 Fails during Discharge	9.30E-04 /D	1 D		9.30E-04
XD2TIE2CDT	Keowee 125V dc Dist Cntr 2DA Tie Breaker 2 Transfers Position	7.50E-08 /H	24 H		1.80E-06

1 D = Demand, H = Hour

2 Rules for assigning basic event factors are discussed in Table C.1-4.

Table A.8-8

Keeowee Auxiliary Power System Dominant Minimal Cut Sets

Cut Sets For Gate XD1DASRCES: Loss Of Power On 125 V dc Distribution Center 1DA During Start

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
1)	9.25E-04	99.5	-XD1DALTBYM	5.48E-03	Normal Power To Dist. Center 1DA Is In Test or Maintenance
			XD1KBATBYF	9.30E-04	Keowee Battery No. 1 Fails During Discharge
2)	5.10E-06	0.5	XD1DALTBYM	5.48E-03	Normal Power To Dist. Center 1DA Is In Test or Maintenance
			XD2KBATBYF	9.30E-04	Keowee Battery No. 2 Fails during Discharge
Total:	9.30E-04				

Table A.8-9

Keeowee Auxiliary Power System Dominant Minimal Cut Sets

Cut Sets For Gate XD2DASRCES: Loss Of Power On 125 V dc Distribution Center 2DA During Start

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
1)	9.25E-04	99.5	-XD2DALTBYM	5.48E-03	Normal Power To Dist Cntr 2DA Is In Test or Maintenance
			XD2KBATBYF	9.30E-04	Keowee Battery No. 2 Fails during Discharge
2)	5.10E-06	0.5	XD1KBATBYF	9.30E-04	Keowee Battery No. 1 Fails During Discharge
			XD2DALTBYM	5.48E-03	Normal Power To Dist Cntr 2DA Is In Test or Maintenance
Total:	9.30E-04				

Table A.8-10

Keeowee Auxiliary Power System Dominant Minimal Cut Sets

Cut Sets For Gate XD1DAR: Loss Of Power On 125 V dc Distribution Center 1DA During Run

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
1)	6.92E-04	96.6	-XD1DALTBYM	5.48E-03	Normal Power To Dist. Center 1DA Is In Test or Maintenance
			XD1CKC1BCF	6.96E-04	Battery Charger KC1 Fails
			XD1KB1XRHE	1.00E+00	Keowee Standby Battery Charger SBC Not Lined Up in 1 Hour
2)	7.68E-06	1.1	XD1DARXBDF	7.68E-06	DC Distribution Center 1DA Faulted during Run
3)	6.44E-06	0.9	-XD1DALTBYM	5.48E-03	Normal Power To Dist. Center 1DA Is In Test or Maintenance
			XA1XAMCBLF	6.48E-06	600 V ac MCC 1XA Fault
			XD1KB1XRHE	1.00E+00	Keowee Standby Battery Charger SBC Not Lined Up in 1 Hour
4)	3.79E-06	0.5	-XD1DALTBYM	5.48E-03	Normal Power To Dist Cntr 2DA Is In Test or Maintenance
			XD1DALTBYM	5.48E-03	Normal Power To Dist. Center 1DA Is In Test or Maintenance
			XD2CKC2BCF	6.96E-04	Battery Charger KC2 Fails
			XD2KB2XRHE	1.00E+00	Keowee Standby Battery Charger SBC Not Lined Up in 1 Hour
5)	1.79E-06	0.3	-XD1DALTBYM	5.48E-03	Normal Power To Dist. Center 1DA Is In Test or Maintenance
			XD1BK1ACDT	1.80E-06	Battery No. 1 Breaker 1A Transfers Position
6)	1.79E-06	0.3	-XD1DALTBYM	5.48E-03	Normal Power To Dist. Center 1DA Is In Test or Maintenance
			XD1DA1CCDT	1.80E-06	125 V dc Breaker 1C (from charger KC1) Transfers Position
			XD1KB1XRHE	1.00E+00	Keowee Standby Battery Charger SBC Not Lined Up in 1 Hour

Table A.8-10

Keeowee Auxiliary Power System Dominant Minimal Cut Sets

Cut Sets For Gate XD1DAR: Loss Of Power On 125 V dc Distribution Center 1DA During Run

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
7)	1.79E-06	0.3	-XD1DALTBYM	5.48E-03	Normal Power To Dist. Center 1DA Is In Test or Maintenance
			XA1A2BTCDT	1.80E-06	600 V ac Breaker 1XA-2BT Transfers Position
			XD1KB1XRHE	1.00E+00	Keowee Standby Battery Charger SBC Not Lined Up in 1 Hour
8)	4.21E-08	<0.1	XD1DALTBYM	5.48E-03	Normal Power To Dist. Center 1DA Is In Test or Maintenance
			XD2DARXBDF	7.68E-06	DC Distribution Center 2DA Faulted During Run
9)	3.53E-08	<0.1	-XD1DALTBYM	5.48E-03	Normal Power To Dist Cntr 2DA Is In Test or Maintenance
			XA2XAMCBLF	6.48E-06	600 V ac MCC-2XA Fault
			XD1DALTBYM	5.48E-03	Normal Power To Dist. Center 1DA Is In Test or Maintenance
			XD2KB2XRHE	1.00E+00	Keowee Standby Battery Charger SBC Not Lined Up in 1 Hour
Total:	7.16E-04				

Table A.8-11

Keowee Auxiliary Power System Dominant Minimal Cutsets

Cutsets For Gate XA1XA: Loss of Power on Keowee 600 Vac MCC 1XA

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
1)	2.18E-05	59.3	-XA1XAALBLM	2.74E-03	MCC 1XA Is Connected to Its Alternate Source of Power
			XA1X2CCCLT	2.18E-05	600 V ac Breaker 1X-2C Transfers Position
2)	6.48E-06	17.7	XA1XAMCBLF	6.48E-06	600 V ac MCC 1XA Fault
3)	6.46E-06	17.6	-XA1XAALBLM	2.74E-03	MCC 1XA Is Connected to Its Alternate Source of Power
			XA1XXXXBLF	6.48E-06	600 V ac Switchgear 1X Fault
4)	8.55E-07	2.3	-XA1XAALBLM	2.74E-03	MCC 1XA Is Connected to Its Alternate Source of Power
			KK2UNITHYM	3.80E-02	The Overhead Unit (2) Is Unavailable Due To Maintenance
			PAC1TC4C4T	2.26E-05	4160 V ac Breaker 1TC-4 Transfers Open
5)	6.82E-07	1.9	-XA1XAALBLM	2.74E-03	MCC 1XA Is Connected to Its Alternate Source of Power
			KK2UNITHYM	3.80E-02	The Overhead Unit (2) Is Unavailable Due To Maintenance
			XA1XCXXTLF	1.80E-05	4160/600 V ac Transformer CX Fails
6)	3.64E-07	1.0	-XA1XAALBLM	2.74E-03	MCC 1XA Is Connected to Its Alternate Source of Power
			KK2UNITHYM	3.80E-02	The Overhead Unit (2) Is Unavailable Due To Maintenance
			PACX1TCBHF	9.60E-06	4160 Vac Switchgear 1TC Fails
Total:	3.67E-05				

Table A.8-12

Keowee Auxiliary Power System Dominant Minimal Cut Sets

Cut Sets For Gate XA2XA: Loss Of Power On Keowee 600 V ac MCC 2XA

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
1)	2.18E-05	62.6	-XA2XAALBLM	2.74E-03	MCC 2XA Is Connected to Its Alternate Power Source
			XA2X2BXCLT	2.18E-05	600 V ac Breaker 2X-2B Transfers Position
2)	6.48E-06	18.6	XA2XAMCBLF	6.48E-06	600 V ac MCC-2XA Fault
3)	6.46E-06	18.6	-XA2XAALBLM	2.74E-03	MCC 2XA Is Connected to Its Alternate Power Source
			XA2XXXXBLF	6.48E-06	600 V ac Switchgear 2X Fault
Total:	3.48E-05				

Table A.8-13

Loss Of Power On 125 V dc Distribution Center 1DA (2DA) During Run
Dominant Contributors To Unavailability

Rank	Event Description	Mean Unavailability[1]	Approximate Unavailability Contribution[2]
1	XD1(2)CKC1(2)BCF Battery Charger KC1 (KC2) Fails	6.92E-04	96.7%
2	XD1(2)DARXBDF Distribution Center 1DA (2DA) Faulted during Run	7.68E-06	1.1%
3	XA1(2)XAMCBLF 600 Vac MCC 1XA (2XA) Fault	6.44E-06	0.9%
4	XD1(2)DALTBYM Normal Power to Distribution Center 1DA (2DA) is in Test or Maintenance	3.87E-06	0.5%
5	XD2(1)CKC2(1)BCF Battery Charger KC2 (KC1) Fails	3.79E-06	0.5%

[1] Mean Unavailability is defined as the summation of the values all cut sets in which the event appears.

[2] The contribution to unavailability is calculated by dividing the mean unavailability by the overall system unavailability and then multiplying by 100 percent.

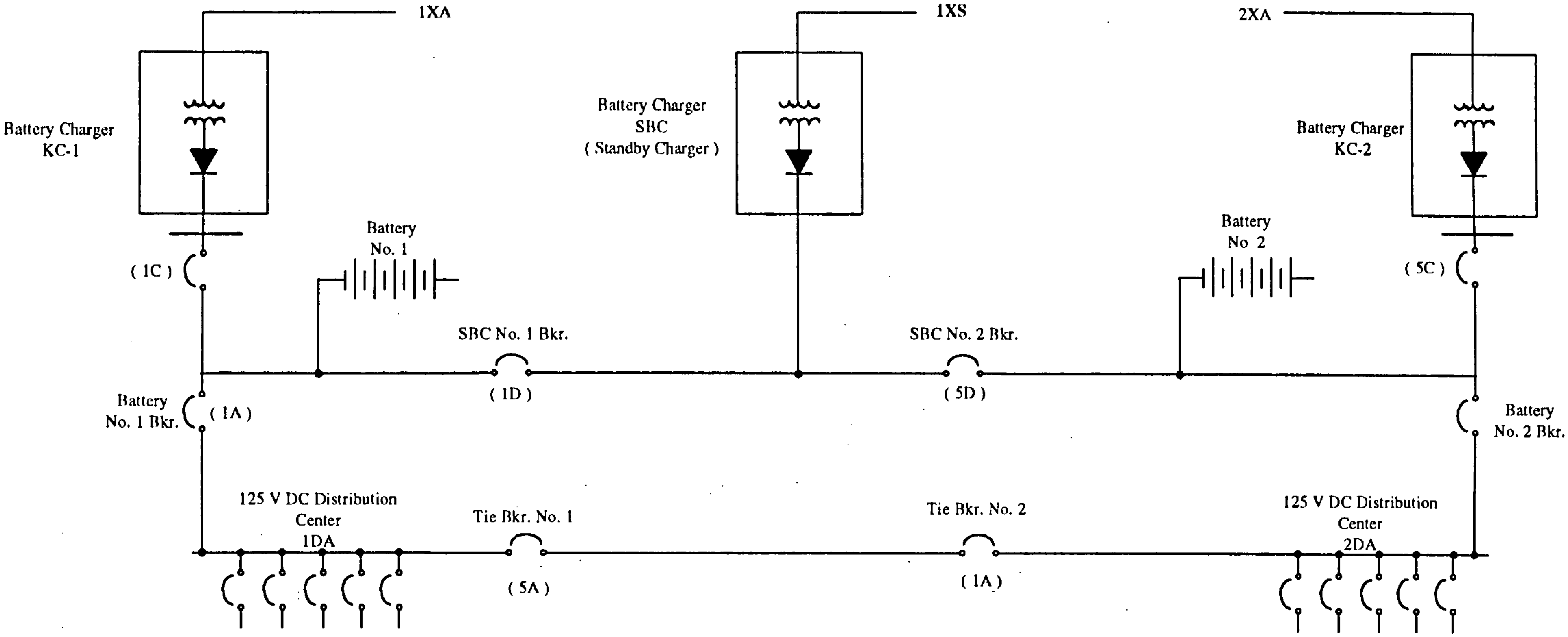


Figure A.8-1 Keowee DC Auxiliary Power System Simplified Diagram

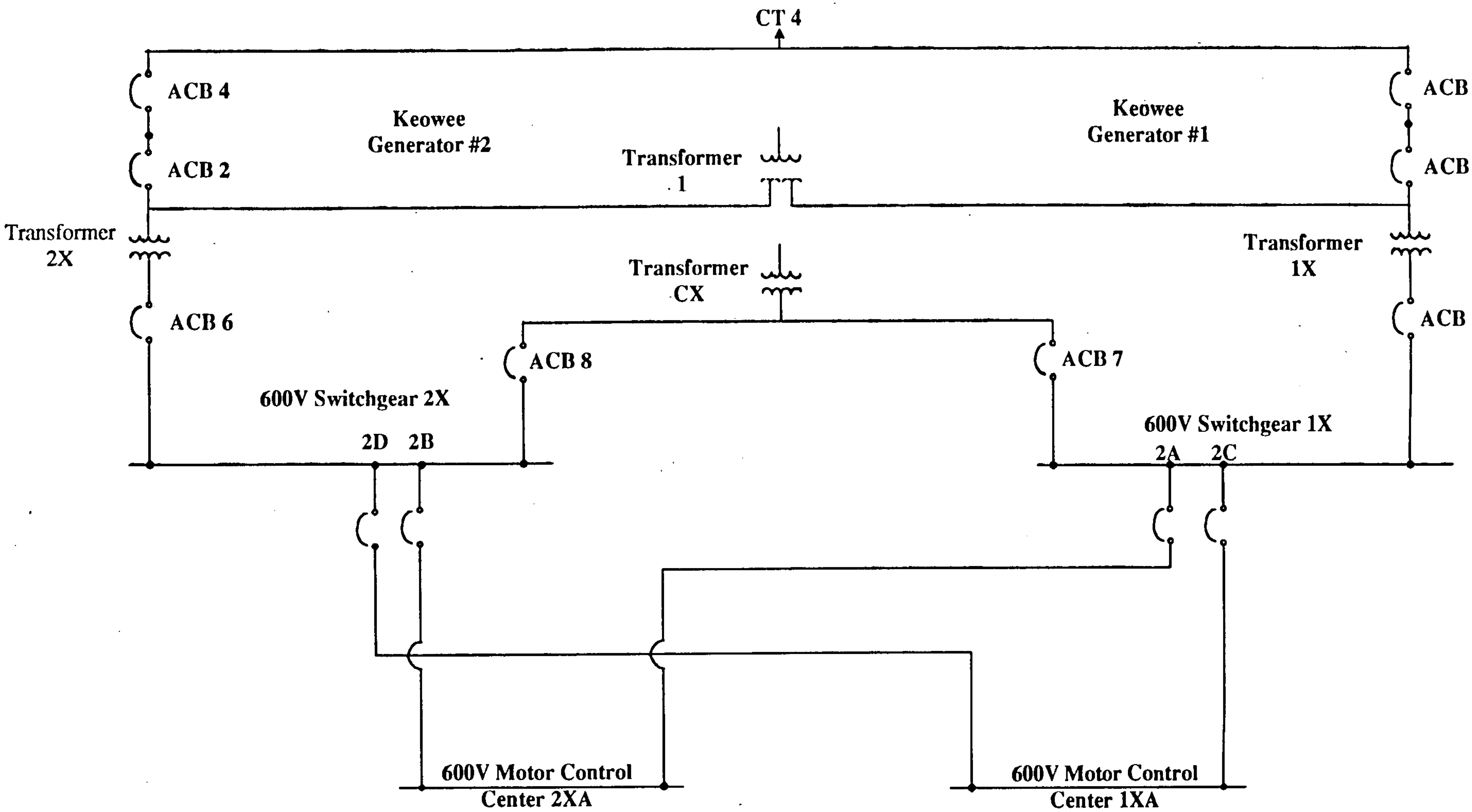
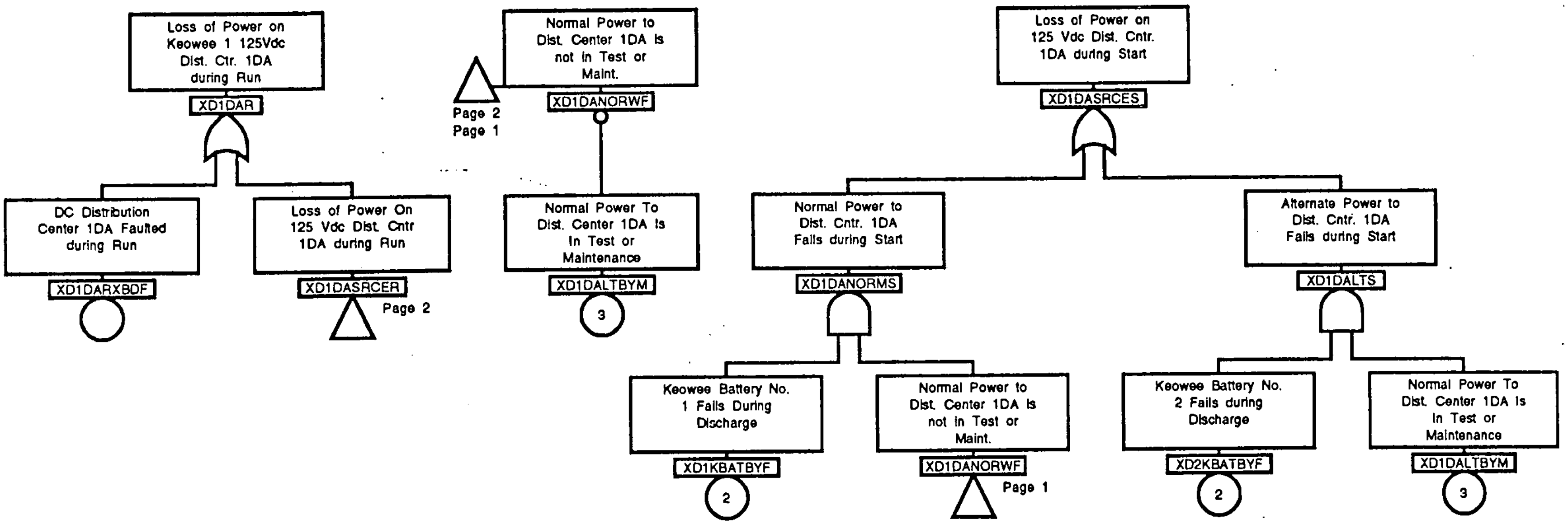
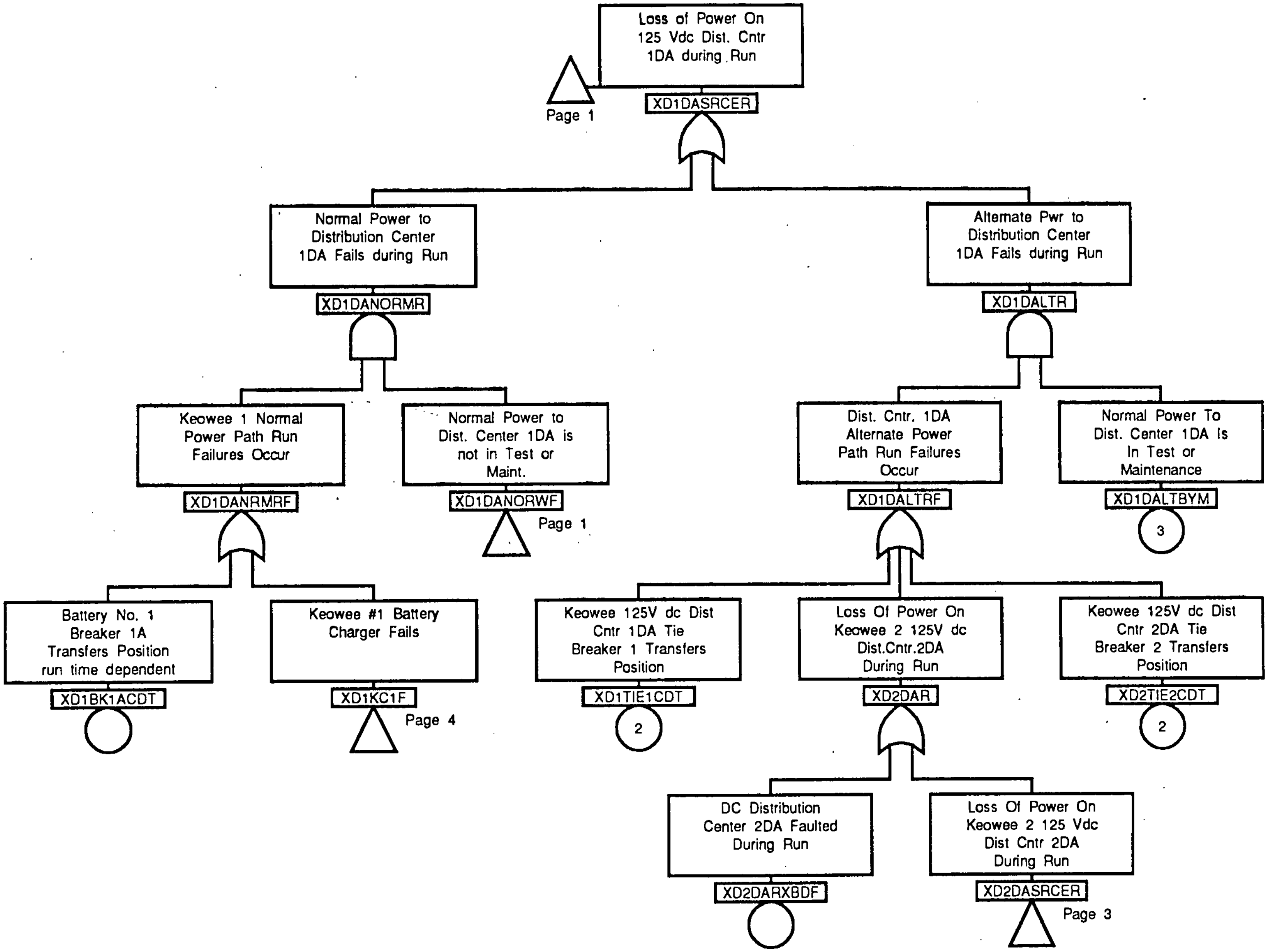


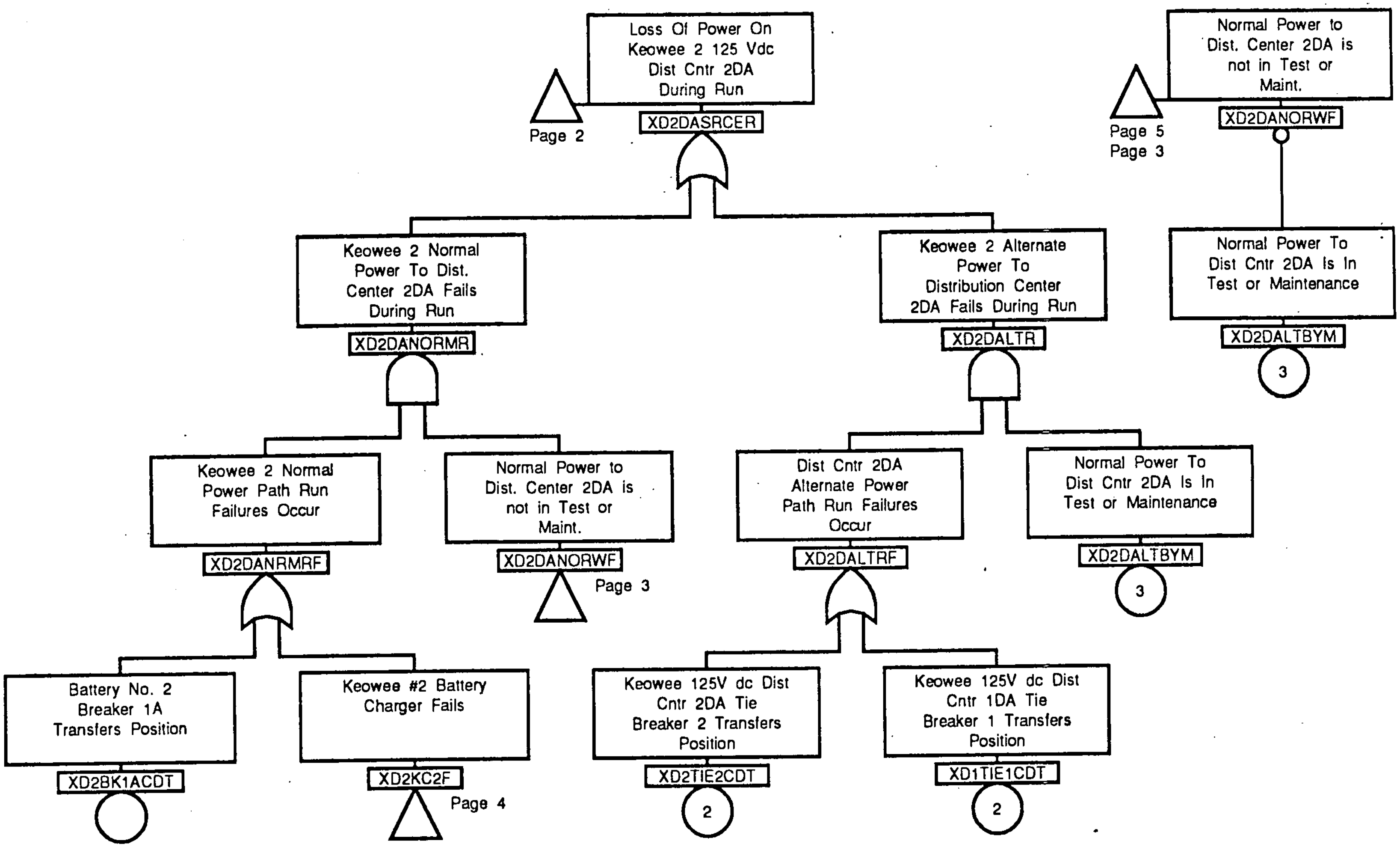
Figure A.8-2 Keowee AC Auxiliary Power System Simplified Diagram



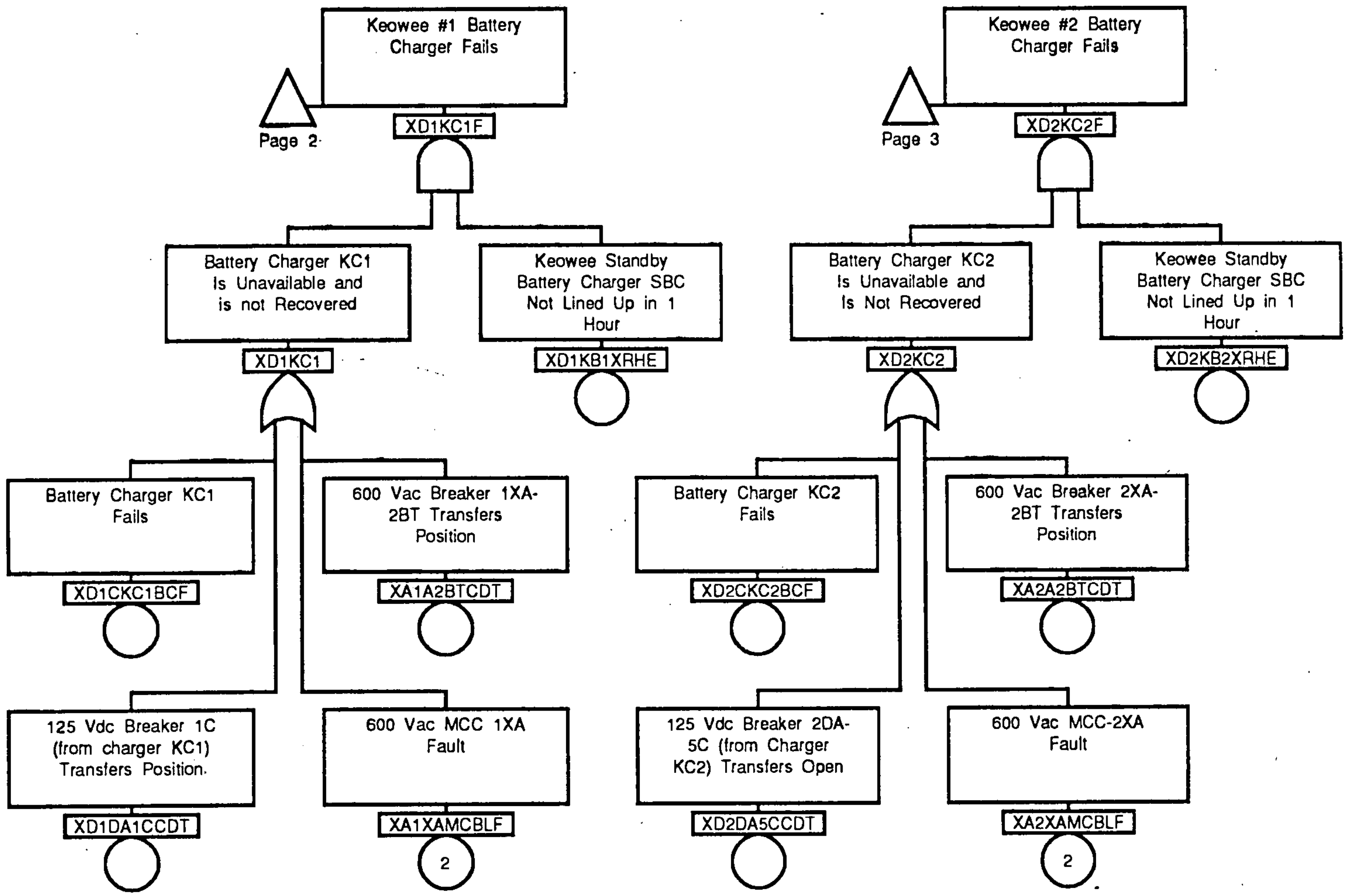
Keowee Auxiliary Power Fault Tree	FIGURE A.8-3	Page 1



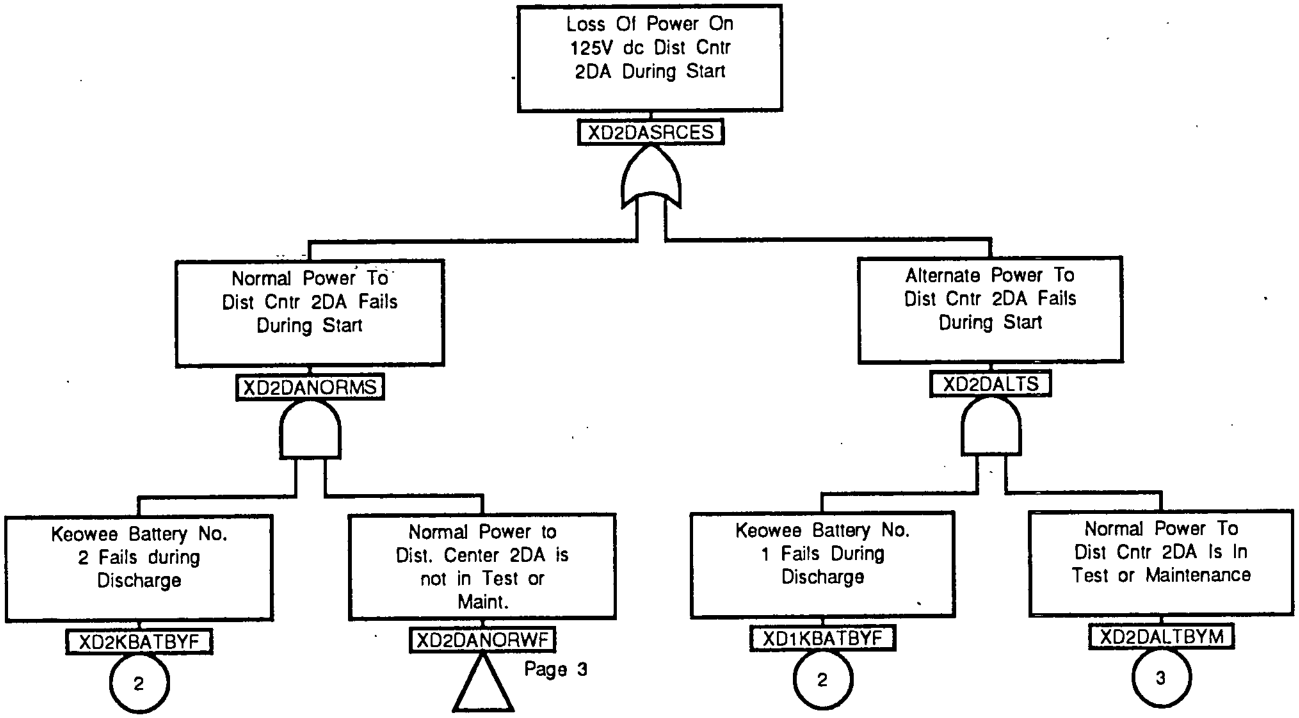
Keowee Auxiliary Power Fault T	FIGURE A.8-3	Pa 2



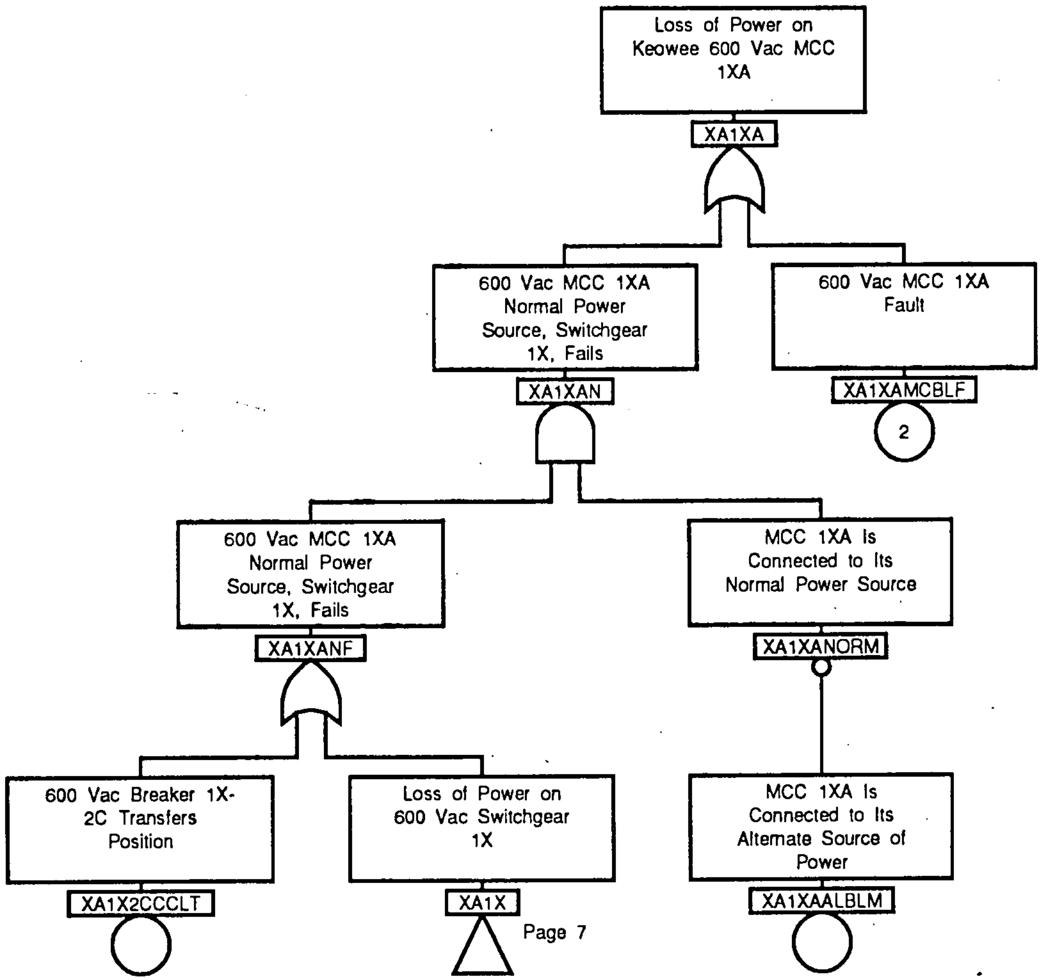
Keowee Auxiliary Power Fault Tree | FIGURE A.8-3 |

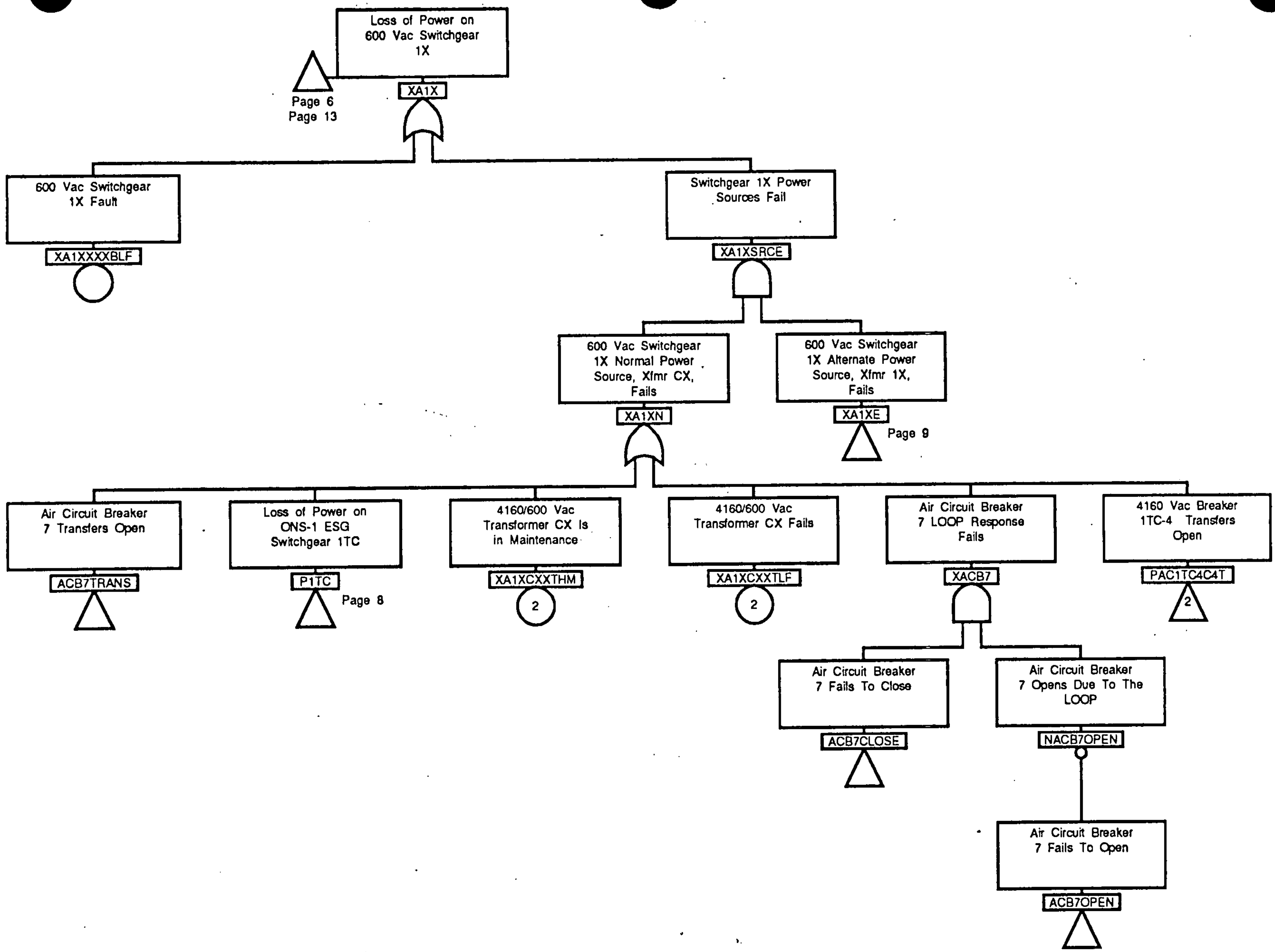


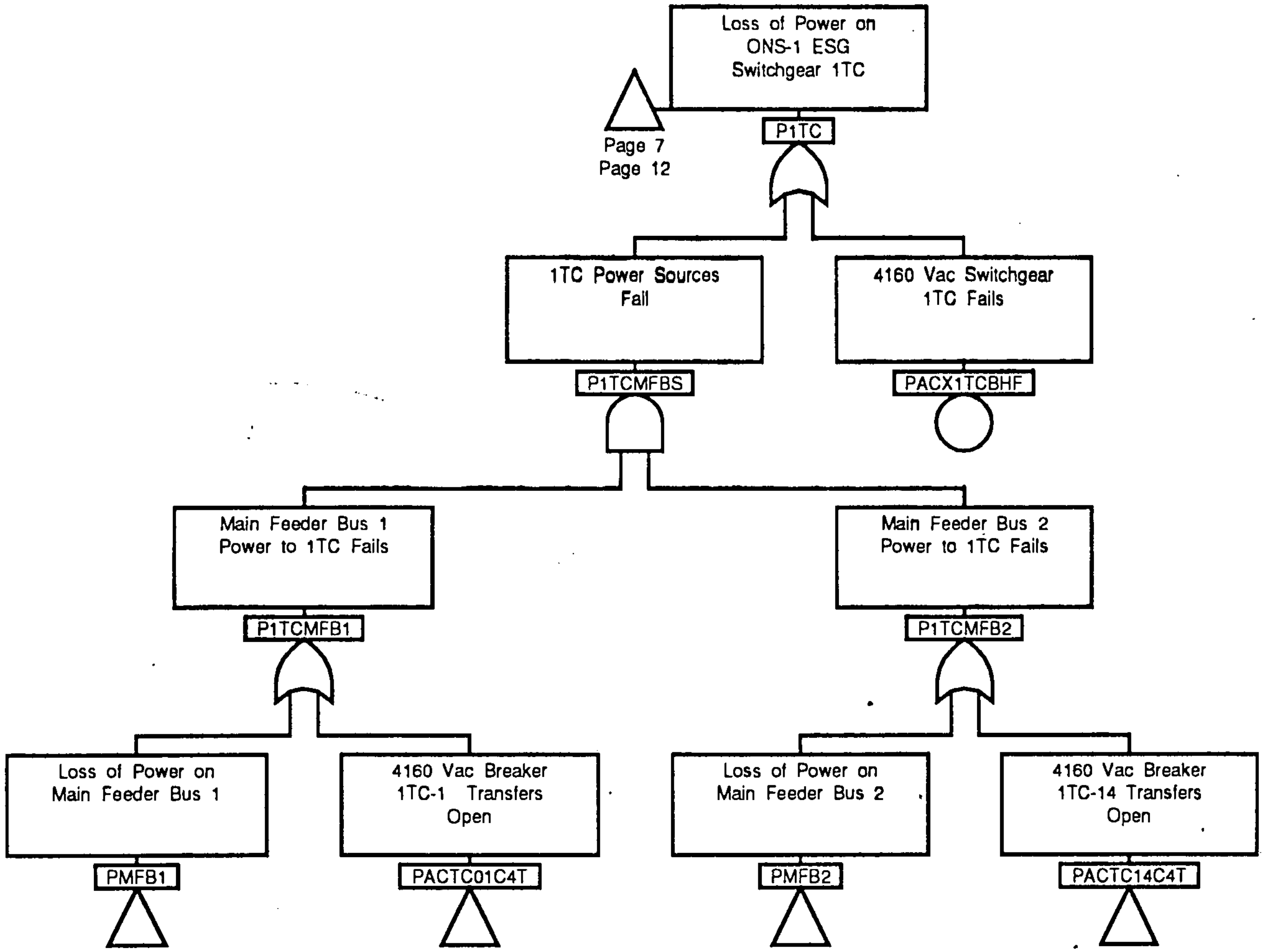
Keowee Auxiliary Power Fault Tr	FIGURE A.8-3	Pa 4

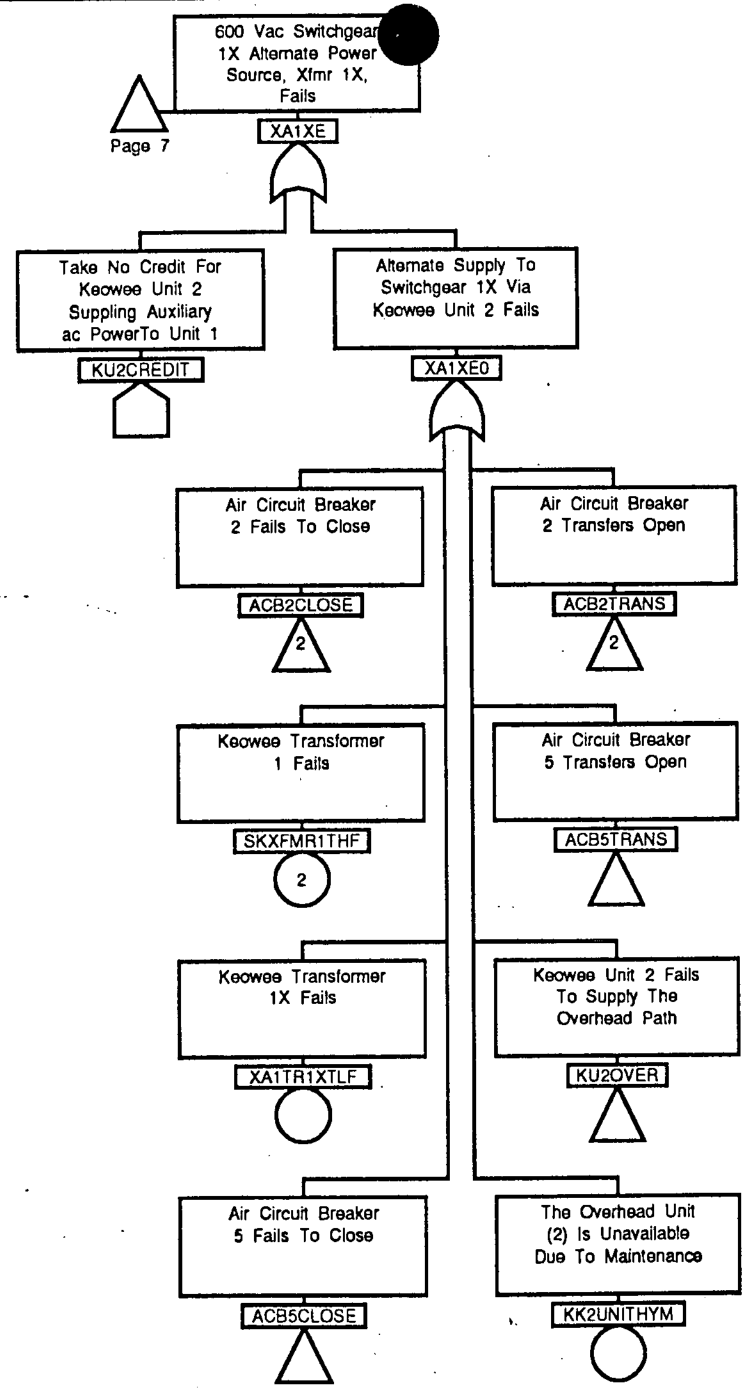


Keowee Auxiliary Power Fault Tree	FIGURE A.8-3	Page 5

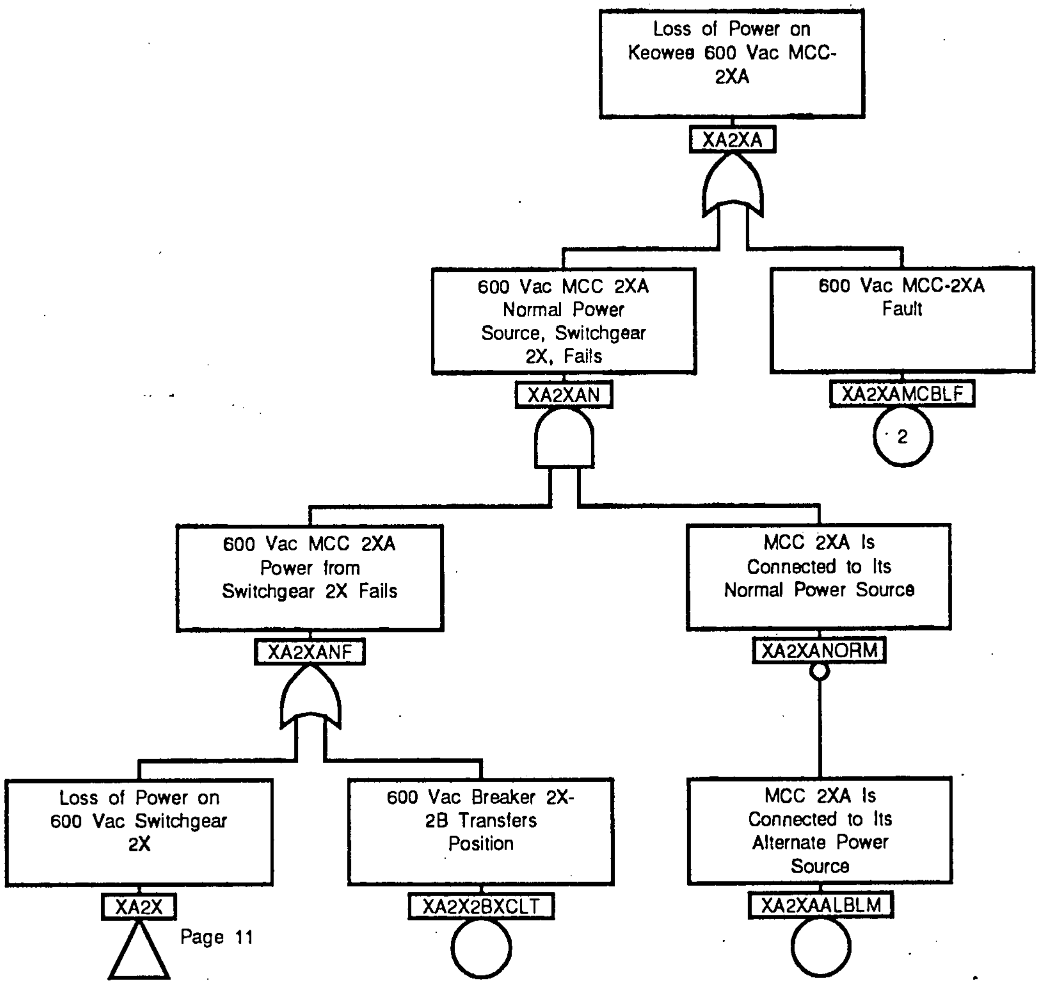

Loss of Power on Keowee 600 Vac MCC 1XA
XA1XA
600 Vac MCC 1XA Normal Power Source, Switchgear 1X, Fails
XA1XAN
600 Vac MCC 1XA Fault
XA1XAMCBLF
2
600 Vac MCC 1XA Normal Power Source, Switchgear 1X, Fails
XA1XANF
MCC 1XA Is Connected to Its Normal Power Source
XA1XANORM
600 Vac Breaker 1X-2C Transfers Position
XA1X2CCCLT
Loss of Power on 600 Vac Switchgear 1X
XA1X
Page 7
MCC 1XA Is Connected to Its Alternate Source of Power
XA1XAALBLM


Loss of Power on 600 Vac Switchgear 1X
XA1X
Page 6
Page 13
600 Vac Switchgear 1X Fault
XA1XXXXBLF
Switchgear 1X Power Sources Fail
XA1XSRCE
600 Vac Switchgear 1X Normal Power Source, Xfmr CX, Fails
XA1XN
600 Vac Switchgear 1X Alternate Power Source, Xfmr 1X, Fails
XA1XE
Page 9
Air Circuit Breaker 7 Transfers Open
ACB7TRANS
Loss of Power on ONS-1 ESG Switchgear 1TC
P1TC
Page 8
4160/600 Vac Transformer CX Is in Maintenance
XA1XCXXTHM
2
4160/600 Vac Transformer CX Fails
XA1XCXXTLF
2
Air Circuit Breaker 7 LOOP Response Fails
XACB7
4160 Vac Breaker 1TC-4 Transfers Open
PAC1TC4C4T
2
Air Circuit Breaker 7 Fails To Close
ACB7CLOSE
Air Circuit Breaker 7 Opens Due To The LOOP
NACB7OPEN
Air Circuit Breaker 7 Fails To Open
ACB7OPEN


Loss of Power on ONS-1 ESG Switchgear 1TC
P1TC
Page 7
Page 12
1TC Power Sources Fail
P1TCMFBS
4160 Vac Switchgear 1TC Fails
PACX1TCBHF
Main Feeder Bus 1 Power to 1TC Fails
P1TCMFB1
Main Feeder Bus 2 Power to 1TC Fails
P1TCMFB2
Loss of Power on Main Feeder Bus 1
PMFB1
4160 Vac Breaker 1TC-1 Transfers Open
PACTC01C4T
Loss of Power on Main Feeder Bus 2
PMFB2
4160 Vac Breaker 1TC-14 Transfers Open
PACTC14C4T

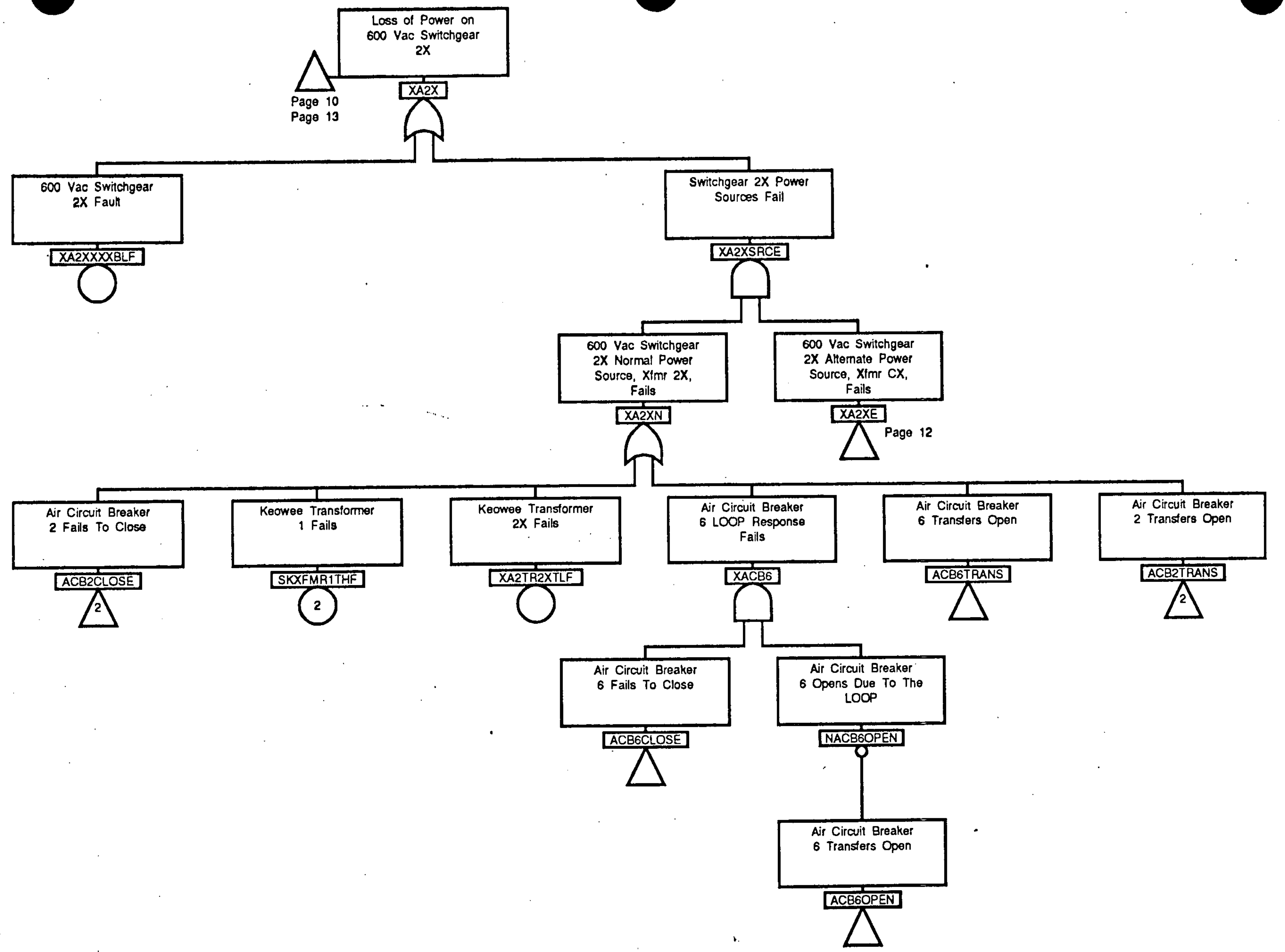


Keowee Auxiliary Power Fault Tree	FIGURE A.8-3	Page 9

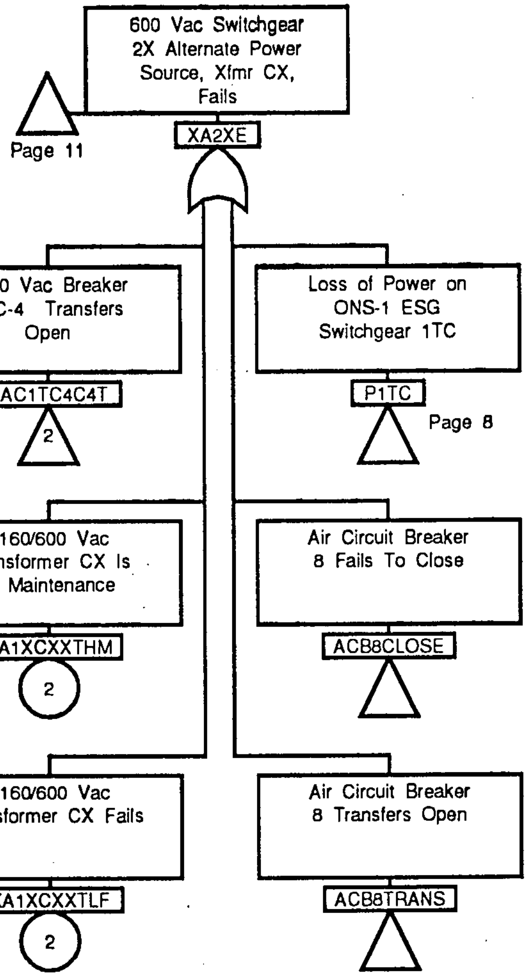


Keowee Auxiliary Power Fault T

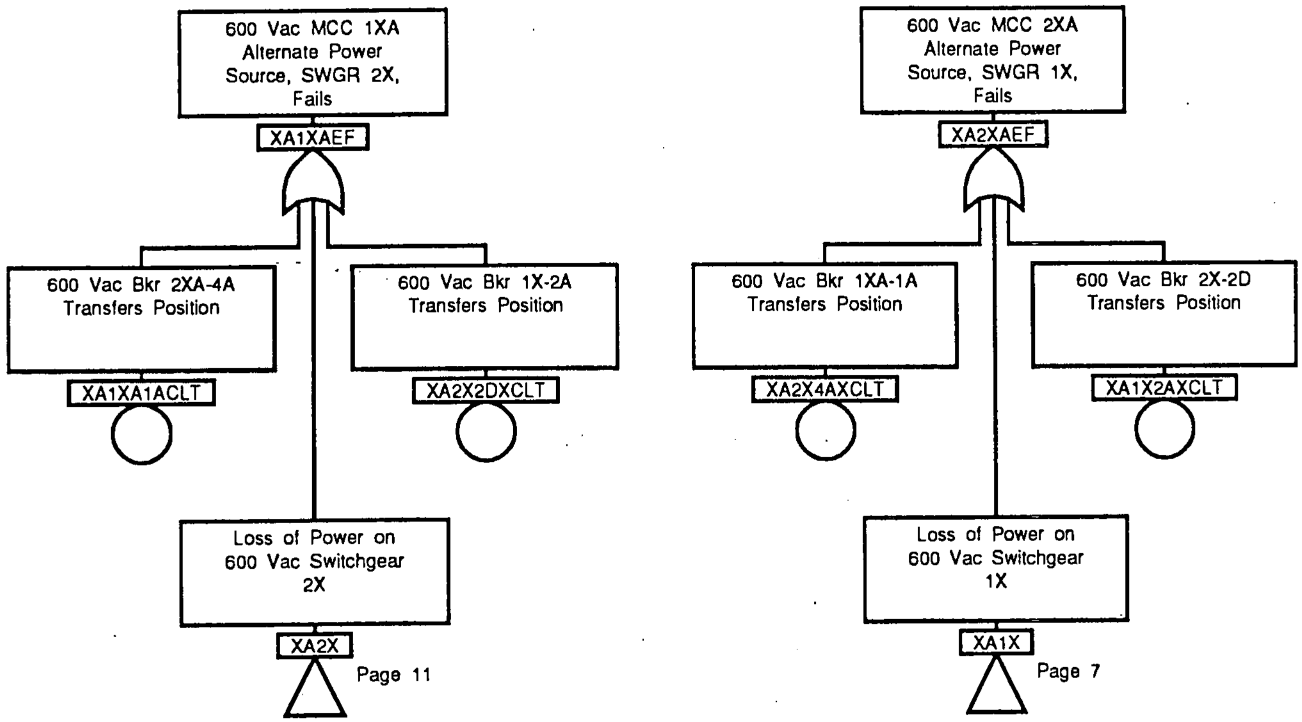
FIGURE A.8-3



Keowee Auxiliary Power Fault Tree	FIGURE A.8-3	Page 11



600 Vac Switchgear 2X Alternate Power Source, Xfmr CX, Fails
XA2XE
Page 11
4160 Vac Breaker 1TC-4 Transfers Open
PAC1TC4C4T
2
Loss of Power on ONS-1 ESG Switchgear 1TC
P1TC
Page 8
4160/600 Vac Transformer CX Is in Maintenance
XA1XCXXTHM
2
Air Circuit Breaker 8 Fails To Close
ACB8CLOSE
4160/600 Vac Transformer CX Fails
XA1XCXXTLF
2
Air Circuit Breaker 8 Transfers Open
ACB8TRANS



Keowee Auxiliary Power Fault Tree	FIGURE A.8-3	Page 13

Gate/Event Name	Page	Zone	Gate/Event Name	Page	Zone	Gate/Event Name	Page	Zone	Gate/Event Name	Page	Zone
ACB2CLOSE	9		XA1X	13		XA2XE	11		XD2DALTBYM	3	
ACB2CLOSE	11		XA1X2AXCLT	13		XA2XE	12		XD2DALTBYM	3	
ACB2TRANS	9		XA1X2CCCLT	6		XA2XN	11		XD2DALTBYM	5	
ACB2TRANS	11		XA1XA	6		XA2XSRCE	11		XD2DALTR	3	
ACB5CLOSE	9		XA1XA1ACLT	13		XA2XXXXBLF	11		XD2DALTRF	3	
ACB5TRANS	9		XA1XAALBLM	6		XACB6	11		XD2DALTS	5	
ACB6CLOSE	11		XA1XAEF	13		XACB7	7		XD2DANORMR	3	
ACB6OPEN	11		XA1XAMCBLF	4		XD1BK1ACDT	2		XD2DANORMS	5	
ACB6TRANS	11		XA1XAMCBLF	6		XD1CKC1BCF	4		XD2DANORWF	3	
ACB7CLOSE	7		XA1XAN	6		XD1DA1CCDT	4		XD2DANORWF	3	
ACB7OPEN	7		XA1XANF	6		XD1DALTBYM	1		XD2DANORWF	5	
ACB7TRANS	7		XA1XANORM	6		XD1DALTBYM	1		XD2DANRMRF	3	
ACB8CLOSE	12		XA1XCXXTHM	7		XD1DALTBYM	2		XD2DAR	2	
ACB8TRANS	12		XA1XCXXTHM	12		XD1DALTR	2		XD2DARXBDF	2	
KK2UNITHYM	9		XA1XCXXTLF	7		XD1DALTRF	2		XD2DASRCER	2	
KU2CREDIT	9		XA1XCXXTLF	12		XD1DALTS	1		XD2DASRCER	3	
KU2OVER	9		XA1XE	7		XD1DANORMR	2		XD2DASRCES	5	
NACB6OPEN	11		XA1XE	9		XD1DANORMS	1		XD2KB2XRHE	4	
NACB7OPEN	7		XA1XE0	9		XD1DANORWF	1		XD2KBATBYF	1	
P1TC	7		XA1XN	7		XD1DANORWF	1		XD2KBATBYF	5	
P1TC	8		XA1XSRCE	7		XD1DANORWF	2		XD2KC2	4	
P1TC	12		XA1XXXXBLF	7		XD1DANRMRF	2		XD2KC2F	3	
P1TCMFB1	8		XA2A2BTCDT	4		XD1DAR	1		XD2KC2F	4	
P1TCMFB2	8		XA2TR2XTLF	11		XD1DARXBDF	1		XD2TIE2CDT	2	
P1TCMFBS	8		XA2X	10		XD1DASRCER	1		XD2TIE2CDT	3	
PAC1TC4C4T	7		XA2X	11		XD1DASRCER	2				
PAC1TC4C4T	12		XA2X	13		XD1DASRCES	1				
PACTC01C4T	8		XA2X2BXCLT	10		XD1KB1XRHE	4				
PACTC14C4T	8		XA2X2DXCLT	13		XD1KBATBYF	1				
PACX1TCBHF	8		XA2X4AXCLT	13		XD1KBATBYF	5				
PMFB1	8		XA2XA	10		XD1KC1	4				
PMFB2	8		XA2XAALBLM	10		XD1KC1F	2				
SKXFMR1THF	9		XA2XAEF	13		XD1KC1F	4				
SKXFMR1THF	11		XA2XAMCBLF	4		XD1TIE1CDT	2				
XA1A2BTCDT	4		XA2XAMCBLF	10		XD1TIE1CDT	3				
XA1TR1XTLF	9		XA2XAN	10		XD2BK1ACDT	3				
XA1X	6		XA2XANF	10		XD2CKC2BCF	4				
XA1X	7		XA2XANORM	10		XD2DA5CCDT	4				

APPENDIX A.9
230 KV SWITCHYARD 125 VDC POWER SYSTEM

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LIST OF TABLES

LIST OF FIGURES

A.9 230 KV SWITCHYARD DC POWER SYSTEM

A.9.1 OBJECTIVES

The main objective of this analysis is to develop a logic model of the 230 kV Switchyard DC Power System. This model is combined with the high level logic model and remaining system models to form an integrated model for assessing the reliability of Keowee. Other objectives are to identify major contributors to system unreliability, significant potential human errors and common-cause failure modes.

The scope of this analysis is limited to 230 kV Switchyard 125 V dc Power System (SWYD DC System) equipment required to initiate a Keowee emergency start, to establish the overhead power path and maintain the overhead power path for 24 hours following a loss of off-site power condition.

A.9.2 SYSTEM DESIGN

The SWYD DC System is a support system for the 230 kV Switchyard and provides control power to the 230 kV Switchyard power circuit breakers (PCBs), protective and control relays (including EGTPS relays and Oconee 1, 2, and 3 Degraded Grid Protection relays), indicating lights, annunciators, carrier equipment, and other switchyard monitoring equipment that requires an uninterruptible power source.

The SWYD DC System is composed of two strings. Each string contains a battery, a battery charger, a distribution center, and four panelboards. It provides continuous power at the proper voltage during all plant conditions for one hour. If the battery chargers or the ac power to the chargers fails, the batteries shall continue to supply power to the loads, with adequate voltage, for a minimum of one hour. The system is shown on Figure A.9-1.

There is a bus tie with breakers to enable the the distribution centers to be connected and a standby battery charger to back up either of the normal battery chargers. One string supplies power for primary control and protective relaying. The other string supplies for back up control and protective relaying. Each PCB gets power from redundant

panelboards for close and trip control. Each PCB has two trip coils. Each PCB has one close coil with diodes isolating two power sources for the coil.

A.9.3 SYSTEM BOUNDARIES

Electrical Power Supplies

The ac power for the battery chargers is supplied by 480 V ac panelboards SPA and SPB. SPA and SPB are fed from Oconee 1 and Oconee 2, respectively.

Environmental Control Systems

The SWYD DC System is located in the relay house which is equipped with an HVAC system to keep the temperature at about 77F.

A.9.4 INSTRUMENTATION AND CONTROLS

All 125 V dc switching is done manually and locally at the two dc distribution centers, the battery chargers and the dc panelboards located in the 230 kV relay house. Each battery charger has monitoring devices necessary to place the charger in service, change the charging rate and indicate current and voltage. A 0-150 V range voltmeter and a 0-75 amp range ammeter are on each charger. A clear indicating lamp, when on, shows that 3-phase ac input power is available and the phase rotation is correct.

There are two ground detecting systems mounted on the dc system test panel. There is a white "positive ground" and a white "negative ground" indicating lamp on each ground detector. These lights are normally on and shift to double brilliancy when a ground is present on their respective bus. A white "battery tie" light is normally on and shifts to double brilliancy when the battery tie breakers are closed.

One annunciator alarm is located in the Oconee Unit 1 and 2 control room. The alarm is "230 kV SWYD. BATT TROUBLE" and is on electric board 1EF2 statalarm panel SA6. The alarm is actuated by the relaying schemes for the chargers or the relaying schemes for the batteries. The relaying scheme for battery charger SY-1 includes a dc undervoltage

relay LVR/SY-1 and an ac failure alarm relay PLR/SY-1. Undervoltage relay LVR is connected to the battery charger dc output. When actuated , relay LVR picks up alarm relay 74BT/SY-1 on the dc test panel. AC failure alarm relay PLR is connected to the battery charger ac input. When actuated, relay PLR also picks up 74BT/SY-1. The battery relaying includes a dc undervoltage (80) relay, and positive ground detection (64P) and negative ground detection (64N) relays. When actuated these relays actuate the string battery 74BT alarm relay. These relays actuate computer, annunciator, and events recorder information.

A.9.5 LOCATION WITHIN THE PLANT

All 230 kV Switchyard 125 V dc Power System equipment is in the 230 kV switchyard relay house which is located on the yellow bus side of the swithyard near PCBs 18 and 21. Equipment for the two strings are on opposite sides of the the room with an aisle separating the strings. Each battery is in a room separated from the other battery and from other equipment of the associated string.

A.9.6 NORMAL OPERATION

Normally both strings of the system are in service. Each battery is on float charge and is available to supply dc power to the loads in the event a battery charger is lost. The breakers between the standby battery charger and the distribution centers are normally open.

A.9.7 PERFORMANCE DURING KEOWEE EMERGENCY OPERATION

The 230 kV Switchyard 125 V dc Power System requires no realignment or equipment startup for emergency conditions. To supply loads on both strings for one hour at least one battery must be available with the bus ties closed.

A.9.8 TEST AND MAINTENANCE

Testing

The SWYD DC System testing requirements are detailed in Table A.9-2.

Maintenance

The SWYD DC System maintenance requirements are listed in Table A.9-3.

A.9.9 OPERATING EXPERIENCE

A summary of significant operating events is provided in Table A.9-4.

A.9.10 ASSUMPTIONS

A.9.10.1 SYSTEM DESIGN ASSUMPTIONS

If a battery charger is lost or power to the battery chargers is lost, the associated battery is capable of supplying its loads for one hour.

A.9.10.2 OPERATIONAL ASSUMPTIONS

Frequent battery maintenance requiring the removal of a battery from service requires that the two distribution centers be tied together through the bus tie breakers. The normal and alternant alignments of Distribution Center SY-DC1 are modeled; only the normal alignment for Distribution Center SY-DC2 is modeled to prevent circular logic in the model.

A.9.10.3 MODELING ASSUMPTIONS

The mission time for the SWYD DC System is 24 hours. This is conservative since individual loads will likely require control power only in the early stages of the LOOP. By the time additional control power is required the battery chargers should be recovered.

A.9.11 FAULT TREE ANALYSIS

A.9.11.1 TOP EVENT SUCCESS CRITERIA

Success of the SWYD DC System requires that the EGTPS receives control power long enough to detect the LOOP and provide start signals to the Keowee hydro units. In the event the underground power path to the Main Feeder Busses is not completed, then the SWYD PCBs must have control power long enough to isolate the Yellow Bus and close the overhead power path to the startup transformers. Emergency power from Keowee should be available within 23 seconds of the time the emergency start signal is received.

A.9.11.2 DETAILED FAILURE CRITERIA

A loss of power to any of the distribution centers or panelboards is considered a failure. Only alternate alignments for battery test or maintenance is permitted.

A.9.11.3 DESCRIPTION OF FAULT TREE

The 230 kV Switchyard 125 V dc Power System fault tree is shown in Figure A.9-2. The Fault Tree Modeling Guidelines (Appendix B) were followed in developing the fault tree. A list of all fault tree transfers is presented in Table A.9-5.

Human errors in restoration of SWYD DC System equipment following test or maintenance would be immediately recognized. Therefore, no latent human errors have been included in the model.

Common cause analysis was performed as described in Appendix C.2. Common-cause events impacting the model are described in Section A.9.12.5.

A.9.11.4 RELIABILITY DATA

Section 5.3 discusses development of the reliability data.

Plant-specific data is used for maintenance events. The following maintenance event is included in the SWYD DC System model:

DDC1ALXBWM

This event accounts for maintenance and testing on the batteries. For modeling simplicity, all of this unavailability is placed on Battery SY-1. Each battery is in maintenance or testing for approximately 100 hours per year. Thus, the unavailability of battery SY-1 due to testing or maintenance is:

100 hr./8760 hr. = 1.14E-2.

System reliability data is listed in Table A.9-5.

A.9.11.6 COMMON-CAUSE ASSESSMENT

DDCBATTCOM.

The DC Channels share the same design, maintenance procedures, operating conditions, environmental conditions, etc. A failure of both batteries leads to a failure of the SWYD DC System to operate. Therefore, these common cause events are included in the fault tree to represent these coupling mechanisms.

A.9.12 RESULTS

Reliability of the SWYD DC System is defined as the probability that the system will succeed in supporting Keowee emergency operation (black start plus a 24 hour run). The system model yields a failure probability of approximately 9.7E-04 for the individual panelboards. Thus the reliability of each SWYD DC System string is computed to be 99.90%.

Table A.9-6 lists the dominant minimal cut sets (failure sequences) for the 230 kV Switchyard DC. The dominant contributor to the failure of either string of the SWYD DC System is the demand failure of its battery. Common cause failure of the batteries is the next highest contributor to system unreliability.

A.9.13 REFERENCES

A.9.13.1 DOCUMENTS

1. OSS-0254.00-00-2009, Rev. 1, <u>230 kV Switchyard 125 V dc Power System</u>

A.9.13.2 DRAWINGS

1. O-802, Rev. 22, <u>125 V dc Power System, 230 kV Switchyard</u>

Table A.9-1

System Power Supplies

Component	Power Supply	Compartment Number
125 V dc Distribution Center		
SY-DC1	125V Battery SY-1	Breaker #1B
SY-DC2	125V Battery SY-2	Breaker #1B
Switchyard DC Panelboard	125 V dc Distribution Center	
DYA	SY-DC1	1DL
DYB	SY-DC1	1DC
DYC	SY-DC1	1DR
DYD	SY-DC1	1EL
DYE	SY-DC2	1DL
DYF	SY-DC2	1EL
DYG	SY-DC2	1DC
DYH	SY-DC2	1DR

Table A.9-2

System Test Procedures

Procedure	Test Frequency	Description
IP/0/A/3000/004/B		Instructions for conducting equilizer charge on 230 kV Switchyard batteries.
IP/0/A/3000/011/D	Quarterly	230 kV Switchyard Battery quarterly surveillance
IP/0/A/3000/015	Annual	125 V dc 230 kV Switchyard Battery service test and annual surveillance
IP/0/A/3000/015/A		230 kV Switchyard Battery Charger performance test.

Table A.9-3

230 kV Switchyard 125 V dc Power System Maintenance Procedures

Procedure	Maintenance Frequency	Description
IP/0/A/3000/001/D	Daily	230 kV Switchyard Battery daily surveillance
IP/0/A/3011/002/A		230 kV Switchyard Battery Charger preventative maintenance.

Table A.9-4

230 kV Switchyard 125 V dc Power System Significant Operating Events

Date	Unit	Component	Event Summary
10/19/92	2	230 kV Swyd SY-2 Battery Charger; Switchyard breaker failure relays.	During 230 kV Switchyard maintenance to replace SY-2 Battery, the SY-2 Battery Charger was lined up to supply 125 V dc Distribution Center SY-DC2 without being connected to a Switchyard Battery. Large voltage swings on the DC bus occurred and caused breaker failure relays to actuate isolating the 230 kV Switchyard Red and Yellow Buses and causing a LOOP on Oconee Unit 2.

Table A.9-5

230 kV Switchyard 125 Vdc Power System Reliability Data

Event Name	Description	Failure Rate[1]	Factor	Rationale For Factor[2]	Failure Probability
DDC11BXCDT	125 Vdc Battery Breaker SY-DC1-1B Transfers Open	7.50E-08 /H	24 H		1.80E-06
DDC11CXCDT	125 Vdc Breaker SY-DC1-1C Transfers Open	7.50E-08 /H	24 H		1.80E-06
DDC11DCCDT	125 Vdc Breaker SY-DC1-1DC Transfers Open	7.50E-08 /H	24 H		1.80E-06
DDC11DLCDT	125 Vdc Breaker SY-DC1-1DL Transfers Open	7.50E-08 /H	24 H		1.80E-06
DDC11DRCDT	125 Vdc Breaker SY-DC1-1DR Transfers Open	7.50E-08 /H	24 H		1.80E-06
DDC1ALXBYM	Battery SY-1 Is In Maintenance or				1.14E-02
DDC1BATBYF	Battery SY-1 Fails During Discharge	9.30E-04 /D	1 D		9.30E-04
DDC1FLTBDF	SY-DC1 Is Faulted	3.20E-07 /H	24 H		7.68E-06
DDC21BXCDT	125 Vdc Battery Breaker SY-DC2-1B Transfers Open	7.50E-08 /H	24 H		7.50E-08
DDC21CXCDT	125 Vdc Breaker SY-DC2-1C Transfers Open	7.50E-08 /H	24 H		1.80E-06
DDC21DCCDT	125 Vdc Breaker SY-DC2-1DC Transfers Open	7.50E-08 /H	24 H		1.80E-06
DDC21DLCDT	125 Vdc Breaker SY-DC2-1DL Transfers Open	7.50E-08 /H	24 H		1.80E-06
DDC21DRCDT	125 Vdc Breaker SY-DC2-1DR Transfers Open	7.50E-08 /H	24 H		1.80E-06
DDC2BATBYF	Battery SY-2 Fails During Discharge	9.30E-04 /D	1 D		9.30E-04

Table A.9-5

230 kV Switchyard 125 Vdc Power System Reliability Data

Event Name	Description	Failure Rate[1]	Factor	Rationale For Factor[2]	Failure Probability
DDC2FLTBDF	SY-DC2 Is Faulted	3.20E-07 /H	24 H		7.68E-06
DDCBATTCOM	Common Cause Failure of Switchyard Batteries				2.70E-05
DDCDYAXBDF	125 Vdc Switchyard DC Panelboard DYA Is Faulted	3.20E-07 /H	24 H		7.68E-06
DDCDYBXBDF	125 Vdc Switchyard DC Panelboard DYB Is Faulted	3.20E-07 /H	24 H		7.68E-06
DDCDYCXBDF	125 Vdc Switchyard DC Panelboard DYC Is Faulted	3.20E-07 /H	24 H		7.68E-06
DDCDYEXBDF	125 Vdc Switchyard DC Panelboard DYE Is Faulted	3.20E-07 /H	24 H		7.68E-06
DDCDYFXBDF	125 Vdc Switchyard DC Panelboard DYF Is Faulted	3.20E-07 /H	24 H		7.68E-06
DDCDYGXBDF	125 Vdc Switchyard DC Panelboard DYG Is Faulted	3.20E-07 /H	24 H		7.68E-06

[1] D = Demand, H = Hour

[2] Rules for assigning basic event factors are discussed in Table C.1-4.

Table A.9-6

230 kV Switchyard 125 Vdc Power System Dominant Minimal Cut Sets

Cut Sets For Gate SDCDYA: Loss of Power on 125 Vdc Switchyard Panelboard DYA

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
1)	9.19E-04	94.4	-DDC1ALXBYM	1.14E-02	Battery SY-1 Is In Maintenanceor
			DDC1BATBYF	9.30E-04	Battery SY-1 Fails During Discharge
2)	2.67E-05	2.7	-DDC1ALXBYM	1.14E-02	Battery SY-1 Is In Maintenanceor
			DDCBATTCOM	2.70E-05	Common Cause Failure of Switchyard Batteries
3)	1.06E-05	1.1	DDC1ALXBYM	1.14E-02	Battery SY-1 Is In Maintenanceor
			DDC2BATBYF	9.30E-04	Battery SY-2 Fails During Discharge
4)	7.68E-06	0.8	DDCDYAXBDF	7.68E-06	125 Vdc Switchyard DC Panelboard DYA Is Faulted
5)	7.68E-06	0.8	DDC1FLTBDF	7.68E-06	SY-DC1 Is Faulted
6)	1.80E-06	0.2	DDC11DLCDT	1.80E-06	125 Vdc Breaker SY-DC1-1DL Transfers Open
7)	1.78E-06	0.2	-DDC1ALXBYM	1.14E-02	Battery SY-1 Is In Maintenanceor
			DDC11BXCDT	1.80E-06	125 Vdc Battery Breaker SY-DC1-1B Transfers Open
Total:	9.76E-04				

Table A.9-6

230 kV Switchyard 125 Vdc Power System Dominant Minimal Cut Sets

Cut Sets For Gate SDCDYB: Loss oF Power on 125 Vdc Switchyard Panelboard DYB

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
1)	9.19E-04	94.2	-DDC1ALXBYM	1.14E-02	Battery SY-1 Is In Maintenanceor
			DDC1BATBYF	9.30E-04	Battery SY-1 Fails During Discharge
2)	2.67E-05	2.7	-DDC1ALXBYM	1.14E-02	Battery SY-1 Is In Maintenanceor
			DDCBATTCOM	2.70E-05	Common Cause Failure of Switchyard Batteries
3)	1.06E-05	1.1	DDC1ALXBYM	1.14E-02	Battery SY-1 Is In Maintenanceor
			DDC2BATBYF	9.30E-04	Battery SY-2 Fails During Discharge
4)	7.68E-06	0.8	DDCDYBXBDF	7.68E-06	125 Vdc Switchyard DC Panelboard DYB Is Faulted
5)	7.68E-06	0.8	DDC1FLTBDF	7.68E-06	SY-DC1 Is Faulted
6)	1.80E-06	0.2	DDC11DCCDT	1.80E-06	125 Vdc Breaker SY-DC1-1DC Transfers Open
7)	1.78E-06	0.2	-DDC1ALXBYM	1.14E-02	Battery SY-1 Is In Maintenanceor
			DDC11BXCDT	1.80E-06	125 Vdc Battery Breaker SY-DC1-1B Transfers Open
Total:	9.76E-04				

Table A.9-6

230 kV Switchyard 125 Vdc Power System Dominant Minimal Cut Sets

Cut Sets For Gate SDCDYC: Loss of Power on 125 Vdc Switchyard Panelboard DYC

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
1)	9.19E-04	94.2	-DC1ALXBYM	1.14E-02	Battery SY-1 Is In Maintenanceor
			DDC1BATBYF	9.30E-04	Battery SY-1 Fails During Discharge
2)	2.67E-05	2.7	-DDC1ALXBYM	1.14E-02	Battery SY-1 Is In Maintenanceor
			DDCBATTCOM	2.70E-05	Common Cause Failure of Switchyard Batteries
3)	1.06E-05	1.1	DDC1ALXBYM	1.14E-02	Battery SY-1 Is In Maintenanceor
			DDC2BATBYF	9.30E-04	Battery SY-2 Fails During Discharge
4)	7.68E-06	0.8	DDCDYCXBDF	7.68E-06	125 Vdc Switchyard DC Panelboard DYC Is Faulted
5)	7.68E-06	0.8	DDC1FLTBDF	7.68E-06	SY-DC1 Is Faulted
6)	1.80E-06	0.2	DDC11DRCDT	1.80E-06	125 Vdc Breaker SY-DC1-1DR Transfers Open
7)	1.57E-06	0.2	-DDC1ALXBYM	1.14E-02	Battery SY-1 Is In Maintenanceor
			DDC11BXCDT	1.80E-06	125 Vdc Battery Breaker SY-DC1-1B Transfers Open
Total:	9.76E-04				

Table A.9-6

230 kV Switchyard 125 Vdc Power System Dominant Minimal Cut Sets

Cut Sets For Gate SDCDYE: Loss of Power on 125 Vdc Switchyard Panelboard DYE

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
1)	9.30E-04	95.3	DDC2BATBYF	9.30E-04	Battery SY-2 Fails During Discharge
2)	2.67E-05	2.7	-DDC1ALXBYM	1.14E-02	Battery SY-1 Is In Maintenanceor
			DDCBATTCOM	2.70E-05	Common Cause Failure of Switchyard Batteries
3)	7.68E-06	0.8	DDC2FLTBDF	7.68E-06	SY-DC2 Is Faulted
4)	7.68E-06	0.8	DDCDYEXBDF	7.68E-06	125 Vdc Switchyard DC Panelboard DYE Is Faulted
5)	1.80E-06	0.2	DDC21DLCDT	1.80E-06	125 Vdc Breaker SY-DC2-1DL Transfers Open
6)	1.80E-06	0.2	DDC21BXCDT	1.80E-06	125 Vdc Battery Breaker SY-DC2-1B Transfers Open
Total:	9.76E-04				

Table A.9-6

230 kV Switchyard 125 Vdc Power System Dominant Minimal Cut Sets

Cut Sets For Gate SDCDYF: Loss of Power on 125 Vdc Switchyard Panelboard DYF

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
1)	9.30E-04	95.3	DDC2BATBYF	9.30E-04	Battery SY-2 Fails During Discharge
2)	2.67E-05	2.7	-DDC1ALXBYM	1.14E-02	Battery SY-1 Is In Maintenanceor
			DDCBATTCOM	2.70E-05	Common Cause Failure of Switchyard Batteries
3)	7.68E-06	0.8	DDC2FLTBDF	7.68E-06	SY-DC2 Is Faulted
4)	7.68E-06	0.8	DDCDYFXBDF	7.68E-06	125 Vdc Switchyard DC Panelboard DYF Is Faulted
5)	1.80E-06	0.2	DDC21DCCDT	1.80E-06	125 Vdc Breaker SY-DC2-1DC Transfers Open
6)	1.80E-06	0.2	DDC21BXCDT	1.80E-06	125 Vdc Battery Breaker SY-DC2-1B Transfers Open
Total:	9.76E-04				

Table A.9-6

230 kV Switchyard 125 Vdc Power System Dominant Minimal Cut Sets

Cut Sets For Gate SDCDYG: Loss of Power on 125 Vdc Switchyard Panelboard DYG

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
1)	9.30E-04	95.3	DDC2BATBYF	9.30E-04	Battery SY-2 Fails During Discharge
2)	2.67E-05	2.7	-DDC1ALXBYM	1.14E-02	Battery SY-1 Is In Maintenanceor
			DDCBATTCOM	2.70E-05	Common Cause Failure of Switchyard Batteries
3)	7.68E-06	0.8	DDC2FLTBDF	7.68E-06	SY-DC2 Is Faulted
4)	7.68E-06	0.8	DDCDYGXBDF	7.68E-06	125 Vdc Switchyard DC Panelboard DYG Is Faulted
5)	1.80E-06	0.2	DDC21DRCDT	1.80E-06	125 Vdc Breaker SY-DC2-1DR Transfers Open
6)	1.80E-06	0.2	DDC21BXCDT	1.80E-06	125 Vdc Battery Breaker SY-DC2-1B Transfers Open
Total:	9.76E-04				

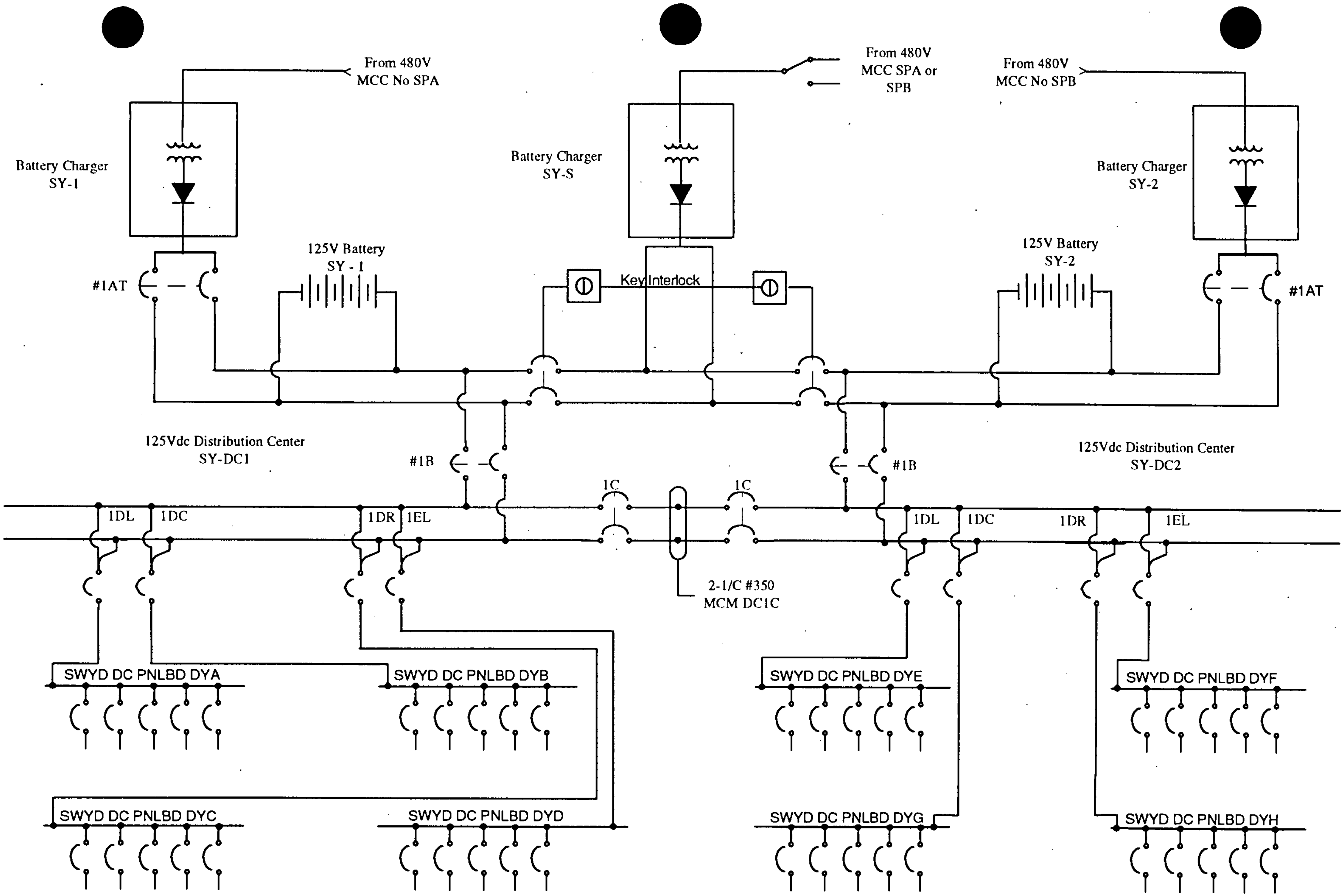
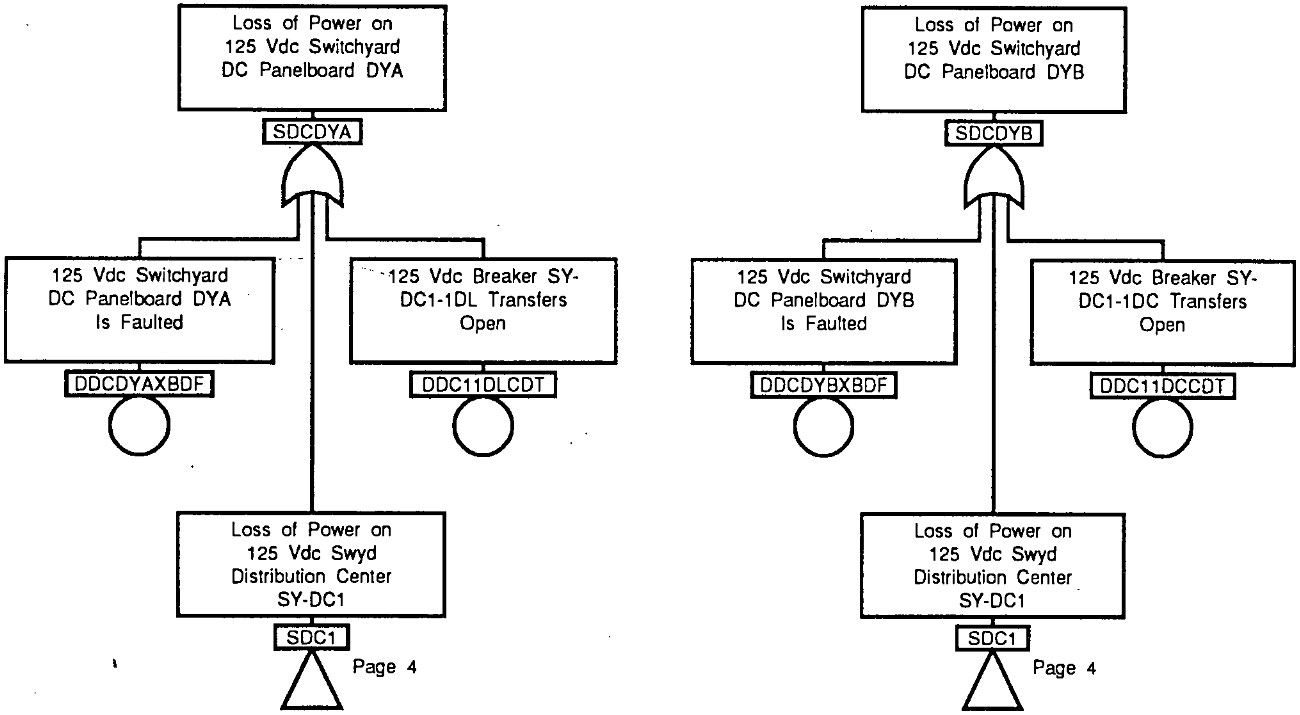
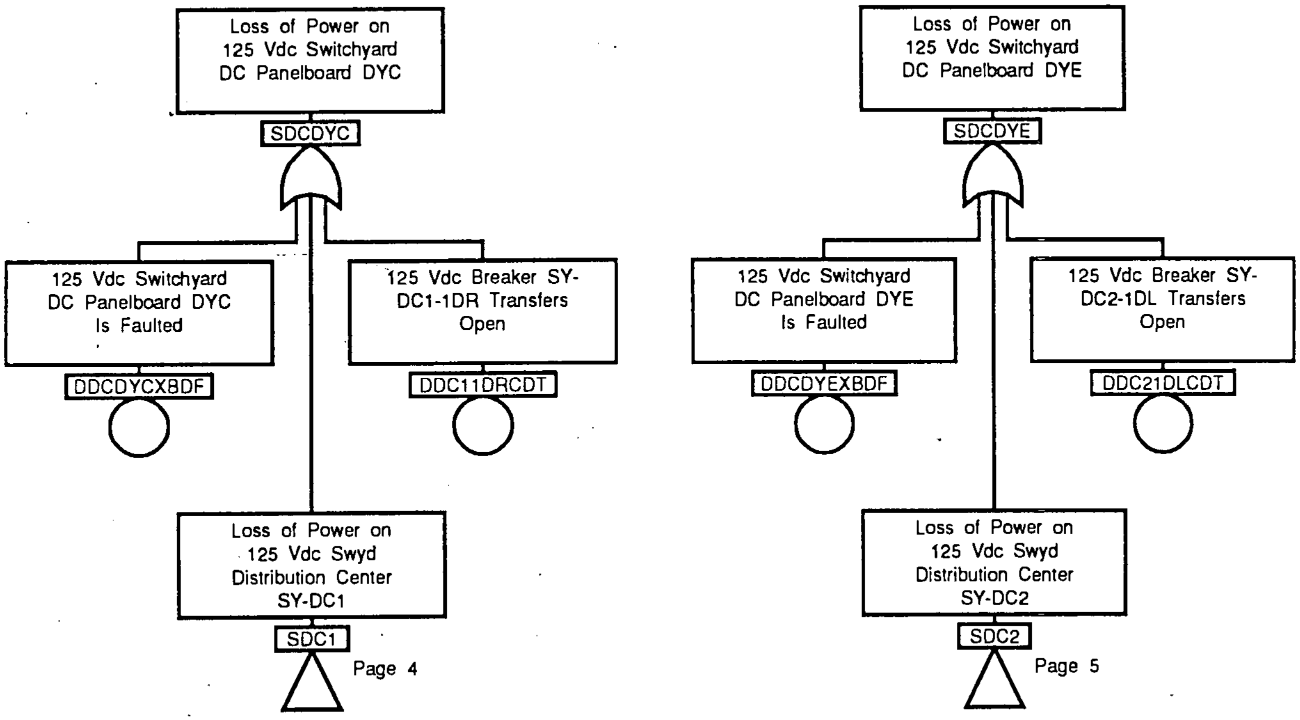


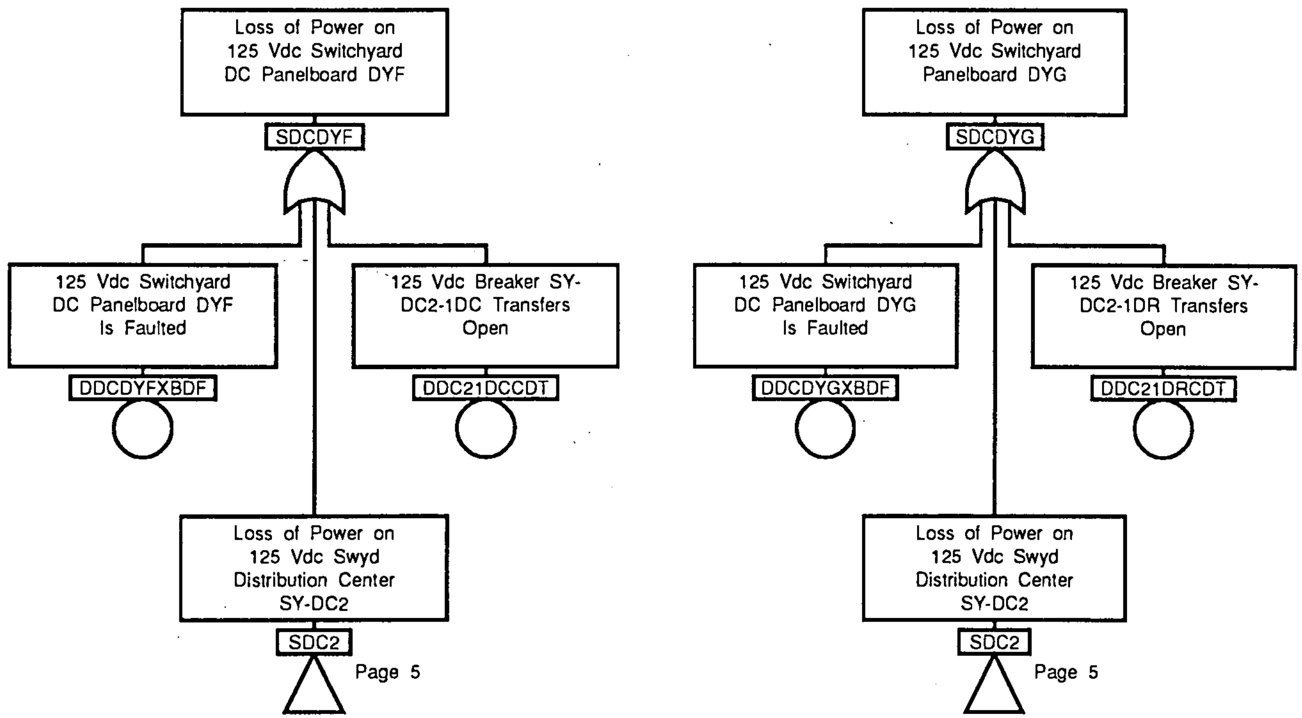
Figure A.9-1 230 KV SWYD 125 V DC



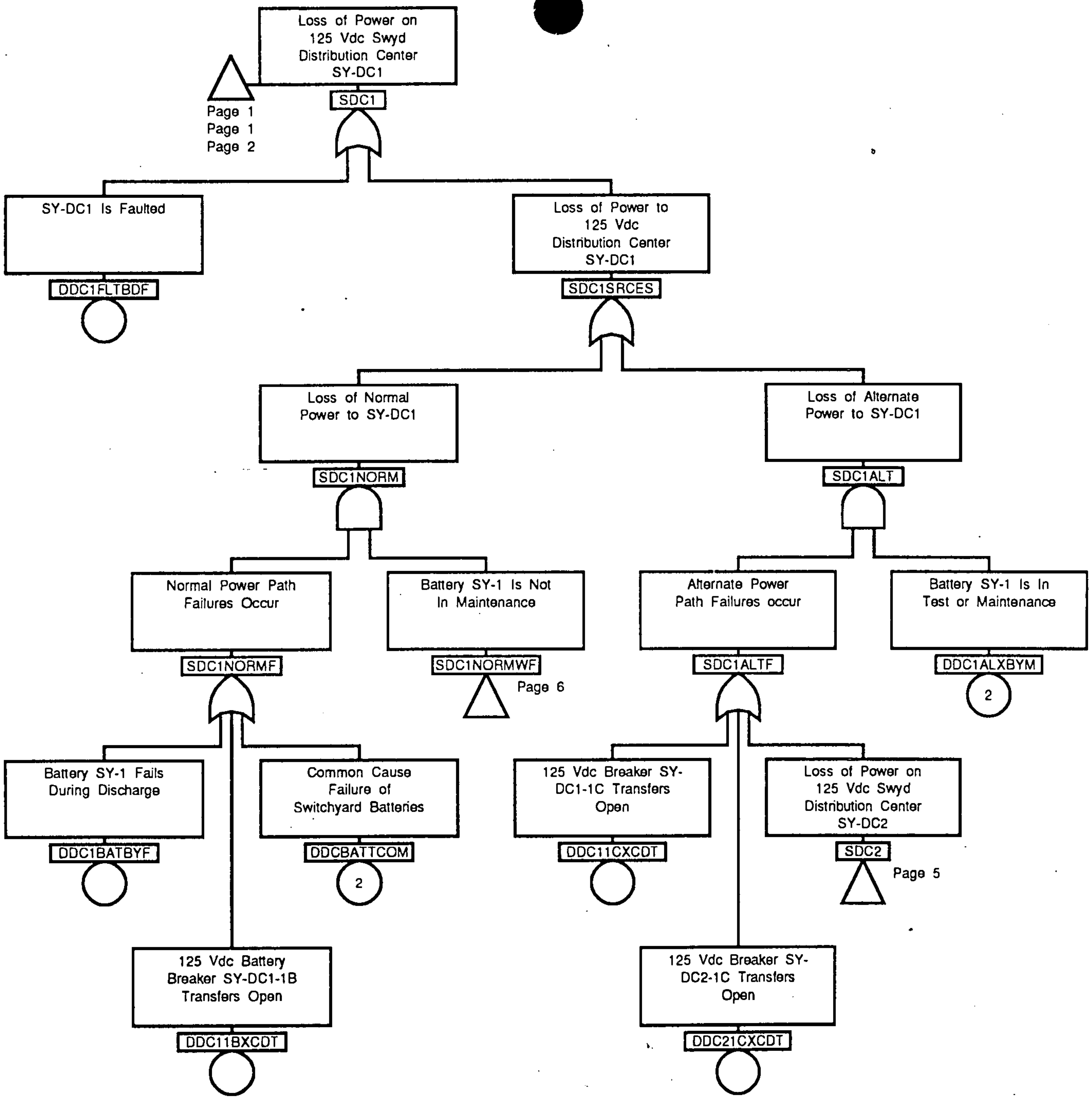
Switchyard DC Power Fault Tr	FIGURE A.9-2	Pa 1



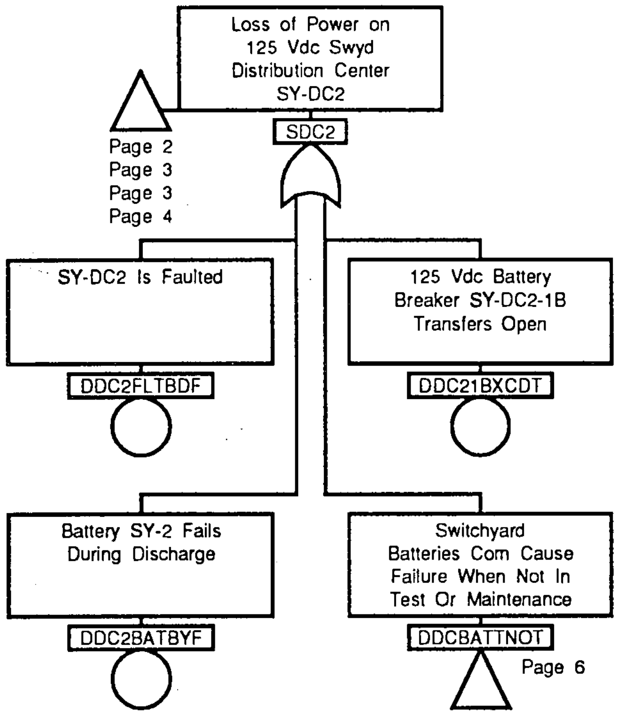
Switchyard DC Power Fault Tree | FIGURE A.9-2 |



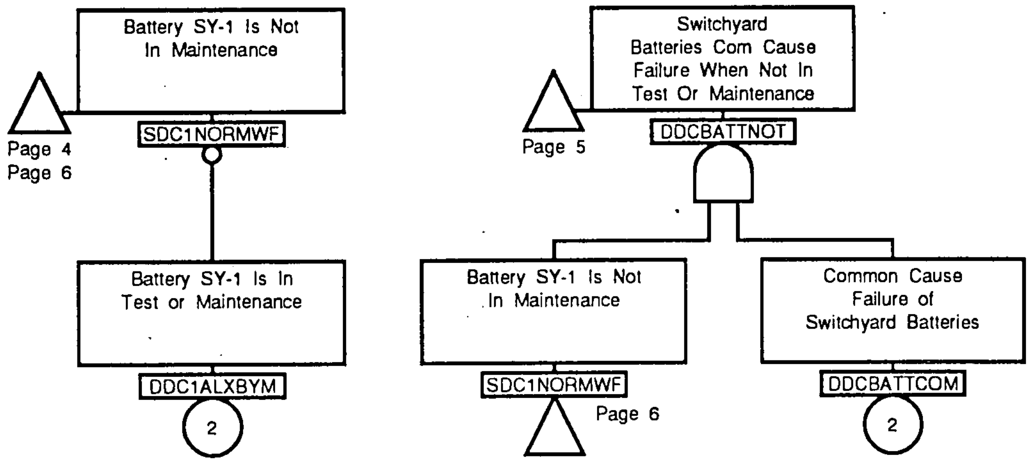
Switchyard DC Power Fault Tr[illegible]	FIGURE A.9-2	Pa[illegible] 3



Switchyard DC Power Fault Tree	FIGURE A.9-2	Page 4



Switchyard DC Power Fault Tr	FIGURE A.9-2	P 5



Battery SY-1 Is Not In Maintenance
SDC1NORMWF
Page 4
Page 6
Battery SY-1 Is In Test or Maintenance
DDC1ALXBYM
2
Switchyard Batteries Com Cause Failure When Not In Test Or Maintenance
DDCBATTNOT
Page 5
Battery SY-1 Is Not In Maintenance
SDC1NORMWF
Page 6
Common Cause Failure of Switchyard Batteries
DDCBATTCOM
2

Gate/Event Name	Page	Zone	Gate/Event Name	Page	Zone	Gate/Event Name	Page	Zone	Gate/Event Name	Page	Zone
DDC11BXCDT	4		SDC2	2							
DDC11CXCDT	4		SDC2	3							
DDC11DCCDT	1		SDC2	3							
DDC11DLCDT	1		SDC2	4							
DDC11DRCDT	2		SDC2	5							
DDC1ALXBYM	4		SDCDYA	1							
DDC1ALXBYM	6		SDCDYB	1							
DDC1BATBYF	4		SDCDYC	2							
DDC1FLTBDF	4		SDCDYE	2							
DDC21BXCDT	5		SDCDYF	3							
DDC21CXCDT	4		SDCDYG	3							
DDC21DCCDT	3										
DDC21DLCDT	2										
DDC21DRCDT	3										
DDC2BATBYF	5										
DDC2FLTBDF	5										
DDCBATTCOM	4										
DDCBATTCOM	6										
DDCBATTNOT	5										
DDCBATTNOT	6										
DDCDYAXBDF	1										
DDCDYBXBDF	1										
DDCDYCXBDF	2										
DDCDYEXBDF	2										
DDCDYFXBDF	3										
DDCDYGXBDF	3										
SDC1	1										
SDC1	1										
SDC1	2										
SDC1	4										
SDC1ALT	4										
SDC1ALTF	4										
SDC1NORM	4										
SDC1NORMF	4										
SDC1NORMWF	4										
SDC1NORMWF	6										
SDC1NORMWF	6										
SDC1SRCES	4										

APPENDIX A.10
GOVERNOR AND TURBINE

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A.10 GOVERNOR AND TURBINE

A.10.1 OBJECTIVES

The main objective of this analysis is to develop a logic model of the Governor and Turbine. This model is combined with the high-level model and remaining system models to form an integrated model for assessing the reliability of Keowee. Other objectives are to identify major contributors to system unreliability, significant potential human errors and common cause failure modes.

The scope of this analysis is limited to Governor and Turbine equipment required to support a Keowee emergency start and load run. The analysis assumes a loss of offsite power has occurred, so that Keowee Auxiliary AC Power is not available during the start.

A.10.2 SYSTEM DESIGN

Turbine

Keowee utilizes an Allis Chalmers turbine rated at 96,000 hp at a speed of 128.6 rpm and net head of 99 ft. It is a Francis type reaction turbine, with blades fixed to the turbine shaft. The turbine transforms a portion of the kinetic energy of the water flowing through it into rotational energy of the turbine assembly. Water pressure above the runner, and suction or "draft" underneath, cause the runner and turbine shaft to rotate.

Keowee output is proportional to the mass flow rate through the turbine. Flow rate depends on wicket gate position, which is controlled by the governor, and net effective head (the difference between forebay level and tailrace level).

Water enters Keowee through the intake, flows down the penstock and into the spiral case, which surrounds the turbine. As the wicket gates are opened, water flows diagonally across the runners, down the draft tube, and out to the tailrace.

The wicket gates are streamlined, adjustable linkages that control the rate of flow through the turbine. The 20 wicket gates operate in unison, positioned by the gate operating system. The governor hydraulically positions the open and close gate servomotors, moving the gate ring, which operates mechanisms connecting the gate ring to the gates.

The generator thrust/guide bearing provides lateral and axial support to the turbine. The generator thrust/guide bearing is lubricated by the High Pressure Oil System, discussed in Appendix A.7.

The turbine guide bearing also prevents excessive lateral movement of the turbine-generator shaft. This bearing is lubricated by the Guide Bearing Oil System, discussed in Appendix A.12.

The turbine shaft is sealed by the packing box, located below the guide bearing. The packing is cooled and lubricated by water from the Cooling Water System (Appendix A.14). Water exiting the packing box collects in the turbine sump and is removed by the Turbine Sump Pump System (Appendix A.13). This water must be removed to preclude the possibility of reaching the turbine guide bearing and jeopardizing turbine operation.

A Farval Automatic Lubrication System provides a measured quantity of grease to each wicket gate stem bushing and each connection of the gate operating mechanism. The system consists of a motor-driven central pumping station operated by a control panel with timers, a supply line to each branch of the system and a metering valve for each lubrication point. The lubrication cycle is adjustable from 1 to 24 hours; the duration of each cycle is adjustable from zero to five minutes. The system is divided into two branches. One branch lubricates more frequently than does the other.

Governor

The function of the Woodward governor is to regulate the rotational speed of the turbine shaft by controlling the flow of water through the wicket gates to the turbine blades. The governor brings the turbine shaft up to synchronous speed (128.6 rpm), maintains it at that speed to match generator output to system frequency, and stops the turbine when shutting down.

The governor is also used to help in unwatering the unit for maintenance. First, the cylinder gate is lowered into the intake structure and unwatering valves are opened, allowing water within the station to drain out to the tailrace. Then the governor is used to position the wicket gates for maintenance. Drains and sump pumps are used to further empty the draft tube, allowing access to the unit parts normally under water.

The Governor system includes mechanical flyballs, a hydraulic valve system, a restoring connection between the wicket gates and the valve system, and a compensating dashpot.

The governor flyball assembly is used for speed sensing. It includes a synchronous motor whose speed is directly proportional to turbine speed, since it is driven by a permanent magnet generator (PMG) attached to the generator shaft. The motor rotates at three times the speed of the PMG, enabling it to respond to minute changes in turbine speed to initiate a repositioning of the wicket gates, thereby returning the turbine to its correct speed.

The hydraulic power system consists of a pilot valve, a distributing valve, servomotors, and a source of pressurized oil (Governor Oil System) to supply the valves and servomotors. The pilot valve uses system pressure and directs oil to the servomotors through the distributing valve. Auxiliary control consists of a control knob, gearing and associated linkages and auxiliary valve, which supply governor oil to the servomotors to manually open or close the wicket gates.

Three Woodward screw-type pumping units supply oil under pressure to the Governor Oil Pressure Tank, for use by the governor. The pumping units are located on top of the governor oil sump. (The Governor Oil System is discussed in Appendix A.11.)

The restoring mechanism includes an enclosed cable running from the wicket gate operating ring to the governor. This mechanism provides a mechanical signal to the governor, enabling it to regulate the gates at the desired position.

The compensating dashpot is a device that provides a dampening effect on governor operation. It introduces a temporary speed level setting change while the wicket gates are in motion, allowing the gates to approach their desired position in a smooth manner.

The mechanical flyballs, pilot valve, distributing valve, hydraulic system, restoring mechanism and compensating dashpot are located in the Governor Actuator Cabinet.

A.10.3 SYSTEM BOUNDARIES

The governor depends on Keowee Start and Run Control signals (Appendix A.5) and the Governor Oil System for proper operation, as represented in the block diagram of Figure A.10-1. The turbine requires support from the Turbine Guide Bearing Oil System and the Turbine Sump Pump System.

A.10.4 INSTRUMENTATION AND CONTROLS

The governor normally operates automatically but can be manually controlled from the Governor Actuator Cabinet (GAC).

The transfer valve is a three-way hydraulic valve located on the front of the GAC. It permits the operator to select either the distributing valve or the auxiliary valve for use in hydraulically moving the wicket gates. The auxiliary valve is only used during maintenance and performs the same function as the distributing valve. However, the governor protection devices are bypassed when using the auxiliary valve.

The speed changer knob is used to manually change the operating speed of the unit. It may be used to adjust the unit speed before the unit is on line or adjust unit load after the unit is tied to the grid.

The speed droop adjustment allows the operator to select how quickly the unit responds to changes in power or frequency.

Governor oil pump controls are located on the GAC. For convenience, a tachometer is also provided on the GAC.

A.10.5 LOCATION WITHIN THE PLANT

The Governor Actuator Cabinet, which houses the governor actuator and on which are the local governor controls, is located in the Mechanical Equipment Gallery, elevation 683' 6". The gate servomotors and gate operating system are located in the Turbine Wheelpit, at an elevation of approximately 675'. The turbine runner and turbine-generator shaft extend through the Keowee Powerhouse from an elevation of approximately 657' to 694'.

A.10.6 NORMAL OPERATION

Shutdown Solenoid 99SD and Partial Shutdown Solenoid 99SN, housed in the GAC, are the primary devices that control the governor actuator. (Their input signals and power supply are discussed in Appendix A.5.)

When 99SD and 99SN are energized, the gates open toward the pre-set no-load position. At 50 rpm, 99SN will de-energize, and the gates will close to a position slightly greater no-load. When speed reaches 122 rpm, 99SN is re-energized, and the unit is released to governor control. While in governor control, the governor head assembly maintains the turbine at synchronous speed.

If 99SN becomes de-energized during the unit run, it overrides governor control to take the wicket gates to the no-load position. If 99SD becomes de-energized, the unit is shutdown.

A.10.7 PERFORMANCE DURING KEOWEE EMERGENCY OPERATION

Governor and Turbine operation is the same during normal and emergency operation. However, the logic sending signals to 99SN and 99SD is less restrictive for emergency operation. For example, loss of cooling water flow to the generator thrust bearing oil cooler, generator air coolers, or turbine packing box causes a normal generator lockout, but not an emergency lockout. Oil level falling to 5.5" in the turbine guide bearing upper oil reservoir will cause a normal lockout, but must fall to 4.5" to de-energize Shutdown Solenoid Aux. Relay 99SX and shut down the unit during emergency operation.

A.10.8 TEST AND MAINTENANCE

Testing

Each week, the DC Guide Bearing Oil pump and DC Turbine Sump Pump are verified to operate, the governor echelon control knob is switched to change the role of each governor oil pump, and packing box strainers WLFL-1, 2 are cleaned.

The Governor and Turbine are functionally verified to operate each time a unit is used to generate power to the grid.

The Governor and Turbine testing requirements are detailed in Table A.10-1.

Maintenance

The following maintenance is performed on an as-needed basis:

- turbine-generator shaft is cleaned and coated with a protective coating
- turbine bearing is inspected
- servomotor packing is adjusted or replaced
- turbine shaft packing is replaced.

All turbine parts, above and below water, are verified to be in as-designed condition bi-annually, or as needed.

The pilot valve filter and governor oil pump filters are inspected monthly.

The governor receives a complete inspection and maintenance annually or as needed.

Semi-annually, the governor oil sump strainer basket is verified to be clean and free of obstruction.

The Governor and Turbine maintenance requirements are summarized in Table A.10-2.

A.10.9 OPERATING EXPERIENCE

No failures occurred over the period of data consideration that are attributed directly to either the governor or turbine that would fail an emergency start or run.

A.10.10 ASSUMPTIONS

A.10.10.1 SYSTEM DESIGN ASSUMPTIONS

1. During a Keowee run, the governor requires the Governor Oil System to supply oil at the proper pressure so that it can then supply the servomotors. Failure of the Governor Oil System is indicated by several alarms, such as: governor oil tank (governor oil sump) level high, governor oil tank level low, governor pressure tank

level high, and governor oil pressure low. Since the unit is considered unavailable until the problem is corrected, a start failure for the Governor Oil system is not modeled.

2. During a Keowee run, the turbine requires the Turbine Sump Pump system to remove turbine packing leakage. If leakage were allowed to accumulate, it might reach the turbine guide bearing and degrade bearing operation, resulting in a run failure of Keowee. However, since the system is not required for a Keowee start, start failure of the Turbine Sump Pump system is not modeled.

3. During a Keowee run, the turbine requires the Turbine Guide Bearing Oil system to cool and lubricate the guide bearing. Low turbine guide bearing oil level will prohibit an emergency start. However, since the affected Keowee unit is considered unavailable if the system is unavailable, start failure of the Turbine Guide Bearing Oil system is not modeled.

A.10.10.2 OPERATIONAL ASSUMPTIONS

1. Each unit's governor and turbine is assumed to be available for emergency power generation. Maintenance events that render the unit unavailable are captured in the high-level model. Maintenance events that affect the support systems are included in the support system models.

A.10.10.3 MODELING ASSUMPTIONS

1. The governor and turbine are each modeled as single components, since industry failure rate data is not generally available on a subcomponent level.

A.10.11 <u>FAULT TREE ANALYSIS</u>

A.10.11.1 TOP EVENT SUCCESS CRITERIA

Success of the Governor and Turbine requires that they perform as needed during a Keowee emergency cold start, hot start (if previously generating to the grid), and run. To succeed, all governor and turbine support systems must also be successful.

A.10.11.2 DETAILED FAILURE CRITERIA

1. The governor requires acceptable control signals from the Keowee start and run logic.
2. The governor must properly position the wicket gates during a start and run.
3. The turbine must perform properly during a start and run.
4. The Governor Oil System, Turbine Guide Bearing Oil System, and Turbine Sump Pump System must perform their support function properly during a Keowee run.

A.10.11.3 DESCRIPTION OF FAULT TREE

The Governor and Turbine fault tree is shown in Figure A.10-2. The Fault Tree Modeling Guidelines (Appendix B) were followed in developing the fault tree. A list of Unit 1 fault tree transfers is presented in Table A.10-3. Modules were not developed for the Keowee fault trees.

The governor and turbine are each modeled as single components, since industry failure rate data is not generally available on a subcomponent level. Control signals for the governor are modeled in detail in Appendix A.5, Keowee Start & Run Control.

Human reliability analysis was performed as described in Section 5.5 and Appendix C.3. Human events impacting the model are described in Section A.10.11.4.

Common cause analysis was performed as described in Section 5.4 and Appendix C.2. Common cause events impacting the model are described in Section A.10.11.6.

A.10.11.4 HUMAN INTERACTIONS

Human actions by the maintenance technicians can adversely affect Governor and Turbine reliability. The Governor & Turbine fault tree is an intermediate level tree and contains one latent human error event per unit. In addition, each of the support system models (Governor Oil, Turbine Guide Bearing Oil, and Turbine Sump Pump systems) include latent human error basic events.

WK1GVCDLHE, WK2GVCDLHE

These basic events account for the potential of the maintenance technicians or operators to fail to properly restore the governor following maintenance or testing.

A.10.11.5 RELIABILITY DATA

Plant-specific data was used to calculate failure rates for the following undeveloped events.

WK1GVCDDEX, WK2GVCDDEX

These events represent failure of the governor to properly position the wicket gates during a cold start. Since no start failures occurred over the ten year period under consideration, the failure rate is estimated using the following equation, from section 5.3 of the main report:

$$\phi(A) = \frac{0.2275}{T}$$

where $\phi(A)$ = the failure rate of interest
T = exposure time or number of demands.

Then $\phi(A)$ = 0.2275 / The no. of cold starts on units 1 and 2
= 0.2275 / No. of all starts on units 1 and 2 - No. of hot starts
= 0.2275 / (3390 + 3098 - 11)
= 3.5E-5.

WK1GVHTDEX, WK2GVHTDEX

These events represent failure of the governor to properly position the wicket gates during a hot start. A plant-specific failure probability was not calculated for these events since only a small number of hot starts (11) occurred over the ten year period of data consideration. As a screening value, the cold start failure rate was increased by an order of magnitude and used here.

WK1GVRNDEX, WK2GVRNDEX

These events represent failure of the governor to properly position the wicket gates during a Keowee run. Since no run failures occurred over the ten year period under consideration, the failure probability is estimated using the equation from section 5.3 of the main report as follows:

$$\phi(A) \text{ x } 24 \text{ hrs} = (0.2275 / \text{The run time on units 1 and 2})(24 \text{ hrs})$$
$$= (0.2275 / 9713)(24)$$
$$= 5.6\text{E-}4.$$

WK1SPD2DEX, WK2SPD2DEX

These events represent failure of the governor which results in an overspeed of the affected Keowee turbine. Modification NSM-ON-52966 is designed to provide protection from this failure mode.

Ten percent of the value of WK1(2)GVRNDEX is used here as a screening value.

WK1TBCDDEX, WK2TBCDDEX

These events represent failure of the turbine during a cold start and were quantified using the same numbers as were used for WK1GVCDDEX, WK2GVCDDEX.

WK1TBHTDEX, WK2TBHTDEX

These events represent failure of the turbine during a hot start. As for the governor, a plant-specific failure probability was not calculated for these events due to the small number of hot starts. As a screening value, the cold start failure rate was increased by an order of magnitude and used here.

WK1TBRNDEX, WK2TBRNDEX

These events represent failure of the turbine during a Keowee run and were quantified using the same numbers as were used for WK1GVRNDEX, WK2GVRNDEX.

Maintenance events that render the unit unavailable are captured in the high-level model. Maintenance events that affect the support systems are included in the support system models. There are no maintenance events included in the Governor & Turbine fault tree.

The Governor and Turbine statalarms are listed in Table A.10-4. Only alarm 1SA2-15 actually pertains to the governor or turbine directly. The others fall within the domain of the support systems. Nonetheless, they reflect governor or turbine operating conditions, and are included here also for convenience.

System reliability data is listed in Table A.10-5. Basic event factors are not needed for this model, since they are included in the developed event calculations.

A.10.11.6 COMMON CAUSE ASSESSMENT

Common cause failure of the Governor and Turbine of both units is represented in the high-level fault tree (Appendix A.1) by the following events:

WKCSTRTCOM -- CCF of the governors to cold start
WKHSTRTCOM -- CCF of the governors to hot start
WK00RUNCOM -- CCF of the governors to run.

The process of identifying and quantifying common cause failures is described in detail in Appendix C.2.

A.10.12 <u>RESULTS</u>

Reliability of the Governor and Turbine is defined as the probability that they will succeed in supporting Keowee emergency operation (black start plus a 24 hour run). The reliability of units 1 and 2 is the same since the basic event failure probabilities are the same for both units.

Each unit model contains three top gates. The first, failure of the governor or turbine during a cold start, yields a failure probability of approximately 3.3E-4. Thus the reliability of each unit's governor and turbine during a cold start is computed to be 99.97%. The second, failure of the governor or turbine during a hot start, yields a failure probability of approximately 7.0E-4, for a reliability of 99.93%. The third, failure of the

governor or turbine during a run, yields a failure probability of approximately 1.18E-3, and a reliability of 99.88%.

Table A.10-6 lists the cut sets (failure sequences) for the Governor and Turbine. Since the system cut sets are normally obtained after setting the transfer gate failure probabilities to zero, that leaves, for this instance, only the turbine and governor developed events and governor cold start latent human error. The contributors to unavailability are shown in Table A.10-7. Failures of the governor and turbine while running contribute the most to system unreliability, followed next by failures while hot starting, and last by failures while cold starting. However, it should be noted again that, since no valid governor or turbine emergency operation failures have occurred, these failure probabilities were derived using the chi-squared approximation. Also, due to lack of sufficient data, the hot start failure probabilities were based on the cold start failure probabilities. Thus, the results are driven by these modeling assumptions.

A.10.13 REFERENCES

A.10.13.1 DOCUMENTS

1. OSS-0245.00-00-2005, Rev. 2, Keowee Emergency Power Design Basis Document.

2. OP-OC-EL-KHG, Rev. 8, Keowee Operations Training Material.

A.10.13.2 PROCEDURES

1. MP/1/A/2000/017, Change 5, Unit No. 1 Turbine And Governor Weekly Preventive Maintenance.

2. MP/1/A/2000/018, Change 4, Unit No. 1 Turbine And Governor Monthly Preventive Maintenance.

3. MP/1/B/2000/051, Change 1, Cleaning Of Unit No. 1 Turbine-Generator Shaft.

4. MP/1/A/2200/003, Change 4, Governor Actuator No. 1 Inspection And Maintenance.

5. MP/1/A/2200/004, Change 1, Replacement Of Unit No. 1 Turbine Shaft Packing.

6. MP/1/A/2200/008, Change 3, Unit No. 1 Hydraulic Turbine Inspection.

7. MP/1/A/2200/009, Change 0, Unit No. 1 Turbine Bearing Inspection Or Replacement.

8. MP/1/A/2200/010, Change 1, Unit No. 1 Servomotor Packing Maintenance.

9. OP/0/A/2000/043, Change 6, Keowee Shift Turnover And Rounds.

A.10.13.3 DRAWINGS (Unit 1)

1. KEE-111 series.

2. KEE-113 series.

Table A.10-1

Governor and Turbine Test Procedures

Procedure	Test Frequency	Description
MP/1/A/2000/017, Unit No. 1 Turbine And Governor Weekly Preventive Maintenance	Weekly	Check operation of DC Sump Pump and DC GBO Pump; check GBO Pump reduction gear oil levels; clean packing box strainer; rotate OG pump echelon control.

Table A.10-2

Governor and Turbine Maintenance Procedures

Procedure	Maintenance Frequency	Description
MP/1/A/2000/018, Unit No. 1 Turbine And Governor Monthly Preventive Maintenance	Monthly	Clean governor pump unloader filters, GBO filter, Turbine Sump strainer, and pilot valve filters. Verify generator guide and thrust bearing oil levels are normal; no loose connections on governor terminal blocks.
	Bi-monthly	Verify water supply strainer is clean and free of obstruction.
	Semi-annually	Verify sump basket strainer is clean and free of obstruction.
MP/1/B/2000/051, Cleaning Of Unit No. 1 Turbine-Generator Shaft	As needed	Clean turbine-generator shaft and apply protective coating.
MP/1/A/2200/003, Governor Actuator No. 1 Inspection And Maintenance	Annually or as needed	Perform complete inspection and maintenance on governor actuator.

Table A.10-2

Governor and Turbine Maintenance Procedures

Procedure	Maintenance Frequency	Description
MP/1/A/2200/004, Replacement Of Unit No. 1 Turbine Shaft Packing	As needed	Replace turbine shaft packing.
MP/1/A/2200/008, Unit No. 1 Hydraulic Turbine Inspection	Bi-annually (odd-numbered years)	Perform complete inspection of turbine above water and under water parts.
MP/1/A/2200/009, Unit No. 1 Turbine Bearing Inspection Or Replacement	As needed	Inspect and/or replace turbine bearing.
MP/1/A/2200/010, Unit No. 1 Servomotor Packing Maintenance	As needed	Temporarily adjust or replace servomotor packing.

Table A.10-3

Governor and Turbine Fault Tree Transfers (Unit 1)*

Transfer Gate Name	Description	Component Supplied
BK1000	Keowee Unit 1 Turbine Guide Bearing Oil Cooler Fails During Run	Turbine No. 1
OK1600	Keowee Unit 1 Governor Oil System Fails Keowee Run	Governor No. 1
PK12000	Keowee Unit 1 Turb. Sump Pump Fails To Remove Leakage During Keowee Run	Turbine No. 1
YK1CLDSTRT	Keowee 1 Governor Control Fails During A Cold Start	Governor No. 1
YK1HOTSTRT	Keowee 1 Governor Control Fails During A Hot Start	Governor No. 1
YK1RUNCNTL	Keowee 1 Governor Control Fails During Run	Governor No. 1

*Unit 2 transfer gates are similar.

Table A.10-4

Governor and Turbine Statalarms (Common And Unit 1*)

Point No.	Alarm	Actuator
SA1-44	GOV. AIR TEMP. HIGH	23G1X & 23G2X
SA1-45	GOV. AIR PRESS. LOW	63L3/PS9
1SA1-1	TURB. #1 BRG. OIL PUMP TROUBLE	30Y
1SA1-2	TURB. #1 BRG. OIL LEVEL LOW	63TA/2X
1SA1-3	TURB. #1 PKG. BOX WTR. PRESS. LOW	63KX
1SA1-4	TURB. #1 WATER SUMP LEVEL HIGH	63SBX
1SA1-11	GOV. #1 OIL TANK LEVEL HIGH	63GT/2X
1SA1-12	GOV. #1 OIL TANK LEVEL LOW	63GT/1X
1SA1-13	GOV. #1 MAIN VALVE CLOSED	63GT/1X
1SA1-15	GOV. #1 PRESS. TANK LEVEL HIGH	63GPX
1SA1-16	GOV. #1 OIL PUMP EXCESS RUNNING	88GTX
1SA1-50	UNIT #1 D.C. SUPPLY FAILURE	8DX, 8GX, 8SX
1SA2-7	TURB. #1 BRG. TEMP. HIGH	38T2X
1SA2-8	TURB. #1 PKG. BOX TEMP. HIGH	26P2X
1SA2-15	TURB. #1 SHEAR PIN FAILURE	74S
1SA2-18	GOV. #1 OIL PRESS. LOW	63QX
1SA2-19	GOV. #1 OIL PUMP 1A EMERG. RUN	99K1

*Unit 2 alarms are similar.

Table A.10-5

Governor And Turbine Reliability Data

Event Name	Description	Failure Probability
WK1GVCDDEX	Keowee Unit 1 Gov. Fails to Position Wicket Gates During a Cold Start	3.50E-05
WK1GVCDLHE	Latent Human Error Fails Keowee 1 Governor During Cold Start	2.60E-04
WK1GVHTDEX	Keowee Unit 1 Gov. Fails to Position Wicket Gates During Hot Start	3.50E-04
WK1GVRNDEX	Keowee Unit 1 Gov. Fails to Position Wicket Gates With Unit Running	5.60E-04
WK1SPD2DEX	Keowee Unit 1 Governor Failure Creates Overspeed Condition	5.60E-05
WK1TBCDDEX	Keowee Unit 1 Turbine Fails During a Cold Start	3.50E-05
WK1TBHTDEX	Keowee Unit 1 Turbine Fails During a Hot Start	3.50E-04
WK1TBRNDEX	Keowee Unit 1 Turbine Fails With the Unit Running	5.60E-04
WK2GVCDDEX	Keowee Unit 2 Gov. Fails to Position Wicket Gates During Cold Start	3.50E-05
WK2GVCDLHE	Latent Human Error Fails Keowee 2 Governor During Cold Start	2.60E-04
WK2GVHTDEX	Keowee Unit 2 Gov. Fails to Position Wicket Gates During Hot Start	3.50E-04
WK2GVRNDEX	Keowee Unit 2 Gov. Fails to Position Wicket Gates With Unit Running	5.60E-04
WK2SPD2DEX	Keowee Unit 2 Governor Failure Creates Overspeed Condition	5.60E-05
WK2TBCDDEX	Keowee Unit 2 Turbine Fails During a Cold Start	3.50E-05
WK2TBHTDEX	Keowee Unit 2 Turbine Fails During a Hot Start	3.50E-04
WK2TBRNDEX	Keowee Unit 2 Turbine Fails With the Unit Running	5.60E-04

Table A.10-6

Governor And Turbine Dominant Minimal Cutsets (Unit 1)

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
Cutsets For Gate KU1GVTBCLD, Keowee Unit 1 Governor Or Turbine Fails During A Cold Start:					
1)	2.6E-04	78.8	WK1GVCDLHE	2.6E-04	Latent Human Error Fails Keowee 1 Governor During Cold Start
2)	3.5E-05	10.6	WK1GVCDDEX	3.5E-05	Keowee Unit 1 Gov. Fails to Position Wicket Gates During a Cold Start
3)	3.5E-05	10.6	WK1TBCDDEX	3.5E-05	Keowee Unit 1 Turbine Fails During a Cold Start
Total: 3.30E-04					
Cutsets For Gate KU1GVTBHOT, Keowee Unit 1 Governor Or Turbine Fail During A Hot Start:					
1)	3.5E-04	50	WK1GVHTDEX	3.5E-04	Keowee Unit 1 Gov. Fails to Position Wicket Gates During A Hot Start
2)	3.5E-04	50	WK1TBHTDEX	3.5E-04	Keowee Unit 1 Turbine Fails During a Hot Start
Total: 7.00E-04					

Table A.10-6

Governor And Turbine Dominant Minimal Cutsets (Unit 1)

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
Cutsets For Gate KU1GVTBRUN, Keowee Unit 1 Governor Or Turbine Fail While Unit Runs:					
1)	5.6E-04	47.5	WK1GVRNDEX	5.6E-04	Keowee Unit 1 Gov. Fails to Position Wicket Gates With Unit Running
2)	5.6E-04	47.5	WK1TBRNDEX	5.6E-04	Keowee Unit 1 Turbine Fails With the Unit Running
3)	5.6E-05	4.7	WK1SPD2DEX	5.6E-05	Keowee Unit 1 Governor Failure Creates Overspeed Condition
Total:	1.18E-03				

Table A.10-7

Governor and Turbine Dominant Contributors To Unavailability (Unit 1)

Rank	Event Description	Mean Unavailability[1]	Approximate Unavailability Contribution[2]
During Cold Start:			
1	WK1GVCDLHE - Latent Human Error Fails Keowee Unit 1 Governor During A Cold Start	2.6E-04	78.8%
2	WK1GVCDDEX - Keowee Unit 1 Gov. Fails to Position Wicket Gates During A Cold Start	3.5E-05	10.6%
3	WK1TBCDDEX - Keowee Unit 1 Turbine Fails During A Cold Start	3.5E-05	10.6%
During Hot Start:			
1	WK1GVHTDEX - Keowee Unit 1 Gov. Fails to Position Wicket Gates During A Hot Start	3.5E-04	50%
2	WK1TBHTDEX - Keowee Unit 1 Turbine Fails During A Hot Start	3.5E-04	50%

Table A.10-7

Governor and Turbine Dominant Contributors To Unavailability (Unit 1)

Rank	Event Description	Mean Unavailability[1]	Approximate Unavailability Contribution[2]
During Run:			
1	WK1GVRNDEX - Keowee Unit 1 Gov. Fails to Position Wicket Gates With Unit Running	5.6E-04	47.5%
2	WK1TBRNDEX - Keowee Unit 1 Turbine Fails With the Unit Running	5.6E-04	47.5%
3	WK1SPD2DEX - Keowee Unit 1 Governor Failure Creates Overspeed Condition	5.6E-05	4.7%

1 Mean unavailability is defined as the summation of the values of all cut sets in which the event appears.

2 The contribution to unavailability is calculated by dividing the mean unavailability by the overall system unavailability and then multiplying by 100 percent.

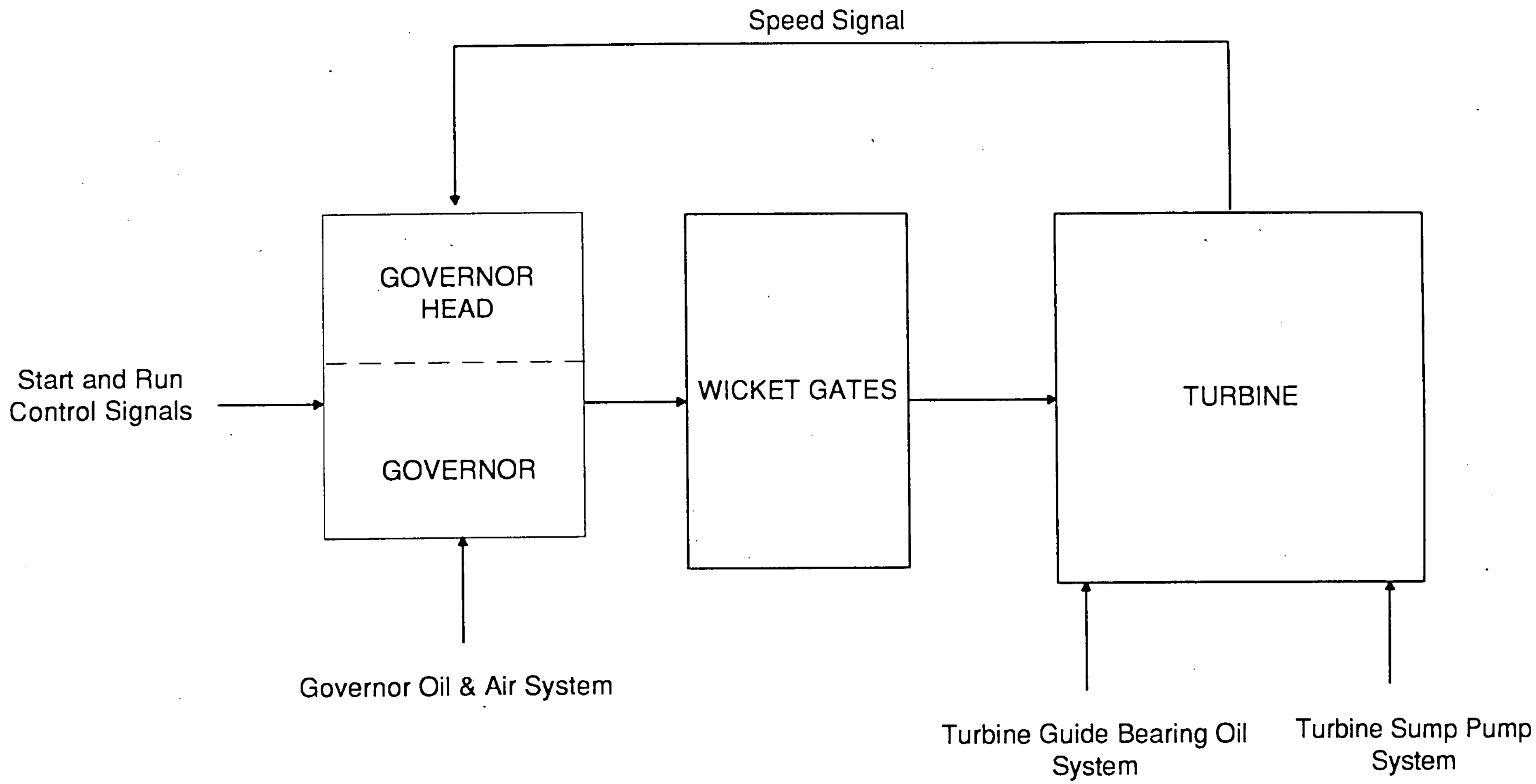
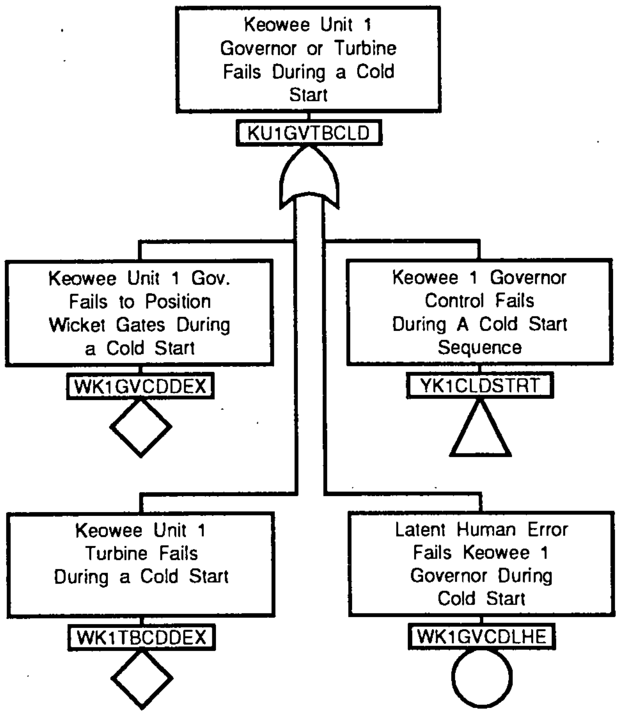
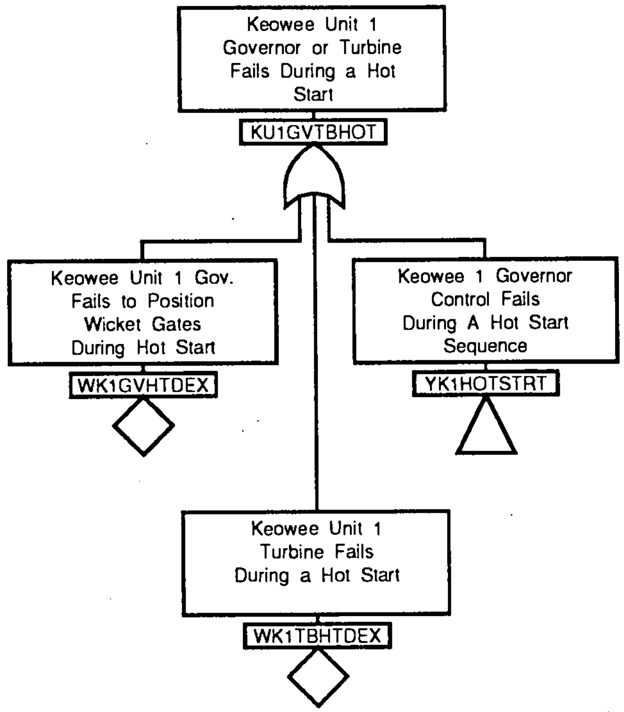


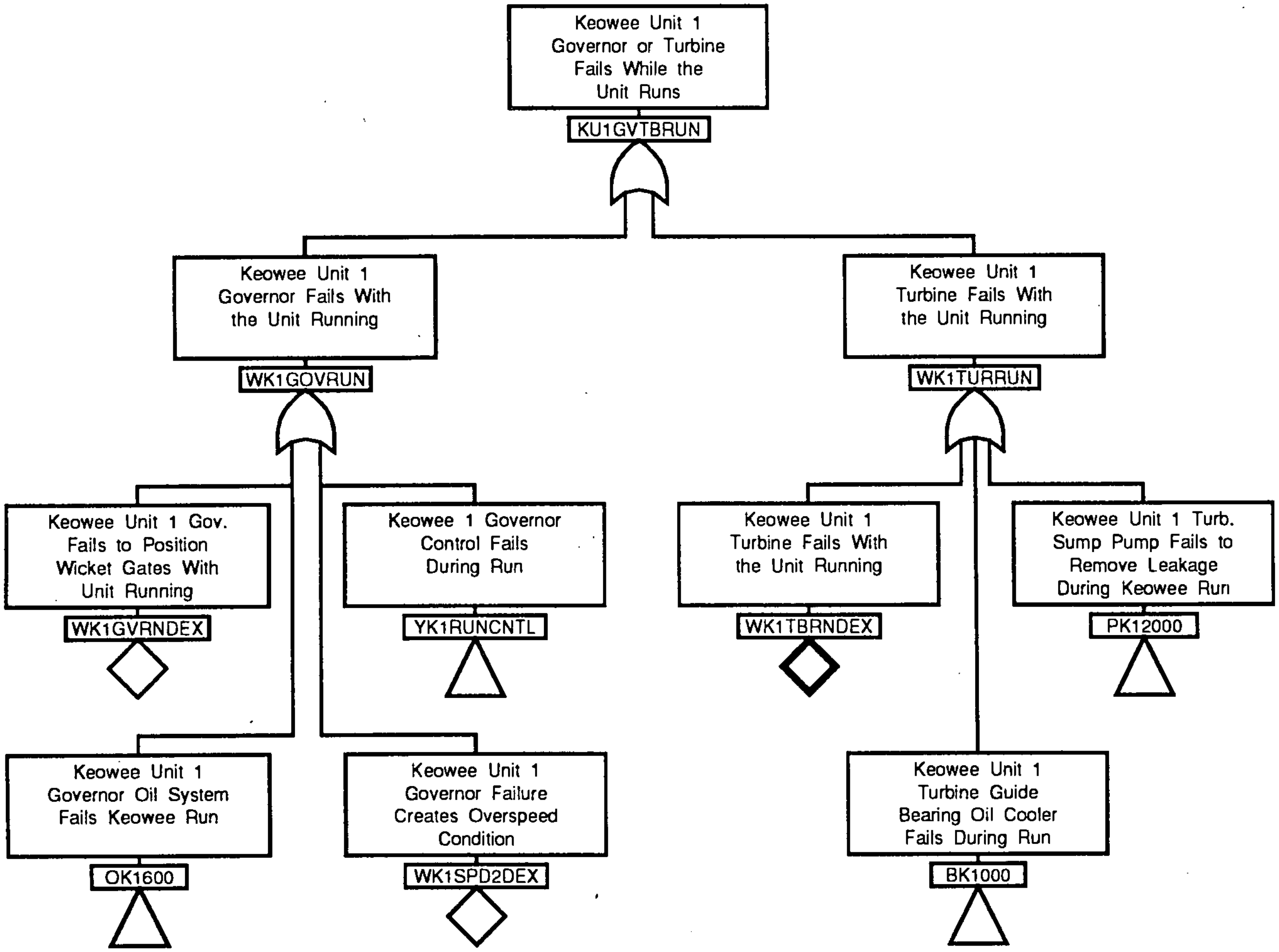
Figure A.10-1 Block Diagram of Governor and Turbine Control



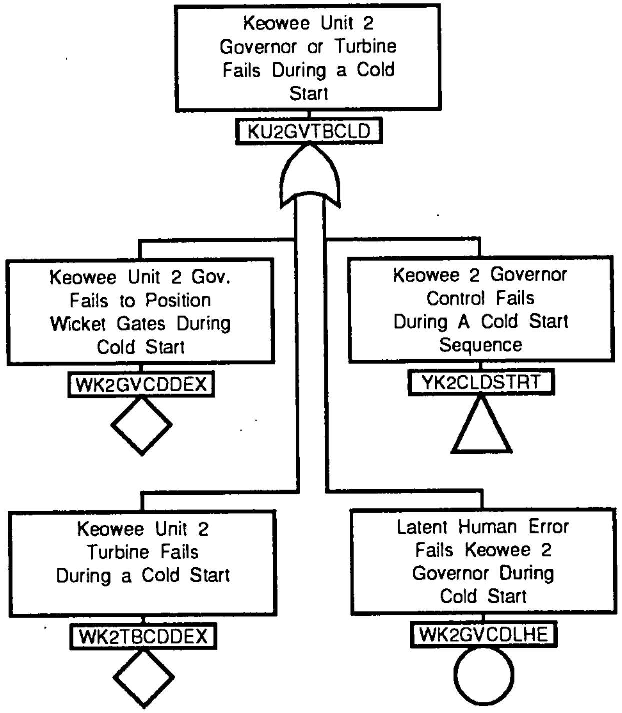
Keowee Governor and Turbine Faul[illegible]ee	FIGURE A.10-2	P[illegible] 1



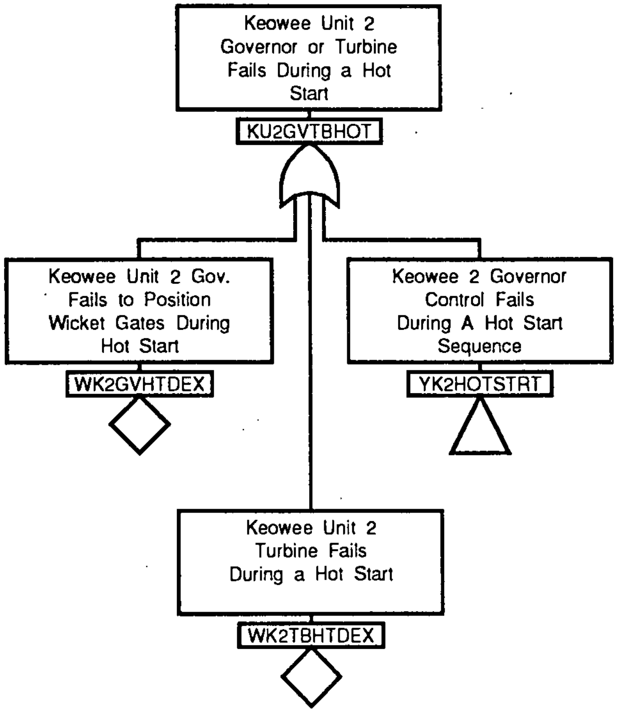
Keowee Governor and Turbine Fault Tree | FIGURE A.10-2 | Page 2



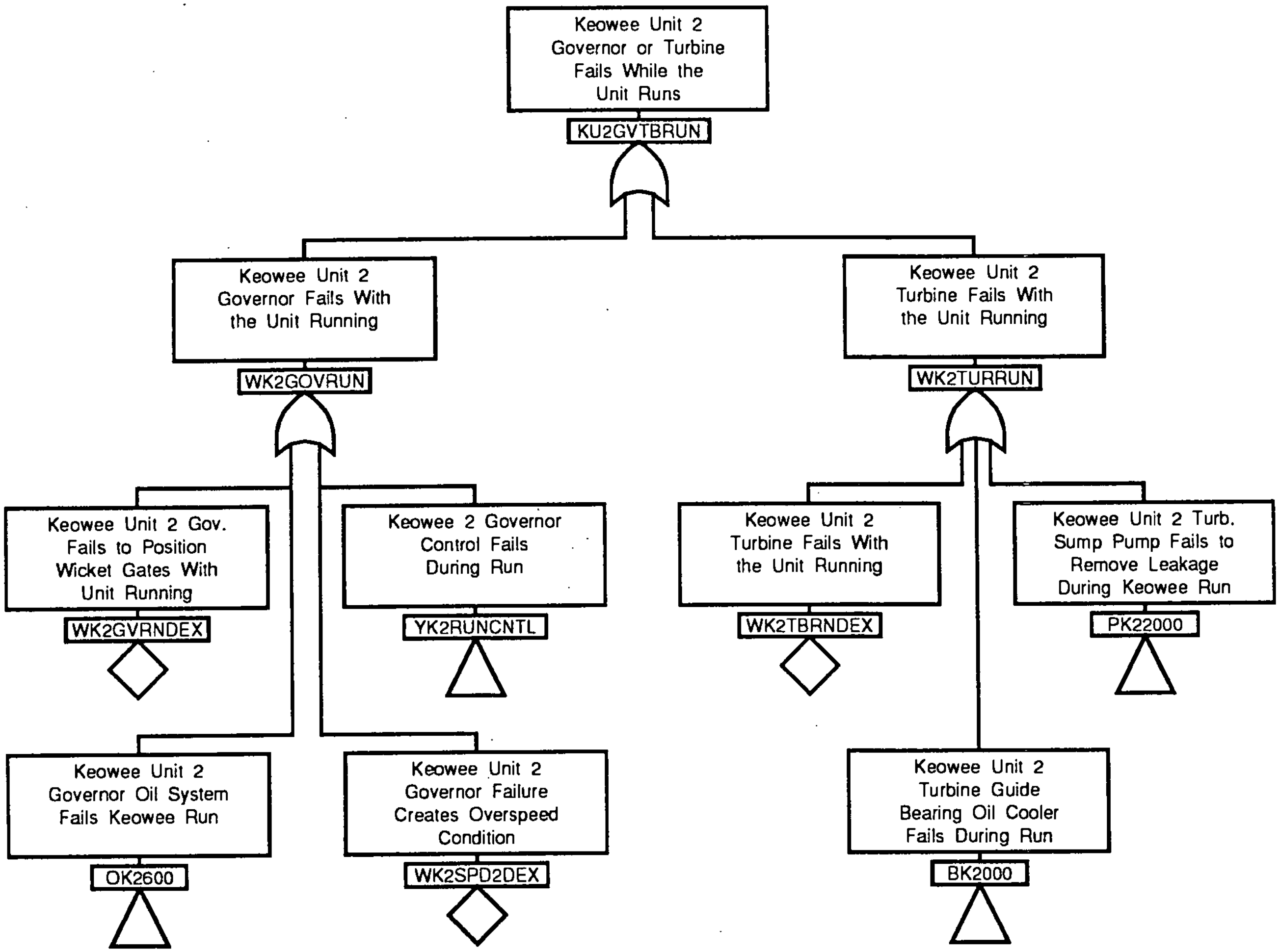
Keowee Governor and Turbine Fault Tree	FIGURE A.10-2	Page 3



Keowee Governor and Turbine Fault Tree | FIGURE A.10-2 |



Keowee Governor and Turbine Fault Tree | FIGURE A.10-2 | Page 5



Keowee Governor and Turbine Fault Tree | FIGURE A.10-2

Gate/Event Name	Page	Zone	Gate/Event Name	Page	Zone	Gate/Event Name	Page	Zone	Gate/Event Name	Page	Zone
BK1000	3										
BK2000	6										
KU1GVTBCLD	1										
KU1GVTBHOT	2										
KU1GVTBRUN	3										
KU2GVTBCLD	4										
KU2GVTBHOT	5										
KU2GVTBRUN	6										
OK1600	3										
OK2600	6										
PK12000	3										
PK22000	6										
WK1GOVRUN	3										
WK1GVCDDEX	1										
WK1GVCDLHE	1										
WK1GVHTDEX	2										
WK1GVRNDEX	3										
WK1SPD2DEX	3										
WK1TBCDDEX	1										
WK1TBHTDEX	2										
WK1TBRNDEX	3										
WK1TURRUN	3										
WK2GOVRUN	6										
WK2GVCDDEX	4										
WK2GVCDLHE	4										
WK2GVHTDEX	5										
WK2GVRNDEX	6										
WK2SPD2DEX	6										
WK2TBCDDEX	4										
WK2TBHTDEX	5										
WK2TBRNDEX	6										
WK2TURRUN	6										
YK1CLDSTRT	1										
YK1HOTSTRT	2										
YK1RUNCNTL	3										
YK2CLDSTRT	4										
YK2HOTSTRT	5										
YK2RUNCNTL	6										

APPENDIX A.11
GOVERNOR OIL AND GOVERNOR AIR SYSTEMS

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A.11 GOVERNOR OIL (OG) AND GOVERNOR AIR (AG) SYSTEMS

A.11.1 OBJECTIVES

The main objective of this analysis is to develop a logic model of the Governor Oil (OG) and Governor Air (AG) Systems. This model is combined with the high-level model and remaining system models to form an integrated model for assessing the reliability of Keowee. Other objectives are to identify major contributors to system unreliability, significant potential human errors and common cause failure modes.

The scope of this analysis is limited to OG and AG equipment required to support a Keowee emergency start and load run. The analysis assumes a loss of offsite power has occurred, so that Keowee Auxiliary AC Power is not available during the start.

A.11.2 SYSTEM DESIGN

Governor Air System

The function of the AG System is to provide and maintain a blanket of pressurized air in the Governor Oil Pressure Tank (GOPT). The AG System is also required to maintain its pressure boundary, so that governor air pressure, and consequently governor oil pressure, is not lost.

As shown in Figure A.11-1, the AG System is comprised of an Air Receiver Tank (ART) with a condensation drain valve, a header that connects the Air Receiver Tank directly to the GOPT, and piping and valves that connect the Air Receiver Tank to the governor air compressors.

Air leakage from the AG System occurs over time, resulting in increased oil level in the GOPT. About once a week, Operators align the compressors to add air to the ART. However, the air compressors are normally isolated, and are not relied upon during a Keowee start or run.

Governor Oil System

The OG System provides pressurized oil to the Keowee turbine governor. The governor directs the oil as needed to the open and close servomotors, to hydraulically position the turbine wicket gates to match generator load.

The OG System is comprised of three pump trains, each aligned to take suction from the Governor Oil Sump and discharge to the 4" header connecting the governor and the GOPT. A 1" pressure sensing line fitted with a pressure switch for each pump also connects the GOPT to the governor.

Normally only one pump is required to maintain system pressure. In the automatic mode, the **lead** pump maintains the normal operating pressure. The **half-lead** and **lag** pumps will start at progressively lower set points if the lead pump is unsuccessful in maintaining pressure. Each pump train is equipped with a relief valve that will divert flow back to the sump if its respective pump does not shut down at its pressure setpoint. An echelon control knob is repositioned each week to change the role of each pump.

The motor-driven positive-displacement OG pumps are powered from 600 V ac auxiliary power motor control centers. Each Keowee unit's auxiliary power supplies its own OG pumps.

A float valve prevents air from entering the governor header on low oil level in the GOPT. If the float valve were to fail closed, governor pressure would be lost. Although pressure would decrease in the governor header, the 1" sensing line would remain pressurized by the GOPT, and the pressure switches would not signal the pumps to turn on. To solve this problem, an "emergency" pressure switch, OGPS-4, was added to the governor header. This switch will start the 'A' OG Pump, which will then run continuously. The switch also energizes the Governor Oil Pump Emergency Control relay, which activates a statalarm in the Control Room.

Note: The electrical elementaries use the device names 63QV/A, -B, and -C for referring to pressure switches OGPS-1, -2, and -3, respectively. Pressure switch OGPS-4 is referred to as 1PS12 or 63Q-4 on the elementaries.

A.11.3 SYSTEM BOUNDARIES

Electrical Power Supplies

The Keowee Auxiliary Power System provides power to the Unit 1 and 2 governor oil pumping units via 600 V ac motor control centers 1XA and 2XA, respectively. Control power is furnished to the Unit 1 and 2 OG Pump 'A' emergency control relays (99K1, 99K2) from 125 V dc distribution centers 1DA and 2DA, respectively. The power supplies for the modeled components are listed in Table A.11-1.

A.11.4 INSTRUMENTATION AND CONTROLS

Pump control switches for each OG pump are located on the Governor Actuator Cabinet. The three possible switch positions are 'CONT.,' 'OFF,' and 'INTER.' In the 'CONT.' position, the pump runs continuously, provided that the Shutdown Solenoid Aux. Relay, 99SX, is not energized. The switches (188GA, 188GB, and 188GC for OG Pumps 'A,' 'B,' and 'C,' respectively) are normally left in the 'INTER.' position, so that the pumps run intermittently as controlled by the pressure switches.

Pressure switches OGPS-1, OGPS-2, and OGPS-3 provide normal control for OG Pumps 'A,' 'B,' and 'C,' respectively. The lead pump's pressure switch closes when pressure drops below 318 psig, and reopens when pressure reaches 350 psig. The half-lead pump's pressure switch closes should pressure drops below 308 psig, and reopens when pressure reaches 341 psig. The lag pump's pressure switch closes if pressure drops below 298 psig, and reopens when pressure reaches 332 psig. The pressure switches are located in the 1" sensing line connecting the GOPT to the governor.

Emergency Control Pressure Switch OGPS-4 starts OG pump 'A' if pressure drops to 280 psig in the 4" supply header connecting the GOPT to the governor.

A.11.5 LOCATION WITHIN THE PLANT

The OG pumps, ART, GOPT and associated valves and piping are located in the Mechanical Equipment Gallery, elevation 683' 6", adjacent to the Governor Actuator Cabinet.

A.11.6 NORMAL OPERATION

The AG System remains pressurized to approximately 350 psig. The Air Receiver Tank is isolated from the Governor Air Compressors and is connected directly to the Governor Oil Pressure Tank.

The three OG pumps are aligned in parallel to take suction from the Governor Sump and discharge to the 4" header running between the governor and GOPT. The lead pump runs approximately every two hours for one to two minutes to restore system pressure.

The OG System is in service regardless of whether or not the respective Keowee unit is generating power, since oil is continually depleted from the GOPT. The largest oil load during unit operation are the gate servomotors. The largest loads during unit standby is the governor oil motor vibrator. Oil leakage through pump seals and past valve seats also contribute to falling level in the GOPT. After the oil has been used by the governor, it is returned to the OG sump via a 5" return line.

A.11.7 PERFORMANCE DURING KEOWEE EMERGENCY OPERATION

AG and OG System operation is the same during normal and emergency operation. However, during an emergency start under blackout conditions, Keowee Auxiliary Power is not available to the OG pumps

A.11.8 TEST AND MAINTENANCE

Twice-daily rounds and regular preventive maintenance are used to verify and maintain proper operation of the OG and AG systems.

Testing

On an annual frequency, the following system components are verified to operate properly:

- OG pumps unload within the proper pressure range
- OG pump pressure check valves seal off properly
- Unloader pressure switches open and close within the proper pressure ranges
- OG relief valves bypass oil within the proper pressure range

- 'Emergency' pressure switch OGPS-4 opens and closes within the proper pressure range
- OG pump excessive run timer operates as designed.

Note: In February, 1995, a modification was installed to extend the sight glass range on the GOPT and a test of the float valve was added to the governor oil pump assemblies maintenance procedure. Also, calibration of AG instrumentation was proceduralized.

The OG and AG System testing requirements are detailed in Table A.11-2.

Maintenance

The OG and AG systems are inspected twice a day, during rounds. During the rounds, governor oil and air pressure are verified to be within the proper range. Level in the GOPT is verified to be between the high and low marks, checks are made for any excessive oil or air leakage, and motor control center breakers are checked for proper position.

Governor oil filtration is performed as needed, based on oil sample results. Oil samples are taken semi-annually.

The OG and AG system maintenance requirements are listed in Table A.11-3.

A.11.9 OPERATING EXPERIENCE

A summary of significant operating events is provided in Table A.11-4.

A.11.10 ASSUMPTIONS

A.11.10.1 SYSTEM DESIGN ASSUMPTIONS

1. AG System air leakage is minimal, such that governor air compressors are not needed during the mission time.

A.11.10.2 OPERATIONAL ASSUMPTIONS

1. OG Pump 'A' is operating as the lead pump.

2. The pump control switches are in the "Inter." (intermittent operation) position, which allows each pump to come on automatically, if needed, when its actuation pressure is reached.

A.11.10.3 MODELING ASSUMPTIONS

1. The Governor Oil system does not contribute to Keowee start failures since the system operates continuously, and low oil pressure and level are alarmed. The Keowee unit is considered unavailable while repairs are made to restore the Governor Oil system.

2. Failure of an OG pump to load is considered a pump start failure.

3. Manual valve OG-8 is not modeled as transferring position since it is locked closed.

4. Failure of drain valve OG-2 is not modeled since the drain line is capped.

5. If manual valve OG-10 were to transfer closed, the 1" oil sensing line would depressurize as the governor used oil. However, as pressure drops, the pressure switches would signal the OG pumps to turn on. Since failure of OG-10 does not lead to system failure, it is not included in the model.

6. Loss of air through manual valve AG-3 would require an additional failure of check valve AG-2. Loss of air through relief valve AG-1 would require failures of both AG-2 and AG-3. Therefore, these failures are not modeled.

7. For modeling convenience, failures of the governor oil pumps' echelon controller are considered to be included in the pumps' start and run failure rate.

A.11.11 FAULT TREE ANALYSIS

A.11.11.1 TOP EVENT SUCCESS CRITERIA

Success of the OG and AG systems requires that at least one of the three OG pumps supplies the GOPT, and that system pressure and integrity is maintained.

A.11.11.2 DETAILED FAILURE CRITERIA

1. Failure of all three OG pump trains leads to the top event.

2. AG System failure leads to OG System failure.

3. Failure of GOPT leads to the top event.

4. Isolation of the GOPT from the 4" governor oil header occurs if the float valve OG-7 or manual valve OG-9 transfer closed. Subsequent failure of "emergency" pressure sensing leads to the top event.

A.11.11.3 DESCRIPTION OF FAULT TREE

The OG and AG system fault tree is shown in Figure A.11-2. The Fault Tree Modeling Guidelines (Appendix B) were followed in developing the fault tree. A list of all fault tree transfers is presented in Table A.11-5. Modules were not developed for the Keowee fault trees.

Human reliability analysis was performed as described in Section 5.5. Human events impacting the model are described in Section A.11.11.4.

Common cause analysis was performed as described in Section 5.4. Common cause events impacting the model are described in Section A.11.11.6.

A.11.11.4 HUMAN INTERACTIONS

Human actions by the maintenance technicians can adversely affect OG and AG system reliability. Those events explicitly included in the system fault tree are discussed below.

OK1001BLHE, OK1001CLHE, OK2002BLHE, OK2002CLHE

These basic events account for the potential of the maintenance technicians to fail to properly restore the 'B' and 'C' OG pumps. Since these pumps are not likely to be run again until they are selected as the lead pump, there is the possibility that any latent human errors affecting pump performance will not be discovered until the pump is operated over an extended period of time. A corresponding event is not included for the 'A' pump since, as the lead pump, it operates approximately every two hours.

A.11.11.5 RELIABILITY DATA

Section 5.3 discusses development of the reliability data. For the base case solution, the plant-specific failure rate data and generic failure rate data were combined using a Bayesian update.

Plant-specific data is used for maintenance events. The following maintenance events are included in the OG System model.

OK1OG1CTRM, OK2OG1CTRM

These events account for maintenance and testing on the Unit 1 and Unit 2 OG pump trains. For modeling simplicity, all of the unavailability is placed on the 'C' train. Each pump train is in maintenance or testing for approximately 10 hours per year. Thus, the unavailability of pump train C due to testing or maintenance is:

30 hr / 8760 hr = 3.42E-3.

Plant-specific data is also used for the float valve failure rate, since generic failure rate information is not available.

As discussed in Section 5.3, consideration of relevant statalarms is part of the process of determining each basic event factor. OG System statalarms are listed in Table A.11-6.

System reliability data is listed in Table A.11-7.

A.11.11.6 COMMON CAUSE ASSESSMENT

OK1PSTRCOM, OK2PSTRCOM, OK1PRUNCOM, OK2PRUNCOM

The OG pumps share the same design, maintenance procedures, operating conditions, environmental conditions, etc. A failure of all OG pumps leads to a failure of the OG System to operate. Therefore, these common cause events are included in the fault tree to represent these coupling mechanisms.

OK1PSTRCOM and OK2PSTRCOM represent a common cause failure of the OG pumps to start; OK1PRUNCOM and OK2PRUNCOM represent the common cause failure to run. The above events couple all three pumps for a single unit, but do not couple across units.

Common cause failure of *both* units' governor oil systems to run is represented in the high-level fault tree (Appendix A.1) by event OK0PRUNCOM.

The quantification of common cause events is described in detail in Appendix C.2.

A.11.12 RESULTS

Reliability of the OG and AG systems is defined as the probability that these systems will succeed in supporting a Keowee emergency operation (black start plus a 24 hour run). The system model yields a failure probability of approximately 3.11E-4 for both units 1 and 2. Thus the reliability of each unit's OG and AG System is computed to be 99.97%.

Table A.11-8 lists the dominant minimal cut sets (failure sequences) for the Governor Oil and Governor Air Systems for unit 1. The exposure times for unit 2 are the same as for unit 1 since the unit 2 system is also always in service. Unit 2 has the same equipment as unit 1 does, so results for the unit 2 top gate, OK2600, are identical to those for the unit 1 top gate, OK1600.

A list of dominant contributors to unavailability is shown in Table A.11-9. By far, the dominant contributors to the unavailability of the OG and AG systems are spurious operation of pressure boundary relief valves AG-4 or OG-3. Common cause failure of the OG pumps to start is the next highest contributor to system unreliability. Passive failures of the Air Receiver Tank and Governor Oil Pressure Tank also contribute to system unavailability.

A.11.13 REFERENCES

A.11.13.1 DOCUMENTS

1. OSS-0245.00-00-1031, Rev. 1, Keowee Mechanical Systems.

A.11.13.2 PROCEDURES

1. MP/1/A/2000/018, Change 4, Unit No. 1 Turbine And Governor Monthly Preventive Maintenance.

2. MP/1/A/2000/041, Change 2, Unit No. 1 Governor Oil Filtration.

3. MP/1/A/2200/001, Change 2, Governor No. 1 Oil Pump Assemblies Inspection And Maintenance.

4. OP/0/A/2000/043, Change 6, Keowee Shift Turnover And Rounds.

A.11.13.3 DRAWINGS

1. KEE-6, Rev. 7, Keowee Development Unit 1 & 2, Tabulation, Statalarm No. SA1, Station Alarms.

2. KEE-106, Rev. 3, Keowee Development Unit #1, Tabulation, Statalarm List #1SA1, T-G System Condition Alarms.

3. KEE-106-1, Rev. 3, Keowee Development Unit #1, Tabulation, Statalarm List #1SA2, T-G System Running Alarms.

4. KEE-107, Rev. 2, Keowee Hydro Station Unit No. 1, Elementary Diagram, Governor Oil Pump No. 1A, 1B & 1C.

5. KEE-111, Rev. 11, Keowee Hydro Station Unit No. 1, Elementary Diagram, Turbine And Governor Systems Start-up Control.

6. KEE-111-A,, Keowee Hydro Station Unit No. 1, Elementary Diagram, Turbine And Governor Systems Start-up Control.

7. KEE-207, Rev. 2, Keowee Hydro Station Unit No. 2, Elementary Diagram, Governor Oil Pump No. 2A, 2B & 2C.

8. KEE-211, Rev. 9, Keowee Hydro Station Unit No. 2, Elementary Diagram, Turbine And Governor Systems Start-up Control.

9. KEE-211-A,, Keowee Hydro Station Unit No. 2, Elementary Diagram, Turbine And Governor Systems Start-up Control.

10. KFD-104A-1.1, Rev. 1, Keowee Hydro Station Unit 1, Flow Diagram Of Governor Air System.

11. KFD-105A-1.1,, Keowee Hydro Station Unit 1, Flow Diagram Of Governor Oil System.

Table A.11-1

Governor Oil And Air System Power Supplies

Component	Power Supply[1]	Compartment Number
OG Pump 1A	600 V ac MCC 1XA	1D
OG Pump 1B	600 V ac MCC 1XA	2E
OG Pump 1C	600 V ac MCC 1XA	4D
OG Pump 2A	600 V ac MCC 2XA	1D
OG Pump 2B	600 V ac MCC 2XA	2E
OG Pump 2C	600 V ac MCC 2XA	4D
OG Pump 1A 'Emergency' Control Relays 99K1, 99K2	125 V dc DC 1DA	3BR
OG Pump 2A 'Emergency' Control Relays 99K1, 99K2	125 V dc DC 2DA	3BR

[1] MCC = Motor Control Center
DC = Distribution Center

Table A.11-2

Governor Oil And Air System Test Procedures

Procedure	Test Frequency	Description
MP/1/A/2000/018, Unit No. 1 Turbine And Governor Monthly Preventive Maintenance	Monthly	Governor pump unloader filters are verified to be clean and free of obstruction.
	Semi-annually	Governor sump basket strainer is verified to be clean and free of obstruction.
MP/1/A/2200/001, Governor No. 1 Oil Pump Assemblies Inspection And Maintenance.	Annually or as needed	Verification that OG pumps unload within the proper pressure range, pump discharge check valves seal off properly, unloader pressure switches open and close within the proper pressure range, OG relief valves bypass oil within the proper pressure range, 'emergency' pressure switch OGPS-4 opens and closes within the proper pressure range, OG pump excessive run timer operates as designed, and check valves meet INPO inspection guidelines.

Table A.11-3

Governor Oil And Air System Maintenance Procedures

Procedure	Maintenance Frequency	Description
MP/1/A/2000/041, Unit No. 1 Governor Oil Filtration Preventive Maintenance	As needed. Need is established based on results of semi-annual oil samples.	Governor oil is filtered for 40 hours.

Table A.11-4

Governor Oil And Air System Significant Operating Events

Date	Unit	Component	Event Summary
2/21/84	1	OG Pump 1B	Pump loading and unloading too soon due to worn unloader assembly.
2/21/84	1	OG Pump 1C	Discovered pump running unloaded due to worn unloader assembly.
4/11/84	1	OG Pump 1B	Pump failed to load and unload properly. No components replaced but unloader valve and pressure switch adjusted and friction relieved in all valves.
4/11/84	1	OG Pump 1C	Pump failed to load and unload properly. No components replaced but unloader valve and pressure switch adjusted and friction relieved in all valves.
5/6/84	2	OG-3	OG System not functioning properly due to cracked seat on GOPT relief valve.

Table A.11-4

Governor Oil And Air System Significant Operating Events

Date	Unit	Component	Event Summary
6/19/84	2	OG-3	GOPT relief valve inadvertently damaged during implementation of Fire Protection NSM, causing the valve to have a small air leak.
3/6/85	1	OG Pump 1C and 88GT timer relay	Discovered pump running unloaded, yet received no statalarm on excessive running due to inoperable timer.
3/16/87	2	OG-13	OG Pump 2A ran unloaded, bypassing flow through relief valve.
8/23/88	2	OG Pump 2C	Replaced failed bearing.
9/13/88	1	OG-7	OG System not functioning properly due to inoperable GOPT float valve.

Table A.11-5

Governor Oil And Air System Fault Tree Transfers

Transfer Gate Name	Description	Components Supplied
XA1XA	Loss of Power on Keowee 600 V ac MCC 1XA	OG Pumps 1A, 1B, 1C
XA2XA	Loss of Power on Keowee 600 V ac MCC 2XA	OG Pumps 2A, 2B, 2C
XD1DAR	Loss of Power on Keowee 125 V dc Distribution Center 1DA During Run	OG Pump 1A Emergency Control Relay 99K1
XD2DAR	Loss of Power on Keowee 125 V dc Distribution Center 2DA During Run	OG Pump 2A Emergency Control Relay 99K1

Table A.11-6

Governor Oil And Air System Statalarms (Unit 1)*

Point No.	Alarm	Actuator
SA1-44	GOV. AIR TEMP. HIGH	23G1X & 23G2X
SA1-45	GOV. AIR PRESS. LOW	63L3/PS9
1SA1-11	GOV. #1 OIL TANK LEVEL HIGH	63GT/2X
1SA1-12	GOV. #1 OIL TANK LEVEL LOW	63GT/1X
1SA1-15	GOV. #1 PRESS. TANK LEVEL HIGH	63GPX
1SA1-16	GOV. #1 OIL PUMP EXCESS RUNNING	88GTX
1SA2-18	GOV. #1 OIL PRESS. LOW	63QX
1SA2-19	GOV. #1 OIL PUMP 1A EMERG. RUN	99K1
1SA1-50	UNIT #1 D.C. SUPPLY FAILURE	8GX

*Unit 2 alarms are similar.

Table A.11-7

Governor Oil And Air System Reliability Data

Event Name	Description	Failure Rate[1]	Factor	Rationale For Factor[2]	Failure Probability
OK10001PSC	Pressure Switch 1OGPS-1 Fails to Close (Normal Control Signal)	2.90E-06 /D	15 D	See OK10001AGPR	4.35E-05
OK10002PSC	Pressure Switch 1OGPS-2 Fails to Close	2.90E-06 /D	8 D	See OK10001BGPR	2.32E-05
OK10003PSC	Pressure Switch 1OGPS-3 Fails to Close	2.90E-06 /D	4 D	See OK10001CGPR	1.16E-05
OK10003RVT	Safety Relief Valve 1OG-3 Spurious Operation	5.60E-06 /H	24 H	Rule 1: Gov. Oil Level High alarm	1.34E-04
OK10003TKF	Unit 1 Governor Oil Pressure Tank Fails	4.60E-07 /H	24 H	Rule 1: Gov. Oil Level High alarm	1.10E-05
OK10004PSC	Pressure Switch 1OGPS-4 Fails to Close	2.90E-06 /D	1 D	Needed to sense loss of press. in Gov. supply hdr.	2.90E-06
OK10007FVT	Float Valve 1OG-7 Transfers Closed	5.83E-06 /H	24 H	Rule 1: Gov. Oil Press Low Alarm	1.40E-04
OK10009VVT	Manual Valve 1OG-9 Transfers Closed	1.70E-08 /H	24 H	Rule 1: Gov. Oil Press Low Alarm	4.08E-07
OK10011CVO	Check Valve 1OG-11 Fails to Open	2.30E-06 /D	15 D	Challenged every time pump A starts	3.45E-05
OK10011CVT	Check Valve 1OG-11 Transfers Closed	1.30E-07 /H	0.75 H	Can transfer any time pump A is running	9.75E-08
OK10012VVT	Manual Globe Valve 1OG-12 Transfers Closed	1.70E-08 /H	30 H	Can tx any time during pump A exposure time	5.10E-07
OK10013RVT	Relief Valve 1OG-13 Spurious Operation	5.60E-06 /H	0.75 H	Can transfer any time pump A is running	4.20E-06
OK10014CVO	Check Valve 1OG-14 Fails to Open	2.30E-06 /D	8 D	Challenged every time pump B starts	1.84E-05
OK10014CVT	Check Valve 1OG-14 Transfers Closed	1.30E-07 /H	0.5 H	Can transfer any time pump B is running	6.50E-08
OK10015VVT	Manual Globe Valve 1OG-15 Transfers Closed	1.70E-08 /H	192 H	Assumes pump was in service 2 weeks ago: (0.5)(2 wks) + 24 hrs = 192 hrs	3.26E-06

Table A.11-7

Governor Oil And Air System Reliability Data

Event Name	Description	Failure Rate[1]	Factor	Rationale For Factor[2]	Failure Probability
OK10016RVT	Relief Valve 1OG-16 Transfers Open	5.60E-06 /H	0.5 H	Can transfer any time pump B is running	2.80E-06
OK10017CVO	Check Valve 1OG-17 Fails to Open	2.30E-06 /D	4 D	Challenged every time pump C starts	9.20E-06
OK10017CVT	Check Valve 1OG-17 Transfers Closed	1.30E-07 /H	0.25 H	Can transfer any time pump C is running	3.25E-08
OK10018VVT	Manual Globe Valve 1OG-18 Transfers Closed	1.70E-08 /H	108 H	Assumes pump was in service 1 week ago: (.5)(1 week) + 24 hrs = 108 hrs	1.84E-06
OK10019RVT	Relief Valve 1OG-19 Spurious Operation	5.60E-06 /H	0.25 H	Can transfer any time pump C is running	1.40E-06
OK1001AGPR	OG Pump 1A Fails to Run	1.40E-05 /H	0.375 H	Rule 4: pump operation feeds computer point. Pump runs for 1-2 min. every 2 hrs. Lead pump is needed for entire mission time: (15 runs[1])(1.5 min/run)(1 hr/60 min) = 0.375 hr	5.25E-06
OK1001AGPS	OG Pump 1A Fails to Start	9.70E-05 /D	15 D	See OK10001AGPR. (30 hr)(1 st/2 hr) = 15 starts	1.45E-03
OK1001BGPR	OG Pump 1B Fails to Run	1.40E-05 /H	0.25 H	Pump B is needed if pump A fails (assumed to fail after 15 hrs): (8 runs)(1.5 min/run)(1 hr/60 min) = 0.25 hr	3.50E-06
OK1001BGPS	OG Pump 1B Fails to Start	9.70E-05 /D	8 D	(15 hr)(1 start/2 hr) = 8 starts	7.76E-04
OK1001BLHE	Latent Human Error Fails OG Pump 1B				3.20E-03

Table A.11-7

Governor Oil And Air System Reliability Data

Event Name	Description	Failure Rate[1]	Factor	Rationale For Factor[2]	Failure Probability
OK1001CGPR	OG Pump 1C Fails to Run	1.40E-05 /H	0.125 H	Pump C is needed if pumps A and B fail (assumed to fail after 22.5 hrs): (4 runs)(1.5 min/run)(1 hr/60 min) = 0.125 hr	1.75E-06
OK1001CGPS	OG Pump 1C Fails to Start	9.70E-05 /D	4 D	(7.5 hr)(1 start/2 hr) = 4 starts	3.88E-04
OK1001CLHE	Latent Human Error Fails OG Pump 1C				3.20E-03
OK188GASWT	Keowee 1 Governor Oil Control Switch 188GA Spurious Operation	7.00E-08 /H	30 H	See OK10012VVT	2.10E-06
OK188GBSWT	Keowee 1 Control Switch 188GB Spurious Operation	7.00E-08 /H	192 H	See OK10015VVT	1.34E-05
OK188GCSWT	Keowee 1 Control Switch 188GC Spurious Operation	7.00E-08 /H	108 H	See OK10018VVT	7.56E-06
OK199K1RYD	Keowee 1 Relay 99K1 Fails To Operate On Demand	3.30E-05 /D	1 D	Needed if loss of press. sensed in Gov. supply hdr.	3.30E-05
OK199K1RYT	Keowee Unit 1 Relay 99K1 Spurious Operation	3.60E-07 /H	24 H	Needed if loss of press. sensed in Gov. supply hdr.	8.64E-06
OK199K2RYD	Keowee 1 Relay 99K2 Fails To Operate On Demand	3.30E-05 /D	1 D	Needed if loss of press. sensed in Gov. supply hdr.	3.30E-05
OK1AG01TKF	Air Receiver Tank 1AGTK-1 Fails	4.60E-07 /H	24 H	Rule 1: Gov. Oil Level High alarm	1.10E-05
OK1AG04RVT	Safety Relief Valve 1AG-4 Spurious Operation	5.60E-06 /H	24 H	Rule 1: Gov. Oil Level High alarm	1.34E-04
OK1AG05VVT	Manual Valve 1AG-5 Transfers Position	1.70E-08 /H	24 H	Rule 1: Gov. Oil Level High alarm	4.08E-07
OK1OG1CTRM	OG Pump 1C Train In Maintenance Or Testing				3.42E-03
OK1PRUNCOM	Common Cause Failure of Unit 1 OG Pumps to Run				1.12E-07

Table A.11-7

Governor Oil And Air System Reliability Data

Event Name	Description	Failure Rate[1]	Factor	Rationale For Factor[2]	Failure Probability
OK1PSTRCOM	Common Cause Failure of Unit 1 OG Pumps to Start				2.04E-05
OK1XA1DCLT	Low Voltage Circuit Breaker 1XA-1D Transfers Position	9.10E-07 /H	30 H	Rule 4	2.73E-05
OK1XA2ECLT	Low Voltage Circuit Breaker 1XA-2E Transfers Position	9.10E-07 /H	30 H	Rule 4	2.73E-05
OK1XA4DCLT	Low Voltage Circuit Breaker 1XA-4D Transfers Position	9.10E-07 /H	30 H	Rule 4	2.73E-05
OK20001PSC	Pressure Switch 2OGPS-1 Fails to Close (Normal Control Signal)	2.90E-06 /D	15 D	Factors for Unit 2 are the same as for Unit 1 since, for both units, the OG and AG systems are continually in service.	4.35E-05
OK20002PSC	Pressure Switch 2OGPS-2 Fails to Close	2.90E-06 /D	8 D		2.32E-05
OK20003PSC	Pressure Switch 2OGPS-3 Fails to Close	2.90E-06 /D	4 D		1.16E-05
OK20003RVT	Safety Relief Valve 2OG-3 Spurious Operation	5.60E-06 /H	24 H		1.34E-04
OK20003TKF	Unit 2 Governor Oil Pressure Tank Fails	4.60E-07 /H	24 H		1.10E-05
OK20004PSC	Pressure Switch 2OGPS-4 Fails to Close	2.90E-06 /D	1 D		2.90E-06
OK20007FVT	Float Valve 2OG-7 Transfers Closed	5.83E-06 /H	24 H		1.40E-04
OK20009VVT	Manual Valve 2OG-9 Transfers Closed	1.70E-08 /H	24 H		4.08E-07
OK20011CVO	Check Valve 2OG-11 Fails to Open	2.30E-06 /D	15 D		3.45E-05
OK20011CVT	Check Valve 2OG-11 Transfers Closed	1.30E-07 /H	0.75 H		9.75E-08
OK20012VVT	Manual Globe Valve 2OG-12 Transfers Closed	1.70E-08 /H	30 H		5.10E-07
OK20013RVT	Relief Valve 2OG-13 Spurious Operation	5.60E-06 /H	0.75 H		4.20E-06

Table A.11-7

Governor Oil And Air System Reliability Data

Event Name	Description	Failure Rate[1]	Factor	Rationale For Factor[2]	Failure Probability
OK20014CVO	Check Valve 2OG-14 Fails to Open	2.30E-06 /D	8 D	Factors for Unit 2 are the same as for Unit 1 since, for both units, the OG and AG systems are continually in service.	1.84E-05
OK20014CVT	Check Valve 2OG-14 Transfers Closed	1.30E-07 /H	0.5 H		6.50E-08
OK20015VVT	Manual Globe Valve 2OG-15 Transfers Closed	1.70E-08 /H	192 H		3.26E-06
OK20016RVT	Relief Valve 2OG-16 Transfers Open	5.60E-06 /H	0.5 H		2.80E-06
OK20017CVO	Check Valve 2OG-17 Fails to Open	2.30E-06 /D	4 D		9.20E-06
OK20017CVT	Check Valve 2OG-17 Transfers Closed	1.30E-07 /H	0.25 H		3.25E-08
OK20018VVT	Manual Globe Valve 2OG-18 Transfers Closed	1.70E-08 /H	108 H		1.84E-06
OK20019RVT	Relief Valve 2OG-19 Spurious Operation	5.60E-06 /H	0.25 H		1.40E-06
OK2002AGPR	OG Pump 2A Fails to Run	1.40E-05 /H	0.375 H		5.25E-06
OK2002AGPS	OG Pump 2A Fails to Start	9.70E-05 /D	15 D		1.45E-03
OK2002BGPR	OG Pump 2B Fails to Run	1.40E-05 /H	0.25 H		3.50E-06
OK2002BGPS	OG Pump 2B Fails to Start	9.70E-05 /D	8 D		7.76E-04
OK2002BLHE	Latent Human Error Fails OG Pump 2B				3.20E-03
OK2002CGPR	OG Pump 2C Fails to Run	1.40E-05 /H	0.125 H		1.75E-06
OK2002CGPS	OG Pump 2C Fails to Start	9.70E-05 /D	4 D		3.88E-04
OK2002CLHE	Latent Human Error Fails OG Pump 2C				3.20E-03
OK288GASWT	Keowee 2 Governor Oil Control Switch 188GA Spurious Operation	7.00E-08 /H	30 H		2.10E-06
OK288GBSWT	Keowee 2 Control Switch 188GB Spurious Operation	7.00E-08 /H	192 H		1.34E-05

Table A.11-7

Governor Oil And Air System Reliability Data

Event Name	Description	Failure Rate[1]	Factor	Rationale For Factor[2]	Failure Probability
OK288GCSWT	Keowee 2 Control Switch 188GC Spurious Operation	7.00E-08 /H	108 H	Factors for Unit 2 are the same as for Unit 1 since, for both units, the OG and AG systems are continually in service.	7.56E-06
OK299K1RYD	Keowee 2 Relay 99K1 Fails To Operate On Demand	3.30E-05 /D	1 D		3.30E-05
OK299K1RYT	Keowee Unit 2 Relay 99K1 Spurious Operation	3.60E-07 /H			8.64E-06
OK299K2RYD	Relay 99K2 Fails To Operate On Demand	3.30E-05 /D	1 D		3.30E-05
OK2AG04RVT	Safety Relief Valve 2AG-4 Spurious Operation	5.60E-06 /H	24 H		1.34E-04
OK2AG05VVT	Manual Valve 2AG-5 Transfers Position	1.70E-08 /H	24 H		4.08E-07
OK2AGO1TKF	Air Receiver Tank 2AGTK-1 Fails	4.60E-07 /H	24 H		1.10E-05
OK2OG2CTRM	OG Pump 2C Train In Maintenance Or Testing				3.42E-03
OK2PRUNCOM	Common Cause Failure of Unit 2 OG Pumps to Run				1.12E-07
OK2PSTRCOM	Common Cause Failure of Unit 2 OG Pumps to Start				2.04E-05
OK2XA1DCLT	Low Voltage Circuit Breaker 2XA-1D Transfers Position	9.10E-07 /H	30 H		2.73E-05
OK2XA2ECLT	Low Voltage Circuit Breaker 2XA-2E Transfers Position	9.10E-07 /H	30 H		2.73E-05
OK2XA4DCLT	Low Voltage Circuit Breaker 2XA-4D Transfers Position	9.10E-07 /H	30 H		2.73E-05

Table A.11-7

Governor Oil And Air System Reliability Data

Event Name	Description	Failure Rate[1]	Factor	Rationale For Factor[2]	Failure Probability
XD1DA3BCDT	125 Vdc Breaker 1DA-3BR Transfers Open	7.50E-08 /H	24 H	Rule 1: Loss of DC Supply Failure alarm	1.80E-06
XD2DA3BCDT	125 Vdc Breaker 2DA-3BR Transfers Open	7.50E-08 /H	24 H	Rule 1: Loss of DC Supply Failure alarm	1.80E-06

[1] D = Demand, H = Hour

[2] Rules for assigning basic event factors are discussed in Table C.1-4.

Table A.11-8

Governor Oil And Air System Dominant Minimal Cutsets

Cutsets For Gate OK1600: Keowee Unit 1 Governor Oil System Fails Keowee Run

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
1)	1.34E-04	43.1	OK10003RVT	1.34E-04	Safety Relief Valve 1OG-3 Spurious Operation
2)	1.34E-04	43.1	OK1AG04RVT	1.34E-04	Safety Relief Valve 1AG-4 Spurious Operation
3)	2.04E-05	6.6	OK1PSTRCOM	2.04E-05	Common Cause Failure of Unit 1 OG Pumps to Start
4)	1.10E-05	3.5	OK1AG01TKF	1.10E-05	Air Receiver Tank 1AGTK-1 Fails
5)	1.10E-05	3.5	OK10003TKF	1.10E-05	Unit 1 Governor Oil Pressure Tank Fails
6)	4.08E-07	0.1	OK1AG05VVT	4.08E-07	Manual Valve 1AG-5 Transfers Position
7)	2.03E-07	0.1	OK10007FVT OK1001AGPS	1.40E-04 1.45E-03	Float Valve 1OG-7 Transfers Closed OG Pump 1A Fails to Start
8)	1.12E-07	0.0	OK1PRUNCOM	1.12E-07	Common Cause Failure of Unit 1 OG Pumps to Run

Total: 3.11E-4

Table A.11-9

Governor Oil And Air System Dominant Contributors To Unavailability

Rank	Event Description	Mean Unavailability[1]	Approximate Unavailability Contribution[2]
1	OK10003RVT - Safety Relief Valve 1OG-3 Spurious Operation	1.34E-04	43.1%
2	OK1AG04RVT - Safety Relief Valve 1AG-4 Spurious Operation	1.34E-04	43.1%
3	OK1PSTRCOM - Common Cause Failure of Unit 1 OG Pumps to Start	2.04E-05	6.6%
4	OK1AG01TKF - Air Receiver Tank 1AGTK-1 Fails	1.10E-05	3.5%
5	OK10003TKF - Unit 1 Governor Oil Pressure Tank Fails	1.10E-05	3.5%

[1] Mean unavailability is defined as the summation of the values of all cut sets in which the event appears.

[2] The contribution to unavailability is calculated by dividing the mean unavailability by the overall system unavailability and then multiplying by 100 percent.

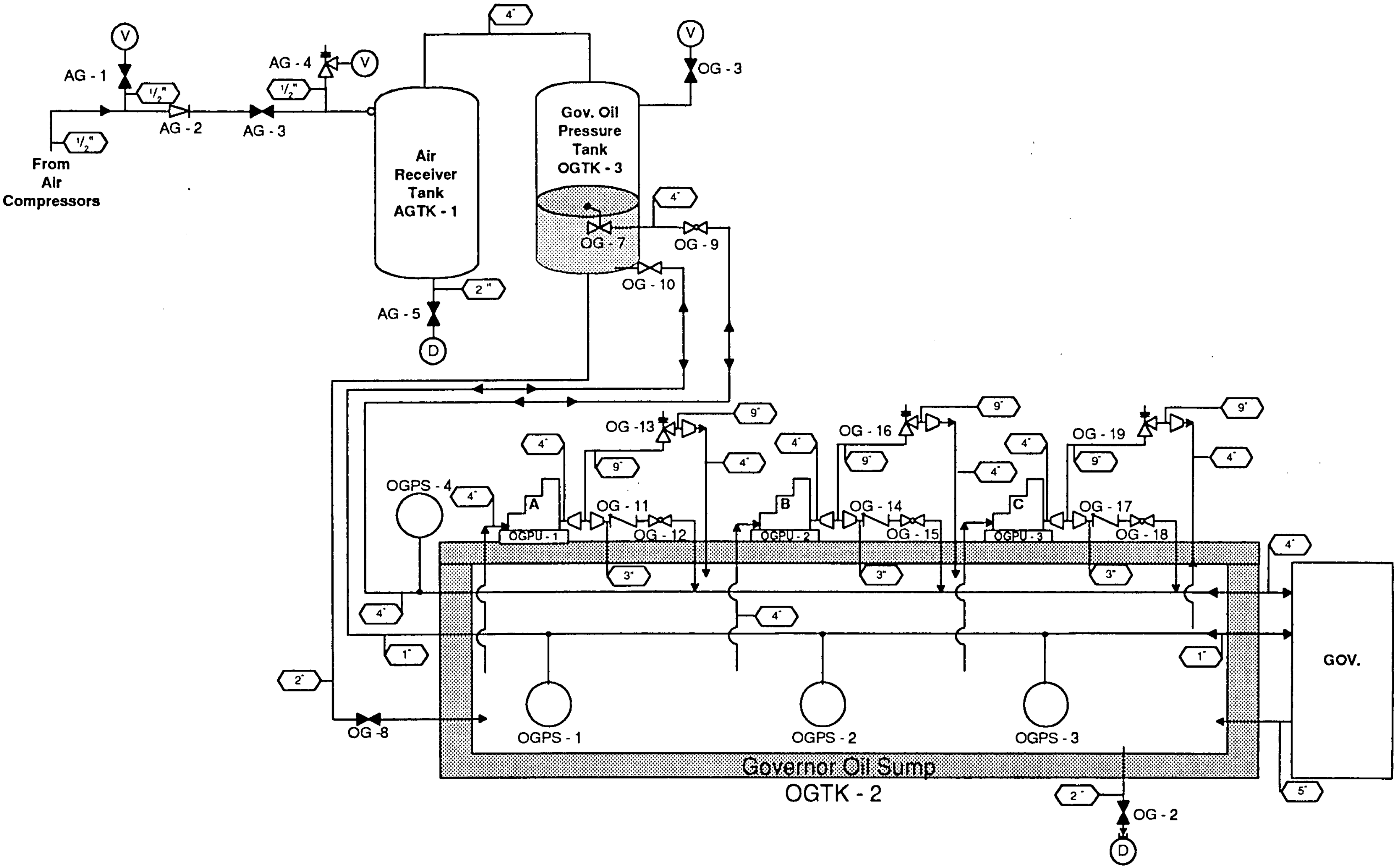
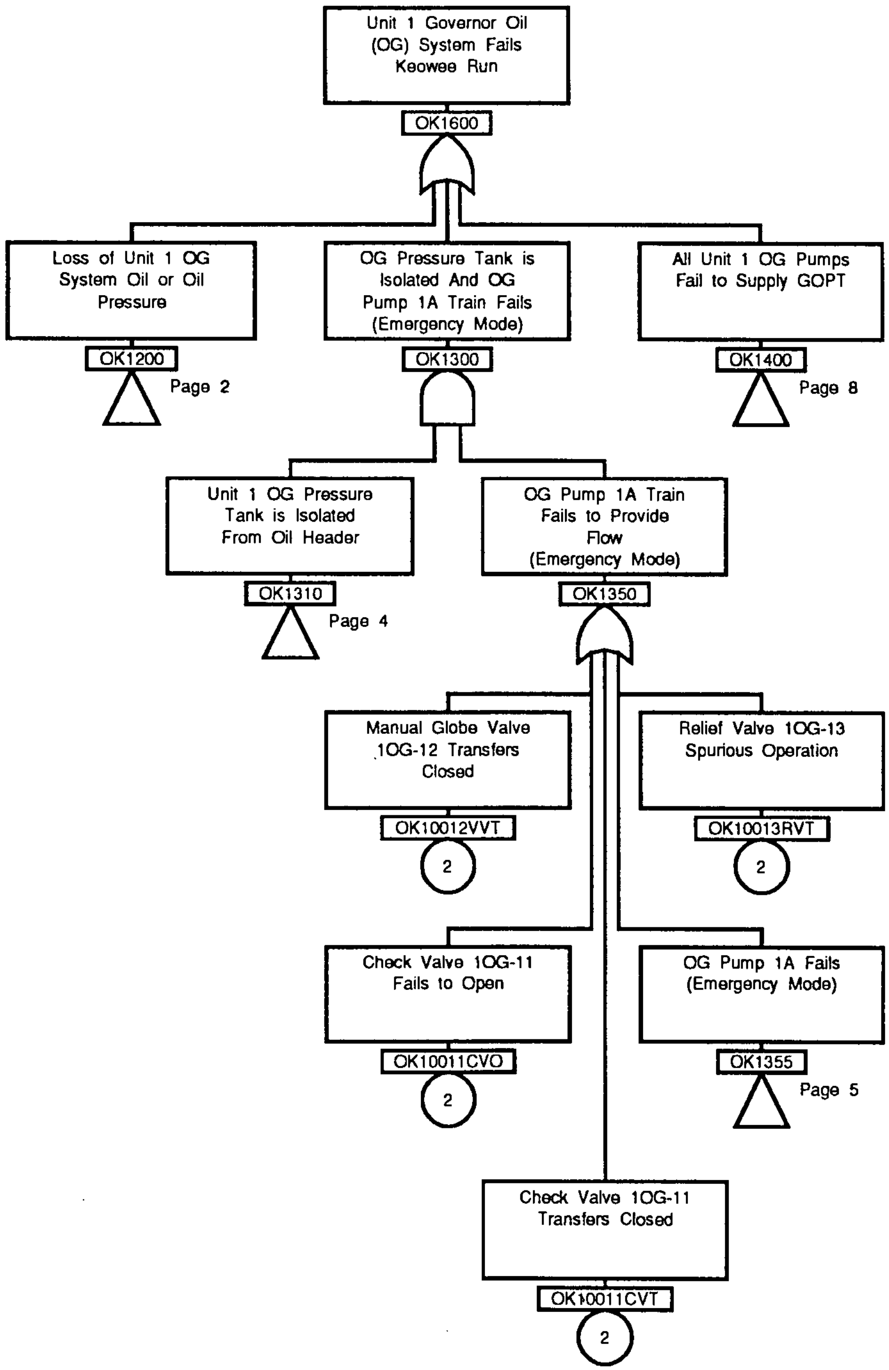
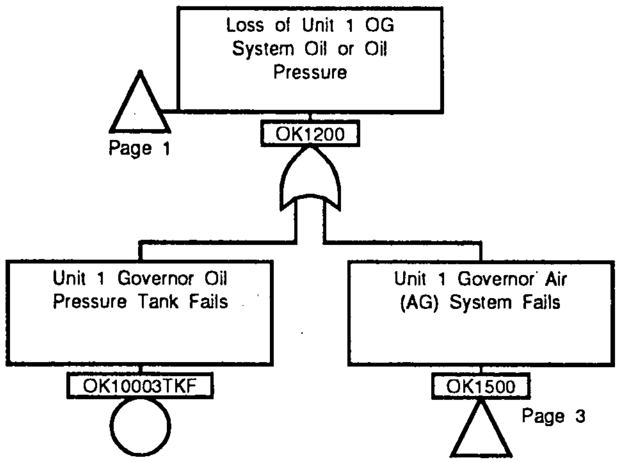


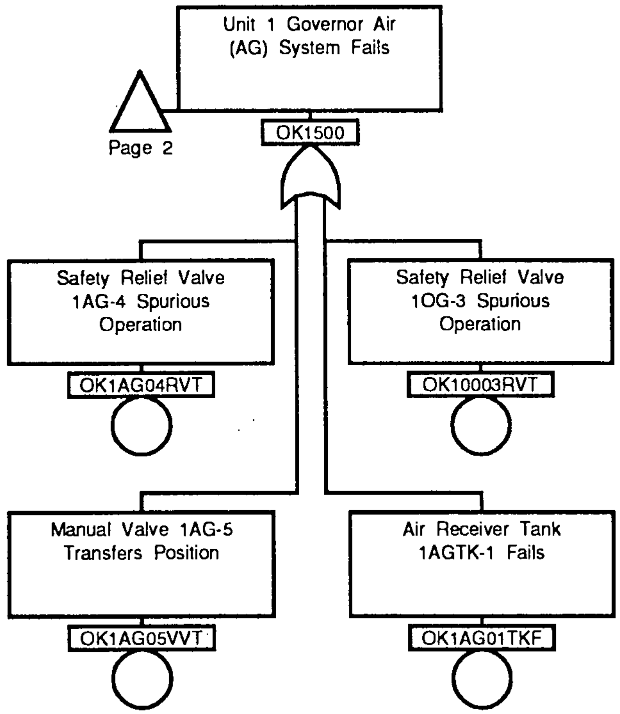
Figure A.11-1 Simplified Flow Diagram of the Governor Oil & Air System

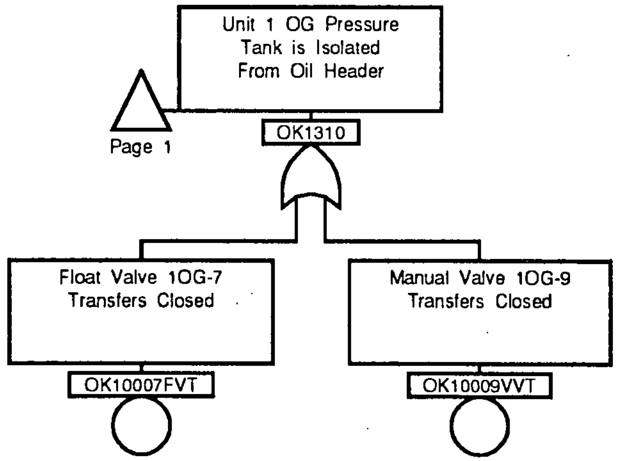


Governor Oil And Air System Fault Tree	FIGURE A.11-2	Page 1

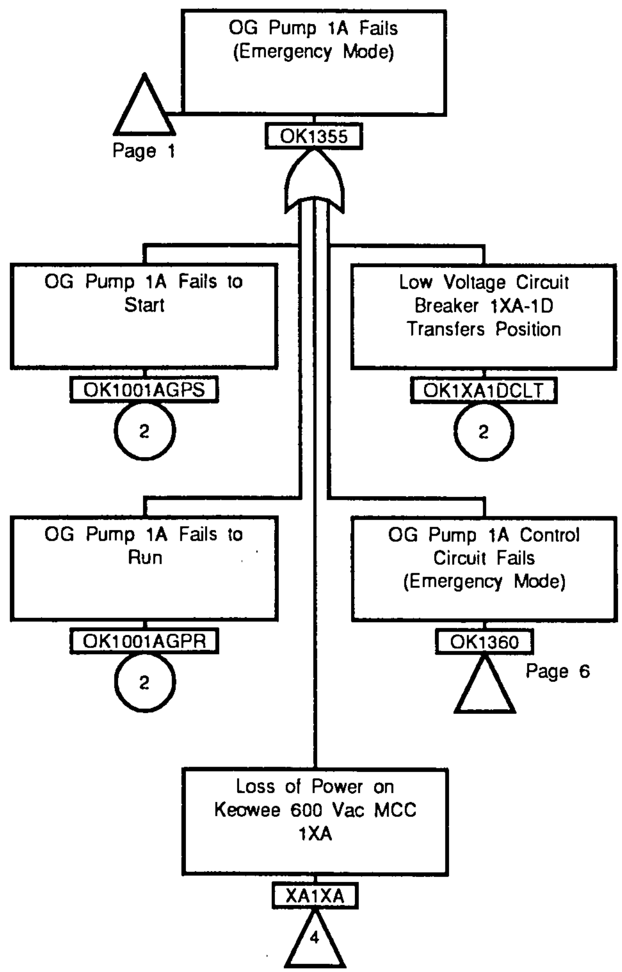


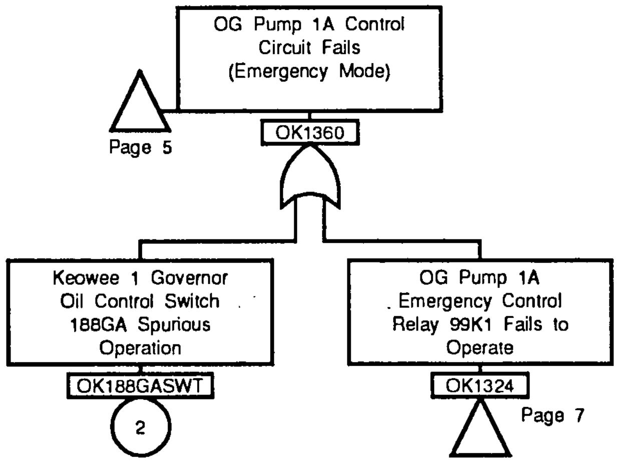
Governor Oil And Air System Fault Tree | FIGURE A.11-2 |

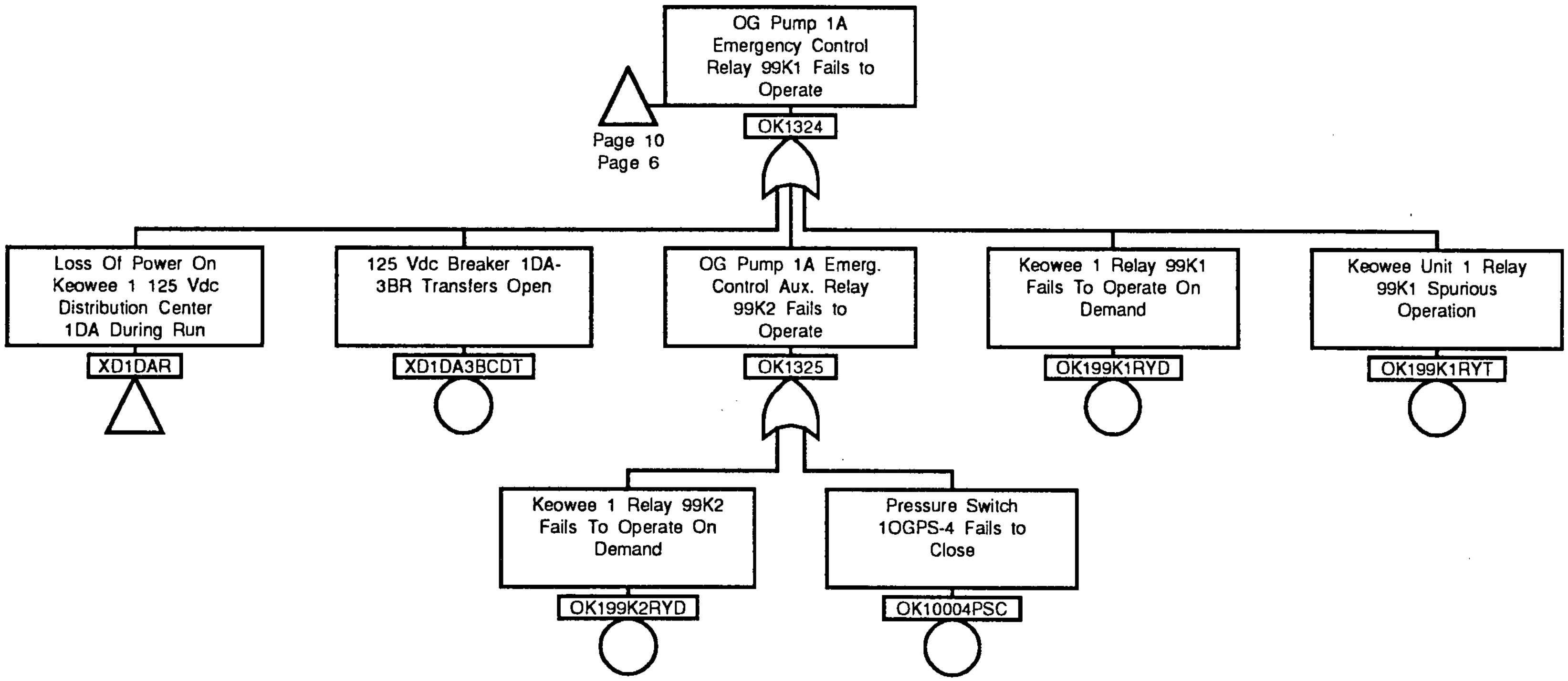

Unit 1 Governor Air (AG) System Fails
Page 2
OK1500
Safety Relief Valve 1AG-4 Spurious Operation
OK1AG04RVT
Safety Relief Valve 1OG-3 Spurious Operation
OK10003RVT
Manual Valve 1AG-5 Transfers Position
OK1AG05VVT
Air Receiver Tank 1AGTK-1 Fails
OK1AG01TKF

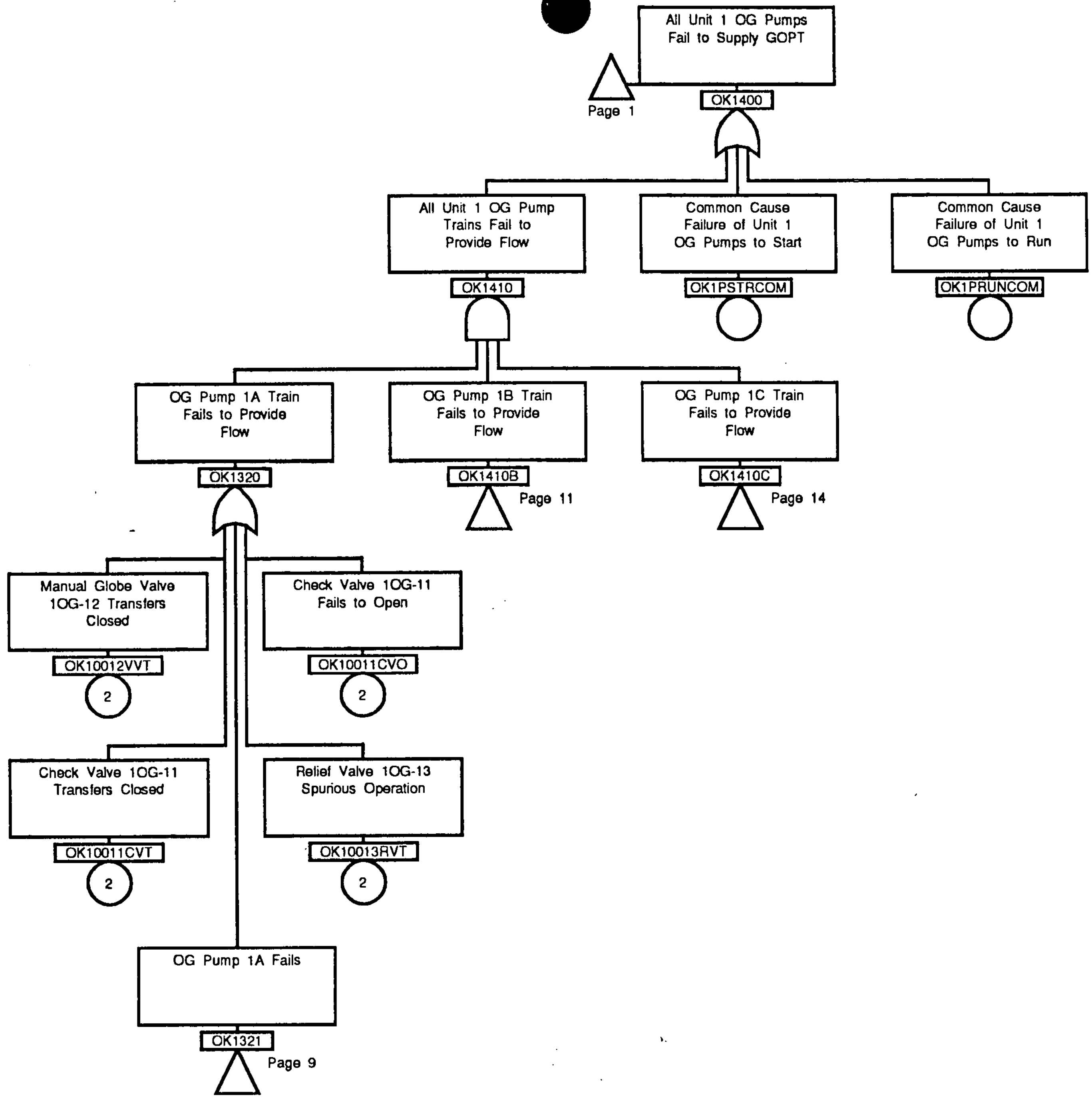


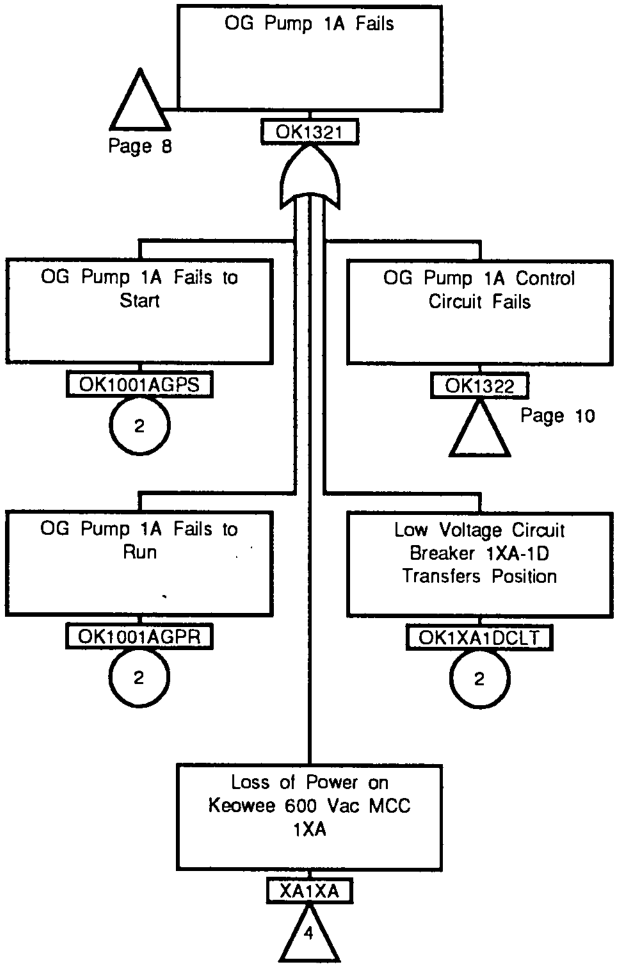
Governor Oil And Air System Fault Tree	FIGURE A.11-2	Page 4

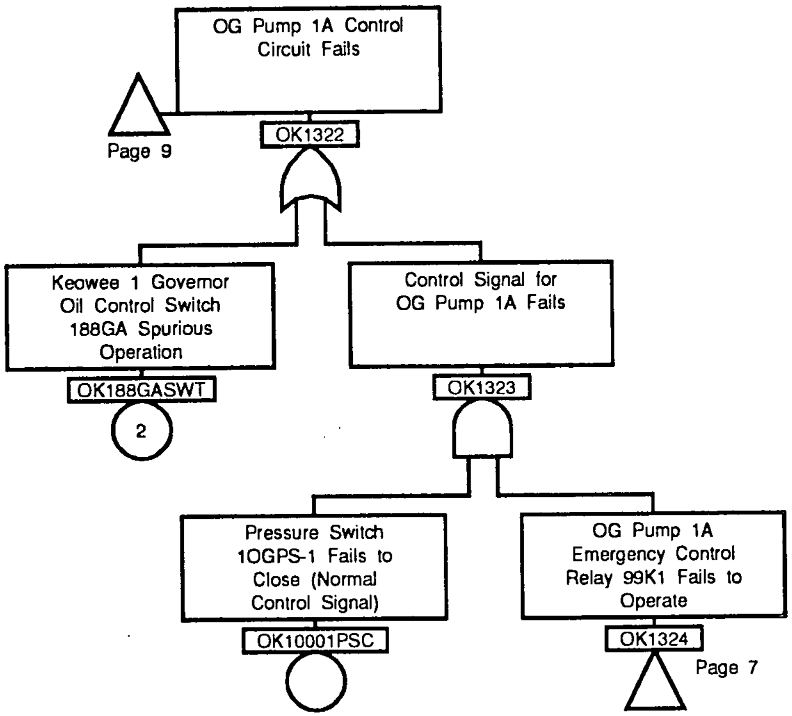

OG Pump 1A Fails (Emergency Mode)
OK1355
Page 1
OG Pump 1A Fails to Start
OK1001AGPS
2
Low Voltage Circuit Breaker 1XA-1D Transfers Position
OK1XA1DCLT
2
OG Pump 1A Fails to Run
OK1001AGPR
2
OG Pump 1A Control Circuit Fails (Emergency Mode)
OK1360
Page 6
Loss of Power on Keowee 600 Vac MCC 1XA
XA1XA
4

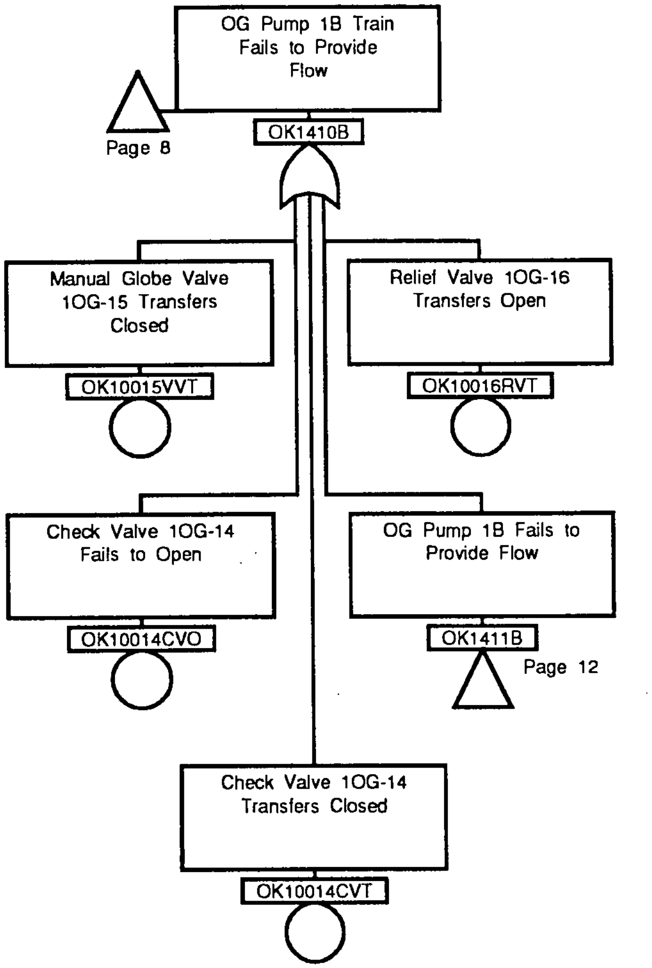

OG Pump 1A Control Circuit Fails (Emergency Mode)
Page 5
OK1360
Keowee 1 Governor Oil Control Switch 188GA Spurious Operation
OK188GASWT
2
OG Pump 1A Emergency Control Relay 99K1 Fails to Operate
OK1324
Page 7


OG Pump 1A Emergency Control Relay 99K1 Fails to Operate
OK1324
Page 10
Page 6
Loss Of Power On Keowee 1 125 Vdc Distribution Center 1DA During Run
XD1DAR
125 Vdc Breaker 1DA-3BR Transfers Open
XD1DA3BCDT
OG Pump 1A Emerg. Control Aux. Relay 99K2 Fails to Operate
OK1325
Keowee 1 Relay 99K1 Fails To Operate On Demand
OK199K1RYD
Keowee Unit 1 Relay 99K1 Spurious Operation
OK199K1RYT
Keowee 1 Relay 99K2 Fails To Operate On Demand
OK199K2RYD
Pressure Switch 1OGPS-4 Fails to Close
OK10004PSC

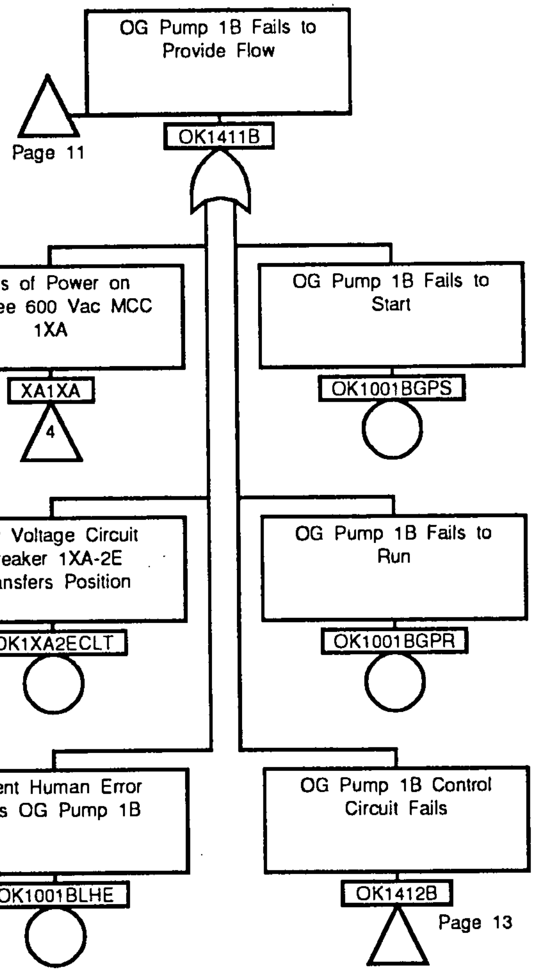

All Unit 1 OG Pumps Fail to Supply GOPT
Page 1
OK1400
All Unit 1 OG Pump Trains Fail to Provide Flow
OK1410
Common Cause Failure of Unit 1 OG Pumps to Start
OK1PSTRCOM
Common Cause Failure of Unit 1 OG Pumps to Run
OK1PRUNCOM
OG Pump 1A Train Fails to Provide Flow
OK1320
OG Pump 1B Train Fails to Provide Flow
OK1410B
Page 11
OG Pump 1C Train Fails to Provide Flow
OK1410C
Page 14
Manual Globe Valve 1OG-12 Transfers Closed
OK10012VVT
2
Check Valve 1OG-11 Fails to Open
OK10011CVO
2
Check Valve 1OG-11 Transfers Closed
OK10011CVT
2
Relief Valve 1OG-13 Spurious Operation
OK10013RVT
2
OG Pump 1A Fails
OK1321
Page 9


OG Pump 1A Fails
Page 8
OK1321
OG Pump 1A Fails to Start
OK1001AGPS
2
OG Pump 1A Control Circuit Fails
OK1322
Page 10
OG Pump 1A Fails to Run
OK1001AGPR
2
Low Voltage Circuit Breaker 1XA-1D Transfers Position
OK1XA1DCLT
2
Loss of Power on Keowee 600 Vac MCC 1XA
XA1XA
4

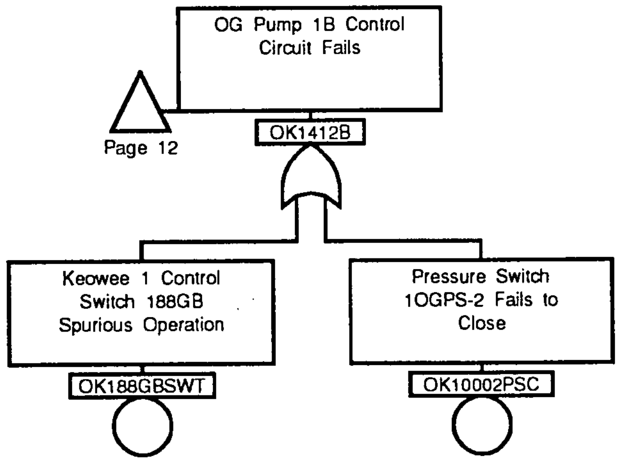

OG Pump 1A Control Circuit Fails
Page 9
OK1322
Keowee 1 Governor Oil Control Switch 188GA Spurious Operation
OK188GASWT
2
Control Signal for OG Pump 1A Fails
OK1323
Pressure Switch 1OGPS-1 Fails to Close (Normal Control Signal)
OK10001PSC
OG Pump 1A Emergency Control Relay 99K1 Fails to Operate
OK1324
Page 7



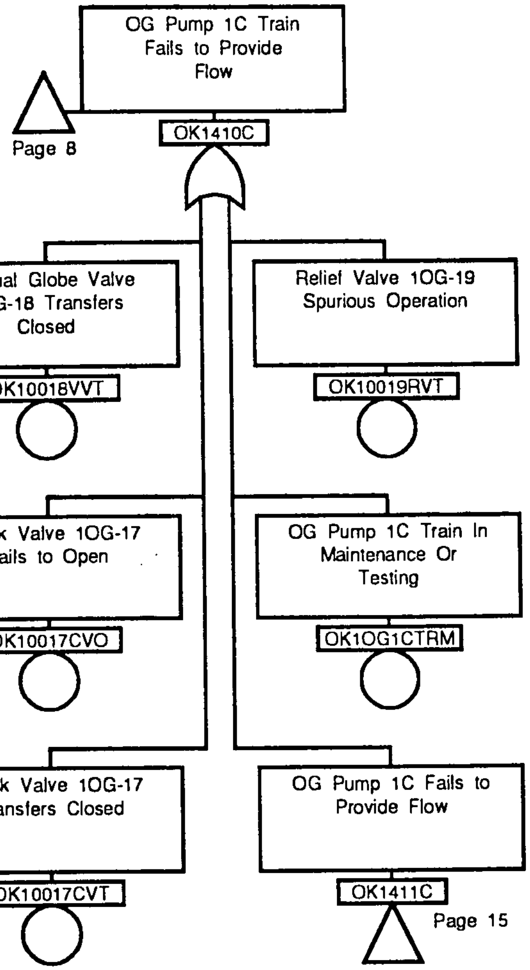
Governor Oil And Air System Fault ree	FIGURE A.11-2	Pa 11



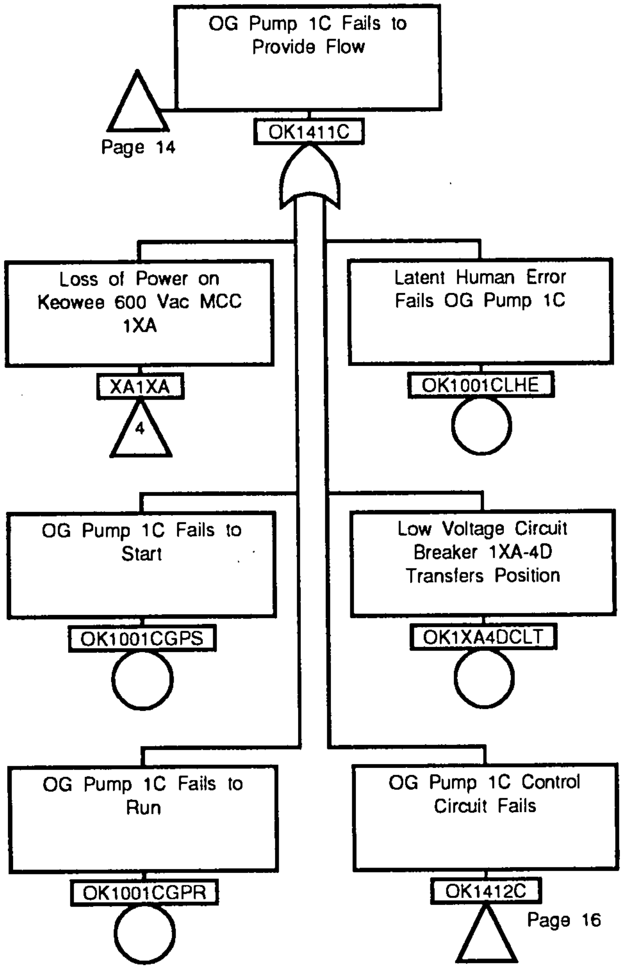
OG Pump 1B Fails to Provide Flow
OK1411B
Page 11
Loss of Power on Keowee 600 Vac MCC 1XA
XA1XA
4
OG Pump 1B Fails to Start
OK1001BGPS
Low Voltage Circuit Breaker 1XA-2E Transfers Position
OK1XA2ECLT
OG Pump 1B Fails to Run
OK1001BGPR
Latent Human Error Fails OG Pump 1B
OK1001BLHE
OG Pump 1B Control Circuit Fails
OK1412B
Page 13



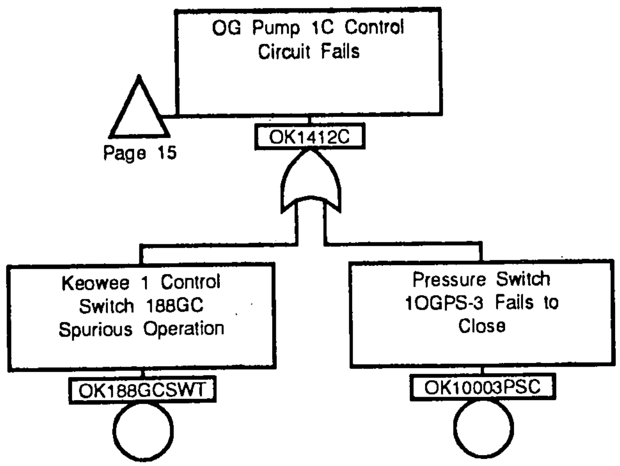
Governor Oil And Air System Fault Tree	FIGURE A.11-2	Page 13



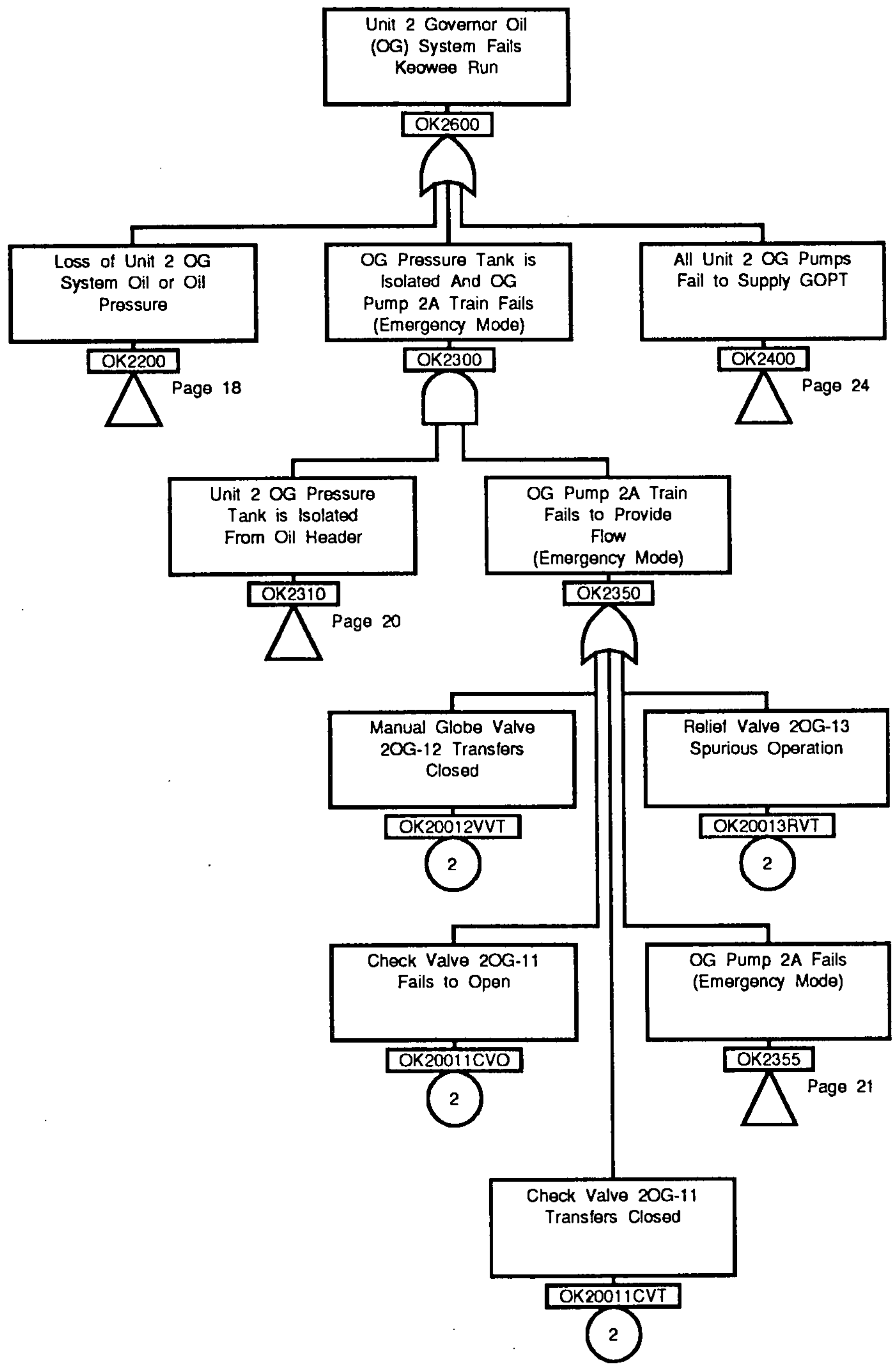
Governor Oil And Air System Fault Tree | FIGURE A.11-2 |



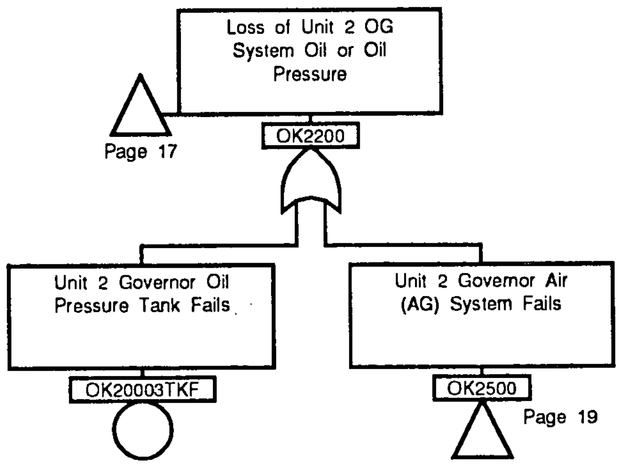
Governor Oil And Air System Fault Tree | FIGURE A.11-2 |



Governor Oil And Air System Fault Tree | FIGURE A.11-2 |

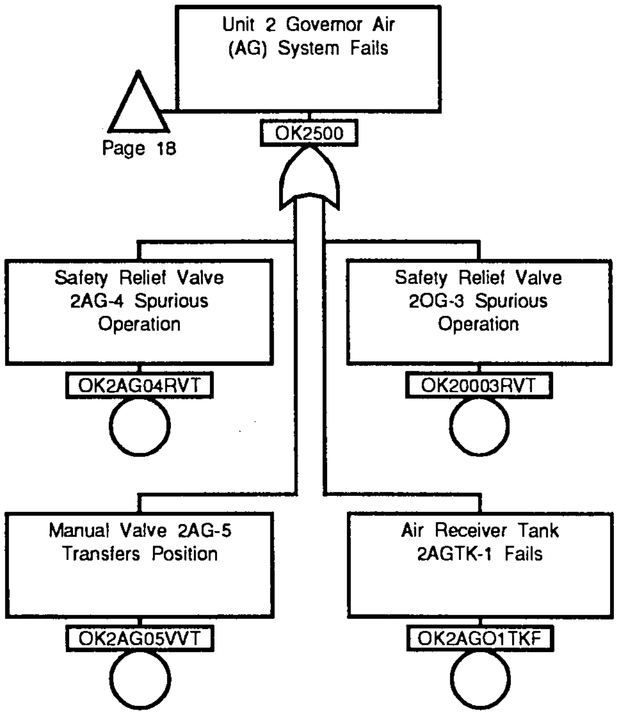


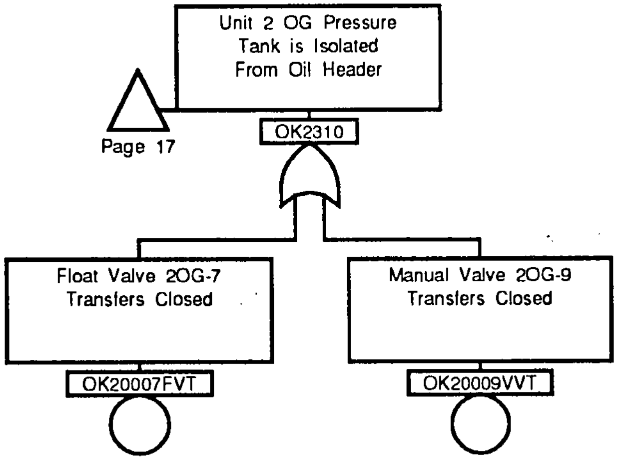
Governor Oil And Air System Fault Tree	FIGURE A.11-2	Page 17

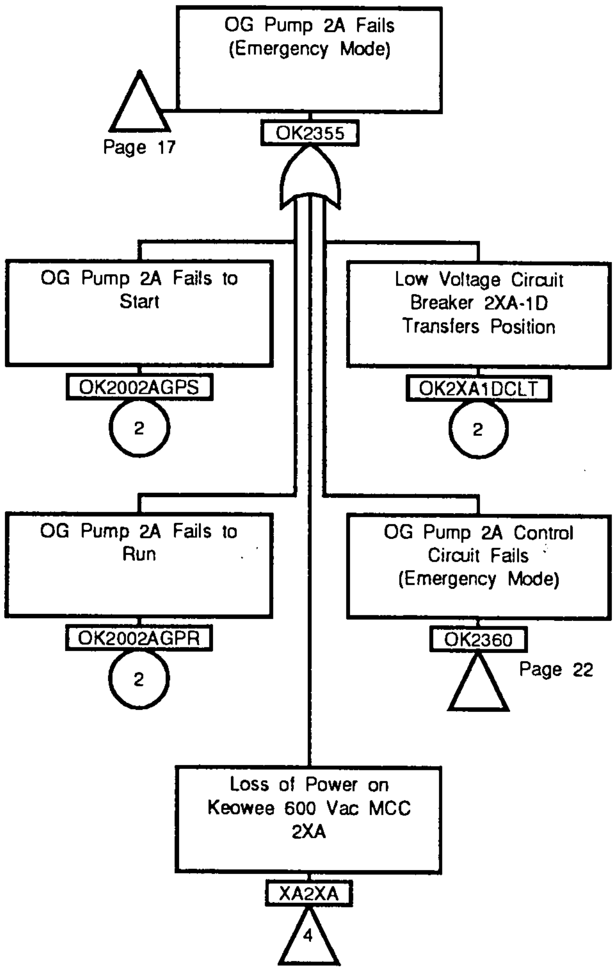


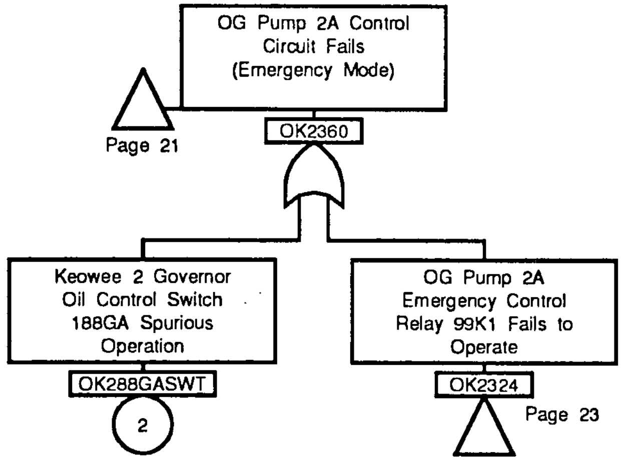
Governor Oil And Air System Fault Tree

FIGURE A.11-2

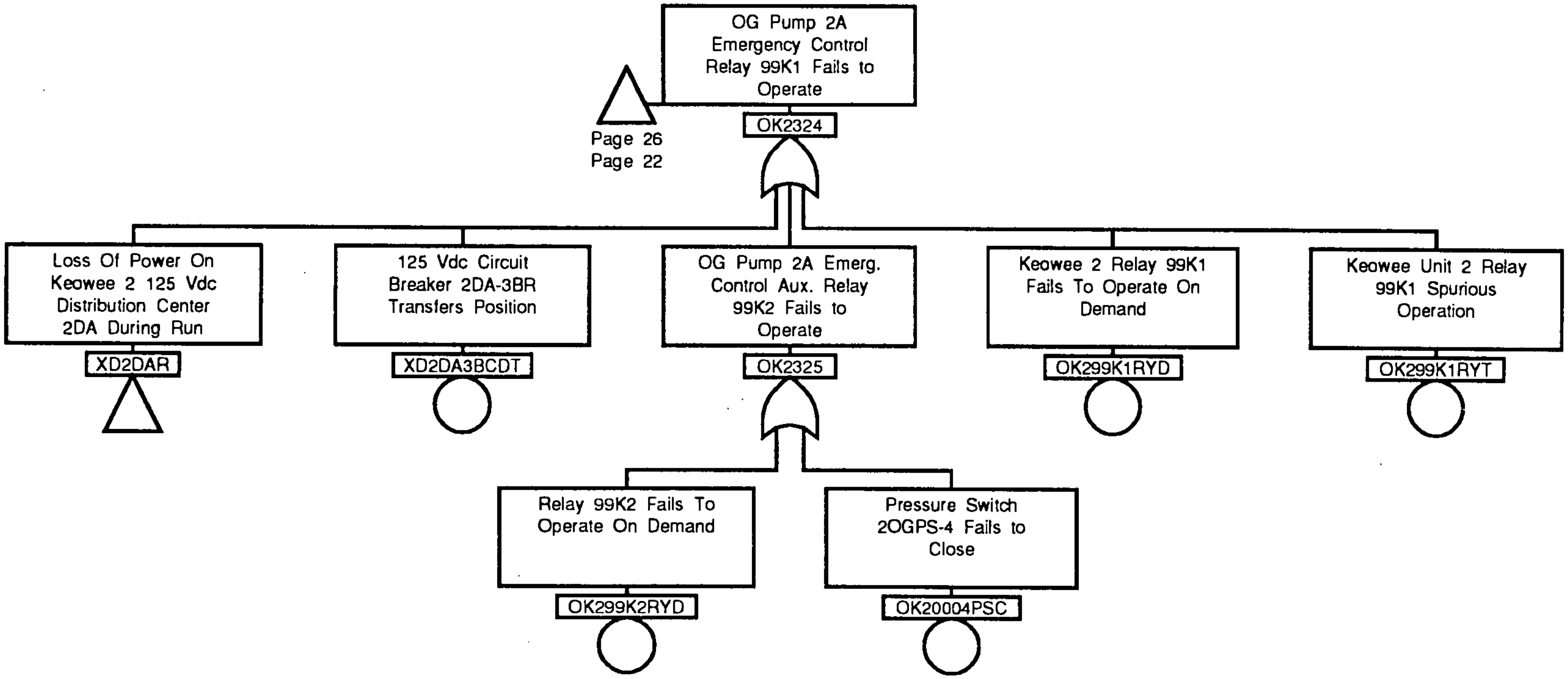

Unit 2 Governor Air (AG) System Fails
OK2500
Page 18
Safety Relief Valve 2AG-4 Spurious Operation
OK2AG04RVT
Safety Relief Valve 2OG-3 Spurious Operation
OK20003RVT
Manual Valve 2AG-5 Transfers Position
OK2AG05VVT
Air Receiver Tank 2AGTK-1 Fails
OK2AGO1TKF


Unit 2 OG Pressure Tank is Isolated From Oil Header
OK2310
Page 17
Float Valve 2OG-7 Transfers Closed
OK20007FVT
Manual Valve 2OG-9 Transfers Closed
OK20009VVT

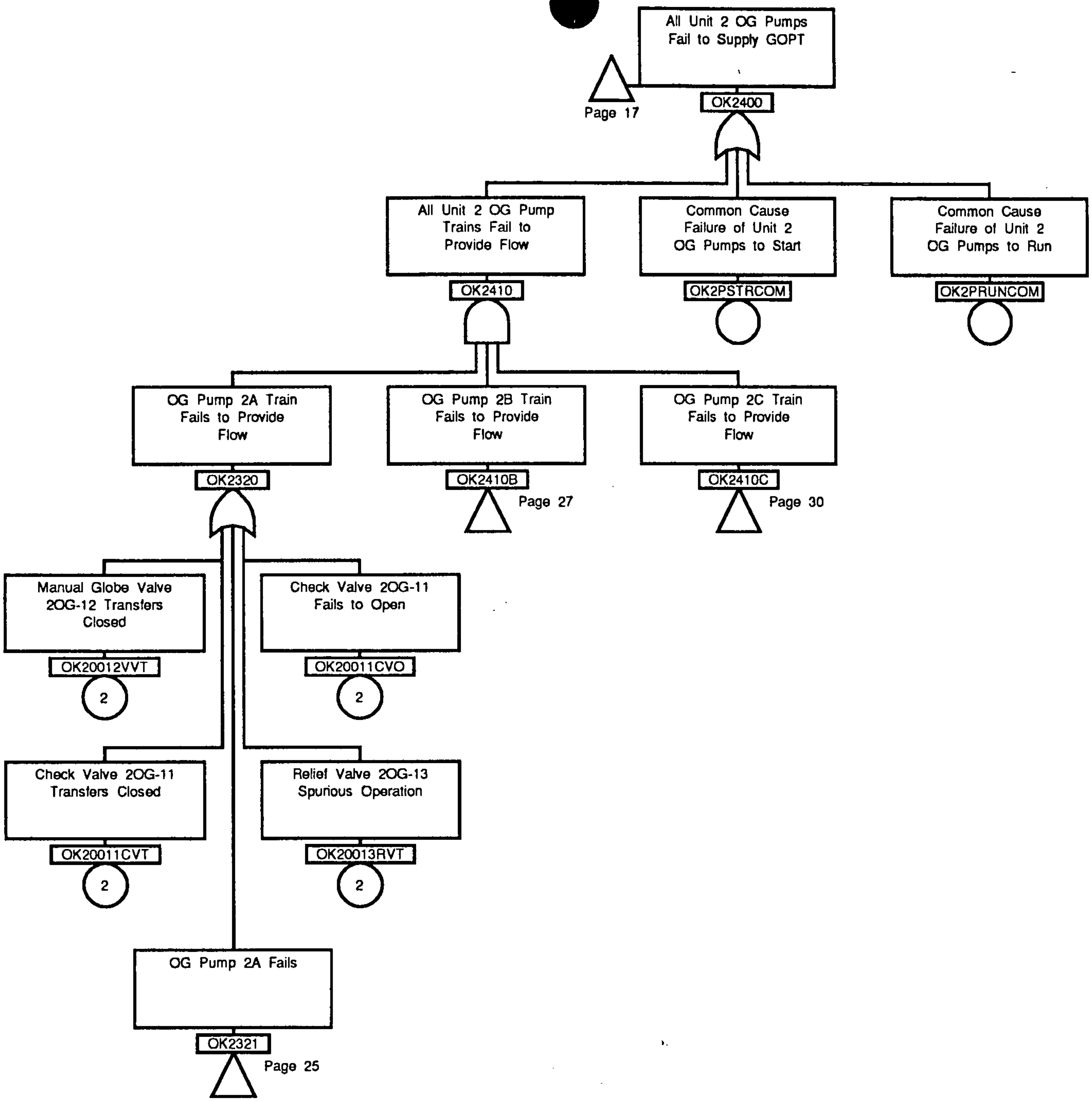

OG Pump 2A Fails (Emergency Mode)
OK2355
Page 17
OG Pump 2A Fails to Start
OK2002AGPS
2
Low Voltage Circuit Breaker 2XA-1D Transfers Position
OK2XA1DCLT
2
OG Pump 2A Fails to Run
OK2002AGPR
2
OG Pump 2A Control Circuit Fails (Emergency Mode)
OK2360
Page 22
Loss of Power on Keowee 600 Vac MCC 2XA
XA2XA
4



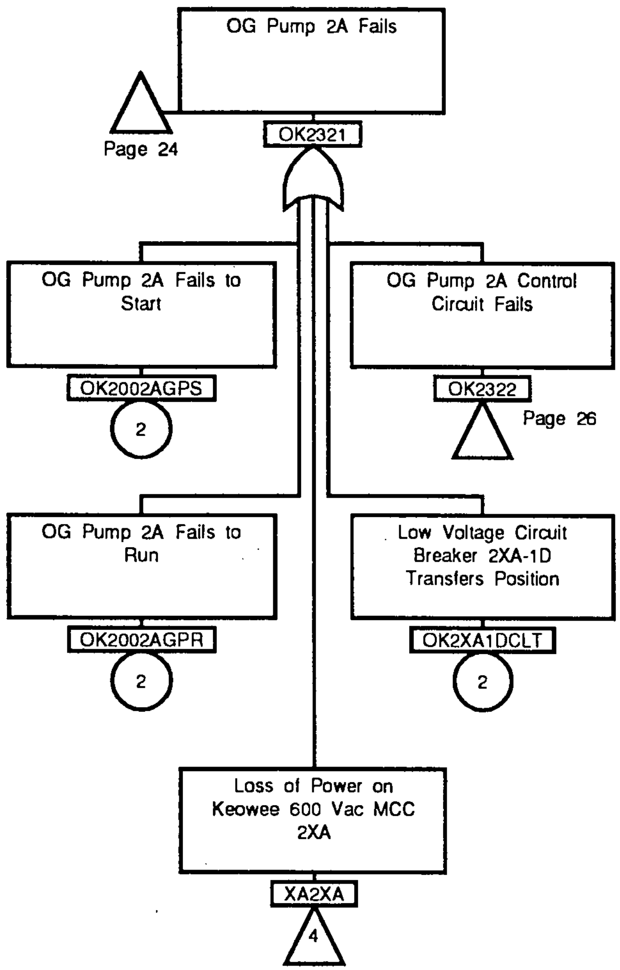
OG Pump 2A Control
Circuit Fails
(Emergency Mode)
OK2360
Page 21
Keowee 2 Governor
Oil Control Switch
188GA Spurious
Operation
OK288GASWT
2
OG Pump 2A
Emergency Control
Relay 99K1 Fails to
Operate
OK2324
Page 23

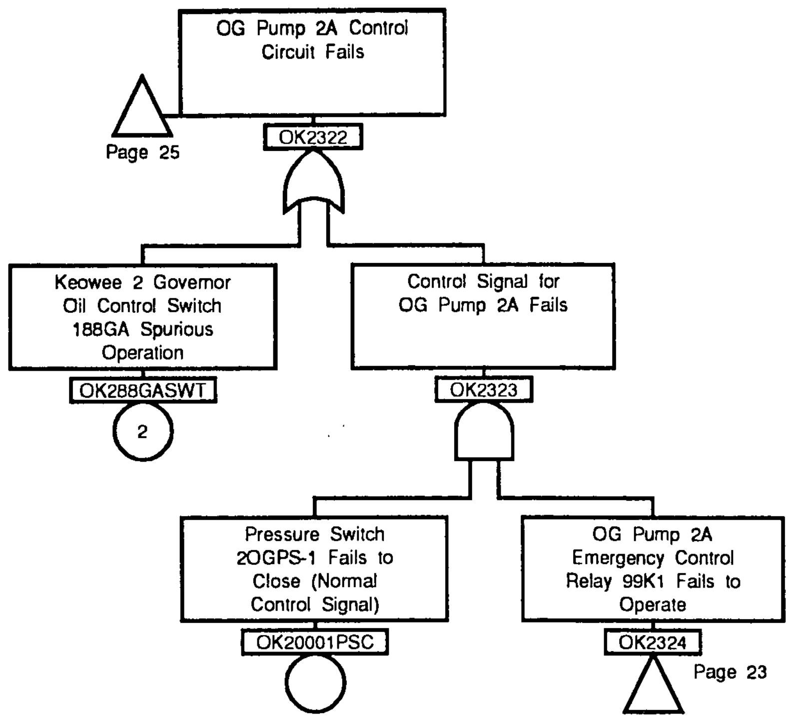


OG Pump 2A Emergency Control Relay 99K1 Fails to Operate
OK2324
Page 26
Page 22
Loss Of Power On Keowee 2 125 Vdc Distribution Center 2DA During Run
XD2DAR
125 Vdc Circuit Breaker 2DA-3BR Transfers Position
XD2DA3BCDT
OG Pump 2A Emerg. Control Aux. Relay 99K2 Fails to Operate
OK2325
Keowee 2 Relay 99K1 Fails To Operate On Demand
OK299K1RYD
Keowee Unit 2 Relay 99K1 Spurious Operation
OK299K1RYT
Relay 99K2 Fails To Operate On Demand
OK299K2RYD
Pressure Switch 2OGPS-4 Fails to Close
OK20004PSC

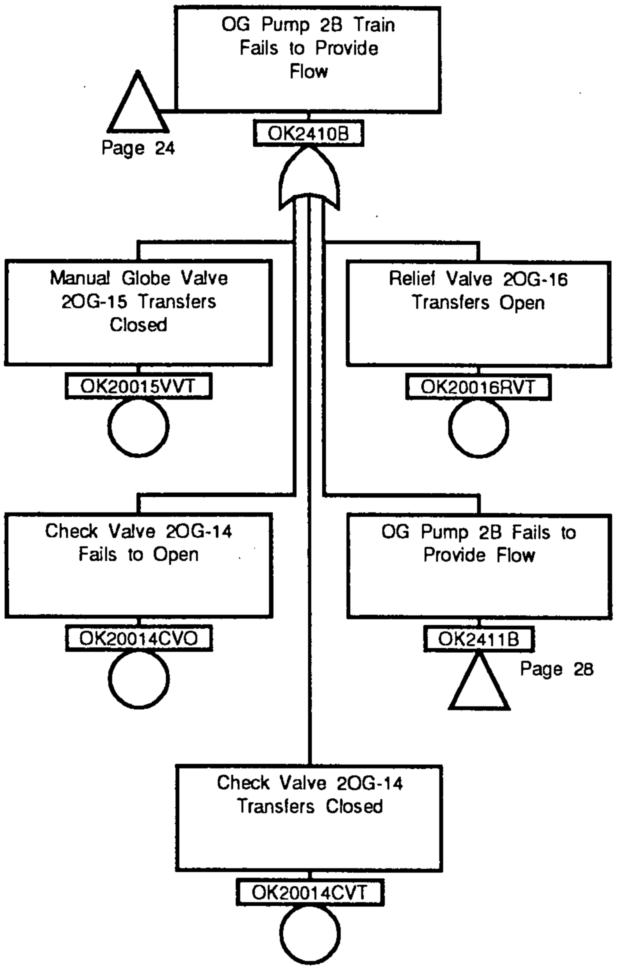


All Unit 2 OG Pumps Fail to Supply GOPT
OK2400
Page 17
All Unit 2 OG Pump Trains Fail to Provide Flow
OK2410
Common Cause Failure of Unit 2 OG Pumps to Start
OK2PSTRCOM
Common Cause Failure of Unit 2 OG Pumps to Run
OK2PRUNCOM
OG Pump 2A Train Fails to Provide Flow
OK2320
OG Pump 2B Train Fails to Provide Flow
OK2410B
Page 27
OG Pump 2C Train Fails to Provide Flow
OK2410C
Page 30
Manual Globe Valve 2OG-12 Transfers Closed
OK20012VVT
2
Check Valve 2OG-11 Fails to Open
OK20011CVO
2
Check Valve 2OG-11 Transfers Closed
OK20011CVT
2
Relief Valve 2OG-13 Spurious Operation
OK20013RVT
2
OG Pump 2A Fails
OK2321
Page 25

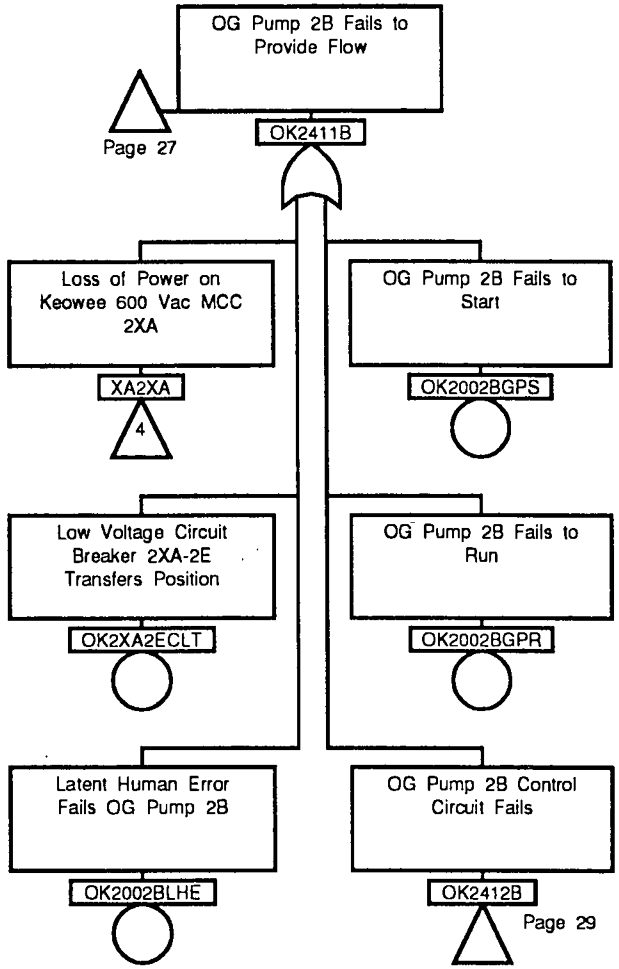

OG Pump 2A Fails
Page 24
OK2321
OG Pump 2A Fails to Start
OK2002AGPS
2
OG Pump 2A Control Circuit Fails
OK2322
Page 26
OG Pump 2A Fails to Run
OK2002AGPR
2
Low Voltage Circuit Breaker 2XA-1D Transfers Position
OK2XA1DCLT
2
Loss of Power on Keowee 600 Vac MCC 2XA
XA2XA
4



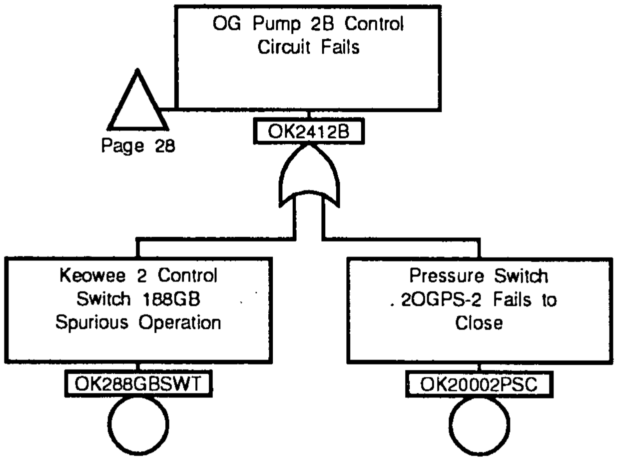
Governor Oil And Air System Fault Tree | FIGURE A.11-2 |

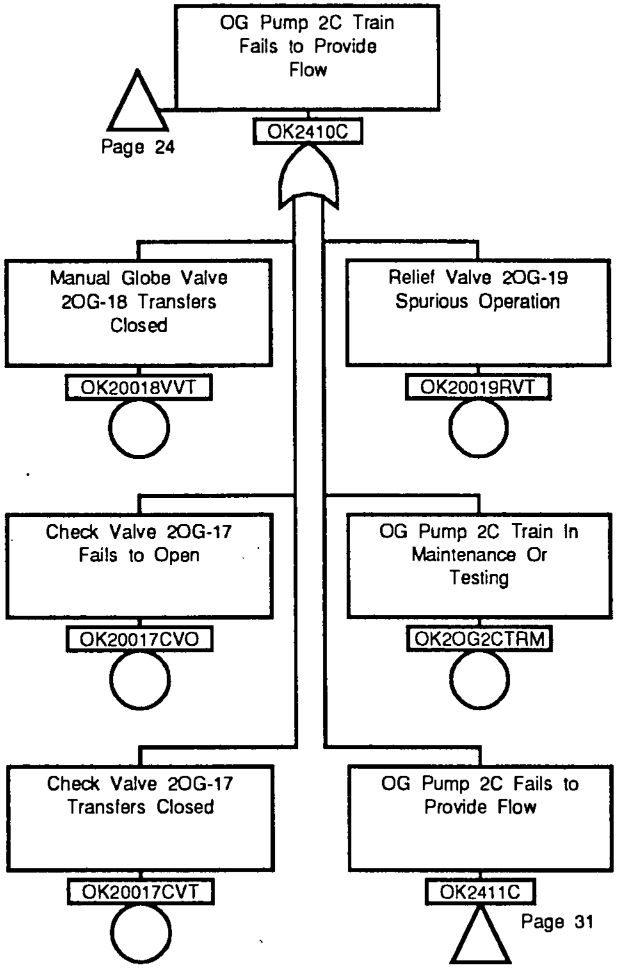


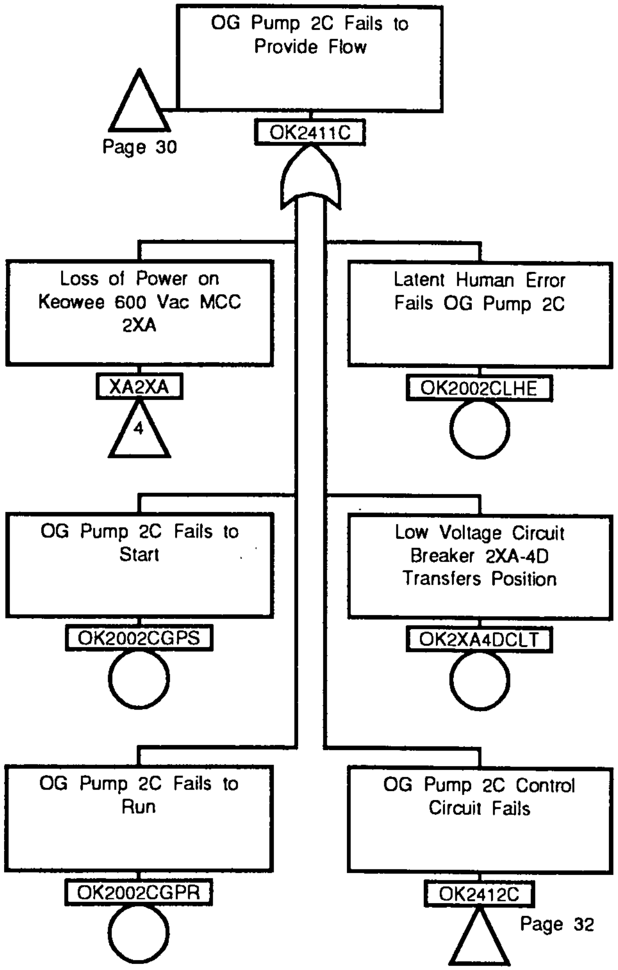
OG Pump 2B Train Fails to Provide Flow
OK2410B
Page 24
Manual Globe Valve 2OG-15 Transfers Closed
OK20015VVT
Relief Valve 2OG-16 Transfers Open
OK20016RVT
Check Valve 2OG-14 Fails to Open
OK20014CVO
OG Pump 2B Fails to Provide Flow
OK2411B
Page 28
Check Valve 2OG-14 Transfers Closed
OK20014CVT

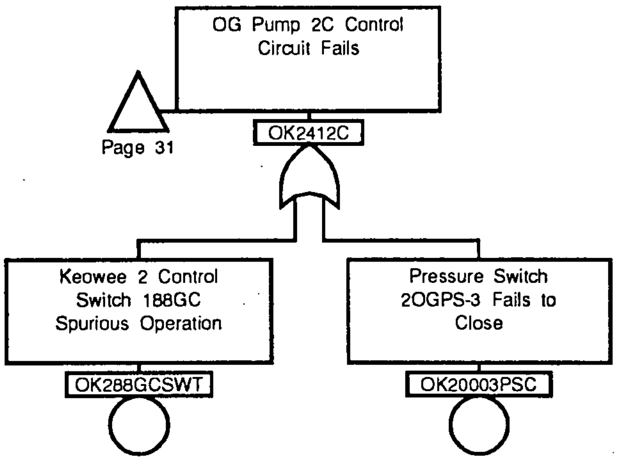


Governor Oil And Air System Fault Tree	FIGURE A.11-2	Page 28


OG Pump 2B Control Circuit Fails
OK2412B
Page 28
Keowee 2 Control Switch 188GB Spurious Operation
OK288GBSWT
Pressure Switch 2OGPS-2 Fails to Close
OK20002PSC


OG Pump 2C Train Fails to Provide Flow
OK2410C
Page 24
Manual Globe Valve 2OG-18 Transfers Closed
OK20018VVT
Relief Valve 2OG-19 Spurious Operation
OK20019RVT
Check Valve 2OG-17 Fails to Open
OK20017CVO
OG Pump 2C Train In Maintenance Or Testing
OK2OG2CTRM
Check Valve 2OG-17 Transfers Closed
OK20017CVT
OG Pump 2C Fails to Provide Flow
OK2411C
Page 31


OG Pump 2C Fails to Provide Flow
Page 30
OK2411C
Loss of Power on Keowee 600 Vac MCC 2XA
XA2XA
4
Latent Human Error Fails OG Pump 2C
OK2002CLHE
OG Pump 2C Fails to Start
OK2002CGPS
Low Voltage Circuit Breaker 2XA-4D Transfers Position
OK2XA4DCLT
OG Pump 2C Fails to Run
OK2002CGPR
OG Pump 2C Control Circuit Fails
OK2412C
Page 32


OG Pump 2C Control Circuit Fails
OK2412C
Page 31
Keowee 2 Control Switch 188GC Spurious Operation
OK288GCSWT
Pressure Switch 2OGPS-3 Fails to Close
OK20003PSC

Gate/Event Name	Page	Zone	Gate/Event Name	Page	Zone	Gate/Event Name	Page	Zone	Gate/Event Name	Page	Zone
OK10001PSC	10		OK1310	4		OK199K1RYD	7		OK2002AGPR	25	
OK10002PSC	13		OK1320	8		OK199K1RYT	7		OK2002AGPS	21	
OK10003PSC	16		OK1321	8		OK199K2RYD	7		OK2002AGPS	25	
OK10003RVT	3		OK1321	9		OK1AG01TKF	3		OK2002BGPR	28	
OK10003TKF	2		OK1322	9		OK1AG04RVT	3		OK2002BGPS	28	
OK10004PSC	7		OK1322	10		OK1AG05VVT	3		OK2002BLHE	28	
OK10007FVT	4		OK1323	10		OK1OG1CTRM	14		OK2002CGPR	31	
OK10009VVT	4		OK1324	6		OK1PRUNCOM	8		OK2002CGPS	31	
OK10011CVO	1		OK1324	7		OK1PSTRCOM	8		OK2002CLHE	31	
OK10011CVO	8		OK1324	10		OK1XA1DCLT	5		OK2200	17	
OK10011CVT	1		OK1325	7		OK1XA1DCLT	9		OK2200	18	
OK10011CVT	8		OK1350	1		OK1XA2ECLT	12		OK2300	17	
OK10012VVT	1		OK1355	1		OK1XA4DCLT	15		OK2310	17	
OK10012VVT	8		OK1355	5		OK20001PSC	26		OK2310	20	
OK10013RVT	1		OK1360	5		OK20002PSC	29		OK2320	24	
OK10013RVT	8		OK1360	6		OK20003PSC	32		OK2321	24	
OK10014CVO	11		OK1400	1		OK20003RVT	19		OK2321	25	
OK10014CVT	11		OK1400	8		OK20003TKF	18		OK2322	25	
OK10015VVT	11		OK1410	8		OK20004PSC	23		OK2322	26	
OK10016RVT	11		OK1410B	8		OK20007FVT	20		OK2323	26	
OK10017CVO	14		OK1410B	11		OK20009VVT	20		OK2324	22	
OK10017CVT	14		OK1410C	8		OK20011CVO	17		OK2324	23	
OK10018VVT	14		OK1410C	14		OK20011CVO	24		OK2324	26	
OK10019RVT	14		OK1411B	11		OK20011CVT	17		OK2325	23	
OK1001AGPR	5		OK1411B	12		OK20011CVT	24		OK2350	17	
OK1001AGPR	9		OK1411C	14		OK20012VVT	17		OK2355	17	
OK1001AGPS	5		OK1411C	15		OK20012VVT	24		OK2355	21	
OK1001AGPS	9		OK1412B	12		OK20013RVT	17		OK2360	21	
OK1001BGPR	12		OK1412B	13		OK20013RVT	24		OK2360	22	
OK1001BGPS	12		OK1412C	15		OK20014CVO	27		OK2400	17	
OK1001BLHE	12		OK1412C	16		OK20014CVT	27		OK2400	24	
OK1001CGPR	15		OK1500	2		OK20015VVT	27		OK2410	24	
OK1001CGPS	15		OK1500	3		OK20016RVT	27		OK2410B	24	
OK1001CLHE	15		OK1600	1		OK20017CVO	30		OK2410B	27	
OK1200	1		OK188GASWT	6		OK20017CVT	30		OK2410C	24	
OK1200	2		OK188GASWT	10		OK20018VVT	30		OK2410C	30	
OK1300	1		OK188GBSWT	13		OK20019RVT	30		OK2411B	27	
OK1310	1		OK188GCSWT	16		OK2002AGPR	21		OK2411B	28	

Gate/Event Name	Page	Zone	Gate/Event Name	Page	Zone	Gate/Event Name	Page	Zone	Gate/Event Name	Page	Zone
OK2411C	30										
OK2411C	31										
OK2412B	28										
OK2412B	29										
OK2412C	31										
OK2412C	32										
OK2500	18										
OK2500	19										
OK2600	17										
OK288GASWT	22										
OK288GASWT	26										
OK288GBSWT	29										
OK288GCSWT	32										
OK299K1RYD	23										
OK299K1RYT	23										
OK299K2RYD	23										
OK2AG04RVT	19										
OK2AG05VVT	19										
OK2AGO1TKF	19										
OK2OG2CTRM	30										
OK2PRUNCOM	24										
OK2PSTRCOM	24										
OK2XA1DCLT	21										
OK2XA1DCLT	25										
OK2XA2ECLT	28										
OK2XA4DCLT	31										
XA1XA	5										
XA1XA	9										
XA1XA	12										
XA1XA	15										
XA2XA	21										
XA2XA	25										
XA2XA	28										
XA2XA	31										
XD1DA3BCDT	7										
XD1DAR	7										
XD2DA3BCDT	23										
XD2DAR	23										

APPENDIX A.12
TURBINE GUIDE BEARING OIL SYSTEM

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A.12 TURBINE GUIDE BEARING OIL (GBO) SYSTEM

A.12.1 OBJECTIVES

The main objective of this analysis is to develop a logic model of the Turbine Guide Bearing Oil (GBO) System. This model is combined with the high-level model and remaining system models to form an integrated model for assessing the reliability of Keowee. Other objectives are to identify major contributors to system unreliability, significant potential human errors and common cause failure modes.

The scope of this analysis is limited to GBO equipment required to support a Keowee emergency start and load run. The analysis assumes a loss of offsite power has occurred, so that Keowee Auxiliary AC Power is not available during the start.

A.12.2 SYSTEM DESIGN

The function of the Turbine Guide Bearing Oil system is to provide lubrication and cooling to the turbine guide bearing.

Oil in the system is recirculated continuously, during unit operation and shutdown conditions. As shown in Figure A.12-1, the GBO system contains an ac pump, which runs continuously, and a standby dc pump. Both pumps are capable of taking suction from the Lower Oil Reservoir (LOR), pumping through the Turbine Guide Bearing Oil Cooler and filter, to the Upper Oil Reservoir (UOR). The oil then gravity flows through the bearing along grooves in the babbitt lining. The dc pump is actuated automatically if (1) the ac pump is turned off or loses power, or (2) oil level in the UOR drops to 5.5".

Two overflow lines are provided from the UOR to the LOR to prevent overfilling the UOR.

The GBO system is equipped to alarm on low oil level in the UOR, high turbine bearing temperature, ac pump failure, and loss of supply power to the dc pump.

System success requires that the ac or the dc pump train supply the UOR.

The Turbine Guide Bearing Oil Cooler is not required to be operable for a 24 hr mission time.

A.12.3 SYSTEM BOUNDARIES

Cooling Water System

Cooling water to the Turbine Guide Bearing Oil Cooler is provided by the Cooling Water (WL) System.

Electrical Power Supplies

The Keowee Auxiliary Power AC System provides power to the Unit 1 and 2 GBO ac pumps via 600 V ac motor control centers 1XA and 2XA, respectively. The Keowee Auxiliary Power DC System provides power to the Unit 1 and 2 GBO dc pumps and their control relays from 125 V dc distribution centers 1DA and 2DA, respectively. The power supplies for the modeled components are listed in Table A.12-1.

A.12.4 INSTRUMENTATION AND CONTROLS

Control switches for the ac and dc GBO pumps are located on Electrical Control Panels CB2 (for unit 1) and CB9 (for unit 2) in the Keowee Control Room. The ac pump control switches are normally left in the ON position, to enable continuous operation, while the dc pump control switches are left in the AUTO position.

The ac pump is controlled simply by the ON-OFF control switch. The dc pump control circuitry involves several relays that are normally energized following a unit start, and other relays that become energized should the level in the UOR fall to 5.5" or the ac pump shut off. The following relay conditions will start the dc pump:

- Turbine Bearing Low Oil Level Aux. Relay 63TA/2X is energized while Shutdown Solenoid Aux. Relay 99SX is energized
- Oil Pump Aux. Relay 88X is de-energized while Master Relay 4A is energized
- AC Bearing Oil Pump Aux. Relay 88AX is de-energized while Master Relay 4A is energized.

Once the dc pump is started, a seal-in contact will keep the pump running, provided that Rotation Sensing Aux. Relay 14DX is energized.

If oil in the UOR falls to 4.5", level transmitter GBOLT-1 (device 63TB) energizes Turbine Guide Bearing Oil Aux. Relay 63TB/1X, which de-energizes Shutdown Solenoid Aux. Relay 99SX and shuts down the unit (even during emergency operation).

A.12.5 LOCATION WITHIN THE PLANT

The GBO pumps, cooler, upper and lower oil reservoirs, and associated valves and piping, are located in close proximity to the turbine guide bearing, within the Turbine Wheelpit, at an elevation of approximately 675'.

A.12.6 NORMAL OPERATION

The ac pump runs continuously to take suction from the LOR and deliver oil to the UOR via the GBO cooler and filter. The dc pump is aligned in parallel with the ac pump and is enabled to automatically start should the ac pump become de-energized or level in the UOR drop to 5.5".

The GBO System is in service regardless of whether or not the respective Keowee unit is generating power, since oil must be continuously supplied to the turbine bearing.

A.12.7 PERFORMANCE DURING KEOWEE EMERGENCY OPERATION

GBO System operation is the same during normal and emergency operation. However, during an emergency start under blackout conditions, Keowee Auxiliary AC Power is not available to the ac pump. Under this condition, the dc pump would start and run until shut off.

A.12.8 TEST AND MAINTENANCE

Testing

The dc GBO Pump is started once a week and run for approximately 30 minutes. Devices that detect and signal low oil in the UOR are tested annually.

The GBO system testing requirements are detailed in Table A.12-2.

Maintenance

The GBO system is inspected twice a day, during rounds. During the rounds, the Operators verify that a GBO pump is operating, the turbine bearing flow meter indicates flow, and there is no leakage from the turbine bearing oil reservoir.

Guide bearing oil is filtered as needed, based on semi-annual oil sample results . The guide bearing oil cooler receives an inspection every three years.

The GBO system maintenance requirements are listed in Table A.12-3.

A.12.9 OPERATING EXPERIENCE

A summary of significant operating events is provided in Table A.12-4.

A.12.10 ASSUMPTIONS

A.12.10.1 SYSTEM DESIGN ASSUMPTIONS

1. The Turbine Guide Bearing Oil Cooler is required to be in service if CCW inlet temperature is greater than or equal to 65°F. However, test results indicate that the bearing temperature rise over the first 24 hours is well below the value at which bearing degradation would occur. Thus the cooler is not included in the system model.

A.12.10.2 OPERATIONAL ASSUMPTIONS

1. The ac GBO pump control switch is in the ON position.

2. The dc GBO pump control switch is in the AUTO position.

A.12.10.3 MODELING ASSUMPTIONS

1. The GBO system operates continuously, and alarms on low oil level in the UOR. Thus, if the GBO system is not able to function properly, the Keowee unit is shut down and the system repaired. Therefore, the GBO system does not have the potential to fail a Keowee start. System unavailability is captured in the Keowee unavailability number.

2. The LOR immersion heaters are not modeled. These heaters are used to maintain the oil above room temperature. Prior to an emergency start, if the heaters were not operating properly, to the point that flow began to degrade, level in the UOR would begin to drop. At 5.5" (decreasing), level transmitter GBOLT-2 (device 63TA) activates a statalarm, starts the dc pump, and signals for a normal lockout. During an emergency run, with the heat input from the bearing, it is not expected that cool bearing oil temperature would contribute to bearing failure.

A.12.11 FAULT TREE ANALYSIS

A.12.11.1 TOP EVENT SUCCESS CRITERIA

Success of the GBO System requires the ac or dc GBO pump to supply the UOR, and system integrity to be maintained.

A.12.11.2 DETAILED FAILURE CRITERIA

1. Failure of both the ac and dc GBO pump trains leads to the top event.

2. Loss of system oil, by GBO manual boundary valves transferring open, leads to the top event.

3. Loss of oil flow path, by GBO filter becoming clogged or GBO manual valves transferring closed, leads to the top event.

A.12.11.3 DESCRIPTION OF FAULT TREE

The GBO System fault tree is shown in Figure A.12-2. The Fault Tree Modeling Guidelines (Appendix B) were followed in developing the fault tree. A list of all fault tree transfers is presented in Table A.12-5. Modules were not developed for the Keowee fault trees.

Human reliability analysis was performed as described in Section 5.5 and Appendix C.3. Human events impacting the model are described in Section A.12.11.4.

Common cause analysis was performed as described in Section 5.4 and Appendix C.2. Common cause events impacting the model are described in Section A.12.11.5.

Gates BK1661B, BK2661B model the failure of Rotation Sensing Relay 14DX to energize. These gates are not utilized by the GBO fault tree but by the Cooling Water System fault tree. They are placed here for an organizational reason: run failure of the 14DX relay is also developed here (and used in the GBO fault tree).

A.12.11.4 HUMAN INTERACTIONS

Human actions by the maintenance technicians can adversely affect GBO System reliability. Those events explicitly included in the system fault tree are discussed below.

<u>BK1GBDCLHE, BK2GBDCLHE</u>

These basic events account for the potential of the maintenance technicians or operators to fail to properly restore the dc GBO pump train following maintenance or testing. Unlike the ac pump, which is in constant operation, the dc pump is normally only run for approximately 30 minutes each week for testing, so there is a possibility that a latent human error exists that will not be discovered until the pump is demanded to emergency start, or is required to run for a longer period of time.

A.12.11.5 RELIABILITY DATA

Section 5.3 discusses development of the reliability data. For the base case solution, the plant-specific component failure rate data and generic failure rate data were combined using a Bayesian update.

Plant-specific data is used for maintenance events. The following maintenance events are included in the GBO System model.

BK1GODCTRM, BK2GODCTRM

These events account for maintenance and testing on the Unit 1 and Unit 2 GBO pump trains that would render the trains unavailable. For modeling simplicity, all of the unavailability is placed on the dc train. Each pump train is in maintenance for approximately 5 hours per year. (Although the dc pump is tested for approximately 30 minutes per week this does not contribute to unavailability, since the pump train is performing its function of supplying the UOR). Thus, the unavailability attributed to the dc pump train due to testing or maintenance is:

(5 hr + 5 hr)/8760 hr = 1.14E-3.

As discussed in Section 5.3, consideration of relevant statalarms is part of the process of determining each basic event factor. GBO System statalarms are listed in Table A.12-6.

System reliability data is listed in Table A.12-7.

A.12.11.6 COMMON-CAUSE ASSESSMENT

Common cause failure of the GBO System is represented in the high-level fault tree by event BKGBOILCOM. (See Appendix A.1)

A.12.12 RESULTS

Reliability of the GBO System is defined as the probability that the system will succeed in supporting Keowee emergency operation (black start plus a 24 hour run). The system

model yields a failure probability of approximately 4.7E-5 (applicable to either unit). Thus the reliability of each unit's GBO system over the mission time is computed to be 99.99 %.

Table A.12-8 lists the dominant minimal cut sets (failure sequences) for the Turbine Guide Bearing Oil System. A list of dominant contributors to unavailability is shown in Table A.12-9. By far, the dominant contributor to the unavailability of the GBO System is failure of the oil flow path due to clogging of filter GBOFL-1. Failure of the ac GBO pump to run and failure of the dc pump train due to latent human error also contribute to system unavailability.

A.12.13 REFERENCES

A.12.13.1 DOCUMENTS

1. OSS-0245.00-00-1031, Rev. 1, Keowee Mechanical Systems.

A.12.13.2 PROCEDURES

1. IP/1/A/0400/021, Change 1, Unit No. 1 Magnetrol Model TF-21 Liquid Level Control Switch Calibration.

2. IP/1/B/0400/002, Change 1, United Electric Type J-6 Pressure Switch Calibration.

3. IP/1/B/0400/005, Change 2, Moore Model 33 Nullmatic Temperature Transmitter Calibration.

4. MP/1/A/2000/017, Change 5, Unit No. 1 Turbine, Governor, And Generator Preventive Maintenance.

5. MP/1/A/2000/018, Change 4, Unit No. 1 Turbine And Governor Monthly Preventive Maintenance.

6. MP/1/A/2000/025, Change 5, Turbine Guide Bearing Oil Cooler 3 Year Inspection And Maintenance.

7. MP/1/A/2000/040, Change 2, Unit No. 1 Turbine Guide Bearing Oil Filtration.

8. MP/1/A/2000/042, Change 3, Unit No. 1 Turbine Guide Bearing Oil Change.

9. OP/0/A/2000/043, Change 6, Keowee Shift Turnover And Rounds.

A.12.13.3 DRAWINGS

1. KEE-106, Rev. 3, Keowee Development Unit #1, Tabulation, Statalarm List #1SA1, T-G System Condition Alarms.

2. KEE-106-1, Rev. 3, Keowee Development Unit #1, Tabulation, Statalarm List #1SA2, T-G System Running Alarms.

3. KEE-108, Rev. 6, Keowee Hydro Station Unit No. 1, Elementary Diagram, Turbine No. 1 Bearing Oil Pump.

4. KEE-111, Rev. 11, Keowee Hydro Station Unit No. 1, Elementary Diagram, Turbine And Governor Systems Start-up Control.

5. KEE-111-A, Rev. 0, Keowee Hydro Station Unit No. 1, Elementary Diagram, Turbine And Governor System.

6. KEE-113, Rev. 8, Keowee Hydro Station Unit No. 1, Elementary Diagram, Master Control System, Start-up Controls.

7. KEE-113-4, Rev. 8, Keowee Hydro Station Unit No. 1, Elementary Diagram, Master Control System, Turbine Miscellaneous Relaying.

8. KEE-113-5, Rev. 8, Keowee Hydro Station Unit No. 1, Elementary Diagram, Master Control System, Turbine Miscellaneous Relaying.

9. KEE-206, Rev. 3, Keowee Development Unit #2, Tabulation, Statalarm List #2SA1, T-G System Condition Alarms.

10. KEE-206-1, Rev. 3, Keowee Development Unit #2, Tabulation, Statalarm List #2SA2, T-G System Running Alarms.

11. KEE-208, Rev. 4, Keowee Hydro Station Unit No. 2, Elementary Diagram, Turbine No. 1 Bearing Oil Pump.

12. KEE-211, Rev. 9, Keowee Hydro Station Unit No. 2, Elementary Diagram, Turbine And Governor Systems Start-up Control.

13. KEE-211-A, Rev. 0, Keowee Hydro Station Unit No. 2, Elementary Diagram, Turbine And Governor System.

14. KEE-213, Rev. 5, Keowee Hydro Station Unit No. 2, Elementary Diagram, Master Control System, Start-up Controls.

15. KEE-213-4, Rev. 6, Keowee Hydro Station Unit No. 2, Elementary Diagram, Master Control System, Turbine Miscellaneous Relaying.

16. KEE-213-5, Rev. 6, Keowee Hydro Station Unit No. 2, Elementary Diagram, Master Control System, Turbine Miscellaneous Relaying.

17. KFD-101A-1.1, Rev. 1, Keowee Hydro Station Unit 1, Flow Diagram Of Turbine Guide Bearing Oil System.

18. KFD-101A-2.1, Rev. 1, Keowee Hydro Station Unit 2, Flow Diagram Of Turbine Guide Bearing Oil System.

19. KM-200-126, Rev. DHA, Elementary Diagram For Duke Power Co., Keowee Development.

Table A.12-1

Turbine Guide Bearing Oil System Power Supplies

Component	Power Supply[1]	Compartment Number
Unit 1 AC GBO Pump	600 V ac MCC 1XA	1C
Unit 2 AC GBO Pump	600 V ac MCC 2XA	1C
Unit 1 DC GBO Pump	125 V dc DC 1DA	5B
Unit 2 DC GBO Pump	125 V dc DC 2DA	1B

[1] MCC = Motor Control Center
DC = Distribution Center

Table A.12-2

Turbine Guide Bearing Oil System Test Procedures

Procedure	Test Frequency	Description
IP/1/A/0400/021, Unit No. 1 Magnetrol Model TF-21 Liquid Level Control Switch Calibration	Annually	Verify GBO level switches operate within calibration limits.
IP/1/B/0400/002, United Electric Type J-6 Pressure Switch Calibration	Annually	Verify GBO pressure switches operate within calibration limits.
IP/1/B/0400/005, Moore Model 33 Nullmatic Temperature Transmitter Calibration	Annually	Verify GBO temperature transmitters operate within calibration limits.
MP/1/A/2000/017, Unit No. 1 Turbine, Governor, And Generator Preventive Maintenance	Weekly	Verify that AC and DC GBO pump reduction gear oil levels are at FULL mark. Verify DC pump operation.

Table A.12-3

Turbine Guide Bearing Oil System Maintenance Procedures

Procedure	Maintenance Frequency	Description
MP/1/A/2000/018, Unit No. 1 Turbine And Governor Monthly Preventive Maintenance	Monthly	Verification that GBO level is at the normal level, GBO filters are clean and free of obstruction. Record any oil leaks found.
MP/1/A/2000/025, Unit No. 1 Turbine Guide Bearing Oil Cooler 3 Year Inspection And Maintenance	Every 3 years	Clean shell side of oil cooler. Verify oil and water supply and discharge valves are left open.
MP/1/A/2000/040, Unit No. 1 Turbine Guide Bearing Oil Filtration	As needed. Need is established based on results of semi-annual oil samples.	Guide bearing oil is filtered for 24 hours.
MP/1/A/2000/042, Unit No. 1 Turbine Guide Bearing Oil Change	As needed.	Guide bearing oil is replaced with dried and filtered oil from Lube Oil Tank.

Table A.12-4

Turbine Guide Bearing Oil System Significant Operating Events

Date	Unit	Component	Event Summary
5/11/84	1	GBO DC Pump	Pump motor windings shorted during weekly test.
6/15/85	1	Speed Sw. 14/2	Mercury speed switch not working properly.
11/5/92	2	63TA/2X	Broken contact lug on Turb. Brng. Low Oil Aux. Relay caused unit trip.
7/8/93	2	GBO AC Pump	Pump failed due to shorted motor windings.
10/28/93	2	GBO Cooler	Broken solder joint on discharge side of cooler due to overtorquing the hex nut during preventive maintenance.

Table A.12-5

Turbine Guide Bearing Oil System Fault Tree Transfers (Unit 1)*

Transfer Gate Name	Description	Components Supplied
FK1100	WL Fails To Cool The Unit 1 Turbine Guide Bearing Oil Cooler	1GBOHX-1
XA1XA	Loss of Power on Keowee 600 V ac MCC 1XA	Unit 1 AC GBO Pump
XD1DAR	Loss of Power on Keowee 125 V dc Distribution Center 1DA During Run	Unit 1 DC GBO Pump
YK199SXSRT	Keowee 1 Shutdown Aux. Relay Fails To Pick Up On Start	Unit 1 DC GBO Pump
YK1MR4ARUN	Keowee 1 Master Relay 4A Drops Out During Run	Unit 1 DC GBO Pump
YK1MR4ASRT	Keowee 1 Master Relay 4A Fails To Pick Up On Start	Unit 1 DC GBO Pump
YK1SXRUNF	Keowee 1 Shutdown Aux. Relay Permissive Circuit Fails During Run	Unit 1 DC GBO Pump

*Unit 2 transfers are similar.

Table A.12-6

Turbine Guide Bearing Oil System Statalarms (Unit 1)*

Point No.	Alarm	Actuator
1SA1-1	TURB. #1 BRG. OIL PUMP TROUBLE	30Y
1SA1-2	TURB. #1 BRG. OIL LEVEL LOW	63TA/2X
1SA2-7	TURB. #1 BRG. TEMP. HIGH	38T2X
1SA1-50	UNIT #1 D.C. SUPPLY FAILURE	8DX

*Unit 2 alarms are similar.

Table A.12-7

Turbine Guide Bearing Oil System Reliability Data

Event Name	Description	Failure Rate[1]	Factor	Rationale For Factor[2]	Failure Probability
BK1088XRYD	Keowee 1 Turbine GBO Rly 88X Fails to Drop Out	8.64E-06 /D	1 D	Drops out on low oil in UOR	3.30E-05
BK1088XRYT	Keowee 1 Turbine GBO Rly 88X Spur. Operation	3.60E-07 /H	24 H	Rule 1: GBO Low Level alarm	8.64E-06
BK114/2SSD	Keowee 1 Speed Switch 14/2 Fails On Demand	1.80E-05 /D	1 D	Switch changes state on unit start	1.80E-05
BK114/2SST	Keowee 1 Speed Switch 14/2 Spur. Transfers Closed	4.20E-06 /H	24 H	Switch changes state on unit start	1.03E-04
BK114DXRYD	Keowee 1 Rotation Sensing Aux. Relay 14DX Fails to Energize	3.30E-05 /D	1 D	Relay energized as turbine begins to spin	3.30E-05
BK114DXRYT	Keowee 1 Rotation Sensing Aux. Relay 14DX Spuriously Drops Out	3.60E-07 /H	24 H	Relay energized as turbine begins to spin	8.64E-06
BK114T2RYD	Keowee 1 Rotation Sensing Timer 14T2 Fails to De-energize	3.30E-05 /D	1 D	Relay de-energized as turbine begins to spin	3.30E-05
BK114T2RYT	Keowee 1 Rotation Sensing Timer 14T2 Spurious Operation	3.60E-07 /H	24 H	Relay de-energized as turbine begins to spin	8.64E-06
BK1188ASWT	Keowee 1 AC GBO Pump Control Switch S188A Spurious Operation	7.00E-08 /H	24 H	Rule 1: GBO Pump Trouble alarm	1.68E-05
BK1188DSWT	Unit 1 DC GBO Pump Control Switch S188D Spurious Operation	7.00E-08 /H	108 H	DC pump trn. is tested once each week	7.56E-06
BK1631XRYD	Keowee 1 Relay 63TA/1X Fails to De-energize	3.30E-05 /D	1 D	Drops out on low oil in UOR	3.30E-05
BK1631XRYT	Keowee 1 GBO Level Relay 63TA/1X Spurious Operation	3.60E-07 /H	24 H	Rule 1: GBO Low Level alarm	8.64E-06
BK1632XRYD	Keowee 1 Brng. Low Oil Level Aux. Relay 63TA/2X Fails To Operate On Demand	3.30E-05 /D	1 D	Energized on low oil in UOR	3.30E-05

Table A.12-7

Turbine Guide Bearing Oil System Reliability Data

Event Name	Description	Failure Rate[1]	Factor	Rationale For Factor[2]	Failure Probability
BK1632XRYT	Keowee 1 Turb. Brng. Low Oil Level Aux. Rly 63TA/2X Spurious Operation	3.60E-07 /H	24 H	Rule 1: GBO Low Level alarm	8.64E-06
BK163TALSD	Turbine No. 1 GBO Level Sw. 63TA Fails On Demand	1.60E-03 /D	1 D	Switch changes state on low level in the UOR	1.60E-03
BK163TALST	Turbine No. 1 GBO Level Sw. 63TA Spurious Operation	3.10E-07 /H	24 H	Rule 1: GBO Low Level alarm	7.44E-06
BK188AXRYD	Unit 1 AC Bearing Oil Pump Aux. Relay 88AX Fails to Drop Out	3.30E-05 /D	1 D	Drops out if AC pump is de-energized	3.30E-05
BK188AXRYT	Unit 1 AC Bearing Oil Pump Aux. Relay 88AX Fails to Remain De-energized	3.60E-07 /H	24 H	Rule 1: GBO Pump Trouble alarm	8.64E-06
BK1DA5BCDT	DC Circuit Breaker 1DA-5B Transfers Position	7.50E-08 /H	24 H	Rule 1: DC Supply Failure alarm	1.80E-06
BK1GBDCGPR	Unit 1 DC Turbine GBO Pump Fails To Run	1.40E-05 /H	12 H	DC pump is needed if AC pump fails (AC pump assumed to fail halfway through its mission)	1.68E-04
BK1GBDCGPS	Unit 1 DC Turbine GBO Pump Fails To Start On Demand	9.70E-05 /D	1 D	DC pump is the standby pump; starts as needed	9.70E-05
BK1GBDCLHE	Latent Human Error Fails Unit 1 DC Guide Bearing Oil Pump Discharge Path				3.20E-03
BK1GBO1CVC	Check Valve 1GBO-1 Fails to Close on Demand	3.50E-04 /D	1 D	Closes on DC pump start	3.50E-04
BK1GBO1CVO	Check Valve 1GBO-1 Fails To Open On Demand	2.30E-06 /D	1 D	Opens when AC pump restarts	2.30E-06
BK1GBO1CVT	Check Valve 1GBO-1 Transfers Closed	1.30E-07 /H	24 H	Rule 1: GBO Pump Trouble alarm	3.12E-06
BK1GBO1FTC	Filter 1GBOFL-1 Becomes Clogged	1.80E-06 /H	24 H	Rule 1: GBO Low Level alarm	4.32E-05

Table A.12-7

Turbine Guide Bearing Oil System Reliability Data

Event Name	Description	Failure Rate[1]	Factor	Rationale For Factor[2]	Failure Probability
BK1GBO2VVT	Manual Valve 1GBO-2 Transfers Position	1.70E-08 /H	24 H	Rule 1: GBO Pump Trouble alarm	4.08E-07
BK1GBO3CVO	Check Valve 1GBO-3 Fails To Open On Demand	2.30E-06 /D	1 D	Opens on DC pump start	2.30E-06
BK1GBO3CVT	Check Valve 1GBO-3 Transfers Closed	1.30E-07 /H	12 H	See BK1GBDCGPR	1.56E-06
BK1GBO4VVT	Manual Valve 1GBO-4 Transfers Position	1.70E-08 /H	108 H	See BK1188DSWT	1.84E-06
BK1GBO5VVT	Manual Valve 1GBO-5 Transfers Position	1.70E-08 /H	24 H	Rule 1: GBO Low Level alarm	4.08E-07
BK1GBO6VVT	Manual Valve 1GBO-6 Transfers Position	1.70E-08 /H	24 H	Rule 1: GBO Low Level alarm	4.08E-07
BK1GBO8VVT	Manual Valve 1GBO-8 Transfers Position	1.70E-08 /H	24 H	Rule 1: GBO Low Level alarm	4.08E-07
BK1GBO9VVT	Manual Valve 1GBO-9 Transfers Position	1.70E-08 /H	24 H	Rule 1: GBO Low Level alarm	4.08E-07
BK1GOACGPR	Unit 1 AC Turbine GBO Pump Fails To Run	1.40E-05 /H	24 H	Rule 1: GBO Pump Trouble alarm	3.36E-04
BK1GOACGPS	Unit 1 AC Turbine GBO Pump Fails To Start	9.70E-05 /D	1 D	Since blackout during start, pump would have to restart after aux. ac power is restored	9.70E-05
BK1GODCTRM	Unit 1 DC Turbine GBO Pump Train In Maintenance				1.14E-03

Table A.12-7

Turbine Guide Bearing Oil System Reliability Data

Event Name	Description	Failure Rate[1]	Factor	Rationale For Factor[2]	Failure Probability
BK1XA1CCLT	600 V Circuit Breaker 1XA-1C Transfers Position	9.10E-07 /H	24 H	Rule 1: GBO Pump Trouble alarm	2.18E-05
BK2088XRYD	Keowee 2 Turbine GBO Rly 88X Fails to Drop Out	3.30E-05 /D	1 D	Same rationale as for unit 1, since both systems operate continuously.	3.30E-05
BK2088XRYT	Keowee 2 Turbine GBO Rly 88X Spur. Operation	3.60E-07 /H	24 H		8.64E-06
BK214/2SSD	Keowee 2 Speed Switch 14/2 Fails On Demand	1.80E-05 /D	1 D		1.80E-05
BK214/2SST	Keowee 2 Speed Switch 14/2 Spuriously Transfers Closed	4.20E-06 /H	24 H		1.03E-04
BK214DXRYD	Keowee 2 Rotation Sensing Aux. Relay 14DX Fails to Energize	3.30E-05 /D	1 D		3.30E-05
BK214DXRYT	Keowee 2 Rotation Sensing Aux. Relay 14DX Spurious Operation	3.60E-07 /H	24 H		8.64E-06
BK214T2RYD	Keowee 2 Rotation Sensing Timer 14T2 Fails to De-energize	3.30E-05 /D	1 D		3.30E-05
BK214T2RYT	Keowee 2 Rotation Sensing Timer 14T2 Fails to Remain De-energized	3.60E-07 /H	24 H		8.64E-06
BK2188ASWT	Unit 2 AC GBO Pump Control Switch S188A Spurious Operation	7.00E-08 /H	24 H		1.68E-05
BK2188DSWT	Unit 2 DC GBO Pump Control Switch S188D Spurious Operation	7.00E-08 /H	108 H		7.56E-06
BK2631XRYD	Keowee 2 Relay 63TA/1X Fails to De-energize	3.30E-05 /D	1 D		3.30E-05

Table A.12-7

Turbine Guide Bearing Oil System Reliability Data

Event Name	Description	Failure Rate[1]	Factor	Rationale For Factor[2]	Failure Probability
BK2631XRYT	Keowee 2 GBO Level Relay 63TA/1X Spurious Operation	3.60E-07 /H	24 H	Same rationale as for unit 1, since both systems operate continuously.	8.64E-06
BK2632XRYD	Keowee 2 Brng. Low Oil Level Aux. Relay 63TA/2X Fails To Operate On Demand	3.30E-05 /D	1 D		3.30E-05
BK2632XRYT	Keowee 2 Turb. Brng. Low Oil Level Aux. Relay 63TA/2X Spurious Operation	3.60E-07 /H	24 H		8.64E-06
BK263TALSD	Turbine No. 2 Bearing Oil Level Switch 63TA Fails on Demand	1.60E-03 /D	1 D		1.60E-03
BK263TALST	Turbine No. 2 Bearing Oil Level Switch 63TA Spurious Operation	3.10E-07 /H	24 H		7.44E-06
BK288AXRYD	Unit 2 AC Bearing Oil Pump Aux. Relay 88AX Fails to Drop Out	3.30E-05 /D	1 D		3.30E-05
BK288AXRYT	Unit 2 AC Bearing Oil Pump Aux. Relay 88AX Fails to Remain De-energized	3.60E-07 /H	24 H		8.64E-06
BK2DA1BCDT	DC Circuit Breaker 2DA-1B Transfers Position	7.50E-08 /H	24 H		1.80E-06
BK2GBDCGPR	Unit 2 DC Turbine GBO Pump Fails To Run	1.40E-05 /H	12 H		1.68E-04
BK2GBDCGPS	Unit 2 DC Turbine GBO Pump Fails To Start On Demand	9.70E-05 /D	1 D		9.70E-05
BK2GBDCLHE	Latent Human Error Fails Unit 2 DC Guide Bearing Oil Pump Discharge Path				3.20E-03
BK2GBO1CVC	Check Valve 2GBO-1 Fails to Close on Demand	3.50E-04 /D	1 D		3.50E-04

Table A.12-7

Turbine Guide Bearing Oil System Reliability Data

Event Name	Description	Failure Rate[1]	Factor	Rationale For Factor[2]	Failure Probability
BK2GBO1CVO	Check Valve 2GBO-1 Fails To Open On Demand	2.30E-06 /D	1 D	Same rationale as for unit 1, since both systems operate continuously.	2.30E-06
BK2GBO1CVT	Check Valve 2GBO-1 Transfers Closed	1.30E-07 /H	24 H		3.12E-06
BK2GBO1FTC	Filter 2GBOFL-1 Becomes Clogged	1.80E-06 /H	24 H		4.32E-05
BK2GBO2VVT	Manual Valve 2GBO-2 Transfers Position	1.70E-08 /H	24 H		4.08E-07
BK2GBO3CVO	Check Valve 2GBO-3 Fails To Open On Demand	2.30E-06 /D	1 D		2.30E-06
BK2GBO3CVT	Check Valve 2GBO-3 Transfers Closed	1.30E-07 /H	12 H		1.56E-06
BK2GBO4VVT	Manual Valve 2GBO-4 Transfers Position	1.70E-08 /H	108 H		1.84E-06
BK2GBO5VVT	Manual Valve 2GBO-5 Transfers Position	1.70E-08 /H	24 H		4.08E-07
BK2GBO6VVT	Manual Valve 2GBO-6 Transfers Position	1.70E-08 /H	24 H		4.08E-07
BK2GBO8VVT	Manual Valve 2GBO-8 Transfers Position	1.70E-08 /H	24 H		4.08E-07
BK2GBO9VVT	Manual Valve 2GBO-9 Transfers Position	1.70E-08 /H	24 H		4.08E-07
BK2GOACGPR	Unit 2 AC Turbine GBO Pump Fails To Run	1.40E-05 /H	24 H		3.36E-04
BK2GOACGPS	Unit 2 AC Turbine GBO Pump Fails To Start	9.70E-05 /D	1 D		9.70E-05

Table A.12-7

Turbine Guide Bearing Oil System Reliability Data

Event Name	Description	Failure Rate[1]	Factor	Rationale For Factor[2]	Failure Probability
BK2GODCTRM	Unit 2 DC Turbine GBO Pump Train In Maintenance			Same rationale as for unit 1, since both systems operate continuously.	1.14E-03
BK2XA1CCLT	600 V Circuit Breaker 2XA-1C Transfers Position	9.10E-07 /H	24 H		2.18E-05
XD1DA3BCDT	125 Vdc Breaker 1DA-3BR Trans. Open	7.50E-08 /H	24 H	Rule 1: DC Supply Failure alarm	1.80E-06
XD1DA4ACDT	DC Circuit Breaker 1DA-4AR Transfers Position	7.50E-08 /H	24 H	Rule 1: DC Supply Failure alarm	1.80E-06
XD2DA2ACDT	DC Circuit Breaker 2DA-2AR Transfers Position	7.50E-08 /H	24 H	Rule 1: DC Supply Failure alarm	1.80E-06
XD2DA3BCDT	125 Vdc Circuit Breaker 2DA-3BR Transfers Position	7.50E-08 /H	24 H	Rule 1: DC Supply Failure alarm	1.80E-06

[1] D = Demand, H = Hour

[2] Rules for assigning basic event factors are discussed in Table C.1-4.

Table A.12-8

Turbine Guide Bearing Oil System Dominant Minimal Cutsets

Cutsets For Gate BK1000: Keowee Unit 1 Turbine Guide Bearing Oil System Fails During Run

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
1)	4.32E-05	91.7	BK1GBO1FTC	4.32E-05	Filter 1GBOFL-1 Becomes Clogged
2)	1.08E-06	2.3	BK1GBDCLHE	3.20E-03	Latent Human Error Fails Unit 1 DC Guide Bearing Oil Pump Discharge Path
			BK1GOACGPR	3.36E-04	Unit 1 AC Turbine GBO Pump Fails To Run
3)	4.08E-07	0.9	BK1GBO9VVT	4.08E-07	Manual Valve 1GBO-9 Transfers Position
4)	4.08E-07	0.9	BK1GBO8VVT	4.08E-07	Manual Valve 1GBO-8 Transfers Position
5)	4.08E-07	0.9	BK1GBO6VVT	4.08E-07	Manual Valve 1GBO-6 Transfers Position
6)	4.08E-07	0.9	BK1GBO5VVT	4.08E-07	Manual Valve 1GBO-5 Transfers Position
7)	3.83E-07	0.8	BK1GOACGPR	3.36E-04	Unit 1 AC Turbine GBO Pump Fails To Run
			BK1GODCTRM	1.14E-03	Unit 1 DC Turbine GBO Pump Train In Maintenance
8)	3.10E-07	0.7	BK1GBDCLHE	3.20E-03	Latent Human Error Fails Unit 1 DC Guide Bearing Oil Pump Discharge Path
			BK1GOACGPS	9.70E-05	Unit 1 AC Turbine GBO Pump Fails To Start

Table A.12-8

Turbine Guide Bearing Oil System Dominant Minimal Cutsets

Cutsets For Gate BK1000: Keowee Unit 1 Turbine Guide Bearing Oil System Fails Keowee Run

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
9)	1.18E-07	0.3	BK1GBO1CVC	3.50E-04	Check Valve 1GBO-1 Fails to Close on Demand
			BK1GOACGPR	3.36E-04	Unit 1 AC Turbine GBO Pump Fails To Run
10)	1.11E-07	0.2	BK1GOACGPS	9.70E-05	Unit 1 AC Turbine GBO Pump Fails To Start
			BK1GODCTRM	1.14E-03	Unit 1 DC Turbine GBO Pump Train In Maintenance
11)	6.98E-08	0.1	BK1GBDCLHE	3.20E-03	Latent Human Error Fails Unit 1 DC Guide Bearing Oil Pump Discharge Path
			BK1XA1CCLT	2.18E-05	600 V Circuit Breaker 1XA-1C Transfers Position
12)	5.64E-08	0.1	BK1GBDCGPR	1.68E-04	Unit 1 DC Turbine GBO Pump Fails To Run
			BK1GOACGPR	3.36E-04	Unit 1 AC Turbine GBO Pump Fails To Run
13)	3.39E-08	0.1	BK1GBO1CVC	3.50E-04	Check Valve 1GBO-1 Fails to Close on Demand
			BK1GOACGPS	9.70E-05	Unit 1 AC Turbine GBO Pump Fails To Start
14)	3.26E-08	0.1	BK1GBDCGPS	9.70E-05	Unit 1 DC Turbine GBO Pump Fails To Start On Demand
			BK1GOACGPR	3.36E-04	Unit 1 AC Turbine GBO Pump Fails To Run
15)	2.49E-08	0.1	BK1GODCTRM	1.14E-03	Unit 1 DC Turbine GBO Pump Train In Maintenance
			BK1XA1CCLT	2.18E-05	600 V Circuit Breaker 1XA-1C Transfers Position

Table A.12-8

Turbine Guide Bearing Oil System Dominant Minimal Cutsets

Cutsets For Gate BK1000: Keowee Unit 1 Turbine Guide Bearing Oil System Fails Keowee Run

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
16)	1.63E-08	0.0	BK1GBDCGPR	1.68E-04	Unit 1 DC Turbine GBO Pump Fails To Run
			BK1GOACGPS	9.70E-05	Unit 1 AC Turbine GBO Pump Fails To Start
Total:	4.71E-05				

Table A.12-9

Turbine Guide Bearing Oil System Dominant Contributors To Unavailability

Rank	Event Description	Mean Unavailability[1]	Approximate Unavailability Contribution[2]
1	BK1GBO1FTC - Filter 1GBOFL-1 Becomes Clogged	4.32E-05	91.8%
2	BK1GOACGPR - Unit 1 AC Turbine GBO Pump Fails To Run	1.67E-06	3.5%
3	BK1GBDCLHE - Latent Human Error Fails Unit 1 DC Guide Bearing Oil Pump Discharge Path	1.46E-06	3.1 %

1 Mean unavailability is defined as the summation of the values of all cut sets in which the event appears.

2 The contribution to unavailability is calculated by dividing the mean unavailability by the overall system unavailability and then multiplying by 100 percent.

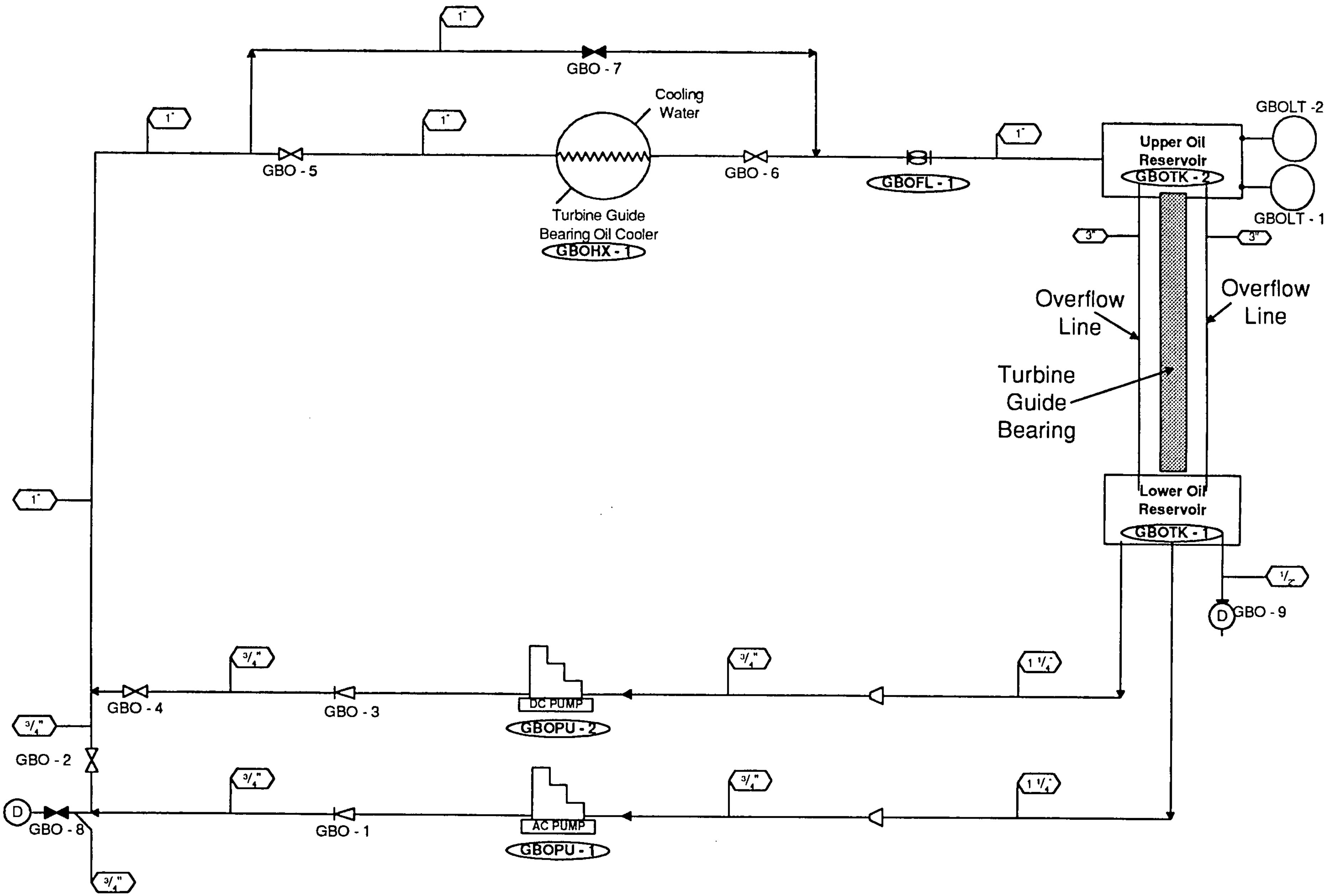
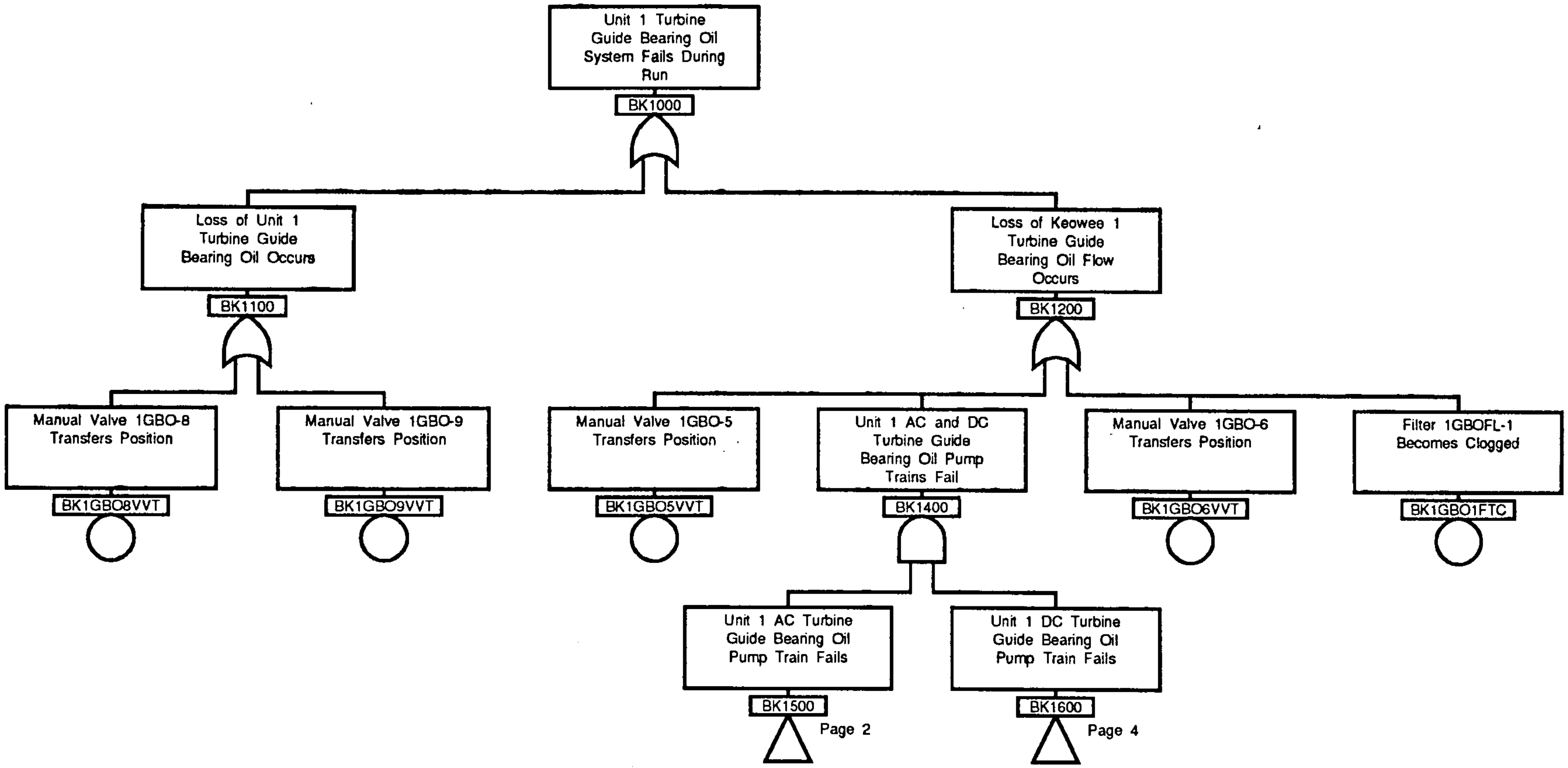
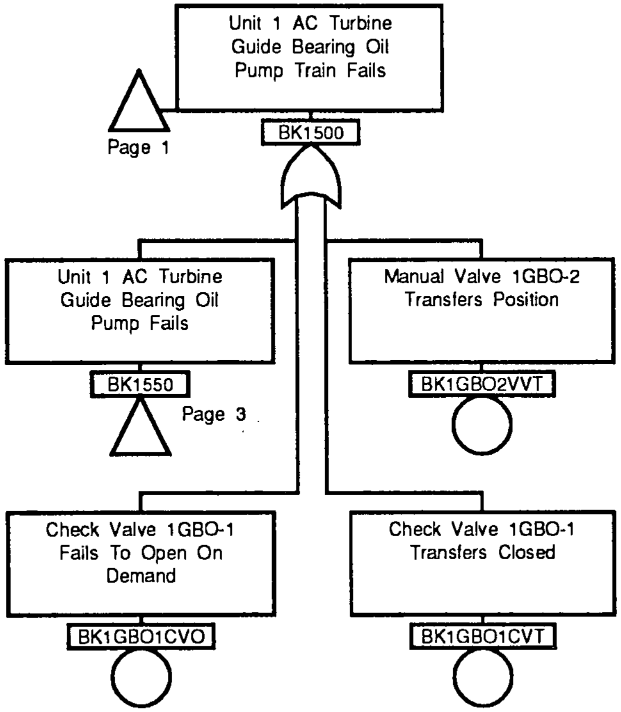


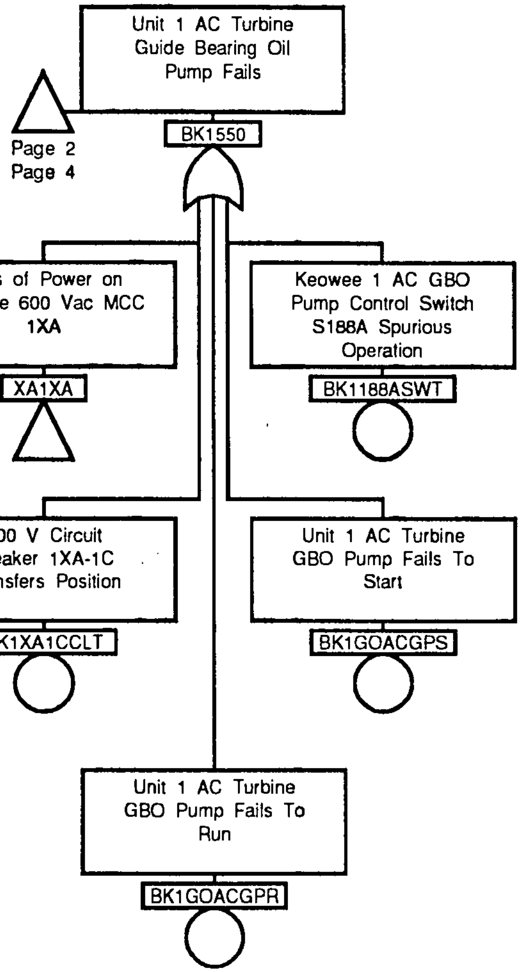
Figure A.12-1 Simplified Flow Diagram of the Turbine Guide Bearing Oil System



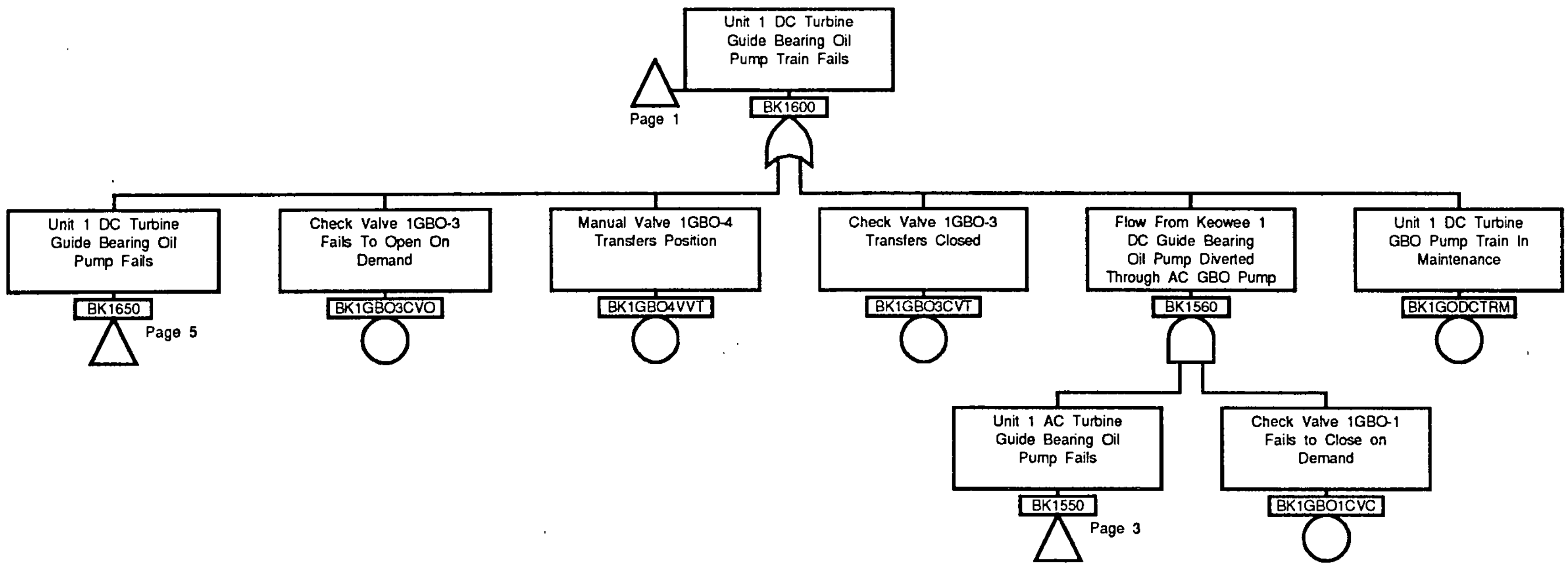
Guide Bearing Oil System Fault Tree | FIGURE A.12-2 |

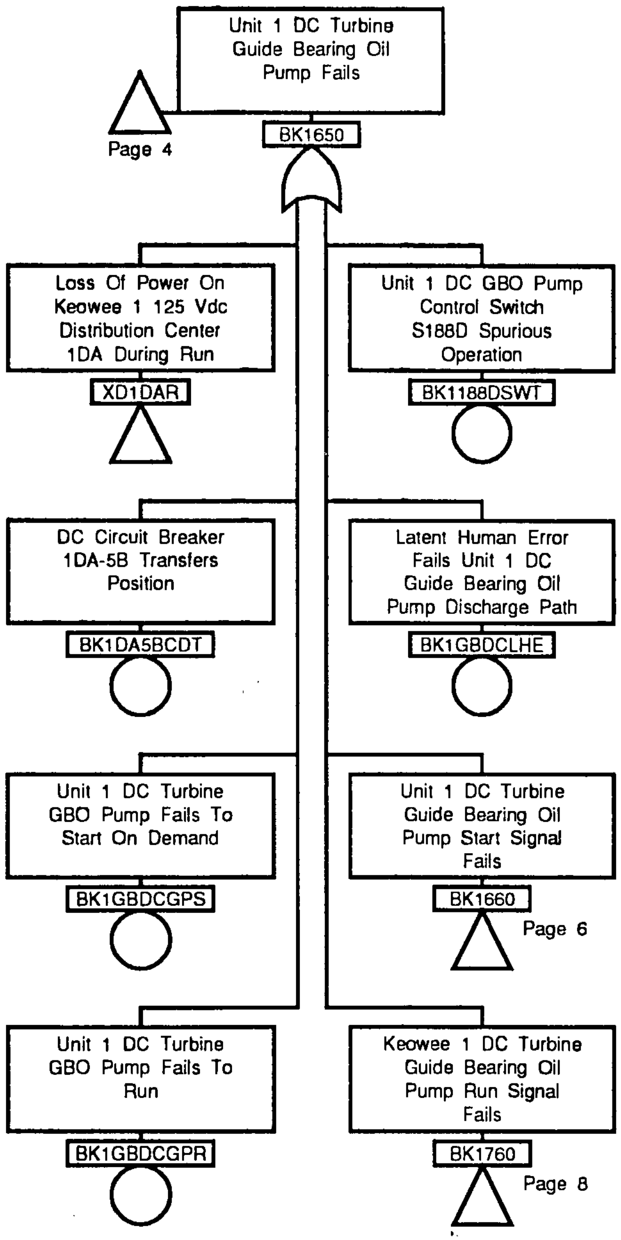


Guide Bearing Oil System Fault Tree	FIGURE A.12-2	Page 2

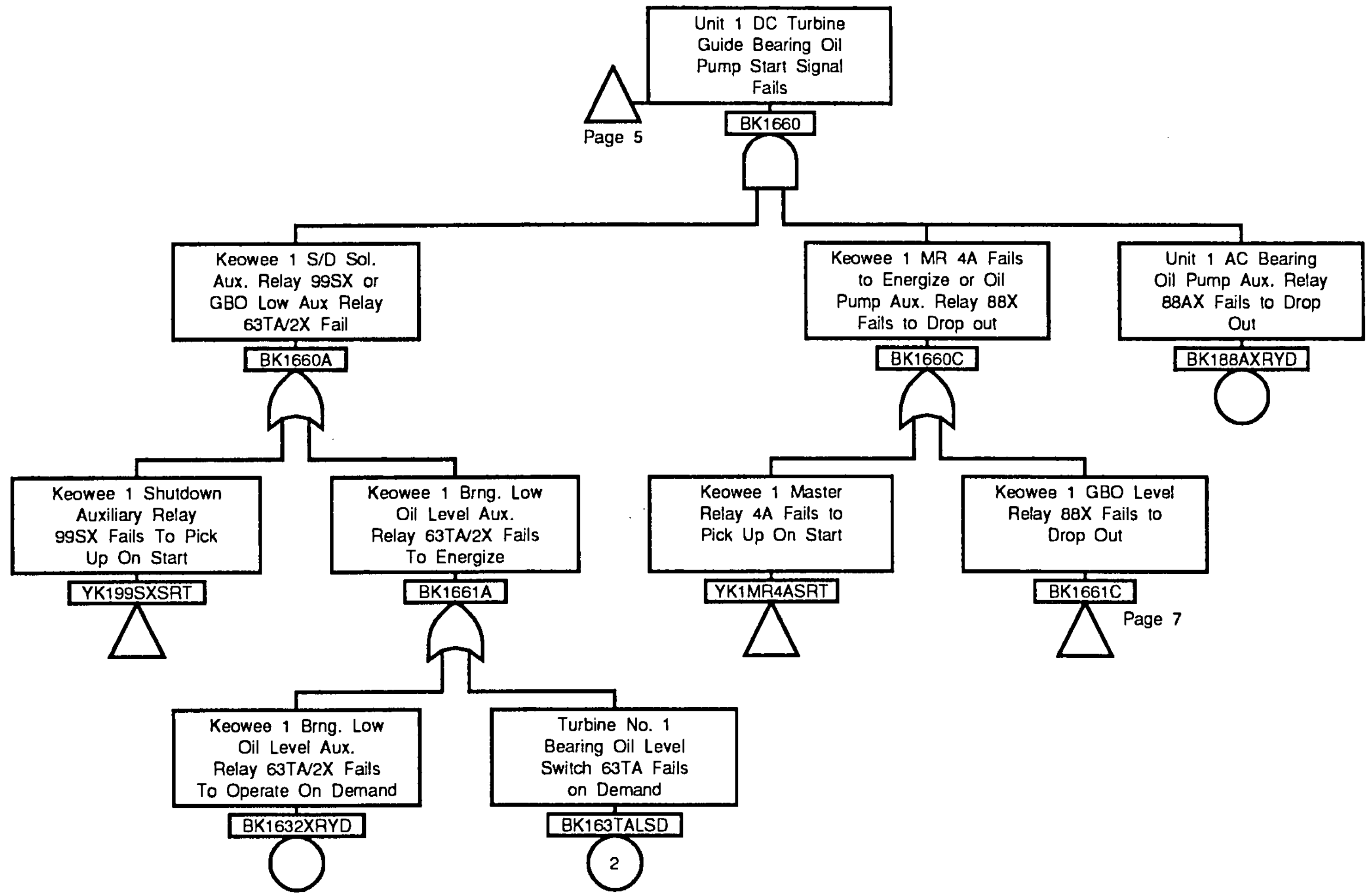


Guide Bearing Oil System Fault Tree | FIGURE A.12-2 |

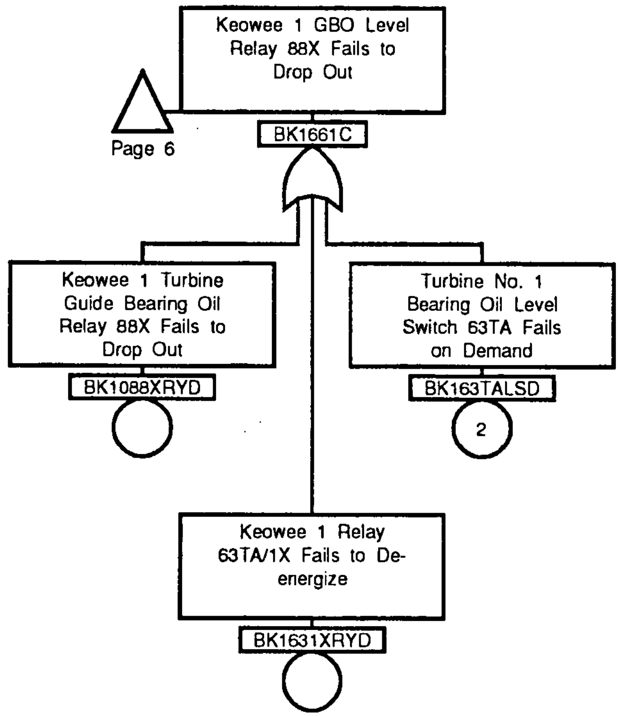

Unit 1 DC Turbine Guide Bearing Oil Pump Train Fails
BK1600
Page 1
Unit 1 DC Turbine Guide Bearing Oil Pump Fails
BK1650
Page 5
Check Valve 1GBO-3 Fails To Open On Demand
BK1GBO3CVO
Manual Valve 1GBO-4 Transfers Position
BK1GBO4VVT
Check Valve 1GBO-3 Transfers Closed
BK1GBO3CVT
Flow From Keowee 1 DC Guide Bearing Oil Pump Diverted Through AC GBO Pump
BK1560
Unit 1 DC Turbine GBO Pump Train In Maintenance
BK1GODCTRM
Unit 1 AC Turbine Guide Bearing Oil Pump Fails
BK1550
Page 3
Check Valve 1GBO-1 Fails to Close on Demand
BK1GBO1CVC

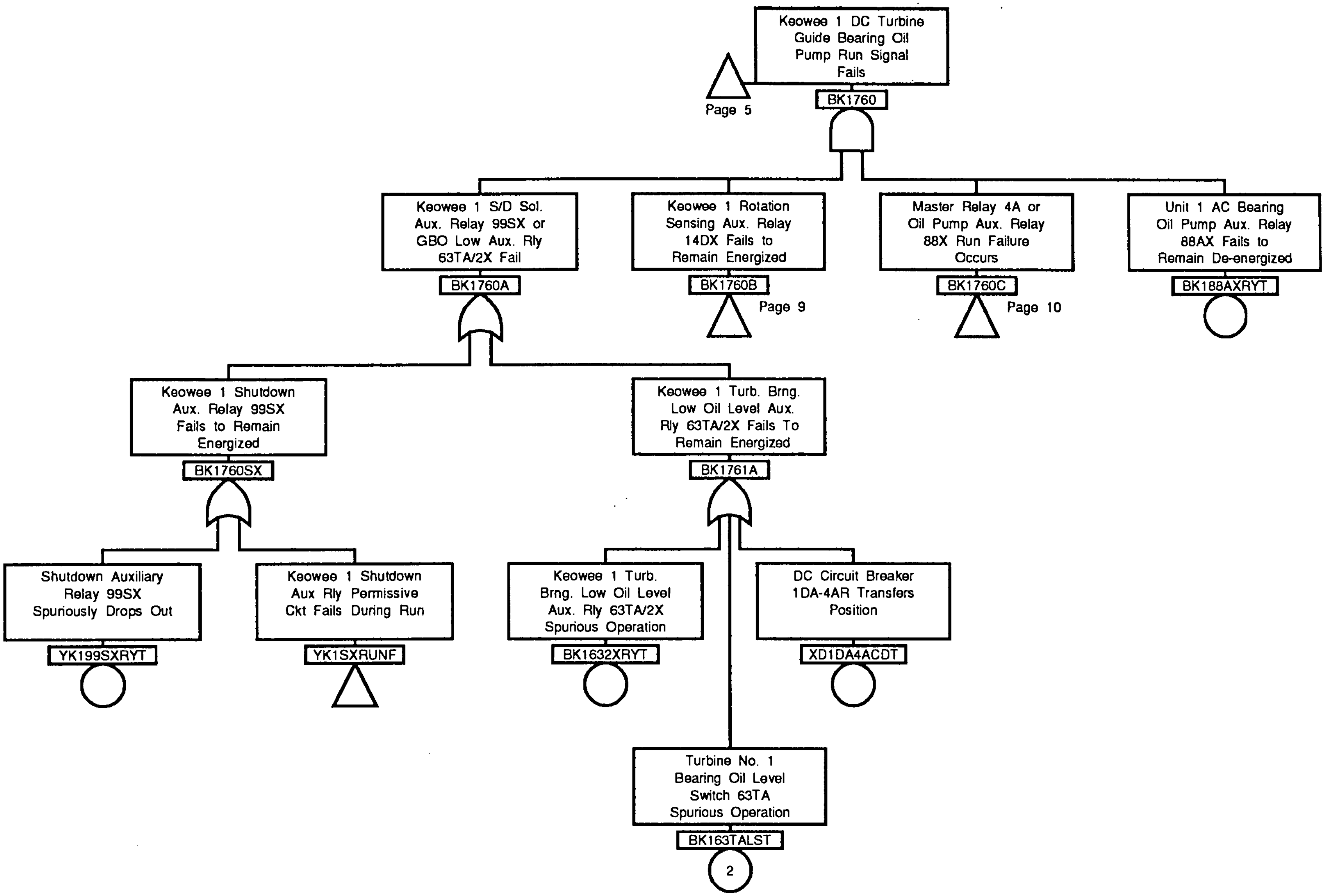


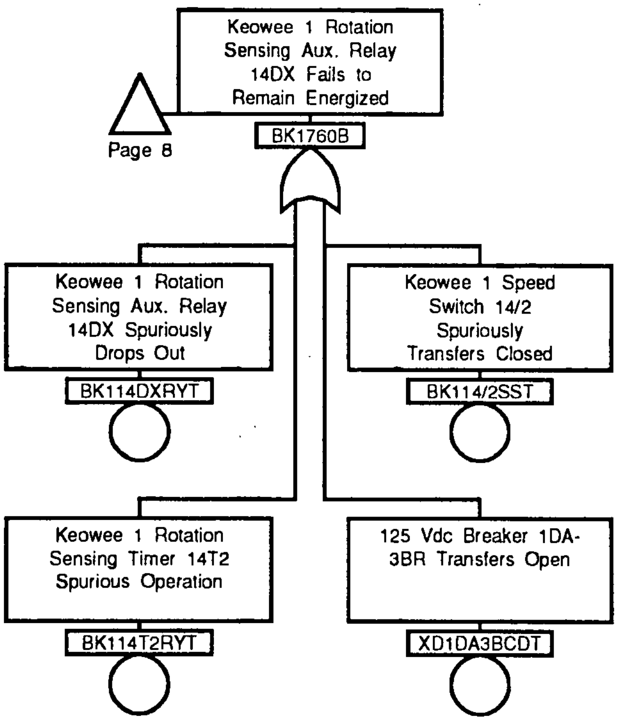
Unit 1 DC Turbine Guide Bearing Oil Pump Fails
BK1650
Page 4
Loss Of Power On Keowee 1 125 Vdc Distribution Center 1DA During Run
XD1DAR
Unit 1 DC GBO Pump Control Switch S188D Spurious Operation
BK1188DSWT
DC Circuit Breaker 1DA-5B Transfers Position
BK1DA5BCDT
Latent Human Error Fails Unit 1 DC Guide Bearing Oil Pump Discharge Path
BK1GBDCLHE
Unit 1 DC Turbine GBO Pump Fails To Start On Demand
BK1GBDCGPS
Unit 1 DC Turbine Guide Bearing Oil Pump Start Signal Fails
BK1660
Page 6
Unit 1 DC Turbine GBO Pump Fails To Run
BK1GBDCGPR
Keowee 1 DC Turbine Guide Bearing Oil Pump Run Signal Fails
BK1760
Page 8



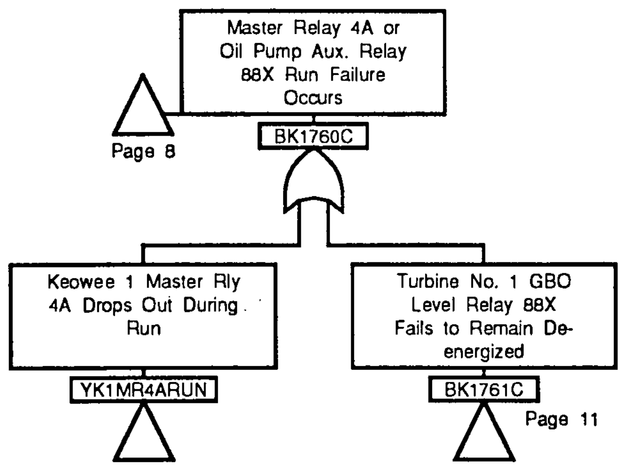
Guide Bearing Oil System Fault Tree | FIGURE A.12-2

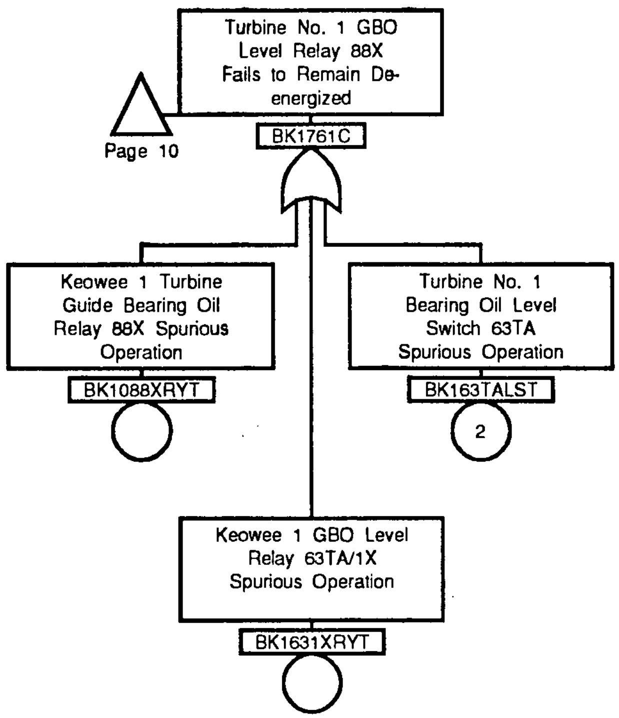

Keowee 1 GBO Level Relay 88X Fails to Drop Out
BK1661C
Page 6
Keowee 1 Turbine Guide Bearing Oil Relay 88X Fails to Drop Out
BK1088XRYD
Turbine No. 1 Bearing Oil Level Switch 63TA Fails on Demand
BK163TALSD
2
Keowee 1 Relay 63TA/1X Fails to De-energize
BK1631XRYD


Keowee 1 DC Turbine Guide Bearing Oil Pump Run Signal Fails
BK1760
Page 5
Keowee 1 S/D Sol. Aux. Relay 99SX or GBO Low Aux. Rly 63TA/2X Fail
BK1760A
Keowee 1 Rotation Sensing Aux. Relay 14DX Fails to Remain Energized
BK1760B
Page 9
Master Relay 4A or Oil Pump Aux. Relay 88X Run Failure Occurs
BK1760C
Page 10
Unit 1 AC Bearing Oil Pump Aux. Relay 88AX Fails to Remain De-energized
BK188AXRYT
Keowee 1 Shutdown Aux. Relay 99SX Fails to Remain Energized
BK1760SX
Keowee 1 Turb. Brng. Low Oil Level Aux. Rly 63TA/2X Fails To Remain Energized
BK1761A
Shutdown Auxiliary Relay 99SX Spuriously Drops Out
YK199SXRYT
Keowee 1 Shutdown Aux Rly Permissive Ckt Fails During Run
YK1SXRUNF
Keowee 1 Turb. Brng. Low Oil Level Aux. Rly 63TA/2X Spurious Operation
BK1632XRYT
DC Circuit Breaker 1DA-4AR Transfers Position
XD1DA4ACDT
Turbine No. 1 Bearing Oil Level Switch 63TA Spurious Operation
BK163TALST
2

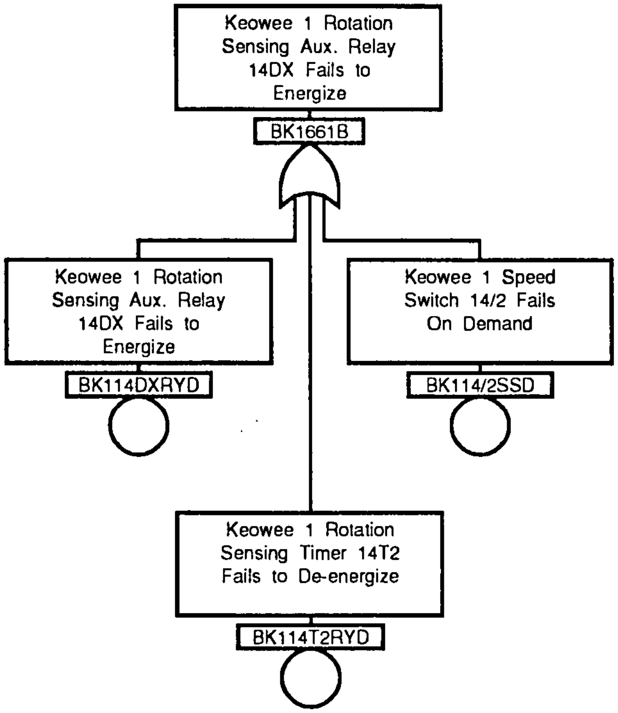


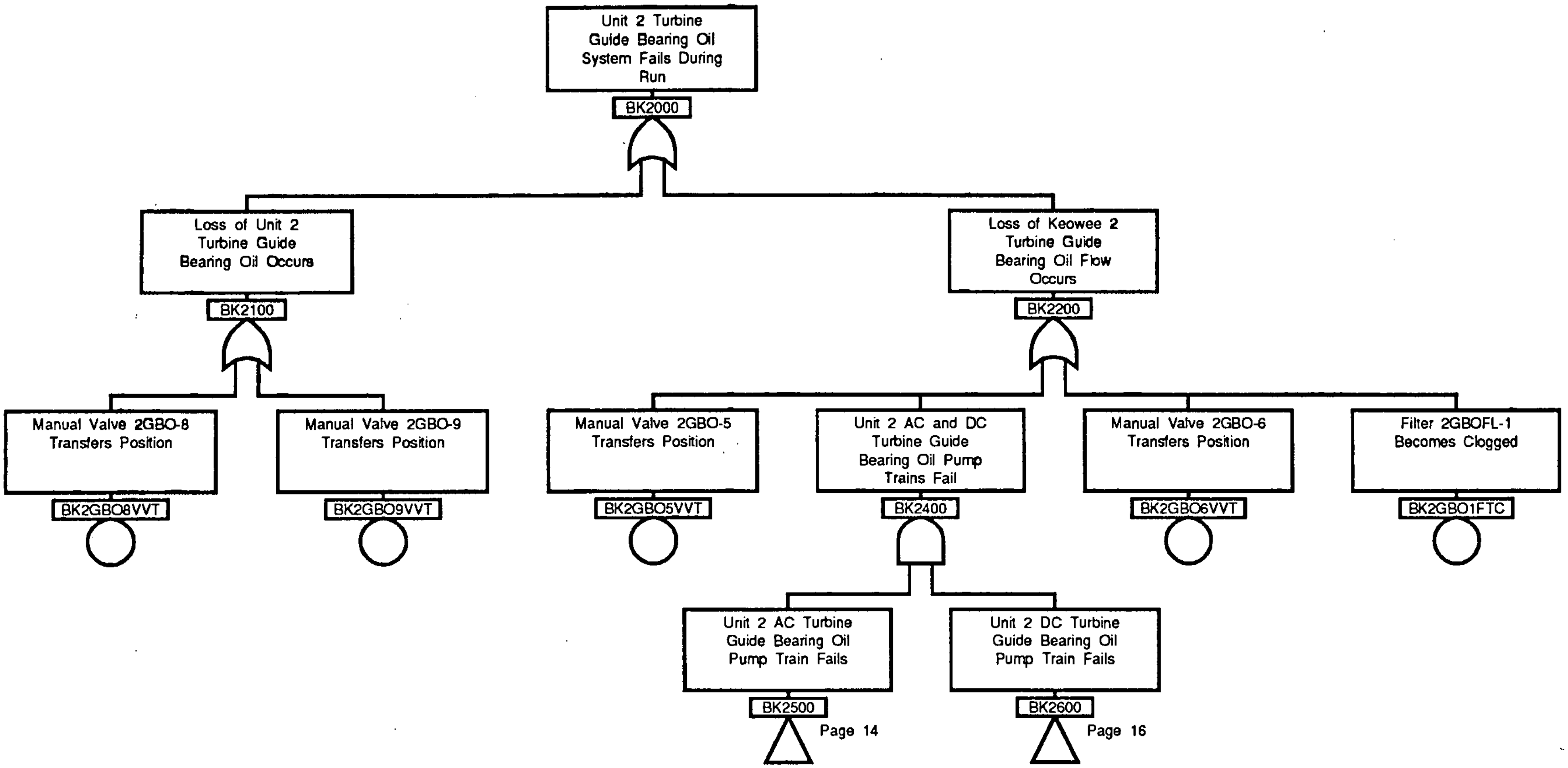
Guide Bearing Oil System Fault Tree | FIGURE A.12-2 |


Master Relay 4A or
Oil Pump Aux. Relay
88X Run Failure
Occurs
BK1760C
Page 8
Keowee 1 Master Rly
4A Drops Out During
Run
YK1MR4ARUN
Turbine No. 1 GBO
Level Relay 88X
Fails to Remain De-
energized
BK1761C
Page 11

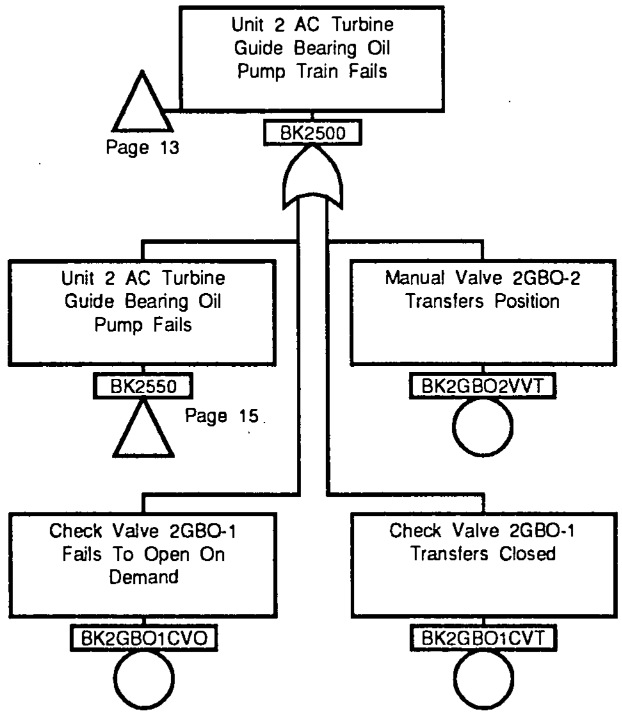


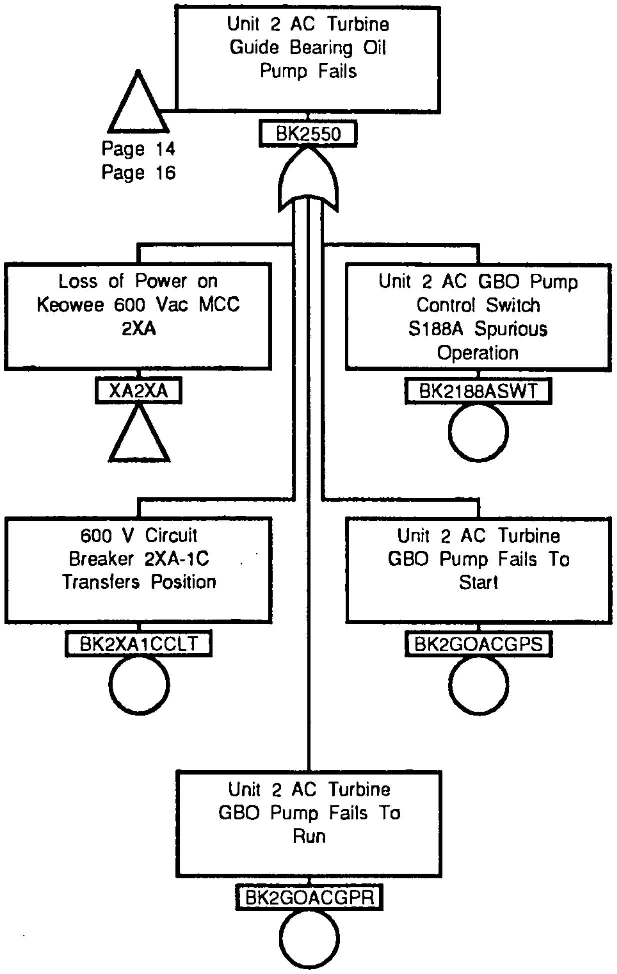
Turbine No. 1 GBO Level Relay 88X Fails to Remain De-energized
BK1761C
Page 10
Keowee 1 Turbine Guide Bearing Oil Relay 88X Spurious Operation
BK1088XRYT
Turbine No. 1 Bearing Oil Level Switch 63TA Spurious Operation
BK163TALST
2
Keowee 1 GBO Level Relay 63TA/1X Spurious Operation
BK1631XRYT

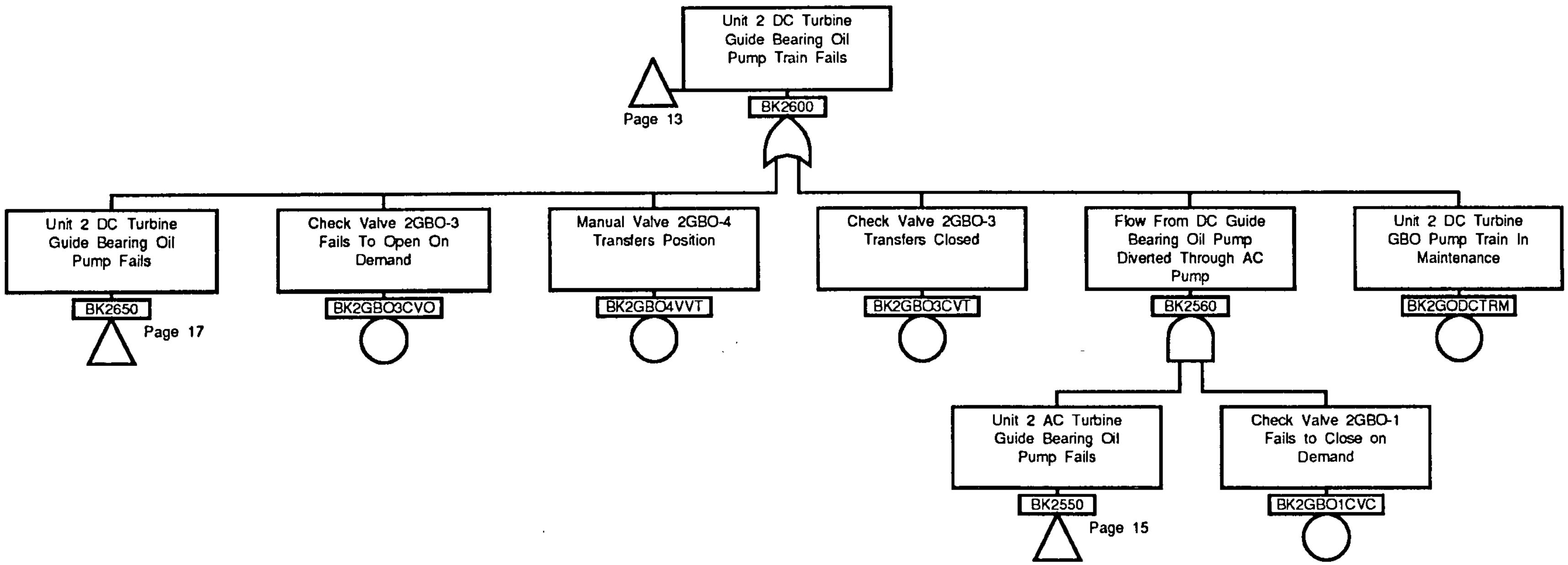

Keowee 1 Rotation Sensing Aux. Relay 14DX Fails to Energize
BK1661B
Keowee 1 Rotation Sensing Aux. Relay 14DX Fails to Energize
BK114DXRYD
Keowee 1 Speed Switch 14/2 Fails On Demand
BK114/2SSD
Keowee 1 Rotation Sensing Timer 14T2 Fails to De-energize
BK114T2RYD



Guide Bearing Oil System Fault Tree | FIGURE A.12-2 |


Unit 2 AC Turbine Guide Bearing Oil Pump Train Fails
BK2500
Page 13
Unit 2 AC Turbine Guide Bearing Oil Pump Fails
BK2550
Page 15
Manual Valve 2GBO-2 Transfers Position
BK2GBO2VVT
Check Valve 2GBO-1 Fails To Open On Demand
BK2GBO1CVO
Check Valve 2GBO-1 Transfers Closed
BK2GBO1CVT


Unit 2 AC Turbine Guide Bearing Oil Pump Fails
BK2550
Page 14
Page 16
Loss of Power on Keowee 600 Vac MCC 2XA
XA2XA
Unit 2 AC GBO Pump Control Switch S188A Spurious Operation
BK2188ASWT
600 V Circuit Breaker 2XA-1C Transfers Position
BK2XA1CCLT
Unit 2 AC Turbine GBO Pump Fails To Start
BK2GOACGPS
Unit 2 AC Turbine GBO Pump Fails To Run
BK2GOACGPR


Unit 2 DC Turbine Guide Bearing Oil Pump Train Fails
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Unit 2 DC Turbine Guide Bearing Oil Pump Fails
BK2650
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BK2GBO4VVT
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BK2560
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BK2GODCTRM
Unit 2 AC Turbine Guide Bearing Oil Pump Fails
BK2550
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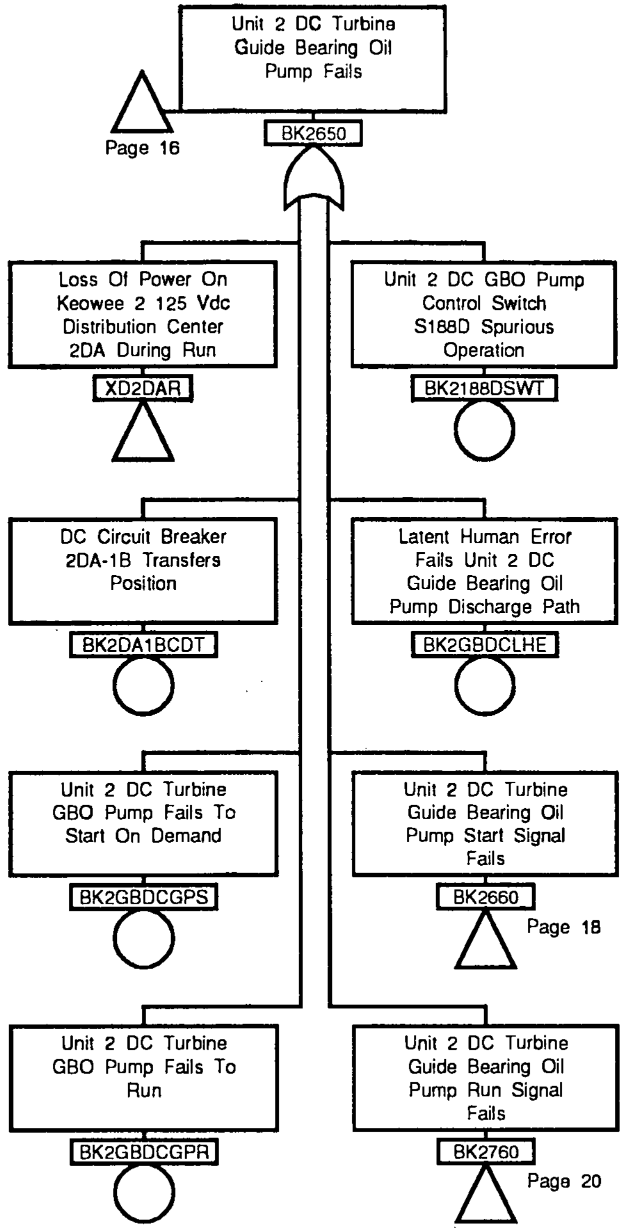
BK2GBO1CVC



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BK2GBDCGPR
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BK2760
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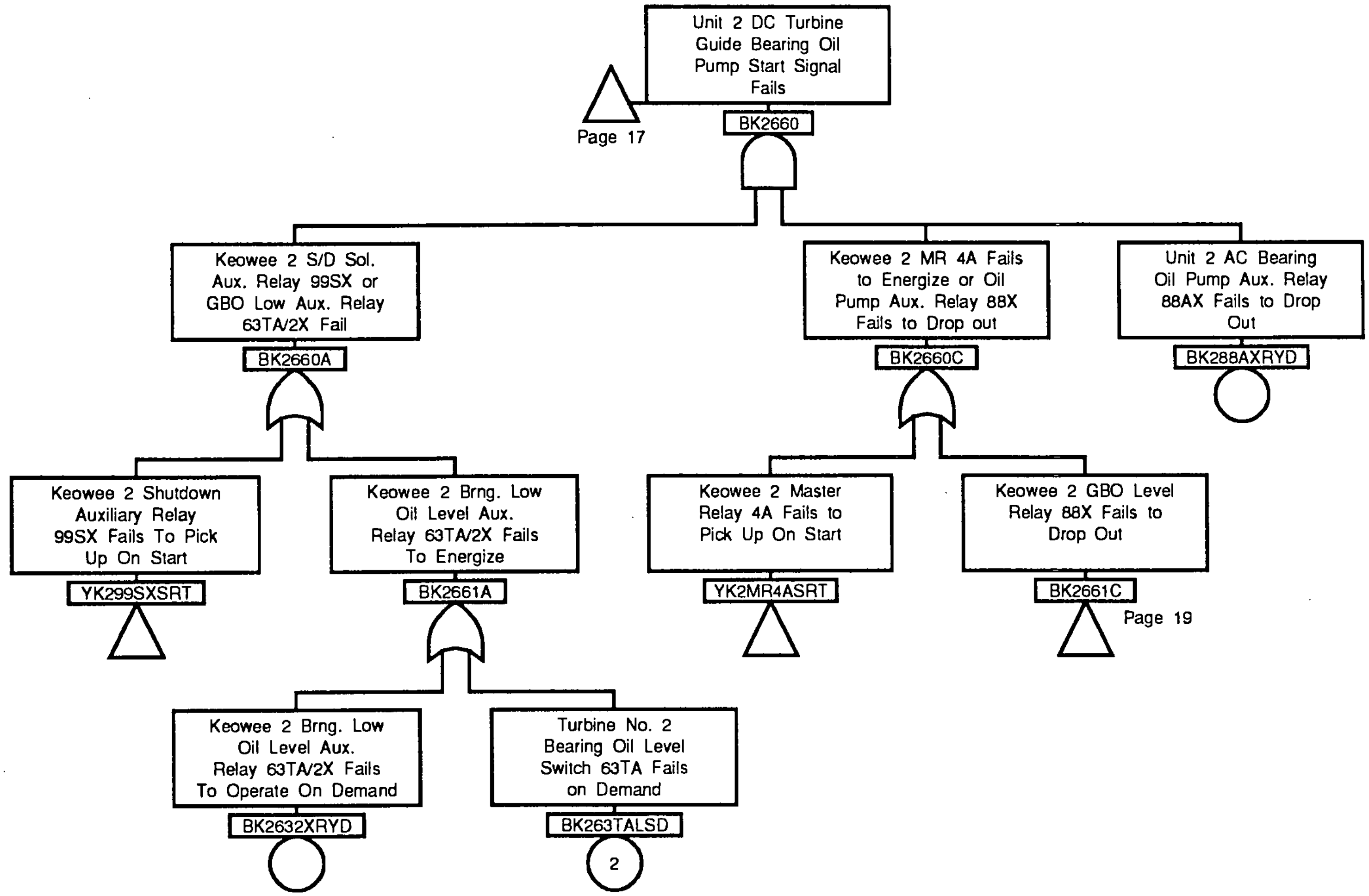
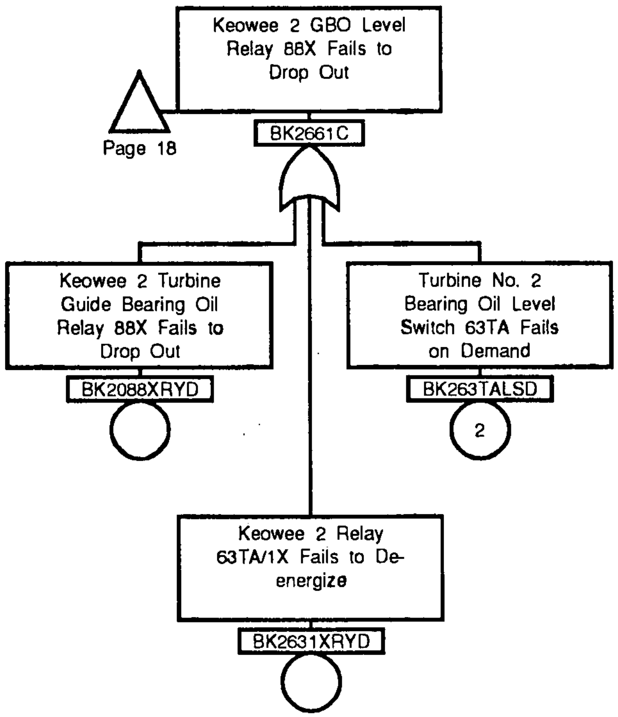
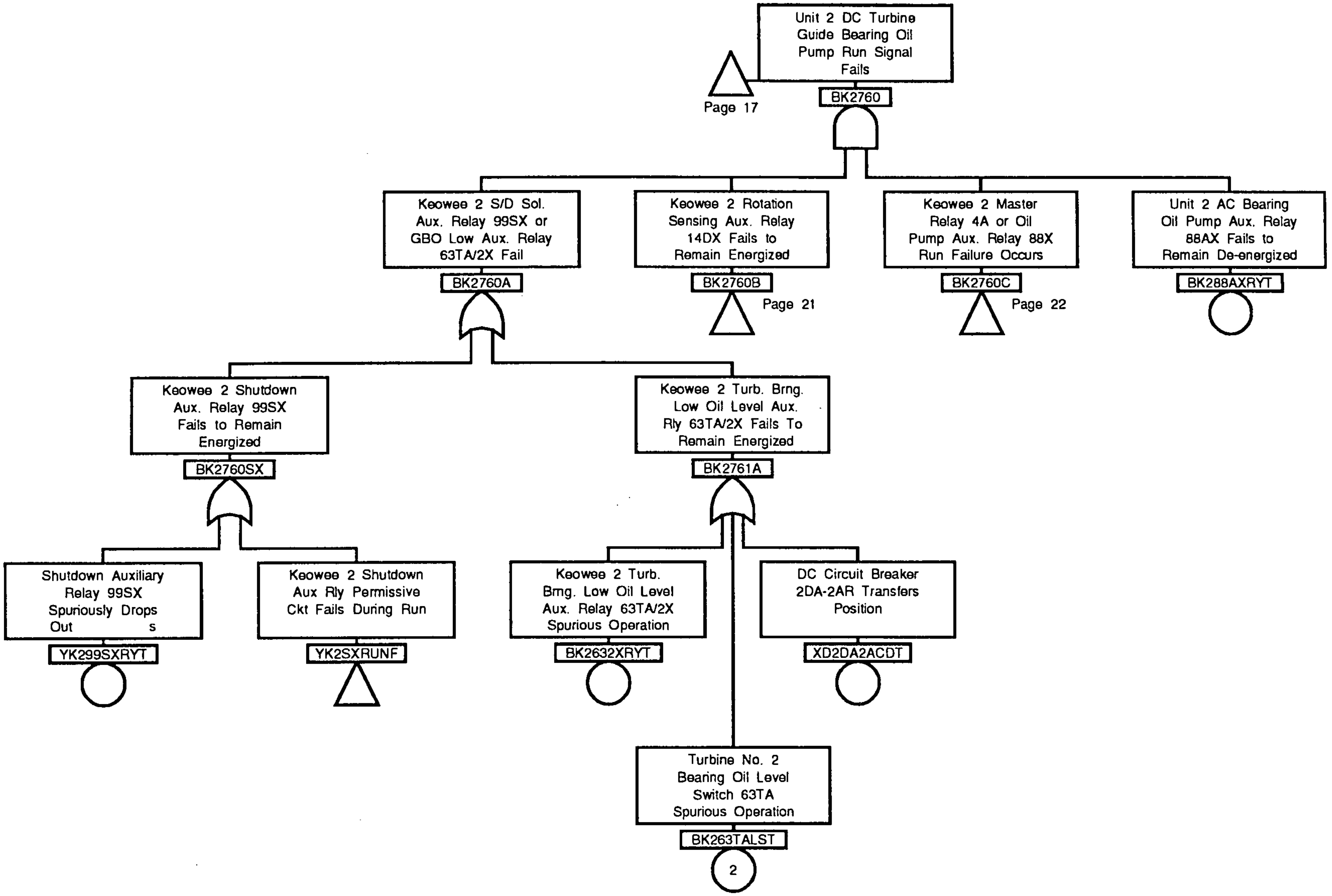


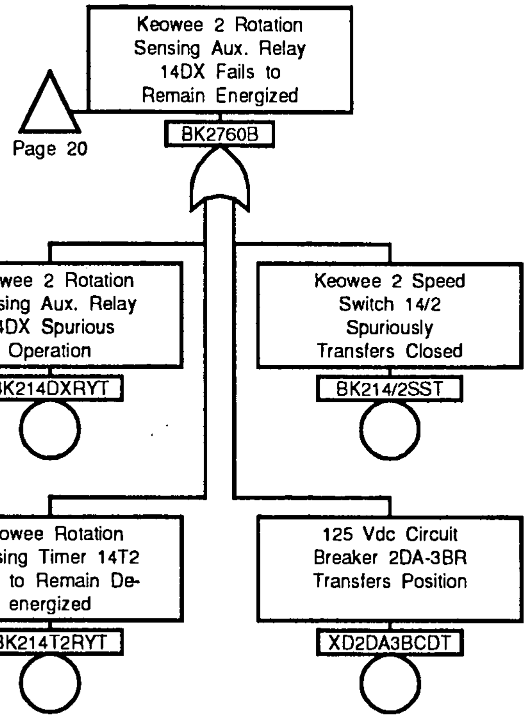
Guide Bearing Oil System Fault Tree	FIGURE A.12-2	Page 18



Guide Bearing Oil System Fault Tree | FIGURE A.12-2 |



Guide Bearing Oil System Fault Tree | FIGURE A.12-2 |


Keowee 2 Rotation Sensing Aux. Relay 14DX Fails to Remain Energized
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BK214DXRYT
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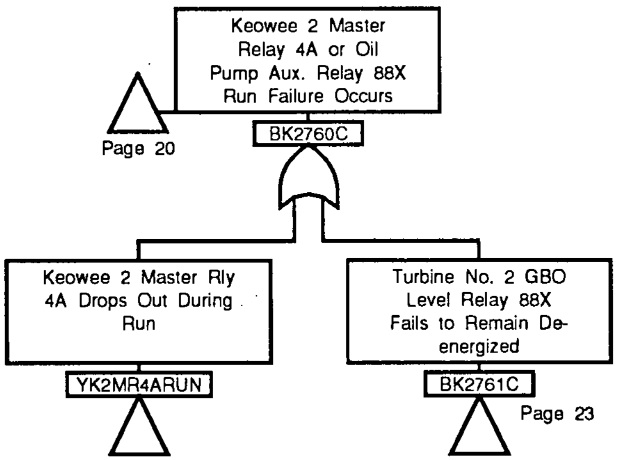
Keowee Rotation Sensing Timer 14T2 Fails to Remain De-energized
BK214T2RYT
125 Vdc Circuit Breaker 2DA-3BR Transfers Position
XD2DA3BCDT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Turbine No. 2 GBO Level Relay 88X Fails to Remain De-energized
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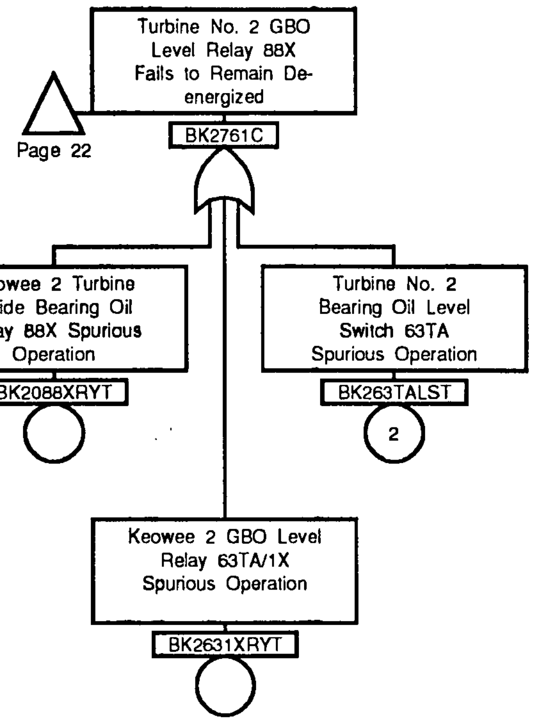
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Turbine No. 2 Bearing Oil Level Switch 63TA Spurious Operation
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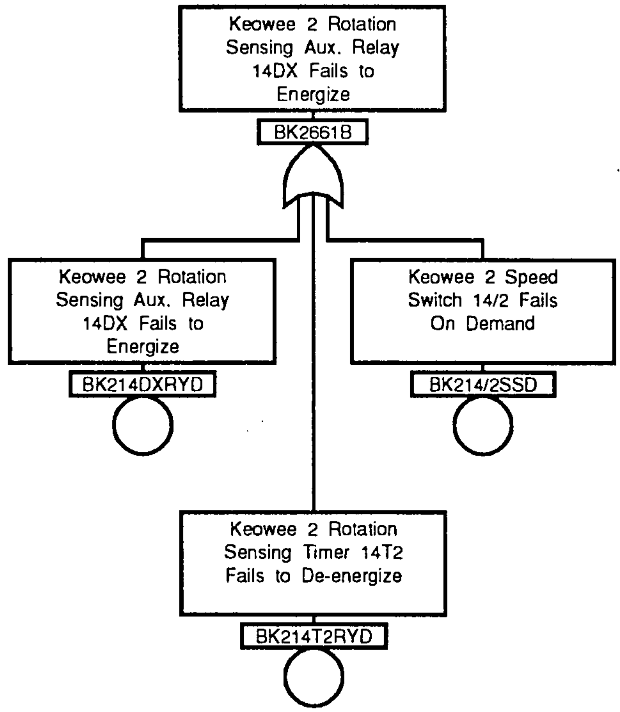
2
Keowee 2 GBO Level Relay 63TA/1X Spurious Operation
BK2631XRYT


Keowee 2 Rotation Sensing Aux. Relay 14DX Fails to Energize
BK2661B
Keowee 2 Rotation Sensing Aux. Relay 14DX Fails to Energize
BK214DXRYD
Keowee 2 Speed Switch 14/2 Fails On Demand
BK214/2SSD
Keowee 2 Rotation Sensing Timer 14T2 Fails to De-energize
BK214T2RYD

Gate/Event Name	Page	Zone	Gate/Event Name	Page	Zone	Gate/Event Name	Page	Zone	Gate/Event Name	Page	Zone
BK1000	1		BK1661C	6		BK2100	13		BK2760	20	
BK1088XRYD	7		BK1661C	7		BK214/2SSD	24		BK2760A	20	
BK1088XRYT	11		BK1760	5		BK214/2SST	21		BK2760B	20	
BK1100	1		BK1760	8		BK214DXRYD	24		BK2760B	21	
BK114/2SSD	12		BK1760A	8		BK214DXRYT	21		BK2760C	20	
BK114/2SST	9		BK1760B	8		BK214T2RYD	24		BK2760C	22	
BK114DXRYD	12		BK1760B	9		BK214T2RYT	21		BK2760SX	20	
BK114DXRYT	9		BK1760C	8		BK2188ASWT	15		BK2761A	20	
BK114T2RYD	12		BK1760C	10		BK2188DSWT	17		BK2761C	22	
BK114T2RYT	9		BK1760SX	8		BK2200	13		BK2761C	23	
BK1188ASWT	3		BK1761A	8		BK2400	13		BK288AXRYD	18	
BK1188DSWT	5		BK1761C	10		BK2500	13		BK288AXRYT	20	
BK1200	1		BK1761C	11		BK2500	14		BK2DA1BCDT	17	
BK1400	1		BK188AXRYD	6		BK2550	14		BK2GBDCGPR	17	
BK1500	1		BK188AXRYT	8		BK2550	15		BK2GBDCGPS	17	
BK1500	2		BK1DA5BCDT	5		BK2550	16		BK2GBDCLHE	17	
BK1550	2		BK1GBDCGPR	5		BK2560	16		BK2GBO1CVC	16	
BK1550	3		BK1GBDCGPS	5		BK2600	13		BK2GBO1CVO	14	
BK1550	4		BK1GBDCLHE	5		BK2600	16		BK2GBO1CVT	14	
BK1560	4		BK1GBO1CVC	4		BK2631XRYD	19		BK2GBO1FTC	13	
BK1600	1		BK1GBO1CVO	2		BK2631XRYT	23		BK2GBO2VVT	14	
BK1600	4		BK1GBO1CVT	2		BK2632XRYD	18		BK2GBO3CVO	16	
BK1631XRYD	7		BK1GBO1FTC	1		BK2632XRYT	20		BK2GBO3CVT	16	
BK1631XRYT	11		BK1GBO2VVT	2		BK263TALSD	18		BK2GBO4VVT	16	
BK1632XRYD	6		BK1GBO3CVO	4		BK263TALSD	19		BK2GBO5VVT	13	
BK1632XRYT	8		BK1GBO3CVT	4		BK263TALST	20		BK2GBO6VVT	13	
BK163TALSD	6		BK1GBO4VVT	4		BK263TALST	23		BK2GBO8VVT	13	
BK163TALSD	7		BK1GBO5VVT	1		BK2650	16		BK2GBO9VVT	13	
BK163TALST	8		BK1GBO6VVT	1		BK2650	17		BK2GOACGPR	15	
BK163TALST	11		BK1GBO8VVT	1		BK2660	17		BK2GOACGPS	15	
BK1650	4		BK1GBO9VVT	1		BK2660	18		BK2GODCTRM	16	
BK1650	5		BK1GOACGPR	3		BK2660A	18		BK2XA1CCLT	15	
BK1660	5		BK1GOACGPS	3		BK2660C	18		XA1XA	3	
BK1660	6		BK1GODCTRM	4		BK2661A	18		XA2XA	15	
BK1660A	6		BK1XA1CCLT	3		BK2661B	24		XD1DA3BCDT	9	
BK1660C	6		BK2000	13		BK2661C	18		XD1DA4ACDT	8	
BK1661A	6		BK2088XRYD	19		BK2661C	19		XD1DAR	5	
BK1661B	12		BK2088XRYT	23		BK2760	17		XD2DA2ACDT	20	

Gate/Event Name	Page	Zone	Gate/Event Name	Page	Zone	Gate/Event Name	Page	Zone	Gate/Event Name	Page	Zone
XD2DA3BCDT	21										
XD2DAR	17										
YK199SXRYT	8										
YK199SXSRT	6										
YK1MR4ARUN	10										
YK1MR4ASRT	6										
YK1SXRUNF	8										
YK299SXRYT	20										
YK299SXSRT	18										
YK2MR4ARUN	22										
YK2MR4ASRT	18										
YK2SXRUNF	20										

APPENDIX A.13
TURBINE SUMP SYSTEM

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A.13 TURBINE SUMP (TS) SYSTEM

A.13.1 OBJECTIVES

The main objective of this analysis is to develop a logic model of the Turbine Sump (TS) System. This model is combined with the high-level model and remaining system models to form an integrated model for assessing the reliability of Keowee. Other objectives are to identify major contributors to system unreliability, significant potential human errors and common cause failure modes.

The scope of this analysis is limited to TS equipment required to support a Keowee emergency start and load run. The analysis assumes a loss of offsite power has occurred, so that Keowee Auxiliary AC Power is not available during the start.

A.13.2 SYSTEM DESIGN

Whenever Keowee's intake structure is open, cooling water is supplied to each unit's turbine shaft packing. The water cools and lubricates the packing and then flows into the draft tube or turbine sump. Water also leaks from the spiral case through the turbine packing box and into the turbine sump. The function of the Turbine Sump (TS) System is to pump water from the turbine sump to a drain header.

As shown in Figure A.13-1, the system consists of an ac and dc pump train, both aligned to take suction from the basement of the turbine's inner head cover and discharge to a drain header. A spare ac pump is also installed. However, it is not modeled since power cables need to be removed from the normal ac pump and connected to the spare prior to its use.

Success of the TS System requires either the ac or dc TS pump train to remove leakage, and requires the Turbine Packing Box and packing itself to maintain integrity.

A.13.3 SYSTEM BOUNDARIES

Cooling Water System

Cooling water to the Turbine Packing Box is provided by the Cooling Water (WL) System.

Electrical Power Supplies

The Keowee Auxiliary AC Power System provides power to the Unit 1 and 2 TS ac pumps via 600 V ac motor control centers 1XA and 2XA, respectively. The Keowee Auxiliary DC Power System provides power to the Unit 1 and 2 TS dc pumps from 125 V dc distribution centers 1DA and 2DA, respectively. The power supplies for the modeled components are listed in Table A.13-1.

A.13.4 INSTRUMENTATION AND CONTROLS

Turbine Sump System control is accomplished automatically by two float switches. Float switch 63SA closes when turbine sump level reaches 6" to start the TS ac pump. Float switch 63SB closes if turbine sump level reaches 9" to start the TS dc pump.

Note: The electrical elementaries use the device names 63SA and 63SB for referring to level switches TSLS-1 and TSLS-2, respectively.

A.13.5 LOCATION WITHIN THE PLANT

This system is located in the Turbine Wheel Pit, an elevation of approximately 670'.

A.13.6 NORMAL OPERATION

The TS System is initiated by float switches. The ac pump is actuated at a water level of 6", the backup dc pump at a level of 9". The ac pump normally starts every two minutes or so when the unit is running, and every three to four minutes when the unit is shutdown. Each pump runs for about 15 seconds following a start to lower the sump water level to below its float switch setpoint.

A.13.7 PERFORMANCE DURING KEOWEE EMERGENCY OPERATION

TS system operation is the same during normal and emergency operation. However, during an emergency start under blackout conditions, Keowee Auxiliary Power is not available to the TS ac pump.

A.13.8 TEST AND MAINTENANCE

Testing

Each week the dc TS Pump is verified to operate correctly. Annually, the pump float switches are verified to operate within their calibration limits.

The TS system testing requirements are provided in Table A.13-2.

Maintenance

Each month, the turbine sump strainer is cleaned and verified to be free of obstruction. This system maintenance requirement is listed in Table A.13-3.

A.13.9 OPERATING EXPERIENCE

A summary of significant operating events is provided in Table A.13-4.

A.13.10 ASSUMPTIONS

A.13.10.1 SYSTEM DESIGN ASSUMPTIONS

1. During a Keowee run, the turbine requires the Turbine Sump Pump system to remove turbine packing leakage. If leakage were allowed to accumulate, it might reach the turbine guide bearing and degrade bearing operation, resulting in a run failure of Keowee. However, since the system is not required for a Keowee start, start failure of the Turbine Sump Pump system is not modeled.

A.13.10.2 OPERATIONAL ASSUMPTIONS

1. The ac TS pump train is aligned to the turbine sump. Unless in maintenance, the dc TS pump train is also aligned to the turbine sump, and ready to discharge to the drain header.

A.13.10.3 MODELING ASSUMPTIONS

1. A flood in the Wheel Pit produced by turbine packing failure or turbine packing box failure exceeds the removal capacity of the TS system.

A.13.11 FAULT TREE ANALYSIS

A.13.11.1 TOP EVENT SUCCESS CRITERIA

Success of the TS System requires that at least one of the turbine sump pump trains removes water from the turbine sump, and that the turbine shaft packing and packing box maintain integrity.

A.13.11.2 DETAILED FAILURE CRITERIA

1. Failure of the ac and dc turbine sump pump trains leads to the top event.

2. Common cause failure of the TS System leads to the top event.

3. Failure of the turbine shaft packing or packing box to maintain integrity leads to the top event.

A.13.11.3 DESCRIPTION OF FAULT TREE

The TS System fault tree is shown in Figure A.13-2. The Fault Tree Modeling Guidelines (Appendix B) were followed in developing the fault tree. A list of all fault tree transfers is presented in Table A.13-5. Modules were not developed for the Keowee fault trees.

Human reliability analysis was performed as described in Section 5.5 and Appendix C.3. Human events impacting the model are described in Section A.13.11.4.

Common cause analysis was performed as described in Section 5.4 and Appendix C.2. Common cause events impacting the model are described in Section A.13.11.6.

A.13.11.4 HUMAN INTERACTIONS

Human actions by the maintenance technicians or operators can adversely affect TS System reliability. Those events explicitly included in the system fault tree are discussed below.

PK1TSDCLHE, PK2TSDCLHE

These basic events account for the potential of the maintenance technicians or operators to fail to properly restore the dc Turbine Sump Pump following maintenance or weekly testing. Since this pump is likely not to be run again until the next weekly test, there is a possibility that a latent human error exists that will not be discovered until the pump is challenged again, or is required to run over a greater period of time.

A.13.11.5 RELIABILITY DATA

Section 5.3 discusses development of the reliability data. For the base case solution, the plant-specific failure rate data and generic failure rate data were combined using a Bayesian update.

Plant-specific data is used for maintenance events. The following maintenance events are included in the TS System model.

PK1TSDCTRM, PK2TSDCTRM

These events account for maintenance and testing on the ac and dc TS pump trains. For modeling simplicity, all of this unavailability is placed on the dc train. Each pump train is in maintenance or testing for approximately 3 hours per year. Thus, the unavailability ascribed to the dc pump train due to testing or maintenance is:

6 hr / 8760 hr = 6.85E-4.

Plant-specific data is also used for developed events. The following developed events are included in the TS System model.

PK1PACKDEX, PK2PACKDEX

These events account for the failure probability of the turbine shaft packing. Since no packing failures have occurred over the ten year period under consideration, the failure rate is estimated using the following equation, from section 5.3 of the main report:

$$\phi(A) = \frac{0.2275}{T}$$

where $\phi(A)$ = the failure rate of interest
T = exposure time or number of demands.

Then $\phi(A)$ x 24 = {0.2275 / [(Station Availability hrs)(2 packing assemblies)]}(24 hrs)
= {0.2275 / [(87600 - 458.57)(2)]}(24)
= 3.1E-5.

PK1TSACGPR, PK2TSACGPR

These events represent failure of the ac Turbine Sump Pump to start ***or*** run. The large number of starts (720 over a 24 hr period), if combined with the generic pump start failure probability, leads to a failure probability greater than one. Thus the pump run failure rate is used, and the pump is modeled as running continuously, although in actuality it runs about 12.5 % of the time.

As discussed in Section 5.3, consideration of relevant statalarms is part of the process of determining each basic event factor. TS System statalarms are listed in Table A.13-6.

System reliability data is listed in Table A.13-7.

A.13.11.6 COMMON CAUSE ASSESSMENT

PK1ACDCCOM, PK2ACDCCOM

The ac and dc TS pumps share the same maintenance practices, environmental conditions, etc. A failure of both TS pumps leads to a failure of the unit's TS system to operate. Therefore, these common cause events are included in the fault tree to represent these coupling mechanisms on a single unit level.

Common cause failure of both units' TS System is represented in the high-level fault tree by event PK0SUMPCOM. (See Appendix A.1)

A.13.12 RESULTS

Reliability of the TS System is defined as the probability that the system will succeed in supporting Keowee emergency operation (black start plus a 24 hour run). The system model yields a failure probability of approximately 7.6E-5, applicable for each unit. Thus the reliability of each unit's TS system is computed to be 99.99%.

Table A.13-8 lists the dominant minimal cut sets (failure sequences) for the Turbine Sump System. A list of dominant contributors to unavailability is shown in Table A.13-9. The dominant contributor to system unavailability is turbine shaft packing failure (whose failure probability was estimated using the chi-squared approximation, since no failures have occurred). Common cause failure of the TS System is the next highest contributor to system unreliability. Turbine packing box failure is the next highest contributor to system unreliability. Ac Turbine Sump Pump start or run failures, and latent human error associated with the dc Turbine Sump Pump, also contribute slightly to system unreliability.

A.13.13 REFERENCES

A.13.13.1 DOCUMENTS

1. OSS-0245.00-00-1031, Rev. 1, Keowee Mechanical Systems Design Basis Document.

A.13.13.2 PROCEDURES

1. IP/1/A/0400/022, Change 0, Unit No. 1 Magnetrol Model TF-201 Liquid Level Control Switch Calibration.

2. MP/1/A/2000/017, Change 5, Unit No. 1 Turbine And Governor Weekly Preventive Maintenance.

3. MP/1/A/2000/018, Change 4, Unit No. 1 Turbine And Governor Monthly Preventive Maintenance.

A.13.13.3 DRAWINGS

1. KEE-106, Rev. 3, Keowee Development Unit #1, Tabulation, Statalarm List #1SA1, T-G System Condition Alarms.

2. KEE-106-1, Rev. 3, Keowee Development Unit #1, Tabulation, Statalarm List #1SA2, T-G System Running Alarms.

3. KEE-109, Rev. 5, Keowee Hydro Station Unit No. 1, Elementary Diagram, Turbine Controls, Turbine No. 1 Sump Pumps.

4. KEE-206, Rev. 3, Keowee Development Unit #2, Tabulation, Statalarm List #2SA1, T-G System Condition Alarms.

5. KEE-206-1, Rev. 3, Keowee Development Unit #2, Tabulation, Statalarm List #2SA2, T-G System Running Alarms.

6. KEE-209, Rev. 3, Keowee Hydro Station Unit No. 2, Elementary Diagram, Turbine Controls, Turbine No. 2 Sump Pumps.

7. KFD-102A-1.1, , Keowee Hydro Station Unit 1, Flow Diagram Of Turbine Sump System.

8. KFD-102A-2.1, , Keowee Hydro Station Unit 2, Flow Diagram Of Turbine Sump System.

Table A.13-1

Turbine Sump System Power Supplies

Component	Power Supply[1]	Compartment Number
Unit 1 AC TS Pump	600 V ac MCC 1XA	2C
Unit 1 DC TS Pump	125 V dc DC 1DA	5C
Unit 2 AC TS Pump	600 V ac MCC 2XA	2C
Unit 2 DC TS Pump	125 V dc DC 2DA	1C

[1] MCC = Motor Control Center
DC = Distribution Center

Table A.13-2

Turbine Sump System Test Procedures

Procedure	Test Frequency	Description
MP/1/A/2000/017, Unit No. 1 Turbine And Governor Weekly Preventive Maintenance	Weekly	Verify operation of DC Sump Pump.
IP/1/A/0400/022, Unit No. 1 Magnetrol Model TF-201 Liquid Level Control Switch Calibration	Annually	Verify sump pump float switches operate within calibration limits.

Table A.13-3

Turbine Sump System Maintenance Procedures

Procedure	Maintenance Frequency	Description
MP/1/A/2000/018, Unit No. 1 Turbine And Governor Monthly Preventive Maintenance	Monthly	Clean Turbine Sump strainer.

Table A.13-4

Turbine Sump System Significant Operating Events

Date	Unit	Component	Event Summary
10/27/87	1	TS AC Pump float switch	Pump not starting due to float switch being out of calibration. (Note: this event occurred prior to implementation of a calibration program for these switches.)

Table A.13-5

Turbine Sump System Fault Tree Transfers

Transfer Gate Name	Description	Components Supplied
FK1200	WL Fails To Cool Keowee 1 Turbine Packing Box	Wheelpit (potential to flood)
XA1XA	Loss of Power on Keowee 600 V ac MCC 1XA	Unit 1 TS AC Pump
XD1DAR	Loss of Power on Keowee 125 V dc Distribution Center 1DA During Run	Unit 1 TS DC Pump
FK2200	WL Fails To Cool Keowee 2 Turbine Packing Box	Wheelpit (potential to flood)
XA2XA	Loss of Power on Keowee 600 V ac MCC 2XA	Unit 2 TS AC Pump
XD2DAR	Loss of Power on Keowee 125 V dc Distribution Center 2DA During Run	Unit 2 TS DC Pump

Table A.13-6

Turbine Sump System Statalarms (Unit 1)*

Point No.	Alarm	Actuator
1SA1-3	TURB. #1 PKG. BOX WTR. PRESS. LOW	63KX
1SA1-4	TURB. #1 WATER SUMP LEVEL HIGH	63SBX
1SA1-50	UNIT #1 D.C. SUPPLY FAILURE	8SX
1SA2-8	TURB. #1 PKG. BOX TEMP. HIGH	26P2X

*Unit 2 alarms are similar.

Table A.13-7

Turbine Sump System Reliability Data

Event Name	Description	Failure Rate[1]	Factor	Rationale For Factor[2]	Failure Probability
FK1TRHXHXF	Turbine Packing Box Heat Exchanger 1TRHX-1 Fails	6.40E-07 /H	24 H	Rule 1: Sump level and packing box alarms	1.54E-05
FK2TRHXHXF	Turbine Packing Box Heat Exchanger 2TRHX-1 Fails	6.40E-07 /H	24 H	Rule 1: Sump level and packing box alarms	1.54E-05
PK163SALST	Unit 1 AC Turb. Sump Pump Float Switch 63SA Transfers	3.10E-07 /H	30 H	Rule 4; wheelpit inspection during rounds reveals whether or not pump trn. is operating properly	9.30E-06
PK163SBLST	Unit 1 DC Turb. Sump Pump Float Switch 63SB Transfers	3.10E-07 /H	15 H	To determine the DC pump trn. factor, the AC train is assumed to fail after half its exposure time	4.65E-06
PK1ACDCCOM	Common Cause Failure of Unit 1 TS System				2.77E-05
PK1DA5CCDT	125 Vdc Circuit Breaker 1DA-5C Transfers Position	7.50E-08 /H	24 H	Rule 1: Loss of DC Supply Failure alarm	1.80E-06
PK1PACKDEX	Turbine No. 1 Packing Fails				3.10E-05
PK1TS01VVT	Manual Valve 1TS-1 Transfers Position	1.70E-08 /H	30 H	See rationale for PK163SALST	5.10E-07
PK1TS02CVT	Check Valve 1TS-2 Fails to Open or Trans. Closed	1.30E-07 /H	30 H	See rationale for PK163SALST	3.90E-06
PK1TS03VVT	Manual Valve 1TS-3 Transfers Position	1.70E-08 /H	108 H	DC pump train is tested once a week (.5)(1 week) + 24 hrs = 108 hrs	1.84E-06
PK1TS04CVT	Check Valve 1TS-4 Fails to Open or Transfers Closed	1.30E-07 /H	15 H	See rationale for PK163SBLST	1.95E-06
PK1TSACGPR	AC Sump Pump 1TSPU-1 Fails To Start Or Run	1.40E-05 /H	30 H	See rationale for PK163SALST	4.20E-04

Table A.13-7

Turbine Sump System Reliability Data

Event Name	Description	Failure Rate[1]	Factor	Rationale For Factor[2]	Failure Probability
PK1TSDCGPR	DC Sump Pump 1TSPU-2 Fails To Start Or Run	1.40E-05 /H	15 H	See rationale for PK163SBLST	2.10E-04
PK1TSDCLHE	Latent Human Error Fails Turb. No. 1 DC Sump Pump				3.20E-03
PK1TSDCTRM	Turbine No. 1 DC Pump Train In Maint. Or Testing				6.85E-04
PK1XA2CCLT	600 V Circuit Breaker 1XA-2C Transfers Position	9.10E-07/H	30 H	Can transfer anytime during AC pump's exposure time	2.73E-05
PK263SALST	Unit 2 AC Turb. Sump Pump Float Switch 63SA Transfers	3.10E-07 /H	30 H	Factors for Unit 2 are the same as for Unit 1 since the TS system is continually in service.	9.30E-06
PK263SBLST	Unit 2 DC Turb. Sump Pump Float Switch 63SB Transfers	3.10E-07 /H	15 H		4.65E-06
PK2ACDCCOM	Common Cause Failure of Unit 2 TS System				2.77E-05
PK2DA1CCDT	125 Vdc Circuit Breaker 2DA-1C Transfers Position	7.50E-08 /H	24 H		1.80E-06
PK2PACKDEX	Turbine No. 2 Packing Fails				3.10E-05
PK2TS01VVT	Manual Valve 2TS-1 Transfers Position	1.70E-08 /H	30 H		5.10E-07
PK2TS02CVT	Check Valve 2TS-2 Fails to Open or Trans. Closed	1.30E-07 /H	30 H		3.90E-06
PK2TS03VVT	Manual Valve 2TS-3 Transfers Position	1.70E-08 /H	108 H		1.84E-06
PK2TS04CVT	Check Valve 2TS-4 Fails to Open or Trans. Closed	1.30E-07 /H	15 H		1.95E-06
PK2TSACGPR	AC Sump Pump 2TSPU-1 Fails To Start Or Run	1.40E-05 /H	30 H		4.20E-04

Table A.13-7

Turbine Sump System Reliability Data

Event Name	Description	Failure Rate[1]	Factor	Rationale For Factor[2]	Failure Probability
PK2TSDCGPR	DC Sump Pump 2TSPU-2 Fails To Start Or Run	1.40E-05 /H	15 H	Factors for Unit 2 are the same as for Unit 1 since the TS system is continually in service.	2.10E-04
PK2TSDCLHE	Latent Human Error Fails Turb. No. 2 DC Sump Pump				3.20E-03
PK2TSDCTRM	Turbine No. 2 DC Pump Train In Maint. Or Testing				6.85E-04
PK2XA2CCLT	Low Voltage Circuit Breaker 2XA-2C Transfers	9.10E-07/H	30 H		2.73E-05

[1] D = Demand, H = Hour

[2] Rules for assigning basic event factors are discussed in Table C.1-4.

Table A.13-8

Turbine Sump System Dominant Minimal Cutsets

Cutsets For Gate PK12000: Keowee Unit 1 Turb. Sump Pump Fails to Remove Leakage During Keowee Run

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
1)	3.10E-05	40.8	PK1PACKDEX	3.10E-05	Turbine No. 1 Packing Fails
2)	2.77E-05	36.4	PK1ACDCCOM	2.77E-05	Common Cause Failure of Unit 1 Turbine Sump Pump System
3)	1.06E-05	20.3	FK1TRHXHXF	1.06E-05	Turbine Packing Box Heat Exchanger 1TRHX-1 Fails
4)	1.34E-06	1.8	PK1TSACGPR PK1TSDCLHE	4.20E-04 3.20E-03	AC Sump Pump 1TSPU-1 Fails To Start Or Run Latent Human Error Fails Turbine No. 1 DC Sump Pump
5)	2.88E-07	0.4	PK1TSACGPR PK1TSDCTRM	4.20E-04 6.85E-04	AC Sump Pump 1TSPU-1 Fails To Start Or Run Turbine No. 1 DC Pump Train In Maintenance Or Testing
6)	8.82E-08	0.1	PK1TSACGPR PK1TSDCGPR	4.20E-04 2.10E-04	AC Sump Pump 1TSPU-1 Fails To Start Or Run DC Sump Pump 1TSPU-2 Fails To Start Or Run
7)	8.74E-08	0.1	PK1TSDCLHE PK1XA2CCLT	3.20E-03 2.73E-05	Latent Human Error Fails Turbine No. 1 DC Sump Pump 600 V Circuit Breaker 1XA-2C Transfers Position

Table A.13-8

Turbine Sump System Dominant Minimal Cutsets

Cutsets For Gate PK12000: Keowee Unit 1 Turb. Sump Pump Fails to Remove Leakage During Keowee Run

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
8)	2.98E-08	0.0	PK163SALST	9.30E-06	Unit 1 AC Turbine Sump Pump Float Switch 63SA Fails
			PK1TSDCLHE	3.20E-03	Latent Human Error Fails Turbine No. 1 DC Sump Pump
9)	1.87E-08	0.0	PK1TSDCTRM	6.85E-04	Turbine No. 1 DC Pump Train In Maintenance Or Testing
			PK1XA2CCLT	2.73E-05	600 V Circuit Breaker 1XA-2C Transfers Position
10)	1.25E-08	0.0	PK1TS02CVT	3.90E-06	Check Valve 1TS-2 Fails to Open or Transfers Closed
			PK1TSDCLHE	3.20E-03	Latent Human Error Fails Turbine No. 1 DC Sump Pump

Total: 7.6E-05

Table A.13-9

Turbine Sump System Dominant Contributors To Unavailability

Rank	Event Description	Mean Unavailability[1]	Approximate Unavailability Contribution[2]
1	PK1PACKDEX - Turbine No. 1 Packing Fails	3.10E-05	40.8%
2	PK1ACDCCOM - Common Cause Failure of Unit 1 TS Pump System	2.77E-05	36.5%
3	FK1TRHXHXF - Turbine Packing Box Heat Exchanger 1TRHX-1 Fails	1.54E-05	20.3%
4	PK1TSACGPR - AC Sump Pump 1TSPU-1 Fails to Start or Run	1.72E-06	2.3%
5	PK1TSDCLHE - Latent Human Error Fails Turbine No. 1 DC Sump Pump	1.47E-06	1.9%

[1] Mean unavailability is defined as the summation of the values of all cut sets in which the event appears.

[2] The contribution to unavailability is calculated by dividing the mean unavailability by the overall system unavailability and then multiplying by 100 percent.

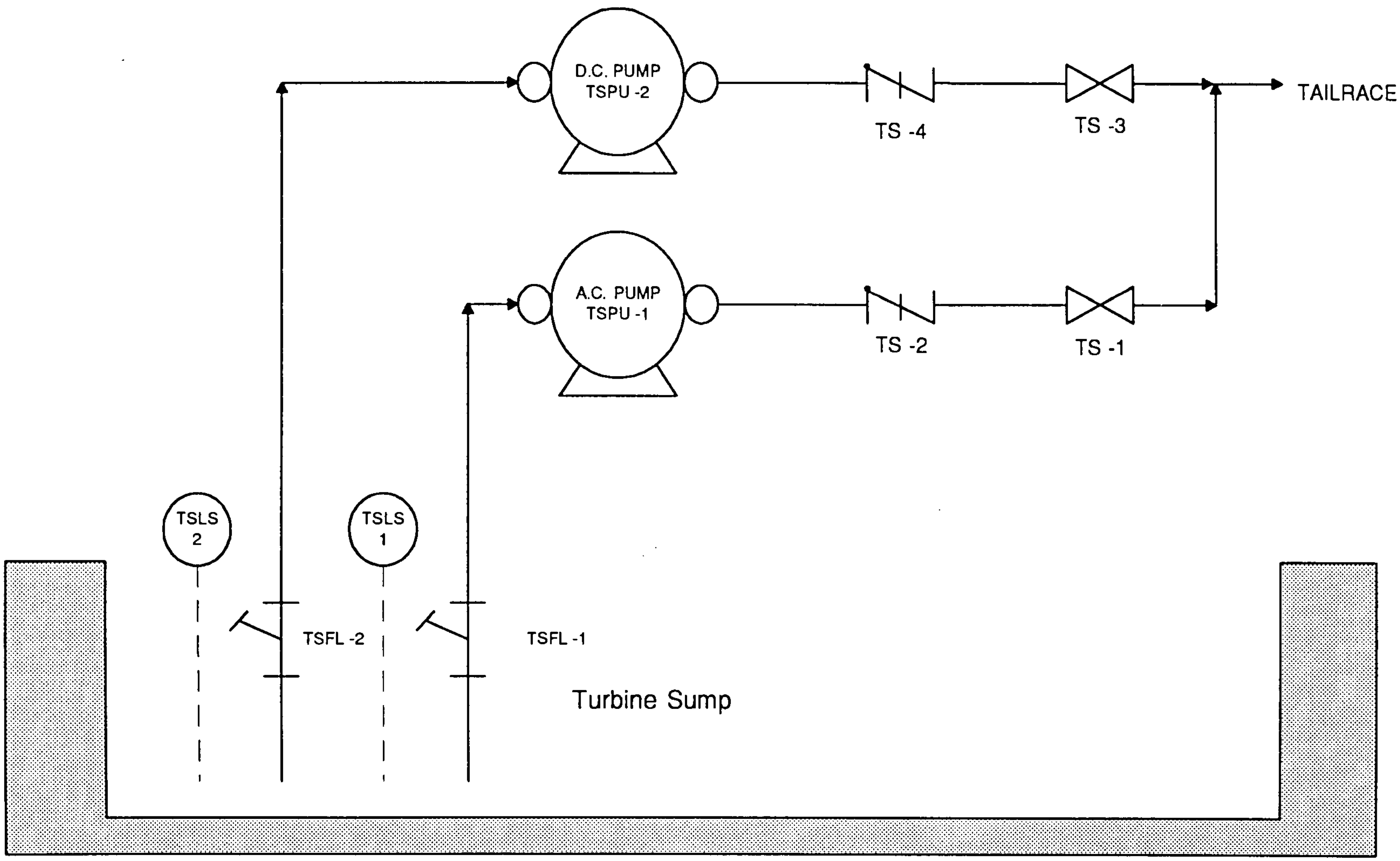
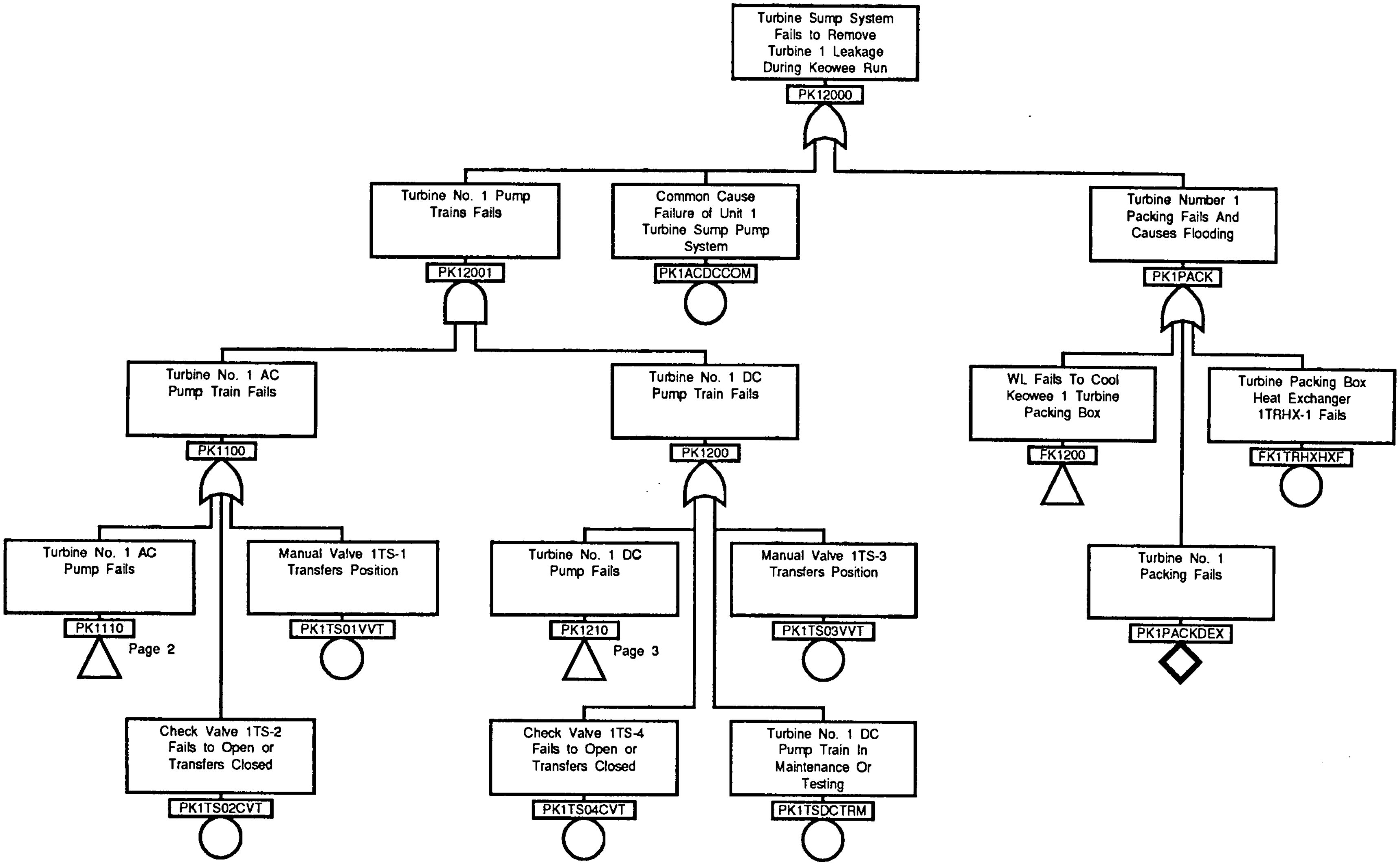
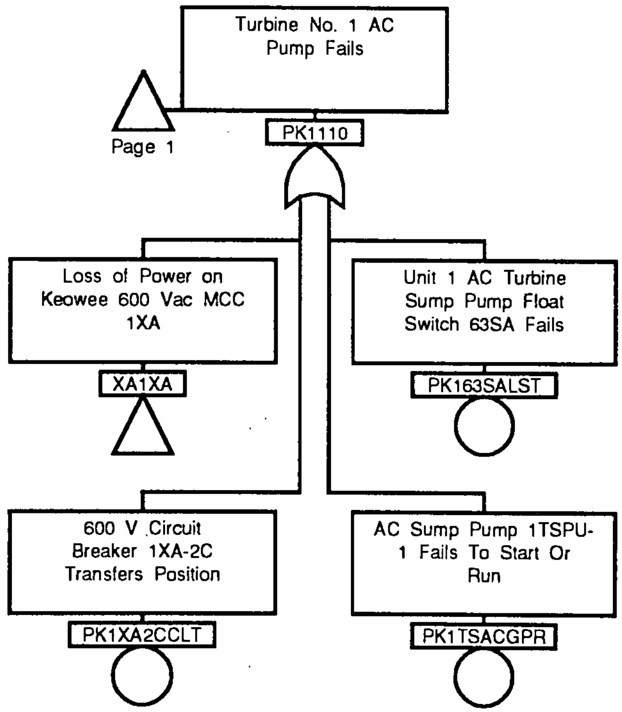


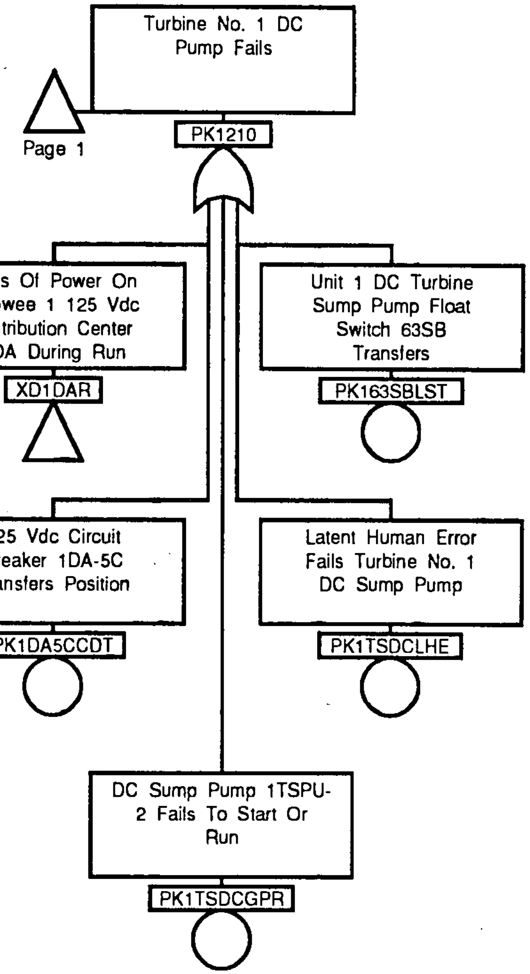
Figure A.13-1 Simplified Flow Diagram of The Turbine Sump Pump System



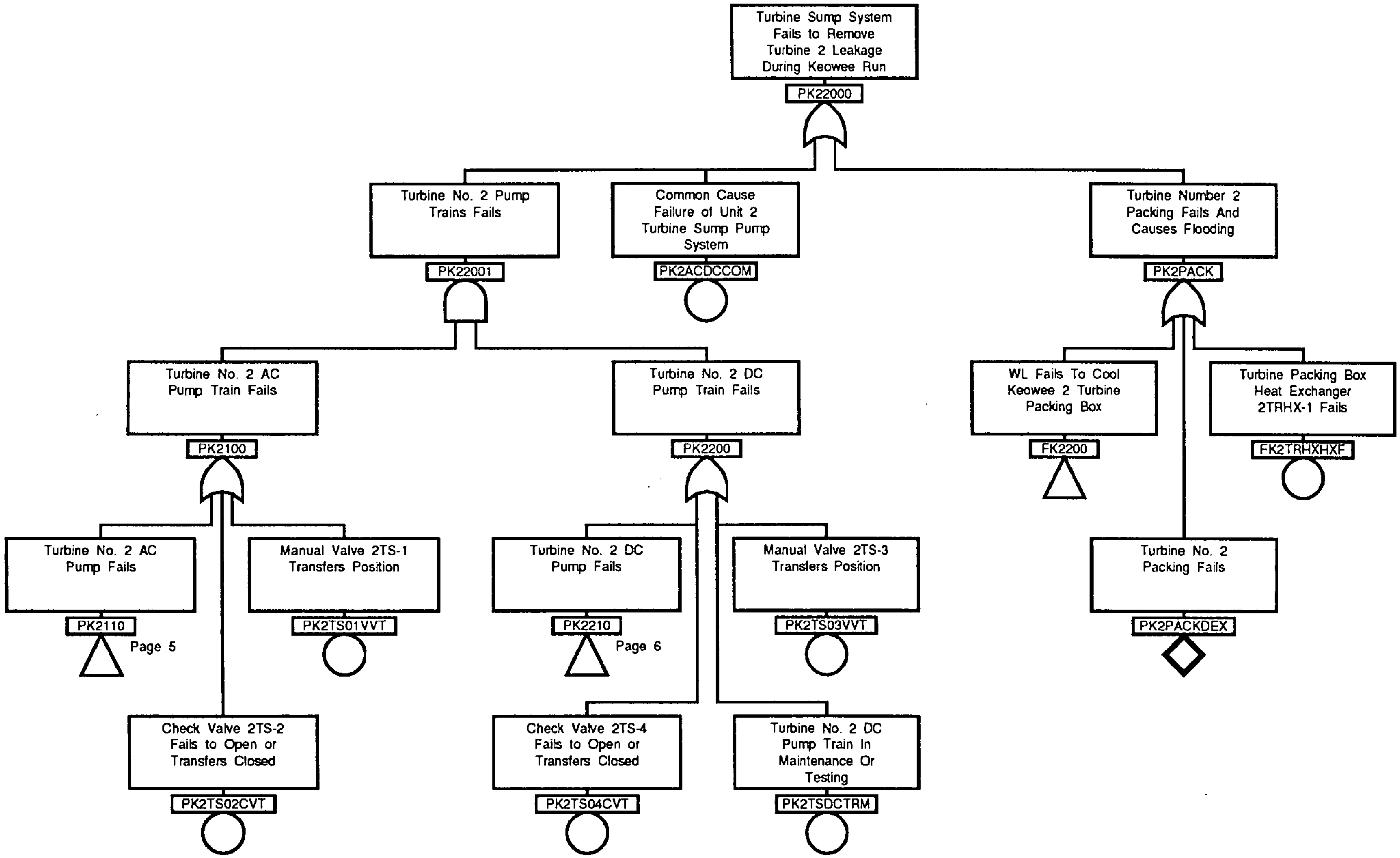
Turbine Sump System Fails to Remove Turbine 1 Leakage During Keowee Run
PK12000
Turbine No. 1 Pump Trains Fails
PK12001
Common Cause Failure of Unit 1 Turbine Sump Pump System
PK1ACDCCOM
Turbine Number 1 Packing Fails And Causes Flooding
PK1PACK
Turbine No. 1 AC Pump Train Fails
PK1100
Turbine No. 1 DC Pump Train Fails
PK1200
WL Fails To Cool Keowee 1 Turbine Packing Box
FK1200
Turbine Packing Box Heat Exchanger 1TRHX-1 Fails
FK1TRHXHXF
Turbine No. 1 AC Pump Fails
PK1110
Page 2
Manual Valve 1TS-1 Transfers Position
PK1TS01VVT
Turbine No. 1 DC Pump Fails
PK1210
Page 3
Manual Valve 1TS-3 Transfers Position
PK1TS03VVT
Turbine No. 1 Packing Fails
PK1PACKDEX
Check Valve 1TS-2 Fails to Open or Transfers Closed
PK1TS02CVT
Check Valve 1TS-4 Fails to Open or Transfers Closed
PK1TS04CVT
Turbine No. 1 DC Pump Train In Maintenance Or Testing
PK1TSDCTRM



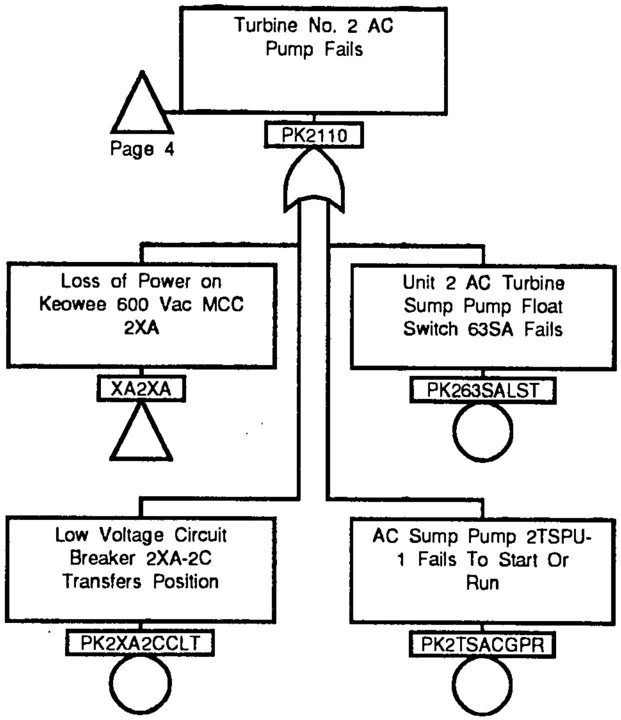
Turbine Sump Pump System Fault Tree | FIGURE A.13-2 |



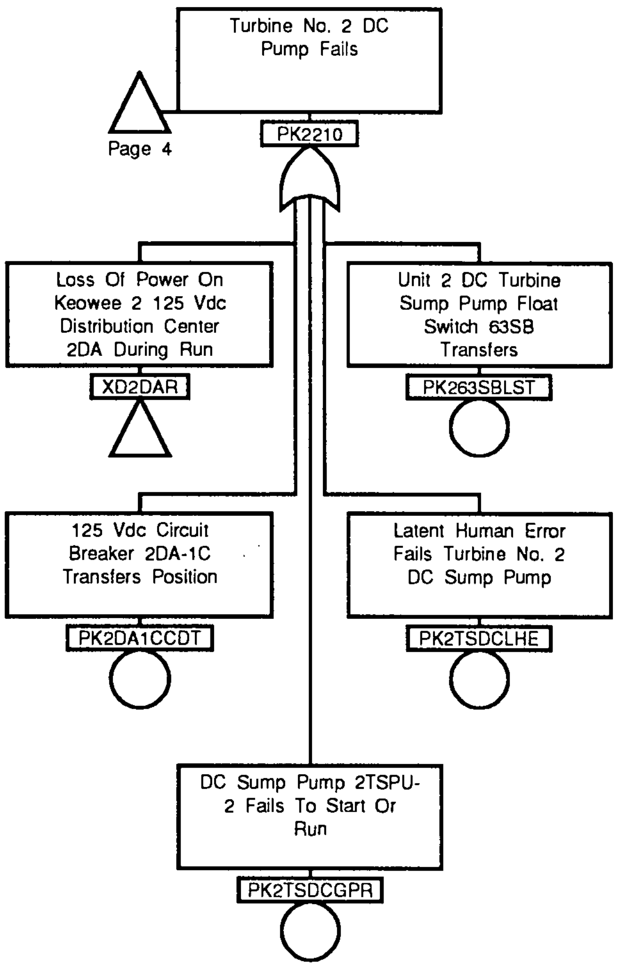
Turbine Sump Pump System Fault Tree | FIGURE A.13-2 |



Turbine Sump Pump System Fault Tree | FIGURE A.13-2 |



Turbine Sump Pump System Fault Tree | FIGURE A.13-2 |



Turbine Sump Pump System Fault Tree | FIGURE A.13-2 |

Gate/Event Name	Page	Zone	Gate/Event Name	Page	Zone	Gate/Event Name	Page	Zone	Gate/Event Name	Page	Zone
FK1200	1		PK2DA1CCDT	6							
FK1TRHXHXF	1		PK2PACK	4							
FK2200	4		PK2PACKDEX	4							
FK2TRHXHXF	4		PK2TS01VVT	4							
PK1100	1		PK2TS02CVT	4							
PK1110	1		PK2TS03VVT	4							
PK1110	2		PK2TS04CVT	4							
PK1200	1		PK2TSACGPR	5							
PK12000	1		PK2TSDCGPR	6							
PK12001	1		PK2TSDCLHE	6							
PK1210	1		PK2TSDCTRM	4							
PK1210	3		PK2XA2CCLT	5							
PK163SALST	2		XA1XA	2							
PK163SBLST	3		XA2XA	5							
PK1ACDCCOM	1		XD1DAR	3							
PK1DA5CCDT	3		XD2DAR	6							
PK1PACK	1										
PK1PACKDEX	1										
PK1TS01VVT	1										
PK1TS02CVT	1										
PK1TS03VVT	1										
PK1TS04CVT	1										
PK1TSACGPR	2										
PK1TSDCGPR	3										
PK1TSDCLHE	3										
PK1TSDCTRM	1										
PK1XA2CCLT	2										
PK2100	4										
PK2110	4										
PK2110	5										
PK2200	4										
PK22000	4										
PK22001	4										
PK2210	4										
PK2210	6										
PK263SALST	5										
PK263SBLST	6										
PK2ACDCCOM	4										

APPENDIX A.14
COOLING WATER (WL) SYSTEM

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A.14 COOLING WATER (WL) SYSTEM

A.14.1 OBJECTIVES

The main objective of this analysis is to develop a logic model of the Cooling Water (WL) System. This model is combined with the high-level model and remaining system models to form an integrated model for assessing the reliability of Keowee. Other objectives are to identify major contributors to system unreliability, significant potential human errors and common cause failure modes.

The scope of this analysis is limited to WL equipment required to support a Keowee emergency start and load run.

A.14.2 SYSTEM DESIGN

A.14.2.1 OVERVIEW

The WL system provides cooling to three loads required for emergency operation:

1. the Turbine Packing Box,
2. eight Generator Thrust Bearing Oil Coolers, and
3. six Generator Air Coolers.

Figure A.14-1 provides a diagram of the WL system as analyzed. Water enters Keowee through the Intake Structure and gravity flows down the power tunnel to each units' penstock. Water then gravity flows through an opening in the unit 1 penstock to locked-open manual valve 0WL-1, then divides to supply each Keowee unit. If the Intake Structure is open, cooling water is supplied to the Turbine Packing Box, since the piping to this load branches off of the main header upstream of the Cooling Water Control valve, WL-11. WL-11 opens on unit start to supply the generator coolers.

A.14.2.2 FILTERING

Cooling water is first filtered at the Intake Structure by eight trash racks, equally spaced along the structure's perimeter. Openings in the trash racks are various sizes, up to a

maximum of approximately 6" x 28". Cooling water is next filtered as it passes from the unit 1 penstock to the 12" supply line through a grate with approximately 3" openings.

Cooling water to all plant loads next passes through filter WLFL-1, which has opening sizes of approximately 1/4". Cooling water to the Generator Thrust Bearing Coolers and Generator Air Coolers is not further filtered. However, water to the Turbine Packing Box passes through filter WLFL-2, which has a finer mesh strainer than does WLFL-1.

A.14.3 SYSTEM BOUNDARIES

Electrical Power Supplies

Control power is furnished to the Unit 1 and 2 WL Control valve solenoid and control relays from 125 V dc distribution centers 1DA and 2DA, respectively. The power supplies for the modeled components are listed in Table A.14-1.

Other System Boundaries

Logic for Rotation-Sensing Aux. Relay 14DX is taken from the Turbine Guide Bearing Oil System fault tree (Appendix A.12).

A.14.4 INSTRUMENTATION AND CONTROLS

Control switches for the cooling water control valve, WL-11, are located on Electrical Control Boards CB2 (unit 1) and CB9 (unit 2) in the Keowee Control Room. The switches are normally left in the AUTO position, enabling the valve to open when Master Relay 4B is energized.

WL-11 opens when its solenoid is de-energized by Master Relay 4B. A contact on Rotation-Sensing Relay 14DX opens when turbine rotation is sensed to prevent re-energization of the cooling water control valve solenoid, provided that Turbine Guide Bearing Oil level is satisfactory, as monitored by Oil Pump Aux. Relay 88X.

Note: On the electrical elementary drawings, the cooling water control valve solenoid is represented by its device name, 20G.

A.14.5 LOCATION WITHIN THE PLANT

The 12" WL supply line runs from the unit 1 penstock to the Compressor Gallery, where it splits to supply the various safety-related loads of each unit: the generator air and oil coolers and the turbine packing boxes, as well as the non-safety-related loads: the turbine guide bearing oil coolers, governor air and depressing air aftercoolers, and the HVAC cooling unit.

A.14.6 NORMAL OPERATION

Cooling water to the Turbine Packing Box is normally supplied at all times. On unit start, Cooling Water Control Valve WL-11 opens to supply the Generator Air Coolers and Thrust Bearing Oil Coolers.

Water pressure at the Turbine Packing Box is sensed by pressure transmitter WLPT-1, which will shut the unit down if pressure is less than 6.8 psig. It also signals an alarm at pressures below 17.8 psig. Temperature transmitter TRTT-1 will trip the unit if packing box temperature reaches 104 ^{o}F.

Flow switch WLPS-4 monitors WL flow to the Generator Thrust Bearing Coolers and will signal an alarm and shut down the unit if flow decreases below 125 gpm for 15 minutes.

Flow switch WLPS-3 monitors WL flow to the Generator Air Coolers and will signal an alarm and shut down the unit if flow decreases below 1250 gpm for 15 minutes.

A.14.7 PERFORMANCE DURING KEOWEE EMERGENCY OPERATION

WL system operation is the same during normal and emergency operation. However, the devices mentioned in Section A.14.6 are not permitted to shut the unit down during emergency operation.

A.14.8 TEST AND MAINTENANCE

Testing

A functional test of the WL system is effected each time the unit operates, since failure to cool the Turbine Packing Box, Generator Thrust Bearing Oil Coolers, and Generator Air Coolers is alarmed.

Pressure instruments associated with the WL system are testing on an annual basis, as listed in Table A.14-2.

Maintenance

The WL system maintenance requirements are listed in Table A.14-3.

A.14.9 OPERATING EXPERIENCE

As shown in Table A.14-4, only one event occurred over the ten year period of data consideration pertaining to the WL system model. This event involved a breach of Turbine Guide Bearing Oil Cooler integrity. However, since it involved the discharge of the cooler, unit operation was not affected.

A.14.10 ASSUMPTIONS

A.14.10.1 SYSTEM DESIGN ASSUMPTIONS

None.

A.14.10.2 OPERATIONAL ASSUMPTIONS

1. Cooling Water Control Switch S120G is in the AUTO position.

A.14.10.3 MODELING ASSUMPTIONS

1. Cooling water is not needed for a Keowee start, since failure to supply any of the three safety-related loads during an emergency start does not cause the unit to shut down.

2. System unavailability is captured by unit availability, which is included in the High-Level tree (Appendix A.1).

3. Generator oil and air coolers, and the discharge paths from these coolers, are included in the Generator model (Appendix A.7).

A.14.11 FAULT TREE ANALYSIS

A.14.11.1 TOP EVENT SUCCESS CRITERIA

Success of the WL System requires that Cooling Water Control Valve WL-11 remains open, the Turbine Packing Box functions properly, and the flowpaths to the three safety-related loads remain available.

A.14.11.2 DETAILED FAILURE CRITERIA

1. Failure of valves or filters in the flowpaths to the three safety-related loads leads to WL system failure.

2. Failure of Cooling Water Control Valve WL-11 to open or remain open leads to system failure.

3. Failure of the Turbine Packing Box leads to WL system failure by providing a potential bypass flowpath.

A.14.11.3 DESCRIPTION OF FAULT TREE

The WL System fault tree, shown in Figure A.14-2, contains three top gates for each Keowee unit, corresponding to the failure to cool each of the safety-related loads. Table A.14-6 lists the top gates contained in the tree.

The Fault Tree Modeling Guidelines (Appendix B) were followed in developing the fault tree. A list of all fault tree transfers is presented in Table A.14-5.

Human reliability analysis was performed as described in Section 5.5. Human events impacting the model are described in Section A.14.11.4.

Common cause analysis was performed as described in Section 5.4. Common cause events impacting the model are described in Section A.14.11.5.

A.14.11.4 HUMAN INTERACTIONS

Human actions by the maintenance technicians or operators can adversely affect WL System reliability. Those events explicitly included in the system fault tree are quantified in Appendix C.3 and are discussed below.

FK1120GHE, FK2120GLHE

These basic events account for the potential of the operators to leave the Cooling Water Control Valve control switch in the OFF position.

FK1GBHXLHE, FK2GBHXLHE

These basic events account for the potential to fail to properly restore the Guide Bearing Oil Heat Exchanger following maintenance.

A.14.11.5 RELIABILITY DATA

Section 5.3 discusses development of the reliability data. For the base case solution, the plant-specific failure rate data and generic failure rate data were combined using a Bayesian update.

As discussed in Section 5.3, consideration of relevant statalarms is part of the process of determining each basic event factor. WL System statalarms are listed in Table A.14-7.

System reliability data is listed in Table A.14-8.

A.14.11.6 COMMON CAUSE ASSESSMENT

Each unit's WL System shares the same design, maintenance procedures, operating conditions, environmental conditions, etc., and rely on a common water source, penstock, and manual valve (0WL-1). The following common cause events are included in the high-level tree (Appendix A.1) to represent the most important of these coupling mechanisms:

FK0FISHCOM -- common cause failure of WL-1 filters due to intake debris
FKVALVECOM -- common cause failure of WL Cooling Water Control Valves

Quantification of these events is discussed in Section 5.4 and Appendix C.2.

A.14.12 RESULTS

Reliability of the WL System is defined as the probability that the system will succeed in supporting Keowee emergency operation (black start plus a 24 hour run). The system model yields a failure probability of approximately 3.6E-4 or less for each top gate for units 1 and 2. Thus the reliability of the WL function represented by each top gate is computed to be 99.96% or greater.

Tables A.14-9 through A.14-14 list the dominant minimal cut sets (failure sequences) for each top gate in the Cooling Water System model. A list of dominant contributors to unavailability is shown in Tables A.14-15 through A.14-20. The dominant contributors to the unavailability of the WL System are failure of the Cooling Water Control Valve to open or remain open, clogging of the WL filters, and failure of the turbine packing box heat exchanger.

A.14.13 REFERENCES

A.14.13.1 DOCUMENTS

1. OSS-0245.00-00-1031, Rev. 1, Keowee Mechanical Systems.

A.14.13.2 PROCEDURES

1. IP/1/B/0400/001, Change 2, United Electric Type J302 Pressure Switch Calibration.

2. IP/1/B/0400/002, Change 1, United Electric Type J-6 Pressure Switch Calibration.

3. IP/1/B/0400/003, Change 2, Barton Model 258 Indicating Switch Calibration.

4. IP/1/B/0400/005, Change 2, Moore Model 33 Nullmatic Temperature Transmitter Calibration.

5. MP/1/A/2000/017, Change 5, Unit No. 1 Turbine, Governor, And Generator Preventive Maintenance.

6. MP/1/A/2000/018, Change 4, Unit No. 1 Turbine And Governor Monthly Preventive Maintenance.

7. OP/0/A/2000/043, Change 6, Keowee Shift Turnover And Rounds.

A.14.13.3 DRAWINGS

1. K-66, Rev. 4, Keowee Intake Structure, Trashracks, Layout And Details.

2. KEE-102, Rev. 2, Keowee, Solenoid Valve List, Unit 1.

3. KEE-106, Rev. 3, Keowee Development Unit #1, Tabulation, Statalarm List #1SA1, T-G System Condition Alarms.

4. KEE-106-1, Rev. 3, Keowee Development Unit #1, Tabulation, Statalarm List #1SA2, T-G System Running Alarms.

5. KEE-113-2, Rev. 8, Keowee Hydro Station Unit No. 1, Elementary Diagram, Master Control System, Gen. Miscellaneous Relaying.

6. KEE-202, Rev. 2, Keowee, Solenoid Valve List, Unit 2.

7. KEE-206, Rev. 3, Keowee Development Unit #2, Tabulation, Statalarm List #2SA1, T-G System Condition Alarms.

8. KEE-206-1, Rev. 3, Keowee Development Unit #2, Tabulation, Statalarm List #2SA2, T-G System Running Alarms.

9. KEE-213-2, Rev. 6, Keowee Hydro Station Unit No. 2, Elementary Diagram, Master Control System, Gen. Miscellaneous Relaying.

10. KFD-100A-1.1, Rev. 1, Keowee Hydro Station Unit 1, Flow Diagram Of Turbine Generator Cooling Water System.

11. KFD-100A-2.1, Rev. 1, Keowee Hydro Station Unit 2, Flow Diagram Of Turbine Generator Cooling Water System.

Table A.14-1

Cooling Water System Power Supplies

Component	Power Supply[1]	Compartment Number
Unit 1 Turbine GBO Level Relay 88X	125 V dc Distribution Center 1DA	4AR
Unit 2 Turbine GBO Level Relay 88X	125 V dc Distribution Center 2DA	2AR

Table A.14-2

Cooling Water System Test Procedures

Procedure	Test Frequency	Description
IP/1/B/0400/001, United Electric Type J302 Pressure Switch Calibration	Annually	Verify Turbine Packing Box water pressure switches operate within calibration limits.
IP/1/B/0400/002, United Electric Type J-6 Pressure Switch Calibration	Annually	Verify Turbine Packing Box Temp. pressure switches operate within calibration limits.
IP/1/B/0400/003, Barton Model 258 Indicating Switch Calibration	Annually	Verify Generator Cooling Water and Thrust Bearing Cooling Water flow indicators operate within calibration limits.
IP/1/B/0400/005, Moore Model 33 Nullmatic Temperature Transmitter Calibration	Annually	Verify Turbine Packing Box Temp. transmitters operate within calibration limits.

Table A.14-3

Cooling Water System Maintenance Procedures

Procedure	Maintenance Frequency	Description
MP/1/A/2000/017, Unit No. 1 Turbine And Governor Monthly Preventive Maintenance	Weekly	Swap turbine packing box cooling water strainer to strainer previously out of service; clean strainer just removed from service
MP/1/A/2000/018, Unit No. 1 Turbine And Governor Monthly Preventive Maintenance	Bi-monthly	Verify unit main water supply strainer is clean and free of obstruction.

Table A.14-4

Cooling Water System Significant Operating Events

Date	Unit	Component	Event Summary
10/28/93	2	GBO Cooler	Broken solder joint on discharge side of cooler due to overtorquing the hex nut during preventive maintenance.

Table A.14-5

Cooling Water System Fault Tree Transfers

Transfer Gate Name	Description	Components Supplied[1]
BK1661B	Keowee 1 Rotation Sensing Aux. Relay 14DX Fails To Energize	Unit 1 14DX Relay
BK1760B	Keowee 1 Rotation Sensing Aux. Relay 14DX Fails To Remain Energized	Unit 1 14DX Relay
BK2661B	Keowee 2 Rotation Sensing Aux. Relay 14DX Fails To Energize	Unit 2 14DX Relay
BK2760B	Keowee 2 Rotation Sensing Aux. Relay 14DX Fails To Remain Energized	Unit 2 14DX Relay
XD1DAR	Loss of Power on Keowee 1 125 Vdc Distribution Center 1DA During Run	Unit 1 88X Relay
XD2DAR	Loss of Power on Keowee 2 125 Vdc Distribution Center 2DA During Run	Unit 2 88X Relay
YK1MR4BRUN	Keowee 1 Master Relay 4B Drops Out During Run	Unit 1 4B Relay
YK2MR4BRUN	Keowee 2 Master Relay 4B Drops Out During Run	Unit 2 4B Relay

[1]These relays are in the control circuit of Main Cooling Water Control Valve, WL-11.

Table A.14-6

Cooling Water System Fault Tree Top Gates

Gate Name	Description
Unit 1:	
FK1200	WL Fails To Cool Keowee 1 Turbine Packing Box
FK1300	WL Fails To Supply Unit 1 Generator Thrust Bearing Cooling
FK1400	WL Fails To Supply Unit 1 Generator Air Coolers
Unit 2:	
FK2200	WL Fails To Cool Keowee 2 Turbine Packing Box
FK2300	WL Fails To Supply Unit 2 Generator Thrust Bearing Cooling
FK2400	WL Fails To Supply Unit 2 Generator Air Coolers

Table A.14-7

Cooling Water System Statalarms

Point No.	Alarm	Actuator
1SA1-3	TURB. #1 PKG. BOX WTR. PRESS. LOW	63KX
1SA1-13	GOV. #1 MAIN VALVE CLOSED	20TX
1SA2-8	TURB. #1 PKG. BOX TEMP. HIGH	26P2X
2SA1-3	TURB. #2 PKG. BOX WTR. PRESS. LOW	63KX
2SA1-13	GOV. #2 MAIN VALVE CLOSED	20TX
2SA2-8	TURB. #2 PKG. BOX TEMP. HIGH	26P2X

Table A.14-8

Cooling Water System Reliability Data

Event Name	Description	Failure Rate[1]	Factor	Rationale For Factor[2]	Failure Probability
BK1088XRYT	Keowee 1 Turbine GBO Rly 88X Spurious Operation	3.60E-07 /H	24 H	Rule 1: GBO Low Level alarm	8.64E-06
BK1631XRYT	Keowee 1 GBO Level Relay 63TA/1X Spurious Operation	3.60E-07 /H	24 H	Rule 1: GBO Low Level alarm	8.64E-06
BK163TALST	Turbine No. 1 GBO Level Sw. 63TA Spurious Operation	3.10E-07 /H	24 H	Rule 1: GBO Low Level alarm	7.44E-06
FK0WL01VVT	Locked-Open Manual Valve 0WL-1 Trans.	1.70E-08 /H	24 H	Rule 1: Turb. Pkg. Box Press. alarm	4.08E-07
FK1120GLHE	Unit 1 Control Switch S120G Left in OFF Position				3.20E-03
FK1120GSWT	Unit 1 Control Switch S120G Spurious Operation	7.00E-08 /H	108 H	Rule 6	7.56E-06
FK1FL01FRF	Filter 1WLFL-1 Becomes Clogged	9.80E-07 /H	24 H	Rule 1: Turb. Pkg. Box Press. alarm	2.35E-05
FK1FL02FRF	Filter 1WLFL-2 Becomes Clogged	9.80E-07 /H	24 H	Rule 1: Turb. Pkg. Box Press. alarm	2.35E-05
FK1TRHXHXF	Turbine Packing Box Heat Exch. 1TRHX-1 Fails	6.40E-07 /H	24 H	Rule 1: Turb. Pkg. Box Press. Low alarm	1.54E-05
FK1WL03VVT	Manual Valve 1WL-3 Transfers Position	1.70E-08 /H	24 H	Rule 1: Turb. Pkg. Box Press. alarm	4.08E-07
FK1WL04VVT	Manual Valve 1WL-4 Transfers Position	1.70E-08 /H	24 H	Rule 1: Turb. Pkg. Box Press. alarm	4.08E-07
FK1WL05VVT	Manual Valve 1WL-5 Transfers Position	1.70E-08 /H	24 H	Rule 1: Turb. Pkg. Box Press. alarm	4.08E-07
FK1WL06VVT	Manual Valve 1WL-6 Transfers Position	1.70E-08 /H	24 H	Rule 1: Turb. Pkg. Box Press. alarm	4.08E-07

Table A.14-8

Cooling Water System Reliability Data

Event Name	Description	Failure Rate[1]	Factor	Rationale For Factor[2]	Failure Probability
FK1WL07VVT	Manual Valve 1WL-7 Transfers Position	1.70E-08 /H	24 H	Rule 1: Turb. Pkg. Box Press. alarm	4.08E-07
FK1WL08VVT	Manual Valve 1WL-8 Transfers Position	1.70E-08 /H	24 H	Rule 1: Turb. Pkg. Box Press. alarm	4.08E-07
FK1WL09VVT	Manual Valve 1WL-9 Transfers Position	1.70E-08 /H	24 H	Rule 1: Turb. Pkg. Box Press. alarm	4.08E-07
FK1WL11AVO	Cooling Water Control Valve 1WL-11 Fails To Open On Demand	2.80E-04 /D	1 D	Valve opens on unit start	2.80E-04
FK1WL11AVT	Cooling Water Control Valve 1WL-11 Trans. Clsd.	2.30E-06 /H	24 H		5.52E-05
FK1WL12VVT	Manual Valve 1WL-12 Transfers Position	1.70E-08 /H	108 H	Rule 6	1.84E-06
FK1WL15VVT	Manual Valve 1WL-15 Transfers Position	1.70E-08 /H	108 H	Rule 6	1.84E-06
FK1WL42VVT	Manual Valve 1WL-42 Transfers Position	1.70E-08 /H	108 H	Rule 6	1.84E-06
FK1WL43VVT	Manual Valve 1WL-43 Transfers Position	1.70E-08 /H	108 H	Rule 6	1.84E-06
XD1DA4ACDT	DC Circuit Breaker 1DA-4AR Transfers Position	7.50E-08 /H	24 H	Rule 1: DC Supply Failure alarm	1.80E-06
YK1MR4BRYD	Keowee 1 Start Master Relay 4B Fails To Pick Up	3.30E-05 /D	1 D	Relay energized on unit start	3.30E-05
BK2088XRYT	Keowee 1 Turbine GBO Rly 88X Spurious Operation	3.60E-07 /H	24 H	Rule 1: GBO Low Level alarm	8.64E-06
BK2631XRYT	Keowee 2 GBO Level Relay 63TA/1X Spurious Operation	3.60E-07 /H	24 H	Rule 1: GBO Low Level alarm	8.64E-06

Table A.14-8

Cooling Water System Reliability Data

Event Name	Description	Failure Rate[1]	Factor	Rationale For Factor[2]	Failure Probability
BK263TALST	Turbine No. 2 GBO Level Sw. 63TA Spurious Operation	3.10E-07 /H	24 H	Rule 1: GBO Low Level alarm	7.44E-06
FK2120GLHE	Unit 2 Control Switch S120G Left in OFF Position				2.60E-04
FK2120GSWT	Unit 2 Control Switch S120G Spurious Operation	7.00E-08 /H	36 H	Rule 6	2.52E-06
FK2FL01FRF	Filter 2WLFL-1 Becomes Clogged	9.80E-07 /H	24 H	Rule 1: Turb. Pkg. Box Press. alarm	2.35E-05
FK2FL02FRF	Filter 2WLFL-2 Becomes Clogged	9.80E-07 /H	24 H	Rule 1: Turb. Pkg. Box Press. alarm	2.35E-05
FK2TRHXHXF	Turbine Packing Box Heat Exch. 2TRHX-1 Fails	6.40E-07 /H	24 H	Rule 1: Turb. Pkg. Box Press. Low alarm	1.54E-05
FK2WL03VVT	Manual Valve 2WL-3 Transfers Position	1.70E-08 /H	24 H	Rule 1: Turb. Pkg. Box Press. alarm	4.08E-07
FK2WL04VVT	Manual Valve 2WL-4 Transfers Position	1.70E-08 /H	24 H	Rule 1: Turb. Pkg. Box Press. alarm	4.08E-07
FK2WL05VVT	Manual Valve 2WL-5 Transfers Position	1.70E-08 /H	24 H	Rule 1: Turb. Pkg. Box Press. alarm	4.08E-07
FK2WL06VVT	Manual Valve 2WL-6 Transfers Position	1.70E-08 /H	24 H	Rule 1: Turb. Pkg. Box Press. alarm	4.08E-07
FK2WL07VVT	Manual Valve 2WL-7 Transfers Position	1.70E-08 /H	24 H	Rule 1: Turb. Pkg. Box Press. alarm	4.08E-07
FK2WL08VVT	Manual Valve 2WL-8 Transfers Position	1.70E-08 /H	24 H	Rule 1: Turb. Pkg. Box Press. alarm	4.08E-07
FK2WL09VVT	Manual Valve 2WL-9 Transfers Position	1.70E-08 /H	24 H	Rule 1: Turb. Pkg. Box Press. alarm	4.08E-07

Table A.14-8

Cooling Water System Reliability Data

Event Name	Description	Failure Rate[1]	Factor	Rationale For Factor[2]	Failure Probability
FK2WL11AVO	Cooling Water Control Valve 2WL-11 Fails To Open On Demand	2.80E-04 /D	1 D	Valve opens on unit start	2.80E-04
FK2WL11AVT	Cooling Water Control Valve 2WL-11 Trans. Clsd.	2.30E-06 /H	24 H		5.52E-05
FK2WL12VVT	Manual Valve 2WL-12 Trans. Position	1.70E-08 /H	36 H	Rule 6	6.12E-07
FK2WL15VVT	Manual Valve 2WL-15 Trans. Position	1.70E-08 /H	36 H	Rule 6	6.12E-07
FK2WL42VVT	Manual Valve 2WL-42 Trans. Position	1.70E-08 /H	36 H	Rule 6	6.12E-07
FK2WL43VVT	Manual Valve 2WL-43 Trans. Position	1.70E-08 /H	36 H	Rule 6	6.12E-07
XD2DA2ACDT	DC Circuit Breaker 2DA-2AR Transfers Position	7.50E-08 /H	24 H	Rule 1: DC Supply Failure alarm	1.80E-06
YK2MR4BRYD	Keowee 2 Start Master Relay 4B Fails To Pick Up	3.30E-05 /D	1 D	Relay energized on unit start	3.30E-05

[1] D = Demand, H = Hour

[2] Rules for assigning basic event factors are discussed in Table C.1-4.

Table A.14-9

Cooling Water System Dominant Minimal Cutsets

Cutsets For Gate FK1200: WL Fails To Cool Keowee 1 Turbine Packing Box

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
1)	2.35E-05	35.8	FK1FL01FRF	2.35E-05	Filter 1WLFL-1 Becomes Clogged
2)	2.35E-05	35.8	FK1FL02FRF	2.35E-05	Filter 1WLFL-2 Becomes Clogged
3)	1.54E-05	23.4	FK1TRHXHXF	1.54E-05	Turbine Packing Box Heat Exchanger 1TRHX-1 Fails
4)	4.08E-07	0.6	FK0WL01VVT	4.08E-07	Locked-Open Manual Valve 0WL-1 Transfers Position
5)	4.08E-07	0.6	FK1WL06VVT	4.08E-07	Manual Valve 1WL-6 Transfers Position
6)	4.08E-07	0.6	FK1WL03VVT	4.08E-07	Manual Valve 1WL-3 Transfers Position
7)	4.08E-07	0.6	FK1WL08VVT	4.08E-07	Manual Valve 1WL-8 Transfers Position
8)	4.08E-07	0.6	FK1WL05VVT	4.08E-07	Manual Valve 1WL-5 Transfers Position
9)	4.08E-07	0.6	FK1WL04VVT	4.08E-07	Manual Valve 1WL-4 Transfers Position
10)	4.08E-07	0.6	FK1WL09VVT	4.08E-07	Manual Valve 1WL-9 Transfers Position
11)	4.08E-07	0.6	FK1WL07VVT	4.08E-07	Manual Valve 1WL-7 Transfers Position
Total:	6.57E-05				

Table A.14-10

Cooling Water System Dominant Minimal Cutsets

Cutsets For Gate FK1300: WL Fails To Supply Unit 1 Generator Thrust Bearing Cooling

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
1)	2.80E-04	76.7	FK1WL11AVO	2.80E-04	Cooling Water Control Valve 1WL-11 Fails To Open On Demand
2)	5.52E-05	15.1	FK1WL11AVT	5.52E-05	Cooling Water Control Valve 1WL-11 Transfers Closed
3)	2.35E-05	6.4	FK1FL01FRF	2.35E-05	Filter 1WLFL-1 Becomes Clogged
4)	1.84E-06	0.5	FK1WL43VVT	1.84E-06	Manual Valve 1WL-43 Transfers Position
5)	1.84E-06	0.5	FK1WL42VVT	1.84E-06	Manual Valve 1WL-42 Transfers Position
6)	1.84E-06	0.5	FK1WL12VVT	1.84E-06	Manual Valve 1WL-12 Transfers Position
7)	4.08E-07	0.1	FK0WL01VVT	4.08E-07	Locked-Open Manual Valve 0WL-1 Transfers Position
8)	2.76E-08	0.0	BK1631XRYT	8.64E-06	Keowee 1 GBO Level Relay 63TA/1X Spurious Operation
			FK1120GLHE	3.20E-03	Unit 1 Control Switch S120G Left in OFF Position
9)	2.76E-08	0.0	BK1088XRYT	8.64E-06	Keowee 1 Turbine Guide Bearing Oil Relay 88X Spurious Operation
			FK1120GLHE	3.20E-03	Unit 1 Control Switch S120G Left in OFF Position

Total: 3.65E-04

Table A.14-11

Cooling Water System Dominant Minimal Cutsets

Cutsets For Gate FK1400: WL Fails To Supply Unit 1 Generator Air Coolers

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
1)	2.80E-04	77.1	FK1WL11AVO	2.80E-04	Cooling Water Control Valve 1WL-11 Fails To Open On Demand
2)	5.52E-05	15.2	FK1WL11AVT	5.52E-05	Cooling Water Control Valve 1WL-11 Transfers Closed
3)	2.35E-05	6.5	FK1FL01FRF	2.35E-05	Filter 1WLFL-1 Becomes Clogged
4)	1.84E-06	0.5	FK1WL15VVT	1.84E-06	Manual Valve 1WL-15 Transfers Position
5)	1.84E-06	0.5	FK1WL12VVT	1.84E-06	Manual Valve 1WL-12 Transfers Position
6)	4.08E-07	0.1	FK0WL01VVT	4.08E-07	Locked-Open Manual Valve 0WL-1 Transfers Position
7)	2.76E-08	0.0	BK1631XRYT FK1120GLHE	8.64E-06 3.20E-03	Keowee 1 GBO Level Relay 63TA/1X Spurious Operation Unit 1 Control Switch S120G Left in OFF Position
8)	2.76E-08	0.0	BK1088XRYT FK1120GLHE	8.64E-06 3.20E-03	Keowee 1 Turbine Guide Bearing Oil Relay 88X Spurious Operation Unit 1 Control Switch S120G Left in OFF Position
9)	2.38E-08	0.0	BK163TALST FK1120GLHE	7.44E-06 3.20E-03	Turbine No. 1 Bearing Oil Level Switch 63TA Spurious Operation Unit 1 Control Switch S120G Left in OFF Position
Total:	3.63E-04				

Table A.14-12

Cooling Water System Dominant Minimal Cutsets

Cutsets For Gate FK2200: WL Fails To Cool Keowee 2 Turbine Packing Box

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
1)	2.35E-05	35.8	FK2FL01FRF	2.35E-05	Filter 2WLFL-1 Becomes Clogged
2)	2.35E-05	35.8	FK2FL02FRF	2.35E-05	Filter 2WLFL-2 Becomes Clogged
3)	1.54E-05	23.4	FK2TRHXHXF	1.54E-05	Turbine Packing Box Heat Exchanger 2TRHX-1 Fails
4)	4.08E-07	0.6	FK0WL01VVT	4.08E-07	Locked-Open Manual Valve 0WL-1 Transfers Position
5)	4.08E-07	0.6	FK2WL06VVT	4.08E-07	Manual Valve 2WL-6 Transfers Position
6)	4.08E-07	0.6	FK2WL03VVT	4.08E-07	Manual Valve 2WL-3 Transfers Position
7)	4.08E-07	0.6	FK2WL08VVT	4.08E-07	Manual Valve 2WL-8 Transfers Position
8)	4.08E-07	0.6	FK2WL05VVT	4.08E-07	Manual Valve 2WL-5 Transfers Position
9)	4.08E-07	0.6	FK2WL04VVT	4.08E-07	Manual Valve 2WL-4 Transfers Position
10)	4.08E-07	0.6	FK2WL09VVT	4.08E-07	Manual Valve 2WL-9 Transfers Position
11)	4.08E-07	0.6	FK2WL07VVT	4.08E-07	Manual Valve 2WL-7 Transfers Position
Total: 6.57E-05					

Table A.14-13

Cooling Water System Dominant Minimal Cutsets

Cutsets For Gate FK2300: WL Fails To Supply Unit 2 Generator Thrust Bearing Cooling

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
1)	2.80E-04	77.6	FK2WL11AVO	2.80E-04	Cooling Water Control Valve 2WL-11 Fails To Open On Demand
2)	5.52E-05	15.3	FK2WL11AVT	5.52E-05	Cooling Water Control Valve 2WL-11 Transfers Closed
3)	2.35E-05	6.5	FK2FL01FRF	2.35E-05	Filter 2WLFL-1 Becomes Clogged
4)	6.12E-07	0.2	FK2WL43VVT	6.12E-07	Manual Valve 2WL-43 Transfers Position
5)	6.12E-07	0.2	FK2WL12VVT	6.12E-07	Manual Valve 2WL-12 Transfers Position
6)	6.12E-07	0.2	FK2WL42VVT	6.12E-07	Manual Valve 2WL-42 Transfers Position
7)	4.08E-07	0.1	FK0WL01VVT	4.08E-07	Locked-Open Manual Valve 0WL-1 Transfers Position
Total:	3.61E-04				

Table A.14-14

Cooling Water System Dominant Minimal Cutsets

Cutsets For Gate FK2400: WL Fails To Supply Unit 2 Generator Air Coolers

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
1)	2.80E-04	77.8	FK2WL11AVO	2.80E-04	Cooling Water Control Valve 2WL-11 Fails To Open On Demand
2)	5.52E-05	15.3	FK2WL11AVT	5.52E-05	Cooling Water Control Valve 2WL-11 Transfers Closed
3)	2.35E-05	6.5	FK2FL01FRF	2.35E-05	Filter 2WLFL-1 Becomes Clogged
4)	6.12E-07	0.2	FK2WL15VVT	6.12E-07	Manual Valve 2WL-15 Transfers Position
5)	6.12E-07	0.2	FK2WL12VVT	6.12E-07	Manual Valve 2WL-12 Transfers Position
6)	4.08E-07	0.1	FK0WL01VVT	4.08E-07	Locked-Open Manual Valve 0WL-1 Transfers Position
Total:	3.60E-04				

Table A.14-15

Cooling Water System Dominant Contributors To Unavailability

Gate FK1200: WL Fails To Cool The Unit 1 Turbine Packing Box

Rank	Event Description	Mean Unavailability[1]	Approximate Unavailability Contribution[2]
1	FK1FL01FRF - Filter 1WLFL-1 Becomes Clogged	2.35E-05	35.8%
2	FK1FL02FRF - Filter 1WLFL-2 Becomes Clogged	2.35E-05	35.8%
3	FK1TRHXHXF - Turbine Packing Box Heat Exchanger 1TRHX-1 Fails	1.54E-05	23.4%
4	FK0WL01VVT - Locked-Open Manual Valve 0WL-1 Transfers Position	4.08E-07	0.6%
5	FK1WLxxVVT - Manual Valve 1WL-xx Transfers Position xx = 3,4,...,9	4.08E-07	0.6% (each)

1 Mean unavailability is defined as the summation of the values of all cut sets in which the event appears.

2 The contribution to unavailability is calculated by dividing the mean unavailability by the overall system unavailability and then multiplying by 100 percent.

Table A.14-16

Cooling Water System Dominant Contributors To Unavailability

Gate FK1300: WL Fails To Supply Unit 1 Generator Thrust Bearing Coolers

Rank	Event Description	Mean Unavailability[1]	Approximate Unavailability Contribution[2]
1	FK1WL11AVO - Cooling Water Control Valve 1WL-11 Fails To Open On Demand	2.80E-04	76.7%
2	FK1WL11AVT - Cooling Water Control Valve 1WL-11 Transfers Closed	5.52E-05	15.1%
3	FK1FL01FRF - Filter 1WLFL-1 Becomes Clogged	2.35E-05	6.4%

1 Mean unavailability is defined as the summation of the values of all cut sets in which the event appears.

2 The contribution to unavailability is calculated by dividing the mean unavailability by the overall system unavailability and then multiplying by 100 percent.

Table A.14-17

Cooling Water System Dominant Contributors To Unavailability

Gate FK1400: WL Fails To Supply Unit 1 Generator Air Coolers

Rank	Event Description	Mean Unavailability[1]	Approximate Unavailability Contribution[2]
1	FK1WL11AVO - Cooling Water Control Valve 1WL-11 Fails To Open On Demand	2.80E-04	77.1%
2	FK1WL11AVT - Cooling Water Control Valve 1WL-11 Transfers Closed	5.52E-05	15.2%
3	FK1FL01FRF - Filter 1WLFL-1 Becomes Clogged	2.35E-05	6.5%

1 Mean unavailability is defined as the summation of the values of all cut sets in which the event appears.

2 The contribution to unavailability is calculated by dividing the mean unavailability by the overall system unavailability and then multiplying by 100 percent.

Table A.14-18

Cooling Water System Dominant Contributors To Unavailability

Gate FK2200: WL Fails To Cool The Unit 2 Turbine Packing Box

Rank	Event Description	Mean Unavailability[1]	Approximate Unavailability Contribution[2]
1	FK2FL01FRF - Filter 2WLFL-1 Becomes Clogged	2.35E-05	35.8%
2	FK2FL02FRF - Filter 2WLFL-2 Becomes Clogged	2.35E-05	35.8%
3	FK2TRHXHXF - Turbine Packing Box Heat Exchanger 2TRHX-1 Fails	1.54E-05	23.4%
4	FK0WL01VVT - Locked-Open Manual Valve 0WL-1 Transfers Position	4.08E-07	0.6%
5	FK2WLxxVVT - Manual Valve 2WL-xx Transfers Position xx = 3,4,...,9	4.08E-07	0.6% (each)

1 Mean unavailability is defined as the summation of the values of all cut sets in which the event appears.

2 The contribution to unavailability is calculated by dividing the mean unavailability by the overall system unavailability and then multiplying by 100 percent.

Table A.14-19

Cooling Water System Dominant Contributors To Unavailability

Gate FK2300: WL Fails To Supply Unit 2 Generator Thrust Bearing Coolers

Rank	Event Description	Mean Unavailability[1]	Approximate Unavailability Contribution[2]
1	FK2WL11AVO - Cooling Water Control Valve 1WL-11 Fails To Open On Demand	2.80E-04	77.6%
2	FK2WL11AVT - Cooling Water Control Valve 1WL-11 Transfers Closed	5.52E-05	15.3%
3	FK2FL01FRF - Filter 1WLFL-1 Becomes Clogged	2.35E-05	6.5%

1 Mean unavailability is defined as the summation of the values of all cut sets in which the event appears.

2 The contribution to unavailability is calculated by dividing the mean unavailability by the overall system unavailability and then multiplying by 100 percent.

Table A.14-20

Cooling Water System Dominant Contributors To Unavailability

Gate FK2400: WL Fails To Supply Unit 2 Generator Air Coolers

Rank	Event Description	Mean Unavailability[1]	Approximate Unavailability Contribution[2]
1	FK2WL11AVO - Cooling Water Control Valve 1WL-11 Fails To Open On Demand	2.80E-04	77.8%
2	FK2WL11AVT - Cooling Water Control Valve 1WL-11 Transfers Closed	5.52E-05	15.3%
3	FK2FL01FRF - Filter 1WLFL-1 Becomes Clogged	2.35E-05	6.5%

1 Mean unavailability is defined as the summation of the values of all cut sets in which the event appears.

2 The contribution to unavailability is calculated by dividing the mean unavailability by the overall system unavailability and then multiplying by 100 percent.

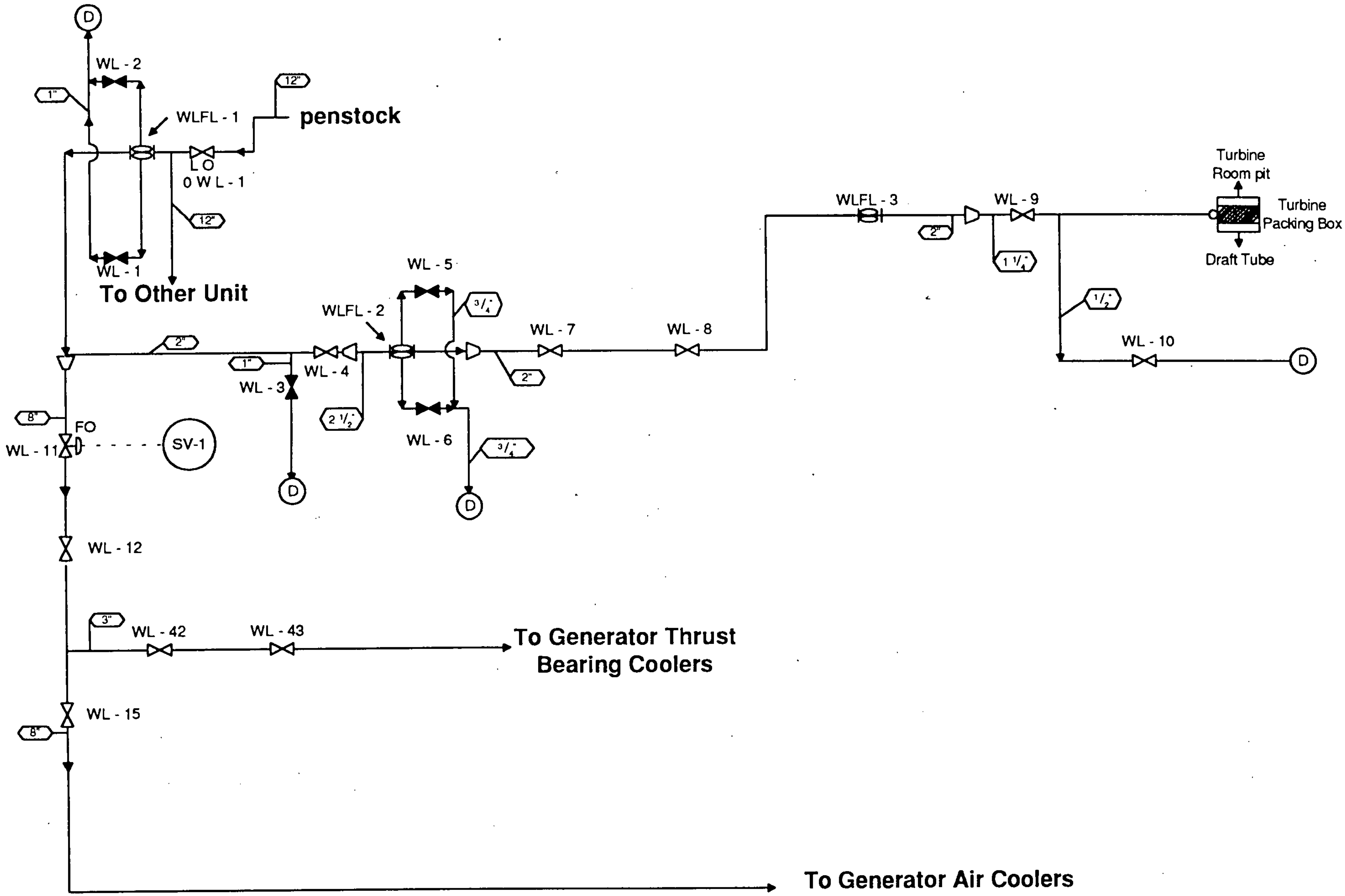
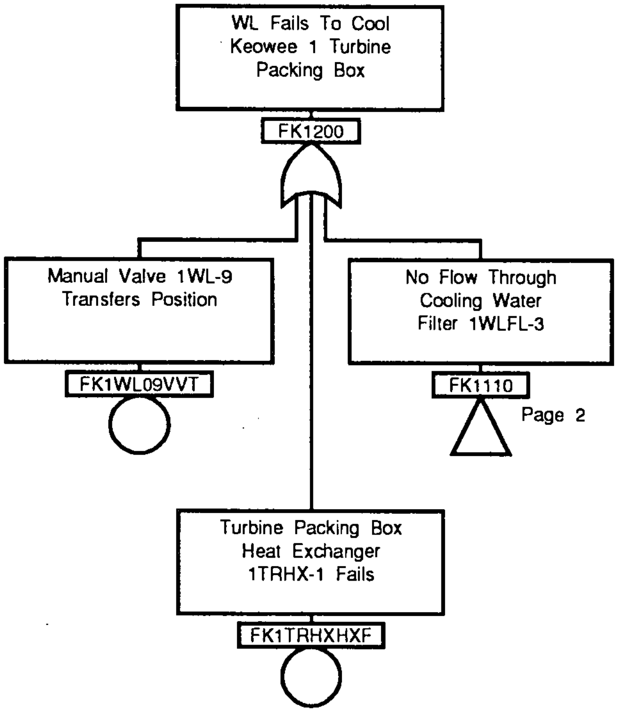
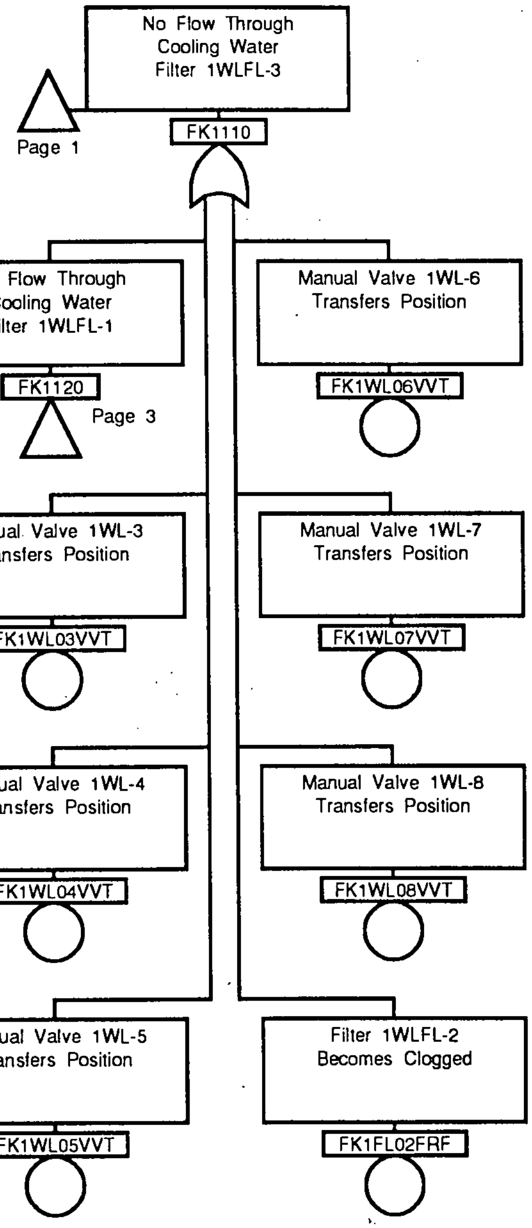


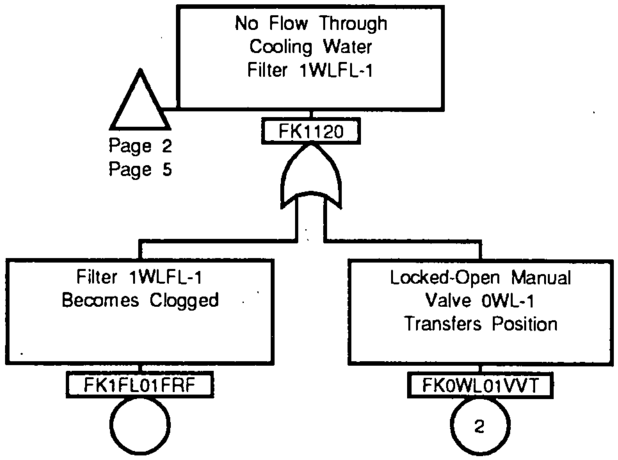
Figure A.14-1 Simplified Flow Diagram of the Turbine Generator Cooling Water System



Cooling Water System Fault Tree | FIGURE A.14-2 |



Cooling Water System Fault Tree	FIGURE A.14-2	Page 2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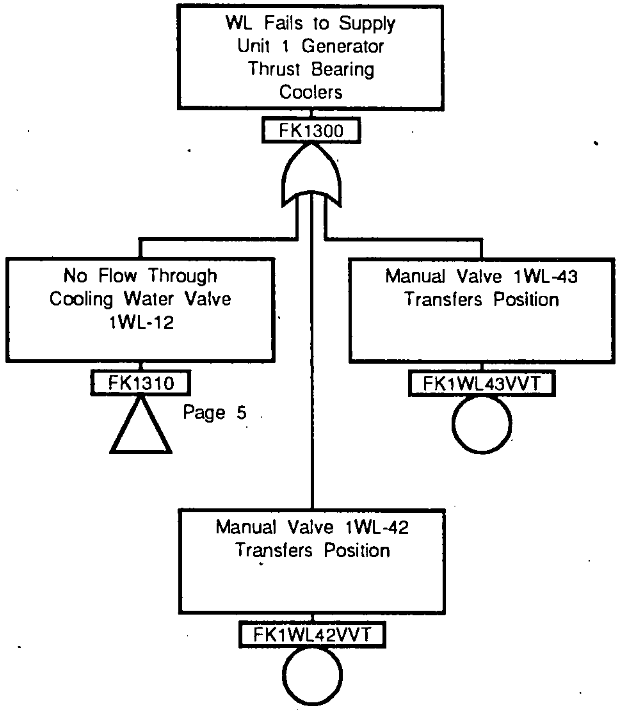
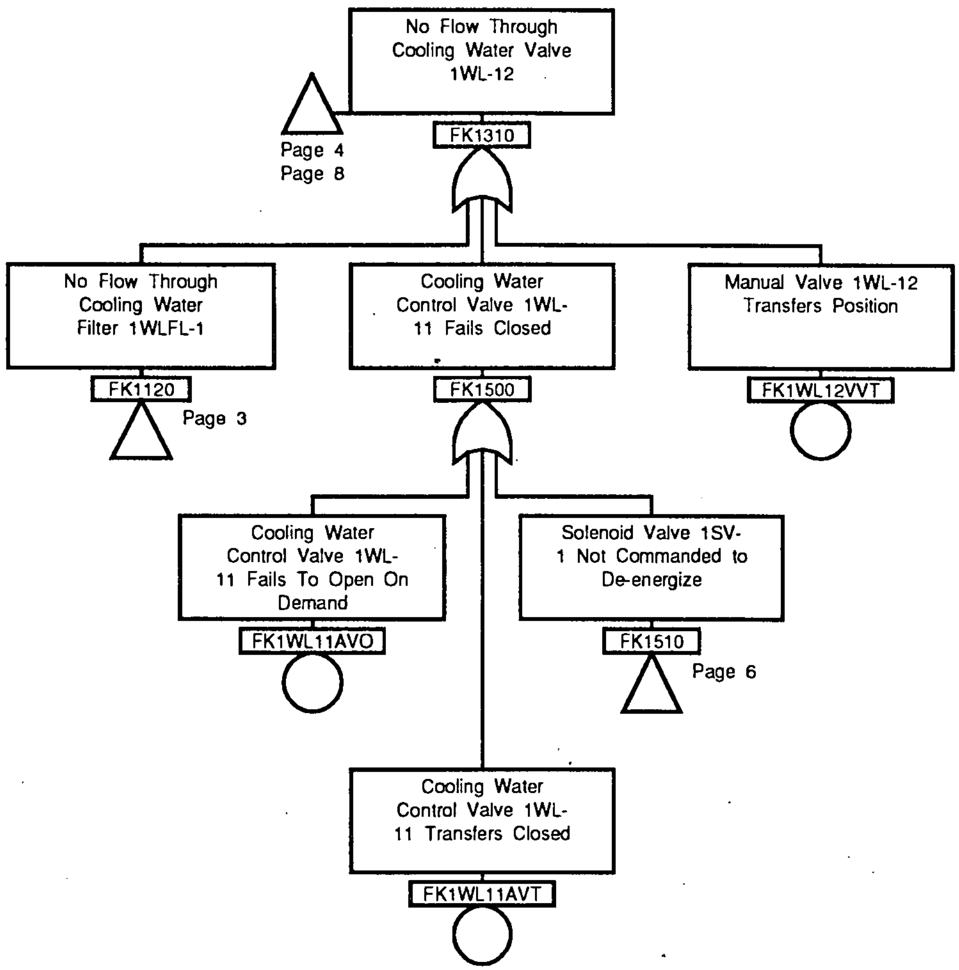
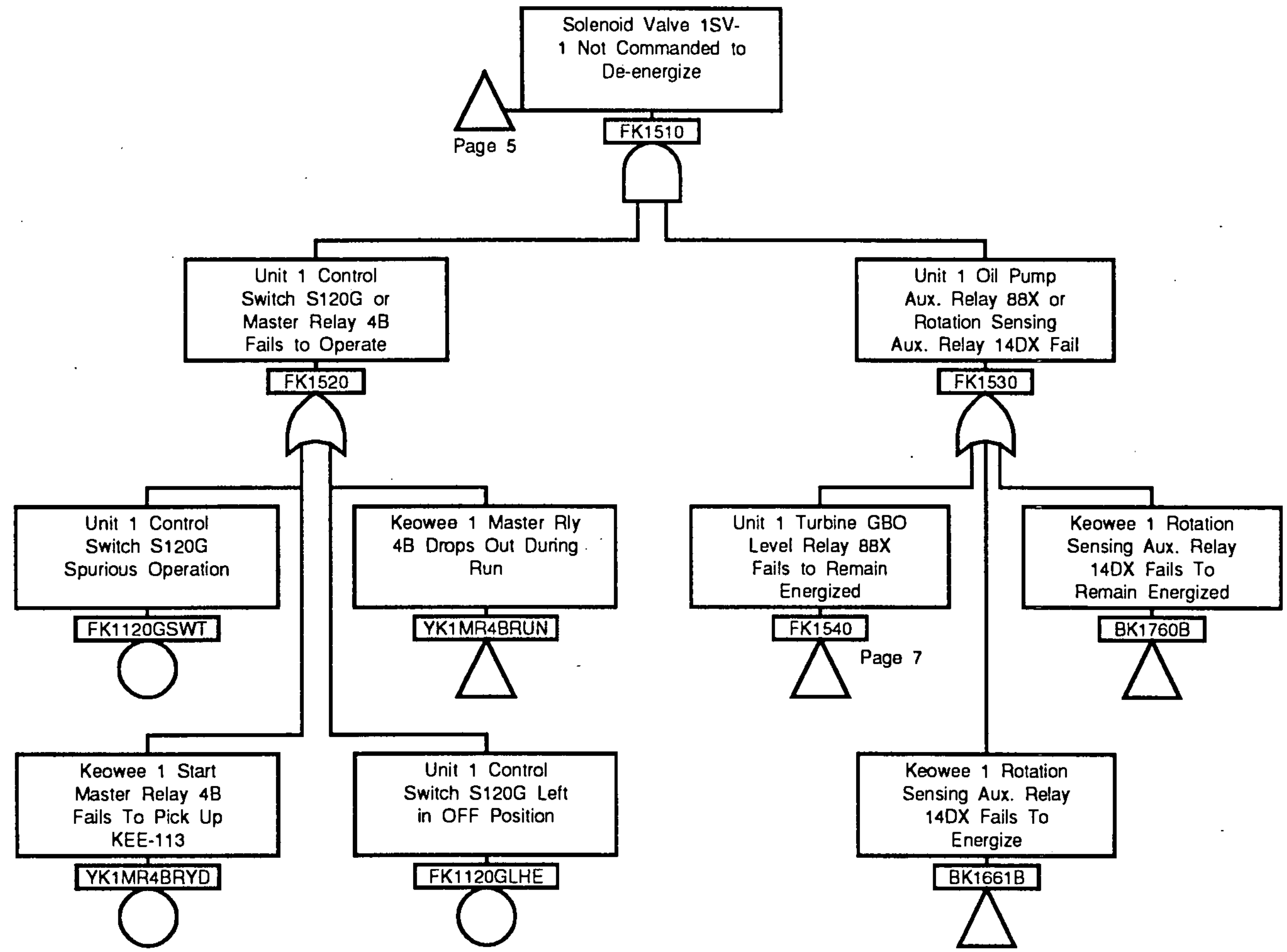
FK1120
Page 2
Page 5
Filter 1WLFL-1 Becomes Clogged
FK1FL01FRF
Locked-Open Manual Valve 0WL-1 Transfers Position
FK0WL01VVT
2



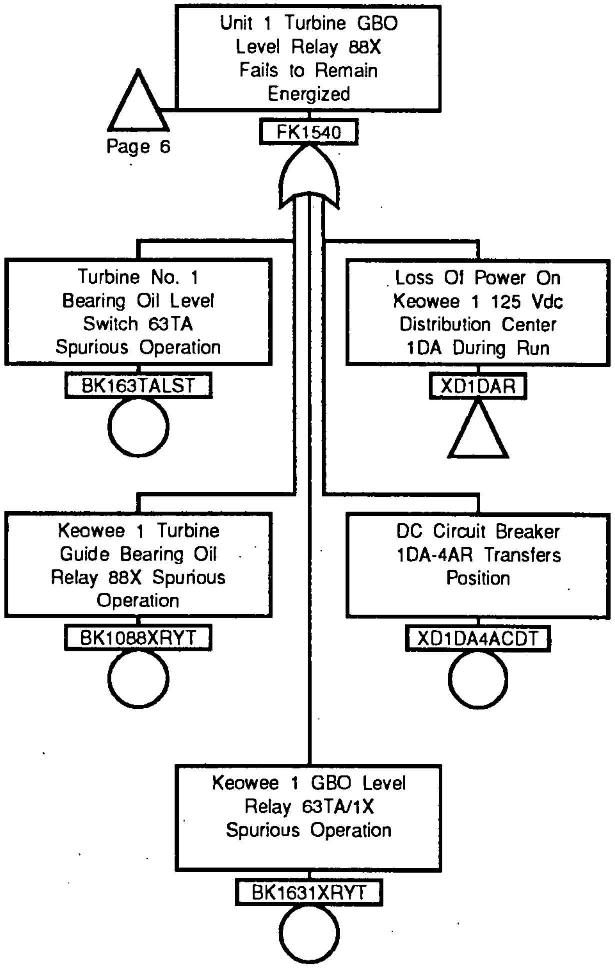
Cooling Water System Fault Tree | FIGURE A.14-2 |



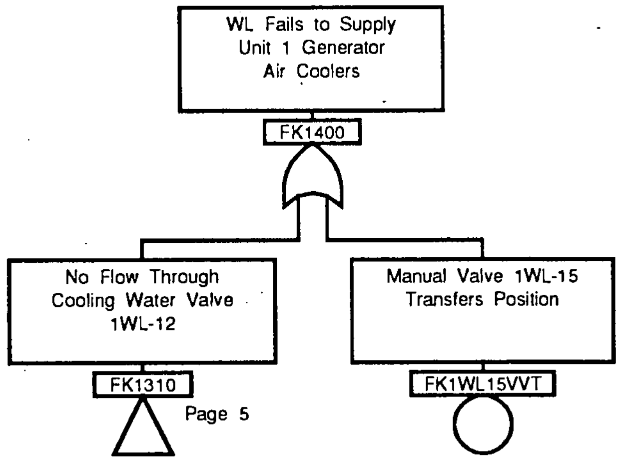
Cooling Water System Fault Tree | FIGURE A.14-2 |

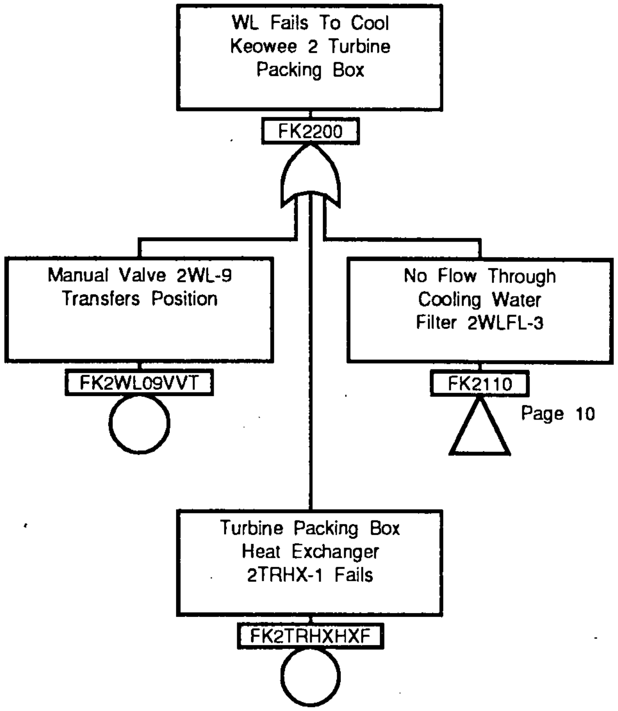


Solenoid Valve 1SV-1 Not Commanded to De-energize
FK1510
Page 5
Unit 1 Control Switch S120G or Master Relay 4B Fails to Operate
FK1520
Unit 1 Oil Pump Aux. Relay 88X or Rotation Sensing Aux. Relay 14DX Fail
FK1530
Unit 1 Control Switch S120G Spurious Operation
FK1120GSWT
Keowee 1 Master Rly 4B Drops Out During Run
YK1MR4BRUN
Unit 1 Turbine GBO Level Relay 88X Fails to Remain Energized
FK1540
Page 7
Keowee 1 Rotation Sensing Aux. Relay 14DX Fails To Remain Energized
BK1760B
Keowee 1 Start Master Relay 4B Fails To Pick Up KEE-113
YK1MR4BRYD
Unit 1 Control Switch S120G Left in OFF Position
FK1120GLHE
Keowee 1 Rotation Sensing Aux. Relay 14DX Fails To Energize
BK1661B

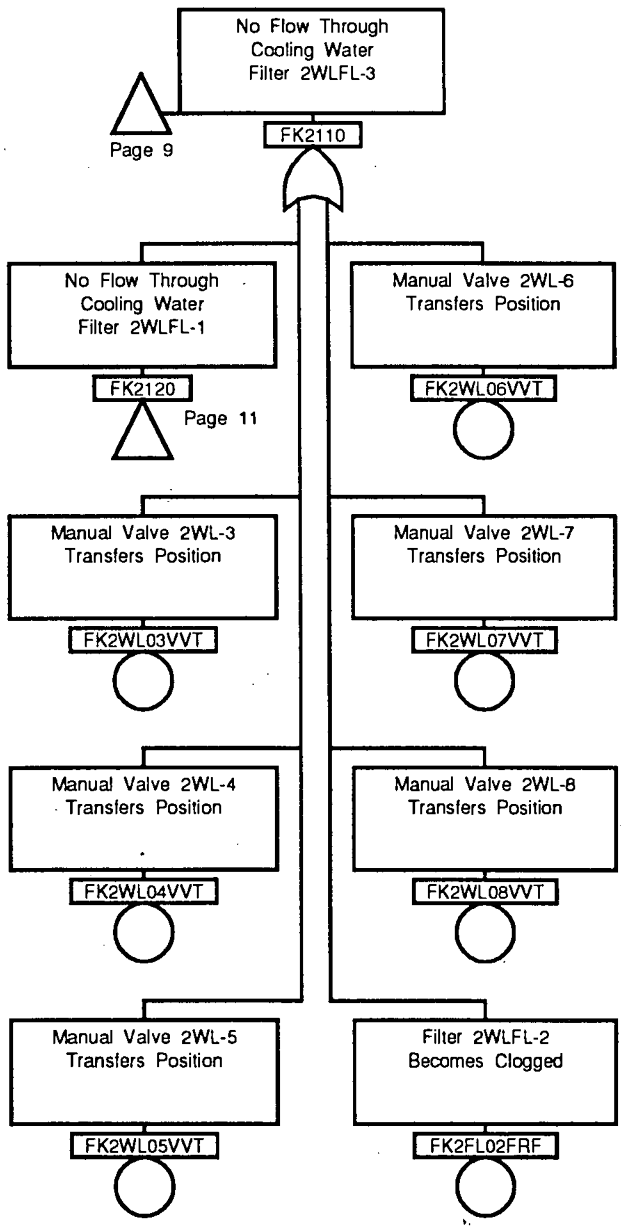


Cooling Water System Fault Tree | FIGURE A.14-2 |

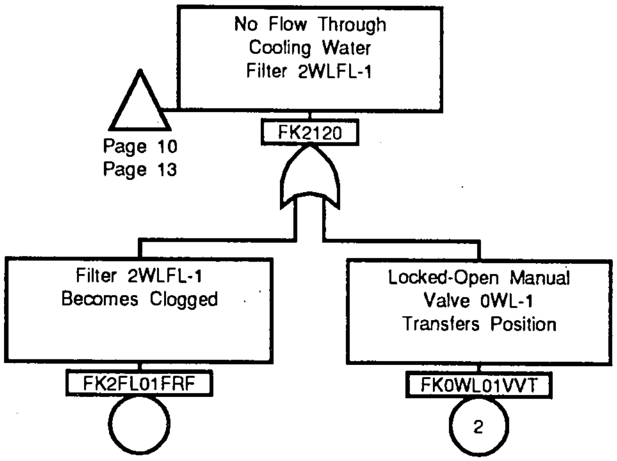

WL Fails to Supply Unit 1 Generator Air Coolers
FK1400
No Flow Through Cooling Water Valve 1WL-12
FK1310
Page 5
Manual Valve 1WL-15 Transfers Position
FK1WL15VVT



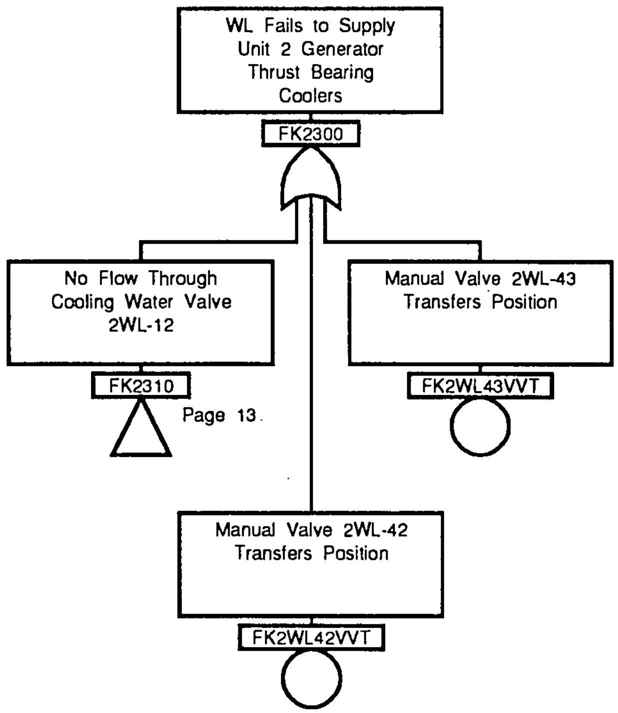
WL Fails To Cool Keowee 2 Turbine Packing Box
FK2200
Manual Valve 2WL-9 Transfers Position
FK2WL09VVT
No Flow Through Cooling Water Filter 2WLFL-3
FK2110
Page 10
Turbine Packing Box Heat Exchanger 2TRHX-1 Fails
FK2TRHXHXF



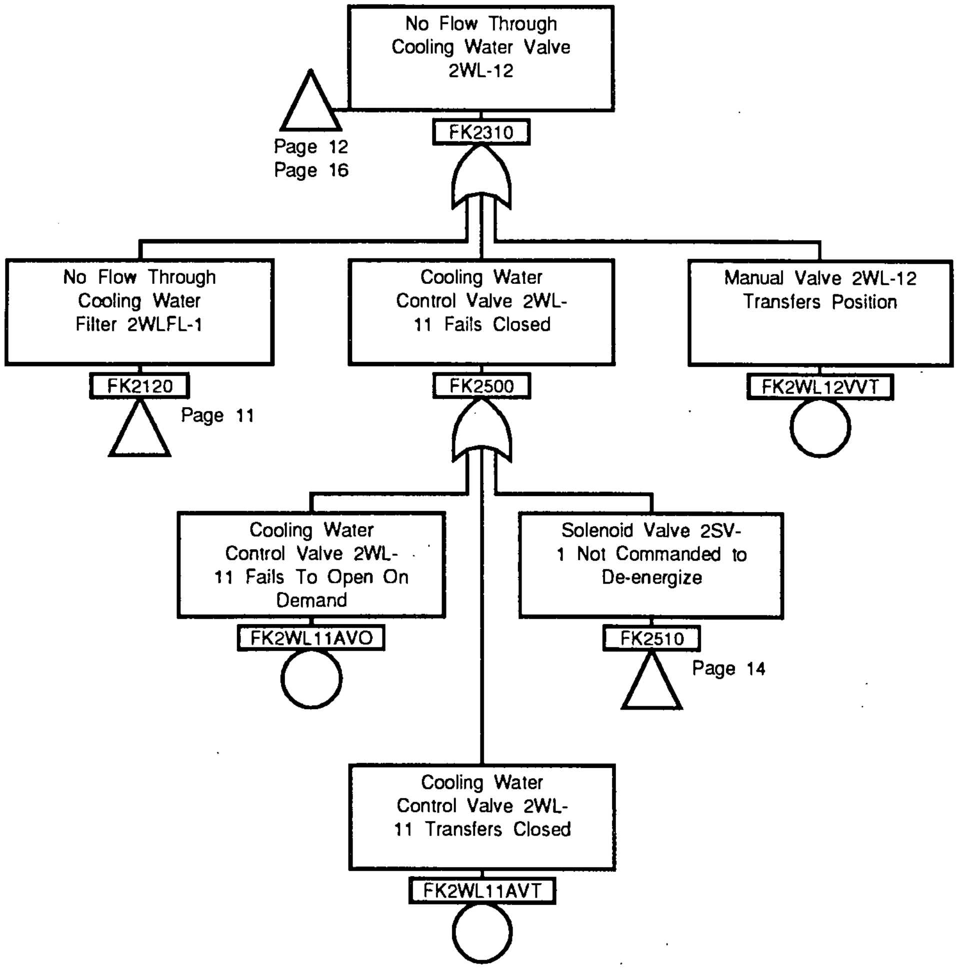
Cooling Water System Fault Tree | FIGURE A.14-2 |

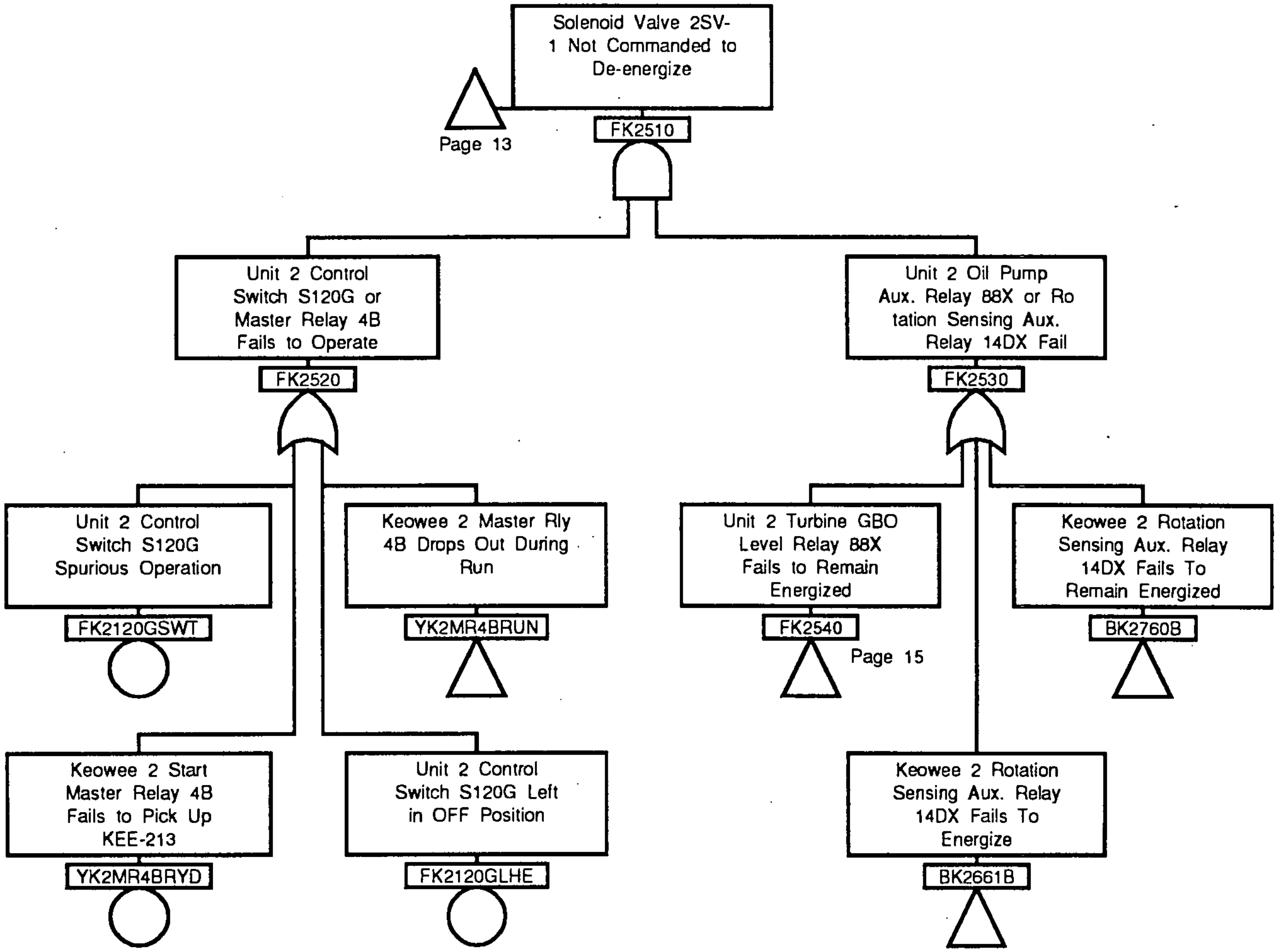


Cooling Water System Fault Tree | FIGURE A.14-2 |

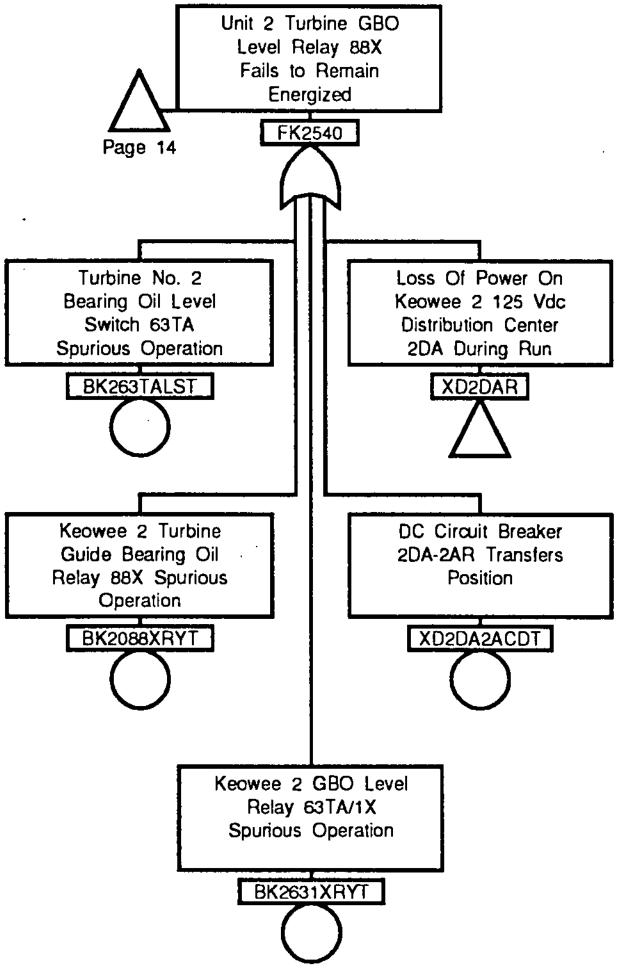


Cooling Water System Fault Tree	FIGURE A.14-2	

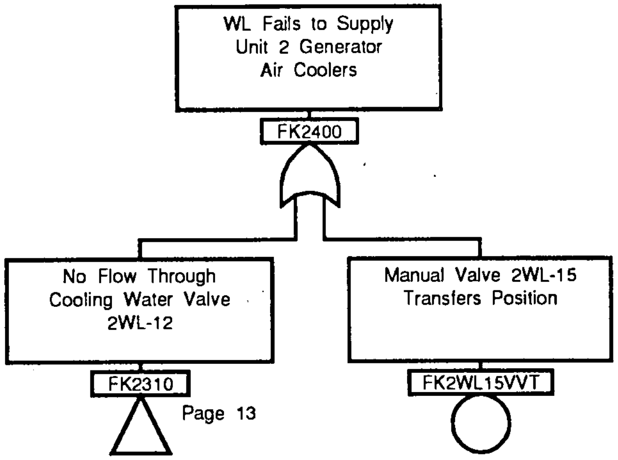

No Flow Through Cooling Water Valve 2WL-12
FK2310
Page 12
Page 16
No Flow Through Cooling Water Filter 2WLFL-1
FK2120
Page 11
Cooling Water Control Valve 2WL-11 Fails Closed
FK2500
Manual Valve 2WL-12 Transfers Position
FK2WL12VVT
Cooling Water Control Valve 2WL-11 Fails To Open On Demand
FK2WL11AVO
Solenoid Valve 2SV-1 Not Commanded to De-energize
FK2510
Page 14
Cooling Water Control Valve 2WL-11 Transfers Closed
FK2WL11AVT



Cooling Water System Fault Tree | FIGURE A.14-2 |



Unit 2 Turbine GBO Level Relay 88X Fails to Remain Energized
FK2540
Page 14
Turbine No. 2 Bearing Oil Level Switch 63TA Spurious Operation
BK263TALST
Loss Of Power On Keowee 2 125 Vdc Distribution Center 2DA During Run
XD2DAR
Keowee 2 Turbine Guide Bearing Oil Relay 88X Spurious Operation
BK2088XRYT
DC Circuit Breaker 2DA-2AR Transfers Position
XD2DA2ACDT
Keowee 2 GBO Level Relay 63TA/1X Spurious Operation
BK2631XRYT



Cooling Water System Fault Tree | FIGURE A.14-2 |

Gate/Event Name	Page	Zone	Gate/Event Name	Page	Zone	Gate/Event Name	Page	Zone	Gate/Event Name	Page	Zone
BK1088XRYT	7		FK1WL06VVT	2		FK2WL08VVT	10				
BK1631XRYT	7		FK1WL07VVT	2		FK2WL09VVT	9				
BK163TALST	7		FK1WL08VVT	2		FK2WL11AVO	13				
BK1661B	6		FK1WL09VVT	1		FK2WL11AVT	13				
BK1760B	6		FK1WL11AVO	5		FK2WL12VVT	13				
BK2088XRYT	15		FK1WL11AVT	5		FK2WL15VVT	16				
BK2631XRYT	15		FK1WL12VVT	5		FK2WL42VVT	12				
BK263TALST	15		FK1WL15VVT	8		FK2WL43VVT	12				
BK2661B	14		FK1WL42VVT	4		XD1DA4ACDT	7				
BK2760B	14		FK1WL43VVT	4		XD1DAR	7				
FK0WL01VVT	3		FK2110	9		XD2DA2ACDT	15				
FK0WL01VVT	11		FK2110	10		XD2DAR	15				
FK1110	1		FK2120	10		YK1MR4BRUN	6				
FK1110	2		FK2120	11		YK1MR4BRYD	6				
FK1120	2		FK2120	13		YK2MR4BRUN	14				
FK1120	3		FK2120GLHE	14		YK2MR4BRYD	14				
FK1120	5		FK2120GSWT	14							
FK1120GLHE	6		FK2200	9							
FK1120GSWT	6		FK2300	12							
FK1200	1		FK2310	12							
FK1300	4		FK2310	13							
FK1310	4		FK2310	16							
FK1310	5		FK2400	16							
FK1310	8		FK2500	13							
FK1400	8		FK2510	13							
FK1500	5		FK2510	14							
FK1510	5		FK2520	14							
FK1510	6		FK2530	14							
FK1520	6		FK2540	14							
FK1530	6		FK2540	15							
FK1540	6		FK2FL01FRF	11							
FK1540	7		FK2FL02FRF	10							
FK1FL01FRF	3		FK2TRHXHXF	9							
FK1FL02FRF	2		FK2WL03VVT	10							
FK1TRHXHXF	1		FK2WL04VVT	10							
FK1WL03VVT	2		FK2WL05VVT	10							
FK1WL04VVT	2		FK2WL06VVT	10							
FK1WL05VVT	2		FK2WL07VVT	10							

APPENDIX B

SYSTEM MODELING GUIDELINES

TABLE OF CONTENTS

B.0 SYSTEM MODELING GUIDELINES

B.1 INTRODUCTION

This appendix provides guidance for the development, modeling, and documentation of Keowee system/component fault tree models. It is written as a guide and does not attempt to provide an exacting treatise of fault tree modeling techniques and rules. The format of this guide follows the logical progression of fault tree modeling. It is assumed that the analyst has a basic knowledge of fault tree modeling and a working language of its terms and methods.

B.2 GETTING STARTED

B.2.1 SOURCES OF INFORMATION

The first step in modeling a system is to become familiar with its design, operation, and function. This step is vital in order to provide a realistic and correct model of the system. Many sources of information can assist the analyst, including the following:

- system descriptions, Design Basis Documents
- procedures (e.g., operating, emergency, test, maintenance)
- piping, electrical, and flow diagrams
- prior studies and inspections.

These sources can provide beneficial information on system design and operation. The analyst should discuss the operation and design of the system with the system designer and with plant personnel. Insights from these sources can provide the analyst with a wealth of information for use in understanding and modeling the system.

B.2.2 DEFINING SUCCESS CRITERIA

B.2.2.1 System Purpose

The information described above will provide the means for determining the purpose of the system as designed. This purpose should, in most cases, correspond to the system

purpose required in the model. It is possible that the system may be analyzed in a way which was not included in the system description. In that case, the system procedures and documents will not help in defining success criteria. For example, many systems used to recover from accident conditions may be aligned in a manner quite different from normal operation. It is very important that the analyst determine if the system will be used in a normal or an off-normal condition.

B.2.2.2 Operating Conditions

Attention should be given to system operation in determining operating times. A system can be classified as operational, alternating, or standby. An example of an operational system is the Turbine Guide Bearing Oil System. Since this system must operate continuously, certain failure modes (such as most demand failures) can be eliminated. Most failure modes which would have prevented the startup of the system need not be modeled, since failure of the system to start makes the Keowee unit unavailable.

Standby systems are not normally in operation -- they wait until they are required to perform their designed function. The External Grid Trouble Protection System is an example of a standby system. This system does not normally perform its design function (other than monitoring 230 kV switchyard buses). However, if undervoltage or underfrequency is sensed in the switchyard for a certain period of time, the system initiates a Keowee emergency start. Systems of this type require special attention to maintenance, testing, and latent human errors. Valves transferring position (if applicable) and demand failures are failure modes which must be accounted for when modeling a standby system. If the system test interval is relatively small, the probability of valves or other equipment changing states is reduced. If, however, the time between valve status checks by flow testing is relatively long, the probability of transferring states becomes much greater and can dominate a model. The analyst should investigate how often equipment status is verified by operation. Simply checking a valve indicator does not always ensure that the valve is in the correct position.

Alternating systems typically have two or more redundant trains which, during normal operation, are operated on a cyclic basis over a specified time period. For example, the Governor Oil System is designed with three redundant trains. Each train is capable of maintaining system pressure. It is station practice to place one pump train in the lead configuration, with the other two trains initiating at progressively lower pressures.

The status of the three trains is rotated weekly. Thus, over a given period of time, each train should have been in operation during one-third of the time and in standby for the remaining time. During abnormal conditions, more than one train may be required to start. To model this event requires one train to be modeled as an operating train and the other two to be in standby. Since the challenge can occur at any time over the period of interest, it is difficult to determine which train will be operational and which will be in standby. To be exact, two models for each train can be developed. Each model would represent a different status of the train (operational or standby). These two models would then be weighted by the time that the train would spend in that particular condition. The two train models would then be combined to create a system unavailability model. This method requires that all failure modes for each train branch be modeled, thus resulting in a very complex model.

A simplified approach can be used to reduce the modeling required without losing any information. This method is based on three assumptions: (1) each train is run for equal periods of time, (2) each train contains identical components, and (3) the failure of each train yields identical results and conditions.

Using the above information, the complex model can be written as:

$$P(T) = P(\text{train A}) \times P(\text{train B})$$

$$= 0.5 \times P(A(op)) \times P(B(st)) + 0.5 \times P(B(op)) \times P(A(st))$$

Since $P(B(op)) = P(A(op))$ and $P(A(st)) = P(B(st))$, the equation is simplified to:

$$P(T) = P(A(op)) \times P(B(st))$$

Therefore, if train A is the operational train and train B the standby train, the solution is the same as if a more complex model were used. This approach greatly reduces the modeling required, since there is no need for two models for each train and the operating train will not require demand failures (if the train operates continuously). For continuity of the model, train A is usually designated the operational train and additional trains are standby trains. The standby trains will typically dominate the cut set listing, since they contain demand failures not modeled for train A. In essence, the idea of train A and train

B is replaced by the idea of operating versus standby trains. It is important to ensure that the system does not violate the assumptions used by this method before applying it.

B.2.2.3 Top Event Definition

Top event definitions are determined by the specific needs of the system or fault trees. For example, if the analysis is limited to only the Cooling Water System, then the top event may be failure to provide flow to the four safety-related loads. But if the analysis is for an integrated study, the Cooling Water System may have several top events, broken down into failure to provide flow to each safety-related load. The top events must relate to the basis for the model.

A failure model top event should not contain success-oriented language. If one goal of the model is to represent "Failure To Provide Cooling To The Turbine Packing Box," it would be confusing to define the top event as "Cooling Water Provides Flow To The Turbine Packing Box." The top event must state the required criteria and reflect the desired result.

B.3 FAULT TREE MODELING

B.3.1 DEFINING OF BOUNDARIES

Before analysts begin to develop a system model, they must first define the limit of the analysis. If boundaries are not chosen, an analyst may begin modeling a specific valve in a system and proceed to model the entire plant. To prevent this occurrence, follow these guidelines:

- For lines leaving the system of interest, model until and including the first closed valve or line cap, or until another analyst's model begins. For example, in the Keowee PRA, it was to decided to include the Generator Air Cooler cooling water discharge line in the Generator model. The analyst responsible for Cooling Water System would model up to, but not including, the Generator Air Coolers. The Generator analyst would then begin at the coolers and include any additional failure modes associated within the cooling water discharge line. The interface will be handled by transfers, which is discussed in Section B.3.6.1.

- Tap lines and test lines need to be modeled only if they are greater than one fourth the diameter of the main header.

- Instrumentation needs to be modeled only if it directly influences system operation. For example, a flow measurement device, which is used only to provide indication of flow, need not be modeled unless it is used to operate equipment manually in the system being modeled. However, if a flow device is used to regulate a throttle valve, the flow device should be included in the model. In summary, functional instrumentation is required in the model while informational instrumentation is not.

- Lines or components which are not used or provide no means of system failure can also be excluded from the analysis. For example, at Keowee, cooling water is provided to the Generator Thrust Bearing Coolers and Air Coolers upon unit start. However, cooling water is not required to emergency start the unit. Thus, failure of the Cooling Water System does not relate to an emergency start and is not modeled as a start failure. However, cooling water failure is modeled as run failure mode of Keowee.

- Support system requirements are not modeled but are noted instead, and the support system analyst should be required to model the requirement.

- Once the boundaries are developed, redraw the system to aid in system modeling. The simplified diagram also acts as documentation for determining interfaces and support requirements by indicating what is included in the system model. Since some models may include multiple systems, a normal flow diagram may not be as easily used as a simplified diagram.

B.3.2 LEVEL OF DETAIL

A prime consideration in model development is level of detail. The available data is important in determining the level of detail. It does not make sense to model a pump down to the contacts and bearings if the only data available deals with the overall pump failure rate. In general, the more encompassing the failure mode, the more readily available the data. However, it is not adequate to model a pump as "pump fails," if start and run failure data is available.

Data can also be helpful in determining what failures to model. Once the simplified diagram is created, specific components should be examined and an estimate made of their importance to the model. By using the data, independent failure modes of components may be eliminated from the model. For example, if a system has a pump with a particular failure probability of lE-2 and a manual valve with a failure probability of lE-5, the manual valve will probably not contribute significantly to the top event and may be deleted from the model. Any component failure mode which is less than the cutoff failure probability or is less than one tenth of one percent of the dominant failure mode for a particular model may be omitted from the model. The system analyst should document the omitted failure modes in system modeling assumptions.

B.3.3 LOGIC MODEL DEVELOPMENT

There are many methods used to develop system models. This document does not advocate any particular method, but provides a guide to some of the more common ways of structuring the model. If analysts have the basic knowledge of fault tree modeling, any method with which they are comfortable is appropriate.

One method of modeling a system is the **nodal approach**. The system is first divided into nodes. A node is a point which is either arbitrarily chosen or where several paths converge or diverge. The branches of the fault tree are based on the status at a particular node. For example, if the desired result is to provide flow from one node to another node, then the model would have a corresponding branch which contained the components between the two nodes.

The **block approach** is another method of modeling. In this approach, the system is divided into function blocks. For example, the Cooling Water System provides flow to the Turbine Packing Box and Guide Bearing Oil Cooler from a common header. A logic block can be constructed up to the header and then linked to blocks which include the packing box and oil cooler.

Another approach is simply to start at either the beginning or the end of a system and work forward or backward. This is a **brute force method** in which an analyst models the system all at once. Using the Keowee Start/Run Control Signals as an example, an analyst could start modeling at the solenoid valves that open the wicket gates and work backward until all failure modes are included.

In summary, the nodal and block approaches are good methods to use when constructing support system models, since the models will have natural break points (e.g., common header and specific header). The nodal approach is probably the easiest to learn and follow. The brute force method is probably all that is required for simple models with only a few components. Do not spend time developing a nodal model for a four-component system. Conversely, the brute force method is not suggested on complex systems which will have several diverging paths.. This method will lead to duplication of component failures and will greatly enlarge the model. Finally, remember that a large model is not always better. It is easy to remove duplicate logic to reduce the size of the model. Review the model several times, looking for areas which do not affect the result and ways to improve the organization.

B.3.4 BASIC EVENTS

B.3.4.1 Basic Event Types

The Keowee PRA utilizes the following event types:

- component failure events
- human error events
- developed events
- common-cause events
- maintenance events
- conditional events
- complement events
- information events
- recovery events.

Component failure events indicate specific failure modes of components. The failure mode is dictated by data available and the level of detail of the analysis. Appendix D of the PRA lists the modeled components and failure modes. Component failure events are the major building blocks of system analysis.

Human error events represent the human element in system operation. A *latent human error* occurs before the mission and causes failure of a component or system. An example of a latent human error is the improper restoration of a valve following a test. A

commission error occurs during the mission and prevents the component or system from performing its function. An example of a commission human error is an operator inappropriately resetting an emergency start signal.

Developed events are plant-specific events representing a single component or small group of components for which generic failure rates are not readily available. Plant-specific failure rates are determined and documented by the system modeler of these events.

Conditional events are used to direct logic after a change in conditions. For example, Keowee switchgear 2X can only supply motor control center 2XA when the motor control center is aligned to its normal power source.

Information events are placed in the model to provide insight relevant to certain system failures. They are always AND-ed with failure modes and act as a guide during cut set analysis. For example, proposed station modifications may be included as information events.

Complement events are formed by NOT-ing other events. For example, if a Keowee unit is in maintenance then that unit can not experience a run failure. Complement events are used to avoid generating invalid cut sets.

Recovery events involve post-initiator actions taken to correct an abnormal situation. Recovery actions may or may not be proceduralized. Recovery event failure probabilities are typically dominated by the human error contribution. Recovery of Keowee Aux. Power Breakers by manual control is an example of a recovery event found in the Keowee model.

Recovery events are similar to developed events in that they represent a sequence of events which, if modeled, could create a very complex model, without significantly affecting the results.

Common-cause events represent failure of two or more components due to a common mode of failure. Systems and components are reviewed for coupling mechanisms such as same design, maintenance practices, operating conditions, and environmental

susceptibilities. Failures of like active components and systems are addressed using the Multiple Greek Letter method.

Maintenance events represent the probability that a given system train is unavailable due to test or maintenance during the mission time. Plant-specific maintenance data is used to estimate the unavailability.

In conclusion, many types of events are modeled in the Keowee reliability study, and careful use of each type will enhance model accuracy and comprehension. The number of events included should be minimized while still capturing the important events. Conditional events can be useful in limiting the size of the system model. Information events should be used only where they enhance understanding of the model or cut sets. Human errors, maintenance events, and common cause events should be modeled at an appropriate level in the tree.

B.3.4.2 Failure Modes

Failure modes define the possible ways in which components can fail. For example, a pump may fail. A more specific model would include two failure modes, such as "fails to start" and "fails to run." These failure modes could be further refined until each failure mode of each part of the pump was modeled. In general, failure modes are broken down to the level of detail needed to achieve the model's objective and for which data is available.

B.3.4.3 Basic Event Naming Scheme

Basic event names should consist of ten characters and have the following format:

Fault Tree Identifier	Specific Component	Generic Component Type	Failure Mode

The first letter of the component name will be used as the identifier. The last three letters are reserved for the type code. The fault tree identifiers used in the Keowee PRA are shown in Table B-1.

The specific component identifier allows up to six characters which identify the specific component or event of concern. These are to remain compatible with the component numbering on the drawings wherever possible. In some cases, a separate numbering scheme may have to be designated by the analyst for faults under consideration. The analyst must maintain a clear key to any arbitrary codes used and must transmit that code for inclusion in future revisions of the document.

The component identifier and failure mode are contained in the type code. Table C.1-5 provides a listing of the type codes used in the Keowee PRA.

B.3.4 STANDARD EVENT DESCRIPTIONS

In defining component failures, the analyst must consistently and logically explain the failure mode being modeled. There are several different ways to state the same failure event. Although none of these ways are wrong, a consistent naming scheme should be adopted. As an example, the failure of a valve to open can be written in the following ways:

- fails to open
- remains closed
- does not open
- does not change state
- fails to open on demand
- fails when commanded open
- fails
- fails in closed position.

Each of these descriptions is correct, but some are more confusing than others. The use of a standard description will aid in the review of system by other analysts.

B.3.5 GATES

B.3.5.1 Gate Types

The following gate types are allowed:

- AND gates
- OR gates
- Combination (COM) gates
- Inhibit gates
- NOT gates

An **AND gate** is used to represent the Boolean intersection of two or more terms. If there are several inputs to an AND gate all must fail to cause the gate failure description to be true. Redundant trains are typically combined under an AND gate.

An **OR gate** is used to represent the Boolean union of two or more terms. If two components are combined under an OR gate together, then the failure of either one will cause the undesired condition to occur. For example, if two valves are in series, then either valve transferring position would cause the line to be blocked. Nonessential systems are usually single-failure oriented and have many components combined under OR gates.

Combination gates are used to represent combinations of two or more component failures which may occur in more than one way. Control signals and instrumentation typically work with two of three and two of four logic. AND gates and OR gates are actually special cases of combination gates. An AND gate is an "all of all" gate while an OR gate is a "one of all" gate.

Inhibit gates are used to control events. They will occur in the use of initiating events, recovery events, modeling flags, and conditional switches. They "hold" the event combined with one of the above events until the desired event is true. In reality, an inhibit gate is very similar to an AND gate.

NOT gates are used to represent the complement of an event. They are numerically equal to one minus the probability of the event. They are used to prevent mutually exclusive

events from occurring and can be used in controlling logic loops (see Section B.3.6.2). They are also used when the probability of an event is close to unity and the complement value has numeric significance. For example, if the value of a pump failure is 1E-4, then the NOT of the event is 0.9999. When the complement is combined under an AND gate with another failure, the product is very close to the other failure's probability. However, if the failure of a pump is 0.4, then the complement is 0.6, and the product of the complement and another failure is significantly less than the other failure's probability. This situation typically occurs in modeling event trees, seismic analysis, tornado analysis, and unreliable components. Thus caution should be used when including NOT gates in your model.

B.3.5.2 Gate Naming Scheme

Preferably, gates names should consist of less than ten characters, to assist in differentiating them from basic event names. Gate names may be descriptive or numbered, using a scheme like the one below:

Fault Tree Code	Gate Number

When transferring to a gate in another tree be sure to name the gate accurately.

B.3.5.3 Standard Gate Definitions

There is no strict naming scheme for gate descriptions, but there are a few rules to remember. Describe the gate in terms of its inputs. The use of correct descriptions will greatly aid in review of the models and later modifications. Avoid using the same description on different gates. If an original description is not possible for each successive gate perhaps they could be combined. Mention key failures of components contained within the gate logic. For example, one description might be "Keowee Unit 1 Fails To Start." This description would indicate that the failures contained within this gate are related only to Keowee start failures. The gate should not contain run failure events which would indicate failure due to operational faults.

B.3.6 LINKING FAULT TREES

B.3.6.1 Transfers

There are two types of transfers; one is a transfer within a system model and the other is a transfer outside a system model. Transfers within a system model deal with branches of a fault tree having common failure points. For example, all governor oil pumps are fed from the same motor control center. Commonalities should be raised to the highest level practical within the model.

Any time a component requires a support system to function, a transfer to that system is required. A pump which requires cooling water from a cooling water system will require a transfer from the cooling water system. The support system analyst is responsible for developing the required transfers, but the front-line system analyst is responsible for assuring that all interfaces between the system and the required support systems have been modeled.

Events representing a transfer to a required support system are given a zero probability during creation of the front-line system fault tree. When the various system fault trees are combined together in preparation for integrated solution, the front-line system fault tree will link with the support system fault tree and drop the transfer event with the zero probability. The zero probability transfer event is used when solving the front-line system fault tree by itself to generate system level cut sets.

B.3.6.2 Circular Logic

In some cases the integrated tree may contain circular logic; that is, a gate whose value is dependent on itself. Circular logic must be removed from the tree before a solution is possible. When circular logic is detected, one or more of the input trees must be modified so that the circle is broken without losing the impact of the failures on the top gate. An often encountered case of circular logic that is applicable to the Keowee PRA follows.

The auxiliary ac power system relies on the availability of the dc power system to provide power for the operation of various circuit breakers in the ac power system. The dc power system relies on batteries and battery chargers to provide a continuous and long term supply of dc power. If the ac power supply to the chargers is included in the model for

the dc power system a circular logic develops: ac relies on dc which relies on ac. This circle is broken by not including the transfer to the auxiliary ac power tree in the dc power system logic. Because the ac power system failures result in the unit failing through other system transfers, the loss of this input into the dc power system tree does not cause the solution to "miss" failures and under predict the failure probability.

B.4 MODULARIZATION

Modularization involves the collapsing of independent events into a single independent event (module) to reduce computer size and time requirements. However, this process has the drawback that details of the module's composition are lost. Since computer requirements for the Keowee fault trees are easily accommodated modules will not be developed for the Keowee PRA.

B.5 ASSUMPTIONS AND GENERAL RULES

Use the following assumptions and general rules in developing system models.

- Piping taps whose diameter is one fourth the main header need not be modeled.

- Instrumentation devices (flow, temp., press.) which do not provide direct input to system operation should not be modeled, unless they would block flow of the line if plugged.

- Locked-closed manual valves are not modeled as transferring position. Locked-open manual valves may be modeled as transferring position if significant.

- Passive failures of piping and electrical wiring are not modeled.

- Possible system train cross-connects should be modeled.

- Maintenance will generally be assessed on a train level.

- All maintenance will be assigned to the standby train.

- Human errors should be modeled as high as possible in system models.

- If only one train of a system is operational, it is assumed to be train A.
- The front-line system analyst is responsible for informing the support system analyst of a need for a transfer development.
- Relief valves should not include a transfers closed failure mode.
- All system models will be developed on a train level whenever possible.
- Component interlocks will be explicitly modeled.

B.6 SYSTEM DOCUMENTATION

To provide documentation for each model, a system write-up is required. This stand-alone document provides a basis for review and modification of the model as needed. It also allows other analysts to use prior work in developing new studies.

B.7 UPDATING MODELS

Once a model is developed, it may need to be modified later. These modifications may be caused by errors, revised estimates, or system modifications. Each time the model is changed, the model's revision number should be updated.

Table B-1

Keowee PRA Fault Tree Identifiers

Fault Tree Identifier	System Identifier	System/Component
A	ACBs	Air Circuit Breakers
B	GBO	Turbine Guide Bearing Oil
D	--	Switchyard DC Power
E	VR	Generator Excitation
F	WL	Generator Cooling Water System
G	GEN	Keowee Generator
K	--	Keowee High-Level Fault Tree
L	EGTPS	External Grid Trouble Protection System
O	OG,AG	Governor Oil and Air Systems
P	TS	Turbine Sump Pump System
S	--	Emergency Power Paths
W	MT	Governor & Turbine
X	--	Auxiliary Power System
Y	--	Emergency Start/Run Control

APPENDIX C.1
COMPONENT FAILURE DATA ANALYSIS

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C.1 COMPONENT FAILURE DATA ANALYSIS

C.1.1 INTRODUCTION

This appendix provides details on the data collection and type code development processes. This appendix also provides the development of the train and component maintenance events used in the system models and a listing of the developed events.

C.1.2 DATA COLLECTION PROCESS

A flowchart of the data collection process is provided in Figure C.1-1. The process involved collecting Keowee data for the ten year period from January 1, 1984 to December 31, 1993, compiling the relevant data, and processing the data to obtain the desired outputs. The desired outputs from this effort are:

- the number of normal and emergency starts
- each units' total run hours
- the number of unit start and run failures
- unit and station unavailability
- maintenance and testing unavailabilities on a train or component
- a list of component failures which affected (or could have affected) emergency operation capability

The following data sources were reviewed during the process:

- Keowee Operators Logs
- Oconee Reactor Operators Logs
- Keowee Switchboard Logs
- Work Request Database
- Keowee Maintenance Procedures
- Problem Investigation Process (PIP) Database
- Problem Investigation Report (PIR) Database
- Incident Investigation Report (IIR) Database
- Licensee Event Report (LER) Database
- Keowee Station Personnel
- Jocasee Station Personnel

The data collection results are provided in the sections that utilize that data. Sections C.1.3 through C.1.5 discuss how the data collection results are used to calculate plant-specific failure rates, maintenance unavailabilities, and failure probabilities for developed events. Section 5.2 of the main report discusses the data collection results on a unit level.

C.1.3 TYPE CODE DEVELOPMENT

C.1.3.1 OVERVIEW

A Bayesian-updated type code was developed for use in solving the Keowee PRA fault trees. The ***type code*** provides a convenient way to apply the same failure rate to all Keowee equipment of the same type. The failure probability for a given component is calculated by multiplying the type code failure rate by the appropriate basic event factor.

The type code development process is shown in Figure 5.3-1. After the models are developed, the basic event databases are combined, and all of the basic events are printed to a file. A spreadsheet program may then be used to open the file and sort the events by tree, type code and name. (The tree field designates which tree(s) the event is found in, and is a convenient way to couple the event with a system modeler.)

Next, each modeler determines the hours of exposure or number of demands on components represented by their basic events for the ten year period of data consideration (1984-1993). The modeler assigns a denominator code for each event. The codes are translated into numbers, the numbers for each type code are summed, and the sums are used in the **denominators** to calculate a plant-specific failure rate for each component type. Data is also compiled on the number of emergency and normal starts, unit run time and availability to assist in quantifying the denominators.

For the period of data collection, a list of failures relating to the basic events in the model is compiled. These failures are categorized by component type and are totaled. These totals go into the **numerators** for the plant-specific failure rate calculations.

A generic type code is developed from a screening of various industry sources. Finally, the generic and plant-specific failure rates are combined using the Bayesian update method.

C.1.3.2 GENERIC FAILURE RATE TYPE CODE

The generic type code database is taken primarily from the Davis-Besse IPE (Reference 1), which developed generic failure rates by aggregating several sources. The data for **BYF**, the code for "Battery Fails to Provide Output," was determined using the same methodology. The INEL report Generic Component Failure Data Base For Light Water And Liquid Sodium Reactor PRAs (Reference 2) is utilized for some of the switch failure rates, the heat exchanger leak failure rate, and the push-button transfer failure rate. IEEE Std. 500 (Reference 3) is used as the source for the PCB failure rates and the diode failure rate.

C.1.3.3 PLANT-SPECIFIC FAILURE RATE TYPE CODE

Initially, data on *all* Keowee component failures were collected, since the Keowee PRA Model Basic Event List was under development throughout the data collection process. Once the list of basic events was completed, only the relevant failures (those for the components being modeled) were retained. The complete component failure listing, along with all supporting documentation, is contained in the Keowee PRA Project Data Notebook.

Table C.1-1 provides a brief description of the component failures affecting the Keowee model. Failures of each component type were summed and then used for the numerator in calculating the plant-specific failure rates.

To determine the denominators to be used in the plant-specific failure rate calculations, each modeler determines the exposure time, or number of demands, for their basic events during the ten year period of data collection and assigns a denominator code to that event. The denominator codes, values and descriptions are provided in Table C.1-2. For example, since the Emergency Start Relays are demanded to energize for all emergency starts, the modeler chooses **ES** as the code.

For components that are demanded on an atypical basis a computation is performed to determine the appropriate denominator. For example, a governor oil pump normally starts every two hours, and runs for approximately three minutes before shutting off. The pump operates when the unit is in service as well as when shut down, since governor oil is

continuously recirculated. Normally, only one of the three pumps is needed to maintain system pressure. Thus, for unit 1:

No. of starts per Gov. Oil Pump	=	(Available hrs. over 10 yr. period)
		* (1 start/ 2 hrs.)/ 3 pumps
	=	(85,755)(0.5)/3
	=	14,292 starts/pump
Run time per Gov. Oil Pump	=	(14,292 runs/pump)
		* (1.5 min./ run)(1 hr./60 min.)
	=	(14,292)(1.5)/60
	=	357 hrs/pump

The results of the denominator calculations are shown in Table C.1-3.

The Chi-Squared variate at the 50% cumulative probability level is used estimate plant-specific failure rates for components that have not experienced a failure. The Advanced Light Water Reactor Utility Requirements Document (Reference 4) utilizes the following equation to estimate failure rates where no failures have occurred (such as for large-break LOCAs):

$$\phi(A) = \frac{X_{50}^2(2n+1)}{2T}$$

where $\phi(A)$ = the failure rate of interest
$X_{50}^2(2n+1)$ = the chi-squared quantile at the 50% cumulative probability level, with $2n + 1$ degrees of freedom
n = the number of failures observed
T = exposure time or number of demands.

(The 50% quantile is the median point of a data set: half of the values occur below this value and half above.)

For the case where no failures have been observed, $n = 0$, and $X_{50}^2(1) = 0.455$. Thus the equation simplifies to:

$$\phi(A) = \frac{0.2275}{T}$$

Each modeler also determines the basic event factor, which, when multiplied by the type code failure rate produces the basic event's failure probability. For time-dependent failures, the ***factor*** represents the exposure time over which a component has the opportunity to fail prior to a start (before the problem is detected and corrected), plus the appropriate mission time. For demand failures, the factor is the number of demands a component may receive prior to a start, if failures would go undetected, plus any demands during a Keowee start or run. Rules for determining the factor are provided in Table C.1-4. The basic event factors are developed and provided in the system appendices.

C.1.3.4 BAYESIAN-UPDATED FAILURE RATE TYPE CODE

A third type code was developed by combining generic and plant-specific evidence using the Bayesian update. The Bayesian-update process is based on Bayes' theorem, which states that

$$f(\lambda|E) = \frac{f(\lambda)L(E|\lambda)}{\int_0^\infty f(\lambda)L(E|\lambda)d\lambda}$$

where
λ = the failure rate of interest
$f(\lambda)$ = the **prior distribution**; the probability density function of λ based on generic information (which excludes the plant-specific evidence, E)
$f(\lambda|E)$ = the **posterior distribution**; the probability density function of λ, conditional on the plant-specific evidence, E
$L(E|\lambda)$ = the **likelihood function**; the probability density function of the plant-specific evidence E for a given value of λ.

The update was performed with a spreadsheet that uses the same algorithm as is used in the EPRI Component Reliability Parameter System Bayesian-update software (which is included with Ref. 5).

To perform the integration analytically, the spreadsheet first translates the generic failure rate mean and error factor into a "conjugate" prior distribution -- a gamma distribution for time-dependent failures, a beta distribution for demand-type failures. The Bayesian-

updated posterior distribution is then obtained using the equations below. Finally, the posterior distribution is converted to a lognormal distribution.

Time-Dependent Failures

For time-dependent failures, the gamma distribution is used as the model. The α and β parameters that characterize this conjugate prior distribution are calculated from the lognormal parameters (μ, σ) as follows:

$$\alpha = \mu^2 / \sigma^2 \qquad\qquad \beta = \mu / \sigma^2$$

The updated mean and variance are then calculated by:

$$x' = (\alpha + k) / (\beta + \tau) \qquad\qquad \mathrm{var}\,(x') = (\alpha + k) / (\beta + \tau)^2$$

where k is the number of failures and τ is the exposure time.

Demand Failures

For demand-type failures, the beta distribution is used as the model. The α and β parameters that characterize this conjugate prior distribution are calculated from the lognormal parameters (μ, σ) as follows:

$$\alpha = \mu^2 (1 - \mu)/ \sigma^2 - \mu \qquad\qquad \beta = \mu (1 - \mu) / \sigma^2 - 1$$

The updated mean and variance are obtained by applying Bayes' Theorem to the plant-specific data as follows:

$$q' = (\alpha + K) / (\alpha + \beta + N)$$
$$\mathrm{var}\,(q') = [(\alpha + K) (\beta + N - K)] / [(\alpha + \beta + N)^2 (\alpha + \beta + N + 1)]$$

where K is the number of failures and N is the number of demands over the period of data consideration.

Because of the extensive operational experience at Keowee, the Bayesian updated failure rates are heavily influenced by the Keowee data. The generic, plant-specific, and Bayesian-updated failure rate type codes are tabulated in Table C.1-5.

C.1.4 KEOWEE TRAIN/COMPONENT MAINTENANCE UNAVAILABILITIES

Table C.1-6 provides a list of maintenance-related train or component basic events modeled in the Keowee PRA. These basic events represent the historical unavailability of the equipment over the ten year period of data collection. For these events, unavailability of the train or component does not render the unit unavailable.

C.1.5 KEOWEE UNDEVELOPED EVENTS

Table C.1-7 lists the undeveloped events that are included in the model. An ***undeveloped event*** provides a plant-specific failure rate for single component or small group of components for which a generic failure rate is not available. The failure probability of each event is determined by a simple calculation. The development of these events is provided in the appropriate system appendix.

C.1.6 REFERENCES

1. Individual Plant Examination For The Davis-Besse Nuclear Power Station, Toledo Edison Company, 1993.

2. Generic Component Failure Data Base For Light Water And Liquid Sodium Reactor PRAs, EGG-SSRE-8875, Idaho National Engineering Laboratory, 1990.

3. IEEE Guide To The Collection And Presentation Of Electrical, Electronic, Sensing Component, And Mechanical Equipment Reliability Data For Nuclear Power Generating Stations, IEEE Std. 500-1984, Institute Of Electrical And Electronic Engineers, Inc., 1983.

4. EPRI, NP-6780-L, Rev. 4, Vol. 2, Ch. 1, App. A, PRA Key Assumptions And Groundrules, April, 1992.

5. EPRI, TR-103514, Projects 3323-01, -02, Final Report, Maintenance Effectiveness Evaluation Database Tools, February, 1994.

Table C.1-1: Keowee PRA Component Failures Sorted By Type Code

DATE	UNIT	TYPE CODE	COMPONENT	EVENT DESCRIPTION	EFFECT ON UNIT OPERATION
8-21-87	1	**ACBDEX**	**ACB-3**	Oconee attempted to line unit 1 up to the underground but they could not get ACB-3 to close. Keowee tried closing ACB-3 by-hand locally but it would not close. This problem was due to a **loose terminal**, DS-15 in the ACB-3 cabinet.	Not able to power CT4 from unit 1. Loss of ACB-3 so unexpectantly would put the unit in an LCO.
2-28-90	2	**ACBDEX**	ACB-2 **Blast Valve Pin**	ACB-2 out of service to replace a bad Blast Valve Pin in ACB-2.	Unit 2 can be used to feed CT4 but cannot generate to the grid.
10-19-92	1	**ACBDEX**	ACB-5, ACB-7 **Impact Spring**	**Oconee LOOP Event** - Initially Unit 1 was generating to the grid and Unit 2 was lined up to the underground path. When the Swyd Isolation and the 1st ES actuation occurred, ACB-1 tripped and then reclosed. Unit 2 started and was supplying CT4. The K Operator tripped ACB-1 which de-energized all of Keowee's auxiliaries. ACB-5 and ACB-7 failed to transfer as designed to re-energize the 1X Swgr. A Main Transformer lockout prevented re-closing ACB-1. It is believed that ACB-5 and ACB-7 failed to transfer due to misactuation of the **Impact Spring** in the DB 50 Alarm Switch Circuits.	The operator, not knowing the cause of the problem, took action to protect the Unit 1 Generator by tripping ACB-1 which resulted in the loss of all Keowee Auxiliary Power.
11-28-92	2	**ACBDEX**	ACB-2 **Exhaust Valve Connection Rod**	Keowee Unit 2 was started for system generation but ACB-2 would not close either automatically or manually. The operator found a smoking relay in the ACB-2 cabinet. The problem was caused by a broken **exhaust valve connection rod** which caused the x-relay (52X/MG-6 relay) to remain energized until it overheated and burned up.	**EMERG. START FAILURE** This is being counted as an Emerg. Start failure due to the fact that this unit was aligned to the overhead Emergency Power Path.

Table C.1-1: Keowee PRA Component Failures Sorted By Type Code

DATE	UNIT	TYPE CODE	COMPONENT	EVENT DESCRIPTION	EFFECT ON UNIT OPERATION
2-24-87	2	**BASE ADJ DEX**	Voltage Regulator **Base Adjust Reset Switch**	Unit 2 was started for system generation but it tripped due to no VARs. Keowee received a Hi Limit light on the Voltage Adjust. Found **reset switch on the Base Adjust** not running back to reset position. Cleaned switch (S4) with contact cleaner and ran unit locally - Sat.	**AUTO START FAILURE.** No effect on Emergency Start capability because the run back switch was above the minimum voltage setting.
3-27-90	1	**BASE ADJ DEX**	Voltage Regulator **Base Adjust (70B Cam Switch)**	Started Unit 2 for system generation but unit would not start. Found problem to be due to the 70B cam switch not resetting to its preset position. This caused the 70BX relay to drop out. Cleaned contacts and unit started.	**EMERG. START FAILURE.** This is being counted as an ES failure since we don't know what the Base Adjust setting was when the unit was started. It may have been positioned at a setting which provided voltage less than 13.8kV.
9-20-92	2	**BASE ADJ DEX**	Voltage Regulator **Base Adjust & Volts Adjust**	Unit 2 started from Keowee for system generation but voltage regulator did not come on. Unit 2 started in manual and paralled from Keowee. 70BX relay wasn't picked up so this stopped unit from starting. Ran Base Adjuster back and forth a couple of times and sprayed Base Adjuster contacts and 70BX relay picked up. The problem with regulator appeared to be **dirty Base Adjust contacts**. Actual Voltage Regulator problem still not resolved.	**AUTO START FAILURE.** Voltage regulator failing to come on would not have prevented the unit from performing an Emergency Start since the Base Adjuster is set sufficiently to carry the emergency Oconee loads.
9-20-93	1	**BASE ADJ DEX**	Voltage Regulator **Base Adjuster (70B)**	During Keowee Emer. Start test, unit 1 failed to reach rated voltage of 13.8 during test, only 13.3 KV. The base adjuster had failed and was replaced.	Keowee unit 1 would have been capable to perform its design function.

Table C.1-1: Keowee PRA Component Failures Sorted By Type Code

DATE	UNIT	TYPE CODE	COMPONENT	EVENT DESCRIPTION	EFFECT ON UNIT OPERATION
1-26-84	1	**BCF**	**Battery Charger #1**	Found Battery Charger #1 Amperes swinging from 0 to 40 amps. It was determined that an AC surge on the charger had blown 4 fuses in the **filter circuit**. Replaced the fuses and placed charger back in service.	No effect on unit operation.
9-25-86	2	**BCF**	#2 Battery Charger **Firing Module**	#2 AC Battery Charger failed. Replaced blown fuses but charger still would not come on. Replaced **Firing Module** in Battery Charger and tested charger satisfactorily.	No effect on unit operation.
9-29-86	2	**BCF**	#2 Battery Charger **Control Cards**	#2 Battery Charger acting up. Work Request written to check / repair #2 charger voltage output. Cleaned contact pins on control cards.	No effect on unit operation.
11-28-88	2	**BCF**	#2 Battery Charger **Float Voltage Adjust Sw.**	Problem with #2 Battery Charger. Problem due to dirty contacts on the float voltage adjust switch.	No effect on unit operation.
12-17-92	2	**BCF**	Battery Charger #2 **Current Limiter Feedback Circuit**	On 12-16-92 when Battery Bank #1 and Battery Charger #1 were removed from service for maintenance, Battery Charger #2 began exhibiting erratic amp readings. Attempts made to adjust voltage to stabalize #2 Charger failed. Maint. personnel replaced the power supply, current control, voltage control, and the firing modules and returned #2 charger to service. On 12-17-92 during Emergency Start test, Battery Charger #2 A/C input switch tripped. #2 Battery Charger was removed from service. The problem was traced to a loose connection in the current limiter feedback circuit.	No effect on unit operation.

Table C.1-1: Keowee PRA Component Failures Sorted By Type Code

DATE	UNIT	TYPE CODE	COMPONENT	EVENT DESCRIPTION	EFFECT ON UNIT OPERATION
12-21-92	2	BCF **DIF**	Battery Charger #2 **Surge Voltage Suppressor (Rectifier)**	Smoke detector over #2 Battery Charger alarmed. Removed charger from service. Found burned diodes.	No effect on unit operation.
9-30-91	1	**CHC**	**PCB-21**	PCB-21 would not close. Sync relay (25/21) in control circuit open due to voltage on yellow buss side appearing high. The problem was not with PCB-21 which functioned as it was designed to do. The Sync relay in the control circuit (close) showed an over voltage condition on the yellow bus which kept the contacts open preventing a control close for the control room. Adjusted voltage feeding "ready to operate setting". "Sync ready" tested good.	Unit 1 Generator output isolated from the 230KV Yellow Bus.
2-1-94	0	**CHT**	**PCB-7**	While placing the "Dacus White Line" in service PCB 8 tripped and PCB-7 tripped and then reclosed when PCB-10 was closed. Relay 21GX-1, a "ground distance impedance relay" for the Dacus Black line, had caused PCB's 7 & 8 to trip because it sensed a fault on the Dacus Black line. When PCB-10 closed, a load shift made the Dacus Black line see a fault and initiate a trip of PCB's 7 & 8. The 21GX-1 relay had sensed a fault because following preventative maintenance on the Dacus Black line, a "potential device ground switch" was not returned to the "normal" or "ungrounded " position.	Plant safety not affected.

Table C.1-1: Keowee PRA Component Failures Sorted By Type Code

DATE	UNIT	TYPE CODE	COMPONENT	EVENT DESCRIPTION	EFFECT ON UNIT OPERATION
2-1-94	0	**CHT**	**PCB-8**	While placing the "Dacus White Line" in service PCB 8 tripped and PCB-7 tripped and then reclosed when PCB-10 was closed. Relay 21GX-1, a "ground distance impedance relay" for the Dacus Black line, had caused PCB's 7 & 8 to trip because it sensed a fault on the Dacus Black line. When PCB-10 closed, a load shift made the Dacus Black line see a fault and initiate a trip of PCB's 7 & 8. The 21GX-1 relay had sensed a fault because following preventative maintenance on the Dacus Black line, a "potential device ground switch" was not returned to the "normal" or "ungrounded " position.	Plant safety not affected.
9-20-88	2	**CLC**	Load Center 1X **1XA Stby Supply Breaker**	When clearing Load Center 1X for breaker inspection, the 1XA standby supply breaker failed to close. Replaced it with the spare breaker and closed 1XA from the control room.	No effect on Emergency Start capability.
11-24-92	2	**CLC**	**ACB-6** **ACB-8**	While attempting to tie Keowee Unit 2 to the overhead after a successful Emergency Start Test of both units, feeder breakers for loadcenter 2X, ACB-6 and ACB-8, would not close manually, which left Keowee Unit-2 without power. Problem believed to be due to **inadequate DC voltage** available to close the breakers with the newly installed anti-pump circuitry. Time Delays were installed to compensate for the problem.	No effect on unit operation.

Table C.1-1: Keowee PRA Component Failures Sorted By Type Code

DATE	UNIT	TYPE CODE	COMPONENT	EVENT DESCRIPTION	EFFECT ON UNIT OPERATION
7-24-86	2	CO2DEX	No Failure	Received #2 Keowee Emergency Lockout due to **CO2 actuation caused by electricians at Oconee** performing NSM on Keowee Unit 1 CO2 switches. Event occurred when the wires were lifted for unit one but when testing the switch, the Unit 2 switch was depressed.	**Human Error.** Unit 2 unavailable for generation.
1-31-87	1	FUF CLT	ACB-5 **Trip Circuit Fuse**	Oconee was performing a test on PCB 8 and 9 when ACB-5 tripped. Would not reclose. Problem determined to be due to a blown fuse in ACB-5 trip circuit.	No effect on Emergency Start capability.
7-17-92	2	FUF	ACB-8 **Close Circuit "1B" Positive 10 amp Fuse (OT10)**	Keowee Operator found blown fuse in ACB-8 closing circuit during a time when Unit 1 was out of service and Unit 2 was lined up to feed CT4 and the standby busses with Unit 2 auxiliaries being fed through ACB-6. This made Unit 2 technically inoperable.	No effect on Emergency Start capability.
10-20-92	1	FUF	ACB-5 **Control Circuit Fuse (+)**	While testing the ACB5/ACB7 swapover function, ACB 5 failed to close when ACB 7 was tripped. Found positive leg fuse in control circuit blown.	No effect on Emergency Start capability.
4-5-93	2	FUF	Voltage Regulator Field Flash Breaker **DC Control Power Fuse (NON-15)**	Unit 2 started for system generation but Field Flash Breaker failed to close. Problem was due to a blown fuse in the DC control circuitry for the breaker. Fuse was replaced and the unit tested successfully.	**EMERG. START FAILURE.** Unit 2 unavailable for Emergency Start.

Table C.1-1: Keowee PRA Component Failures Sorted By Type Code

DATE	UNIT	TYPE CODE	COMPONENT	EVENT DESCRIPTION	EFFECT ON UNIT OPERATION
4-30-87	2	**FVT**	#2 Generator Cooling Water **Vacuum Line Float Valve**	Unit 2 taken out of service to repair Generator Cooling Water Discharge Vacuum Valve. Valve was making noise because the float had a hole in it. Removed, welded, and replaced float.	No effect on unit operation. This float valve is located in the discharge line of the cooler and operates to prevent the water from being siphoned from the cooler during shutdown periods.
11-17-87	1	**FVT**	#1 Generator Cooling Water **Vacuum Line Float Valve**	Unit 1 Key Inhibited to repair the Generator #1 Cooling Water discharge vacuum line float valve. Replaced broken float.	No effect on unit operation. This float valve is located in the discharge line of the cooler and operates to prevent the water from being siphoned from the cooler during shutdown periods.
9-13-88	1	**FVT**	Governor Oil Pressure Tank **Float Valve**	Keowee having trouble with unit 1 Governor Oil Pumps. Problem found to be due to a bad pressure tank float valve. Replaced float valve and system functioned satisfactorily.	Unit 1 out of service for dispatcher and Emergency Start to replace #1 Governor Control Pressure Tank Float Valve.
7-5-85	1	**GOV START DEX**	Governor Control System **33XY Switch Linkage** (See KEE-111-1A)	Unit 1 started for operability verification after weekly maintenance but failed to reach rated speed. Oconee adjusted gate limit out to 70 % and the unit was able to reach rated speed.The problem was determined to be due to the linkage on the **33XY switch** binding.	No effect on Emergency Start. This portion of circuitry bypassed during ES.
5-11-88	1	**GPR**	Turbine Bearing Oil System **DC Oil Pump Motor**	Had oil fire in DC Turbine Oil Pump. Replaced DC Bearing Oil Pump Motor.	Received Alarm Lockout when motor was deenergized but it did not affect Unit 1's Emergency Start capability.
7-8-93	2	**GPR**	**AC Turbine Bearing Oil Pump**	Found DC Turbine Bearing Oil Pump running. AC pump was not running. AC pump removed by work request. Motor had shorted windings.	No effect on Emergency Start capability.

Table C.1-1: Keowee PRA Component Failures Sorted By Type Code

DATE	UNIT	TYPE CODE	COMPONENT	EVENT DESCRIPTION	EFFECT ON UNIT OPERATION
3-6-85	1	GPS RYD	Governor Oil System **88GT Timer**	Found Governor Oil Pump 1C running unloaded, but didn't receive a statalarm on excessive running. The problem was due to a bad 88GT Timer. Replaced the timer.	No effect on unit operation.
2-21-84	1	GPS	**Governor Oil Pump 1C**	Found Governor Oil Pump 1C running unloaded. Upon inspection, the pump had a worn unloader assembly. Replaced the pilot valve seat, the snap action plunger, the pilot valve bushing, the pilot valve plunger, and the unloader switch.	No effect on unit operation.
2-21-84	1	GPS	**Governor Oil Pump 1B**	Found Governor Oil Pump 1B loading and unloading too soon. Upon inspection, the pump had a worn unloader assembly. Replaced the pilot valve seat, the pilot valve spring, the snap action plunger, the pilot valve bushing, the pilot valve plunger, and the unloader switch.	No effect on unit operation.
4-11-84	1	GPS	**Governor Oil Pump 1B**	Governor Oil Pump 1B failed to load and unload properly. Replaced no components but did adjust unloader valve and pressure switch and relieved all friction in valves.	No effect on unit operation.
4-11-84	1	GPS	**Governor Oil Pump 1C**	Governor Oil Pump 1C failed to load and unload properly. Replaced no components but did adjust unloader valve and pressure switch and relieved all friction in valves.	No effect on unit operation.
8-23-88	2	GPS	Governor 2C Oil Pump **Pump Bearing**	Governor Oil Pump 2C placed in lag position because it has a bad bearing. Bearing replaced and unit returned to service.	No effect on Emergency Start capability.

Table C.1-1: Keowee PRA Component Failures Sorted By Type Code

DATE	UNIT	TYPE CODE	COMPONENT	EVENT DESCRIPTION	EFFECT ON UNIT OPERATION
10-27-87	1	**GPS**	AC Turbine Sump Pump **Flow Switch Contacts**	Received alarm on #1 Turbine Water Sump High Level and DC sump pump started but the AC pump did not. AC Sump Pump breaker not tripped. Reset AC pump breaker but pump still would not start. Technician adjusted the **Flow Switch Contacts** and the pump worked fine.	No effect on unit operation. AC backup sump pumps installed on 11/2/87.
11-19-85	2	**HGR**	**#2 Generator**	Unit 2 was generating to the grid when it received a Normal Lockout due to a Generator Field Ground. The problem was due to the electrical connection between two generator rotor field poles having burned out. The root cause of the burned out connection was believed to be due to vibration.	**EMERG. RUN FAILURE.** Unit 2 was unavailable for Emerg. Start for 181 hours to repair the generator.
12-2-92	2	**HGS**	**#2 Generator** Y Phase PT Circuit	Unit 2 started for operability test. The unit tripped by emergency lockout on #2 generator ground fault overcurrent (59GN2). Found nicked wire (53) between 290-1X and 290-4X with a nick in the insulation from a screw used to attach the cover plate of the Voltage Regulator. Problem was caused by I & E technicians as they were completing a Configuration Control Inspection of Safety Related cabinet wiring.	**EMERG. START FAILURE. Human Error.** Unit 2 unavailable for Emergency Start.
10-28-93	2	**HUMAN ERROR**	Turbine Guide Bearing Oil System **Oil Cooler**	During performance of the PM on the unit 2 Turbine Guide Bearing Oil Cooler, the soldered joint on the down stream side of the cooler came loose due to the torque applied to the hex nut.	Because the broken joint is on the down stream side of the cooler, there is no concern for unit operation.

Table C.1-1: Keowee PRA Component Failures Sorted By Type Code

DATE	UNIT	TYPE CODE	COMPONENT	EVENT DESCRIPTION	EFFECT ON UNIT OPERATION
5-7-84	2	**LHE**	Voltage Regulator (No Component Failure)	Unit 2 started for system generation but received a Normal Lockout. The voltage regulator would not come on in auto (unit would run in manual). The cause of the problem was determined to be due to the **Base Adjuster** having a preset position (S3-S4) which gave a low no-load machine voltage (12.8kV instead of rated 13.8kV) which did not match the Volts Adjust setting of 13.8kV setting when the voltage reg. came on in auto. The mismatch caused a time delay greater than the Volts-Hertz time delay relay setting which shut down the unit. The Base Adjust was reset to 13.8kV and the unit started several times successfully.	**EMERG. START FAILURE.** This is being counted as an ES failure due to the fact that the Base Adjust was set for only 12.8 kV instead of the 13.8kV required to supply Oconee's emergency loads.
3-27-86	2	**LHE**	Lightning Arrestors	At 1300 on 3-26-86 maintenance personnel were changing lightning arrestors on unit 2. Due to a stripped bolt on the insulator, the capacitor was not re-installed on the **X-phase.** Oconee decided to leave it off until another capacitor could be ordered from Westinghouse. At 0016 on 3-27-86, Unit 2 was started by Oconee to Op. test the unit but anEmergency Lockout was received due to a Gen. Ground Fault Overvoltage (59GN2 Relay). The reason for this relay action was due to the fact that the x-phase capacitor was removed and when the unit started, it caused a capacitor imbalance whichgave the 59GN target. The Y and Z phase capacitors were removed and the unit tested sat.	**Human Error.** Although this is technically an Emergency Start failure, the **unit had not been returned to service** since the maintenance action had been performed.

Table C.1-1: Keowee PRA Component Failures Sorted By Type Code

DATE	UNIT	TYPE CODE	COMPONENT	EVENT DESCRIPTION	EFFECT ON UNIT OPERATION
5-10-84	2	**NLODEX**	Voltage Regulator Logic **Relay 94RA**	On 5-10-84 Oconee attempted 2 automatic starts for system generation but each time a unit Normal Lockout was received. After the 2nd start attempt the unit was started in manual from Oconee successfully. The problem was determined to be due to a bad relay. **Relay 94RA** (manual to auto transfer relay) was replaced. On 5-14-84 the Volts/Hertz relay was reset from 124 volts AC to 127.8 volts on pickup and 118.3 volts on dropout.Unit 2 was out of the auto mode for the entire period. This problem seems to be related to the problem on 5-7-84.	No effect on Emergency Start capability. Relay 94RA is bypassed on ES.
8-1-88	2	**NLODEX**	Genarator Cooling Water Flow Indicator Switch (No Failure)	Unit 2 tripped while generating to the grid due to Generator Cooling Water Alarm lockout. Operator readjusted cooling water flow which seemed to correct the problem.	**AUTO RUN FAILURE.** No effect on Emergency Start capability.
8-18-88	2	**NLODEX**	Generator Cooling Water Alarm Circuit **Timer, 63GCAT**	Unit 2 tripped while generating to the grid due to Generator Cooling Alarm lockout. Jumpered out 63CT Timer contacts and restarted unit. Replaced 63CT Timer because it had a bad coil.	**AUTO RUN FAILURE.** No effect on Emergency Start capability.
9-29-92	2	**R6D**	ACB-2 **27T2X Relay** (MG-6 Relay)	During the performance of post-mod. testing, it was discovered that ACB-2 did not close immediately after opening ACB-1 as the procedure required. Investigation revealed that relay 27T2X (West. MG-6 relay) did not have the proper gap as specified by the manufacturer. The plastic armature stop nut broke apart while the gap was being adjusted. Stop nut was replaced and the proper contact gap was set. This relay was unaffected by the modification.	Keowee Unit 2 overhead emergency power path inoperable.

Table C.1-1: Keowee PRA Component Failures Sorted By Type Code

DATE	UNIT	TYPE CODE	COMPONENT	EVENT DESCRIPTION	EFFECT ON UNIT OPERATION
5-22-89	2	**R6D**	**Voltage Regulator**	Started Unit 2 for system generation. After the unit paralled the operator could not get the VARs to come up. Received a #2 incomplete start statalarm and the unit tripped. A subsequent start was successful. Reason for failure is unknown however, the sequence of events indicates that the Voltage Regulator never came on. Possibly due to the 90X1C relay problem.	**AUTO START FAILURE.** No effect on Emergency Start capability since ACB-2 had closed.
10-17-90	2	**R6D**	**Voltage Regulator** (MG-6 Relay)	Unit 2 started and paralleled but the Voltage Regulator did not come on. Sprayed **90X1C Relay** contacts with contact cleaner and the Voltage Regulator functioned properly on subsequent test starts.	**AUTO START FAILURE.** Voltage regulator failing to come on would not have prevented the unit from performing an Emergency Start since the Base Adjuster is set sufficiently to carry the emergency Oconee loads.
10-18-90	2	**R6D**	**Voltage Regulator** (MG-6)	Started Unit 2 for system generation but the Voltage Regulator did not come on. Found a dirty 90XIC contact. Cleaned the contact and the Voltage Regulator functioned properly on subsequent test starts.	**AUTO START FAILURE.** Voltage regulator failing to come on would not have prevented the unit from performing an Emergency Start since the Base Adjuster is set sufficiently to carry the emergency Oconee loads.
9-6-92	2	**R6D**	Voltage Regulator **90XIC Relay Contacts**	Started Unit 2 for system generation but the Voltage Regulator failed to come on. The problem appeared to be due to dirty 90XIC contacts (Westinghouse MG-6 relay). The contacts were cleaned and the unit started successfully.	**AUTO START FAILURE.** Voltage regulator failing to come on would not have prevented the unit from performing an Emergency Start since the Base Adjuster is set sufficiently to carry the emergency Oconee loads.

Table C.1-1: Keowee PRA Component Failures Sorted By Type Code

DATE	UNIT	TYPE CODE	COMPONENT	EVENT DESCRIPTION	EFFECT ON UNIT OPERATION
5-6-84	2	**RVT**	Governor Pressure Tank **Safety Valve**	The first indication of a problem was a Unit 2 Governor trouble alarm. Oil pump 2C was found running, sucking air. The Pressure Tank oil level was up past the high level alarm and the safety valve was popping off. The problem was due to the safety valve having a **cracked seat.** The valve was replaced.	No effect on unit operation.
3-16-87	2	**RVT**	**Governor Oil Pump 2A**	Governor Oil Pump 2A running unloaded. Problem due to pump bypassing through **relief valve.** Adjusted pump relief valve to relieve at 365 psi.	No effect on unit operation.
6-19-84	2	**RVT**	Governor Pressure Tank **Safety Relief Valve**	While performing an NSM on Keowee's Fire Protection System, SSD personnell accidently hit the Unit 2 Governor Pressure Tank Safety Relief valve which caused the valve to have a **small air leak.** A new valve was ordered since there were no replacements in stock.	**Human Error.** No effect on Emergency Start capability.
10-22-92	1	**RYD**	ACB-1 **Timer 52-1TD (contact 4A)**	Unit 1 had just been shut down and a cabinet inspection team was performing a cabinet inspection in Cabinet 1LC1 at Keowee when they discovered a broken lug on Emergency Start **Timer 52-1TD (contact 4A)** which trips ACB-1 on receipt of an ES signal. Unit 1 was out of service for 2.5 hours to replace the broken lug.	The overhead Emergency Power path was OOS for the time required to replace the broken lug. Had this lug been completely broken off such that there was no continuity for that conductor, the unit would not be able to provide Emergency Power via the overhead path.

Table C.1-1: Keowee PRA Component Failures Sorted By Type Code

DATE	UNIT	TYPE CODE	COMPONENT	EVENT DESCRIPTION	EFFECT ON UNIT OPERATION
7-4-84	2	**RYD**	**Voltage Regulator** (No Component Failure)	Unit 2 started for system generation but received a Normal Lockout due to Regulator problems. The Voltage Regulator went into automatic before the generator was up to rated speed (ie. rated volts at less than rated frequency). This caused the V/Hz relay to operate which in time tripped the lockout after a time delay. Also the governor is slow around 115 RPM and needs to be checked. The V-Hz relay setting was increased from 127.5 VAC to 128.5 VAC and the **Time Delay was increased to 16 seconds.**	No effect on Emergency Start capability. This problem is similar to earlier events concerning the Unit 2 Voltage Regulator on 5-7-84 and 5-10-84. It seems like the problem could have been corrected the first time by the Westinghouse Rep. had he increased the V-Hz Time Delay.
10-4-91	2	**RYD**	Voltage Regulator **70BX Relay**	Unit 2 started for system generation. Unit shut down by incomplete start. The problem was believed to be due to dirty contacts on the 70BX switch. Cleaned contacts and unit 2 was started satisfactorily.	**AUTO START FAILURE.** This would not have prevented an Emergency Start had it been required since the 70BX relay is bypassed by ES circuitry.
4-12-93	2	**RYD**	Voltage Regulator #2 Field Flash Breaker **Closing Coil**	Unit 2 Keowee Alarm lockout due to Field Flash Breaker failure during startup for system generation. Closing coil had burned. Replaced closing coil and plunger assembly.	**EMERG. START FAILURE.** Unit 2 unavailable for Emergency Start.
9-6-91	2	**RYT**	Voltage Regulator Field Breaker **99SY Relay**	Started Unit 2 for system generation. Field Breaker failed to close. Problem was due to the 99SY relay being open. Replaced relay and tested unit satisfactorily. The 99SY relay is an auxiliary relay off of the Shutdown Solenoid Auxiliary Relay circuit. the 99SX relay energizes the governor and the 99SY relay to close the Field Breaker.	**EMERG. START FAILURE.** Unit 2 unavailable for Emergency Start.

Table C.1-1: Keowee PRA Component Failures Sorted By Type Code

DATE	UNIT	TYPE CODE	COMPONENT	EVENT DESCRIPTION	EFFECT ON UNIT OPERATION
11-5-92	2	**RYT**	**63TA/2X-C2**	Unit 2 was generating to the grid. A unit 2 Trip was received, followed by the closure of #2 Governor Main Valve. The trip was initiated when a **wire lug was broken on 63TA/2X-C2 relay** during a wiring inspection in cabinet 2LC2.	**EMERG. RUN FAILURE. Human Error.** Unit 2 was out of operation and the Overhead path was out of service while the lug was being replaced.
11-20-86	1 / 2	**RYT**	230 KV Switchyard Auxiliary Tripping Relay **94T/K relay** (GE relay)	Keowee main step-up transformer "locked out" and PCB's 8 and 9 tripped open, which isolated Oconee's overhead emergency power path, as a result of relay actuation **(94T/K)** caused by vibration due to drilling and grinding on a panel at Keowee for installation of events recorder per NSM-931. The 94T/K relay is known to be mechanically senative.	Loss of Keowee's overhead emergency power path.
6-15-85	1	**SST**	Generator Air Brake System **Speed Switch, 14/2**	Oconee received a #1 Generator Air Brake failure alarm. The unit was not running at the time. The problem was determined to be due to **mercury speed switch, 14/2** not working properly. The switch was replaced.	No effect on unit operation.
4-23-86	2	**SUPPLY BREAKER DEX**	Voltage Regulator **#2 Supply Breaker**	At 1540 Oconee started Unit 2 to check operability, but ACB-2 failed to close. Started the unit from Keowee and observed that the **Supply Breaker** did not close.Upon inspection, the breaker did not appear to be jacked all the way in. The breaker had moved back in its slot enough to break contact. The breaker was jacked in and tested satisfactorily.	**EMERG. START FAILURE.** Unit 2 unavailable or Emergency Start.

Table C.1-1: Keowee PRA Component Failures Sorted By Type Code

DATE	UNIT	TYPE CODE	COMPONENT	EVENT DESCRIPTION	EFFECT ON UNIT OPERATION
4-24-86	2	SUPPLY BREAKER DEX	Voltage Regulator **#2 Supply Breaker (latch release plunger)**	At 0649 Oconee attempted to start Unit 2 for system generation, but the **Supply Breaker** did not close. The unit was then started from Keowee. The Field breaker closed but the Supply Breaker failed to close. The next start attempt from Keowee was successful but the following attempt from Oconee was not. The problem was determined to be due to a corroded **latch release plunger** in the Generator Supply Breaker. This latch release plunger prevented the breaker from operating as expected.	**EMERG. START FAILURE.** Unit 2 unavailable for Emergency Start.
9-16-93	1	SUPPLY BREAKER DEX	Voltage Regulator #1 Field Supply Breaker **Breaker Mechanism Cotter Pin**	Keowee unit 1 failed to emergency start per PT/0A/0620/16 due to the Field Supply and Field Flashing breakers failing to close. The supply breaker did not close due to a 'trip free' operation caused by a missing cotter pin in the pin that connects the close solenoid armature to the breaker toggle mechanism. As a result, the closing coil remained energized because the auxiliary contacts did not function to energize the y-relay to drop out the x-relay which de-energizes the close coil.	**EMERG. START FAILURE.** Loss of a required Emergency Power Source. This is a valid Emergency start failure and it occurred during an ES test.
5-30-85	1 / 2	SWO	**Keowee Emergency Start Circuitry, Channel A**	Key inhibited Unit 2. Unit 1 Emergency started for test. Unit 1 operated as designed but the **Emergency Start Switch** would not reset (Unit 1 was shut down because of the KA relay had been cleared). Start testing postponed until problem with Start switch can be resolved. The problem was found to be due to **two broken wires and one loose connection.**	Per the U2 Ro Logs, Emergency Start capability was still available.

Table C.1-1: Keowee PRA Component Failures Sorted By Type Code

DATE	UNIT	TYPE CODE	COMPONENT	EVENT DESCRIPTION	EFFECT ON UNIT OPERATION
8-28-85		**THF**	**CT-3 (Unit 3 S/U Trans.)**	Oconee Unit 3 was in a refueling outage with its auxiliary power being supplied by startup transformer CT-3 when the transformers Fault Pressure Relay actuated. This initiated a lockout which cleared and de-energized the transformer and the Unit 3 Main Feeder Buses resulting in a LOOP for Unit 3. It was evident that a fault pressure condition did exist in the transformer, but the root cause of the fault pressure condition could not be determined from tests or inspections.	Both Keowee units Emerg. started and the standby transformer CT-4 was energized within 30 sec. after initiation of the event.
5-4-93	1	**VOLT ADJ DEX**	Voltage Regulator **Volts-Hertz Limiter Card**	Keowee unit 1 Voltage Regulator OOS. Unit 1 was shut down while generating to the grid due to VARs going in the hole. The unit did not respond to the Voltage Adjust or the Base Adjust controls. Entered 72 Hr. LCO.	**EMERG. RUN FAILURE.** Unit 1 unavailable for emergency start.
5-28-86	1	**X RELAY**	Voltage Regulator **Field Breaker**	Oconee started Unit 1 for system generation but the Field Breaker did not close. The unit was started and ran in local / manual satisfactorily. Oconee performed an operability test on unit 1 and it worked fine. No problem was identified.	**EMERG. START FAILURE.** Unit 1 unavailable for Emergency Start.
2-6-88	1	**X RELAY**	Voltage Regulator **Field Breaker**	Started Unit 1 for system generation. The unit rolled off but excitation did not close. Aborted start on #1. Started Unit 1 again and everything worked okay.	**EMERG. START FAILURE.** Whenever the generator excitation doesn't close in, the unit will not start in any mode.
3-15-88	1	**X RELAY**	Voltage Regulator **Field Breaker**	Started Unit 1 for system generation but the Excitation Breakers failed to close. Aborted start. Started, paralleled, placed Unit 1 on LFC. Unit started fine this start.	**EMERG. START FAILURE.** Whenever the generator excitation doesn't close in, the unit will not start in any mode.

Table C.1-1: Keowee PRA Component Failures Sorted By Type Code

DATE	UNIT	TYPE CODE	COMPONENT	EVENT DESCRIPTION	EFFECT ON UNIT OPERATION
5-23-88	1	X RELAY	Voltage Regulator **Field Breaker**	When doing retest on Unit 1 the unit came on but the excitation supply did not close. The unit shut down due to an incomplete sequence. Did another start and the unit worked okay.	**EMERG. START FAILURE.** Whenever the generator excitation doesn't close in, the unit will not start in any mode.
9-28-88	1	X RELAY	**Voltage Regulator**	Started Unit 1 for weekly PM. Unit would not start up. Shut down unit. Started unit and paralled. Shut down unit. Started Unit 1 but it did not parallel. Shut unit down. Unit 1 started, paralled, and on LFC. Reason for failed start attempts unknown.	**AUTO START FAILURE.** No effect on Emergency Start capability.
6-3-91	2	X RELAY	**Voltage Regulator**	Unit 2 started for system generation but the Voltage Regulator failed to come on. Attempted a 2nd start and the regulator worked fine.	**AUTO START FAILURE.** The Voltage Regulator failing to come on in auto would not have prevented an Emergency Start had it been required.
11-20-84	2	X RELAY	#2 Supply Breaker **X Relay Coil**	Oconee started Unit 2 for operability test to take Unit 1 out of service for annual PMG inspection but the #2 Supply Breaker failed to close. The breaker was removed and inspected but the cause of the **problem was not found.** Unit 2 was run several times successfully with no re-occurrence of the problem.	**EMERG. START FAILURE.** Unit 2 was not available for Emergency Start during this occurrence.
12-4-84	2	X RELAY	#2 Supply Breaker **X Relay Coil**	Oconee attempted an auto start of Unit 2 but the Supply Breaker failed to close. Replaced **X-relay coil and adjusted mechanical linkage to relay.** Tested breaker successfully 15 times.	**EMERG. START FAILURE.** Unit 2 was not available for Emergency Start during this occurrence.

Table C.1-1: Keowee PRA Component Failures Sorted By Type Code

DATE	UNIT	TYPE CODE	COMPONENT	EVENT DESCRIPTION	EFFECT ON UNIT OPERATION
7-28-87	1	**X RELAY**	#1 Supply Breaker **X Relay**	With both units shut down, the Keowee operator discovered that the unit 1 Supply Breaker closing coil was burning. Replaced closing coil and 41 AX relay (x relay).	Unit 1 unavailable for Emergency Start.
2-9-89	1	**X RELAY**	#1 Field Supply Breaker **X Relay**	Oconee started Unit 1 to test the Overhead Path, but the Supply Breaker did not close. Problem was determined to be due to the X Relay sticking. Replaced relay and the worked fine.	**EMERG. START FAILURE.** Unit 1 unavailable for Emergency Start.
2-12-90	1	**X RELAY**	#1 Field Breaker **X Relay**	Started Unit 1 for system generation but excitation breakers did not close. Problem was found to be due to X Relay coil sticking. Replaced X Relay unit tested satisfactorily.	**EMERG. START FAILURE.** Failure of the generator excitation to close in would have prevented an Emergency Start had it been required.
12-26-90	1	**X RELAY**	Voltage Regulator **Field Breaker** (X-Relay)	Started Unit 1 for system generation but Generator Excitation Breakers did not close in. A 2nd start attempt was successful. **This is one of a series of phantom Unit 1 start failures which resulted in the replacement of all excitation breaker X relays.**	**EMERG. START FAILURE.** Failure of the generator excitation to close in would have prevented an Emergency Start had it been required.
1-16-91	1	**X RELAY**	Voltage Regulator **Field Breaker** (X-Relay)	Started Unit 1 for weekly preventative maintenance but Generator Excitation Breakers did not close in. A 2nd start attempt was successful. **This is one of a series of phantom Unit 1 start failures which resulted in the replacement of all excitation breaker X relays.**	**EMERG. START FAILURE.** Failure of the generator excitation to close in would have prevented an Emergency Start had it been required.

Table C.1-1: Keowee PRA Component Failures Sorted By Type Code

DATE	UNIT	TYPE CODE	COMPONENT	EVENT DESCRIPTION	EFFECT ON UNIT OPERATION
1-21-91	1	**X RELAY**	Voltage Regulator **Field Breaker** (X-Relay)	Oconee started Unit 1 for test but Generator Excitation Breakers did not close in. A 2nd start attempt was successful. **This is one of a series of phantom Unit 1 start failures which resulted in the replacement of all excitation breaker X relays.**	**EMERG. START FAILURE.** Failure of the generator excitation to close in would have prevented an Emergency Start had it been required.
2-1-91	1	**X RELAY**	Voltage Regulator **Field Breaker** (X-Relay)	Started Unit 1 for system generation but Generator Excitation Breakers did not close in. A 2nd start attempt was successful. **This is one of a series of phantom Unit 1 start failures which resulted in the replacement of all excitation breaker X relays.**	**EMERG. START FAILURE.** Failure of the generator excitation to close in would have prevented an Emergency Start had it been required.
3-31-91	1	**X RELAY**	Voltage Regulator **Field Breaker** (X-Relay)	Started Unit 1 for system generation but Generator Excitation Breakers did not close in. A 2nd start attempt was successful. **This is one of a series of phantom Unit 1 start failures which resulted in the replacement of all excitation breaker X relays.**	**EMERG. START FAILURE.** Failure of the generator excitation to close in would have prevented an Emergency Start had it been required.
4-7-91	1	**X RELAY**	Voltage Regulator **Field Breaker** (X-Relay)	Started Unit 1 for system generation. The Field Supply Breaker did not close in. A 2nd start attempt was successful. Supply Breaker was replaced with spare breaker and both tested satisfactorily. Cause of problem unknown. **This is one of a series of phantom Unit 1 start failures which resulted in the replacement of all excitation breaker X relays.**	**EMERG. START FAILURE.** Failure of the generator excitation to close in would have prevented an Emergency Start had it been required.

Table C.1-1: Keowee PRA Component Failures Sorted By Type Code

DATE	UNIT	TYPE CODE	COMPONENT	EVENT DESCRIPTION	EFFECT ON UNIT OPERATION
5-31-91	1	**X RELAY**	Voltage Regulator **Field Breaker** (X-Relay)	Unit 1 started for system generation. Unit rolled off but the Supply, Field, and Field Flashing Breakers failed to close. **This is one of a series of phantom Unit 1 start failures which resulted in the replacement of all excitation breaker X relays.**	**EMERG. START FAILURE.** Failure of the generator excitation to close in would have prevented an Emergency Start had it been required.
6-7-91	1	**X RELAY**	Voltage Regulator **Field Breaker** (X-Relay)	Started Unit 1 for system generation but excitation didn't close in. Immediately attempted another start and unit started and closed in satisfactorily. **This is one of a series of phantom Unit 1 start failures which resulted in the replacement of all excitation breaker X relays.**	**EMERG. START FAILURE.** Failure of the generator excitation to close in would have prevented an Emergency Start had it been required.
6-11-91	1	**X RELAY**	#1 Field Supply Breaker **X Relay**	Oconee started Unit 1 for PT. The Field Supply Breaker failed to close. The problem was found to be due to the X Relay not resetting after the last shutdown. Relay was reset and Unit 1 ran satisfactorily.	**EMERG. START FAILURE.** Unit 1 unavailable for Emergency Start.
1-29-92	1	**X RELAY**	Voltage Regulator **Field Supply Breaker** (X -Relay)	Started Unit 1 for system generation but the generator excitation did not close in. Checked circuitry with no problems found. Restarted unit and everything worked as designed. Keowee operators to check that X-Coil has reset after each Unit 1 and Unit 2 shutdown. **This is one of a series of phantom Unit 1 start failures which resulted in the replacement of all excitation breaker X relays.**	**EMERG. START FAILURE.** Unit 1 was not available for Emergency Start during this occurrence.

Table C.1-1: Keowee PRA Component Failures Sorted By Type Code

DATE	UNIT	TYPE CODE	COMPONENT	EVENT DESCRIPTION	EFFECT ON UNIT OPERATION
2-13-92	1	**X RELAY**	Voltage Regulator Field Breaker **X-Relay**	After a normal shutdown of Unit 1 for system generation on 2/13/92, it was discovered that the Unit 1 Field Flashing Breaker X-Relay had not reset as designed. This made Unit 1 inoperable. Checking the X-Relay within 14 minutes after the occurrence revealed that the X-Relay coil had reset on its own. Unit 1 was operability tested satisfactorily.	Unit 1 was not available for Emergency Start until the relay was reset (approx. 14 min).
2-20-92	1	**X RELAY**	Voltage Regulator Field Breaker **X-Relay**	After a normal shutdown of Unit 1 for system generation on 2/20/92, it was discovered that the Unit 1 Field Flashing Breaker X-Relay had not reset as designed. This made Unit 1 inoperable. Unit 1 was taken out of service to troubleshoot problem with X-Relay failing to reset. The Field Breaker was removed and cleaned and some burrs were removed from the X-Relay cylinder. Unit 1 was operability tested satisfactorily.	Unit 1 was not available for Emergency Start during this occurrence.
3-1-92	1	**X RELAY**	ACB-5 **X-Relay**	After Oconee had completed the performance of a Switchyard test and had closed PCB's 8 & 9, ACB-5 failed to close automatically. Problem determined to be due to X-Relay failure of ACB-5.	No effect on Emergency Start capability.
3-17-92	1	**X RELAY**	Voltage Regulator **Field Breaker X-Relay**	Replaced X-Relay on Unit 1 Field Breaker per procedure MP/0/A/2001/3 and per Gary Edens request. Relay installed failed during functional test. Failed relay was replaced by another relay and functionally tested satisfactorily.	Unit 1 was unavailable for Emergency Start for the time required to complete this Work Request.

Table C.1-1: Keowee PRA Component Failures Sorted By Type Code

DATE	UNIT	TYPE CODE	COMPONENT	EVENT DESCRIPTION	EFFECT ON UNIT OPERATION
5-1-92	1	**X RELAY**	Voltage Regulator Field Breaker **X-Relay**	After a normal shutdown of Unit 1 for system generation on 5/1/92, it was discovered that the Unit 1 Field Flashing Breaker X-Relay had not reset as designed. This made Unit 1 inoperable. Checking the X-Relay within 30 minutes after the occurrence revealed that the X-Relay coil had reset on its own. Unit 1 was operability tested satisfactorily.	Unit 1 was not available for Emergency Start until the relay was reset (approx. 30 min).
6-12-92	1	**X RELAY**	Voltage Regulator Field Breaker **X-Relay**	After a normal shutdown of Unit 1 for system generation on 6/12/92, it was discovered that the Unit 1 Field Flashing Breaker X-Relay had not reset as designed. This made Unit 1 inoperable. The relay was manually reset and Unit 1 was operability tested satisfactorily.	Unit 1 was not available for Emergency Start until the relay was reset (50 min).
10-19-92	2	**X RELAY**	**ACB-8** (X-Relay)	**Oconee LOOP Event** - Following the Keowee Operator tripping ACB-1 and relay operation in the Oconee 230 KV switchyard causing a Main Transformer lockout, ACB-8 failed to close to re-energize 2X. It is believed that ACB-8 failed to close due to a **stuck x-relay.**	Unit 2 running with no auxiliary power available.

Table C.1-2: Keowee PRA Denominator Assignment Codes

Denominator Code	Denominator Value	Description
AR1	5285 hrs	Failure mode has the opportunity to occur during a Normal or Emergency Run of Keowee Unit 1
AR2	4428 hrs	Failure mode has the opportunity to occur during a Normal or Emergency Run of Keowee Unit 2
AS1	3390 demands	Failure mode has the opportunity to occur during a Normal or Emergency Start of Keowee Unit 1
AS2	3098 demands	Failure mode has the opportunity to occur during a Normal or Emergency Start of Keowee Unit 2
AV1	85,755 hrs	Failure mode has the opportunity to occur any time Unit 1 is available
AV2	85,657 hrs	Failure mode has the opportunity to occur any time Unit 2 is available
CON	87,600 hrs	Failure mode has the opportunity to occur continuously during the 10 year period of study
ES	113 demands	Failure mode has the opportunity to occur only during an Emergency Start of the Keowee Units
Bi-MTH	61 demands	Failure mode has the opportunity to occur only every 8 weeks (corresponding to a unit swap cycle)
QTR	40 demands	Failure mode has the opportunity to occur only during a quarterly test
x days	*x* days	Component was exposed for *x* days during the 10 year period
x D	*x* demands	Component was demanded *x* times during the 10 year period
x H	*x* hrs	Component was exposed for *x* hours during the 10 year period

Basic Event	Description	Tree	Denom. Code	Denom. Value	Totals
FK1WL11 AVO	Cooling Water Control Valve 1WL-11 Fails To Open On Demand	FZ	AS1	3390	
FK2WL11 AVO	Cooling Water Control Valve 2WL-11 Fails To Open On Demand	FZ	AS2	3098	**6488**
FK1WL11 AVT	Cooling Water Control Valve 1WL-11 Transfers Closed	FZ	AR1	5285	
FK2WL11 AVT	Cooling Water Control Valve 2WL-11 Transfers Closed	FZ	AR2	4428	**9713**
XD1CKC1 BCF	Battery Charger KC1 Fails	XZ	AV1	85755	
XD2CKC2 BCF	Battery Charger KC2 Fails	XZ	AV2	85657	**171412**
DDC1FLT BDF	SY-DC1 Is Faulted	DZ	CON	87600	
DDC2FLT BDF	SY-DC2 Is Faulted	DZ	CON	87600	
DDCDYAX BDF	125 Vdc Switchyard DC Panelboard DYA Is Faulted	DZ	CON	87600	
DDCDYBX BDF	125 Vdc Switchyard DC Panelboard DYB Is Faulted	DZ	CON	87600	
DDCDYCX BDF	125 Vdc Switchyard DC Panelboard DYC Is Faulted	DZ	CON	87600	
DDCDYEX BDF	125 Vdc Switchyard DC Panelboard DYE Is Faulted	DZ	CON	87600	
DDCDYFX BDF	125 Vdc Switchyard DC Panelboard DYF Is Faulted	DZ	CON	87600	
DDCDYGX BDF	125 Vdc Switchyard DC Panelboard DYG Is Faulted	DZ	CON	87600	
XD1DARX BDF	DC Distribution Center 1DA Faulted during Run	XZ	AV1	85755	
XD2DARX BDF	DC Distribution Center 2DA Faulted During Run	XZ	AV2	85657	**872212**
KK1OVER BHF	Fault Occurs On The Overhead Power Path	SZ	CON	87600	
KK1UNDR BHF	Fault Occurs On The Underground Power Path	SZ	CON	87600	
PACX1TC BHF	4160 Vac Switchgear 1TC Fails	XZ	CON	87600	
SPC14KV BHF	13.8 kV Bus Faulted	SZ	CON	87600	**350400**
XA1XAMC BLF	600 Vac MCC 1XA Fault	XZ	AV1	85755	
XA1XXXX BLF	600 Vac Switchgear 1X Fault	XZ	AV1	85755	
XA2XAMC BLF	600 Vac MCC-2XA Fault	XZ	AV2	85657	
XA2XXXX BLF	600 Vac Switchgear 2X Fault	XZ	AV2	85657	**342824**
DDC1BAT BYF	Battery SY-1 Fails During Discharge	DZ	20H	20	
DDC2BAT BYF	Battery SY-2 Fails During Discharge	DZ	20H	20	
XD1KBAT BYF	Keowee Battery No. 1 Fails During Discharge	XZ	10H	10	
XD2KBAT BYF	Keowee Battery No. 2 Fails during Discharge	XZ	10H	10	**60**

Table C.1-3: Denominator Totals For Keowee-Specific Failure Rates

Basic Event		Description	Tree	Denom. Code	Denom. Value	**Totals**
PAC1TC4	C4T	4160 Vac Breaker 1TC-4 Transfers Open	XZ	CON	87600	
PACTC01	C4T	4160 Vac Breaker 1TC-1 Transfers Open	XZ	CON	87600	
PACTC14	C4T	4160 Vac Breaker 1TC-14 Transfers Open	XZ	CON	87600	**262800**
AB004EC	CDT	DC Circuit Breaker 1DA-4EC Transfers Position	AZ	AV1	85755	
AD1B4AL	CDT	Breaker 4AL In 125 V dc Distribution Center 1DA Transfers Open	AZ	AV1	85755	
AD1C3CC	CDT	Breaker 3CC In 125V dc Distribution Center 1DA Transfers Position	AZ	AV1	85755	
AD1C3CL	CDT	Breaker 3CL In 125V dc Distribution Center 1DA Transfers Position	AZ	AV1	85755	
AD1SCLR	CDT	Breaker 3CL In 125V dc Distribution Center 1DA Transfers Position (Rec)	AZ	(alt. name)	0	
AD2B2AL	CDT	Breaker 2AL In 125V dc Distribution Center 2DA Transfers Open	AZ	AV2	85657	
AD2B3CC	CDT	Breaker 3CC In 125V dc Distribution Center 2DA Transfers Position	AZ	AV2	85657	
AD2C3CC	CDT	Breaker 3CC In 125V dc Distribution Center 2DA Transfers Position	SZ	AV2	85657	
AD2C3CL	CDT	Breaker 3CL In 125V dc Distribution Center 2DA Transfers Position	AZ	AV2	85657	
BK1DA5B	CDT	DC Circuit Breaker 1DA-5B Transfers Position	BZ	AV1	85755	
BK2DA1B	CDT	DC Circuit Breaker 2DA-1B Transfers Position	BZ	AV2	85657	
DDC11BX	CDT	125 Vdc Battery Breaker SY-DC1-1B Transfers Open	DZ	CON	87600	
DDC11CX	CDT	125 Vdc Breaker SY-DC1-1C Transfers Open	DZ	CON	87600	
DDC11DC	CDT	125 Vdc Breaker SY-DC1-1DC Transfers Open	DZ	CON	87600	
DDC11DL	CDT	125 Vdc Breaker SY-DC1-1DL Transfers Open	DZ	CON	87600	
DDC11DR	CDT	125 Vdc Breaker SY-DC1-1DR Transfers Open	DZ	CON	87600	
DDC21BX	CDT	125 Vdc Battery Breaker SY-DC2-1B Transfers Open	DZ	CON	87600	
DDC21CX	CDT	125 Vdc Breaker SY-DC2-1C Transfers Open	DZ	CON	87600	
DDC21DC	CDT	125 Vdc Breaker SY-DC2-1DC Transfers Open	DZ	CON	87600	
DDC21DL	CDT	125 Vdc Breaker SY-DC2-1DL Transfers Open	DZ	CON	87600	
DDC21DR	CDT	125 Vdc Breaker SY-DC2-1DR Transfers Open	DZ	CON	87600	
ED11D3D	CDT	Breaker 3D In 125V dc Distribution Center 1DA Transfers Open	EZ	AV1	85755	
ED13BR2	CDT	Breaker 3BR In 125V dc Distribution Center 1DA Transfers Open	EZ	AV1	85755	
ED22D3D	CDT	Breaker 2D In 125V dc Distribution Center 2DA Transfers Open	EZ	AV2	85657	
ED23BR2	CDT	Breaker 3BR In 125V dc Distribution Center 2DA Transfers Open	EZ	AV2	85657	
LDCYC13	CDT	Switchyard 125 Vdc Panelboard DYC Breaker 13 Transfers Open	LZ	CON	87600	
LDCYC14	CDT	Switchyard 125 Vdc Panelboard DYC Breaker 14 Transfers Open	LZ	CON	87600	
LDCYG12	CDT	Switchyard 125 Vdc Panelboard DYG Breaker 12 Transfers Open	LZ	CON	87600	
LDCYG18	CDT	Switchyard 125 Vdc Panelboard DYG Breaker 18 Transfers Open	LZ	CON	87600	

Table C.1-3: Denominator Totals For Keowee-Specific Failure Rates

Basic Event	Description	Tree	Denom. Code	Denom. Value	Totals
PK1DA5C CDT	125 Vdc Circuit Breaker 1DA-5C Transfers Position	PZ	AV1	85755	
PK2DA1C CDT	125 Vdc Circuit Breaker 2DA-1C Transfers Position	PZ	AV2	85657	
SDCDA12 CDT	125 Vdc Swyd Control Power Pnlbd DYA Bkr 12 Xfrs Open	SZ	CON	87600	
SDCDA15 CDT	125 Vdc Swyd Control Power Pnlbd DYA Bkr 15 Xfrs Open	SZ	CON	87600	
SDCDA17 CDT	125 Vdc Swyd Control Power Pnlbd DYA Bkr 17 Xfrs Open	SZ	CON	87600	
SDCDB01 CDT	125 Vdc Swyd Control Power Pnlbd DYB Bkr 1 Xfrs Open	SZ	CON	87600	
SDCDB13 CDT	125 Vdc Swyd Control Power Pnlbd DYB Bkr 13 Xfrs Open	SZ	CON	87600	
SDCDC12 CDT	125 Vdc Swyd Control Power Pnlbd DYC Bkr 12 Xfrs Open	SZ	CON	87600	
SDCDE12 CDT	125 Vdc Swyd Control Power Pnlbd DYE Bkr 12 Xfrs Open	SZ	CON	87600	
SDCDE15 CDT	125 Vdc Swyd Control Power Pnlbd DYE Bkr 15 Xfrs Open	SZ	CON	87600	
SDCDE17 CDT	125 Vdc Swyd Control Power Pnlbd DYE Bkr 17 Xfrs Open	SZ	CON	87600	
SDCDF01 CDT	125 Vdc Swyd Control Power Pnlbd DYF Bkr 1 Xfrs Open	SZ	CON	87600	
SDCDF13 CDT	125 Vdc Swyd Control Power Pnlbd DYF Bkr 13 Xfrs Open	SZ	CON	87600	
SDCDG16 CDT	125 Vdc Swyd Control Power Pnlbd DYG Bkr 16 Xfrs Open	SZ	CON	87600	
SDCDYA8 CDT	125 Vdc Swyd Control Power Pnlbd DYA Bkr 8 Xfrs Open	SZ	CON	87600	
SDCDYA9 CDT	125 Vdc Swyd Control Power Pnlbd DYA Bkr 9 Xfrs Open	SZ	CON	87600	
SDCDYB4 CDT	125 Vdc Swyd Control Power Pnlbd DYB Bkr 4 Xfrs Open	SZ	CON	87600	
SDCDYB6 CDT	125 Vdc Swyd Control Power Pnlbd DYB Bkr 6 Xfrs Open	SZ	CON	87600	
SDCDYB8 CDT	125 Vdc Swyd Control Power Pnlbd DYB Bkr 8 Xfrs Open	SZ	CON	87600	
SDCDYE8 CDT	125 Vdc Swyd Control Power Pnlbd DYE Bkr 8 Xfrs Open	SZ	CON	87600	
SDCDYE9 CDT	125 Vdc Swyd Control Power Pnlbd DYE Bkr 9 Xfrs Open	SZ	CON	87600	
SDCDYF4 CDT	125 Vdc Swyd Control Power Pnlbd DYF Bkr 4 Xfrs Open	SZ	CON	87600	
SDCDYF6 CDT	125 Vdc Swyd Control Power Pnlbd DYF Bkr 6 Xfrs Open	SZ	CON	87600	
SDCDYF8 CDT	125 Vdc Swyd Control Power Pnlbd DYF Bkr 8 Xfrs Open	SZ	CON	87600	
XA1A2BT CDT	600 Vac Breaker 1XA-2BT Transfers Position	XZ	AV1	85755	
XA2A2BT CDT	600 Vac Breaker 2XA-2BT Transfers Position	XZ	AV2	85657	
XD104CC CDT	Breaker 1DA-4CC Transfers Open	YZ	AV1	85755	
XD104CR CDT	Breaker 1DA-4CR Transfers Open	YZ	AV1	85755	
XD1BK1A CDT	Battery No. 1 Breaker 1A Transfers Position run time dependent	XZ	AV1	85755	
XD1DA1C CDT	125 Vdc Breaker 1C (from charger KC1) Transfers Position	XZ	AV1	85755	
XD1DA3B CDT	125 Vdc Breaker 1DA-3BR Transfers Open	BOZ	AV1	85755	
XD1DA4A CDT	DC Circuit Breaker 1DA-4AR Transfers Position	BFZ	AV1	85755	
XD1TIE1 CDT	Keowee 125V dc Dist Cntr 1DA Tie Breaker 1 Transfers Position	XZ	20H	20	
XD202CC CDT	Breaker 2DA-2CC Transfers Open	YZ	AV2	85657	

Table C.1-3: Denominator Totals For Keowee-Specific Failure Rates

Basic Event		Description	Tree	Denom. Code	Denom. Value	**Totals**
XD204CC	CDT	Breaker 2DA-4CC Transfers Open	YZ	AV2	85657	
XD2BK1A	CDT	Battery No. 2 Breaker 1A Transfers Position	XZ	AV2	85657	
XD2DA2A	CDT	DC Circuit Breaker 2DA-2AR Transfers Position	BFZ	AV2	85657	
XD2DA3B	CDT	125 Vdc Circuit Breaker 2DA-3BR Transfers Position	BOZ	AV2	85657	
XD2DA5C	CDT	125 Vdc Breaker 2DA-5C (from Charger KC2) Transfers Open	XZ	AV2	85657	
XD2TIE2	CDT	Keowee 125V dc Dist Cntr 2DA Tie Breaker 2 Transfers Position	XZ	20H	20	
YO1DIA2	CDT	DC Circuit Breaker 1DIA-2 Transfers Position	YZ	CON	87600	
YO1DIB2	CDT	DC Circuit Breaker 1DIB-2 Transfers Position	YZ	CON	87600	
YO2DIA2	CDT	Breaker 2DIA-2 Transfers Position	YZ	CON	87600	
YO2DIB2	CDT	Breaker 2DIB-2 Transfers Position	YZ	CON	87600	
YO3DIA2	CDT	Breaker 3DIA-2 Transfers Open	YZ	CON	87600	
YO3DIB2	CDT	Breaker 3DIB-2 Transfers Open	YZ	CON	87600	**6250420**
SPCB008		(close failure not modeled but experience considered)		239D	239	
SPCB009	CHC	SWYD PCB-9 Fails To Close On Demand	SZ	166D	166	
SPCB012		(close failure not modeled but experience considered)		297D	297	
SPCB015		(close failure not modeled but experience considered)		0	0	
SPCB017		(close failure not modeled but experience considered)		336D	336	
SPCB021		(close failure not modeled but experience considered)		179D	179	
SPCB024		(close failure not modeled but experience considered)		214D	214	
SPCB026		(close failure not modeled but experience considered)		237D	237	
SPCB028		(close failure not modeled but experience considered)		157D	157	
SPCB030		(close failure not modeled but experience considered)		204D	204	
SPCB033		(close failure not modeled but experience considered)		234D	234	**2263**
SPCB008	CHO	SWYD PCB-8 Fails to Trip	SZ	239D	239	
SPCB009	CHO	SWYD PCB-9 Fails To Trip	SZ	166D	166	
SPCB012	CHO	SWYD PCB-12 Fails To Trip	SZ	297D	297	
SPCB015	CHO	SWYD PCB-15 Fails To Trip On Demand	SZ	0	0	
SPCB017	CHO	SWYD PCB-17 Fails To Trip On Demand	SZ	336D	336	
SPCB021	CHO	SWYD PCB-21 Fails To Trip On Demand	SZ	179D	179	
SPCB024	CHO	SWYD PCB-24 Fails To Trip On Demand	SZ	214D	214	
SPCB026	CHO	SWYD PCB-26 Fails To Trip On Demand	SZ	237D	237	
SPCB028	CHO	SWYD PCB-28 Fails To Trip On Demand	SZ	157D	157	

Table C.1-3: Denominator Totals For Keowee-Specific Failure Rates

Basic Event		Description	Tree	Denom. Code	Denom. Value	Totals
SPCB030		(open failure not modeled but experience considered)		204D	204	
SPCB033	CHO	SWYD PCB-33 Fails To Open On Demand	SZ	234D	234	**2263**
SPCB008		(transfer failure not modeled but experience considered)		1571 days	49584	
SYPCB09	CHT	Switchyard Power Circuit Breaker 9 Transfers Open	SZ	1537 days	48768	
SPCB012		(transfer failure not modeled but experience considered)		2087 days	61968	
SPCB015		(transfer failure not modeled but experience considered)		1576 days	49704	
SPCB017		(transfer failure not modeled but experience considered)		2123 days	62832	
SPCB021		(transfer failure not modeled but experience considered)		1766 days	54264	
SPCB024		(transfer failure not modeled but experience considered)		2111 days	62544	
SPCB026		(transfer failure not modeled but experience considered)		2123 days	62832	
SPCB028		(transfer failure not modeled but experience considered)		1766 days	54264	
SYPCB30	CHT	Switchyard Power Circuit Breaker 30 Transfers Open	SZ	1766 days	54264	
SPCB033		(transfer failure not modeled but experience considered)		1772 days	54408	**615432**
BK1XA1C	CLT	600 V Circuit Breaker 1XA-1C Transfers Position	BZ	AV1	85755	
BK2XA1C	CLT	600 V Circuit Breaker 2XA-1C Transfers Position	BZ	AV2	85657	
OK1XA1D	CLT	Low Voltage Circuit Breaker 1XA-1D Transfers Position	OZ	AV1	85755	
OK1XA2E	CLT	Low Voltage Circuit Breaker 1XA-2E Transfers Position	OZ	AV1	85755	
OK1XA4D	CLT	Low Voltage Circuit Breaker 1XA-4D Transfers Position	OZ	AV1	85755	
OK2XA1D	CLT	Low Voltage Circuit Breaker 2XA-1D Transfers Position	OZ	AV2	85657	
OK2XA2E	CLT	Low Voltage Circuit Breaker 2XA-2E Transfers Position	OZ	AV2	85657	
OK2XA4D	CLT	Low Voltage Circuit Breaker 2XA-4D Transfers Position	OZ	AV2	85657	
PK1XA2C	CLT	600 V Circuit Breaker 1XA-2C Transfers Position	PZ	AV1	85755	
PK2XA2C	CLT	Low Voltage Circuit Breaker 2XA-2C Transfers Position	PZ	AV2	85657	
XA1X2AX	CLT	600 Vac Bkr 2X-2D Transfers Position	XZ	AV1	85755	
XA1X2CC	CLT	600 Vac Breaker 1X-2C Transfers Position	XZ	AV1	85755	
XA1XA1A	CLT	600 Vac Bkr 2XA-4A Transfers Position	XZ	AV1	85755	
XA2X2BX	CLT	600 Vac Breaker 2X-2B Transfers Position	XZ	AV2	85657	
XA2X2DX	CLT	600 Vac Bkr 1X-2A Transfers Position	XZ	AV2	85657	
XA2X4AX	CLT	600 Vac Bkr 1XA-1A Transfers Position	XZ	AV2	85657	**1371296**
BK1GBO1	CVC	Check Valve 1GBO-1 Fails to Close on Demand	BZ	520D	520	
BK2GBO1	CVC	Check Valve 2GBO-1 Fails to Close on Demand	BZ	520D	520	**1040**

Table C.1-3: Denominator Totals For Keowee-Specific Failure Rates

Basic Event	Description	Tree	Denom. Code	Denom. Value	Totals
BK1GBO1 CVO	Check Valve 1GBO-1 Fails To Open On Demand	BZ	520D	520	
BK1GBO3 CVO	Check Valve 1GBO-3 Fails To Open On Demand	BZ	520D	520	
BK2GBO1 CVO	Check Valve 2GBO-1 Fails To Open On Demand	BZ	520D	520	
BK2GBO3 CVO	Check Valve 2GBO-3 Fails To Open On Demand	BZ	520D	520	
OK10011 CVO	Check Valve 1OG-11 Fails to Open	OZ	14292D	14292	
OK10014 CVO	Check Valve 1OG-14 Fails to Open	OZ	14292D	14292	
OK10017 CVO	Check Valve 1OG-17 Fails to Open	OZ	14292D	14292	
OK20011 CVO	Check Valve 2OG-11 Fails to Open	OZ	14276D	14292	
OK20014 CVO	Check Valve 2OG-14 Fails to Open	OZ	14276D	14292	
OK20017 CVO	Check Valve 2OG-17 Fails to Open	OZ	14276D	14292	**87832**
BK1GBO1 CVT	Check Valve 1GBO-1 Transfers Closed	BZ	AV1	85755	
BK1GBO3 CVT	Check Valve 1GBO-3 Transfers Closed	BZ	87H	87	
BK2GBO1 CVT	Check Valve 2GBO-1 Transfers Closed	BZ	AV2	85657	
BK2GBO3 CVT	Check Valve 2GBO-3 Transfers Closed	BZ	87H	87	
OK10011 CVT	Check Valve 1OG-11 Transfers Closed	OZ	714H	714	
OK10014 CVT	Check Valve 1OG-14 Transfers Closed	OZ	714H	714	
OK10017 CVT	Check Valve 1OG-17 Transfers Closed	OZ	714H	714	
OK20011 CVT	Check Valve 2OG-11 Transfers Closed	OZ	714H	714	
OK20014 CVT	Check Valve 2OG-14 Transfers Closed	OZ	714H	714	
OK20017 CVT	Check Valve 2OG-17 Transfers Closed	OZ	714H	714	
PK1TS02 CVT	Check Valve 1TS-2 Fails to Open or Transfers Closed	PZ	10950H	10950	
PK1TS04 CVT	Check Valve 1TS-4 Fails to Open or Transfers Closed	PZ	2H	2	
PK2TS02 CVT	Check Valve 2TS-2 Fails to Open or Transfers Closed	PZ	10950H	10950	
PK2TS04 CVT	Check Valve 2TS-4 Fails to Open or Transfers Closed	PZ	2H	2	**197774**
SDCAIDD DIF	Control Power From DYA To PCB 9 Isolating Diode Fails	SZ	CON	87600	
SDCEIDD DIF	Control Power From DYE To PCB-9 Isolating Diode Fails	SZ	CON	87600	**175200**
FK1FL01 FRF	Filter 1WLFL-1 Becomes Clogged	FZ	AV1	85755	
FK1FL02 FRF	Filter 1WLFL-2 Becomes Clogged	FZ	AV1	85755	
FK2FL01 FRF	Filter 2WLFL-1 Becomes Clogged	FZ	AV2	85657	
FK2FL02 FRF	Filter 2WLFL-2 Becomes Clogged	FZ	AV2	85657	**342824**

Table C.1-3: Denominator Totals For Keowee-Specific Failure Rates

Basic Event		Description	Tree	Denom. Code	Denom. Value	**Totals**
BK1GBO1	FTC	Filter 1GBOFL-1 Becomes Clogged	BZ	AV1	85755	
BK2GBO1	FTC	Filter 2GBOFL-1 Becomes Clogged	BZ	AV2	85657	**171412**
AB510A1	FUF	One Or More Control Power Fuses For X, Y And CC Fail	AZ	AV1	85755	
AB610A1	FUF	One Or More Control Power Fuses For X, Y And CC Fail	AZ	AV2	85657	
AB610AF	FUF	One Or More Control Power Fuses For Relay 27X/2X Fail	AZ	AV2	85657	
AB710A1	FUF	One Or More Control Power Fuses For X, Y And CC Fail	AZ	AV1	85755	
AB710AF	FUF	One Or More Air Circuit Breaker 7 Control Power Fuses Fail	AZ	AV1	85755	
AB810A1	FUF	One Or More Control Power Fuses For X, Y And CC Fail	AZ	AV2	85657	
EK1F30A	FUF	Keowee Unit 1 Excitation Cabinet Fan Fuses Fail	EZ	AV1	85755	
EK2F30A	FUF	Keowee Unit 2 Excitation Cabinet Fan Fuses Fail	EZ	AV2	85657	
YK1D4CR	FUF	Fuse 1DA-4CR Fails	YZ	AV1	85755	
YK2D2CC	FUF	Fuse 2DA-2CC Fails	YZ	AV2	85657	**857060**
OK10007	FVT	Float Valve 1OG-7 Transfers Closed	OZ	AV1	85755	
OK20007	FVT	Float Valve 2OG-7 Transfers Closed	OZ	AV2	85657	**171412**
BK1GBDC	GPR	Unit 1 DC Turbine GBO Pump Fails To Run	BZ	87H	87	
BK1GOAC	GPR	Unit 1 AC Turbine GBO Pump Fails To Run	BZ	AV1	85755	
BK2GBDC	GPR	Unit 2 DC Turbine GBO Pump Fails To Run	BZ	87H	87	
BK2GOAC	GPR	Unit 2 AC Turbine GBO Pump Fails To Run	BZ	AV2	85657	
OK1001A	GPR	OG Pump 1A Fails to Run	OZ	357H	357	
OK1001B	GPR	OG Pump 1B Fails to Run	OZ	357H	357	
OK1001C	GPR	OG Pump 1C Fails to Run	OZ	357H	357	
OK2002A	GPR	OG Pump 2A Fails to Run	OZ	357H	357	
OK2002B	GPR	OG Pump 2B Fails to Run	OZ	357H	357	
OK2002C	GPR	OG Pump 2C Fails to Run	OZ	357H	357	
PK1TSAC	GPR	AC Sump Pump 1TSPU-1 Fails To Start Or Run	PZ	10950H	10950	
PK1TSDC	GPR	DC Sump Pump 1TSPU-2 Fails To Start Or Run	PZ	2H	2	
PK2TSAC	GPR	AC Sump Pump 2TSPU-1 Fails To Start Or Run	PZ	10950H	10950	
PK2TSDC	GPR	DC Sump Pump 2TSPU-2 Fails To Start Or Run	PZ	2H	2	**195632**
BK1GBDC	GPS	Unit 1 DC Turbine GBO Pump Fails To Start On Demand	BZ	520D	520	

Table C.1-3: Denominator Totals For Keowee-Specific Failure Rates

Basic Event		Description	Tree	Denom. Code	Denom. Value	Totals
BK1GOAC	GPS	Unit 1 AC Turbine GBO Pump Fails To Start	BZ	520D	520	
BK2GBDC	GPS	Unit 2 DC Turbine GBO Pump Fails To Start On Demand	BZ	520D	520	
BK2GOAC	GPS	Unit 2 AC Turbine GBO Pump Fails To Start	BZ	520D	520	
OK1001A	GPS	OG Pump 1A Fails to Start	OZ	14292D	14292	
OK1001B	GPS	OG Pump 1B Fails to Start	OZ	14292D	14292	
OK1001C	GPS	OG Pump 1C Fails to Start	OZ	14292D	14292	
OK2002A	GPS	OG Pump 2A Fails to Start	OZ	14276D	14276	
OK2002B	GPS	OG Pump 2B Fails to Start	OZ	14276D	14276	
OK2002C	GPS	OG Pump 2C Fails to Start	OZ	14276D	14276	**87784**
GK10001	HGR	Keowee Unit 1 Generator Fault While the Unit Runs	GZ	AR1	5285	
GK20001	HGR	Keowee Unit 2 Generator Fault While the Unit Runs	GZ	AR1	5285	**10570**
GK10001	HGS	Keowee Unit 1 Generator Fault Causes Unit Start Failure	GZ	AS1	3390	
GK20002	HGS	Keowee Unit 2 Generator Fault Causes Unit Start Failure	GZ	AS2	3098	**6488**
FK1TRHX	HXF	Turbine Packing Box Heat Exchanger 1TRHX-1 Fails	FPZ	AV1	85755	
FK2TRHX	HXF	Turbine Packing Box Heat Exchanger 2TRHX-1 Fails	FPZ	AV2	85657	
GK1GAC1	HXF	Generator Air Cooler 1GAHW-1 Fails	GZ	AR1	5285	
GK1GAC2	HXF	Generator Air Cooler 1GAHW-2 Fails	GZ	AR1	5285	
GK1GAC3	HXF	Generator Air Cooler 1GAHW-3 Fails	GZ	AR1	5285	
GK1GAC4	HXF	Generator Air Cooler 1GAHW-4 Fails	GZ	AR1	5285	
GK1GAC5	HXF	Generator Air Cooler 1GAHW-5 Fails	GZ	AR1	5285	
GK1GAC6	HXF	Generator Air Cooler 1GAHW-6 Fails	GZ	AR1	5285	
GK1HPO1	HXF	Generator Thrust Bearing Cooler 1HPOHX-1 Fails	GZ	AR1	5285	
GK1HPO2	HXF	Generator Thrust Bearing Cooler 1HPOHX-2 Fails	GZ	AR1	5285	
GK1HPO3	HXF	Generator Thrust Bearing Cooler 1HPOHX-3 Fails	GZ	AR1	5285	
GK1HPO4	HXF	Generator Thrust Bearing Cooler 1HPOHX-4 Fails	GZ	AR1	5285	
GK1HPO5	HXF	Generator Thrust Bearing Cooler 1HPOHX-5 Fails	GZ	AR1	5285	
GK1HPO6	HXF	Generator Thrust Bearing Cooler 1HPOHX-6 Fails	GZ	AR1	5285	
GK1HPO7	HXF	Generator Thrust Bearing Cooler 1HPOHX-7 Fails	GZ	AR1	5285	
GK1HPO8	HXF	Generator Thrust Bearing Cooler 1HPOHX-8 Fails	GZ	AR1	5285	
GK2GAC1	HXF	Generator Air Cooler 2GAHW-1 Fails	GZ	AR2	4428	
GK2GAC2	HXF	Generator Air Cooler 2GAHW-2 Fails	GZ	AR2	4428	

Table C.1-3: Denominator Totals For Keowee-Specific Failure Rates

Basic Event	Description	Tree	Denom. Code	Denom. Value	Totals
GK2GAC3 HXF	Generator Air Cooler 2GAHW-3 Fails	GZ	AR2	4428	
GK2GAC4 HXF	Generator Air Cooler 2GAHW-4 Fails	GZ	AR2	4428	
GK2GAC5 HXF	Generator Air Cooler 2GAHW-5 Fails	GZ	AR2	4428	
GK2GAC6 HXF	Generator Air Cooler 2GAHW-6 Fails	GZ	AR2	4428	
GK2HPO1 HXF	Generator Thrust Bearing Cooler 2HPOHX-1 Fails	GZ	AR2	4428	
GK2HPO2 HXF	Generator Thrust Bearing Cooler 2HPOHX-2 Fails	GZ	AR2	4428	
GK2HPO3 HXF	Generator Thrust Bearing Cooler 2HPOHX-3 Fails	GZ	AR2	4428	
GK2HPO4 HXF	Generator Thrust Bearing Cooler 2HPOHX-4 Fails	GZ	AR2	4428	
GK2HPO5 HXF	Generator Thrust Bearing Cooler 2HPOHX-5 Fails	GZ	AR2	4428	
GK2HPO6 HXF	Generator Thrust Bearing Cooler 2HPOHX-6 Fails	GZ	AR2	4428	
GK2HPO7 HXF	Generator Thrust Bearing Cooler 2HPOHX-7 Fails	GZ	AR2	4428	
GK2HPO8 HXF	Generator Thrust Bearing Cooler 2HPOHX-8 Fails	GZ	AR2	4428	**307394**
GK1GAC1 HXL	Heat Exchanger 1GAC1 Leaks	GZ	AV1	85755	
GK1GAC2 HXL	Heat Exchanger 1GAC2 Leaks	GZ	AV1	85755	
GK1GAC3 HXL	Heat Exchanger 1GAC3 Leaks	GZ	AV1	85755	
GK1GAC4 HXL	Heat Exchanger 1GAC4 Leaks	GZ	AV1	85755	
GK1GAC5 HXL	Heat Exchanger 1GAC5 Leaks	GZ	AV1	85755	
GK1GAC6 HXL	Heat Exchanger 1GAC6 Leaks	GZ	AV1	85755	
GK2GAC1 HXL	Heat Exchanger 2GAC1 Leaks	GZ	AV2	85657	
GK2GAC2 HXL	Heat Exchanger 2GAC2 Leaks	GZ	AV2	85657	
GK2GAC3 HXL	Heat Exchanger 2GAC3 Leaks	GZ	AV2	85657	
GK2GAC4 HXL	Heat Exchanger 2GAC4 Leaks	GZ	AV2	85657	
GK2GAC5 HXL	Heat Exchanger 2GAC5 Leaks	GZ	AV2	85657	
GK2GAC6 HXL	Heat Exchanger 2GAC6 Leaks	GZ	AV2	85657	**1028472**
BK163TA LSD	Turbine No. 1 Bearing Oil Level Switch 63TA Fails on Demand	BZ	1D	1	
BK263TA LSD	Turbine No. 2 Bearing Oil Level Switch 63TA Fails on Demand	BZ	1D	1	***not used***
BK163TA LST	Turbine No. 1 Bearing Oil Level Switch 63TA Spurious Operation	BFZ	AV1	85755	
BK263TA LST	Turbine No. 2 Bearing Oil Level Switch 63TA Spurious Operation	BFZ	AV2	85657	
PK163SA LST	Unit 1 AC Turbine Sump Pump Float Switch 63SA Fails	PZ	10950H	10950	
PK163SB LST	Unit 1 DC Turbine Sump Pump Float Switch 63SB Transfers	PZ	2	2	
PK263SA LST	Unit 2 AC Turbine Sump Pump Float Switch 63SA Fails	PZ	10950H	10950	

Table C.1-3: Denominator Totals For Keowee-Specific Failure Rates

Basic Event		Description	Tree	Denom. Code	Denom. Value	**Totals**
PK263SB	LST	Unit 2 DC Turbine Sump Pump Float Switch 63SB Transfers	PZ	2H	2	
YK163BH	LST	Keowee 1 Gen Thrst Brng Oil Lvl Hi Sw 63BL/H Sprsly Clsd , -113-3	YZ	AV1	85755	
YK163BL	LST	Keowee 1 Gen Thrst Brng Oil Lvl Lo Sw 63BL/L Spuriously Operates ,-113-	YZ	AV1	85755	
YK163TB	LST	Keowee 1 Turb Guide Brng Lo Lvl Sensor Sw Spuriously Closes KEE-113-4	YZ	AV1	85755	
YK263BH	LST	Keowee 2 Gen Thrst Brng Oil Lvl Hi Sw 63BL/H Sprsly Clsd	YZ	AV2	85657	
YK263BL	LST	Keowee 2 Gen Thrst Brng Oil Lvl Lo Sw 63BL/L Sprsly Opn	YZ	AV2	85657	
YK263TB	LST	Keowee 2 Turb Guide Brng Lo Lvl Sensor Sw Sprsly Closes	YZ	AV2	85657	**707552**
AB2PUSH	PBT	Trip Pushbutton On ACB2 Spurious Operation	AZ	AR2	4428	
AB3PUSH	PBT	Trip Pushbutton On ACB3 Spurious Operation	AZ	AV1	85755	
AB4PUSH	PBT	Trip Pushbutton On ACB-4 Spurious Operation	AZ	AV2	85657	
AB5PUSH	PBT	Trip Pushbutton On ACB5 Spurious Operation	AZ	AV1	85755	
AB6PUSH	PBT	Trip Pushbutton On ACB6 Spurious Operation	AZ	AV2	85657	
AB7PUSH	PBT	Trip Pushbutton On ACB7 Spurious Operation	AZ	AV1	85755	
AB8PUSH	PBT	Trip Pushbutton On ACB8 Spurious Operation	AZ	AV2	85657	**518664**
OK10001	PSC	Pressure Switch 1OGPS-1 Fails to Close (Normal Control Signal)	OZ	14292D	14292	
OK10002	PSC	Pressure Switch 1OGPS-2 Fails to Close	OZ	14292D	14292	
OK10003	PSC	Pressure Switch 1OGPS-3 Fails to Close	OZ	14292D	14292	
OK10004	PSC	Pressure Switch 1OGPS-4 Fails to Close	OZ	9D	9	
OK20001	PSC	Pressure Switch 2OGPS-1 Fails to Close (Normal Control Signal)	OZ	14276D	14276	
OK20002	PSC	Pressure Switch 2OGPS-2 Fails to Close	OZ	14276D	14276	
OK20003	PSC	Pressure Switch 2OGPS-3 Fails to Close	OZ	14276D	14276	
OK20004	PSC	Pressure Switch 2OGPS-4 Fails to Close	OZ	9D	9	**85722**
AB1PS02	PST	Air Circuit Breaker 1 Accumulator Pressure Switch PS2 Fails Low	AZ	AV1	85755	
AB1PSWT	PST	Air Circuit Breaker 1 Accumulator Pressure Switch Fails Low	SZ	AV1	85755	
AB2PS02	PST	Air Circuit Breaker 2 Accumulator Pressure Switch PS2 Fails Low	AZ	AV2	85657	
AB2PSWT	PST	Air Circuit Breaker 2 Accumulator Pressure Switch Fails Low	SZ	AV2	85657	
AB3PS02	PST	Air Circuit Breaker 3 Accumulator Pressure Switch PS2 Fails Low	AZ	AV1	85755	
AB3PSWT	PST	Air Circuit Breaker 3 Accumulator Pressure Switch Fails Low	SZ	AV1	85755	
AB4PS02	PST	Air Circuit Breaker 4 Accumulator Pressure Switch PS2 Indicates Low Pressure	AZ	AV2	85657	
AB4PSWT	PST	Air Circuit Breaker 4 Accumulator Pressure Switch Indicates Low Air Pressure	SZ	AV2	85657	
GK1063F	PST	Keowee 1 Gen CO2 Sys Press Switch 63F Spurious Operation	GZ	AV1	85755	

Table C.1-3: Denominator Totals For Keowee-Specific Failure Rates

Basic Event		Description	Tree	Denom. Code	Denom. Value	**Totals**
GK2063F	PST	Keowee 2 Gen CO2 Sys Press Switch 63F Spurious Operation	GZ	AV2	85657	**857060**
AA1271P	R6D	Transformer 1X Undervoltage Relay 27/1X Fails To Pick Up	AZ	QTR	40	
AA127CP	R6D	Transformer CX Undervoltage Relay 27/CX1 Fails To Pick Up	AZ	QTR	40	
AA127X2	R6D	Transformer CX Undervoltage Relay 27/CX1 Fails To Drop Out	AZ	QTR	40	
AA2272P	R6D	Transformer 2X Undervoltage Relay 27/2X Fails To Pick Up	AZ	QTR	40	
AA2272X	R6D	Transformer 2X Undervoltage Relay 27/2X Fails To Drop Out	AZ	QTR	40	
AA227CP	R6D	Transformer CX Undervoltage Relay 27/CX2 Fails To Pick Up	AZ	QTR	40	
AA227T2	R6D	Transformer 2X Undervoltage Relay (27T/2X) Fails To Drop Out	AZ	QTR	40	
AB1R52Z	R6D	Air Circuit Breaker 1 Relay 52Z Fails To Operate	AZ	AS1	3390	
AB252Y2	R6D	Air Circuit Breaker 2 Relay 52Y Failed To Drop Out Following Last Demand	AZ	AS1	3390	
AB2R52X	R6D	Air Circuit Breaker 2 Relay 52X Fails To Operate	AZ	AS2	3098	
AB2R52Z	R6D	Air Circuit Breaker 2 Relay 52Z Fails To Operate	AZ	AS2	3098	
AB352Y2	R6D	Air Circuit Breaker 3 Relay 52Y Failed To Drop Out Following Last Demand	AZ	Bi-MTH	61	
AB3R52X	R6D	Air Circuit Breaker 3 Relay 52X Fails To Operate	AZ	Bi-MTH	61	
AB3R52Z	R6D	Air Circuit Breaker 3 Relay 52Z Fails To Operate	AZ	Bi-MTH	61	
AB452Y2	R6D	Air Circuit Breaker 4 Relay 52Y Failed To Drop Out Following Last Demand	AZ	Bi-MTH	61	
AB4R52X	R6D	Air Circuit Breaker 4 Relay 52X Fails To Operate	AZ	Bi-MTH	61	
EK141AX	R6D	Keowee Unit 1 Relay 41/AX Fails To Pick-up And Latch	EZ	AS1	3390	
EK241AX	R6D	Keowee Unit 2 Relay 41/AX Fails To Pick-up And Latch	EZ	AS2	3098	
KA127T1	R6D	Xfmr 1X UV Relay 27T/1X Fails To Pick-up	KZ	QTR	40	**20089**
AA1271X	R6T	Transformer 1X Undervoltage Relay 27/1X Spuriously De-energizes	AZ	CON	87600	
AA127C1	R6T	Transformer CX Undervoltage Relay 27/CX1 Spuriously De-energizes	AZ	CON	87600	
AA2272X	R6T	Transformer 2X Undervoltage Relay 27/2X Spuriously De-energizes	AZ	CON	87600	
AA227C2	R6T	Transformer CX Undervoltage Relay 27/CX2 Spuriously De-energizes	AZ	CON	87600	
AB252Y2	R6T	Air Circuit Breaker 2 Y-relay Spurious Operation	AZ	AV2	85657	
AB2R52Z	R6T	Air Circuit Breaker 2 Relay 52Z Spurious Operation	AZ	AV2	85657	
AB352Y2	R6T	Air Circuit Breaker 3 Y-relay Spurious Operation	AZ	AV1	85755	
AB3R52Z	R6T	Air Circuit Breaker 3 Relay 52Z Spurious Operation	AZ	AV1	85755	
AB452Y2	R6T	Air Circuit Breaker 4 Y-relay Spurious Operation	AZ	AV2	85657	
AB4R52Z	R6T	Air Circuit Breaker 4 Relay 52Z Spurious Operation	AZ	AV2	85657	
EK141AX	R6T	Keowee Unit 1 Relay 41/AX Spuriously Resets	EZ	AV1	85755	
EK1R9C1	R6T	Keowee Unit 1 Relay 90X1C Spurious Operation	EZ	AV1	85755	

Table C.1-3: Denominator Totals For Keowee-Specific Failure Rates

Basic Event		Description	Tree	Denom. Code	Denom. Value	**Totals**
EK241AX	R6T	Keowee Unit 2 Relay 41/AX Spuriously Resets	EZ	AV2	85657	
EK2R9C2	R6T	Keowee Unit 2 Relay 90X1C Spurious Operation	EZ	AV2	85657	
KA127T1	R6T	Xfrmr 1X UV Relay 27T/1X Spuriously De-energizes	KZ	AV1	85755	
KA227T2	R6T	Xfmr 2X UV Relay 27T/2x Spuriously De-energizes	KZ	AV2	85657	**1378774**
OK10003	RVT	Safety Relief Valve 1OG-3 Spurious Operation	OZ	AV1	85755	
OK10013	RVT	Relief Valve 1OG-13 Spurious Operation	OZ	714H	714	
OK10016	RVT	Relief Valve 1OG-16 Transfers Open	OZ	714H	714	
OK10019	RVT	Relief Valve 1OG-19 Spurious Operation	OZ	714H	714	
OK1AG04	RVT	Safety Relief Valve 1AG-4 Spurious Operation	OZ	714H	714	
OK20003	RVT	Safety Relief Valve 2OG-3 Spurious Operation	OZ	714H	714	
OK20013	RVT	Relief Valve 2OG-13 Spurious Operation	OZ	714H	714	
OK20016	RVT	Relief Valve 2OG-16 Transfers Open	OZ	714H	714	
OK20019	RVT	Relief Valve 2OG-19 Spurious Operation	OZ	714H	714	
OK2AG04	RVT	Safety Relief Valve 2AG-4 Spurious Operation	OZ	AV2	85657	**177124**
AA127X1	RYD	Auxiliary Relay 27X/1X Fails To Operate On Demand	AZ	QTR	40	
AA127XC	RYD	Auxiliary Relay 27/CX1 Fails To Operate On Demand	AZ	QTR	40	
AA227C2	RYD	Auxiliary Relay 27X/CX2 Fails To Operate On Demand	AZ	QTR	40	
AA227X2	RYD	Auxiliary Relay 27X/2X Fails To Operate On Demand	AZ	QTR	40	
AB0086T	RYD	Keowee Main Tx Lock Out Relay 86T Fails To Operate On Demand	AZ	10D	10	
AB0624C	RYD	Time Delay Relay 62-4c Fails To Operate On Demand	AZ	0	0	
AB086E1	RYD	Emergency Lock Out Relay 86E-1 Fails To Operate On Demand	AZ	10D	10	
AB086TG	RYD	General Keowee Main Tx Lock Out Sensing Relay Fails To Operate	AZ	0	0	
AB552CC	RYD	Air Circuit Breaker 5 Close Coil CC Fails On Demand	AZ	Bi-MTH	61	
AB583S5	RYD	Time Delay Relay 83S5 Fails To Pick Up	AZ	Bi-MTH	61	
AB5R52X	RYD	Air Circuit Breaker 5 Relay 52X Fails To Operate	AZ	6D	6	
AB5R52Y	RYD	Air Circuit Breaker 5 Relay 52Y Failed To Drop Out At Last Demand	AZ	6D	6	
AB652CC	RYD	Air Circuit Breaker 6 Close Coil CC Fails On Demand	AZ	Bi-MTH	61	
AB652TC	RYD	Air Circuit Breaker 6 Trip Coil 52TC Fails Fails To Operate	AZ	Bi-MTH	61	
AB6R52X	RYD	Air Circuit Breaker 6 Relay 52X Fails To Operate	AZ	6D	6	
AB6R52Y	RYD	Air Circuit Breaker 6 Relay 52Y Failed To Drop Out At Last Demand	AZ	6D	6	
AB752CC	RYD	Air Circuit Breaker 7 Close Coil CC Fails On Demand	AZ	Bi-MTH	61	
AB752TC	RYD	Air Circuit Breaker 7 Trip Coil TC Fails On Demand	AZ	Bi-MTH	61	

Table C.1-3: Denominator Totals For Keowee-Specific Failure Rates

Basic Event		Description	Tree	Denom. Code	Denom. Value	Totals
AB7R52X	RYD	Air Circuit Breaker 7 Relay 52X Fails To Operate	AZ	6D	6	
AB7R52Y	RYD	Air Circuit Breaker 7 Relay 52Y Failed To Drop Out At Last Demand	AZ	6D	6	
AB852CC	RYD	Air Circuit Breaker 8 Close Coil CC Fails On Demand	AZ	Bi-MTH	61	
AB86E1A	RYD	Emergency Lock Out Aux. Relay 86E-1a Fails To Operate On Demand	AZ	10D	10	
AB86E1G	RYD	Keowee Unit 1 Emergency Lock Out Sensing Relay Fails To Operate	AZ	0	0	
AB883S8	RYD	Time Delay Relay 83S8 Fails To Pick Up	AZ	Bi-MTH	61	
AB8R52X	RYD	Air Circuit Breaker 8 Relay 52X Fails To Operate	AZ	6D	6	
AB8R52Y	RYD	Air Circuit Breaker 8 Relay 52Y Failed To Drop Out At Last Demand	AZ	6D	6	
AK1141X	RYD	Auxiliary Relay 14GOV/1X Fails To Pick-up	AZ	0	0	
AK121TD	RYD	Time Delay Relay 2-1TD Fails To Pick-up	AZ	0	0	
AK152TD	RYD	Time Delay Relay 52-1TD Fails To Pick-up	AZ	ES	111	
AK152XG	RYD	Relay 52XG/1 Fails To Pick Up When The Unit Is Started	AZ	0	0	
AK1GV1X	RYD	Relay 14GOV/1X Fails To Pick-up	AZ	0	0	
AK2142X	RYD	Auxiliary Relay 14GOV/2X Fails To Pick-up	AZ	0	0	
AK222TD	RYD	Time Delay Relay 2-2TD Fails To Pick-up	AZ	0	0	
AK252TD	RYD	Time Delay Relay 52-2TD Fails To Operate	AZ	ES	111	
AK252W0	RYD	KU2 Relay 52W Fails To Pick-up	AZ	AS2	3098	
AK252XG	RYD	Auxiliary Relay 52XG/2 Fails To Pick-up	AZ	0	0	
AK2GV2X	RYD	Relay 14GOV/2X Fails To Pick-up	AZ	0	0	
BK1088X	RYD	Keowee 1 Turbine Guide Bearing Oil Relay 88X Fails to Drop Out	BZ	1D	1	
BK114DX	RYD	Keowee 1 Rotation Sensing Aux. Relay 14DX Fails to Energize	BZ	AS1	3390	
BK114T2	RYD	Keowee 1 Rotation Sensing Timer 14T2 Fails to De-energize	BZ	AS1	3390	
BK1631X	RYD	Keowee 1 Relay 63TA/1X Fails to De-energize	BZ	1D	1	
BK1632X	RYD	Keowee 1 Brng. Low Oil Level Aux. Relay 63TA/2X Fails To Operate On Demand	BZ	1D	1	
BK188AX	RYD	Unit 1 AC Bearing Oil Pump Aux. Relay 88AX Fails to Drop Out	BZ	520D	520	
BK2088X	RYD	Keowee 2 Turbine Guide Bearing Oil Relay 88X Fails to Drop Out	BZ	1D	1	
BK214DX	RYD	Keowee 2 Rotation Sensing Aux. Relay 14DX Fails to Energize	BZ	AS2	3098	
BK214T2	RYD	Keowee 2 Rotation Sensing Timer 14T2 Fails to De-energize	BZ	AS2	3098	
BK2631X	RYD	Keowee 2 Relay 63TA/1X Fails to De-energize	BZ	1D	1	
BK2632X	RYD	Keowee 2 Brng. Low Oil Level Aux. Relay 63TA/2X Fails To Operate On Demand	BZ	1D	1	
BK288AX	RYD	Unit 2 AC Bearing Oil Pump Aux. Relay 88AX Fails to Drop Out	BZ	520D	520	
EK131TD	RYD	Keowee Unit 1 Field Flashing Breaker Time Delay Relay 31/TD Fails To Operate	EZ	AS1	3390	
EK1415Y	RYD	KHU1 Generator Supply Breaker Y-relay Failed To Drop-out At Last Operation	EZ	AS1	3390	
EK141CF	RYD	Keowee Unit 1 Field Flashing Breaker Close Coil Fails To Operate On Demand	EZ	AS1	3390	

Table C.1-3: Denominator Totals For Keowee-Specific Failure Rates

Basic Event	Description	Tree	Denom. Code	Denom. Value	Totals
EK188SV RYD	Keowee Unit 1 Fan Control Relay 88SV Fails On Demand	EZ	AS1	3390	
EK199SX RYD	Auxiliary Relay 99SX1 Fails To Pick-up	EZ	AS1	3390	
EK199SY RYD	Keowee Unit 1 Relay 99SY Fails To Pick-up	EZ	AS1	3390	
EK1F31X RYD	Keowee Unit 1 Field Flashing Breaker Relay 31/X Fails To Pick-up On Demand	EZ	AS1: 1993	418	
EK1F41C RYD	Keowee Unit 1 Field Breaker Close Coil Fails To Operate On Demand	EZ	AS1	3390	
EK1R31T RYD	Keowee Unit 1 Field Flashing Breaker Trip Coil 31/T Fails To Operate	EZ	AS1	3390	
EK1R31Y RYD	KHU1 Gen Field Flashing Breaker Y-relay Failed To Drop Out At Last Operation	EZ	AS1: 1993	418	
EK1R41X RYD	Keowee Unit 1 Field Breaker Relay 41/X Fails To Pick-up On Demand	EZ	AS1: 1993	418	
EK1R41Y RYD	KHU1 Generator Field Breaker Y-relay Failed To Drop-out At Last Operation	EZ	AS1: 1993	418	
EK1S41C RYD	Keowee Unit 1 Supply Breaker Close Coil Fails To Operate On Demand	EZ	AS1	3390	
EK1S41X RYD	Keowee Unit 1 Supply Breaker Relay 41-52X Fails To Pick-up On Demand	EZ	AS1: 1993	418	
EK1VHSV RYD	Keowee Unit 1 Volts/Hertz Relay SV Fails To Trip Field Flashing Breaker	EZ	AS1	3390	
EK231TD RYD	Keowee Unit 2 Field Flashing Breaker Time Delay Relay 31/TD Fails To Operate	EZ	AS2	3098	
EK2415Y RYD	KHU2 Gen Supply Breaker Y-relay Failed To Drop-out At Last Operation	EZ	AS2: 1993	224	
EK241CF RYD	Keowee Unit 2 Field Flashing Breaker Close Coil Fails To Operat On Demand	EZ	AS2	3098	
EK288SV RYD	Keowee Unit 2 Fan Control Relay 88SV Fails On Demand	EZ	AS2	3098	
EK299SX RYD	Auxiliary Relay 99SX2 Fails To Pick-up	EZ	AS2	3098	
EK299SY RYD	Keowee Unit 2 Relay 99SY Fails To Pick-up	EZ	AS2	3098	
EK2F31X RYD	Keowee Unit 2 Field Flashing Breaker Relay 31/X Fails To Pick-up On Demand	EZ	AS2: 1993	224	
EK2F41C RYD	Keowee Unit 2 Field Breaker Close Coil Fails To Operate On Demand	EZ	AS2	3098	
EK2R31T RYD	Keowee Unit 2 Field Flashing Breaker Trip Coil 31/T Fails To Operate	EZ	AS2	3098	
EK2R31Y RYD	KHU2 Gen Field Flashing Breaker Y-relay Failed To Drop At Last Operation	EZ	AS2: 1993	224	
EK2R41X RYD	Keowee Unit 2 Field Breaker Relay 41/X Fails To Pick-up On Demand	EZ	AS2: 1993	224	
EK2R41Y RYD	KHU2 Generator Field Breaker Y-relay Failed To Drop-out At Last Operation	EZ	AS2: 1993	224	
EK2S41C RYD	Keowee Unit 2 Supply Breaker Close Coil Fails To Operate On Demand	EZ	AS2	3098	
EK2S41X RYD	Keowee Unit 2 Supply Breaker Relay 41-52X Fails To Pick-up On Demand	EZ	AS2: 1993	224	
EK2VHSV RYD	Keowee Unit 2 Volts/Hertz Relay SV Fails To Trip Field Flashing Breaker	EZ	AS2	3098	
EU1C1RO RYD	ONS1 ESG Chan. 1 Ro Relay Fails To Pick Up OEE-120	YZ	0.00E+00	0	
EU1C2RO RYD	ONS1 ESG Chan. 2 Ro Relay Fails to Pick Up	YZ	0.00E+00	0	
EU2C1RO RYD	ONS2 ESG Chan. 1 Ro Relay Fails to Pick Up OEE-220	YZ	0.00E+00	0	
EU2C2RO RYD	ONS2 ESG Chan. 2 Ro Relay Fails to Pick Up OEE-220-1	YZ	0.00E+00	0	
EU3C1RO RYD	ONS3 ESG Chan. 1 Ro Relay Fails to Pick Up OEE-320	YZ	0.00E+00	0	
EU3C2RO RYD	ONS3 ESG Chan. 2 Ro Relay Fails to Pick Up OEE-320-1	YZ	0.00E+00	0	
L27BRX1 RYD	Snsng Rly 27B/RX1 Fails to Drop Out on Undervoltage OEE-76-3, -4	LZ	QTR	40	

Table C.1-3: Denominator Totals For Keowee-Specific Failure Rates

Basic Event		Description		Tree	Denom. Code	Denom. Value	Totals
L27BRX2	RYD	Snsng Rly 27B/RX2 Fails to Drop Out on Undervoltage	OEE-76-3, -8	LZ	QTR	40	
L27BRY1	RYD	Snsng Rly 27B/RY1 Fails to Drop Out on Undervoltage	OEE-76-3, -4	LZ	QTR	40	
L27BRY2	RYD	Snsng Rly 27B/RY2 Fails to Drop Out on Undervoltage	OEE-76-3, -8	LZ	QTR	40	
L27BRZ1	RYD	Snsng Rly 27B/RZ1 Fails to Drop Out on Undervoltage	OEE-76-3, -4	LZ	QTR	40	
L27BRZ2	RYD	Snsng Rly 27B/RZ2 Fails to Drop Out on Undervoltage	OEE-76-3, -8	LZ	QTR	40	
L27BYX1	RYD	Snsng Rly 27B/YX1 Fails to Drop Out on Undervoltage	OEE-76-3, -4	LZ	QTR	40	
L27BYX2	RYD	Snsng Rly 27B/YX2 Fails to Drop Out on Undervoltage	OEE-76-3, -8	LZ	QTR	40	
L27BYY1	RYD	Snsng Rly 27B/YY1 Fails to Drop Out on Undervoltage	OEE-76-3, -4	LZ	QTR	40	
L27BYY2	RYD	Snsng Rly 27B/YY2 Fails to Drop Out on Undervoltage	OEE-76-3, -8	LZ	QTR	40	
L27BYZ1	RYD	Snsng Rly 27B/YZ1 Fails to Drop Out on Undervoltage	OEE-76-3, -4	LZ	QTR	40	
L27BYZ2	RYD	Snsng Rly 27B/YZ2 Fails to Drop Out on Undervoltage	OEE-76-3, -8	LZ	QTR	40	
L27XPX1	RYD	Ch 1 Phase X UV Aux. Relay Fails To Pick Up	OEE-76-4	LZ	QTR	40	
L27XPX2	RYD	Ch 2 Phase X UV Aux. Relay Fails To Pick Up	OEE-76-8	LZ	QTR	40	
L27XPY1	RYD	Ch 1 Phase Y UV Aux. Relay Fails to Pick Up	OEE-76-4	LZ	QTR	40	
L27XPY2	RYD	Ch 2 Phase Y UV Aux. Relay Fails to Pick Up	OEE-76-8	LZ	QTR	40	
L27XPZ1	RYD	Ch 1 Phase Z UV Aux. Relay Fails To Pick Up	OEE-76-4	LZ	QTR	40	
L27XPZ2	RYD	Ch 2 Phase Z UV Aux. Relay Fails To Pick Up	OEE-76-8	LZ	QTR	40	
L27XRX1	RYD	Red Bus Phase X1 Undervoltage Aux. Relay Fails To Pick Up	OEE-76-4	LZ	QTR	40	
L27XRX2	RYD	Red Bus Phase X2 Undervoltage Aux. Relay Fails To Pick Up	OEE-76-8	LZ	QTR	40	
L27XRY1	RYD	Red Bus Phase Y1 Undervoltage Aux. Relay Fails To Pick Up	OEE-76-4	LZ	QTR	40	
L27XRY2	RYD	Red Bus Phase Y2 Undervoltage Aux. Relay Fails to Pick Up	OEE-76-8	LZ	QTR	40	
L27XRZ1	RYD	Red Bus Phase Z1 Undervoltage Aux. Relay Fails To Pick Up	OEE-76-4	LZ	QTR	40	
L27XRZ2	RYD	Red Bus Phase Z2 Undervoltage Aux. Relay Fails To Pick Up	OEE-76-8	LZ	QTR	40	
L27XSTA	RYD	Keowee Start Relay 27X/STA Fails To Pick Up		LSZ	QTR	40	
L27XSTB	RYD	Keowee Start Relay 27X/STB Fails To Pick Up		LSZ	QTR	40	
L27XYX1	RYD	Yellow Bus Phase X1 Undervoltage Aux. Relay Fails To Pick Up	OEE-76-4	LZ	QTR	40	
L27XYX2	RYD	Yellow Bus Phase X2 Undervoltage Aux. Relay Fails To Pick Up	OEE-76-8	LZ	QTR	40	
L27XYY1	RYD	Yellow Bus Phase Y1 Undervoltage Aux. Relay Fails To Pick Up	OEE-76-4	LZ	QTR	40	
L27XYY2	RYD	Yellow Bus Phase Y2 Undervoltage Aux. Relay Fails to Pick Up	OEE-76-8	LZ	QTR	40	
L27XYZ1	RYD	Yellow Bus Phase Z1 Undervoltage Aux. Relay Fails To Pick Up	OEE-76-4	LZ	QTR	40	
L27XYZ2	RYD	Yellow Bus Phase Z2 Undervoltage Aux. Relay Fails to Pick Up	OEE-76-8	LZ	QTR	40	
L81BRX1	RYD	Sensing Relay 81BL/RX1 Fails to Drop Out on Underfrequency		LZ	QTR	40	
L81BRX2	RYD	Sensing Relay 81BL/RX2 Fails to Drop Out on Underfrequency		LZ	QTR	40	
L81BRY1	RYD	Sensing Relay 81BL/RY1 Fails to Drop Out on Underfrequency		LZ	QTR	40	

Table C.1-3: Denominator Totals For Keowee-Specific Failure Rates

Basic Event		Description	Tree	Denom. Code	Denom. Value	**Totals**
L81BRY2	RYD	Sensing Relay 81BL/RY2 Fails to Drop Out on Underfrequency	LZ	QTR	40	
L81BRZ1	RYD	Sensing Relay 81BL/RZ1 Fails to Drop Out on Underfrequency	LZ	QTR	40	
L81BRZ2	RYD	Sensing Relay 81BL/RZ2 Fails to Drop Out on Underfrequency	LZ	QTR	40	
L81BYX1	RYD	Sensing Relay 81BL/YX1 Fails to Drop Out on Underfrequency	LZ	QTR	40	
L81BYX2	RYD	Sensing Relay 81BL/YX2 Fails to Drop Out on Underfrequency	LZ	QTR	40	
L81BYY1	RYD	Sensing Relay 81BL/YY1 Fails to Drop Out on Underfrequency	LZ	QTR	40	
L81BYY2	RYD	Sensing Relay 81BL/YY2 Fails to Drop Out on Underfrequency	LZ	QTR	40	
L81BYZ1	RYD	Sensing Relay 81BL/YZ1 Fails to Drop Out on Underfrequency	LZ	QTR	40	
L81BYZ2	RYD	Sensing Relay 81BL/YZ2 Fails to Drop Out On Underfrequency	LZ	QTR	40	
L81XPX1	RYD	Ch 1 Phase X Underfrequency Aux. Rly Fails to Pick Up	LZ	QTR	40	
L81XPX2	RYD	Ch 2 Phase X Underfrequency Aux. Rly Fails to Pick Up	LZ	QTR	40	
L81XPY1	RYD	Ch 1 Phase Y Underfrequency Aux. Rly Fails to Pick Up	LZ	QTR	40	
L81XPY2	RYD	Ch 2 Phase Y Underfrequency Aux. Rly Fails to Pick Up	LZ	QTR	40	
L81XPZ1	RYD	Ch 1 Phase Z Underfrequency Aux. Rly Fails to Pick Up	LZ	QTR	40	
L81XPZ2	RYD	Ch 2 Phase Z Underfrequency Aux. Rly Fails to Pick up	LZ	QTR	40	
L81XRX1	RYD	Red Bus Phase X1 Underfrequency Aux. Rly Fails to Pick Up	LZ	QTR	40	
L81XRX2	RYD	Red Bus Phase X2 Underfrequency Aux. Rly Fails to Pick Up	LZ	QTR	40	
L81XRY1	RYD	Red Bus Phase Y1 Underfrequency Aux. Rly Fails to Pick Up	LZ	QTR	40	
L81XRY2	RYD	Red Bus Phase Y2 Underfrequency Aux. Rly Fails to Pick Up	LZ	QTR	40	
L81XRZ1	RYD	Red Bus Phase Z1 Underfrequency Aux. Rly Fails to Pick Up	LZ	QTR	40	
L81XRZ2	RYD	Red Bus Phase Z2 Underfrequency Aux. Rly Fails to Pick Up	LZ	QTR	40	
L81XYX1	RYD	Yellow Bus Phase X1 Underfrequency Aux. Rly Fails to Pick Up	LZ	QTR	40	
L81XYX2	RYD	Yellow Bus Phase X2 Underfrequency Aux. Rly Fails to Pick Up	LZ	QTR	40	
L81XYY1	RYD	Yellow Bus Phase Y1 Underfrequency Aux. Rly Fails to Pick Up	LZ	QTR	40	
L81XYY2	RYD	Yellow Bus Phase Y2 Underfrequency Aux. Rly Fails to Pick Up	LZ	QTR	40	
L81XYZ1	RYD	Yellow Bus Phase Z1 Underfrequency Aux. Rly Fails to Pick Up	LZ	QTR	40	
L81XYZ2	RYD	Yellow Bus Phase Z2 Underfrequency Aux. Rly Fails to Pick Up	LZ	QTR	40	
LC94F1A	RYD	EGTPS Underfrequency Relay 94/F1A Fails to Pick Up	LZ	QTR	40	
LC94F1B	RYD	EGTPS Underfrequency Relay 94/F1B Fails to Pick Up	LZ	QTR	40	
LC94F1D	RYD	EGTPS Underfrequency Relay 94/F1D Fails to Pick Up	LZ	QTR	40	
LC94F2A	RYD	EGTPS Underfrequency Relay 94/F2A Fails to Pick Up	LZ	QTR	40	
LC94F2B	RYD	EGTPS Underfrequency Relay 94/F2B Fails to Pick Up	LZ	QTR	40	
LC94F2C	RYD	EGTPS Underfrequency Relay 94/F2C Fails to Pick Up	LZ	QTR	40	
LC94F2D	RYD	EGTPS Underfrequency Relay 94/F2D Fails to Pick Up	LZ	QTR	40	

Table C.1-3: Denominator Totals For Keowee-Specific Failure Rates

Basic Event		Description	Tree	Denom. Code	Denom. Value	Totals
LC94V1A	RYD	EGTPS Undervoltage Relay 94/V1A Fails to Pick Up	LZ	QTR	40	
LC94V1B	RYD	EGTPS Undervoltage Relay 94/V1B Fails To Pick Up OEE-76-4	LZ	QTR	40	
LC94V1D	RYD	EGTPS Undervoltage Relay 94/V1D Fails to Pick Up OEE-76-4	LZ	QTR	40	
LC94V2A	RYD	EGTPS Undervoltage Relay 94/V2A Fails to Pick Up	LZ	QTR	40	
LC94V2B	RYD	EGTPS Undervoltage Relay 94/V2B Fails To Pick Up	LZ	QTR	40	
LC94V2C	RYD	EGTPS Undervoltage Relay 94/V2C Fails to Pick Up	LZ	QTR	40	
OK199K1	RYD	Keowee 1 Relay 99K1 Fails To Operate On Demand	OZ	9D	9	
OK199K2	RYD	Keowee 1 Relay 99K2 Fails To Operate On Demand	OZ	9D	9	
OK299K1	RYD	Keowee 2 Relay 99K1 Fails To Operate On Demand	OZ	9D	9	
OK299K2	RYD	Relay 99K2 Fails To Operate On Demand	OZ	9D	9	
S127EX1	RYD	Unit 1 Startup Bus UV Aux Relay 27EX1 Fails to Pick Up	SZ	0	0	
S127EXV	RYD	Unit 1 Startup Bus UV Aux Relay 27EX Fails to Pick Up	SZ	0	0	
S227EX1	RYD	Unit 2 Startup Bus UV Aux Relay 27EX1 Fails to Pick Up	SZ	0	0	
S227EXV	RYD	Unit 2 Startup Bus UV Aux Relay 27EX Fails to Pick Up	SZ	0	0	
S27XSC1	RYD	Channel 1 Swyd Isolated Rly, 27X/SC1, Fails to Pick Up	SZ	QTR	40	
S27XSC2	RYD	Channel 2 Swyd Isolated Rly, 27X/SC2, Fails to Pick Up	SZ	QTR	40	
S27XTD1	RYD	Channel 1 Swyd Isolated Time Delay Rly, 27XTD/SC1, Fails	SZ	QTR	40	
S27XTD2	RYD	Channel 2 Swyd Isolated Time Delay Rly, 27XTD/SC2, Fails	SZ	QTR	40	
S327EX1	RYD	Unit 3 Standby Bus UV Aux Relay 27EX1 Fails to Pick Up	SZ	1D	1	
S327EXV	RYD	Unit 3 Startup Bus UV Trip Aux Relay 27EX Fails to Pick Up	SZ	6D	6	
YK199SD	RYD	Keowee 1 Shutdown Solenoid 99SD Fails To Pick Up	YZ	AS1	3390	
YK199SN	RYD	K1 Emergency Load Solenoid 99SN Fails To Pick Up/Drop Out	YZ	AS1*2	6780	
YK199SX	RYD	Keowee 1 Shutdown Solenoid Aux Relay 99SX Fails to Pick Up	YZ	AS1	3390	
YK1ES1A	RYD	Keowee 1 Emergency Start Aux Relay 1ESRX/1A Fails To Pick Up OEE-120	YZ	ES	111	
YK1ES1B	RYD	Keowee 1 Emergency Start Aux Relay 1ESRX/1B Fails To Pick Up OEE-120-1	YZ	ES	111	
YK1ES2A	RYD	Keowee 1 Emergency Start Aux Relay 1ESRX/2A Fails To Pick Up OEE-120	YZ	ES	111	
YK1ES2B	RYD	Keowee 1 Emergency Start Aux Relay 1ESRX/2B Fails To Pick Up OEE-120-1	YZ	ES	111	
YK1MR4A	RYD	Keowee 1 Start Master Relay 4A Fails To Pick Up KEE-113	YZ	AS1	3390	
YK1MR4B	RYD	Keowee 1 Start Master Relay 4B Fails To Pick Up KEE-113	FZ	AS1	3390	
YK299SD	RYD	Keowee 2 Shutdown Solenoid 99SD Fails To Pick Up	YZ	AS2	3098	
YK299SN	RYD	Keowee 2 Emergency Load Solenoid 99SN Fails To Operate	YZ	AS2*2	6196	
YK299SX	RYD	Keowee 2 Shutdown Solenoid Aux Relay 99SX Fails to Pick Up	YZ	AS2	3098	
YK2ES1A	RYD	Keowee 2 Emergency Start Aux Relay 2ESRX/1A Fails To Pick Up OEE-120	YZ	ES	111	
YK2ES1B	RYD	Keowee 2 Emergency Start Aux Relay 2ESRX/1B Fails to Pick Up OEE-120-1	YZ	ES	111	

Table C.1-3: Denominator Totals For Keowee-Specific Failure Rates

Basic Event	Description	Tree	Denom. Code	Denom. Value	Totals
YK2ES2A RYD	Keowee 2 Emergency Start Aux Relay 2ESRX/2A Fails to Pick Up OEE-120	YZ	ES	111	
YK2ES2B RYD	Keowee 2 Emergency Start Aux Relay 2ESRX/2B Fails to Pick Up OEE-120-1	YZ	ES	111	
YK2MR4A RYD	Keowee 2 Start Master Relay 4A Fails To Pick Up KEE-213	YZ	AS2	3098	
YK2MR4B RYD	Keowee 2 Start Master Relay 4B Fails to Pick Up KEE-213	FZ	AS2	3098	
YO1XXKA RYD	ONS1 Ch A Keowee Emergency Start Relay KA Fails to Pick Up OEE-120	YZ	ES	111	
YO1XXKB RYD	Oconee Unit 1 Chan. B Keowee Emergency Start Relay Fails OEE-120-1	YZ	ES	111	
YO2CR2A RYD	ONS2 Ch A Keowee Emergency Start Relay CR2A Fails to Pick Up OEE-220	YZ	ES	111	
YO2CR2B RYD	ONS2 Keowee Emergency Start Relay CR2B Fails to Pick Up OEE-220-1	YZ	ES	111	
YO3CR3A RYD	ONS3 Ch A Keowee Emergency Start Relay CR3A Fails To Pick Up OEE-320	YZ	ES	111	
YO3CR3B RYD	ONS3 Keowee Emer Start Relay CR3B Fails to Pick Up OEE-320-1	YZ	ES	111	**126969**
AA127R1 RYT	Auxiliary Relay 27X/CX1 Spurious Operation	AZ	CON	87600	
AA127X1 RYT	Auxiliary Relay 27X/1X Spurious Operation	AZ	CON	87600	
AA186CX RYT	Transformer CX Differential Lock Out Relay 86CX Spurious Operation	AZ	CON	87600	
AA186S1 RYT	Switchgear 1X Lockout Relay 86S/1X Spurious Operation	AZ	CON	87600	
AA187CX RYT	Transformer CX Differential Relay 87CX Spurious Operation	AZ	CON	87600	
AA227R2 RYT	Auxiliary Relay 27X/CX2 Spurious Operation	AZ	CON	87600	
AA227X2 RYT	Auxiliary Relay 27X/2X Spurious Operation	AZ	CON	87600	
AA286S2 RYT	Switchgear 2X Lockout Relay 86S/2X Spurious Operation	AZ	CON	87600	
AB22BV1 RYT	Backup Undervoltage Relay 2BV1 Spurious Operation	AZ	AR2	4428	
AB251G2 RYT	Air Circuit Breaker 2 Overcurrent Ground Relay 51G-2 Spurious Operation	AZ	AR2	4428	
AB2R462 RYT	Air Circuit Breaker 2 Negative Sequence Relay 46-2 Spurious Operation	AZ	AR2	4428	
AB51431 RYT	Auxiliary Relay 143X/1 Spuriously Energizes	AZ	AV1	85755	
AB552TC RYT	Air Circuit Breaker 5 Trip Coil 52TC Spurious Operation	AZ	AV1	85755	
AB552Y2 RYT	Air Circuit Breaker 5 Y-relay Spurious Operation	AZ	AV2: 1993	8541	
AB652TC RYT	Air Circuit Breaker 6 Trip Coil 52TC Spurious Operation	AZ	AV1	85755	
AB652Y2 RYT	Air Circuit Breaker 6 Y-relay Spurious Operation	AZ	AV2: 1993	8541	
AB752TC RYT	Air Circuit Breaker 7 Trip Coil 52TC Spurious Operation	AZ	AV1	85755	
AB752Y2 RYT	Air Circuit Breaker 7 Y-relay Spurious Operation	AZ	AV1: 1993	8564.6	
AB81432 RYT	Auxiliary Relay 143X/2 Spuriously Energizes	AZ	AV2	85657	
AB852TC RYT	Air Circuit Breaker 8 Trip Coil 52TC Spurious Operation	AZ	AV2	85657	
AB852Y2 RYT	Air Circuit Breaker 8 Y-relay Spurious Operation	AZ	AV2: 1993	8541	
AK152TD RYT	Time Delay Relay 52-1TD Spurious Operation	AZ	AV1	85755	
AK152XG RYT	Relay 52XG/1 Spuriously Drops Out While The Unit Is Running	AZ	0	0	

Table C.1-3: Denominator Totals For Keowee-Specific Failure Rates

Basic Event		Description	Tree	Denom. Code	Denom. Value	Totals
AK1AX34	RYT	Relay 52AX/34 Spuriously Drops-out	AZ	0	0	
AK1X34X	RYT	Relay 52AX/34X Spuriously Drops-out	AZ	0	0	
AK252TD	RYT	Time Delay Relay 52-2TD Spurious Operation	AZ	AV2	85657	
BK1088X	RYT	Keowee 1 Turbine Guide Bearing Oil Relay 88X Spurious Operation	BFZ	AV1	85755	
BK114DX	RYT	Keowee 1 Rotation Sensing Aux. Relay 14DX Spuriously Drops Out	BZ	AR1	5285	
BK114T2	RYT	Keowee 1 Rotation Sensing Timer 14T2 Spurious Operation	BZ	AR1	5285	
BK1631X	RYT	Keowee 1 GBO Level Relay 63TA/1X Spurious Operation	BFZ	AV1	85755	
BK1632X	RYT	Keowee 1 Turb. Brng. Low Oil Level Aux. Rly 63TA/2X Spurious Operation	BZ	AV1	85755	
BK188AX	RYT	Unit 1 AC Bearing Oil Pump Aux. Relay 88AX Fails to Remain De-energized	BZ	AV1	85755	
BK2088X	RYT	Keowee 2 Turbine Guide Bearing Oil Relay 88X Spurious Operation	BFZ	AV2	85657	
BK214DX	RYT	Keowee 2 Rotation Sensing Aux. Relay 14DX Spurious Operation	BZ	AR2	4428	
BK214T2	RYT	Keowee Rotation Sensing Timer 14T2 Fails to Remain De-energized	BZ	AR2	4428	
BK2631X	RYT	Keowee 2 GBO Level Relay 63TA/1X Spurious Operation	BFZ	AV2	85657	
BK2632X	RYT	Keowee 2 Turb. Brng. Low Oil Level Aux. Relay 63TA/2X Spurious Operation	BZ	AV2	85657	
BK288AX	RYT	Unit 2 AC Bearing Oil Pump Aux. Relay 88AX Fails to Remain De-energized	BZ	AV2	85657	
EK131TD	RYT	Keowee Unit 1 Field Flashing Breaker Time Delay Relay 31/TD Spurious Operation	EZ	AV1	85755	
EK1415Y	RYT	KHU1 Generator Supply Breaker Y-relay Spurious Operation	EZ	AV1: 1993	8564.6	
EK186E2	RYT	Keowee Unit 1 Lockout Auxiliary Relay 86EX-2 Is Picked-up	EZ	AV1	85755	
EK186EX	RYT	Keowee Unit 1 Gen Lockout Auxiliary Relay 86EX-1 Spurious Actuation	EZ	AV1	85755	
EK186X2	RYT	Keowee Unit 1 Generator Lockout Auxiliary Relay 86EX-1 Spurious Actuation	EZ	0	0	
EK188SV	RYT	Keowee Unit 1 Fan Control Relay 88SV Prior To Or During The Run	EZ	AV1	85755	
EK1901A	RYT	Keowee Unit 1 Relay 90X1A Spurious Operation	EZ	AV1	85755	
EK199SY	RYT	Keowee Unit 1 Relay 99SY Drops Out	EZ	AR1	5285	
EK1R31Y	RYT	KHU1 Generator Field Flashing Breaker Y-relay Spurious Operation	EZ	AV1: 1993	8564.6	
EK1R41Y	RYT	Keowee Unit 1 Generator Field Breaker Y-relay Spurious Operation	EZ	AV1: 1993	8564.6	
EK1R9A1	RYT	Keowee Unit 1 Relay 90X1A/TD Spurious Operation	EZ	AV1	85755	
EK231TD	RYT	Keowee Unit 2 Field Flashing Breaker Time Delay Relay 31/TD Spurious Operation	EZ	AV2	85657	
EK2415Y	RYT	KHU2 Generator Supply Breaker Y-relay Spurious Operation	EZ	AV2: 1993	8541	
EK286E2	RYT	Keowee Unit 2 Lockout Auxiliary Relay 86EX-2 Is Picked-up	EZ	AV2	85657	
EK286EX	RYT	Keowee Unit 2 Generator Lockout Auxiliary Relay 86EX-1 Spurious Actuation	EZ	AV2	85657	
EK286X2	RYT	Keowee Unit 2 Generator Lockout Auxiliary Relay 86EX-1 Spurious Actuation	EZ	0	0	
EK288SV	RYT	Keowee Unit 2 Fan Control Relay 88SV Prior To Or During The Run	EZ	AV2	85657	
EK2901A	RYT	Keowee Unit 2 Relay 90X1A Spurious Operation	EZ	AV2	85657	
EK299SY	RYT	Keowee Unit 2 Relay 99SY Drops Out	EZ	AR2	4428	

Table C.1-3: Denominator Totals For Keowee-Specific Failure Rates

Basic Event		Description	Tree	Denom. Code	Denom. Value	Totals
EK2R31Y	RYT	KHU2 Generator Field Flashing Breaker Y-relay Spurious Operation	EZ	AV2: 1993	8541	
EK2R41Y	RYT	KHU2 Generator Field Breaker Y-relay Spurious Operation	EZ	AV2: 1993	8541	
EK2R9A2	RYT	Keowee Unit 2 Relay 90X1A/TD Spurious Operation	EZ	AV2	85657	
GK112TD	RYT	Time Delay Relay 12XTD/1 Spuriously Picks-up	GZ	0	0	
GK112X1	RYT	Relay 12X/1 Spuriously Picks-up	GZ	0	0	
GK13SUI	RYT	Keowee Unit 1 Startup Inhibit Switch Auxiliary Relay S3SUIX Spurious Actuation	GZ	CON	87600	
GK140G1	RYT	Keowee Unit 1 Loss Of Generator Field Relay 40G1 Spurious Actuation	GZ	AR1	5285	
GK159GN	RYT	Keowee Unit 1 Generator Ground Fault Relay 59GN1 Spurious Actuation	GZ	AR1	5285	
GK162TD	RYT	Keowee Unit 1 Generator Backup Trip Timer 62-1TD Spurious Operation	GZ	AR1	5285	
GK163FX	RYT	Keowee Unit 1 Generator Fire Relay 63FX Spurious Actuation	GZ	AV1	85755	
GK186E1	RYT	Keowee 1 Emergency Lockout Relay 86E-1 Spuriously Picks Up	GZ	AV1	85755	
GK187G1	RYT	Keowee Unit 1 Generator Differential Relay 87G-1 Spurious Actuation	GZ	AR1	5285	
GK187GB	RYT	Keowee Unit 1 Generator Bus Differential Relay 87GB Spurious Actuation	GZ	AR1	5285	
GK187TE	RYT	Keowee Unit 1 Exitation Transformer Differential Relay 87T-1E Spur. Actuation	GZ	AR1	5285	
GK212TD	RYT	Time Delay Relay 12XTD/2 Spuriously Picks-up	GZ	0	0	
GK212X2	RYT	Relay 12X/2 Spuriously Picks-up	GZ	0	0	
GK23SUI	RYT	Keowee Unit 2 Startup Inhibit Switch Auxiliary Relay S3SUIX Spurious Actuation	GZ	CON	87600	
GK240G1	RYT	Keowee Unit 2 Loss Of Generator Field Relay 40G1 Spurious Actuation	GZ	AR2	4428	
GK259GN	RYT	Keowee Unit 2 Generator Ground Fault Relay 59GN2 Spurious Actuation	GZ	AR2	4428	
GK262TD	RYT	Keowee Unit 2 Generator Backup Trip Timer 62-2TD Spurious Operation	GZ	AR2	4428	
GK263FX	RYT	Keowee Unit 2 Generator Fire Relay 63FX Spurious Actuation	GZ	AV2	85657	
GK286E2	RYT	Keowee 2 Emergency Lockout Relay 86E-2 Spuriously Picks Up	GZ	AV2	85657	
GK287G2	RYT	Keowee Unit 2 Generator Differential Relay 87G-2 Spurious Actuation	GZ	AR2	4428	
GK287GB	RYT	Keowee Unit 2 Generator Bus Differential Relay 87GB Spurious Actuation	GZ	AR2	4428	
GK287TE	RYT	Keowee Unit 2 Excitation Transformer Differential Relay 87T-2E Spur. Actuation	GZ	AR2	4428	
OK199K1	RYT	Keowee Unit 1 Relay 99K1 Spurious Operation	OZ	AV1	85755	
OK299K1	RYT	Keowee Unit 2 Relay 99K1 Spurious Operation	OZ	AV2	85657	
S127E1V	RYT	Unit 1 Startup Bus Undervoltage Relay 27E1 Fails	SZ	0	0	
S127EUV	RYT	Unit 1 Startup Bus Undervoltage Relay 27E Fails	SZ	CON	87600	
S227E1V	RYT	Unit 2 Startup Bus Undervoltage Relay 27E1 Fails	SZ	0	0	
S227EUV	RYT	Unit 2 Startup Bus Undervoltage Relay 27E Fails	SZ	CON	87600	
S327E1V	RYT	Unit 3 Startup Bus Undervoltage Trip Relay 27E1 Fails	SZ	1yr	8760	
S327EUV	RYT	Unit 3 Startup Bus Undervoltage Trip Relay 27E Fails	SZ	CON	87600	
SB18UX1	RYT	Auxiliary Relay 8UX-1 Spurious Operation	SZ	AV1	85755	

Table C.1-3: Denominator Totals For Keowee-Specific Failure Rates

Basic Event		Description	Tree	Denom. Code	Denom. Value	**Totals**
SB28UX2	RYT	Auxiliary Relay 8UX-2 Spurious Operation	SZ	AV2	85657	
SB38UX3	RYT	Auxiliary Relay 8UX-3 Spurious Operation	SZ	AV1	85755	
SB48UX4	RYT	Auxiliary Relay 8UX-4 Spurious Operation	SZ	AV2	85657	
SK194GB	RYT	Keowee Unit 1 94GB Auxiliary Relay Spurious Operation	SZ	CON	87600	
SK294GB	RYT	Keowee Unit 2 94GB Auxiliary Relay Spurious Operation	SZ	CON	87600	
SPC51TN	RYT	Main Step Up Transformer Neutral Ground Relay 51TN Spurious Operation	SZ	CON	87600	
SPC62AB	RYT	ACB Back-up Trip Timer 62AB Spurious Operation	SZ	CON	87600	
SPC631X	RYT	Auxiliary Relay 63H1X Spurious Operation	SZ	CON	87600	
SPC871X	RYT	Transformer 1X Differential Relay 87T-1X Spurious Operation	SZ	AV1	85755	
SPC872X	RYT	Transformer 2X Differential Relay 87T-2X Spurious Operation	SZ	AV2	85657	
SPC87T1	RYT	Main Step Up Transformer Differential Relay 87T Spurious Operation	SZ	CON	87600	
SPC94TK	RYT	Auxiliary Relay 94T/K Spurious Operation	SZ	CON	87600	
SPCD87L	RYT	Line Differential Relay 87L Spurious Operation	SZ	CON	87600	
SPCR86T	RYT	Lock Out Relay 86T Spurious Operation	SZ	CON	87600	
SY30R94	RYT	PCB 30 Relay 94 Spuriously Picks Up	SZ	CON	87600	
SY51TN2	RYT	230kV Neutral Ground Relay Spuriously Picks Up	SZ	CON	87600	
SY51TN4	RYT	4.16kV Neutral Ground Relay Spuriously Picks Up	SZ	CON	87600	
SY51TN6	RYT	6.9kV Neutral Ground Relay 51TN Spuriously Picks Up	SZ	CON	87600	
SY62X1F	RYT	Breaker Failure Relay 62X1 Spuriously Picks Up	SZ	CON	87600	
SY62X2F	RYT	Breaker Failure Relay 62X2 Spuriously Picks Up	SZ	CON	87600	
SY62XXF	RYT	Breaker Failure Relay 62X Spuriously Picks Up	SZ	CON	87600	
SY86BUI	RYT	CT3 6.9kV Start Up Bus Lockout Relay Spuriously Picks Up	SZ	CON	87600	
SY86CT3	RYT	Transformer CT3 Lockout Relay Spuriously Picks Up	SZ	CON	87600	
SY86YA9	RYT	Yellow Bus Lockout Auxiliary Relay 86YA9 Spuriously Picks Up	SZ	CON	87600	
SY86YJ3	RYT	Yellow Bus Lockout Auxiliary Relay 86YJ30 Spuriously Picks Up	SZ	CON	87600	
SY87BYX	RYT	Yellow Bus X Phase Differential Relay 87BYX Spuriously Picks Up	SZ	CON	87600	
SY87BYY	RYT	Yellow Bus Y Phase Differential Relay 87BYY Spuriously Picks Up	SZ	CON	87600	
SY87BYZ	RYT	Yellow Bus Z Phase Differential Relay 86BYZ Spuriously Picks Up	SZ	CON	87600	
SY87LXX	RYT	Differential Auxiliary Relay 87LX Spuriously Picks Up	SZ	CON	87600	
SY94L1X	RYT	Protective Relay 94L Spuriously Picks Up	SZ	CON	87600	
SYE1362	RYT	E13 Bkr Failure Relay 62B Spuriously Picks Up	SZ	CON	87600	
SYE2362	RYT	E23 Bkr Failure Relay 62B Spuriously Picks Up	SZ	CON	87600	
SYP2862	RYT	PCB 28 Breaker Failure Relay 62B Spuriously Picks Up	SZ	CON	87600	
SYP3062	RYT	PCB 30 Breaker Failure Relay 62B Spuriously Picks Up	SZ	CON	87600	

Table C.1-3: Denominator Totals For Keowee-Specific Failure Rates

Basic Event		Description	Tree	Denom. Code	Denom. Value	**Totals**
SYP86TX	RYT	PCB 30 LOR 86TX Spuriously Picks Up	SZ	CON	87600	
SYPL86T	RYT	PCB 30 LOR 86T Spuriously Picks Up	SZ	CON	87600	
SYPL87L	RYT	Differential Relay 87L Spuriously Picks Up	SZ	CON	87600	
SYR86BY	RYT	Yellow Bus Lockout Relay 86BY Spuriously Picks Up	SZ	CON	87600	
SYS63FP	RYT	Fault Pressure Relay 63FP Spuriously Picks Up	SZ	CON	87600	
SYSX50B	RYT	Transformer CT3 Fault Detector Relay 50B Spuriously Picks Up	SZ	CON	87600	
SYX87TB	RYT	Differential Relay 87B Spuriously Picks Up	SZ	CON	87600	
SYXX87T	RYT	Differential Relay 87T Spuriously Picks Up	SZ	CON	87600	
U5086EF	RYT	Overcurrent Relay 50 Spuriously Actuates Lockout Rly 86EF	SZ	CON	87600	
U5186EF	RYT	Time Delay Overcurrent Relay 51 Actuates Lockout Relay 86EF	SZ	CON	87600	
U51TNC4	RYT	CT4 Neutral Ground Rly Actuates CT4 LOR 86T/CT4	SZ	CON	87600	
U62BSK1	RYT	SK1 Breaker Failure Relay 62BXSK1 Spuriously Picks Up	SZ	CON	87600	
U62BSK2	RYT	SK2 Breaker Failure Relay 62BXSK2 Spuriously Picks Up	SZ	CON	87600	
U86CT4X	RYT	Auxiliary Lockout Relay 86CT4X Spuriously Picks Up	SZ	CON	87600	
U86TCT4	RYT	CT4 Lockout Relay 86T/CT4 Spuriously Picks Up	SZ	CON	87600	
U87TCT4	RYT	Spurious Op of CT4 Differential Rly 87T Actuates LOR 86EF	SZ	CON	87600	
UXX86EF	RYT	Lockout Relay 86EF Spuriously Picks Up	SZ	CON	87600	
YK14AMR	RYT	Keowee 1 Master Relay 4A Spuriously Drops Out	YZ	AR1	5285	
YK14BMR	RYT	Keowee 1 Master Relay 4B Spuriously Drops Out	YZ	AR1	5285	
YK163BH	RYT	Keowee 1 Gen Thrst Brng Oil Lvl Hi Rly 63BL/HX Sprsly Picks Up ,-113-	YZ	AV1	85755	
YK163BL	RYT	Keowee 1 Gen Thrst Brng Oil Lvl Lo Rly 63BL/LXTD Sprsly Pcks Up , -113-	YZ	AV1	85755	
YK163TB	RYT	Keowee 1 Turb Gd Brng Oil Lvl Lo Rly 63TB/1X Sprsly Picks Up ,-113-4	YZ	AV1	85755	
YK199SD	RYT	Keowee 1 Shutdown Solenoid Spuriously Drops Out	YZ	AR1	5285	
YK199SN	RYT	Emergency Load Solenoid 99SN Spuriously Drops Out	YZ	AR1	5285	
YK199SX	RYT	Shutdown Auxiliary Relay 99SX Spuriously Drops Out	BYZ	AR1	5285	
YK24AMR	RYT	Keowee 2 Master Relay 4A Spuriously Drops Out	YZ	AR2	4428	
YK24BMR	RYT	Keowee 2 Master Relay 4B Spuriously Drops Out	YZ	AR2	4428	
YK263BH	RYT	Keowee 2 Gen Thrst Brng Oil Lvl Hi Rly 63BL/HX Sprsly Picks Up	YZ	AV2	85657	
YK263BL	RYT	Keowee 2 Gen Thrst Brng Oil Lvl Lo Rly 63BL/LXTD Sprsly Pcks Up	YZ	AV2	85657	
YK263TB	RYT	Keowee 2 Turb Gd Brng Oil Lvl Lo Rly 63TB/1X Sprsly Picks Up	YZ	AV2	85657	
YK299SD	RYT	Keowee 2 Shutdown Solenoid Spuriously Drops Out	YZ	AR2	4428	
YK299SN	RYT	Emergency Load Solenoid 99SN Spuriously Drops Out	YZ	AR2	4428	
YK299SX	RYT	Shutdown Auxiliary Relay 99SX Spuriously Drops Out	AZ	AR2	4428	**9354504**

Table C.1-3: Denominator Totals For Keowee-Specific Failure Rates

Basic Event		Description	Tree	Denom. Code	Denom. Value	**Totals**
BK114/2	SSD	Keowee 1 Speed Switch 14/2 Fails On Demand	BZ	AS1	3390	
BK214/2	SSD	Keowee 2 Speed Switch 14/2 Fails On Demand	BZ	AS2	3098	
YK114X3	SSD	Keowee 1 Speed Switch 14-3 Fails to Open at 65 rpm	YZ	AS1	3390	
YK1SS13	SSD	Keowee 1 Speed Switch 13 Fails to Close at 122 rpm	YZ	AS1	3390	
YK214X3	SSD	KHU#2 Speed Switch 14-3 Fails to Open at 65 rpm	YZ	AS2	3098	
YK2SS13	SSD	Keowee 2 Speed Switch 13 Fails to Close at 122 rpm	YZ	AS2	3098	**19464**
AK212OS	SST	Turbine Overspeed Switch Indicates Overspeed	AZ	AV2	85657	
BK114/2	SST	Keowee 1 Speed Switch 14/2 Spuriously Transfers Closed	BZ	AR1	5285	
BK214/2	SST	Keowee 2 Speed Switch 14/2 Spuriously Transfers Closed	BZ	AR2	4428	
GK1O121	SST	Speed Switch 12/1 Falsely Indicates High Speed	GZ	AR1	5285	
GK2O121	SST	Speed Switch 12/2 Falsely Indicates High Speed	GZ	AR2	4428	
YK1SS12	SST	Keowee 1 Overspeed Switch 12 Spuriously Picks Up	YZ	AR1	5285	
YK2SS12	SST	Keowee 2 Overspeed Switch 12 Spuriously Picks Up	YZ	AR2	4428	**114796**
AB152TC	SVO	Air Circuit Breaker 1 Trip Coil Fails To Operate	AZ	AS1	3390	
AB252CC	SVO	Air Circuit Breaker 2 Close Coil Fails To Operate	AZ	AS2	3098	
AB252TC	SVO	Air Circuit Breaker 2 Trip Coil Fails To Operate	AZ	AS2	3098	
AB352CC	SVO	Air Circuit Breaker 3 Close Coil Fails To Operate	AZ	Bi-MTH	61	
AB352TC	SVO	Air Circuit Breaker 3 Trip Coil Fails To Operate	AZ	Bi-MTH	61	
AB452CC	SVO	Air Circuit Breaker 4 Close Coil Fails To Operate	AZ	Bi-MTH	61	**9769**
AB252TC	SVT	Air Circuit Breaker 2 Trip Coil Spurious Operation	AZ	AV2	85657	
AB352TC	SVT	Air Circuit Breaker 3 Trip Coil Spurious Operation	AZ	AV1	85755	
AB452TC	SVT	Air Circuit Breaker 4 Trip Coil Spurious Operation	AZ	AV2	85657	**257069**
AB4CLSE	SWC	Air Circuit Breaker 4 Close Switch Fails To Close On Demand	AZ	MTH	61	
YO1S1AF	SWC	Control Switch S1A Fails To Close On Demand	YZ	0.00E+00	0	
YO1S1BF	SWC	Control Switch S1B Fails To Close On Demand	YZ	0.00E+00	0	
YO2SSWA	SWC	Control Switch 2SSW'A' Fails To Close On Demand	YZ	0.00E+00	0	
YO2SSWB	SWC	Control Switch 2SSW'B' Fails To Close On Demand	YZ	0.00E+00	0	
YO3S1AF	SWC	Control Switch S1A Fails To Close On Demand	YZ	0.00E+00	0	
YO3S1BF	SWC	Control Switch S1B Fails To Close On Demand	YZ	0.00E+00	0	
YO3SSWA	SWC	Control Switch 3SSW'A' Fails To Close On Demand	YZ	0.00E+00	0	

Table C.1-3: Denominator Totals For Keowee-Specific Failure Rates

Basic Event		Description	Tree	Denom. Code	Denom. Value	Totals
YO3SSWB	SWC	Control Switch 3SSW'B' Fails To Close On Demand	YZ	0.00E+00	0	**61**
AB21521	SWT	Control Switch 152-2 Spurious Operation	AZ	AV1	85755	
AB2KEYI	SWT	Air Circuit Breaker 2 Key Interlock Switch Transfers Open	AZ	AV2	85657	
AB31523	SWT	Control Switch 152-3 Spurious Operation	AZ	AV1	85755	
AB41523	SWT	Control Switch 152-4 Spurious Operation	AZ	AV2	85657	
AB4KEYI	SWT	Air Circuit Breaker 4 Key Interlock Switch Transfers Open	AZ	AV2	85657	
AB4LORE	SWT	Air Circuit Breaker 4 Local/Remote Switch Contact Transfers Position	AZ	AV2	85657	
AB51431	SWT	Manual/Auto Control Switch 143/1 Spuriously Transfers Into Manual	AZ	AV1	85755	
AB5KEYI	SWT	Air Circuit Breaker 5 Key Interlock Switch Transfers Open	AZ	AV1	85755	
AB61432	SWT	Manual/Auto Control Switch 143/2 Spuriously Transfers Into Manual	AZ	AV2	85657	
AB6KEYI	SWT	Air Circuit Breaker 6 Key Interlock Switch Transfers Open	AZ	AV2	85657	
AB7KEYI	SWT	Air Circuit Breaker 7 Key Interlock Switch Transfers Open	AZ	AV1	85755	
AB8KEYI	SWT	Air Circuit Breaker 8 Key Interlock Switch Transfers Open	AZ	AV2	85657	
BK1188A	SWT	Keowee 1 AC GBO Pump Control Switch S188A Spurious Operation	BZ	AV1	85755	
BK1188D	SWT	Unit 1 DC GBO Pump Control Switch S188D Spurious Operation	BZ	2H	2	
BK2188A	SWT	Unit 2 AC GBO Pump Control Switch S188A Spurious Operation	BZ	AV1	85755	
BK2188D	SWT	Unit 2 DC GBO Pump Control Switch S188D Spurious Operation	BZ	2H	2	
EK14152	SWT	KHU1 Generator Supply Breaker Trip Control Switch 141-52/T Spurious Operation	EZ	AV1	85755	
EK1415T	SWT	Spurious Operation Of The KHU1 Supply Breaker Trip Switch	EZ	0	0	
EK1S141	SWT	KHU1 Field Breaker Trip Control Switch 141/T Spurious Operation	EZ	0	0	
EK1S31T	SWT	KHU1 Field Flashing Breaker Trip Control Switch 131/T Spurious Operation	EZ	AV1	85755	
EK1S41T	SWT	Keowee Unit 1 Field Breaker Trip Control Switch Transfers Position	EZ	AV1	85755	
EK24152	SWT	KHU2 Generator Supply Breaker Trip Control Switch Spurious Operation	EZ	AV2	85657	
EK2415T	SWT	Spurious Operation Of The KHU2 Supply Breaker Trip Switch	EZ	0	0	
EK2S141	SWT	KHU2 Field Breaker Trip Control Switch Spurious Operation	EZ	0	0	
EK2S31T	SWT	KHU2 Field Flashing Breaker Trip Control Switch 131/T Spurious Operation	EZ	AV2	85657	
EK2S41T	SWT	Keowee Unit 2 Field Breaker Trip Control Switch Transfers Position	EZ	AV2	85657	
FK1120G	SWT	Unit 1 Control Switch S120G Spurious Operation	FZ	CON	87600	
FK2120G	SWT	Unit 2 Control Switch S120G Spurious Operation	FZ	CON	87600	
GK13SUI	SWT	Keowee Unit 1 Startup Inhibit Switch 3SUI Spurious Operation	GZ	CON	87600	
GK23SUI	SWT	Keowee Unit 2 Startup Inhibit Swtich 3SUI Spurious Operation	GZ	CON	87600	
OK188GA	SWT	Keowee 1 Governor Oil Control Switch 188GA Spurious Operation	OZ	714H	714	
OK188GB	SWT	Keowee 1 Control Switch 188GB Spurious Operation	OZ	714H	714	

Basic Event		Description	Tree	Denom. Code	Denom. Value	Totals
OK188GC	SWT	Keowee 1 Control Switch 188GC Spurious Operation	OZ	714H	714	
OK288GA	SWT	Keowee 2 Governor Oil Control Switch 188GA Spurious Operation	OZ	714H	714	
OK288GB	SWT	Keowee 2 Control Switch 188GB Spurious Operation	OZ	714H	714	
OK288GC	SWT	Keowee 2 Control Switch 188GC Spurious Operation	OZ	714H	714	
SPCGLAS	SWT	Break Glass Switch Spurious Operation	SZ	CON	87600	
YK13SUI	SWT	KHU#1 Startup Inhibit Sw 3SUI Xfrs to Inhibit , -113	YZ	AR1	5285	
YK23SUI	SWT	KHU#2 Startup Inhbt Sw 3SUI Sprsly Xfrs to Inhibit , -213	YZ	AR2	4428	**2166121**
EK1EXC1	TGF	Keowee Unit 1 Gen Excitation Transformer Is Failed	EZ	0	0	
EK1EXC2	TGF	Keowee Unit 1 Generator Excitation Transformer Fails	EZ	AV1	85755	
EK2EXC1	TGF	Keowee Unit 2 Generator Excitation Transformer Is Failed	EZ	0	0	
EK2EXC2	TGF	Keowee Unit 2 Generator Excitation Transformer Fails	EZ	AV2	85657	**171412**
SKXFMR1	THF	Keowee Transformer 1 Fails	XZ	CON	87600	
SXFRCT3	THF	Transformer CT3 Faulted	SZ	CON	87600	
UACXCT4	THF	Transformer CT4 Failed	SZ	CON	87600	**262800**
OK10003	TKF	Unit 1 Governor Oil Pressure Tank Fails	OZ	AV1	85755	
OK1AG01	TKF	Air Receiver Tank 1AGTK-1 Fails	OZ	AV1	85755	
OK20003	TKF	Unit 2 Governor Oil Pressure Tank Fails	OZ	AV2	85657	
OK2AGO1	TKF	Air Receiver Tank 2AGTK-1 Fails	OZ	AV2	85657	**342824**
EK1FAN1	TLF	Keowee Unit 1 Generator Excitation Fan Power Transformer Fails	EZ	AR1	5285	
EK2FAN1	TLF	Keowee Unit 2 Generator Excitation Fan Power Transformer Fails	EZ	AR2	4428	
XA1TR1X	TLF	Keowee Transformer 1X Fails	XZ	CON	87600	
XA1XCXX	TLF	4160/600 Vac Transformer CX Fails	XZ	CON	87600	
XA2TR2X	TLF	Keowee Transformer 2X Fails	XZ	CON	87600	**272513**
BK1GBO2	VVT	Manual Valve 1GBO-2 Transfers Position	BZ	AV1	85755	
BK1GBO4	VVT	Manual Valve 1GBO-4 Transfers Position	BZ	AV1	85755	
BK1GBO5	VVT	Manual Valve 1GBO-5 Transfers Position	BZ	AV1	85755	
BK1GBO6	VVT	Manual Valve 1GBO-6 Transfers Position	BZ	AV1	85755	
BK1GBO8	VVT	Manual Valve 1GBO-8 Transfers Position	BZ	AV1	85755	
BK1GBO9	VVT	Manual Valve 1GBO-9 Transfers Position	BZ	AV1	85755	

Basic Event		Description	Tree	Denom. Code	Denom. Value	**Totals**
BK2GBO2	VVT	Manual Valve 2GBO-2 Transfers Position	BZ	AV2	85657	
BK2GBO4	VVT	Manual Valve 2GBO-4 Transfers Position	BZ	AV2	85657	
BK2GBO5	VVT	Manual Valve 2GBO-5 Transfers Position	BZ	AV2	85657	
BK2GBO6	VVT	Manual Valve 2GBO-6 Transfers Position	BZ	AV2	85657	
BK2GBO8	VVT	Manual Valve 2GBO-8 Transfers Position	BZ	AV2	85657	
BK2GBO9	VVT	Manual Valve 2GBO-9 Transfers Position	BZ	AV2	85657	
FK0WL01	VVT	Locked-Open Manual Valve 0WL-1 Transfers Position	FZ	AV1	85755	
FK1WL03	VVT	Manual Valve 1WL-3 Transfers Position	FZ	AV1	85755	
FK1WL04	VVT	Manual Valve 1WL-4 Transfers Position	FZ	AV1	85755	
FK1WL05	VVT	Manual Valve 1WL-5 Transfers Position	FZ	AV1	85755	
FK1WL06	VVT	Manual Valve 1WL-6 Transfers Position	FZ	AV1	85755	
FK1WL07	VVT	Manual Valve 1WL-7 Transfers Position	FZ	AV1	85755	
FK1WL08	VVT	Manual Valve 1WL-8 Transfers Position	FZ	AV1	85755	
FK1WL09	VVT	Manual Valve 1WL-9 Transfers Position	FZ	AV1	85755	
FK1WL12	VVT	Manual Valve 1WL-12 Transfers Position	FZ	AV1	85755	
FK1WL15	VVT	Manual Valve 1WL-15 Transfers Position	FZ	AV1	85755	
FK1WL42	VVT	Manual Valve 1WL-42 Transfers Position	FZ	AV1	85755	
FK1WL43	VVT	Manual Valve 1WL-43 Transfers Position	FZ	AV1	85755	
FK2WL03	VVT	Manual Valve 2WL-3 Transfers Position	FZ	AV2	85657	
FK2WL04	VVT	Manual Valve 2WL-4 Transfers Position	FZ	AV2	85657	
FK2WL05	VVT	Manual Valve 2WL-5 Transfers Position	FZ	AV2	85657	
FK2WL06	VVT	Manual Valve 2WL-6 Transfers Position	FZ	AV2	85657	
FK2WL07	VVT	Manual Valve 2WL-7 Transfers Position	FZ	AV2	85657	
FK2WL08	VVT	Manual Valve 2WL-8 Transfers Position	FZ	AV2	85657	
FK2WL09	VVT	Manual Valve 2WL-9 Transfers Position	FZ	AV2	85657	
FK2WL12	VVT	Manual Valve 2WL-12 Transfers Position	FZ	AV2	85657	
FK2WL15	VVT	Manual Valve 2WL-15 Transfers Position	FZ	AV2	85657	
FK2WL42	VVT	Manual Valve 2WL-42 Transfers Position	FZ	AV2	85657	
FK2WL43	VVT	Manual Valve 2WL-43 Transfers Position	FZ	AV2	85657	
GK1HPO6	VVT	Genrator Bearing Oil Leak Because Manual Valve 1HPO-6 Transfers Position	GZ	AV1	85755	
GK1WL16	VVT	Manual Valve 1WL-16 Transfers Position	GZ	AV1	85755	
GK1WL17	VVT	Manual Valve 1WL-17 Transfers Position	GZ	AV1	85755	
GK1WL18	VVT	Manual Valve 1WL18 Transfers Position	GZ	AV1	85755	
GK1WL19	VVT	Manual Valve 1WL19 Transfers Position	GZ	AV1	85755	

Basic Event	Description	Tree	Denom. Code	Denom. Value	Totals
GK1WL20 VVT	Manual Valve 1WL-20 Transfers Position	GZ	AV1	85755	
GK1WL21 VVT	Manual Valve 1WL-21 Transfers Position	GZ	AV1	85755	
GK1WL22 VVT	Manual Valve 1WL22 Transfers Position	GZ	AV1	85755	
GK1WL23 VVT	Manual Valve 1WL23 Transfers Position	GZ	AV1	85755	
GK1WL24 VVT	Manual Valve 1WL-24 Transfers Position	GZ	AV1	85755	
GK1WL25 VVT	Manual Valve 1WL-25 Transfers Position	GZ	AV1	85755	
GK1WL26 VVT	Manual Valve 1WL26 Transfers Position	GZ	AV1	85755	
GK1WL27 VVT	Manual Valve 1WL27 Transfers Position	GZ	AV1	85755	
GK1WL28 VVT	Manual Valve 1WL-28 Transfers Position	GZ	AV1	85755	
GK1WL29 VVT	Manual Valve 1WL-29 Transfers Position	GZ	AV1	85755	
GK1WL30 VVT	Manual Valve 1WL30 Transfers Position	GZ	AV1	85755	
GK1WL31 VVT	Manual Valve 1WL31 Transfers Position	GZ	AV1	85755	
GK1WL32 VVT	Manual Valve 1WL-32 Transfers Position	GZ	AV1	85755	
GK1WL33 VVT	Manual Valve 1WL-33 Transfers Position	GZ	AV1	85755	
GK1WL34 VVT	Manual Valve 1WL34 Transfers Position	GZ	AV1	85755	
GK1WL35 VVT	Manual Valve 1WL35 Transfers Position	GZ	AV1	85755	
GK1WL36 VVT	Manual Valve 1WL-36 Transfers Position	GZ	AV1	85755	
GK1WL37 VVT	Manual Valve 1WL-37 Transfers Position	GZ	AV1	85755	
GK1WL38 VVT	Manual Valve 1WL38 Transfers Position	GZ	AV1	85755	
GK1WL39 VVT	Manual Valve 1WL39 Transfers Position	GZ	AV1	85755	
GK1WL41 VVT	Keowee 1 Manual Valve 1WL-41 Transfers Position to Block Discharge Path	GZ	AV1	85755	
GK1WL44 VVT	Manual Valve 1WL-44 Transfers Position	GZ	AV1	85755	
GK1WL45 VVT	Manual Valve 1WL-45 Transfers Position	GZ	AV1	85755	
GK1WL46 VVT	Manual Valve 1WL-46 Transfers Position	GZ	AV1	85755	
GK1WL47 VVT	Manual Valve 1WL-47 Transfers Position	GZ	AV1	85755	
GK1WL48 VVT	Manual Valve 1WL-48 Transfers Position	GZ	AV1	85755	
GK1WL49 VVT	Manual Valve 1WL-49 Transfers Position	GZ	AV1	85755	
GK1WL50 VVT	Manual Valve 1WL-50 Transfers Position	GZ	AV1	85755	
GK1WL51 VVT	Manual Valve 1WL-51 Transfers Position	GZ	AV1	85755	
GK1WL52 VVT	Manual Valve 1WL-52 Transfers Position	GZ	AV1	85755	
GK1WL53 VVT	Manual Valve 1WL-53 Transfers Position	GZ	AV1	85755	
GK1WL54 VVT	Manual Valve 1WL-54 Transfers Position	GZ	AV1	85755	
GK1WL55 VVT	Manual Valve 1WL-55 Transfers Position	GZ	AV1	85755	
GK1WL56 VVT	Manual Valve 1WL-56 Transfers Position	GZ	AV1	85755	

Table C.1-3: Denominator Totals For Keowee-Specific Failure Rates

Basic Event	Description	Tree	Denom. Code	Denom. Value	**Totals**
GK1WL57 VVT	Manual Valve 1WL-57 Transfers Position	GZ	AV1	85755	
GK1WL58 VVT	Manual Valve 1WL-58 Transfers Position	GZ	AV1	85755	
GK1WL59 VVT	Manual Valve 1WL-59 Transfers Position	GZ	AV1	85755	
GK1WL60 VVT	Manual Valve 1WL-60 Transfers Position	GZ	AV1	85755	
GK1WL61 VVT	Manual Valve 1WL-61 Transfers Position	GZ	AV1	85755	
GK1WL62 VVT	Manual Valve 1WL-62 Transfers Position	GZ	AV1	85755	
GK1WL63 VVT	Manual Valve 1WL-63 Transfers Position	GZ	AV1	85755	
GK1WL64 VVT	Manual Valve 1WL-64 Transfers Position	GZ	AV1	85755	
GK1WL65 VVT	Manual Valve 1WL-65 Transfers Position	GZ	AV1	85755	
GK1WL66 VVT	Manual Valve 1WL-66 Transfers Position	GZ	AV1	85755	
GK1WL67 VVT	Manual Valve 1WL-67 Transfers Position	GZ	AV1	85755	
GK1WL68 VVT	Manual Valve 1WL-68 Transfers Position	GZ	AV1	85755	
GK1WL69 VVT	Manual Valve 1WL-69 Transfers Position	GZ	AV1	85755	
GK1WL70 VVT	Manual Valve 1WL-70 Transfers Position	GZ	AV1	85755	
GK1WL71 VVT	Manual Valve 1WL-71 Transfers Position	GZ	AV1	85755	
GK1WL72 VVT	Manual Valve 1WL-72 Transfers Position	GZ	AV1	85755	
GK1WL73 VVT	Manual Valve 1WL-73 Transfers Position	GZ	AV1	85755	
GK1WL74 VVT	Manual Valve 1WL-74 Transfers Position	GZ	AV1	85755	
GK1WL75 VVT	Manual Valve 1WL-75 Transfers Position	GZ	AV1	85755	
GK1WL76 VVT	Manual Valve 1WL76 Transfers Position and Blocks Discharge Path	GZ	AV1	85755	
GK1WL78 VVT	Manual Valve 1WL78 Transfers Position and Blocks Discharge Path	GZ	AV1	85755	
GK2HPO6 VVT	Genrator Bearing Oil Leak Because Manual Valve 2HPO-6 Transfers Position	GZ	AV2	85657	
GK2WL16 VVT	Manual Valve 2WL-16 Transfers Position	GZ	AV2	85657	
GK2WL17 VVT	Manual Valve 2WL-17 Transfers Position	GZ	AV2	85657	
GK2WL18 VVT	Manual Valve 2WL18 Transfers Position	GZ	AV2	85657	
GK2WL19 VVT	Manual Valve 2WL19 Transfers Position	GZ	AV2	85657	
GK2WL20 VVT	Manual Valve 2WL-20 Transfers Position	GZ	AV2	85657	
GK2WL21 VVT	Manual Valve 2WL-21 Transfers Position	GZ	AV2	85657	
GK2WL22 VVT	Manual Valve 2WL22 Transfers Position	GZ	AV2	85657	
GK2WL23 VVT	Manual Valve 2WL23 Transfers Position	GZ	AV2	85657	
GK2WL24 VVT	Manual Valve 2WL-24 Transfers Position	GZ	AV2	85657	
GK2WL25 VVT	Manual Valve 2WL-25 Transfers Position	GZ	AV2	85657	
GK2WL26 VVT	Manual Valve 2WL26 Transfers Position	GZ	AV2	85657	
GK2WL27 VVT	Manual Valve 2WL27 Transfers Position	GZ	AV2	85657	

Basic Event	Description	Tree	Denom. Code	Denom. Value	**Totals**
GK2WL28 VVT	Manual Valve 2WL-28 Transfers Position	GZ	AV2	85657	
GK2WL29 VVT	Manual Valve 2WL-29 Transfers Position	GZ	AV2	85657	
GK2WL30 VVT	Manual Valve 2WL30 Transfers Position	GZ	AV2	85657	
GK2WL31 VVT	Manual Valve 2WL31 Transfers Position	GZ	AV2	85657	
GK2WL32 VVT	Manual Valve 2WL-32 Transfers Position	GZ	AV2	85657	
GK2WL33 VVT	Manual Valve 2WL-33 Transfers Position	GZ	AV2	85657	
GK2WL34 VVT	Manual Valve 2WL34 Transfers Position	GZ	AV2	85657	
GK2WL35 VVT	Manual Valve 2WL35 Transfers Position	GZ	AV2	85657	
GK2WL36 VVT	Manual Valve 2WL-36 Transfers Position	GZ	AV2	85657	
GK2WL37 VVT	Manual Valve 2WL-37 Transfers Position	GZ	AV2	85657	
GK2WL38 VVT	Manual Valve 2WL38 Transfers Position	GZ	AV2	85657	
GK2WL39 VVT	Manual Valve 2WL39 Transfers Position	GZ	AV2	85657	
GK2WL41 VVT	Keowee 2 Manual Valve 2WL-41 Transfers Position to Block Discharge Path	GZ	AV2	85657	
GK2WL44 VVT	Manual Valve 2WL-44 Transfers Position	GZ	AV2	85657	
GK2WL45 VVT	Manual Valve 2WL-45 Transfers Position	GZ	AV2	85657	
GK2WL46 VVT	Manual Valve 2WL-46 Transfers Position	GZ	AV2	85657	
GK2WL47 VVT	Manual Valve 2WL-47 Transfers Position	GZ	AV2	85657	
GK2WL48 VVT	Manual Valve 2WL-48 Transfers Position	GZ	AV2	85657	
GK2WL49 VVT	Manual Valve 2WL-49 Transfers Position	GZ	AV2	85657	
GK2WL50 VVT	Manual Valve 2WL-50 Transfers Position	GZ	AV2	85657	
GK2WL51 VVT	Manual Valve 2WL-51 Transfers Position	GZ	AV2	85657	
GK2WL52 VVT	Manual Valve 2WL-52 Transfers Position	GZ	AV2	85657	
GK2WL53 VVT	Manual Valve 2WL-53 Transfers Position	GZ	AV2	85657	
GK2WL54 VVT	Manual Valve 2WL-54 Transfers Position	GZ	AV2	85657	
GK2WL55 VVT	Manual Valve 2WL-55 Transfers Position	GZ	AV2	85657	
GK2WL56 VVT	Manual Valve 2WL-56 Transfers Position	GZ	AV2	85657	
GK2WL57 VVT	Manual Valve 2WL-57 Transfers Position	GZ	AV2	85657	
GK2WL58 VVT	Manual Valve 2WL-58 Transfers Position	GZ	AV2	85657	
GK2WL59 VVT	Manual Valve 2WL-59 Transfers Position	GZ	AV2	85657	
GK2WL60 VVT	Manual Valve 2WL-60 Transfers Position	GZ	AV2	85657	
GK2WL61 VVT	Manual Valve 2WL-61 Transfers Position	GZ	AV2	85657	
GK2WL62 VVT	Manual Valve 2WL-62 Transfers Position	GZ	AV2	85657	
GK2WL63 VVT	Manual Valve 2WL-63 Transfers Position	GZ	AV2	85657	
GK2WL64 VVT	Manual Valve 2WL-64 Transfers Position	GZ	AV2	85657	

Table C.1-3: Denominator Totals For Keowee-Specific Failure Rates

Basic Event	Description	Tree	Denom. Code	Denom. Value	Totals
GK2WL65 VVT	Manual Valve 2WL-65 Transfers Position	GZ	AV2	85657	
GK2WL66 VVT	Manual Valve 2WL-66 Transfers Position	GZ	AV2	85657	
GK2WL67 VVT	Manual Valve 2WL-67 Transfers Position	GZ	AV2	85657	
GK2WL68 VVT	Manual Valve 2WL-68 Transfers Position	GZ	AV2	85657	
GK2WL69 VVT	Manual Valve 2WL-69 Transfers Position	GZ	AV2	85657	
GK2WL70 VVT	Manual Valve 2WL-70 Transfers Position	GZ	AV2	85657	
GK2WL71 VVT	Manual Valve 2WL-71 Transfers Position	GZ	AV2	85657	
GK2WL72 VVT	Manual Valve 2WL-72 Transfers Position	GZ	AV2	85657	
GK2WL73 VVT	Manual Valve 2WL-73 Transfers Position	GZ	AV2	85657	
GK2WL74 VVT	Manual Valve 2WL-74 Transfers Position	GZ	AV2	85657	
GK2WL75 VVT	Manual Valve 2WL-75 Transfers Position	GZ	AV2	85657	
GK2WL76 VVT	Manual Valve 2WL76 Transfers Position and Blocks Discharge Path	GZ	AV2	85657	
GK2WL78 VVT	Manual Valve 2WL78 Transfers Position and Blocks Discharge Path	GZ	AV2	85657	
OK10009 VVT	Manual Valve 1OG-9 Transfers Closed	OZ	AV1	85755	
OK10012 VVT	Manual Globe Valve 1OG-12 Transfers Closed	OZ	AV1	85755	
OK10015 VVT	Manual Globe Valve 1OG-15 Transfers Closed	OZ	AV1	85755	
OK10018 VVT	Manual Globe Valve 1OG-18 Transfers Closed	OZ	AV1	85755	
OK1AG05 VVT	Manual Valve 1AG-5 Transfers Position	OZ	AV1	85755	
OK20009 VVT	Manual Valve 2OG-9 Transfers Closed	OZ	AV2	85657	
OK20012 VVT	Manual Globe Valve 2OG-12 Transfers Closed	OZ	AV2	85657	
OK20015 VVT	Manual Globe Valve 2OG-15 Transfers Closed	OZ	AV2	85657	
OK20018 VVT	Manual Globe Valve 2OG-18 Transfers Closed	OZ	AV2	85657	
OK2AG05 VVT	Manual Valve 2AG-5 Transfers Position	OZ	AV2	85657	
PK1TS01 VVT	Manual Valve 1TS-1 Transfers Position	PZ	AV1	85755	
PK1TS03 VVT	Manual Valve 1TS-3 Transfers Position	PZ	AV1	85755	
PK2TS01 VVT	Manual Valve 2TS-1 Transfers Position	PZ	AV2	85657	
PK2TS03 VVT	Manual Valve 2TS-3 Transfers Position	PZ	AV2	85657	**14484363**

Table C.1-3: Denominator Totals For Keowee-Specific Failure Rates

Table C.1-4: Keowee PRA Basic Event Factor Assignment Rules

Rule No.	Failure Symptoms	Effect on Keowee	Calc. Method	Exposure Time
1.	Statalarm in Control Room when Keowee is in the Standby Mode	Fails the unit run (Failures that fail the unit to start should not be included in the models)	Mission time for Keowee to run	24 hrs for both Unit 1 and Unit 2
2.	Indicated Either by Computer Printout or by Rounds	Fails the Unit Start	Half the Time Between Rounds	6 hrs for both Unit 1 and Unit 2
3.	Indicated either by computer printout or by rounds	Fails the unit start or run but applied to run failure basic event	Mission time for Keowee to run	24 hrs for both Unit 1 and Unit 2
4.	Indicated either by computer printout or by rounds	Fails the unit run but not a start	Half the time between rounds plus the mission time for Keowee to run	30 hrs for both Unit 1 and Unit 2
5.	Fails a unit start	Fails the unit to start	Half the time between normal starts	84 hrs for Unit 1, 12 hrs for Unit 2.
6.	Fails a unit run	Fails the unit to run but does not fail a start	Half the time between normal starts plus the unit mission time	108 hrs for Unit 1, 36 hrs for Unit 2
7.	Fails a monthly surveillance test	Fails the unit to start	Half the time between monthly surveillance tests	360 hrs for both Unit 1 and Unit 2
8.	Fails a unit start following a unit swap	Fails the unit to *emergency* start	Half the time between unit swaps	360 hrs for Unit 1
9.	Fails a unit run following a unit swap	Fails the unit to run but does not fail an *emergency* start	Half the time between unit swaps plus half the unit mission time	372 hrs for Unit 1

Table C.1-4: Keowee PRA Basic Event Factor Assignment Rules

Rule No.	Failure Symptoms	Effect on Keowee	Calc. Method	Exposure Time
10.	Fails a unit run following a unit swap	Fails the unit to run but does not fail an *emergency* start	Half the time between unit swaps plus the unit mission time	384 hrs for Unit 1
11.	Fails a quarterly surveillance test	Fails the unit to start	Half the time between quarterly surveillance tests	1092 hrs for both Unit 1 and Unit 2
12.	Fails a yearly surveillance test	Fails the unit to start	Half the time between yearly surveillance tests	4380 hrs for both Unit 1 and Unit 2

Table C.1-5: Keowee Type Code Data Bases

Component	Failure Mode	Type Code	Generic Failure Rate		Error Factor	Source	No. of Failures	Denominator	Plant-Specific Failure Rate	Bayesian-Updated Failure Rate	Error Factor
Air Operated Valve	Fails to Open on Demand	**AVO**	**2.20E-03**	/d	2.8	Davis-Besse IPE	0	6488	**3.51E-05**	**2.8E-04**	2.8
Air Operated Valve	Transfers Closed	**AVT**	**2.70E-06**	/hr	10	Davis-Besse IPE	0	9713	**2.34E-05**	**2.3E-06**	10.0
Battery Charger	Fails to Maintain Output	**BCF**	**1.10E-05**	/hr	4.9	Davis-Besse IPE	6	171412	**3.50E-05**	**2.9E-05**	1.9
Electric Bus (DC)	Fails	**BDF**	**6.10E-07**	/hr	5.2	Davis-Besse IPE	0	872212	**2.61E-07**	**3.2E-07**	5.2
Electric Bus (4 Kv or Higher AC)	Fails	**BHF**	**5.30E-07**	/hr	5.1	Davis-Besse IPE	0	350400	**6.49E-07**	**4.0E-07**	5.1
Electric Bus (600 Vac or Lower)	Fails	**BLF**	**3.60E-07**	/hr	6.4	Davis-Besse IPE	0	342824	**6.64E-07**	**2.7E-07**	6.4
Battery	Fails to Provide Output	**BYF**	**1.18E-03**	/d	7.8	Composite	0	60	**3.79E-03**	**9.3E-04**	7.8
Circuit Breaker (4 or 6.9 Kv AC)	Fails to Remain Closed	**C4T**	**1.90E-06**	/hr	5.7	Davis-Besse IPE	0	262800	**8.66E-07**	**9.4E-07**	5.7
Circuit Breaker (DC)	Spurious Operation	**CDT**	**1.90E-06**	/hr	5.7	Davis-Besse IPE	0	6250420	**3.64E-08**	**7.5E-08**	5.7
Circuit Breaker (PCB)	Fails to Close on Demand	**CHC**	**7.20E-05**	/d	10	IEEE 500, p. 115	1	2263	**4.42E-04**	**2.6E-04**	3.7
Human Error	Error of Commision	**CHE**	**N/A**	N/A	N/A	N/A	N/A		**N/A**	**N/A**	N/A
Circuit Breaker (PCB)	Fails to Open on Demand	**CHO**	**4.00E-05**	/d	10	IEEE 500, p. 115	0	2263	**1.01E-04**	**2.6E-05**	10.0
Circuit Breaker (PCB)	Spurious Operation	**CHT**	**3.00E-07**	/hr	10	IEEE 500, p. 115	2	615432	**3.25E-06**	**1.9E-06**	2.8
Circuit Breaker (Low Voltage AC)	Spurious Operation	**CLT**	**1.90E-06**	/hr	5.7	Davis-Besse IPE	1	1371296	**7.29E-07**	**9.1E-07**	3.3

Table C.1-5: Keowee Type Code Data Bases

Component	Failure Mode	Type Code	Generic Failure Rate		Error Factor	Source	No. of Failures	Denominator	Plant-Specific Failure Rate	Bayesian-Updated Failure Rate	Error Factor
Common Cause		COM	N/A	N/A	N/A	N/A	N/A		N/A	N/A	N/A
Check Valve	Fails to Close on Demand	CVC	9.70E-04	/d	5.2	Davis-Besse IPE	0	1040	2.19E-04	3.5E-04	5.2
Check Valve	Fails to Open on Demand	CVO	1.90E-04	/d	8.9	Davis-Besse IPE	0	87832	2.59E-06	2.3E-06	8.9
Check Valve	Fails to Remain Open	CVT	4.50E-07	/hr	20	Davis-Besse IPE	0	197774	1.15E-06	1.3E-07	20.0
Undeveloped Event		DEX	N/A	N/A	N/A	N/A	N/A		N/A	N/A	N/A
Human Error	Dynamic Human Error	DHE	N/A	N/A	N/A	N/A	N/A		N/A	N/A	N/A
Diode	Fails to Operate	DIF	1.22E-06	/hr	10	IEEE 500	1	175200	5.71E-06	3.8E-06	3.7
Battery	Unavailable Due to Maintenance or Testing	DYM	N/A	N/A	N/A	N/A	N/A		N/A	N/A	N/A
Filter or Strainer (Raw Water)	Plugs/fails to Deliver Flow	FRF	1.20E-05	/hr	6.6	Davis-Besse IPE	0	342824	6.64E-07	9.8E-07	6.6
Filter or Strainer (Oil)	Plugs/fails to Deliver Flow	FTC	1.20E-05	/hr	6.6	Davis-Besse IPE	0	171412	1.33E-06	1.8E-06	6.6
Electrical Fuse	Fails to Remain Closed	FUF	6.30E-07	/hr	9.4	Davis-Besse IPE	4	857060	4.67E-06	3.6E-06	2.1
Float Valve	Fails to Remain Open	FVT	Unavailable	/hr	N/A	N/A	1	171412	5.83E-06	N/A	N/A
Pump	Fails to Run	GPR	2.40E-05	/hr	3.2	Davis-Besse IPE	2	195632	1.02E-05	1.4E-05	2.3
Pump	Fails to Start on Demand	GPS	3.10E-03	/d	3.2	Davis-Besse IPE	7	87784	7.97E-05	9.7E-05	1.7

Table C.1-5: Keowee Type Code Data Bases

Component	Failure Mode	Type Code	Generic Failure Rate		Error Factor	Source	No. of Failures	Denominator	Plant-Specific Failure Rate	Bayesian-Updated Failure Rate	Error Factor
Hydro-Electric Generator	Fails to Run	**HGR**	**N/A**	/hr	N/A	N/A	1	10570	**9.46E-05**	**N/A**	N/A
Hydro-Electric Generator	Fails to Start	**HGS**	**N/A**	/d	N/A	N/A	1	6488	**1.54E-04**	**N/A**	N/A
Heat Exchanger	Fails to Transfer Heat	**HXF**	**3.40E-06**	/hr	8.2	Davis-Besse IPE	0	307394	**7.40E-07**	**6.4E-07**	8.2
Heat Exchanger	External Leak	**HXL**	**3.00E-07**	/hr	10	EGG-SRE-8875	0	1028472	**2.21E-07**	**1.0E-07**	10
Keowee Station	Out of Service for Maintenance or Testing	**HYM**	**N/A**	N/A	N/A	N/A	N/A		**N/A**	**N/A**	N/A
Human Error	Latent (Pre-initiator) Human Error	**LHE**	**N/A**	N/A	N/A	N/A	N/A		**N/A**	**N/A**	N/A
Switch (Level)	Fails to Operate on Demand	**LSD**	**1.60E-03**	/d	4.3	Davis-Besse IPE	0		**Inadequate Info.**	**N/A**	N/A
Switch (Level)	Spurious Operation	**LST**	**2.30E-06**	/hr	8	Davis-Besse IPE	0	707552	**3.22E-07**	**3.1E-07**	8.0
Switch (Push Button)	Spurious Operation	**PBT**	**1.00E-06**	/hr	10	EGG-SRE-8875	0	518664	**4.39E-07**	**2.4E-07**	10.0
Switch (Pressure)	Fails to Close on Demand	**PSC**	**2.60E-04**	/d	8.1	Davis-Besse IPE	0	85722	**2.65E-06**	**2.9E-06**	8.1
Switch (Pressure)	Spurious Operation	**PST**	**8.50E-07**	/hr	4.6	Davis-Besse IPE	0	857060	**2.65E-07**	**4.3E-07**	4.6
Relay (MG6)	Fails to Operate on Demand	**R6D**	**N/A**	/d	N/A	N/A	5	20089	**2.49E-04**	**N/A**	N/A
Relay (MG6)	Spurious Operation	**R6T**	**N/A**	/hr	N/A	N/A	0	1378774	**1.65E-07**	**N/A**	N/A

Table C.1-5: Keowee Type Code Data Bases

Component	Failure Mode	Type Code	Generic Failure Rate		Error Factor	Source	No. of Failures	Denominator	Plant-Specific Failure Rate	Bayesian-Updated Failure Rate	Error Factor
Human Error	Failure to Recover	**RHE**	**N/A**	N/A	N/A	N/A	N/A		**N/A**	**N/A**	N/A
Relief Valve	Spurious Operation	**RVT**	**1.70E-06**	/hr	4.2	Davis-Besse IPE	3	177124	**1.69E-05**	**5.6E-06**	2.2
Relay	Fails to Operate on Demand	**RYD**	**1.90E-04**	/d	9	Davis-Besse IPE	4	126969	**3.15E-05**	**3.3E-05**	2.1
Relay	Spurious Operation	**RYT**	**1.00E-06**	/hr	5	Davis-Besse IPE	3	9354504	**3.21E-07**	**3.6E-07**	2.3
Switch (Speed)	Fails on Demand	**SSD**	**2.50E-04**	/d	6.4	Davis-Besse IPE	0	19464	**1.17E-05**	**1.8E-05**	6.4
Switch (Speed)	Spurious Operation	**SST**	**1.00E-06**	/hr	10	EGG-SRE-8875	1	114796	**8.71E-06**	**4.2E-06**	3.7
Solenoid Valve	Fails to Open on Demand	**SVO**	**2.80E-03**	/d	7.5	Davis-Besse IPE	0	9769	**2.33E-05**	**2.9E-05**	7.5
Solenoid Valve	Spurious Operation	**SVT**	**4.10E-07**	/hr	3	Davis-Besse IPE	0	257069	**8.85E-07**	**3.9E-07**	3.0
Switch	Fails to Close on Demand	**SWC**	**1.00E-05**	/d	5	EGG-SRE-8875	0	61	**3.73E-03**	**1.0E-05**	5.0
Switch	Spurious Operation	**SWT**	**1.00E-06**	/hr	10	EGG-SRE-8875	0	2166121	**1.05E-07**	**7.0E-08**	10.0
Transformer(Excitation)	Fails to Maintain Power	**TGF**	**2.00E-06**	/hr	7	Davis-Besse IPE	0	171412	**1.33E-06**	**9.8E-07**	7.0
Transformer (High Voltage)	Fails to Maintain Power	**THF**	**2.00E-06**	/hr	7	Davis-Besse IPE	1	262800	**3.81E-06**	**3.1E-06**	3.4
Transformer (High Voltage)	Unavailable Due to Maintenance or Testing	**THM**	**N/A**	N/A	N/A	N/A	N/A		**N/A**	**N/A**	N/A
Tank	Fails to Maintain Pressure	**TKF**	**7.50E-07**	/hr	6.3	Davis-Besse IPE	0	342824	**6.64E-07**	**4.6E-07**	6.3

Table C.1-5: Keowee Type Code Data Bases

Component	Failure Mode	Type Code	Generic Failure Rate		Error Factor	Source	No. of Failures	Denominator	Plant-Specific Failure Rate	Bayesian-Updated Failure Rate	Error Factor
Transformer (Low Voltage)	Fails to Maintain Power	**TLF**	**2.00E-06**	/hr	7	Davis-Besse IPE	0	272513	**8.35E-07**	**7.5E-07**	7.0
System Train	Unavailable Due to Maintenance or Testing	**TRM**	**N/A**	N/A	N/A	N/A	N/A		**N/A**	**N/A**	N/A
Manual Valve	Transfers Position	**VVT**	**8.00E-08**	/hr	7.3	Davis-Besse IPE	0	14484363	**1.57E-08**	**1.7E-08**	7.3

Table C.1-6: Keowee PRA Train And Component Maintenance / Testing Events

Basic Event	Description	Unavailable Hrs.[1]	Source	Calculation (Unavailable Hrs. / Period Hrs.)	Unavailability
BK1GODCTRM	Unit 1 DC Turbine GBO Pump Train In Maintenance.	5 hrs. / pump / yr. for Annual Maint.	Keowee Station Personnel	(2 x 5) / 8760	1.14E-03
BK2GODCTRM	Unit 2 DC Turbine GBO Pump Train In Maintenance.	5 hrs. / pump / yr. for Annual Maint.	Keowee Station Personnel	(2 x 5) / 8760	1.14E-03
DDC1ALXBWM	Switchyard Battery Number 1 Is In Maintenance Or Test.	(72.0 - 120.0) hrs. / Battery / yr. for Annual Maint.	Keowee Battery Maint. Personnel	100 / 8760	1.14E-02
OK1OG1CTRM	OG Pump 1C Train In Maintenance Or Testing.	10 hrs. / pump / yr. for Annual Maint.	Keowee Station Personnel	(3 x 10) / 8760	3.42E-03
OK2OG2CTRM	OG Pump 2C Train In Maintenance Or Testing.	10 hrs. / pump / yr. for Annual Maint.	Keowee Station Personnel	(3 x 10) / 8760	3.42E-03
PK1TSDCTRM	Turbine No. 1 DC Pump Train In Maintenance Or Testing.	3 hrs. / pump / yr. for Annual Maint.	Keowee Station Personnel	(2 x 3) / 8760	6.85E-04
PK2TSDCTRM	Turbine No. 2 DC Pump Train In Maintenance Or Testing.	3 hrs. / pump / yr. for Annual Maint.	Keowee Station Personnel	(2 x 3) / 8760	6.85E-04
SXFRCT3THM	Transformer CT3 Is In Maintenance.		Oconee PRA		1.74E-04

Table C.1-6: Keowee PRA Train And Component Maintenance / Testing Events

Basic Event	Description	Unavailable Hrs.	Source	Calculation (Unavailable Hrs. / Period Hrs.)	Unavailability
SXFRCT4THM	Transformer CT4 Is In Maintenance.	24.0 hrs. / 3 yr. PM or 8.0 hrs / yr.	Oconee Swyd. Maint. Personnel	8 / 8760	9.13E-04
XA1XCXXTHM	Transformer CX Is In Maintenance.	12.0 hrs. / 3 yr. PM or 4.0 hrs / yr.	Oconee Swyd. Maint. Personnel	4 / 8760	4.57E-04
XD1DALTBYM	Normal Power To Dist. Center 1DA Is In Test and Maintenance (Keowee Battery Maintenance).	48 hrs. / Battery / yr. for Annual Maint.	Keowee Station Personnel	48 / 8760	5.48E-03
XD2DALTBYM	Normal Power To Dist. Center 2DA Is In Test and Maintenance (Keowee Battery Maintenance).	48 hrs. / Battery / yr. for Annual Maint.	Keowee Station Personnel	48 / 8760	5.48E-03

[1]Unavailability is placed on one train or component but includes maintenance unavailability for all trains or components.

Table C.1-7: Keowee PRA Undeveloped Events

Basic Event	Description	Failure Probability	Appendix Reference
AB1ACCUDEX	Air Circuit Breaker 1 Accumulator Air Pressure Low	3.51E-05	A.4
AB1FALTDEX	Fault Occurs at ACB-1 When The Breaker Trips	0.00E+00	A.4
AB1MECHDEX	Air Circuit Breaker 1 Fails To Open Due To Mechanical Failure	1.51E-04	A.4
AB2ACCUDEX	Air Circuit Breaker 2 Accumulator Air Pressure Low	3.51E-05	A.4
AB2MCH2DEX	Air Circuit Breaker 2 Fails To Close Due To Mechanical Failure	3.02E-04	A.4
AB2MECHDEX	Air Circuit Breaker 2 Fails To Open Due To Mechanical Failure	1.51E-04	A.4
AB3ACCUDEX	Air Circuit Breaker 3 Accumulator Air Pressure Low	3.51E-05	A.4
AB3MCH2DEX	Air Circuit Breaker 3 Fails To Close Due To Mechanical Failure	3.02E-04	A.4
AB3MECHDEX	Air Circuit Breaker 3 Fails To Open Due To Mechanical Failure	1.51E-04	A.4
AB4ACCUDEX	Air Circuit Breaker 4 Accumulator Air Pressure Low	3.51E-05	A.4
AB4MCH2DEX	Air Circuit Breaker 4 Fails To Close Due To Mechanical Failure	3.02E-04	A.4
AB5MCH2DEX	Air Circuit Breaker 5 Fails To Close Due To Mechanical Failure	7.04E-03	A.4
AB6MCH2DEX	Air Circuit Breaker 6 Fails To Close Due To Mechanical Failure	7.04E-03	A.4
AB6MECHDEX	Air Circuit Breaker 6 Fails To Open Due To Mechanical Failure	8.01E-04	A.4
AB7MCH2DEX	Air Circuit Breaker 7 Fails To Close Due To Mechanical Failure	7.04E-03	A.4
AB7MECHDEX	Air Circuit Breaker 7 Fails To Open Due To Mechanical Failure	8.01E-04	A.4
AB8MCH2DEX	Air Circuit Breaker 8 Fails To Close Due To Mechanical Failure	7.04E-03	A.4
ACBAIRPDEX	ACB Air Supply Fails Causing Low Pressure In All ACB Accumulators	2.00E-03	A.4
AK114GVDEX	KU1 Magnetic Speed Switch System Fails	1.00E-04	A.4
AK214GVDEX	KU2 Magnetic Speed Switch System Fails	1.00E-04	A.4
AK2GATEDEX	Wicket Gate Limit Switch Indicates Gate Position Is Below No-load Setting	2.11E-05	A.4
D1DIAXXDEX	Loss Of Power On 125 V dc Panelboard 1DIA	6.50E-06	A.5
D1DIBXXDEX	Loss Of Power On 125 V dc Panelboard 1DIB	6.50E-06	A.5

Table C.1-7: Keowee PRA Undeveloped Events

Basic Event	Description	Failure Probability	Appendix Reference
D2DIAXXDEX	Loss Of Power On 125 V dc Panelboard 2DIA	6.50E-06	A.5
D2DIBXXDEX	Loss of Power on 125 V dc Panelboard 2DIB	6.50E-06	A.5
D3DIAXXDEX	Loss Of Power On 125 V dc Panelboard 3DIA	6.50E-06	A.5
D3DIBXXDEX	Loss Of Power On 125 Vdc Panelboard 3DIB	6.50E-06	A.5
EK1BAS2DEX	KHU-1 Base Adjust Fails To Maintain Generator Output Within Acceptable Range	1.24E-03	A.6
EK1BASEDEX	Keowee Unit 1 Base Adjust Fails To Establish Correct Unit Voltage	6.17E-04	A.6
EK1DIODDEX	Keowee Unit 1 Exciter Fan Supply Diode Bridge Fails	2.88E-04	A.6
EK1FLDMDEX	Keowee Unit 1 Field Breaker Fails To Close Due To Mechanical Failure	7.71E-05	A.6
EK1FLSMDEX	Keowee Unit 1 Field Flashing Breaker Fails To Close Due To Mechanical Failure	7.71E-05	A.6
EK1SPYMDEX	Keowee Unit 1 Supply Breaker Fails To Close Due To Mehanical Failure	4.62E-04	A.6
EK1VREGDEX	KHU-1 Voltage Adjust Failure Drives Generator Output Too High/Low	2.47E-03	A.6
EK2BAS2DEX	KHU-2 Base Adjust Fails To Maintain Generator Output Within Acceptable Range	1.24E-03	A.6
EK2BASEDEX	Keowee Unit 2 Base Adjust Fails To Establish Correct Unit Voltage	6.17E-04	A.6
EK2DIODDEX	Keowee Unit 2 Exciter Fan Supply Diode Bridge Fails	2.88E-04	A.6
EK2FLDMDEX	Keowee Unit 2 Field Breaker Fails To Close Due To Mechanical Failure	7.71E-05	A.6
EK2FLSMDEX	Keowee Unit 2 Field Flashing Breaker Fails To Close Due To Mechanical Failure	7.71E-05	A.6
EK2SPYMDEX	Keowee Unit 2 Supply Breaker Fails To Close Due To Mehanical Failure	4.62E-04	A.6
EK2VREGDEX	KHU-2 Voltage Adjust Failure Drives Generator Output Too High/Low	2.47E-03	A.6
GK1FIREDEX	Spurious Actuation of Unit 1 Gen. CO2 Fire Supression System	3.19E-05	A.7
GK2FIREDEX	Spurious Actuation of Unit 2 Gen. CO2 Fire Supression System	7.00E-05	A.7
K12COM1DEX	Grid Degradation Occurs And Causes Failure Of Both Keowee Units	1.00E-06	A.1

Table C.1-7: Keowee PRA Undeveloped Events

Basic Event	Description	Failure Probability	Appendix Reference
KB4CONNDEX	Air Circuit Breaker 4 Connects Unit 2 To The Underground Path	1.10E-07	A.1
KK1BOTHDEX	Keowee Units 1 And 2 Are Supplying The Grid	0.00E+00	A.1
KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid	0.00E+00	A.1
KK2RUNSDEX	Keowee Unit 2 Only Is Supplying The Grid	6.00E-02	A.1
OFACTORDEX	Overload Susceptibility Factor	1.00E+00	A.9
PK1PACKDEX	Turbine No. 1 Packing Fails	3.10E-05	A.13
PK2PACKDEX	Turbine No. 2 Packing Fails	3.10E-05	A.13
WK1GVCDDEX	Keowee Unit 1 Gov. Fails to Position Wicket Gates During a Cold Start	3.50E-05	A.10
WK1GVHTDEX	Keowee Unit 1 Gov. Fails to Position Wicket Gates During Hot Start	3.50E-04	A.10
WK1GVRNDEX	Keowee Unit 1 Gov. Fails to Position Wicket Gates With Unit Running	5.60E-04	A.10
WK1SPD1DEX	Potentially Damaging Overspeed Condition Occures At Load Rejection	1.00E+00	A.10
WK1SPD2DEX	Keowee Unit 1 Governor Failure Creates Overspeed Condition	5.60E-05	A.10
WK1TBCDDEX	Keowee Unit 1 Turbine Fails During a Cold Start	3.50E-05	A.10
WK1TBHTDEX	Keowee Unit 1 Turbine Fails During a Hot Start	3.50E-04	A.10
WK1TBRNDEX	Keowee Unit 1 Turbine Fails With the Unit Running	5.60E-04	A.10
WK2GVCDDEX	Keowee Unit 2 Gov. Fails to Position Wicket Gates During Cold Start	3.50E-05	A.10
WK2GVHTDEX	Keowee Unit 2 Gov. Fails to Position Wicket Gates During Hot Start	3.50E-04	A.10
WK2GVRNDEX	Keowee Unit 2 Gov. Fails to Position Wicket Gates With Unit Running	5.60E-04	A.10
WK2SPD2DEX	Keowee Unit 2 Governor Failure Creates Overspeed Condition	5.60E-05	A.10
WK2TBCDDEX	Keowee Unit 2 Turbine Fails During a Cold Start	3.50E-05	A.10
WK2TBHTDEX	Keowee Unit 2 Turbine Fails During a Hot Start	3.50E-04	A.10
WK2TBRNDEX	Keowee Unit 2 Turbine Fails With the Unit Running	5.60E-04	A.10
YK186N1DEX	Keowee 1 Normal Lockout Actuates	9.89E-03	A.5
YK286N2DEX	Keowee Unit 2 Normal Lockout Activates	7.41E-03	A.5

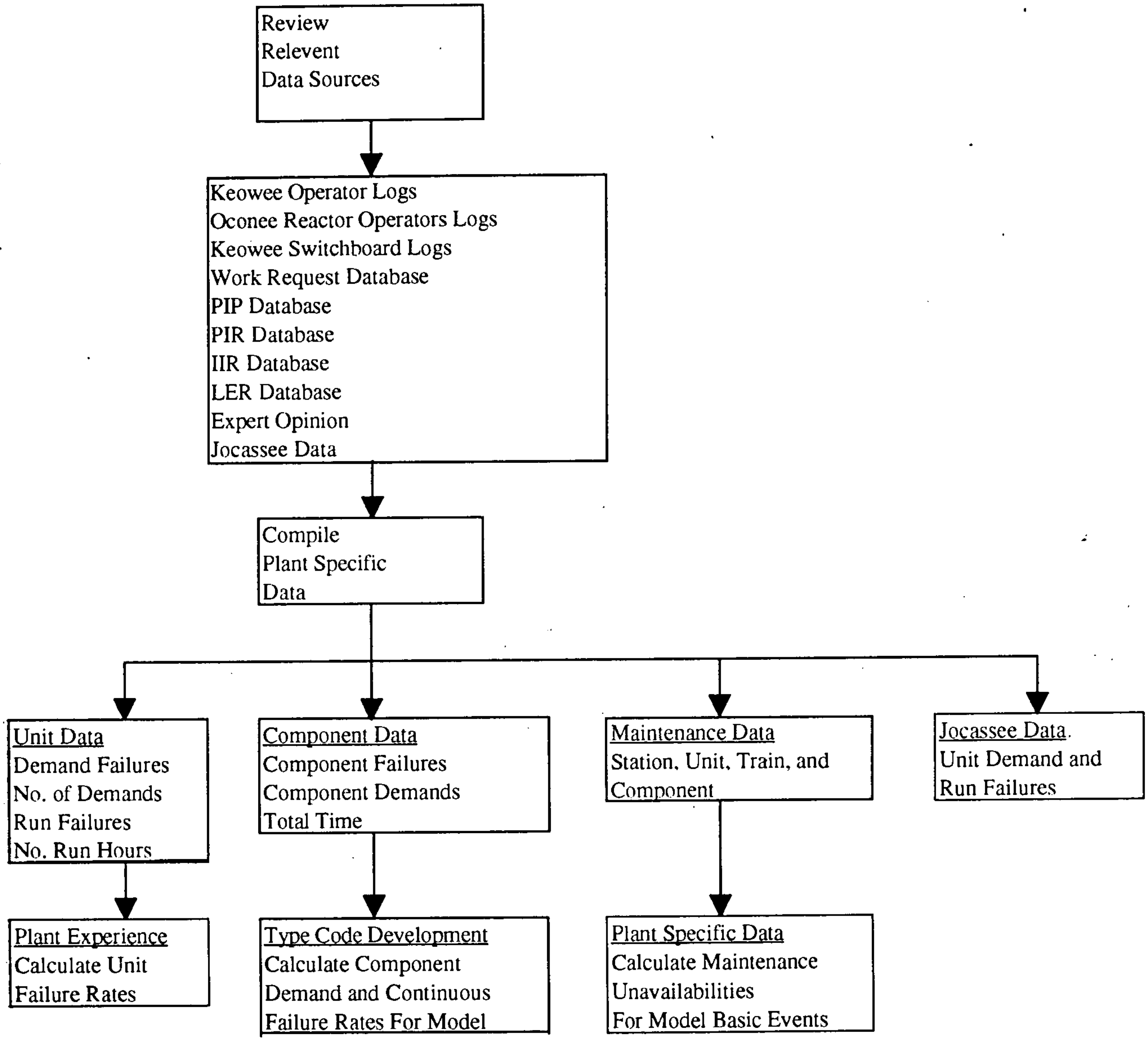

Figure C.1-1: Keowee PRA Data Collection Process Flowchart

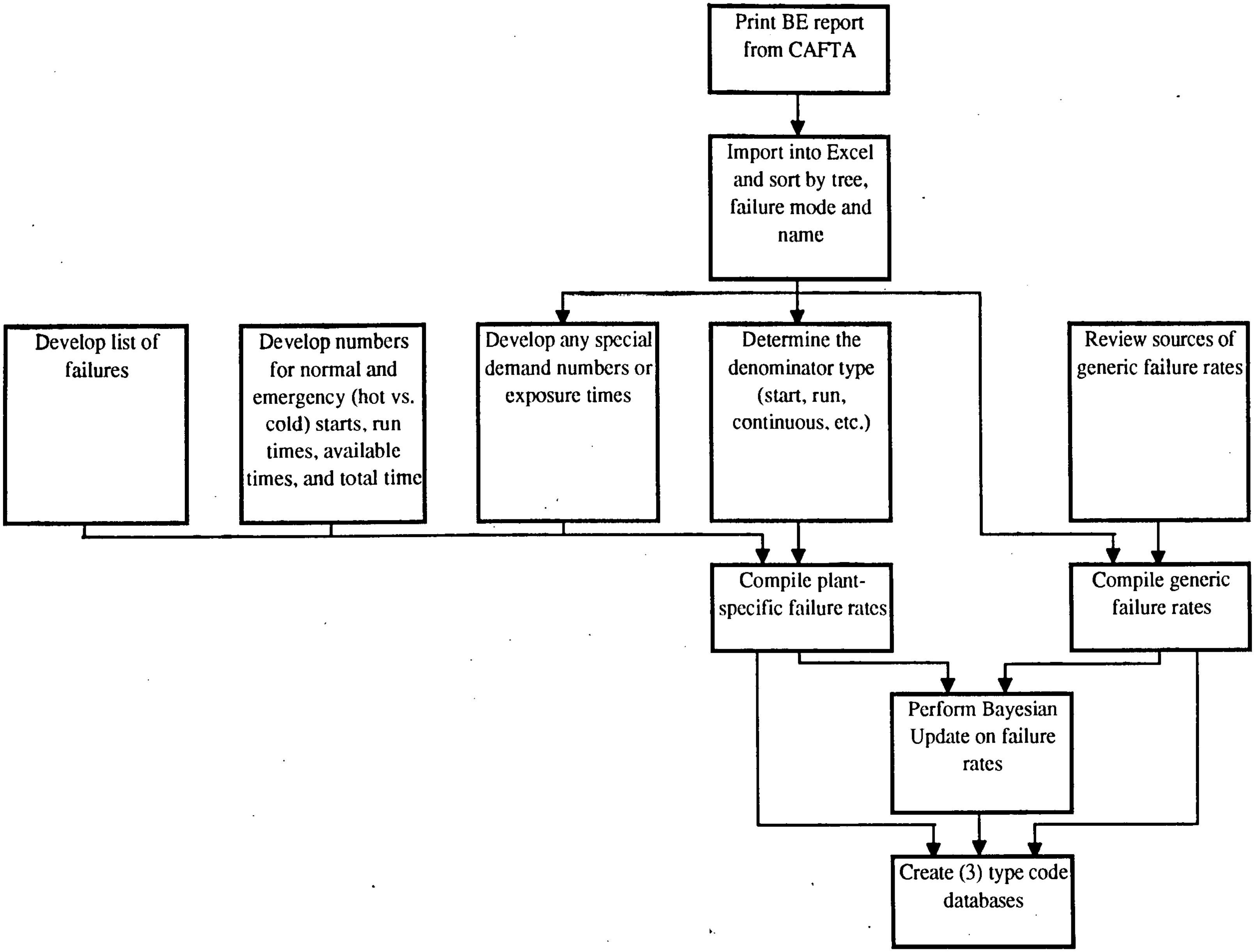

Figure C.1-2: Keowee PRA Type Code Development Flowchart

APPENDIX C.2
COMMON CAUSE ASSESSMENT

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C.2 COMMON CAUSE ASSESSMENT

C.2.1 INTRODUCTION

Common cause failure mechanisms are an important aspect of a probabilistic safety study that have been recognized in many PRA studies to be major contributors to plant risk and system unavailability. A common cause failure event is an event resulting in multiple failures of a specified set of (usually similar) components due to a shared cause. This section describes the process used to assess the impact of potential common cause failure events on Keowee reliability.

In recent years, the NRC and nuclear utilities have spent a great deal of effort collecting data and developing modeling techniques for the treatment of common cause events. This research has lead to the development of suggested procedures and appropriate methods and techniques to perform a common cause failure analysis. These procedures provide a framework to evaluate potential events and use industry data to calculate common cause event probabilities. When adequate data is available, these methods and values are preferred over the use of generic common cause parameters. Using these methods, actual Keowee operating data and industry data were used to the greatest extent possible to quantify potential Keowee common cause events.

C.2.2 ASSESSMENT PROCESS

C.2.2.1 OVERVIEW

The assessment process used is based heavily on the guidance of NUREG/CR-4780 (Reference 1) that suggests a procedural framework to perform a common cause assessment. However, a number of enhancements and simplifications were made to tailor this process to the Keowee project. NUREG/CR-5801 (Reference 3) provides some of the basis for these enhancements. Figure C.2-1 provides a graphical representation of the process used to assess common cause events for the Keowee study.

The assessment process began with a general familiarization of the system design and operation. The next step of problem definition and logic model development was important in the determination of the level of common cause event modeling and

development of preliminary common cause basic events. These steps were performed concurrently with other Keowee analysis tasks at the beginning of the project.

In parallel with logic model development activities for the Keowee systems, a thorough review of the Keowee Operating History was performed along with a qualitative common cause failure analysis. Industry experience was also examined by reviewing EPRI Report TR-100382 (Reference 4) which provides information on actual events in recent years. These activities were used in conjunction with the system logic models to define appropriate common cause basic events and to develop a database of plant specific events for estimating parameters of the common cause probability models.

The qualitative analysis attempted to identify potential common cause failure mechanisms and the coupling mechanisms which could lead to the failure of redundant components and systems. Functional, spatial, and human coupling mechanisms were considered for the Keowee systems. Keowee defensive strategies were examined for their ability to detect and prevent root cause failure mechanisms.

Due to the limited scope of the Keowee study, a formal quantitative screening was not necessary. It is recognized however that common cause basic events that are less than 1E-06 will not be significant contributors to Keowee unavailability. A peer review was performed to assess the appropriateness of the preliminary common cause basic events before final quantification.

The CCDAT program was used to automate the data classification and screening process, and the parameter estimation process (Reference 5). This program was used to classify and screen Keowee specific operating events and applicable industry data into a Keowee specific alignment database. Using the Keowee database, a final quantification of the applicable common cause basic events was performed for the Multiple Greek Letter (MGL) quantification model. Some events were quantified using other data sources such as Reference 10, or were quantified using generic common cause MGL parameters. The MGL parameters were used to calculate common cause multipliers for each basic event. These common cause basic event probabilities were computed by calculating an independent failure probability for a single component or train of equipment and multiplying it with the common cause multiplier. The basic event probabilities were then input into the Keowee system logic model for the final model solution.

The results of the final system solution were evaluated and a sensitivity analysis of various model parameters performed. Common cause event probabilities were adjusted accordingly when parameters such as component failure rates, operating configurations, or test and maintenance frequencies were changed for sensitivity analysis.

The results of this assessment are discussed in section C.2.5 and in section 7.0 of the overall study results.

C.2.2.2 OPERATING HISTORY REVIEW

A detailed review of the Keowee operating data was performed for the years 1980 - 1993. This data period is 4 years longer than the data period for other Keowee component failure data. This period was chosen to capture possibly rare common cause events that might not be included in the 10 year data period. The information reviewed included Licensee Event Reports, Plant Problem Investigation Reports (PIPs, PIRs, IIRs), and Keowee operator log entries. The Oconee IPE documentation files also provided additional information on events occurring during the period 1980 - 1987.

Table C.2-1 contains a list of events identified during this review with potential common cause implications. Four events were classified as actual failure events and used later in the data analysis. The other events were screened from the data analysis because they were not actual failures (only postulated failures in LERs), did not actually fail or degrade multiple components, or because the problem was no longer relevant.

Two of the LER events reported potential common mode failures that require special treatment because they entail special combinations of independent failures under specific operating conditions. The common cause mechanism arises from the potential to have both of the Keowee units connected to the same path unsynchronized, and subsequently damage both generators. These events were explicitly modeled in the high level tree accounting for each of the operating conditions and independent failures necessary to trigger the event.

Industry data was also reviewed for pertinent information on emergency power systems and components that may be similar to those at Keowee. Reference 4 provides a listing and description of common cause events in recent years including events involving diesel generators and circuit breakers. None of the diesel generator events were judged to be applicable to the Keowee analysis. The data on circuit breakers was judged to be

applicable and was used for Keowee basic event quantification (See section C.2.2.5.1 on Data Classification and Analysis).

References 8 and 9 were also reviewed for insights on common cause events in the industry. The focus of these reports is on the effectiveness of various defensive strategies to prevent common cause failures. Since their focus was not on event quantification, the events compiled in these reports were not suitable for further data analysis. The reports' conclusions do, however, provide additional background information for assessing certain Keowee defensive strategies.

C.2.2.3 QUALITATIVE ANALYSIS

C.2.2.3.1 Qualitative Procedure

A qualitative analysis examines the root causes of component failures, the degree of similarity and dependence between redundant components, and the defensive mechanisms that can prevent multiple failures. This examination determines qualitatively the perceived coupling strength, operational impact, effectiveness of defensive strategies, for particular components and specific failure modes. A Keowee qualitative analysis was performed to provide part of the basis for the selection of common cause component groups as well as to provide insight into possible improvements in common cause defensive tactics. An overview of this is provided below. A more detailed description of the qualitative analysis procedure and results is contained in the project files.

The method used to perform this analysis is a 5 step process based in large part on a generic cause approach (Reference 1 & 2). This approach calls for the identification of a wide range of postulated causes of CCF events that are systematically reviewed and screened according to their importance and relevance to the Keowee systems. In addition, each component/failure mode combination is reviewed for the effectiveness of defensive mechanisms to detect and prevent multiple failures. An outline of this modified qualitative analysis procedure is provided below.

Step 1 - Identifying important root causes of component failures and defining the groups of components that are susceptible to each root cause of failure. Table C.2-2 provides a list of generic root cause considered for mechanical and electrical systems and components. Table C.2-3 provides

a list of component groups for which these generic root causes were qualitatively evaluated.

Step 2 - Perform a screening on each root cause and component group combination and eliminate those combinations that are unlikely to lead to system failures or are determined to be unimportant when compared to other failures for the system.

Step 3 - Perform a screening on each harsh environment-related combination to determine if there is a root cause event that can trigger the scenario.

Step 4 - Determine the component minimal cut sets that are involved in each root cause and component group combination retained for analysis and eliminate scenarios that are not credible or not relevant.

Step 5 - Review effectiveness of defensive tactics in detecting or preventing CCF events and eliminate scenarios that are unlikely due to strong defensive measures.

The defensive measures considered in this analysis were barriers, personnel training, quality control, preventive maintenance, surveillance testing and inspection, procedural and administrative controls, design margins, and diversity. NUREG/CR-5460 (Reference 7) was used as a reference for the applicability and effectiveness of CCF defensive tactics to various common cause failure modes. References 8 and 9 provide additional insights on the effectiveness of certain defensive strategies to prevent common cause failures.

C.2.2.3.1 Qualitative Results

The qualitative analysis has two results that are passed on to the system modeling and common cause quantification stages. First, combinations of components and failure modes that were not screened out were considered for common cause basic events. Second, in the quantification of basic events, the relative strength of coupling mechanisms and defensive mechanisms was used to calculate or select MGL parameters. Table C.2-4 denotes which events were considered "strongly defended" in the quantification process.

In general, most of the Keowee defensive strategies are considered to be similar to other nuclear facilities in their effectiveness at detecting and preventing common cause failures. However, the areas of periodic testing and design margin are thought to be

substantially better than an average plant for many failure modes. Recent improvements in administrative controls, procedure development, and personnel training are believed to have adequately addressed previous deficiencies in these areas. Therefore, defensive strategies such as procedural and administrative controls and personnel training are now considered to be similar in effectiveness as the same strategies at other nuclear facilities.

Typically one of the Keowee units is started at least once per day for system generation. Unit operation in this mode provides a full functional check of most of the Keowee systems and components. This has a defensive effect similar to frequent testing and staggered testing. As both units rotate duties of system generation, the length of exposure to common cause errors on both units is very small.

Another important Keowee defense is design margin. Because Keowee was designed for system generation loads, many components are "over-designed" for handling emergency loads. For example, the Keowee generator is rated at 87.5 MVA, however, emergency loads are limited to 30 MVA on the overhead path (CT3) and to 22.4 MVA on the underground path (CT4). It would be expected that emergency operation would also be less demanding on generator cooling and other cooling systems.

C.2.2.4 COMMON CAUSE MODELING

One of the important steps in this assessment was choosing an appropriate level to model common cause events. In a typical plant level PRA analysis, there are several different safety functions to be accomplished and many front-line and support systems needed to mitigate an accident. These common cause events are typically treated on a "system level" or by major components. For example, a diesel generator fault tree might be modeled with a CCF to start, CCF to run, and a CCF of cooling water valves to open. Individual diesel sub-systems and sub-components are not all treated individually for common cause. All common cause failure events for a given component found in historical data are usually lumped together to estimate the "system level" common cause failure probability.

It would be perfectly valid to model Keowee similarly on a "system level" also. In this case, the term "system level" is meant to imply that the entire Keowee plant could be modeled as a two train system. Common cause failure of Keowee was treated this way in the Oconee IPE (Reference 6). One drawback to this approach is that insights are

primarily based on a few events in the historical data and do not reflect potential vulnerabilities to other common cause failure modes. To overcome this limitation, common cause modeling can be moved "down" to the sub-system and component level. Modeling at this level requires additional effort to determine the appropriate basic events, collect data, and quantify values.

Because of the perceived importance of common cause failure modes on Keowee reliability, the Keowee project team decided to perform a component level assessment to gain as much insight as possible into potential Keowee common cause events. Modeling of common cause events at this level permits the examination of coupling and defensive mechanisms and allows credit for operator recovery of certain common cause failure modes. One drawback of component level modeling is the limited availability of generic or plant specific common cause failure data.

Another modeling concern identified during the selection of common cause basic events was the potential for important "single unit" common cause failures. These failures affect redundant components on only one unit. The governor oil pumps, turbine sump pumps, and auxiliary power breakers were identified as systems with potential "single unit" common cause failures.

Also, the auxiliary power breakers have the potential for common cause failure of ACBs 5 & 6, or ACBs 7 & 8. Either of these combinations of breaker failures will not fail unit operation by themselves. However, a common cause failure of ACBs 7 & 8 would be important in sequences involving loss of power to the main transformer, because these breakers are needed for the underground 4160V power supply. The same is true for ACBs 5 & 6 if the underground power supply is unavailable, and auxiliary power is needed from the overhead path. These special combinations of common cause breakers were modeled for the Auxiliary Power System.

Common cause component failures which affect the switchyard or either power path were also considered. No important dependencies or coupling mechanisms were found between the overhead and underground paths. However, several common cause events that would only affect the switchyard and overhead path were included in the model.

During the review process another common cause event was identified for the Standby Bus Undervoltage Relays. Common cause events SU127UVCOM, SU227UVCOM, and

SU327UVCOM were added to represent common cause relay failures which could cause failure of the overhead path to the Standby Bus.

C.2.2.5 QUANTIFICATION OF COMMON CAUSE BASIC EVENTS

A list of common cause basic events was developed using the component groups identified in the qualitative analysis, the review of Keowee operating history, and the system fault trees developed for the Keowee systems. Each component which survived the qualitative screening analysis was assigned to at least one basic event. Potential events which did not survive the screening were considered unimportant relative to those which passed. The operating history review and fault tree review provided a reference to see that events considered were reasonable and consistent with the rest of the Keowee reliability model.

Multiple events were modeled for systems if different combinations of failures within the group could affect both units or only a single unit. Separate basic events were also modeled for component start and run failures if they were applicable. Table C.2-4 provides a listing of all common cause basic events used in the Keowee model and the results of the event quantification.

The Multiple Greek Letter (MGL) quantification model was chosen based on widespread familiarity among PRA analysts and the availability of "generic beta factors" in the literature. Wherever possible, Keowee specific, and industry data were used to quantify an event. For those events in which no common cause data was available, generic common cause parameters were applied according to the perceived strength of coupling mechanisms and the effectiveness of Keowee defensive tactics. Treatment of these events is discussed in section C.2.2.5.2.

The Keowee event FK0FISHCOM, however, required a quantification method different from the MGL model. The treatment of this event is described in section C.2.2.5.3.

The MGL parameters generated were used to compute a common cause multiplier for each common cause basic event based on the redundancy of the component group and the number of failures of interest for that event. A summary of the equations for calculating the common cause multiplier is given in Table C.2-5.

The common cause basic event probability is obtained by multiplying the independent failure probability of a single component (or single train of equipment) with the common cause multiplier. The independent failure probability was generally taken as the sum of all random failures from the system fault trees that failed the function provided by the component group. This probability was usually determined by solving the system fault tree at an intermediate gate that specifically represented failure of the component or system of interest.

Some of the events in Table C.2-4 are referred to as "combination events." These basic events represent a failure of multiple subsystems or multiple groups of sub-components which have different levels of redundancy or different MGL parameters for each sub-group. In these cases, the event probability is the summation of the probability of each sub-group. For example, common cause failure of the Keowee Start Signal (Y0STARTCOM) represents the common cause failure potential of three different sets of relays. Each set of relays has different levels of redundancy. Generic MGL parameters were applied according to the different levels of redundancy for each set of relays. The individual probabilities are added to provide the combined probability of common cause failure of the start signal. This treatment is preferred over having three separate basic events that all have the exact same effect on the units. Other similar events were treated likewise.

C.2.2.5.1 Data Classification and Analysis

Finding common cause data for the Keowee systems was difficult since most industry research efforts have focused on nuclear plant components such as pumps, valves, and diesel generators.

The EPRI database (Reference 4) was found to contain information on circuit breakers that was generally applicable to the Keowee generator breakers, field breakers, field supply breakers, and the auxiliary power breakers. The CCDAT program (Reference 5) was used to align this data into a Keowee specific database for each of these breaker groups. Keowee breaker failure events from Table C.2-1 were also classified and input into these databases.

Each industry event was thoroughly reviewed for its applicability to the particular set of Keowee breakers. Careful consideration was given to the root causes, coupling mechanisms, system design, and operating conditions in these events in determining their

full or partial applicability to Keowee. Reference 3 provides some guidance in the selection of cause and coupling applicability factors, and mapping parameters. Credit was taken in the event applicability factors for the ability of Keowee defensive tactics to prevent the particular failure mode or decouple redundant equipment. The assessments performed for each of these events and the subsequent parameter estimates were documented in the project files.

Data from the EPRI ALWR program was found for air operated valves and batteries (Reference 10). Since there were no Keowee events involving AOVs or batteries and the descriptions for the event data were not readily available, the beta factors computed in Reference 10 were used without modification for common cause failure of the Keowee AOVs and batteries.

C.2.2.5.2 Quantification Using Generic Common Cause Parameters

Because of the unavailability of common cause data for many of the Keowee components, it was necessary to estimate these common cause values using engineering judgment. Table C.2-6 provides a list of suggested generic MGL parameters from Reference 3. These values are considered to be conservative but reasonable estimates.

Some additional credit was taken for Keowee defensive measures that were thought to prevent common cause failures either by preventing the failure mode or by decoupling the root cause between the components. Credit was taken only when the defense is thought to be significantly better than that for similar generic components. If a common cause basic event was moderately or strongly defended, the generic beta factor applied was reduced by a factor of 2. This factor is based on Reference 3 (Section 5.5.1.3.1) which provides some guidance for accounting for qualitative differences between a generic plant and a target plant. Table C.2-7 provides a list of modified generic MGL parameters used for basic events that are considered to be "well defended."

For "combination events" that are described in section C.2.2.5, individual MGL parameters and component failure rates were computed for each sub-component. Each sub-component failure probability was multiplied by its corresponding common cause multiplier. All of the sub-component common cause probabilities were then combined to determine an overall group common cause failure probability.

C.2.2.5.3 Treatment of Event FK0FISHCOM

The Keowee event FK0FISHCOM represents the failure of the generator cooling water (WL) system due to debris clogging the inlet strainers to both units. These strainers are connected to a common intake header that brings cooling water in from the Unit 1 Spiral Case. The introduction of foreign material, trash, or biological fouling into the common header could lead to the failure of both strainers when unit operation is demanded.

An event of this type occurred at Keowee on February 2, 1981. With both units generating to the grid, a school of shad (small fish) was drawn into the intake and into the cooling water header. Unit 1 tripped off-line on low cooling water flow. Unit 2 also had low cooling water flow but had not tripped when "on-call" operators arrived from off-site to clear the strainers. An inspection found that the cooling water inlet screen in the Unit 1 spiral case was damaged.

From a functional standpoint this failure event more closely resembles a "single failure" that affects both units rather than the coupled failure of redundant components. Therefore, it is more appropriate to quantify this event as a basic failure rate instead of deriving a set of MGL parameters. The mean failure rate is given as the number of failures divided by the estimated number of station hours. Station hours are used instead of unit run hours since the intake header is shared between units. The event probability for FK0FISHCOM is equal to the basic failure rate (per hour) times the 24 hour mission time.

C.2.3 RECOVERY OF COMMON CAUSE FAILURES

The top common cause events were reviewed for potential operator recoveries. Repair of damaged equipment was not considered likely due to the time required for technicians to respond and complete repairs. However, other actions that could be performed by the Keowee operator, Keowee "on-call" operator, or Oconee operators were considered. Three potential recovery actions were identified for application to Keowee common cause cut sets.

Event FK0FISHRHE is the recovery of Keowee generator cooling by operators clearing the WL inlet strainer of debris to restore cooling water flow. This event was applied to the cut set involving the event FK0FISHCOM.

Event Y0STARTRHE is the recovery of a Keowee start circuitry failure by operators using manual start circuitry to start and load the Keowee units. A manual (normal) start can be performed at Keowee and is proceduralized. This recovery event was applied to cut sets involving the events Y0STARTCOM and L0EGTPSCOM.

Another potential recovery is the restoration of auxiliary AC power by Keowee operators manually closing failed breakers (AB0SWGRRHE). Since most potential common cause failures are expected to affect only the control circuitry for these breakers, the possibility exists for operators to circumvent these failures by manually closing the needed breakers. Because this action is not proceduralized and may require the presence of an "on-call" operator, only minimal credit was taken for restoring auxiliary power following a breaker(s) failing to close.

The quantification of recovery event values is discussed further in section 5.5 and Appendix C.3.

C.2.4 ANALYSIS REVIEW

The common cause modeling and event quantification were reviewed by the entire Keowee project team prior to final Keowee system model integration and solution. The analysis was also reviewed by an independent outside consultant with previous experience in common cause analysis. As a result of this review, improvements were made in the data analysis for the excitation breakers and in the common cause modeling of the emergency start circuitry, and an event was added to model common cause failure of the switchyard DC power system.

C.2.5 RESULTS

The results of the event quantification are presented in Table C.2-4. The impact of these events on the Keowee model (which considers operator recoveries) is presented in Table C.2-8. This table presents a comparison of the Fussell-Vesely (FV) importance factors for common cause events and event rankings based on importance. The FV factors represent the contribution fraction of each basic event to the total failure probability of Keowee. The common cause ranking shows the order of importance of the common cause events. The overall ranking shows where each common cause event ranked in an

importance listing of all Keowee basic events. These rankings show that common cause failures play an important role in Keowee unreliability.

C.2.5.1 COMMON CAUSE CONTRIBUTION TO KEOWEE UNRELIABILITY

Collectively, the common cause run failure probability equals 7.23E-04 or 9.8% of the total Keowee failure probability. The dominant contributors to common cause run failure were failure of auxiliary power breakers to close, clogging of the WL inlet strainers, and failure of the governors to run.

The collective common cause start failure probability equals 1.46E-04 or 2.0% of the total Keowee failure probability. The dominate contributors to common cause start failure were failure of voltage regulators, excitation breakers, and batteries.

The modeling of special common mode failures involving the failure of the generators due to unsynchronized connection of both generators was shown to be an unimportant contributor to Keowee unreliability. The total failure probability of these failure modes was 3.6E-06 or 0.05 percent of the total failure probability.

C.2.5.2 SENSITIVITY STUDY

As a sensitivity study, the overall common cause results were compared with a "system level" analysis of Keowee common cause failure to start and to run. Actual operating data was used for the unit start and run probabilities (See Figure 7.2-2 and Table 7.2-6). For one case, a generic "Beta-factor" of 0.1 was used for start and a value of 0.05 used for run failures. For another case, a Keowee specific "Beta-factor" was calculated using Keowee failure data. The system common cause failure probabilities calculated using these different "Beta-factors" were compared to the total probabilities for all the component-level failure events. A case for recovered and unrecovered component-level events was also examined.

This comparison showed that the "component level" common cause modeling results were relatively close to the "system level" analysis results. Therefore, this level of modeling provides a reasonable estimate of overall common cause failure potential and accurately reflects actual operating experience seen at Keowee. See Figure 5.4-1 for a summary of these results.

The sensitivity case that examined the removal of credit for operator recovery showed that the common cause run failure probability increased from 7.23E-04 to 3.36E-03. For common cause start failure, the probability only increased from 1.46E-04 to 1.50E-04.

C.2.6 INSIGHTS

Common cause failures are important contributors to overall Keowee unreliability making up 11.7% of the total Keowee failure probability. The most probable common cause failures are Keowee run failures involving auxiliary AC power or loss of cooling water. Operator recovery of these run failures has an important impact on the overall reliability of Keowee.

The use of at least one Keowee unit for daily system generation provides a strong defense against most common cause failure modes. Unit operation in this manner provides a full functional check of the most important systems needed for emergency operation. The additional design margin provided for higher system generating loads is another important defense mechanism for the generator and cooling water systems.

C.2.7 REFERENCES

1. A. Mosleh, et al., Procedures for Treating Common Cause Failures in Safety and Reliability Studies (Vol. I: *Procedural Framework and Examples*), NUREG/CR-4780 (EPRI NP-5613), January 1988.

2. A. Mosleh, et al., Procedures for Treating Common Cause Failures in Safety and Reliability Studies (Vol. II: *Analytical Background and Techniques*), NUREG/CR-4780 (EPRI NP-5613), January 1989.

3. A. Mosleh, Procedures for Treating Common Cause Failures in Safety and Reliability Studies, NUREG/CR-5801, April 1993.

4. Fleming, K. N., et. al., A Database of Common-Cause Events for Risk and Reliability Applications, Electric Power Research Institute, EPRI TR-100382, June 1992.

5. Common-Cause Data Analysis Tool (CCDAT) User's Manual, Electric Power Research Institute, EPRI TR-102747, August 1993.

6. Oconee PRA Report, Revision 1, (Oconee IPE), Duke Power Company, December 1989.

7. H. M. Paula, G. W. Parry, et al., A Cause-Defense Approach to the Understanding and Analysis of Common Cause Failures, NUREG/CR-5460 (SAND89-2368), March 1990.

8. S. Israel, Insights from Common-Mode Failure Events, USNRC, AEOD/E92-02, June 1992.

9. S. Israel, Insights from Common-Mode Failure Events, USNRC, AEOD/E92-02 Supplement 1, June 1992.

10. Advanced Light Water Reactor Utility Requirements Document (Vol. II: *ALWR Evolutionary Plant*), EPRI NP-6780, Chapter 1, Appendix A - *PRA Key Assumptions And Groundrules*, Revision 4, April 1992.

Table C.2-1

Common Cause Failure Operating History Review

Date	PIP/PIR/LER	Description	Database Applicability
2-2-81	KH Log	Damaged inlet screen allowed fish (shad) to clog generator cooling water inlet strainers.	Keowee Common Cause Run Failure
7-24-86	ONS & KH Log	KH#2 Gen. Lockout on CO2 release in generator due to test error by maintenance technician (hit test button for wrong unit)	**Screened** - error was immediately alarmed and quickly recovered. KH#1 was still available but w/o CO2 fire protection. Event counted under unavailability hours, but points out potential human coupling. Also the test switches in question were located in ONS C.R.
6-19-89	2-O89-0099 269/89-11	T.S. violation due to defective procedure - Outage test proc. disabled both Keowee power paths. (Could be a place for procedural/human coupling)	**Screened** - This failure mode is applicable only to the standby bus, and is outside of Keowee system boundary, however, should review this again for OPRA update.
3-27-90	KH Log & WR-58732B	Unit 2 failed to start for sys generation. Found 70B cam switch not resetting to preset position causing 70BX relay to drop out. Technicians didn't record the position where cam stopped which determines the output voltage.	**Screened** - No actual multiple failures occurred. Available voltage output on emerg. start is unknown. A potential CCF could occur if voltage is set too low for equip to run but too high for EPSL to switch to alternate unit. Operator recovery is to swap power sources.
1-8-91	4-O91-0003 269/91-01	Single failure could cause open U/G feeder breaker to close thus tying both units together out of synch.	**Screened** - since there were no actual failures. Strong defense presently provided by admin controls. **[Synchronization failures explicitly modeled in high level tree]**
6-11-91	4-O91-0063	Breaker failed to close due to X-relay - mech binding (due to frame to coil misalignment) prevented relay from dropping out. Both Units had suspect relays in field, field supply, field flash, and aux. power bkrs. A previously removed X-relay failed test due to same cause.	Potential Common Cause Start Failure A small probability exists that multiple failures could have occurred at the same time. It is assumed that the previously removed X-relay that failed was removed from service due to some other reason.
8-27-92	0-O92-0409 269/92-11	Keowee Hydro declared inop - potential single failure identified during design review. (failure of aux contacts in ACB could cause both units to align to overhead path out of synch) This is not an actual failure event.	**Screened** - since there were no actual demand failures. (Note: There were 2 aux. contact failures during 1976, but these did not affect any start demands.) **[Synchronization failures explicitly modeled in high level tree]**

Table C.2-1

Common Cause Failure Operating History Review

Date	PIP/PIR/LER	Description	Database Applicability
10-12-92	4-O92-0538 269/92-16	Design review determined a single fault in the ACBs which would cause the protective relaying to lockout both the overhead and underground paths. Note: This is not an actual failure.	**Screened** - since no actual failures occurred. Strong defense presently provided by admin controls.
10-19-92	0-O92-0563 270/92-04	Swyd event caused LOOP to ONS#2. KH1&2 started and loaded. KO tripped ACB 1 which normal lost Aux Pwr. MST locked out. Alt bkrs failed to auto-close. After MST reset, ACB 5 failed to auto-close. Later, unexpected trip of KH#2 and restart failed.	Failures of ACB-8 appears to be independent of other ACB failures. Failure of ACB-5 & -7 appears to be a CCF due to low voltage problem described below in LER 269/92-18. If one bkr fails due to this problem, then a "latch trip" makes the other bkr unavailable. This event will be combined with event below.
12-2-92	0-O92-0684 269/92-18	ACB-6 & -8 failed to close. DC voltage inadequate to assure bkr operation. Modified to ensure that close coil remains energized longer to assure bkr operation. ACB-5 & -7, field bkr, and field supply bkr also susceptible.	Common Cause Start Failure on Field & Supply Breakers Common Cause Run Failure on Auxiliary Power Breakers (The 10/19/92 failures of ACB-5 & -7 were due to same low voltage problem.)
1-11-93	0-O93-0041 269/93-01	Eng. Review determined that Unit running at max output (with lake level differential high) could overspeed on a load rejection (such as emergency start) and trip field breakers. This isn't an actual failure but units have been run near these conditions.	**Screened** - since no actual failures and that operating the units under these extreme conditions is very unusual. The probability of a coincident emergency start is also very low. Adequate time should be available to recover the units for most sequences except for med. or large LOCA. However, recovery actions are not proceduralized. * Administrative Controls now in place restrict generator ouput based on lake levels to preclude this failure mode.

Table C.2-2

Generic Root Causes Examined for Qualitative Analysis

Mechanical Systems	Electrical Systems
Manufacturer or Design Deficiency	**Manufacturer or Design Deficiency**
- output too low (pressure, level, flow, . .)	- inferior QC/defective materials
- component fails to start/actuate	- Unanticipated Interaction / Deficiency
- component fails to run	- component fails to start/run
Maintenance Error	**Maintenance Error**
- improper adjustment/alignment	- improper adjustment/miscalibration
- improper lubrication/wrong part/etc.	- improper lubrication/wrong part/etc.
- inadequate repair/restoration	- inadequate repair/restoration
Procedure Error/Deficiency	**Procedure Error/Deficiency**
- Error in procedure	- Error in procedure
- Inadequate procedure	- Inadequate procedure
- failure to follow procedure	- failure to follow procedure
- component out of position	- component out of position
- wrong component/unit	- wrong component/unit
Installation Error	**Installation Error**
- pipe break/leak	- damaged wires or components
- damage to components	- mech. installation (not as designed)
- mechanical binding	- electrical installation (not as designed)
- flow blockage/checkvalves backwards	- breach of environmental barrier
- breach of environmental barrier	- poor housekeeping (trash, debris, etc.)
- sensing line blocked	
Harsh Environment	**Harsh Environment**
- corrosion	- corrosion / dust
- excess moisture or humidity	- excess moisture or humidity
- temperature too high/low	- temperature too high/low
- internal biofouling	- internal biofouling
- water/contaiminates in lube oil	- water/contaiminates in air supply
- chemical exp. from cleaning/painting	- chemical exp. from cleaning/painting

Table C.2-3 - List of Common Cause Component Groups

Component Group Name	*Including The Following Systems & Equipment*
CCF of Generator Cooling Water System	WL valves and piping WL strainers Intake from Spiral Case Control Circuitry and instrumentation
CCF of Generator Breakers	Breaker Mechanical Components Control Circuitry Air System Protective Circuitry Disconnects and Buswork
CCF of DC Power	Batteries and Chargers Circuit Breakers Control Circuitry Terminals and Connections
CCF of Aux Power System	Breaker Mechanical Components Control Circuitry 1X, 2X, & CX transformers Buswork, cabling, connections XS, XA Loadcenters
CCF of Keowee Generators	Internal windings and components Generator High Pressure Oil System components Generator Air Cooling System components Generator Protective Circuitry (lockouts)
CCF of Excitation Breakers	Breaker Mechanical Components Control Circuitry
CCF of Turbine	Turbine and Wicket Gates Guide Bearing Guide Bearing Oil System Turbine Sump Pump System Control & Protective Circuitry
CCF of Governor	Woodward Governor Shutdown/Emerg. Load Solenoids Governor Oil and Air Systems Speed Switches Control Circuitry and Master Relays
CCF of Voltage Regulators	Base Adjust Voltage Error Circuitry Relays and Controls Wiring and Connections
CCF of Emergency Start Signal	Relays & Contacts Wiring and Connections
CCF of Switchyard Isolation Signal	Relays & Contacts Wiring and Connections
CCF of Keowee Dam Internal Structures	Intake Structure - Headgate/Screens Penstock Spiral Cases Draft Tubes

Table C.2-4

List of Common Cause Basic Events

Event Name	*Description*	*Strong Defense*	*Combination Event*	*MGL Parameter Source*	*Multiplier*	*Independent* Failure Prob.*	*Basic Event Probability*
AB0SWGRCOM	CCF of All Keowee Auxiliary Power Breakers			CCDAT	0.084	7.96E-03	6.69E-04
AB23BKRCOM†	CCF of Keowee Generator Breakers ACB-2 & -3	✓		CCDAT	0.095	1.17E-03	1.12E-04
AB24BKRCOM	CCF of Unit 2 Generator Breakers ACB-2 & -4	✓		CCDAT	0.095	1.17E-03	1.12E-04
ACBXFERCOM	ACB-2 and ACB-3 Transfer Open			App. C.2 Table C.2-6	0.05	2.55E-05	1.28E-06
AK1OFRQCOM†	CCF of KU1 Overfrequency Relays to Reset			App. C.2 Table C.2-6	0.1	3.30E-05	3.30E-06
AK2OFRQCOM†	CCF of KU2 Overfrequency Relays to Reset			App. C.2 Table C.2-6	0.1	3.30E-05	3.30E-06
BKGBOILCOM	CCF of Turbine Guide Bearing Oil System			App. C.2 Table C.2-6	0.02	9.70E-05	1.94E-06
DDCBATTCOM	CCF of Swyd Batteries SY-1 and SY-2			ALWR Util. Req. Doc	0.029	9.30E-04	2.70E-05
E12EXCTCOM	CCF of Excitation Breakers	✓	Field Bkr.	CCDAT	0.033	2.19E-04	5.31E-05
		✓	F. Supply Bkr.	CCDAT	0.033	8.17E-04	
		✓	F. Flashing Close	App. C.2 Table C.2-7	0.05	2.03E-04	
		✓	F. Flashing Open	App. C.2 Table C.2-7	0.05	1.76E-04	
EK00RUNCOM	CCF of Voltage Regulators to Continue			App. C.2 Table C.2-6	0.05	2.47E-03	1.24E-04
EKSTARTCOM	CCF of Voltage Regulators on Start			App. C.2 Table C.2-6	0.1	6.17E-04	6.17E-05
FK0FISHCOM	Common Mode Failure of Strainers Due to Debris			Explicitly Calculated	N/A	N/A	2.55E-03
FKVALVECOM	CCF of WL Cooling Water Control Valves			ALWR Util. Req. Doc	.088	2.80E-04	2.46E-05
GK0COOLCOM	CCF of Keowee Generator Air Cooling	✓		App. C.2 Table C.2-7	0.03	1.54E-05	4.61E-07
GK0LOCKCOM	Common Cause Actuation of Gen. Lockouts			App. C.2 Table C.2-6	0.05	8.11E-05	4.06E-06
GKHPOILCOM	CCF of Generator Thrust Bearings	✓		App. C.2 Table C.2-7	0.03	1.54E-05	4.61E-07

Table C.2-4

List of Common Cause Basic Events

Event Name	*Description*	*Strong Defense*	*Combination Event*	*MGL Parameter Source*	*Multiplier*	*Independent* Failure Prob.*	*Basic Event Probability*
L0EGTPSCOM	CCF of Swyd UV and UF Detection Circuitry		(3 sets of at least 4 or more relays)	App. C.2 Table C.2-6	0.018	9.90E-05	1.78E-06
OK0PRUNCOM	CCF of Both Governor Oil Systems Fail to Run	✓ ✓	Pump fails (start) Pump fails (run)	App. C.2 Table C.2-7 App. C.2 Table C.2-7	0.01 0.005	1.46E-03 1.40E-05	1.46E-05
OK1PRUNCOM	CCF of Unit 1 Governor Oil Pumps Fail to Run	✓		App. C.2 Table C.2-7	0.008	1.40E-05	1.12E-07
OK1PSTRCOM	CCF of Unit 1 Governor Oil Pumps Fail to Start	✓		App. C.2 Table C.2-7	0.014	1.46E-03	2.04E-05
OK2PRUNCOM	CCF of Unit 2 Governor Oil Pumps Fail to Run	✓		App. C.2 Table C.2-7	0.008	1.40E-05	1.12E-07
OK2PSTRCOM	CCF of Unit 2 Governor Oil Pumps Fail to Start	✓		App. C.2 Table C.2-7	0.014	1.46E-03	2.04E-05
PK0SUMPCOM	CCF of Both Turbine Sump Pump Systems	✓ ✓	Pumps/Valves Suction Line	App. C.2 Table C.2-7 App. C.2 Table C.2-7	0.005 0.03	3.47E-04 2.35E-05	2.44E-06
PK1ACDCCOM	CCF of Keowee 1 AC & DC Sump Pumps	✓	Pumps/Valves Suction Line	App. C.2 Table C.2-7 (multiplier is assumed)	0.012 1.0	3.47E-04 1.61E-05	2.77E-05
PK2ACDCCOM	CCF of Keowee 2 AC & DC Sump Pumps	✓	Pumps/Valves Suction Line	App. C.2 Table C.2-7 (multiplier is assumed)	0.012 1.0	3.47E-04 1.61E-05	2.77E-05
SU127UVCOM	CCF of Oconee Unit 1 Standby Bus UV Relays			App. C.2 Table C.2-7	0.05	2.37E-03	1.18E-04
SU227UVCOM	CCF of Oconee Unit 2 Standby Bus UV Relays			App. C.2 Table C.2-7	0.05	2.37E-03	1.18E-04
SU327UVCOM	CCF of Oconee Unit 3 Standby Bus UV Relays			App. C.2 Table C.2-7	0.05	2.37E-03	1.18E-04
WK00RUNCOM	CCF of Keowee Governors to Run	✓		App. C.2 Table C.2-7	0.03	6.97E-04	2.09E-05
WKCSTRTCOM	CCF of Keowee Governors to Cold Start	✓		App. C.2 Table C.2-7	0.05	2.24E-04	1.12E-05
WKHSTRTCOM†	CCF of Keowee Governors to Hot Start	✓		App. C.2 Table C.2-7	0.05	7.00E-05	3.50E-06

Table C.2-4

List of Common Cause Basic Events

Event Name	*Description*	*Strong Defense*	*Combination Event*	*MGL Parameter Source*	*Multiplier*	*Independent* Failure Prob.*	*Basic Event Probability*
XA0SWGRCOM	CCF of Transformers 1X, 2X, & CX			App. C.2 Table C.2-6	0.05	2.45E-05	1.22E-06
XA1BKRSCOM	CCF of 1X Aux Power Breakers ACB-5 & -7			CCDAT	0.039	7.96E-03	3.10E-04
XA2BKRSCOM	CCF of 2X Aux Power Breakers ACB-6 & -8			CCDAT	0.039	7.96E-03	3.10E-04
XA56BKRCOM	CCF of Aux Power Breakers ACB-5 & -6			CCDAT	0.039	7.96E-03	3.10E-04
XA78BKRCOM	CCF of Aux Power Breakers ACB-7 & -8			CCDAT	0.039	7.96E-03	3.10E-04
XD0BATTCOM	CCF of Keowee Station Batteries (Start)			ALWR Util. Req. Doc	0.029	9.30E-04	2.70E-05
XD0CHRGCOM	CCF of Keowee Battery Chargers (Run)			App. C.2 Table C.2-6	0.05	6.96E-04	3.48E-05
Y0STARTCOM	CCF of Emergency Start Signal		27X relays	App. C.2 Table C.2-6	0.1	3.30E-05	7.26E-06
			KA/KB relays	App. C.2 Table C.2-6	0.1	3.30E-05	
			ESRX relays	App. C.2 Table C.2-6	0.02	3.30E-05	

* Note: Probability based on bayesian updated independent component failure rates.

† Note: These events only apply to a sensitivity case and are not included in the base case solution.

Table C.2-5

Summary of MGL Model Equations for Event Quantification

Size of CCF Group	Number of Failures	Common Cause Multipliers
2	1 2	$1-\beta$ β
3	1 2 3	$1-\beta$ $1/2\beta(1-\gamma)$ $\beta\gamma$
4	1 2 3 4	$1-\beta$ $1/3\beta(1-\gamma)$ $1/3\beta\gamma(1-\delta)$ $\beta\gamma\delta$

Note that the "number of failures" column in this table refers to a set of specific components. For example, if the common cause group included three valves, A, B, and C, then the common cause multiplier of two of the three valves would be applied separately to each possible combination (i.e., AB, AC, and BC).

Table C.2-6

Generic MGL Parameters

	Failure to Operate or Actuate on Demand			Failure to Continue or Spurious Actuation		
System Size	β	γ	δ	β	γ	δ
2	0.10	-	-	0.05	-	-
3	0.10	0.27	-	0.05	0.27	-
4	0.11	0.42	0.40	0.06	0.42	0.40

Note: Higher order MGL parameters will be given a value of 1.0

Table C.2-7

Modified Generic MGL Parameters (w/Strong Keowee Defenses)

	Failure to Operate or Actuate on Demand			Failure to Continue or Spurious Actuation		
System Size	β	γ	δ	β	γ	δ
2	0.05	-	-	0.03	-	-
3	0.05	0.27	-	0.03	0.27	-
4	0.06	0.42	0.40	0.03	0.42	0.40

Note: Higher order MGL parameters will be given a value of 1.0

Table C.2-8

Keowee Common Cause Event Results

CCF Event Name	Run Failure Prob.	Start Failure Prob.	Recovery Event	Non-Recovery Factor	Run Failure Contribution	Start Failure Contribution	Importance (Fussell-Vesely)	Overall Rank	CCF Rank
AB0SWGRCOM	6.69E-04		AB0SWGRRHE	0.5	3.22E-04		0.0432	5	1
FK0FISHCOM	2.55E-03		FK0FISHRHE	0.063	1.54E-04		0.0207	7	2
EK00RUNCOM	1.24E-04				1.19E-04		0.0160	10	3
EKSTARTCOM		6.17E-05				5.58E-05	0.0075	14	4
E12EXCTCOM		5.31E-05				4.80E-05	0.0064	19	5
XD0CHRGCOM	3.48E-05				3.35E-05		0.0045	22	6
XD0BATTCOM		2.70E-05				2.59E-05	0.0035	29	7
FKVALVECOM	2.46E-05				2.37E-05		0.0032	31	8
WK00RUNCOM	2.09E-05				2.01E-05		0.0027	34	9
OK0PRUNCOM	1.46E-05				1.41E-05		0.0019	38	10
WKCSTRTCOM		1.12E-05				1.01E-05	0.0014	52	11
XA78BKRCOM	3.10E-04		AB0SWGRRHE	0.5	9.62E-06		0.0013	53	12
XA1BKRSCOM	3.10E-04		AB0SWGRRHE	0.5	8.66E-06 (1)		0.0012	54	13
XA2BKRSCOM	3.10E-04		AB0SWGRRHE	0.5	4.05E-06 (1)		0.0005	75	14
GK0LOCKCOM	4.06E-06				3.90E-06		0.0005	79	15
Y0STARTCOM		7.26E-06	Y0STARTRHE	0.5		3.63E-06	0.0005	80	16
AB24BKRCOM		1.12E-04				2.37E-06 (1)	0.0003	89	17
PK0SUMPCOM	2.44E-06				2.35E-06		0.0003	90	18
BKGBOILCOM	1.94E-06				1.87E-06		0.0003	96	19
PK1ACDCCOM	2.77E-05				1.37E-06 (1)		0.0002	136	20
ACBXFERCOM	1.28E-06				1.23E-06		0.0002	141	21
XA0SWGRCOM	1.22E-06				1.18E-06		0.0002	143	22
OK1PSTRCOM	2.04E-05				9.99E-07 (1)		0.0001	150	23
PK2ACDCCOM	2.77E-05				5.00E-07 (1)		0.0001	197	24
GKHPOILCOM	4.61E-07				4.40E-07		0.0001	210	25
GK0COOLCOM	4.61E-07				4.40E-07		0.0001	211	26
				Total (recovered)	**7.23E-04**	**1.46E-04**			
				Total (unrecovered)	3.36E-03	1.50E-04			

Note 1: These events only affect a single Keowee Unit but their contribution is still counted in the totals.

All other modeled common cause events contributed less than 0.01%.

Keowee PRA CCF Assessment Process

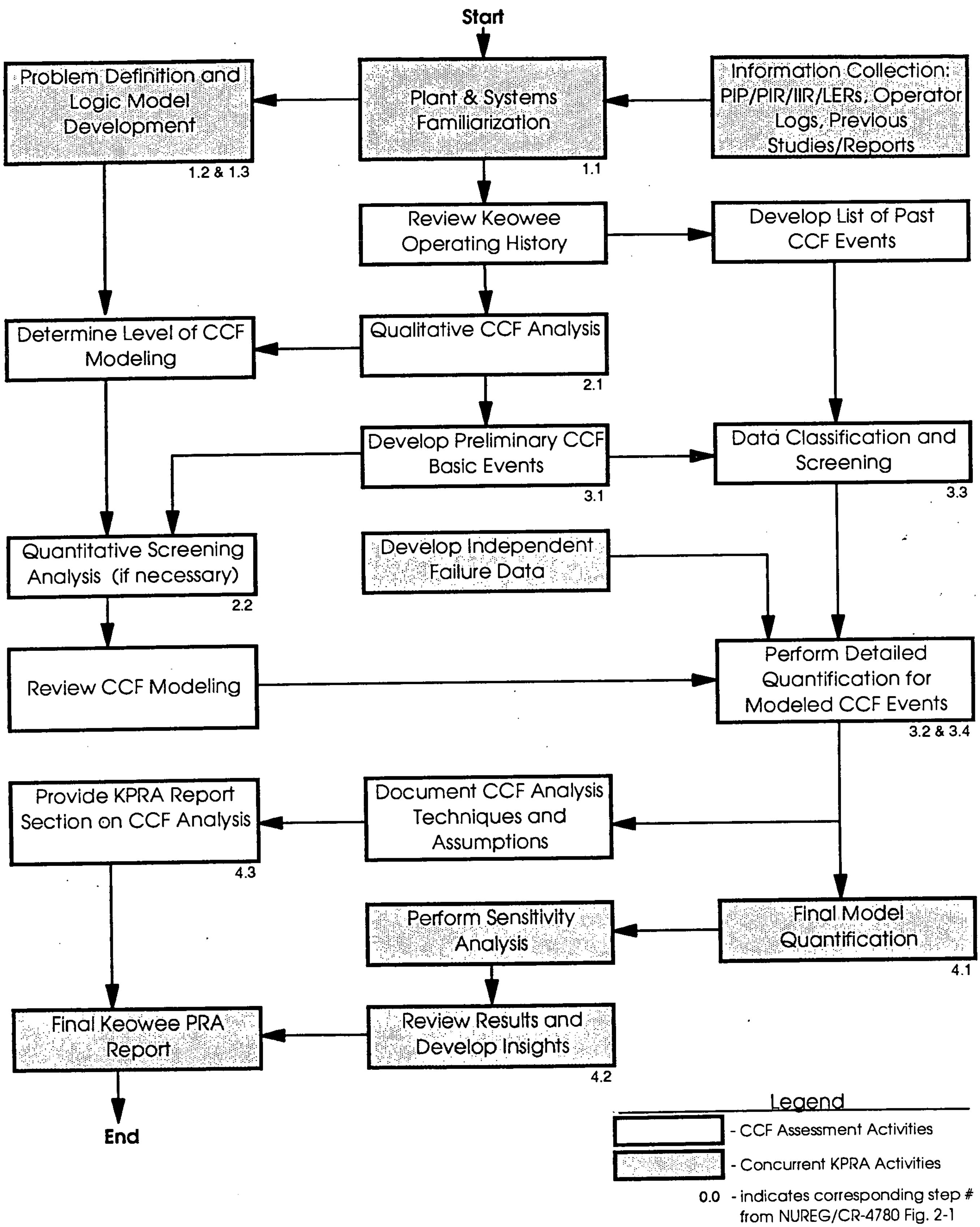

Figure C.2-1

APPENDIX C.3
HUMAN RELIABILITY ANALYSIS

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C.3 HUMAN RELIABILITY ANALYSIS

C.3.1 PURPOSE

This appendix is intended to provide a broad overview of the Keowee human reliability analysis and to provide a reference source for the results of that analysis. In the interest of simplification, some details have been omitted from the sections in this Appendix. More detailed documentation of the Keowee Reliability Analysis is contained in a notebook called The Keowee Human Reliability Analysis Tier 2 Document.

C.3.2 SCOPE

The results of the Keowee Reliability Analysis are produced by constructing and solving fault tree models. A fault tree is a logic diagram which shows the equipment failures needed to make a system fail. Fault trees for individual Keowee systems were linked to produce results representing Keowee failures. The fault tree results are lists of events (called sequences or cut sets) which represent ways that Keowee can fail. Each event in a sequence has a probability, so that the total probability of Keowee failure can be estimated.

Some of the events used in the Keowee system fault trees model human failures which must occur for sequences to result in Keowee failure.

Human reliability events for the Keowee system fault trees were identified by Keowee system modelers who considered the particular features of the systems they were modeling, the past history associated with those systems, and human reliability aspects associated with the procedures governing use of those systems. The identified human reliability events were an input to the human reliability analysis.

Scope of the human reliability analysis includes producing a list of quantified, documented human reliability events to be used in the Keowee system fault trees for quantification, or to be used to "recover" the sequences produced by the Keowee fault tree model.

C.3.3 PROCESS

The Keowee human reliability analysis was performed consistent with the process contained in EPRI TR-101711, SHARP 1- A Revised Systematic Human Action Reliability Procedure (Reference 1). The methods used were intended to be consistent with the spirit and purpose of the SHARP 1 steps.

This process used in performing the Keowee PRA human reliability analysis included the steps of: 1) An initial walkdown of Keowee for human reliability and other concerns, 2) a review of Keowee and industry operational events, 3) a review of Keowee procedures, 4) event identification and integration into plant model, 5) event quantification, 6) recovery analysis and 7) an internal review of the human reliability analysis.

C.3.3.1 INITIAL WALKDOWN

The initial walkdown of Keowee was performed on February 1st, 1994. This was after several meetings to discuss the Keowee Reliability Analysis, but before the systems analysis or the human reliability analysis were past the planning stage. The walkdown was performed by the whole Keowee Reliability Analysis team. Keowee systems experts from Oconee assisted in the walkdown.

Keowee operators were briefly interviewed during the walkdown. Items discussed included procedure use and staffing.

Features of interest for human reliability at Keowee were noted during the walkdown. These included a newly installed emergency start indicator light, battery supplied emergency lights and telephones installed for communication between Keowee and Oconee. The Keowee control panels were photographed, as were other important pieces of Keowee equipment. The Keowee remote section panel at Oconee was also photographed.

This walkdown proved useful in establishing contact with Keowee personnel and in familiarizing Keowee Reliability Analysis project engineers with the station. The photographs taken were useful in answering questions about Keowee details that arose during the analysis.

C.3.3.2 REVIEW OF PAST HISTORY

The Keowee past history review for human reliability concerns consisted of a review of problem investigation reports (PIPs) and licensee event reports (LERs) associated with Keowee, a review of Keowee operating logs and a review of Keowee training documentation.

In addition to Keowee past history, industry past history was also reviewed for human reliability concerns. This review consisted of an identification of important industry events involving a degradation of emergency power. The event histories reviewed were selected from volumes of NUREG/CR-4674, Precursors to Potential Severe Core Damage Accidents (Reference 2). These event histories were reviewed by the human reliability analyst and routed to other Keowee Reliability Analysis Group members for review of human reliability and other concerns.

The result of the past history review was the identification of some potential human reliability concerns for modeling in the Keowee PRA. One concern discovered was that the Keowee voltage regulator base adjustment could be mis-set prior to generator operation. The automatic feature of the regulator may not correct a large error of this type. As a result of this concern, human error events were included in the Keowee fault tree.

Another concern identified was that, prior to the October 1992 loss of power event, the condition of procedures at Keowee and Oconee did not have adequate defense against certain mistakes. (This last concern had already been identified and corrected at Keowee and Oconee). As a result of this concern, a sensitivity study was performed on the pre-1992 condition of Keowee. This is described in section 7.5.

C.3.3.3 REVIEW OF KEOWEE PROCEDURES / EVENT SCREENING

The SHARP 1 process suggests both a quantitative and qualitative screening for human reliability events. Irrelevant actions are eliminated qualitatively. The quantitative screening is used to reduce the number of modeled actions. The intent of the SHARP 1 screening is to insure that human error potential of procedures is reviewed methodologically and that no important potential errors are overlooked.

The spirit of the screening suggested by SHARP was followed by performing a review of procedures and documenting relevant human reliability insights. This review was tabulated and routed to systems engineers so that important human reliability events found in procedures could be included in the system models. This review has been documented in the Keowee Human Reliability Analysis Tier 2 notebook.

One suggestion for the quantitative screening in the SHARP 1 manual is to set human error values to 1.0 for the initial fault tree soution. This insures that no dependencies among human reliability events are overlooked. This suggestion was followed in the initial solution of the Keowee fault tree. No unanticipated dependencies in human reliability actions were found in the review of the resulting cut sets.

C.3.3.4 EVENT IDENTIFICATION AND INTEGRATION

System fault tree models were developed concurrently with the review of Keowee and industry operating history and concurrently with the review of procedures. During this phase, the Keowee Reliability Analysis team held meetings to insure that modeling assumptions were well understood and properly applied and that human reliability events were modeled appropriately.

Communication between systems analysts and the human reliability analyst led to the refinement of both the system models and human reliability event definitions. For example, some human actions originally modeled as distinct events were combined because they affected the same component.

Preliminary drafts of the initial human reliability event quantifications and of the systems models were available and were reviewed prior to the solution of the integrated model so that any problems with these models, or with their integration, could be discovered at that time.

C.3.3.5 INTERVIEWS

Numerous interviews and phone conversations were conducted during the process of the Keowee Human Reliability Analysis. Personnel contacted included:

* a Keowee "on call" operator,

* the Oconee Systems Analyst for Keowee Electrical Systems,
* the Oconee Systems Analyst for Keowee Mechanical Systems,
* and the Oconee Switchyard Coordinator

In addition to these interviews, meetings of the Keowee Reliability Assessment group were held periodically. Suggestions for the human reliability analysis were frequently made at these meetings.

The Keowee PRA, including the human reliability analysis, was reviewed by an outside consultant retained for that purpose.

The results of input from these various sources were incorporated into this analysis.

C.3.3.6 QUANTIFICATION

Human reliability event quantification is a process of assigning probability numbers to specific human actions. The following paragraphs describe how this was accomplished for the Keowee human reliability analysis.

C.3.3.6.1 Types of Events Considered

A sequence from a fault tree solution usually contains an event known as an initiating event (or initiator) which along with the other sequence events is required for the analyzed risk. For the Keowee Reliability Analysis, this initiator is a loss of offsite power at Oconee for which emergency power from Keowee is needed.

The types of human reliability events normally found in a reliability (or risk) analysis are characterized as to whether they are assumed to occur prior to the initiator or after the initiator. For the Keowee PRA these are:

> Latent Human Errors (designated by LHE in the last three letters of the event name), which are pre-initiator events.
>
> RHE events. These are post-initiator human reliability errors associated with actions for which the correct response is not proceduralized.

DHE events. These are post-initiator human reliability errors associated with actions for which the correct response is proceduralized.

LHE events involve the disabling of equipment due to faulty post maintenance alignment. An example of a latent human error (LHE) is the event for the manual / auto switch for bus 1X left in manual (event name AB51431LHE, see Enclosure C.3-1).

DHE and RHE events involve actions taken to correct an abnormal situation. An example of a DHE event is the closing of breaker ACB-2 from the Keowee control room when it fails to close automatically (event ABEOPRCSDHE see Enclosure C.3-2). An example of an RHE event is the failure to recover Keowee auxiliary power breakers by manual control when they cannot be operated from the Keowee control room (event AB0SWGRRHE see Enclosure C.3-2).

A fourth type of event was characterized and quantified to model the condition of Keowee prior to recent upgrades. This type of event, called an error of commission, is a type of post initiator event. In an error of commission, an operator takes an incorrect step due to misdiagnosis or poor procedures, and causes a failure of the Keowee unit. For the Keowee Reliability Analysis, this type event has the letters CHE in the last three places of the event name. An example of this type of event is the resetting of Keowee emergency start signals prior to clearing Keowee normal lockouts (event YKEMSTRCHE see Enclosure C.3-3).

C.3.3.6.2 Considerations at Keowee

Quantification methods for human reliability analyses focus on the conditions of the plant being modeled. Some techniques focus heavily on timing considerations, while other techniques focus on particular features of the procedures and crew setup. The methods chosen for the Keowee Reliability Analysis focus on the procedures and crew setup. Therefore, features which were important to the event quantification done for the Keowee PRA were staffing levels, training and procedures.

Timing of human reliability actions was also considered. Timing considerations played a role with respect to reasonableness of crediting recovery actions and the availability of personnel to accomplish specific types of recoveries. For example, no credit was taken for recovery of iniital human failures by additional personnel who may arrive later in an

event. Timing considerations are not judged to be important enough to justify the use of a "time reliability model" with this analysis (see sections C.3.3.6.3 through C.3.3.6.5 for further elaboration of quantification details).

C.3.3.6.2.1 Staffing

There are at least three people at Keowee in addition to a desk security guard during normal working hours. These are the station supervisor and two operators. After normal working hours and on weekends there is one operator. This operator is a roving watch. The roving watch does not have the expertise to trouble shoot Keowee equipment problems. To provide this function there are special operators called Keowee *on call* technical specialists who have this expertise. Two on call technical specialists and the station manager will have a beeper at all times. It is an immediate action for the roving watch to contact one of the on call technical specialists if Keowee should get an emergency start due to a loss of power at Oconee. The on call technical specialist can respond at Keowee within one hour of being notified.

During an event at Keowee, the Keowee roving watch could call for help from non-licensed operators (NLOs) at Oconee. These NLOs could be expected to respond within 10 minutes of the request.

There are also Keowee control features (including alarms) at Oconee; however, operations of Keowee would normally be expected to occur at Keowee. In order to operate Keowee breakers at Oconee, the Keowee operator must transfer to Oconee control.

C.3.3.6.2.2 Procedures and Training

There is a set of Keowee specific procedures at Keowee, with some duplicates at Oconee. The procedures can be classified as maintenance procedures (with a designation including the letters IP, MP or OP), abnormal condition procedures (APs) and alarm response procedures (SAs).

Some features of Keowee procedures affect human error potential. Keowee maintenance procedures require double verification for the removal and restoration of most major equipment. Maintenance procedures, which change the state of equipment that could

render a Keowee unit inoperable, also require an operability verification upon completion of the work. Safety tags at Keowee are governed by the same procedures that govern these at Oconee. Tags must be cleared prior to the restoration of equipment.

Keowee is designed to supply AC power to Oconee automatically in an emergency without operator intervention. Abnormal conditon procedures and alarm response procedures are used if operator action at Keowee becomes necessary.

The abnormal condition procedure referred to in this analysis is Keowee Emergency Start (procedure number AP/0/A/2000/002). This procedure is trained on by Keowee personnel and all Oconee personnel. This procedure directs actions at Keowee. It includes steps to verify the expected conditions. If conditions are not as expected and the auxiliary buses are de energized, it contains steps to restore power to these buses. This procedure also contains enclosures for manually starting either Keowee unit.

Steps in the Keowee alarm response procedures do not have blank spaces for initialed steps as do the other Keowee procedures.

The description of how these features affected individual human reliability events is found in the summary descriptions of these events in Enclosures C.3-1 through C.3-3.

C.3.3.6.3 Quantification of Latent Human Errors

Latent human errors involve the improper post maintenance restoration of equipment.

C.3.3.6.3.1 Latent Human Error Quantification Methodology

The Keowee human reliability modeling was done at a more detailed level than previous human reliability efforts at Duke. Latent human errors were modeled at the level of major components such as air circuit breakers. In some cases, latent human errors were modeled at a level of sub-components such as control switches, disconnects or valves.

Event trees were developed to quantify latent human errors based on values found in NUREG/CR-1278 (THERP, Reference 3). These are included in this appendix as Figure C.3-1, Figure C.3-2 and Figure C.3-3.

Figure C.3-1 is the event tree for components which are functionally tested. Figure C.3-2 is the same event tree with no credit for a functional test. Figure C.3-3 is the Figure C.3-1 event tree with branch values set lower (due to credit for tagging procedures or key control).

The bordered section below describes the quantification for the latent human error event tree.

The branch values for these event trees were quantified as follows (refer to Figure C.3-1):

PM — This event indicates that maintenance was done. It is set to one (pre-initiator maintenance is assumed).

PROC. U? — This event asks whether a procedure which should be used for the maintenance is used. The value for this is based on Table 20-6 in the THERP document (Reference 3) "Failure to Use a Written Procedure Under Normal Operating Conditions." That event has a value of 1.0E-02. This is multiplied by 2 to account for a higher task load (for a resulting value of 2.0E-02). The task load number is arrived at using table 20-16 of the THERP document ("moderately high" task load, step by step procedures).

RESTORE? — This event asks whether the equipment is restored when the procedure is used. The value for this comes from Table 20-7 in the THERP document "Long List". The value for this (3.0E-03) is multiplied by 2 for task load (see PROC U? above).

MISTAKE? — This event models the failure to restore equipment if a procedure is available and should be used, but is not. The up branch probability is based on the value in THERP Table 20-7. This value has been multiplied by 2 for task load.

I. VERIF. — This event asks whether a mistake, made while following a maintenance procedure, was captured due to independent

verification. The value is taken from THERP Table 20-22 (item 1). This is multiplied by 2 for task load.

OP. TEST This event asks whether a mistake, made during maintenance, was captured during an operability test. The value for this event (0.05) is not based on THERP. However, this value is conservative compared to the value found in the RMIEMP document (NUREG/CR-4772, a value of 0.01is found on page 4-6). A higher value for OP. TEST is used for the case where no procedure was used for the initial maintenance.

A value of 0.1 is used to credit the daily rounds sheet. This value is found in NUREG/CR-4772 (Reference 6) on page 4-6.

For items which are tagged (Figure C.3-3), the value for the RESTORE? and MISTAKE? events were divided by the error factor (the error factor was 5 in both cases).

Air circuit breaker components are tagged and controlled by keys during maintenance. However, for a "generic" latent human error which prevents these breakers from opening and closing, no additional credit is taken for red tags or key control. This is because the breaker maintenance may involve work on components which are not specifically tagged.

Note: Credit is taken for tags for the more specific LHE event of the neutral ground disconnects left open (see enclosure C.3-1 for events GK1NGDCLHE and GK2NGDCLHE). Credit for tags is also taken for the LHE for CT-4 disconnects (event SXFRCT4LHE).

The latent human error events were classified as follows:

1) Post maintenance errors for components which are not functionally tested and not checked on the daily rounds sheet.
2) Post maintenance errors for components which are not functionally tested but which are checked on the daily rounds sheet.
3) Post maintenance errors for components which are functionally tested.

4) Post maintenance errors for components which are functionally tested and which have a red tags associated with maintenance.

The following values are assigned to the types of errors above:

1) 3.2E-03 - Based on Figure C.3-2
2) 3.2E-04 - Based on Figure C.3-2, X 0.1
3) 2.6E-04 - Based on Figure C.3-1
4) 5.2E-05 - Based on Figure C.3-3

C.3.3.6.3.2 Latent Human Error Quantification Results

Summary descriptions of the latent human error events and the quantification results are found in Enclosure C.3-1.

Data sheets were filled out for all Latent Human Error events. These are the same data sheets used for other types of events. A sample data sheet (filled out) is included as Figure C.3-4.

C.3.3.6.4 <u>Quantification of DHE and RHE Events</u>

C.3.3.6.4.1 DHE and RHE Event Quantification Methodology

DHE and RHE events involve operator response to abnormal conditions.

Methodologies for evaluating these events fall into the general categories of *time reliability* models and *cause based* models. A time reliability model would include a correlation which could be used, with such data as available time and required time, to produce a human error probability. A cause based model would include a correlation which would use such parameters as *type of procedure* and *staffing level* to produce a human error probability.

A shortcoming commonly found in human reliability models for post initiator events is that the correlations do not address the "action phase" of a modeled event. Since these models only look at the *thought process* of an event, any error associated with the *actions* of the event is not explicitly accounted for.

Previous PRAs at Duke were done using a version of the EPRI Human Cognitive Reliability (HCR) model. This is a time reliability model. For this analysis, it was decided to use a more recent, cause based, correlation. The correlation used was the decision tree model of EPRI TR-100259 (Reference 4).

The EPRI TR-100259 decision tree model has the advantages that it forces a detailed review of procedures associated with the event and that it uses "performance shaping factors" to arrive at event probabilities. Performance shaping factors are factors such as procedure structure and training levels that can influence human behavior. The lack of explicit modeling of this sort of factor was noted by expert reviewers as a drawback of the HCR model.

Because the decision tree model relies on features associated with procedures, it cannot be applied to non-proceduralized actions. For the Keowee Reliability Analysis, any non-proceduralized events are quantified using engineering judgment.

The failure probability values obtained from the decision tree approach does not account for the "action phase" of the events. Failure associated with the "action phase" is accounted for by adding a value of 0.05 to the human error probabilities for those events which involved a series of actions outside of the control rooms. The value of 0.05 is judged to be conservative compared to values obtained from other sources (THERP and the HCR model).

C.3.3.6.4.2 DHE and RHE Event Quantification Results

Summary descriptions of the DHE and RHE events and the quantification results are found in Enclosure C.3-2

A sample data sheet filled out for an RHE event is included as Figure C.3-4 in this appendix. Such sheets were filled out for all explicitly modeled human reliability events.

C.3.3.6.5 <u>Quantification of Errors of Commission</u>

Errors of commission are caused by erroneous decision making, a poor understanding of the rules and procedures or inadequate problem solving, which result in inappropriate

actions being taken. This type of error is not normally included in reliability (or risk) analysis because of the difficulty in identifying such errors. This has been noted by some as a deficiency of most past PRA efforts (in the industry).

Errors of commission were considered for the Keowee Reliability Analysis because errors of this type were identified during the review of operating history.

Techniques for identifying and quantifying errors of commission for risk and reliability analysis are relatively new. These techniques involve a detailed review of procedures to discover opportunities for errors of commission. During the review of Keowee (and relevant Oconee) procedures, no obvious procedure deficiencies, which could lead to errors of commission, were discovered. However, the review of operating history indicated that errors of commission had occurred in the past.

The two errors of commission identified both occurred during the October 19, 1992 loss of offsite power event at Oconee Unit 2 (LER 270/92-04). One error was the tripping of ACB-1 (the output breaker from the overhead aligned unit) by the Keowee operator. This happened because the operator failed to realize that an emergency start had occurred. Another error was the premature resetting of Keowee emergency start signals by operators at Oconee. Because Keowee had a normal lockout, this caused Keowee Unit 2 to trip. These errors have led to design and procedural changes that would make them unlikely in the future.

Because of corrections made for past commission errors, and because no obvious problems were noted in the review of procedures, errors of commission were not modeled for the current configuration of Keowee. Instead, the past errors of commission were assigned values for a sensitivity study on the effects of changes made since October 1992.

C.3.3.6.5.1 Error of Commission Quantification Methodology

The quantification method used for evaluating errors of commission for the Keowee Reliability Analysis project is found in a report entitled INTENT: A Method For Estimating Human Error Probabilities for Errors of Intention (EGG-SRE-9178, Reference 5). This method involves classifying the errors and using performance shaping factors to evaluate the probability values based on an assumed distribution.

C.3.3.6.5.2 Error of Commission Quantification Results

Summary descriptions of the identified errors of commission and the quantification results are found in Enclosure C.3-3.

C.3.3.7 APPLICATION OF DHE AND RHE EVENTS

Once the Keowee fault tree was solved, some of the resulting sequences could still be "recovered" with credit for operator action. The DHE and RHE events used were identified at a meeting of the Keowee Reliability Analysis project team. These DHE and RHE events were then quantified using the method described in section C.3.3.5.5 above.

Recovery rules were developed for applying the recoveries to individual sequences. These recovery rules are described in Enclosure C.3-4.

As a "reality check" the DHE and RHE events were discussed with a Keowee on call operator. Recovery methods were also reviewed when the draft of this report was reviewed by Keowee and Oconee plant personnel.

C.3.3.8 INTERNAL REVIEW OF HUMAN RELIABILITY ANALYSIS

C.3.3.8.1 Review of DHE and RHE Events

The initial list of recovered Keowee PRA sequences was reviewed by a Keowee on call operator. The purpose of this review was to insure that all DHE and RHE events identified by the Keowee Reliability Analysis project team were realistic responses to the conditions in the sequences. The review also verified that the situation in the sequence of events would be noticeable and that there were no circumstances in the sequence of events which would prevent a timely response.

The operator review of modeled DHE and RHE events resulted in a slight change in the definition of one DHE event.

C.3.3.8.2 Sensitivity Studies

A sensitivity study was performed to judge the effects on Keowee reliability of changes made to procedures since October 1992. These changes had effects on some latent human errors and recoveries. For the pre-October 1992, case errors of commission were also modeled.

The review of procedures for this sensitivity study indicated that , for the most part, procedures were little changed prior to October 1992. However, some values were changed for the pre-October 1992 case.

Some latent human error events had values increased for the pre-October 1992 case, these were:

> EK1BASELHE and EK2BASELHE
> These events model the base adjust for the Keowee voltage regulators being set incorrectly. Prior to October 1992, this failure was more likely (due to a lack of written setpoint guidance).
>
> PT1TSDCLHE and PT2TSDCLHE
> These are latent human errors for the turbine wheel pit sump pump. During the procedure review, it was not verified that a maintenance procedure for these pumps existed prior to October 1992. The value for these events was raised accordingly. This conservative approach did not significantly change the results.

Some DHE and RHE events had values increased for the pre-October 1992 case, these were:

> ABEOPRCDHE
> This is the action to close the overhead breaker for the overhead aligned unit at Keowee. Prior to October 1992, there was no procedural guidance for this action.

FK0FL00DHE

This is the event for the guide bearing oil strainer clogged. In the past there was no specific guidance in procedures to swap these strainers.

XD1K1B1XDHE and XD2KB2XDHE

These events model a failure to align the standby battery chargers. In the past procedures to do this were not as clear.

Some errors of commission were included in the modeling for the pre-October 1992 case these were:

ACBTRIPCHE

This event models the error of inadvertently tripping a Keowee output breaker. The lack of procedural guidance prior to October 1992 made this sort of event more likely.

YKEMSTRCHE

This event is an incorrect resetting of Keowee emergency start signals. Prior to October 1992, the lack of procedural guidance made this event more likely.

The results of the sensitivity study for pre-1992 conditions can be found in section 7.5.

C.3.3.8.3 Review of Draft Report

The Keowee human reliability analysis was reviewed at a preliminary stage by members of the Keowee PRA team and by an outside consultant. The draft results of this report were also reviewed by Keowee personnel.

These reviews resulted in slight changes to the model for evaluating latent human errors and to a change in the way the model for evaluating DHE and RHE events was applied.

C.3.4 IMPLICIT MODELING / COMMON CAUSE HUMAN ERRORS

Human reliability actions are often accounted for implicitly in reliability and risk modeling. This can be the result of modeling of failure data which includes human actions or this can be the result of human actions accounted for in the way fault tree sequences are recovered.

In the Keowee PRA analysis human reliability actions are implicitly considered in the common cause analysis. For this reason, common cause latent human error events have not been explicitly modeled.

Dependencies (which may lead to common cause failure) of DHE and RHE events have been considered in the modeling and recovery process. For example, the events to recover the standby battery chargers (XD1B1XDHE and XD2B2XDHE) rely on similar procedures and components. In the initial sequence solution, these events were set to one to insure that they would not appear together in the same sequence.

Human reliability actions are also implicitly considered in the modeling of some initiating events such as the loss of offsite power at Oconee. This is not a direct consideration with regard to the Keowee Reliability Analysis results because the loss of power initiating event is not explicitly considered.

C.3.5 INSIGHTS AND RECOMMENDATIONS

Based on sensitivity studies performed, it was concluded that human reliability actions do not greatly affect the overall result of the Keowee reliability analysis. Nevertheless, some observations of features which could be improved were made during this review.

The following observations and recommendations are made:

Observation Alarm response procedures at Keowee do not include "place keeping aides". These procedures are considered "information only".

Recommendation
The response procedure for cooling water low flow alarms (1(2)SA2-28) provides an important response to the common cause clogging of Keowee cooling water strainers. This procedure should be changed to include sign off spaces ("place keeping aides") .

Observation
There is no guidance for local operation of Keowee auxiliary power breakers (ACB-5 or ACB-7, or ACB-6 or ACB-8) in the Keowee Emergency Start procedure (AP/0/A/2000/02). Operation of these breakers locally can overcome breaker control system failures.

Recommendation
Guidance for local operation of Keowee auxiliary power breakers (ACB-5 or ACB-7, or ACB-6 or ACB-8) should be placed in the Keowee Emergency Start procedure (AP/0/A/2000/02).

Observation
The procedure which includes maintenance on Keowee generator air coolers (MP/0/A/2005/1) does not include valve numbers or initialed steps for generator air cooler valves.

Recommendation
Procedure MP/0/A/2005/1 should include valve numbers and initialed steps (including independent verification for restoration) for generator air cooler valves.

C.3.6 RESULTS

The result of the Keowee human reliability analysis is the list of events shown in Table C.3-1. These events were used in Keowee Reliability Analysis to calculate the overall probability of Keowee failure. These events are also described in more detail in Enclosures C.3-1, C.3-2 and C.3-3.

C.3.7 REFERENCES

1) Wakefield, D. J. et. al., SHARP 1 - A Revised Systematic Human Action Reliability Procedure EPRI, EPRI TR-101711, December 1992.

2) Minarick, J. W. et al, Precursors to Potential Severe Core Damage Accidents: (1984- 1992) A Status Report, Vols. 1-18, Oak Ridge National Laboratory, NUREG/CR-4674.

3) Swain, A. D., H. E. Guttmann, Handbook of Human Reliability Analysis with Emphasis on Nuclear Plant Applications Final Report, Sandia National Laboratories, NUREG/CR-1278, August 1983.

4) Parry, G. W., Lydell B. O. Y., An Approach to the Analysis of Operator Actions in Probabilistic Risk Assessment, Halliburton NUS Environmental Corp, Gaithersburg, Maryland, EPRI-TR-100259, October 1992.

5) Gertman, David I., et. al., INTENT: A Method For Estimating Human Error Probabilities for Errors of Intention, EG&G Idaho, Idaho Falls, EGG-SRE-9178, November, 1990.

6) Swain, A. D., Accident Sequence Evaluation Program Human Reliability Analysis Procedure, Sandia National Lab SAND86-1996, NUREG/CR-4772, February 1987.

Enclosure C.3-1

LATENT HUMAN ERROR SUMMARY DESCRIPTIONS

The following list includes summary descriptions of the Latent Human Error (LHE) events in the Keowee human reliability analysis. The considerations used for quantification of these events include whether the components changed were independently verified, functionally tested, or checked on the Shift Turnover and Rounds Sheet (procedure OP/0/A/2000/043).

AB2OPENLHE, AB2CLOSLHE

These events are failures of the Keowee overhead path breaker (for the overhead aligned unit) to open (AB2OPENLHE) or close (AB2CLOSLHE) due to a latent human error. This breaker is air operated.

The removal and restoration of this breaker is done per procedure OP/0/A/2000/006. During this procedure, the interconnecting air valve for the breaker air supply is repositioned, and the breaker disconnect is red tagged. For some maintenance, air would be vented from the breaker per a separate procedure specific to the maintenance event. An operability verification is performed upon restoration.

The latent human error disabling this breaker considers that procedure steps are double verified, and that there is a post maintenance operability (functional) test of the breaker. The possibility of the functional test failing to detect the condition is considered in the analysis of this event. This concern may be more valid for the air operated circuit breakers because during the test the breaker air compressors are operating, but during a black start they will not be.

These events are assigned a value of 2.6E-04 based on Figure C.3-1.

AB4CLOSLHE

This event is a failure of the Keowee underground path breaker (for the overhead aligned unit) to close due to a latent human error. This breaker is air operated.

The removal and restoration of this breaker is done per procedure OP/0/A/2000/008. During this procedure, the interconnecting air valve for the breaker air supply is repositioned, and the breaker disconnect is red tagged. For some maintenance, air would be vented from the breaker per a separate procedure specific to the maintenance event. An operability verification is performed upon restoration.

The latent human error disabling this breaker considers that procedure steps are double verified, and that there is a post maintenance functional test of the breaker.

This event is assigned a value of 2.6E-04 based on Figure C.3-1.

AB51431LHE, AB61432LHE

These events are leaving the auto/manual transfer switch for buses 1X or 2X in manual. When in auto, these switches would cause the buses to automatically transfer to their alternate power source if the source feeding them were de-energized.

These switches are transferred during maintenance procedures on the auxiliary power breakers and during procedure OP/0/A/2000/049 the Auxiliary Power Transfer Test. In these procedures, these switches are double verified for changes of position.

The position of these switches is a check off item on the Keowee shift turnover and rounds sheet (OP/0/A/2000/043).

This event is evaluated using Figure C.3-2 with an extra factor of 0.1 credit taken for the rounds sheet. The value used is 3.2E-04.

AB5CLOSLHE, AB6CLOSLHE, AB7CLOSLHE, AB6OPENLHE, AB7OPENLHE

These events are failures of auxiliary power breakers ACB-5, ACB-6, and ACB-7 due to latent human errors. These are not air operated breakers.

ACB-5 is removed for maintenance and restored per OP/0/A/2000/009. ACB-6 is removed and restored per OP/0/A/2000/010. ACB-7 is removed and restored per OP/0/A/2000/11.

When one of the underground auxiliary breakers is removed from service, the overhead auxiliary breaker for that unit is placed in service. Likewise, when an overhead auxiliary breaker is removed from service, the underground auxiliary breaker for that unit is placed in service.

When these breakers are restored to service, they are closed. Thus, these breakers are functionally tested for closing. However, there is no step in the restoration procedures to cycle these breakers. Therefore, the events for the breakers failing to close (AB5CLOSLHE, AB6CLOSLHE, AB7CLOSLHE) are evaluated with Figure C.3-1 which credits a functional test, and assigned a value of 2.6E-04. The events for the breakers failing to open (AB6OPENLHE, AB7OPENLHE) are evaluated with Figure C.3-2 which does not credit a functional test. These events are assigned a value of 3.2E-03.

BK1GBDCLHE, BK2GBDCLHE

These events model a failure of DC turbine guide bearing oil pumps due to a latent human error. BK1GBDCLHE corresponds to the Unit 1 pump and BK2GBDCLHE corresponds to the Unit 2 pump.

These pumps are removed from service and restored per OP/1/A/2000/30 and OP/2/A/2000/30 (for Unit 1 and 2 respectively). These procedures include independent verification. The pumps are tested for indication of operation from the control panel, but since this does not check flow, it is not counted as a functional test. Therefore, these events are evaluated with Figure C.3-2 and assigned a value of 3.2E-03.

EK1BASELHE, EK2BASELHE

These events model a failure to correctly set the voltage regulator base adjust (for Units 1 and 2 respectively). These actions were represented by one failure of this nature in the Keowee operating history. There is no established maintenance procedure for making the base voltage adjustment. In the event that the base adjust had to be set, a special procedure would have to be written to do this. It is assumed that this procedure would include independent verification.

The voltage regulator has an automatic feature which would function even in the event that these settings were not correct. Therefore, incorrect settings may go undetected. No credit is taken for discovery of this error during an operational test. These events are assigned a value of 3.2E-03 based on Figure C.3-2

EK1FLDCLHE, EK1FLSCLHE, EK1FLSOLHE, EK1SPYCLHE, EK2FLDCLHE, EK2FLSCLHE, EK2FLSOLHE, EK2SPYCLHE

These events are associated with the Keowee generator field and field flashing breakers.

Events EK1FLDCLHE and EK2FLDCLHE are the failures of the Unit 1 and Unit 2 (respectively) field breakers to close due to a latent human error. Events EK1FLSCLHE, and EK2FLSCLHE are the failures of the Unit 1 and Unit 2 (respectively) field flashing breakers to close due to a latent human error. Events EK1FLSOLHE and EK2FLSOLHE model the situation where a field flashing breaker could fail to re-open due to some situation caused by a latent human error. Lastly, events EK1SPYCLHE and EK2SPYCLHE are failures of the Unit 1 and Unit 2 field supply breakers to close due to latent human error.

There is assumed to be independent verification for post maintenance restoration of these breakers. Operator interviews also indicated that the generators would be verified operable after any maintenance that removed these breakers from service. Therefore, an operability test is assumed.

These events are assigned a value of 2.6E-04 based on Figure C.3-1.

FK1120GLHE, FK2120GLHE

These events represent the control switch for turbine generator cooling water valves (switch S-120G, the "TG CW" switch) not being in the AUTO position (for Units 1 and 2 respectively).

Credit is taken for independent verification of these switches. Credit is taken for a functional test for the Unit 2 switch because Unit 2 (the overhead aligned unit) is assumed to be tested frequently by paralleling to the grid. No credit is taken for a functional test for the Unit 1 switch.

These switches are located in the Keowee control room on control boards CB-2 and CB-9 (for Unit 1 and 2 respectively). These control boards are checked on the Keowee rounds sheet. However, since this control switch is not a separate item on the sheet, no credit is taken for this check.

Event FK1120GLHE (for the underground unit) is assigned a value of 3.2E-03 based on Figure C.3-2. Event FK2120GLHE (for the overhead unit) are assigned a value of 2.6E-04 based on Figure C.3-1.

GK1BRGVLHE, GK2BRGVLHE

These events are post maintenance failures of the turbine thrust bearing oil heat exchanger cooling water valves due to human error. These valves are repositioned during maintenance on the thrust bearing heat exchangers.

The thrust bearing heat exchangers are removed and restored to service per procedures OP/1/A/2000/0047 and OP/2/A/2000/0047 for Units 1 and 2 respectively. There is a flow test in these procedures. This is considered an operability test.

These events are assigned a value of 2.6E-04 based on Figure C.3-1.

GK1COOLLHE, GK2COOLLHE

These events are post maintenance failures of the generator air cooler heat exchanger cooling water valves due to human error. These valves are repositioned during maintenance on the generator air cooler heat exchangers.

The generator air cooler heat exchangers are removed and restored to service per procedure MP/0/A/2005/001. This procedure includes "QA Inspector" initial blocks which were counted in this analysis for independent verification credit. This procedure includes a step to run the generator at full load (if possible) while observing temperature. This is counted as a functional test.

These events are assigned a value of 2.6E-04 based on Figure C.3-2.

GK1NGDCLHE, GK2NGDCLHE

These events are a post maintenance failure to close the neutral ground disconnects (for Units 1 and 2 respectively) due to human error.

These disconnects are opened and tagged per the procedures to remove the generators from service (OP/0/A/2000/13 and OP/0/A/2000/14 for Units 1 and 2 respectively). These procedures include independent verification and a post-maintenance operability verification.

During quantification of this event, credit is taken for the tag clearing being another level of verification.

These events are assigned a value of 5.2E-05 based on Figure C.3-3.

OK1001BLHE, OK1001CLHE, OK2001BLHE, OK2001CLHE

These events are post maintenance failures of the B and C governor oil pumps (for Units 1 and 2).

These pumps are removed from service and restored to service per procedures OP/0/A/2000/027 and OP/0/A/2000/028 (for Units 1 and 2 respectively). These

procedures include independent verification, but do not include a post maintenance operability verification.

These events are assigned a value of 3.2E-03 based on Figure C.3-2.

PK1TSDCLHE, PK2TSDCLHE

These events are a failure of the DC turbine wheel pit sump pumps (for Unit 1 and 2 respectively) following maintenance due to human error.

These pumps are removed for maintenance and restored per procedure OP/1/A/2000/034. The procedure includes independent verification steps, but does not include an operability test. If the breaker for one of these pumps is left open, this condition will be alarmed. However, it is assumed that the pumps could be rendered inoperable in some other way.

These events are assigned a value of 3.2E-03 based on Figure C.3-2.

SXFRCT4LHE

This event models a latent human error on transformer CT-4. This could happen if the transformer 4160 V disconnects were left open, or were not fully closed after testing.

The transformer 4160 V disconnects are opened during testing about once every three years. There is no post-maintenance test of the disconnects which would insure that they would carry load, however, every 18 months another test is performed that does functionally test the disconnects.

The disconnect enclosure is kept locked. The disconnects would be controlled by tags during transformer maintenance and testing. Every eight hours, a continuity test is performed per the Oconee rounds sheet that tests continuity through the disconnects, however, this test does not test the ability of the disconnects to carry load.

The quantification of this LHE event is a special case. Figure C.3-3 (credit for tags or key control) is modified by removing credit for functional testing. This gives a value of 6.4E-04 for the event. Credit (0.1) for the check on the rounds sheet is then taken. It is

judged that the rounds sheet check would reveal most disconnect problems. The resulting event value is 6.4E-05.

<u>WK1GVDCLHE, WK2GVDCLHE</u>

These events model a failure of the Keowee governor due to a latent human error. WK1GVDCLHE corresponds to the Keowee Unit 1 governor. WK2GVDCLHE corresponds to the Keowee Unit 2 governor.

Work is performed on the governor permanent magnets which are removed from service and restored per procedures OP/0/A/2000/35 AND OP/0/A/2000/36 (for Unit 1 and 2 respectively). These procedures include independent verification and a functional test. Therefore, events WK1GVDCLHE and WK2GVDCLHE were quantified using Figure C.3-1 and were assigned a value of 2.6E-04.

Enclosure C.3-2

DHE AND RHE EVENT SUMMARY DESCRIPTIONS

The following list includes summary descriptions of the DHE and RHE events in the Keowee human reliability analysis. Each event is assumed to occur after a loss of offsite power to Oconee and some failure of Keowee systems.

For proceduralized (DHE) events, the decision tree method of EPRI-TR-100259 is used. The quantification depends on features of the procedures such as the presence of initialed steps ("place keeping aids").

Some actions are judged to involve a significant failure probability associated with the "action phase". The EPRI decision tree approach does not address this phase of the events. For these events, a value of 0.05 is added to account for the failures associated with the action phase. This value is judged to be conservative based on a review of THERP numbers for valve manipulation errors (see Reference 3, Table 14-1).

The EPRI-TR-100259 event tree method allows credit for "revisitation" of procedure steps based on the structure of the procedure or credit for extra crew. Keowee procedures are not set up for revisiting steps. Initially, there is assumed to be one operator on a roving watch at Keowee. Because of considerations like these, "revisitation" was not credited in this analysis.

AB0SWGRRHE

This event is a failure to recover power to one or both of the Keowee auxiliary buses via manual breaker manipulation outside of the Keowee control room.

This action would be taken following a breaker control problem which resulted in a failure of automatic breaker closure and a failure of breaker closure from the Keowee control room.

Based on past LERs and past communication with Keowee, there is assumed to be one hour available before loss of governor oil causes the Wicket gates to the Keowee turbines to fail as is. This failure is assumed to result in a failure of Keowee turbines.

The action to manually close the auxiliary bus breakers is not included in the Keowee emergency start procedure (AP/0/A/2000/002). However, the emergency start procedure has operators attempt to close the auxiliary bus breakers from the Keowee control room and then contact the Keowee on call operator. Based on interviews, the Keowee on call operator could arrive at Keowee in one hour.

The attempt to perform this action may be delayed due to troubleshooting of the breaker closure circuits.

This event is quantified in a published precursor report (Reference 2, Vol. 18 P. B-82) at 0.43.

Based on the above information, a value of 0.5 is conservatively assigned to this action. This value is near the high end of human error estimates. This estimate is consistent with a time reliability quantification of the event where there is as much time available as required. This estimate is assumed to include the probability of any hardware failures and failures of the "action phase".

The data sheet for this event is included as Figure C.3-4.

ABEOPRCDHE

This event is a failure to close the overhead aligned breaker to the overhead unit (assumed to be ACB-2) from the Keowee control room if this breaker fails to close automatically.

This event is proceduralized in the Keowee emergency start procedure, AP/0/A/2000/002. This procedure is trained on by Keowee personnel and all Oconee operating personnel. This procedure focuses on the restoration of power to Keowee auxiliary buses.

This action would be taken after other attempts to restore power to the 2X bus had failed, and stat. alarm 1SA1-20 (600 V swgr. 2X pwr. supply trouble) was locked in.

In order to perform this action, the Keowee operators would check that the main transformer was not locked out and that switchyard breakers PCB-8 and 9 were opened. The check of the main transformer lockout (86T) would be done on the back of the control board in the Keowee control room, while the check of switchyard breakers would require communication with Oconee.

This event is quantified using the method in EPRI TR-100259. For the quantification, the Keowee emergency start procedure is assumed to be practiced. Based on this, and on other details of the procedure, a value of 9.0E-03 is assigned to this event. Because this action can be accomplished from the Keowee control room, the "action phase" of the event is not judged to be a significant contributor. Failures of hardware required for successful accomplishment of this event are explicitly accounted for in the Keowee fault trees.

ABPOPRCDHE

This event is a failure to close the underground aligned breaker to the overhead unit (assumed to be ACB-4) from the Oconee control room if this is the only way to restore power to the Oconee main feeder buses.

This event is proceduralized in the Oconee loss of power procedure, AP/1/A/1700/11. This procedure is trained on by all Oconee operating personnel. Step 5.3 in the loss of power procedure refers operators to section 501 which includes the step to close the Keowee underground breakers. Accomplishment of this step requires recognition that transformer CT-4 is not energized, and requires a transfer of breaker control from Keowee to Oconee.

This event is quantified using the method in EPRI TR-100259. For the quantification, the Oconee loss of power procedure are assumed to be practiced. Based on this, and on other details of the procedure, a value of 9.0E-03 is assigned to this event. Because this action can be accomplished from the Oconee control room, the "action phase" of the event is not judged to be a significant contributor. The probabilities of failures of

hardware required for successful accomplishment of this event are estimated to be negligible compared to the value assigned.

The need to perform the action modeled in this event should be obvious. However, given that this step in the procedure is missed, it is judged to be unlikely to be found by "revisitation". Therefore, the basic human error rate is not modified with recovery credit.

EK0BASEDHE

This event is a failure to recover a miss-setting of the Keowee voltage regulator base adjust. This is done by placing the regulator in manual control and setting the base adjust.

Since no credit is taken for the Keowee voltage regulator automatic adjust feature in the Keowee Reliability Analysis, it is assumed that the failure of the base adjust would cause a noticeable problem with the Keowee unit output voltage. The unit output voltage is verified in the first immediate action of procedure AP/0/A/2000/002, the Keowee emergency start procedure. However, if correct voltage is not obtained, this procedure does not direct an operator response.

The condition is also assumed to cause a "Generator Regulator Trip" stat. alarm at Keowee. The stat. alarm procedures at Keowee do not include sign-off blocks. The stat. alarm procedure directs the operator to put the regulator in manual and perform a manual startup of the Keowee unit. The emergency start AP includes instructions for manual unit start.

This event is quantified using the method in EPRI TR-100259. However, credit is not taken for training or practice on the procedures (based on reliance on a stat. alarm procedure). Multiple procedures are assumed to be in use. No credit was taken for "place keeping aids." Based on these considerations, and on other details of the procedures, a value of 1.90E-02 was assigned to this event. Because this action can be accomplished from the Keowee control room, the "action phase" of the event is not judged to be a significant contributor. The probabilities of failures of hardware required for successful accomplishment of this event are estimated to be negligible compared to the value assigned.

FK0FISHDHE

This event is a failure to recover simultaneous plugging of the main Keowee raw water strainers for both units (strainers 1WL FL001 and 2WL FL001).

The clogging of the strainers is assumed to cause stat. alarms 1SA2-28 and 2SA2-28. These are cooler water flow alarms (for Units 1 and 2 respectively). The response procedures for these alarms direct the swapping of strainers. As with other alarm response procedures, these procedures do not include "place keeping aids". For this action, it was assumed that the debris clogging would necessitate multiple strainer swaps and strainer cleaning.

This action, concurrent with an emergency start and a loss of power at Oconee, could be too much for a single Keowee operator to do. The successful recovery of one Keowee unit would constitute success, however, the same problem on the other unit may be a distraction. An interview with a Keowee operator indicated that non-licensed operators (NLOs) from Oconee could get to Keowee in 10 minutes when required. The interview also indicated that the Keowee operator considered there would be ample time available for this action, and that this action would be reliable.

This event is quantified using the method in EPRI TR-100259. However, credit is not taken for training or practice on the procedures. Multiple procedures are assumed to be in use. No credit is taken for place keeping aids. Because this action included a series of steps outside of the control room, the action phase is judged to be significant. A value of 0.05 was added to the human error probability to account for this. Based on these considerations, a value of 6.3E-02 is assigned to this event. The probabilities of failures of hardware required for successful accomplishment of this action are estimated to be negligible compared to the value assigned.

FK0FL00DHE

This event is a failure to recover clogging of strainers for the guide bearing and packing boxes. This event assumes that this clogging does not take place for both units at the same time.

The clogging of the strainers is assumed to cause stat. alarms 1SA2-7 or 2SA2-7, or 1SA2-8 or 2SA2-8. These are guide bearing high temperature and packing box high temperature alarms (for Units 1 and 2 respectively). When the response procedures for these alarms were reviewed, they did not include guidance to swap these strainers, however, this oversight was being corrected. This action was evaluated as if these procedures <u>did</u> include guidance to swap strainers. As with other alarm response procedures, these procedures do not include "place keeping aids".

This event is quantified using the method in EPRI TR-100259. However, credit is not taken for training or practice on the procedures. Multiple procedures are assumed to be in use. No credit is taken for place keeping aids. Because this action included a series of steps outside of the control room, the action phase was judged to be significant. A value of 0.05 is added to the human error probability to account for this. Based on these considerations, a value of 6.3E-02 is assigned to this event. The probabilities of failures of hardware required for successful accomplishment of this action are estimated to be negligible compared to the value assigned.

<u>FK0GBHXDHE</u>

This event is a failure to recover a miss-positioning of valves for the heat exchanger for the Keowee turbine guide bearing.

The isolation of the heat exchanger is assumed to cause alarms 1SA2-7 or 2SA2-7 (for Unit 1 or Unit 2). These are guide bearing high temperature alarms. The response procedures for these alarms include guidance to unisolate the heat exchangers associated with the guide bearings. As with other alarm response procedures, these procedures do not include "place keeping aids". For this action, it is assumed that the debris clogging will necessitate multiple strainer swaps and strainer cleaning.

The heat exchanger which would be affected by this strainer clogging is isolated six to eight months of the year. This indicates that the heat load from the guide bearing is very small. However, during an emergency start, both Keowee generators would be lightly loaded. The light load on the generators would lead to more wobble of the turbines and would put more load on the bearing.

This event is quantified using the method in EPRI TR-100259. However, credit is not taken for training or practice on the procedures. Multiple procedures are assumed to be in use. No credit is taken for place keeping aids. Because this action included a series of steps outside of the control room, the action phase is judged to be significant. A value of 0.05 is added to the human error probability to account for this. Based on these considerations, a value of 6.3E-02 is assigned to this event. The probabilities of failures of hardware required for successful accomplishment of this action are estimated to be negligible compared to the value assigned.

<u>GK0BRGVRHE</u>

This event is a failure to reopen thrust bearing oil cooler flow path cooling water valves if they are left closed following maintenance.

The isolation of these valves is assumed to cause alarms 1SA2-22 or 2SA2-22 (for Unit 1 or Unit 2). These are thrust bearing high temperature alarms. The response procedures for these alarms include guidance to check the piping to the coolers, but do not specifically mention isolation valves.

There is assumed to be ample time to complete this action. However, during an emergency start, both Keowee generators would be lightly loaded. The light load on the generators would lead to more wobble of the turbines and would put more load on the bearings.

This event is quantified at 0.10. It is about as likely as other actions based on temperature alarm responses which are quantified at 6.3E-02. The 0.10 value is assumed to include any contribution of hardware failures or the action phase of the event.

<u>XD0KBATRHE</u>

This event is a failure to cross connect DC (1DA and 2DA) distribution centers after a failure of one of the Keowee batteries.

This action is not proceduralized. An interview with a Keowee on call operator indicated that this action would be unlikely. Performance of this action would violate a philosophy of unit separation.

This action is assigned a value of 1.0 (failure is assumed). It is retained in the Keowee Reliability Analysis for a sensitivity study.

XD1KB1XDHE, XD2KB1XDHE

These recoveries are failures to line up the standby battery charger in one hour given the failure of the Keowee Unit 1 or Unit 2 battery charger.

The actions considered would be taken in response to alarms 1SA1-44 or 2SA1-44, which are the battery trouble alarms for Unit 1 and Unit 2 respectively. These alarm response procedures direct the operator to align the standby battery charger, but do not include the necessary steps. Instead, the alarm respoonse procedures refer to procedures OP/0/A/2000/021 and OP/0/A/2000/22 (procedures for battery charger number 1 and number 2 respectively) include an enclosure which is designed to enable a lone Keowee operator to complete the alignment.

This event is quantified using the method in EPRI TR-100259. Multiple procedures are assumed to be in use. No credit is taken for place keeping aids (due to the alarm response procedure). Because this action includes a series of steps outside of the control room, the action phase is judged to be significant. A value of 0.05 is added to the human error probability to account for this. Based on these considerations, a value of 6.0E-02 could be assigned to these events, however, a conservative value of 9.3E-02 is assigned based on a previous quantification. The probabilities of failures of hardware required for successful accomplishment are estimated to be negligible compared to the value assigned.

Y0STARTRHE

This event is a failure to perform a normal start of at least one Keowee unit after a failure of the emergency start signals to both Keowee units.

Due to the failure of emergency start signals, emergency start indication would also fail. Because there is no cue for the operator response, this action is assumed to not to be proceduralized. The Keowee operator would have to be notified of this condition by operators at Oconee.

Due to the frequent starting of Keowee, operators would have a recent indication that at least one unit was capable of normal starting. However, this action may be delayed by trouble shooting of the emergency start circuit and efforts to restore power to Oconee from other sources.

Based on the above information, a value of 0.5 is assigned to this action. This value, based on engineering judgment is near the high end of human error estimates. This estimate is assumed to include the probability of any hardware failures and failures of the "action phase."

Enclosure C.3-3

COMMISSION HUMAN ERROR SUMMARY DESCRIPTIONS

The following list includes summary descriptions of the errors of commission (CHE) events in the Keowee human reliability analysis. Both of the events listed were assumed to occur after a loss of offsite power to Oconee. These events result in some failure of Keowee systems due to human error. These events are not included in the base case of the Keowee Reliability Analysis model but are used for a sensitivity study on pre-October 1992 conditions.

ACBTRIPCHE

This event is a tripping of Keowee units by the Keowee operator following an emergency start. This could happen if the operator failed to realize an emergency start signal had occurred and wanted to keep the units from running "unloaded".

This event almost occurred in October 1992 following a loss of offsite power at Oconee (LER 270/92-04), when the operator tripped one of the unit output breakers. Since that time, an additional indication has been installed, and procedures have been implemented to avoid a reoccurrence of this event.

This event is evaluated with a method found in EGG-SRE-9178 (entitled INTENT: A Method for Estimating Human Error Probabilities for Errors of Intention, Reference 5). This method requires the categorization of events as one of 20 categories. Once events are categorized, the event probability is set between upper and lower bounds for the category based on the evaluation of performance shaping factors.

This event is categorized as #12, "symptoms noticed but incorrect interpretation". The resulting value for this action is estimated to be 2.8E-02.

YKEMSTRCHE

This event is a resetting of Keowee emergency start signals at Oconee before the normal lockouts on Keowee are cleared. This would cause the Keowee unit to trip.

This event occurred in October 1992 following a loss of offsite power at Oconee (LER 270/92-04). Since that time, additional procedure precautions have been added to avoid a reoccurrence of this event.

This event is evaluated with a method found in EGG-SRE-9178 (entitled INTENT: A Method for Estimating Human Error Probabilities for Errors of Intention, Reference 5). This method requires the categorization of events as one of 20 categories. Once events are categorized, the event probability is set between upper and lower bounds for the category based on the evaluation of performance shaping factors.

This event is categorized as #13, "correct action taken during wrong plant evolution". The resulting value for this action is estimated to be 5.7E-03.

Enclosure C.3-4

The table on the next two pages shows how DHE and RHE events were applied to Keowee sequences. The first column contains the DHE or RHE events. These are in bold letters. The second through sixth columns have events related to the DHE or RHE event.

If an event in column two through six does not have a minus sign in front of it, the DHE or RHE event applies to this event. If there were two such events in these columns, the DHE or RHE would apply to that combination of events.

Thus, the first event, EK0BASEDHE, applies to EK1BASELHE. Since it also appears in the second row with EK2BASELHE, it applies to this event.

If a DHE or RHE event is not to be applied to a sequence containing a particular event, that event is in columns two through six with a minus sign.

Recovery Rule Table

Recovery Event	Applies to......	But Not to..........			
EK0BASEDHE	EK1BASELHE	-ABPOPRCDHE	-ABEOPRCDHE	-XD1KB1XDHE	-XD2KB2XDHE
EK0BASEDHE	EK2BASELHE	-ABPOPRCDHE	-ABEOPRCDHE	-XD1KB1XDHE	-XD2KB2XDHE
FK0FISHDHE	FK0FISHCOM	-ABPOPRCDHE	-ABEOPRCDHE	-XD1KB1XDHE	-XD2KB2XDHE
FK0FISHDHE	FK2FL01FRF	-ABPOPRCDHE	-ABEOPRCDHE	-XD1KB1XDHE	-XD2KB2XDHE
FK0FISHDHE	FK1FL01FRF	-ABPOPRCDHE	-ABEOPRCDHE	-XD1KB1XDHE	-XD2KB2XDHE
FK0FL00DHE	FK2FL03FRF	-ABPOPRCDHE	-ABEOPRCDHE	-XD1KB1XDHE	-XD2KB2XDHE
FK0FL00DHE	FK1FL03FRF	-ABPOPRCDHE	-ABEOPRCDHE	-XD1KB1XDHE	-XD2KB2XDHE
GK0BRGVRHE	GK2BRGVLHE	-ABPOPRCDHE	-ABEOPRCDHE	-XD1KB1XDHE	-XD2KB2XDHE
GK0BRGVRHE	GK1BRGVLHE	-ABPOPRCDHE	-ABEOPRCDHE	-XD1KB1XDHE	-XD2KB2XDHE
Y0STARTRHE	Y0STARTCOM	-ABPOPRCDHE	-ABEOPRCDHE	-XD1KB1XDHE	-XD2KB2XDHE
Y0STARTRHE	L0EGTPSCOM	-ABPOPRCDHE	-ABEOPRCDHE	-XD1KB1XDHE	-XD2KB2XDHE
AB0SWGRRHE	XA1BKRSCOM	-ABPOPRCDHE	-ABEOPRCDHE	-XD1KB1XDHE	-XD2KB2XDHE
AB0SWGRRHE	XA2BKRSCOM	-ABPOPRCDHE	-ABEOPRCDHE	-XD1KB1XDHE	-XD2KB2XDHE
AB0SWGRRHE	XA56BKRCOM	-ABPOPRCDHE	-ABEOPRCDHE	-XD1KB1XDHE	-XD2KB2XDHE

Recovery Rule Table

Recovery Event	Applies to......	But Not to...........				
AB0SWGRRHE	XA78BKRCOM	-ABPOPRCDHE	-ABEOPRCDHE	-XD1KB1XDHE	-XD2KB2XDHE	
AB0SWGRRHE	AB0SWGRCOM	-ABPOPRCDHE	-ABEOPRCDHE	-XD1KB1XDHE	-XD2KB2XDHE	
XD0KBATRHE	XD2KBATBYF	-XD1DALTDHE	-ABPOPRCDHE	-ABEOPRCDHE	-XD1KB1XDHE	-XD2KB2XDHE
XD0KBATRHE	XD1KBATBYF	-XD2DALTDHE	-ABPOPRCDHE	-ABEOPRCDHE	-XD1KB1XDHE	-XD2KB2XDHE
Y0STARTRHE	Y0STARTCOM	-ABPOPRCDHE	-ABEOPRCDHE	-XD1KB1XDHE	-XD2KB2XDHE	
Y0STARTRHE	L0EGTPSCOM	-ABPOPRCDHE	-ABEOPRCDHE	-XD1KB1XDHE	-XD2KB2XDHE	

Table C.3-1

Keowee Human Reliability Events

Event	Description	Value
AB2CLOSLHE	Air Circuit Breaker 2 Fails To Close Due To A Latent Human Error	2.60E-04
AB2OPENLHE	Air Circuit Breaker 2 Fails To Open Due To A Latent Human Error	2.60E-04
AB4CLOSLHE	Air Circuit Breaker 4 Fails To Close Due To A Latent Human Error	2.60E-04
AB51431LHE	Manual/Auto Control Switch 143/1 Left In Manual	3.20E-04
AB5CLOSLHE	Air Circuit Breaker 5 Fails To Close Due To A Latent Human Error	2.60E-04
AB5OPENLHE	Air Circuit Breaker 5 Fails To Open Due To A Latent Human Error	3.20E-03
AB61432LHE	Manual/Auto Control Switch 143/2 Left In Manual	3.20E-04
AB6CLOSLHE	Air Circuit Breaker 6 Fails To Close Due To A Latent Human Error	2.60E-04
AB6OPENLHE	Air Circuit Breaker 6 Fails To Open Due To A Latent Human Error	3.20E-03
AB7CLOSLHE	Air Circuit Breaker 7 Fails To Close Due To A Latent Human rror	2.60E-04
AB7OPENLHE	Air Circuit Breaker 7 Fails To Open Due To A Latent Human Error	3.20E-03
BK1GBDCLHE	Latent Human Error Fails Unit 1 DC Guide Bearing Oil Pump Discharge Path	3.20E-03
BK2GBDCLHE	Latent Human Error Fails Unit 2 DC Guide Bearing Oil Pump Discharge Path	3.20E-03
EK1BASELHE	Keowee Unit 1 Base Adjust Is Set Incorrectly	3.20E-03
EK1FLDCLHE	Keowee Unit 1 Field Breaker Fails to Close Due to Latent Human Error	2.60E-04
EK1FLSCLHE	Keowee Unit 1 Field Flashing Breaker Fails to Close Due to Latent Human Error	2.60E-04
EK1FLSOLHE	Keowee Unit 1 Field Flashing Breaker Fails to Open Due to Latent Human Error	2.60E-04
EK1SPYCLHE	Keowee Unit 1 Supply Breaker Fails to Close Due to Latent Human Error	2.60E-04

Table C.3-1

Keowee Human Reliability Events

Event	Description	Value
EK2BASELHE	Keowee Unit 2 Base Adjust Is Set Incorrectly	3.20E-03
EK2FLDCLHE	Keowee Unit 2 Field Breaker Fails to Close Due to Latent Human Error	2.60E-04
EK2FLSCLHE	Keowee Unit 2 Field Flashing Breaker Fails to Close Due to Latent Human Error	2.60E-04
EK2FLSOLHE	Keowee Unit 2 Field Flashing Breaker Fails to Open Due to Latent Human Error	2.60E-04
EK2SPYCLHE	Keowee Unit 2 Supply Breaker Fails to Close Due to Latent Human Error	2.60E-04
FK1120GLHE	Control Switch S120G Not in "Auto" Position	3.20E-03
FK2120GLHE	Control Switch S120G Not in "Auto" Position	2.60E-04
GK1BRGVLHE	KHU1 BNG Oil Cooling Path Valves Misaligned	2.60E-04
GK1COOLLHE	KHU1 Generator Air Cooler WL Flow Path Valves Mispositioned	2.60E-04
GK1NGDCLHE	Failure to Close the Unit 1 Neutral Ground Disconnect Following Maintenance	5.20E-05
GK2BRGVLHE	KHU2 BNG OIL Cooling Path Valves Misaligned	2.60E-04
GK2COOLLHE	KHU2 Generator Air Cooler WL Flow Path Valves Mispositioned	2.60E-04
GK2NGDCLHE	Failure to Close the Unit 1 Neutral Ground Disconnect Following Maintenance	5.20E-05
OK1001BLHE	Latent Human Error Fails OG Pump 1B	3.20E-03
OK1001CLHE	Latent Human Error Fails OG Pump 1C	3.20E-03
OK2002BLHE	Latent Human Error Fails OG Pump 2B	3.20E-03
OK2002CLHE	Latent Human Error Fails OG Pump 2C	3.20E-03
PK1TSDCLHE	Latent Human Error Fails Turbine No. 1 DC Sump Pump	3.20E-03

Table C.3-1

Keowee Human Reliability Events

Event	Description	Value
PK2TSDCLHE	Latent Human Error Fails Turbine No. 2 DC Sump Pump	3.20E-03
SXFRCT4LHE	Latent Human Error Fails Transformer CT-4	6.4E-05
WK1GVDCLHE	Latent Human Error Fails Keowee 1 Governor During a Cold Start	2.60E-04
WK2GVDCLHE	Latent Human Error Fails Keowee 2 Governor During a Cold Start	2.60E-04
AB0SWGRRHE	Recovery of Keowee Aux. Power Breakers by Manual Control	5.0E-01
ABEOPRCDHE	Operators Faill To Close Air Circuit Breaker 2	9.00E-03
ABPOPRCDHE	Operators Fail To Close Air Circuit Breaker 4	9.00E-03
EK0BASEDHE	Recovery of Keowee Base Adjust LHE.	1.9E-02
FK0FISHDHE	Recovery of Main WL Strainer Clogging	6.3E-02
FK0FL00DHE	Recovery of Turbine Guide Bearing or Packing WL Filter Clogging	6.3E-02
FK0GBHXDHE	Recovery of Turbine Guide Bearing HX WL Valves	6.3E-02
GK0BRGVRHE	Recovery of Keowee Generator Thrust Bearing Oil Cooling Flow Path WL Valves	1.0E-01
XD0KBATDHE	Cross Connect of Keowee DC Distribution Centers	1.0E00
XD1KB1XDHE	Keowee Standby Battery Charger SBC Not Lined Up in 1 Hour	9.3E-02
XD2KB2XDHE	Keowee Standby Battery Charger SBC Not Lined Up in 1 Hour	9.3E-02
Y0STARTRHE	Recovery of Keowee Auto-Start Failures	5.0E-01
ACBTRIPCHE	Operators Trip Keowee Output Breakers	2.80E-02

Table C.3-1

Keowee Human Reliability Events

Event	Description	Value
YKEMSTRCHE	Operator Incorrectly Resets Keowee Emergency Start	5.66E-03

Figure C.3-1: Keowee Latent Human Errror Credit for Functional Test

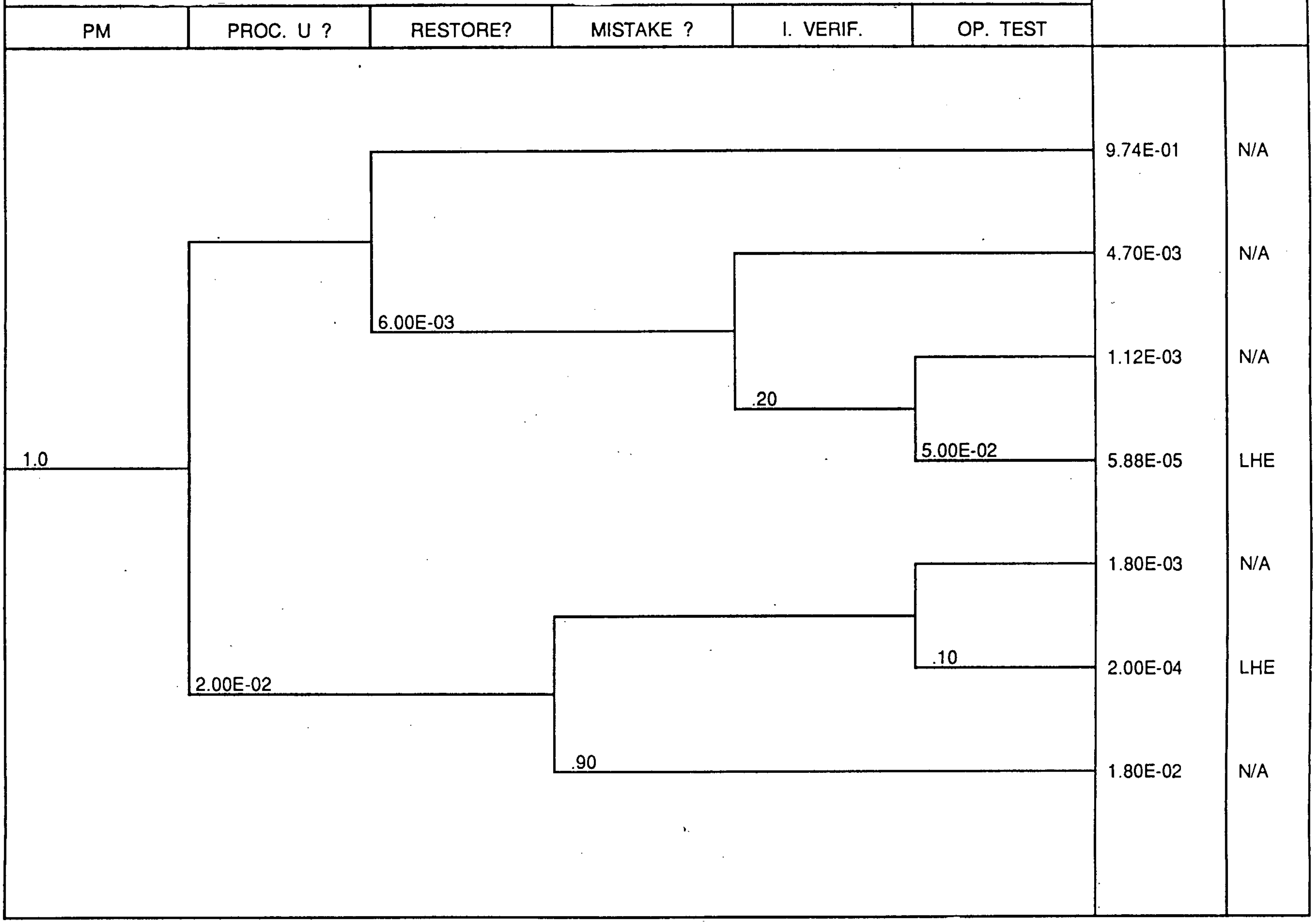


Figure C.3-2: Keowee Latent Human Error <u>No Credit for Functional Test</u>

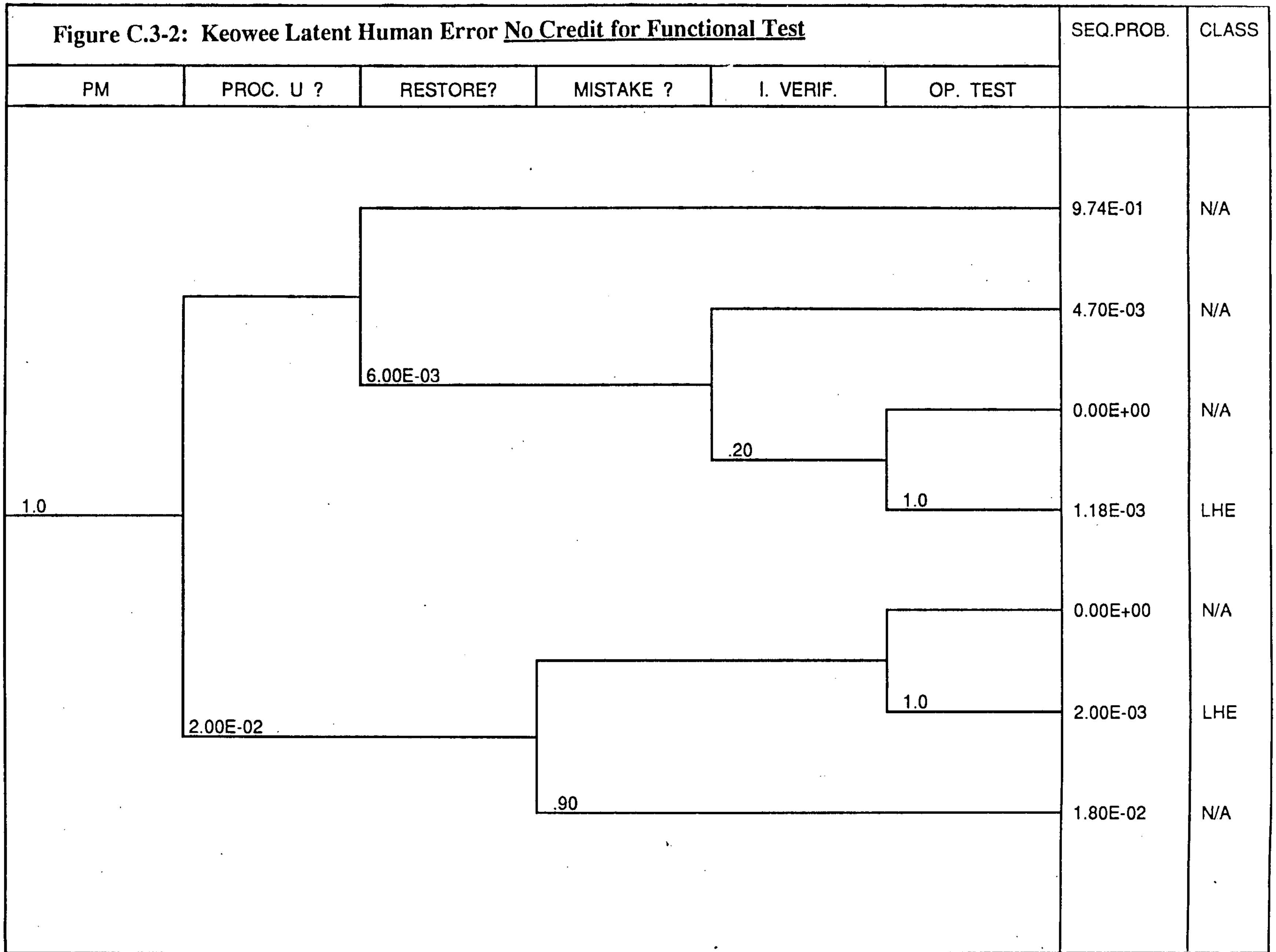
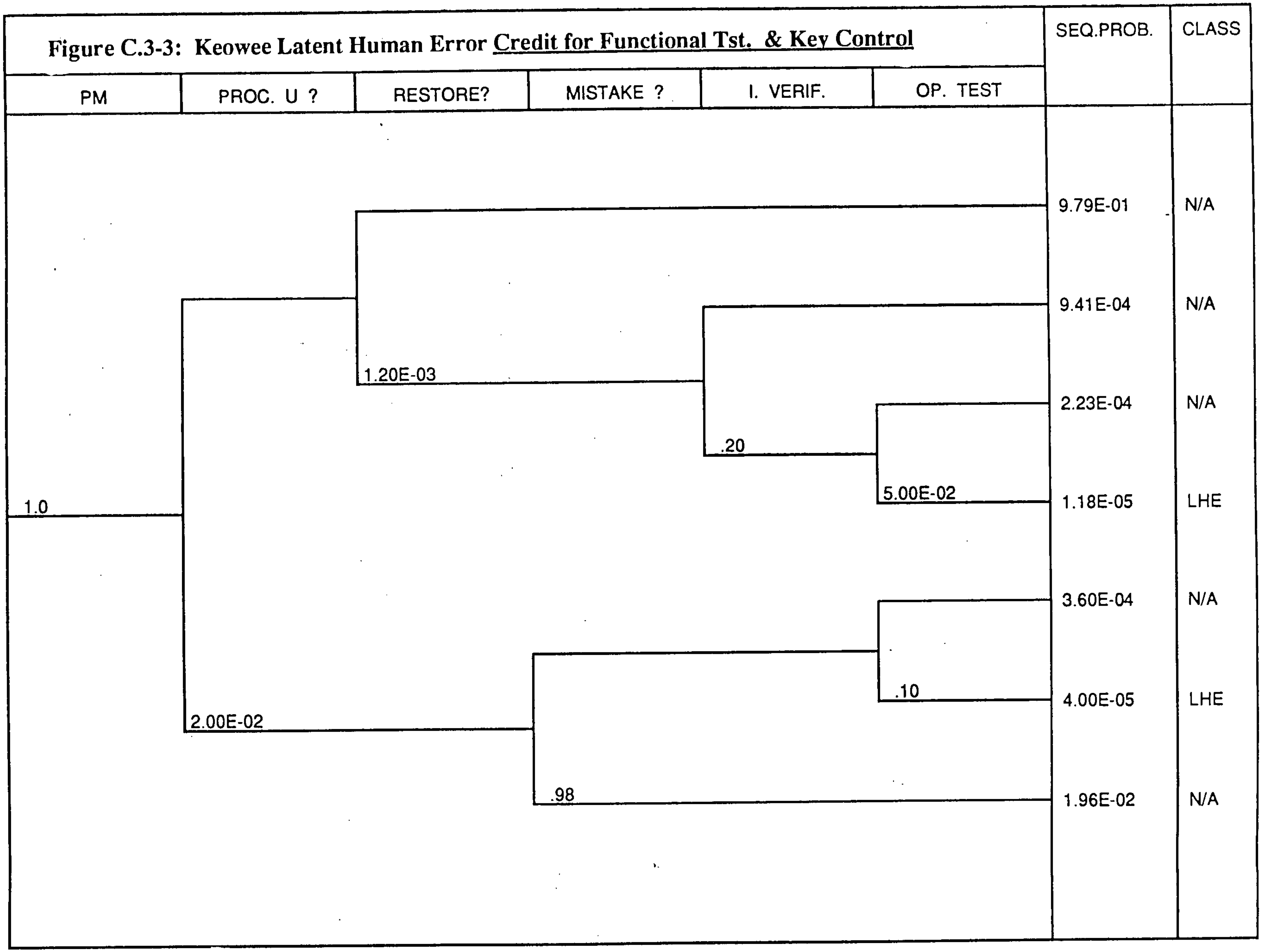


Figure C.3-3: Keowee Latent Human Error Credit for Functional Tst. & Key Control



Keowee Human Reliability Event Data Sheet

Rev. # 0

Event Name: ABOSWGRRHE **Probability:** 5.0E-01 **Importance:** 1.63E-02

Time Critical Y- see additional notes

Event Definition: Recovery of Keowee Aux. Power Breakers by Manual Control **Error Fact.** 5

Assumed to be done after other attempts to resotre aux. power have failed.

Indication/Signal: Alarm for loss of power on 1X and 2X auxiliary buses. (SA1 19, SA1 20)

Quantification

Procedure Number: AP/0/A/2000/002 Step 5.6 is to notify Oconee and call the on call tech.

Possible From Control Room? N See Comments.

Dependencies

Conflict: "troubleshooting" situation, bypass of breaker interlocks by manual operation.

Stress: High workload at Keowee and Oconee

Confusion The attempt to close this breaker should be straight foreward.

Level of Review: Not a factor.

Quantification Method: Engineering Judgment

> Note: A Graphical Representation is Attached. An example Sequence and Summary Description is also attached. For recoveries, see the recovery rule section.

"Action Phase" Quantificatior Not quantified separately.

Expert Interview

Date: 8/31/94

Expert: L. Kachnik **Expert Qualifications:** HRA Analyst

Results: Since this action is not proceduralized, the usual approach cannot be attempted.
Sam Burton has said that the Keowee on call tech. will be at Keowee in an hour.
The on call tech. will have to be contacted sooner than this.

Basis: In the past it has been estimated (based on governor oil) that Keowee will last one hour with no aux. power. 0.5 is what the HCR model would produce for about as much time available as required.

Other Sources For Timing Estimates: NUREG/CR-4674 vol.18 p.B-96 for timing of Keowee failure

Hardware Failure Quantification: Hardware failures are the local breaker switch (accounted for in the model) the alarm system, and the communication system with the on call operator- assumed negligible compared to the value used.

Quantification Comments

This requires contact with the on call technician. Control room operation will have already been attempted.
There is a proceduralized attempt to close breakers from the K-Control room, but this event is for local closing.
Operators at Keowee and Oconee are all trained on this AP- From Sam Burton.

Further quantification notes (if any) on attached sheet.

Sensitivity Study:

Prepared By:	Date:	Reviewed By:	Date:

Reason For Revisio

LJK\ABOSWGR.XLS

Summary Event Description of AB0SWGRHE Rev. # 0

AB0SWGRRHE

This event is a failure to recover power to one or both of the Keowee auxiliary buses via manual breaker manipulation outside of the Keowee control room.

This action would be taken following a breaker control problem which resulted in a failure of automatic breaker closure and a failure of breaker closure from the Keowee control room.

Based on past LERs and past communication with Keowee, there is assumed to be one hour available before loss of governor oil causes the Wicket gates to the Keowee turbines to fail as is. This failure is assumed to result in a failure of Keowee turbines.

The action to manually close the auxiliary bus breakers is not included in the Keowee emergency start procedure (AP/0/A/2000/002). However, the emergency start procedure has operators attempt to close the auxiliary bus breakers from the Keowee control room and then contact the Keowee on call operator. Based on interviews, it was assumed that the Keowee on call operator could arrive at Keowee in one hour.

The attempt to perform this action may be delayed due to troubleshooting of the breaker closure circuits.

This recovery event was quantified in a published precursor report (NUREG/CR-4674 Vol. 18 P. B-82) at 0.43.

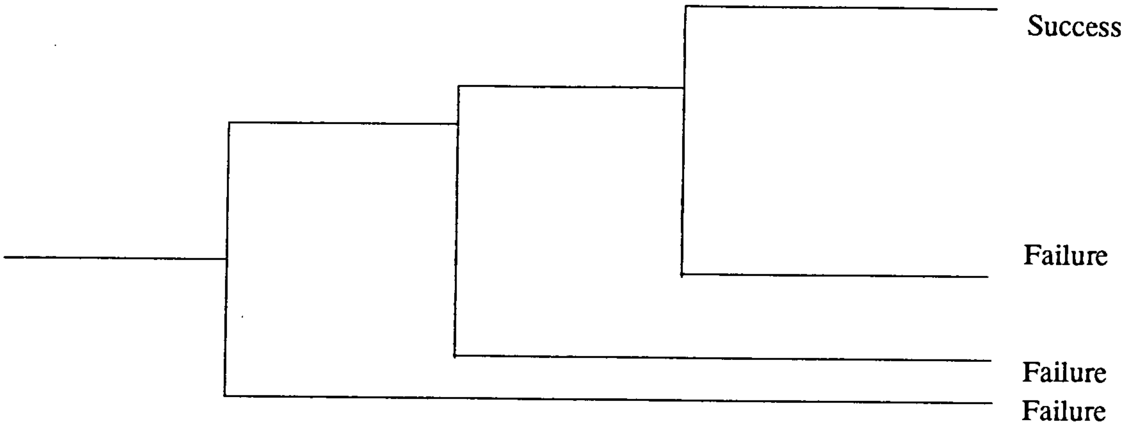
Based on the above information, a value of 0.5 was conservatively assigned to this action. This value, based on engineering judgment, is near the high end of human error estimates. This estimate was assumed to include the probability of any hardware failures and failures of the "action phase".

Graphical Representation of ABOSWGRRHE

Rev. #

AP/0/A/2000/002 Keowee Hydro Station, Emergency Start

Kick IN Step 5.6 (other attempts unsuccessfull)	Recognition SA1 19, SA1 20 alarms activated	Contact of on call operator	Manual closing of breaker



Example Sequence

- KK2UNITHYM	A Single Keowee Unit Is Unavailable Due To Maintenance	3.80E-02	1.09E-04
AB0SWGRCOM	Common Cause Failure Of All Keowee Auxiliary Power Breakers	2.27E-04	
AB0SWGRRHE	Failure To Recover Keowee Auxiliary Power Breakers	5.00E-01	

Further Quantification Notes

There is assumed to be about an hour available from the start of the event untill the Keowee wicket gate hydraulic accumulators bleed down to the point where the unit will fail.

The "on call" operator should be contacted before this time. Manual operation of the breakers should be an obvious recovery since attempts to close breakers from the Keowee control room have failed. However, other attempts to recover from the breaker failure (such as troubleshooting the closing circuit) may interfere with this action.

0.5 assigned to this action is about what the HCR model would produce for a situation of about as much time available as required. This would place the action near the top of quantified human reliability actions. NUREG/CR-4674 Vol.18 P. B82 assigned 0.43 to this recovery.

APPENDIX D
KEOWEE PRA BASIC EVENT DATA

LIST OF TABLES

Table D-1

Keowee PRA Basic Event Data (Base Case)
Bayesian Updated With Recoveries

	NAME	FACTOR	DESC	PROB
1	AA1271PR6D	1	Transformer 1X Undervoltage Relay 27/1X Fails To Pick Up	2.49E-04
2	AA1271XR6T	30	Transformer 1X Undervoltage Relay 27/1X Spuriously De-energizes	1.09E-05
3	AA127C1R6T	24	Transformer CX Undervoltage Relay 27/CX1 Spuriously De-energizes	8.71E-06
4	AA127CPR6D	1	Transformer CX Undervoltage Relay 27/CX1 Fails To Pick Up	2.49E-04
5	AA127R1RYT	24	Auxiliary Relay 27X/CX1 Spurious Operation	8.64E-06
6	AA127X1RYD	1	Auxiliary Relay 27X/1X Fails To Operate On Demand	3.30E-05
7	AA127X1RYT	384	Auxiliary Relay 27X/1X Spurious Operation	1.38E-04
8	AA127X2R6D	1	Transformer CX Undervoltage Relay 27/CX1 Fails To Drop Out	2.49E-04
9	AA127XCRYD	1	Auxiliary Relay 27/CX1 Fails To Operate On Demand	3.30E-05
10	AA186CXRYT	24	Transformer CX Differential Lock Out Relay 86CX Spurious Operation	8.64E-06
11	AA186S1RYT	24	Switchgear 1X Lockout Relay 86S/1X Spurious Operation	8.64E-06
12	AA187CXRYT	24	Transformer CX Differential Relay 87CX Spurious Operation	8.64E-06
13	AA2272PR6D	1	Transformer 2X Undervoltage Relay 27/2X Fails To Pick Up	2.49E-04
14	AA2272XR6D	1	Transformer 2X Undervoltage Relay 27/2X Fails To Drop Out	2.49E-04
15	AA2272XR6T	24	Transformer 2X Undervoltage Relay 27/2X Spuriously De-energizes	8.71E-06
16	AA227C2R6T	30	Transformer CX Undervoltage Relay 27/CX2 Spuriously De-energizes	1.09E-05
17	AA227C2RYD	1	Auxiliary Relay 27X/CX2 Fails To Operate On Demand	3.30E-05
18	AA227CPR6D	1	Transformer CX Undervoltage Relay 27/CX2 Fails To Pick Up	2.49E-04
19	AA227R2RYT	384	Auxiliary Relay 27X/CX2 Spurious Operation	1.38E-04
20	AA227T2R6D	1	Transformer #1 Undervoltage Relay (27T/2X) Fails To Drop Out	2.49E-04
21	AA227X2RYD	1	Auxiliary Relay 27X/2X Fails To Operate On Demand	3.30E-05
22	AA227X2RYT	24	Auxiliary Relay 27X/2X Spurious Operation	8.64E-06
23	AA286S2RYT	24	Switchgear 2X Lockout Relay 86S/2X Spurious Operation	8.64E-06
24	AB004ECCDT	30	DC Circuit Breaker 1DA-4EC Transfers Position	2.25E-06
25	AB0086TRYD	1	Keowee Main Tx Lock Out Relay 86T Fails To Operate On Demand	3.30E-05
26	AB0624CRYD	1	Time Delay Relay 62-4c Fails To Operate On Demand	3.30E-05
27	AB086E1RYD	1	Emergency Lock Out Relay 86E-1 Fails To Operate On Demand	3.30E-05
28	AB086TGRYD	1	General Keowee Main Tx Lock Out Sensing Relay Fails To Operate	3.30E-05
29	AB0SWGRCOM	6.69E-04	Common Cause Failure Of All Keowee Auxiliary Power Breakers	6.69E-04
30	AB0SWGRRHE	5.0E-01	Recovery of Keowee Aux Power Breakers by Manual Control	5.00E-01
31	AB152TCSVO	1	Air Circuit Breaker 1 Trip Coil Fails To Operate	2.90E-05
32	AB1ACCUDEX	3.51E-05	Air Circuit Breaker 1 Accumulator Air Pressure Low	3.51E-05
33	AB1FALTDEX	0.0	Fault Occurs at ACB-1 When The BReaker Trips	0.00E+00
34	AB1MECHDEX	1.51E-4	Air Circuit Breaker 1 Fails To Open Due To Mechanical Failure	1.51E-04
35	AB1OPENLHE	2.60E-4	Air Circuit Breaker 1 Fails To Open Due To A Latent Human Error	2.60E-04
36	AB1PS02PST	12	Air Circuit Breaker 1 Accumulator Pressure Switch PS2 Fails Low	5.16E-06
37	AB1PSWTPST	24	Air Circuit Breaker 1 Accumulator Pressure Switch Fails Low	1.03E-05
38	AB1R52ZR6D	1	Air Circuit Breaker 1 Relay 52Z Fails To Operate	2.49E-04

Table D-1

Keowee PRA Basic Event Data (Base Case)
Bayesian Updated With Recoveries

	NAME	FACTOR	DESC	PROB
39	AB21521SWT	30	Control Switch 152-2 Spurious Operation	2.10E-06
40	AB22BV1RYT	24	Backup Undervoltage Relay 2BV1 Spurious Operation	8.64E-06
41	AB23BKRCOM	1.12e-04	Common Cause Failure Of Air Circuit Breakers 2 And 3 To Close	1.12E-04
42	AB24BKRCOM	1.12E-04	Common Cause Failure Of Air Circuit Breakers 2 And 4 To Close	1.12E-04
43	AB251G2RYT	24	Air Circuit Breaker 2 Overcurrent Ground Relay 51G-2 Spurious Operation	8.64E-06
44	AB252CCSVO	1	Air Circuit Breaker 2 Close Coil Fails To Operate	2.90E-05
45	AB252TCSVO	1	Air Circuit Breaker 2 Trip Coil Fails To Operate	2.90E-05
46	AB252TCSVT	36	Air Circuit Breaker 2 Trip Coil Spurious Operation	1.40E-05
47	AB252Y2R6D	1	Air Circuit Breaker 2 Relay 52Y Failed To Drop Out Following Last Demand	2.49E-04
48	AB252Y2R6T	12	Air Circuit Breaker 2 Y-relay Spurious Operation	4.36E-06
49	AB2ACCUDEX	3.51E-05	Air Circuit Breaker 2 Accumulator Air Pressure Low	3.51E-05
50	AB2CLOSLHE	2.60E-4	Air Circuit Breaker 2 Fails To Close Due To A Latent Human Error	2.60E-04
51	AB2KEYISWT	12	Air Circuit Breaker 2 Key Interlock Switch Transfers Open	8.40E-07
52	AB2MCH2DEX	3.02E-4	Air Circuit Breaker 2 Fails To Close Due To Mechanical Failure	3.02E-04
53	AB2MECHDEX	1.51E-4	Air Circuit Breaker 2 Fails To Open Due To Mechanical Failure	1.51E-04
54	AB2OPENLHE	2.60E-4	Air Circuit Breaker 2 Fails To Open Due To A Latent Human Error	2.60E-04
55	AB2PS02PST	12	Air Circuit Breaker 2 Accumulator Pressure Switch PS2 Fails Low	5.16E-06
56	AB2PSWTPST	24	Air Circuit Breaker 2 Accumulator Pressure Switch Fails Low	1.03E-05
57	AB2PUSHPBT	36	Trip Pushbutton On ACB2 Spurious Operation	8.64E-06
58	AB2R462RYT	24	Air Circuit Breaker 2 Negative Sequence Relay 46-2 Spurious Operation	8.64E-06
59	AB2R52XR6D	1	Air Circuit Breaker 2 Relay 52X Fails To Operate	2.49E-04
60	AB2R52ZR6D	1	Air Circuit Breaker 2 Relay 52Z Fails To Operate	2.49E-04
61	AB2R52ZR6T	36	Air Circuit Breaker 2 Relay 52Z Spurious Operation	1.31E-05
62	AB31523SWT	24	Control Switch 152-3 Spurious Operation	1.68E-06
63	AB352CCSVO	1	Air Circuit Breaker 3 Close Coil Fails To Operate	2.90E-05
64	AB352TCSVO	1	Air Circuit Breaker 3 Trip Coil Fails To Operate	2.90E-05
65	AB352TCSVT	24	Air Circuit Breaker 3 Trip Coil Spurious Operation	9.36E-06
66	AB352Y2R6D	1	Air Circuit Breaker 3 Relay 52Y Failed To Drop Out Following Last Demand	2.49E-04
67	AB352Y2R6T	360	Air Circuit Breaker 3 Y-relay Spurious Operation	1.31E-04
68	AB3ACCUDEX	3.51E-05	Air Circuit Breaker 3 Accumulator Air Pressure Low	3.51E-05
69	AB3CLOSLHE	2.60e-04	Air Circuit Breaker 3 Fails To Close Due To Latent Human Error	2.60E-04
70	AB3MCH2DEX	3.02E-04	Air Circuit Breaker 3 Fails To Close Due To Mechanical Failure	3.02E-04
71	AB3MECHDEX	1.51E-04	Air Circuit Breaker 3 Fails To Open Due To Mechanical Failure	1.51E-04
72	AB3PS02PST	372	Air Circuit Breaker 3 Accumulator Pressure Switch PS2 Fails Low	1.60E-04
73	AB3PSWTPST	24	Air Circuit Breaker 3 Accumulator Pressure Switch Fails Low	1.03E-05
74	AB3PUSHPBT	24	Trip Pushbutton On ACB3 Spurious Operation	5.76E-06
75	AB3R52XR6D	1	Air Circuit Breaker 3 Relay 52X Fails To Operate	2.49E-04
76	AB3R52ZR6D	1	Air Circuit Breaker 3 Relay 52Z Fails To Operate	2.49E-04

Table D-1

Keewee PRA Basic Event Data (Base Case)
Bayesian Updated With Recoveries

	NAME	FACTOR	DESC	PROB
77	AB3R52ZR6T	24	Air Circuit Breaker 3 Relay 52Z Spurious Operation	8.71E-06
78	AB41523SWT	24	Control Switch 152-4 Spurious Operation	1.68E-06
79	AB452CCSVO	1	Air Circuit Breaker 4 Close Coil Fails To Operate	2.90E-05
80	AB452TCSVT	24	Air Circuit Breaker 4 Trip Coil Spurious Operation	9.36E-06
81	AB452Y2R6D	1	Air Circuit Breaker 4 Relay 52Y Failed To Drop Out Following Last Demand	2.49E-04
82	AB452Y2R6T	372	Air Circuit Breaker 4 Y-relay Spurious Operation	1.35E-04
83	AB4ACCUDEX	3.51E-05	Air Circuit Breaker 4 Accumulator Air Pressure Low	3.51E-05
84	AB4CLOSLHE	2.60E-4	Air Circuit Breaker 4 Fails To Close Due To A Latent Human Error	2.60E-04
85	AB4CLSESWC	1	Air Circuit Breaker 4 Close Switch Fails To Close On Demand	1.00E-05
86	AB4KEYISWT	372	Air Circuit Breaker 4 Key Interlock Switch Transfers Open	2.60E-05
87	AB4LORESWT	372	Air Circuit Breaker 4 Local/Remote Switch Contact Transfers Position	2.60E-05
88	AB4MCH2DEX	3.02E-04	Air Circuit Breaker 4 Fails To Close Due To Mechanical Failure	3.02E-04
89	AB4PS02PST	372	Air Circuit Breaker 4 Accumulator Pressure Switch PS2 Indicates Low Pressure	1.60E-04
90	AB4PSWTPST	12	Air Circuit Breaker 4 Accumulator Pressure Switch Indicates Low Air Pressure	5.16E-06
91	AB4PUSHPBT	24	Trip Pushbutton On ACB-4 Spurious Operation	5.76E-06
92	AB4R52XR6D	1	Air Circuit Breaker 4 Relay 52X Fails To Operate	2.49E-04
93	AB4R52ZR6T	24	Air Circuit Breaker 4 Relay 52Z Spurious Operation	8.71E-06
94	AB510A1FUF	6	One Or More Control Power Fuses For X, Y And CC Fail	2.16E-05
95	AB51431LHE	3.20E-4	Manual/Auto Control Switch 143/1 Left In Manual	3.20E-04
96	AB51431RYT	360	Auxiliary Relay 143X/1 Spuriously Energizes	1.30E-04
97	AB51431SWT	360	Manual/Auto Control Switch 143/1 Spuriously Transfers Into Manual	2.52E-05
98	AB552CCRYD	1	Air Circuit Breaker 5 Close Coil CC Fails On Demand	3.30E-05
99	AB552TCRYT	384	Air Circuit Breaker 5 Trip Coil 52TC Spurious Operation	1.38E-04
100	AB552Y2RYT	360	Air Circuit Breaker 5 Y-relay Spurious Operation	1.30E-04
101	AB583S5RYD	1	Time Delay Relay 83S5 Fails To Pick Up	3.30E-05
102	AB5CLOSLHE	2.60E-4	Air Circuit Breaker 5 Fails To Close Due To A Latent Human Error	2.60E-04
103	AB5KEYISWT	360	Air Circuit Breaker 5 Key Interlock Switch Transfers Open	2.52E-05
104	AB5MCH2DEX	7.04E-03	Air Circuit Breaker 5 Fails To Close Due To Mechanical Failure	7.04E-03
105	AB5PUSHPBT	384	Trip Pushbutton On ACB5 Spurious Operation	9.22E-05
106	AB5R52XRYD	1	Air Circuit Breaker 5 Relay 52X Fails To Operate	3.30E-05
107	AB5R52YRYD	1	Air Circuit Breaker 5 Relay 52Y Failed To Drop Out At Last Demand	3.30E-05
108	AB610A1FUF	6	One Or More Control Power Fuses For X, Y And CC Fail	2.16E-05
109	AB610AFFUF	6	One Or More Control Power Fuses For Relay 27X/2X Fail	2.16E-05
110	AB61432LHE	3.20E-4	Manual/Auto Control Switch 143/2 Left In Manual	3.20E-04
111	AB61432SWT	360	Manual/Auto Control Switch 143/2 Spuriously Transfers Into Manual	2.52E-05
112	AB652CCRYD	1	Air Circuit Breaker 6 Close Coil CC Fails On Demand	3.30E-05
113	AB652TCRYD	1	Air Circuit Breaker 6 Trip Coil 52TC Fails Fails To Operate	3.30E-05
114	AB652TCRYT	24	Air Circuit Breaker 6 Trip Coil 52TC Spurious Operation	8.64E-06

Table D-1

Keowee PRA Basic Event Data (Base Case)
Bayesian Updated With Recoveries

	NAME	FACTOR	DESC	PROB
115	AB652Y2RYT	360	Air Circuit Breaker 6 Y-relay Spurious Operation	1.30E-04
116	AB6CLOSLHE	2.60E-4	Air Circuit Breaker 6 Fails To Close Due To A Latent Human Error	2.60E-04
117	AB6KEYISWT	360	Air Circuit Breaker 6 Key Interlock Switch Transfers Open	2.52E-05
118	AB6MCH2DEX	7.04E-03	Air Circuit Breaker 6 Fails To Close Due To Mechanical Failure	7.04E-03
119	AB6MECHDEX	8.01E-04	Air Circuit Breaker 6 Fails To Open Due To Mechanical Failure	8.01E-04
120	AB6OPENLHE	3.20E-3	Air Circuit Breaker 6 Fails To Open Due To A Latent Human Error	3.20E-03
121	AB6PUSHPBT	24	Trip Pushbutton On ACB6 Spurious Operation	5.76E-06
122	AB6R52XRYD	1	Air Circuit Breaker 6 Relay 52X Fails To Operate	3.30E-05
123	AB6R52YRYD	1	Air Circuit Breaker 6 Relay 52Y Failed To Drop Out At Last Demand	3.30E-05
124	AB710A1FUF	6	One Or More Control Power Fuses For X, Y And CC Fail	2.16E-05
125	AB710AFFUF	6	One Or More Air Circuit Breaker 7 Control Power Fuses Fail	2.16E-05
126	AB752CCRYD	1	Air Circuit Breaker 7 Close Coil CC Fails On Demand	3.30E-05
127	AB752TCRYD	1	Air Circuit Breaker 7 Trip Coil TC Fails On Demand	3.30E-05
128	AB752TCRYT	24	Air Circuit Breaker 7 Trip Coil 52TC Spurious Operation	8.64E-06
129	AB752Y2RYT	360	Air Circuit Breaker 7 Y-relay Spurious Operation	1.30E-04
130	AB7CLOSLHE	2.60E-4	Air Circuit Breaker 7 Fails To Close Due To A Latent Human Error	2.60E-04
131	AB7KEYISWT	360	Air Circuit Breaker 7 Key Interlock Switch Transfers Open	2.52E-05
132	AB7MCH2DEX	7.04E-03	Air Circuit Breaker 7 Fails To Close Due To Mechanical Failure	7.04E-03
133	AB7MECHDEX	8.01E-04	Air Circuit Breaker 7 Fails To Open Due To Mechanical Failure	8.01E-04
134	AB7OPENLHE	3.20E-3	Air Circuit Breaker 7 Fails To Open Due To A Latent Human Error	3.20E-03
135	AB7PUSHPBT	30	Trip Pushbutton On ACB7 Spurious Operation	7.20E-06
136	AB7R52XRYD	1	Air Circuit Breaker 7 Relay 52X Fails To Operate	3.30E-05
137	AB7R52YRYD	1	Air Circuit Breaker 7 Relay 52Y Failed To Drop Out At Last Demand	3.30E-05
138	AB810A1FUF	6	One Or More Control Power Fuses For X, Y And CC Fail	2.16E-05
139	AB81432RYT	360	Auxiliary Relay 143X/2 Spuriously Energizes	1.30E-04
140	AB852CCRYD	1	Air Circuit Breaker 8 Close Coil CC Fails On Demand	3.30E-05
141	AB852TCRYT	384	Air Circuit Breaker 8 Trip Coil 52TC Spurious Operation	1.38E-04
142	AB852Y2RYT	360	Air Circuit Breaker 8 Y-relay Spurious Operation	1.30E-04
143	AB86E1ARYD	1	Emergency Lock Out Aux. Relay 86E-1a Fails To Operate On Demand	3.30E-05
144	AB86E1GRYD	1	Keowee Unit 1 Emergency Lock Out Sensing Relay Fails To Operate	3.30E-05
145	AB883S8RYD	1	Time Delay Relay 83S8 Fails To Pick Up	3.30E-05
146	AB8KEYISWT	360	Air Circuit Breaker 8 Key Interlock Switch Transfers Open	2.52E-05
147	AB8MCH2DEX	7.04E-03	Air Circuit Breaker 8 Fails To Close Due To Mechanical Failure	7.04E-03
148	AB8PUSHPBT	384	Trip Pushbutton On ACB8 Spurious Operation	9.22E-05
149	AB8R52XRYD	1	Air Circuit Breaker 8 Relay 52X Fails To Operate	3.30E-05
150	AB8R52YRYD	1	Air Circuit Breaker 8 Relay 52Y Failed To Drop Out At Last Demand	3.30E-05
151	ABEOPRCDHE	9.0E-03	Operators Fail To Close Air Circuit Breaker 2	9.00E-03
152	ABEOPRCRHE	9.0E-03	Operators Fail To Close Air Circuit Breaker 2	9.00E-03

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	NAME	FACTOR	DESC	PROB
153	ABPOPRCRHE	9.0E-03	Operators Fail To Close Air Circuit Breaker 4	9.00E-03
154	ACB4MOD	1	NSM-ON-52966 Is Not In Service	1.00E+00
155	ACBAIRPDEX	2.00E-03	ACB Air Supply Fails Causing Low Pressure In All ACB Accumulators	2.00E-03
156	ACBTRIPCHE	0.0	Operators Trip Generator Output ACBs	0.00E+00
157	ACBXFERCOM	1.28E-06	Common Cause Failure That Results In ACBs 2 & 3 Transfering Open	1.28E-06
158	AD1B4ALCDT	30	Breaker 4AL In 125 V dc Distribution Center 1DA Transfers Open	2.25E-06
159	AD1C3CCCDT	24	Breaker 3CC In 125V dc Distribution Center 1DA Transfers Position	1.80E-06
160	AD1C3CLCDT	24	Breaker 3CL In 125V dc Distribution Center 1DA Transfers Position	1.80E-06
161	AD1SCLRCDT	12	Breaker 3CL In 125V dc Distribution Center 1DA Transfers Position (Rec)	9.00E-07
162	AD2B2ALCDT	30	Breaker 2AL In 125V dc Distribution Center 2DA Transfers Open	2.25E-06
163	AD2B3CCCDT	12	Breaker 3CC In 125V dc Distribution Center 2DA Transfers Position	9.00E-07
164	AD2C3CCCDT	24	Breaker 3CC In 125V dc Distribution Center 2DA Transfers Position	1.80E-06
165	AD2C3CLCDT	24	Breaker 3CL In 125V dc Distribution Center 2DA Transfers Position	1.80E-06
166	AK1141XRYD	1	Auxiliary Relay 14GOV/1X Fails To Pick-up	3.30E-05
167	AK114GVDEX	1.00e-04	KU1 Magnetic Speed Switch System Fails	1.00E-04
168	AK121TDRYD	1	Time Delay Relay 2-1TD Fails To Pick-up	3.30E-05
169	AK152TDRYD	1	Time Delay Relay 52-1TD Fails To Pick-up	3.30E-05
170	AK152TDRYT	4380	Time Delay Relay 52-1TD Spurious Operation	1.58E-03
171	AK152XGRYD	1	Relay 52XG/1 Fails To Pick Up When The Unit Is Started	3.30E-05
172	AK152XGRYT	2	Relay 52XG/1 Spuriously Drops Out While The Unit Is Running	7.20E-07
173	AK1AX34RYT	6	Relay 52AX/34 Spuriously Drops-out	2.16E-06
174	AK1GV1XRYD	1	Relay 14GOV/1X Fails To Pick-up	3.30E-05
175	AK1OFRQCOM	3.30E-06	KU1 CCF Of 2/3 Overfrequency Relays To Reset When Frequency Drops	3.30E-06
176	AK1X34XRYT	6	Relay 52AX/34X Spuriously Drops-out	2.16E-06
177	AK212OSSST	36	Turbine Overspeed Switch Indicates Overspeed	1.51E-04
178	AK2142XRYD	1	Auxiliary Relay 14GOV/2X Fails To Pick-up	3.30E-05
179	AK214GVDEX	1.00e-4	KU2 Magnetic Speed Switch System Fails	1.00E-04
180	AK222TDRYD	1	Time Delay Relay 2-2TD Fails To Pick-up	3.30E-05
181	AK252TDRYD	1	Time Delay Relay 52-2TD Fails To Operate	3.30E-05
182	AK252TDRYT	4380	Time Delay Relay 52-2TD Spurious Operation	1.58E-03
183	AK252WORYD	1	KU2 Relay 52W Fails To Pick-up	3.30E-05
184	AK252XGRYD	1	Auxiliary Relay 52XG/2 Fails To Pick-up	3.30E-05
185	AK2GATEDEX	2.11E-5	Wicket Gate Limit Switch Indicates Gate Position Is Below No-load Setting	2.11E-05
186	AK2GV2XRYD	1	Relay 14GOV/2X Fails To Pick-up	3.30E-05
187	AK2OFRQCOM	3.30E-06	KU2 CCF Of 2/3 Overfrequency Relays To Reset When Frequency Drops	3.30E-06
188	BK1088XRYD	1	Keowee 1 Turbine Guide Bearing Oil Relay 88X Fails to Drop Out	3.30E-05
189	BK1088XRYT	24	Keowee 1 Turbine Guide Bearing Oil Relay 88X Spurious Operation	8.64E-06
190	BK114/2SSD	1	Keowee 1 Speed Switch 14/2 Fails On Demand	1.80E-05

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	NAME	FACTOR	DESC	PROB
191	BK114/2SST	24	Keowee 1 Speed Switch 14/2 Spuriously Transfers Closed	1.01E-04
192	BK114DXRYD	1	Keowee 1 Rotation Sensing Aux. Relay 14DX Fails to Energize	3.30E-05
193	BK114DXRYT	24	Keowee 1 Rotation Sensing Aux. Relay 14DX Spuriously Drops Out	8.64E-06
194	BK114T2RYD	1	Keowee 1 Rotation Sensing Timer 14T2 Fails to De-energize	3.30E-05
195	BK114T2RYT	24	Keowee 1 Rotation Sensing Timer 14T2 Spurious Operation	8.64E-06
196	BK1188ASWT	24	Keowee 1 AC GBO Pump Control Switch S188A Spurious Operation	1.68E-06
197	BK1188DSWT	108	Unit 1 DC GBO Pump Control Switch S188D Spurious Operation	7.56E-06
198	BK1631XRYD	1	Keowee 1 Relay 63TA/1X Fails to De-energize	3.30E-05
199	BK1631XRYT	24	Keowee 1 GBO Level Relay 63TA/1X Spurious Operation	8.64E-06
200	BK1632XRYD	1	Keowee 1 Brng. Low Oil Level Aux. Relay 63TA/2X Fails To Operate On Demand	3.30E-05
201	BK1632XRYT	24	Keowee 1 Turb. Brng. Low Oil Level Aux. Rly 63TA/2X Spurious Operation	8.64E-06
202	BK163TALSD	1	Turbine No. 1 Bearing Oil Level Switch 63TA Fails on Demand	1.60E-03
203	BK163TALST	24	Turbine No. 1 Bearing Oil Level Switch 63TA Spurious Operation	7.44E-06
204	BK188AXRYD	1	Unit 1 AC Bearing Oil Pump Aux. Relay 88AX Fails to Drop Out	3.30E-05
205	BK188AXRYT	24	Unit 1 AC Bearing Oil Pump Aux. Relay 88AX Fails to Remain De-energized	8.64E-06
206	BK1DA5BCDT	24	DC Circuit Breaker 1DA-5B Transfers Position	1.80E-06
207	BK1GBDCGPR	12	Unit 1 DC Turbine GBO Pump Fails To Run	1.68E-04
208	BK1GBDCGPS	1	Unit 1 DC Turbine GBO Pump Fails To Start On Demand	9.70E-05
209	BK1GBDCLHE	3.2E-3	Latent Human Error Fails Unit 1 DC Guide Bearing Oil Pump Discharge Path	3.20E-03
210	BK1GBO1CVC	1	Check Valve 1GBO-1 Fails to Close on Demand	3.50E-04
211	BK1GBO1CVO	1	Check Valve 1GBO-1 Fails To Open On Demand	2.30E-06
212	BK1GBO1CVT	24	Check Valve 1GBO-1 Transfers Closed	3.12E-06
213	BK1GBO1FTC	24	Filter 1GBOFL-1 Becomes Clogged	4.32E-05
214	BK1GBO2VVT	24	Manual Valve 1GBO-2 Transfers Position	4.08E-07
215	BK1GBO3CVO	1	Check Valve 1GBO-3 Fails To Open On Demand	2.30E-06
216	BK1GBO3CVT	12	Check Valve 1GBO-3 Transfers Closed	1.56E-06
217	BK1GBO4VVT	108	Manual Valve 1GBO-4 Transfers Position	1.84E-06
218	BK1GBO5VVT	24	Manual Valve 1GBO-5 Transfers Position	4.08E-07
219	BK1GBO6VVT	24	Manual Valve 1GBO-6 Transfers Position	4.08E-07
220	BK1GBO8VVT	24	Manual Valve 1GBO-8 Transfers Position	4.08E-07
221	BK1GBO9VVT	24	Manual Valve 1GBO-9 Transfers Position	4.08E-07
222	BK1GOACGPR	24	Unit 1 AC Turbine GBO Pump Fails To Run	3.36E-04
223	BK1GOACGPS	1	Unit 1 AC Turbine GBO Pump Fails To Start	9.70E-05
224	BK1GODCTRM	1.14E-3	Unit 1 DC Turbine GBO Pump Train In Maintenance	1.14E-03
225	BK1XA1CCLT	24	600 V Circuit Breaker 1XA-1C Transfers Position	2.18E-05
226	BK2088XRYD	1	Keowee 2 Turbine Guide Bearing Oil Relay 88X Fails to Drop Out	3.30E-05
227	BK2088XRYT	24	Keowee 2 Turbine Guide Bearing Oil Relay 88X Spurious Operation	8.64E-06
228	BK214/2SSD	1	Keowee 2 Speed Switch 14/2 Fails On Demand	1.80E-05

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	NAME	FACTOR	DESC		PROB
229	BK214/2SST	24	Keowee 2 Speed Switch 14/2 Spuriously Transfers Closed		1.01E-04
230	BK214DXRYD	1	Keowee 2 Rotation Sensing Aux. Relay 14DX Fails to Energize		3.30E-05
231	BK214DXRYT	24	Keowee 2 Rotation Sensing Aux. Relay 14DX Spurious Operation		8.64E-06
232	BK214T2RYD	1	Keowee 2 Rotation Sensing Timer 14T2 Fails to De-energize		3.30E-05
233	BK214T2RYT	24	Keowee Rotation Sensing Timer 14T2 Fails to Remain De-energized		8.64E-06
234	BK2188ASWT	24	Unit 2 AC GBO Pump Control Switch S188A Spurious Operation		1.68E-06
235	BK2188DSWT	108	Unit 2 DC GBO Pump Control Switch S188D Spurious Operation		7.56E-06
236	BK2631XRYD	1	Keowee 2 Relay 63TA/1X Fails to De-energize		3.30E-05
237	BK2631XRYT	24	Keowee 2 GBO Level Relay 63TA/1X Spurious Operation		8.64E-06
238	BK2632XRYD	1	Keowee 2 Brng. Low Oil Level Aux. Relay 63TA/2X Fails To Operate On Demand		3.30E-05
239	BK2632XRYT	24	Keowee 2 Turb. Brng. Low Oil Level Aux. Relay 63TA/2X Spurious Operation		8.64E-06
240	BK263TALSD	1	Turbine No. 2 Bearing Oil Level Switch 63TA Fails on Demand		1.60E-03
241	BK263TALST	24	Turbine No. 2 Bearing Oil Level Switch 63TA Spurious Operation		7.44E-06
242	BK288AXRYD	1	Unit 2 AC Bearing Oil Pump Aux. Relay 88AX Fails to Drop Out		3.30E-05
243	BK288AXRYT	24	Unit 2 AC Bearing Oil Pump Aux. Relay 88AX Fails to Remain De-energized		8.64E-06
244	BK2DA1BCDT	24	DC Circuit Breaker 2DA-1B Transfers Position		1.80E-06
245	BK2GBDCGPR	12	Unit 2 DC Turbine GBO Pump Fails To Run		1.68E-04
246	BK2GBDCGPS	1	Unit 2 DC Turbine GBO Pump Fails To Start On Demand		9.70E-05
247	BK2GBDCLHE	3.2E-3	Latent Human Error Fails Unit 2 DC Guide Bearing Oil Pump Discharge Path		3.20E-03
248	BK2GBO1CVC	1	Check Valve 2GBO-1 Fails to Close on Demand		3.50E-04
249	BK2GBO1CVO	1	Check Valve 2GBO-1 Fails To Open On Demand		2.30E-06
250	BK2GBO1CVT	24	Check Valve 2GBO-1 Transfers Closed		3.12E-06
251	BK2GBO1FTC	24	Filter 2GBOFL-1 Becomes Clogged		4.32E-05
252	BK2GBO2VVT	24	Manual Valve 2GBO-2 Transfers Position		4.08E-07
253	BK2GBO3CVO	1	Check Valve 2GBO-3 Fails To Open On Demand		2.30E-06
254	BK2GBO3CVT	12	Check Valve 2GBO-3 Transfers Closed		1.56E-06
255	BK2GBO4VVT	108	Manual Valve 2GBO-4 Transfers Position		1.84E-06
256	BK2GBO5VVT	24	Manual Valve 2GBO-5 Transfers Position		4.08E-07
257	BK2GBO6VVT	24	Manual Valve 2GBO-6 Transfers Position		4.08E-07
258	BK2GBO8VVT	24	Manual Valve 2GBO-8 Transfers Position		4.08E-07
259	BK2GBO9VVT	24	Manual Valve 2GBO-9 Transfers Position		4.08E-07
260	BK2GOACGPR	24	Unit 2 AC Turbine GBO Pump Fails To Run		3.36E-04
261	BK2GOACGPS	1	Unit 2 AC Turbine GBO Pump Fails To Start		9.70E-05
262	BK2GODCTRM	1.14E-3	Unit 2 DC Turbine GBO Pump Train In Maintenance		1.14E-03
263	BK2XA1CCLT	24	600 V Circuit Breaker 2XA-1C Transfers Position		2.18E-05
264	BKGBOILCOM	1.94E-06	Common Cause Failure Of Turbine Guide Bearing Oil System		1.94E-06
265	D1DIAXXDEX	6.50E-06	Loss Of Power On 125 V dc Panelboard 1DIA	OEE-120, O-705	6.50E-06
266	D1DIBXXDEX	6.50E-06	Loss Of Power On 125 V dc Panelboard 1DIB	OEE-120-1, O-705	6.50E-06

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	NAME	FACTOR	DESC	PROB
267	D2DIAXXDEX	6.50E-06	Loss Of Power On 125 V dc Panelboard 2DIA	6.50E-06
268	D2DIBXXDEX	6.50E-06	Loss of Power on 125 V dc Panelboard 2DIB	6.50E-06
269	D3DIAXXDEX	6.50E-06	Loss Of Power On 125 V dc Panelboard 3DIA	6.50E-06
270	D3DIBXXDEX	6.50E-06	Loss Of Power On 125 Vdc Panelboard 3DIB	6.50E-06
271	DDC11BXCDT	24	125 Vdc Battery Breaker SY-DC1-1B Transfers Open	1.80E-06
272	DDC11CXCDT	24	125 Vdc Breaker SY-DC1-1C Transfers Open	1.80E-06
273	DDC11DCCDT	24	125 Vdc Breaker SY-DC1-1DC Transfers Open	1.80E-06
274	DDC11DLCDT	24	125 Vdc Breaker SY-DC1-1DL Transfers Open	1.80E-06
275	DDC11DRCDT	24	125 Vdc Breaker SY-DC1-1DR Transfers Open	1.80E-06
276	DDC1ALXBYM	1.14E-02	Battery SY-1 Is In Test or Maintenance	1.14E-02
277	DDC1BATBYF	1	Battery SY-1 Fails During Discharge	9.30E-04
278	DDC1FLTBDF	24	SY-DC1 Is Faulted	7.68E-06
279	DDC21BXCDT	24	125 Vdc Battery Breaker SY-DC2-1B Transfers Open	1.80E-06
280	DDC21CXCDT	24	125 Vdc Breaker SY-DC2-1C Transfers Open	1.80E-06
281	DDC21DCCDT	24	125 Vdc Breaker SY-DC2-1DC Transfers Open	1.80E-06
282	DDC21DLCDT	24	125 Vdc Breaker SY-DC2-1DL Transfers Open	1.80E-06
283	DDC21DRCDT	24	125 Vdc Breaker SY-DC2-1DR Transfers Open	1.80E-06
284	DDC2BATBYF	1	Battery SY-2 Fails During Discharge	9.30E-04
285	DDC2FLTBDF	24	SY-DC2 Is Faulted	7.68E-06
286	DDCBATTCOM	2.70E-05	Common Cause Failure of Switchyard Batteries	2.70E-05
287	DDCDYAXBDF	24	125 Vdc Switchyard DC Panelboard DYA Is Faulted	7.68E-06
288	DDCDYBXBDF	24	125 Vdc Switchyard DC Panelboard DYB Is Faulted	7.68E-06
289	DDCDYCXBDF	24	125 Vdc Switchyard DC Panelboard DYC Is Faulted	7.68E-06
290	DDCDYEXBDF	24	125 Vdc Switchyard DC Panelboard DYE Is Faulted	7.68E-06
291	DDCDYFXBDF	24	125 Vdc Switchyard DC Panelboard DYF Is Faulted	7.68E-06
292	DDCDYGXBDF	24	125 Vdc Switchyard DC Panelboard DYG Is Faulted	7.68E-06
293	E12EXCTCOM	5.31E-05	Units 1 & 2 Excit Fail Due To Common Cause Failure Of The Breakers	5.31E-05
294	ED11D3DCDT	84	Breaker 3D In 125V dc Distribution Center 1DA Transfers Open	6.30E-06
295	ED13BR2CDT	24	Breaker 3BR In 125V dc Distribution Center 1DA Transfers Open	1.80E-06
296	ED22D3DCDT	24	Breaker 2D In 125V dc Distribution Center 2DA Transfers Open	1.80E-06
297	ED23BR2CDT	24	Breaker 3BR In 125V dc Distribution Center 2DA Transfers Open	1.80E-06
298	EK00RUNCOM	1.24E-4	Common Cause Failure Of Both Units Voltage Regulators To Run	1.24E-04
299	EK0BASERHE	1.9E-02	Recovery of Keowee Base Adjust LHE	1.90E-02
300	EK131TDRYD	1	Keowee Unit 1 Field Flashing Breaker Time Delay Relay 31/TD Fails To Operate	3.30E-05
301	EK131TDRYT	84	Keowee Unit 1 Field Flashing Breaker Time Delay Relay 31/TD Spurious Operation	3.02E-05
302	EK14152SWT	84	KHU1 Generator Supply Breaker Trip Control Switch 141-52/T Spurious Operation	5.88E-06
303	EK1415TSWT	24	Spurious Operation Of The KHU1 Supply Breaker Trip Switch	1.68E-06
304	EK1415YRYD	1	KHU1 Generator Supply Breaker Y-relay Failed To Drop-out At Last Operation	3.30E-05

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	NAME	FACTOR	DESC	PROB
305	EK1415YRYT	84	KHU1 Generator Supply Breaker Y-relay Spurious Operation	3.02E-05
306	EK141AXR6D	1	Keowee Unit 1 Relay 41/AX Fails To Pick-up And Latch	2.49E-04
307	EK141AXR6T	24	Keowee Unit 1 Relay 41/AX Spuriously Resets	8.71E-06
308	EK141CFRYD	1	Keowee Unit 1 Field Flashing Breaker Close Coil Fails To Operate On Demand	3.30E-05
309	EK186E2RYT	6	Keowee Unit 1 Lockout Auxiliary Relay 86EX-2 Is Picked-up	2.16E-06
310	EK186EXRYT	84	Keowee Unit 1 Gen Lockout Auxiliary Relay 86EX-1 Spurious Actuation	3.02E-05
311	EK186X2RYT	24	Keowee Unit 1 Generator Lockout Auxiliary Relay 86EX-1 Spurious Actuation	8.64E-06
312	EK188SVRYD	1	Keowee Unit 1 Fan Control Relay 88SV Fails On Demand	3.30E-05
313	EK188SVRYT	108	Keowee Unit 1 Fan Control Relay 88SV Prior To Or During The Run	3.89E-05
314	EK1901ARYT	84	Keowee Unit 1 Relay 90X1A Spurious Operation	3.02E-05
315	EK199SXRYD	1	Auxiliary Relay 99SX1 Fails To Pick-up	3.02E-05
316	EK199SYRYD	1	Keowee Unit 1 Relay 99SY Fails To Pick-up	3.30E-05
317	EK199SYRYT	24	Keowee Unit 1 Relay 99SY Drops Out	3.30E-05
318	EK1BAS2DEX	1.24E-3	KHU-1 Base Adjust Fails To Maintain Generator Output Within Acceptable Range	8.64E-06
319	EK1BASEDEX	6.17E-4	Keowee Unit 1 Base Adjust Fails To Establish Correct Unit Voltage	1.24E-03
320	EK1BASELHE	3.20E-3	Keowee Unit 1 Base Adjust Is Set Incorrectly	6.17E-04
321	EK1DIODDEX	2.88E-4	Keowee Unit 1 Exciter Fan Supply Diode Bridge Fails	3.20E-03
322	EK1EXC1TGF	84	Keowee Unit 1 Gen Excitation Transformer Is Failed	2.88E-04
323	EK1EXC2TGF	24	Keowee Unit 1 Generator Excitation Transformer Fails	8.23E-05
324	EK1F30AFUF	24	Keowee Unit 1 Excitation Cabinet Fan Fuses Fail	2.35E-05
325	EK1F31XRYD	1	Keowee Unit 1 Field Flashing Breaker Relay 31/X Fails To Pick-up On Demand	8.64E-05
326	EK1F41CRYD	1	Keowee Unit 1 Field Breaker Close Coil Fails To Operate On Demand	3.30E-05
327	EK1FAN1TLF	24	Keowee Unit 1 Generator Excitation Fan Power Transformer Fails	3.30E-05
328	EK1FLDCLHE	2.60E-4	Keowee Unit 1 Field Breaker Fails To Close Due To Latent Human Error	1.80E-05
329	EK1FLDMDEX	7.71E-5	Keowee Unit 1 Field Breaker Fails To Close Due To Mechanical Failure	2.60E-04
330	EK1FLSCLHE	2.60E-4	Keowee Unit 1 Field Flashing Breaker Fails To Close Due To Latent Human Error	7.71E-05
331	EK1FLSMDEX	7.71E-5	Keowee Unit 1 Field Flashing Breaker Fails To Close Due To Mechanical Failure	2.60E-04
332	EK1FLSOLHE	2.60E-4	Keowee Unit 1 Field Flashing Breaker Fails To Open Due To Latent Human Error	7.71E-05
333	EK1R31TRYD	1	Keowee Unit 1 Field Flashing Breaker Trip Coil 31/T Fails To Operate	2.60E-04
334	EK1R31YRYD	1	KHU1 Gen Field Flashing Breaker Y-relay Failed To Drop Out At Last Operation	3.30E-05
335	EK1R31YRYT	84	KHU1 Generator Field Flashing Breaker Y-relay Spurious Operation	3.30E-05
336	EK1R41XRYD	1	Keowee Unit 1 Field Breaker Relay 41/X Fails To Pick-up On Demand	3.02E-05
337	EK1R41YRYD	1	KHU1 Generator Field Breaker Y-relay Failed To Drop-out At Last Operation	3.30E-05
338	EK1R41YRYT	84	Keowee Unit 1 Generator Field Breaker Y-relay Spurious Operation	3.30E-05
339	EK1R9A1RYT	84	Keowee Unit 1 Relay 90X1A/TD Spurious Operation	3.02E-05
340	EK1R9C1R6T	84	Keowee Unit 1 Relay 90X1C Spurious Operation	3.02E-05
341	EK1S141SWT	84	KHU1 Field Breaker Trip Control Switch 141/T Spurious Operation	3.05E-05
342	EK1S31TSWT	84	KHU1 Field Flashing Breaker Trip Control Switch 131/T Spurious Operation	5.88E-06
				5.88E-06

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	NAME	FACTOR	DESC	PROB
343	EK1S41CRYD	1	Keowee Unit 1 Supply Breaker Close Coil Fails To Operate On Demand	3.30E-05
344	EK1S41TSWT	24	Keowee Unit 1 Field Breaker Trip Control Switch Transfers Position	1.68E-06
345	EK1S41XRYD	1	Keowee Unit 1 Supply Breaker Relay 41-52X Fails To Pick-up On Demand	3.30E-05
346	EK1SPYCLHE	2.60E-4	Keowee Unit 1 Supply Breaker Fails To Close Due To Latent Human Error	2.60E-04
347	EK1SPYMDEX	4.62E-4	Keowee Unit 1 Supply Breaker Fails To Close Due To Mehanical Failure	4.62E-04
348	EK1VHSVRYD	1	Keowee Unit 1 Volts/Hertz Relay SV Fails To Trip Field Flashing Breaker	3.30E-05
349	EK1VREGDEX	2.47E-3	KHU-1 Voltage Adjust Failure Drives Generator Output Too High/Low	2.47E-03
350	EK231TDRYD	1	Keowee Unit 2 Field Flashing Breaker Time Delay Relay 31/TD Fails To Operate	3.30E-05
351	EK231TDRYT	12	Keowee Unit 2 Field Flashing Breaker Time Delay Relay 31/TD Spurious Operation	4.32E-06
352	EK24152SWT	12	KHU2 Generator Supply Breaker Trip Control Switch Spurious Operation	8.40E-07
353	EK2415TSWT	24	Spurious Operation Of The KHU2 Supply Breaker Trip Switch	1.68E-06
354	EK2415YRYD	1	KHU2 Gen Supply Breaker Y-relay Failed To Drop-out At Last Operation	3.30E-05
355	EK2415YRYT	12	KHU2 Generator Supply Breaker Y-relay Spurious Operation	4.32E-06
356	EK241AXR6D	1	Keowee Unit 2 Relay 41/AX Fails To Pick-up And Latch	2.49E-04
357	EK241AXR6T	24	Keowee Unit 2 Relay 41/AX Spuriously Resets	8.71E-06
358	EK241CFRYD	1	Keowee Unit 2 Field Flashing Breaker Close Coil Fails To Operat On Demand	3.30E-05
359	EK286E2RYT	6	Keowee Unit 2 Lockout Auxiliary Relay 86EX-2 Is Picked-up	2.16E-06
360	EK286EXRYT	12	Keowee Unit 2 Generator Lockout Auxiliary Relay 86EX-1 Spurious Actùation	4.32E-06
361	EK286X2RYT	24	Keowee Unit 2 Generator Lockout Auxiliary Relay 86EX-1 Spurious Actuation	8.64E-06
362	EK288SVRYD	1	Keowee Unit 2 Fan Control Relay 88SV Fails On Demand	3.30E-05
363	EK288SVRYT	36	Keowee Unit 2 Fan Control Relay 88SV Prior To Or During The Run	1.30E-05
364	EK2901ARYT	12	Keowee Unit 2 Relay 90X1A Spurious Operation	4.32E-06
365	EK299SXRYD	1	Auxiliary Relay 99SX2 Fails To Pick-up	3.30E-05
366	EK299SYRYD	1	Keowee Unit 2 Relay 99SY Fails To Pick-up	3.30E-05
367	EK299SYRYT	24	Keowee Unit 2 Relay 99SY Drops Out	8.64E-06
368	EK2BAS2DEX	1.24E-3	KHU-2 Base Adjust Fails To Maintain Generator Output Within Acceptable Range	1.24E-03
369	EK2BASEDEX	6.17E-4	Keowee Unit 2 Base Adjust Fails To Establish Correct Unit Voltage	6.17E-04
370	EK2BASELHE	3.20E-3	Keowee Unit 2 Base Adjust Is Set Incorrectly	3.20E-03
371	EK2DIODDEX	2.88E-4	Keowee Unit 2 Exciter Fan Supply Diode Bridge Fails	2.88E-04
372	EK2EXC1TGF	12	Keowee Unit 2 Generator Excitation Transformer Is Failed	1.18E-05
373	EK2EXC2TGF	24	Keowee Unit 2 Generator Excitation Transformer Fails	2.35E-05
374	EK2F30AFUF	24	Keowee Unit 2 Excitation Cabinet Fan Fuses Fail	8.64E-05
375	EK2F31XRYD	1	Keowee Unit 2 Field Flashing Breaker Relay 31/X Fails To Pick-up On Demand	3.30E-05
376	EK2F41CRYD	1	Keowee Unit 2 Field Breaker Close Coil Fails To Operate On Demand	3.30E-05
377	EK2FAN1TLF	24	Keowee Unit 2 Generator Excitation Fan Power Transformer Fails	1.80E-05
378	EK2FLDCLHE	2.60E-4	Keowee Unit 2 Field Breaker Fails To Close Due To Latent Human Error	2.60E-04
379	EK2FLDMDEX	7.71E-5	Keowee Unit 2 Field Breaker Fails To Close Due To Mechanical Failure	7.71E-05
380	EK2FLSCLHE	2.60E-4	Keowee Unit 2 Field Flashing Breaker Fails To Close Due To Latent Human Error	2.60E-04

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	NAME	FACTOR	DESC		PROB
381	EK2FLSMDEX	7.71E-5	Keowee Unit 2 Field Flashing Breaker Fails To Close Due To Mechanical Failure		7.71E-05
382	EK2FLSOLHE	2.60E-4	Keowee Unit 2 Field Flashing Breaker Fails To Open Due To Latent Human Error		2.60E-04
383	EK2R31TRYD	1	Keowee Unit 2 Field Flashing Breaker Trip Coil 31/T Fails To Operate		3.30E-05
384	EK2R31YRYD	1	KHU2 Gen Field Flashing Breaker Y-relay Failed To Drop At Last Operation		3.30E-05
385	EK2R31YRYT	12	KHU2 Generator Field Flashing Breaker Y-relay Spurious Operation		4.32E-06
386	EK2R41XRYD	1	Keowee Unit 2 Field Breaker Relay 41/X Fails To Pick-up On Demand		3.30E-05
387	EK2R41YRYD	1	KHU2 Generator Field Breaker Y-relay Failed To Drop-out At Last Operation		3.30E-05
388	EK2R41YRYT	12	KHU2 Generator Field Breaker Y-relay Spurious Operation		4.32E-06
389	EK2R9A2RYT	12	Keowee Unit 2 Relay 90X1A/TD Spurious Operation		4.32E-06
390	EK2R9C2R6T	12	Keowee Unit 2 Relay 90X1C Spurious Operation		4.36E-06
391	EK2S141SWT	12	KHU2 Field Breaker Trip Control Switch Spurious Operation		8.40E-07
392	EK2S31TSWT	12	KHU2 Field Flashing Breaker Trip Control Switch 131/T Spurious Operation		8.40E-07
393	EK2S41CRYD	1	Keowee Unit 2 Supply Breaker Close Coil Fails To Operate On Demand		3.30E-05
394	EK2S41TSWT	24	Keowee Unit 2 Field Breaker Trip Control Switch Transfers Position		1.68E-06
395	EK2S41XRYD	1	Keowee Unit 2 Supply Breaker Relay 41-52X Fails To Pick-up On Demand		3.30E-05
396	EK2SPYCLHE	2.60E-4	Keowee Unit 2 Supply Breaker Fails To Close Due To Latent Human Error		2.60E-04
397	EK2SPYMDEX	4.62E-4	Keowee Unit 2 Supply Breaker Fails To Close Due To Mehanical Failure		4.62E-04
398	EK2VHSVRYD	1	Keowee Unit 2 Volts/Hertz Relay SV Fails To Trip Field Flashing Breaker		3.30E-05
399	EK2VREGDEX	2.47E-3	KHU-2 Voltage Adjust Failure Drives Generator Output Too High/Low		2.47E-03
400	EKSTARTCOM	6.17E-5	Common Cause Failure Of Both Units Voltage Regulators To Start		6.17E-05
401	ESCONDNOT	1	An Engineered Safeguards Condition Does Not Exist		1.00E+00
402	EU1C1RORYD	1	ONS1 ESG Chan. 1 Ro Relay Fails To Pick Up	OEE-120	1.00E+00
403	EU1C2RORYD	1	ONS1 ESG Chan. 2 Ro Relay Fails to Pick Up		1.00E+00
404	EU2C1RORYD	1	ONS2 ESG Chan. 1 Ro Relay Fails to Pick Up	OEE-220	1.00E+00
405	EU2C2RORYD	1	ONS2 ESG Chan. 2 Ro Relay Fails to Pick Up	OEE-220-1	1.00E+00
406	EU3C1RORYD	1	ONS3 ESG Chan. 1 Ro Relay Fails to Pick Up	OEE-320	1.00E+00
407	EU3C2RORYD	1	ONS3 ESG Chan. 2 Ro Relay Fails to Pick Up	OEE-320-1	1.00E+00
408	FK0FISHCOM	2.55E-3	Common Cause Failure Of Both Unit s WL Filters Due To Intake Debris		2.55E-03
409	FK0FISHDHE	6.3E-02	Recovery of Main WL Strainer Clogging		6.30E-02
410	FK0FL00DHE	6.3E-02	Recovery of Trubine Guide Bearing or Packing WL Filter Clogging		6.30E-02
411	FK0WL01VVT	24	Locked-Open Manual Valve 0WL-1 Transfers Position		4.08E-07
412	FK1120GLHE	3.2E-3	Unit 1 Control Switch S120G Left in OFF Position		3.20E-03
413	FK1120GSWT	108	Unit 1 Control Switch S120G Spurious Operation		7.56E-06
414	FK1FL01FRF	24	Filter 1WLFL-1 Becomes Clogged		2.35E-05
415	FK1FL02FRF	24	Filter 1WLFL-2 Becomes Clogged		2.35E-05
416	FK1TRHXHXF	24	Turbine Packing Box Heat Exchanger 1TRHX-1 Fails		1.54E-05
417	FK1WL03VVT	24	Manual Valve 1WL-3 Transfers Position		4.08E-07
418	FK1WL04VVT	24	Manual Valve 1WL-4 Transfers Position		4.08E-07

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	NAME	FACTOR	DESC	PROB
419	FK1WL05VVT	24	Manual Valve 1WL-5 Transfers Position	4.08E-07
420	FK1WL06VVT	24	Manual Valve 1WL-6 Transfers Position	4.08E-07
421	FK1WL07VVT	24	Manual Valve 1WL-7 Transfers Position	4.08E-07
422	FK1WL08VVT	24	Manual Valve 1WL-8 Transfers Position	4.08E-07
423	FK1WL09VVT	24	Manual Valve 1WL-9 Transfers Position	4.08E-07
424	FK1WL11AVO	1	Cooling Water Control Valve 1WL-11 Fails To Open On Demand	2.80E-04
425	FK1WL11AVT	24	Cooling Water Control Valve 1WL-11 Transfers Closed	5.52E-05
426	FK1WL12VVT	108	Manual Valve 1WL-12 Transfers Position	1.84E-06
427	FK1WL15VVT	108	Manual Valve 1WL-15 Transfers Position	1.84E-06
428	FK1WL42VVT	108	Manual Valve 1WL-42 Transfers Position	1.84E-06
429	FK1WL43VVT	108	Manual Valve 1WL-43 Transfers Position	1.84E-06
430	FK2120GLHE	2.6E-4	Unit 2 Control Switch S120G Left in OFF Position	2.60E-04
431	FK2120GSWT	36	Unit 2 Control Switch S120G Spurious Operation	2.52E-06
432	FK2FL01FRF	24	Filter 2WLFL-1 Becomes Clogged	2.35E-05
433	FK2FL02FRF	24	Filter 2WLFL-2 Becomes Clogged	2.35E-05
434	FK2TRHXHXF	24	Turbine Packing Box Heat Exchanger 2TRHX-1 Fails	1.54E-05
435	FK2WL03VVT	24	Manual Valve 2WL-3 Transfers Position	4.08E-07
436	FK2WL04VVT	24	Manual Valve 2WL-4 Transfers Position	4.08E-07
437	FK2WL05VVT	24	Manual Valve 2WL-5 Transfers Position	4.08E-07
438	FK2WL06VVT	24	Manual Valve 2WL-6 Transfers Position	4.08E-07
439	FK2WL07VVT	24	Manual Valve 2WL-7 Transfers Position	4.08E-07
440	FK2WL08VVT	24	Manual Valve 2WL-8 Transfers Position	4.08E-07
441	FK2WL09VVT	24	Manual Valve 2WL-9 Transfers Position	4.08E-07
442	FK2WL11AVO	1	Cooling Water Control Valve 2WL-11 Fails To Open On Demand	2.80E-04
443	FK2WL11AVT	24	Cooling Water Control Valve 2WL-11 Transfers Closed	5.52E-05
444	FK2WL12VVT	36	Manual Valve 2WL-12 Transfers Position	6.12E-07
445	FK2WL15VVT	36	Manual Valve 2WL-15 Transfers Position	6.12E-07
446	FK2WL42VVT	36	Manual Valve 2WL-42 Transfers Position	6.12E-07
447	FK2WL43VVT	36	Manual Valve 2WL-43 Transfers Position	6.12E-07
448	FKVALVECOM	2.46E-5	Common Cause Failure Of Cooling Water Control Valves	2.46E-05
449	GK0BRGVRHE	1.00E-01	Failure To Recover Generator Thrust Bearing Cooling	1.00E-01
450	GK0COOLCOM	4.61E-07	Common Cause Failure of Generator Air Cooling	4.61E-07
451	GK0LOCKCOM	4.06E-06	Common Cause Actuation of Generator Lockouts	4.06E-06
452	GK10001HGR	24	Keowee Unit 1 Generator Fault While the Unit Runs	2.27E-03
453	GK10001HGS	1	Keowee Unit 1 Generator Fault Causes Unit Start Failure	1.54E-04
454	GK1063FPST	24	Keowee 1 Gen CO2 Sys Press Switch 63F Spurious Operation	1.03E-05
455	GK112TDRYT	24	Time Delay Relay 12XTD/1 Spuriously Picks-up	8.64E-06
456	GK112X1RYT	24	Relay 12X/1 Spuriously Picks-up	8.64E-06

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	NAME	FACTOR	DESC	PROB
457	GK13SUIRYT	24	Keowee Unit 1 Startup Inhibit Switch Auxiliary Relay S3SUIX Spurious Actuation	8.64E-06
458	GK13SUISWT	24	Keowee Unit 1 Startup Inhibit Switch 3SUI Spurious Operation	1.68E-06
459	GK140G1RYT	24	Keowee Unit 1 Loss Of Generator Field Relay 40G1 Spurious Actuation	8.64E-06
460	GK159GNRYT	24	Keowee Unit 1 Generator Ground Fault Relay 59GN1 Spurious Actuation	8.64E-06
461	GK162TDRYT	24	Keowee Unit 1 Generator Backup Trip Timer 62-1TD Spurious Operation	8.64E-06
462	GK163FXRYT	24	Keowee Unit 1 Generator Fire Relay 63FX Spurious Actuation	8.64E-06
463	GK186E1RYT	24	Keowee 1 Emergency Lockout Relay 86E-1 Spuriously Picks Up	8.64E-06
464	GK187G1RYT	24	Keowee Unit 1 Generator Differential Relay 87G-1 Spurious Actuation	8.64E-06
465	GK187GBRYT	24	Keowee Unit 1 Generator Bus Differential Relay 87GB Spurious Actuation	8.64E-06
466	GK187TERYT	24	Keowee Unit 1 Exitation Transformer Differential Relay 87T-1E Spur. Actuation	8.64E-06
467	GK1BRGVLHE	2.60E-04	Keowee 1 Gen. Brng Oil Cooling Flow Path Vlvs Mispositioned After Maintenance	2.60E-04
468	GK1COOLLHE	2.60E-04	Keowee 1 Gen. Air Cooler WL Flow Path Vlvs Mispositioned After Maintenance	2.60E-04
469	GK1FIREDEX	3.19E-05	Spurious Actuation of Unit 1 Gen. CO2 Fire Supression System	3.19E-05
470	GK1GAC1HXF	24	Generator Air Cooler 1GAHW-1 Fails	1.54E-05
471	GK1GAC1HXL	108	Heat Exchanger 1GAC1 Leaks	1.08E-05
472	GK1GAC2HXF	24	Generator Air Cooler 1GAHW-2 Fails	1.54E-05
473	GK1GAC2HXL	108	Heat Exchanger 1GAC2 Leaks	1.08E-05
474	GK1GAC3HXF	24	Generator Air Cooler 1GAHW-3 Fails	1.54E-05
475	GK1GAC3HXL	108	Heat Exchanger 1GAC3 Leaks	1.08E-05
476	GK1GAC4HXF	24	Generator Air Cooler 1GAHW-4 Fails	1.54E-05
477	GK1GAC4HXL	108	Heat Exchanger 1GAC4 Leaks	1.08E-05
478	GK1GAC5HXF	24	Generator Air Cooler 1GAHW-5 Fails	1.54E-05
479	GK1GAC5HXL	108	Heat Exchanger 1GAC5 Leaks	1.08E-05
480	GK1GAC6HXF	24	Generator Air Cooler 1GAHW-6 Fails	1.54E-05
481	GK1GAC6HXL	108	Heat Exchanger 1GAC6 Leaks	1.08E-05
482	GK1HPO1HXF	24	Generator Thrust Bearing Cooler 1HPOHX-1 Fails	1.54E-05
483	GK1HPO2HXF	24	Generator Thrust Bearing Cooler 1HPOHX-2 Fails	1.54E-05
484	GK1HPO3HXF	24	Generator Thrust Bearing Cooler 1HPOHX-3 Fails	1.54E-05
485	GK1HPO4HXF	24	Generator Thrust Bearing Cooler 1HPOHX-4 Fails	1.54E-05
486	GK1HPO5HXF	24	Generator Thrust Bearing Cooler 1HPOHX-5 Fails	1.54E-05
487	GK1HPO6HXF	24	Generator Thrust Bearing Cooler 1HPOHX-6 Fails	1.54E-05
488	GK1HPO6VVT	24	Genrator Bearing Oil Leak Because Manual Valve 1HPO-6 Transfers Position	4.08E-07
489	GK1HPO7HXF	24	Generator Thrust Bearing Cooler 1HPOHX-7 Fails	1.54E-05
490	GK1HPO8HXF	24	Generator Thrust Bearing Cooler 1HPOHX-8 Fails	1.54E-05
491	GK1NGDCLHE	5.20E-05	Failure to Close the Unit 1 Neutral Ground Disconnect Following Maintenance	5.20E-05
492	GK1O121SST	24	Speed Switch 12/1 Falsely Indicates High Speed	1.01E-04
493	GK1WL16VVT	384	Manual Valve 1WL-16 Transfers Position	6.53E-06
494	GK1WL17VVT	384	Manual Valve 1WL-17 Transfers Position	6.53E-06

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	NAME	FACTOR	DESC	PROB
495	GK1WL18VVT	108	Manual Valve 1WL18 Transfers Position	1.84E-06
496	GK1WL19VVT	108	Manual Valve 1WL19 Transfers Position	1.84E-06
497	GK1WL20VVT	384	Manual Valve 1WL-20 Transfers Position	6.53E-06
498	GK1WL21VVT	384	Manual Valve 1WL-21 Transfers Position	6.53E-06
499	GK1WL22VVT	108	Manual Valve 1WL22 Transfers Position	1.84E-06
500	GK1WL23VVT	108	Manual Valve 1WL23 Transfers Position	1.84E-06
501	GK1WL24VVT	384	Manual Valve 1WL-24 Transfers Position	6.53E-06
502	GK1WL25VVT	384	Manual Valve 1WL-25 Transfers Position	6.53E-06
503	GK1WL26VVT	108	Manual Valve 1WL26 Transfers Position	1.84E-06
504	GK1WL27VVT	108	Manual Valve 1WL27 Transfers Position	1.84E-06
505	GK1WL28VVT	384	Manual Valve 1WL-28 Transfers Position	6.53E-06
506	GK1WL29VVT	384	Manual Valve 1WL-29 Transfers Position	6.53E-06
507	GK1WL30VVT	108	Manual Valve 1WL30 Transfers Position	1.84E-06
508	GK1WL31VVT	108	Manual Valve 1WL31 Transfers Position	1.84E-06
509	GK1WL32VVT	384	Manual Valve 1WL-32 Transfers Position	6.53E-06
510	GK1WL33VVT	384	Manual Valve 1WL-33 Transfers Position	6.53E-06
511	GK1WL34VVT	108	Manual Valve 1WL34 Transfers Position	1.84E-06
512	GK1WL35VVT	108	Manual Valve 1WL35 Transfers Position	1.84E-06
513	GK1WL36VVT	384	Manual Valve 1WL-36 Transfers Position	6.53E-06
514	GK1WL37VVT	384	Manual Valve 1WL-37 Transfers Position	6.53E-06
515	GK1WL38VVT	108	Manual Valve 1WL38 Transfers Position	1.84E-06
516	GK1WL39VVT	108	Manual Valve 1WL39 Transfers Position	1.84E-06
517	GK1WL41VVT	384	Keowee 1 Manual Valve 1WL-41 Transfers Position to Block Discharge Path	6.53E-06
518	GK1WL44VVT	384	Manual Valve 1WL-44 Transfers Position	6.53E-06
519	GK1WL45VVT	384	Manual Valve 1WL-45 Transfers Position	6.53E-06
520	GK1WL46VVT	108	Manual Valve 1WL-46 Transfers Position	1.84E-06
521	GK1WL47VVT	108	Manual Valve 1WL-47 Transfers Position	1.84E-06
522	GK1WL48VVT	384	Manual Valve 1WL-48 Transfers Position	6.53E-06
523	GK1WL49VVT	384	Manual Valve 1WL-49 Transfers Position	6.53E-06
524	GK1WL50VVT	108	Manual Valve 1WL-50 Transfers Position	1.84E-06
525	GK1WL51VVT	108	Manual Valve 1WL-51 Transfers Position	1.84E-06
526	GK1WL52VVT	384	Manual Valve 1WL-52 Transfers Position	6.53E-06
527	GK1WL53VVT	384	Manual Valve 1WL-53 Transfers Position	6.53E-06
528	GK1WL54VVT	108	Manual Valve 1WL-54 Transfers Position	1.84E-06
529	GK1WL55VVT	108	Manual Valve 1WL-55 Transfers Position	1.84E-06
530	GK1WL56VVT	384	Manual Valve 1WL-56 Transfers Position	6.53E-06
531	GK1WL57VVT	384	Manual Valve 1WL-57 Transfers Position	6.53E-06
532	GK1WL58VVT	108	Manual Valve 1WL-58 Transfers Position	1.84E-06

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	NAME	FACTOR	DESC	PROB
533	GK1WL59VVT	108	Manual Valve 1WL-59 Transfers Position	1.84E-06
534	GK1WL60VVT	384	Manual Valve 1WL-60 Transfers Position	6.53E-06
535	GK1WL61VVT	384	Manual Valve 1WL-61 Transfers Position	6.53E-06
536	GK1WL62VVT	108	Manual Valve 1WL-62 Transfers Position	1.84E-06
537	GK1WL63VVT	108	Manual Valve 1WL-63 Transfers Position	1.84E-06
538	GK1WL64VVT	384	Manual Valve 1WL-64 Transfers Position	6.53E-06
539	GK1WL65VVT	384	Manual Valve 1WL-65 Transfers Position	6.53E-06
540	GK1WL66VVT	108	Manual Valve 1WL-66 Transfers Position	1.84E-06
541	GK1WL67VVT	108	Manual Valve 1WL-67 Transfers Position	1.84E-06
542	GK1WL68VVT	384	Manual Valve 1WL-68 Transfers Position	6.53E-06
543	GK1WL69VVT	384	Manual Valve 1WL-69 Transfers Position	6.53E-06
544	GK1WL70VVT	108	Manual Valve 1WL-70 Transfers Position	1.84E-06
545	GK1WL71VVT	108	Manual Valve 1WL-71 Transfers Position	1.84E-06
546	GK1WL72VVT	384	Manual Valve 1WL-72 Transfers Position	6.53E-06
547	GK1WL73VVT	384	Manual Valve 1WL-73 Transfers Position	6.53E-06
548	GK1WL74VVT	108	Manual Valve 1WL-74 Transfers Position	1.84E-06
549	GK1WL75VVT	108	Manual Valve 1WL-75 Transfers Position	1.84E-06
550	GK1WL76VVT	384	Manual Valve 1WL76 Transfers Position and Blocks Discharge Path	6.53E-06
551	GK1WL78VVT	384	Manual Valve 1WL78 Transfers Position and Blocks Discharge Path	6.53E-06
552	GK20001HGR	24	Keowee Unit 2 Generator Fault While the Unit Runs	2.27E-03
553	GK20002HGS	1	Keowee Unit 2 Generator Fault Causes Unit Start Failure	1.54E-04
554	GK2063FPST	24	Keowee 2 Gen CO2 Sys Press Switch 63F Spurious Operation	1.03E-05
555	GK212TDRYT	24	Time Delay Relay 12XTD/2 Spuriously Picks-up	8.64E-06
556	GK212X2RYT	24	Relay 12X/2 Spuriously Picks-up	8.64E-06
557	GK23SUIRYT	24	Keowee Unit 2 Startup Inhibit Switch Auxiliary Relay S3SUIX Spurious Actuation	8.64E-06
558	GK23SUISWT	24	Keowee Unit 2 Startup Inhibit Swtich 3SUI Spurious Operation	1.68E-06
559	GK240G1RYT	24	Keowee Unit 2 Loss Of Generator Field Relay 40G1 Spurious Actuation	8.64E-06
560	GK259GNRYT	24	Keowee Unit 2 Generator Ground Fault Relay 59GN2 Spurious Actuation	8.64E-06
561	GK262TDRYT	24	Keowee Unit 2 Generator Backup Trip Timer 62-2TD Spurious Operation	8.64E-06
562	GK263FXRYT	24	Keowee Unit 2 Generator Fire Relay 63FX Spurious Actuation	8.64E-06
563	GK286E2RYT	24	Keowee 2 Emergency Lockout Relay 86E-2 Spuriously Picks Up	8.64E-06
564	GK287G2RYT	24	Keowee Unit 2 Generator Differential Relay 87G-2 Spurious Actuation	8.64E-06
565	GK287GBRYT	24	Keowee Unit 2 Generator Bus Differential Relay 87GB Spurious Actuation	8.64E-06
566	GK287TERYT	24	Keowee Unit 2 Excitation Transformer Differential Relay 87T-2E Spur. Actuation	8.64E-06
567	GK2BRGVLHE	2.60E-04	Keowee 2 Gen. Brng Oil Cooling Flow Path Vlvs Mispositioned After Maintenance	2.60E-04
568	GK2COOLLHE	2.60E-04	Keowee 2 Gen. Air Cooler WL Flow Path Vlvs Mispositioned After Maintenance	2.60E-04
569	GK2FIREDEX	7.00E-05	Spurious Actuation of Unit 2 Gen. CO2 Fire Supression System	7.00E-05
570	GK2GAC1HXF	24	Generator Air Cooler 2GAHW-1 Fails	1.54E-05

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	NAME	FACTOR	DESC	PROB
571	GK2GAC1HXL	36	Heat Exchanger 2GAC1 Leaks	3.60E-06
572	GK2GAC2HXF	24	Generator Air Cooler 2GAHW-2 Fails	1.54E-05
573	GK2GAC2HXL	36	Heat Exchanger 2GAC2 Leaks	3.60E-06
574	GK2GAC3HXF	24	Generator Air Cooler 2GAHW-3 Fails	1.54E-05
575	GK2GAC3HXL	36	Heat Exchanger 2GAC3 Leaks	3.60E-06
576	GK2GAC4HXF	24	Generator Air Cooler 2GAHW-4 Fails	1.54E-05
577	GK2GAC4HXL	36	Heat Exchanger 2GAC4 Leaks	3.60E-06
578	GK2GAC5HXF	24	Generator Air Cooler 2GAHW-5 Fails	1.54E-05
579	GK2GAC5HXL	36	Heat Exchanger 2GAC5 Leaks	3.60E-06
580	GK2GAC6HXF	24	Generator Air Cooler 2GAHW-6 Fails	1.54E-05
581	GK2GAC6HXL	36	Heat Exchanger 2GAC6 Leaks	3.60E-06
582	GK2HPO1HXF	24	Generator Thrust Bearing Cooler 2HPOHX-1 Fails	1.54E-05
583	GK2HPO2HXF	24	Generator Thrust Bearing Cooler 2HPOHX-2 Fails	1.54E-05
584	GK2HPO3HXF	24	Generator Thrust Bearing Cooler 2HPOHX-3 Fails	1.54E-05
585	GK2HPO4HXF	24	Generator Thrust Bearing Cooler 2HPOHX-4 Fails	1.54E-05
586	GK2HPO5HXF	24	Generator Thrust Bearing Cooler 2HPOHX-5 Fails	1.54E-05
587	GK2HPO6HXF	24	Generator Thrust Bearing Cooler 2HPOHX-6 Fails	1.54E-05
588	GK2HPO6VVT	24	Genrator Bearing Oil Leak Because Manual Valve 2HPO-6 Transfers Position	4.08E-07
589	GK2HPO7HXF	24	Generator Thrust Bearing Cooler 2HPOHX-7 Fails	1.54E-05
590	GK2HPO8HXF	24	Generator Thrust Bearing Cooler 2HPOHX-8 Fails	1.54E-05
591	GK2NGDCLHE	5.20E-05	Failure to Close the Unit 2 Neutral Ground Disconnect Following Maintenance	5.20E-05
592	GK2O121SST	24	Speed Switch 12/2 Falsely Indicates High Speed	1.01E-04
593	GK2WL16VVT	36	Manual Valve 2WL-16 Transfers Position	6.12E-07
594	GK2WL17VVT	36	Manual Valve 2WL-17 Transfers Position	6.12E-07
595	GK2WL18VVT	36	Manual Valve 2WL18 Transfers Position	6.12E-07
596	GK2WL19VVT	36	Manual Valve 2WL19 Transfers Position	6.12E-07
597	GK2WL20VVT	36	Manual Valve 2WL-20 Transfers Position	6.12E-07
598	GK2WL21VVT	36	Manual Valve 2WL-21 Transfers Position	6.12E-07
599	GK2WL22VVT	36	Manual Valve 2WL22 Transfers Position	6.12E-07
600	GK2WL23VVT	36	Manual Valve 2WL23 Transfers Position	6.12E-07
601	GK2WL24VVT	36	Manual Valve 2WL-24 Transfers Position	6.12E-07
602	GK2WL25VVT	36	Manual Valve 2WL-25 Transfers Position	6.12E-07
603	GK2WL26VVT	36	Manual Valve 2WL26 Transfers Position	6.12E-07
604	GK2WL27VVT	36	Manual Valve 2WL27 Transfers Position	6.12E-07
605	GK2WL28VVT	36	Manual Valve 2WL-28 Transfers Position	6.12E-07
606	GK2WL29VVT	36	Manual Valve 2WL-29 Transfers Position	6.12E-07
607	GK2WL30VVT	36	Manual Valve 2WL30 Transfers Position	6.12E-07
608	GK2WL31VVT	36	Manual Valve 2WL31 Transfers Position	6.12E-07

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Keowee PRA Basic Event Data (Base Case)
Bayesian Updated With Recoveries

	NAME	FACTOR	DESC	PROB
609	GK2WL32VVT	36	Manual Valve 2WL-32 Transfers Position	6.12E-07
610	GK2WL33VVT	36	Manual Valve 2WL-33 Transfers Position	6.12E-07
611	GK2WL34VVT	36	Manual Valve 2WL34 Transfers Position	6.12E-07
612	GK2WL35VVT	36	Manual Valve 2WL35 Transfers Position	6.12E-07
613	GK2WL36VVT	36	Manual Valve 2WL-36 Transfers Position	6.12E-07
614	GK2WL37VVT	36	Manual Valve 2WL-37 Transfers Position	6.12E-07
615	GK2WL38VVT	36	Manual Valve 2WL38 Transfers Position	6.12E-07
616	GK2WL39VVT	36	Manual Valve 2WL39 Transfers Position	6.12E-07
617	GK2WL41VVT	36	Keowee 2 Manual Valve 2WL-41 Transfers Position to Block Discharge Path	6.12E-07
618	GK2WL44VVT	36	Manual Valve 2WL-44 Transfers Position	6.12E-07
619	GK2WL45VVT	36	Manual Valve 2WL-45 Transfers Position	6.12E-07
620	GK2WL46VVT	36	Manual Valve 2WL-46 Transfers Position	6.12E-07
621	GK2WL47VVT	36	Manual Valve 2WL-47 Transfers Position	6.12E-07
622	GK2WL48VVT	36	Manual Valve 2WL-48 Transfers Position	6.12E-07
623	GK2WL49VVT	36	Manual Valve 2WL-49 Transfers Position	6.12E-07
624	GK2WL50VVT	36	Manual Valve 2WL-50 Transfers Position	6.12E-07
625	GK2WL51VVT	36	Manual Valve 2WL-51 Transfers Position	6.12E-07
626	GK2WL52VVT	36	Manual Valve 2WL-52 Transfers Position	6.12E-07
627	GK2WL53VVT	36	Manual Valve 2WL-53 Transfers Position	6.12E-07
628	GK2WL54VVT	36	Manual Valve 2WL-54 Transfers Position	6.12E-07
629	GK2WL55VVT	36	Manual Valve 2WL-55 Transfers Position	6.12E-07
630	GK2WL56VVT	36	Manual Valve 2WL-56 Transfers Position	6.12E-07
631	GK2WL57VVT	36	Manual Valve 2WL-57 Transfers Position	6.12E-07
632	GK2WL58VVT	36	Manual Valve 2WL-58 Transfers Position	6.12E-07
633	GK2WL59VVT	36	Manual Valve 2WL-59 Transfers Position	6.12E-07
634	GK2WL60VVT	36	Manual Valve 2WL-60 Transfers Position	6.12E-07
635	GK2WL61VVT	36	Manual Valve 2WL-61 Transfers Position	6.12E-07
636	GK2WL62VVT	36	Manual Valve 2WL-62 Transfers Position	6.12E-07
637	GK2WL63VVT	36	Manual Valve 2WL-63 Transfers Position	6.12E-07
638	GK2WL64VVT	36	Manual Valve 2WL-64 Transfers Position	6.12E-07
639	GK2WL65VVT	36	Manual Valve 2WL-65 Transfers Position	6.12E-07
640	GK2WL66VVT	36	Manual Valve 2WL-66 Transfers Position	6.12E-07
641	GK2WL67VVT	36	Manual Valve 2WL-67 Transfers Position	6.12E-07
642	GK2WL68VVT	36	Manual Valve 2WL-68 Transfers Position	6.12E-07
643	GK2WL69VVT	36	Manual Valve 2WL-69 Transfers Position	6.12E-07
644	GK2WL70VVT	36	Manual Valve 2WL-70 Transfers Position	6.12E-07
645	GK2WL71VVT	36	Manual Valve 2WL-71 Transfers Position	6.12E-07
646	GK2WL72VVT	36	Manual Valve 2WL-72 Transfers Position	6.12E-07

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	NAME	FACTOR	DESC		PROB
647	GK2WL73VVT	36	Manual Valve 2WL-73 Transfers Position		6.12E-07
648	GK2WL74VVT	36	Manual Valve 2WL-74 Transfers Position		6.12E-07
649	GK2WL75VVT	36	Manual Valve 2WL-75 Transfers Position		6.12E-07
650	GK2WL76VVT	36	Manual Valve 2WL76 Transfers Position and Blocks Discharge Path		6.12E-07
651	GK2WL78VVT	36	Manual Valve 2WL78 Transfers Position and Blocks Discharge Path		6.12E-07
652	GKHPOILCOM	4.61E-07	Common Cause Failure of Generator Thrust Bearings		4.61E-07
653	K12COM1DEX	1.00E-06	Grid Degradation Occurs And Causes Failure Of Both Keowee Units		1.00E-06
654	KA127T1R6D	1	Xfrmr 1X UV Relay 27T/1X Fails To Pick-up		2.49E-04
655	KA127T1R6T	360	Xfrmr 1X UV Relay 27T/1X Spuriously De-energizes		1.31E-04
656	KA227T2R6T	360	Xfmr 2X UV Relay 27T/2x Spuriously De-energizes		1.31E-04
657	KB4CONNDEX	1.1E-7	Air Circuit Breaker 4 Connects Unit 2 To The Underground Path		1.10E-07
658	KK1BOTHDEX	0.0	Keowee Units 1 And 2 Are Supplying The Grid		0.00E+00
659	KK1BOTHHYM	5.23E-3	Both Keowee Units Unavailable Due To Common Maintenance		5.23E-03
660	KK1OVERBHF	24	Fault Occurs On The Overhead Power Path		9.60E-06
661	KK1RUNSDEX	0.0	Keowee Unit 1 Only Is Supplying The Grid		0.00E+00
662	KK1UNDRBHF	24	Fault Occurs On The Underground Power Path		9.60E-06
663	KK2RUNSDEX	0.06	Keowee Unit 2 Only Is Supplying The Grid		6.00E-02
664	KK2UNITHYM	3.80E-2	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-02
665	KU2CREDIT	0	Take No Credit For Keowee Unit 2 Suppling Auxiliary ac PowerTo Unit 1		0.00E+00
666	L0EGTPSCOM	1.78E-06	Common Cause Failure of UV And UF Detection Circuits		1.78E-06
667	L27BRX1RYD	1	Snsng Rly 27B/RX1 Fails to Drop Out on Undervoltage	OEE-76-3, -4	3.30E-05
668	L27BRX2RYD	1	Snsng Rly 27B/RX2 Fails to Drop Out on Undervoltage	OEE-76-3, -8	3.30E-05
669	L27BRY1RYD	1	Snsng Rly 27B/RY1 Fails to Drop Out on Undervoltage	OEE-76-3, -4	3.30E-05
670	L27BRY2RYD	1	Snsng Rly 27B/RY2 Fails to Drop Out on Undervoltage	OEE-76-3, -8	3.30E-05
671	L27BRZ1RYD	1	Snsng Rly 27B/RZ1 Fails to Drop Out on Undervoltage	OEE-76-3, -4	3.30E-05
672	L27BRZ2RYD	1	Snsng Rly 27B/RZ2 Fails to Drop Out on Undervoltage	OEE-76-3, -8	3.30E-05
673	L27BYX1RYD	1	Snsng Rly 27B/YX1 Fails to Drop Out on Undervoltage	OEE-76-3, -4	3.30E-05
674	L27BYX2RYD	1	Snsng Rly 27B/YX2 Fails to Drop Out on Undervoltage	OEE-76-3, -8	3.30E-05
675	L27BYY1RYD	1	Snsng Rly 27B/YY1 Fails to Drop Out on Undervoltage	OEE-76-3, -4	3.30E-05
676	L27BYY2RYD	1	Snsng Rly 27B/YY2 Fails to Drop Out on Undervoltage	OEE-76-3, -8	3.30E-05
677	L27BYZ1RYD	1	Snsng Rly 27B/YZ1 Fails to Drop Out on Undervoltage	OEE-76-3, -4	3.30E-05
678	L27BYZ2RYD	1	Snsng Rly 27B/YZ2 Fails to Drop Out on Undervoltage	OEE-76-3, -8	3.30E-05
679	L27XPX1RYD	1	Ch 1 Phase X UV Aux. Relay Fails To Pick Up	OEE-76-4	3.30E-05
680	L27XPX2RYD	1	Ch 2 Phase X UV Aux. Relay Fails To Pick Up	OEE-76-8	3.30E-05
681	L27XPY1RYD	1	Ch 1 Phase Y UV Aux. Relay Fails to Pick Up	OEE-76-4	3.30E-05
682	L27XPY2RYD	1	Ch 2 Phase Y UV Aux. Relay Fails to Pick Up	OEE-76-8	3.30E-05
683	L27XPZ1RYD	1	Ch 1 Phase Z UV Aux. Relay Fails To Pick Up	OEE-76-4	3.30E-05
684	L27XPZ2RYD	1	Ch 2 Phase Z UV Aux. Relay Fails To Pick Up	OEE-76-8	3.30E-05

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	NAME	FACTOR	DESC	PROB
685	L27XRX1RYD	1	Red Bus Phase X1 Undervoltage Aux. Relay Fails To Pick Up OEE-76-4	3.30E-05
686	L27XRX2RYD	1	Red Bus Phase X2 Undervoltage Aux. Relay Fails To Pick Up OEE-76-8	3.30E-05
687	L27XRY1RYD	1	Red Bus Phase Y1 Undervoltage Aux. Relay Fails To Pick Up OEE-76-4	3.30E-05
688	L27XRY2RYD	1	Red Bus Phase Y2 Undervoltage Aux. Relay Fails to Pick Up OEE-76-8	3.30E-05
689	L27XRZ1RYD	1	Red Bus Phase Z1 Undervoltage Aux. Relay Fails To Pick Up OEE-76-4	3.30E-05
690	L27XRZ2RYD	1	Red Bus Phase Z2 Undervoltage Aux. Relay Fails To Pick Up OEE-76-8	3.30E-05
691	L27XSTARYD	1	Keowee Start Relay 27X/STA Fails To Pick Up	3.30E-05
692	L27XSTBRYD	1	Keowee Start Relay 27X/STB Fails To Pick Up	3.30E-05
693	L27XYX1RYD	1	Yellow Bus Phase X1 Undervoltage Aux. Relay Fails To Pick Up OEE-76-4	3.30E-05
694	L27XYX2RYD	1	Yellow Bus Phase X2 Undervoltage Aux. Relay Fails To Pick Up OEE-76-8	3.30E-05
695	L27XYY1RYD	1	Yellow Bus Phase Y1 Undervoltage Aux. Relay Fails To Pick Up OEE-76-4	3.30E-05
696	L27XYY2RYD	1	Yellow Bus Phase Y2 Undervoltage Aux. Relay Fails to Pick Up OEE-76-8	3.30E-05
697	L27XYZ1RYD	1	Yellow Bus Phase Z1 Undervoltage Aux. Relay Fails To Pick Up OEE-76-4	3.30E-05
698	L27XYZ2RYD	1	Yellow Bus Phase Z2 Undervoltage Aux. Relay Fails to Pick Up OEE-76-8	3.30E-05
699	L81BRX1RYD	1	Sensing Relay 81BL/RX1 Fails to Drop Out on Underfrequency	3.30E-05
700	L81BRX2RYD	1	Sensing Relay 81BL/RX2 Fails to Drop Out on Underfrequency	3.30E-05
701	L81BRY1RYD	1	Sensing Relay 81BL/RY1 Fails to Drop Out on Underfrequency	3.30E-05
702	L81BRY2RYD	1	Sensing Relay 81BL/RY2 Fails to Drop Out on Underfrequency	3.30E-05
703	L81BRZ1RYD	1	Sensing Relay 81BL/RZ1 Fails to Drop Out on Underfrequency	3.30E-05
704	L81BRZ2RYD	1	Sensing Relay 81BL/RZ2 Fails to Drop Out on Underfrequency	3.30E-05
705	L81BYX1RYD	1	Sensing Relay 81BL/YX1 Fails to Drop Out on Underfrequency	3.30E-05
706	L81BYX2RYD	1	Sensing Relay 81BL/YX2 Fails to Drop Out on Underfrequency	3.30E-05
707	L81BYY1RYD	1	Sensing Relay 81BL/YY1 Fails to Drop Out on Underfrequency	3.30E-05
708	L81BYY2RYD	1	Sensing Relay 81BL/YY2 Fails to Drop Out on Underfrequency	3.30E-05
709	L81BYZ1RYD	1	Sensing Relay 81BL/YZ1 Fails to Drop Out on Underfrequency	3.30E-05
710	L81BYZ2RYD	1	Sensing Relay 81BL/YZ2 Fails to Drop Out On Underfrequency	3.30E-05
711	L81XPX1RYD	1	Ch 1 Phase X Underfrequency Aux. Rly Fails to Pick Up	3.30E-05
712	L81XPX2RYD	1	Ch 2 Phase X Underfrequency Aux. Rly Fails to Pick Up	3.30E-05
713	L81XPY1RYD	1	Ch 1 Phase Y Underfrequency Aux. Rly Fails to Pick Up	3.30E-05
714	L81XPY2RYD	1	Ch 2 Phase Y Underfrequency Aux. Rly Fails to Pick Up	3.30E-05
715	L81XPZ1RYD	1	Ch 1 Phase Z Underfrequency Aux. Rly Fails to Pick Up	3.30E-05
716	L81XPZ2RYD	1	Ch 2 Phase Z Underfrequency Aux. Rly Fails to Pick up	3.30E-05
717	L81XRX1RYD	1	Red Bus Phase X1 Underfrequency Aux. Rly Fails to Pick Up	3.30E-05
718	L81XRX2RYD	1	Red Bus Phase X2 Underfrequency Aux. Rly Fails to Pick Up	3.30E-05
719	L81XRY1RYD	1	Red Bus Phase Y1 Underfrequency Aux. Rly Fails to Pick Up	3.30E-05
720	L81XRY2RYD	1	Red Bus Phase Y2 Underfrequency Aux. Rly Fails to Pick Up	3.30E-05
721	L81XRZ1RYD	1	Red Bus Phase Z1 Underfrequency Aux. Rly Fails to Pick Up	3.30E-05
722	L81XRZ2RYD	1	Red Bus Phase Z2 Underfrequency Aux. Rly Fails to Pick Up	3.30E-05

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	NAME	FACTOR	DESC		PROB
723	L81XYX1RYD	1	Yellow Bus Phase X1 Underfrequency Aux. Rly Fails to Pick Up		3.30E-05
724	L81XYX2RYD	1	Yellow Bus Phase X2 Underfrequency Aux. Rly Fails to Pick Up		3.30E-05
725	L81XYY1RYD	1	Yellow Bus Phase Y1 Underfrequency Aux. Rly Fails to Pick Up		3.30E-05
726	L81XYY2RYD	1	Yellow Bus Phase Y2 Underfrequency Aux. Rly Fails to Pick Up		3.30E-05
727	L81XYZ1RYD	1	Yellow Bus Phase Z1 Underfrequency Aux. Rly Fails to Pick Up		3.30E-05
728	L81XYZ2RYD	1	Yellow Bus Phase Z2 Underfrequency Aux. Rly Fails to Pick Up		3.30E-05
729	LC94F1ARYD	1	EGTPS Underfrequency Relay 94/F1A Fails to Pick Up		3.30E-05
730	LC94F1BRYD	1	EGTPS Underfrequency Relay 94/F1B Fails to Pick Up		3.30E-05
731	LC94F1DRYD	1	EGTPS Underfrequency Relay 94/F1D Fails to Pick Up		3.30E-05
732	LC94F2ARYD	1	EGTPS Underfrequency Relay 94/F2A Fails to Pick Up		3.30E-05
733	LC94F2BRYD	1	EGTPS Underfrequency Relay 94/F2B Fails to Pick Up		3.30E-05
734	LC94F2CRYD	1	EGTPS Underfrequency Relay 94/F2C Fails to Pick Up		3.30E-05
735	LC94F2DRYD	1	EGTPS Underfrequency Relay 94/F2D Fails to Pick Up		3.30E-05
736	LC94V1ARYD	1	EGTPS Undervoltage Relay 94/V1A Fails to Pick Up		3.30E-05
737	LC94V1BRYD	1	EGTPS Undervoltage Relay 94/V1B Fails To Pick Up	OEE-76-4	3.30E-05
738	LC94V1DRYD	1	EGTPS Undervoltage Relay 94/V1D Fails to Pick Up	OEE-76-4	3.30E-05
739	LC94V2ARYD	1	EGTPS Undervoltage Relay 94/V2A Fails to Pick Up		3.30E-05
740	LC94V2BRYD	1	EGTPS Undervoltage Relay 94/V2B Fails To Pick Up		3.30E-05
741	LC94V2CRYD	1	EGTPS Undervoltage Relay 94/V2C Fails to Pick Up		3.30E-05
742	LDCYC13CDT	24	Switchyard 125 Vdc Panelboard DYC Breaker 13 Transfers Open	OEE-76-4 / O-802	1.80E-06
743	LDCYC14CDT	24	Switchyard 125 Vdc Panelboard DYC Breaker 14 Transfers Open	OEE-76-4 / O-802	1.80E-06
744	LDCYG12CDT	24	Switchyard 125 Vdc Panelboard DYG Breaker 12 Transfers Open		1.80E-06
745	LDCYG18CDT	24	Switchyard 125 Vdc Panelboard DYG Breaker 18 Transfers Open		1.80E-06
746	OFACTORDEX	1.0	Overload Susceptibility Factor		1.00E+00
747	OK0PRUNCOM	1.46E-05	Common Cause Failure Of Both Governor Oil Systems To Run		1.46E-05
748	OK10001PSC	15	Pressure Switch 1OGPS-1 Fails to Close (Normal	Control Signal)	4.35E-05
749	OK10002PSC	8	Pressure Switch 1OGPS-2 Fails to Close		2.32E-05
750	OK10003PSC	4	Pressure Switch 1OGPS-3 Fails to Close		1.16E-05
751	OK10003RVT	24	Safety Relief Valve 1OG-3 Spurious Operation		1.34E-04
752	OK10003TKF	24	Unit 1 Governor Oil Pressure Tank Fails		1.10E-05
753	OK10004PSC	1	Pressure Switch 1OGPS-4 Fails to Close		2.90E-06
754	OK10007FVT	24	Float Valve 1OG-7 Transfers Closed		1.40E-04
755	OK10009VVT	24	Manual Valve 1OG-9 Transfers Closed		4.08E-07
756	OK10011CVO	15	Check Valve 1OG-11 Fails to Open		3.45E-05
757	OK10011CVT	0.75	Check Valve 1OG-11 Transfers Closed		9.75E-08
758	OK10012VVT	30	Manual Globe Valve 1OG-12 Transfers Closed		5.10E-07
759	OK10013RVT	0.75	Relief Valve 1OG-13 Spurious Operation		4.20E-06
760	OK10014CVO	8	Check Valve 1OG-14 Fails to Open		1.84E-05

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	NAME	FACTOR	DESC	PROB
761	OK10014CVT	0.5	Check Valve 1OG-14 Transfers Closed	6.50E-08
762	OK10015VVT	192	Manual Globe Valve 1OG-15 Transfers Closed	3.26E-06
763	OK10016RVT	0.5	Relief Valve 1OG-16 Transfers Open	2.80E-06
764	OK10017CVO	4	Check Valve 1OG-17 Fails to Open	9.20E-06
765	OK10017CVT	0.25	Check Valve 1OG-17 Transfers Closed	3.25E-08
766	OK10018VVT	108	Manual Globe Valve 1OG-18 Transfers Closed	1.84E-06
767	OK10019RVT	0.25	Relief Valve 1OG-19 Spurious Operation	1.40E-06
768	OK1001AGPR	0.375	OG Pump 1A Fails to Run	5.25E-06
769	OK1001AGPS	15	OG Pump 1A Fails to Start	1.45E-03
770	OK1001BGPR	0.25	OG Pump 1B Fails to Run	3.50E-06
771	OK1001BGPS	8	OG Pump 1B Fails to Start	7.76E-04
772	OK1001BLHE	3.2E-3	Latent Human Error Fails OG Pump 1B	3.20E-03
773	OK1001CGPR	0.125	OG Pump 1C Fails to Run	1.75E-06
774	OK1001CGPS	4	OG Pump 1C Fails to Start	3.88E-04
775	OK1001CLHE	3.2E-3	Latent Human Error Fails OG Pump 1C	3.20E-03
776	OK188GASWT	30	Keowee 1 Governor Oil Control Switch 188GA Spurious Operation	2.10E-06
777	OK188GBSWT	192	Keowee 1 Control Switch 188GB Spurious Operation	1.34E-05
778	OK188GCSWT	108	Keowee 1 Control Switch 188GC Spurious Operation	7.56E-06
779	OK199K1RYD	1	Keowee 1 Relay 99K1 Fails To Operate On Demand	3.30E-05
780	OK199K1RYT	24	Keowee Unit 1 Relay 99K1 Spurious Operation	8.64E-06
781	OK199K2RYD	1	Keowee 1 Relay 99K2 Fails To Operate On Demand	3.30E-05
782	OK1AG01TKF	24	Air Receiver Tank 1AGTK-1 Fails	1.10E-05
783	OK1AG04RVT	24	Safety Relief Valve 1AG-4 Spurious Operation	1.34E-04
784	OK1AG05VVT	24	Manual Valve 1AG-5 Transfers Position	4.08E-07
785	OK1OG1CTRM	3.42E-3	OG Pump 1C Train In Maintenance Or Testing	3.42E-03
786	OK1PRUNCOM	1.12E-07	Common Cause Failure of Unit 1 OG Pumps to Run	1.12E-07
787	OK1PSTRCOM	2.04E-05	Common Cause Failure of Unit 1 OG Pumps to Start	2.04E-05
788	OK1XA1DCLT	30	Low Voltage Circuit Breaker 1XA-1D Transfers Position	2.73E-05
789	OK1XA2ECLT	30	Low Voltage Circuit Breaker 1XA-2E Transfers Position	2.73E-05
790	OK1XA4DCLT	30	Low Voltage Circuit Breaker 1XA-4D Transfers Position	2.73E-05
791	OK20001PSC	15	Pressure Switch 2OGPS-1 Fails to Close (Normal Control Signal)	4.35E-05
792	OK20002PSC	8	Pressure Switch 2OGPS-2 Fails to Close	2.32E-05
793	OK20003PSC	4	Pressure Switch 2OGPS-3 Fails to Close	1.16E-05
794	OK20003RVT	24	Safety Relief Valve 2OG-3 Spurious Operation	1.34E-04
795	OK20003TKF	24	Unit 2 Governor Oil Pressure Tank Fails	1.10E-05
796	OK20004PSC	1	Pressure Switch 2OGPS-4 Fails to Close	2.90E-06
797	OK20007FVT	24	Float Valve 2OG-7 Transfers Closed	1.40E-04
798	OK20009VVT	24	Manual Valve 2OG-9 Transfers Closed	4.08E-07

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	NAME	FACTOR	DESC	PROB
799	OK20011CVO	15	Check Valve 2OG-11 Fails to Open	3.45E-05
800	OK20011CVT	0.75	Check Valve 2OG-11 Transfers Closed	9.75E-08
801	OK20012VVT	30	Manual Globe Valve 2OG-12 Transfers Closed	5.10E-07
802	OK20013RVT	0.75	Relief Valve 2OG-13 Spurious Operation	4.20E-06
803	OK20014CVO	8	Check Valve 2OG-14 Fails to Open	1.84E-05
804	OK20014CVT	0.5	Check Valve 2OG-14 Transfers Closed	6.50E-08
805	OK20015VVT	192	Manual Globe Valve 2OG-15 Transfers Closed	3.26E-06
806	OK20016RVT	0.5	Relief Valve 2OG-16 Transfers Open	2.80E-06
807	OK20017CVO	4	Check Valve 2OG-17 Fails to Open	9.20E-06
808	OK20017CVT	0.25	Check Valve 2OG-17 Transfers Closed	3.25E-08
809	OK20018VVT	108	Manual Globe Valve 2OG-18 Transfers Closed	1.84E-06
810	OK20019RVT	0.25	Relief Valve 2OG-19 Spurious Operation	1.40E-06
811	OK2002AGPR	0.375	OG Pump 2A Fails to Run	5.25E-06
812	OK2002AGPS	15	OG Pump 2A Fails to Start	1.45E-03
813	OK2002BGPR	0.25	OG Pump 2B Fails to Run	3.50E-06
814	OK2002BGPS	8	OG Pump 2B Fails to Start	7.76E-04
815	OK2002BLHE	3.2E-3	Latent Human Error Fails OG Pump 2B	3.20E-03
816	OK2002CGPR	0.125	OG Pump 2C Fails to Run	1.75E-06
817	OK2002CGPS	4	OG Pump 2C Fails to Start	3.88E-04
818	OK2002CLHE	3.2E-3	Latent Human Error Fails OG Pump 2C	3.20E-03
819	OK288GASWT	30	Keowee 2 Governor Oil Control Switch 188GA Spurious Operation	2.10E-06
820	OK288GBSWT	192	Keowee 2 Control Switch 188GB Spurious Operation	1.34E-05
821	OK288GCSWT	108	Keowee 2 Control Switch 188GC Spurious Operation	7.56E-06
822	OK299K1RYD	1	Keowee 2 Relay 99K1 Fails To Operate On Demand	3.30E-05
823	OK299K1RYT	24	Keowee Unit 2 Relay 99K1 Spurious Operation	8.64E-06
824	OK299K2RYD	1	Relay 99K2 Fails To Operate On Demand	3.30E-05
825	OK2AG04RVT	24	Safety Relief Valve 2AG-4 Spurious Operation	1.34E-04
826	OK2AG05VVT	24	Manual Valve 2AG-5 Transfers Position	4.08E-07
827	OK2AGO1TKF	24	Air Receiver Tank 2AGTK-1 Fails	1.10E-05
828	OK2OG2CTRM	3.42E-3	OG Pump 2C Train In Maintenance Or Testing	3.42E-03
829	OK2PRUNCOM	1.12E-07	Common Cause Failure of Unit 2 OG Pumps to Run	1.12E-07
830	OK2PSTRCOM	2.04E-05	Common Cause Failure of Unit 2 OG Pumps to Start	2.04E-05
831	OK2XA1DCLT	30	Low Voltage Circuit Breaker 2XA-1D Transfers Position	2.73E-05
832	OK2XA2ECLT	30	Low Voltage Circuit Breaker 2XA-2E Transfers Position	2.73E-05
833	OK2XA4DCLT	30	Low Voltage Circuit Breaker 2XA-4D Transfers Position	2.73E-05
834	OMOD	0	Startup Bus UV Sensing Mod Is In Service	0.00E+00
835	PAC1TC4C4T	24	4160 Vac Breaker 1TC-4 Transfers Open	2.26E-05
836	PACTC01C4T	24	4160 Vac Breaker 1TC-1 Transfers Open	2.26E-05

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	NAME	FACTOR	DESC	PROB
837	PACTC14C4T	24	4160 Vac Breaker 1TC-14 Transfers Open	2.26E-05
838	PACX1TCBHF	24	4160 Vac Switchgear 1TC Fails	9.60E-06
839	PK0SUMPCOM	2.44E-06	Common Cause Failure Of Turbine Sump Pump System	2.44E-06
840	PK163SALST	30	Unit 1 AC Turbine Sump Pump Float Switch 63SA Fails	9.30E-06
841	PK163SBLST	15	Unit 1 DC Turbine Sump Pump Float Switch 63SB Transfers	4.65E-06
842	PK1ACDCCOM	2.77E-05	Common Cause Failure of Unit 1 Turbine Sump Pump System	2.77E-05
843	PK1DA5CCDT	24	125 Vdc Circuit Breaker 1DA-5C Transfers Position	1.80E-06
844	PK1PACKDEX	3.1E-5	Turbine No. 1 Packing Fails	3.10E-05
845	PK1TS01VVT	30	Manual Valve 1TS-1 Transfers Position	5.10E-07
846	PK1TS02CVT	30	Check Valve 1TS-2 Fails to Open or Transfers Closed	3.90E-06
847	PK1TS03VVT	108	Manual Valve 1TS-3 Transfers Position	1.84E-06
848	PK1TS04CVT	15	Check Valve 1TS-4 Fails to Open or Transfers Closed	1.95E-06
849	PK1TSACGPR	30	AC Sump Pump 1TSPU-1 Fails To Start Or Run	4.20E-04
850	PK1TSDCGPR	15	DC Sump Pump 1TSPU-2 Fails To Start Or Run	2.10E-04
851	PK1TSDCLHE	3.2E-3	Latent Human Error Fails Turbine No. 1 DC Sump Pump	3.20E-03
852	PK1TSDCTRM	6.85E-4	Turbine No. 1 DC Pump Train In Maintenance Or Testing	6.85E-04
853	PK1XA2CCLT	30	600 V Circuit Breaker 1XA-2C Transfers Position	2.73E-05
854	PK263SALST	30	Unit 2 AC Turbine Sump Pump Float Switch 63SA Fails	9.30E-06
855	PK263SBLST	15	Unit 2 DC Turbine Sump Pump Float Switch 63SB Transfers	4.65E-06
856	PK2ACDCCOM	2.77E-05	Common Cause Failure of Unit 2 Turbine Sump Pump System	2.77E-05
857	PK2DA1CCDT	24	125 Vdc Circuit Breaker 2DA-1C Transfers Position	1.80E-06
858	PK2PACKDEX	3.1E-5	Turbine No. 2 Packing Fails	3.10E-05
859	PK2TS01VVT	30	Manual Valve 2TS-1 Transfers Position	5.10E-07
860	PK2TS02CVT	30	Check Valve 2TS-2 Fails to Open or Transfers Closed	3.90E-06
861	PK2TS03VVT	108	Manual Valve 2TS-3 Transfers Position	1.84E-06
862	PK2TS04CVT	15	Check Valve 2TS-4 Fails to Open or Transfers Closed	1.95E-06
863	PK2TSACGPR	30	AC Sump Pump 2TSPU-1 Fails To Start Or Run	4.20E-04
864	PK2TSDCGPR	15	DC Sump Pump 2TSPU-2 Fails To Start Or Run	2.10E-04
865	PK2TSDCLHE	3.2E-3	Latent Human Error Fails Turbine No. 2 DC Sump Pump	3.20E-03
866	PK2TSDCTRM	6.85E-4	Turbine No. 2 DC Pump Train In Maintenance Or Testing	6.85E-04
867	PK2XA2CCLT	30	Low Voltage Circuit Breaker 2XA-2C Transfers Position	2.73E-05
868	PMFB1	5.60E-03	Loss of Power on Main Feeder Bus 1	5.60E-03
869	PMFB2	5.60E-03	Loss of Power on Main Feeder Bus 2	5.60E-03
870	S127E1VRYT	9	Unit 1 Startup Bus Undervoltage Relay 27E1 Fails	2.33E-03
871	S127EUVRYT	9	Unit 1 Startup Bus Undervoltage Relay 27E Fails	2.33E-03
872	S127EX1RYD	1	Unit 1 Startup Bus UV Aux Relay 27EX1 Fails to Pick Up	3.30E-05
873	S127EXVRYD	1	Unit 1 Startup Bus UV Aux Relay 27EX Fails to Pick Up	3.30E-05
874	S227E1VRYT	9	Unit 2 Startup Bus Undervoltage Relay 27E1 Fails	2.33E-03

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	NAME	FACTOR	DESC	PROB
875	S227EUVRYT	9	Unit 2 Startup Bus Undervoltage Relay 27E Fails	2.33E-03
876	S227EX1RYD	1	Unit 2 Startup Bus UV Aux Relay 27EX1 Fails to Pick Up	3.30E-05
877	S227EXVRYD	1	Unit 2 Startup Bus UV Aux Relay 27EX Fails to Pick Up	3.30E-05
878	S27XSC1RYD	1	Channel 1 Swyd Isolated Rly, 27X/SC1, Fails to Pick Up	3.30E-05
879	S27XSC2RYD	1	Channel 2 Swyd Isolated Rly, 27X/SC2, Fails to Pick Up	3.30E-05
880	S27XTD1RYD	1	Channel 1 Swyd Isolated Time Delay Rly, 27XTD/SC1, Fails	3.30E-05
881	S27XTD2RYD	1	Channel 2 Swyd Isolated Time Delay Rly, 27XTD/SC2, Fails	3.30E-05
882	S327E1VRYT	9	Unit 3 Startup Bus Undervoltage Trip Relay 27E1 Fails	2.33E-03
883	S327EUVRYT	9	Unit 3 Startup Bus Undervoltage Trip Relay 27E Fails	2.33E-03
884	S327EX1RYD	1	Unit 3 Standby Bus UV Aux Relay 27EX1 Fails to Pick Up	3.30E-05
885	S327EXVRYD	1	Unit 3 Startup Bus UV Trip Aux Relay 27EX Fails to Pick Up	3.30E-05
886	SB18UX1RYT	24	Auxiliary Relay 8UX-1 Spurious Operation	8.64E-06
887	SB28UX2RYT	24	Auxiliary Relay 8UX-2 Spurious Operation	8.64E-06
888	SB38UX3RYT	24	Auxiliary Relay 8UX-3 Spurious Operation	8.64E-06
889	SB48UX4RYT	24	Auxiliary Relay 8UX-4 Spurious Operation	8.64E-06
890	SDCAIDDDIF	24	Control Power From DYA To PCB 9 Isolating Diode Fails	9.12E-05
891	SDCDA12CDT	24	125 Vdc Swyd Control Power Pnlbd DYA Bkr 12 Xfrs Open	1.80E-06
892	SDCDA15CDT	24	125 Vdc Swyd Control Power Pnlbd DYA Bkr 15 Xfrs Open	1.80E-06
893	SDCDA17CDT	24	125 Vdc Swyd Control Power Pnlbd DYA Bkr 17 Xfrs Open	1.80E-06
894	SDCDB01CDT	24	125 Vdc Swyd Control Power Pnlbd DYB Bkr 1 Xfrs Open	1.80E-06
895	SDCDB13CDT	24	125 Vdc Swyd Control Power Pnlbd DYB Bkr 13 Xfrs Open	1.80E-06
896	SDCDC12CDT	24	125 Vdc Swyd Control Power Pnlbd DYC Bkr 12 Xfrs Open	1.80E-06
897	SDCDE12CDT	24	125 Vdc Swyd Control Power Pnlbd DYE Bkr 12 Xfrs Open	1.80E-06
898	SDCDE15CDT	24	125 Vdc Swyd Control Power Pnlbd DYE Bkr 15 Xfrs Open	1.80E-06
899	SDCDE17CDT	24	125 Vdc Swyd Control Power Pnlbd DYE Bkr 17 Xfrs Open	1.80E-06
900	SDCDF01CDT	24	125 Vdc Swyd Control Power Pnlbd DYF Bkr 1 Xfrs Open	1.80E-06
901	SDCDF13CDT	24	125 Vdc Swyd Control Power Pnlbd DYF Bkr 13 Xfrs Open	1.80E-06
902	SDCDG16CDT	24	125 Vdc Swyd Control Power Pnlbd DYG Bkr 16 Xfrs Open	1.80E-06
903	SDCDYA8CDT	24	125 Vdc Swyd Control Power Pnlbd DYA Bkr 8 Xfrs Open OEE-38	1.80E-06
904	SDCDYA9CDT	24	125 Vdc Swyd Control Power Pnlbd DYA Bkr 9 Xfrs Open	1.80E-06
905	SDCDYB4CDT	24	125 Vdc Swyd Control Power Pnlbd DYB Bkr 4 Xfrs Open	1.80E-06
906	SDCDYB6CDT	24	125 Vdc Swyd Control Power Pnlbd DYB Bkr 6 Xfrs Open	1.80E-06
907	SDCDYB8CDT	24	125 Vdc Swyd Control Power Pnlbd DYB Bkr 8 Xfrs Open	1.80E-06
908	SDCDYE8CDT	24	125 Vdc Swyd Control Power Pnlbd DYE Bkr 8 Xfrs Open	1.80E-06
909	SDCDYE9CDT	24	125 Vdc Swyd Control Power Pnlbd DYE Bkr 9 Xfrs Open	1.80E-06
910	SDCDYF4CDT	24	125 Vdc Swyd Control Power Pnlbd DYF Bkr 4 Xfrs Open	1.80E-06
911	SDCDYF6CDT	24	125 Vdc Swyd Control Power Pnlbd DYF Bkr 6 Xfrs Open	1.80E-06
912	SDCDYF8CDT	24	125 Vdc Swyd Control Power Pnlbd DYF Bkr 8 Xfrs Open	1.80E-06

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	NAME	FACTOR	DESC	PROB
913	SDCEIDDDIF	24	Control Power From DYE To PCB-9 Isolating Diode Fails	9.12E-05
914	SK194GBRYT	24	Keowee Unit 1 94GB Auxiliary Relay Spurious Operation	8.64E-06
915	SK294GBRYT	24	Keowee Unit 2 94GB Auxiliary Relay Spurious Operation	8.64E-06
916	SKXFMR1THF	24	Keowee Transformer 1 Fails	7.44E-05
917	SPC14KVBHF	24	13.8 kV Bus Faulted	9.60E-06
918	SPC51TNRYT	24	Main Step Up Transformer Neutral Ground Relay 51TN Spurious Operation	8.64E-06
919	SPC62ABRYT	24	ACB Back-up Trip Timer 62AB Spurious Operation	8.64E-06
920	SPC631XRYT	24	Auxiliary Relay 63H1X Spurious Operation	8.64E-06
921	SPC871XRYT	72	Transformer 1X Differential Relay 87T-1X Spurious Operation	2.59E-05
922	SPC872XRYT	72	Transformer 2X Differential Relay 87T-2X Spurious Operation	2.59E-05
923	SPC87T1RYT	72	Main Step Up Transformer Differential Relay 87T Spurious Operation	2.59E-05
924	SPC94TKRYT	24	Auxiliary Relay 94T/K Spurious Operation	8.64E-06
925	SPCB008CHO	1	SWYD PCB-8 Fails to Trip	2.60E-05
926	SPCB009CHC	1	SWYD PCB-9 Fails To Close On Demand	2.60E-04
927	SPCB009CHO	1	SWYD PCB-9 Fails To Trip	2.60E-05
928	SPCB012CHO	1	SWYD PCB-12 Fails To Trip	2.60E-05
929	SPCB015CHO	1	SWYD PCB-15 Fails To Trip On Demand	2.60E-05
930	SPCB017CHO	1	SWYD PCB-17 Fails To Trip On Demand	2.60E-05
931	SPCB021CHO	1	SWYD PCB-21 Fails To Trip On Demand	2.60E-05
932	SPCB024CHO	1	SWYD PCB-24 Fails To Trip On Demand	2.60E-05
933	SPCB026CHO	1	SWYD PCB-26 Fails To Trip On Demand	2.60E-05
934	SPCB028CHO	1	SWYD PCB-28 Fails To Trip On Demand	2.60E-05
935	SPCB033CHO	1	SWYD PCB-33 Fails To Open On Demand	2.60E-05
936	SPCD87LRYT	24	Line Differential Relay 87L Spurious Operation	8.64E-06
937	SPCGLASSWT	24	Break Glass Switch Spurious Operation	1.68E-06
938	SPCR86TRYT	24	Lock Out Relay 86T Spurious Operation	8.64E-06
939	SU127UVCOM	1.18E-04	Common Cause Failure of Unit 1 SU Bus Undervoltage Relays	1.18E-04
940	SU227UVCOM	1.18E-04	Common Cause Failure of Unit 2 SU Bus Undervoltage Relays	1.18E-04
941	SU327UVCOM	1.18E-04	Common Cause Failure of Unit 3 SU Bus Undervoltage Relays	1.18E-04
942	SXFRCT3THF	24	Transformer CT3 Faulted	7.44E-05
943	SXFRCT3THM	1.74E-04	Transformer CT3 Is In Maintenance	1.74E-04
944	SXFRCT4LHE	6.40E-05	Latent Human Error on CT4 Maintenance	6.40E-05
945	SXFRCT4THM	9.13E-04	Transformer CT4 Is In Maintenance	9.13E-04
946	SY30R94RYT	24	PCB 30 Relay 94 Spuriously Picks Up	8.64E-06
947	SY51TN2RYT	24	230kV Neutral Ground Relay Spuriously Picks Up	8.64E-06
948	SY51TN4RYT	24	4.16kV Neutral Ground Relay Spuriously Picks Up	8.64E-06
949	SY51TN6RYT	24	6.9kV Neutral Ground Relay 51TN Spuriously Picks Up	8.64E-06
950	SY62X1FRYT	24	Breaker Failure Relay 62X1 Spuriously Picks Up	8.64E-06

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	NAME	FACTOR	DESC	PROB
951	SY62X2FRYT	24	Breaker Failure Relay 62X2 Spuriously Picks Up	8.64E-06
952	SY62XXFRYT	24	Breaker Failure Relay 62X Spuriously Picks Up	8.64E-06
953	SY86BUIRYT	24	CT3 6.9kV Start Up Bus Lockout Relay Spuriously Picks Up	8.64E-06
954	SY86CT3RYT	24	Transformer CT3 Lockout Relay Spuriously Picks Up	8.64E-06
955	SY86YA9RYT	24	Yellow Bus Lockout Auxiliary Relay 86YA9 Spuriously Picks Up	8.64E-06
956	SY86YJ3RYT	24	Yellow Bus Lockout Auxiliary Relay 86YJ30 Spuriously Picks Up	8.64E-06
957	SY87BYXRYT	24	Yellow Bus X Phase Differential Relay 87BYX Spuriously Picks Up	8.64E-06
958	SY87BYYRYT	24	Yellow Bus Y Phase Differential Relay 87BYY Spuriously Picks Up	8.64E-06
959	SY87BYZRYT	24	Yellow Bus Z Phase Differential Relay 86BYZ Spuriously Picks Up	8.64E-06
960	SY87LXXRYT	24	Differential Auxiliary Relay 87LX Spuriously Picks Up	8.64E-06
961	SY94L1XRYT	24	Protective Relay 94L Spuriously Picks Up	8.64E-06
962	SYE1362RYT	24	E13 Bkr Failure Relay 62B Spuriously Picks Up	8.64E-06
963	SYE2362RYT	24	E23 Bkr Failure Relay 62B Spuriously Picks Up	8.64E-06
964	SYP2862RYT	24	PCB 28 Breaker Failure Relay 62B Spuriously Picks Up	8.64E-06
965	SYP3062RYT	24	PCB 30 Breaker Failure Relay 62B Spuriously Picks Up	8.64E-06
966	SYP86TXRYT	24	PCB 30 LOR 86TX Spuriously Picks Up	8.64E-06
967	SYPCB09CHT	24	Switchyard Power Circuit Breaker 9 Transfers Open	4.56E-05
968	SYPCB30CHT	24	Switchyard Power Circuit Breaker 30 Transfers Open	4.56E-05
969	SYPL86TRYT	24	PCB 30 LOR 86T Spuriously Picks Up	8.64E-06
970	SYPL87LRYT	24	Differential Relay 87L Spuriously Picks Up	8.64E-06
971	SYR86BYRYT	24	Yellow Bus Lockout Relay 86BY Spuriously Picks Up	8.64E-06
972	SYS63FPRYT	24	Fault Pressure Relay 63FP Spuriously Picks Up	8.64E-06
973	SYSX50BRYT	24	Transformer CT3 Fault Detector Relay 50B Spuriously Picks Up	8.64E-06
974	SYX87TBRYT	24	Differential Relay 87B Spuriously Picks Up	8.64E-06
975	SYXX87TRYT	24	Differential Relay 87T Spuriously Picks Up	8.64E-06
976	U5086EFRYT	24	Overcurrent Relay 50 Spuriously Actuates Lockout Rly 86EF	8.64E-06
977	U5186EFRYT	24	Time Delay Overcurrent Relay 51 Actuates Lockout Relay 86EF	8.64E-06
978	U51TNC4RYT	24	CT4 Neutral Ground Rly Actuates CT4 LOR 86T/CT4	8.64E-06
979	U62BSK1RYT	24	SK1 Breaker Failure Relay 62BXSK1 Spuriously Picks Up	8.64E-06
980	U62BSK2RYT	24	SK2 Breaker Failure Relay 62BXSK2 Spuriously Picks Up	8.64E-06
981	U86CT4XRYT	24	Auxiliary Lockout Relay 86CT4X Spuriously Picks Up	8.64E-06
982	U86TCT4RYT	24	CT4 Lockout Relay 86T/CT4 Spuriously Picks Up	8.64E-06
983	U87TCT4RYT	24	Spurious Op of CT4 Differential Rly 87T Actuates LOR 86EF	8.64E-06
984	UACXCT4THF	24	Transformer CT4 Failed	7.44E-05
985	UXX86EFRYT	24	Lockout Relay 86EF Spuriously Picks Up	8.64E-06
986	WK00RUNCOM	2.09E-05	Common Cause Failure of Keowee Governors to Run	2.09E-05
987	WK1GVCDDEX	3.5E-05	Keowee Unit 1 Gov. Fails to Position Wicket Gates During a Cold Start	3.50E-05
988	WK1GVCDLHE	2.6E-4	Latent Human Error Fails Keowee 1 Governor During Cold Start	2.60E-04

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	NAME	FACTOR	DESC	PROB
989	WK1GVHTDEX	3.5E-04	Keowee Unit 1 Gov. Fails to Position Wicket Gates During Hot Start	3.50E-04
990	WK1GVRNDEX	5.6E-4	Keowee Unit 1 Gov. Fails to Position Wicket Gates With Unit Running	5.60E-04
991	WK1SPD1DEX	1.0	Potentially Damaging Overspeed Condition Occures At Load Rejection	1.00E+00
992	WK1SPD2DEX	5.6E-05	Keowee Unit 1 Governor Failure Creates Overspeed Condition	5.60E-05
993	WK1TBCDDEX	3.5E-5	Keowee Unit 1 Turbine Fails During a Cold Start	3.50E-05
994	WK1TBHTDEX	3.5E-4	Keowee Unit 1 Turbine Fails During a Hot Start	3.50E-04
995	WK1TBRNDEX	5.6e-4	Keowee Unit 1 Turbine Fails With the Unit Running	5.60E-04
996	WK2GVCDDEX	3.5E-05	Keowee Unit 2 Gov. Fails to Position Wicket Gates During Cold Start	3.50E-05
997	WK2GVCDLHE	2.6E-4	Latent Human Error Fails Keowee 2 Governor During Cold Start	2.60E-04
998	WK2GVHTDEX	3.5E-04	Keowee Unit 2 Gov. Fails to Position Wicket Gates During Hot Start	3.50E-04
999	WK2GVRNDEX	5.6E-4	Keowee Unit 2 Gov. Fails to Position Wicket Gates With Unit Running	5.60E-04
1000	WK2SPD2DEX	5.6E-05	Keowee Unit 2 Governor Failure Creates Overspeed Condition	5.60E-05
1001	WK2TBCDDEX	3.5E-5	Keowee Unit 2 Turbine Fails During a Cold Start	3.50E-05
1002	WK2TBHTDEX	3.5E-4	Keowee Unit 2 Turbine Fails During a Hot Start	3.50E-04
1003	WK2TBRNDEX	5.6E-4	Keowee Unit 2 Turbine Fails With the Unit Running	5.60E-04
1004	WKCSTRTCOM	1.12E-05	Common Cause Failure of Keowee Governors to Cold Start	1.12E-05
1005	WKHSTRTCOM	3.50E-6	Common Cause Failure of Keowee Governors to Hot Start	3.50E-06
1006	XA0SWGRCOM	1.22E-06	Common Cause Failure Of Transformers 1X, 2X, And CX	1.22E-06
1007	XA1A2BTCDT	24	600 Vac Breaker 1XA-2BT Transfers Position K-704	1.80E-06
1008	XA1BKRSCOM	3.10E-04	CCF of 1X Aux Power Breakers ACB-5 & -7	3.10E-04
1009	XA1TR1XTLF	24	Keowee Transformer 1X Fails	1.80E-05
1010	XA1X2AXCLT	24	600 Vac Bkr 2X-2D Transfers Position	2.18E-05
1011	XA1X2CCCLT	24	600 Vac Breaker 1X-2C Transfers Position	2.18E-05
1012	XA1XA1ACLT	24	600 Vac Bkr 2XA-4A Transfers Position	2.18E-05
1013	XA1XAALBLM	2.74E-03	MCC 1XA Is Connected to Its Alternate Source of Power	2.74E-03
1014	XA1XAMCBLF	24	600 Vac MCC 1XA Fault	6.48E-06
1015	XA1XCXXTHM	4.57E-4	4160/600 Vac Transformer CX Is in Maintenance	4.57E-04
1016	XA1XCXXTLF	24	4160/600 Vac Transformer CX Fails	1.80E-05
1017	XA1XXXXBLF	24	600 Vac Switchgear 1X Fault	6.48E-06
1018	XA2A2BTCDT	24	600 Vac Breaker 2XA-2BT Transfers Position	1.80E-06
1019	XA2BKRSCOM	3.10E-04	CCF of Aux Power Breakers ACB-6 & -8	3.10E-04
1020	XA2TR2XTLF	24	Keowee Transformer 2X Fails	1.80E-05
1021	XA2X2BXCLT	24	600 Vac Breaker 2X-2B Transfers Position	2.18E-05
1022	XA2X2DXCLT	24	600 Vac Bkr 1X-2A Transfers Position	2.18E-05
1023	XA2X4AXCLT	24	600 Vac Bkr 1XA-1A Transfers Position	2.18E-05
1024	XA2XAALBLM	2.74E-03	MCC 2XA Is Connected to Its Alternate Power Source	2.74E-03
1025	XA2XAMCBLF	24	600 Vac MCC-2XA Fault	6.48E-06
1026	XA2XXXXBLF	24	600 Vac Switchgear 2X Fault	6.48E-06

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Keowee PRA Basic Event Data (Base Case)
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	NAME	FACTOR	DESC		PROB
1027	XA56BKRCOM	3.10E-04	Common Cause Failure Of ACB-5 And ACB-6 To Close		3.10E-04
1028	XA78BKRCOM	3.10E-04	Common Cause Failure Of ACB-7 And ACB-8 To Close		3.10E-04
1029	XD0BATTCOM	2.70E-05	Common Cause Failure Of Keowee I&C Power Batteries		2.70E-05
1030	XD0CHRGCOM	3.48E-05	Common Cause Failure Of Keowee Battery Chargers		3.48E-05
1031	XD0KBATRHE	1.00E+00	Failure To Recover DC Power By Cross Connecting The Distribution Centers		1.00E+00
1032	XD104CCCDT	24	Breaker 1DA-4CC Transfers Open		1.80E-06
1033	XD104CRCDT	6	Breaker 1DA-4CR Transfers Open		4.50E-07
1034	XD1BK1ACDT	24	Battery No. 1 Breaker 1A Transfers Position	run time dependent	1.80E-06
1035	XD1CKC1BCF	24	Battery Charger KC1 Fails		6.96E-04
1036	XD1DA1CCDT	24	125 Vdc Breaker 1C (from charger KC1) Transfers Position		1.80E-06
1037	XD1DA3BCDT	24	125 Vdc Breaker 1DA-3BR Transfers Open		1.80E-06
1038	XD1DA4ACDT	24	DC Circuit Breaker 1DA-4AR Transfers Position		1.80E-06
1039	XD1DALTBYM	5.48E-03	Normal Power To Dist. Center 1DA Is In Test or Maintenance		5.48E-03
1040	XD1DARXBDF	24	DC Distribution Center 1DA Faulted during Run		7.68E-06
1041	XD1KB1XDHE	1	Keowee Standby Battery Charger SBC Not Lined Up in 1 Hour		1.00E+00
1042	XD1KB1XRHE	9.3e-02	Keowee Standby Battery Charger SBC Not Lined Up in 1 Hour		9.30E-02
1043	XD1KBATBYF	1	Keowee Battery No. 1 Fails During Discharge		9.30E-04
1044	XD1TIE1CDT	24	Keowee 125V dc Dist Cntr 1DA Tie Breaker 1 Transfers Position		1.80E-06
1045	XD202CCCDT	6	Breaker 2DA-2CC Transfers Open		4.50E-07
1046	XD204CCCDT	24	Breaker 2DA-4CC Transfers Open	K-704	1.80E-06
1047	XD2BK1ACDT	24	Battery No. 2 Breaker 1A Transfers Position		1.80E-06
1048	XD2CKC2BCF	24	Battery Charger KC2 Fails		6.96E-04
1049	XD2DA2ACDT	24	DC Circuit Breaker 2DA-2AR Transfers Position		1.80E-06
1050	XD2DA3BCDT	24	125 Vdc Circuit Breaker 2DA-3BR Transfers Position		1.80E-06
1051	XD2DA5CCDT	24	125 Vdc Breaker 2DA-5C (from Charger KC2) Transfers Open		1.80E-06
1052	XD2DALTBYM	5.48E-03	Normal Power To Dist Cntr 2DA Is In Test or Maintenance		5.48E-03
1053	XD2DARXBDF	24	DC Distribution Center 2DA Faulted During Run		7.68E-06
1054	XD2KB2XDHE	1	Keowee Standby Battery Charger SBC Not Lined Up in 1 Hour		1.00E+00
1055	XD2KB2XRHE	9.3E-02	Keowee Standby Battery Charger SBC Not Lined Up in 1 Hour		9.30E-02
1056	XD2KBATBYF	1	Keowee Battery No. 2 Fails during Discharge		9.30E-04
1057	XD2TIE2CDT	24	Keowee 125V dc Dist Cntr 2DA Tie Breaker 2 Transfers Position		1.80E-06
1058	Y0STARTCOM	7.26E-06	Common Cause Failure Of Emergency Start Signal		7.26E-06
1059	Y0STARTRHE	1.00E+00	Operators Fail To Manually Start Keowee		1.00E+00
1060	YK114X3SSD	1	Keowee 1 Speed Switch 14-3 Fails to Open at 65 rpm	KEE-111	1.80E-05
1061	YK13SUISWT	24	KHU#1 Startup Inhibit Sw 3SUI Xfrs to Inhibit	KEE-111, -113	1.68E-06
1062	YK14AMRRYT	24	Keowee 1 Master Relay 4A Spuriously Drops Out		8.64E-06
1063	YK14BMRRYT	24	Keowee 1 Master Relay 4B Spuriously Drops Out		8.64E-06
1064	YK163BHLST	24	Keowee 1 Gen Thrst Brng Oil Lvl Hi Sw 63BL/H Sprsly Clsd	KEE-111, -113-3	7.44E-06

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	NAME	FACTOR	DESC	PROB
1065	YK163BHRYT	24	Keowee 1 Gen Thrst Brng Oil Lvl Hi Rly 63BL/HX Sprsly Picks Up KEE-111,-113-	8.64E-06
1066	YK163BLLST	24	Keowee 1 Gen Thrst Brng Oil Lvl Lo Sw 63BL/L Spuriously Operates KEE-111,-113-	7.44E-06
1067	YK163BLRYT	24	Keowee 1 Gen Thrst Brng Oil Lvl Lo Rly 63BL/LXTD Sprsly Pcks Up KEE-111, -113-	8.64E-06
1068	YK163TBLST	24	Keowee 1 Turb Guide Brng Lo Lvl Sensor Sw Spuriously Closes KEE-113-4	7.44E-06
1069	YK163TBRYT	24	Keowee 1 Turb Gd Brng Oil Lvl Lo Rly 63TB/1X Sprsly Picks Up KEE-111,-113-4	8.64E-06
1070	YK186N1DEX	9.89E-03	Keowee 1 Normal Lockout Actuates	9.89E-03
1071	YK199SDRYD	1	Keowee 1 Shutdown Solenoid 99SD Fails To Pick Up	3.30E-05
1072	YK199SDRYT	24	Keowee 1 Shutdown Solenoid Spuriously Drops Out	8.64E-06
1073	YK199SNRYD	1	K1 Emergency Load Solenoid 99SN Fails To Pick Up/Drop Out	3.30E-05
1074	YK199SNRYT	24	Emergency Load Solenoid 99SN Spuriously Drops Out	8.64E-06
1075	YK199SXRYD	1	Keowee 1 Shutdown Solenoid Aux Relay 99SX Fails to Pick Up KEE-111	3.30E-05
1076	YK199SXRYT	24	Shutdown Auxiliary Relay 99SX Spuriously Drops Out	8.64E-06
1077	YK1D4CRFUF	6	Fuse 1DA-4CR Fails	2.16E-05
1078	YK1ES1ARYD	1	Keowee 1 Emergency Start Aux Relay 1ESRX/1A Fails To Pick Up OEE-120	3.30E-05
1079	YK1ES1BRYD	1	Keowee 1 Emergency Start Aux Relay 1ESRX/1B Fails To Pick Up OEE-120-1	3.30E-05
1080	YK1ES2ARYD	1	Keowee 1 Emergency Start Aux Relay 1ESRX/2A Fails To Pick Up OEE-120	3.30E-05
1081	YK1ES2BRYD	1	Keowee 1 Emergency Start Aux Relay 1ESRX/2B Fails To Pick Up OEE-120-1	3.30E-05
1082	YK1MR4ARYD	1	Keowee 1 Start Master Relay 4A Fails To Pick Up KEE-113	3.30E-05
1083	YK1MR4BRYD	1	Keowee 1 Start Master Relay 4B Fails To Pick Up KEE-113	3.30E-05
1084	YK1SS12SST	24	Keowee 1 Overspeed Switch 12 Spuriously Picks Up KEE-111	1.01E-04
1085	YK1SS13SSD	1	Keowee 1 Speed Switch 13 Fails to Close at 122 rpm KEE-111	1.80E-05
1086	YK214X3SSD	1	KHU#2 Speed Switch 14-3 Fails to Open at 65 rpm KEE-211	1.80E-05
1087	YK23SUISWT	24	KHU#2 Startup Inhbt Sw 3SUI Sprsly Xfrs to Inhibit KEE-211, -213	1.68E-06
1088	YK24AMRRYT	24	Keowee 2 Master Relay 4A Spuriously Drops Out	8.64E-06
1089	YK24BMRRYT	24	Keowee 2 Master Relay 4B Spuriously Drops Out	8.64E-06
1090	YK263BHLST	24	Keowee 2 Gen Thrst Brng Oil Lvl Hi Sw 63BL/H Sprsly Clsd	7.44E-06
1091	YK263BHRYT	24	Keowee 2 Gen Thrst Brng Oil Lvl Hi Rly 63BL/HX Sprsly Picks Up KEE-211	8.64E-06
1092	YK263BLLST	24	Keowee 2 Gen Thrst Brng Oil Lvl Lo Sw 63BL/L Sprsly Opn	7.44E-06
1093	YK263BLRYT	24	Keowee 2 Gen Thrst Brng Oil Lvl Lo Rly 63BL/LXTD Sprsly Pcks Up KEE-211	8.64E-06
1094	YK263TBLST	24	Keowee 2 Turb Guide Brng Lo Lvl Sensor Sw Sprsly Closes	7.44E-06
1095	YK263TBRYT	24	Keowee 2 Turb Gd Brng Oil Lvl Lo Rly 63TB/1X Sprsly Picks Up KEE-211	8.64E-06
1096	YK286N2DEX	7.41E-03	Keowee Unit 2 Normal Lockout Activates	7.41E-03
1097	YK299SDRYD	1	Keowee 2 Shutdown Solenoid 99SD Fails To Pick Up	3.30E-05
1098	YK299SDRYT	24	Keowee 2 Shutdown Solenoid Spuriously Drops Out	8.64E-06
1099	YK299SNRYD	1	Keowee 2 Emergency Load Solenoid 99SN Fails To Operate	3.30E-05
1100	YK299SNRYT	24	Emergency Load Solenoid 99SN Spuriously Drops Out	8.64E-06
1101	YK299SXRYD	1	Keowee 2 Shutdown Solenoid Aux Relay 99SX Fails to Pick Up KEE-211	3.30E-05
1102	YK299SXRYT	24	Shutdown Auxiliary Relay 99SX Spuriously Drops Out s	8.64E-06

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	NAME	FACTOR	DESC	PROB
1103	YK2D2CCFUF	6	Fuse 2DA-2CC Fails	2.16E-05
1104	YK2ES1ARYD	1	Keowee 2 Emergency Start Aux Relay 2ESRX/1A Fails To Pick Up OEE-120	3.30E-05
1105	YK2ES1BRYD	1	Keowee 2 Emergency Start Aux Relay 2ESRX/1B Fails to Pick Up OEE-120-1	3.30E-05
1106	YK2ES2ARYD	1	Keowee 2 Emergency Start Aux Relay 2ESRX/2A Fails to Pick Up OEE-120	3.30E-05
1107	YK2ES2BRYD	1	Keowee 2 Emergency Start Aux Relay 2ESRX/2B Fails to Pick Up OEE-120-1	3.30E-05
1108	YK2MR4ARYD	1	Keowee 2 Start Master Relay 4A Fails To Pick Up KEE-213	3.30E-05
1109	YK2MR4BRYD	1	Keowee 2 Start Master Relay 4B Fails to Pick Up KEE-213	3.30E-05
1110	YK2SS12SST	24	Keowee 2 Overspeed Switch 12 Spuriously Picks Up KEE-211	1.01E-04
1111	YK2SS13SSD	1	Keowee 2 Speed Switch 13 Fails to Close at 122 rpm KEE-211	1.80E-05
1112	YKEMSRTCHE	0	Operator Incorrectly Resets Keowee Emergency Start Signals	0.00E+00
1113	YO1DIA2CDT	30	DC Circuit Breaker 1DIA-2 Transfers Position	2.25E-06
1114	YO1DIB2CDT	30	DC Circuit Breaker 1DIB-2 Transfers Position	2.25E-06
1115	YO1MFBMA	1	ONS1 MFB Monitor Channel A Keowee Start Signal Fails	1.00E+00
1116	YO1MFBMB	1	ONS1 MFB Monitor Channel B Keowee Start Signal Fails	1.00E+00
1117	YO1OPSARHE	1	Operator fails to operate Keowee start switch S1A	1.00E+00
1118	YO1OPSBRHE	1	Operator fails to operate Keowee start switch S1B	1.00E+00
1119	YO1S1AFSWC	1	Control Switch S1A Fails To Close On Demand	1.00E-05
1120	YO1S1BFSWC	1	Control Switch S1B Fails To Close On Demand	1.00E-05
1121	YO1XXKARYD	1	ONS1 Ch A Keowee Emergency Start Relay KA Fails to Pick Up OEE-120	3.30E-05
1122	YO1XXKBRYD	1	Oconee Unit 1 Chan. B Keowee Emergency Start Relay Fails OEE-120-1	3.30E-05
1123	YO2CR2ARYD	1	ONS2 Ch A Keowee Emergency Start Relay CR2A Fails to Pick Up OEE-220	3.30E-05
1124	YO2CR2BRYD	1	ONS2 Keowee Emergency Start Relay CR2B Fails to Pick Up OEE-220-1	3.30E-05
1125	YO2DIA2CDT	30	Breaker 2DIA-2 Transfers Position	2.25E-06
1126	YO2DIB2CDT	30	Breaker 2DIB-2 Transfers Position	2.25E-06
1127	YO2MFBMA	1	ONS2 MFB Monitor CH A Keowee Start Sig Fails	1.00E+00
1128	YO2MFBMB	1	ONS2 MFB Monitor Ch B Keowee Start Sig Fails	1.00E+00
1129	YO2SSWARHE	1	Operator Fails to Operate Keowee Start Switch 2SSW'A'	1.00E+00
1130	YO2SSWASWC	1	Control Switch 2SSW'A' Fails To Close On Demand	1.00E-05
1131	YO2SSWBRHE	1	Operator Fails to Operate Keowee Start Switch 2SSW'B'	1.00E+00
1132	YO2SSWBSWC	1	Control Switch 2SSW'B' Fails To Close On Demand	1.00E-05
1133	YO3CR3ARYD	1	ONS3 Ch A Keowee Emergency Start Relay CR3A Fails To Pick Up OEE-320	3.30E-05
1134	YO3CR3BRYD	1	ONS3 Keowee Emer Start Relay CR3B Fails to Pick Up OEE-320-1	3.30E-05
1135	YO3DIA2CDT	30	Breaker 3DIA-2 Transfers Open OEE-320, O-2705	2.25E-06
1136	YO3DIB2CDT	30	Breaker 3DIB-2 Transfers Open OEE-320-1, O-2705	2.25E-06
1137	YO3MFBMA	3.96E-03	ONS3 MFB Monitor Ch A Keowee Start Sig Fails	3.96E-03
1138	YO3MFBMB	3.96E-03	ONS3 MFB Monitor Ch B Keowee Start Sig Fails	3.96E-03
1139	YO3OPFARHE	1	Operator fails to operate Keowee Start Switch 3S1A	1.00E+00
1140	YO3OPFBRHE	1	Operator Fails to Operate Keowee Start Switch 3S1B	1.00E+00

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Keowee PRA Basic Event Data (Base Case)
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	NAME	FACTOR	DESC	PROB
1141	YO3S1AFSWC	1	Control Switch S1A Fails To Close On Demand	1.00E-05
1142	YO3S1BFSWC	1	Control Switch S1B Fails To Close On Demand	1.00E-05
1143	YO3SSWARHE	1	Operator fails to operate Keowee Start Switch 3SSW'A'	1.00E+00
1144	YO3SSWASWC	1	Control Switch 3SSW'A' Fails To Close On Demand	1.00E-05
1145	YO3SSWBRHE	1	Operator Fails to Operate Keowee Start Switch 3SSW'B'	1.00E+00
1146	YO3SSWBSWC	1	Control Switch 3SSW'B' Fails To Close On Demand	1.00E-05

Table D-2

Keowee PRA Basic Event Data
Generic

	NAME	FACTOR	DESC	PROB
1	AA1271PR6D	1	Transformer 1X Undervoltage Relay 27/1X Fails To Pick Up	2.49E-04
2	AA1271XR6T	30	Transformer 1X Undervoltage Relay 27/1X Spuriously De-energizes	1.09E-05
3	AA127C1R6T	24	Transformer CX Undervoltage Relay 27/CX1 Spuriously De-energizes	8.71E-06
4	AA127CPR6D	1	Transformer CX Undervoltage Relay 27/CX1 Fails To Pick Up	2.49E-04
5	AA127R1RYT	24	Auxiliary Relay 27X/CX1 Spurious Operation	2.40E-05
6	AA127X1RYD	1	Auxiliary Relay 27X/1X Fails To Operate On Demand	1.90E-04
7	AA127X1RYT	384	Auxiliary Relay 27X/1X Spurious Operation	3.84E-04
8	AA127X2R6D	1	Transformer CX Undervoltage Relay 27/CX1 Fails To Drop Out	2.49E-04
9	AA127XCRYD	1	Auxiliary Relay 27/CX1 Fails To Operate On Demand	1.90E-04
10	AA186CXRYT	24	Transformer CX Differential Lock Out Relay 86CX Spurious Operation	2.40E-05
11	AA186S1RYT	24	Switchgear 1X Lockout Relay 86S/1X Spurious Operation	2.40E-05
12	AA187CXRYT	24	Transformer CX Differential Relay 87CX Spurious Operation	2.40E-05
13	AA2272PR6D	1	Transformer 2X Undervoltage Relay 27/2X Fails To Pick Up	2.49E-04
14	AA2272XR6D	1	Transformer 2X Undervoltage Relay 27/2X Fails To Drop Out	2.49E-04
15	AA2272XR6T	24	Transformer 2X Undervoltage Relay 27/2X Spuriously De-energizes	8.71E-06
16	AA227C2R6T	30	Transformer CX Undervoltage Relay 27/CX2 Spuriously De-energizes	1.09E-05
17	AA227C2RYD	1	Auxiliary Relay 27X/CX2 Fails To Operate On Demand	1.90E-04
18	AA227CPR6D	1	Transformer CX Undervoltage Relay 27/CX2 Fails To Pick Up	2.49E-04
19	AA227R2RYT	384	Auxiliary Relay 27X/CX2 Spurious Operation	3.84E-04
20	AA227T2R6D	1	Transformer #1 Undervoltage Relay (27T/2X) Fails To Drop Out	2.49E-04
21	AA227X2RYD	1	Auxiliary Relay 27X/2X Fails To Operate On Demand	1.90E-04
22	AA227X2RYT	24	Auxiliary Relay 27X/2X Spurious Operation	2.40E-05
23	AA286S2RYT	24	Switchgear 2X Lockout Relay 86S/2X Spurious Operation	2.40E-05
24	AB004ECCDT	30	DC Circuit Breaker 1DA-4EC Transfers Position	5.70E-05
25	AB0086TRYD	1	Keowee Main Tx Lock Out Relay 86T Fails To Operate On Demand	1.90E-04
26	AB0624CRYD	1	Time Delay Relay 62-4c Fails To Operate On Demand	1.90E-04
27	AB086E1RYD	1	Emergency Lock Out Relay 86E-1 Fails To Operate On Demand	1.90E-04
28	AB086TGRYD	1	General Keowee Main Tx Lock Out Sensing Relay Fails To Operate	1.90E-04
29	AB0SWGRCOM	8.26E-04	Common Cause Failure Of All Keowee Auxiliary Power Breakers	8.26E-04
30	AB0SWGRRHE	1.0	Failure To Recover Keowee Aux Power Breakers by Manual Control	1.00E+00
31	AB152TCSVO	1	Air Circuit Breaker 1 Trip Coil Fails To Operate	2.80E-03
32	AB1ACCUDEX	3.51E-05	Air Circuit Breaker 1 Accumulator Air Pressure Low	3.51E-05
33	AB1FALTDEX	0.0	Fault Occurs at ACB-1 When The BReaker Trips	0.00E+00
34	AB1MECHDEX	1.51E-4	Air Circuit Breaker 1 Fails To Open Due To Mechanical Failure	1.51E-04
35	AB1OPENLHE	2.60E-4	Air Circuit Breaker 1 Fails To Open Due To A Latent Human Error	2.60E-04
36	AB1PS02PST	12	Air Circuit Breaker 1 Accumulator Pressure Switch PS2 Fails Low	1.02E-05
37	AB1PSWTPST	24	Air Circuit Breaker 1 Accumulator Pressure Switch Fails Low	2.04E-05
38	AB1R52ZR6D	1	Air Circuit Breaker 1 Relay 52Z Fails To Operate	2.49E-04

Table D-2

Keowee PRA Basic Event Data
Generic

	NAME	FACTOR	DESC	PROB
39	AB21521SWT	30	Control Switch 152-2 Spurious Operation	3.00E-05
40	AB22BV1RYT	24	Backup Undervoltage Relay 2BV1 Spurious Operation	2.40E-05
41	AB23BKRCOM	3.98e-04	Common Cause Failure Of Air Circuit Breakers 2 And 3 To Close	3.98E-04
42	AB24BKRCOM	3.98E-04	Common Cause Failure Of Air Circuit Breakers 2 And 4 To Close	3.98E-04
43	AB251G2RYT	24	Air Circuit Breaker 2 Overcurrent Ground Relay 51G-2 Spurious Operation	2.40E-05
44	AB252CCSVO	1	Air Circuit Breaker 2 Close Coil Fails To Operate	2.80E-03
45	AB252TCSVO	1	Air Circuit Breaker 2 Trip Coil Fails To Operate	2.80E-03
46	AB252TCSVT	36	Air Circuit Breaker 2 Trip Coil Spurious Operation	1.48E-05
47	AB252Y2R6D	1	Air Circuit Breaker 2 Relay 52Y Failed To Drop Out Following Last Demand	2.49E-04
48	AB252Y2R6T	12	Air Circuit Breaker 2 Y-relay Spurious Operation	4.36E-06
49	AB2ACCUDEX	3.51E-05	Air Circuit Breaker 2 Accumulator Air Pressure Low	3.51E-05
50	AB2CLOSLHE	2.60E-4	Air Circuit Breaker 2 Fails To Close Due To A Latent Human Error	2.60E-04
51	AB2KEYISWT	12	Air Circuit Breaker 2 Key Interlock Switch Transfers Open	1.20E-05
52	AB2MCH2DEX	3.02E-4	Air Circuit Breaker 2 Fails To Close Due To Mechanical Failure	3.02E-04
53	AB2MECHDEX	1.51E-4	Air Circuit Breaker 2 Fails To Open Due To Mechanical Failure	1.51E-04
54	AB2OPENLHE	2.60E-4	Air Circuit Breaker 2 Fails To Open Due To A Latent Human Error	2.60E-04
55	AB2PS02PST	12	Air Circuit Breaker 2 Accumulator Pressure Switch PS2 Fails Low	1.02E-05
56	AB2PSWTPST	24	Air Circuit Breaker 2 Accumulator Pressure Switch Fails Low	2.04E-05
57	AB2PUSHPBT	36	Trip Pushbutton On ACB2 Spurious Operation	3.60E-05
58	AB2R462RYT	24	Air Circuit Breaker 2 Negative Sequence Relay 46-2 Spurious Operation	2.40E-05
59	AB2R52XR6D	1	Air Circuit Breaker 2 Relay 52X Fails To Operate	2.49E-04
60	AB2R52ZR6D	1	Air Circuit Breaker 2 Relay 52Z Fails To Operate	2.49E-04
61	AB2R52ZR6T	36	Air Circuit Breaker 2 Relay 52Z Spurious Operation	1.31E-05
62	AB31523SWT	24	Control Switch 152-3 Spurious Operation	2.40E-05
63	AB352CCSVO	1	Air Circuit Breaker 3 Close Coil Fails To Operate	2.80E-03
64	AB352TCSVO	1	Air Circuit Breaker 3 Trip Coil Fails To Operate	2.80E-03
65	AB352TCSVT	24	Air Circuit Breaker 3 Trip Coil Spurious Operation	9.84E-06
66	AB352Y2R6D	1	Air Circuit Breaker 3 Relay 52Y Failed To Drop Out Following Last Demand	2.49E-04
67	AB352Y2R6T	360	Air Circuit Breaker 3 Y-relay Spurious Operation	1.31E-04
68	AB3ACCUDEX	3.51E-05	Air Circuit Breaker 3 Accumulator Air Pressure Low	3.51E-05
69	AB3CLOSLHE	2.60e-04	Air Circuit Breaker 3 Fails To Close Due To Latent Human Error	2.60E-04
70	AB3MCH2DEX	3.02E-04	Air Circuit Breaker 3 Fails To Close Due To Mechanical Failure	3.02E-04
71	AB3MECHDEX	1.51E-04	Air Circuit Breaker 3 Fails To Open Due To Mechanical Failure	1.51E-04
72	AB3PS02PST	372	Air Circuit Breaker 3 Accumulator Pressure Switch PS2 Fails Low	3.16E-04
73	AB3PSWTPST	24	Air Circuit Breaker 3 Accumulator Pressure Switch Fails Low	2.04E-05
74	AB3PUSHPBT	24	Trip Pushbutton On ACB3 Spurious Operation	2.40E-05
75	AB3R52XR6D	1	Air Circuit Breaker 3 Relay 52X Fails To Operate	2.49E-04
76	AB3R52ZR6D	1	Air Circuit Breaker 3 Relay 52Z Fails To Operate	2.49E-04

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Keowee PRA Basic Event Data
Generic

	NAME	FACTOR	DESC	PROB
77	AB3R52ZR6T	24	Air Circuit Breaker 3 Relay 52Z Spurious Operation	8.71E-06
78	AB41523SWT	24	Control Switch 152-4 Spurious Operation	2.40E-05
79	AB452CCSVO	1	Air Circuit Breaker 4 Close Coil Fails To Operate	2.80E-03
80	AB452TCSVT	24	Air Circuit Breaker 4 Trip Coil Spurious Operation	9.84E-06
81	AB452Y2R6D	1	Air Circuit Breaker 4 Relay 52Y Failed To Drop Out Following Last Demand	2.49E-04
82	AB452Y2R6T	372	Air Circuit Breaker 4 Y-relay Spurious Operation	1.35E-04
83	AB4ACCUDEX	3.51E-05	Air Circuit Breaker 4 Accumulator Air Pressure Low	3.51E-05
84	AB4CLOSLHE	2.60E-4	Air Circuit Breaker 4 Fails To Close Due To A Latent Human Error	2.60E-04
85	AB4CLSESWC	1	Air Circuit Breaker 4 Close Switch Fails To Close On Demand	1.00E-05
86	AB4KEYISWT	372	Air Circuit Breaker 4 Key Interlock Switch Transfers Open	3.72E-04
87	AB4LORESWT	372	Air Circuit Breaker 4 Local/Remote Switch Contact Transfers Position	3.72E-04
88	AB4MCH2DEX	3.02E-04	Air Circuit Breaker 4 Fails To Close Due To Mechanical Failure	3.02E-04
89	AB4PS02PST	372	Air Circuit Breaker 4 Accumulator Pressure Switch PS2 Indicates Low Pressure	3.16E-04
90	AB4PSWTPST	12	Air Circuit Breaker 4 Accumulator Pressure Switch Indicates Low Air Pressure	1.02E-05
91	AB4PUSHPBT	24	Trip Pushbutton On ACB-4 Spurious Operation	2.40E-05
92	AB4R52XR6D	1	Air Circuit Breaker 4 Relay 52X Fails To Operate	2.49E-04
93	AB4R52ZR6T	24	Air Circuit Breaker 4 Relay 52Z Spurious Operation	8.71E-06
94	AB510A1FUF	6	One Or More Control Power Fuses For X, Y And CC Fail	3.78E-06
95	AB51431LHE	3.20E-4	Manual/Auto Control Switch 143/1 Left In Manual	3.20E-04
96	AB51431RYT	360	Auxiliary Relay 143X/1 Spuriously Energizes	3.60E-04
97	AB51431SWT	360	Manual/Auto Control Switch 143/1 Spuriously Transfers Into Manual	3.60E-04
98	AB552CCRYD	1	Air Circuit Breaker 5 Close Coil CC Fails On Demand	1.90E-04
99	AB552TCRYT	384	Air Circuit Breaker 5 Trip Coil 52TC Spurious Operation	3.84E-04
100	AB552Y2RYT	360	Air Circuit Breaker 5 Y-relay Spurious Operation	3.60E-04
101	AB583S5RYD	1	Time Delay Relay 83S5 Fails To Pick Up	1.90E-04
102	AB5CLOSLHE	2.60E-4	Air Circuit Breaker 5 Fails To Close Due To A Latent Human Error	2.60E-04
103	AB5KEYISWT	360	Air Circuit Breaker 5 Key Interlock Switch Transfers Open	3.60E-04
104	AB5MCH2DEX	7.04E-03	Air Circuit Breaker 5 Fails To Close Due To Mechanical Failure	7.04E-03
105	AB5PUSHPBT	384	Trip Pushbutton On ACB5 Spurious Operation	3.84E-04
106	AB5R52XRYD	1	Air Circuit Breaker 5 Relay 52X Fails To Operate	1.90E-04
107	AB5R52YRYD	1	Air Circuit Breaker 5 Relay 52Y Failed To Drop Out At Last Demand	1.90E-04
108	AB610A1FUF	6	One Or More Control Power Fuses For X, Y And CC Fail	3.78E-06
109	AB610AFFUF	6	One Or More Control Power Fuses For Relay 27X/2X Fail	3.78E-06
110	AB61432LHE	3.20E-4	Manual/Auto Control Switch 143/2 Left In Manual	3.20E-04
111	AB61432SWT	360	Manual/Auto Control Switch 143/2 Spuriously Transfers Into Manual	3.60E-04
112	AB652CCRYD	1	Air Circuit Breaker 6 Close Coil CC Fails On Demand	1.90E-04
113	AB652TCRYD	1	Air Circuit Breaker 6 Trip Coil 52TC Fails Fails To Operate	1.90E-04
114	AB652TCRYT	24	Air Circuit Breaker 6 Trip Coil 52TC Spurious Operation	2.40E-05

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Keowee PRA Basic Event Data
Generic

	NAME	FACTOR	DESC	PROB
115	AB652Y2RYT	360	Air Circuit Breaker 6 Y-relay Spurious Operation	3.60E-04
116	AB6CLOSLHE	2.60E-4	Air Circuit Breaker 6 Fails To Close Due To A Latent Human Error	2.60E-04
117	AB6KEYISWT	360	Air Circuit Breaker 6 Key Interlock Switch Transfers Open	3.60E-04
118	AB6MCH2DEX	7.04E-03	Air Circuit Breaker 6 Fails To Close Due To Mechanical Failure	7.04E-03
119	AB6MECHDEX	8.01E-04	Air Circuit Breaker 6 Fails To Open Due To Mechanical Failure	8.01E-04
120	AB6OPENLHE	3.20E-3	Air Circuit Breaker 6 Fails To Open Due To A Latent Human Error	3.20E-03
121	AB6PUSHPBT	24	Trip Pushbutton On ACB6 Spurious Operation	2.40E-05
122	AB6R52XRYD	1	Air Circuit Breaker 6 Relay 52X Fails To Operate	1.90E-04
123	AB6R52YRYD	1	Air Circuit Breaker 6 Relay 52Y Failed To Drop Out At Last Demand	1.90E-04
124	AB710A1FUF	6	One Or More Control Power Fuses For X, Y And CC Fail	3.78E-06
125	AB710AFFUF	6	One Or More Air Circuit Breaker 7 Control Power Fuses Fail	3.78E-06
126	AB752CCRYD	1	Air Circuit Breaker 7 Close Coil CC Fails On Demand	1.90E-04
127	AB752TCRYD	1	Air Circuit Breaker 7 Trip Coil TC Fails On Demand	1.90E-04
128	AB752TCRYT	24	Air Circuit Breaker 7 Trip Coil 52TC Spurious Operation	2.40E-05
129	AB752Y2RYT	360	Air Circuit Breaker 7 Y-relay Spurious Operation	3.60E-04
130	AB7CLOSLHE	2.60E-4	Air Circuit Breaker 7 Fails To Close Due To A Latent Human Error	2.60E-04
131	AB7KEYISWT	360	Air Circuit Breaker 7 Key Interlock Switch Transfers Open	3.60E-04
132	AB7MCH2DEX	7.04E-03	Air Circuit Breaker 7 Fails To Close Due To Mechanical Failure	7.04E-03
133	AB7MECHDEX	8.01E-04	Air Circuit Breaker 7 Fails To Open Due To Mechanical Failure	8.01E-04
134	AB7OPENLHE	3.20E-3	Air Circuit Breaker 7 Fails To Open Due To A Latent Human Error	3.20E-03
135	AB7PUSHPBT	30	Trip Pushbutton On ACB7 Spurious Operation	3.00E-05
136	AB7R52XRYD	1	Air Circuit Breaker 7 Relay 52X Fails To Operate	1.90E-04
137	AB7R52YRYD	1	Air Circuit Breaker 7 Relay 52Y Failed To Drop Out At Last Demand	1.90E-04
138	AB810A1FUF	6	One Or More Control Power Fuses For X, Y And CC Fail	3.78E-06
139	AB81432RYT	360	Auxiliary Relay 143X/2 Spuriously Energizes	3.60E-04
140	AB852CCRYD	1	Air Circuit Breaker 8 Close Coil CC Fails On Demand	1.90E-04
141	AB852TCRYT	384	Air Circuit Breaker 8 Trip Coil 52TC Spurious Operation	3.84E-04
142	AB852Y2RYT	360	Air Circuit Breaker 8 Y-relay Spurious Operation	3.60E-04
143	AB86E1ARYD	1	Emergency Lock Out Aux. Relay 86E-1a Fails To Operate On Demand	1.90E-04
144	AB86E1GRYD	1	Keowee Unit 1 Emergency Lock Out Sensing Relay Fails To Operate	1.90E-04
145	AB883S8RYD	1	Time Delay Relay 83S8 Fails To Pick Up	1.90E-04
146	AB8KEYISWT	360	Air Circuit Breaker 8 Key Interlock Switch Transfers Open	3.60E-04
147	AB8MCH2DEX	7.04E-03	Air Circuit Breaker 8 Fails To Close Due To Mechanical Failure	7.04E-03
148	AB8PUSHPBT	384	Trip Pushbutton On ACB8 Spurious Operation	3.84E-04
149	AB8R52XRYD	1	Air Circuit Breaker 8 Relay 52X Fails To Operate	1.90E-04
150	AB8R52YRYD	1	Air Circuit Breaker 8 Relay 52Y Failed To Drop Out At Last Demand	1.90E-04
151	ABEOPRCDHE	1.0	Operators Fail To Close Air Circuit Breaker 2	1.00E+00
152	ABEOPRCRHE	1	Operators Fail To Close Air Circuit Breaker 2	1.00E+00

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Keowee PRA Basic Event Data
Generic

	NAME	FACTOR	DESC	PROB
153	ABPOPRCRHE	1.0	Operators Fail To Close Air Circuit Breaker 4	1.00E+00
154	ACB4MOD	1	NSM-ON-52966 Is Not In Service	1.00E+00
155	ACBAIRPDEX	2.00E-03	ACB Air Supply Fails Causing Low Pressure In All ACB Accumulators	2.00E-03
156	ACBTRIPCHE	0.0	Operators Trip Generator Output ACBs	0.00E+00
157	ACBXFERCOM	3.33E-06	Common Cause Failure That Results In ACBs 2 & 3 Transfering Open	3.33E-06
158	AD1B4ALCDT	30	Breaker 4AL In 125 V dc Distribution Center 1DA Transfers Open	5.70E-05
159	AD1C3CCCDT	24	Breaker 3CC In 125V dc Distribution Center 1DA Transfers Position	4.56E-05
160	AD1C3CLCDT	24	Breaker 3CL In 125V dc Distribution Center 1DA Transfers Position	4.56E-05
161	AD1SCLRCDT	12	Breaker 3CL In 125V dc Distribution Center 1DA Transfers Position (Rec)	2.28E-05
162	AD2B2ALCDT	30	Breaker 2AL In 125V dc Distribution Center 2DA Transfers Open	5.70E-05
163	AD2B3CCCDT	12	Breaker 3CC In 125V dc Distribution Center 2DA Transfers Position	2.28E-05
164	AD2C3CCCDT	24	Breaker 3CC In 125V dc Distribution Center 2DA Transfers Position	4.56E-05
165	AD2C3CLCDT	24	Breaker 3CL In 125V dc Distribution Center 2DA Transfers Position	4.56E-05
166	AK1141XRYD	1	Auxiliary Relay 14GOV/1X Fails To Pick-up	1.90E-04
167	AK114GVDEX	1.00e-04	KU1 Magnetic Speed Switch System Fails	1.00E-04
168	AK121TDRYD	1	Time Delay Relay 2-1TD Fails To Pick-up	1.90E-04
169	AK152TDRYD	1	Time Delay Relay 52-1TD Fails To Pick-up	1.90E-04
170	AK152TDRYT	4380	Time Delay Relay 52-1TD Spurious Operation	4.38E-03
171	AK152XGRYD	1	Relay 52XG/1 Fails To Pick Up When The Unit Is Started	1.90E-04
172	AK152XGRYT	2	Relay 52XG/1 Spuriously Drops Out While The Unit Is Running	2.00E-06
173	AK1AX34RYT	6	Relay 52AX/34 Spuriously Drops-out	6.00E-06
174	AK1GV1XRYD	1	Relay 14GOV/1X Fails To Pick-up	1.90E-04
175	AK1OFRQCOM	1.90E-05	KU1 CCF Of 2/3 Overfrequency Relays To Reset When Frequency Drops	1.90E-05
176	AK1X34XRYT	6	Relay 52AX/34X Spuriously Drops-out	6.00E-06
177	AK212OSSST	36	Turbine Overspeed Switch Indicates Overspeed	3.60E-05
178	AK2142XRYD	1	Auxiliary Relay 14GOV/2X Fails To Pick-up	1.90E-04
179	AK214GVDEX	1.00e-4	KU2 Magnetic Speed Switch System Fails	1.00E-04
180	AK222TDRYD	1	Time Delay Relay 2-2TD Fails To Pick-up	1.90E-04
181	AK252TDRYD	1	Time Delay Relay 52-2TD Fails To Operate	1.90E-04
182	AK252TDRYT	4380	Time Delay Relay 52-2TD Spurious Operation	4.38E-03
183	AK252W0RYD	1	KU2 Relay 52W Fails To Pick-up	1.90E-04
184	AK252XGRYD	1	Auxiliary Relay 52XG/2 Fails To Pick-up	1.90E-04
185	AK2GATEDEX	2.11E-5	Wicket Gate Limit Switch Indicates Gate Position Is Below No-load Setting	2.11E-05
186	AK2GV2XRYD	1	Relay 14GOV/2X Fails To Pick-up	1.90E-04
187	AK2OFRQCOM	1.90E-05	KU2 CCF Of 2/3 Overfrequency Relays To Reset When Frequency Drops	1.90E-05
188	BK1088XRYD	1	Keowee 1 Turbine Guide Bearing Oil Relay 88X Fails to Drop Out	1.90E-04
189	BK1088XRYT	24	Keowee 1 Turbine Guide Bearing Oil Relay 88X Spurious Operation	2.40E-05
190	BK114/2SSD	1	Keowee 1 Speed Switch 14/2 Fails On Demand	2.50E-04

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Keowee PRA Basic Event Data
Generic

	NAME	FACTOR	DESC	PROB
191	BK114/2SST	24	Keowee 1 Speed Switch 14/2 Spuriously Transfers Closed	2.40E-05
192	BK114DXRYD	1	Keowee 1 Rotation Sensing Aux. Relay 14DX Fails to Energize	1.90E-04
193	BK114DXRYT	24	Keowee 1 Rotation Sensing Aux. Relay 14DX Spuriously Drops Out	2.40E-05
194	BK114T2RYD	1	Keowee 1 Rotation Sensing Timer 14T2 Fails to De-energize	1.90E-04
195	BK114T2RYT	24	Keowee 1 Rotation Sensing Timer 14T2 Spurious Operation	2.40E-05
196	BK1188ASWT	24	Keowee 1 AC GBO Pump Control Switch S188A Spurious Operation	2.40E-05
197	BK1188DSWT	108	Unit 1 DC GBO Pump Control Switch S188D Spurious Operation	1.08E-04
198	BK1631XRYD	1	Keowee 1 Relay 63TA/1X Fails to De-energize	1.90E-04
199	BK1631XRYT	24	Keowee 1 GBO Level Relay 63TA/1X Spurious Operation	2.40E-05
200	BK1632XRYD	1	Keowee 1 Brng. Low Oil Level Aux. Relay 63TA/2X Fails To Operate On Demand	1.90E-04
201	BK1632XRYT	24	Keowee 1 Turb. Brng. Low Oil Level Aux. Rly 63TA/2X Spurious Operation	2.40E-05
202	BK163TALSD	1	Turbine No. 1 Bearing Oil Level Switch 63TA Fails on Demand	1.60E-03
203	BK163TALST	24	Turbine No. 1 Bearing Oil Level Switch 63TA Spurious Operation	5.52E-05
204	BK188AXRYD	1	Unit 1 AC Bearing Oil Pump Aux. Relay 88AX Fails to Drop Out	1.90E-04
205	BK188AXRYT	24	Unit 1 AC Bearing Oil Pump Aux. Relay 88AX Fails to Remain De-energized	2.40E-05
206	BK1DA5BCDT	24	DC Circuit Breaker 1DA-5B Transfers Position	4.56E-05
207	BK1GBDCGPR	12	Unit 1 DC Turbine GBO Pump Fails To Run	2.88E-04
208	BK1GBDCGPS	1	Unit 1 DC Turbine GBO Pump Fails To Start On Demand	3.10E-03
209	BK1GBDCLHE	3.2E-3	Latent Human Error Fails Unit 1 DC Guide Bearing Oil Pump Discharge Path	3.20E-03
210	BK1GBO1CVC	1	Check Valve 1GBO-1 Fails to Close on Demand	9.70E-04
211	BK1GBO1CVO	1	Check Valve 1GBO-1 Fails To Open On Demand	1.90E-04
212	BK1GBO1CVT	24	Check Valve 1GBO-1 Transfers Closed	1.08E-05
213	BK1GBO1FTC	24	Filter 1GBOFL-1 Becomes Clogged	2.88E-04
214	BK1GBO2VVT	24	Manual Valve 1GBO-2 Transfers Position	1.92E-06
215	BK1GBO3CVO	1	Check Valve 1GBO-3 Fails To Open On Demand	1.90E-04
216	BK1GBO3CVT	12	Check Valve 1GBO-3 Transfers Closed	5.40E-06
217	BK1GBO4VVT	108	Manual Valve 1GBO-4 Transfers Position	8.64E-06
218	BK1GBO5VVT	24	Manual Valve 1GBO-5 Transfers Position	1.92E-06
219	BK1GBO6VVT	24	Manual Valve 1GBO-6 Transfers Position	1.92E-06
220	BK1GBO8VVT	24	Manual Valve 1GBO-8 Transfers Position	1.92E-06
221	BK1GBO9VVT	24	Manual Valve 1GBO-9 Transfers Position	1.92E-06
222	BK1GOACGPR	24	Unit 1 AC Turbine GBO Pump Fails To Run	5.76E-04
223	BK1GOACGPS	1	Unit 1 AC Turbine GBO Pump Fails To Start	3.10E-03
224	BK1GODCTRM	1.14E-3	Unit 1 DC Turbine GBO Pump Train In Maintenance	1.14E-03
225	BK1XA1CCLT	24	600 V Circuit Breaker 1XA-1C Transfers Position	4.56E-05
226	BK2088XRYD	1	Keowee 2 Turbine Guide Bearing Oil Relay 88X Fails to Drop Out	1.90E-04
227	BK2088XRYT	24	Keowee 2 Turbine Guide Bearing Oil Relay 88X Spurious Operation	2.40E-05
228	BK214/2SSD	1	Keowee 2 Speed Switch 14/2 Fails On Demand	2.50E-04

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Keowee PRA Basic Event Data
Generic

	NAME	FACTOR	DESC		PROB
229	BK214/2SST	24	Keowee 2 Speed Switch 14/2 Spuriously Transfers Closed		2.40E-05
230	BK214DXRYD	1	Keowee 2 Rotation Sensing Aux. Relay 14DX Fails to Energize		1.90E-04
231	BK214DXRYT	24	Keowee 2 Rotation Sensing Aux. Relay 14DX Spurious Operation		2.40E-05
232	BK214T2RYD	1	Keowee 2 Rotation Sensing Timer 14T2 Fails to De-energize		1.90E-04
233	BK214T2RYT	24	Keowee Rotation Sensing Timer 14T2 Fails to Remain De-energized		2.40E-05
234	BK2188ASWT	24	Unit 2 AC GBO Pump Control Switch S188A Spurious Operation		2.40E-05
235	BK2188DSWT	108	Unit 2 DC GBO Pump Control Switch S188D Spurious Operation		1.08E-04
236	BK2631XRYD	1	Keowee 2 Relay 63TA/1X Fails to De-energize		1.90E-04
237	BK2631XRYT	24	Keowee 2 GBO Level Relay 63TA/1X Spurious Operation		2.40E-05
238	BK2632XRYD	1	Keowee 2 Brng. Low Oil Level Aux. Relay 63TA/2X Fails To Operate On Demand		1.90E-04
239	BK2632XRYT	24	Keowee 2 Turb. Brng. Low Oil Level Aux. Relay 63TA/2X Spurious Operation		2.40E-05
240	BK263TALSD	1	Turbine No. 2 Bearing Oil Level Switch 63TA Fails on Demand		1.60E-03
241	BK263TALST	24	Turbine No. 2 Bearing Oil Level Switch 63TA Spurious Operation		5.52E-05
242	BK288AXRYD	1	Unit 2 AC Bearing Oil Pump Aux. Relay 88AX Fails to Drop Out		1.90E-04
243	BK288AXRYT	24	Unit 2 AC Bearing Oil Pump Aux. Relay 88AX Fails to Remain De-energized		2.40E-05
244	BK2DA1BCDT	24	DC Circuit Breaker 2DA-1B Transfers Position		4.56E-05
245	BK2GBDCGPR	12	Unit 2 DC Turbine GBO Pump Fails To Run		2.88E-04
246	BK2GBDCGPS	1	Unit 2 DC Turbine GBO Pump Fails To Start On Demand		3.10E-03
247	BK2GBDCLHE	3.2E-3	Latent Human Error Fails Unit 2 DC Guide Bearing Oil Pump Discharge Path		3.20E-03
248	BK2GBO1CVC	1	Check Valve 2GBO-1 Fails to Close on Demand		9.70E-04
249	BK2GBO1CVO	1	Check Valve 2GBO-1 Fails To Open On Demand		1.90E-04
250	BK2GBO1CVT	24	Check Valve 2GBO-1 Transfers Closed		1.08E-05
251	BK2GBO1FTC	24	Filter 2GBOFL-1 Becomes Clogged		2.88E-04
252	BK2GBO2VVT	24	Manual Valve 2GBO-2 Transfers Position		1.92E-06
253	BK2GBO3CVO	1	Check Valve 2GBO-3 Fails To Open On Demand		1.90E-04
254	BK2GBO3CVT	12	Check Valve 2GBO-3 Transfers Closed		5.40E-06
255	BK2GBO4VVT	108	Manual Valve 2GBO-4 Transfers Position		8.64E-06
256	BK2GBO5VVT	24	Manual Valve 2GBO-5 Transfers Position		1.92E-06
257	BK2GBO6VVT	24	Manual Valve 2GBO-6 Transfers Position		1.92E-06
258	BK2GBO8VVT	24	Manual Valve 2GBO-8 Transfers Position		1.92E-06
259	BK2GBO9VVT	24	Manual Valve 2GBO-9 Transfers Position		1.92E-06
260	BK2GOACGPR	24	Unit 2 AC Turbine GBO Pump Fails To Run		5.76E-04
261	BK2GOACGPS	1	Unit 2 AC Turbine GBO Pump Fails To Start		3.10E-03
262	BK2GODCTRM	1.14E-3	Unit 2 DC Turbine GBO Pump Train In Maintenance		1.14E-03
263	BK2XA1CCLT	24	600 V Circuit Breaker 2XA-1C Transfers Position		4.56E-05
264	BKGBOILCOM	6.20E-05	Common Cause Failure Of Turbine Guide Bearing Oil System		6.20E-05
265	D1DIAXXDEX	6.50E-06	Loss Of Power On 125 V dc Panelboard 1DIA	OEE-120, O-705	6.50E-06
266	D1DIBXXDEX	6.50E-06	Loss Of Power On 125 V dc Panelboard 1DIB	OEE-120-1, O-705	6.50E-06

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Keowee PRA Basic Event Data
Generic

	NAME	FACTOR	DESC	PROB
267	D2DIAXXDEX	6.50E-06	Loss Of Power On 125 V dc Panelboard 2DIA	6.50E-06
268	D2DIBXXDEX	6.50E-06	Loss of Power on 125 V dc Panelboard 2DIB	6.50E-06
269	D3DIAXXDEX	6.50E-06	Loss Of Power On 125 V dc Panelboard 3DIA	6.50E-06
270	D3DIBXXDEX	6.50E-06	Loss Of Power On 125 Vdc Panelboard 3DIB	6.50E-06
271	DDC11BXCDT	24	125 Vdc Battery Breaker SY-DC1-1B Transfers Open	4.56E-05
272	DDC11CXCDT	24	125 Vdc Breaker SY-DC1-1C Transfers Open	4.56E-05
273	DDC11DCCDT	24	125 Vdc Breaker SY-DC1-1DC Transfers Open	4.56E-05
274	DDC11DLCDT	24	125 Vdc Breaker SY-DC1-1DL Transfers Open	4.56E-05
275	DDC11DRCDT	24	125 Vdc Breaker SY-DC1-1DR Transfers Open	4.56E-05
276	DDC1ALXBYM	1.14E-02	Battery SY-1 Is In Test or Maintenance	1.14E-02
277	DDC1BATBYF	1	Battery SY-1 Fails During Discharge	1.18E-03
278	DDC1FLTBDF	24	SY-DC1 Is Faulted	1.46E-05
279	DDC21BXCDT	24	125 Vdc Battery Breaker SY-DC2-1B Transfers Open	4.56E-05
280	DDC21CXCDT	24	125 Vdc Breaker SY-DC2-1C Transfers Open	4.56E-05
281	DDC21DCCDT	24	125 Vdc Breaker SY-DC2-1DC Transfers Open	4.56E-05
282	DDC21DLCDT	24	125 Vdc Breaker SY-DC2-1DL Transfers Open	4.56E-05
283	DDC21DRCDT	24	125 Vdc Breaker SY-DC2-1DR Transfers Open	4.56E-05
284	DDC2BATBYF	1	Battery SY-2 Fails During Discharge	1.18E-03
285	DDC2FLTBDF	24	SY-DC2 Is Faulted	1.46E-05
286	DDCBATTCOM	3.42E-05	Common Cause Failure of Switchyard Batteries	3.42E-05
287	DDCDYAXBDF	24	125 Vdc Switchyard DC Panelboard DYA Is Faulted	1.46E-05
288	DDCDYBXBDF	24	125 Vdc Switchyard DC Panelboard DYB Is Faulted	1.46E-05
289	DDCDYCXBDF	24	125 Vdc Switchyard DC Panelboard DYC Is Faulted	1.46E-05
290	DDCDYEXBDF	24	125 Vdc Switchyard DC Panelboard DYE Is Faulted	1.46E-05
291	DDCDYFXBDF	24	125 Vdc Switchyard DC Panelboard DYF Is Faulted	1.46E-05
292	DDCDYGXBDF	24	125 Vdc Switchyard DC Panelboard DYG Is Faulted	1.46E-05
293	E12EXCTCOM	1.41E-04	Units 1 & 2 Excit Fail Due To Common Cause Failure Of The Breakers	1.41E-04
294	ED11D3DCDT	84	Breaker 3D In 125V dc Distribution Center 1DA Transfers Open	1.60E-04
295	ED13BR2CDT	24	Breaker 3BR In 125V dc Distribution Center 1DA Transfers Open	4.56E-05
296	ED22D3DCDT	24	Breaker 2D In 125V dc Distribution Center 2DA Transfers Open	4.56E-05
297	ED23BR2CDT	24	Breaker 3BR In 125V dc Distribution Center 2DA Transfers Open	4.56E-05
298	EK00RUNCOM	1.24E-4	Common Cause Failure Of Both Units Voltage Regulators To Run	1.24E-04
299	EK0BASERHE	1.0	Failure To Recover From Keowee Base Adjust LHE	1.00E+00
300	EK131TDRYD	1	Keowee Unit 1 Field Flashing Breaker Time Delay Relay 31/TD Fails To Operate	1.90E-04
301	EK131TDRYT	84	Keowee Unit 1 Field Flashing Breaker Time Delay Relay 31/TD Spurious Operation	8.40E-05
302	EK14152SWT	84	KHU1 Generator Supply Breaker Trip Control Switch 141-52/T Spurious Operation	8.40E-05
303	EK1415TSWT	24	Spurious Operation Of The KHU1 Supply Breaker Trip Switch	2.40E-05
304	EK1415YRYD	1	KHU1 Generator Supply Breaker Y-relay Failed To Drop-out At Last Operation	1.90E-04

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Keowee PRA Basic Event Data
Generic

	NAME	FACTOR	DESC	PROB
305	EK1415YRYT	84	KHU1 Generator Supply Breaker Y-relay Spurious Operation	8.40E-05
306	EK141AXR6D	1	Keowee Unit 1 Relay 41/AX Fails To Pick-up And Latch	2.49E-04
307	EK141AXR6T	24	Keowee Unit 1 Relay 41/AX Spuriously Resets	8.71E-06
308	EK141CFRYD	1	Keowee Unit 1 Field Flashing Breaker Close Coil Fails To Operate On Demand	1.90E-04
309	EK186E2RYT	6	Keowee Unit 1 Lockout Auxiliary Relay 86EX-2 Is Picked-up	6.00E-06
310	EK186EXRYT	84	Keowee Unit 1 Gen Lockout Auxiliary Relay 86EX-1 Spurious Actuation	8.40E-05
311	EK186X2RYT	24	Keowee Unit 1 Generator Lockout Auxiliary Relay 86EX-1 Spurious Actuation	2.40E-05
312	EK188SVRYD	1	Keowee Unit 1 Fan Control Relay 88SV Fails On Demand	1.90E-04
313	EK188SVRYT	108	Keowee Unit 1 Fan Control Relay 88SV Prior To Or During The Run	1.08E-04
314	EK1901ARYT	84	Keowee Unit 1 Relay 90X1A Spurious Operation	8.40E-05
315	EK199SXRYD	1	Auxiliary Relay 99SX1 Fails To Pick-up	1.90E-04
316	EK199SYRYD	1	Keowee Unit 1 Relay 99SY Fails To Pick-up	1.90E-04
317	EK199SYRYT	24	Keowee Unit 1 Relay 99SY Drops Out	2.40E-05
318	EK1BAS2DEX	1.24E-3	KHU-1 Base Adjust Fails To Maintain Generator Output Within Acceptable Range	1.24E-03
319	EK1BASEDEX	6.17E-4	Keowee Unit 1 Base Adjust Fails To Establish Correct Unit Voltage	6.17E-04
320	EK1BASELHE	3.20E-3	Keowee Unit 1 Base Adjust Is Set Incorrectly	3.20E-03
321	EK1DIODDEX	2.88E-4	Keowee Unit 1 Exciter Fan Supply Diode Bridge Fails	2.88E-04
322	EK1EXC1TGF	84	Keowee Unit 1 Gen Excitation Transformer Is Failed	1.68E-04
323	EK1EXC2TGF	24	Keowee Unit 1 Generator Excitation Transformer Fails	4.80E-05
324	EK1F30AFUF	24	Keowee Unit 1 Excitation Cabinet Fan Fuses Fail	1.51E-05
325	EK1F31XRYD	1	Keowee Unit 1 Field Flashing Breaker Relay 31/X Fails To Pick-up On Demand	1.90E-04
326	EK1F41CRYD	1	Keowee Unit 1 Field Breaker Close Coil Fails To Operate On Demand	1.90E-04
327	EK1FAN1TLF	24	Keowee Unit 1 Generator Excitation Fan Power Transformer Fails	4.80E-05
328	EK1FLDCLHE	2.60E-4	Keowee Unit 1 Field Breaker Fails To Close Due To Latent Human Error	2.60E-04
329	EK1FLDMDEX	7.71E-5	Keowee Unit 1 Field Breaker Fails To Close Due To Mechanical Failure	7.71E-05
330	EK1FLSCLHE	2.60E-4	Keowee Unit 1 Field Flashing Breaker Fails To Close Due To Latent Human Error	2.60E-04
331	EK1FLSMDEX	7.71E-5	Keowee Unit 1 Field Flashing Breaker Fails To Close Due To Mechanical Failure	7.71E-05
332	EK1FLSOLHE	2.60E-4	Keowee Unit 1 Field Flashing Breaker Fails To Open Due To Latent Human Error	2.60E-04
333	EK1R31TRYD	1	Keowee Unit 1 Field Flashing Breaker Trip Coil 31/T Fails To Operate	1.90E-04
334	EK1R31YRYD	1	KHU1 Gen Field Flashing Breaker Y-relay Failed To Drop Out At Last Operation	1.90E-04
335	EK1R31YRYT	84	KHU1 Generator Field Flashing Breaker Y-relay Spurious Operation	8.40E-05
336	EK1R41XRYD	1	Keowee Unit 1 Field Breaker Relay 41/X Fails To Pick-up On Demand	1.90E-04
337	EK1R41YRYD	1	KHU1 Generator Field Breaker Y-relay Failed To Drop-out At Last Operation	1.90E-04
338	EK1R41YRYT	84	Keowee Unit 1 Generator Field Breaker Y-relay Spurious Operation	8.40E-05
339	EK1R9A1RYT	84	Keowee Unit 1 Relay 90X1A/TD Spurious Operation	8.40E-05
340	EK1R9C1R6T	84	Keowee Unit 1 Relay 90X1C Spurious Operation	3.05E-05
341	EK1S141SWT	84	KHU1 Field Breaker Trip Control Switch 141/T Spurious Operation	8.40E-05
342	EK1S31TSWT	84	KHU1 Field Flashing Breaker Trip Control Switch 131/T Spurious Operation	8.40E-05

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Keewee PRA Basic Event Data
Generic

	NAME	FACTOR	DESC	PROB
343	EK1S41CRYD	1	Keowee Unit 1 Supply Breaker Close Coil Fails To Operate On Demand	1.90E-04
344	EK1S41TSWT	24	Keowee Unit 1 Field Breaker Trip Control Switch Transfers Position	2.40E-05
345	EK1S41XRYD	1	Keowee Unit 1 Supply Breaker Relay 41-52X Fails To Pick-up On Demand	1.90E-04
346	EK1SPYCLHE	2.60E-4	Keowee Unit 1 Supply Breaker Fails To Close Due To Latent Human Error	2.60E-04
347	EK1SPYMDEX	4.62E-4	Keowee Unit 1 Supply Breaker Fails To Close Due To Mehanical Failure	4.62E-04
348	EK1VHSVRYD	1	Keowee Unit 1 Volts/Hertz Relay SV Fails To Trip Field Flashing Breaker	1.90E-04
349	EK1VREGDEX	2.47E-3	KHU-1 Voltage Adjust Failure Drives Generator Output Too High/Low	2.47E-03
350	EK231TDRYD	1	Keowee Unit 2 Field Flashing Breaker Time Delay Relay 31/TD Fails To Operate	1.90E-04
351	EK231TDRYT	12	Keowee Unit 2 Field Flashing Breaker Time Delay Relay 31/TD Spurious Operation	1.20E-05
352	EK24152SWT	12	KHU2 Generator Supply Breaker Trip Control Switch Spurious Operation	1.20E-05
353	EK2415TSWT	24	Spurious Operation Of The KHU2 Supply Breaker Trip Switch	2.40E-05
354	EK2415YRYD	1	KHU2 Gen Supply Breaker Y-relay Failed To Drop-out At Last Operation	1.90E-04
355	EK2415YRYT	12	KHU2 Generator Supply Breaker Y-relay Spurious Operation	1.20E-05
356	EK241AXR6D	1	Keowee Unit 2 Relay 41/AX Fails To Pick-up And Latch	2.49E-04
357	EK241AXR6T	24	Keowee Unit 2 Relay 41/AX Spuriously Resets	8.71E-06
358	EK241CFRYD	1	Keowee Unit 2 Field Flashing Breaker Close Coil Fails To Operat On Demand	1.90E-04
359	EK286E2RYT	6	Keowee Unit 2 Lockout Auxiliary Relay 86EX-2 Is Picked-up	6.00E-06
360	EK286EXRYT	12	Keowee Unit 2 Generator Lockout Auxiliary Relay 86EX-1 Spurious Actuation	1.20E-05
361	EK286X2RYT	24	Keowee Unit 2 Generator Lockout Auxiliary Relay 86EX-1 Spurious Actuation	2.40E-05
362	EK288SVRYD	1	Keowee Unit 2 Fan Control Relay 88SV Fails On Demand	1.90E-04
363	EK288SVRYT	36	Keowee Unit 2 Fan Control Relay 88SV Prior To Or During The Run	3.60E-05
364	EK2901ARYT	12	Keowee Unit 2 Relay 90X1A Spurious Operation	1.20E-05
365	EK299SXRYD	1	Auxiliary Relay 99SX2 Fails To Pick-up	1.90E-04
366	EK299SYRYD	1	Keowee Unit 2 Relay 99SY Fails To Pick-up	1.90E-04
367	EK299SYRYT	24	Keowee Unit 2 Relay 99SY Drops Out	2.40E-05
368	EK2BAS2DEX	1.24E-3	KHU-2 Base Adjust Fails To Maintain Generator Output Within Acceptable Range	1.24E-03
369	EK2BASEDEX	6.17E-4	Keowee Unit 2 Base Adjust Fails To Establish Correct Unit Voltage	6.17E-04
370	EK2BASELHE	3.20E-3	Keowee Unit 2 Base Adjust Is Set Incorrectly	3.20E-03
371	EK2DIODDEX	2.88E-4	Keowee Unit 2 Exciter Fan Supply Diode Bridge Fails	2.88E-04
372	EK2EXC1TGF	12	Keowee Unit 2 Generator Excitation Transformer Is Failed	2.40E-05
373	EK2EXC2TGF	24	Keowee Unit 2 Generator Excitation Transformer Fails	4.80E-05
374	EK2F30AFUF	24	Keowee Unit 2 Excitation Cabinet Fan Fuses Fail	1.51E-05
375	EK2F31XRYD	1	Keowee Unit 2 Field Flashing Breaker Relay 31/X Fails To Pick-up On Demand	1.90E-04
376	EK2F41CRYD	1	Keowee Unit 2 Field Breaker Close Coil Fails To Operate On Demand	1.90E-04
377	EK2FAN1TLF	24	Keowee Unit 2 Generator Excitation Fan Power Transformer Fails	4.80E-05
378	EK2FLDCLHE	2.60E-4	Keowee Unit 2 Field Breaker Fails To Close Due To Latent Human Error	2.60E-04
379	EK2FLDMDEX	7.71E-5	Keowee Unit 2 Field Breaker Fails To Close Due To Mechanical Failure	7.71E-05
380	EK2FLSCLHE	2.60E-4	Keowee Unit 2 Field Flashing Breaker Fails To Close Due To Latent Human Error	2.60E-04

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Keowee PRA Basic Event Data
Generic

	NAME	FACTOR	DESC	PROB
381	EK2FLSMDEX	7.71E-5	Keowee Unit 2 Field Flashing Breaker Fails To Close Due To Mechanical Failure	7.71E-05
382	EK2FLSOLHE	2.60E-4	Keowee Unit 2 Field Flashing Breaker Fails To Open Due To Latent Human Error	2.60E-04
383	EK2R31TRYD	1	Keowee Unit 2 Field Flashing Breaker Trip Coil 31/T Fails To Operate	1.90E-04
384	EK2R31YRYD	1	KHU2 Gen Field Flashing Breaker Y-relay Failed To Drop At Last Operation	1.90E-04
385	EK2R31YRYT	12	KHU2 Generator Field Flashing Breaker Y-relay Spurious Operation	1.20E-05
386	EK2R41XRYD	1	Keowee Unit 2 Field Breaker Relay 41/X Fails To Pick-up On Demand	1.90E-04
387	EK2R41YRYD	1	KHU2 Generator Field Breaker Y-relay Failed To Drop-out At Last Operation	1.90E-04
388	EK2R41YRYT	12	KHU2 Generator Field Breaker Y-relay Spurious Operation	1.20E-05
389	EK2R9A2RYT	12	Keowee Unit 2 Relay 90X1A/TD Spurious Operation	1.20E-05
390	EK2R9C2R6T	12	Keowee Unit 2 Relay 90X1C Spurious Operation	4.36E-06
391	EK2S141SWT	12	KHU2 Field Breaker Trip Control Switch Spurious Operation	1.20E-05
392	EK2S31TSWT	12	KHU2 Field Flashing Breaker Trip Control Switch 131/T Spurious Operation	1.20E-05
393	EK2S41CRYD	1	Keowee Unit 2 Supply Breaker Close Coil Fails To Operate On Demand	1.90E-04
394	EK2S41TSWT	24	Keowee Unit 2 Field Breaker Trip Control Switch Transfers Position	2.40E-05
395	EK2S41XRYD	1	Keowee Unit 2 Supply Breaker Relay 41-52X Fails To Pick-up On Demand	1.90E-04
396	EK2SPYCLHE	2.60E-4	Keowee Unit 2 Supply Breaker Fails To Close Due To Latent Human Error	2.60E-04
397	EK2SPYMDEX	4.62E-4	Keowee Unit 2 Supply Breaker Fails To Close Due To Mehanical Failure	4.62E-04
398	EK2VHSVRYD	1	Keowee Unit 2 Volts/Hertz Relay SV Fails To Trip Field Flashing Breaker	1.90E-04
399	EK2VREGDEX	2.47E-3	KHU-2 Voltage Adjust Failure Drives Generator Output Too High/Low	2.47E-03
400	EKSTARTCOM	6.17E-5	Common Cause Failure Of Both Units Voltage Regulators To Start	6.17E-05
401	ESCONDNOT	1	An Engineered Safeguards Condition Does Not Exist	1.00E+00
402	EU1C1RORYD	1	ONS1 ESG Chan. 1 Ro Relay Fails To Pick Up OEE-120	1.00E+00
403	EU1C2RORYD	1	ONS1 ESG Chan. 2 Ro Relay Fails to Pick Up	1.00E+00
404	EU2C1RORYD	1	ONS2 ESG Chan. 1 Ro Relay Fails to Pick Up OEE-220	1.00E+00
405	EU2C2RORYD	1	ONS2 ESG Chan. 2 Ro Relay Fails to Pick Up OEE-220-1	1.00E+00
406	EU3C1RORYD	1	ONS3 ESG Chan. 1 Ro Relay Fails to Pick Up OEE-320	1.00E+00
407	EU3C2RORYD	1	ONS3 ESG Chan. 2 Ro Relay Fails to Pick Up OEE-320-1	1.00E+00
408	FK0FISHCOM	2.55E-3	Common Cause Failure Of Both Unit s WL Filters Due To Intake Debris	2.55E-03
409	FK0FISHDHE	1.0	Failure To Recover From MainTure WL Strainer Clogging	1.00E+00
410	FK0FL00DHE	1.0	Failure To Recover From Turbine Guide Bearing or Packing WL Filter Clogging	1.00E+00
411	FK0WL01VVT	24	Locked-Open Manual Valve 0WL-1 Transfers Position	1.92E-06
412	FK1120GLHE	3.2E-3	Unit 1 Control Switch S120G Left in OFF Position	3.20E-03
413	FK1120GSWT	108	Unit 1 Control Switch S120G Spurious Operation	1.08E-04
414	FK1FL01FRF	24	Filter 1WLFL-1 Becomes Clogged	2.88E-04
415	FK1FL02FRF	24	Filter 1WLFL-2 Becomes Clogged	2.88E-04
416	FK1TRHXHXF	24	Turbine Packing Box Heat Exchanger 1TRHX-1 Fails	8.16E-05
417	FK1WL03VVT	24	Manual Valve 1WL-3 Transfers Position	1.92E-06
418	FK1WL04VVT	24	Manual Valve 1WL-4 Transfers Position	1.92E-06

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Keowee PRA Basic Event Data
Generic

	NAME	FACTOR	DESC	PROB
419	FK1WL05VVT	24	Manual Valve 1WL-5 Transfers Position	1.92E-06
420	FK1WL06VVT	24	Manual Valve 1WL-6 Transfers Position	1.92E-06
421	FK1WL07VVT	24	Manual Valve 1WL-7 Transfers Position	1.92E-06
422	FK1WL08VVT	24	Manual Valve 1WL-8 Transfers Position	1.92E-06
423	FK1WL09VVT	24	Manual Valve 1WL-9 Transfers Position	1.92E-06
424	FK1WL11AVO	1	Cooling Water Control Valve 1WL-11 Fails To Open On Demand	2.20E-03
425	FK1WL11AVT	24	Cooling Water Control Valve 1WL-11 Transfers Closed	6.48E-05
426	FK1WL12VVT	108	Manual Valve 1WL-12 Transfers Position	8.64E-06
427	FK1WL15VVT	108	Manual Valve 1WL-15 Transfers Position	8.64E-06
428	FK1WL42VVT	108	Manual Valve 1WL-42 Transfers Position	8.64E-06
429	FK1WL43VVT	108	Manual Valve 1WL-43 Transfers Position	8.64E-06
430	FK2120GLHE	2.6E-4	Unit 2 Control Switch S120G Left in OFF Position	2.60E-04
431	FK2120GSWT	36	Unit 2 Control Switch S120G Spurious Operation	3.60E-05
432	FK2FL01FRF	24	Filter 2WLFL-1 Becomes Clogged	2.88E-04
433	FK2FL02FRF	24	Filter 2WLFL-2 Becomes Clogged	2.88E-04
434	FK2TRHXHXF	24	Turbine Packing Box Heat Exchanger 2TRHX-1 Fails	8.16E-05
435	FK2WL03VVT	24	Manual Valve 2WL-3 Transfers Position	1.92E-06
436	FK2WL04VVT	24	Manual Valve 2WL-4 Transfers Position	1.92E-06
437	FK2WL05VVT	24	Manual Valve 2WL-5 Transfers Position	1.92E-06
438	FK2WL06VVT	24	Manual Valve 2WL-6 Transfers Position	1.92E-06
439	FK2WL07VVT	24	Manual Valve 2WL-7 Transfers Position	1.92E-06
440	FK2WL08VVT	24	Manual Valve 2WL-8 Transfers Position	1.92E-06
441	FK2WL09VVT	24	Manual Valve 2WL-9 Transfers Position	1.92E-06
442	FK2WL11AVO	1	Cooling Water Control Valve 2WL-11 Fails To Open On Demand	2.20E-03
443	FK2WL11AVT	24	Cooling Water Control Valve 2WL-11 Transfers Closed	6.48E-05
444	FK2WL12VVT	36	Manual Valve 2WL-12 Transfers Position	2.88E-06
445	FK2WL15VVT	36	Manual Valve 2WL-15 Transfers Position	2.88E-06
446	FK2WL42VVT	36	Manual Valve 2WL-42 Transfers Position	2.88E-06
447	FK2WL43VVT	36	Manual Valve 2WL-43 Transfers Position	2.88E-06
448	FKVALVECOM	1.94E-4	Common Cause Failure Of Cooling Water Control Valves	1.94E-04
449	GK0COOLCOM	2.45E-06	Common Cause Failure of Generator Air Cooling	2.45E-06
450	GK0LOCKCOM	1.32E-05	Common Cause Actuation of Generator Lockouts	1.32E-05
451	GK10001HGR	24	Keowee Unit 1 Generator Fault While the Unit Runs	2.27E-03
452	GK10001HGS	1	Keowee Unit 1 Generator Fault Causes Unit Start Failure	1.54E-04
453	GK1063FPST	24	Keowee 1 Gen CO2 Sys Press Switch 63F Spurious Operation	2.04E-05
454	GK112TDRYT	24	Time Delay Relay 12XTD/1 Spuriously Picks-up	2.40E-05
455	GK112X1RYT	24	Relay 12X/1 Spuriously Picks-up	2.40E-05
456	GK13SUIRYT	24	Keowee Unit 1 Startup Inhibit Switch Auxiliary Relay S3SUIX Spurious Actuation	2.40E-05

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Keowee PRA Basic Event Data
Generic

	NAME	FACTOR	DESC	PROB
457	GK13SUISWT	24	Keowee Unit 1 Startup Inhibit Switch 3SUI Spurious Operation	2.40E-05
458	GK140G1RYT	24	Keowee Unit 1 Loss Of Generator Field Relay 40G1 Spurious Actuation	2.40E-05
459	GK159GNRYT	24	Keowee Unit 1 Generator Ground Fault Relay 59GN1 Spurious Actuation	2.40E-05
460	GK162TDRYT	24	Keowee Unit 1 Generator Backup Trip Timer 62-1TD Spurious Operation	2.40E-05
461	GK163FXRYT	24	Keowee Unit 1 Generator Fire Relay 63FX Spurious Actuation	2.40E-05
462	GK186E1RYT	24	Keowee 1 Emergency Lockout Relay 86E-1 Spuriously Picks Up	2.40E-05
463	GK187G1RYT	24	Keowee Unit 1 Generator Differential Relay 87G-1 Spurious Actuation	2.40E-05
464	GK187GBRYT	24	Keowee Unit 1 Generator Bus Differential Relay 87GB Spurious Actuation	2.40E-05
465	GK187TERYT	24	Keowee Unit 1 Exitation Transformer Differential Relay 87T-1E Spur. Actuation	2.40E-05
466	GK1BRGVLHE	2.60E-04	Keowee 1 Gen. Brng Oil Cooling Flow Path Vlvs Mispositioned After Maintenance	2.60E-04
467	GK1COOLLHE	2.60E-04	Keowee 1 Gen. Air Cooler WL Flow Path Vlvs Mispositioned After Maintenance	2.60E-04
468	GK1FIREDEX	3.19E-05	Spurious Actuation of Unit 1 Gen. CO2 Fire Supression System	3.19E-05
469	GK1GAC1HXF	24	Generator Air Cooler 1GAHW-1 Fails	8.16E-05
470	GK1GAC1HXL	108	Heat Exchanger 1GAC1 Leaks	3.24E-05
471	GK1GAC2HXF	24	Generator Air Cooler 1GAHW-2 Fails	8.16E-05
472	GK1GAC2HXL	108	Heat Exchanger 1GAC2 Leaks	3.24E-05
473	GK1GAC3HXF	24	Generator Air Cooler 1GAHW-3 Fails	8.16E-05
474	GK1GAC3HXL	108	Heat Exchanger 1GAC3 Leaks	3.24E-05
475	GK1GAC4HXF	24	Generator Air Cooler 1GAHW-4 Fails	8.16E-05
476	GK1GAC4HXL	108	Heat Exchanger 1GAC4 Leaks	3.24E-05
477	GK1GAC5HXF	24	Generator Air Cooler 1GAHW-5 Fails	8.16E-05
478	GK1GAC5HXL	108	Heat Exchanger 1GAC5 Leaks	3.24E-05
479	GK1GAC6HXF	24	Generator Air Cooler 1GAHW-6 Fails	8.16E-05
480	GK1GAC6HXL	108	Heat Exchanger 1GAC6 Leaks	3.24E-05
481	GK1HPO1HXF	24	Generator Thrust Bearing Cooler 1HPOHX-1 Fails	8.16E-05
482	GK1HPO2HXF	24	Generator Thrust Bearing Cooler 1HPOHX-2 Fails	8.16E-05
483	GK1HPO3HXF	24	Generator Thrust Bearing Cooler 1HPOHX-3 Fails	8.16E-05
484	GK1HPO4HXF	24	Generator Thrust Bearing Cooler 1HPOHX-4 Fails	8.16E-05
485	GK1HPO5HXF	24	Generator Thrust Bearing Cooler 1HPOHX-5 Fails	8.16E-05
486	GK1HPO6HXF	24	Generator Thrust Bearing Cooler 1HPOHX-6 Fails	8.16E-05
487	GK1HPO6VVT	24	Genrator Bearing Oil Leak Because Manual Valve 1HPO-6 Transfers Position	1.92E-06
488	GK1HPO7HXF	24	Generator Thrust Bearing Cooler 1HPOHX-7 Fails	8.16E-05
489	GK1HPO8HXF	24	Generator Thrust Bearing Cooler 1HPOHX-8 Fails	8.16E-05
490	GK1NGDCLHE	5.20E-05	Failure to Close the Unit 1 Neutral Ground Disconnect Following Maintenance	5.20E-05
491	GK1O121SST	24	Speed Switch 12/1 Falsely Indicates High Speed	2.40E-05
492	GK1WL16VVT	384	Manual Valve 1WL-16 Transfers Position	3.07E-05
493	GK1WL17VVT	384	Manual Valve 1WL-17 Transfers Position	3.07E-05
494	GK1WL18VVT	108	Manual Valve 1WL18 Transfers Position	8.64E-06

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Keowee PRA Basic Event Data
Generic

	NAME	FACTOR	DESC	PROB
495	GK1WL19VVT	108	Manual Valve 1WL19 Transfers Position	8.64E-06
496	GK1WL20VVT	384	Manual Valve 1WL-20 Transfers Position	3.07E-05
497	GK1WL21VVT	384	Manual Valve 1WL-21 Transfers Position	3.07E-05
498	GK1WL22VVT	108	Manual Valve 1WL22 Transfers Position	8.64E-06
499	GK1WL23VVT	108	Manual Valve 1WL23 Transfers Position	8.64E-06
500	GK1WL24VVT	384	Manual Valve 1WL-24 Transfers Position	3.07E-05
501	GK1WL25VVT	384	Manual Valve 1WL-25 Transfers Position	3.07E-05
502	GK1WL26VVT	108	Manual Valve 1WL26 Transfers Position	8.64E-06
503	GK1WL27VVT	108	Manual Valve 1WL27 Transfers Position	8.64E-06
504	GK1WL28VVT	384	Manual Valve 1WL-28 Transfers Position	3.07E-05
505	GK1WL29VVT	384	Manual Valve 1WL-29 Transfers Position	3.07E-05
506	GK1WL30VVT	108	Manual Valve 1WL30 Transfers Position	8.64E-06
507	GK1WL31VVT	108	Manual Valve 1WL31 Transfers Position	8.64E-06
508	GK1WL32VVT	384	Manual Valve 1WL-32 Transfers Position	3.07E-05
509	GK1WL33VVT	384	Manual Valve 1WL-33 Transfers Position	3.07E-05
510	GK1WL34VVT	108	Manual Valve 1WL34 Transfers Position	8.64E-06
511	GK1WL35VVT	108	Manual Valve 1WL35 Transfers Position	8.64E-06
512	GK1WL36VVT	384	Manual Valve 1WL-36 Transfers Position	3.07E-05
513	GK1WL37VVT	384	Manual Valve 1WL-37 Transfers Position	3.07E-05
514	GK1WL38VVT	108	Manual Valve 1WL38 Transfers Position	8.64E-06
515	GK1WL39VVT	108	Manual Valve 1WL39 Transfers Position	8.64E-06
516	GK1WL41VVT	384	Keowee 1 Manual Valve 1WL-41 Transfers Position to Block Discharge Path	3.07E-05
517	GK1WL44VVT	384	Manual Valve 1WL-44 Transfers Position	3.07E-05
518	GK1WL45VVT	384	Manual Valve 1WL-45 Transfers Position	3.07E-05
519	GK1WL46VVT	108	Manual Valve 1WL-46 Transfers Position	8.64E-06
520	GK1WL47VVT	108	Manual Valve 1WL-47 Transfers Position	8.64E-06
521	GK1WL48VVT	384	Manual Valve 1WL-48 Transfers Position	3.07E-05
522	GK1WL49VVT	384	Manual Valve 1WL-49 Transfers Position	3.07E-05
523	GK1WL50VVT	108	Manual Valve 1WL-50 Transfers Position	8.64E-06
524	GK1WL51VVT	108	Manual Valve 1WL-51 Transfers Position	8.64E-06
525	GK1WL52VVT	384	Manual Valve 1WL-52 Transfers Position	3.07E-05
526	GK1WL53VVT	384	Manual Valve 1WL-53 Transfers Position	3.07E-05
527	GK1WL54VVT	108	Manual Valve 1WL-54 Transfers Position	8.64E-06
528	GK1WL55VVT	108	Manual Valve 1WL-55 Transfers Position	8.64E-06
529	GK1WL56VVT	384	Manual Valve 1WL-56 Transfers Position	3.07E-05
530	GK1WL57VVT	384	Manual Valve 1WL-57 Transfers Position	3.07E-05
531	GK1WL58VVT	108	Manual Valve 1WL-58 Transfers Position	8.64E-06
532	GK1WL59VVT	108	Manual Valve 1WL-59 Transfers Position	8.64E-06

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Keowee PRA Basic Event Data
Generic

	NAME	FACTOR	DESC	PROB
533	GK1WL60VVT	384	Manual Valve 1WL-60 Transfers Position	3.07E-05
534	GK1WL61VVT	384	Manual Valve 1WL-61 Transfers Position	3.07E-05
535	GK1WL62VVT	108	Manual Valve 1WL-62 Transfers Position	8.64E-06
536	GK1WL63VVT	108	Manual Valve 1WL-63 Transfers Position	8.64E-06
537	GK1WL64VVT	384	Manual Valve 1WL-64 Transfers Position	3.07E-05
538	GK1WL65VVT	384	Manual Valve 1WL-65 Transfers Position	3.07E-05
539	GK1WL66VVT	108	Manual Valve 1WL-66 Transfers Position	8.64E-06
540	GK1WL67VVT	108	Manual Valve 1WL-67 Transfers Position	8.64E-06
541	GK1WL68VVT	384	Manual Valve 1WL-68 Transfers Position	3.07E-05
542	GK1WL69VVT	384	Manual Valve 1WL-69 Transfers Position	3.07E-05
543	GK1WL70VVT	108	Manual Valve 1WL-70 Transfers Position	8.64E-06
544	GK1WL71VVT	108	Manual Valve 1WL-71 Transfers Position	8.64E-06
545	GK1WL72VVT	384	Manual Valve 1WL-72 Transfers Position	3.07E-05
546	GK1WL73VVT	384	Manual Valve 1WL-73 Transfers Position	3.07E-05
547	GK1WL74VVT	108	Manual Valve 1WL-74 Transfers Position	8.64E-06
548	GK1WL75VVT	108	Manual Valve 1WL-75 Transfers Position	8.64E-06
549	GK1WL76VVT	384	Manual Valve 1WL76 Transfers Position and Blocks Discharge Path	3.07E-05
550	GK1WL78VVT	384	Manual Valve 1WL78 Transfers Position and Blocks Discharge Path	3.07E-05
551	GK20001HGR	24	Keowee Unit 2 Generator Fault While the Unit Runs	2.27E-03
552	GK20002HGS	1	Keowee Unit 2 Generator Fault Causes Unit Start Failure	1.54E-04
553	GK2063FPST	24	Keowee 2 Gen CO2 Sys Press Switch 63F Spurious Operation	2.04E-05
554	GK212TDRYT	24	Time Delay Relay 12XTD/2 Spuriously Picks-up	2.40E-05
555	GK212X2RYT	24	Relay 12X/2 Spuriously Picks-up	2.40E-05
556	GK23SUIRYT	24	Keowee Unit 2 Startup Inhibit Switch Auxiliary Relay S3SUIX Spurious Actuation	2.40E-05
557	GK23SUISWT	24	Keowee Unit 2 Startup Inhibit Swtich 3SUI Spurious Operation	2.40E-05
558	GK240G1RYT	24	Keowee Unit 2 Loss Of Generator Field Relay 40G1 Spurious Actuation	2.40E-05
559	GK259GNRYT	24	Keowee Unit 2 Generator Ground Fault Relay 59GN2 Spurious Actuation	2.40E-05
560	GK262TDRYT	24	Keowee Unit 2 Generator Backup Trip Timer 62-2TD Spurious Operation	2.40E-05
561	GK263FXRYT	24	Keowee Unit 2 Generator Fire Relay 63FX Spurious Actuation	2.40E-05
562	GK286E2RYT	24	Keowee 2 Emergency Lockout Relay 86E-2 Spuriously Picks Up	2.40E-05
563	GK287G2RYT	24	Keowee Unit 2 Generator Differential Relay 87G-2 Spurious Actuation	2.40E-05
564	GK287GBRYT	24	Keowee Unit 2 Generator Bus Differential Relay 87GB Spurious Actuation	2.40E-05
565	GK287TERYT	24	Keowee Unit 2 Excitation Transformer Differential Relay 87T-2E Spur. Actuation	2.40E-05
566	GK2BRGVLHE	2.60E-04	Keowee 2 Gen. Brng. Oil Cooling Flow Path Vlvs Mispositioned After Maintenance	2.60E-04
567	GK2COOLLHE	2.60E-04	Keowee 2 Gen. Air Cooler WL Flow Path Vlvs Mispositioned After Maintenance	2.60E-04
568	GK2FIREDEX	7.00E-05	Spurious Actuation of Unit 2 Gen. CO2 Fire Supression System	7.00E-05
569	GK2GAC1HXF	24	Generator Air Cooler 2GAHW-1 Fails	8.16E-05
570	GK2GAC1HXL	36	Heat Exchanger 2GAC1 Leaks	1.08E-05

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Keowee PRA Basic Event Data
Generic

	NAME	FACTOR	DESC	PROB
571	GK2GAC2HXF	24	Generator Air Cooler 2GAHW-2 Fails	8.16E-05
572	GK2GAC2HXL	36	Heat Exchanger 2GAC2 Leaks	1.08E-05
573	GK2GAC3HXF	24	Generator Air Cooler 2GAHW-3 Fails	8.16E-05
574	GK2GAC3HXL	36	Heat Exchanger 2GAC3 Leaks	1.08E-05
575	GK2GAC4HXF	24	Generator Air Cooler 2GAHW-4 Fails	8.16E-05
576	GK2GAC4HXL	36	Heat Exchanger 2GAC4 Leaks	1.08E-05
577	GK2GAC5HXF	24	Generator Air Cooler 2GAHW-5 Fails	8.16E-05
578	GK2GAC5HXL	36	Heat Exchanger 2GAC5 Leaks	1.08E-05
579	GK2GAC6HXF	24	Generator Air Cooler 2GAHW-6 Fails	8.16E-05
580	GK2GAC6HXL	36	Heat Exchanger 2GAC6 Leaks	1.08E-05
581	GK2HPO1HXF	24	Generator Thrust Bearing Cooler 2HPOHX-1 Fails	8.16E-05
582	GK2HPO2HXF	24	Generator Thrust Bearing Cooler 2HPOHX-2 Fails	8.16E-05
583	GK2HPO3HXF	24	Generator Thrust Bearing Cooler 2HPOHX-3 Fails	8.16E-05
584	GK2HPO4HXF	24	Generator Thrust Bearing Cooler 2HPOHX-4 Fails	8.16E-05
585	GK2HPO5HXF	24	Generator Thrust Bearing Cooler 2HPOHX-5 Fails	8.16E-05
586	GK2HPO6HXF	24	Generator Thrust Bearing Cooler 2HPOHX-6 Fails	8.16E-05
587	GK2HPO6VVT	24	Genrator Bearing Oil Leak Because Manual Valve 2HPO-6 Transfers Position	1.92E-06
588	GK2HPO7HXF	24	Generator Thrust Bearing Cooler 2HPOHX-7 Fails	8.16E-05
589	GK2HPO8HXF	24	Generator Thrust Bearing Cooler 2HPOHX-8 Fails	8.16E-05
590	GK2NGDCLHE	5.20E-05	Failure to Close the Unit 2 Neutral Ground Disconnect Following Maintenance	5.20E-05
591	GK2O121SST	24	Speed Switch 12/2 Falsely Indicates High Speed	2.40E-05
592	GK2WL16VVT	36	Manual Valve 2WL-16 Transfers Position	2.88E-06
593	GK2WL17VVT	36	Manual Valve 2WL-17 Transfers Position	2.88E-06
594	GK2WL18VVT	36	Manual Valve 2WL18 Transfers Position	2.88E-06
595	GK2WL19VVT	36	Manual Valve 2WL19 Transfers Position	2.88E-06
596	GK2WL20VVT	36	Manual Valve 2WL-20 Transfers Position	2.88E-06
597	GK2WL21VVT	36	Manual Valve 2WL-21 Transfers Position	2.88E-06
598	GK2WL22VVT	36	Manual Valve 2WL22 Transfers Position	2.88E-06
599	GK2WL23VVT	36	Manual Valve 2WL23 Transfers Position	2.88E-06
600	GK2WL24VVT	36	Manual Valve 2WL-24 Transfers Position	2.88E-06
601	GK2WL25VVT	36	Manual Valve 2WL-25 Transfers Position	2.88E-06
602	GK2WL26VVT	36	Manual Valve 2WL26 Transfers Position	2.88E-06
603	GK2WL27VVT	36	Manual Valve 2WL27 Transfers Position	2.88E-06
604	GK2WL28VVT	36	Manual Valve 2WL-28 Transfers Position	2.88E-06
605	GK2WL29VVT	36	Manual Valve 2WL-29 Transfers Position	2.88E-06
606	GK2WL30VVT	36	Manual Valve 2WL30 Transfers Position	2.88E-06
607	GK2WL31VVT	36	Manual Valve 2WL31 Transfers Position	2.88E-06
608	GK2WL32VVT	36	Manual Valve 2WL-32 Transfers Position	2.88E-06

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Keowee PRA Basic Event Data
Generic

	NAME	FACTOR	DESC	PROB
609	GK2WL33VVT	36	Manual Valve 2WL-33 Transfers Position	2.88E-06
610	GK2WL34VVT	36	Manual Valve 2WL34 Transfers Position	2.88E-06
611	GK2WL35VVT	36	Manual Valve 2WL35 Transfers Position	2.88E-06
612	GK2WL36VVT	36	Manual Valve 2WL-36 Transfers Position	2.88E-06
613	GK2WL37VVT	36	Manual Valve 2WL-37 Transfers Position	2.88E-06
614	GK2WL38VVT	36	Manual Valve 2WL38 Transfers Position	2.88E-06
615	GK2WL39VVT	36	Manual Valve 2WL39 Transfers Position	2.88E-06
616	GK2WL41VVT	36	Keowee 2 Manual Valve 2WL-41 Transfers Position to Block Discharge Path	2.88E-06
617	GK2WL44VVT	36	Manual Valve 2WL-44 Transfers Position	2.88E-06
618	GK2WL45VVT	36	Manual Valve 2WL-45 Transfers Position	2.88E-06
619	GK2WL46VVT	36	Manual Valve 2WL-46 Transfers Position	2.88E-06
620	GK2WL47VVT	36	Manual Valve 2WL-47 Transfers Position	2.88E-06
621	GK2WL48VVT	36	Manual Valve 2WL-48 Transfers Position	2.88E-06
622	GK2WL49VVT	36	Manual Valve 2WL-49 Transfers Position	2.88E-06
623	GK2WL50VVT	36	Manual Valve 2WL-50 Transfers Position	2.88E-06
624	GK2WL51VVT	36	Manual Valve 2WL-51 Transfers Position	2.88E-06
625	GK2WL52VVT	36	Manual Valve 2WL-52 Transfers Position	2.88E-06
626	GK2WL53VVT	36	Manual Valve 2WL-53 Transfers Position	2.88E-06
627	GK2WL54VVT	36	Manual Valve 2WL-54 Transfers Position	2.88E-06
628	GK2WL55VVT	36	Manual Valve 2WL-55 Transfers Position	2.88E-06
629	GK2WL56VVT	36	Manual Valve 2WL-56 Transfers Position	2.88E-06
630	GK2WL57VVT	36	Manual Valve 2WL-57 Transfers Position	2.88E-06
631	GK2WL58VVT	36	Manual Valve 2WL-58 Transfers Position	2.88E-06
632	GK2WL59VVT	36	Manual Valve 2WL-59 Transfers Position	2.88E-06
633	GK2WL60VVT	36	Manual Valve 2WL-60 Transfers Position	2.88E-06
634	GK2WL61VVT	36	Manual Valve 2WL-61 Transfers Position	2.88E-06
635	GK2WL62VVT	36	Manual Valve 2WL-62 Transfers Position	2.88E-06
636	GK2WL63VVT	36	Manual Valve 2WL-63 Transfers Position	2.88E-06
637	GK2WL64VVT	36	Manual Valve 2WL-64 Transfers Position	2.88E-06
638	GK2WL65VVT	36	Manual Valve 2WL-65 Transfers Position	2.88E-06
639	GK2WL66VVT	36	Manual Valve 2WL-66 Transfers Position	2.88E-06
640	GK2WL67VVT	36	Manual Valve 2WL-67 Transfers Position	2.88E-06
641	GK2WL68VVT	36	Manual Valve 2WL-68 Transfers Position	2.88E-06
642	GK2WL69VVT	36	Manual Valve 2WL-69 Transfers Position	2.88E-06
643	GK2WL70VVT	36	Manual Valve 2WL-70 Transfers Position	2.88E-06
644	GK2WL71VVT	36	Manual Valve 2WL-71 Transfers Position	2.88E-06
645	GK2WL72VVT	36	Manual Valve 2WL-72 Transfers Position	2.88E-06
646	GK2WL73VVT	36	Manual Valve 2WL-73 Transfers Position	2.88E-06

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Keowee PRA Basic Event Data
Generic

	NAME	FACTOR	DESC		PROB
647	GK2WL74VVT	36	Manual Valve 2WL-74 Transfers Position		2.88E-06
648	GK2WL75VVT	36	Manual Valve 2WL-75 Transfers Position		2.88E-06
649	GK2WL76VVT	36	Manual Valve 2WL76 Transfers Position and Blocks Discharge Path		2.88E-06
650	GK2WL78VVT	36	Manual Valve 2WL78 Transfers Position and Blocks Discharge Path		2.88E-06
651	GKHPOILCOM	2.45E-06	Common Cause Failure of Generator Thrust Bearings		2.45E-06
652	K12COM1DEX	1.00E-06	Grid Degradation Occurs And Causes Failure Of Both Keowee Units		1.00E-06
653	KA127T1R6D	1	Xfrmr 1X UV Relay 27T/1X Fails To Pick-up		2.49E-04
654	KA127T1R6T	360	Xfrmr 1X UV Relay 27T/1X Spuriously De-energizes		1.31E-04
655	KA227T2R6T	360	Xfmr 2X UV Relay 27T/2x Spuriously De-energizes		1.31E-04
656	KB4CONNDEX	1.1E-7	Air Circuit Breaker 4 Connects Unit 2 To The Underground Path		1.10E-07
657	KK1BOTHDEX	0.0	Keowee Units 1 And 2 Are Supplying The Grid		0.00E+00
658	KK1BOTHHYM	5.23E-3	Both Keowee Units Unavailable Due To Common Maintenance		5.23E-03
659	KK1OVERBHF	24	Fault Occurs On The Overhead Power Path		1.27E-05
660	KK1RUNSDEX	0.0	Keowee Unit 1 Only Is Supplying The Grid		0.00E+00
661	KK1UNDRBHF	24	Fault Occurs On The Underground Power Path		1.27E-05
662	KK2RUNSDEX	0.06	Keowee Unit 2 Only Is Supplying The Grid		6.00E-02
663	KK2UNITHYM	3.80E-2	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-02
664	KU2CREDIT	0	Take No Credit For Keowee Unit 2 Suppling Auxiliary ac PowerTo Unit 1		0.00E+00
665	L0EGTPSCOM	1.03E-05	Common Cause Failure of UV And UF Detection Circuits		1.03E-05
666	L27BRX1RYD	1	Snsng Rly 27B/RX1 Fails to Drop Out on Undervoltage	OEE-76-3, -4	1.90E-04
667	L27BRX2RYD	1	Snsng Rly 27B/RX2 Fails to Drop Out on Undervoltage	OEE-76-3, -8	1.90E-04
668	L27BRY1RYD	1	Snsng Rly 27B/RY1 Fails to Drop Out on Undervoltage	OEE-76-3, -4	1.90E-04
669	L27BRY2RYD	1	Snsng Rly 27B/RY2 Fails to Drop Out on Undervoltage	OEE-76-3, -8	1.90E-04
670	L27BRZ1RYD	1	Snsng Rly 27B/RZ1 Fails to Drop Out on Undervoltage	OEE-76-3, -4	1.90E-04
671	L27BRZ2RYD	1	Snsng Rly 27B/RZ2 Fails to Drop Out on Undervoltage	OEE-76-3, -8	1.90E-04
672	L27BYX1RYD	1	Snsng Rly 27B/YX1 Fails to Drop Out on Undervoltage	OEE-76-3, -4	1.90E-04
673	L27BYX2RYD	1	Snsng Rly 27B/YX2 Fails to Drop Out on Undervoltage	OEE-76-3, -8	1.90E-04
674	L27BYY1RYD	1	Snsng Rly 27B/YY1 Fails to Drop Out on Undervoltage	OEE-76-3, -4	1.90E-04
675	L27BYY2RYD	1	Snsng Rly 27B/YY2 Fails to Drop Out on Undervoltage	OEE-76-3, -8	1.90E-04
676	L27BYZ1RYD	1	Snsng Rly 27B/YZ1 Fails to Drop Out on Undervoltage	OEE-76-3, -4	1.90E-04
677	L27BYZ2RYD	1	Snsng Rly 27B/YZ2 Fails to Drop Out on Undervoltage	OEE-76-3, -8	1.90E-04
678	L27XPX1RYD	1	Ch 1 Phase X UV Aux. Relay Fails To Pick Up	OEE-76-4	1.90E-04
679	L27XPX2RYD	1	Ch 2 Phase X UV Aux. Relay Fails To Pick Up	OEE-76-8	1.90E-04
680	L27XPY1RYD	1	Ch 1 Phase Y UV Aux. Relay Fails to Pick Up	OEE-76-4	1.90E-04
681	L27XPY2RYD	1	Ch 2 Phase Y UV Aux. Relay Fails to Pick Up	OEE-76-8	1.90E-04
682	L27XPZ1RYD	1	Ch 1 Phase Z UV Aux. Relay Fails To Pick Up	OEE-76-4	1.90E-04
683	L27XPZ2RYD	1	Ch 2 Phase Z UV Aux. Relay Fails To Pick Up	OEE-76-8	1.90E-04
684	L27XRX1RYD	1	Red Bus Phase X1 Undervoltage Aux. Relay Fails To Pick Up	OEE-76-4	1.90E-04

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Keowee PRA Basic Event Data
Generic

	NAME	FACTOR	DESC	PROB
685	L27XRX2RYD	1	Red Bus Phase X2 Undervoltage Aux. Relay Fails To Pick Up OEE-76-8	1.90E-04
686	L27XRY1RYD	1	Red Bus Phase Y1 Undervoltage Aux. Relay Fails To Pick Up OEE-76-4	1.90E-04
687	L27XRY2RYD	1	Red Bus Phase Y2 Undervoltage Aux. Relay Fails to Pick Up OEE-76-8	1.90E-04
688	L27XRZ1RYD	1	Red Bus Phase Z1 Undervoltage Aux. Relay Fails To Pick Up OEE-76-4	1.90E-04
689	L27XRZ2RYD	1	Red Bus Phase Z2 Undervoltage Aux. Relay Fails To Pick Up OEE-76-8	1.90E-04
690	L27XSTARYD	1	Keowee Start Relay 27X/STA Fails To Pick Up	1.90E-04
691	L27XSTBRYD	1	Keowee Start Relay 27X/STB Fails To Pick Up	1.90E-04
692	L27XYX1RYD	1	Yellow Bus Phase X1 Undervoltage Aux. Relay Fails To Pick Up OEE-76-4	1.90E-04
693	L27XYX2RYD	1	Yellow Bus Phase X2 Undervoltage Aux. Relay Fails To Pick Up OEE-76-8	1.90E-04
694	L27XYY1RYD	1	Yellow Bus Phase Y1 Undervoltage Aux. Relay Fails To Pick Up OEE-76-4	1.90E-04
695	L27XYY2RYD	1	Yellow Bus Phase Y2 Undervoltage Aux. Relay Fails to Pick Up OEE-76-8	1.90E-04
696	L27XYZ1RYD	1	Yellow Bus Phase Z1 Undervoltage Aux. Relay Fails To Pick Up OEE-76-4	1.90E-04
697	L27XYZ2RYD	1	Yellow Bus Phase Z2 Undervoltage Aux. Relay Fails to Pick Up OEE-76-8	1.90E-04
698	L81BRX1RYD	1	Sensing Relay 81BL/RX1 Fails to Drop Out on Underfrequency	1.90E-04
699	L81BRX2RYD	1	Sensing Relay 81BL/RX2 Fails to Drop Out on Underfrequency	1.90E-04
700	L81BRY1RYD	1	Sensing Relay 81BL/RY1 Fails to Drop Out on Underfrequency	1.90E-04
701	L81BRY2RYD	1	Sensing Relay 81BL/RY2 Fails to Drop Out on Underfrequency	1.90E-04
702	L81BRZ1RYD	1	Sensing Relay 81BL/RZ1 Fails to Drop Out on Underfrequency	1.90E-04
703	L81BRZ2RYD	1	Sensing Relay 81BL/RZ2 Fails to Drop Out on Underfrequency	1.90E-04
704	L81BYX1RYD	1	Sensing Relay 81BL/YX1 Fails to Drop Out on Underfrequency	1.90E-04
705	L81BYX2RYD	1	Sensing Relay 81BL/YX2 Fails to Drop Out on Underfrequency	1.90E-04
706	L81BYY1RYD	1	Sensing Relay 81BL/YY1 Fails to Drop Out on Underfrequency	1.90E-04
707	L81BYY2RYD	1	Sensing Relay 81BL/YY2 Fails to Drop Out on Underfrequency	1.90E-04
708	L81BYZ1RYD	1	Sensing Relay 81BL/YZ1 Fails to Drop Out on Underfrequency	1.90E-04
709	L81BYZ2RYD	1	Sensing Relay 81BL/YZ2 Fails to Drop Out On Underfrequency	1.90E-04
710	L81XPX1RYD	1	Ch 1 Phase X Underfrequency Aux. Rly Fails to Pick Up	1.90E-04
711	L81XPX2RYD	1	Ch 2 Phase X Underfrequency Aux. Rly Fails to Pick Up	1.90E-04
712	L81XPY1RYD	1	Ch 1 Phase Y Underfrequency Aux. Rly Fails to Pick Up	1.90E-04
713	L81XPY2RYD	1	Ch 2 Phase Y Underfrequency Aux. Rly Fails to Pick Up	1.90E-04
714	L81XPZ1RYD	1	Ch 1 Phase Z Underfrequency Aux. Rly Fails to Pick Up	1.90E-04
715	L81XPZ2RYD	1	Ch 2 Phase Z Underfrequency Aux. Rly Fails to Pick up	1.90E-04
716	L81XRX1RYD	1	Red Bus Phase X1 Underfrequency Aux. Rly Fails to Pick Up	1.90E-04
717	L81XRX2RYD	1	Red Bus Phase X2 Underfrequency Aux. Rly Fails to Pick Up	1.90E-04
718	L81XRY1RYD	1	Red Bus Phase Y1 Underfrequency Aux. Rly Fails to Pick Up	1.90E-04
719	L81XRY2RYD	1	Red Bus Phase Y2 Underfrequency Aux. Rly Fails to Pick Up	1.90E-04
720	L81XRZ1RYD	1	Red Bus Phase Z1 Underfrequency Aux. Rly Fails to Pick Up	1.90E-04
721	L81XRZ2RYD	1	Red Bus Phase Z2 Underfrequency Aux. Rly Fails to Pick Up	1.90E-04
722	L81XYX1RYD	1	Yellow Bus Phase X1 Underfrequency Aux. Rly Fails to Pick Up	1.90E-04

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Keewee PRA Basic Event Data
Generic

	NAME	FACTOR	DESC		PROB
723	L81XYX2RYD	1	Yellow Bus Phase X2 Underfrequency Aux. Rly Fails to Pick Up		1.90E-04
724	L81XYY1RYD	1	Yellow Bus Phase Y1 Underfrequency Aux. Rly Fails to Pick Up		1.90E-04
725	L81XYY2RYD	1	Yellow Bus Phase Y2 Underfrequency Aux. Rly Fails to Pick Up		1.90E-04
726	L81XYZ1RYD	1	Yellow Bus Phase Z1 Underfrequency Aux. Rly Fails to Pick Up		1.90E-04
727	L81XYZ2RYD	1	Yellow Bus Phase Z2 Underfrequency Aux. Rly Fails to Pick Up		1.90E-04
728	LC94F1ARYD	1	EGTPS Underfrequency Relay 94/F1A Fails to Pick Up		1.90E-04
729	LC94F1BRYD	1	EGTPS Underfrequency Relay 94/F1B Fails to Pick Up		1.90E-04
730	LC94F1DRYD	1	EGTPS Underfrequency Relay 94/F1D Fails to Pick Up		1.90E-04
731	LC94F2ARYD	1	EGTPS Underfrequency Relay 94/F2A Fails to Pick Up		1.90E-04
732	LC94F2BRYD	1	EGTPS Underfrequency Relay 94/F2B Fails to Pick Up		1.90E-04
733	LC94F2CRYD	1	EGTPS Underfrequency Relay 94/F2C Fails to Pick Up		1.90E-04
734	LC94F2DRYD	1	EGTPS Underfrequency Relay 94/F2D Fails to Pick Up		1.90E-04
735	LC94V1ARYD	1	EGTPS Undervoltage Relay 94/V1A Fails to Pick Up		1.90E-04
736	LC94V1BRYD	1	EGTPS Undervoltage Relay 94/V1B Fails To Pick Up	OEE-76-4	1.90E-04
737	LC94V1DRYD	1	EGTPS Undervoltage Relay 94/V1D Fails to Pick Up	OEE-76-4	1.90E-04
738	LC94V2ARYD	1	EGTPS Undervoltage Relay 94/V2A Fails to Pick Up		1.90E-04
739	LC94V2BRYD	1	EGTPS Undervoltage Relay 94/V2B Fails To Pick Up		1.90E-04
740	LC94V2CRYD	1	EGTPS Undervoltage Relay 94/V2C Fails to Pick Up		1.90E-04
741	LDCYC13CDT	24	Switchyard 125 Vdc Panelboard DYC Breaker 13 Transfers Open	OEE-76-4 / O-802	4.56E-05
742	LDCYC14CDT	24	Switchyard 125 Vdc Panelboard DYC Breaker 14 Transfers Open	OEE-76-4 / O-802	4.56E-05
743	LDCYG12CDT	24	Switchyard 125 Vdc Panelboard DYG Breaker 12 Transfers Open		4.56E-05
744	LDCYG18CDT	24	Switchyard 125 Vdc Panelboard DYG Breaker 18 Transfers Open		4.56E-05
745	OFACTORDEX	1.0	Overload Susceptibility Factor		1.00E+00
746	OK0PRUNCOM	4.65E-04	Common Cause Failure Of Both Governor Oil Systems To Run		4.65E-04
747	OK10001PSC	15	Pressure Switch 1OGPS-1 Fails to Close (Normal	Control Signal)	3.90E-03
748	OK10002PSC	8	Pressure Switch 1OGPS-2 Fails to Close		2.08E-03
749	OK10003PSC	4	Pressure Switch 1OGPS-3 Fails to Close		1.04E-03
750	OK10003RVT	24	Safety Relief Valve 1OG-3 Spurious Operation		4.08E-05
751	OK10003TKF	24	Unit 1 Governor Oil Pressure Tank Fails		1.80E-05
752	OK10004PSC	1	Pressure Switch 1OGPS-4 Fails to Close		2.60E-04
753	OK10007FVT	24	Float Valve 1OG-7 Transfers Closed		4.20E-04
754	OK10009VVT	24	Manual Valve 1OG-9 Transfers Closed		1.92E-06
755	OK10011CVO	15	Check Valve 1OG-11 Fails to Open		2.85E-03
756	OK10011CVT	0.75	Check Valve 1OG-11 Transfers Closed		3.37E-07
757	OK10012VVT	30	Manual Globe Valve 1OG-12 Transfers Closed		2.40E-06
758	OK10013RVT	0.75	Relief Valve 1OG-13 Spurious Operation		1.27E-06
759	OK10014CVO	8	Check Valve 1OG-14 Fails to Open		1.52E-03
760	OK10014CVT	0.5	Check Valve 1OG-14 Transfers Closed		2.25E-07

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Keowee PRA Basic Event Data
Generic

	NAME	FACTOR	DESC	PROB
761	OK10015VVT	192	Manual Globe Valve 1OG-15 Transfers Closed	1.54E-05
762	OK10016RVT	0.5	Relief Valve 1OG-16 Transfers Open	8.50E-07
763	OK10017CVO	4	Check Valve 1OG-17 Fails to Open	7.60E-04
764	OK10017CVT	0.25	Check Valve 1OG-17 Transfers Closed	1.12E-07
765	OK10018VVT	108	Manual Globe Valve 1OG-18 Transfers Closed	8.64E-06
766	OK10019RVT	0.25	Relief Valve 1OG-19 Spurious Operation	4.25E-07
767	OK1001AGPR	0.375	OG Pump 1A Fails to Run	9.00E-06
768	OK1001AGPS	15	OG Pump 1A Fails to Start	4.65E-02
769	OK1001BGPR	0.25	OG Pump 1B Fails to Run	6.00E-06
770	OK1001BGPS	8	OG Pump 1B Fails to Start	2.48E-02
771	OK1001BLHE	3.2E-3	Latent Human Error Fails OG Pump 1B	3.20E-03
772	OK1001CGPR	0.125	OG Pump 1C Fails to Run	3.00E-06
773	OK1001CGPS	4	OG Pump 1C Fails to Start	1.24E-02
774	OK1001CLHE	3.2E-3	Latent Human Error Fails OG Pump 1C	3.20E-03
775	OK188GASWT	30	Keowee 1 Governor Oil Control Switch 188GA Spurious Operation	3.00E-05
776	OK188GBSWT	192	Keowee 1 Control Switch 188GB Spurious Operation	1.92E-04
777	OK188GCSWT	108	Keowee 1 Control Switch 188GC Spurious Operation	1.08E-04
778	OK199K1RYD	1	Keowee 1 Relay 99K1 Fails To Operate On Demand	1.90E-04
779	OK199K1RYT	24	Keowee Unit 1 Relay 99K1 Spurious Operation	2.40E-05
780	OK199K2RYD	1	Keowee 1 Relay 99K2 Fails To Operate On Demand	1.90E-04
781	OK1AG01TKF	24	Air Receiver Tank 1AGTK-1 Fails	1.80E-05
782	OK1AG04RVT	24	Safety Relief Valve 1AG-4 Spurious Operation	4.08E-05
783	OK1AG05VVT	24	Manual Valve 1AG-5 Transfers Position	1.92E-06
784	OK1OG1CTRM	3.42E-3	OG Pump 1C Train In Maintenance Or Testing	3.42E-03
785	OK1PRUNCOM	1.92E-07	Common Cause Failure of Unit 1 OG Pumps to Run	1.92E-07
786	OK1PSTRCOM	6.51E-04	Common Cause Failure of Unit 1 OG Pumps to Start	6.51E-04
787	OK1XA1DCLT	30	Low Voltage Circuit Breaker 1XA-1D Transfers Position	5.70E-05
788	OK1XA2ECLT	30	Low Voltage Circuit Breaker 1XA-2E Transfers Position	5.70E-05
789	OK1XA4DCLT	30	Low Voltage Circuit Breaker 1XA-4D Transfers Position	5.70E-05
790	OK20001PSC	15	Pressure Switch 2OGPS-1 Fails to Close (Normal Control Signal)	3.90E-03
791	OK20002PSC	8	Pressure Switch 2OGPS-2 Fails to Close	2.08E-03
792	OK20003PSC	4	Pressure Switch 2OGPS-3 Fails to Close	1.04E-03
793	OK20003RVT	24	Safety Relief Valve 2OG-3 Spurious Operation	4.08E-05
794	OK20003TKF	24	Unit 2 Governor Oil Pressure Tank Fails	1.80E-05
795	OK20004PSC	1	Pressure Switch 2OGPS-4 Fails to Close	2.60E-04
796	OK20007FVT	24	Float Valve 2OG-7 Transfers Closed	4.20E-04
797	OK20009VVT	24	Manual Valve 2OG-9 Transfers Closed	1.92E-06
798	OK20011CVO	15	Check Valve 2OG-11 Fails to Open	2.85E-03

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Keowee PRA Basic Event Data
Generic

	NAME	FACTOR	DESC	PROB
799	OK20011CVT	0.75	Check Valve 2OG-11 Transfers Closed	3.37E-07
800	OK20012VVT	30	Manual Globe Valve 2OG-12 Transfers Closed	2.40E-06
801	OK20013RVT	0.75	Relief Valve 2OG-13 Spurious Operation	1.27E-06
802	OK20014CVO	8	Check Valve 2OG-14 Fails to Open	1.52E-03
803	OK20014CVT	0.5	Check Valve 2OG-14 Transfers Closed	2.25E-07
804	OK20015VVT	192	Manual Globe Valve 2OG-15 Transfers Closed	1.54E-05
805	OK20016RVT	0.5	Relief Valve 2OG-16 Transfers Open	8.50E-07
806	OK20017CVO	4	Check Valve 2OG-17 Fails to Open	7.60E-04
807	OK20017CVT	0.25	Check Valve 2OG-17 Transfers Closed	1.12E-07
808	OK20018VVT	108	Manual Globe Valve 2OG-18 Transfers Closed	8.64E-06
809	OK20019RVT	0.25	Relief Valve 2OG-19 Spurious Operation	4.25E-07
810	OK2002AGPR	0.375	OG Pump 2A Fails to Run	9.00E-06
811	OK2002AGPS	15	OG Pump 2A Fails to Start	4.65E-02
812	OK2002BGPR	0.25	OG Pump 2B Fails to Run	6.00E-06
813	OK2002BGPS	8	OG Pump 2B Fails to Start	2.48E-02
814	OK2002BLHE	3.2E-3	Latent Human Error Fails OG Pump 2B	3.20E-03
815	OK2002CGPR	0.125	OG Pump 2C Fails to Run	3.00E-06
816	OK2002CGPS	4	OG Pump 2C Fails to Start	1.24E-02
817	OK2002CLHE	3.2E-3	Latent Human Error Fails OG Pump 2C	3.20E-03
818	OK288GASWT	30	Keowee 2 Governor Oil Control Switch 188GA Spurious Operation	3.00E-05
819	OK288GBSWT	192	Keowee 2 Control Switch 188GB Spurious Operation	1.92E-04
820	OK288GCSWT	108	Keowee 2 Control Switch 188GC Spurious Operation	1.08E-04
821	OK299K1RYD	1	Keowee 2 Relay 99K1 Fails To Operate On Demand	1.90E-04
822	OK299K1RYT	24	Keowee Unit 2 Relay 99K1 Spurious Operation	2.40E-05
823	OK299K2RYD	1	Relay 99K2 Fails To Operate On Demand	1.90E-04
824	OK2AG04RVT	24	Safety Relief Valve 2AG-4 Spurious Operation	4.08E-05
825	OK2AG05VVT	24	Manual Valve 2AG-5 Transfers Position	1.92E-06
826	OK2AG01TKF	24	Air Receiver Tank 2AGTK-1 Fails	1.80E-05
827	OK2OG2CTRM	3.42E-3	OG Pump 2C Train In Maintenance Or Testing	3.42E-03
828	OK2PRUNCOM	1.92E-07	Common Cause Failure of Unit 2 OG Pumps to Run	1.92E-07
829	OK2PSTRCOM	6.51E-04	Common Cause Failure of Unit 2 OG Pumps to Start	6.51E-04
830	OK2XA1DCLT	30	Low Voltage Circuit Breaker 2XA-1D Transfers Position	5.70E-05
831	OK2XA2ECLT	30	Low Voltage Circuit Breaker 2XA-2E Transfers Position	5.70E-05
832	OK2XA4DCLT	30	Low Voltage Circuit Breaker 2XA-4D Transfers Position	5.70E-05
833	OMOD	0	Startup Bus UV Sensing Mod Is In Service	0.00E+00
834	PAC1TC4C4T	24	4160 Vac Breaker 1TC-4 Transfers Open	4.56E-05
835	PACTC01C4T	24	4160 Vac Breaker 1TC-1 Transfers Open	4.56E-05
836	PACTC14C4T	24	4160 Vac Breaker 1TC-14 Transfers Open	4.56E-05

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Keowee PRA Basic Event Data
Generic

	NAME	FACTOR	DESC	PROB
837	PACX1TCBHF	24	4160 Vac Switchgear 1TC Fails	1.27E-05
838	PK0SUMPCOM	1.19E-05	Common Cause Failure Of Turbine Sump Pump System	1.19E-05
839	PK163SALST	30	Unit 1 AC Turbine Sump Pump Float Switch 63SA Fails	6.90E-05
840	PK163SBLST	15	Unit 1 DC Turbine Sump Pump Float Switch 63SB Transfers	3.45E-05
841	PK1ACDCCOM	2.96E-04	Common Cause Failure of Unit 1 Turbine Sump Pump System	2.96E-04
842	PK1DA5CCDT	24	125 Vdc Circuit Breaker 1DA-5C Transfers Position	4.56E-05
843	PK1PACKDEX	3.1E-5	Turbine No. 1 Packing Fails	3.10E-05
844	PK1TS01VVT	30	Manual Valve 1TS-1 Transfers Position	2.40E-06
845	PK1TS02CVT	30	Check Valve 1TS-2 Fails to Open or Transfers Closed	1.35E-05
846	PK1TS03VVT	108	Manual Valve 1TS-3 Transfers Position	8.64E-06
847	PK1TS04CVT	15	Check Valve 1TS-4 Fails to Open or Transfers Closed	6.75E-06
848	PK1TSACGPR	30	AC Sump Pump 1TSPU-1 Fails To Start Or Run	7.20E-04
849	PK1TSDCGPR	15	DC Sump Pump 1TSPU-2 Fails To Start Or Run	3.60E-04
850	PK1TSDCLHE	3.2E-3	Latent Human Error Fails Turbine No. 1 DC Sump Pump	3.20E-03
851	PK1TSDCTRM	6.85E-4	Turbine No. 1 DC Pump Train In Maintenance Or Testing	6.85E-04
852	PK1XA2CCLT	30	600 V Circuit Breaker 1XA-2C Transfers Position	5.70E-05
853	PK263SALST	30	Unit 2 AC Turbine Sump Pump Float Switch 63SA Fails	6.90E-05
854	PK263SBLST	15	Unit 2 DC Turbine Sump Pump Float Switch 63SB Transfers	3.45E-05
855	PK2ACDCCOM	2.96E-04	Common Cause Failure of Unit 2 Turbine Sump Pump System	2.96E-04
856	PK2DA1CCDT	24	125 Vdc Circuit Breaker 2DA-1C Transfers Position	4.56E-05
857	PK2PACKDEX	3.1E-5	Turbine No. 2 Packing Fails	3.10E-05
858	PK2TS01VVT	30	Manual Valve 2TS-1 Transfers Position	2.40E-06
859	PK2TS02CVT	30	Check Valve 2TS-2 Fails to Open or Transfers Closed	1.35E-05
860	PK2TS03VVT	108	Manual Valve 2TS-3 Transfers Position	8.64E-06
861	PK2TS04CVT	15	Check Valve 2TS-4 Fails to Open or Transfers Closed	6.75E-06
862	PK2TSACGPR	30	AC Sump Pump 2TSPU-1 Fails To Start Or Run	7.20E-04
863	PK2TSDCGPR	15	DC Sump Pump 2TSPU-2 Fails To Start Or Run	3.60E-04
864	PK2TSDCLHE	3.2E-3	Latent Human Error Fails Turbine No. 2 DC Sump Pump	3.20E-03
865	PK2TSDCTRM	6.85E-4	Turbine No. 2 DC Pump Train In Maintenance Or Testing	6.85E-04
866	PK2XA2CCLT	30	Low Voltage Circuit Breaker 2XA-2C Transfers Position	5.70E-05
867	PMFB1	5.60E-03	Loss of Power on Main Feeder Bus 1	5.60E-03
868	PMFB2	5.60E-03	Loss of Power on Main Feeder Bus 2	5.60E-03
869	S127E1VRYT	9	Unit 1 Startup Bus Undervoltage Relay 27E1 Fails	6.48E-03
870	S127EUVRYT	9	Unit 1 Startup Bus Undervoltage Relay 27E Fails	6.48E-03
871	S127EX1RYD	1	Unit 1 Startup Bus UV Aux Relay 27EX1 Fails to Pick Up	1.90E-04
872	S127EXVRYD	1	Unit 1 Startup Bus UV Aux Relay 27EX Fails to Pick Up	1.90E-04
873	S227E1VRYT	9	Unit 2 Startup Bus Undervoltage Relay 27E1 Fails	6.48E-03
874	S227EUVRYT	9	Unit 2 Startup Bus Undervoltage Relay 27E Fails	6.48E-03

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Keowee PRA Basic Event Data
Generic

	NAME	FACTOR	DESC		PROB
875	S227EX1RYD	1	Unit 2 Startup Bus UV Aux Relay 27EX1 Fails to Pick Up		1.90E-04
876	S227EXVRYD	1	Unit 2 Startup Bus UV Aux Relay 27EX Fails to Pick Up		1.90E-04
877	S27XSC1RYD	1	Channel 1 Swyd Isolated Rly, 27X/SC1, Fails to Pick Up		1.90E-04
878	S27XSC2RYD	1	Channel 2 Swyd Isolated Rly, 27X/SC2, Fails to Pick Up		1.90E-04
879	S27XTD1RYD	1	Channel 1 Swyd Isolated Time Delay Rly, 27XTD/SC1, Fails		1.90E-04
880	S27XTD2RYD	1	Channel 2 Swyd Isolated Time Delay Rly, 27XTD/SC2, Fails		1.90E-04
881	S327E1VRYT	9	Unit 3 Startup Bus Undervoltage Trip Relay 27E1 Fails		6.48E-03
882	S327EUVRYT	9	Unit 3 Startup Bus Undervoltage Trip Relay 27E Fails		6.48E-03
883	S327EX1RYD	1	Unit 3 Standby Bus UV Aux Relay 27EX1 Fails to Pick Up		1.90E-04
884	S327EXVRYD	1	Unit 3 Startup Bus UV Trip Aux Relay 27EX Fails to Pick Up		1.90E-04
885	SB18UX1RYT	24	Auxiliary Relay 8UX-1 Spurious Operation		2.40E-05
886	SB28UX2RYT	24	Auxiliary Relay 8UX-2 Spurious Operation		2.40E-05
887	SB38UX3RYT	24	Auxiliary Relay 8UX-3 Spurious Operation		2.40E-05
888	SB48UX4RYT	24	Auxiliary Relay 8UX-4 Spurious Operation		2.40E-05
889	SDCAIDDDIF	24	Control Power From DYA To PCB 9 Isolating Diode Fails		2.93E-05
890	SDCDA12CDT	24	125 Vdc Swyd Control Power Pnlbd DYA Bkr 12 Xfrs Open		4.56E-05
891	SDCDA15CDT	24	125 Vdc Swyd Control Power Pnlbd DYA Bkr 15 Xfrs Open		4.56E-05
892	SDCDA17CDT	24	125 Vdc Swyd Control Power Pnlbd DYA Bkr 17 Xfrs Open		4.56E-05
893	SDCDB01CDT	24	125 Vdc Swyd Control Power Pnlbd DYB Bkr 1 Xfrs Open		4.56E-05
894	SDCDB13CDT	24	125 Vdc Swyd Control Power Pnlbd DYB Bkr 13 Xfrs Open		4.56E-05
895	SDCDC12CDT	24	125 Vdc Swyd Control Power Pnlbd DYC Bkr 12 Xfrs Open		4.56E-05
896	SDCDE12CDT	24	125 Vdc Swyd Control Power Pnlbd DYE Bkr 12 Xfrs Open		4.56E-05
897	SDCDE15CDT	24	125 Vdc Swyd Control Power Pnlbd DYE Bkr 15 Xfrs Open		4.56E-05
898	SDCDE17CDT	24	125 Vdc Swyd Control Power Pnlbd DYE Bkr 17 Xfrs Open		4.56E-05
899	SDCDF01CDT	24	125 Vdc Swyd Control Power Pnlbd DYF Bkr 1 Xfrs Open		4.56E-05
900	SDCDF13CDT	24	125 Vdc Swyd Control Power Pnlbd DYF Bkr 13 Xfrs Open		4.56E-05
901	SDCDG16CDT	24	125 Vdc Swyd Control Power Pnlbd DYG Bkr 16 Xfrs Open		4.56E-05
902	SDCDYA8CDT	24	125 Vdc Swyd Control Power Pnlbd DYA Bkr 8 Xfrs Open	OEE-38	4.56E-05
903	SDCDYA9CDT	24	125 Vdc Swyd Control Power Pnlbd DYA Bkr 9 Xfrs Open		4.56E-05
904	SDCDYB4CDT	24	125 Vdc Swyd Control Power Pnlbd DYB Bkr 4 Xfrs Open		4.56E-05
905	SDCDYB6CDT	24	125 Vdc Swyd Control Power Pnlbd DYB Bkr 6 Xfrs Open		4.56E-05
906	SDCDYB8CDT	24	125 Vdc Swyd Control Power Pnlbd DYB Bkr 8 Xfrs Open		4.56E-05
907	SDCDYE8CDT	24	125 Vdc Swyd Control Power Pnlbd DYE Bkr 8 Xfrs Open		4.56E-05
908	SDCDYE9CDT	24	125 Vdc Swyd Control Power Pnlbd DYE Bkr 9 Xfrs Open		4.56E-05
909	SDCDYF4CDT	24	125 Vdc Swyd Control Power Pnlbd DYF Bkr 4 Xfrs Open		4.56E-05
910	SDCDYF6CDT	24	125 Vdc Swyd Control Power Pnlbd DYF Bkr 6 Xfrs Open		4.56E-05
911	SDCDYF8CDT	24	125 Vdc Swyd Control Power Pnlbd DYF Bkr 8 Xfrs Open		4.56E-05
912	SDCEIDDDIF	24	Control Power From DYE To PCB-9 Isolating Diode Fails		2.93E-05

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Keowee PRA Basic Event Data
Generic

	NAME	FACTOR	DESC	PROB
913	SK194GBRYT	24	Keowee Unit 1 94GB Auxiliary Relay Spurious Operation	2.40E-05
914	SK294GBRYT	24	Keowee Unit 2 94GB Auxiliary Relay Spurious Operation	2.40E-05
915	SKXFMR1THF	24	Keowee Transformer 1 Fails	4.80E-05
916	SPC14KVBHF	24	13.8 kV Bus Faulted	1.27E-05
917	SPC51TNRYT	24	Main Step Up Transformer Neutral Ground Relay 51TN Spurious Operation	2.40E-05
918	SPC62ABRYT	24	ACB Back-up Trip Timer 62AB Spurious Operation	2.40E-05
919	SPC631XRYT	24	Auxiliary Relay 63H1X Spurious Operation	2.40E-05
920	SPC871XRYT	72	Transformer 1X Differential Relay 87T-1X Spurious Operation	7.20E-05
921	SPC872XRYT	72	Transformer 2X Differential Relay 87T-2X Spurious Operation	7.20E-05
922	SPC87T1RYT	72	Main Step Up Transformer Differential Relay 87T Spurious Operation	7.20E-05
923	SPC94TKRYT	24	Auxiliary Relay 94T/K Spurious Operation	2.40E-05
924	SPCB008CHO	1	SWYD PCB-8 Fails to Trip	4.00E-05
925	SPCB009CHC	1	SWYD PCB-9 Fails To Close On Demand	7.20E-05
926	SPCB009CHO	1	SWYD PCB-9 Fails To Trip	4.00E-05
927	SPCB012CHO	1	SWYD PCB-12 Fails To Trip	4.00E-05
928	SPCB015CHO	1	SWYD PCB-15 Fails To Trip On Demand	4.00E-05
929	SPCB017CHO	1	SWYD PCB-17 Fails To Trip On Demand	4.00E-05
930	SPCB021CHO	1	SWYD PCB-21 Fails To Trip On Demand	4.00E-05
931	SPCB024CHO	1	SWYD PCB-24 Fails To Trip On Demand	4.00E-05
932	SPCB026CHO	1	SWYD PCB-26 Fails To Trip On Demand	4.00E-05
933	SPCB028CHO	1	SWYD PCB-28 Fails To Trip On Demand	4.00E-05
934	SPCB033CHO	1	SWYD PCB-33 Fails To Open On Demand	4.00E-05
935	SPCD87LRYT	24	Line Differential Relay 87L Spurious Operation	2.40E-05
936	SPCGLASSWT	24	Break Glass Switch Spurious Operation	2.40E-05
937	SPCR86TRYT	24	Lock Out Relay 86T Spurious Operation	2.40E-05
938	SU127UVCOM	3.29E-04	Common Cause Failure of Unit 1 SU Bus Undervoltage Relays	3.29E-04
939	SU227UVCOM	3.29E-04	Common Cause Failure of Unit 2 SU Bus Undervoltage Relays	3.29E-04
940	SU327UVCOM	3.29E-04	Common Cause Failure of Unit 3 SU Bus Undervoltage Relays	3.29E-04
941	SXFRCT3THF	24	Transformer CT3 Faulted	4.80E-05
942	SXFRCT3THM	1.74E-04	Transformer CT3 Is In Maintenance	1.74E-04
943	SXFRCT4LHE	6.40E-05	Latent Human Error on CT4 Maintenance	6.40E-05
944	SXFRCT4THM	9.13E-04	Transformer CT4 Is In Maintenance	9.13E-04
945	SY30R94RYT	24	PCB 30 Relay 94 Spuriously Picks Up	2.40E-05
946	SY51TN2RYT	24	230kV Neutral Ground Relay Spuriously Picks Up	2.40E-05
947	SY51TN4RYT	24	4.16kV Neutral Ground Relay Spuriously Picks Up	2.40E-05
948	SY51TN6RYT	24	6.9kV Neutral Ground Relay 51TN Spuriously Picks Up	2.40E-05
949	SY62X1FRYT	24	Breaker Failure Relay 62X1 Spuriously Picks Up	2.40E-05
950	SY62X2FRYT	24	Breaker Failure Relay 62X2 Spuriously Picks Up	2.40E-05

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Keowee PRA Basic Event Data
Generic

	NAME	FACTOR	DESC	PROB
951	SY62XXFRYT	24	Breaker Failure Relay 62X Spuriously Picks Up	2.40E-05
952	SY86BUIRYT	24	CT3 6.9kV Start Up Bus Lockout Relay Spuriously Picks Up	2.40E-05
953	SY86CT3RYT	24	Transformer CT3 Lockout Relay Spuriously Picks Up	2.40E-05
954	SY86YA9RYT	24	Yellow Bus Lockout Auxiliary Relay 86YA9 Spuriously Picks Up	2.40E-05
955	SY86YJ3RYT	24	Yellow Bus Lockout Auxiliary Relay 86YJ30 Spuriously Picks Up	2.40E-05
956	SY87BYXRYT	24	Yellow Bus X Phase Differential Relay 87BYX Spuriously Picks Up	2.40E-05
957	SY87BYYRYT	24	Yellow Bus Y Phase Differential Relay 87BYY Spuriously Picks Up	2.40E-05
958	SY87BYZRYT	24	Yellow Bus Z Phase Differential Relay 86BYZ Spuriously Picks Up	2.40E-05
959	SY87LXXRYT	24	Differential Auxiliary Relay 87LX Spuriously Picks Up	2.40E-05
960	SY94L1XRYT	24	Protective Relay 94L Spuriously Picks Up	2.40E-05
961	SYE1362RYT	24	E13 Bkr Failure Relay 62B Spuriously Picks Up	2.40E-05
962	SYE2362RYT	24	E23 Bkr Failure Relay 62B Spuriously Picks Up	2.40E-05
963	SYP2862RYT	24	PCB 28 Breaker Failure Relay 62B Spuriously Picks Up	2.40E-05
964	SYP3062RYT	24	PCB 30 Breaker Failure Relay 62B Spuriously Picks Up	2.40E-05
965	SYP86TXRYT	24	PCB 30 LOR 86TX Spuriously Picks Up	2.40E-05
966	SYPCB09CHT	24	Switchyard Power Circuit Breaker 9 Transfers Open	7.20E-06
967	SYPCB30CHT	24	Switchyard Power Circuit Breaker 30 Transfers Open	7.20E-06
968	SYPL86TRYT	24	PCB 30 LOR 86T Spuriously Picks Up	2.40E-05
969	SYPL87LRYT	24	Differential Relay 87L Spuriously Picks Up	2.40E-05
970	SYR86BYRYT	24	Yellow Bus Lockout Relay 86BY Spuriously Picks Up	2.40E-05
971	SYS63FPRYT	24	Fault Pressure Relay 63FP Spuriously Picks Up	2.40E-05
972	SYSX50BRYT	24	Transformer CT3 Fault Detector Relay 50B Spuriously Picks Up	2.40E-05
973	SYX87TBRYT	24	Differential Relay 87B Spuriously Picks Up	2.40E-05
974	SYXX87TRYT	24	Differential Relay 87T Spuriously Picks Up	2.40E-05
975	U5086EFRYT	24	Overcurrent Relay 50 Spuriously Actuates Lockout Rly 86EF	2.40E-05
976	U5186EFRYT	24	Time Delay Overcurrent Relay 51 Actuates Lockout Relay 86EF	2.40E-05
977	U51TNC4RYT	24	CT4 Neutral Ground Rly Actuates CT4 LOR 86T/CT4	2.40E-05
978	U62BSK1RYT	24	SK1 Breaker Failure Relay 62BXSK1 Spuriously Picks Up	2.40E-05
979	U62BSK2RYT	24	SK2 Breaker Failure Relay 62BXSK2 Spuriously Picks Up	2.40E-05
980	U86CT4XRYT	24	Auxiliary Lockout Relay 86CT4X Spuriously Picks Up	2.40E-05
981	U86TCT4RYT	24	CT4 Lockout Relay 86T/CT4 Spuriously Picks Up	2.40E-05
982	U87TCT4RYT	24	Spurious Op of CT4 Differential Rly 87T Actuates LOR 86EF	2.40E-05
983	UACXCT4THF	24	Transformer CT4 Failed	4.80E-05
984	UXX86EFRYT	24	Lockout Relay 86EF Spuriously Picks Up	2.40E-05
985	WK00RUNCOM	1.96E-05	Common Cause Failure of Keowee Governors to Run	1.96E-05
986	WK1GVCDDEX	3.5E-05	Keowee Unit 1 Gov. Fails to Position Wicket Gates During a Cold Start	3.50E-05
987	WK1GVCDLHE	2.6E-4	Latent Human Error Fails Keowee 1 Governor During Cold Start	2.60E-04
988	WK1GVHTDEX	3.5E-04	Keowee Unit 1 Gov. Fails to Position Wicket Gates During Hot Start	3.50E-04

Table D-2

Keowee PRA Basic Event Data
Generic

	NAME	FACTOR	DESC	PROB
989	WK1GVRNDEX	5.6E-4	Keowee Unit 1 Gov. Fails to Position Wicket Gates With Unit Running	5.60E-04
990	WK1SPD1DEX	1.0	Potentially Damaging Overspeed Condition Occures At Load Rejection	1.00E+00
991	WK1SPD2DEX	5.6E-05	Keowee Unit 1 Governor Failure Creates Overspeed Condition	5.60E-05
992	WK1TBCDDEX	3.5E-5	Keowee Unit 1 Turbine Fails During a Cold Start	3.50E-05
993	WK1TBHTDEX	3.5E-4	Keowee Unit 1 Turbine Fails During a Hot Start	3.50E-04
994	WK1TBRNDEX	5.6e-4	Keowee Unit 1 Turbine Fails With the Unit Running	5.60E-04
995	WK2GVCDDEX	3.5E-05	Keowee Unit 2 Gov. Fails to Position Wicket Gates During Cold Start	3.50E-05
996	WK2GVCDLHE	2.6E-4	Latent Human Error Fails Keowee 2 Governor During Cold Start	2.60E-04
997	WK2GVHTDEX	3.5E-04	Keowee Unit 2 Gov. Fails to Position Wicket Gates During Hot Start	3.50E-04
998	WK2GVRNDEX	5.6E-4	Keowee Unit 2 Gov. Fails to Position Wicket Gates With Unit Running	5.60E-04
999	WK2SPD2DEX	5.6E-05	Keowee Unit 2 Governor Failure Creates Overspeed Condition	5.60E-05
1000	WK2TBCDDEX	3.5E-5	Keowee Unit 2 Turbine Fails During a Cold Start	3.50E-05
1001	WK2TBHTDEX	3.5E-4	Keowee Unit 2 Turbine Fails During a Hot Start	3.50E-04
1002	WK2TBRNDEX	5.6E-4	Keowee Unit 2 Turbine Fails With the Unit Running	5.60E-04
1003	WKCSTRTCOM	4.66E-04	Common Cause Failure of Keowee Governors to Cold Start	4.66E-04
1004	WKHSTRTCOM	3.50E-6	Common Cause Failure of Keowee Governors to Hot Start	3.50E-06
1005	XA0SWGRCOM	2.83E-06	Common Cause Failure Of Transformers 1X, 2X, And CX	2.83E-06
1006	XA1A2BTCDT	24	600 Vac Breaker 1XA-2BT Transfers Position K-704	4.56E-05
1007	XA1BKRSCOM	3.84E-04	CCF of 1X Aux Power Breakers ACB-5 & -7	3.84E-04
1008	XA1TR1XTLF	24	Keowee Transformer 1X Fails	4.80E-05
1009	XA1X2AXCLT	24	600 Vac Bkr 2X-2D Transfers Position	4.56E-05
1010	XA1X2CCCLT	24	600 Vac Breaker 1X-2C Transfers Position	4.56E-05
1011	XA1XA1ACLT	24	600 Vac Bkr 2XA-4A Transfers Position	4.56E-05
1012	XA1XAALBLM	2.74E-03	MCC 1XA Is Connected to Its Alternate Source of Power	2.74E-03
1013	XA1XAMCBLF	24	600 Vac MCC 1XA Fault	8.64E-06
1014	XA1XCXXTHM	4.57E-4	4160/600 Vac Transformer CX Is in Maintenance	4.57E-04
1015	XA1XCXXTLF	24	4160/600 Vac Transformer CX Fails	4.80E-05
1016	XA1XXXXBLF	24	600 Vac Switchgear 1X Fault	8.64E-06
1017	XA2A2BTCDT	24	600 Vac Breaker 2XA-2BT Transfers Position	4.56E-05
1018	XA2BKRSCOM	3.84E-04	CCF of Aux Power Breakers ACB-6 & -8	3.84E-04
1019	XA2TR2XTLF	24	Keowee Transformer 2X Fails	4.80E-05
1020	XA2X2BXCLT	24	600 Vac Breaker 2X-2B Transfers Position	4.56E-05
1021	XA2X2DXCLT	24	600 Vac Bkr 1X-2A Transfers Position	4.56E-05
1022	XA2X4AXCLT	24	600 Vac Bkr 1XA-1A Transfers Position	4.56E-05
1023	XA2XAALBLM	2.74E-03	MCC 2XA Is Connected to Its Alternate Power Source	2.74E-03
1024	XA2XAMCBLF	24	600 Vac MCC-2XA Fault	8.64E-06
1025	XA2XXXXBLF	24	600 Vac Switchgear 2X Fault	8.64E-06
1026	XA56BKRCOM	3.84E-04	Common Cause Failure Of ACB-5 And ACB-6 To Close	3.84E-04

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Keowee PRA Basic Event Data
Generic

	NAME	FACTOR	DESC		PROB
1027	XA78BKRCOM	3.84E-04	Common Cause Failure Of ACB-7 And ACB-8 To Close		3.84E-04
1028	XD0BATTCOM	3.42E-05	Common Cause Failure Of Keowee I&C Power Batteries		3.42E-05
1029	XD0CHRGCOM	1.32E-05	Common Cause Failure Of Keowee Battery Chargers		1.32E-05
1030	XD104CCCDT	24	Breaker 1DA-4CC Transfers Open		4.56E-05
1031	XD104CRCDT	6	Breaker 1DA-4CR Transfers Open		1.14E-05
1032	XD1BK1ACDT	24	Battery No. 1 Breaker 1A Transfers Position	run time dependent	4.56E-05
1033	XD1CKC1BCF	24	Battery Charger KC1 Fails		2.64E-04
1034	XD1DA1CCDT	24	125 Vdc Breaker 1C (from charger KC1) Transfers Position		4.56E-05
1035	XD1DA3BCDT	24	125 Vdc Breaker 1DA-3BR Transfers Open		4.56E-05
1036	XD1DA4ACDT	24	DC Circuit Breaker 1DA-4AR Transfers Position		4.56E-05
1037	XD1DALTBYM	5.48E-03	Normal Power To Dist. Center 1DA Is In Test or Maintenance		5.48E-03
1038	XD1DARXBDF	24	DC Distribution Center 1DA Faulted during Run		1.46E-05
1039	XD1KB1XDHE	1	Keowee Standby Battery Charger SBC Not Lined Up in 1 Hour		1.00E+00
1040	XD1KB1XRHE	1	Keowee Standby Battery Charger SBC Not Lined Up in 1 Hour		1.00E+00
1041	XD1KBATBYF	1	Keowee Battery No. 1 Fails During Discharge		1.18E-03
1042	XD1TIE1CDT	24	Keowee 125V dc Dist Cntr 1DA Tie Breaker 1 Transfers Position		4.56E-05
1043	XD202CCCDT	6	Breaker 2DA-2CC Transfers Open		1.14E-05
1044	XD204CCCDT	24	Breaker 2DA-4CC Transfers Open	K-704	4.56E-05
1045	XD2BK1ACDT	24	Battery No. 2 Breaker 1A Transfers Position		4.56E-05
1046	XD2CKC2BCF	24	Battery Charger KC2 Fails		2.64E-04
1047	XD2DA2ACDT	24	DC Circuit Breaker 2DA-2AR Transfers Position		4.56E-05
1048	XD2DA3BCDT	24	125 Vdc Circuit Breaker 2DA-3BR Transfers Position		4.56E-05
1049	XD2DA5CCDT	24	125 Vdc Breaker 2DA-5C (from Charger KC2) Transfers Open		4.56E-05
1050	XD2DALTBYM	5.48E-03	Normal Power To Dist Cntr 2DA Is In Test or Maintenance		5.48E-03
1051	XD2DARXBDF	24	DC Distribution Center 2DA Faulted During Run		1.46E-05
1052	XD2KB2XDHE	1	Keowee Standby Battery Charger SBC Not Lined Up in 1 Hour		1.00E+00
1053	XD2KB2XRHE	1	Keowee Standby Battery Charger SBC Not Lined Up in 1 Hour		1.00E+00
1054	XD2KBATBYF	1	Keowee Battery No. 2 Fails during Discharge		1.18E-03
1055	XD2TIE2CDT	24	Keowee 125V dc Dist Cntr 2DA Tie Breaker 2 Transfers Position		4.56E-05
1056	Y0STARTCOM	4.18E-05	Common Cause Failure Of Emergency Start Signal		4.18E-05
1057	YK114X3SSD	1	Keowee 1 Speed Switch 14-3 Fails to Open at 65 rpm	KEE-111	2.50E-04
1058	YK13SUISWT	24	KHU#1 Startup Inhibit Sw 3SUI Xfrs to Inhibit	KEE-111, -113	2.40E-05
1059	YK14AMRRYT	24	Keowee 1 Master Relay 4A Spuriously Drops Out		2.40E-05
1060	YK14BMRRYT	24	Keowee 1 Master Relay 4B Spuriously Drops Out		2.40E-05
1061	YK163BHLST	24	Keowee 1 Gen Thrst Brng Oil Lvl Hi Sw 63BL/H Sprsly Clsd	KEE-111, -113-3	5.52E-05
1062	YK163BHRYT	24	Keowee 1 Gen Thrst Brng Oil Lvl Hi Rly 63BL/HX Sprsly Picks Up	KEE-111,-113-	2.40E-05
1063	YK163BLLST	24	Keowee 1 Gen Thrst Brng Oil Lvl Lo Sw 63BL/L Spuriously Operates	KEE-111,-113-	5.52E-05
1064	YK163BLRYT	24	Keowee 1 Gen Thrst Brng Oil Lvl Lo Rly 63BL/LXTD Sprsly Pcks Up	KEE-111, -113-	2.40E-05

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Keowee PRA Basic Event Data
Generic

	NAME	FACTOR	DESC	PROB
1065	YK163TBLST	24	Keowee 1 Turb Guide Brng Lo Lvl Sensor Sw Spuriously Closes KEE-113-4	5.52E-05
1066	YK163TBRYT	24	Keowee 1 Turb Gd Brng Oil Lvl Lo Rly 63TB/1X Sprsly Picks Up KEE-111,-113-4	2.40E-05
1067	YK186N1DEX	9.89E-03	Keowee 1 Normal Lockout Actuates	9.89E-03
1068	YK199SDRYD	1	Keowee 1 Shutdown Solenoid 99SD Fails To Pick Up	1.90E-04
1069	YK199SDRYT	24	Keowee 1 Shutdown Solenoid Spuriously Drops Out	2.40E-05
1070	YK199SNRYD	1	K1 Emergency Load Solenoid 99SN Fails To Pick Up/Drop Out	1.90E-04
1071	YK199SNRYT	24	Emergency Load Solenoid 99SN Spuriously Drops Out	2.40E-05
1072	YK199SXRYD	1	Keowee 1 Shutdown Solenoid Aux Relay 99SX Fails to Pick Up KEE-111	1.90E-04
1073	YK199SXRYT	24	Shutdown Auxiliary Relay 99SX Spuriously Drops Out	2.40E-05
1074	YK1D4CRFUF	6	Fuse 1DA-4CR Fails	3.78E-06
1075	YK1ES1ARYD	1	Keowee 1 Emergency Start Aux Relay 1ESRX/1A Fails To Pick Up OEE-120	1.90E-04
1076	YK1ES1BRYD	1	Keowee 1 Emergency Start Aux Relay 1ESRX/1B Fails To Pick Up OEE-120-1	1.90E-04
1077	YK1ES2ARYD	1	Keowee 1 Emergency Start Aux Relay 1ESRX/2A Fails To Pick Up OEE-120	1.90E-04
1078	YK1ES2BRYD	1	Keowee 1 Emergency Start Aux Relay 1ESRX/2B Fails To Pick Up OEE-120-1	1.90E-04
1079	YK1MR4ARYD	1	Keowee 1 Start Master Relay 4A Fails To Pick Up KEE-113	1.90E-04
1080	YK1MR4BRYD	1	Keowee 1 Start Master Relay 4B Fails To Pick Up KEE-113	1.90E-04
1081	YK1SS12SST	24	Keowee 1 Overspeed Switch 12 Spuriously Picks Up KEE-111	2.40E-05
1082	YK1SS13SSD	1	Keowee 1 Speed Switch 13 Fails to Close at 122 rpm KEE-111	2.50E-04
1083	YK214X3SSD	1	KHU#2 Speed Switch 14-3 Fails to Open at 65 rpm KEE-211	2.50E-04
1084	YK23SUISWT	24	KHU#2 Startup Inhbt Sw 3SUI Sprsly Xfrs to Inhibit KEE-211, -213	2.40E-05
1085	YK24AMRRYT	24	Keowee 2 Master Relay 4A Spuriously Drops Out	2.40E-05
1086	YK24BMRRYT	24	Keowee 2 Master Relay 4B Spuriously Drops Out	2.40E-05
1087	YK263BHLST	24	Keowee 2 Gen Thrst Brng Oil Lvl Hi Sw 63BL/H Sprsly Clsd	5.52E-05
1088	YK263BHRYT	24	Keowee 2 Gen Thrst Brng Oil Lvl Hi Rly 63BL/HX Sprsly Picks Up KEE-211	2.40E-05
1089	YK263BLLST	24	Keowee 2 Gen Thrst Brng Oil Lvl Lo Sw 63BL/L Sprsly Opn	5.52E-05
1090	YK263BLRYT	24	Keowee 2 Gen Thrst Brng Oil Lvl Lo Rly 63BL/LXTD Sprsly Pcks Up KEE-211	2.40E-05
1091	YK263TBLST	24	Keowee 2 Turb Guide Brng Lo Lvl Sensor Sw Sprsly Closes	5.52E-05
1092	YK263TBRYT	24	Keowee 2 Turb Gd Brng Oil Lvl Lo Rly 63TB/1X Sprsly Picks Up KEE-211	2.40E-05
1093	YK286N2DEX	7.41E-03	Keowee Unit 2 Normal Lockout Activates	7.41E-03
1094	YK299SDRYD	1	Keowee 2 Shutdown Solenoid 99SD Fails To Pick Up	1.90E-04
1095	YK299SDRYT	24	Keowee 2 Shutdown Solenoid Spuriously Drops Out	2.40E-05
1096	YK299SNRYD	1	Keowee 2 Emergency Load Solenoid 99SN Fails To Operate	1.90E-04
1097	YK299SNRYT	24	Emergency Load Solenoid 99SN Spuriously Drops Out	2.40E-05
1098	YK299SXRYD	1	Keowee 2 Shutdown Solenoid Aux Relay 99SX Fails to Pick Up KEE-211	1.90E-04
1099	YK299SXRYT	24	Shutdown Auxiliary Relay 99SX Spuriously Drops Out s	2.40E-05
1100	YK2D2CCFUF	6	Fuse 2DA-2CC Fails	3.78E-06
1101	YK2ES1ARYD	1	Keowee 2 Emergency Start Aux Relay 2ESRX/1A Fails To Pick Up OEE-120	1.90E-04
1102	YK2ES1BRYD	1	Keowee 2 Emergency Start Aux Relay 2ESRX/1B Fails to Pick Up OEE-120-1	1.90E-04

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Keowee PRA Basic Event Data
Generic

	NAME	FACTOR	DESC	PROB
1103	YK2ES2ARYD	1	Keowee 2 Emergency Start Aux Relay 2ESRX/2A Fails to Pick Up OEE-120	1.90E-04
1104	YK2ES2BRYD	1	Keowee 2 Emergency Start Aux Relay 2ESRX/2B Fails to Pick Up OEE-120-1	1.90E-04
1105	YK2MR4ARYD	1	Keowee 2 Start Master Relay 4A Fails To Pick Up KEE-213	1.90E-04
1106	YK2MR4BRYD	1	Keowee 2 Start Master Relay 4B Fails to Pick Up KEE-213	1.90E-04
1107	YK2SS12SST	24	Keowee 2 Overspeed Switch 12 Spuriously Picks Up KEE-211	2.40E-05
1108	YK2SS13SSD	1	Keowee 2 Speed Switch 13 Fails to Close at 122 rpm KEE-211	2.50E-04
1109	YKEMSRTCHE	0	Operator Incorrectly Resets Keowee Emergency Start Signals	0.00E+00
1110	YO1DIA2CDT	30	DC Circuit Breaker 1DIA-2 Transfers Position	5.70E-05
1111	YO1DIB2CDT	30	DC Circuit Breaker 1DIB-2 Transfers Position	5.70E-05
1112	YO1MFBMA	1	ONS1 MFB Monitor Channel A Keowee Start Signal Fails	1.00E+00
1113	YO1MFBMB	1	ONS1 MFB Monitor Channel B Keowee Start Signal Fails	1.00E+00
1114	YO1OPSARHE	1	Operator fails to operate Keowee start switch S1A	1.00E+00
1115	YO1OPSBRHE	1	Operator fails to operate Keowee start switch S1B	1.00E+00
1116	YO1S1AFSWC	1	Control Switch S1A Fails To Close On Demand	1.00E-05
1117	YO1S1BFSWC	1	Control Switch S1B Fails To Close On Demand	1.00E-05
1118	YO1XXKARYD	1	ONS1 Ch A Keowee Emergency Start Relay KA Fails to Pick Up OEE-120	1.90E-04
1119	YO1XXKBRYD	1	Oconee Unit 1 Chan. B Keowee Emergency Start Relay Fails OEE-120-1	1.90E-04
1120	YO2CR2ARYD	1	ONS2 Ch A Keowee Emergency Start Relay CR2A Fails to Pick Up OEE-220	1.90E-04
1121	YO2CR2BRYD	1	ONS2 Keowee Emergency Start Relay CR2B Fails to Pick Up OEE-220-1	1.90E-04
1122	YO2DIA2CDT	30	Breaker 2DIA-2 Transfers Position	5.70E-05
1123	YO2DIB2CDT	30	Breaker 2DIB-2 Transfers Position	5.70E-05
1124	YO2MFBMA	1	ONS2 MFB Monitor CH A Keowee Start Sig Fails	1.00E+00
1125	YO2MFBMB	1	ONS2 MFB Monitor Ch B Keowee Start Sig Fails	1.00E+00
1126	YO2SSWARHE	1	Operator Fails to Operate Keowee Start Switch 2SSW'A'	1.00E+00
1127	YO2SSWASWC	1	Control Switch 2SSW'A' Fails To Close On Demand	1.00E-05
1128	YO2SSWBRHE	1	Operator Fails to Operate Keowee Start Switch 2SSW'B'	1.00E+00
1129	YO2SSWBSWC	1	Control Switch 2SSW'B' Fails To Close On Demand	1.00E-05
1130	YO3CR3ARYD	1	ONS3 Ch A Keowee Emergency Start Relay CR3A Fails To Pick Up OEE-320	1.90E-04
1131	YO3CR3BRYD	1	ONS3 Keowee Emer Start Relay CR3B Fails to Pick Up OEE-320-1	1.90E-04
1132	YO3DIA2CDT	30	Breaker 3DIA-2 Transfers Open OEE-320, O-2705	5.70E-05
1133	YO3DIB2CDT	30	Breaker 3DIB-2 Transfers Open OEE-320-1, O-2705	5.70E-05
1134	YO3MFBMA	3.96E-03	ONS3 MFB Monitor Ch A Keowee Start Sig Fails	3.96E-03
1135	YO3MFBMB	3.96E-03	ONS3 MFB Monitor Ch B Keowee Start Sig Fails	3.96E-03
1136	YO3OPFARHE	1	Operator fails to operate Keowee Start Switch 3S1A	1.00E+00
1137	YO3OPFBRHE	1	Operator Fails to Operate Keowee Start Switch 3S1B	1.00E+00
1138	YO3S1AFSWC	1	Control Switch S1A Fails To Close On Demand	1.00E-05
1139	YO3S1BFSWC	1	Control Switch S1B Fails To Close On Demand	1.00E-05
1140	YO3SSWARHE	1	Operator fails to operate Keowee Start Switch 3SSW'A'	1.00E+00

Table D-2

Keowee PRA Basic Event Data
Generic

	NAME	FACTOR	DESC	PROB
1141	YO3SSWASWC	1	Control Switch 3SSW'A' Fails To Close On Demand	1.00E-05
1142	YO3SSWBRHE	1	Operator Fails to Operate Keowee Start Switch 3SSW'B'	1.00E+00
1143	YO3SSWBSWC	1	Control Switch 3SSW'B' Fails To Close On Demand	1.00E-05

Table D-3

Basic Event Data for the Oconee-Keowee AC Power/Core Damage Models

	NAME	FACTOR	DESC	PROB
1	AA1271PR6D	1	Transformer 1X Undervoltage Relay 27/1X Fails To Pick Up	2.49E-04
2	AA1271XR6T	30	Transformer 1X Undervoltage Relay 27/1X Spuriously De-energizes	1.09E-05
3	AA127C1R6T	24	Transformer CX Undervoltage Relay 27/CX1 Spuriously De-energizes	8.71E-06
4	AA127CPR6D	1	Transformer CX Undervoltage Relay 27/CX1 Fails To Pick Up	2.49E-04
5	AA127R1RYT	24	Auxiliary Relay 27X/CX1 Spurious Operation	8.64E-06
6	AA127X1RYD	1	Auxiliary Relay 27X/1X Fails To Operate On Demand	3.30E-05
7	AA127X1RYT	384	Auxiliary Relay 27X/1X Spurious Operation	1.38E-04
8	AA127X2R6D	1	Transformer CX Undervoltage Relay 27/CX1 Fails To Drop Out	2.49E-04
9	AA127XCRYD	1	Auxiliary Relay 27/CX1 Fails To Operate On Demand	3.30E-05
10	AA186CXRYT	24	Transformer CX Differential Lock Out Relay 86CX Spurious Operation	8.64E-06
11	AA186S1RYT	24	Switchgear 1X Lockout Relay 86S/1X Spurious Operation	8.64E-06
12	AA187CXRYT	24	Transformer CX Differential Relay 87CX Spurious Operation	8.64E-06
13	AA2272PR6D	1	Transformer 2X Undervoltage Relay 27/2X Fails To Pick Up	2.49E-04
14	AA2272XR6D	1	Transformer 2X Undervoltage Relay 27/2X Fails To Drop Out	2.49E-04
15	AA2272XR6T	24	Transformer 2X Undervoltage Relay 27/2X Spuriously De-energizes	8.71E-06
16	AA227C2R6T	30	Transformer CX Undervoltage Relay 27/CX2 Spuriously De-energizes	1.09E-05
17	AA227C2RYD	1	Auxiliary Relay 27X/CX2 Fails To Operate On Demand	3.30E-05
18	AA227CPR6D	1	Transformer CX Undervoltage Relay 27/CX2 Fails To Pick Up	2.49E-04
19	AA227R2RYT	384	Auxiliary Relay 27X/CX2 Spurious Operation	1.38E-04
20	AA227T2R6D	1	Transformer #1 Undervoltage Relay (27T/2X) Fails To Drop Out	2.49E-04
21	AA227X2RYD	1	Auxiliary Relay 27X/2X Fails To Operate On Demand	3.30E-05
22	AA227X2RYT	24	Auxiliary Relay 27X/2X Spurious Operation	8.64E-06
23	AA286S2RYT	24	Switchgear 2X Lockout Relay 86S/2X Spurious Operation	8.64E-06
24	AB004ECCDT	30	DC Circuit Breaker 1DA-4EC Transfers Position	2.25E-06
25	AB0086TRYD	1	Keowee Main Tx Lock Out Relay 86T Fails To Operate On Demand	3.30E-05
26	AB0624CRYD	1	Time Delay Relay 62-4c Fails To Operate On Demand	3.30E-05
27	AB086E1RYD	1	Emergency Lock Out Relay 86E-1 Fails To Operate On Demand	3.30E-05
28	AB086TGRYD	1	General Keowee Main Tx Lock Out Sensing Relay Fails To Operate	3.30E-05
29	AB0SWGRCOM	6.69E-04	Common Cause Failure Of All Keowee Auxiliary Power Breakers	6.69E-04
30	AB0SWGRRHE	5.0E-01	Recovery of Keowee Aux Power Breakers by Manual Control	5.00E-01
31	AB152TCSVO	1	Air Circuit Breaker 1 Trip Coil Fails To Operate	2.90E-05
32	AB1ACCUDEX	3.51E-05	Air Circuit Breaker 1 Accumulator Air Pressure Low	3.51E-05
33	AB1FALTDEX	0.0	Fault Occurs at ACB-1 When The BReaker Trips	0.00E+00
34	AB1MECHDEX	1.51E-4	Air Circuit Breaker 1 Fails To Open Due To Mechanical Failure	1.51E-04
35	AB1OPENLHE	2.60E-4	Air Circuit Breaker 1 Fails To Open Due To A Latent Human Error	2.60E-04
36	AB1PS02PST	12	Air Circuit Breaker 1 Accumulator Pressure Switch PS2 Fails Low	5.16E-06
37	AB1PSWTPST	24	Air Circuit Breaker 1 Accumulator Pressure Switch Fails Low	1.03E-05
38	AB1R52ZR6D	1	Air Circuit Breaker 1 Relay 52Z Fails To Operate	2.49E-04
39	AB21521SWT	30	Control Switch 152-2 Spurious Operation	2.10E-06

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Basic Event Data for the Oconee-Keowee AC Power/Core Damage Models

	NAME	FACTOR	DESC	PROB
40	AB22BV1RYT	24	Backup Undervoltage Relay 2BV1 Spurious Operation	8.64E-06
41	AB23BKRCOM	1.12e-04	Common Cause Failure Of Air Circuit Breakers 2 And 3 To Close	1.12E-04
42	AB24BKRCOM	1.12E-04	Common Cause Failure Of Air Circuit Breakers 2 And 4 To Close	1.12E-04
43	AB251G2RYT	24	Air Circuit Breaker 2 Overcurrent Ground Relay 51G-2 Spurious Operation	8.64E-06
44	AB252CCSVO	1	Air Circuit Breaker 2 Close Coil Fails To Operate	2.90E-05
45	AB252TCSVO	1	Air Circuit Breaker 2 Trip Coil Fails To Operate	2.90E-05
46	AB252TCSVT	36	Air Circuit Breaker 2 Trip Coil Spurious Operation	2.90E-05
47	AB252Y2R6D	1	Air Circuit Breaker 2 Relay 52Y Failed To Drop Out Following Last Demand	1.40E-05
48	AB252Y2R6T	12	Air Circuit Breaker 2 Y-relay Spurious Operation	2.49E-04
49	AB2ACCUDEX	3.51E-05	Air Circuit Breaker 2 Accumulator Air Pressure Low	4.36E-06
50	AB2CLOSLHE	2.60E-4	Air Circuit Breaker 2 Fails To Close Due To A Latent Human Error	3.51E-05
51	AB2KEYISWT	12	Air Circuit Breaker 2 Key Interlock Switch Transfers Open	2.60E-04
52	AB2MCH2DEX	3.02E-4	Air Circuit Breaker 2 Fails To Close Due To Mechanical Failure	8.40E-07
53	AB2MECHDEX	1.51E-4	Air Circuit Breaker 2 Fails To Open Due To Mechanical Failure	3.02E-04
54	AB2OPENLHE	2.60E-4	Air Circuit Breaker 2 Fails To Open Due To A Latent Human Error	1.51E-04
55	AB2PS02PST	12	Air Circuit Breaker 2 Accumulator Pressure Switch PS2 Fails Low	2.60E-04
56	AB2PSWTPST	24	Air Circuit Breaker 2 Accumulator Pressure Switch Fails Low	5.16E-06
57	AB2PUSHPBT	36	Trip Pushbutton On ACB2 Spurious Operation	1.03E-05
58	AB2R462RYT	24	Air Circuit Breaker 2 Negative Sequence Relay 46-2 Spurious Operation	8.64E-06
59	AB2R52XR6D	1	Air Circuit Breaker 2 Relay 52X Fails To Operate	8.64E-06
60	AB2R52ZR6D	1	Air Circuit Breaker 2 Relay 52Z Fails To Operate	2.49E-04
61	AB2R52ZR6T	36	Air Circuit Breaker 2 Relay 52Z Spurious Operation	2.49E-04
62	AB31523SWT	24	Control Switch 152-3 Spurious Operation	1.31E-05
63	AB352CCSVO	1	Air Circuit Breaker 3 Close Coil Fails To Operate	1.68E-06
64	AB352TCSVO	1	Air Circuit Breaker 3 Trip Coil Fails To Operate	2.90E-05
65	AB352TCSVT	24	Air Circuit Breaker 3 Trip Coil Spurious Operation	2.90E-05
66	AB352Y2R6D	1	Air Circuit Breaker 3 Relay 52Y Failed To Drop Out Following Last Demand	9.36E-06
67	AB352Y2R6T	360	Air Circuit Breaker 3 Y-relay Spurious Operation	2.49E-04
68	AB3ACCUDEX	3.51E-05	Air Circuit Breaker 3 Accumulator Air Pressure Low	1.31E-04
69	AB3CLOSLHE	2.60e-04	Air Circuit Breaker 3 Fails To Close Due To Latent Human Error	3.51E-05
70	AB3MCH2DEX	3.02E-04	Air Circuit Breaker 3 Fails To Close Due To Mechanical Failure	2.60E-04
71	AB3MECHDEX	1.51E-04	Air Circuit Breaker 3 Fails To Open Due To Mechanical Failure	3.02E-04
72	AB3PS02PST	372	Air Circuit Breaker 3 Accumulator Pressure Switch PS2 Fails Low	1.51E-04
73	AB3PSWTPST	24	Air Circuit Breaker 3 Accumulator Pressure Switch Fails Low	1.60E-04
74	AB3PUSHPBT	24	Trip Pushbutton On ACB3 Spurious Operation	1.03E-05
75	AB3R52XR6D	1	Air Circuit Breaker 3 Relay 52X Fails To Operate	5.76E-06
76	AB3R52ZR6D	1	Air Circuit Breaker 3 Relay 52Z Fails To Operate	2.49E-04
77	AB3R52ZR6T	24	Air Circuit Breaker 3 Relay 52Z Spurious Operation	2.49E-04
78	AB41523SWT	24	Control Switch 152-4 Spurious Operation	8.71E-06
				1.68E-06

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Basic Event Data for the Oconee-Keowee AC Power/Core Damage Models

	NAME	FACTOR	DESC	PROB
79	AB452CCSVO	1	Air Circuit Breaker 4 Close Coil Fails To Operate	2.90E-05
80	AB452TCSVT	24	Air Circuit Breaker 4 Trip Coil Spurious Operation	9.36E-06
81	AB452Y2R6D	1	Air Circuit Breaker 4 Relay 52Y Failed To Drop Out Following Last Demand	2.49E-04
82	AB452Y2R6T	372	Air Circuit Breaker 4 Y-relay Spurious Operation	1.35E-04
83	AB4ACCUDEX	3.51E-05	Air Circuit Breaker 4 Accumulator Air Pressure Low	3.51E-05
84	AB4CLOSLHE	2.60E-4	Air Circuit Breaker 4 Fails To Close Due To A Latent Human Error	2.60E-04
85	AB4CLSESWC	1	Air Circuit Breaker 4 Close Switch Fails To Close On Demand	1.00E-05
86	AB4KEYISWT	372	Air Circuit Breaker 4 Key Interlock Switch Transfers Open	2.60E-05
87	AB4LORESWT	372	Air Circuit Breaker 4 Local/Remote Switch Contact Transfers Position	2.60E-05
88	AB4MCH2DEX	3.02E-04	Air Circuit Breaker 4 Fails To Close Due To Mechanical Failure	3.02E-04
89	AB4PS02PST	372	Air Circuit Breaker 4 Accumulator Pressure Switch PS2 Indicates Low Pressure	1.60E-04
90	AB4PSWTPST	12	Air Circuit Breaker 4 Accumulator Pressure Switch Indicates Low Air Pressure	5.16E-06
91	AB4PUSHPBT	24	Trip Pushbutton On ACB-4 Spurious Operation	5.76E-06
92	AB4R52XR6D	1	Air Circuit Breaker 4 Relay 52X Fails To Operate	2.49E-04
93	AB4R52ZR6T	24	Air Circuit Breaker 4 Relay 52Z Spurious Operation	8.71E-06
94	AB510A1FUF	6	One Or More Control Power Fuses For X, Y And CC Fail	2.16E-05
95	AB51431LHE	3.20E-4	Manual/Auto Control Switch 143/1 Left In Manual	3.20E-04
96	AB51431RYT	360	Auxiliary Relay 143X/1 Spuriously Energizes	1.30E-04
97	AB51431SWT	360	Manual/Auto Control Switch 143/1 Spuriously Transfers Into Manual	2.52E-05
98	AB552CCRYD	1	Air Circuit Breaker 5 Close Coil CC Fails On Demand	3.30E-05
99	AB552TCRYT	384	Air Circuit Breaker 5 Trip Coil 52TC Spurious Operation	1.38E-04
100	AB552Y2RYT	360	Air Circuit Breaker 5 Y-relay Spurious Operation	1.30E-04
101	AB583S5RYD	1	Time Delay Relay 83S5 Fails To Pick Up	3.30E-05
102	AB5CLOSLHE	2.60E-4	Air Circuit Breaker 5 Fails To Close Due To A Latent Human Error	2.60E-04
103	AB5KEYISWT	360	Air Circuit Breaker 5 Key Interlock Switch Transfers Open	2.52E-05
104	AB5MCH2DEX	7.04E-03	Air Circuit Breaker 5 Fails To Close Due To Mechanical Failure	7.04E-03
105	AB5PUSHPBT	384	Trip Pushbutton On ACB5 Spurious Operation	9.22E-05
106	AB5R52XRYD	1	Air Circuit Breaker 5 Relay 52X Fails To Operate	3.30E-05
107	AB5R52YRYD	1	Air Circuit Breaker 5 Relay 52Y Failed To Drop Out At Last Demand	3.30E-05
108	AB610A1FUF	6	One Or More Control Power Fuses For X, Y And CC Fail	2.16E-05
109	AB610AFFUF	6	One Or More Control Power Fuses For Relay 27X/2X Fail	2.16E-05
110	AB61432LHE	3.20E-4	Manual/Auto Control Switch 143/2 Left In Manual	3.20E-04
111	AB61432SWT	360	Manual/Auto Control Switch 143/2 Spuriously Transfers Into Manual	2.52E-05
112	AB652CCRYD	1	Air Circuit Breaker 6 Close Coil CC Fails On Demand	3.30E-05
113	AB652TCRYD	1	Air Circuit Breaker 6 Trip Coil 52TC Fails Fails To Operate	3.30E-05
114	AB652TCRYT	24	Air Circuit Breaker 6 Trip Coil 52TC Spurious Operation	8.64E-06
115	AB652Y2RYT	360	Air Circuit Breaker 6 Y-relay Spurious Operation	1.30E-04
116	AB6CLOSLHE	2.60E-4	Air Circuit Breaker 6 Fails To Close Due To A Latent Human Error	2.60E-04
117	AB6KEYISWT	360	Air Circuit Breaker 6 Key Interlock Switch Transfers Open	2.52E-05

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Basic Event Data for the Oconee-Keowee AC Power/Core Damage Models

	NAME	FACTOR	DESC	PROB
118	AB6MCH2DEX	7.04E-03	Air Circuit Breaker 6 Fails To Close Due To Mechanical Failure	7.04E-03
119	AB6MECHDEX	8.01E-04	Air Circuit Breaker 6 Fails To Open Due To Mechanical Failure	8.01E-04
120	AB6OPENLHE	3.20E-3	Air Circuit Breaker 6 Fails To Open Due To A Latent Human Error	3.20E-03
121	AB6PUSHPBT	24	Trip Pushbutton On ACB6 Spurious Operation	5.76E-06
122	AB6R52XRYD	1	Air Circuit Breaker 6 Relay 52X Fails To Operate	3.30E-05
123	AB6R52YRYD	1	Air Circuit Breaker 6 Relay 52Y Failed To Drop Out At Last Demand	3.30E-05
124	AB710A1FUF	6	One Or More Control Power Fuses For X, Y And CC Fail	2.16E-05
125	AB710AFFUF	6	One Or More Air Circuit Breaker 7 Control Power Fuses Fail	2.16E-05
126	AB752CCRYD	1	Air Circuit Breaker 7 Close Coil CC Fails On Demand	3.30E-05
127	AB752TCRYD	1	Air Circuit Breaker 7 Trip Coil TC Fails On Demand	3.30E-05
128	AB752TCRYT	24	Air Circuit Breaker 7 Trip Coil 52TC Spurious Operation	8.64E-06
129	AB752Y2RYT	360	Air Circuit Breaker 7 Y-relay Spurious Operation	1.30E-04
130	AB7CLOSLHE	2.60E-4	Air Circuit Breaker 7 Fails To Close Due To A Latent Human Error	2.60E-04
131	AB7KEYISWT	360	Air Circuit Breaker 7 Key Interlock Switch Transfers Open	2.52E-05
132	AB7MCH2DEX	7.04E-03	Air Circuit Breaker 7 Fails To Close Due To Mechanical Failure	7.04E-03
133	AB7MECHDEX	8.01E-04	Air Circuit Breaker 7 Fails To Open Due To Mechanical Failure	8.01E-04
134	AB7OPENLHE	3.20E-3	Air Circuit Breaker 7 Fails To Open Due To A Latent Human Error	3.20E-03
135	AB7PUSHPBT	30	Trip Pushbutton On ACB7 Spurious Operation	7.20E-06
136	AB7R52XRYD	1	Air Circuit Breaker 7 Relay 52X Fails To Operate	3.30E-05
137	AB7R52YRYD	1	Air Circuit Breaker 7 Relay 52Y Failed To Drop Out At Last Demand	3.30E-05
138	AB810A1FUF	6	One Or More Control Power Fuses For X, Y And CC Fail	2.16E-05
139	AB81432RYT	360	Auxiliary Relay 143X/2 Spuriously Energizes	1.30E-04
140	AB852CCRYD	1	Air Circuit Breaker 8 Close Coil CC Fails On Demand	3.30E-05
141	AB852TCRYT	384	Air Circuit Breaker 8 Trip Coil 52TC Spurious Operation	1.38E-04
142	AB852Y2RYT	360	Air Circuit Breaker 8 Y-relay Spurious Operation	1.30E-04
143	AB86E1ARYD	1	Emergency Lock Out Aux. Relay 86E-1a Fails To Operate On Demand	3.30E-05
144	AB86E1GRYD	1	Keowee Unit 1 Emergency Lock Out Sensing Relay Fails To Operate	3.30E-05
145	AB883S8RYD	1	Time Delay Relay 83S8 Fails To Pick Up	3.30E-05
146	AB8KEYISWT	360	Air Circuit Breaker 8 Key Interlock Switch Transfers Open	2.52E-05
147	AB8MCH2DEX	7.04E-03	Air Circuit Breaker 8 Fails To Close Due To Mechanical Failure	7.04E-03
148	AB8PUSHPBT	384	Trip Pushbutton On ACB8 Spurious Operation	9.22E-05
149	AB8R52XRYD	1	Air Circuit Breaker 8 Relay 52X Fails To Operate	3.30E-05
150	AB8R52YRYD	1	Air Circuit Breaker 8 Relay 52Y Failed To Drop Out At Last Demand	3.30E-05
151	ABEOPRCDHE	9.0E-03	Operators Fail To Close Air Circuit Breaker 2	9.00E-03
152	ABEOPRCRHE	1	Operators Fail To Close Air Circuit Breaker 2	1.00E+00
153	ABPOPRCRHE	9.0E-03	Operators Fail To Close Air Circuit Breaker 4	9.00E-03
154	ACB4MOD	1	NSM-ON-52966 Is Not In Service	1.00E+00
155	ACBAIRPDEX	2.00E-03	ACB Air Supply Fails Causing Low Pressure In All ACB Accumulators	2.00E-03
156	ACBTRIPCHE	0.0	Operators Trip Generator Output ACBs	0.00E+00

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Basic Event Data for the Oconee-Keowee AC Power/Core Damage Models

	NAME	FACTOR	DESC	PROB
157	ACBXFERCOM	1.28E-06	Common Cause Failure That Results In ACBs 2 & 3 Transfering Open	1.28E-06
158	AD1B4ALCDT	30	Breaker 4AL In 125 V dc Distribution Center 1DA Transfers Open	2.25E-06
159	AD1C3CCCDT	24	Breaker 3CC In 125V dc Distribution Center 1DA Transfers Position	1.80E-06
160	AD1C3CLCDT	24	Breaker 3CL In 125V dc Distribution Center 1DA Transfers Position	1.80E-06
161	AD1SCLRCDT	12	Breaker 3CL In 125V dc Distribution Center 1DA Transfers Position (Rec)	9.00E-07
162	AD2B2ALCDT	30	Breaker 2AL In 125V dc Distribution Center 2DA Transfers Open	2.25E-06
163	AD2B3CCCDT	12	Breaker 3CC In 125V dc Distribution Center 2DA Transfers Position	9.00E-07
164	AD2C3CCCDT	24	Breaker 3CC In 125V dc Distribution Center 2DA Transfers Position	1.80E-06
165	AD2C3CLCDT	24	Breaker 3CL In 125V dc Distribution Center 2DA Transfers Position	1.80E-06
166	AIRTOP	0.000E+00	Loss Of Instrument Air System Pressure	0.00E+00
167	AK1141XRYD	1	Auxiliary Relay 14GOV/1X Fails To Pick-up	3.30E-05
168	AK114GVDEX	1.00e-04	KU1 Magnetic Speed Switch System Fails	1.00E-04
169	AK121TDRYD	1	Time Delay Relay 2-1TD Fails To Pick-up	3.30E-05
170	AK152TDRYD	1	Time Delay Relay 52-1TD Fails To Pick-up	3.30E-05
171	AK152TDRYT	4380	Time Delay Relay 52-1TD Spurious Operation	1.58E-03
172	AK152XGRYD	1	Relay 52XG/1 Fails To Pick Up When The Unit Is Started	3.30E-05
173	AK152XGRYT	2	Relay 52XG/1 Spuriously Drops Out While The Unit Is Running	7.20E-07
174	AK1AX34RYT	6	Relay 52AX/34 Spuriously Drops-out	2.16E-06
175	AK1GV1XRYD	1	Relay 14GOV/1X Fails To Pick-up	3.30E-05
176	AK1OFRQCOM	3.30E-06	KU1 CCF Of 2/3 Overfrequency Relays To Reset When Frequency Drops	3.30E-06
177	AK1X34XRYT	6	Relay 52AX/34X Spuriously Drops-out	2.16E-06
178	AK212OSSST	36	Turbine Overspeed Switch Indicates Overspeed	1.51E-04
179	AK2142XRYD	1	Auxiliary Relay 14GOV/2X Fails To Pick-up	3.30E-05
180	AK214GVDEX	1.00e-4	KU2 Magnetic Speed Switch System Fails	1.00E-04
181	AK222TDRYD	1	Time Delay Relay 2-2TD Fails To Pick-up	3.30E-05
182	AK252TDRYD	1	Time Delay Relay 52-2TD Fails To Operate	3.30E-05
183	AK252TDRYT	4380	Time Delay Relay 52-2TD Spurious Operation	1.58E-03
184	AK252W0RYD	1	KU2 Relay 52W Fails To Pick-up	3.30E-05
185	AK252XGRYD	1	Auxiliary Relay 52XG/2 Fails To Pick-up	3.30E-05
186	AK2GATEDEX	2.11E-5	Wicket Gate Limit Switch Indicates Gate Position Is Below No-load Setting	2.11E-05
187	AK2GV2XRYD	1	Relay 14GOV/2X Fails To Pick-up	3.30E-05
188	AK2OFRQCOM	3.30E-06	KU2 CCF Of 2/3 Overfrequency Relays To Reset When Frequency Drops	3.30E-06
189	BK1088XRYD	1	Keowee 1 Turbine Guide Bearing Oil Relay 88X Fails to Drop Out	3.30E-05
190	BK1088XRYT	24	Keowee 1 Turbine Guide Bearing Oil Relay 88X Spurious Operation	8.64E-06
191	BK114/2SSD	1	Keowee 1 Speed Switch 14/2 Fails On Demand	1.80E-05
192	BK114/2SST	24	Keowee 1 Speed Switch 14/2 Spuriously Transfers Closed	1.01E-04
193	BK114DXRYD	1	Keowee 1 Rotation Sensing Aux. Relay 14DX Fails to Energize	3.30E-05
194	BK114DXRYT	24	Keowee 1 Rotation Sensing Aux. Relay 14DX Spuriously Drops Out	8.64E-06
195	BK114T2RYD	1	Keowee 1 Rotation Sensing Timer 14T2 Fails to De-energize	3.30E-05

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Basic Event Data for the Oconee-Keowee AC Power/Core Damage Models

	NAME	FACTOR	DESC	PROB
196	BK114T2RYT	24	Keowee 1 Rotation Sensing Timer 14T2 Spurious Operation	8.64E-06
197	BK1188ASWT	24	Keowee 1 AC GBO Pump Control Switch S188A Spurious Operation	1.68E-06
198	BK1188DSWT	108	Unit 1 DC GBO Pump Control Switch S188D Spurious Operation	7.56E-06
199	BK1631XRYD	1	Keowee 1 Relay 63TA/1X Fails to De-energize	3.30E-05
200	BK1631XRYT	24	Keowee 1 GBO Level Relay 63TA/1X Spurious Operation	8.64E-06
201	BK1632XRYD	1	Keowee 1 Brng. Low Oil Level Aux. Relay 63TA/2X Fails To Operate On Demand	3.30E-05
202	BK1632XRYT	24	Keowee 1 Turb. Brng. Low Oil Level Aux. Rly 63TA/2X Spurious Operation	8.64E-06
203	BK163TALSD	1	Turbine No. 1 Bearing Oil Level Switch 63TA Fails on Demand	1.60E-03
204	BK163TALST	24	Turbine No. 1 Bearing Oil Level Switch 63TA Spurious Operation	7.44E-06
205	BK188AXRYD	1	Unit 1 AC Bearing Oil Pump Aux. Relay 88AX Fails to Drop Out	3.30E-05
206	BK188AXRYT	24	Unit 1 AC Bearing Oil Pump Aux. Relay 88AX Fails to Remain De-energized	8.64E-06
207	BK1DA5BCDT	24	DC Circuit Breaker 1DA-5B Transfers Position	1.80E-06
208	BK1GBDCGPR	12	Unit 1 DC Turbine GBO Pump Fails To Run	1.68E-04
209	BK1GBDCGPS	1	Unit 1 DC Turbine GBO Pump Fails To Start On Demand	9.70E-05
210	BK1GBDCLHE	3.2E-3	Latent Human Error Fails Unit 1 DC Guide Bearing Oil Pump Discharge Path	3.20E-03
211	BK1GBO1CVC	1	Check Valve 1GBO-1 Fails to Close on Demand	3.50E-04
212	BK1GBO1CVO	1	Check Valve 1GBO-1 Fails To Open On Demand	2.30E-06
213	BK1GBO1CVT	24	Check Valve 1GBO-1 Transfers Closed	3.12E-06
214	BK1GBO1FTC	24	Filter 1GBOFL-1 Becomes Clogged	4.32E-05
215	BK1GBO2VVT	24	Manual Valve 1GBO-2 Transfers Position	4.08E-07
216	BK1GBO3CVO	1	Check Valve 1GBO-3 Fails To Open On Demand	2.30E-06
217	BK1GBO3CVT	12	Check Valve 1GBO-3 Transfers Closed	1.56E-06
218	BK1GBO4VVT	108	Manual Valve 1GBO-4 Transfers Position	1.84E-06
219	BK1GBO5VVT	24	Manual Valve 1GBO-5 Transfers Position	4.08E-07
220	BK1GBO6VVT	24	Manual Valve 1GBO-6 Transfers Position	4.08E-07
221	BK1GBO8VVT	24	Manual Valve 1GBO-8 Transfers Position	4.08E-07
222	BK1GBO9VVT	24	Manual Valve 1GBO-9 Transfers Position	4.08E-07
223	BK1GOACGPR	24	Unit 1 AC Turbine GBO Pump Fails To Run	3.36E-04
224	BK1GOACGPS	1	Unit 1 AC Turbine GBO Pump Fails To Start	9.70E-05
225	BK1GODCTRM	1.14E-3	Unit 1 DC Turbine GBO Pump Train In Maintenance	1.14E-03
226	BK1XA1CCLT	24	600 V Circuit Breaker 1XA-1C Transfers Position	2.18E-05
227	BK2088XRYD	1	Keowee 2 Turbine Guide Bearing Oil Relay 88X Fails to Drop Out	3.30E-05
228	BK2088XRYT	24	Keowee 2 Turbine Guide Bearing Oil Relay 88X Spurious Operation	8.64E-06
229	BK214/2SSD	1	Keowee 2 Speed Switch 14/2 Fails On Demand	1.80E-05
230	BK214/2SST	24	Keowee 2 Speed Switch 14/2 Spuriously Transfers Closed	1.01E-04
231	BK214DXRYD	1	Keowee 2 Rotation Sensing Aux. Relay 14DX Fails to Energize	3.30E-05
232	BK214DXRYT	24	Keowee 2 Rotation Sensing Aux. Relay 14DX Spurious Operation	8.64E-06
233	BK214T2RYD	1	Keowee 2 Rotation Sensing Timer 14T2 Fails to De-energize	3.30E-05
234	BK214T2RYT	24	Keowee Rotation Sensing Timer 14T2 Fails to Remain De-energized	8.64E-06

Table D-3

Basic Event Data for the Oconee-Keowee AC Power/Core Damage Models

	NAME	FACTOR	DESC		PROB
235	BK2188ASWT	24	Unit 2 AC GBO Pump Control Switch S188A Spurious Operation		1.68E-06
236	BK2188DSWT	108	Unit 2 DC GBO Pump Control Switch S188D Spurious Operation		7.56E-06
237	BK2631XRYD	1	Keowee 2 Relay 63TA/1X Fails to De-energize		3.30E-05
238	BK2631XRYT	24	Keowee 2 GBO Level Relay 63TA/1X Spurious Operation		8.64E-06
239	BK2632XRYD	1	Keowee 2 Brng. Low Oil Level Aux. Relay 63TA/2X Fails To Operate On Demand		3.30E-05
240	BK2632XRYT	24	Keowee 2 Turb. Brng. Low Oil Level Aux. Relay 63TA/2X Spurious Operation		8.64E-06
241	BK263TALSD	1	Turbine No. 2 Bearing Oil Level Switch 63TA Fails on Demand		1.60E-03
242	BK263TALST	24	Turbine No. 2 Bearing Oil Level Switch 63TA Spurious Operation		7.44E-06
243	BK288AXRYD	1	Unit 2 AC Bearing Oil Pump Aux. Relay 88AX Fails to Drop Out		3.30E-05
244	BK288AXRYT	24	Unit 2 AC Bearing Oil Pump Aux. Relay 88AX Fails to Remain De-energized		8.64E-06
245	BK2DA1BCDT	24	DC Circuit Breaker 2DA-1B Transfers Position		1.80E-06
246	BK2GBDCGPR	12	Unit 2 DC Turbine GBO Pump Fails To Run		1.68E-04
247	BK2GBDCGPS	1	Unit 2 DC Turbine GBO Pump Fails To Start On Demand		9.70E-05
248	BK2GBDCLHE	3.2E-3	Latent Human Error Fails Unit 2 DC Guide Bearing Oil Pump Discharge Path		3.20E-03
249	BK2GBO1CVC	1	Check Valve 2GBO-1 Fails to Close on Demand		3.50E-04
250	BK2GBO1CVO	1	Check Valve 2GBO-1 Fails To Open On Demand		2.30E-06
251	BK2GBO1CVT	24	Check Valve 2GBO-1 Transfers Closed		3.12E-06
252	BK2GBO1FTC	24	Filter 2GBOFL-1 Becomes Clogged		4.32E-05
253	BK2GBO2VVT	24	Manual Valve 2GBO-2 Transfers Position		4.08E-07
254	BK2GBO3CVO	1	Check Valve 2GBO-3 Fails To Open On Demand		2.30E-06
255	BK2GBO3CVT	12	Check Valve 2GBO-3 Transfers Closed		1.56E-06
256	BK2GBO4VVT	108	Manual Valve 2GBO-4 Transfers Position		1.84E-06
257	BK2GBO5VVT	24	Manual Valve 2GBO-5 Transfers Position		4.08E-07
258	BK2GBO6VVT	24	Manual Valve 2GBO-6 Transfers Position		4.08E-07
259	BK2GBO8VVT	24	Manual Valve 2GBO-8 Transfers Position		4.08E-07
260	BK2GBO9VVT	24	Manual Valve 2GBO-9 Transfers Position		4.08E-07
261	BK2GOACGPR	24	Unit 2 AC Turbine GBO Pump Fails To Run		3.36E-04
262	BK2GOACGPS	1	Unit 2 AC Turbine GBO Pump Fails To Start		9.70E-05
263	BK2GODCTRM	1.14E-3	Unit 2 DC Turbine GBO Pump Train In Maintenance		1.14E-03
264	BK2XA1CCLT	24	600 V Circuit Breaker 2XA-1C Transfers Position		2.18E-05
265	BKGBOILCOM	1.94E-06	Common Cause Failure Of Turbine Guide Bearing Oil System		1.94E-06
266	D1DIAXXDEX	6.50E-06	Loss Of Power On 125 V dc Panelboard 1DIA	OEE-120, O-705	6.50E-06
267	D1DIBXXDEX	6.50E-06	Loss Of Power On 125 V dc Panelboard 1DIB	OEE-120-1, O-705	6.50E-06
268	D1DIC	0.000E+00	Loss Of Power On 125 V dc Panelboard 1DIC		0.00E+00
269	D1DID	0.000E+00	Loss Of Power On 125 V dc Panelboard 1DID		0.00E+00
270	D2DIAXXDEX	6.50E-06	Loss Of Power On 125 V dc Panelboard 2DIA		6.50E-06
271	D2DIBXXDEX	6.50E-06	Loss of Power on 125 V dc Panelboard 2DIB		6.50E-06
272	D3DIAXXDEX	6.50E-06	Loss Of Power On 125 V dc Panelboard 3DIA		6.50E-06
273	D3DIBXXDEX	6.50E-06	Loss Of Power On 125 Vdc Panelboard 3DIB		6.50E-06

Table D-3

Basic Event Data for the Oconee-Keowee AC Power/Core Damage Models

	NAME	FACTOR	DESC	PROB
274	DAC1F4ACLT	24	600 V ac MCC 1XS1 Breaker F4A Transfers Open	2.18E-05
275	DAC2F4DCLT	24	600 V ac MCC 1XS2 Breaker F4D Transfers Open	2.18E-05
276	DAC3F4ACLT	24	600 V ac MCC 3XS1 Breaker F4A Transfers Open (Charger 3CA)	2.18E-05
277	DAC3F4DCLT	24	600 V ac MCC 3XS2 Breaker F4D Transfers Open	2.18E-05
278	DDC11BXCDT	24	125 Vdc Battery Breaker SY-DC1-1B Transfers Open	1.80E-06
279	DDC11CXCDT	24	125 Vdc Breaker SY-DC1-1C Transfers Open	1.80E-06
280	DDC11DCCDT	24	125 Vdc Breaker SY-DC1-1DC Transfers Open	1.80E-06
281	DDC11DLCDT	24	125 Vdc Breaker SY-DC1-1DL Transfers Open	1.80E-06
282	DDC11DRCDT	24	125 Vdc Breaker SY-DC1-1DR Transfers Open	1.80E-06
283	DDC1A1BCDT	24	125 V dc Distribution Center 1DCA Breaker 1B Transfers Open	1.80E-06
284	DDC1A2ACDT	24	125 V dc Battery 1CA Breaker 2A Transfers Open	1.80E-06
285	DDC1A3CCDT	24	125 V dc Distribution Center 1DCA Breaker 3C Transfers Open	1.80E-06
286	DDC1A3DCDT	24	125 V dc Distribution Center 1DCA Breaker 3D Transfers Open	1.80E-06
287	DDC1ALXBYM	1.14E-02	Battery SY-1 Is In Test or Maintenance	1.14E-02
288	DDC1B1BCDT	24	125 V dc Distribution Center 1DCB Breaker 1B Transfers Open	1.80E-06
289	DDC1B2ACDT	24	125 V dc Battery 1CB Breaker 2A Transfers Open	1.80E-06
290	DDC1B3CCDT	24	125 V dc Distribution Center 1DCB Breaker 3C Transfers Open	1.80E-06
291	DDC1B3DCDT	24	125 V dc Distribution Center 1DCB Breaker 3D Transfers Open	1.80E-06
292	DDC1BATBYF	1	Battery SY-1 Fails During Discharge	9.30E-04
293	DDC1DCABDF	24	125 V dc Distribution Center 1DCA Fault	7.68E-06
294	DDC1DCABDM	1	125 V dc Distribution Center 1DCA Is In Maintenance	3.94E-07
295	DDC1DCABYF	1	125 V dc Battery 1CA Fails	9.30E-04
296	DDC1DCBBDF	24	125 V dc Distribution Center 1DCB Fault	7.68E-06
297	DDC1DCBBDM	1	125 V dc Distribution Center 1DCB Is In Maintenance	3.94E-07
298	DDC1DCBBYF	1	125 V dc Battery 1CB Fails	9.30E-04
299	DDC1FLTBDF	24	SY-DC1 Is Faulted	7.68E-06
300	DDC21BXCDT	24	125 Vdc Battery Breaker SY-DC2-1B Transfers Open	1.80E-06
301	DDC21CXCDT	24	125 Vdc Breaker SY-DC2-1C Transfers Open	1.80E-06
302	DDC21DCCDT	24	125 Vdc Breaker SY-DC2-1DC Transfers Open	1.80E-06
303	DDC21DLCDT	24	125 Vdc Breaker SY-DC2-1DL Transfers Open	1.80E-06
304	DDC21DRCDT	24	125 Vdc Breaker SY-DC2-1DR Transfers Open	1.80E-06
305	DDC2BATBYF	1	Battery SY-2 Fails During Discharge	9.30E-04
306	DDC2FLTBDF	24	SY-DC2 Is Faulted	7.68E-06
307	DDC3A1BCDT	24	125 V dc Distribution Center 3DCA Breaker 1B Transfers Open	1.80E-06
308	DDC3A2ACDT	24	125 V dc Battery 3CA Breaker 2A Transfers Open	1.80E-06
309	DDC3A3CCDT	24	125 V dc Distribution Center 3DCA Breaker 3C Transfers Open	1.80E-06
310	DDC3A3DCDT	24	125 V dc Distribution Center 3DCA Breaker 3D Transfers Open	1.80E-06
311	DDC3B1BCDT	24	125 V dc Distribution Center 3DCB Breaker 1B Transfers Open	1.80E-06
312	DDC3B2ACDT	24	125 V dc Battery 3CB Breaker 2A Transfers Open	1.80E-06

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Basic Event Data for the Oconee-Keowee AC Power/Core Damage Models

	NAME	FACTOR	DESC	PROB
313	DDC3B3CCDT	24	125 V dc Distribution Center 3DCB Breaker 3C Transfers Open	1.80E-06
314	DDC3B3DCDT	24	125 V dc Distribution Center 3DCB Breaker 3D Transfers Open	1.80E-06
315	DDC3DCABDF	24	125 V dc Distribution Center 3DCA Fault	7.68E-06
316	DDC3DCABDM	1	125 V dc Distribution Center 3DCA Is In Maintenance	3.94E-07
317	DDC3DCABYF	1	125 V dc Battery 3CA Fails	9.30E-04
318	DDC3DCBBDF	24	125 V dc Distribution Center 3DCB Fault	7.68E-06
319	DDC3DCBBDM	1	125 V dc Distribution Center 3DCB Is In Maintenance	3.94E-07
320	DDC3DCBBYF	1	125 V dc Battery 3CB Fails	9.30E-04
321	DDC3DIABDF	24	125 V dc Power Panelboard 3DIA Fault	7.68E-06
322	DDC3DIABDM	1	125 V dc Power Panelboard 3DIA Is In Maintenance	3.94E-07
323	DDC3DIBBDF	24	125 V dc Power Panelboard 3DIB Fault	7.68E-06
324	DDC3DIBBDM	1	125 V dc Power Panelboard 3DIB Is In Maintenance	3.94E-07
325	DDC3DICBDF	24	125 V dc Panelboard 3DIC Fault	7.68E-06
326	DDC3DICBDM	1	125 V dc Panelboard 3DIC Is In Maintenance	3.94E-07
327	DDC3DIDBDF	24	125 V dc Power Panelboard 3DID Fault	7.68E-06
328	DDC3DIDBDM	1	125 V dc Power Panelboard 3DID Is In Maintenance	3.94E-07
329	DDCADA1DIF	24	Isolating Transfer Diode 3ADA Circuit 1 Failure	9.12E-05
330	DDCADA2DIF	24	Isolating Transfer Diode 3ADA Circuit 2 Failure	9.12E-05
331	DDCADB1DIF	24	Isolating Transfer Diode 3ADB Circuit 1 Failure	9.12E-05
332	DDCADB2DIF	24	Isolating Transfer Diode 3ADB Circuit 2 Failure	9.12E-05
333	DDCADC1DIF	24	Isolating Transfer Diode 3ADC Circuit 1 Failure	9.12E-05
334	DDCADC2DIF	24	Isolating Transfer Diode 3ADC Circuit 2 Failure	9.12E-05
335	DDCADD1DIF	24	Isolating Transfer Diode 3ADD Circuit 1 Failure	9.12E-05
336	DDCADD2DIF	24	Isolating Transfer Diode 3ADD Circuit 2 Failure	9.12E-05
337	DDCBATTCOM	2.70E-05	Common Cause Failure of Switchyard Batteries	2.70E-05
338	DDCBATTDEX	1.0	AC Power Is Not Restored To Battery Chargers	1.00E+00
339	DDCDYAXBDF	24	125 Vdc Switchyard DC Panelboard DYA Is Faulted	7.68E-06
340	DDCDYBXBDF	24	125 Vdc Switchyard DC Panelboard DYB Is Faulted	7.68E-06
341	DDCDYCXBDF	24	125 Vdc Switchyard DC Panelboard DYC Is Faulted	7.68E-06
342	DDCDYEXBDF	24	125 Vdc Switchyard DC Panelboard DYE Is Faulted	7.68E-06
343	DDCDYFXBDF	24	125 Vdc Switchyard DC Panelboard DYF Is Faulted	7.68E-06
344	DDCDYGXBDF	24	125 Vdc Switchyard DC Panelboard DYG Is Faulted	7.68E-06
345	DDCUN31DIM	6.930E-04	Unit 1 Backup To Unit 3 Isolated At Diode For Ground Detect.	6.93E-04
346	DDCX1CABCF	24	Battery Charger 1CA Fails	6.96E-04
347	DDCX1CBBCF	24	Battery Charger 1CB Fails	6.96E-04
348	DDCX3CABCF	24	Battery Charger 3CA Fails	6.96E-04
349	DDCX3CBBCF	24	Battery Charger 3CB Fails	6.96E-04
350	E12EXCTCOM	5.31E-05	Units 1 & 2 Excit Fail Due To Common Cause Failure Of The Breakers	5.31E-05
351	ED11D3DCDT	84	Breaker 3D In 125V dc Distribution Center 1DA Transfers Open	6.30E-06

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Basic Event Data for the Oconee-Keowee AC Power/Core Damage Models

	NAME	FACTOR	DESC	PROB
352	ED13BR2CDT	24	Breaker 3BR In 125V dc Distribution Center 1DA Transfers Open	1.80E-06
353	ED22D3DCDT	24	Breaker 2D In 125V dc Distribution Center 2DA Transfers Open	1.80E-06
354	ED23BR2CDT	24	Breaker 3BR In 125V dc Distribution Center 2DA Transfers Open	1.80E-06
355	EK00RUNCOM	1.24E-4	Common Cause Failure Of Both Units Voltage Regulators To Run	1.24E-04
356	EK0BASERHE	1.9E-02	Recovery of Keowee Base Adjust LHE	1.90E-02
357	EK131TDRYD	1	Keowee Unit 1 Field Flashing Breaker Time Delay Relay 31/TD Fails To Operate	3.30E-05
358	EK131TDRYT	84	Keowee Unit 1 Field Flashing Breaker Time Delay Relay 31/TD Spurious Operation	3.02E-05
359	EK14152SWT	84	KHU1 Generator Supply Breaker Trip Control Switch 141-52/T Spurious Operation	5.88E-06
360	EK1415TSWT	24	Spurious Operation Of The KHU1 Supply Breaker Trip Switch	1.68E-06
361	EK1415YRYD	1	KHU1 Generator Supply Breaker Y-relay Failed To Drop-out At Last Operation	3.30E-05
362	EK1415YRYT	84	KHU1 Generator Supply Breaker Y-relay Spurious Operation	3.02E-05
363	EK141AXR6D	1	Keowee Unit 1 Relay 41/AX Fails To Pick-up And Latch	2.49E-04
364	EK141AXR6T	24	Keowee Unit 1 Relay 41/AX Spuriously Resets	8.71E-06
365	EK141CFRYD	1	Keowee Unit 1 Field Flashing Breaker Close Coil Fails To Operate On Demand	3.30E-05
366	EK186E2RYT	6	Keowee Unit 1 Lockout Auxiliary Relay 86EX-2 Is Picked-up	2.16E-06
367	EK186EXRYT	84	Keowee Unit 1 Gen Lockout Auxiliary Relay 86EX-1 Spurious Actuation	3.02E-05
368	EK186X2RYT	24	Keowee Unit 1 Generator Lockout Auxiliary Relay 86EX-1 Spurious Actuation	8.64E-06
369	EK188SVRYD	1	Keowee Unit 1 Fan Control Relay 88SV Fails On Demand	3.30E-05
370	EK188SVRYT	108	Keowee Unit 1 Fan Control Relay 88SV Prior To Or During The Run	3.89E-05
371	EK1901ARYT	84	Keowee Unit 1 Relay 90X1A Spurious Operation	3.02E-05
372	EK199SXRYD	1	Auxiliary Relay 99SX1 Fails To Pick-up	3.30E-05
373	EK199SYRYD	1	Keowee Unit 1 Relay 99SY Fails To Pick-up	3.30E-05
374	EK199SYRYT	24	Keowee Unit 1 Relay 99SY Drops Out	8.64E-06
375	EK1BAS2DEX	1.24E-3	KHU-1 Base Adjust Fails To Maintain Generator Output Within Acceptable Range	1.24E-03
376	EK1BASEDEX	6.17E-4	Keowee Unit 1 Base Adjust Fails To Establish Correct Unit Voltage	6.17E-04
377	EK1BASELHE	3.20E-3	Keowee Unit 1 Base Adjust Is Set Incorrectly	3.20E-03
378	EK1DIODDEX	2.88E-4	Keowee Unit 1 Exciter Fan Supply Diode Bridge Fails	2.88E-04
379	EK1EXC1TGF	84	Keowee Unit 1 Gen Excitation Transformer Is Failed	8.23E-05
380	EK1EXC2TGF	24	Keowee Unit 1 Generator Excitation Transformer Fails	2.35E-05
381	EK1F30AFUF	24	Keowee Unit 1 Excitation Cabinet Fan Fuses Fail	8.64E-05
382	EK1F31XRYD	1	Keowee Unit 1 Field Flashing Breaker Relay 31/X Fails To Pick-up On Demand	3.30E-05
383	EK1F41CRYD	1	Keowee Unit 1 Field Breaker Close Coil Fails To Operate On Demand	3.30E-05
384	EK1FAN1TLF	24	Keowee Unit 1 Generator Excitation Fan Power Transformer Fails	1.80E-05
385	EK1FLDCLHE	2.60E-4	Keowee Unit 1 Field Breaker Fails To Close Due To Latent Human Error	2.60E-04
386	EK1FLDMDEX	7.71E-5	Keowee Unit 1 Field Breaker Fails To Close Due To Mechanical Failure	7.71E-05
387	EK1FLSCLHE	2.60E-4	Keowee Unit 1 Field Flashing Breaker Fails To Close Due To Latent Human Error	2.60E-04
388	EK1FLSMDEX	7.71E-5	Keowee Unit 1 Field Flashing Breaker Fails To Close Due To Mechanical Failure	7.71E-05
389	EK1FLSOLHE	2.60E-4	Keowee Unit 1 Field Flashing Breaker Fails To Open Due To Latent Human Error	2.60E-04
390	EK1R31TRYD	1	Keowee Unit 1 Field Flashing Breaker Trip Coil 31/T Fails To Operate	3.30E-05

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Basic Event Data for the Oconee-Keowee AC Power/Core Damage Models

	NAME	FACTOR	DESC	PROB
391	EK1R31YRYD	1	KHU1 Gen Field Flashing Breaker Y-relay Failed To Drop Out At Last Operation	3.30E-05
392	EK1R31YRYT	84	KHU1 Generator Field Flashing Breaker Y-relay Spurious Operation	3.02E-05
393	EK1R41XRYD	1	Keowee Unit 1 Field Breaker Relay 41/X Fails To Pick-up On Demand	3.30E-05
394	EK1R41YRYD	1	KHU1 Generator Field Breaker Y-relay Failed To Drop-out At Last Operation	3.30E-05
395	EK1R41YRYT	84	Keowee Unit 1 Generator Field Breaker Y-relay Spurious Operation	3.02E-05
396	EK1R9A1RYT	84	Keowee Unit 1 Relay 90X1A/TD Spurious Operation	3.02E-05
397	EK1R9C1R6T	84	Keowee Unit 1 Relay 90X1C Spurious Operation	3.05E-05
398	EK1S141SWT	84	KHU1 Field Breaker Trip Control Switch 141/T Spurious Operation	5.88E-06
399	EK1S31TSWT	84	KHU1 Field Flashing Breaker Trip Control Switch 131/T Spurious Operation	5.88E-06
400	EK1S41CRYD	1	Keowee Unit 1 Supply Breaker Close Coil Fails To Operate On Demand	3.30E-05
401	EK1S41TSWT	24	Keowee Unit 1 Field Breaker Trip Control Switch Transfers Position	1.68E-06
402	EK1S41XRYD	1	Keowee Unit 1 Supply Breaker Relay 41-52X Fails To Pick-up On Demand	3.30E-05
403	EK1SPYCLHE	2.60E-4	Keowee Unit 1 Supply Breaker Fails To Close Due To Latent Human Error	2.60E-04
404	EK1SPYMDEX	4.62E-4	Keowee Unit 1 Supply Breaker Fails To Close Due To Mehanical Failure	4.62E-04
405	EK1VHSVRYD	1	Keowee Unit 1 Volts/Hertz Relay SV Fails To Trip Field Flashing Breaker	3.30E-05
406	EK1VREGDEX	2.47E-3	KHU-1 Voltage Adjust Failure Drives Generator Output Too High/Low	2.47E-03
407	EK231TDRYD	1	Keowee Unit 2 Field Flashing Breaker Time Delay Relay 31/TD Fails To Operate	3.30E-05
408	EK231TDRYT	12	Keowee Unit 2 Field Flashing Breaker Time Delay Relay 31/TD Spurious Operation	4.32E-06
409	EK24152SWT	12	KHU2 Generator Supply Breaker Trip Control Switch Spurious Operation	8.40E-07
410	EK2415TSWT	24	Spurious Operation Of The KHU2 Supply Breaker Trip Switch	1.68E-06
411	EK2415YRYD	1	KHU2 Gen Supply Breaker Y-relay Failed To Drop-out At Last Operation	3.30E-05
412	EK2415YRYT	12	KHU2 Generator Supply Breaker Y-relay Spurious Operation	4.32E-06
413	EK241AXR6D	1	Keowee Unit 2 Relay 41/AX Fails To Pick-up And Latch	2.49E-04
414	EK241AXR6T	24	Keowee Unit 2 Relay 41/AX Spuriously Resets	8.71E-06
415	EK241CFRYD	1	Keowee Unit 2 Field Flashing Breaker Close Coil Fails To Operat On Demand	3.30E-05
416	EK286E2RYT	6	Keowee Unit 2 Lockout Auxiliary Relay 86EX-2 Is Picked-up	2.16E-06
417	EK286EXRYT	12	Keowee Unit 2 Generator Lockout Auxiliary Relay 86EX-1 Spurious Actuation	4.32E-06
418	EK286X2RYT	24	Keowee Unit 2 Generator Lockout Auxiliary Relay 86EX-1 Spurious Actuation	8.64E-06
419	EK288SVRYD	1	Keowee Unit 2 Fan Control Relay 88SV Fails On Demand	3.30E-05
420	EK288SVRYT	36	Keowee Unit 2 Fan Control Relay 88SV Prior To Or During The Run	1.30E-05
421	EK2901ARYT	12	Keowee Unit 2 Relay 90X1A Spurious Operation	4.32E-06
422	EK299SXRYD	1	Auxiliary Relay 99SX2 Fails To Pick-up	3.30E-05
423	EK299SYRYD	1	Keowee Unit 2 Relay 99SY Fails To Pick-up	3.30E-05
424	EK299SYRYT	24	Keowee Unit 2 Relay 99SY Drops Out	8.64E-06
425	EK2BAS2DEX	1.24E-3	KHU-2 Base Adjust Fails To Maintain Generator Output Within Acceptable Range	1.24E-03
426	EK2BASEDEX	6.17E-4	Keowee Unit 2 Base Adjust Fails To Establish Correct Unit Voltage	6.17E-04
427	EK2BASELHE	3.20E-3	Keowee Unit 2 Base Adjust Is Set Incorrectly	3.20E-03
428	EK2DIODDEX	2.88E-4	Keowee Unit 2 Exciter Fan Supply Diode Bridge Fails	2.88E-04
429	EK2EXC1TGF	12	Keowee Unit 2 Generator Excitation Transformer Is Failed	1.18E-05

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Basic Event Data for the Oconee-Keowee AC Power/Core Damage Models

	NAME	FACTOR	DESC		PROB
430	EK2EXC2TGF	24	Keowee Unit 2 Generator Excitation Transformer Fails		2.35E-05
431	EK2F30AFUF	24	Keowee Unit 2 Excitation Cabinet Fan Fuses Fail		8.64E-05
432	EK2F31XRYD	1	Keowee Unit 2 Field Flashing Breaker Relay 31/X Fails To Pick-up On Demand		3.30E-05
433	EK2F41CRYD	1	Keowee Unit 2 Field Breaker Close Coil Fails To Operate On Demand		3.30E-05
434	EK2FAN1TLF	24	Keowee Unit 2 Generator Excitation Fan Power Transformer Fails		1.80E-05
435	EK2FLDCLHE	2.60E-4	Keowee Unit 2 Field Breaker Fails To Close Due To Latent Human Error		2.60E-04
436	EK2FLDMDEX	7.71E-5	Keowee Unit 2 Field Breaker Fails To Close Due To Mechanical Failure		7.71E-05
437	EK2FLSCLHE	2.60E-4	Keowee Unit 2 Field Flashing Breaker Fails To Close Due To Latent Human Error		2.60E-04
438	EK2FLSMDEX	7.71E-5	Keowee Unit 2 Field Flashing Breaker Fails To Close Due To Mechanical Failure		7.71E-05
439	EK2FLSOLHE	2.60E-4	Keowee Unit 2 Field Flashing Breaker Fails To Open Due To Latent Human Error		2.60E-04
440	EK2R31TRYD	1	Keowee Unit 2 Field Flashing Breaker Trip Coil 31/T Fails To Operate		3.30E-05
441	EK2R31YRYD	1	KHU2 Gen Field Flashing Breaker Y-relay Failed To Drop At Last Operation		3.30E-05
442	EK2R31YRYT	12	KHU2 Generator Field Flashing Breaker Y-relay Spurious Operation		4.32E-06
443	EK2R41XRYD	1	Keowee Unit 2 Field Breaker Relay 41/X Fails To Pick-up On Demand		3.30E-05
444	EK2R41YRYD	1	KHU2 Generator Field Breaker Y-relay Failed To Drop-out At Last Operation		3.30E-05
445	EK2R41YRYT	12	KHU2 Generator Field Breaker Y-relay Spurious Operation		4.32E-06
446	EK2R9A2RYT	12	Keowee Unit 2 Relay 90X1A/TD Spurious Operation		4.32E-06
447	EK2R9C2R6T	12	Keowee Unit 2 Relay 90X1C Spurious Operation		4.36E-06
448	EK2S141SWT	12	KHU2 Field Breaker Trip Control Switch Spurious Operation		8.40E-07
449	EK2S31TSWT	12	KHU2 Field Flashing Breaker Trip Control Switch 131/T Spurious Operation		8.40E-07
450	EK2S41CRYD	1	Keowee Unit 2 Supply Breaker Close Coil Fails To Operate On Demand		3.30E-05
451	EK2S41TSWT	24	Keowee Unit 2 Field Breaker Trip Control Switch Transfers Position		1.68E-06
452	EK2S41XRYD	1	Keowee Unit 2 Supply Breaker Relay 41-52X Fails To Pick-up On Demand		3.30E-05
453	EK2SPYCLHE	2.60E-4	Keowee Unit 2 Supply Breaker Fails To Close Due To Latent Human Error		2.60E-04
454	EK2SPYMDEX	4.62E-4	Keowee Unit 2 Supply Breaker Fails To Close Due To Mehanical Failure		4.62E-04
455	EK2VHSVRYD	1	Keowee Unit 2 Volts/Hertz Relay SV Fails To Trip Field Flashing Breaker		3.30E-05
456	EK2VREGDEX	2.47E-3	KHU-2 Voltage Adjust Failure Drives Generator Output Too High/Low		2.47E-03
457	EKSTARTCOM	6.17E-5	Common Cause Failure Of Both Units Voltage Regulators To Start		6.17E-05
458	ESCONDNOT	1	An Engineered Safeguards Condition Does Not Exist		1.00E+00
459	EU1C1RORYD	1	ONS1 ESG Chan. 1 Ro Relay Fails To Pick Up	OEE-120	1.00E+00
460	EU1C2RORYD	1	ONS1 ESG Chan. 2 Ro Relay Fails to Pick Up		1.00E+00
461	EU2C1RORYD	1	ONS2 ESG Chan. 1 Ro Relay Fails to Pick Up	OEE-220	1.00E+00
462	EU2C2RORYD	1	ONS2 ESG Chan. 2 Ro Relay Fails to Pick Up	OEE-220-1	1.00E+00
463	EU3C1RORYD	1	ONS3 ESG Chan. 1 Ro Relay Fails to Pick Up	OEE-320	1.00E+00
464	EU3C2RORYD	1	ONS3 ESG Chan. 2 Ro Relay Fails to Pick Up	OEE-320-1	1.00E+00
465	FAC3XAACLT	46	208 V ac MCC 3XAA Breaker R5C Transfers Open (3LPSW-137)		1.00E-03
466	FAC3XS3DEX	1.000E+00	Loss Of Power On 3XS3 Does Not Also Fail Power On 3XC		1.00E+00
467	FACCR1ECLT	24	208 V ac MCC 3XC Breaker R1E Transfers Open (3C-391)		2.18E-05
468	FACGA7CCLT	24	208 V ac MCC 3XGA Breaker F7C Transfers Open (3C-156)		2.18E-05

Table D-3

Basic Event Data for the Oconee-Keowee AC Power/Core Damage Models

	NAME	FACTOR	DESC	PROB
469	FACGB3ACLT	9	208 V ac MCC 3XGB Breaker R3A Transfers Open (3C-124)	5.90E-03
470	FACX3XCDEX	1.000E+00	Power Loss On 3XAA Does Not Also Fail Power On 3XC	1.00E+00
471	FCW0088VVT	46	Manual Valve CCW-88 Transfers Closed	1.88E-05
472	FCW0089VVT	46	Manual Valve CCW-89 Transfers Closed	1.88E-05
473	FCW0304CVO	1	Check Valve CCW-304 Fails To Open	2.30E-06
474	FCW0304CVT	24	Check Valve CCW-304 Transfers Closed After Opening	3.12E-06
475	FCW03R6RYD	1	Relay 3R6 Fails To Close	3.30E-05
476	FCWS34CCLT	46	208 V ac MCC 3XS3 Breaker 4C Transfers Open (TDEFWP Oil Cooler Pump)	1.00E-03
477	FCWTBOCGPR	24	Oil Cooler Pump Fails To Run For The Required Time	3.36E-04
478	FCWTBOCGPS	1	Oil Cooler Pump Fails To Start On Demand	9.70E-05
479	FCX0010AVT	24	Air-Operated Valve 3C-10 Transfers Closed	5.52E-05
480	FCX0013VVT	24	Manual Valve 3C-13 Transfers Closed	4.08E-07
481	FCX0016VVT	24	Manual Valve 3C-16 Transfers Closed	4.08E-07
482	FCX0072VVT	24	Manual Valve 3C-72 Transfers Closed	4.08E-07
483	FCX0075VVT	24	Manual Valve 3C-75 Transfers Closed	4.08E-07
484	FCX0106VVT	24	Manual Valve 3C-106 Transfers Closed	4.08E-07
485	FCX0113VVT	24	Manual Valve 3C-113 Transfers Closed	4.08E-07
486	FCX0120VVT	24	Manual Valve 3C-120 Transfers Closed	4.08E-07
487	FCX0124MVO	1	Motor-Operated Valve 3C-124 Fails To Open On Demand	4.00E-03
488	FCX0127VVT	9	Manual Valve 3C-127 Transfers Closed	1.10E-04
489	FCX0128AVO	1	Air-Operated Valve 3C-128 Fails To Open On Demand	2.80E-04
490	FCX0130VVT	9	Manual Valve 3C-130 Transfers Closed	1.10E-04
491	FCX0131VVT	9	Manual Valve 3C-131 Transfers Closed	1.10E-04
492	FCX0156MVC	1	Motor-Operated Valve 3C-156 Fails to Close On Demand	4.00E-03
493	FCX0156MVT	36	Motor-Operated Valve 3C-156 Transfers Closed	4.68E-06
494	FCX0157VVT	46	Locked Open Manual Valve 3C-157 Transfers Closed	1.88E-05
495	FCX0391MVO	1	Motor-Operated Valve 3C-391 Fails To Open On Demand	4.00E-03
496	FCXC187AVT	36	Air-Operated Valve C-187 Transfers Open	8.28E-05
497	FCXLS17LTF	36	Hotwell Level Transmitter Controlling C-187 Fails Low	1.80E-04
498	FCXLS28LTF	24	Hotwell Level Transmitter Controlling Hotwell Pumps Fails	1.20E-04
499	FCXR151RYT	24	Relay R-151 Fails Energized	8.64E-06
500	FEF0232CVO	1	Check Valve 3FDW-232 Fails To Open On Demand	2.30E-06
501	FEF0232CVT	24	Check Valve 3FDW-232 Transfers Closed	3.12E-06
502	FEF0233CVO	1	Check Valve 3FDW-233 Fails To Open On Demand	2.30E-06
503	FEF0233CVT	24	Check Valve 3FDW-233 Transfers Closed	3.12E-06
504	FEF0309VVT	9	Locked Open Manual Valve 3FDW-309 Transfers Closed	1.10E-04
505	FEF0310VVT	9	Locked Open Manual Valve 3FDW-310 Transfers Closed	1.10E-04
506	FEF0311CVO	1	Check Valve 3FDW-311 Fails To Open On Demand	2.30E-06
507	FEF0311CVT	24	Check Valve 3FDW-311 Transfers Closed	3.12E-06

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Basic Event Data for the Oconee-Keowee AC Power/Core Damage Models

	NAME	FACTOR	DESC	PROB
508	FEF0312CVO	1	Check Valve 3FDW-312 Fails To Open On Demand	2.30E-06
509	FEF0312CVT	24	Check Valve 3FDW-312 Transfers Closed	3.12E-06
510	FEF0315AVC	1	Air-Operated Valve 3FDW-315 Fails To Close To Throttle Flow	2.00E-03
511	FEF0315AVO	1	Air-Operated Valve 3FDW-315 Fails To Open On Demand	2.80E-04
512	FEF0315AVT	24	Air-Operated Valve 3FDW-315 Transfers Closed	5.52E-05
513	FEF0316AVC	1	Air-Operated Valve 3FDW-316 Fails To Close To Throttle Flow	2.00E-03
514	FEF0316AVO	1	Air-Operated Valve 3FDW-316 Fails To Open	2.80E-04
515	FEF0316AVT	24	Air-Operated Valve 3FDW-316 Transfers Closed	5.52E-05
516	FEF0317CVO	1	Check Valve 3FDW-317 Fails To Open On Demand	2.30E-06
517	FEF0317CVT	24	Check Valve 3FDW-317 Transfers Closed	3.12E-06
518	FEF0318CVO	1	Check Valve 3FDW-318 Fails To Open On Demand	2.30E-06
519	FEF0318CVT	24	Check Valve 3FDW-318 Transfers Closed	3.12E-06
520	FEF0345CVO	1	Check Valve 3FDW-345 Fails To Open On Demand	2.30E-06
521	FEF0345CVT	24	Check Valve 3FDW-345 Transfers Closed	3.12E-06
522	FEF0346CVO	1	Check Valve 3FDW-346 Fails To Open On Demand	2.30E-06
523	FEF0346CVT	24	Check Valve 3FDW-346 Transfers Closed	3.12E-06
524	FEF0347MVT	46	Motor-Operated Valve 3FDW-347 Transfers Closed	1.44E-04
525	FEF0368MVT	36	Motor-Operated Valve 3FDW-368 Transfers Closed	4.68E-06
526	FEF0369MVT	36	Motor-Operated Valve 3FDW-369 Transfers Closed	4.68E-06
527	FEF0382PST	9	Pressure Switch 3PS-382 Fails	2.79E-03
528	FEF0383PST	9	Pressure Switch 3PS-383 Fails	2.79E-03
529	FEF0384PST	9	Pressure Switch 3PS-384 Fails	2.79E-03
530	FEF0385PST	9	Pressure Switch 3PS-385 Fails	2.79E-03
531	FEF0386PST	9	Pressure Switch 3PS-386 Fails	2.79E-03
532	FEF0387PST	9	Pressure Switch 3PS-387 Fails	2.79E-03
533	FEF0388PST	9	Pressure Switch 3PS-388 Fails	2.79E-03
534	FEF0389PST	9	Pressure Switch 3PS-389 Fails	2.79E-03
535	FEF0403PST	9	Pressure Switch 3PS-403 Fails	2.79E-03
536	FEF0407PST	9	Pressure Switch 3PS-407 Fails	2.79E-03
537	FEF0415PST	9	Pressure Switch 3PS-415 Fails	2.79E-03
538	FEF0419PST	9	Pressure Switch 3PS-419 Fails	2.79E-03
539	FEF0442CVO	1	Check Valve 3FDW-442 Fails To Open On Demand	2.30E-06
540	FEF0442CVT	24	Check Valve 3FDW-442 Transfers Closed	3.12E-06
541	FEF1516COM	1.400E-04	Common Cause Failure Of Air-Operated Valves FDW-315 and 316 To Open	1.40E-04
542	FEFEFW2DHE	5.000E-03	Operators Fail To Throttle EFW Pump Flow	5.00E-03
543	FEFMFLBDEX	3.000E-01	Percentage Of Condensate/FDW Piping At Or Below Hotwell Elev	3.00E-01
544	FEFMFLBRHE	1.000E+00	Operators Fail To Isolate A MFLB Before The USTs Drain To The Hotwell	1.00E+00
545	FEFRCIRDHE	1.000E-03	Operators Fail To Align Recirculation From Hotwell To Upper Surge Tanks	1.00E-03
546	FEFSWCHDHE	5.000E-02	Operators Fail To Switch TDEFW Pump Suction To Hotwell	5.00E-02

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Basic Event Data for the Oconee-Keowee AC Power/Core Damage Models

	NAME	FACTOR	DESC	PROB
547	FEFTDFPLHE	3.000E-03	Turbine-Driven EFW Pump Fails Due To Latent Human Error	3.00E-03
548	FEFTDFPTPR	24	Turbine-Driven EFW Pump Fails To Run For The Required Time	6.00E-02
549	FEFTDFPTPS	1	Turbine-Driven EFW Pump Fails To Start On Demand	1.40E-03
550	FEFTDFPTRM	9.400E-03	Turbine-Driven EFW Pump Is In Maintenance	9.40E-03
551	FEFTDP2TPS	1	Turbine-Driven EFW Pump Fails To Restart On Demand	1.40E-03
552	FEFTRNALHE	3.000E-03	EFW System Header 3A Fails Due To Latent Human Error	3.00E-03
553	FEFTRNATRM	2.700E-04	EFW System Header 3A Is In Maintenance	2.70E-04
554	FEFTRNBLHE	3.000E-03	EFW System Header 3B Fails Due To Latent Human Error	3.00E-03
555	FEFTRNBTRM	2.700E-04	EFW System Train 3B Is In Maintenance	2.70E-04
556	FEFWUSTLHE	1.000E-04	Insufficient Inventory In UST For EFW Pump Suction	1.00E-04
557	FEFWUSTTKF	24	Upper Surge Tanks Fail	1.10E-05
558	FHS0033VVT	24	Manual Valve 3HPSW-33 Transfers Closed	4.08E-07
559	FHS0184AVO	1	Air-Operated Valve HPSW-184 Fails To Open	2.80E-04
560	FHS0184AVT	24	Air-Operated Valve HPSW-184 Transfers Closed After Opening	5.52E-05
561	FHS0189VVT	46	Manual Valve 3HPSW-189 Transfers Closed	1.88E-05
562	FHS0191RGO	1	Regulating Valve 3HPSW-191 Fails To Open On Demand	1.60E-03
563	FHS0191RGT	24	Regulating Valve 3HPSW-191 Transfers Closed	1.92E-05
564	FHS0192VVT	46	Manual Valve 3HPSW-192 Transfers Closed	1.88E-05
565	FHS0193CVO	1	Check Valve 3HPSW-193 Fails To Open On Demand	2.30E-06
566	FHS0193CVT	24	Check Valve 3HPSW-193 Transfers Closed	3.12E-06
567	FHS0248VVT	46	Manual Valve 3HPSW-248 Transfers Closed	1.88E-05
568	FK0FISHCOM	2.55E-3	Common Cause Failure Of Both Unit s WL Filters Due To Intake Debris	2.55E-03
569	FK0FISHDHE	6.3E-02	Recovery of Main WL Strainer Clogging	6.30E-02
570	FK0FLOODHE	6.3E-02	Recovery of Trubine Guide Bearing or Packing WL Filter Clogging	6.30E-02
571	FK0WL01VVT	24	Locked-Open Manual Valve 0WL-1 Transfers Position	4.08E-07
572	FK1120GLHE	3.2E-3	Unit 1 Control Switch S120G Left in OFF Position	3.20E-03
573	FK1120GSWT	108	Unit 1 Control Switch S120G Spurious Operation	7.56E-06
574	FK1FL01FRF	24	Filter 1WLFL-1 Becomes Clogged	2.35E-05
575	FK1FL02FRF	24	Filter 1WLFL-2 Becomes Clogged	2.35E-05
576	FK1FL03FRF	24	Filter 1WLFL-3 Becomes Clogged	2.35E-05
577	FK1TRHXHXF	24	Turbine Packing Box Heat Exchanger 1TRHX-1 Fails	1.54E-05
578	FK1WL03VVT	24	Manual Valve 1WL-3 Transfers Position	4.08E-07
579	FK1WL04VVT	24	Manual Valve 1WL-4 Transfers Position	4.08E-07
580	FK1WL05VVT	24	Manual Valve 1WL-5 Transfers Position	4.08E-07
581	FK1WL06VVT	24	Manual Valve 1WL-6 Transfers Position	4.08E-07
582	FK1WL07VVT	24	Manual Valve 1WL-7 Transfers Position	4.08E-07
583	FK1WL08VVT	24	Manual Valve 1WL-8 Transfers Position	4.08E-07
584	FK1WL09VVT	24	Manual Valve 1WL-9 Transfers Position	4.08E-07
585	FK1WL11AVO	1	Cooling Water Control Valve 1WL-11 Fails To Open On Demand	2.80E-04

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Basic Event Data for the Oconee-Keowee AC Power/Core Damage Models

	NAME	FACTOR	DESC	PROB
586	FK1WL11AVT	24	Cooling Water Control Valve 1WL-11 Transfers Closed	5.52E-05
587	FK1WL12VVT	108	Manual Valve 1WL-12 Transfers Position	1.84E-06
588	FK1WL15VVT	108	Manual Valve 1WL-15 Transfers Position	1.84E-06
589	FK1WL42VVT	108	Manual Valve 1WL-42 Transfers Position	1.84E-06
590	FK1WL43VVT	108	Manual Valve 1WL-43 Transfers Position	1.84E-06
591	FK2120GLHE	2.6E-4	Unit 2 Control Switch S120G Left in OFF Position	2.60E-04
592	FK2120GSWT	36	Unit 2 Control Switch S120G Spurious Operation	2.52E-06
593	FK2FL01FRF	24	Filter 2WLFL-1 Becomes Clogged	2.35E-05
594	FK2FL02FRF	24	Filter 2WLFL-2 Becomes Clogged	2.35E-05
595	FK2FL03FRF	24	Filter 2WLFL-3 Becomes Clogged	2.35E-05
596	FK2TRHXHXF	24	Turbine Packing Box Heat Exchanger 2TRHX-1 Fails	1.54E-05
597	FK2WL03VVT	24	Manual Valve 2WL-3 Transfers Position	4.08E-07
598	FK2WL04VVT	24	Manual Valve 2WL-4 Transfers Position	4.08E-07
599	FK2WL05VVT	24	Manual Valve 2WL-5 Transfers Position	4.08E-07
600	FK2WL06VVT	24	Manual Valve 2WL-6 Transfers Position	4.08E-07
601	FK2WL07VVT	24	Manual Valve 2WL-7 Transfers Position	4.08E-07
602	FK2WL08VVT	24	Manual Valve 2WL-8 Transfers Position	4.08E-07
603	FK2WL09VVT	24	Manual Valve 2WL-9 Transfers Position	4.08E-07
604	FK2WL11AVO	1	Cooling Water Control Valve 2WL-11 Fails To Open On Demand	2.80E-04
605	FK2WL11AVT	24	Cooling Water Control Valve 2WL-11 Transfers Closed	5.52E-05
606	FK2WL12VVT	36	Manual Valve 2WL-12 Transfers Position	6.12E-07
607	FK2WL15VVT	36	Manual Valve 2WL-15 Transfers Position	6.12E-07
608	FK2WL42VVT	36	Manual Valve 2WL-42 Transfers Position	6.12E-07
609	FK2WL43VVT	36	Manual Valve 2WL-43 Transfers Position	6.12E-07
610	FKVALVECOM	2.46E-5	Common Cause Failure Of Cooling Water Control Valves	2.46E-05
611	FLII	5.800E-03	Large, Isolable Condenser Inlet Turbine Building Flood	5.80E-03
612	FLS0136VVT	46	Manual Valve 3LPSW-136 Transfers Closed	1.88E-05
613	FLS0137MVO	1	Motor-Operated Valve 3LPSW-137 Fails To Open On Demand	4.00E-03
614	FLS0137MVT	24	Motor-Operated Valve 3LPSW-137 Transfers Closed After Opening	3.12E-06
615	FLS0138AVO	1	Air-Operated Valve 3LPSW-138 Fails To Open On Demand	2.80E-04
616	FLS0138AVT	24	Air-Operated Valve 3LPSW-138 Transfers Closed After Opening	5.52E-05
617	FLS0687CVO	1	Check Valve 3LPSW-687 Fails To Open On Demand	2.30E-06
618	FLS0687CVT	24	Check Valve 3LPSW-687 Transfers Closed	3.12E-06
619	FMII	8.800E-03	Medium, Isolable Condenser Inlet Turbine Bldg Flood	8.80E-03
620	FMN	6.200E-04	Medium, Non-Isolable Turbine Building Flood	6.20E-04
621	FMS0082MVT	46	Motor-Operated Valve 3MS-82 Transfers Closed	1.44E-04
622	FMS0083CVO	1	Check Valve 3MS-83 Fails To Open On Demand	2.30E-06
623	FMS0083CVT	24	Check Valve 3MS-83 Transfers Closed	3.12E-06
624	FMS0084MVT	46	Motor-Operated Valve 3MS-84 Transfers Closed	1.44E-04

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Basic Event Data for the Oconee-Keowee AC Power/Core Damage Models

	NAME	FACTOR	DESC	PROB
625	FMS0085CVO	1	Check Valve 3MS-85 Fails To Open On Demand	2.30E-06
626	FMS0085CVT	24	Check Valve 3MS-85 Transfers Closed	3.12E-06
627	FMS0086VVT	46	Locked Open Manual Valve 3MS-86 Transfers Closed	1.88E-05
628	FMS0087AVT	46	Air-Operated Valve 3MS-87 Transfers Closed	2.54E-03
629	FMS0089VVT	46	Manual Valve 3MS-89 Transfers Closed	1.88E-05
630	FMS0090VVT	46	Manual Valve 3MS-90 Transfers Closed	1.88E-05
631	FMS0091CVO	1	Check Valve 3MS-91 Fails To Open On Demand	2.30E-06
632	FMS0091CVT	24	Check Valve 3MS-91 Transfers Closed	3.12E-06
633	FMS0093AVO	1	Air-Operated Valve 3MS-93 Fails To Open On Demand	2.80E-04
634	FMS0093AVT	24	Air-Operated Valve 3MS-93 Transfers Closed	5.52E-05
635	FMS0093LLD	1	Limit Switch On Air-Operated Valve 3MS-93 Fails	5.50E-07
636	FMS093BAVO	1	Air-Operated Valve 3MS-93 Fails To Reopen On Demand	2.80E-04
637	GK0BRGVRHE	1.00E+00	Failure To Recover Thrust Bearing Cooling	1.00E+00
638	GK0COOLCOM	4.61E-07	Common Cause Failure of Generator Air Cooling	4.61E-07
639	GK0LOCKCOM	4.06E-06	Common Cause Actuation of Generator Lockouts	4.06E-06
640	GK10001HGR	24	Keowee Unit 1 Generator Fault While the Unit Runs	2.27E-03
641	GK10001HGS	1	Keowee Unit 1 Generator Fault Causes Unit Start Failure	1.54E-04
642	GK1063FPST	24	Keowee 1 Gen CO2 Sys Press Switch 63F Spurious Operation	1.03E-05
643	GK112TDRYT	24	Time Delay Relay 12XTD/1 Spuriously Picks-up	8.64E-06
644	GK112X1RYT	24	Relay 12X/1 Spuriously Picks-up	8.64E-06
645	GK13SUIRYT	24	Keowee Unit 1 Startup Inhibit Switch Auxiliary Relay S3SUIX Spurious Actuation	8.64E-06
646	GK13SUISWT	24	Keowee Unit 1 Startup Inhibit Switch 3SUI Spurious Operation	1.68E-06
647	GK140G1RYT	24	Keowee Unit 1 Loss Of Generator Field Relay 40G1 Spurious Actuation	8.64E-06
648	GK159GNRYT	24	Keowee Unit 1 Generator Ground Fault Relay 59GN1 Spurious Actuation	8.64E-06
649	GK162TDRYT	24	Keowee Unit 1 Generator Backup Trip Timer 62-1TD Spurious Operation	8.64E-06
650	GK163FXRYT	24	Keowee Unit 1 Generator Fire Relay 63FX Spurious Actuation	8.64E-06
651	GK186E1RYT	24	Keowee 1 Emergency Lockout Relay 86E-1 Spuriously Picks Up	8.64E-06
652	GK187G1RYT	24	Keowee Unit 1 Generator Differential Relay 87G-1 Spurious Actuation	8.64E-06
653	GK187GBRYT	24	Keowee Unit 1 Generator Bus Differential Relay 87GB Spurious Actuation	8.64E-06
654	GK187TERYT	24	Keowee Unit 1 Exitation Transformer Differential Relay 87T-1E Spur. Actuation	8.64E-06
655	GK1BRGVLHE	2.60E-04	Keowee 1 Gen. Brng Oil Cooling Flow Path Vlvs Mispositioned After Maintenance	2.60E-04
656	GK1COOLLHE	2.60E-04	Keowee 1 Gen. Air Cooler WL Flow Path Vlvs Mispositioned After Maintenance	2.60E-04
657	GK1FIREDEX	3.19E-05	Spurious Actuation of Unit 1 Gen. CO2 Fire Supression System	3.19E-05
658	GK1GAC1HXF	24	Generator Air Cooler 1GAHW-1 Fails	1.54E-05
659	GK1GAC1HXL	108	Heat Exchanger 1GAC1 Leaks	1.08E-05
660	GK1GAC2HXF	24	Generator Air Cooler 1GAHW-2 Fails	1.54E-05
661	GK1GAC2HXL	108	Heat Exchanger 1GAC2 Leaks	1.08E-05
662	GK1GAC3HXF	24	Generator Air Cooler 1GAHW-3 Fails	1.54E-05
663	GK1GAC3HXL	108	Heat Exchanger 1GAC3 Leaks	1.08E-05

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Basic Event Data for the Oconee-Keowee AC Power/Core Damage Models

	NAME	FACTOR	DESC	PROB
664	GK1GAC4HXF	24	Generator Air Cooler 1GAHW-4 Fails	1.54E-05
665	GK1GAC4HXL	108	Heat Exchanger 1GAC4 Leaks	1.08E-05
666	GK1GAC5HXF	24	Generator Air Cooler 1GAHW-5 Fails	1.54E-05
667	GK1GAC5HXL	108	Heat Exchanger 1GAC5 Leaks	1.08E-05
668	GK1GAC6HXF	24	Generator Air Cooler 1GAHW-6 Fails	1.54E-05
669	GK1GAC6HXL	108	Heat Exchanger 1GAC6 Leaks	1.08E-05
670	GK1HPO1HXF	24	Generator Thrust Bearing Cooler 1HPOHX-1 Fails	1.54E-05
671	GK1HPO2HXF	24	Generator Thrust Bearing Cooler 1HPOHX-2 Fails	1.54E-05
672	GK1HPO3HXF	24	Generator Thrust Bearing Cooler 1HPOHX-3 Fails	1.54E-05
673	GK1HPO4HXF	24	Generator Thrust Bearing Cooler 1HPOHX-4 Fails	1.54E-05
674	GK1HPO5HXF	24	Generator Thrust Bearing Cooler 1HPOHX-5 Fails	1.54E-05
675	GK1HPO6HXF	24	Generator Thrust Bearing Cooler 1HPOHX-6 Fails	1.54E-05
676	GK1HPO6VVT	24	Genrator Bearing Oil Leak Because Manual Valve 1HPO-6 Transfers Position	4.08E-07
677	GK1HPO7HXF	24	Generator Thrust Bearing Cooler 1HPOHX-7 Fails	1.54E-05
678	GK1HPO8HXF	24	Generator Thrust Bearing Cooler 1HPOHX-8 Fails	1.54E-05
679	GK1NGDCLHE	5.20E-05	Failure to Close the Unit 1 Neutral Ground Disconnect Following Maintenance	5.20E-05
680	GK1O121SST	24	Speed Switch 12/1 Falsely Indicates High Speed	1.01E-04
681	GK1WL16VVT	384	Manual Valve 1WL-16 Transfers Position	6.53E-06
682	GK1WL17VVT	384	Manual Valve 1WL-17 Transfers Position	6.53E-06
683	GK1WL18VVT	108	Manual Valve 1WL18 Transfers Position	1.84E-06
684	GK1WL19VVT	108	Manual Valve 1WL19 Transfers Position	1.84E-06
685	GK1WL20VVT	384	Manual Valve 1WL-20 Transfers Position	6.53E-06
686	GK1WL21VVT	384	Manual Valve 1WL-21 Transfers Position	6.53E-06
687	GK1WL22VVT	108	Manual Valve 1WL22 Transfers Position	1.84E-06
688	GK1WL23VVT	108	Manual Valve 1WL23 Transfers Position	1.84E-06
689	GK1WL24VVT	384	Manual Valve 1WL-24 Transfers Position	6.53E-06
690	GK1WL25VVT	384	Manual Valve 1WL-25 Transfers Position	6.53E-06
691	GK1WL26VVT	108	Manual Valve 1WL26 Transfers Position	1.84E-06
692	GK1WL27VVT	108	Manual Valve 1WL27 Transfers Position	1.84E-06
693	GK1WL28VVT	384	Manual Valve 1WL-28 Transfers Position	6.53E-06
694	GK1WL29VVT	384	Manual Valve 1WL-29 Transfers Position	6.53E-06
695	GK1WL30VVT	108	Manual Valve 1WL30 Transfers Position	1.84E-06
696	GK1WL31VVT	108	Manual Valve 1WL31 Transfers Position	1.84E-06
697	GK1WL32VVT	384	Manual Valve 1WL-32 Transfers Position	6.53E-06
698	GK1WL33VVT	384	Manual Valve 1WL-33 Transfers Position	6.53E-06
699	GK1WL34VVT	108	Manual Valve 1WL34 Transfers Position	1.84E-06
700	GK1WL35VVT	108	Manual Valve 1WL35 Transfers Position	1.84E-06
701	GK1WL36VVT	384	Manual Valve 1WL-36 Transfers Position	6.53E-06
702	GK1WL37VVT	384	Manual Valve 1WL-37 Transfers Position	6.53E-06

Table D-3

Basic Event Data for the Oconee-Keowee AC Power/Core Damage Models

	NAME	FACTOR	DESC	PROB
703	GK1WL38VVT	108	Manual Valve 1WL38 Transfers Position	1.84E-06
704	GK1WL39VVT	108	Manual Valve 1WL39 Transfers Position	1.84E-06
705	GK1WL41VVT	384	Keowee 1 Manual Valve 1WL-41 Transfers Position to Block Discharge Path	6.53E-06
706	GK1WL44VVT	384	Manual Valve 1WL-44 Transfers Position	6.53E-06
707	GK1WL45VVT	384	Manual Valve 1WL-45 Transfers Position	6.53E-06
708	GK1WL46VVT	108	Manual Valve 1WL-46 Transfers Position	1.84E-06
709	GK1WL47VVT	108	Manual Valve 1WL-47 Transfers Position	1.84E-06
710	GK1WL48VVT	384	Manual Valve 1WL-48 Transfers Position	6.53E-06
711	GK1WL49VVT	384	Manual Valve 1WL-49 Transfers Position	6.53E-06
712	GK1WL50VVT	108	Manual Valve 1WL-50 Transfers Position	1.84E-06
713	GK1WL51VVT	108	Manual Valve 1WL-51 Transfers Position	1.84E-06
714	GK1WL52VVT	384	Manual Valve 1WL-52 Transfers Position	6.53E-06
715	GK1WL53VVT	384	Manual Valve 1WL-53 Transfers Position	6.53E-06
716	GK1WL54VVT	108	Manual Valve 1WL-54 Transfers Position	1.84E-06
717	GK1WL55VVT	108	Manual Valve 1WL-55 Transfers Position	1.84E-06
718	GK1WL56VVT	384	Manual Valve 1WL-56 Transfers Position	6.53E-06
719	GK1WL57VVT	384	Manual Valve 1WL-57 Transfers Position	6.53E-06
720	GK1WL58VVT	108	Manual Valve 1WL-58 Transfers Position	1.84E-06
721	GK1WL59VVT	108	Manual Valve 1WL-59 Transfers Position	1.84E-06
722	GK1WL60VVT	384	Manual Valve 1WL-60 Transfers Position	6.53E-06
723	GK1WL61VVT	384	Manual Valve 1WL-61 Transfers Position	6.53E-06
724	GK1WL62VVT	108	Manual Valve 1WL-62 Transfers Position	1.84E-06
725	GK1WL63VVT	108	Manual Valve 1WL-63 Transfers Position	1.84E-06
726	GK1WL64VVT	384	Manual Valve 1WL-64 Transfers Position	6.53E-06
727	GK1WL65VVT	384	Manual Valve 1WL-65 Transfers Position	6.53E-06
728	GK1WL66VVT	108	Manual Valve 1WL-66 Transfers Position	1.84E-06
729	GK1WL67VVT	108	Manual Valve 1WL-67 Transfers Position	1.84E-06
730	GK1WL68VVT	384	Manual Valve 1WL-68 Transfers Position	6.53E-06
731	GK1WL69VVT	384	Manual Valve 1WL-69 Transfers Position	6.53E-06
732	GK1WL70VVT	108	Manual Valve 1WL-70 Transfers Position	1.84E-06
733	GK1WL71VVT	108	Manual Valve 1WL-71 Transfers Position	1.84E-06
734	GK1WL72VVT	384	Manual Valve 1WL-72 Transfers Position	6.53E-06
735	GK1WL73VVT	384	Manual Valve 1WL-73 Transfers Position	6.53E-06
736	GK1WL74VVT	108	Manual Valve 1WL-74 Transfers Position	1.84E-06
737	GK1WL75VVT	108	Manual Valve 1WL-75 Transfers Position	1.84E-06
738	GK1WL76VVT	384	Manual Valve 1WL76 Transfers Position and Blocks Discharge Path	6.53E-06
739	GK1WL78VVT	384	Manual Valve 1WL78 Transfers Position and Blocks Discharge Path	6.53E-06
740	GK20001HGR	24	Keowee Unit 2 Generator Fault While the Unit Runs	2.27E-03
741	GK20002HGS	1	Keowee Unit 2 Generator Fault Causes Unit Start Failure	1.54E-04

Table D-3

Basic Event Data for the Oconee-Keowee AC Power/Core Damage Models

	NAME	FACTOR	DESC	PROB
742	GK2063FPST	24	Keowee 2 Gen CO2 Sys Press Switch 63F Spurious Operation	1.03E-05
743	GK212TDRYT	24	Time Delay Relay 12XTD/2 Spuriously Picks-up	8.64E-06
744	GK212X2RYT	24	Relay 12X/2 Spuriously Picks-up	8.64E-06
745	GK23SUIRYT	24	Keowee Unit 2 Startup Inhibit Switch Auxiliary Relay S3SUIX Spurious Actuation	8.64E-06
746	GK23SUISWT	24	Keowee Unit 2 Startup Inhibit Swtich 3SUI Spurious Operation	1.68E-06
747	GK240G1RYT	24	Keowee Unit 2 Loss Of Generator Field Relay 40G1 Spurious Actuation	8.64E-06
748	GK259GNRYT	24	Keowee Unit 2 Generator Ground Fault Relay 59GN2 Spurious Actuation	8.64E-06
749	GK262TDRYT	24	Keowee Unit 2 Generator Backup Trip Timer 62-2TD Spurious Operation	8.64E-06
750	GK263FXRYT	24	Keowee Unit 2 Generator Fire Relay 63FX Spurious Actuation	8.64E-06
751	GK286E2RYT	24	Keowee 2 Emergency Lockout Relay 86E-2 Spuriously Picks Up	8.64E-06
752	GK287G2RYT	24	Keowee Unit 2 Generator Differential Relay 87G-2 Spurious Actuation	8.64E-06
753	GK287GBRYT	24	Keowee Unit 2 Generator Bus Differential Relay 87GB Spurious Actuation	8.64E-06
754	GK287TERYT	24	Keowee Unit 2 Excitation Transformer Differential Relay 87T-2E Spur. Actuation	8.64E-06
755	GK2BRGVLHE	2.60E-04	Keowee 2 Gen. Brng Oil Cooling Flow Path Vlvs Mispositioned After Maintenance	2.60E-04
756	GK2COOLLHE	2.60E-04	Keowee 2 Gen. Air Cooler WL Flow Path Vlvs Mispositioned After Maintenance	2.60E-04
757	GK2FIREDEX	7.00E-05	Spurious Actuation of Unit 2 Gen. CO2 Fire Supression System	7.00E-05
758	GK2GAC1HXF	24	Generator Air Cooler 2GAHW-1 Fails	1.54E-05
759	GK2GAC1HXL	36	Heat Exchanger 2GAC1 Leaks	3.60E-06
760	GK2GAC2HXF	24	Generator Air Cooler 2GAHW-2 Fails	1.54E-05
761	GK2GAC2HXL	36	Heat Exchanger 2GAC2 Leaks	3.60E-06
762	GK2GAC3HXF	24	Generator Air Cooler 2GAHW-3 Fails	1.54E-05
763	GK2GAC3HXL	36	Heat Exchanger 2GAC3 Leaks	3.60E-06
764	GK2GAC4HXF	24	Generator Air Cooler 2GAHW-4 Fails	1.54E-05
765	GK2GAC4HXL	36	Heat Exchanger 2GAC4 Leaks	3.60E-06
766	GK2GAC5HXF	24	Generator Air Cooler 2GAHW-5 Fails	1.54E-05
767	GK2GAC5HXL	36	Heat Exchanger 2GAC5 Leaks	3.60E-06
768	GK2GAC6HXF	24	Generator Air Cooler 2GAHW-6 Fails	1.54E-05
769	GK2GAC6HXL	36	Heat Exchanger 2GAC6 Leaks	3.60E-06
770	GK2HPO1HXF	24	Generator Thrust Bearing Cooler 2HPOHX-1 Fails	1.54E-05
771	GK2HPO2HXF	24	Generator Thrust Bearing Cooler 2HPOHX-2 Fails	1.54E-05
772	GK2HPO3HXF	24	Generator Thrust Bearing Cooler 2HPOHX-3 Fails	1.54E-05
773	GK2HPO4HXF	24	Generator Thrust Bearing Cooler 2HPOHX-4 Fails	1.54E-05
774	GK2HPO5HXF	24	Generator Thrust Bearing Cooler 2HPOHX-5 Fails	1.54E-05
775	GK2HPO6HXF	24	Generator Thrust Bearing Cooler 2HPOHX-6 Fails	1.54E-05
776	GK2HPO6VVT	24	Genrator Bearing Oil Leak Because Manual Valve 2HPO-6 Transfers Position	4.08E-07
777	GK2HPO7HXF	24	Generator Thrust Bearing Cooler 2HPOHX-7 Fails	1.54E-05
778	GK2HPO8HXF	24	Generator Thrust Bearing Cooler 2HPOHX-8 Fails	1.54E-05
779	GK2NGDCLHE	5.20E-05	Failure to Close the Unit 2 Neutral Ground Disconnect Following Maintenance	5.20E-05
780	GK2O121SST	24	Speed Switch 12/2 Falsely Indicates High Speed	1.01E-04

Table D-3

Basic Event Data for the Oconee-Keowee AC Power/Core Damage Models

	NAME	FACTOR	DESC	PROB
781	GK2WL16VVT	36	Manual Valve 2WL-16 Transfers Position	6.12E-07
782	GK2WL17VVT	36	Manual Valve 2WL-17 Transfers Position	6.12E-07
783	GK2WL18VVT	36	Manual Valve 2WL18 Transfers Position	6.12E-07
784	GK2WL19VVT	36	Manual Valve 2WL19 Transfers Position	6.12E-07
785	GK2WL20VVT	36	Manual Valve 2WL-20 Transfers Position	6.12E-07
786	GK2WL21VVT	36	Manual Valve 2WL-21 Transfers Position	6.12E-07
787	GK2WL22VVT	36	Manual Valve 2WL22 Transfers Position	6.12E-07
788	GK2WL23VVT	36	Manual Valve 2WL23 Transfers Position	6.12E-07
789	GK2WL24VVT	36	Manual Valve 2WL-24 Transfers Position	6.12E-07
790	GK2WL25VVT	36	Manual Valve 2WL-25 Transfers Position	6.12E-07
791	GK2WL26VVT	36	Manual Valve 2WL26 Transfers Position	6.12E-07
792	GK2WL27VVT	36	Manual Valve 2WL27 Transfers Position	6.12E-07
793	GK2WL28VVT	36	Manual Valve 2WL-28 Transfers Position	6.12E-07
794	GK2WL29VVT	36	Manual Valve 2WL-29 Transfers Position	6.12E-07
795	GK2WL30VVT	36	Manual Valve 2WL30 Transfers Position	6.12E-07
796	GK2WL31VVT	36	Manual Valve 2WL31 Transfers Position	6.12E-07
797	GK2WL32VVT	36	Manual Valve 2WL-32 Transfers Position	6.12E-07
798	GK2WL33VVT	36	Manual Valve 2WL-33 Transfers Position	6.12E-07
799	GK2WL34VVT	36	Manual Valve 2WL34 Transfers Position	6.12E-07
800	GK2WL35VVT	36	Manual Valve 2WL35 Transfers Position	6.12E-07
801	GK2WL36VVT	36	Manual Valve 2WL-36 Transfers Position	6.12E-07
802	GK2WL37VVT	36	Manual Valve 2WL-37 Transfers Position	6.12E-07
803	GK2WL38VVT	36	Manual Valve 2WL38 Transfers Position	6.12E-07
804	GK2WL39VVT	36	Manual Valve 2WL39 Transfers Position	6.12E-07
805	GK2WL41VVT	36	Keowee 2 Manual Valve 2WL-41 Transfers Position to Block Discharge Path	6.12E-07
806	GK2WL44VVT	36	Manual Valve 2WL-44 Transfers Position	6.12E-07
807	GK2WL45VVT	36	Manual Valve 2WL-45 Transfers Position	6.12E-07
808	GK2WL46VVT	36	Manual Valve 2WL-46 Transfers Position	6.12E-07
809	GK2WL47VVT	36	Manual Valve 2WL-47 Transfers Position	6.12E-07
810	GK2WL48VVT	36	Manual Valve 2WL-48 Transfers Position	6.12E-07
811	GK2WL49VVT	36	Manual Valve 2WL-49 Transfers Position	6.12E-07
812	GK2WL50VVT	36	Manual Valve 2WL-50 Transfers Position	6.12E-07
813	GK2WL51VVT	36	Manual Valve 2WL-51 Transfers Position	6.12E-07
814	GK2WL52VVT	36	Manual Valve 2WL-52 Transfers Position	6.12E-07
815	GK2WL53VVT	36	Manual Valve 2WL-53 Transfers Position	6.12E-07
816	GK2WL54VVT	36	Manual Valve 2WL-54 Transfers Position	6.12E-07
817	GK2WL55VVT	36	Manual Valve 2WL-55 Transfers Position	6.12E-07
818	GK2WL56VVT	36	Manual Valve 2WL-56 Transfers Position	6.12E-07
819	GK2WL57VVT	36	Manual Valve 2WL-57 Transfers Position	6.12E-07

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Basic Event Data for the Oconee-Keowee AC Power/Core Damage Models

	NAME	FACTOR	DESC		PROB
820	GK2WL58VVT	36	Manual Valve 2WL-58 Transfers Position		6.12E-07
821	GK2WL59VVT	36	Manual Valve 2WL-59 Transfers Position		6.12E-07
822	GK2WL60VVT	36	Manual Valve 2WL-60 Transfers Position		6.12E-07
823	GK2WL61VVT	36	Manual Valve 2WL-61 Transfers Position		6.12E-07
824	GK2WL62VVT	36	Manual Valve 2WL-62 Transfers Position		6.12E-07
825	GK2WL63VVT	36	Manual Valve 2WL-63 Transfers Position		6.12E-07
826	GK2WL64VVT	36	Manual Valve 2WL-64 Transfers Position		6.12E-07
827	GK2WL65VVT	36	Manual Valve 2WL-65 Transfers Position		6.12E-07
828	GK2WL66VVT	36	Manual Valve 2WL-66 Transfers Position		6.12E-07
829	GK2WL67VVT	36	Manual Valve 2WL-67 Transfers Position		6.12E-07
830	GK2WL68VVT	36	Manual Valve 2WL-68 Transfers Position		6.12E-07
831	GK2WL69VVT	36	Manual Valve 2WL-69 Transfers Position		6.12E-07
832	GK2WL70VVT	36	Manual Valve 2WL-70 Transfers Position		6.12E-07
833	GK2WL71VVT	36	Manual Valve 2WL-71 Transfers Position		6.12E-07
834	GK2WL72VVT	36	Manual Valve 2WL-72 Transfers Position		6.12E-07
835	GK2WL73VVT	36	Manual Valve 2WL-73 Transfers Position		6.12E-07
836	GK2WL74VVT	36	Manual Valve 2WL-74 Transfers Position		6.12E-07
837	GK2WL75VVT	36	Manual Valve 2WL-75 Transfers Position		6.12E-07
838	GK2WL76VVT	36	Manual Valve 2WL76 Transfers Position and Blocks Discharge Path		6.12E-07
839	GK2WL78VVT	36	Manual Valve 2WL78 Transfers Position and Blocks Discharge Path		6.12E-07
840	GKHPOILCOM	4.61E-07	Common Cause Failure of Generator Thrust Bearings		4.61E-07
841	K12COM1DEX	1.00E-06	Grid Degradation Occurs And Causes Failure Of Both Keowee Units		1.00E-06
842	KA127T1R6D	1	Xfrmr 1X UV Relay 27T/1X Fails To Pick-up		2.49E-04
843	KA127T1R6T	360	Xfrmr 1X UV Relay 27T/1X Spuriously De-energizes		1.31E-04
844	KA227T2R6T	360	Xfmr 2X UV Relay 27T/2x Spuriously De-energizes		1.31E-04
845	KB4CONNDEX	1.1E-7	Air Circuit Breaker 4 Connects Unit 2 To The Underground Path		1.10E-07
846	KK1BOTHDEX	0.0	Keowee Units 1 And 2 Are Supplying The Grid		0.00E+00
847	KK1BOTHHYM	5.23E-3	Both Keowee Units Unavailable Due To Common Maintenance		5.23E-03
848	KK1OVERBHF	24	Fault Occurs On The Overhead Power Path		9.60E-06
849	KK1RUNSDEX	0.0	Keowee Unit 1 Only Is Supplying The Grid		0.00E+00
850	KK1UNDRBHF	24	Fault Occurs On The Underground Power Path		9.60E-06
851	KK2RUNSDEX	0.06	Keowee Unit 2 Only Is Supplying The Grid		6.00E-02
852	KK2UNITHYM	3.80E-2	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-02
853	KU2CREDIT	0	Take No Credit For Keowee Unit 2 Suppling Auxiliary ac PowerTo Unit 1		0.00E+00
854	L0EGTPSCOM	1.78E-06	Common Cause Failure of UV And UF Detection Circuits		1.78E-06
855	L27BRX1RYD	1	Snsng Rly 27B/RX1 Fails to Drop Out on Undervoltage	OEE-76-3, -4	3.30E-05
856	L27BRX2RYD	1	Snsng Rly 27B/RX2 Fails to Drop Out on Undervoltage	OEE-76-3, -8	3.30E-05
857	L27BRY1RYD	1	Snsng Rly 27B/RY1 Fails to Drop Out on Undervoltage	OEE-76-3, -4	3.30E-05
858	L27BRY2RYD	1	Snsng Rly 27B/RY2 Fails to Drop Out on Undervoltage	OEE-76-3, -8	3.30E-05

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Basic Event Data for the Oconee-Keowee AC Power/Core Damage Models

	NAME	FACTOR	DESC		PROB
859	L27BRZ1RYD	1	Snsng Rly 27B/RZ1 Fails to Drop Out on Undervoltage	OEE-76-3, -4	3.30E-05
860	L27BRZ2RYD	1	Snsng Rly 27B/RZ2 Fails to Drop Out on Undervoltage	OEE-76-3, -8	3.30E-05
861	L27BYX1RYD	1	Snsng Rly 27B/YX1 Fails to Drop Out on Undervoltage	OEE-76-3, -4	3.30E-05
862	L27BYX2RYD	1	Snsng Rly 27B/YX2 Fails to Drop Out on Undervoltage	OEE-76-3, -8	3.30E-05
863	L27BYY1RYD	1	Snsng Rly 27B/YY1 Fails to Drop Out on Undervoltage	OEE-76-3, -4	3.30E-05
864	L27BYY2RYD	1	Snsng Rly 27B/YY2 Fails to Drop Out on Undervoltage	OEE-76-3, -8	3.30E-05
865	L27BYZ1RYD	1	Snsng Rly 27B/YZ1 Fails to Drop Out on Undervoltage	OEE-76-3, -4	3.30E-05
866	L27BYZ2RYD	1	Snsng Rly 27B/YZ2 Fails to Drop Out on Undervoltage	OEE-76-3, -8	3.30E-05
867	L27XPX1RYD	1	Ch 1 Phase X UV Aux. Relay Fails To Pick Up	OEE-76-4	3.30E-05
868	L27XPX2RYD	1	Ch 2 Phase X UV Aux. Relay Fails To Pick Up	OEE-76-8	3.30E-05
869	L27XPY1RYD	1	Ch 1 Phase Y UV Aux. Relay Fails to Pick Up	OEE-76-4	3.30E-05
870	L27XPY2RYD	1	Ch 2 Phase Y UV Aux. Relay Fails to Pick Up	OEE-76-8	3.30E-05
871	L27XPZ1RYD	1	Ch 1 Phase Z UV Aux. Relay Fails To Pick Up	OEE-76-4	3.30E-05
872	L27XPZ2RYD	1	Ch 2 Phase Z UV Aux. Relay Fails To Pick Up	OEE-76-8	3.30E-05
873	L27XRX1RYD	1	Red Bus Phase X1 Undervoltage Aux. Relay Fails To Pick Up	OEE-76-4	3.30E-05
874	L27XRX2RYD	1	Red Bus Phase X2 Undervoltage Aux. Relay Fails To Pick Up	OEE-76-8	3.30E-05
875	L27XRY1RYD	1	Red Bus Phase Y1 Undervoltage Aux. Relay Fails To Pick Up	OEE-76-4	3.30E-05
876	L27XRY2RYD	1	Red Bus Phase Y2 Undervoltage Aux. Relay Fails to Pick Up	OEE-76-8	3.30E-05
877	L27XRZ1RYD	1	Red Bus Phase Z1 Undervoltage Aux. Relay Fails To Pick Up	OEE-76-4	3.30E-05
878	L27XRZ2RYD	1	Red Bus Phase Z2 Undervoltage Aux. Relay Fails To Pick Up	OEE-76-8	3.30E-05
879	L27XSTARYD	1	Keowee Start Relay 27X/STA Fails To Pick Up		3.30E-05
880	L27XSTBRYD	1	Keowee Start Relay 27X/STB Fails To Pick Up		3.30E-05
881	L27XYX1RYD	1	Yellow Bus Phase X1 Undervoltage Aux. Relay Fails To Pick Up	OEE-76-4	3.30E-05
882	L27XYX2RYD	1	Yellow Bus Phase X2 Undervoltage Aux. Relay Fails To Pick Up	OEE-76-8	3.30E-05
883	L27XYY1RYD	1	Yellow Bus Phase Y1 Undervoltage Aux. Relay Fails To Pick Up	OEE-76-4	3.30E-05
884	L27XYY2RYD	1	Yellow Bus Phase Y2 Undervoltage Aux. Relay Fails to Pick Up	OEE-76-8	3.30E-05
885	L27XYZ1RYD	1	Yellow Bus Phase Z1 Undervoltage Aux. Relay Fails To Pick Up	OEE-76-4	3.30E-05
886	L27XYZ2RYD	1	Yellow Bus Phase Z2 Undervoltage Aux. Relay Fails to Pick Up	OEE-76-8	3.30E-05
887	L81BRX1RYD	1	Sensing Relay 81BL/RX1 Fails to Drop Out on Underfrequency		3.30E-05
888	L81BRX2RYD	1	Sensing Relay 81BL/RX2 Fails to Drop Out on Underfrequency		3.30E-05
889	L81BRY1RYD	1	Sensing Relay 81BL/RY1 Fails to Drop Out on Underfrequency		3.30E-05
890	L81BRY2RYD	1	Sensing Relay 81BL/RY2 Fails to Drop Out on Underfrequency		3.30E-05
891	L81BRZ1RYD	1	Sensing Relay 81BL/RZ1 Fails to Drop Out on Underfrequency		3.30E-05
892	L81BRZ2RYD	1	Sensing Relay 81BL/RZ2 Fails to Drop Out on Underfrequency		3.30E-05
893	L81BYX1RYD	1	Sensing Relay 81BL/YX1 Fails to Drop Out on Underfrequency		3.30E-05
894	L81BYX2RYD	1	Sensing Relay 81BL/YX2 Fails to Drop Out on Underfrequency		3.30E-05
895	L81BYY1RYD	1	Sensing Relay 81BL/YY1 Fails to Drop Out on Underfrequency		3.30E-05
896	L81BYY2RYD	1	Sensing Relay 81BL/YY2 Fails to Drop Out on Underfrequency		3.30E-05
897	L81BYZ1RYD	1	Sensing Relay 81BL/YZ1 Fails to Drop Out on Underfrequency		3.30E-05

Table D-3

Basic Event Data for the Oconee-Keowee AC Power/Core Damage Models

	NAME	FACTOR	DESC		PROB
898	L81BYZ2RYD	1	Sensing Relay 81BL/YZ2 Fails to Drop Out On Underfrequency		3.30E-05
899	L81XPX1RYD	1	Ch 1 Phase X Underfrequency Aux. Rly Fails to Pick Up		3.30E-05
900	L81XPX2RYD	1	Ch 2 Phase X Underfrequency Aux. Rly Fails to Pick Up		3.30E-05
901	L81XPY1RYD	1	Ch 1 Phase Y Underfrequency Aux. Rly Fails to Pick Up		3.30E-05
902	L81XPY2RYD	1	Ch 2 Phase Y Underfrequency Aux. Rly Fails to Pick Up		3.30E-05
903	L81XPZ1RYD	1	Ch 1 Phase Z Underfrequency Aux. Rly Fails to Pick Up		3.30E-05
904	L81XPZ2RYD	1	Ch 2 Phase Z Underfrequency Aux. Rly Fails to Pick up		3.30E-05
905	L81XRX1RYD	1	Red Bus Phase X1 Underfrequency Aux. Rly Fails to Pick Up		3.30E-05
906	L81XRX2RYD	1	Red Bus Phase X2 Underfrequency Aux. Rly Fails to Pick Up		3.30E-05
907	L81XRY1RYD	1	Red Bus Phase Y1 Underfrequency Aux. Rly Fails to Pick Up		3.30E-05
908	L81XRY2RYD	1	Red Bus Phase Y2 Underfrequency Aux. Rly Fails to Pick Up		3.30E-05
909	L81XRZ1RYD	1	Red Bus Phase Z1 Underfrequency Aux. Rly Fails to Pick Up		3.30E-05
910	L81XRZ2RYD	1	Red Bus Phase Z2 Underfrequency Aux. Rly Fails to Pick Up		3.30E-05
911	L81XYX1RYD	1	Yellow Bus Phase X1 Underfrequency Aux. Rly Fails to Pick Up		3.30E-05
912	L81XYX2RYD	1	Yellow Bus Phase X2 Underfrequency Aux. Rly Fails to Pick Up		3.30E-05
913	L81XYY1RYD	1	Yellow Bus Phase Y1 Underfrequency Aux. Rly Fails to Pick Up		3.30E-05
914	L81XYY2RYD	1	Yellow Bus Phase Y2 Underfrequency Aux. Rly Fails to Pick Up		3.30E-05
915	L81XYZ1RYD	1	Yellow Bus Phase Z1 Underfrequency Aux. Rly Fails to Pick Up		3.30E-05
916	L81XYZ2RYD	1	Yellow Bus Phase Z2 Underfrequency Aux. Rly Fails to Pick Up		3.30E-05
917	LC94F1ARYD	1	EGTPS Underfrequency Relay 94/F1A Fails to Pick Up		3.30E-05
918	LC94F1BRYD	1	EGTPS Underfrequency Relay 94/F1B Fails to Pick Up		3.30E-05
919	LC94F1DRYD	1	EGTPS Underfrequency Relay 94/F1D Fails to Pick Up		3.30E-05
920	LC94F2ARYD	1	EGTPS Underfrequency Relay 94/F2A Fails to Pick Up		3.30E-05
921	LC94F2BRYD	1	EGTPS Underfrequency Relay 94/F2B Fails to Pick Up		3.30E-05
922	LC94F2CRYD	1	EGTPS Underfrequency Relay 94/F2C Fails to Pick Up		3.30E-05
923	LC94F2DRYD	1	EGTPS Underfrequency Relay 94/F2D Fails to Pick Up		3.30E-05
924	LC94V1ARYD	1	EGTPS Undervoltage Relay 94/V1A Fails to Pick Up		3.30E-05
925	LC94V1BRYD	1	EGTPS Undervoltage Relay 94/V1B Fails To Pick Up	OEE-76-4	3.30E-05
926	LC94V1DRYD	1	EGTPS Undervoltage Relay 94/V1D Fails to Pick Up	OEE-76-4	3.30E-05
927	LC94V2ARYD	1	EGTPS Undervoltage Relay 94/V2A Fails to Pick Up		3.30E-05
928	LC94V2BRYD	1	EGTPS Undervoltage Relay 94/V2B Fails To Pick Up		3.30E-05
929	LC94V2CRYD	1	EGTPS Undervoltage Relay 94/V2C Fails to Pick Up		3.30E-05
930	LDCYC13CDT	24	Switchyard 125 Vdc Panelboard DYC Breaker 13 Transfers Open	OEE-76-4 / O-802	1.80E-06
931	LDCYC14CDT	24	Switchyard 125 Vdc Panelboard DYC Breaker 14 Transfers Open	OEE-76-4 / O-802	1.80E-06
932	LDCYG12CDT	24	Switchyard 125 Vdc Panelboard DYG Breaker 12 Transfers Open		1.80E-06
933	LDCYG18CDT	24	Switchyard 125 Vdc Panelboard DYG Breaker 18 Transfers Open		1.80E-06
934	NAC01BLCLT	46	SSF 600 V ac MCC 3XSF Breaker F01BL Transfers Open (3CCW-287)		1.00E-03
935	NAC01BRCLT	46	SSF 600 V ac MCC 3XSF Breaker F01BR Transfers Open (3CCW-268)		1.00E-03
936	NAC211ADEX	4.270E-04	Loss Of Power On Unit 2 600 V ac Load Center 2X11A		4.27E-04

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Basic Event Data for the Oconee-Keowee AC Power/Core Damage Models

	NAME	FACTOR	DESC	PROB
937	NAC385BCLT	36	600 V ac LC 3X8 Breaker 5B Transfers Open (Feed To 3XSF)	3.28E-05
938	NAC3X12CLC	1	SSF 208 V ac MCC 3XSF-1 Breaker 2A Fails To Close (3SF-97)	4.00E-04
939	NAC3X12CLT	24	SSF 208 V ac MCC 3XSF-1 Breaker 2A Transfers Open (3SF-97)	2.18E-05
940	NAC3X1ACLT	36	SSF 208 V ac MCC 3XSF Breaker 1A Transfers Open (From Xfmr. 3XSF)	3.28E-05
941	NAC3X1DCLT	46	SSF 208 V ac MCC 3XSF1 Breaker 1D Transfers Open (CCW-269)	1.00E-03
942	NAC3X1ZBLF	36	SSF 208 V ac MCC 3XSF-1 Bus Fails	9.72E-06
943	NAC3X2ACLC	1	SSF 600 V ac MCC 3XSF Breaker 2A Fails To Close (3SF-82)	4.00E-04
944	NAC3X2ACLT	24	SSF 600 V ac MCC 3XSF Breaker 2A Transfers Open (3SF-82)	2.18E-05
945	NAC3X2BCLT	36	SSF 208 V ac MCC 3XSF Breaker 2BL Transfers Open (To 3XSF-1)	3.28E-05
946	NAC3X2CCLC	1	SSF 600 V ac MCC 3XSF Breaker 2C Fails To Close (3HP-398)	4.00E-04
947	NAC3X2CCLT	24	SSF 600 V ac MCC 3XSF Breaker 2C Transfers Open (3HP-398)	2.18E-05
948	NAC3X2VBLF	36	SSF 208 V ac MCC 3XSF Bus Fails	9.72E-06
949	NAC3X3ACLC	1	SSF 600 V ac MCC 3XSF Breaker 3A Fails To Close (From OXSF)	4.00E-04
950	NAC3X3ACLT	24	600 V ac SSF MCC 3XSF Breaker 3A Transfers Open (From OXSF)	2.18E-05
951	NAC3X4ACLT	36	SSF 600 V ac MCC 3XSF Breaker 4A Transfers Open (To Xfmr. 3XSF)	3.28E-05
952	NAC3X4CCLC	1	SSF 600 V ac MCC 3XSF Breaker 4C Fails To Close (RCM Pump)	4.00E-04
953	NAC3X4CCLT	24	SSF 600 V ac MCC 3XSF Breaker 4C Transfers Open (RCM Pump)	2.18E-05
954	NAC3X5ACLT	36	SSF 600 V ac MCC 3XSF Breaker 5A Transfers Open (From 3X8)	3.28E-05
955	NAC3XSFBLF	36	600 V ac SSF MCC 3XSF Bus Fails	9.72E-06
956	NAC3XSFBLM	1	600 V ac SSF MCC 3XSF Bus Is In Maintenance	3.94E-07
957	NAC3XSFTLF	36	SSF Transformer 3XSF Fails	2.70E-05
958	NACDJ01HXF	16	Diesel Jacket Heat Exchanger 1 Fails	2.46E-04
959	NACDJ02HXF	16	Diesel Jacket Heat Exchanger 2 Fails	2.46E-04
960	NACDJPUGPR	24	Diesel Service Water Pump Fails To Run	3.36E-04
961	NACDJPUGPS	1	Diesel Service Water Pump Fails To Start	9.70E-05
962	NACFO4BCLT	46	600 V ac SSF MCC XSF Breaker FO4B Transfers Open	1.00E-03
963	NACFO7CCLC	1	SSF 600 V ac MCC XSF Breaker FO7C Fails To Close (DSW Pump)	4.00E-04
964	NACFO7CCLT	24	SSF 600 V ac MCC XSF Breaker FO7C Transfers Open (DSW Pump)	2.18E-05
965	NACLC38DEX	4.270E-04	Loss Of Power On 600 V ac LC 3X8	4.27E-04
966	NACMFB2DEX	4.830E-03	Loss Of Power On Unit 2 Main Feeder Bus	4.83E-03
967	NACO5BLCLT	36	600 V ac SSF MCC XSF Breaker FO5BL Transfers Open	3.28E-05
968	NACOTS1BHF	36	SSF 4160 V ac Switchgear OTS1 Bus Fails	1.44E-05
969	NACOTS1BHM	1	4160 V ac SSF Switchgear OTS1 Is In Maintenance	1.39E-05
970	NACOTS1C4T	36	4160 V ac Switchgear OTS1 Breaker 1 Transfers Open (MFB U2)	3.38E-05
971	NACOTS1T4F	36	SSF Transformer OTS1 Fails	3.60E-06
972	NACOTS2C4C	1	4160 V ac SSF Switchgear OTS1 Breaker 2 Fails To Close (SSF ASW Pump)	3.00E-04
973	NACOTS2C4T	24	4160 V ac SSF Switchgear OTS1 Breaker 2 Transfers Open (SSF ASW Pump)	2.26E-05
974	NACOTS3C4T	36	SSF 4160 V ac Switchgear OTS1 Breaker 3 Transfers Open (To Xfmr. OXSF)	3.38E-05
975	NACOTS4C4C	1	4160 V ac Switchgear OTS1 Breaker 4 Fails To Close (From Diesel)	3.00E-04

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Basic Event Data for the Oconee-Keowee AC Power/Core Damage Models

	NAME	FACTOR	DESC	PROB
976	NACOTS4C4T	24	4160 V ac Switchgear OTS1 Breaker 4 Transfers Open (From Diesel)	2.26E-05
977	NACOX4BCLT	36	600 V ac SSF LC OXSF Breaker 4B Transfers Open (From Xfmr. OXSF)	3.28E-05
978	NACOX4CCLT	24	SSF 600 V ac LC OXSF Breaker 4C Transfers Open (To XSF)	2.18E-05
979	NACOX5CCLT	24	SSF 600 V ac LC OXSF Breaker 5C Transfers Open (Feed To 3XSF)	2.18E-05
980	NACOXSFBLF	36	SSF 600 V ac LC OXSF Bus Fails	9.72E-06
981	NACSFDGDGM	3.500E-02	SSF Diesel Generator Is In Maintenance	3.50E-02
982	NACSFDGDGR	24	SSF Diesel Generator Fails To Run	7.20E-02
983	NACSFDGDGS	1	SSF Diesel Generator Fails To Start	1.20E-02
984	NACSFDGLHE	3.000E-03	SSF Diesel Generator Is Left Unavailable After Test Or Maintenance	3.00E-03
985	NACXS6ACLC	1	SSF 600 V ac MCC XSF Breaker 6A Fails To Close (From OXSF)	4.00E-04
986	NACXS6ACLT	24	SSF 600 V ac MCC XSF Breaker 6A Transfers Open (From OXSF)	2.18E-05
987	NACXS8ACLT	36	600 V ac SSF MCC XSF Breaker 8A Transfers Open (From 2X11A)	3.28E-05
988	NACXSFZBLF	36	600 V ac SSF MCC XSF Bus Fails	9.72E-06
989	NACXSFZBLM	1	600 V ac SSF MCC XSF Bus In Maintenance	3.94E-07
990	NCW0125VVT	15	Manual Valve CCW-125 Transfers Closed	2.23E-03
991	NCW0266VVT	16	Manual Valve CCW-266 Transfers Closed	6.53E-06
992	NCW0268MVO	1	MOV 3CCW-268 Fails To Open On Demand	4.00E-03
993	NCW0268MVT	24	MOV 3CCW-268 Transfers Closed After Opening	3.12E-06
994	NCW0269MVO	1	MOV CCW-269 Fails To Open	4.00E-03
995	NCW0274CVO	1	Check Valve CCW-274 Fails To Open	2.30E-06
996	NCW0276VVT	24	Manual Valve CCW-276 Transfers Closed	4.08E-07
997	NCW0277AVT	24	Flow Control Valve CCW-277 Transfers Closed	5.52E-05
998	NCW0278VVT	24	Manual Valve CCW-278 Transfers Closed	4.08E-07
999	NCW0279VVT	24	Manual Valve CCW-279 Transfers Closed	4.08E-07
1000	NCW0280AVT	24	Flow Control Valve CCW-280 Transfers Closed	5.52E-05
1001	NCW0281VVT	24	Manual Valve CCW-281 Transfers Closed	4.08E-07
1002	NCW0282VVT	24	Manual Valve CCW-282 Transfers Closed	4.08E-07
1003	NCW0283VVT	16	Manual Valve CCW-283 Transfers Closed	6.53E-06
1004	NCW0284CVO	1	Check Valve CCW-284 Fails To Open	2.30E-06
1005	NCW0284CVT	24	Check Valve CCW-284 Transfers Closed After Opening	3.12E-06
1006	NCW0285VVT	16	Manual Valve CCW-285 Transfers Closed	6.53E-06
1007	NCW0287MVO	1	MOV 3CCW-287 Fails To Open On Demand	4.00E-03
1008	NCW0287MVT	24	MOV 3CCW-287 Transfers Closed After Opening	3.12E-06
1009	NCW0289CVO	1	Check Valve CCW-289 Fails To Open	2.30E-06
1010	NCW0289CVT	24	Check Valve CCW-289 Transfers Closed	3.12E-06
1011	NCW0292VVT	46	Manual Valve CCW-292 Transfers Closed	1.88E-05
1012	NCW0343VVT	46	Manual Valve CCW-343 Transfers Closed	1.88E-05
1013	NCW0384VVT	24	Manual Valve CCW-384 Transfers Closed After Opening	4.08E-07
1014	NCWFL01FLF	36	SSF HVAC Service Water Filter Fl-1 Clogs	7.20E-05

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Basic Event Data for the Oconee-Keowee AC Power/Core Damage Models

	NAME	FACTOR	DESC	PROB
1015	NCWPMP1GPR	24	HVAC Service Water Pump 1 Fails To Run	3.36E-04
1016	NCWPMP2GPR	24	HVAC Service Water Pump 2 Fails To Run	3.36E-04
1017	NCWPMP2GPS	1	HVAC Service Water Pump 2 Fails To Start	9.70E-05
1018	NCWSUBPDHE	1.000E-02	Operators Fail To Refill CCW Inlet Line With Portable Pump	1.00E-02
1019	NDCDCSFBYF	1	Battery DCSF Fails	9.30E-04
1020	NDCSF3BCDT	36	Battery DCSF Breaker 3B Transfers Open (To Dist. Center)	2.70E-06
1021	NDCSF4ACDT	36	125 V dc SSF Dist. Center DCSF Breaker 4A Transfers Open (Feed From CSF)	2.70E-06
1022	NDCSF4BCDT	16	125 V dc Distribution Center DCSF Breaker 4B Transfers Open	2.88E-05
1023	NDCSF5CCDT	36	SSF 125 V dc Dist. Center DCSF Breaker 5CR Transfers Open (To OTS1)	2.70E-06
1024	NDCSF5LCDT	36	SSF 125 V dc Dist. Center DCSF Breaker 5CL Transfers Open (To OXSF)	2.70E-06
1025	NDCSFZZBDF	36	125 V dc SSF Distribution Center DCSF Bus Fails	1.15E-05
1026	NDCSFZZBDM	1	125 V dc SSF Distribution Center DCSF Is In Maintenance	3.94E-07
1027	NHP3398MVO	1	Motor-Operated Valve 3HP-398 Fails To Open	4.00E-03
1028	NHP3398MVT	24	Motor-Operated Valve 3HP-398 Transfers Closed After Opening	3.12E-06
1029	NHP3399CVO	1	Check Valve 3HP-399 Fails To Open	2.30E-06
1030	NHP3399CVT	24	Check Valve 3HP-399 Transfers Closed	3.12E-06
1031	NHP3400CVO	1	Check Valve 3HP-400 Fails To Open	2.30E-06
1032	NHP3400CVT	24	Check Valve 3HP-400 Transfers Closed	3.12E-06
1033	NHP3401CVO	1	Check Valve 3HP-401 Fails To Open	2.30E-06
1034	NHP3401CVT	24	Check Valve 3HP-401 Transfers Closed	3.12E-06
1035	NHP3402CVO	1	Check Valve 3HP-402 Fails To Open	2.30E-06
1036	NHP3402CVT	24	Check Valve 3HP-402 Transfers Closed	3.12E-06
1037	NHP3404RVT	24	Relief Valve 3HP-404 Transfers Open	1.34E-04
1038	NMF0232CVO	1	Check Valve 3FDW-232 Fails To Open On Demand	2.30E-06
1039	NMF0233CVO	1	Check Valve 3FDW-233 Fails To Open On Demand	2.30E-06
1040	NMF0346CVO	1	Check Valve FDW-346 Fails To Open	2.30E-06
1041	NMF0346CVT	24	Check Valve 3FDW-346 Transfers Closed	3.12E-06
1042	NMF0347MVO	1	MOV 3FDW-347 Fails To Open After Being Throttled	4.00E-03
1043	NMF0442CVO	1	Check Valve 3FDW-442 Fails To Open	2.30E-06
1044	NMF0442CVT	24	Check Valve 3FDW-442 Transfers Closed	3.12E-06
1045	NSF0ASWDHE	1.000E-01	Operators Fail To Align The SSF ASW System For Operation	1.00E-01
1046	NSF0RCMDHE	1.000E-01	Operators Fail To Align The SSF RCM System For Operation	1.00E-01
1047	NSF3082MVO	1	Motor-Operated Valve 3SF-82 Fails To Open	4.00E-03
1048	NSF3082MVT	24	Motor-Operated Valve 3SF-82 Transfers Closed After Opening	3.12E-06
1049	NSF3097MVO	1	Motor-Operated Valve 3SF-97 Fails To Open	4.00E-03
1050	NSF3097MVT	24	Motor-Operated Valve 3SF-97 Transfers Closed After Opening	3.12E-06
1051	NSF3101VVT	46	Manual Valve 3SF-101 Transfers Closed	1.88E-05
1052	NSF3F01FLF	46	SSF Unit 3 RCM Filter SSF-SF1 Clogs	2.21E-03
1053	NSF3FL2FLF	46	Unit 3 SSF Reactor Coolant Makeup Y Strainer Clogs	2.21E-03

Table D-3

Basic Event Data for the Oconee-Keowee AC Power/Core Damage Models

	NAME	FACTOR	DESC	PROB
1054	NSF3PU1DPR	24	Unit 3 SSF RCM Pump Fails To Run	5.90E-04
1055	NSF3PU1DPS	1	Unit 3 SSF RCM Pump Fails To Start	1.90E-03
1056	NSF3PU1TRM	1.000E-04	SSF Unit 3 RCM Pump Train Is In Maintenance	1.00E-04
1057	NSFAHU0FLF	24	HVAC Air Handling Unit Filter Fails	4.80E-05
1058	NSFAHUCHXF	24	HVAC Air Handling Unit Cooling Coils Fail	1.54E-05
1059	NSFAHUFFNR	24	HVAC Air Handling Unit Fan Fails To Run	2.40E-04
1060	NSFASWZLHE	3.000E-03	SSF ASW System Left Unavailable After Test Or Maintenance	3.00E-03
1061	NSFCON1CMR	24	Train 1 Refrigerant Compressor Fails To Run	2.40E-03
1062	NSFCON1HXF	24	Train 1 Refrigerant Condenser Fails	1.54E-05
1063	NSFCON2CMR	24	Train 2 Refrigerant Compressor Fails To Run	2.40E-03
1064	NSFCON2CMS	1	Train 2 Refrigerant Compressor Fails To Start	1.00E-02
1065	NSFCON2HXF	24	Train 2 Refrigerant Condenser Fails	1.54E-05
1066	NSFPU02GPR	24	SSF ASW Pump Fails To Run	3.36E-04
1067	NSFPU02GPS	1	SSF ASW Pump Fails To Start On Demand	9.70E-05
1068	NSFPU02TRM	6.70E-03	SSF ASW Pump Train Is In Maintenance	6.70E-03
1069	NSFRCMULHE	3.000E-03	SSF RCM System Is Left Unavailable After Test Or Maintenance	3.00E-03
1070	NSFSSF0REC	1	SSF Module	1.00E+00
1071	NSFSSF6REC	1	SSF Module	1.00E+00
1072	NSFTIMEDHE	1.00E-02	Operators Fail To Deploy To The Standby Shutdown Facility In Time	1.00E-02
1073	OFACTORDEX	1.0	Overload Susceptibility Factor	1.00E+00
1074	OK0PRUNCOM	1.46E-05	Common Cause Failure Of Both Governor Oil Systems To Run	1.46E-05
1075	OK10001PSC	15	Pressure Switch 1OGPS-1 Fails to Close (Normal Control Signal)	4.35E-05
1076	OK10002PSC	8	Pressure Switch 1OGPS-2 Fails to Close	2.32E-05
1077	OK10003PSC	4	Pressure Switch 1OGPS-3 Fails to Close	1.16E-05
1078	OK10003RVT	24	Safety Relief Valve 1OG-3 Spurious Operation	1.34E-04
1079	OK10003TKF	24	Unit 1 Governor Oil Pressure Tank Fails	1.10E-05
1080	OK10004PSC	1	Pressure Switch 1OGPS-4 Fails to Close	2.90E-06
1081	OK10007FVT	24	Float Valve 1OG-7 Transfers Closed	1.40E-04
1082	OK10009VVT	24	Manual Valve 1OG-9 Transfers Closed	4.08E-07
1083	OK10011CVO	15	Check Valve 1OG-11 Fails to Open	3.45E-05
1084	OK10011CVT	0.75	Check Valve 1OG-11 Transfers Closed	9.75E-08
1085	OK10012VVT	30	Manual Globe Valve 1OG-12 Transfers Closed	5.10E-07
1086	OK10013RVT	0.75	Relief Valve 1OG-13 Spurious Operation	4.20E-06
1087	OK10014CVO	8	Check Valve 1OG-14 Fails to Open	1.84E-05
1088	OK10014CVT	0.5	Check Valve 1OG-14 Transfers Closed	6.50E-08
1089	OK10015VVT	192	Manual Globe Valve 1OG-15 Transfers Closed	3.26E-06
1090	OK10016RVT	0.5	Relief Valve 1OG-16 Transfers Open	2.80E-06
1091	OK10017CVO	4	Check Valve 1OG-17 Fails to Open	9.20E-06
1092	OK10017CVT	0.25	Check Valve 1OG-17 Transfers Closed	3.25E-08

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Basic Event Data for the Oconee-Keowee AC Power/Core Damage Models

	NAME	FACTOR	DESC	PROB
1093	OK10018VVT	108	Manual Globe Valve 1OG-18 Transfers Closed	1.84E-06
1094	OK10019RVT	0.25	Relief Valve 1OG-19 Spurious Operation	1.40E-06
1095	OK1001AGPR	0.375	OG Pump 1A Fails to Run	5.25E-06
1096	OK1001AGPS	15	OG Pump 1A Fails to Start	1.45E-03
1097	OK1001BGPR	0.25	OG Pump 1B Fails to Run	3.50E-06
1098	OK1001BGPS	8	OG Pump 1B Fails to Start	7.76E-04
1099	OK1001BLHE	3.2E-3	Latent Human Error Fails OG Pump 1B	3.20E-03
1100	OK1001CGPR	0.125	OG Pump 1C Fails to Run	1.75E-06
1101	OK1001CGPS	4	OG Pump 1C Fails to Start	3.88E-04
1102	OK1001CLHE	3.2E-3	Latent Human Error Fails OG Pump 1C	3.20E-03
1103	OK188GASWT	30	Keowee 1 Governor Oil Control Switch 188GA Spurious Operation	2.10E-06
1104	OK188GBSWT	192	Keowee 1 Control Switch 188GB Spurious Operation	1.34E-05
1105	OK188GCSWT	108	Keowee 1 Control Switch 188GC Spurious Operation	7.56E-06
1106	OK199K1RYD	1	Keowee 1 Relay 99K1 Fails To Operate On Demand	3.30E-05
1107	OK199K1RYT	24	Keowee Unit 1 Relay 99K1 Spurious Operation	8.64E-06
1108	OK199K2RYD	1	Keowee 1 Relay 99K2 Fails To Operate On Demand	3.30E-05
1109	OK1AG01TKF	24	Air Receiver Tank 1AGTK-1 Fails	1.10E-05
1110	OK1AG04RVT	24	Safety Relief Valve 1AG-4 Spurious Operation	1.34E-04
1111	OK1AG05VVT	24	Manual Valve 1AG-5 Transfers Position	4.08E-07
1112	OK1OG1CTRM	3.42E-3	OG Pump 1C Train In Maintenance Or Testing	3.42E-03
1113	OK1PRUNCOM	1.12E-07	Common Cause Failure of Unit 1 OG Pumps to Run	1.12E-07
1114	OK1PSTRCOM	2.04E-05	Common Cause Failure of Unit 1 OG Pumps to Start	2.04E-05
1115	OK1XA1DCLT	30	Low Voltage Circuit Breaker 1XA-1D Transfers Position	2.73E-05
1116	OK1XA2ECLT	30	Low Voltage Circuit Breaker 1XA-2E Transfers Position	2.73E-05
1117	OK1XA4DCLT	30	Low Voltage Circuit Breaker 1XA-4D Transfers Position	2.73E-05
1118	OK20001PSC	15	Pressure Switch 2OGPS-1 Fails to Close (Normal Control Signal)	4.35E-05
1119	OK20002PSC	8	Pressure Switch 2OGPS-2 Fails to Close	2.32E-05
1120	OK20003PSC	4	Pressure Switch 2OGPS-3 Fails to Close	1.16E-05
1121	OK20003RVT	24	Safety Relief Valve 2OG-3 Spurious Operation	1.34E-04
1122	OK20003TKF	24	Unit 2 Governor Oil Pressure Tank Fails	1.10E-05
1123	OK20004PSC	1	Pressure Switch 2OGPS-4 Fails to Close	2.90E-06
1124	OK20007FVT	24	Float Valve 2OG-7 Transfers Closed	1.40E-04
1125	OK20009VVT	24	Manual Valve 2OG-9 Transfers Closed	4.08E-07
1126	OK20011CVO	15	Check Valve 2OG-11 Fails to Open	3.45E-05
1127	OK20011CVT	0.75	Check Valve 2OG-11 Transfers Closed	9.75E-08
1128	OK20012VVT	30	Manual Globe Valve 2OG-12 Transfers Closed	5.10E-07
1129	OK20013RVT	0.75	Relief Valve 2OG-13 Spurious Operation	4.20E-06
1130	OK20014CVO	8	Check Valve 2OG-14 Fails to Open	1.84E-05
1131	OK20014CVT	0.5	Check Valve 2OG-14 Transfers Closed	6.50E-08

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Basic Event Data for the Oconee-Keowee AC Power/Core Damage Models

	NAME	FACTOR	DESC	PROB
1132	OK20015VVT	192	Manual Globe Valve 2OG-15 Transfers Closed	3.26E-06
1133	OK20016RVT	0.5	Relief Valve 2OG-16 Transfers Open	2.80E-06
1134	OK20017CVO	4	Check Valve 2OG-17 Fails to Open	9.20E-06
1135	OK20017CVT	0.25	Check Valve 2OG-17 Transfers Closed	3.25E-08
1136	OK20018VVT	108	Manual Globe Valve 2OG-18 Transfers Closed	1.84E-06
1137	OK20019RVT	0.25	Relief Valve 2OG-19 Spurious Operation	1.40E-06
1138	OK2002AGPR	0.375	OG Pump 2A Fails to Run	5.25E-06
1139	OK2002AGPS	15	OG Pump 2A Fails to Start	1.45E-03
1140	OK2002BGPR	0.25	OG Pump 2B Fails to Run	3.50E-06
1141	OK2002BGPS	8	OG Pump 2B Fails to Start	7.76E-04
1142	OK2002BLHE	3.2E-3	Latent Human Error Fails OG Pump 2B	3.20E-03
1143	OK2002CGPR	0.125	OG Pump 2C Fails to Run	1.75E-06
1144	OK2002CGPS	4	OG Pump 2C Fails to Start	3.88E-04
1145	OK2002CLHE	3.2E-3	Latent Human Error Fails OG Pump 2C	3.20E-03
1146	OK288GASWT	30	Keowee 2 Governor Oil Control Switch 188GA Spurious Operation	2.10E-06
1147	OK288GBSWT	192	Keowee 2 Control Switch 188GB Spurious Operation	1.34E-05
1148	OK288GCSWT	108	Keowee 2 Control Switch 188GC Spurious Operation	7.56E-06
1149	OK299K1RYD	1	Keowee 2 Relay 99K1 Fails To Operate On Demand	3.30E-05
1150	OK299K1RYT	24	Keowee Unit 2 Relay 99K1 Spurious Operation	8.64E-06
1151	OK299K2RYD	1	Relay 99K2 Fails To Operate On Demand	3.30E-05
1152	OK2AG04RVT	24	Safety Relief Valve 2AG-4 Spurious Operation	1.34E-04
1153	OK2AG05VVT	24	Manual Valve 2AG-5 Transfers Position	4.08E-07
1154	OK2AG01TKF	24	Air Receiver Tank 2AGTK-1 Fails	1.10E-05
1155	OK2OG2CTRM	3.42E-3	OG Pump 2C Train In Maintenance Or Testing	3.42E-03
1156	OK2PRUNCOM	1.12E-07	Common Cause Failure of Unit 2 OG Pumps to Run	1.12E-07
1157	OK2PSTRCOM	2.04E-05	Common Cause Failure of Unit 2 OG Pumps to Start	2.04E-05
1158	OK2XA1DCLT	30	Low Voltage Circuit Breaker 2XA-1D Transfers Position	2.73E-05
1159	OK2XA2ECLT	30	Low Voltage Circuit Breaker 2XA-2E Transfers Position	2.73E-05
1160	OK2XA4DCLT	30	Low Voltage Circuit Breaker 2XA-4D Transfers Position	2.73E-05
1161	OMOD	1	Startup Bus UV Sensing Mod Is In Service	1.00E+00
1162	P2C3XAA	0.000E+00	Loss Of Power From 208 V ac Motor Control Center 3XAA	0.00E+00
1163	P2C3XC	0.000E+00	Loss Of Power From 208 V ac Motor Control Center 3XC	0.00E+00
1164	P2C3XGA	0.000E+00	Loss Of Power From 208 V ac Motor Control Center 3XGA	0.00E+00
1165	P2C3XGB	0.000E+00	Loss Of Power From 208 V ac Motor Control Center 3XGB	0.00E+00
1166	P2C3XS3	0.000E+00	Loss Of Power From 208 V ac Motor Control Center 3XS3	0.00E+00
1167	PAC0T5WDEX	1.00E-01	Modifier Since Keowee Maintenance Is Scheduled For Mild Weather Periods	1.00E-01
1168	PAC1TC4C4T	24	4160 Vac Breaker 1TC-4 Transfers Open	2.26E-05
1169	PACE1CSMOD	3.800E-03	Breaker E1 Closing Circuit Fails	3.80E-03
1170	PACE1E2COM	8.900E-05	Common Cause Failure Of Breakers E1 And E2 To Close	8.90E-05

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Basic Event Data for the Oconee-Keowee AC Power/Core Damage Models

	NAME	FACTOR	DESC	PROB
1171	PACE2CSMOD	3.800E-03	Breaker E2 Closing Circuit Fails	3.80E-03
1172	PACLEE1REC	1.0e-02	Operators Fail To Align Power From Lee Steam Station To Standby Buses	1.00E-02
1173	PACLEE2REC	5.0e-02	Operators Fail To Align Power From Lee Steam Station To Standby Buses	5.00E-02
1174	PACLEESCTR	24	Lee Steam Station Combustion Turbines Fail To Run For The Required Time	2.23E-03
1175	PACLINEDEX	7.800E-03	100 kV ac Overhead Line From Lee Steam Station To CT5 Fails	7.80E-03
1176	PACMFB1BHF	24	Main Feeder Bus 1 Local Bus Fault	9.60E-06
1177	PACMFB1BHM	1	Main Feeder Bus 1 Is In Maintenance	1.39E-05
1178	PACMFB2BHF	24	Main Feeder Bus 2 Local Bus Fault	9.60E-06
1179	PACMFB2BHM	1	Main Feeder Bus 2 Is In Maintenance	1.39E-05
1180	PACN1N2COM	3.000E-05	Common Cause Failure Of Breakers N1 And N2 To Open	3.00E-05
1181	PACN1N2REC	5.0e-02	Operators Fail To Open Breakers N1 and N2 Within 40 Minutes	5.00E-02
1182	PACS1CSMOD	2.833E-03	S1 Closing Circuit Components Fail	2.83E-03
1183	PACS1S2COM	8.900E-05	Common Cause Failure Of Breakers S1 And S2 To Close	8.90E-05
1184	PACS1S2REC	5.0e-02	Operators Fail To Close Breakers S1 and S2 Within 40 Minutes	5.00E-02
1185	PACS2CSMOD	2.833E-03	S2 Closing Circuit Components Fail	2.83E-03
1186	PACSBY1BHF	24	Standby Bus 1 Fails	9.60E-06
1187	PACSBY2BHF	24	Standby Bus 2 Fails	9.60E-06
1188	PACSK12COM	8.900E-05	Common Cause Failure Of Breakers SK1 And SK2 To Close	8.90E-05
1189	PACSK12REC	5.0e-02	Operators Fail To Close Breakers SK1 and SK2 Within 40 Minutes	5.00E-02
1190	PACSK1CMOD	1.303E-03	Breaker SK1 Closing Circuit Component Failure	1.30E-03
1191	PACSK2CMOD	1.303E-03	Breaker SK2 Closing Circuit Component Failure	1.30E-03
1192	PACSTRTBHF	24	Startup Bus Fails	9.60E-06
1193	PACTC01C4T	24	4160 Vac Breaker 1TC-1 Transfers Open	2.26E-05
1194	PACTC14C4T	24	4160 Vac Breaker 1TC-14 Transfers Open	2.26E-05
1195	PACX1TCBHF	24	4160 Vac Switchgear 1TC Fails	9.60E-06
1196	PACXCT5THF	24	Transformer CT5 Fails	7.44E-05
1197	PACXE01C4C	1	Breaker E1 Fails To Close	3.00E-04
1198	PACXE02C4C	1	Breaker E2 Fails To Close	3.00E-04
1199	PACXN01C4O	1	4160 V ac Breaker N1 Fails To Open	3.00E-04
1200	PACXN02C4O	1	4160 V ac Breaker N2 Fails To Open	3.00E-04
1201	PACXS01C4C	1	Breaker S1 Fails To Close	3.00E-04
1202	PACXS02C4C	1	Breaker S2 Fails To Close	3.00E-04
1203	PACXSB1BHM	1.020E-03	Standby Bus 1 Is In Maintenance	1.02E-03
1204	PACXSB2BHM	1.020E-03	Standby Bus 2 Is In Maintenance	1.02E-03
1205	PACXSK1C4C	1	4160 V ac Breaker SK1 Fails To Close	3.00E-04
1206	PACXSK2C4C	1	4160 V ac Breaker SK2 Fails To Close	3.00E-04
1207	PACXSL1C4T	24	4160 V ac Standby Breaker SL1 Transfers Open	2.26E-05
1208	PACXSL2C4T	24	4160 V ac Standby Breaker SL2 Transfers Open	2.26E-05
1209	PDC1C25CDT	24	Breaker 1DIC-25 Transfers Open	1.80E-06

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Basic Event Data for the Oconee-Keowee AC Power/Core Damage Models

	NAME	FACTOR	DESC	PROB
1210	PDC1D27CDT	24	Breaker 1DID-27 Transfers Open	1.80E-06
1211	PDCA026CDT	24	Breaker 3DIA-26 Transfers Open	1.80E-06
1212	PDCC027CDT	24	Breaker 3DIC-27 Transfers Open	1.80E-06
1213	PK0SUMPCOM	2.44E-06	Common Cause Failure Of Turbine Sump Pump System	2.44E-06
1214	PK163SALST	30	Unit 1 AC Turbine Sump Pump Float Switch 63SA Fails	9.30E-06
1215	PK163SBLST	15	Unit 1 DC Turbine Sump Pump Float Switch 63SB Transfers	4.65E-06
1216	PK1ACDCCOM	2.77E-05	Common Cause Failure of Unit 1 Turbine Sump Pump System	2.77E-05
1217	PK1DA5CCDT	24	125 Vdc Circuit Breaker 1DA-5C Transfers Position	1.80E-06
1218	PK1PACKDEX	3.1E-5	Turbine No. 1 Packing Fails	3.10E-05
1219	PK1TS01VVT	30	Manual Valve 1TS-1 Transfers Position	5.10E-07
1220	PK1TS02CVT	30	Check Valve 1TS-2 Fails to Open or Transfers Closed	3.90E-06
1221	PK1TS03VVT	108	Manual Valve 1TS-3 Transfers Position	1.84E-06
1222	PK1TS04CVT	15	Check Valve 1TS-4 Fails to Open or Transfers Closed	1.95E-06
1223	PK1TSACGPR	30	AC Sump Pump 1TSPU-1 Fails To Start Or Run	4.20E-04
1224	PK1TSDCGPR	15	DC Sump Pump 1TSPU-2 Fails To Start Or Run	2.10E-04
1225	PK1TSDCLHE	3.2E-3	Latent Human Error Fails Turbine No. 1 DC Sump Pump	3.20E-03
1226	PK1TSDCTRM	6.85E-4	Turbine No. 1 DC Pump Train In Maintenance Or Testing	6.85E-04
1227	PK1XA2CCLT	30	600 V Circuit Breaker 1XA-2C Transfers Position	2.73E-05
1228	PK263SALST	30	Unit 2 AC Turbine Sump Pump Float Switch 63SA Fails	9.30E-06
1229	PK263SBLST	15	Unit 2 DC Turbine Sump Pump Float Switch 63SB Transfers	4.65E-06
1230	PK2ACDCCOM	2.77E-05	Common Cause Failure of Unit 2 Turbine Sump Pump System	2.77E-05
1231	PK2DA1CCDT	24	125 Vdc Circuit Breaker 2DA-1C Transfers Position	1.80E-06
1232	PK2PACKDEX	3.1E-5	Turbine No. 2 Packing Fails	3.10E-05
1233	PK2TS01VVT	30	Manual Valve 2TS-1 Transfers Position	5.10E-07
1234	PK2TS02CVT	30	Check Valve 2TS-2 Fails to Open or Transfers Closed	3.90E-06
1235	PK2TS03VVT	108	Manual Valve 2TS-3 Transfers Position	1.84E-06
1236	PK2TS04CVT	15	Check Valve 2TS-4 Fails to Open or Transfers Closed	1.95E-06
1237	PK2TSACGPR	30	AC Sump Pump 2TSPU-1 Fails To Start Or Run	4.20E-04
1238	PK2TSDCGPR	15	DC Sump Pump 2TSPU-2 Fails To Start Or Run	2.10E-04
1239	PK2TSDCLHE	3.2E-3	Latent Human Error Fails Turbine No. 2 DC Sump Pump	3.20E-03
1240	PK2TSDCTRM	6.85E-4	Turbine No. 2 DC Pump Train In Maintenance Or Testing	6.85E-04
1241	PK2XA2CCLT	30	Low Voltage Circuit Breaker 2XA-2C Transfers Position	2.73E-05
1242	S127E1VRYT	9	Unit 1 Startup Bus Undervoltage Relay 27E1 Fails	2.33E-03
1243	S127EUVRYT	9	Unit 1 Startup Bus Undervoltage Relay 27E Fails	2.33E-03
1244	S127EX1RYD	1	Unit 1 Startup Bus UV Aux Relay 27EX1 Fails to Pick Up	3.30E-05
1245	S127EXVRYD	1	Unit 1 Startup Bus UV Aux Relay 27EX Fails to Pick Up	3.30E-05
1246	S227E1VRYT	9	Unit 2 Startup Bus Undervoltage Relay 27E1 Fails	2.33E-03
1247	S227EUVRYT	9	Unit 2 Startup Bus Undervoltage Relay 27E Fails	2.33E-03
1248	S227EX1RYD	1	Unit 2 Startup Bus UV Aux Relay 27EX1 Fails to Pick Up	3.30E-05

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Basic Event Data for the Oconee-Keowee AC Power/Core Damage Models

	NAME	FACTOR	DESC		PROB
1249	S227EXVRYD	1	Unit 2 Startup Bus UV Aux Relay 27EX Fails to Pick Up		3.30E-05
1250	S27XSC1RYD	1	Channel 1 Swyd Isolated Rly, 27X/SC1, Fails to Pick Up		3.30E-05
1251	S27XSC2RYD	1	Channel 2 Swyd Isolated Rly, 27X/SC2, Fails to Pick Up		3.30E-05
1252	S27XTD1RYD	1	Channel 1 Swyd Isolated Time Delay Rly, 27XTD/SC1, Fails		3.30E-05
1253	S27XTD2RYD	1	Channel 2 Swyd Isolated Time Delay Rly, 27XTD/SC2, Fails		3.30E-05
1254	S327E1VRYT	9	Unit 3 Startup Bus Undervoltage Trip Relay 27E1 Fails		2.33E-03
1255	S327EUVRYT	9	Unit 3 Startup Bus Undervoltage Trip Relay 27E Fails		2.33E-03
1256	S327EX1RYD	1	Unit 3 Standby Bus UV Aux Relay 27EX1 Fails to Pick Up		3.30E-05
1257	S327EXVRYD	1	Unit 3 Startup Bus UV Trip Aux Relay 27EX Fails to Pick Up		3.30E-05
1258	SB18UX1RYT	24	Auxiliary Relay 8UX-1 Spurious Operation		8.64E-06
1259	SB28UX2RYT	24	Auxiliary Relay 8UX-2 Spurious Operation		8.64E-06
1260	SB38UX3RYT	24	Auxiliary Relay 8UX-3 Spurious Operation		8.64E-06
1261	SB48UX4RYT	24	Auxiliary Relay 8UX-4 Spurious Operation		8.64E-06
1262	SDCAIDDDIF	24	Control Power From DYA To PCB 9 Isolating Diode Fails		9.12E-05
1263	SDCDA12CDT	24	125 Vdc Swyd Control Power Pnlbd DYA Bkr 12 Xfrs Open		1.80E-06
1264	SDCDA15CDT	24	125 Vdc Swyd Control Power Pnlbd DYA Bkr 15 Xfrs Open		1.80E-06
1265	SDCDA17CDT	24	125 Vdc Swyd Control Power Pnlbd DYA Bkr 17 Xfrs Open		1.80E-06
1266	SDCDB01CDT	24	125 Vdc Swyd Control Power Pnlbd DYB Bkr 1 Xfrs Open		1.80E-06
1267	SDCDB13CDT	24	125 Vdc Swyd Control Power Pnlbd DYB Bkr 13 Xfrs Open		1.80E-06
1268	SDCDC12CDT	24	125 Vdc Swyd Control Power Pnlbd DYC Bkr 12 Xfrs Open		1.80E-06
1269	SDCDE12CDT	24	125 Vdc Swyd Control Power Pnlbd DYE Bkr 12 Xfrs Open		1.80E-06
1270	SDCDE15CDT	24	125 Vdc Swyd Control Power Pnlbd DYE Bkr 15 Xfrs Open		1.80E-06
1271	SDCDE17CDT	24	125 Vdc Swyd Control Power Pnlbd DYE Bkr 17 Xfrs Open		1.80E-06
1272	SDCDF01CDT	24	125 Vdc Swyd Control Power Pnlbd DYF Bkr 1 Xfrs Open		1.80E-06
1273	SDCDF13CDT	24	125 Vdc Swyd Control Power Pnlbd DYF Bkr 13 Xfrs Open		1.80E-06
1274	SDCDG16CDT	24	125 Vdc Swyd Control Power Pnlbd DYG Bkr 16 Xfrs Open		1.80E-06
1275	SDCDYA8CDT	24	125 Vdc Swyd Control Power Pnlbd DYA Bkr 8 Xfrs Open	OEE-38	1.80E-06
1276	SDCDYA9CDT	24	125 Vdc Swyd Control Power Pnlbd DYA Bkr 9 Xfrs Open		1.80E-06
1277	SDCDYB4CDT	24	125 Vdc Swyd Control Power Pnlbd DYB Bkr 4 Xfrs Open		1.80E-06
1278	SDCDYB6CDT	24	125 Vdc Swyd Control Power Pnlbd DYB Bkr 6 Xfrs Open		1.80E-06
1279	SDCDYB8CDT	24	125 Vdc Swyd Control Power Pnlbd DYB Bkr 8 Xfrs Open		1.80E-06
1280	SDCDYE8CDT	24	125 Vdc Swyd Control Power Pnlbd DYE Bkr 8 Xfrs Open		1.80E-06
1281	SDCDYE9CDT	24	125 Vdc Swyd Control Power Pnlbd DYE Bkr 9 Xfrs Open		1.80E-06
1282	SDCDYF4CDT	24	125 Vdc Swyd Control Power Pnlbd DYF Bkr 4 Xfrs Open		1.80E-06
1283	SDCDYF6CDT	24	125 Vdc Swyd Control Power Pnlbd DYF Bkr 6 Xfrs Open		1.80E-06
1284	SDCDYF8CDT	24	125 Vdc Swyd Control Power Pnlbd DYF Bkr 8 Xfrs Open		1.80E-06
1285	SDCEIDDDIF	24	Control Power From DYE To PCB-9 Isolating Diode Fails		9.12E-05
1286	SK194GBRYT	24	Keowee Unit 1 94GB Auxiliary Relay Spurious Operation		8.64E-06
1287	SK294GBRYT	24	Keowee Unit 2 94GB Auxiliary Relay Spurious Operation		8.64E-06

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Basic Event Data for the Oconee-Keowee AC Power/Core Damage Models

	NAME	FACTOR	DESC	PROB
1288	SKXFMR1THF	24	Keowee Transformer 1 Fails	7.44E-05
1289	SPC14KVBHF	24	13.8 kV Bus Faulted	9.60E-06
1290	SPC51TNRYT	24	Main Step Up Transformer Neutral Ground Relay 51TN Spurious Operation	8.64E-06
1291	SPC62ABRYT	24	ACB Back-up Trip Timer 62AB Spurious Operation	8.64E-06
1292	SPC631XRYT	24	Auxiliary Relay 63H1X Spurious Operation	8.64E-06
1293	SPC871XRYT	72	Transformer 1X Differential Relay 87T-1X Spurious Operation	2.59E-05
1294	SPC872XRYT	72	Transformer 2X Differential Relay 87T-2X Spurious Operation	2.59E-05
1295	SPC87T1RYT	72	Main Step Up Transformer Differential Relay 87T Spurious Operation	2.59E-05
1296	SPC94TKRYT	24	Auxiliary Relay 94T/K Spurious Operation	8.64E-06
1297	SPCB008CHO	1	SWYD PCB-8 Fails to Trip	2.60E-05
1298	SPCB009CHC	1	SWYD PCB-9 Fails To Close On Demand	2.60E-04
1299	SPCB009CHO	1	SWYD PCB-9 Fails To Trip	2.60E-05
1300	SPCB012CHO	1	SWYD PCB-12 Fails To Trip	2.60E-05
1301	SPCB015CHO	1	SWYD PCB-15 Fails To Trip On Demand	2.60E-05
1302	SPCB017CHO	1	SWYD PCB-17 Fails To Trip On Demand	2.60E-05
1303	SPCB021CHO	1	SWYD PCB-21 Fails To Trip On Demand	2.60E-05
1304	SPCB024CHO	1	SWYD PCB-24 Fails To Trip On Demand	2.60E-05
1305	SPCB026CHO	1	SWYD PCB-26 Fails To Trip On Demand	2.60E-05
1306	SPCB028CHO	1	SWYD PCB-28 Fails To Trip On Demand	2.60E-05
1307	SPCB033CHO	1	SWYD PCB-33 Fails To Open On Demand	2.60E-05
1308	SPCD87LRYT	24	Line Differential Relay 87L Spurious Operation	8.64E-06
1309	SPCGLASSWT	24	Break Glass Switch Spurious Operation	1.68E-06
1310	SPCR86TRYT	24	Lock Out Relay 86T Spurious Operation	8.64E-06
1311	SU127UVCOM	1.18E-04	Common Cause Failure of Unit 1 SU Bus Undervoltage Relays	1.18E-04
1312	SU227UVCOM	1.18E-04	Common Cause Failure of Unit 2 SU Bus Undervoltage Relays	1.18E-04
1313	SU327UVCOM	1.18E-04	Common Cause Failure of Unit 3 SU Bus Undervoltage Relays	1.18E-04
1314	SXFRCT3THF	24	Transformer CT3 Faulted	7.44E-05
1315	SXFRCT3THM	1.74E-04	Transformer CT3 Is In Maintenance	1.74E-04
1316	SXFRCT4LHE	6.40E-05	Latent Human Error on CT4 Maintenance	6.40E-05
1317	SXFRCT4THM	9.13E-04	Transformer CT4 Is In Maintenance	9.13E-04
1318	SY30R94RYT	24	PCB 30 Relay 94 Spuriously Picks Up	8.64E-06
1319	SY51TN2RYT	24	230kV Neutral Ground Relay Spuriously Picks Up	8.64E-06
1320	SY51TN4RYT	24	4.16kV Neutral Ground Relay Spuriously Picks Up	8.64E-06
1321	SY51TN6RYT	24	6.9kV Neutral Ground Relay 51TN Spuriously Picks Up	8.64E-06
1322	SY62X1FRYT	24	Breaker Failure Relay 62X1 Spuriously Picks Up	8.64E-06
1323	SY62X2FRYT	24	Breaker Failure Relay 62X2 Spuriously Picks Up	8.64E-06
1324	SY62XXFRYT	24	Breaker Failure Relay 62X Spuriously Picks Up	8.64E-06
1325	SY86BUIRYT	24	CT3 6.9kV Start Up Bus Lockout Relay Spuriously Picks Up	8.64E-06
1326	SY86CT3RYT	24	Transformer CT3 Lockout Relay Spuriously Picks Up	8.64E-06

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Basic Event Data for the Oconee-Keowee AC Power/Core Damage Models

	NAME	FACTOR	DESC	PROB
1327	SY86YA9RYT	24	Yellow Bus Lockout Auxiliary Relay 86YA9 Spuriously Picks Up	8.64E-06
1328	SY86YJ3RYT	24	Yellow Bus Lockout Auxiliary Relay 86YJ30 Spuriously Picks Up	8.64E-06
1329	SY87BYXRYT	24	Yellow Bus X Phase Differential Relay 87BYX Spuriously Picks Up	8.64E-06
1330	SY87BYYRYT	24	Yellow Bus Y Phase Differential Relay 87BYY Spuriously Picks Up	8.64E-06
1331	SY87BYZRYT	24	Yellow Bus Z Phase Differential Relay 86BYZ Spuriously Picks Up	8.64E-06
1332	SY87LXXRYT	24	Differential Auxiliary Relay 87LX Spuriously Picks Up	8.64E-06
1333	SY94L1XRYT	24	Protective Relay 94L Spuriously Picks Up	8.64E-06
1334	SYE1362RYT	24	E13 Bkr Failure Relay 62B Spuriously Picks Up	8.64E-06
1335	SYE2362RYT	24	E23 Bkr Failure Relay 62B Spuriously Picks Up	8.64E-06
1336	SYP2862RYT	24	PCB 28 Breaker Failure Relay 62B Spuriously Picks Up	8.64E-06
1337	SYP3062RYT	24	PCB 30 Breaker Failure Relay 62B Spuriously Picks Up	8.64E-06
1338	SYP86TXRYT	24	PCB 30 LOR 86TX Spuriously Picks Up	8.64E-06
1339	SYPCB09CHT	24	Switchyard Power Circuit Breaker 9 Transfers Open	4.56E-05
1340	SYPCB30CHT	24	Switchyard Power Circuit Breaker 30 Transfers Open	4.56E-05
1341	SYPL86TRYT	24	PCB 30 LOR 86T Spuriously Picks Up	8.64E-06
1342	SYPL87LRYT	24	Differential Relay 87L Spuriously Picks Up	8.64E-06
1343	SYR86BYRYT	24	Yellow Bus Lockout Relay 86BY Spuriously Picks Up	8.64E-06
1344	SYS63FPRYT	24	Fault Pressure Relay 63FP Spuriously Picks Up	8.64E-06
1345	SYSX50BRYT	24	Transformer CT3 Fault Detector Relay 50B Spuriously Picks Up	8.64E-06
1346	SYX87TBRYT	24	Differential Relay 87B Spuriously Picks Up	8.64E-06
1347	SYXX87TRYT	24	Differential Relay 87T Spuriously Picks Up	8.64E-06
1348	T10	4.000E-03	Large Feedwater Line Break Initiator	4.00E-03
1349	T5FEEDF	2.730E-02	Failure Of Electrical Grid Or Main Feeders Initiating Event	2.73E-02
1350	T5SUBF	4.86E-02	Loss Of The Oconee Station Switchyards Initiating Event	4.86E-02
1351	T5WEATH	1.440E-02	Loss Of Off-Site Power Due To Severe Weather Initiating Event	1.44E-02
1352	TACOFF1REC	6.70E-01	Offsite power not recov. given start failures and no SSHR	6.70E-01
1353	TACOFF2REC	2.20E-01	Offsite power not recov. given start failures with SSHR	2.20E-01
1354	TACOFF3REC	6.50E-02	Offsite power not recov. given 1 run failures with SSHR	6.50E-02
1355	TACOFF4REC	5.10E-02	Offsite power not recov. given 2 run failures with SSHR	5.10E-02
1356	TACOFF5REC	1.40E-01	Offsite power not recov. given 1 run failures and no SSHR	1.40E-01
1357	TACOFF6REC	7.30E-02	Offsite power not recov. given 2 run failures and no SSHR	7.30E-02
1358	U5086EFRYT	24	Overcurrent Relay 50 Spuriously Actuates Lockout Rly 86EF	8.64E-06
1359	U5186EFRYT	24	Time Delay Overcurrent Relay 51 Actuates Lockout Relay 86EF	8.64E-06
1360	U51TNC4RYT	24	CT4 Neutral Ground Rly Actuates CT4 LOR 86T/CT4	8.64E-06
1361	U62BSK1RYT	24	SK1 Breaker Failure Relay 62BXSK1 Spuriously Picks Up	8.64E-06
1362	U62BSK2RYT	24	SK2 Breaker Failure Relay 62BXSK2 Spuriously Picks Up	8.64E-06
1363	U86CT4XRYT	24	Auxiliary Lockout Relay 86CT4X Spuriously Picks Up	8.64E-06
1364	U86TCT4RYT	24	CT4 Lockout Relay 86T/CT4 Spuriously Picks Up	8.64E-06
1365	U87TCT4RYT	24	Spurious Op of CT4 Differential Rly 87T Actuates LOR 86EF	8.64E-06

Table D-3

Basic Event Data for the Oconee-Keowee AC Power/Core Damage Models

	NAME	FACTOR	DESC	PROB
1366	UACXCT4THF	24	Transformer CT4 Failed	7.44E-05
1367	UXX86EFRYT	24	Lockout Relay 86EF Spuriously Picks Up	8.64E-06
1368	W100	0.000E+00	No Flow From Low Pressure Service Water Header 3A	0.00E+00
1369	WH3	0.000E+00	All High Pressure Service Water Supplies Fail	0.00E+00
1370	WK00RUNCOM	2.09E-05	Common Cause Failure of Keowee Governors to Run	2.09E-05
1371	WK1GVCDDEX	3.5E-05	Keowee Unit 1 Gov. Fails to Position Wicket Gates During a Cold Start	3.50E-05
1372	WK1GVCDLHE	2.6E-4	Latent Human Error Fails Keowee 1 Governor During Cold Start	2.60E-04
1373	WK1GVHTDEX	3.5E-04	Keowee Unit 1 Gov. Fails to Position Wicket Gates During Hot Start	3.50E-04
1374	WK1GVRNDEX	5.6E-4	Keowee Unit 1 Gov. Fails to Position Wicket Gates With Unit Running	5.60E-04
1375	WK1SPD1DEX	1.0	Potentially Damaging Overspeed Condition Occures At Load Rejection	1.00E+00
1376	WK1SPD2DEX	5.6E-05	Keowee Unit 1 Governor Failure Creates Overspeed Condition	5.60E-05
1377	WK1TBCDDEX	3.5E-5	Keowee Unit 1 Turbine Fails During a Cold Start	3.50E-05
1378	WK1TBHTDEX	3.5E-4	Keowee Unit 1 Turbine Fails During a Hot Start	3.50E-04
1379	WK1TBRNDEX	5.6e-4	Keowee Unit 1 Turbine Fails With the Unit Running	5.60E-04
1380	WK2GVCDDEX	3.5E-05	Keowee Unit 2 Gov. Fails to Position Wicket Gates During Cold Start	3.50E-05
1381	WK2GVCDLHE	2.6E-4	Latent Human Error Fails Keowee 2 Governor During Cold Start	2.60E-04
1382	WK2GVHTDEX	3.5E-04	Keowee Unit 2 Gov. Fails to Position Wicket Gates During Hot Start	3.50E-04
1383	WK2GVRNDEX	5.6E-4	Keowee Unit 2 Gov. Fails to Position Wicket Gates With Unit Running	5.60E-04
1384	WK2SPD2DEX	5.6E-05	Keowee Unit 2 Governor Failure Creates Overspeed Condition	5.60E-05
1385	WK2TBCDDEX	3.5E-5	Keowee Unit 2 Turbine Fails During a Cold Start	3.50E-05
1386	WK2TBHTDEX	3.5E-4	Keowee Unit 2 Turbine Fails During a Hot Start	3.50E-04
1387	WK2TBRNDEX	5.6E-4	Keowee Unit 2 Turbine Fails With the Unit Running	5.60E-04
1388	WKCSTRTCOM	1.12E-05	Common Cause Failure of Keowee Governors to Cold Start	1.12E-05
1389	WKHSTRTCOM	3.50E-6	Common Cause Failure of Keowee Governors to Hot Start	3.50E-06
1390	XA0SWGRCOM	1.22E-06	Common Cause Failure Of Transformers 1X, 2X, And CX	1.22E-06
1391	XA1A2BTCDT	24	600 Vac Breaker 1XA-2BT Transfers Position K-704	1.80E-06
1392	XA1BKRSCOM	3.10E-04	CCF of 1X Aux Power Breakers ACB-5 & -7	3.10E-04
1393	XA1TR1XTLF	24	Keowee Transformer 1X Fails	1.80E-05
1394	XA1X2AXCLT	24	600 Vac Bkr 2X-2D Transfers Position	2.18E-05
1395	XA1X2CCCLT	24	600 Vac Breaker 1X-2C Transfers Position	2.18E-05
1396	XA1XA1ACLT	24	600 Vac Bkr 2XA-4A Transfers Position	2.18E-05
1397	XA1XAALBLM	2.74E-03	MCC 1XA Is Connected to Its Alternate Source of Power	2.74E-03
1398	XA1XAMCBLF	24	600 Vac MCC 1XA Fault	6.48E-06
1399	XA1XCXXTHM	4.57E-4	4160/600 Vac Transformer CX Is in Maintenance	4.57E-04
1400	XA1XCXXTLF	24	4160/600 Vac Transformer CX Fails	1.80E-05
1401	XA1XXXXBLF	24	600 Vac Switchgear 1X Fault	6.48E-06
1402	XA2A2BTCDT	24	600 Vac Breaker 2XA-2BT Transfers Position	1.80E-06
1403	XA2BKRSCOM	3.10E-04	CCF of Aux Power Breakers ACB-6 & -8	3.10E-04
1404	XA2TR2XTLF	24	Keowee Transformer 2X Fails	1.80E-05

Table D-3

Basic Event Data for the Oconee-Keowee AC Power/Core Damage Models

	NAME	FACTOR	DESC		PROB
1405	XA2X2BXCLT	24	600 Vac Breaker 2X-2B Transfers Position		2.18E-05
1406	XA2X2DXCLT	24	600 Vac Bkr 1X-2A Transfers Position		2.18E-05
1407	XA2X4AXCLT	24	600 Vac Bkr 1XA-1A Transfers Position		2.18E-05
1408	XA2XAALBLM	2.74E-03	MCC 2XA Is Connected to Its Alternate Power Source		2.74E-03
1409	XA2XAMCBLF	24	600 Vac MCC-2XA Fault		6.48E-06
1410	XA2XXXXBLF	24	600 Vac Switchgear 2X Fault		6.48E-06
1411	XA56BKRCOM	3.10E-04	Common Cause Failure Of ACB-5 And ACB-6 To Close		3.10E-04
1412	XA78BKRCOM	3.10E-04	Common Cause Failure Of ACB-7 And ACB-8 To Close		3.10E-04
1413	XCWFLIIDEX	4.330E-03	Fraction Of FLII From Condensate Cooler Flow Path		4.33E-03
1414	XCWFMIIDEX	8.670E-03	Fraction Of FMII From Condensate Cooler Flow Path		8.67E-03
1415	XCWFMNXDEX	1.170E-01	Fraction Of FMN From Condensate Cooler Flow Path		1.17E-01
1416	XD0BATTCOM	2.70E-05	Common Cause Failure Of Keowee I&C Power Batteries		2.70E-05
1417	XD0CHRGCOM	3.48E-05	Common Cause Failure Of Keowee Battery Chargers		3.48E-05
1418	XD0KBATRHE	1.00E+00	Failure To Recover DC Supply From The Other Unit		1.00E+00
1419	XD104CCCDT	24	Breaker 1DA-4CC Transfers Open		1.80E-06
1420	XD104CRCDT	6	Breaker 1DA-4CR Transfers Open		4.50E-07
1421	XD1BK1ACDT	24	Battery No. 1 Breaker 1A Transfers Position	run time dependent	1.80E-06
1422	XD1CKC1BCF	24	Battery Charger KC1 Fails		6.96E-04
1423	XD1DA1CCDT	24	125 Vdc Breaker 1C (from charger KC1) Transfers Position		1.80E-06
1424	XD1DA3BCDT	24	125 Vdc Breaker 1DA-3BR Transfers Open		1.80E-06
1425	XD1DA4ACDT	24	DC Circuit Breaker 1DA-4AR Transfers Position		1.80E-06
1426	XD1DALTBYM	5.48E-03	Normal Power To Dist. Center 1DA Is In Test or Maintenance		5.48E-03
1427	XD1DARXBDF	24	DC Distribution Center 1DA Faulted during Run		7.68E-06
1428	XD1KB1XDHE	1	Keowee Standby Battery Charger SBC Not Lined Up in 1 Hour		1.00E+00
1429	XD1KB1XRHE	1	Keowee Standby Battery Charger SBC Not Lined Up in 1 Hour		1.00E+00
1430	XD1KBATBYF	1	Keowee Battery No. 1 Fails During Discharge		9.30E-04
1431	XD1TIE1CDT	24	Keowee 125V dc Dist Cntr 1DA Tie Breaker 1 Transfers Position		1.80E-06
1432	XD202CCCDT	6	Breaker 2DA-2CC Transfers Open		4.50E-07
1433	XD204CCCDT	24	Breaker 2DA-4CC Transfers Open	K-704	1.80E-06
1434	XD2BK1ACDT	24	Battery No. 2 Breaker 1A Transfers Position		1.80E-06
1435	XD2CKC2BCF	24	Battery Charger KC2 Fails		6.96E-04
1436	XD2DA2ACDT	24	DC Circuit Breaker 2DA-2AR Transfers Position		1.80E-06
1437	XD2DA3BCDT	24	125 Vdc Circuit Breaker 2DA-3BR Transfers Position		1.80E-06
1438	XD2DA5CCDT	24	125 Vdc Breaker 2DA-5C (from Charger KC2) Transfers Open		1.80E-06
1439	XD2DALTBYM	5.48E-03	Normal Power To Dist Cntr 2DA Is In Test or Maintenance		5.48E-03
1440	XD2DARXBDF	24	DC Distribution Center 2DA Faulted During Run		7.68E-06
1441	XD2KB2XDHE	1	Keowee Standby Battery Charger SBC Not Lined Up in 1 Hour		1.00E+00
1442	XD2KB2XRHE	1	Keowee Standby Battery Charger SBC Not Lined Up in 1 Hour		1.00E+00
1443	XD2KBATBYF	1	Keowee Battery No. 2 Fails during Discharge		9.30E-04

Table D-3

Basic Event Data for the Oconee-Keowee AC Power/Core Damage Models

	NAME	FACTOR	DESC		PROB
1444	XD2TIE2CDT	24	Keowee 125V dc Dist Cntr 2DA Tie Breaker 2 Transfers Position		1.80E-06
1445	Y0STARTCOM	7.26E-06	Common Cause Failure Of Emergency Start Signal		7.26E-06
1446	Y0STARTRHE	1.00E+00	Operators Fail To Manually Start Keowee		1.00E+00
1447	YK114X3SSD	1	Keowee 1 Speed Switch 14-3 Fails to Open at 65 rpm	KEE-111	1.80E-05
1448	YK13SUISWT	24	KHU#1 Startup Inhibit Sw 3SUI Xfrs to Inhibit	KEE-111, -113	1.68E-06
1449	YK14AMRRYT	24	Keowee 1 Master Relay 4A Spuriously Drops Out		8.64E-06
1450	YK14BMRRYT	24	Keowee 1 Master Relay 4B Spuriously Drops Out		8.64E-06
1451	YK163BHLST	24	Keowee 1 Gen Thrst Brng Oil Lvl Hi Sw 63BL/H Sprsly Clsd	KEE-111, -113-3	7.44E-06
1452	YK163BHRYT	24	Keowee 1 Gen Thrst Brng Oil Lvl Hi Rly 63BL/HX Sprsly Picks Up	KEE-111,-113-	8.64E-06
1453	YK163BLLST	24	Keowee 1 Gen Thrst Brng Oil Lvl Lo Sw 63BL/L Spuriously Operates	KEE-111,-113-	7.44E-06
1454	YK163BLRYT	24	Keowee 1 Gen Thrst Brng Oil Lvl Lo Rly 63BL/LXTD Sprsly Pcks Up	KEE-111, -113-	8.64E-06
1455	YK163TBLST	24	Keowee 1 Turb Guide Brng Lo Lvl Sensor Sw Spuriously Closes	KEE-113-4	7.44E-06
1456	YK163TBRYT	24	Keowee 1 Turb Gd Brng Oil Lvl Lo Rly 63TB/1X Sprsly Picks Up	KEE-111,-113-4	8.64E-06
1457	YK186N1DEX	9.89E-03	Keowee 1 Normal Lockout Actuates		9.89E-03
1458	YK199SDRYD	1	Keowee 1 Shutdown Solenoid 99SD Fails To Pick Up		3.30E-05
1459	YK199SDRYT	24	Keowee 1 Shutdown Solenoid Spuriously Drops Out		8.64E-06
1460	YK199SNRYD	1	K1 Emergency Load Solenoid 99SN Fails To Pick Up/Drop Out		3.30E-05
1461	YK199SNRYT	24	Emergency Load Solenoid 99SN Spuriously Drops Out		8.64E-06
1462	YK199SXRYD	1	Keowee 1 Shutdown Solenoid Aux Relay 99SX Fails to Pick Up	KEE-111	3.30E-05
1463	YK199SXRYT	24	Shutdown Auxiliary Relay 99SX Spuriously Drops Out		8.64E-06
1464	YK1D4CRFUF	6	Fuse 1DA-4CR Fails		2.16E-05
1465	YK1ES1ARYD	1	Keowee 1 Emergency Start Aux Relay 1ESRX/1A Fails To Pick Up	OEE-120	3.30E-05
1466	YK1ES1BRYD	1	Keowee 1 Emergency Start Aux Relay 1ESRX/1B Fails To Pick Up	OEE-120-1	3.30E-05
1467	YK1ES2ARYD	1	Keowee 1 Emergency Start Aux Relay 1ESRX/2A Fails To Pick Up	OEE-120	3.30E-05
1468	YK1ES2BRYD	1	Keowee 1 Emergency Start Aux Relay 1ESRX/2B Fails To Pick Up	OEE-120-1	3.30E-05
1469	YK1MR4ARYD	1	Keowee 1 Start Master Relay 4A Fails To Pick Up	KEE-113	3.30E-05
1470	YK1MR4BRYD	1	Keowee 1 Start Master Relay 4B Fails To Pick Up	KEE-113	3.30E-05
1471	YK1SS12SST	24	Keowee 1 Overspeed Switch 12 Spuriously Picks Up	KEE-111	1.01E-04
1472	YK1SS13SSD	1	Keowee 1 Speed Switch 13 Fails to Close at 122 rpm	KEE-111	1.80E-05
1473	YK214X3SSD	1	KHU#2 Speed Switch 14-3 Fails to Open at 65 rpm	KEE-211	1.80E-05
1474	YK23SUISWT	24	KHU#2 Startup Inhbt Sw 3SUI Sprsly Xtrs to Inhibit	KEE-211, -213	1.68E-06
1475	YK24AMRRYT	24	Keowee 2 Master Relay 4A Spuriously Drops Out		8.64E-06
1476	YK24BMRRYT	24	Keowee 2 Master Relay 4B Spuriously Drops Out		8.64E-06
1477	YK263BHLST	24	Keowee 2 Gen Thrst Brng Oil Lvl Hi Sw 63BL/H Sprsly Clsd		7.44E-06
1478	YK263BHRYT	24	Keowee 2 Gen Thrst Brng Oil Lvl Hi Rly 63BL/HX Sprsly Picks Up	KEE-211	8.64E-06
1479	YK263BLLST	24	Keowee 2 Gen Thrst Brng Oil Lvl Lo Sw 63BL/L Sprsly Opn		7.44E-06
1480	YK263BLRYT	24	Keowee 2 Gen Thrst Brng Oil Lvl Lo Rly 63BL/LXTD Sprsly Pcks Up	KEE-211	8.64E-06
1481	YK263TBLST	24	Keowee 2 Turb Guide Brng Lo Lvl Sensor Sw Sprsly Closes		7.44E-06
1482	YK263TBRYT	24	Keowee 2 Turb Gd Brng Oil Lvl Lo Rly 63TB/1X Sprsly Picks Up	KEE-211	8.64E-06

Table D-3

Basic Event Data for the Oconee-Keowee AC Power/Core Damage Models

	NAME	FACTOR	DESC		PROB
1483	YK286N2DEX	7.41E-03	Keowee Unit 2 Normal Lockout Activates		7.41E-03
1484	YK299SDRYD	1	Keowee 2 Shutdown Solenoid 99SD Fails To Pick Up		3.30E-05
1485	YK299SDRYT	24	Keowee 2 Shutdown Solenoid Spuriously Drops Out		8.64E-06
1486	YK299SNRYD	1	Keowee 2 Emergency Load Solenoid 99SN Fails To Operate		3.30E-05
1487	YK299SNRYT	24	Emergency Load Solenoid 99SN Spuriously Drops Out		8.64E-06
1488	YK299SXRYD	1	Keowee 2 Shutdown Solenoid Aux Relay 99SX Fails to Pick Up	KEE-211	3.30E-05
1489	YK299SXRYT	24	Shutdown Auxiliary Relay 99SX Spuriously Drops Out	s	8.64E-06
1490	YK2D2CCFUF	6	Fuse 2DA-2CC Fails		2.16E-05
1491	YK2ES1ARYD	1	Keowee 2 Emergency Start Aux Relay 2ESRX/1A Fails To Pick Up	OEE-120	3.30E-05
1492	YK2ES1BRYD	1	Keowee 2 Emergency Start Aux Relay 2ESRX/1B Fails to Pick Up	OEE-120-1	3.30E-05
1493	YK2ES2ARYD	1	Keowee 2 Emergency Start Aux Relay 2ESRX/2A Fails to Pick Up	OEE-120	3.30E-05
1494	YK2ES2BRYD	1	Keowee 2 Emergency Start Aux Relay 2ESRX/2B Fails to Pick Up	OEE-120-1	3.30E-05
1495	YK2MR4ARYD	1	Keowee 2 Start Master Relay 4A Fails To Pick Up	KEE-213	3.30E-05
1496	YK2MR4BRYD	1	Keowee 2 Start Master Relay 4B Fails to Pick Up	KEE-213	3.30E-05
1497	YK2SS12SST	24	Keowee 2 Overspeed Switch 12 Spuriously Picks Up	KEE-211	1.01E-04
1498	YK2SS13SSD	1	Keowee 2 Speed Switch 13 Fails to Close at 122 rpm	KEE-211	1.80E-05
1499	YKEMSRTCHE	0	Operator Incorrectly Resets Keowee Emergency Start Signals		0.00E+00
1500	YO1DIA2CDT	30	DC Circuit Breaker 1DIA-2 Transfers Position		2.25E-06
1501	YO1DIB2CDT	30	DC Circuit Breaker 1DIB-2 Transfers Position		2.25E-06
1502	YO1MFBMA	1	ONS1 MFB Monitor Channel A Keowee Start Signal Fails		1.00E+00
1503	YO1MFBMB	1	ONS1 MFB Monitor Channel B Keowee Start Signal Fails		1.00E+00
1504	YO1OPSARHE	1	Operator fails to operate Keowee start switch S1A		1.00E+00
1505	YO1OPSBRHE	1	Operator fails to operate Keowee start switch S1B		1.00E+00
1506	YO1S1AFSWC	1	Control Switch S1A Fails To Close On Demand		1.00E-05
1507	YO1S1BFSWC	1	Control Switch S1B Fails To Close On Demand		1.00E-05
1508	YO1XXKARYD	1	ONS1 Ch A Keowee Emergency Start Relay KA Fails to Pick Up	OEE-120	3.30E-05
1509	YO1XXKBRYD	1	Oconee Unit 1 Chan. B Keowee Emergency Start Relay Fails	OEE-120-1	3.30E-05
1510	YO2CR2ARYD	1	ONS2 Ch A Keowee Emergency Start Relay CR2A Fails to Pick Up	OEE-220	3.30E-05
1511	YO2CR2BRYD	1	ONS2 Keowee Emergency Start Relay CR2B Fails to Pick Up	OEE-220-1	3.30E-05
1512	YO2DIA2CDT	30	Breaker 2DIA-2 Transfers Position		2.25E-06
1513	YO2DIB2CDT	30	Breaker 2DIB-2 Transfers Position		2.25E-06
1514	YO2MFBMA	1	ONS2 MFB Monitor CH A Keowee Start Sig Fails		1.00E+00
1515	YO2MFBMB	1	ONS2 MFB Monitor Ch B Keowee Start Sig Fails		1.00E+00
1516	YO2SSWARHE	1	Operator Fails to Operate Keowee Start Switch 2SSW'A'		1.00E+00
1517	YO2SSWASWC	1	Control Switch 2SSW'A' Fails To Close On Demand		1.00E-05
1518	YO2SSWBRHE	1	Operator Fails to Operate Keowee Start Switch 2SSW'B'		1.00E+00
1519	YO2SSWBSWC	1	Control Switch 2SSW'B' Fails To Close On Demand		1.00E-05
1520	YO3CR3ARYD	1	ONS3 Ch A Keowee Emergency Start Relay CR3A Fails To Pick Up	OEE-320	3.30E-05
1521	YO3CR3BRYD	1	ONS3 Keowee Emer Start Relay CR3B Fails to Pick Up	OEE-320-1	3.30E-05

Table D-3

Basic Event Data for the Oconee-Keowee AC Power/Core Damage Models

	NAME	FACTOR	DESC		PROB
1522	YO3DIA2CDT	30	Breaker 3DIA-2 Transfers Open	OEE-320, O-2705	2.25E-06
1523	YO3DIB2CDT	30	Breaker 3DIB-2 Transfers Open	OEE-320-1, O-2705	2.25E-06
1524	YO3MFBMA	3.96E-03	ONS3 MFB Monitor Ch A Keowee Start Sig Fails		3.96E-03
1525	YO3MFBMB	3.96E-03	ONS3 MFB Monitor Ch B Keowee Start Sig Fails		3.96E-03
1526	YO3OPFARHE	1	Operator fails to operate Keowee Start Switch 3S1A		1.00E+00
1527	YO3OPFBRHE	1	Operator Fails to Operate Keowee Start Switch 3S1B		1.00E+00
1528	YO3S1AFSWC	1	Control Switch S1A Fails To Close On Demand		1.00E-05
1529	YO3S1BFSWC	1	Control Switch S1B Fails To Close On Demand		1.00E-05
1530	YO3SSWARHE	1	Operator fails to operate Keowee Start Switch 3SSW'A'		1.00E+00
1531	YO3SSWASWC	1	Control Switch 3SSW'A' Fails To Close On Demand		1.00E-05
1532	YO3SSWBRHE	1	Operator Fails to Operate Keowee Start Switch 3SSW'B'		1.00E+00
1533	YO3SSWBSWC	1	Control Switch 3SSW'B' Fails To Close On Demand		1.00E-05

APPENDIX E
SENSITIVITY STUDIES

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E.0 SENSITIVITY STUDIES

This Appendix provides the detailed information as necessary for the Keowee PRA sensitivity studies.

E.1 GENERIC VERSUS BAYESIAN UPDATED DATA

This study provides an evaluation of the sensitivity of the Keowee results to the plant-specific data used in the Bayesian-update process. The results are discussed in Section 7.5. The data file for the generic data, which does not include credit for recoveries, is included in Appendix D, Table D-2. This data assumes the current operating configuration. Common cause events were also modified by substituting generic component failure rates in place of the Bayesian-updated failure rates used to calculate the component independent failure rates. The common cause multipliers remained the same.

E.2 GRID-CYCLED VERSUS STANDBY UNIT RELIABILITY

The reliabilities of the grid-cycled unit and the standby unit are expected to be different. Evaluating this difference is important in understanding the overall Keowee reliability results. The comparisons for this sensitivity study are made using the results of reliability calculations for Keowee Unit 1 (7-day exposure) and Keowee Unit 2 (1-day exposure) for the current operating mode with no credit for recoveries. This data is included as Table E-1.

E.3 RECOVERED VERSUS UNRECOVERED RESULTS

The unrecovered result is an intermediate result in the process of obtaining the base case solution. This is the result following step 1 of the process described in Section 4.6.2. Comparison of this result to that of the base case provides information on the improvement in reliability obtained by considering operator actions. The unrecovered data file is included as Table E-1. The data with all recoveries included and quantified is included in Appendix D, Table D-1.

E.4 HUMAN ERROR SENSITIVITY STUDIES

E.4.1 LATENT HUMAN ERRORS

The importance of the Latent Human Errors (LHEs) in the calculated failure probability is evaluated by setting these failure probabilities to 0.0 in the recovered Bayesian updated data and comparing the result to the base case analysis. The recovered Bayesian updated data is included in Appendix D, Table D-1.

E.4.2 HUMAN ERROR PROBABILITIES PRIOR TO THE 1992 LOSS OF OFFSITE POWER

Human error rates based on the conditions prior to the event are established and substituted into the base case data. The revised human error probabilities are presented in Table 4.8-1.

E.5 INFREQUENTLY TESTED/DEMANDED COMPONENTS CHALLENGED DURING EMERGENCY STARTS

The objectives of this study are to:

1. Determine the effect on unit and station failure probabilities of swapping unit alignment on a quarterly basis instead of on a monthly basis.

2. Investigate the sensitivity of the model to an order-of-magnitude increase in the demand failure probability for **all components which are not frequently tested** but are challenged during emergency operation (assuming a black start). (The effect of components that have not been challenged to *run* for a while is already included in the model by means of the longer exposure times. For example, many of the manual valves on the unit aligned to the underground path in the generator model have exposure times of 384 hours, since their failure may not be revealed until that unit is placed in service.)

3. Investigate the sensitivity of the model to an order-of-magnitude increase in the demand failure probability for **all components** which are demanded to operate during emergency operation (assuming a black start).

The study is comprised of the following steps.

Objective 1:

1. Identify the basic events with exposure times derived from the length of time since the last unit start or run.

2. Increase the identified exposure times as follows, to correspond with extending to a quarterly swap of the units:

   360 hrs to 3 * 360 hrs = 1080 hrs
   372 hrs to (3 * 360 + 12) hrs = 1092 hrs
   384 hrs to (3 * 360 + 24) hrs = 1104 hrs

3. Generate cut sets for the emergency start gate KU2STARTF, run gate KU2RUN, and top gate KEOWTOP.

4. Add recoveries to the KEOWTOP cut sets.

5. Compare the new gate failure probabilities with the base case.

Objective 2:

1. Identify the components that are challenged during emergency operation with black start which are tested less frequently than every week.

2. Increase the failure probabilities corresponding to the identified components by an order of magnitude.

3. Generate cut sets for the emergency start gate KU2STARTF, run gate KU2RUN, and top gate KEOWTOP.

4. Add recoveries to the KEOWTOP cut sets.

5. Compare the new gate failure probabilities with the base case.

Objective 3:

1. Identify the components that are challenged during emergency operation (with black start).

2. Increase the failure probabilities corresponding to the identified components by an order of magnitude.

3. Generate cut sets for the emergency start gate KU2STARTF, run gate KU2RUN, and top gate KEOWTOP.

4. Add recoveries to the KEOWTOP cut sets.

5. Compare the new gate failure probabilities with the base case.

Results

Objective 1:

The results show that Keowee reliability is negligibly affected by increasing the unit swap interval from a monthly to a quarterly basis: the sum of the recovered cut sets for model top gate KEOWTOP is increased by about 0.5%.

Table E-2 lists the events of interest for this part of the sensitivity study.

Objective 2:

The following components are demanded during emergency operation with black start, but not during normal operation, and are tested less frequently than every week:

- Emergency Start Relays
- Emergency Start Aux. Relays

- Keowee Start Relays 27X/STA, 27X/STB
- EGTPS undervoltage and underfrequency relays
- Switchyard isolated relays
- PCBs 9, 12, 15, 17, 21, 24, 26, 28, 30, and 33
- Relays and control switch associated with the operation of ACBs 3, 4, 5, 6, 7, and 8
- Solenoid-operated valves associated with the operation of ACBs 3 and 4
- Undervoltage Relays for transformers 1X, 2X and CX
- Pressure switch and relays associated with Governor Oil "emergency" pressure sensing
- Relays and level switch associated with Turbine Guide Bearing Oil Level
- Switchyard batteries SY-1, SY-2

Failures modes associated with the above equipment are represented by 166 basic events, which constitute 15% of the approximately 1135 basic events (excluding recovery events) in the model.

This case was solved at a truncation limit of 1E-7, since attempting to solve at the usual 1E-8 produced too many cut sets for CAFTA's Cut Set Editor, and the Recovery program, to handle. The results are compared to the base case solution truncated to the same value.

The results show that the **start failure probability of a unit is roughly doubled**, the **unit run failure probability is negligibly impacted, and the station failure probability is moderately impacted.**

Testing programs are in place for all of the components within the scope of this study.

Table E-3 lists the relevant events for this part of the sensitivity study.

Objective 3:

To put the results of objective 2 into perspective, this additional sensitivity study was performed. As expected, the results show that Keowee reliability is impacted more when the failure rates are increased for **all** equipment challenged during emergency operation following a blackout start.

In this case, the failure probability for KEOWTOP is increased by approximately 30%, versus 15% for the previous case where failure probabilities for "infrequently challenged components" are increased by an order of magnitude.

Table E-4 summarizes the sensitivity study results.

E.6 MG-6 RELAY FAILURE RATE

Over the ten year period of data consideration, 1984-1994, there have been 5 MG6 relay demand failures. These failures occurred over the years 1989-1992. Assuming that all of these failures had occurred over a period of one year would increase the plant-specific failure rate by a factor of ten.

The objective of this study is to determine the sensitivity of the model's results to an order-of-magnitude increase in the plant-specific failure rate of MG6 relays.

The study is comprised of the following steps.

1. Increase the plant-specific failure rate for MG6 relays by a factor of 10.
2. Generate cut sets for the model's top gate, KEOWTOP, using the modified type code database.
3. Add recoveries to the KEOWTOP cut sets.
4. Compare with the base case results.

Results

Increasing the plant-specific failure rate for MG6 relays by an order of magnitude causes the failure probability for KEOWTOP to increase by about 4%, from 7.35E-3 to 7.67E-3. Thus an order-of-magnitude increase in the plant-specific failure rate for MG6 relays has only a small impact on the reliability of Keowee.

E.7 UNCERTAINTY ANALYSIS

The objective of this study is to determine the probability distribution for the KRA top gate KEOWTOP.

1. Add error factor and distribution type information to the type code and basic event databases. A categorization method is employed as follows:
   a) Component failure type codes for which generic failure rates are available are assigned the error factor calculated by the Bayesian-update spreadsheet.
   b) Basic events representing scheduled maintenance are assigned an error factor of 3.
   c) Human errors are assigned error factors of 5 or 10, depending on their failure probability value as follows:

Failure Probability	Error Factor
< 0.001	10
0.001 - 0.01	5

   (Events AB0SWGRREC and Y0STARTREC are assigned error factors of 2 due to their relatively high failure probability of 0.5)
   d) Due to higher uncertainty, common-cause events, developed events, and plant-specific type code failure rates are assigned an error factor of 10.

2. Load the base case cut sets (Bayesian-updated, recoveries added) into CAFTA.

3. Use the CAFTA Uncertainty Analysis utility to evaluate the cut sets.

Error factors are assigned to the type codes. If a basic event does not derive its value from a type code (namely, developed events, human error events and common cause events), then the error factor is assigned to the basic event. No error factors are assigned to the number of demands or exposure time.

Results

The point estimate value (considering no uncertainty) for the gate KEOWTOP is 7.35E-3. Using a 5000 sample simulation, the estimated mean value was 7.32E-3.

The fifth and 95th percentiles have an estimated value of 2.93E-3 and 1.53E-2, respectively. The overall error factor for KEOWTOP is about 2.3.

Table E-5 provides the basic event and type code input values for this study. Figure E-1 provides a graphical representation of the probability distribution estimation for model top gate KEOWTOP. Figure E-2 shows the corresponding cumulative probability for KEOWTOP.

E.8 ONE VERSUS TWO UNITS GENERATING TO THE GRID

As a result of the recent system design basis engineering studies identifying postulated failures, only one Keowee unit is currently being used for grid generation. Because the use of two units on the grid is an anticipated mode of operation in the future, it is desirable to evaluate the reliability of Keowee in this configuration. This sensitivity study addresses this issue. The sensitivity of the Keowee failure probability to the fraction of time that the two units generate simultaneously is also investigated. This fraction is set to 0.30 in the study.

E.8.1 DATA CHANGES

In the base case analysis the exposure times on the standby unit are longer than those on the grid-cycled unit. As a result, the standby unit is calculated to have a slightly higher failure rate. This sensitivity study is performed by modifying the data base to reflect the change in operating modes, and the implementation of NSM-ON-52966. These changes include the basic events reflecting the probability that unit 1 is generating to the grid and revising the exposure times on the unit 1 components to reflect the daily operation of the unit.

This study is performed only with the Bayesian-updated data. The data bases used in this sensitivity study are included as Tables E-6 and E-7.

E.8.2 NSM-ON-52966

In order for Keowee to again use two units when generating to the grid, certain single failures identified in engineering studies must be corrected. These single failures are being addressed through the implementation of NSM-ON-52966. The Keowee reliability model

has been developed with the implementation of this NSM as a consideration. An event is included in the model to turn on and off those parts of the model affected by this NSM. The results of the sensitivity study where two units are allowed to generate to the grid assumes that the NSM is in service, as this is an expected requirement to return to this mode of operation. The implementation of the NSM is specified by setting event ACB4MOD to 0. The tree is solved with the new data to obtain the failure probability.

This NSM addresses three major issues related to the ability of Keowee to provide emergency power to Oconee. These issues and the resolution implemented in the NSM are briefly described here.

Part 1

This part of the modification addresses the single failure concern relative to the differential protective relay zone overlap when a fault within one of the overhead generator breakers (ACB-1 or ACB-2) is postulated to occur.

When a fault occurs on the overhead breaker on the unit designated as the underground supply, it can lead to the loss of both units as an emergency supply for Oconee. When the fault occurs, the protective relaying for the generator of the affected breaker will lock-out the generator, failing the underground power source. The protective relaying for the overhead transformer also senses the fault at the breaker. This results in a lock-out of the overhead transformer, failing the overhead power path but not the generator.

The NSM mitigates this failure mode by sensing the generator lock-out in combination with the overhead transformer lock-out and automatically transferring the available generator (originally designated to the overhead path) to the available underground power path. This transfer restores an emergency power supply to Oconee. Appropriate control logic and breaker interlocks are included to accomplish the transfer.

Part 2

The NSM also addresses concerns related to the potential for an over-frequency condition to exist when Keowee is connected to Oconee. Over-frequency could result during automatic load rejections or as a result of governor failures. The potential exists for the

Oconee equipment to be damaged if connected to the Keowee supply when an over-frequency condition is occurring at Keowee.

Protection from the over-frequency due to load rejection is accomplished by the addition of over-frequency relays and time delays. The control logic acts to trip and block the Keowee generator output breakers and the SK breakers at Oconee during the period of vulnerability.

Protection from the governor failure (run-away governor) is accomplished through the addition of magnetic speed switches and auxiliary relays. The system detects a failed governor by sensing the speed of the governor fly-ball motor and acts to trip the generator breakers, after a time delay, if an overspeed is indicated.

Part 3

This portion of the NSM modifies existing control logic to address the concerns identified in PIP-0-094-0808. The concern relates to systems interactions following a decrease in air pressure in any of the generator breakers. A loss of air pressure on an underground ACB would result in lock-out of the overhead transformer, actuation of the 86T relay via the 94GB relay. Although this is not a single failure concern in that the underground path is still available, some concern has been expressed over the apparent lack of independence of the power paths.

This concern is addressed by blocking the actuation of the 94GB when an emergency start signal is present and removing the logic which provides actuation of the 94GB due to loss of air or dc power on the underground generator breaker.

Table E-1

Keowee PRA Basic Event Data
Current Operating Configuration - Bayesian Update/Unrecovered

	NAME	FACTOR	DESCRIPTION	PROBABILITY
1	AA1271PR6D	1	Transformer 1X Undervoltage Relay 27/1X Fails To Pick Up	2.49E-04
2	AA1271XR6T	30	Transformer 1X Undervoltage Relay 27/1X Spuriously De-energizes	1.09E-05
3	AA127C1R6T	24	Transformer CX Undervoltage Relay 27/CX1 Spuriously De-energizes	8.71E-06
4	AA127CPR6D	1	Transformer CX Undervoltage Relay 27/CX1 Fails To Pick Up	2.49E-04
5	AA127R1RYT	24	Auxiliary Relay 27X/CX1 Spurious Operation	8.64E-06
6	AA127X1RYD	1	Auxiliary Relay 27X/1X Fails To Operate On Demand	3.30E-05
7	AA127X1RYT	384	Auxiliary Relay 27X/1X Spurious Operation	1.38E-04
8	AA127X2R6D	1	Transformer CX Undervoltage Relay 27/CX1 Fails To Drop Out	2.49E-04
9	AA127XCRYD	1	Auxiliary Relay 27/CX1 Fails To Operate On Demand	3.30E-05
10	AA186CXRYT	24	Transformer CX Differential Lock Out Relay 86CX Spurious Operation	8.64E-06
11	AA186S1RYT	24	Switchgear 1X Lockout Relay 86S/1X Spurious Operation	8.64E-06
12	AA187CXRYT	24	Transformer CX Differential Relay 87CX Spurious Operation	8.64E-06
13	AA2272PR6D	1	Transformer 2X Undervoltage Relay 27/2X Fails To Pick Up	2.49E-04
14	AA2272XR6D	1	Transformer 2X Undervoltage Relay 27/2X Fails To Drop Out	2.49E-04
15	AA2272XR6T	24	Transformer 2X Undervoltage Relay 27/2X Spuriously De-energizes	8.71E-06
16	AA227C2R6T	30	Transformer CX Undervoltage Relay 27/CX2 Spuriously De-energizes	1.09E-05
17	AA227C2RYD	1	Auxiliary Relay 27X/CX2 Fails To Operate On Demand	3.30E-05
18	AA227CPR6D	1	Transformer CX Undervoltage Relay 27/CX2 Fails To Pick Up	2.49E-04
19	AA227R2RYT	384	Auxiliary Relay 27X/CX2 Spurious Operation	1.38E-04
20	AA227T2R6D	1	Transformer #1 Undervoltage Relay (27T/2X) Fails To Drop Out	2.49E-04
21	AA227X2RYD	1	Auxiliary Relay 27X/2X Fails To Operate On Demand	3.30E-05
22	AA227X2RYT	24	Auxiliary Relay 27X/2X Spurious Operation	8.64E-06
23	AA286S2RYT	24	Switchgear 2X Lockout Relay 86S/2X Spurious Operation	8.64E-06
24	AB004ECCDT	30	DC Circuit Breaker 1DA-4EC Transfers Position	2.25E-06
25	AB0086TRYD	1	Keowee Main Tx Lock Out Relay 86T Fails To Operate On Demand	3.30E-05
26	AB0624CRYD	1	Time Delay Relay 62-4c Fails To Operate On Demand	3.30E-05
27	AB086E1RYD	1	Emergency Lock Out Relay 86E-1 Fails To Operate On Demand	3.30E-05
28	AB086TGRYD	1	General Keowee Main Tx Lock Out Sensing Relay Fails To Operate	3.30E-05
29	AB0SWGRCOM	6.69E-04	Common Cause Failure Of All Keowee Auxiliary Power Breakers	6.69E-04
30	AB0SWGRRHE	1.0	Failure To Recover Keowee Aux Power Breakers by Manual Control	1.00E+00
31	AB152TCSVO	1	Air Circuit Breaker 1 Trip Coil Fails To Operate	2.90E-05
32	AB1ACCUDEX	3.51E-05	Air Circuit Breaker 1 Accumulator Air Pressure Low	3.51E-05
33	AB1FALTDEX	0.0	Fault Occurs at ACB-1 When The BReaker Trips	0.00E+00
34	AB1MECHDEX	1.51E-4	Air Circuit Breaker 1 Fails To Open Due To Mechanical Failure	1.51E-04
35	AB1OPENLHE	2.60E-4	Air Circuit Breaker 1 Fails To Open Due To A Latent Human Error	2.60E-04
36	AB1PS02PST	12	Air Circuit Breaker 1 Accumulator Pressure Switch PS2 Fails Low	5.16E-06
37	AB1PSWTPST	24	Air Circuit Breaker 1 Accumulator Pressure Switch Fails Low	1.03E-05

Table E-1

Keowee PRA Basic Event Data
Current Operating Configuration - Bayesian Update/Unrecovered

	NAME	FACTOR	DESCRIPTION	PROBABILITY
38	AB1R52ZR6D	1	Air Circuit Breaker 1 Relay 52Z Fails To Operate	2.49E-04
39	AB21521SWT	30	Control Switch 152-2 Spurious Operation	2.10E-06
40	AB22BV1RYT	24	Backup Undervoltage Relay 2BV1 Spurious Operation	8.64E-06
41	AB23BKRCOM	1.12e-04	Common Cause Failure Of Air Circuit Breakers 2 And 3 To Close	1.12E-04
42	AB24BKRCOM	1.12E-04	Common Cause Failure Of Air Circuit Breakers 2 And 4 To Close	1.12E-04
43	AB251G2RYT	24	Air Circuit Breaker 2 Overcurrent Ground Relay 51G-2 Spurious Operation	8.64E-06
44	AB252CCSVO	1	Air Circuit Breaker 2 Close Coil Fails To Operate	2.90E-05
45	AB252TCSVO	1	Air Circuit Breaker 2 Trip Coil Fails To Operate	2.90E-05
46	AB252TCSVT	36	Air Circuit Breaker 2 Trip Coil Spurious Operation	1.40E-05
47	AB252Y2R6D	1	Air Circuit Breaker 2 Relay 52Y Failed To Drop Out Following Last Demand	2.49E-04
48	AB252Y2R6T	12	Air Circuit Breaker 2 Y-relay Spurious Operation	4.36E-06
49	AB2ACCUDEX	3.51E-05	Air Circuit Breaker 2 Accumulator Air Pressure Low	3.51E-05
50	AB2CLOSLHE	2.60E-4	Air Circuit Breaker 2 Fails To Close Due To A Latent Human Error	2.60E-04
51	AB2KEYISWT	12	Air Circuit Breaker 2 Key Interlock Switch Transfers Open	8.40E-07
52	AB2MCH2DEX	3.02E-4	Air Circuit Breaker 2 Fails To Close Due To Mechanical Failure	3.02E-04
53	AB2MECHDEX	1.51E-4	Air Circuit Breaker 2 Fails To Open Due To Mechanical Failure	1.51E-04
54	AB2OPENLHE	2.60E-4	Air Circuit Breaker 2 Fails To Open Due To A Latent Human Error	2.60E-04
55	AB2PS02PST	12	Air Circuit Breaker 2 Accumulator Pressure Switch PS2 Fails Low	5.16E-06
56	AB2PSWTPST	24	Air Circuit Breaker 2 Accumulator Pressure Switch Fails Low	1.03E-05
57	AB2PUSHPBT	36	Trip Pushbutton On ACB2 Spurious Operation	8.64E-06
58	AB2R462RYT	24	Air Circuit Breaker 2 Negative Sequence Relay 46-2 Spurious Operation	8.64E-06
59	AB2R52XR6D	1	Air Circuit Breaker 2 Relay 52X Fails To Operate	2.49E-04
60	AB2R52ZR6D	1	Air Circuit Breaker 2 Relay 52Z Fails To Operate	2.49E-04
61	AB2R52ZR6T	36	Air Circuit Breaker 2 Relay 52Z Spurious Operation	1.31E-05
62	AB31523SWT	24	Control Switch 152-3 Spurious Operation	1.68E-06
63	AB352CCSVO	1	Air Circuit Breaker 3 Close Coil Fails To Operate	2.90E-05
64	AB352TCSVO	1	Air Circuit Breaker 3 Trip Coil Fails To Operate	2.90E-05
65	AB352TCSVT	24	Air Circuit Breaker 3 Trip Coil Spurious Operation	9.36E-06
66	AB352Y2R6D	1	Air Circuit Breaker 3 Relay 52Y Failed To Drop Out Following Last Demand	2.49E-04
67	AB352Y2R6T	360	Air Circuit Breaker 3 Y-relay Spurious Operation	1.31E-04
68	AB3ACCUDEX	3.51E-05	Air Circuit Breaker 3 Accumulator Air Pressure Low	3.51E-05
69	AB3CLOSLHE	2.60e-04	Air Circuit Breaker 3 Fails To Close Due To Latent Human Error	2.60E-04
70	AB3MCH2DEX	3.02E-04	Air Circuit Breaker 3 Fails To Close Due To Mechanical Failure	3.02E-04
71	AB3MECHDEX	1.51E-04	Air Circuit Breaker 3 Fails To Open Due To Mechanical Failure	1.51E-04
72	AB3PS02PST	372	Air Circuit Breaker 3 Accumulator Pressure Switch PS2 Fails Low	1.60E-04
73	AB3PSWTPST	24	Air Circuit Breaker 3 Accumulator Pressure Switch Fails Low	1.03E-05
74	AB3PUSHPBT	24	Trip Pushbutton On ACB3 Spurious Operation	5.76E-06

Table E-1

Keowee PRA Basic Event Data
Current Operating Configuration - Bayesian Update/Unrecovered

	NAME	FACTOR	DESCRIPTION	PROBABILITY
75	AB3R52XR6D	1	Air Circuit Breaker 3 Relay 52X Fails To Operate	2.49E-04
76	AB3R52ZR6D	1	Air Circuit Breaker 3 Relay 52Z Fails To Operate	2.49E-04
77	AB3R52ZR6T	24	Air Circuit Breaker 3 Relay 52Z Spurious Operation	8.71E-06
78	AB41523SWT	24	Control Switch 152-4 Spurious Operation	1.68E-06
79	AB452CCSVO	1	Air Circuit Breaker 4 Close Coil Fails To Operate	2.90E-05
80	AB452TCSVT	24	Air Circuit Breaker 4 Trip Coil Spurious Operation	9.36E-06
81	AB452Y2R6D	1	Air Circuit Breaker 4 Relay 52Y Failed To Drop Out Following Last Demand	2.49E-04
82	AB452Y2R6T	372	Air Circuit Breaker 4 Y-relay Spurious Operation	1.35E-04
83	AB4ACCUDEX	3.51E-05	Air Circuit Breaker 4 Accumulator Air Pressure Low	3.51E-05
84	AB4CLOSLHE	2.60E-4	Air Circuit Breaker 4 Fails To Close Due To A Latent Human Error	2.60E-04
85	AB4CLSESWC	1	Air Circuit Breaker 4 Close Switch Fails To Close On Demand	1.00E-05
86	AB4KEYISWT	372	Air Circuit Breaker 4 Key Interlock Switch Transfers Open	2.60E-05
87	AB4LORESWT	372	Air Circuit Breaker 4 Local/Remote Switch Contact Transfers Position	2.60E-05
88	AB4MCH2DEX	3.02E-04	Air Circuit Breaker 4 Fails To Close Due To Mechanical Failure	3.02E-04
89	AB4PS02PST	372	Air Circuit Breaker 4 Accumulator Pressure Switch PS2 Indicates Low Pressure	1.60E-04
90	AB4PSWTPST	12	Air Circuit Breaker 4 Accumulator Pressure Switch Indicates Low Air Pressure	5.16E-06
91	AB4PUSHPBT	24	Trip Pushbutton On ACB-4 Spurious Operation	5.76E-06
92	AB4R52XR6D	1	Air Circuit Breaker 4 Relay 52X Fails To Operate	2.49E-04
93	AB4R52ZR6T	24	Air Circuit Breaker 4 Relay 52Z Spurious Operation	8.71E-06
94	AB510A1FUF	6	One Or More Control Power Fuses For X, Y And CC Fail	2.16E-05
95	AB51431LHE	3.20E-4	Manual/Auto Control Switch 143/1 Left In Manual	3.20E-04
96	AB51431RYT	360	Auxiliary Relay 143X/1 Spuriously Energizes	1.30E-04
97	AB51431SWT	360	Manual/Auto Control Switch 143/1 Spuriously Transfers Into Manual	2.52E-05
98	AB552CCRYD	1	Air Circuit Breaker 5 Close Coil CC Fails On Demand	3.30E-05
99	AB552TCRYT	384	Air Circuit Breaker 5 Trip Coil 52TC Spurious Operation	1.38E-04
100	AB552Y2RYT	360	Air Circuit Breaker 5 Y-relay Spurious Operation	1.30E-04
101	AB583S5RYD	1	Time Delay Relay 83S5 Fails To Pick Up	3.30E-05
102	AB5CLOSLHE	2.60E-4	Air Circuit Breaker 5 Fails To Close Due To A Latent Human Error	2.60E-04
103	AB5KEYISWT	360	Air Circuit Breaker 5 Key Interlock Switch Transfers Open	2.52E-05
104	AB5MCH2DEX	7.04E-03	Air Circuit Breaker 5 Fails To Close Due To Mechanical Failure	7.04E-03
105	AB5PUSHPBT	384	Trip Pushbutton On ACB5 Spurious Operation	9.22E-05
106	AB5R52XRYD	1	Air Circuit Breaker 5 Relay 52X Fails To Operate	3.30E-05
107	AB5R52YRYD	1	Air Circuit Breaker 5 Relay 52Y Failed To Drop Out At Last Demand	3.30E-05
108	AB610A1FUF	6	One Or More Control Power Fuses For X, Y And CC Fail	2.16E-05
109	AB610AFFUF	6	One Or More Control Power Fuses For Relay 27X/2X Fail	2.16E-05
110	AB61432LHE	3.20E-4	Manual/Auto Control Switch 143/2 Left In Manual	3.20E-04
111	AB61432SWT	360	Manual/Auto Control Switch 143/2 Spuriously Transfers Into Manual	2.52E-05

Table E-1

Keowee PRA Basic Event Data
Current Operating Configuration - Bayesian Update/Unrecovered

	NAME	FACTOR	DESCRIPTION	PROBABILITY
112	AB652CCRYD	1	Air Circuit Breaker 6 Close Coil CC Fails On Demand	3.30E-05
113	AB652TCRYD	1	Air Circuit Breaker 6 Trip Coil 52TC Fails Fails To Operate	3.30E-05
114	AB652TCRYT	24	Air Circuit Breaker 6 Trip Coil 52TC Spurious Operation	8.64E-06
115	AB652Y2RYT	360	Air Circuit Breaker 6 Y-relay Spurious Operation	1.30E-04
116	AB6CLOSLHE	2.60E-4	Air Circuit Breaker 6 Fails To Close Due To A Latent Human Error	2.60E-04
117	AB6KEYISWT	360	Air Circuit Breaker 6 Key Interlock Switch Transfers Open	2.52E-05
118	AB6MCH2DEX	7.04E-03	Air Circuit Breaker 6 Fails To Close Due To Mechanical Failure	7.04E-03
119	AB6MECHDEX	8.01E-04	Air Circuit Breaker 6 Fails To Open Due To Mechanical Failure	8.01E-04
120	AB6OPENLHE	3.20E-3	Air Circuit Breaker 6 Fails To Open Due To A Latent Human Error	3.20E-03
121	AB6PUSHPBT	24	Trip Pushbutton On ACB6 Spurious Operation	5.76E-06
122	AB6R52XRYD	1	Air Circuit Breaker 6 Relay 52X Fails To Operate	3.30E-05
123	AB6R52YRYD	1	Air Circuit Breaker 6 Relay 52Y Failed To Drop Out At Last Demand	3.30E-05
124	AB710A1FUF	6	One Or More Control Power Fuses For X, Y And CC Fail	2.16E-05
125	AB710AFFUF	6	One Or More Air Circuit Breaker 7 Control Power Fuses Fail	2.16E-05
126	AB752CCRYD	1	Air Circuit Breaker 7 Close Coil CC Fails On Demand	3.30E-05
127	AB752TCRYD	1	Air Circuit Breaker 7 Trip Coil TC Fails On Demand	3.30E-05
128	AB752TCRYT	24	Air Circuit Breaker 7 Trip Coil 52TC Spurious Operation	8.64E-06
129	AB752Y2RYT	360	Air Circuit Breaker 7 Y-relay Spurious Operation	1.30E-04
130	AB7CLOSLHE	2.60E-4	Air Circuit Breaker 7 Fails To Close Due To A Latent Human Error	2.60E-04
131	AB7KEYISWT	360	Air Circuit Breaker 7 Key Interlock Switch Transfers Open	2.52E-05
132	AB7MCH2DEX	7.04E-03	Air Circuit Breaker 7 Fails To Close Due To Mechanical Failure	7.04E-03
133	AB7MECHDEX	8.01E-04	Air Circuit Breaker 7 Fails To Open Due To Mechanical Failure	8.01E-04
134	AB7OPENLHE	3.20E-3	Air Circuit Breaker 7 Fails To Open Due To A Latent Human Error	3.20E-03
135	AB7PUSHPBT	30	Trip Pushbutton On ACB7 Spurious Operation	7.20E-06
136	AB7R52XRYD	1	Air Circuit Breaker 7 Relay 52X Fails To Operate	3.30E-05
137	AB7R52YRYD	1	Air Circuit Breaker 7 Relay 52Y Failed To Drop Out At Last Demand	3.30E-05
138	AB810A1FUF	6	One Or More Control Power Fuses For X, Y And CC Fail	2.16E-05
139	AB81432RYT	360	Auxiliary Relay 143X/2 Spuriously Energizes	1.30E-04
140	AB852CCRYD	1	Air Circuit Breaker 8 Close Coil CC Fails On Demand	3.30E-05
141	AB852TCRYT	384	Air Circuit Breaker 8 Trip Coil 52TC Spurious Operation	1.38E-04
142	AB852Y2RYT	360	Air Circuit Breaker 8 Y-relay Spurious Operation	1.30E-04
143	AB86E1ARYD	1	Emergency Lock Out Aux. Relay 86E-1a Fails To Operate On Demand	3.30E-05
144	AB86E1GRYD	1	Keowee Unit 1 Emergency Lock Out Sensing Relay Fails To Operate	3.30E-05
145	AB883S8RYD	1	Time Delay Relay 83S8 Fails To Pick Up	3.30E-05
146	AB8KEYISWT	360	Air Circuit Breaker 8 Key Interlock Switch Transfers Open	2.52E-05
147	AB8MCH2DEX	7.04E-03	Air Circuit Breaker 8 Fails To Close Due To Mechanical Failure	7.04E-03
148	AB8PUSHPBT	384	Trip Pushbutton On ACB8 Spurious Operation	9.22E-05

Table E-1

Keowee PRA Basic Event Data
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	NAME	FACTOR	DESCRIPTION	PROBABILITY
149	AB8R52XRYD	1	Air Circuit Breaker 8 Relay 52X Fails To Operate	3.30E-05
150	AB8R52YRYD	1	Air Circuit Breaker 8 Relay 52Y Failed To Drop Out At Last Demand	3.30E-05
151	ABEOPRCDHE	1.0	Operators Fail To Close Air Circuit Breaker 2	1.00E+00
152	ABEOPRCRHE	1	Operators Fail To Close Air Circuit Breaker 2	1.00E+00
153	ABPOPRCRHE	1.0	Operators Fail To Close Air Circuit Breaker 4	1.00E+00
154	ACB4MOD	1	NSM-ON-52966 Is Not In Service	1.00E+00
155	ACBAIRPDEX	2.00E-03	ACB Air Supply Fails Causing Low Pressure In All ACB Accumulators	2.00E-03
156	ACBTRIPCHE	0.0	Operators Trip Generator Output ACBs	0.00E+00
157	ACBXFERCOM	1.28E-06	Common Cause Failure That Results In ACBs 2 & 3 Transfering Open	1.28E-06
158	AD1B4ALCDT	30	Breaker 4AL In 125 V dc Distribution Center 1DA Transfers Open	2.25E-06
159	AD1C3CCCDT	24	Breaker 3CC In 125V dc Distribution Center 1DA Transfers Position	1.80E-06
160	AD1C3CLCDT	24	Breaker 3CL In 125V dc Distribution Center 1DA Transfers Position	1.80E-06
161	AD1SCLRCDT	12	Breaker 3CL In 125V dc Distribution Center 1DA Transfers Position (Rec)	9.00E-07
162	AD2B2ALCDT	30	Breaker 2AL In 125V dc Distribution Center 2DA Transfers Open	2.25E-06
163	AD2B3CCCDT	12	Breaker 3CC In 125V dc Distribution Center 2DA Transfers Position	9.00E-07
164	AD2C3CCCDT	24	Breaker 3CC In 125V dc Distribution Center 2DA Transfers Position	1.80E-06
165	AD2C3CLCDT	24	Breaker 3CL In 125V dc Distribution Center 2DA Transfers Position	1.80E-06
166	AK1141XRYD	1	Auxiliary Relay 14GOV/1X Fails To Pick-up	3.30E-05
167	AK114GVDEX	1.00e-04	KU1 Magnetic Speed Switch System Fails	1.00E-04
168	AK121TDRYD	1	Time Delay Relay 2-1TD Fails To Pick-up	3.30E-05
169	AK152TDRYD	1	Time Delay Relay 52-1TD Fails To Pick-up	3.30E-05
170	AK152TDRYT	4380	Time Delay Relay 52-1TD Spurious Operation	1.58E-03
171	AK152XGRYD	1	Relay 52XG/1 Fails To Pick Up When The Unit Is Started	3.30E-05
172	AK152XGRYT	2	Relay 52XG/1 Spuriously Drops Out While The Unit Is Running	7.20E-07
173	AK1AX34RYT	6	Relay 52AX/34 Spuriously Drops-out	2.16E-06
174	AK1GV1XRYD	1	Relay 14GOV/1X Fails To Pick-up	3.30E-05
175	AK1OFRQCOM	3.30E-06	KU1 CCF Of 2/3 Overfrequency Relays To Reset When Frequency Drops	3.30E-06
176	AK1X34XRYT	6	Relay 52AX/34X Spuriously Drops-out	2.16E-06
177	AK212OSSST	36	Turbine Overspeed Switch Indicates Overspeed	1.51E-04
178	AK2142XRYD	1	Auxiliary Relay 14GOV/2X Fails To Pick-up	3.30E-05
179	AK214GVDEX	1.00e-4	KU2 Magnetic Speed Switch System Fails	1.00E-04
180	AK222TDRYD	1	Time Delay Relay 2-2TD Fails To Pick-up	3.30E-05
181	AK252TDRYD	1	Time Delay Relay 52-2TD Fails To Operate	3.30E-05
182	AK252TDRYT	4380	Time Delay Relay 52-2TD Spurious Operation	1.58E-03
183	AK252W0RYD	1	KU2 Relay 52W Fails To Pick-up	3.30E-05
184	AK252XGRYD	1	Auxiliary Relay 52XG/2 Fails To Pick-up	3.30E-05
185	AK2GATEDEX	2.11E-5	Wicket Gate Limit Switch Indicates Gate Position Is Below No-load Setting	2.11E-05

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Keowee PRA Basic Event Data
Current Operating Configuration - Bayesian Update/Unrecovered

	NAME	FACTOR	DESCRIPTION	PROBABILITY
186	AK2GV2XRYD	1	Relay 14GOV/2X Fails To Pick-up	3.30E-05
187	AK2OFRQCOM	3.30E-06	KU2 CCF Of 2/3 Overfrequency Relays To Reset When Frequency Drops	3.30E-06
188	BK1088XRYD	1	Keowee 1 Turbine Guide Bearing Oil Relay 88X Fails to Drop Out	3.30E-05
189	BK1088XRYT	24	Keowee 1 Turbine Guide Bearing Oil Relay 88X Spurious Operation	8.64E-06
190	BK114/2SSD	1	Keowee 1 Speed Switch 14/2 Fails On Demand	1.80E-05
191	BK114/2SST	24	Keowee 1 Speed Switch 14/2 Spuriously Transfers Closed	1.01E-04
192	BK114DXRYD	1	Keowee 1 Rotation Sensing Aux. Relay 14DX Fails to Energize	3.30E-05
193	BK114DXRYT	24	Keowee 1 Rotation Sensing Aux. Relay 14DX Spuriously Drops Out	8.64E-06
194	BK114T2RYD	1	Keowee 1 Rotation Sensing Timer 14T2 Fails to De-energize	3.30E-05
195	BK114T2RYT	24	Keowee 1 Rotation Sensing Timer 14T2 Spurious Operation	8.64E-06
196	BK1188ASWT	24	Keowee 1 AC GBO Pump Control Switch S188A Spurious Operation	1.68E-06
197	BK1188DSWT	108	Unit 1 DC GBO Pump Control Switch S188D Spurious Operation	7.56E-06
198	BK1631XRYD	1	Keowee 1 Relay 63TA/1X Fails to De-energize	3.30E-05
199	BK1631XRYT	24	Keowee 1 GBO Level Relay 63TA/1X Spurious Operation	8.64E-06
200	BK1632XRYD	1	Keowee 1 Brng. Low Oil Level Aux. Relay 63TA/2X Fails To Operate On Demand	3.30E-05
201	BK1632XRYT	24	Keowee 1 Turb. Brng. Low Oil Level Aux. Rly 63TA/2X Spurious Operation	8.64E-06
202	BK163TALSD	1	Turbine No. 1 Bearing Oil Level Switch 63TA Fails on Demand	1.60E-03
203	BK163TALST	24	Turbine No. 1 Bearing Oil Level Switch 63TA Spurious Operation	7.44E-06
204	BK188AXRYD	1	Unit 1 AC Bearing Oil Pump Aux. Relay 88AX Fails to Drop Out	3.30E-05
205	BK188AXRYT	24	Unit 1 AC Bearing Oil Pump Aux. Relay 88AX Fails to Remain De-energized	8.64E-06
206	BK1DA5BCDT	24	DC Circuit Breaker 1DA-5B Transfers Position	1.80E-06
207	BK1GBDCGPR	12	Unit 1 DC Turbine GBO Pump Fails To Run	1.68E-04
208	BK1GBDCGPS	1	Unit 1 DC Turbine GBO Pump Fails To Start On Demand	9.70E-05
209	BK1GBDCLHE	3.2E-3	Latent Human Error Fails Unit 1 DC Guide Bearing Oil Pump Discharge Path	3.20E-03
210	BK1GBO1CVC	1	Check Valve 1GBO-1 Fails to Close on Demand	3.50E-04
211	BK1GBO1CVO	1	Check Valve 1GBO-1 Fails To Open On Demand	2.30E-06
212	BK1GBO1CVT	24	Check Valve 1GBO-1 Transfers Closed	3.12E-06
213	BK1GBO1FTC	24	Filter 1GBOFL-1 Becomes Clogged	4.32E-05
214	BK1GBO2VVT	24	Manual Valve 1GBO-2 Transfers Position	4.08E-07
215	BK1GBO3CVO	1	Check Valve 1GBO-3 Fails To Open On Demand	2.30E-06
216	BK1GBO3CVT	12	Check Valve 1GBO-3 Transfers Closed	1.56E-06
217	BK1GBO4VVT	108	Manual Valve 1GBO-4 Transfers Position	1.84E-06
218	BK1GBO5VVT	24	Manual Valve 1GBO-5 Transfers Position	4.08E-07
219	BK1GBO6VVT	24	Manual Valve 1GBO-6 Transfers Position	4.08E-07
220	BK1GBO8VVT	24	Manual Valve 1GBO-8 Transfers Position	4.08E-07
221	BK1GBO9VVT	24	Manual Valve 1GBO-9 Transfers Position	4.08E-07
222	BK1GOACGPR	24	Unit 1 AC Turbine GBO Pump Fails To Run	3.36E-04

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Keowee PRA Basic Event Data
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	NAME	FACTOR	DESCRIPTION	PROBABILITY
223	BK1GOACGPS	1	Unit 1 AC Turbine GBO Pump Fails To Start	9.70E-05
224	BK1GODCTRM	1.14E-3	Unit 1 DC Turbine GBO Pump Train In Maintenance	1.14E-03
225	BK1XA1CCLT	24	600 V Circuit Breaker 1XA-1C Transfers Position	2.18E-05
226	BK2088XRYD	1	Keowee 2 Turbine Guide Bearing Oil Relay 88X Fails to Drop Out	3.30E-05
227	BK2088XRYT	24	Keowee 2 Turbine Guide Bearing Oil Relay 88X Spurious Operation	8.64E-06
228	BK214/2SSD	1	Keowee 2 Speed Switch 14/2 Fails On Demand	1.80E-05
229	BK214/2SST	24	Keowee 2 Speed Switch 14/2 Spuriously Transfers Closed	1.01E-04
230	BK214DXRYD	1	Keowee 2 Rotation Sensing Aux. Relay 14DX Fails to Energize	3.30E-05
231	BK214DXRYT	24	Keowee 2 Rotation Sensing Aux. Relay 14DX Spurious Operation	8.64E-06
232	BK214T2RYD	1	Keowee 2 Rotation Sensing Timer 14T2 Fails to De-energize	3.30E-05
233	BK214T2RYT	24	Keowee Rotation Sensing Timer 14T2 Fails to Remain De-energized	8.64E-06
234	BK2188ASWT	24	Unit 2 AC GBO Pump Control Switch S188A Spurious Operation	1.68E-06
235	BK2188DSWT	108	Unit 2 DC GBO Pump Control Switch S188D Spurious Operation	7.56E-06
236	BK2631XRYD	1	Keowee 2 Relay 63TA/1X Fails to De-energize	3.30E-05
237	BK2631XRYT	24	Keowee 2 GBO Level Relay 63TA/1X Spurious Operation	8.64E-06
238	BK2632XRYD	1	Keowee 2 Brng. Low Oil Level Aux. Relay 63TA/2X Fails To Operate On Demand	3.30E-05
239	BK2632XRYT	24	Keowee 2 Turb. Brng. Low Oil Level Aux. Relay 63TA/2X Spurious Operation	8.64E-06
240	BK263TALSD	1	Turbine No. 2 Bearing Oil Level Switch 63TA Fails on Demand	1.60E-03
241	BK263TALST	24	Turbine No. 2 Bearing Oil Level Switch 63TA Spurious Operation	7.44E-06
242	BK288AXRYD	1	Unit 2 AC Bearing Oil Pump Aux. Relay 88AX Fails to Drop Out	3.30E-05
243	BK288AXRYT	24	Unit 2 AC Bearing Oil Pump Aux. Relay 88AX Fails to Remain De-energized	8.64E-06
244	BK2DA1BCDT	24	DC Circuit Breaker 2DA-1B Transfers Position	1.80E-06
245	BK2GBDCGPR	12	Unit 2 DC Turbine GBO Pump Fails To Run	1.68E-04
246	BK2GBDCGPS	1	Unit 2 DC Turbine GBO Pump Fails To Start On Demand	9.70E-05
247	BK2GBDCLHE	3.2E-3	Latent Human Error Fails Unit 2 DC Guide Bearing Oil Pump Discharge Path	3.20E-03
248	BK2GBO1CVC	1	Check Valve 2GBO-1 Fails to Close on Demand	3.50E-04
249	BK2GBO1CVO	1	Check Valve 2GBO-1 Fails To Open On Demand	2.30E-06
250	BK2GBO1CVT	24	Check Valve 2GBO-1 Transfers Closed	3.12E-06
251	BK2GBO1FTC	24	Filter 2GBOFL-1 Becomes Clogged	4.32E-05
252	BK2GBO2VVT	24	Manual Valve 2GBO-2 Transfers Position	4.08E-07
253	BK2GBO3CVO	1	Check Valve 2GBO-3 Fails To Open On Demand	2.30E-06
254	BK2GBO3CVT	12	Check Valve 2GBO-3 Transfers Closed	1.56E-06
255	BK2GBO4VVT	108	Manual Valve 2GBO-4 Transfers Position	1.84E-06
256	BK2GBO5VVT	24	Manual Valve 2GBO-5 Transfers Position	4.08E-07
257	BK2GBO6VVT	24	Manual Valve 2GBO-6 Transfers Position	4.08E-07
258	BK2GBO8VVT	24	Manual Valve 2GBO-8 Transfers Position	4.08E-07
259	BK2GBO9VVT	24	Manual Valve 2GBO-9 Transfers Position	4.08E-07

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Keowee PRA Basic Event Data
Current Operating Configuration - Bayesian Update/Unrecovered

	NAME	FACTOR	DESCRIPTION		PROBABILITY
260	BK2GOACGPR	24	Unit 2 AC Turbine GBO Pump Fails To Run		3.36E-04
261	BK2GOACGPS	1	Unit 2 AC Turbine GBO Pump Fails To Start		9.70E-05
262	BK2GODCTRM	1.14E-3	Unit 2 DC Turbine GBO Pump Train In Maintenance		1.14E-03
263	BK2XA1CCLT	24	600 V Circuit Breaker 2XA-1C Transfers Position		2.18E-05
264	BKGBOILCOM	1.94E-06	Common Cause Failure Of Turbine Guide Bearing Oil System		1.94E-06
265	D1DIAXXDEX	6.50E-06	Loss Of Power On 125 V dc Panelboard 1DIA	OEE-120, O-705	6.50E-06
266	D1DIBXXDEX	6.50E-06	Loss Of Power On 125 V dc Panelboard 1DIB	OEE-120-1, O-705	6.50E-06
267	D2DIAXXDEX	6.50E-06	Loss Of Power On 125 V dc Panelboard 2DIA		6.50E-06
268	D2DIBXXDEX	6.50E-06	Loss of Power on 125 V dc Panelboard 2DIB		6.50E-06
269	D3DIAXXDEX	6.50E-06	Loss Of Power On 125 V dc Panelboard 3DIA		6.50E-06
270	D3DIBXXDEX	6.50E-06	Loss Of Power On 125 Vdc Panelboard 3DIB		6.50E-06
271	DDC11BXCDT	24	125 Vdc Battery Breaker SY-DC1-1B Transfers Open		1.80E-06
272	DDC11CXCDT	24	125 Vdc Breaker SY-DC1-1C Transfers Open		1.80E-06
273	DDC11DCCDT	24	125 Vdc Breaker SY-DC1-1DC Transfers Open		1.80E-06
274	DDC11DLCDT	24	125 Vdc Breaker SY-DC1-1DL Transfers Open		1.80E-06
275	DDC11DRCDT	24	125 Vdc Breaker SY-DC1-1DR Transfers Open		1.80E-06
276	DDC1ALXBYM	1.14E-02	Battery SY-1 Is In Test or Maintenance		1.14E-02
277	DDC1BATBYF	1	Battery SY-1 Fails During Discharge		9.30E-04
278	DDC1FLTBDF	24	SY-DC1 Is Faulted		7.68E-06
279	DDC21BXCDT	24	125 Vdc Battery Breaker SY-DC2-1B Transfers Open		1.80E-06
280	DDC21CXCDT	24	125 Vdc Breaker SY-DC2-1C Transfers Open		1.80E-06
281	DDC21DCCDT	24	125 Vdc Breaker SY-DC2-1DC Transfers Open		1.80E-06
282	DDC21DLCDT	24	125 Vdc Breaker SY-DC2-1DL Transfers Open		1.80E-06
283	DDC21DRCDT	24	125 Vdc Breaker SY-DC2-1DR Transfers Open		1.80E-06
284	DDC2BATBYF	1	Battery SY-2 Fails During Discharge		9.30E-04
285	DDC2FLTBDF	24	SY-DC2 Is Faulted		7.68E-06
286	DDCBATTCOM	2.70E-05	Common Cause Failure of Switchyard Batteries		2.70E-05
287	DDCDYAXBDF	24	125 Vdc Switchyard DC Panelboard DYA Is Faulted		7.68E-06
288	DDCDYBXBDF	24	125 Vdc Switchyard DC Panelboard DYB Is Faulted		7.68E-06
289	DDCDYCXBDF	24	125 Vdc Switchyard DC Panelboard DYC Is Faulted		7.68E-06
290	DDCDYEXBDF	24	125 Vdc Switchyard DC Panelboard DYE Is Faulted		7.68E-06
291	DDCDYFXBDF	24	125 Vdc Switchyard DC Panelboard DYF Is Faulted		7.68E-06
292	DDCDYGXBDF	24	125 Vdc Switchyard DC Panelboard DYG Is Faulted		7.68E-06
293	E12EXCTCOM	5.31E-05	Units 1 & 2 Excit Fail Due To Common Cause Failure Of The Breakers		5.31E-05
294	ED11D3DCDT	84	Breaker 3D In 125V dc Distribution Center 1DA Transfers Open		6.30E-06
295	ED13BR2CDT	24	Breaker 3BR In 125V dc Distribution Center 1DA Transfers Open		1.80E-06
296	ED22D3DCDT	24	Breaker 2D In 125V dc Distribution Center 2DA Transfers Open		1.80E-06

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Keowee PRA Basic Event Data
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	NAME	FACTOR	DESCRIPTION	PROBABILITY
297	ED23BR2CDT	24	Breaker 3BR In 125V dc Distribution Center 2DA Transfers Open	1.80E-06
298	EK00RUNCOM	1.24E-4	Common Cause Failure Of Both Units Voltage Regulators To Run	1.24E-04
299	EK0BASERHE	1.0	Failure To Recover From Keowee Base Adjust LHE	1.00E+00
300	EK131TDRYD	1	Keowee Unit 1 Field Flashing Breaker Time Delay Relay 31/TD Fails To Operate	3.30E-05
301	EK131TDRYT	84	Keowee Unit 1 Field Flashing Breaker Time Delay Relay 31/TD Spurious Operation	3.02E-05
302	EK14152SWT	84	KHU1 Generator Supply Breaker Trip Control Switch 141-52/T Spurious Operation	5.88E-06
303	EK1415TSWT	24	Spurious Operation Of The KHU1 Supply Breaker Trip Switch	1.68E-06
304	EK1415YRYD	1	KHU1 Generator Supply Breaker Y-relay Failed To Drop-out At Last Operation	3.30E-05
305	EK1415YRYT	84	KHU1 Generator Supply Breaker Y-relay Spurious Operation	3.02E-05
306	EK141AXR6D	1	Keowee Unit 1 Relay 41/AX Fails To Pick-up And Latch	2.49E-04
307	EK141AXR6T	24	Keowee Unit 1 Relay 41/AX Spuriously Resets	8.71E-06
308	EK141CFRYD	1	Keowee Unit 1 Field Flashing Breaker Close Coil Fails To Operate On Demand	3.30E-05
309	EK186E2RYT	6	Keowee Unit 1 Lockout Auxiliary Relay 86EX-2 Is Picked-up	2.16E-06
310	EK186EXRYT	84	Keowee Unit 1 Gen Lockout Auxiliary Relay 86EX-1 Spurious Actuation	3.02E-05
311	EK186X2RYT	24	Keowee Unit 1 Generator Lockout Auxiliary Relay 86EX-1 Spurious Actuation	8.64E-06
312	EK188SVRYD	1	Keowee Unit 1 Fan Control Relay 88SV Fails On Demand	3.30E-05
313	EK188SVRYT	108	Keowee Unit 1 Fan Control Relay 88SV Prior To Or During The Run	3.89E-05
314	EK1901ARYT	84	Keowee Unit 1 Relay 90X1A Spurious Operation	3.02E-05
315	EK199SXRYD	1	Auxiliary Relay 99SX1 Fails To Pick-up	3.30E-05
316	EK199SYRYD	1	Keowee Unit 1 Relay 99SY Fails To Pick-up	3.30E-05
317	EK199SYRYT	24	Keowee Unit 1 Relay 99SY Drops Out	8.64E-06
318	EK1BAS2DEX	1.24E-3	KHU-1 Base Adjust Fails To Maintain Generator Output Within Acceptable Range	1.24E-03
319	EK1BASEDEX	6.17E-4	Keowee Unit 1 Base Adjust Fails To Establish Correct Unit Voltage	6.17E-04
320	EK1BASELHE	3.20E-3	Keowee Unit 1 Base Adjust Is Set Incorrectly	3.20E-03
321	EK1DIODDEX	2.88E-4	Keowee Unit 1 Exciter Fan Supply Diode Bridge Fails	2.88E-04
322	EK1EXC1TGF	84	Keowee Unit 1 Gen Excitation Transformer Is Failed	8.23E-05
323	EK1EXC2TGF	24	Keowee Unit 1 Generator Excitation Transformer Fails	2.35E-05
324	EK1F30AFUF	24	Keowee Unit 1 Excitation Cabinet Fan Fuses Fail	8.64E-05
325	EK1F31XRYD	1	Keowee Unit 1 Field Flashing Breaker Relay 31/X Fails To Pick-up On Demand	3.30E-05
326	EK1F41CRYD	1	Keowee Unit 1 Field Breaker Close Coil Fails To Operate On Demand	3.30E-05
327	EK1FAN1TLF	24	Keowee Unit 1 Generator Excitation Fan Power Transformer Fails	1.80E-05
328	EK1FLDCLHE	2.60E-4	Keowee Unit 1 Field Breaker Fails To Close Due To Latent Human Error	2.60E-04
329	EK1FLDMDEX	7.71E-5	Keowee Unit 1 Field Breaker Fails To Close Due To Mechanical Failure	7.71E-05
330	EK1FLSCLHE	2.60E-4	Keowee Unit 1 Field Flashing Breaker Fails To Close Due To Latent Human Error	2.60E-04
331	EK1FLSMDEX	7.71E-5	Keowee Unit 1 Field Flashing Breaker Fails To Close Due To Mechanical Failure	7.71E-05
332	EK1FLSOLHE	2.60E-4	Keowee Unit 1 Field Flashing Breaker Fails To Open Due To Latent Human Error	2.60E-04
333	EK1R31TRYD	1	Keowee Unit 1 Field Flashing Breaker Trip Coil 31/T Fails To Operate	3.30E-05

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Keowee PRA Basic Event Data
Current Operating Configuration - Bayesian Update/Unrecovered

	NAME	FACTOR.	DESCRIPTION	PROBABILITY
334	EK1R31YRYD	1	KHU1 Gen Field Flashing Breaker Y-relay Failed To Drop Out At Last Operation	3.30E-05
335	EK1R31YRYT	84	KHU1 Generator Field Flashing Breaker Y-relay Spurious Operation	3.02E-05
336	EK1R41XRYD	1	Keowee Unit 1 Field Breaker Relay 41/X Fails To Pick-up On Demand	3.30E-05
337	EK1R41YRYD	1	KHU1 Generator Field Breaker Y-relay Failed To Drop-out At Last Operation	3.30E-05
338	EK1R41YRYT	84	Keowee Unit 1 Generator Field Breaker Y-relay Spurious Operation	3.02E-05
339	EK1R9A1RYT	84	Keowee Unit 1 Relay 90X1A/TD Spurious Operation	3.02E-05
340	EK1R9C1R6T	84	Keowee Unit 1 Relay 90X1C Spurious Operation	3.05E-05
341	EK1S141SWT	84	KHU1 Field Breaker Trip Control Switch 141/T Spurious Operation	5.88E-06
342	EK1S31TSWT	84	KHU1 Field Flashing Breaker Trip Control Switch 131/T Spurious Operation	5.88E-06
343	EK1S41CRYD	1	Keowee Unit 1 Supply Breaker Close Coil Fails To Operate On Demand	3.30E-05
344	EK1S41TSWT	24	Keowee Unit 1 Field Breaker Trip Control Switch Transfers Position	1.68E-06
345	EK1S41XRYD	1	Keowee Unit 1 Supply Breaker Relay 41-52X Fails To Pick-up On Demand	3.30E-05
346	EK1SPYCLHE	2.60E-4	Keowee Unit 1 Supply Breaker Fails To Close Due To Latent Human Error	2.60E-04
347	EK1SPYMDEX	4.62E-4	Keowee Unit 1 Supply Breaker Fails To Close Due To Mehanical Failure	4.62E-04
348	EK1VHSVRYD	1	Keowee Unit 1 Volts/Hertz Relay SV Fails To Trip Field Flashing Breaker	3.30E-05
349	EK1VREGDEX	2.47E-3	KHU-1 Voltage Adjust Failure Drives Generator Output Too High/Low	2.47E-03
350	EK231TDRYD	1	Keowee Unit 2 Field Flashing Breaker Time Delay Relay 31/TD Fails To Operate	3.30E-05
351	EK231TDRYT	12	Keowee Unit 2 Field Flashing Breaker Time Delay Relay 31/TD Spurious Operation	4.32E-06
352	EK24152SWT	12	KHU2 Generator Supply Breaker Trip Control Switch Spurious Operation	8.40E-07
353	EK2415TSWT	24	Spurious Operation Of The KHU2 Supply Breaker Trip Switch	1.68E-06
354	EK2415YRYD	1	KHU2 Gen Supply Breaker Y-relay Failed To Drop-out At Last Operation	3.30E-05
355	EK2415YRYT	12	KHU2 Generator Supply Breaker Y-relay Spurious Operation	4.32E-06
356	EK241AXR6D	1	Keowee Unit 2 Relay 41/AX Fails To Pick-up And Latch	2.49E-04
357	EK241AXR6T	24	Keowee Unit 2 Relay 41/AX Spuriously Resets	8.71E-06
358	EK241CFRYD	1	Keowee Unit 2 Field Flashing Breaker Close Coil Fails To Operat On Demand	3.30E-05
359	EK286E2RYT	6	Keowee Unit 2 Lockout Auxiliary Relay 86EX-2 Is Picked-up	2.16E-06
360	EK286EXRYT	12	Keowee Unit 2 Generator Lockout Auxiliary Relay 86EX-1 Spurious Actuation	4.32E-06
361	EK286X2RYT	24	Keowee Unit 2 Generator Lockout Auxiliary Relay 86EX-1 Spurious Actuation	8.64E-06
362	EK288SVRYD	1	Keowee Unit 2 Fan Control Relay 88SV Fails On Demand	3.30E-05
363	EK288SVRYT	36	Keowee Unit 2 Fan Control Relay 88SV Prior To Or During The Run	1.30E-05
364	EK2901ARYT	12	Keowee Unit 2 Relay 90X1A Spurious Operation	4.32E-06
365	EK299SXRYD	1	Auxiliary Relay 99SX2 Fails To Pick-up	3.30E-05
366	EK299SYRYD	1	Keowee Unit 2 Relay 99SY Fails To Pick-up	3.30E-05
367	EK299SYRYT	24	Keowee Unit 2 Relay 99SY Drops Out	8.64E-06
368	EK2BAS2DEX	1.24E-3	KHU-2 Base Adjust Fails To Maintain Generator Output Within Acceptable Range	1.24E-03
369	EK2BASEDEX	6.17E-4	Keowee Unit 2 Base Adjust Fails To Establish Correct Unit Voltage	6.17E-04
370	EK2BASELHE	3.20E-3	Keowee Unit 2 Base Adjust Is Set Incorrectly	3.20E-03

Table E-1

Keowee PRA Basic Event Data
Current Operating Configuration - Bayesian Update/Unrecovered

	NAME	FACTOR	DESCRIPTION	PROBABILITY
371	EK2DIODDEX	2.88E-4	Keowee Unit 2 Exciter Fan Supply Diode Bridge Fails	2.88E-04
372	EK2EXC1TGF	12	Keowee Unit 2 Generator Excitation Transformer Is Failed	1.18E-05
373	EK2EXC2TGF	24	Keowee Unit 2 Generator Excitation Transformer Fails	2.35E-05
374	EK2F30AFUF	24	Keowee Unit 2 Excitation Cabinet Fan Fuses Fail	8.64E-05
375	EK2F31XRYD	1	Keowee Unit 2 Field Flashing Breaker Relay 31/X Fails To Pick-up On Demand	3.30E-05
376	EK2F41CRYD	1	Keowee Unit 2 Field Breaker Close Coil Fails To Operate On Demand	3.30E-05
377	EK2FAN1TLF	24	Keowee Unit 2 Generator Excitation Fan Power Transformer Fails	1.80E-05
378	EK2FLDCLHE	2.60E-4	Keowee Unit 2 Field Breaker Fails To Close Due To Latent Human Error	2.60E-04
379	EK2FLDMDEX	7.71E-5	Keowee Unit 2 Field Breaker Fails To Close Due To Mechanical Failure	7.71E-05
380	EK2FLSCLHE	2.60E-4	Keowee Unit 2 Field Flashing Breaker Fails To Close Due To Latent Human Error	2.60E-04
381	EK2FLSMDEX	7.71E-5	Keowee Unit 2 Field Flashing Breaker Fails To Close Due To Mechanical Failure	7.71E-05
382	EK2FLSOLHE	2.60E-4	Keowee Unit 2 Field Flashing Breaker Fails To Open Due To Latent Human Error	2.60E-04
383	EK2R31TRYD	1	Keowee Unit 2 Field Flashing Breaker Trip Coil 31/T Fails To Operate	3.30E-05
384	EK2R31YRYD	1	KHU2 Gen Field Flashing Breaker Y-relay Failed To Drop At Last Operation	3.30E-05
385	EK2R31YRYT	12	KHU2 Generator Field Flashing Breaker Y-relay Spurious Operation	4.32E-06
386	EK2R41XRYD	1	Keowee Unit 2 Field Breaker Relay 41/X Fails To Pick-up On Demand	3.30E-05
387	EK2R41YRYD	1	KHU2 Generator Field Breaker Y-relay Failed To Drop-out At Last Operation	3.30E-05
388	EK2R41YRYT	12	KHU2 Generator Field Breaker Y-relay Spurious Operation	4.32E-06
389	EK2R9A2RYT	12	Keowee Unit 2 Relay 90X1A/TD Spurious Operation	4.32E-06
390	EK2R9C2R6T	12	Keowee Unit 2 Relay 90X1C Spurious Operation	4.36E-06
391	EK2S141SWT	12	KHU2 Field Breaker Trip Control Switch Spurious Operation	8.40E-07
392	EK2S31TSWT	12	KHU2 Field Flashing Breaker Trip Control Switch 131/T Spurious Operation	8.40E-07
393	EK2S41CRYD	1	Keowee Unit 2 Supply Breaker Close Coil Fails To Operate On Demand	3.30E-05
394	EK2S41TSWT	24	Keowee Unit 2 Field Breaker Trip Control Switch Transfers Position	1.68E-06
395	EK2S41XRYD	1	Keowee Unit 2 Supply Breaker Relay 41-52X Fails To Pick-up On Demand	3.30E-05
396	EK2SPYCLHE	2.60E-4	Keowee Unit 2 Supply Breaker Fails To Close Due To Latent Human Error	2.60E-04
397	EK2SPYMDEX	4.62E-4	Keowee Unit 2 Supply Breaker Fails To Close Due To Mehanical Failure	4.62E-04
398	EK2VHSVRYD	1	Keowee Unit 2 Volts/Hertz Relay SV Fails To Trip Field Flashing Breaker	3.30E-05
399	EK2VREGDEX	2.47E-3	KHU-2 Voltage Adjust Failure Drives Generator Output Too High/Low	2.47E-03
400	EKSTARTCOM	6.17E-5	Common Cause Failure Of Both Units Voltage Regulators To Start	6.17E-05
401	ESCONDNOT	1	An Engineered Safeguards Condition Does Not Exist	1.00E+00
402	EU1C1RORYD	1	ONS1 ESG Chan. 1 Ro Relay Fails To Pick Up OEE-120	1.00E+00
403	EU1C2RORYD	1	ONS1 ESG Chan. 2 Ro Relay Fails to Pick Up	1.00E+00
404	EU2C1RORYD	1	ONS2 ESG Chan. 1 Ro Relay Fails to Pick Up OEE-220	1.00E+00
405	EU2C2RORYD	1	ONS2 ESG Chan. 2 Ro Relay Fails to Pick Up OEE-220-1	1.00E+00
406	EU3C1RORYD	1	ONS3 ESG Chan. 1 Ro Relay Fails to Pick Up OEE-320	1.00E+00
407	EU3C2RORYD	1	ONS3 ESG Chan. 2 Ro Relay Fails to Pick Up OEE-320-1	1.00E+00

Table E-1

Keowee PRA Basic Event Data
Current Operating Configuration - Bayesian Update/Unrecovered

	NAME	FACTOR	DESCRIPTION	PROBABILITY
408	FK0FISHCOM	2.55E-3	Common Cause Failure Of Both Unit s WL Filters Due To Intake Debris	2.55E-03
409	FK0FISHDHE	1.0	Failure To Recover From MainTure WL Strainer Clogging	1.00E+00
410	FK0FL00DHE	1.0	Failure To Recover From Turbine Guide Bearing or Packing WL Filter Clogging	1.00E+00
411	FK0WL01VVT	24	Locked-Open Manual Valve 0WL-1 Transfers Position	4.08E-07
412	FK1120GLHE	3.2E-3	Unit 1 Control Switch S120G Left in OFF Position	3.20E-03
413	FK1120GSWT	108	Unit 1 Control Switch S120G Spurious Operation	7.56E-06
414	FK1FL01FRF	24	Filter 1WLFL-1 Becomes Clogged	2.35E-05
415	FK1FL02FRF	24	Filter 1WLFL-2 Becomes Clogged	2.35E-05
416	FK1TRHXHXF	24	Turbine Packing Box Heat Exchanger 1TRHX-1 Fails	1.54E-05
417	FK1WL03VVT	24	Manual Valve 1WL-3 Transfers Position	4.08E-07
418	FK1WL04VVT	24	Manual Valve 1WL-4 Transfers Position	4.08E-07
419	FK1WL05VVT	24	Manual Valve 1WL-5 Transfers Position	4.08E-07
420	FK1WL06VVT	24	Manual Valve 1WL-6 Transfers Position	4.08E-07
421	FK1WL07VVT	24	Manual Valve 1WL-7 Transfers Position	4.08E-07
422	FK1WL08VVT	24	Manual Valve 1WL-8 Transfers Position	4.08E-07
423	FK1WL09VVT	24	Manual Valve 1WL-9 Transfers Position	4.08E-07
424	FK1WL11AVO	1	Cooling Water Control Valve 1WL-11 Fails To Open On Demand	2.80E-04
425	FK1WL11AVT	24	Cooling Water Control Valve 1WL-11 Transfers Closed	5.52E-05
426	FK1WL12VVT	108	Manual Valve 1WL-12 Transfers Position	1.84E-06
427	FK1WL15VVT	108	Manual Valve 1WL-15 Transfers Position	1.84E-06
428	FK1WL42VVT	108	Manual Valve 1WL-42 Transfers Position	1.84E-06
429	FK1WL43VVT	108	Manual Valve 1WL-43 Transfers Position	1.84E-06
430	FK2120GLHE	2.6E-4	Unit 2 Control Switch S120G Left in OFF Position	2.60E-04
431	FK2120GSWT	36	Unit 2 Control Switch S120G Spurious Operation	2.52E-06
432	FK2FL01FRF	24	Filter 2WLFL-1 Becomes Clogged	2.35E-05
433	FK2FL02FRF	24	Filter 2WLFL-2 Becomes Clogged	2.35E-05
434	FK2TRHXHXF	24	Turbine Packing Box Heat Exchanger 2TRHX-1 Fails	1.54E-05
435	FK2WL03VVT	24	Manual Valve 2WL-3 Transfers Position	4.08E-07
436	FK2WL04VVT	24	Manual Valve 2WL-4 Transfers Position	4.08E-07
437	FK2WL05VVT	24	Manual Valve 2WL-5 Transfers Position	4.08E-07
438	FK2WL06VVT	24	Manual Valve 2WL-6 Transfers Position	4.08E-07
439	FK2WL07VVT	24	Manual Valve 2WL-7 Transfers Position	4.08E-07
440	FK2WL08VVT	24	Manual Valve 2WL-8 Transfers Position	4.08E-07
441	FK2WL09VVT	24	Manual Valve 2WL-9 Transfers Position	4.08E-07
442	FK2WL11AVO	1	Cooling Water Control Valve 2WL-11 Fails To Open On Demand	2.80E-04
443	FK2WL11AVT	24	Cooling Water Control Valve 2WL-11 Transfers Closed	5.52E-05
444	FK2WL12VVT	36	Manual Valve 2WL-12 Transfers Position	6.12E-07

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Keowee PRA Basic Event Data
Current Operating Configuration - Bayesian Update/Unrecovered

	NAME	FACTOR	DESCRIPTION	PROBABILITY
445	FK2WL15VVT	36	Manual Valve 2WL-15 Transfers Position	6.12E-07
446	FK2WL42VVT	36	Manual Valve 2WL-42 Transfers Position	6.12E-07
447	FK2WL43VVT	36	Manual Valve 2WL-43 Transfers Position	6.12E-07
448	FKVALVECOM	2.46E-5	Common Cause Failure Of Cooling Water Control Valves	2.46E-05
449	GK0COOLCOM	4.61E-07	Common Cause Failure of Generator Air Cooling	4.61E-07
450	GK0LOCKCOM	4.06E-06	Common Cause Actuation of Generator Lockouts	4.06E-06
451	GK10001HGR	24	Keowee Unit 1 Generator Fault While the Unit Runs	2.27E-03
452	GK10001HGS	1	Keowee Unit 1 Generator Fault Causes Unit Start Failure	1.54E-04
453	GK1063FPST	24	Keowee 1 Gen CO2 Sys Press Switch 63F Spurious Operation	1.03E-05
454	GK112TDRYT	24	Time Delay Relay 12XTD/1 Spuriously Picks-up	8.64E-06
455	GK112X1RYT	24	Relay 12X/1 Spuriously Picks-up	8.64E-06
456	GK13SUIRYT	24	Keowee Unit 1 Startup Inhibit Switch Auxiliary Relay S3SUIX Spurious Actuation	8.64E-06
457	GK13SUISWT	24	Keowee Unit 1 Startup Inhibit Switch 3SUI Spurious Operation	1.68E-06
458	GK140G1RYT	24	Keowee Unit 1 Loss Of Generator Field Relay 40G1 Spurious Actuation	8.64E-06
459	GK159GNRYT	24	Keowee Unit 1 Generator Ground Fault Relay 59GN1 Spurious Actuation	8.64E-06
460	GK162TDRYT	24	Keowee Unit 1 Generator Backup Trip Timer 62-1TD Spurious Operation	8.64E-06
461	GK163FXRYT	24	Keowee Unit 1 Generator Fire Relay 63FX Spurious Actuation	8.64E-06
462	GK186E1RYT	24	Keowee 1 Emergency Lockout Relay 86E-1 Spuriously Picks Up	8.64E-06
463	GK187G1RYT	24	Keowee Unit 1 Generator Differential Relay 87G-1 Spurious Actuation	8.64E-06
464	GK187GBRYT	24	Keowee Unit 1 Generator Bus Differential Relay 87GB Spurious Actuation	8.64E-06
465	GK187TERYT	24	Keowee Unit 1 Exitation Transformer Differential Relay 87T-1E Spur. Actuation	8.64E-06
466	GK1BRGVLHE	2.60E-04	Keowee 1 Gen. Brng Oil Cooling Flow Path Vlvs Mispositioned After Maintenance	2.60E-04
467	GK1COOLLHE	2.60E-04	Keowee 1 Gen. Air Cooler WL Flow Path Vlvs Mispositioned After Maintenance	2.60E-04
468	GK1FIREDEX	3.19E-05	Spurious Actuation of Unit 1 Gen. CO2 Fire Supression System	3.19E-05
469	GK1GAC1HXF	24	Generator Air Cooler 1GAHW-1 Fails	1.54E-05
470	GK1GAC1HXL	108	Heat Exchanger 1GAC1 Leaks	1.08E-05
471	GK1GAC2HXF	24	Generator Air Cooler 1GAHW-2 Fails	1.54E-05
472	GK1GAC2HXL	108	Heat Exchanger 1GAC2 Leaks	1.08E-05
473	GK1GAC3HXF	24	Generator Air Cooler 1GAHW-3 Fails	1.54E-05
474	GK1GAC3HXL	108	Heat Exchanger 1GAC3 Leaks	1.08E-05
475	GK1GAC4HXF	24	Generator Air Cooler 1GAHW-4 Fails	1.54E-05
476	GK1GAC4HXL	108	Heat Exchanger 1GAC4 Leaks	1.08E-05
477	GK1GAC5HXF	24	Generator Air Cooler 1GAHW-5 Fails	1.54E-05
478	GK1GAC5HXL	108	Heat Exchanger 1GAC5 Leaks	1.08E-05
479	GK1GAC6HXF	24	Generator Air Cooler 1GAHW-6 Fails	1.54E-05
480	GK1GAC6HXL	108	Heat Exchanger 1GAC6 Leaks	1.08E-05
481	GK1HPO1HXF	24	Generator Thrust Bearing Cooler 1HPOHX-1 Fails	1.54E-05

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Keowee PRA Basic Event Data
Current Operating Configuration - Bayesian Update/Unrecovered

	NAME	FACTOR	DESCRIPTION	PROBABILITY
482	GK1HPO2HXF	24	Generator Thrust Bearing Cooler 1HPOHX-2 Fails	1.54E-05
483	GK1HPO3HXF	24	Generator Thrust Bearing Cooler 1HPOHX-3 Fails	1.54E-05
484	GK1HPO4HXF	24	Generator Thrust Bearing Cooler 1HPOHX-4 Fails	1.54E-05
485	GK1HPO5HXF	24	Generator Thrust Bearing Cooler 1HPOHX-5 Fails	1.54E-05
486	GK1HPO6HXF	24	Generator Thrust Bearing Cooler 1HPOHX-6 Fails	1.54E-05
487	GK1HPO6VVT	24	Genrator Bearing Oil Leak Because Manual Valve 1HPO-6 Transfers Position	4.08E-07
488	GK1HPO7HXF	24	Generator Thrust Bearing Cooler 1HPOHX-7 Fails	1.54E-05
489	GK1HPO8HXF	24	Generator Thrust Bearing Cooler 1HPOHX-8 Fails	1.54E-05
490	GK1NGDCLHE	5.20E-05	Failure to Close the Unit 1 Neutral Ground Disconnect Following Maintenance	5.20E-05
491	GK1O121SST	24	Speed Switch 12/1 Falsely Indicates High Speed	1.01E-04
492	GK1WL16VVT	384	Manual Valve 1WL-16 Transfers Position	6.53E-06
493	GK1WL17VVT	384	Manual Valve 1WL-17 Transfers Position	6.53E-06
494	GK1WL18VVT	108	Manual Valve 1WL18 Transfers Position	1.84E-06
495	GK1WL19VVT	108	Manual Valve 1WL19 Transfers Position	1.84E-06
496	GK1WL20VVT	384	Manual Valve 1WL-20 Transfers Position	6.53E-06
497	GK1WL21VVT	384	Manual Valve 1WL-21 Transfers Position	6.53E-06
498	GK1WL22VVT	108	Manual Valve 1WL22 Transfers Position	1.84E-06
499	GK1WL23VVT	108	Manual Valve 1WL23 Transfers Position	1.84E-06
500	GK1WL24VVT	384	Manual Valve 1WL-24 Transfers Position	6.53E-06
501	GK1WL25VVT	384	Manual Valve 1WL-25 Transfers Position	6.53E-06
502	GK1WL26VVT	108	Manual Valve 1WL26 Transfers Position	1.84E-06
503	GK1WL27VVT	108	Manual Valve 1WL27 Transfers Position	1.84E-06
504	GK1WL28VVT	384	Manual Valve 1WL-28 Transfers Position	6.53E-06
505	GK1WL29VVT	384	Manual Valve 1WL-29 Transfers Position	6.53E-06
506	GK1WL30VVT	108	Manual Valve 1WL30 Transfers Position	1.84E-06
507	GK1WL31VVT	108	Manual Valve 1WL31 Transfers Position	1.84E-06
508	GK1WL32VVT	384	Manual Valve 1WL-32 Transfers Position	6.53E-06
509	GK1WL33VVT	384	Manual Valve 1WL-33 Transfers Position	6.53E-06
510	GK1WL34VVT	108	Manual Valve 1WL34 Transfers Position	1.84E-06
511	GK1WL35VVT	108	Manual Valve 1WL35 Transfers Position	1.84E-06
512	GK1WL36VVT	384	Manual Valve 1WL-36 Transfers Position	6.53E-06
513	GK1WL37VVT	384	Manual Valve 1WL-37 Transfers Position	6.53E-06
514	GK1WL38VVT	108	Manual Valve 1WL38 Transfers Position	1.84E-06
515	GK1WL39VVT	108	Manual Valve 1WL39 Transfers Position	1.84E-06
516	GK1WL41VVT	384	Keowee 1 Manual Valve 1WL-41 Transfers Position to Block Discharge Path	6.53E-06
517	GK1WL44VVT	384	Manual Valve 1WL-44 Transfers Position	6.53E-06
518	GK1WL45VVT	384	Manual Valve 1WL-45 Transfers Position	6.53E-06

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Keowee PRA Basic Event Data
Current Operating Configuration - Bayesian Update/Unrecovered

	NAME	FACTOR	DESCRIPTION	PROBABILITY
519	GK1WL46VVT	108	Manual Valve 1WL-46 Transfers Position	1.84E-06
520	GK1WL47VVT	108	Manual Valve 1WL-47 Transfers Position	1.84E-06
521	GK1WL48VVT	384	Manual Valve 1WL-48 Transfers Position	6.53E-06
522	GK1WL49VVT	384	Manual Valve 1WL-49 Transfers Position	6.53E-06
523	GK1WL50VVT	108	Manual Valve 1WL-50 Transfers Position	1.84E-06
524	GK1WL51VVT	108	Manual Valve 1WL-51 Transfers Position	1.84E-06
525	GK1WL52VVT	384	Manual Valve 1WL-52 Transfers Position	6.53E-06
526	GK1WL53VVT	384	Manual Valve 1WL-53 Transfers Position	6.53E-06
527	GK1WL54VVT	108	Manual Valve 1WL-54 Transfers Position	1.84E-06
528	GK1WL55VVT	108	Manual Valve 1WL-55 Transfers Position	1.84E-06
529	GK1WL56VVT	384	Manual Valve 1WL-56 Transfers Position	6.53E-06
530	GK1WL57VVT	384	Manual Valve 1WL-57 Transfers Position	6.53E-06
531	GK1WL58VVT	108	Manual Valve 1WL-58 Transfers Position	1.84E-06
532	GK1WL59VVT	108	Manual Valve 1WL-59 Transfers Position	1.84E-06
533	GK1WL60VVT	384	Manual Valve 1WL-60 Transfers Position	6.53E-06
534	GK1WL61VVT	384	Manual Valve 1WL-61 Transfers Position	6.53E-06
535	GK1WL62VVT	108	Manual Valve 1WL-62 Transfers Position	1.84E-06
536	GK1WL63VVT	108	Manual Valve 1WL-63 Transfers Position	1.84E-06
537	GK1WL64VVT	384	Manual Valve 1WL-64 Transfers Position	6.53E-06
538	GK1WL65VVT	384	Manual Valve 1WL-65 Transfers Position	6.53E-06
539	GK1WL66VVT	108	Manual Valve 1WL-66 Transfers Position	1.84E-06
540	GK1WL67VVT	108	Manual Valve 1WL-67 Transfers Position	1.84E-06
541	GK1WL68VVT	384	Manual Valve 1WL-68 Transfers Position	6.53E-06
542	GK1WL69VVT	384	Manual Valve 1WL-69 Transfers Position	6.53E-06
543	GK1WL70VVT	108	Manual Valve 1WL-70 Transfers Position	1.84E-06
544	GK1WL71VVT	108	Manual Valve 1WL-71 Transfers Position	1.84E-06
545	GK1WL72VVT	384	Manual Valve 1WL-72 Transfers Position	6.53E-06
546	GK1WL73VVT	384	Manual Valve 1WL-73 Transfers Position	6.53E-06
547	GK1WL74VVT	108	Manual Valve 1WL-74 Transfers Position	1.84E-06
548	GK1WL75VVT	108	Manual Valve 1WL-75 Transfers Position	1.84E-06
549	GK1WL76VVT	384	Manual Valve 1WL76 Transfers Position and Blocks Discharge Path	6.53E-06
550	GK1WL78VVT	384	Manual Valve 1WL78 Transfers Position and Blocks Discharge Path	6.53E-06
551	GK20001HGR	24	Keowee Unit 2 Generator Fault While the Unit Runs	2.27E-03
552	GK20002HGS	1	Keowee Unit 2 Generator Fault Causes Unit Start Failure	1.54E-04
553	GK2063FPST	24	Keowee 2 Gen CO2 Sys Press Switch 63F Spurious Operation	1.03E-05
554	GK212TDRYT	24	Time Delay Relay 12XTD/2 Spuriously Picks-up	8.64E-06
555	GK212X2RYT	24	Relay 12X/2 Spuriously Picks-up	8.64E-06

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Keowee PRA Basic Event Data
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	NAME	FACTOR	DESCRIPTION	PROBABILITY
556	GK23SUIRYT	24	Keowee Unit 2 Startup Inhibit Switch Auxiliary Relay S3SUIX Spurious Actuation	8.64E-06
557	GK23SUISWT	24	Keowee Unit 2 Startup Inhibit Swtich 3SUI Spurious Operation	1.68E-06
558	GK240G1RYT	24	Keowee Unit 2 Loss Of Generator Field Relay 40G1 Spurious Actuation	8.64E-06
559	GK259GNRYT	24	Keowee Unit 2 Generator Ground Fault Relay 59GN2 Spurious Actuation	8.64E-06
560	GK262TDRYT	24	Keowee Unit 2 Generator Backup Trip Timer 62-2TD Spurious Operation	8.64E-06
561	GK263FXRYT	24	Keowee Unit 2 Generator Fire Relay 63FX Spurious Actuation	8.64E-06
562	GK286E2RYT	24	Keowee 2 Emergency Lockout Relay 86E-2 Spuriously Picks Up	8.64E-06
563	GK287G2RYT	24	Keowee Unit 2 Generator Differential Relay 87G-2 Spurious Actuation	8.64E-06
564	GK287GBRYT	24	Keowee Unit 2 Generator Bus Differential Relay 87GB Spurious Actuation	8.64E-06
565	GK287TERYT	24	Keowee Unit 2 Excitation Transformer Differential Relay 87T-2E Spur. Actuation	8.64E-06
566	GK2BRGVLHE	2.60E-04	Keowee 2 Gen. Brng Oil Cooling Flow Path Vlvs Mispositioned After Maintenance	2.60E-04
567	GK2COOLLHE	2.60E-04	Keowee 2 Gen. Air Cooler WL Flow Path Vlvs Mispositioned After Maintenance	2.60E-04
568	GK2FIREDEX	7.00E-05	Spurious Actuation of Unit 2 Gen. CO2 Fire Supression System	7.00E-05
569	GK2GAC1HXF	24	Generator Air Cooler 2GAHW-1 Fails	1.54E-05
570	GK2GAC1HXL	36	Heat Exchanger 2GAC1 Leaks	3.60E-06
571	GK2GAC2HXF	24	Generator Air Cooler 2GAHW-2 Fails	1.54E-05
572	GK2GAC2HXL	36	Heat Exchanger 2GAC2 Leaks	3.60E-06
573	GK2GAC3HXF	24	Generator Air Cooler 2GAHW-3 Fails	1.54E-05
574	GK2GAC3HXL	36	Heat Exchanger 2GAC3 Leaks	3.60E-06
575	GK2GAC4HXF	24	Generator Air Cooler 2GAHW-4 Fails	1.54E-05
576	GK2GAC4HXL	36	Heat Exchanger 2GAC4 Leaks	3.60E-06
577	GK2GAC5HXF	24	Generator Air Cooler 2GAHW-5 Fails	1.54E-05
578	GK2GAC5HXL	36	Heat Exchanger 2GAC5 Leaks	3.60E-06
579	GK2GAC6HXF	24	Generator Air Cooler 2GAHW-6 Fails	1.54E-05
580	GK2GAC6HXL	36	Heat Exchanger 2GAC6 Leaks	3.60E-06
581	GK2HPO1HXF	24	Generator Thrust Bearing Cooler 2HPOHX-1 Fails	1.54E-05
582	GK2HPO2HXF	24	Generator Thrust Bearing Cooler 2HPOHX-2 Fails	1.54E-05
583	GK2HPO3HXF	24	Generator Thrust Bearing Cooler 2HPOHX-3 Fails	1.54E-05
584	GK2HPO4HXF	24	Generator Thrust Bearing Cooler 2HPOHX-4 Fails	1.54E-05
585	GK2HPO5HXF	24	Generator Thrust Bearing Cooler 2HPOHX-5 Fails	1.54E-05
586	GK2HPO6HXF	24	Generator Thrust Bearing Cooler 2HPOHX-6 Fails	1.54E-05
587	GK2HPO6VVT	24	Genrator Bearing Oil Leak Because Manual Valve 2HPO-6 Transfers Position	4.08E-07
588	GK2HPO7HXF	24	Generator Thrust Bearing Cooler 2HPOHX-7 Fails	1.54E-05
589	GK2HPO8HXF	24	Generator Thrust Bearing Cooler 2HPOHX-8 Fails	1.54E-05
590	GK2NGDCLHE	5.20E-05	Failure to Close the Unit 2 Neutral Ground Disconnect Following Maintenance	5.20E-05
591	GK2O121SST	24	Speed Switch 12/2 Falsely Indicates High Speed	1.01E-04
592	GK2WL16VVT	36	Manual Valve 2WL-16 Transfers Position	6.12E-07

Table E-1

Keowee PRA Basic Event Data
Current Operating Configuration - Bayesian Update/Unrecovered

	NAME	FACTOR	DESCRIPTION	PROBABILITY
593	GK2WL17VVT	36	Manual Valve 2WL-17 Transfers Position	6.12E-07
594	GK2WL18VVT	36	Manual Valve 2WL18 Transfers Position	6.12E-07
595	GK2WL19VVT	36	Manual Valve 2WL19 Transfers Position	6.12E-07
596	GK2WL20VVT	36	Manual Valve 2WL-20 Transfers Position	6.12E-07
597	GK2WL21VVT	36	Manual Valve 2WL-21 Transfers Position	6.12E-07
598	GK2WL22VVT	36	Manual Valve 2WL22 Transfers Position	6.12E-07
599	GK2WL23VVT	36	Manual Valve 2WL23 Transfers Position	6.12E-07
600	GK2WL24VVT	36	Manual Valve 2WL-24 Transfers Position	6.12E-07
601	GK2WL25VVT	36	Manual Valve 2WL-25 Transfers Position	6.12E-07
602	GK2WL26VVT	36	Manual Valve 2WL26 Transfers Position	6.12E-07
603	GK2WL27VVT	36	Manual Valve 2WL27 Transfers Position	6.12E-07
604	GK2WL28VVT	36	Manual Valve 2WL-28 Transfers Position	6.12E-07
605	GK2WL29VVT	36	Manual Valve 2WL-29 Transfers Position	6.12E-07
606	GK2WL30VVT	36	Manual Valve 2WL30 Transfers Position	6.12E-07
607	GK2WL31VVT	36	Manual Valve 2WL31 Transfers Position	6.12E-07
608	GK2WL32VVT	36	Manual Valve 2WL-32 Transfers Position	6.12E-07
609	GK2WL33VVT	36	Manual Valve 2WL-33 Transfers Position	6.12E-07
610	GK2WL34VVT	36	Manual Valve 2WL34 Transfers Position	6.12E-07
611	GK2WL35VVT	36	Manual Valve 2WL35 Transfers Position	6.12E-07
612	GK2WL36VVT	36	Manual Valve 2WL-36 Transfers Position	6.12E-07
613	GK2WL37VVT	36	Manual Valve 2WL-37 Transfers Position	6.12E-07
614	GK2WL38VVT	36	Manual Valve 2WL38 Transfers Position	6.12E-07
615	GK2WL39VVT	36	Manual Valve 2WL39 Transfers Position	6.12E-07
616	GK2WL41VVT	36	Keowee 2 Manual Valve 2WL-41 Transfers Position to Block Discharge Path	6.12E-07
617	GK2WL44VVT	36	Manual Valve 2WL-44 Transfers Position	6.12E-07
618	GK2WL45VVT	36	Manual Valve 2WL-45 Transfers Position	6.12E-07
619	GK2WL46VVT	36	Manual Valve 2WL-46 Transfers Position	6.12E-07
620	GK2WL47VVT	36	Manual Valve 2WL-47 Transfers Position	6.12E-07
621	GK2WL48VVT	36	Manual Valve 2WL-48 Transfers Position	6.12E-07
622	GK2WL49VVT	36	Manual Valve 2WL-49 Transfers Position	6.12E-07
623	GK2WL50VVT	36	Manual Valve 2WL-50 Transfers Position	6.12E-07
624	GK2WL51VVT	36	Manual Valve 2WL-51 Transfers Position	6.12E-07
625	GK2WL52VVT	36	Manual Valve 2WL-52 Transfers Position	6.12E-07
626	GK2WL53VVT	36	Manual Valve 2WL-53 Transfers Position	6.12E-07
627	GK2WL54VVT	36	Manual Valve 2WL-54 Transfers Position	6.12E-07
628	GK2WL55VVT	36	Manual Valve 2WL-55 Transfers Position	6.12E-07
629	GK2WL56VVT	36	Manual Valve 2WL-56 Transfers Position	6.12E-07

Table E-1

Keowee PRA Basic Event Data
Current Operating Configuration - Bayesian Update/Unrecovered

	NAME	FACTOR	DESCRIPTION	PROBABILITY
630	GK2WL57VVT	36	Manual Valve 2WL-57 Transfers Position	6.12E-07
631	GK2WL58VVT	36	Manual Valve 2WL-58 Transfers Position	6.12E-07
632	GK2WL59VVT	36	Manual Valve 2WL-59 Transfers Position	6.12E-07
633	GK2WL60VVT	36	Manual Valve 2WL-60 Transfers Position	6.12E-07
634	GK2WL61VVT	36	Manual Valve 2WL-61 Transfers Position	6.12E-07
635	GK2WL62VVT	36	Manual Valve 2WL-62 Transfers Position	6.12E-07
636	GK2WL63VVT	36	Manual Valve 2WL-63 Transfers Position	6.12E-07
637	GK2WL64VVT	36	Manual Valve 2WL-64 Transfers Position	6.12E-07
638	GK2WL65VVT	36	Manual Valve 2WL-65 Transfers Position	6.12E-07
639	GK2WL66VVT	36	Manual Valve 2WL-66 Transfers Position	6.12E-07
640	GK2WL67VVT	36	Manual Valve 2WL-67 Transfers Position	6.12E-07
641	GK2WL68VVT	36	Manual Valve 2WL-68 Transfers Position	6.12E-07
642	GK2WL69VVT	36	Manual Valve 2WL-69 Transfers Position	6.12E-07
643	GK2WL70VVT	36	Manual Valve 2WL-70 Transfers Position	6.12E-07
644	GK2WL71VVT	36	Manual Valve 2WL-71 Transfers Position	6.12E-07
645	GK2WL72VVT	36	Manual Valve 2WL-72 Transfers Position	6.12E-07
646	GK2WL73VVT	36	Manual Valve 2WL-73 Transfers Position	6.12E-07
647	GK2WL74VVT	36	Manual Valve 2WL-74 Transfers Position	6.12E-07
648	GK2WL75VVT	36	Manual Valve 2WL-75 Transfers Position	6.12E-07
649	GK2WL76VVT	36	Manual Valve 2WL76 Transfers Position and Blocks Discharge Path	6.12E-07
650	GK2WL78VVT	36	Manual Valve 2WL78 Transfers Position and Blocks Discharge Path	6.12E-07
651	GKHPOILCOM	4.61E-07	Common Cause Failure of Generator Thrust Bearings	4.61E-07
652	K12COM1DEX	1.00E-06	Grid Degradation Occurs And Causes Failure Of Both Keowee Units	1.00E-06
653	KA127T1R6D	1	Xfrmr 1X UV Relay 27T/1X Fails To Pick-up	2.49E-04
654	KA127T1R6T	360	Xfrmr 1X UV Relay 27T/1X Spuriously De-energizes	1.31E-04
655	KA227T2R6T	360	Xfmr 2X UV Relay 27T/2x Spuriously De-energizes	1.31E-04
656	KB4CONNDEX	1.1E-7	Air Circuit Breaker 4 Connects Unit 2 To The Underground Path	1.10E-07
657	KK1BOTHDEX	0.0	Keowee Units 1 And 2 Are Supplying The Grid	0.00E+00
658	KK1BOTHHYM	5.23E-3	Both Keowee Units Unavailable Due To Common Maintenance	5.23E-03
659	KK1OVERBHF	24	Fault Occurs On The Overhead Power Path	9.60E-06
660	KK1RUNSDEX	0.0	Keowee Unit 1 Only Is Supplying The Grid	0.00E+00
661	KK1UNDRBHF	24	Fault Occurs On The Underground Power Path	9.60E-06
662	KK2RUNSDEX	0.06	Keowee Unit 2 Only Is Supplying The Grid	6.00E-02
663	KK2UNITHYM	3.80E-2	The Overhead Unit (2) Is Unavailable Due To Maintenance	3.80E-02
664	KU2CREDIT	0	Take No Credit For Keowee Unit 2 Suppling Auxiliary ac PowerTo Unit 1	0.00E+00
665	L0EGTPSCOM	1.78E-06	Common Cause Failure of UV And UF Detection Circuits	1.78E-06
666	L27BRX1RYD	1	Snsng Rly 27B/RX1 Fails to Drop Out on Undervoltage OEE-76-3, -4	3.30E-05

Table E-1

Keowee PRA Basic Event Data
Current Operating Configuration - Bayesian Update/Unrecovered

	NAME	FACTOR	DESCRIPTION		PROBABILITY
667	L27BRX2RYD	1	Snsng Rly 27B/RX2 Fails to Drop Out on Undervoltage	OEE-76-3, -8	3.30E-05
668	L27BRY1RYD	1	Snsng Rly 27B/RY1 Fails to Drop Out on Undervoltage	OEE-76-3, -4	3.30E-05
669	L27BRY2RYD	1	Snsng Rly 27B/RY2 Fails to Drop Out on Undervoltage	OEE-76-3, -8	3.30E-05
670	L27BRZ1RYD	1	Snsng Rly 27B/RZ1 Fails to Drop Out on Undervoltage	OEE-76-3, -4	3.30E-05
671	L27BRZ2RYD	1	Snsng Rly 27B/RZ2 Fails to Drop Out on Undervoltage	OEE-76-3, -8	3.30E-05
672	L27BYX1RYD	1	Snsng Rly 27B/YX1 Fails to Drop Out on Undervoltage	OEE-76-3, -4	3.30E-05
673	L27BYX2RYD	1	Snsng Rly 27B/YX2 Fails to Drop Out on Undervoltage	OEE-76-3, -8	3.30E-05
674	L27BYY1RYD	1	Snsng Rly 27B/YY1 Fails to Drop Out on Undervoltage	OEE-76-3, -4	3.30E-05
675	L27BYY2RYD	1	Snsng Rly 27B/YY2 Fails to Drop Out on Undervoltage	OEE-76-3, -8	3.30E-05
676	L27BYZ1RYD	1	Snsng Rly 27B/YZ1 Fails to Drop Out on Undervoltage	OEE-76-3, -4	3.30E-05
677	L27BYZ2RYD	1	Snsng Rly 27B/YZ2 Fails to Drop Out on Undervoltage	OEE-76-3, -8	3.30E-05
678	L27XPX1RYD	1	Ch 1 Phase X UV Aux. Relay Fails To Pick Up	OEE-76-4	3.30E-05
679	L27XPX2RYD	1	Ch 2 Phase X UV Aux. Relay Fails To Pick Up	OEE-76-8	3.30E-05
680	L27XPY1RYD	1	Ch 1 Phase Y UV Aux. Relay Fails to Pick Up	OEE-76-4	3.30E-05
681	L27XPY2RYD	1	Ch 2 Phase Y UV Aux. Relay Fails to Pick Up	OEE-76-8	3.30E-05
682	L27XPZ1RYD	1	Ch 1 Phase Z UV Aux. Relay Fails To Pick Up	OEE-76-4	3.30E-05
683	L27XPZ2RYD	1	Ch 2 Phase Z UV Aux. Relay Fails To Pick Up	OEE-76-8	3.30E-05
684	L27XRX1RYD	1	Red Bus Phase X1 Undervoltage Aux. Relay Fails To Pick Up	OEE-76-4	3.30E-05
685	L27XRX2RYD	1	Red Bus Phase X2 Undervoltage Aux. Relay Fails To Pick Up	OEE-76-8	3.30E-05
686	L27XRY1RYD	1	Red Bus Phase Y1 Undervoltage Aux. Relay Fails To Pick Up	OEE-76-4	3.30E-05
687	L27XRY2RYD	1	Red Bus Phase Y2 Undervoltage Aux. Relay Fails to Pick Up	OEE-76-8	3.30E-05
688	L27XRZ1RYD	1	Red Bus Phase Z1 Undervoltage Aux. Relay Fails To Pick Up	OEE-76-4	3.30E-05
689	L27XRZ2RYD	1	Red Bus Phase Z2 Undervoltage Aux. Relay Fails To Pick Up	OEE-76-8	3.30E-05
690	L27XSTARYD	1	Keowee Start Relay 27X/STA Fails To Pick Up		3.30E-05
691	L27XSTBRYD	1	Keowee Start Relay 27X/STB Fails To Pick Up		3.30E-05
692	L27XYX1RYD	1	Yellow Bus Phase X1 Undervoltage Aux. Relay Fails To Pick Up	OEE-76-4	3.30E-05
693	L27XYX2RYD	1	Yellow Bus Phase X2 Undervoltage Aux. Relay Fails To Pick Up	OEE-76-8	3.30E-05
694	L27XYY1RYD	1	Yellow Bus Phase Y1 Undervoltage Aux. Relay Fails To Pick Up	OEE-76-4	3.30E-05
695	L27XYY2RYD	1	Yellow Bus Phase Y2 Undervoltage Aux. Relay Fails to Pick Up	OEE-76-8	3.30E-05
696	L27XYZ1RYD	1	Yellow Bus Phase Z1 Undervoltage Aux. Relay Fails To Pick Up	OEE-76-4	3.30E-05
697	L27XYZ2RYD	1	Yellow Bus Phase Z2 Undervoltage Aux. Relay Fails to Pick Up	OEE-76-8	3.30E-05
698	L81BRX1RYD	1	Sensing Relay 81BL/RX1 Fails to Drop Out on Underfrequency		3.30E-05
699	L81BRX2RYD	1	Sensing Relay 81BL/RX2 Fails to Drop Out on Underfrequency		3.30E-05
700	L81BRY1RYD	1	Sensing Relay 81BL/RY1 Fails to Drop Out on Underfrequency		3.30E-05
701	L81BRY2RYD	1	Sensing Relay 81BL/RY2 Fails to Drop Out on Underfrequency		3.30E-05
702	L81BRZ1RYD	1	Sensing Relay 81BL/RZ1 Fails to Drop Out on Underfrequency		3.30E-05
703	L81BRZ2RYD	1	Sensing Relay 81BL/RZ2 Fails to Drop Out on Underfrequency		3.30E-05

Table E-1

Keowee PRA Basic Event Data
Current Operating Configuration - Bayesian Update/Unrecovered

	NAME	FACTOR	DESCRIPTION		PROBABILITY
704	L81BYX1RYD	1	Sensing Relay 81BL/YX1 Fails to Drop Out on Underfrequency		3.30E-05
705	L81BYX2RYD	1	Sensing Relay 81BL/YX2 Fails to Drop Out on Underfrequency		3.30E-05
706	L81BYY1RYD	1	Sensing Relay 81BL/YY1 Fails to Drop Out on Underfrequency		3.30E-05
707	L81BYY2RYD	1	Sensing Relay 81BL/YY2 Fails to Drop Out on Underfrequency		3.30E-05
708	L81BYZ1RYD	1	Sensing Relay 81BL/YZ1 Fails to Drop Out on Underfrequency		3.30E-05
709	L81BYZ2RYD	1	Sensing Relay 81BL/YZ2 Fails to Drop Out On Underfrequency		3.30E-05
710	L81XPX1RYD	1	Ch 1 Phase X Underfrequency Aux. Rly Fails to Pick Up		3.30E-05
711	L81XPX2RYD	1	Ch 2 Phase X Underfrequency Aux. Rly Fails to Pick Up		3.30E-05
712	L81XPY1RYD	1	Ch 1 Phase Y Underfrequency Aux. Rly Fails to Pick Up		3.30E-05
713	L81XPY2RYD	1	Ch 2 Phase Y Underfrequency Aux. Rly Fails to Pick Up		3.30E-05
714	L81XPZ1RYD	1	Ch 1 Phase Z Underfrequency Aux. Rly Fails to Pick Up		3.30E-05
715	L81XPZ2RYD	1	Ch 2 Phase Z Underfrequency Aux. Rly Fails to Pick up		3.30E-05
716	L81XRX1RYD	1	Red Bus Phase X1 Underfrequency Aux. Rly Fails to Pick Up		3.30E-05
717	L81XRX2RYD	1	Red Bus Phase X2 Underfrequency Aux. Rly Fails to Pick Up		3.30E-05
718	L81XRY1RYD	1	Red Bus Phase Y1 Underfrequency Aux. Rly Fails to Pick Up		3.30E-05
719	L81XRY2RYD	1	Red Bus Phase Y2 Underfrequency Aux. Rly Fails to Pick Up		3.30E-05
720	L81XRZ1RYD	1	Red Bus Phase Z1 Underfrequency Aux. Rly Fails to Pick Up		3.30E-05
721	L81XRZ2RYD	1	Red Bus Phase Z2 Underfrequency Aux. Rly Fails to Pick Up		3.30E-05
722	L81XYX1RYD	1	Yellow Bus Phase X1 Underfrequency Aux. Rly Fails to Pick Up		3.30E-05
723	L81XYX2RYD	1	Yellow Bus Phase X2 Underfrequency Aux. Rly Fails to Pick Up		3.30E-05
724	L81XYY1RYD	1	Yellow Bus Phase Y1 Underfrequency Aux. Rly Fails to Pick Up		3.30E-05
725	L81XYY2RYD	1	Yellow Bus Phase Y2 Underfrequency Aux. Rly Fails to Pick Up		3.30E-05
726	L81XYZ1RYD	1	Yellow Bus Phase Z1 Underfrequency Aux. Rly Fails to Pick Up		3.30E-05
727	L81XYZ2RYD	1	Yellow Bus Phase Z2 Underfrequency Aux. Rly Fails to Pick Up		3.30E-05
728	LC94F1ARYD	1	EGTPS Underfrequency Relay 94/F1A Fails to Pick Up		3.30E-05
729	LC94F1BRYD	1	EGTPS Underfrequency Relay 94/F1B Fails to Pick Up		3.30E-05
730	LC94F1DRYD	1	EGTPS Underfrequency Relay 94/F1D Fails to Pick Up		3.30E-05
731	LC94F2ARYD	1	EGTPS Underfrequency Relay 94/F2A Fails to Pick Up		3.30E-05
732	LC94F2BRYD	1	EGTPS Underfrequency Relay 94/F2B Fails to Pick Up		3.30E-05
733	LC94F2CRYD	1	EGTPS Underfrequency Relay 94/F2C Fails to Pick Up		3.30E-05
734	LC94F2DRYD	1	EGTPS Underfrequency Relay 94/F2D Fails to Pick Up		3.30E-05
735	LC94V1ARYD	1	EGTPS Undervoltage Relay 94/V1A Fails to Pick Up		3.30E-05
736	LC94V1BRYD	1	EGTPS Undervoltage Relay 94/V1B Fails To Pick Up	OEE-76-4	3.30E-05
737	LC94V1DRYD	1	EGTPS Undervoltage Relay 94/V1D Fails to Pick Up	OEE-76-4	3.30E-05
738	LC94V2ARYD	1	EGTPS Undervoltage Relay 94/V2A Fails to Pick Up		3.30E-05
739	LC94V2BRYD	1	EGTPS Undervoltage Relay 94/V2B Fails To Pick Up		3.30E-05
740	LC94V2CRYD	1	EGTPS Undervoltage Relay 94/V2C Fails to Pick Up		3.30E-05

Table E-1

Keowee PRA Basic Event Data
Current Operating Configuration - Bayesian Update/Unrecovered

	NAME	FACTOR	DESCRIPTION	PROBABILITY
741	LDCYC13CDT	24	Switchyard 125 Vdc Panelboard DYC Breaker 13 Transfers Open OEE-76-4 / O-802	1.80E-06
742	LDCYC14CDT	24	Switchyard 125 Vdc Panelboard DYC Breaker 14 Transfers Open OEE-76-4 / O-802	1.80E-06
743	LDCYG12CDT	24	Switchyard 125 Vdc Panelboard DYG Breaker 12 Transfers Open	1.80E-06
744	LDCYG18CDT	24	Switchyard 125 Vdc Panelboard DYG Breaker 18 Transfers Open	1.80E-06
745	OFACTORDEX	1.0	Overload Susceptibility Factor	1.00E+00
746	OK0PRUNCOM	1.46E-05	Common Cause Failure Of Both Governor Oil Systems To Run	1.46E-05
747	OK10001PSC	15	Pressure Switch 1OGPS-1 Fails to Close (Normal Control Signal)	4.35E-05
748	OK10002PSC	8	Pressure Switch 1OGPS-2 Fails to Close	2.32E-05
749	OK10003PSC	4	Pressure Switch 1OGPS-3 Fails to Close	1.16E-05
750	OK10003RVT	24	Safety Relief Valve 1OG-3 Spurious Operation	1.34E-04
751	OK10003TKF	24	Unit 1 Governor Oil Pressure Tank Fails	1.10E-05
752	OK10004PSC	1	Pressure Switch 1OGPS-4 Fails to Close	2.90E-06
753	OK10007FVT	24	Float Valve 1OG-7 Transfers Closed	1.40E-04
754	OK10009VVT	24	Manual Valve 1OG-9 Transfers Closed	4.08E-07
755	OK10011CVO	15	Check Valve 1OG-11 Fails to Open	3.45E-05
756	OK10011CVT	0.75	Check Valve 1OG-11 Transfers Closed	9.75E-08
757	OK10012VVT	30	Manual Globe Valve 1OG-12 Transfers Closed	5.10E-07
758	OK10013RVT	0.75	Relief Valve 1OG-13 Spurious Operation	4.20E-06
759	OK10014CVO	8	Check Valve 1OG-14 Fails to Open	1.84E-05
760	OK10014CVT	0.5	Check Valve 1OG-14 Transfers Closed	6.50E-08
761	OK10015VVT	192	Manual Globe Valve 1OG-15 Transfers Closed	3.26E-06
762	OK10016RVT	0.5	Relief Valve 1OG-16 Transfers Open	2.80E-06
763	OK10017CVO	4	Check Valve 1OG-17 Fails to Open	9.20E-06
764	OK10017CVT	0.25	Check Valve 1OG-17 Transfers Closed	3.25E-08
765	OK10018VVT	108	Manual Globe Valve 1OG-18 Transfers Closed	1.84E-06
766	OK10019RVT	0.25	Relief Valve 1OG-19 Spurious Operation	1.40E-06
767	OK1001AGPR	0.375	OG Pump 1A Fails to Run	5.25E-06
768	OK1001AGPS	15	OG Pump 1A Fails to Start	1.45E-03
769	OK1001BGPR	0.25	OG Pump 1B Fails to Run	3.50E-06
770	OK1001BGPS	8	OG Pump 1B Fails to Start	7.76E-04
771	OK1001BLHE	3.2E-3	Latent Human Error Fails OG Pump 1B	3.20E-03
772	OK1001CGPR	0.125	OG Pump 1C Fails to Run	1.75E-06
773	OK1001CGPS	4	OG Pump 1C Fails to Start	3.88E-04
774	OK1001CLHE	3.2E-3	Latent Human Error Fails OG Pump 1C	3.20E-03
775	OK188GASWT	30	Keowee 1 Governor Oil Control Switch 188GA Spurious Operation	2.10E-06
776	OK188GBSWT	192	Keowee 1 Control Switch 188GB Spurious Operation	1.34E-05
777	OK188GCSWT	108	Keowee 1 Control Switch 188GC Spurious Operation	7.56E-06

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	NAME	FACTOR	DESCRIPTION	PROBABILITY
778	OK199K1RYD	1	Keowee 1 Relay 99K1 Fails To Operate On Demand	3.30E-05
779	OK199K1RYT	24	Keowee Unit 1 Relay 99K1 Spurious Operation	8.64E-06
780	OK199K2RYD	1	Keowee 1 Relay 99K2 Fails To Operate On Demand	3.30E-05
781	OK1AG01TKF	24	Air Receiver Tank 1AGTK-1 Fails	1.10E-05
782	OK1AG04RVT	24	Safety Relief Valve 1AG-4 Spurious Operation	1.34E-04
783	OK1AG05VVT	24	Manual Valve 1AG-5 Transfers Position	4.08E-07
784	OK1OG1CTRM	3.42E-3	OG Pump 1C Train In Maintenance Or Testing	3.42E-03
785	OK1PRUNCOM	1.12E-07	Common Cause Failure of Unit 1 OG Pumps to Run	1.12E-07
786	OK1PSTRCOM	2.04E-05	Common Cause Failure of Unit 1 OG Pumps to Start	2.04E-05
787	OK1XA1DCLT	30	Low Voltage Circuit Breaker 1XA-1D Transfers Position	2.73E-05
788	OK1XA2ECLT	30	Low Voltage Circuit Breaker 1XA-2E Transfers Position	2.73E-05
789	OK1XA4DCLT	30	Low Voltage Circuit Breaker 1XA-4D Transfers Position	2.73E-05
790	OK20001PSC	15	Pressure Switch 2OGPS-1 Fails to Close (Normal Control Signal)	4.35E-05
791	OK20002PSC	8	Pressure Switch 2OGPS-2 Fails to Close	2.32E-05
792	OK20003PSC	4	Pressure Switch 2OGPS-3 Fails to Close	1.16E-05
793	OK20003RVT	24	Safety Relief Valve 2OG-3 Spurious Operation	1.34E-04
794	OK20003TKF	24	Unit 2 Governor Oil Pressure Tank Fails	1.10E-05
795	OK20004PSC	1	Pressure Switch 2OGPS-4 Fails to Close	2.90E-06
796	OK20007FVT	24	Float Valve 2OG-7 Transfers Closed	1.40E-04
797	OK20009VVT	24	Manual Valve 2OG-9 Transfers Closed	4.08E-07
798	OK20011CVO	15	Check Valve 2OG-11 Fails to Open	3.45E-05
799	OK20011CVT	0.75	Check Valve 2OG-11 Transfers Closed	9.75E-08
800	OK20012VVT	30	Manual Globe Valve 2OG-12 Transfers Closed	5.10E-07
801	OK20013RVT	0.75	Relief Valve 2OG-13 Spurious Operation	4.20E-06
802	OK20014CVO	8	Check Valve 2OG-14 Fails to Open	1.84E-05
803	OK20014CVT	0.5	Check Valve 2OG-14 Transfers Closed	6.50E-08
804	OK20015VVT	192	Manual Globe Valve 2OG-15 Transfers Closed	3.26E-06
805	OK20016RVT	0.5	Relief Valve 2OG-16 Transfers Open	2.80E-06
806	OK20017CVO	4	Check Valve 2OG-17 Fails to Open	9.20E-06
807	OK20017CVT	0.25	Check Valve 2OG-17 Transfers Closed	3.25E-08
808	OK20018VVT	108	Manual Globe Valve 2OG-18 Transfers Closed	1.84E-06
809	OK20019RVT	0.25	Relief Valve 2OG-19 Spurious Operation	1.40E-06
810	OK2002AGPR	0.375	OG Pump 2A Fails to Run	5.25E-06
811	OK2002AGPS	15	OG Pump 2A Fails to Start	1.45E-03
812	OK2002BGPR	0.25	OG Pump 2B Fails to Run	3.50E-06
813	OK2002BGPS	8	OG Pump 2B Fails to Start	7.76E-04
814	OK2002BLHE	3.2E-3	Latent Human Error Fails OG Pump 2B	3.20E-03

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	NAME	FACTOR	DESCRIPTION	PROBABILITY
815	OK2002CGPR	0.125	OG Pump 2C Fails to Run	1.75E-06
816	OK2002CGPS	4	OG Pump 2C Fails to Start	3.88E-04
817	OK2002CLHE	3.2E-3	Latent Human Error Fails OG Pump 2C	3.20E-03
818	OK288GASWT	30	Keowee 2 Governor Oil Control Switch 188GA Spurious Operation	2.10E-06
819	OK288GBSWT	192	Keowee 2 Control Switch 188GB Spurious Operation	1.34E-05
820	OK288GCSWT	108	Keowee 2 Control Switch 188GC Spurious Operation	7.56E-06
821	OK299K1RYD	1	Keowee 2 Relay 99K1 Fails To Operate On Demand	3.30E-05
822	OK299K1RYT	24	Keowee Unit 2 Relay 99K1 Spurious Operation	8.64E-06
823	OK299K2RYD	1	Relay 99K2 Fails To Operate On Demand	3.30E-05
824	OK2AG04RVT	24	Safety Relief Valve 2AG-4 Spurious Operation	1.34E-04
825	OK2AG05VVT	24	Manual Valve 2AG-5 Transfers Position	4.08E-07
826	OK2AGO1TKF	24	Air Receiver Tank 2AGTK-1 Fails	1.10E-05
827	OK2OG2CTRM	3.42E-3	OG Pump 2C Train In Maintenance Or Testing	3.42E-03
828	OK2PRUNCOM	1.12E-07	Common Cause Failure of Unit 2 OG Pumps to Run	1.12E-07
829	OK2PSTRCOM	2.04E-05	Common Cause Failure of Unit 2 OG Pumps to Start	2.04E-05
830	OK2XA1DCLT	30	Low Voltage Circuit Breaker 2XA-1D Transfers Position	2.73E-05
831	OK2XA2ECLT	30	Low Voltage Circuit Breaker 2XA-2E Transfers Position	2.73E-05
832	OK2XA4DCLT	30	Low Voltage Circuit Breaker 2XA-4D Transfers Position	2.73E-05
833	OMOD	0.0	Startup Bus UV Sensing Mod Is In Service	0.00E+00
834	PAC1TC4C4T	24	4160 Vac Breaker 1TC-4 Transfers Open	2.26E-05
835	PACTC01C4T	24	4160 Vac Breaker 1TC-1 Transfers Open	2.26E-05
836	PACTC14C4T	24	4160 Vac Breaker 1TC-14 Transfers Open	2.26E-05
837	PACX1TCBHF	24	4160 Vac Switchgear 1TC Fails	9.60E-06
838	PK0SUMPCOM	2.44E-06	Common Cause Failure Of Turbine Sump Pump System	2.44E-06
839	PK163SALST	30	Unit 1 AC Turbine Sump Pump Float Switch 63SA Fails	9.30E-06
840	PK163SBLST	15	Unit 1 DC Turbine Sump Pump Float Switch 63SB Transfers	4.65E-06
841	PK1ACDCCOM	2.77E-05	Common Cause Failure of Unit 1 Turbine Sump Pump System	2.77E-05
842	PK1DA5CCDT	24	125 Vdc Circuit Breaker 1DA-5C Transfers Position	1.80E-06
843	PK1PACKDEX	3.1E-5	Turbine No. 1 Packing Fails	3.10E-05
844	PK1TS01VVT	30	Manual Valve 1TS-1 Transfers Position	5.10E-07
845	PK1TS02CVT	30	Check Valve 1TS-2 Fails to Open or Transfers Closed	3.90E-06
846	PK1TS03VVT	108	Manual Valve 1TS-3 Transfers Position	1.84E-06
847	PK1TS04CVT	15	Check Valve 1TS-4 Fails to Open or Transfers Closed	1.95E-06
848	PK1TSACGPR	30	AC Sump Pump 1TSPU-1 Fails To Start Or Run	4.20E-04
849	PK1TSDCGPR	15	DC Sump Pump 1TSPU-2 Fails To Start Or Run	2.10E-04
850	PK1TSDCLHE	3.2E-3	Latent Human Error Fails Turbine No. 1 DC Sump Pump	3.20E-03
851	PK1TSDCTRM	6.85E-4	Turbine No. 1 DC Pump Train In Maintenance Or Testing	6.85E-04

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	NAME	FACTOR	DESCRIPTION	PROBABILITY
852	PK1XA2CCLT	30	600 V Circuit Breaker 1XA-2C Transfers Position	2.73E-05
853	PK263SALST	30	Unit 2 AC Turbine Sump Pump Float Switch 63SA Fails	9.30E-06
854	PK263SBLST	15	Unit 2 DC Turbine Sump Pump Float Switch 63SB Transfers	4.65E-06
855	PK2ACDCCOM	2.77E-05	Common Cause Failure of Unit 2 Turbine Sump Pump System	2.77E-05
856	PK2DA1CCDT	24	125 Vdc Circuit Breaker 2DA-1C Transfers Position	1.80E-06
857	PK2PACKDEX	3.1E-5	Turbine No. 2 Packing Fails	3.10E-05
858	PK2TS01VVT	30	Manual Valve 2TS-1 Transfers Position	5.10E-07
859	PK2TS02CVT	30	Check Valve 2TS-2 Fails to Open or Transfers Closed	3.90E-06
860	PK2TS03VVT	108	Manual Valve 2TS-3 Transfers Position	1.84E-06
861	PK2TS04CVT	15	Check Valve 2TS-4 Fails to Open or Transfers Closed	1.95E-06
862	PK2TSACGPR	30	AC Sump Pump 2TSPU-1 Fails To Start Or Run	4.20E-04
863	PK2TSDCGPR	15	DC Sump Pump 2TSPU-2 Fails To Start Or Run	2.10E-04
864	PK2TSDCLHE	3.2E-3	Latent Human Error Fails Turbine No. 2 DC Sump Pump	3.20E-03
865	PK2TSDCTRM	6.85E-4	Turbine No. 2 DC Pump Train In Maintenance Or Testing	6.85E-04
866	PK2XA2CCLT	30	Low Voltage Circuit Breaker 2XA-2C Transfers Position	2.73E-05
867	PMFB1	5.60E-03	Loss of Power on Main Feeder Bus 1	5.60E-03
868	PMFB2	5.60E-03	Loss of Power on Main Feeder Bus 2	5.60E-03
869	S127E1VRYT	9	Unit 1 Startup Bus Undervoltage Relay 27E1 Fails	2.33E-03
870	S127EUVRYT	9	Unit 1 Startup Bus Undervoltage Relay 27E Fails	2.33E-03
871	S127EX1RYD	1	Unit 1 Startup Bus UV Aux Relay 27EX1 Fails to Pick Up	3.30E-05
872	S127EXVRYD	1	Unit 1 Startup Bus UV Aux Relay 27EX Fails to Pick Up	3.30E-05
873	S227E1VRYT	9	Unit 2 Startup Bus Undervoltage Relay 27E1 Fails	2.33E-03
874	S227EUVRYT	9	Unit 2 Startup Bus Undervoltage Relay 27E Fails	2.33E-03
875	S227EX1RYD	1	Unit 2 Startup Bus UV Aux Relay 27EX1 Fails to Pick Up	3.30E-05
876	S227EXVRYD	1	Unit 2 Startup Bus UV Aux Relay 27EX Fails to Pick Up	3.30E-05
877	S27XSC1RYD	1	Channel 1 Swyd Isolated Rly, 27X/SC1, Fails to Pick Up	3.30E-05
878	S27XSC2RYD	1	Channel 2 Swyd Isolated Rly, 27X/SC2, Fails to Pick Up	3.30E-05
879	S27XTD1RYD	1	Channel 1 Swyd Isolated Time Delay Rly, 27XTD/SC1, Fails	3.30E-05
880	S27XTD2RYD	1	Channel 2 Swyd Isolated Time Delay Rly, 27XTD/SC2, Fails	3.30E-05
881	S327E1VRYT	9	Unit 3 Startup Bus Undervoltage Trip Relay 27E1 Fails	2.33E-03
882	S327EUVRYT	9	Unit 3 Startup Bus Undervoltage Trip Relay 27E Fails	2.33E-03
883	S327EX1RYD	1	Unit 3 Standby Bus UV Aux Relay 27EX1 Fails to Pick Up	3.30E-05
884	S327EXVRYD	1	Unit 3 Startup Bus UV Trip Aux Relay 27EX Fails to Pick Up	3.30E-05
885	SB18UX1RYT	24	Auxiliary Relay 8UX-1 Spurious Operation	8.64E-06
886	SB28UX2RYT	24	Auxiliary Relay 8UX-2 Spurious Operation	8.64E-06
887	SB38UX3RYT	24	Auxiliary Relay 8UX-3 Spurious Operation	8.64E-06
888	SB48UX4RYT	24	Auxiliary Relay 8UX-4 Spurious Operation	8.64E-06

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Keowee PRA Basic Event Data
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	NAME	FACTOR	DESCRIPTION		PROBABILITY
889	SDCAIDDDIF	24	Control Power From DYA To PCB 9 Isolating Diode Fails		9.12E-05
890	SDCDA12CDT	24	125 Vdc Swyd Control Power Pnlbd DYA Bkr 12 Xfrs Open		1.80E-06
891	SDCDA15CDT	24	125 Vdc Swyd Control Power Pnlbd DYA Bkr 15 Xfrs Open		1.80E-06
892	SDCDA17CDT	24	125 Vdc Swyd Control Power Pnlbd DYA Bkr 17 Xfrs Open		1.80E-06
893	SDCDB01CDT	24	125 Vdc Swyd Control Power Pnlbd DYB Bkr 1 Xfrs Open		1.80E-06
894	SDCDB13CDT	24	125 Vdc Swyd Control Power Pnlbd DYB Bkr 13 Xfrs Open		1.80E-06
895	SDCDC12CDT	24	125 Vdc Swyd Control Power Pnlbd DYC Bkr 12 Xfrs Open		1.80E-06
896	SDCDE12CDT	24	125 Vdc Swyd Control Power Pnlbd DYE Bkr 12 Xfrs Open		1.80E-06
897	SDCDE15CDT	24	125 Vdc Swyd Control Power Pnlbd DYE Bkr 15 Xfrs Open		1.80E-06
898	SDCDE17CDT	24	125 Vdc Swyd Control Power Pnlbd DYE Bkr 17 Xfrs Open		1.80E-06
899	SDCDF01CDT	24	125 Vdc Swyd Control Power Pnlbd DYF Bkr 1 Xfrs Open		1.80E-06
900	SDCDF13CDT	24	125 Vdc Swyd Control Power Pnlbd DYF Bkr 13 Xfrs Open		1.80E-06
901	SDCDG16CDT	24	125 Vdc Swyd Control Power Pnlbd DYG Bkr 16 Xfrs Open		1.80E-06
902	SDCDYA8CDT	24	125 Vdc Swyd Control Power Pnlbd DYA Bkr 8 Xfrs Open	OEE-38	1.80E-06
903	SDCDYA9CDT	24	125 Vdc Swyd Control Power Pnlbd DYA Bkr 9 Xfrs Open		1.80E-06
904	SDCDYB4CDT	24	125 Vdc Swyd Control Power Pnlbd DYB Bkr 4 Xfrs Open		1.80E-06
905	SDCDYB6CDT	24	125 Vdc Swyd Control Power Pnlbd DYB Bkr 6 Xfrs Open		1.80E-06
906	SDCDYB8CDT	24	125 Vdc Swyd Control Power Pnlbd DYB Bkr 8 Xfrs Open		1.80E-06
907	SDCDYE8CDT	24	125 Vdc Swyd Control Power Pnlbd DYE Bkr 8 Xfrs Open		1.80E-06
908	SDCDYE9CDT	24	125 Vdc Swyd Control Power Pnlbd DYE Bkr 9 Xfrs Open		1.80E-06
909	SDCDYF4CDT	24	125 Vdc Swyd Control Power Pnlbd DYF Bkr 4 Xfrs Open		1.80E-06
910	SDCDYF6CDT	24	125 Vdc Swyd Control Power Pnlbd DYF Bkr 6 Xfrs Open		1.80E-06
911	SDCDYF8CDT	24	125 Vdc Swyd Control Power Pnlbd DYF Bkr 8 Xfrs Open		1.80E-06
912	SDCEIDDDIF	24	Control Power From DYE To PCB-9 Isolating Diode Fails		9.12E-05
913	SK194GBRYT	24	Keowee Unit 1 94GB Auxiliary Relay Spurious Operation		8.64E-06
914	SK294GBRYT	24	Keowee Unit 2 94GB Auxiliary Relay Spurious Operation		8.64E-06
915	SKXFMR1THF	24	Keowee Transformer 1 Fails		7.44E-05
916	SPC14KVBHF	24	13.8 kV Bus Faulted		9.60E-06
917	SPC51TNRYT	24	Main Step Up Transformer Neutral Ground Relay 51TN Spurious Operation		8.64E-06
918	SPC62ABRYT	24	ACB Back-up Trip Timer 62AB Spurious Operation		8.64E-06
919	SPC631XRYT	24	Auxiliary Relay 63H1X Spurious Operation		8.64E-06
920	SPC871XRYT	72	Transformer 1X Differential Relay 87T-1X Spurious Operation		2.59E-05
921	SPC872XRYT	72	Transformer 2X Differential Relay 87T-2X Spurious Operation		2.59E-05
922	SPC87T1RYT	72	Main Step Up Transformer Differential Relay 87T Spurious Operation		2.59E-05
923	SPC94TKRYT	24	Auxiliary Relay 94T/K Spurious Operation		8.64E-06
924	SPCB008CHO	1	SWYD PCB-8 Fails to Trip		2.60E-05
925	SPCB009CHC	1	SWYD PCB-9 Fails To Close On Demand		2.60E-04

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	NAME	FACTOR	DESCRIPTION	PROBABILITY
926	SPCB009CHO	1	SWYD PCB-9 Fails To Trip	2.60E-05
927	SPCB012CHO	1	SWYD PCB-12 Fails To Trip	2.60E-05
928	SPCB015CHO	1	SWYD PCB-15 Fails To Trip On Demand	2.60E-05
929	SPCB017CHO	1	SWYD PCB-17 Fails To Trip On Demand	2.60E-05
930	SPCB021CHO	1	SWYD PCB-21 Fails To Trip On Demand	2.60E-05
931	SPCB024CHO	1	SWYD PCB-24 Fails To Trip On Demand	2.60E-05
932	SPCB026CHO	1	SWYD PCB-26 Fails To Trip On Demand	2.60E-05
933	SPCB028CHO	1	SWYD PCB-28 Fails To Trip On Demand	2.60E-05
934	SPCB033CHO	1	SWYD PCB-33 Fails To Open On Demand	2.60E-05
935	SPCD87LRYT	24	Line Differential Relay 87L Spurious Operation	8.64E-06
936	SPCGLASSWT	24	Break Glass Switch Spurious Operation	1.68E-06
937	SPCR86TRYT	24	Lock Out Relay 86T Spurious Operation	8.64E-06
938	SU127UVCOM	1.18E-04	Common Cause Failure of Unit 1 SU Bus Undervoltage Relays	1.18E-04
939	SU227UVCOM	1.18E-04	Common Cause Failure of Unit 2 SU Bus Undervoltage Relays	1.18E-04
940	SU327UVCOM	1.18E-04	Common Cause Failure of Unit 3 SU Bus Undervoltage Relays	1.18E-04
941	SXFRCT3THF	24	Transformer CT3 Faulted	7.44E-05
942	SXFRCT3THM	1.74E-04	Transformer CT3 Is In Maintenance	1.74E-04
943	SXFRCT4LHE	6.40E-05	Latent Human Error on CT4 Maintenance	6.40E-05
944	SXFRCT4THM	9.13E-04	Transformer CT4 Is In Maintenance	9.13E-04
945	SY30R94RYT	24	PCB 30 Relay 94 Spuriously Picks Up	8.64E-06
946	SY51TN2RYT	24	230kV Neutral Ground Relay Spuriously Picks Up	8.64E-06
947	SY51TN4RYT	24	4.16kV Neutral Ground Relay Spuriously Picks Up	8.64E-06
948	SY51TN6RYT	24	6.9kV Neutral Ground Relay 51TN Spuriously Picks Up	8.64E-06
949	SY62X1FRYT	24	Breaker Failure Relay 62X1 Spuriously Picks Up	8.64E-06
950	SY62X2FRYT	24	Breaker Failure Relay 62X2 Spuriously Picks Up	8.64E-06
951	SY62XXFRYT	24	Breaker Failure Relay 62X Spuriously Picks Up	8.64E-06
952	SY86BUIRYT	24	CT3 6.9kV Start Up Bus Lockout Relay Spuriously Picks Up	8.64E-06
953	SY86CT3RYT	24	Transformer CT3 Lockout Relay Spuriously Picks Up	8.64E-06
954	SY86YA9RYT	24	Yellow Bus Lockout Auxiliary Relay 86YA9 Spuriously Picks Up	8.64E-06
955	SY86YJ3RYT	24	Yellow Bus Lockout Auxiliary Relay 86YJ30 Spuriously Picks Up	8.64E-06
956	SY87BYXRYT	24	Yellow Bus X Phase Differential Relay 87BYX Spuriously Picks Up	8.64E-06
957	SY87BYYRYT	24	Yellow Bus Y Phase Differential Relay 87BYY Spuriously Picks Up	8.64E-06
958	SY87BYZRYT	24	Yellow Bus Z Phase Differential Relay 86BYZ Spuriously Picks Up	8.64E-06
959	SY87LXXRYT	24	Differential Auxiliary Relay 87LX Spuriously Picks Up	8.64E-06
960	SY94L1XRYT	24	Protective Relay 94L Spuriously Picks Up	8.64E-06
961	SYE1362RYT	24	E13 Bkr Failure Relay 62B Spuriously Picks Up	8.64E-06
962	SYE2362RYT	24	E23 Bkr Failure Relay 62B Spuriously Picks Up	8.64E-06

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	NAME	FACTOR	DESCRIPTION	PROBABILITY
963	SYP2862RYT	24	PCB 28 Breaker Failure Relay 62B Spuriously Picks Up	8.64E-06
964	SYP3062RYT	24	PCB 30 Breaker Failure Relay 62B Spuriously Picks Up	8.64E-06
965	SYP86TXRYT	24	PCB 30 LOR 86TX Spuriously Picks Up	8.64E-06
966	SYPCB09CHT	24	Switchyard Power Circuit Breaker 9 Transfers Open	4.56E-05
967	SYPCB30CHT	24	Switchyard Power Circuit Breaker 30 Transfers Open	4.56E-05
968	SYPL86TRYT	24	PCB 30 LOR 86T Spuriously Picks Up	8.64E-06
969	SYPL87LRYT	24	Differential Relay 87L Spuriously Picks Up	8.64E-06
970	SYR86BYRYT	24	Yellow Bus Lockout Relay 86BY Spuriously Picks Up	8.64E-06
971	SYS63FPRYT	24	Fault Pressure Relay 63FP Spuriously Picks Up	8.64E-06
972	SYSX50BRYT	24	Transformer CT3 Fault Detector Relay 50B Spuriously Picks Up	8.64E-06
973	SYX87TBRYT	24	Differential Relay 87B Spuriously Picks Up	8.64E-06
974	SYXX87TRYT	24	Differential Relay 87T Spuriously Picks Up	8.64E-06
975	U5086EFRYT	24	Overcurrent Relay 50 Spuriously Actuates Lockout Rly 86EF	8.64E-06
976	U5186EFRYT	24	Time Delay Overcurrent Relay 51 Actuates Lockout Relay 86EF	8.64E-06
977	U51TNC4RYT	24	CT4 Neutral Ground Rly Actuates CT4 LOR 86T/CT4	8.64E-06
978	U62BSK1RYT	24	SK1 Breaker Failure Relay 62BXSK1 Spuriously Picks Up	8.64E-06
979	U62BSK2RYT	24	SK2 Breaker Failure Relay 62BXSK2 Spuriously Picks Up	8.64E-06
980	U86CT4XRYT	24	Auxiliary Lockout Relay 86CT4X Spuriously Picks Up	8.64E-06
981	U86TCT4RYT	24	CT4 Lockout Relay 86T/CT4 Spuriously Picks Up	8.64E-06
982	U87TCT4RYT	24	Spurious Op of CT4 Differential Rly 87T Actuates LOR 86EF	8.64E-06
983	UACXCT4THF	24	Transformer CT4 Failed	7.44E-05
984	UXX86EFRYT	24	Lockout Relay 86EF Spuriously Picks Up	8.64E-06
985	WK00RUNCOM	2.09E-05	Common Cause Failure of Keowee Governors to Run	2.09E-05
986	WK1GVCDDEX	3.5E-05	Keowee Unit 1 Gov. Fails to Position Wicket Gates During a Cold Start	3.50E-05
987	WK1GVCDLHE	2.6E-4	Latent Human Error Fails Keowee 1 Governor During Cold Start	2.60E-04
988	WK1GVHTDEX	3.5E-04	Keowee Unit 1 Gov. Fails to Position Wicket Gates During Hot Start	3.50E-04
989	WK1GVRNDEX	5.6E-4	Keowee Unit 1 Gov. Fails to Position Wicket Gates With Unit Running	5.60E-04
990	WK1SPD1DEX	1.0	Potentially Damaging Overspeed Condition Occures At Load Rejection	1.00E+00
991	WK1SPD2DEX	5.6E-05	Keowee Unit 1 Governor Failure Creates Overspeed Condition	5.60E-05
992	WK1TBCDDEX	3.5E-5	Keowee Unit 1 Turbine Fails During a Cold Start	3.50E-05
993	WK1TBHTDEX	3.5E-4	Keowee Unit 1 Turbine Fails During a Hot Start	3.50E-04
994	WK1TBRNDEX	5.6e-4	Keowee Unit 1 Turbine Fails With the Unit Running	5.60E-04
995	WK2GVCDDEX	3.5E-05	Keowee Unit 2 Gov. Fails to Position Wicket Gates During Cold Start	3.50E-05
996	WK2GVCDLHE	2.6E-4	Latent Human Error Fails Keowee 2 Governor During Cold Start	2.60E-04
997	WK2GVHTDEX	3.5E-04	Keowee Unit 2 Gov. Fails to Position Wicket Gates During Hot Start	3.50E-04
998	WK2GVRNDEX	5.6E-4	Keowee Unit 2 Gov. Fails to Position Wicket Gates With Unit Running	5.60E-04
999	WK2SPD2DEX	5.6E-05	Keowee Unit 2 Governor Failure Creates Overspeed Condition	5.60E-05

Table E-1

Keowee PRA Basic Event Data
Current Operating Configuration - Bayesian Update/Unrecovered

	NAME	FACTOR	DESCRIPTION		PROBABILITY
1000	WK2TBCDDEX	3.5E-5	Keowee Unit 2 Turbine Fails During a Cold Start		3.50E-05
1001	WK2TBHTDEX	3.5E-4	Keowee Unit 2 Turbine Fails During a Hot Start		3.50E-04
1002	WK2TBRNDEX	5.6E-4	Keowee Unit 2 Turbine Fails With the Unit Running		5.60E-04
1003	WKCSTRTCOM	1.12E-05	Common Cause Failure of Keowee Governors to Cold Start		1.12E-05
1004	WKHSTRTCOM	3.50E-6	Common Cause Failure of Keowee Governors to Hot Start		3.50E-06
1005	XA0SWGRCOM	1.22E-06	Common Cause Failure Of Transformers 1X, 2X, And CX		1.22E-06
1006	XA1A2BTCDT	24	600 Vac Breaker 1XA-2BT Transfers Position	K-704	1.80E-06
1007	XA1BKRSCOM	3.10E-04	CCF of 1X Aux Power Breakers ACB-5 & -7		3.10E-04
1008	XA1TR1XTLF	24	Keowee Transformer 1X Fails		1.80E-05
1009	XA1X2AXCLT	24	600 Vac Bkr 2X-2D Transfers Position		2.18E-05
1010	XA1X2CCCLT	24	600 Vac Breaker 1X-2C Transfers Position		2.18E-05
1011	XA1XA1ACLT	24	600 Vac Bkr 2XA-4A Transfers Position		2.18E-05
1012	XA1XAALBLM	2.74E-03	MCC 1XA Is Connected to Its Alternate Source of Power		2.74E-03
1013	XA1XAMCBLF	24	600 Vac MCC 1XA Fault		6.48E-06
1014	XA1XCXXTHM	4.57E-4	4160/600 Vac Transformer CX Is in Maintenance		4.57E-04
1015	XA1XCXXTLF	24	4160/600 Vac Transformer CX Fails		1.80E-05
1016	XA1XXXXBLF	24	600 Vac Switchgear 1X Fault		6.48E-06
1017	XA2A2BTCDT	24	600 Vac Breaker 2XA-2BT Transfers Position		1.80E-06
1018	XA2BKRSCOM	3.10E-04	CCF of Aux Power Breakers ACB-6 & -8		3.10E-04
1019	XA2TR2XTLF	24	Keowee Transformer 2X Fails		1.80E-05
1020	XA2X2BXCLT	24	600 Vac Breaker 2X-2B Transfers Position		2.18E-05
1021	XA2X2DXCLT	24	600 Vac Bkr 1X-2A Transfers Position		2.18E-05
1022	XA2X4AXCLT	24	600 Vac Bkr 1XA-1A Transfers Position		2.18E-05
1023	XA2XAALBLM	2.74E-03	MCC 2XA Is Connected to Its Alternate Power Source		2.74E-03
1024	XA2XAMCBLF	24	600 Vac MCC-2XA Fault		6.48E-06
1025	XA2XXXXBLF	24	600 Vac Switchgear 2X Fault		6.48E-06
1026	XA56BKRCOM	3.10E-04	Common Cause Failure Of ACB-5 And ACB-6 To Close		3.10E-04
1027	XA78BKRCOM	3.10E-04	Common Cause Failure Of ACB-7 And ACB-8 To Close		3.10E-04
1028	XD0BATTCOM	2.70E-05	Common Cause Failure Of Keowee I&C Power Batteries		2.70E-05
1029	XD0CHRGCOM	3.48E-05	Common Cause Failure Of Keowee Battery Chargers		3.48E-05
1030	XD104CCCDT	24	Breaker 1DA-4CC Transfers Open		1.80E-06
1031	XD104CRCDT	6	Breaker 1DA-4CR Transfers Open		4.50E-07
1032	XD1BK1ACDT	24	Battery No. 1 Breaker 1A Transfers Position	run time dependent	1.80E-06
1033	XD1CKC1BCF	24	Battery Charger KC1 Fails		6.96E-04
1034	XD1DA1CCDT	24	125 Vdc Breaker 1C (from charger KC1) Transfers Position		1.80E-06
1035	XD1DA3BCDT	24	125 Vdc Breaker 1DA-3BR Transfers Open		1.80E-06
1036	XD1DA4ACDT	24	DC Circuit Breaker 1DA-4AR Transfers Position		1.80E-06

Table E-1

Keowee PRA Basic Event Data
Current Operating Configuration - Bayesian Update/Unrecovered

	NAME	FACTOR	DESCRIPTION		PROBABILITY
1037	XD1DALTBYM	5.48E-03	Normal Power To Dist. Center 1DA Is In Test or Maintenance		5.48E-03
1038	XD1DARXBDF	24	DC Distribution Center 1DA Faulted during Run		7.68E-06
1039	XD1KB1XDHE	1	Keowee Standby Battery Charger SBC Not Lined Up in 1 Hour		1.00E+00
1040	XD1KB1XRHE	1	Keowee Standby Battery Charger SBC Not Lined Up in 1 Hour		1.00E+00
1041	XD1KBATBYF	1	Keowee Battery No. 1 Fails During Discharge		9.30E-04
1042	XD1TIE1CDT	24	Keowee 125V dc Dist Cntr 1DA Tie Breaker 1 Transfers Position		1.80E-06
1043	XD202CCCDT	6	Breaker 2DA-2CC Transfers Open		4.50E-07
1044	XD204CCCDT	24	Breaker 2DA-4CC Transfers Open	K-704	1.80E-06
1045	XD2BK1ACDT	24	Battery No. 2 Breaker 1A Transfers Position		1.80E-06
1046	XD2CKC2BCF	24	Battery Charger KC2 Fails		6.96E-04
1047	XD2DA2ACDT	24	DC Circuit Breaker 2DA-2AR Transfers Position		1.80E-06
1048	XD2DA3BCDT	24	125 Vdc Circuit Breaker 2DA-3BR Transfers Position		1.80E-06
1049	XD2DA5CCDT	24	125 Vdc Breaker 2DA-5C (from Charger KC2) Transfers Open		1.80E-06
1050	XD2DALTBYM	5.48E-03	Normal Power To Dist Cntr 2DA Is In Test or Maintenance		5.48E-03
1051	XD2DARXBDF	24	DC Distribution Center 2DA Faulted During Run		7.68E-06
1052	XD2KB2XDHE	1	Keowee Standby Battery Charger SBC Not Lined Up in 1 Hour		1.00E+00
1053	XD2KB2XRHE	1	Keowee Standby Battery Charger SBC Not Lined Up in 1 Hour		1.00E+00
1054	XD2KBATBYF	1	Keowee Battery No. 2 Fails during Discharge		9.30E-04
1055	XD2TIE2CDT	24	Keowee 125V dc Dist Cntr 2DA Tie Breaker 2 Transfers Position		1.80E-06
1056	Y0STARTCOM	7.26E-06	Common Cause Failure Of Emergency Start Signal		7.26E-06
1057	YK114X3SSD	1	Keowee 1 Speed Switch 14-3 Fails to Open at 65 rpm	KEE-111	1.80E-05
1058	YK13SUISWT	24	KHU#1 Startup Inhibit Sw 3SUI Xfrs to Inhibit	KEE-111, -113	1.68E-06
1059	YK14AMRRYT	24	Keowee 1 Master Relay 4A Spuriously Drops Out		8.64E-06
1060	YK14BMRRYT	24	Keowee 1 Master Relay 4B Spuriously Drops Out		8.64E-06
1061	YK163BHLST	24	Keowee 1 Gen Thrst Brng Oil Lvl Hi Sw 63BL/H Sprsly Clsd	KEE-111, -113-3	7.44E-06
1062	YK163BHRYT	24	Keowee 1 Gen Thrst Brng Oil Lvl Hi Rly 63BL/HX Sprsly Picks Up	KEE-111,-113-	8.64E-06
1063	YK163BLLST	24	Keowee 1 Gen Thrst Brng Oil Lvl Lo Sw 63BL/L Spuriously Operates	KEE-111,-113-	7.44E-06
1064	YK163BLRYT	24	Keowee 1 Gen Thrst Brng Oil Lvl Lo Rly 63BL/LXTD Sprsly Pcks Up	KEE-111, -113-	8.64E-06
1065	YK163TBLST	24	Keowee 1 Turb Guide Brng Lo Lvl Sensor Sw Spuriously Closes	KEE-113-4	7.44E-06
1066	YK163TBRYT	24	Keowee 1 Turb Gd Brng Oil Lvl Lo Rly 63TB/1X Sprsly Picks Up	KEE-111,-113-4	8.64E-06
1067	YK186N1DEX	9.89E-03	Keowee 1 Normal Lockout Actuates		9.89E-03
1068	YK199SDRYD	1	Keowee 1 Shutdown Solenoid 99SD Fails To Pick Up		3.30E-05
1069	YK199SDRYT	24	Keowee 1 Shutdown Solenoid Spuriously Drops Out		8.64E-06
1070	YK199SNRYD	1	K1 Emergency Load Solenoid 99SN Fails To Pick Up/Drop Out		3.30E-05
1071	YK199SNRYT	24	Emergency Load Solenoid 99SN Spuriously Drops Out		8.64E-06
1072	YK199SXRYD	1	Keowee 1 Shutdown Solenoid Aux Relay 99SX Fails to Pick Up	KEE-111	3.30E-05
1073	YK199SXRYT	24	Shutdown Auxiliary Relay 99SX Spuriously Drops Out		8.64E-06

Table E-1

Keowee PRA Basic Event Data
Current Operating Configuration - Bayesian Update/Unrecovered

	NAME	FACTOR	DESCRIPTION		PROBABILITY
1074	YK1D4CRFUF	6	Fuse 1DA-4CR Fails		2.16E-05
1075	YK1ES1ARYD	1	Keowee 1 Emergency Start Aux Relay 1ESRX/1A Fails To Pick Up	OEE-120	3.30E-05
1076	YK1ES1BRYD	1	Keowee 1 Emergency Start Aux Relay 1ESRX/1B Fails To Pick Up	OEE-120-1	3.30E-05
1077	YK1ES2ARYD	1	Keowee 1 Emergency Start Aux Relay 1ESRX/2A Fails To Pick Up	OEE-120	3.30E-05
1078	YK1ES2BRYD	1	Keowee 1 Emergency Start Aux Relay 1ESRX/2B Fails To Pick Up	OEE-120-1	3.30E-05
1079	YK1MR4ARYD	1	Keowee 1 Start Master Relay 4A Fails To Pick Up	KEE-113	3.30E-05
1080	YK1MR4BRYD	1	Keowee 1 Start Master Relay 4B Fails To Pick Up	KEE-113	3.30E-05
1081	YK1SS12SST	24	Keowee 1 Overspeed Switch 12 Spuriously Picks Up	KEE-111	1.01E-04
1082	YK1SS13SSD	1	Keowee 1 Speed Switch 13 Fails to Close at 122 rpm	KEE-111	1.80E-05
1083	YK214X3SSD	1	KHU#2 Speed Switch 14-3 Fails to Open at 65 rpm	KEE-211	1.80E-05
1084	YK23SUISWT	24	KHU#2 Startup Inhbt Sw 3SUI Sprsly Xfrs to Inhibit	KEE-211, -213	1.68E-06
1085	YK24AMRRYT	24	Keowee 2 Master Relay 4A Spuriously Drops Out		8.64E-06
1086	YK24BMRRYT	24	Keowee 2 Master Relay 4B Spuriously Drops Out		8.64E-06
1087	YK263BHLST	24	Keowee 2 Gen Thrst Brng Oil Lvl Hi Sw 63BL/H Sprsly Clsd		7.44E-06
1088	YK263BHRYT	24	Keowee 2 Gen Thrst Brng Oil Lvl Hi Rly 63BL/HX Sprsly Picks Up	KEE-211	8.64E-06
1089	YK263BLLST	24	Keowee 2 Gen Thrst Brng Oil Lvl Lo Sw 63BL/L Sprsly Opn		7.44E-06
1090	YK263BLRYT	24	Keowee 2 Gen Thrst Brng Oil Lvl Lo Rly 63BL/LXTD Sprsly Pcks Up	KEE-211	8.64E-06
1091	YK263TBLST	24	Keowee 2 Turb Guide Brng Lo Lvl Sensor Sw Sprsly Closes		7.44E-06
1092	YK263TBRYT	24	Keowee 2 Turb Gd Brng Oil Lvl Lo Rly 63TB/1X Sprsly Picks Up	KEE-211	8.64E-06
1093	YK286N2DEX	7.41E-03	Keowee Unit 2 Normal Lockout Activates		7.41E-03
1094	YK299SDRYD	1	Keowee 2 Shutdown Solenoid 99SD Fails To Pick Up		3.30E-05
1095	YK299SDRYT	24	Keowee 2 Shutdown Solenoid Spuriously Drops Out		8.64E-06
1096	YK299SNRYD	1	Keowee 2 Emergency Load Solenoid 99SN Fails To Operate		3.30E-05
1097	YK299SNRYT	24	Emergency Load Solenoid 99SN Spuriously Drops Out		8.64E-06
1098	YK299SXRYD	1	Keowee 2 Shutdown Solenoid Aux Relay 99SX Fails to Pick Up	KEE-211	3.30E-05
1099	YK299SXRYT	24	Shutdown Auxiliary Relay 99SX Spuriously Drops Out	s	8.64E-06
1100	YK2D2CCFUF	6	Fuse 2DA-2CC Fails		2.16E-05
1101	YK2ES1ARYD	1	Keowee 2 Emergency Start Aux Relay 2ESRX/1A Fails To Pick Up	OEE-120	3.30E-05
1102	YK2ES1BRYD	1	Keowee 2 Emergency Start Aux Relay 2ESRX/1B Fails to Pick Up	OEE-120-1	3.30E-05
1103	YK2ES2ARYD	1	Keowee 2 Emergency Start Aux Relay 2ESRX/2A Fails to Pick Up	OEE-120	3.30E-05
1104	YK2ES2BRYD	1	Keowee 2 Emergency Start Aux Relay 2ESRX/2B Fails to Pick Up	OEE-120-1	3.30E-05
1105	YK2MR4ARYD	1	Keowee 2 Start Master Relay 4A Fails To Pick Up	KEE-213	3.30E-05
1106	YK2MR4BRYD	1	Keowee 2 Start Master Relay 4B Fails to Pick Up	KEE-213	3.30E-05
1107	YK2SS12SST	24	Keowee 2 Overspeed Switch 12 Spuriously Picks Up	KEE-211	1.01E-04
1108	YK2SS13SSD	1	Keowee 2 Speed Switch 13 Fails to Close at 122 rpm	KEE-211	1.80E-05
1109	YKEMSRTCHE	0	Operator Incorrectly Resets Keowee Emergency Start Signals		0.00E+00
1110	YO1DIA2CDT	30	DC Circuit Breaker 1DIA-2 Transfers Position		2.25E-06

Table E-1

Keowee PRA Basic Event Data
Current Operating Configuration - Bayesian Update/Unrecovered

	NAME	FACTOR	DESCRIPTION	PROBABILITY
1111	YO1DIB2CDT	30	DC Circuit Breaker 1DIB-2 Transfers Position	2.25E-06
1112	YO1MFBMA	1	ONS1 MFB Monitor Channel A Keowee Start Signal Fails	1.00E+00
1113	YO1MFBMB	1	ONS1 MFB Monitor Channel B Keowee Start Signal Fails	1.00E+00
1114	YO1OPSARHE	1	Operator fails to operate Keowee start switch S1A	1.00E+00
1115	YO1OPSBRHE	1	Operator fails to operate Keowee start switch S1B	1.00E+00
1116	YO1S1AFSWC	1	Control Switch S1A Fails To Close On Demand	1.00E-05
1117	YO1S1BFSWC	1	Control Switch S1B Fails To Close On Demand	1.00E-05
1118	YO1XXKARYD	1	ONS1 Ch A Keowee Emergency Start Relay KA Fails to Pick Up OEE-120	3.30E-05
1119	YO1XXKBRYD	1	Oconee Unit 1 Chan. B Keowee Emergency Start Relay Fails OEE-120-1	3.30E-05
1120	YO2CR2ARYD	1	ONS2 Ch A Keowee Emergency Start Relay CR2A Fails to Pick Up OEE-220	3.30E-05
1121	YO2CR2BRYD	1	ONS2 Keowee Emergency Start Relay CR2B Fails to Pick Up OEE-220-1	3.30E-05
1122	YO2DIA2CDT	30	Breaker 2DIA-2 Transfers Position	2.25E-06
1123	YO2DIB2CDT	30	Breaker 2DIB-2 Transfers Position	2.25E-06
1124	YO2MFBMA	1	ONS2 MFB Monitor CH A Keowee Start Sig Fails	1.00E+00
1125	YO2MFBMB	1	ONS2 MFB Monitor Ch B Keowee Start Sig Fails	1.00E+00
1126	YO2SSWARHE	1	Operator Fails to Operate Keowee Start Switch 2SSW'A'	1.00E+00
1127	YO2SSWASWC	1	Control Switch 2SSW'A' Fails To Close On Demand	1.00E-05
1128	YO2SSWBRHE	1	Operator Fails to Operate Keowee Start Switch 2SSW'B'	1.00E+00
1129	YO2SSWBSWC	1	Control Switch 2SSW'B' Fails To Close On Demand	1.00E-05
1130	YO3CR3ARYD	1	ONS3 Ch A Keowee Emergency Start Relay CR3A Fails To Pick Up OEE-320	3.30E-05
1131	YO3CR3BRYD	1	ONS3 Keowee Emer Start Relay CR3B Fails to Pick Up OEE-320-1	3.30E-05
1132	YO3DIA2CDT	30	Breaker 3DIA-2 Transfers Open OEE-320, O-2705	2.25E-06
1133	YO3DIB2CDT	30	Breaker 3DIB-2 Transfers Open OEE-320-1, O-2705	2.25E-06
1134	YO3MFBMA	3.96E-03	ONS3 MFB Monitor Ch A Keowee Start Sig Fails	3.96E-03
1135	YO3MFBMB	3.96E-03	ONS3 MFB Monitor Ch B Keowee Start Sig Fails	3.96E-03
1136	YO3OPFARHE	1	Operator fails to operate Keowee Start Switch 3S1A	1.00E+00
1137	YO3OPFBRHE	1	Operator Fails to Operate Keowee Start Switch 3S1B	1.00E+00
1138	YO3S1AFSWC	1	Control Switch S1A Fails To Close On Demand	1.00E-05
1139	YO3S1BFSWC	1	Control Switch S1B Fails To Close On Demand	1.00E-05
1140	YO3SSWARHE	1	Operator fails to operate Keowee Start Switch 3SSW'A'	1.00E+00
1141	YO3SSWASWC	1	Control Switch 3SSW'A' Fails To Close On Demand	1.00E-05
1142	YO3SSWBRHE	1	Operator Fails to Operate Keowee Start Switch 3SSW'B'	1.00E+00
1143	YO3SSWBSWC	1	Control Switch 3SSW'B' Fails To Close On Demand	1.00E-05

Table E-2

Exposure Time Changes For Extending To A Quarterly Unit Swap

Basic Event	Base Case Exposure	Obj. 1 Exposure	Description
AA127X1RYT	384	1104	Auxiliary Relay 27X/1X Spurious Operation
AA227R2RYT	384	1104	Auxiliary Relay 27X/CX2 Spurious Operation
AB352Y2R6T	360	1080	Air Circuit Breaker 3 Y-relay Spurious Operation
AB3PS02PST	372	1092	Air Circuit Breaker 3 Accumulator Pressure Switch PS2 Fails Low
AB452Y2R6T	372	1092	Air Circuit Breaker 4 Y-relay Spurious Operation
AB4KEYISWT	372	1092	Air Circuit Breaker 4 Key Interlock Switch Transfers Open
AB4LORESWT	372	1092	Air Circuit Breaker 4 Local/Remote Switch Contact Transfers Position
AB4PS02PST	372	1092	Air Circuit Breaker 4 Accumulator Pressure Switch PS2 Indicates Low Pressure
AB51431RYT	360	1080	Auxiliary Relay 143X/1 Spuriously Energizes
AB51431SWT	360	1080	Manual/Auto Control Switch 143/1 Spuriously Transfers Into Manual
AB552TCRYT	384	1104	Air Circuit Breaker 5 Trip Coil 52TC Spurious Operation
AB552Y2RYT	360	1080	Air Circuit Breaker 5 Y-relay Spurious Operation
AB5KEYISWT	360	1080	Air Circuit Breaker 5 Key Interlock Switch Transfers Open
AB5PUSHPBT	384	1104	Trip Pushbutton On ACB5 Spurious Operation
AB61432SWT	360	1080	Manual/Auto Control Switch 143/2 Spuriously Transfers Into Manual
AB652Y2RYT	360	1080	Air Circuit Breaker 6 Y-relay Spurious Operation
AB6KEYISWT	360	1080	Air Circuit Breaker 6 Key Interlock Switch Transfers Open
AB752Y2RYT	360	1080	Air Circuit Breaker 7 Y-relay Spurious Operation
AB7KEYISWT	360	1080	Air Circuit Breaker 7 Key Interlock Switch Transfers Open
AB81432RYT	360	1080	Auxiliary Relay 143X/2 Spuriously Energizes
AB852TCRYT	384	1104	Air Circuit Breaker 8 Trip Coil 52TC Spurious Operation
AB852Y2RYT	360	1080	Air Circuit Breaker 8 Y-relay Spurious Operation
AB8KEYISWT	360	1080	Air Circuit Breaker 8 Key Interlock Switch Transfers Open
AB8PUSHPBT	384	1104	Trip Pushbutton On ACB8 Spurious Operation
GK1WL16VVT	384	1104	Manual Valve 1WL-16 Transfers Position
GK1WL17VVT	384	1104	Manual Valve 1WL-17 Transfers Position
GK1WL20VVT	384	1104	Manual Valve 1WL-20 Transfers Position
GK1WL21VVT	384	1104	Manual Valve 1WL-21 Transfers Position
GK1WL24VVT	384	1104	Manual Valve 1WL-24 Transfers Position
GK1WL25VVT	384	1104	Manual Valve 1WL-25 Transfers Position
GK1WL28VVT	384	1104	Manual Valve 1WL-28 Transfers Position

Table E-2

Exposure Time Changes For Extending To A Quarterly Unit Swap

Basic Event	Base Case Exposure	Obj. 1 Exposure	Description
GK1WL29VVT	384	1104	Manual Valve 1WL-29 Transfers Position
GK1WL32VVT	384	1104	Manual Valve 1WL-32 Transfers Position
GK1WL33VVT	384	1104	Manual Valve 1WL-33 Transfers Position
GK1WL36VVT	384	1104	Manual Valve 1WL-36 Transfers Position
GK1WL37VVT	384	1104	Manual Valve 1WL-37 Transfers Position
GK1WL41VVT	384	1104	Keowee 1 Manual Valve 1WL-41 Transfers Position to Block Discharge Path
GK1WL44VVT	384	1104	Manual Valve 1WL-44 Transfers Position
GK1WL45VVT	384	1104	Manual Valve 1WL-45 Transfers Position
GK1WL48VVT	384	1104	Manual Valve 1WL-48 Transfers Position
GK1WL49VVT	384	1104	Manual Valve 1WL-49 Transfers Position
GK1WL52VVT	384	1104	Manual Valve 1WL-52 Transfers Position
GK1WL53VVT	384	1104	Manual Valve 1WL-53 Transfers Position
GK1WL56VVT	384	1104	Manual Valve 1WL-56 Transfers Position
GK1WL57VVT	384	1104	Manual Valve 1WL-57 Transfers Position
GK1WL60VVT	384	1104	Manual Valve 1WL-60 Transfers Position
GK1WL61VVT	384	1104	Manual Valve 1WL-61 Transfers Position
GK1WL64VVT	384	1104	Manual Valve 1WL-64 Transfers Position
GK1WL65VVT	384	1104	Manual Valve 1WL-65 Transfers Position
GK1WL68VVT	384	1104	Manual Valve 1WL-68 Transfers Position
GK1WL69VVT	384	1104	Manual Valve 1WL-69 Transfers Position
GK1WL72VVT	384	1104	Manual Valve 1WL-72 Transfers Position
GK1WL73VVT	384	1104	Manual Valve 1WL-73 Transfers Position
GK1WL76VVT	384	1104	Manual Valve 1WL76 Transfers Position and Blocks Discharge Path
GK1WL78VVT	384	1104	Manual Valve 1WL78 Transfers Position and Blocks Discharge Path
KA127T1R6T	360	1080	Xfrmr 1X UV Relay 27T/1X Spuriously De-energizes
KA227T2R6T	360	1080	Xfrmr 2X UV Relay 27T/2x Spuriously De-energizes

Table E-3

Infrequently Tested/Demanded Keowee Components

Basic Event	Description	Test Frequency
AA1271PR6D	Transformer 1X Undervoltage Relay 27/1X Fails To Pick Up	Quarterly
AA127CPR6D	Transformer CX Undervoltage Relay 27/CX1 Fails To Pick Up	Quarterly
AA127X1RYD	Auxiliary Relay 27X/1X Fails To Operate On Demand	Quarterly
AA127X2R6D	Transformer CX Undervoltage Relay 27/CX1 Fails To Drop Out	Quarterly
AA127XCRYD	Auxiliary Relay 27/CX1 Fails To Operate On Demand	Quarterly
AA2272PR6D	Transformer 2X Undervoltage Relay 27/2X Fails To Pick Up	Quarterly
AA2272XR6D	Transformer 2X Undervoltage Relay 27/2X Fails To Drop Out	Quarterly
AA227C2RYD	Auxiliary Relay 27X/CX2 Fails To Operate On Demand	Quarterly
AA227CPR6D	Transformer CX Undervoltage Relay 27/CX2 Fails To Pick Up	Quarterly
AA227T2R6D	Transformer 2X Undervoltage Relay (27T/2X) Fails To Drop Out	Quarterly
AA227X2RYD	Auxiliary Relay 27X/2X Fails To Operate On Demand	Quarterly
AB0086TRYD	Keowee Main Tx Lock Out Relay 86T Fails To Operate On Demand	Annually
AB086E1RYD	Emergency Lock Out Relay 86E-1 Fails To Operate On Demand	Annually
AB352CCSVO	Air Circuit Breaker 3 Close Coil Fails To Operate	Every other month
AB352TCSVO	Air Circuit Breaker 3 Trip Coil Fails To Operate	Every other month
AB352Y2R6D	Air Circuit Breaker 3 Relay 52Y Failed To Drop Out Following Last Demand	Every other month
AB3R52XR6D	Air Circuit Breaker 3 Relay 52X Fails To Operate	Every other month
AB3R52ZR6D	Air Circuit Breaker 3 Relay 52Z Fails To Operate	Every other month
AB452CCSVO	Air Circuit Breaker 4 Close Coil Fails To Operate	Every other month
AB452Y2R6D	Air Circuit Breaker 4 Relay 52Y Failed To Drop Out Following Last Demand	Every other month
AB4CLSESWC	Air Circuit Breaker 4 Close Switch Fails To Close On Demand	Every other month
AB4R52XR6D	Air Circuit Breaker 4 Relay 52X Fails To Operate	Every other month
AB552CCRYD	Air Circuit Breaker 5 Close Coil CC Fails On Demand	Every other month
AB583S5RYD	Time Delay Relay 83S5 Fails To Pick Up	Every other month
AB5R52XRYD	Air Circuit Breaker 5 Relay 52X Fails To Operate	Every other month

Table E-3

Infrequently Tested/Demanded Keowee Components

Basic Event	Description	Test Frequency
AB5R52YRYD	Air Circuit Breaker 5 Relay 52Y Failed To Drop Out At Last Demand	Every other month
AB652CCRYD	Air Circuit Breaker 6 Close Coil CC Fails On Demand	Every other month
AB652TCRYD	Air Circuit Breaker 6 Trip Coil 52TC Fails Fails To Operate	Every other month
AB6R52XRYD	Air Circuit Breaker 6 Relay 52X Fails To Operate	Every other month
AB6R52YRYD	Air Circuit Breaker 6 Relay 52Y Failed To Drop Out At Last Demand	Every other month
AB752CCRYD	Air Circuit Breaker 7 Close Coil CC Fails On Demand	Every other month
AB752TCRYD	Air Circuit Breaker 7 Trip Coil TC Fails On Demand	Every other month
AB7R52XRYD	Air Circuit Breaker 7 Relay 52X Fails To Operate	Every other month
AB7R52YRYD	Air Circuit Breaker 7 Relay 52Y Failed To Drop Out At Last Demand	Every other month
AB852CCRYD	Air Circuit Breaker 8 Close Coil CC Fails On Demand	Every other month
AB86E1ARYD	Emergency Lock Out Aux. Relay 86E-1a Fails To Operate On Demand	Annually
AB883S8RYD	Time Delay Relay 83S8 Fails To Pick Up	Every other month
AB8R52XRYD	Air Circuit Breaker 8 Relay 52X Fails To Operate	Every other month
AB8R52YRYD	Air Circuit Breaker 8 Relay 52Y Failed To Drop Out At Last Demand	Every other month
AK152TDRYD	Time Delay Relay 52-1TD Fails To Pick-up	All emergency starts
AK252TDRYD	Time Delay Relay 52-2TD Fails To Operate	All emergency starts
BK1088XRYD	Keowee 1 Turbine Guide Bearing Oil Relay 88X Fails to Drop Out	Annually
BK1631XRYD	Keowee 1 Relay 63TA/1X Fails to De-energize	Annually
BK1632XRYD	Keowee 1 Brng. Low Oil Level Aux. Relay 63TA/2X Fails To Operate On Demand	Annually
BK163TALSD	Turbine No. 1 Bearing Oil Level Switch 63TA Fails on Demand	Annually
BK2088XRYD	Keowee 2 Turbine Guide Bearing Oil Relay 88X Fails to Drop Out	Annually
BK2631XRYD	Keowee 2 Relay 63TA/1X Fails to De-energize	Annually
BK2632XRYD	Keowee 2 Brng. Low Oil Level Aux. Relay 63TA/2X Fails To Operate On Demand	Annually
BK263TALSD	Turbine No. 2 Bearing Oil Level Switch 63TA Fails on Demand	Annually
DDC1BATBYF	Battery SY-1 Fails During Discharge	Semi-annually

Table E-3

Infrequently Tested/Demanded Keowee Components

Basic Event	Description	Test Frequency
DDC2BATBYF	Battery SY-2 Fails During Discharge	Semi-annually
KA127T1R6D	Xfrmr 1X UV Relay 27T/1X Fails To Pick-up	Quarterly
L27BRX1RYD	Snsng Rly 27B/RX1 Fails to Drop Out on Undervoltage	Quarterly
L27BRX2RYD	Snsng Rly 27B/RX2 Fails to Drop Out on Undervoltage	Quarterly
L27BRY1RYD	Snsng Rly 27B/RY1 Fails to Drop Out on Undervoltage	Quarterly
L27BRY2RYD	Snsng Rly 27B/RY2 Fails to Drop Out on Undervoltage	Quarterly
L27BRZ1RYD	Snsng Rly 27B/RZ1 Fails to Drop Out on Undervoltage	Quarterly
L27BRZ2RYD	Snsng Rly 27B/RZ2 Fails to Drop Out on Undervoltage	Quarterly
L27BYX1RYD	Snsng Rly 27B/YX1 Fails to Drop Out on Undervoltage	Quarterly
L27BYX2RYD	Snsng Rly 27B/YX2 Fails to Drop Out on Undervoltage	Quarterly
L27BYY1RYD	Snsng Rly 27B/YY1 Fails to Drop Out on Undervoltage	Quarterly
L27BYY2RYD	Snsng Rly 27B/YY2 Fails to Drop Out on Undervoltage	Quarterly
L27BYZ1RYD	Snsng Rly 27B/YZ1 Fails to Drop Out on Undervoltage	Quarterly
L27BYZ2RYD	Snsng Rly 27B/YZ2 Fails to Drop Out on Undervoltage	Quarterly
L27XPX1RYD	Ch 1 Phase X UV Aux. Relay Fails To Pick Up	Quarterly
L27XPX2RYD	Ch 2 Phase X UV Aux. Relay Fails To Pick Up	Quarterly
L27XPY1RYD	Ch 1 Phase Y UV Aux. Relay Fails to Pick Up	Quarterly
L27XPY2RYD	Ch 2 Phase Y UV Aux. Relay Fails to Pick Up	Quarterly
L27XPZ1RYD	Ch 1 Phase Z UV Aux. Relay Fails To Pick Up	Quarterly
L27XPZ2RYD	Ch 2 Phase Z UV Aux. Relay Fails To Pick Up	Quarterly
L27XRX1RYD	Red Bus Phase X1 Undervoltage Aux. Relay Fails To Pick Up	Quarterly
L27XRX2RYD	Red Bus Phase X2 Undervoltage Aux. Relay Fails To Pick Up	Quarterly
L27XRY1RYD	Red Bus Phase Y1 Undervoltage Aux. Relay Fails To Pick Up	Quarterly
L27XRY2RYD	Red Bus Phase Y2 Undervoltage Aux. Relay Fails to Pick Up	Quarterly
L27XRZ1RYD	Red Bus Phase Z1 Undervoltage Aux. Relay Fails To Pick Up	Quarterly

Table E-3

Infrequently Tested/Demanded Keowee Components

Basic Event	Description	Test Frequency
L27XRZ2RYD	Red Bus Phase Z2 Undervoltage Aux. Relay Fails To Pick Up	Quarterly
L27XSTARYD	Keowee Start Relay 27X/STA Fails To Pick Up	Quarterly
L27XSTBRYD	Keowee Start Relay 27X/STB Fails To Pick Up	Quarterly
L27XYX1RYD	Yellow Bus Phase X1 Undervoltage Aux. Relay Fails To Pick Up	Quarterly
L27XYX2RYD	Yellow Bus Phase X2 Undervoltage Aux. Relay Fails To Pick Up	Quarterly
L27XYY1RYD	Yellow Bus Phase Y1 Undervoltage Aux. Relay Fails To Pick Up	Quarterly
L27XYY2RYD	Yellow Bus Phase Y2 Undervoltage Aux. Relay Fails to Pick Up	Quarterly
L27XYZ1RYD	Yellow Bus Phase Z1 Undervoltage Aux. Relay Fails To Pick Up	Quarterly
L27XYZ2RYD	Yellow Bus Phase Z2 Undervoltage Aux. Relay Fails to Pick Up	Quarterly
L81BRX1RYD	Sensing Relay 81BL/RX1 Fails to Drop Out on Underfrequency	Quarterly
L81BRX2RYD	Sensing Relay 81BL/RX2 Fails to Drop Out on Underfrequency	Quarterly
L81BRY1RYD	Sensing Relay 81BL/RY1 Fails to Drop Out on Underfrequency	Quarterly
L81BRY2RYD	Sensing Relay 81BL/RY2 Fails to Drop Out on Underfrequency	Quarterly
L81BRZ1RYD	Sensing Relay 81BL/RZ1 Fails to Drop Out on Underfrequency	Quarterly
L81BRZ2RYD	Sensing Relay 81BL/RZ2 Fails to Drop Out on Underfrequency	Quarterly
L81BYX1RYD	Sensing Relay 81BL/YX1 Fails to Drop Out on Underfrequency	Quarterly
L81BYX2RYD	Sensing Relay 81BL/YX2 Fails to Drop Out on Underfrequency	Quarterly
L81BYY1RYD	Sensing Relay 81BL/YY1 Fails to Drop Out on Underfrequency	Quarterly
L81BYY2RYD	Sensing Relay 81BL/YY2 Fails to Drop Out on Underfrequency	Quarterly
L81BYZ1RYD	Sensing Relay 81BL/YZ1 Fails to Drop Out on Underfrequency	Quarterly
L81BYZ2RYD	Sensing Relay 81BL/YZ2 Fails to Drop Out On Underfrequency	Quarterly
L81XPX1RYD	Ch 1 Phase X Underfrequency Aux. Rly Fails to Pick Up	Quarterly
L81XPX2RYD	Ch 2 Phase X Underfrequency Aux. Rly Fails to Pick Up	Quarterly
L81XPY1RYD	Ch 1 Phase Y Underfrequency Aux. Rly Fails to Pick Up	Quarterly
L81XPY2RYD	Ch 2 Phase Y Underfrequency Aux. Rly Fails to Pick Up	Quarterly

Table E-3

Infrequently Tested/Demanded Keowee Components

Basic Event	Description	Test Frequency
L81XPZ1RYD	Ch 1 Phase Z Underfrequency Aux. Rly Fails to Pick Up	Quarterly
L81XPZ2RYD	Ch 2 Phase Z Underfrequency Aux. Rly Fails to Pick up	Quarterly
L81XRX1RYD	Red Bus Phase X1 Underfrequency Aux. Rly Fails to Pick Up	Quarterly
L81XRX2RYD	Red Bus Phase X2 Underfrequency Aux. Rly Fails to Pick Up	Quarterly
L81XRY1RYD	Red Bus Phase Y1 Underfrequency Aux. Rly Fails to Pick Up	Quarterly
L81XRY2RYD	Red Bus Phase Y2 Underfrequency Aux. Rly Fails to Pick Up	Quarterly
L81XRZ1RYD	Red Bus Phase Z1 Underfrequency Aux. Rly Fails to Pick Up	Quarterly
L81XRZ2RYD	Red Bus Phase Z2 Underfrequency Aux. Rly Fails to Pick Up	Quarterly
L81XYX1RYD	Yellow Bus Phase X1 Underfrequency Aux. Rly Fails to Pick Up	Quarterly
L81XYX2RYD	Yellow Bus Phase X2 Underfrequency Aux. Rly Fails to Pick Up	Quarterly
L81XYY1RYD	Yellow Bus Phase Y1 Underfrequency Aux. Rly Fails to Pick Up	Quarterly
L81XYY2RYD	Yellow Bus Phase Y2 Underfrequency Aux. Rly Fails to Pick Up	Quarterly
L81XYZ1RYD	Yellow Bus Phase Z1 Underfrequency Aux. Rly Fails to Pick Up	Quarterly
L81XYZ2RYD	Yellow Bus Phase Z2 Underfrequency Aux. Rly Fails to Pick Up	Quarterly
LC94F1ARYD	EGTPS Underfrequency Relay 94/F1A Fails to Pick Up	Quarterly
LC94F1BRYD	EGTPS Underfrequency Relay 94/F1B Fails to Pick Up	Quarterly
LC94F1DRYD	EGTPS Underfrequency Relay 94/F1D Fails to Pick Up	Quarterly
LC94F2ARYD	EGTPS Underfrequency Relay 94/F2A Fails to Pick Up	Quarterly
LC94F2BRYD	EGTPS Underfrequency Relay 94/F2B Fails to Pick Up	Quarterly
LC94F2CRYD	EGTPS Underfrequency Relay 94/F2C Fails to Pick Up	Quarterly
LC94F2DRYD	EGTPS Underfrequency Relay 94/F2D Fails to Pick Up	Quarterly
LC94V1ARYD	EGTPS Undervoltage Relay 94/V1A Fails to Pick Up	Quarterly
LC94V1BRYD	EGTPS Undervoltage Relay 94/V1B Fails To Pick U	Quarterly
LC94V1DRYD	EGTPS Undervoltage Relay 94/V1D Fails to Pick Up	Quarterly
LC94V2ARYD	EGTPS Undervoltage Relay 94/V2A Fails to Pick Up	Quarterly

Table E-3

Infrequently Tested/Demanded Keowee Components

Basic Event	Description	Test Frequency
LC94V2BRYD	EGTPS Undervoltage Relay 94/V2B Fails To Pick Up	Quarterly
LC94V2CRYD	EGTPS Undervoltage Relay 94/V2C Fails to Pick Up	Quarterly
OK10004PSC	Pressure Switch 1OGPS-4 Fails to Close	Annually
OK199K1RYD	Keowee 1 Relay 99K1 Fails To Operate On Demand	Annually
OK199K2RYD	Keowee 1 Relay 99K2 Fails To Operate On Demand	Annually
OK20004PSC	Pressure Switch 2OGPS-4 Fails to Close	Annually
OK299K1RYD	Keowee 2 Relay 99K1 Fails To Operate On Demand	Annually
OK299K2RYD	Relay 99K2 Fails To Operate On Demand	Annually
S27XSC1RYD	Channel 1 Swyd Isolated Rly, 27X/SC1, Fails to Pick Up	Quarterly
S27XSC2RYD	Channel 2 Swyd Isolated Rly, 27X/SC2, Fails to Pick Up	Quarterly
S27XTD1RYD	Channel 1 Swyd Isolated Time Delay Rly, 27XTD/SC1, Fails	Quarterly
S27XTD2RYD	Channel 2 Swyd Isolated Time Delay Rly, 27XTD/SC2, Fails	Quarterly
S327EX1RYD	Unit 3 Standby Bus UV Aux Relay 27EX1 Fails to Pick Up	Annually
S327EXVRYD	Unit 3 Startup Bus UV Trip Aux Relay 27EX Fails to Pick Up	Annually
SPCB008CHO	SWYD PCB-8 Fails to Trip	All emergency starts
SPCB009CHC	SWYD PCB-9 Fails To Close On Demand	All emergency starts
SPCB009CHO	SWYD PCB-9 Fails To Trip	All emergency starts
SPCB012CHO	SWYD PCB-12 Fails To Trip	All emergency starts
SPCB015CHO	SWYD PCB-15 Fails To Trip On Demand	All emergency starts
SPCB017CHO	SWYD PCB-17 Fails To Trip On Demand	All emergency starts
SPCB021CHO	SWYD PCB-21 Fails To Trip On Demand	All emergency starts
SPCB024CHO	SWYD PCB-24 Fails To Trip On Demand	All emergency starts
SPCB026CHO	SWYD PCB-26 Fails To Trip On Demand	All emergency starts
SPCB028CHO	SWYD PCB-28 Fails To Trip On Demand	All emergency starts
SPCB033CHO	SWYD PCB-33 Fails To Open On Demand	All emergency starts

Table E-3

Infrequently Tested/Demanded Keowee Components

Basic Event	Description	Test Frequency
XD1KBATBYF	Keowee Battery No. 1 Fails During Discharge	Annually
XD2KBATBYF	Keowee Battery No. 2 Fails during Discharge	Annually
YK1ES1ARYD	Keowee 1 Emergency Start Aux Relay 1ESRX/1A Fails To Pick Up	All emergency starts
YK1ES1BRYD	Keowee 1 Emergency Start Aux Relay 1ESRX/1B Fails To Pick Up	All emergency starts
YK1ES2ARYD	Keowee 1 Emergency Start Aux Relay 1ESRX/2A Fails To Pick Up	All emergency starts
YK1ES2BRYD	Keowee 1 Emergency Start Aux Relay 1ESRX/2B Fails To Pick Up	All emergency starts
YK2ES1ARYD	Keowee 2 Emergency Start Aux Relay 2ESRX/1A Fails To Pick Up	All emergency starts
YK2ES1BRYD	Keowee 2 Emergency Start Aux Relay 2ESRX/1B Fails to Pick Up	All emergency starts
YK2ES2ARYD	Keowee 2 Emergency Start Aux Relay 2ESRX/2A Fails to Pick Up	All emergency starts
YK2ES2BRYD	Keowee 2 Emergency Start Aux Relay 2ESRX/2B Fails to Pick Up	All emergency starts
YO1XXKARYD	ONS1 Ch A Keowee Emergency Start Relay KA Fails to Pick Up	All emergency starts
YO1XXKBRYD	Oconee Unit 1 Chan. B Keowee Emergency Start Relay Fails	All emergency starts
YO2CR2ARYD	ONS2 Ch A Keowee Emergency Start Relay CR2A Fails to Pick Up	All emergency starts
YO2CR2BRYD	ONS2 Keowee Emergency Start Relay CR2B Fails to Pick Up	All emergency starts
YO3CR3ARYD	ONS3 Ch A Keowee Emergency Start Relay CR3A Fails To Pick Up	All emergency starts
YO3CR3BRYD	ONS3 Keowee Emer Start Relay CR3B Fails to Pick Up	All emergency starts

Table E-4

Sensitivity Study Results -- Infrequently Tested/Demanded Components

Gate	Description	Base Case Value	Obj. 1 Value	Percent Increase	Obj. 2 Value	Percent Increase	Obj. 3 Value	Percent Increase
KU2STARTF*	Keowee Unit 2 Fails To Start	7.84E-3	7.84E-3	0	1.62E-2	107	2.44E-2	211
KU2RUN*	Keowee Unit 2 Fails To Run	1.04E-2	1.04E-2	0	1.06E-2	1.9	1.57E-2	51
KEOWTOP	Oconee Emergency Power From Keowee Fails	7.35E-3 7.28E-3**	7.39E-3	0.5	8.40E-3**	15	9.49E-3*	30

* Cutsets for gates KU2STARTF and KU2RUN have not had recovery events added.

** These values are for KEOWTOP solved at a truncation limit of 1E-7. Attempting to solve for objectives 2 and 3 at the usual limit of 1E-8 exceeded CAFTA's limit on the number of cut sets.

Table E-5

Uncertainty Analysis Summary

Input Options

Filename	: INT_TOP.CUT
Module Name	: KEOWTOP
Sample Size	: 5000
Seed	: 3709601
Point Estimate	: 7.35E-03
Number of Modules	: 1
Total Cutsets In All Modules	: 3417
Number of Basic Events	: 507
Number of Type Codes	: 40
Inputs Missing Distributions	: 7

Event	Probability	Reason No Distribution Assigned
ACB4MOD	1	No credit for mod. taken in base case
KK1BOTHDEX	0	Configuration not allowed in base case
KK1RUNSDEX	0	Configuration not allowed in base case
OFACTORDEX	0	Conditioning Event
OMOD	0	No credit for mod. taken in base case
XD0KBATRHE	1	No credit for this recovery taken in base case
Y0STARTRHE	1	No credit for this recovery taken in base case

Moments (With 95% Confidence)

	Low	Estimate	High
Mean	7.21E-03	7.32E-03	7.44E-03
Standard Deviation	4.35E-03	4.26E-03	4.18E-03
Skewness	--	2.28E+00	--
Kurtosis	--	9.01E+00	--

Table E-5

Uncertainty Analysis Summary

Percentiles (With 95% Confidence)

	Low	Estimate	High
Minimum	--	1.44E-03	--
2.5	2.39E-03	2.51E-03	2.61E-03
5.0	2.85E-03	**2.93E-03**	3.01E-03
10.0	3.34E-03	3.40E-03	3.47E-03
20.0	4.07E-03	4.16E-03	4.22E-03
25.0	4.41E-03	4.48E-03	4.56E-03
30.0	4.76E-03	4.86E-03	4.94E-03
40.0	5.48E-03	5.58E-03	5.66E-03
50.0	6.16E-03	**6.26E-03**	6.37E-03
60.0	7.00E-03	7.11E-03	7.23E-03
70.0	7.99E-03	8.15E-03	8.34E-03
75.0	8.73E-03	8.88E-03	9.06E-03
80.0	9.48E-03	9.64E-03	9.87E-03
90.0	1.21E-02	1.24E-02	1.27E-02
95.0	1.48E-02	**1.53E-02**	1.59E-02
97.5	1.81E-02	1.87E-02	1.95E-02
Maximum	--	4.34E-02	--

Input Data Values: Basic Events

Basic Event	Type Code	Mean	Error	Dist. Type[2]	Calc. Type[1]
AA127C1R6T	R6T	24	0		1
AA127CPR6D	R6D	1	0		1
AA127R1RYT	RYT	24	0		1
AA127X2R6D	R6D	1	0		1
AA127XCRYD	RYD	1	0		1
AA186CXRYT	RYT	24	0		1
AA186S1RYT	RYT	24	0		1
AA187CXRYT	RYT	24	0		1
AA2272PR6D	R6D	1	0		1
AA2272XR6D	R6D	1	0		1
AA227CPR6D	R6D	1	0		1
AA227X2RYD	RYD	1	0		1
AA286S2RYT	RYT	24	0		1
AB0SWGRCOM		6.69E-04	10	L	0
AB0SWGRRHE		.5	2	L	0

Table E-5

Uncertainty Analysis Summary

Basic Event	Type Code	Mean	Error	Dist. Type[2]	Calc. Type[1]
AB24BKRCOM		1.12E-04	10	L	0
AB252CCSVO	SVO	1	0		1
AB252TCSVT	SVT		360		1
AB252Y2R6D	R6D	1	0		1
AB2ACCUDEX		3.51E-05	10	L	0
AB2CLOSLHE		2.60E-04	10	L	0
AB2MCH2DEX		3.02E-04	10	L	0
AB2R52XR6D	R6D	1	0		1
AB2R52ZR6T	R6T		360		1
AB31523SWT	SWT	24	0		1
AB352TCSVT	SVT	24	0		1
AB3PUSHPBT	PBT	24	0		1
AB3R52ZR6T	R6T	24	0		1
AB51431LHE		3.20E-04	10	L	0
AB51431SWT	SWT	360	0		1
AB5MCH2DEX		7.04E-03	10	L	0
AB610AFFUF	FUF	6	0		1
AB61432LHE		3.20E-04	10	L	0
AB61432SWT	SWT	360	0		1
AB652CCRYD	RYD	1	0		1
AB652TCRYD	RYD	1	0		1
AB652Y2RYT	RYT	360	0		1
AB6CLOSLHE		2.60E-04	10	L	0
AB6KEYISWT	SWT	360	0		1
AB6MCH2DEX		7.04E-03	10	L	0
AB6MECHDEX		8.01E-04	10	L	0
AB6OPENLHE		3.20E-03	5	L	0
AB6R52XRYD	RYD	1	0		1
AB6R52YRYD	RYD	1	0		1
AB710A1FUF	FUF	6	0		1
AB710AFFUF	FUF	6	0		1
AB752CCRYD	RYD	1	0		1
AB752TCRYD	RYD	1	0		1
AB752TCRYT	RYT	24	0		1
AB752Y2RYT	RYT	360	0		1
AB7CLOSLHE		2.60E-04	10	L	0
AB7KEYISWT	SWT	360	0		1
AB7MCH2DEX		7.04E-03	10	L	0
AB7MECHDEX		8.01E-04	10	L	0

Table E-5

Uncertainty Analysis Summary

Basic Event	Type Code	Mean	Error	Dist. Type[2]	Calc. Type[1]
AB7OPENLHE		3.20E-03	5	L	0
AB7PUSHPBT	PBT	30	0		1
AB7R52XRYD	RYD	1	0		1
AB7R52YRYD	RYD	1	0		1
AB8MCH2DEX		7.04E-03	10	L	0
ABPOPRCRHE		9.00E-03	5	L	0
ACB4MOD		1	0		0
ACBAIRPDEX		2.00E-03	10	L	0
ACBXFERCOM		1.28E-06	10	L	0
AD1B4ALCDT	CDT	30	0		1
AD2B2ALCDT	CDT	30	0		1
BK114/2SST	SST	24	0		1
BK1GBDCLHE		3.20E-03	5	L	0
BK1GBO1FTC	FTC	24	0		1
BK1GBO5VVT	VVT	24	0		1
BK1GBO6VVT	VVT	24	0		1
BK1GBO8VVT	VVT	24	0		1
BK1GBO9VVT	VVT	24	0		1
BK1GOACGPR	GPR	24	0		1
BK1GOACGPS	GPS	1	0		1
BK1GODCTRM		1.14E-03	3	L	0
BK2GBO1FTC	FTC	24	0		1
BKGBOILCOM		1.94E-06	10	L	0
DDC1ALXBYM		1.14E-02	3	L	0
DDCBATTCOM		2.70E-05	10	L	0
E12EXCTCOM		5.31E-05	10	L	0
ED11D3DCDT	CDT	84	0		1
ED13BR2CDT	CDT	24	0		1
ED22D3DCDT	CDT	24	0		1
ED23BR2CDT	CDT	24	0		1
EK00RUNCOM		1.24E-04	10	L	0
EK0BASERHE		1.90E-02	5	L	0
EK131TDRYT	RYT	84	0		1
EK14152SWT	SWT	84	0		1
EK1415TSWT	SWT	24	0		1
EK1415YRYD	RYD	1	0		1
EK1415YRYT	RYT	84	0		1
EK141AXR6D	R6D	1	0		1
EK141AXR6T	R6T	24	0		1

Table E-5

Uncertainty Analysis Summary

Basic Event	Type Code	Mean	Error	Dist. Type[2]	Calc. Type[1]
EK141CFRYD	RYD	1	0		1
EK186E2RYT	RYT	6	0		1
EK186EXRYT	RYT	84	0		1
EK186X2RYT	RYT	24	0		1
EK188SVRYD	RYD	1	0		1
EK188SVRYT	RYT	108	0		1
EK1901ARYT	RYT	84	0		1
EK199SYRYD	RYD	1	0		1
EK199SYRYT	RYT	24	0		1
EK1BAS2DEX		1.24E-03	10	L	0
EK1BASEDEX		6.17E-04	10	L	0
EK1BASELHE		3.20E-03	5	L	0
EK1DIODDEX		2.88E-04	10	L	0
EK1EXC1TGF	TGF	84	0		1
EK1EXC2TGF	TGF	24	0		1
EK1F30AFUF	FUF	24	0		1
EK1F31XRYD	RYD	1	0		1
EK1F41CRYD	RYD	1	0		1
EK1FAN1TLF	TLF	24	0		1
EK1FLDCLHE		2.60E-04	10	L	0
EK1FLDMDEX		7.71E-05	10	L	0
EK1FLSCLHE		2.60E-04	10	L	0
EK1FLSMDEX		7.71E-05	10	L	0
EK1FLSOLHE		2.60E-04	10	L	0
EK1R31TRYD	RYD	1	0		1
EK1R31YRYD	RYD	1	0		1
EK1R31YRYT	RYT	84	0		1
EK1R41XRYD	RYD	1	0		1
EK1R41YRYD	RYD	1	0		1
EK1R41YRYT	RYT	84	0		1
EK1R9A1RYT	RYT	84	0		1
EK1R9C1R6T	R6T	84	0		1
EK1S141SWT	SWT	84	0		1
EK1S31TSWT	SWT	84	0		1
EK1S41CRYD	RYD	1	0		1
EK1S41TSWT	SWT	24	0		1
EK1S41XRYD	RYD	1	0		1
EK1SPYCLHE		2.60E-04	10	L	0
EK1SPYMDEX		4.62E-04	10	L	0

Table E-5

Uncertainty Analysis Summary

Basic Event	Type Code	Mean	Error	Dist. Type[2]	Calc. Type[1]
EK1VREGDEX		2.47E-03	10	L	0
EK231TDRYT	RYT	12	0		1
EK2415TSWT	SWT	24	0		1
EK2415YRYD	RYD	1	0		1
EK2415YRYT	RYT	12	0		1
EK241AXR6D	R6D	1	0		1
EK241AXR6T	R6T	24	0		1
EK241CFRYD	RYD	1	0		1
EK286E2RYT	RYT	6	0		1
EK286EXRYT	RYT	12	0		1
EK286X2RYT	RYT	24	0		1
EK288SVRYD	RYD	1	0		1
EK288SVRYT	RYT	36	0		1
EK2901ARYT	RYT	12	0		1
EK299SYRYD	RYD	1	0		1
EK299SYRYT	RYT	24	0		1
EK2BAS2DEX		1.24E-03	10	L	0
EK2BASEDEX		6.17E-04	10	L	0
EK2BASELHE		3.20E-03	5	L	0
EK2DIODDEX		2.88E-04	10	L	0
EK2EXC1TGF	TGF	12	0		1
EK2EXC2TGF	TGF	24	0		1
EK2F30AFUF	FUF	24	0		1
EK2F31XRYD	RYD	1	0		1
EK2F41CRYD	RYD	1	0		1
EK2FAN1TLF	TLF	24	0		1
EK2FLDCLHE		2.60E-04	10	L	0
EK2FLDMDEX		7.71E-05	10	L	0
EK2FLSCLHE		2.60E-04	10	L	0
EK2FLSMDEX		7.71E-05	10	L	0
EK2FLSOLHE		2.60E-04	10	L	0
EK2R31TRYD	RYD	1	0		1
EK2R31YRYD	RYD	1	0		1
EK2R31YRYT	RYT	12	0		1
EK2R41XRYD	RYD	1	0		1
EK2R41YRYD	RYD	1	0		1
EK2R41YRYT	RYT	12	0		1
EK2R9A2RYT	RYT	12	0		1
EK2R9C2R6T	R6T	12	0		1

Table E-5

Uncertainty Analysis Summary

Basic Event	Type Code	Mean	Error	Dist. Type[2]	Calc. Type[1]
EK2S41CRYD	RYD	1	0		1
EK2S41TSWT	SWT	24	0		1
EK2S41XRYD	RYD	1	0		1
EK2SPYCLHE		2.60E-04	10	L	0
EK2SPYMDEX		4.62E-04	10	L	0
EK2VREGDEX		2.47E-03	10	L	0
EKSTARTCOM		6.17E-05	10	L	0
FK0FISHCOM		2.55E-03	10	L	0
FK0FISHDHE		6.30E-02	5	L	0
FK0WL01VVT	VVT	24	0		1
FK1120GLHE		3.20E-03	5	L	0
FK1FL01FRF	FRF	24	0		1
FK1FL02FRF	FRF	24	0		1
FK1TRHXHXF	HXF	24	0		1
FK1WL03VVT	VVT	24	0		1
FK1WL04VVT	VVT	24	0		1
FK1WL05VVT	VVT	24	0		1
FK1WL06VVT	VVT	24	0		1
FK1WL07VVT	VVT	24	0		1
FK1WL08VVT	VVT	24	0		1
FK1WL09VVT	VVT	24	0		1
FK1WL11AVO	AVO	1	0		1
FK1WL11AVT	AVT	24	0		1
FK1WL12VVT	VVT	108	0		1
FK1WL15VVT	VVT	108	0		1
FK1WL42VVT	VVT	108	0		1
FK1WL43VVT	VVT	108	0		1
FK2FL01FRF	FRF	24	0		1
FK2FL02FRF	FRF	24	0		1
FK2TRHXHXF	HXF	24	0		1
FK2WL11AVO	AVO	1	0		1
FK2WL11AVT	AVT	24	0		1
FKVALVECOM		2.46E-05	10	L	0
GK0BRGVRHE		1.00E-01	5	L	0
GK0COOLCOM		4.61E-07	10	L	0
GK0LOCKCOM		4.06E-06	10	L	0
GK10001HGR	HGR	24	0		1
GK10001HGS	HGS	1	0		1
GK1063FPST	PST	24	0		1

Table E-5

Uncertainty Analysis Summary

Basic Event	Type Code	Mean	Error	Dist. Type[2]	Calc. Type[1]
GK13SUIRYT	RYT	24	0		1
GK13SUISWT	SWT	24	0		1
GK140G1RYT	RYT	24	0		1
GK159GNRYT	RYT	24	0		1
GK162TDRYT	RYT	24	0		1
GK163FXRYT	RYT	24	0		1
GK186E1RYT	RYT	24	0		1
GK187G1RYT	RYT	24	0		1
GK187GBRYT	RYT	24	0		1
GK187TERYT	RYT	24	0		1
GK1BRGVLHE		2.60E-04	10	L	0
GK1COOLLHE		2.60E-04	10	L	0
GK1FIREDEX		3.19E-05	10	L	0
GK1GAC1HXF	HXF	24	0		1
GK1GAC1HXL	HXL	108	0		1
GK1GAC2HXF	HXF	24	0		1
GK1GAC2HXL	HXL	108	0		1
GK1GAC3HXF	HXF	24	0		1
GK1GAC3HXL	HXL	108	0		1
GK1GAC4HXF	HXF	24	0		1
GK1GAC4HXL	HXL	108	0		1
GK1GAC5HXF	HXF	24	0		1
GK1GAC5HXL	HXL	108	0		1
GK1GAC6HXF	HXF	24	0		1
GK1GAC6HXL	HXL	108	0		1
GK1HPO1HXF	HXF	24	0		1
GK1HPO2HXF	HXF	24	0		1
GK1HPO3HXF	HXF	24	0		1
GK1HPO4HXF	HXF	24	0		1
GK1HPO5HXF	HXF	24	0		1
GK1HPO6HXF	HXF	24	0		1
GK1HPO6VVT	VVT	24	0		1
GK1HPO7HXF	HXF	24	0		1
GK1HPO8HXF	HXF	24	0		1
GK1NGDCLHE		5.20E-05	10	L	0
GK1WL16VVT	VVT	384	0		1
GK1WL17VVT	VVT	384	0		1
GK1WL18VVT	VVT	108	0		1
GK1WL19VVT	VVT	108	0		1

Table E-5

Uncertainty Analysis Summary

Basic Event	Type Code	Mean	Error	Dist. Type[2]	Calc. Type[1]
GK1WL20VVT	VVT	384	0		1
GK1WL21VVT	VVT	384	0		1
GK1WL22VVT	VVT	108	0		1
GK1WL23VVT	VVT	108	0		1
GK1WL24VVT	VVT	384	0		1
GK1WL25VVT	VVT	384	0		1
GK1WL26VVT	VVT	108	0		1
GK1WL27VVT	VVT	108	0		1
GK1WL28VVT	VVT	384	0		1
GK1WL29VVT	VVT	384	0		1
GK1WL30VVT	VVT	108	0		1
GK1WL31VVT	VVT	108	0		1
GK1WL32VVT	VVT	384	0		1
GK1WL33VVT	VVT	384	0		1
GK1WL34VVT	VVT	108	0		1
GK1WL35VVT	VVT	108	0		1
GK1WL36VVT	VVT	384	0		1
GK1WL37VVT	VVT	384	0		1
GK1WL38VVT	VVT	108	0		1
GK1WL39VVT	VVT	108	0		1
GK1WL41VVT	VVT	384	0		1
GK1WL44VVT	VVT	384	0		1
GK1WL45VVT	VVT	384	0		1
GK1WL46VVT	VVT	108	0		1
GK1WL47VVT	VVT	108	0		1
GK1WL48VVT	VVT	384	0		1
GK1WL49VVT	VVT	384	0		1
GK1WL50VVT	VVT	108	0		1
GK1WL51VVT	VVT	108	0		1
GK1WL52VVT	VVT	384	0		1
GK1WL53VVT	VVT	384	0		1
GK1WL54VVT	VVT	108	0		1
GK1WL55VVT	VVT	108	0		1
GK1WL56VVT	VVT	384	0		1
GK1WL57VVT	VVT	384	0		1
GK1WL58VVT	VVT	108	0		1
GK1WL59VVT	VVT	108	0		1
GK1WL60VVT	VVT	384	0		1
GK1WL61VVT	VVT	384	0		1

Table E-5

Uncertainty Analysis Summary

Basic Event	Type Code	Mean	Error	Dist. Type[2]	Calc. Type[1]
GK1WL62VVT	VVT	108	0		1
GK1WL63VVT	VVT	108	0		1
GK1WL64VVT	VVT	384	0		1
GK1WL65VVT	VVT	384	0		1
GK1WL66VVT	VVT	108	0		1
GK1WL67VVT	VVT	108	0		1
GK1WL68VVT	VVT	384	0		1
GK1WL69VVT	VVT	384	0		1
GK1WL70VVT	VVT	108	0		1
GK1WL71VVT	VVT	108	0		1
GK1WL72VVT	VVT	384	0		1
GK1WL73VVT	VVT	384	0		1
GK1WL74VVT	VVT	108	0		1
GK1WL75VVT	VVT	108	0		1
GK1WL76VVT	VVT	384	0		1
GK1WL78VVT	VVT	384	0		1
GK20001HGR	HGR	24	0		1
GK20002HGS	HGS	1	0		1
GK2063FPST	PST	24	0		1
GK23SUIRYT	RYT	24	0		1
GK23SUISWT	SWT	24	0		1
GK240G1RYT	RYT	24	0		1
GK259GNRYT	RYT	24	0		1
GK262TDRYT	RYT	24	0		1
GK263FXRYT	RYT	24	0		1
GK286E2RYT	RYT	24	0		1
GK287G2RYT	RYT	24	0		1
GK287GBRYT	RYT	24	0		1
GK287TERYT	RYT	24	0		1
GK2BRGVLHE		2.60E-04	10	L	0
GK2COOLLHE		2.60E-04	10	L	0
GK2FIREDEX		7.00E-05	10	L	0
GK2GAC1HXF	HXF	24	0		1
GK2GAC1HXL	HXL	36	0		1
GK2GAC2HXF	HXF	24	0		1
GK2GAC2HXL	HXL	36	0		1
GK2GAC3HXF	HXF	24	0		1
GK2GAC3HXL	HXL	36	0		1
GK2GAC4HXF	HXF	24	0		1

Table E-5

Uncertainty Analysis Summary

Basic Event	Type Code	Mean	Error	Dist. Type[2]	Calc. Type[1]
GK2GAC4HXL	HXL	36	0		1
GK2GAC5HXF	HXF	24	0		1
GK2GAC5HXL	HXL	36	0		1
GK2GAC6HXF	HXF	24	0		1
GK2GAC6HXL	HXL	36	0		1
GK2HPO1HXF	HXF	24	0		1
GK2HPO2HXF	HXF	24	0		1
GK2HPO3HXF	HXF	24	0		1
GK2HPO4HXF	HXF	24	0		1
GK2HPO5HXF	HXF	24	0		1
GK2HPO6HXF	HXF	24	0		1
GK2HPO7HXF	HXF	24	0		1
GK2HPO8HXF	HXF	24	0		1
GK2NGDCLHE		5.20E-05	10	L	0
GKHPOILCOM		4.61E-07	10	L	0
KA127T1R6D	R6D	1	0		1
KB4CONNDEX		1.10E-07	10	L	0
KK1BOTHDEX		0	0		0
KK1BOTHHYM		5.23E-03	3	L	0
KK1RUNSDEX		0	0		0
KK1UNDRBHF	BHF	24	0		1
KK2RUNSDEX		6.00E-02	10	L	0
KK2UNITHYM		3.80E-02	3	L	0
OFACTORDEX		1	0		0
OK0PRUNCOM		1.46E-05	10	L	0
OK10003RVT	RVT	24	0		1
OK10003TKF	TKF	24	0		1
OK1AG01TKF	TKF	24	0		1
OK1AG04RVT	RVT	24	0		1
OK1AG05VVT	VVT	24	0		1
OK1PSTRCOM		2.04E-05	10	L	0
OK20003RVT	RVT	24	0		1
OK20003TKF	TKF	24	0		1
OK2AG04RVT	RVT	24	0		1
OK2AGO1TKF	TKF	24	0		1
OK2PSTRCOM		2.04E-05	10	L	0
OMOD		0	0		0
PAC1TC4C4T	C4T	24	0		1
PACX1TCBHF	BHF	24	0		1

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Uncertainty Analysis Summary

Basic Event	Type Code	Mean	Error	Dist. Type[2]	Calc. Type[1]
PK0SUMPCOM		2.44E-06	10	L	0
PK1ACDCCOM		2.77E-05	10	L	0
PK1PACKDEX		3.10E-05	10	L	0
PK1TSACGPR	GPR	30	0		1
PK1TSDCLHE		3.20E-03	5	L	0
PK1TSDCTRM		6.85E-04	3	L	0
PK2ACDCCOM		2.77E-05	10	L	0
PK2PACKDEX		3.10E-05	10	L	0
PMFB1		5.60E-03	5	L	0
PMFB2		5.60E-03	5	L	0
S127EUVRYT	RYT	9M	0		1
S127EXVRYD	RYD	1	0		1
S227EUVRYT	RYT	9M	0		1
S227EXVRYD	RYD	1	0		1
SKXFMR1THF	THF	24	0		1
SPC871XRYT	RYT	72	0		1
SPC872XRYT	RYT	72	0		1
SPC87T1RYT	RYT	72	0		1
SPCB008CHO	CHO	1	0		1
SPCB009CHC	CHC	1	0		1
SPCB012CHO	CHO	1	0		1
SPCB015CHO	CHO	1	0		1
SPCB017CHO	CHO	1	0		1
SPCB021CHO	CHO	1	0		1
SPCB024CHO	CHO	1	0		1
SPCB026CHO	CHO	1	0		1
SPCB028CHO	CHO	1	0		1
SPCB033CHO	CHO	1	0		1
SU327UVCOM		1.18E-04	10	L	0
SXFRCT3THF	THF	24	0		1
SXFRCT3THM		1.74E-04	3	L	0
SXFRCT4LHE		6.40E-05	10	L	0
SXFRCT4THM		9.13E-04	3	L	0
SYPCB09CHT	CHT	24	0		1
SYPCB30CHT	CHT	24	0		1
U5086EFRYT	RYT	24	0		1
U5186EFRYT	RYT	24	0		1
U51TNC4RYT	RYT	24	0		1
U62BSK1RYT	RYT	24	0		1

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Uncertainty Analysis Summary

Basic Event	Type Code	Mean	Error	Dist. Type[2]	Calc. Type[1]
U62BSK2RYT	RYT	24	0		1
U86CT4XRYT	RYT	24	0		1
U86TCT4RYT	RYT	24	0		1
U87TCT4RYT	RYT	24	0		1
UACXCT4THF	THF	24	0		1
UXX86EFRYT	RYT	24	0		1
WK00RUNCOM		2.09E-05	10	L	0
WK1GVCDDEX		3.50E-05	10	L	0
WK1GVCDLHE		2.60E-04	10	L	0
WK1GVRNDEX		5.60E-04	10	L	0
WK1SPD2DEX		5.60E-05	10	L	0
WK1TBCDDEX		3.50E-05	10	L	0
WK1TBRNDEX		5.60E-04	10	L	0
WK2GVCDDEX		3.50E-05	10	L	0
WK2GVCDLHE		2.60E-04	10	L	0
WK2GVHTDEX		3.50E-04	10	L	0
WK2GVRNDEX		5.60E-04	10	L	0
WK2SPD2DEX		5.60E-05	10	L	0
WK2TBCDDEX		3.50E-05	10	L	0
WK2TBHTDEX		3.50E-04	10	L	0
WK2TBRNDEX		5.60E-04	10	L	0
WKCSTRTCOM		1.12E-05	10	L	0
XA0SWGRCOM		1.22E-06	10	L	0
XA1BKRSCOM		3.10E-04	10	L	0
XA1X2AXCLT	CLT	24	0		1
XA1X2CCCLT	CLT	24	0		1
XA1XA1ACLT	CLT	24	0		1
XA1XAALBLM		2.74E-03	3	L	0
XA1XAMCBLF	BLF	24	0		1
XA1XCXXTHM		4.57E-04	3	L	0
XA1XCXXTLF	TLF	24	0		1
XA1XXXXBLF	BLF	24	0		1
XA2BKRSCOM		3.10E-04	10	L	0
XA2X2BXCLT	CLT	24	0		1
XA2X2DXCLT	CLT	24	0		1
XA2X4AXCLT	CLT	24	0		1
XA2XAALBLM		2.74E-03	3	L	0
XA2XAMCBLF	BLF	24	0		1
XA2XXXXBLF	BLF	24	0		1

Table E-5

Uncertainty Analysis Summary

Basic Event	Type Code	Mean	Error	Dist. Type[2]	Calc. Type[1]
XA56BKRCOM		3.10E-04	10	L	0
XA78BKRCOM		3.10E-04	10	L	0
XD0BATTCOM		2.70E-05	10	L	0
XD0CHRGCOM		3.48E-05	10	L	0
XD0KBATRHE		1	0		0
XD104CCCDT	CDT	24	0		1
XD1BK1ACDT	CDT	24	0		1
XD1CKC1BCF	BCF	24	0		1
XD1DALTBYM		5.48E-03	3	L	0
XD1DARXBDF	BDF	24	0		1
XD1KB1XRHE		9.30E-02	5	L	0
XD1KBATBYF	BYF	1	0		1
XD204CCCDT	CDT	24	0		1
XD2BK1ACDT	CDT	24	0		1
XD2CKC2BCF	BCF	24	0		1
XD2DALTBYM		5.48E-03	3	L	0
XD2DARXBDF	BDF	24	0		1
XD2KB2XRHE		9.30E-02	5	L	0
XD2KBATBYF	BYF	1	0		1
Y0STARTCOM		7.26E-06	10	L	0
Y0STARTRHE		.5	0		0
YK114X3SSD	SSD	1	0		1
YK13SUISWT	SWT	24	0		1
YK14AMRRYT	RYT	24	0		1
YK163BHLST	LST	24	0		1
YK163BHRYT	RYT	24	0		1
YK163BLLST	LST	24	0		1
YK163BLRYT	RYT	24	0		1
YK163TBLST	LST	24	0		1
YK163TBRYT	RYT	24	0		1
YK199SDRYD	RYD	1	0		1
YK199SDRYT	RYT	24	0		1
YK199SNRYD	RYD	1	0		1
YK199SNRYT	RYT	24	0		1
YK199SXRYD	RYD	1	0		1
YK199SXRYT	RYT	24	0		1
YK1D4CRFUF	FUF	6	0		1
YK1ES1ARYD	RYD	1	0		1
YK1ES2ARYD	RYD	1	0		1

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Uncertainty Analysis Summary

Basic Event	Type Code	Mean	Error	Dist. Type[2]	Calc. Type[1]
YK1MR4ARYD	RYD	1	0		1
YK1SS12SST	SST	24	0		1
YK1SS13SSD	SSD	1	0		1
YK214X3SSD	SSD	1	0		1
YK23SUISWT	SWT	24	0		1
YK24AMRRYT	RYT	24	0		1
YK263BHLST	LST	24	0		1
YK263BHRYT	RYT	24	0		1
YK263BLLST	LST	24	0		1
YK263BLRYT	RYT	24	0		1
YK263TBLST	LST	24	0		1
YK263TBRYT	RYT	24	0		1
YK299SDRYD	RYD	1	0		1
YK299SDRYT	RYT	24	0		1
YK299SNRYD	RYD	1	0		1
YK299SNRYT	RYT	24	0		1
YK299SXRYD	RYD	1	0		1
YK299SXRYT	RYT	24	0		1
YK2D2CCFUF	FUF	6	0		1
YK2ES1BRYD	RYD	1	0		1
YK2ES2BRYD	RYD	1	0		1
YK2MR4ARYD	RYD	1	0		1
YK2SS12SST	SST	24	0		1
YK2SS13SSD	SSD	1	0		1

[1]Calc. type 0: failure probability = mean
Calc. type 1: failure probability = type code failure rate * mean

[2]For calc. type 0, the distribution type is assigned individually to each basic event. For calc. type 1, the basic event distribution type is determined by the type code distribution type

Table E-5

Uncertainty Analysis Summary

Input Data Values: Type Codes

Type Code	Mean	Error	Units	Distribution
AVO	2.80E-04	2.8	N	L
AVT	2.30E-06	10	H	L
BCF	2.90E-05	1.9	H	L
BDF	3.20E-07	5.2	H	L
BHF	4.00E-07	5.1	H	L
BLF	2.70E-07	6.4	H	L
BYF	9.30E-04	7.8	N	L
C4T	9.40E-07	5.7	H	L
CDT	7.50E-08	5.7	H	L
CHC	2.60E-04	3.7	N	L
CHO	2.60E-05	10	N	L
CHT	1.90E-06	2.8	H	L
CLT	9.10E-07	3.3	H	L
FRF	9.80E-07	6.6	H	L
FTC	1.80E-06	6.6	H	L
FUF	3.60E-06	2.1	H	L
GPR	1.40E-05	2.3	H	L
GPS	9.70E-05	1.7	N	L
HGR	9.46E-05	10	H	L
HGS	1.54E-04	10	N	L
HXF	6.40E-07	8.2	H	L
HXL	1.00E-07	10	H	L
LST	3.10E-07	8	H	L
PBT	2.40E-07	10	H	L
PST	4.30E-07	4.6	H	L
R6D	2.49E-04	10	N	L
R6T	3.63E-07	10	H	L
RVT	5.60E-06	2.2	H	L
RYD	3.30E-05	2.1	N	L
RYT	3.60E-07	2.3	H	L
SSD	1.80E-05	6.4	N	L
SST	4.20E-06	3.7	H	L
SVO	2.90E-05	7.5	N	L
SVT	3.90E-07	3	H	L
SWT	7.00E-08	10	H	L
TGF	9.80E-07	7	H	L
THF	3.10E-06	3.4	H	L
TKF	4.60E-07	6.3	H	L
TLF	7.50E-07	7	H	L
VVT	1.70E-08	7.3	H	L

N = per demand; H = per hour

Table E-6

Keowee PRA Basic Event Data
Two Unit Generation - Bayesian Update/Unrecovered

	NAME	FACTOR	DESCRIPTION	PROBABILITY
1	AA1271PR6D	1	Transformer 1X Undervoltage Relay 27/1X Fails To Pick Up	2.49E-04
2	AA1271XR6T	30	Transformer 1X Undervoltage Relay 27/1X Spuriously De-energizes	1.09E-05
3	AA127C1R6T	24	Transformer CX Undervoltage Relay 27/CX1 Spuriously De-energizes	8.71E-06
4	AA127CPR6D	1	Transformer CX Undervoltage Relay 27/CX1 Fails To Pick Up	2.49E-04
5	AA127R1RYT	24	Auxiliary Relay 27X/CX1 Spurious Operation	8.64E-06
6	AA127X1RYD	1	Auxiliary Relay 27X/1X Fails To Operate On Demand	3.30E-05
7	AA127X1RYT	384	Auxiliary Relay 27X/1X Spurious Operation	1.38E-04
8	AA127X2R6D	1	Transformer CX Undervoltage Relay 27/CX1 Fails To Drop Out	2.49E-04
9	AA127XCRYD	1	Auxiliary Relay 27/CX1 Fails To Operate On Demand	3.30E-05
10	AA186CXRYT	24	Transformer CX Differential Lock Out Relay 86CX Spurious Operation	8.64E-06
11	AA186S1RYT	24	Switchgear 1X Lockout Relay 86S/1X Spurious Operation	8.64E-06
12	AA187CXRYT	24	Transformer CX Differential Relay 87CX Spurious Operation	8.64E-06
13	AA2272PR6D	1	Transformer 2X Undervoltage Relay 27/2X Fails To Pick Up	2.49E-04
14	AA2272XR6D	1	Transformer 2X Undervoltage Relay 27/2X Fails To Drop Out	2.49E-04
15	AA2272XR6T	24	Transformer 2X Undervoltage Relay 27/2X Spuriously De-energizes	8.71E-06
16	AA227C2R6T	30	Transformer CX Undervoltage Relay 27/CX2 Spuriously De-energizes	1.09E-05
17	AA227C2RYD	1	Auxiliary Relay 27X/CX2 Fails To Operate On Demand	3.30E-05
18	AA227CPR6D	1	Transformer CX Undervoltage Relay 27/CX2 Fails To Pick Up	2.49E-04
19	AA227R2RYT	384	Auxiliary Relay 27X/CX2 Spurious Operation	1.38E-04
20	AA227T2R6D	1	Transformer 2X Undervoltage Relay (27T/2X) Fails To Drop Out	2.49E-04
21	AA227X2RYD	1	Auxiliary Relay 27X/2X Fails To Operate On Demand	3.30E-05
22	AA227X2RYT	24	Auxiliary Relay 27X/2X Spurious Operation	8.64E-06
23	AA286S2RYT	24	Switchgear 2X Lockout Relay 86S/2X Spurious Operation	8.64E-06
24	AB004ECCDT	30	DC Circuit Breaker 1DA-4EC Transfers Position	2.25E-06
25	AB0086TRYD	1	Keowee Main Tx Lock Out Relay 86T Fails To Operate On Demand	3.30E-05
26	AB0624CRYD	1	Time Delay Relay 62-4c Fails To Operate On Demand	3.30E-05
27	AB086E1RYD	1	Emergency Lock Out Relay 86E-1 Fails To Operate On Demand	3.30E-05
28	AB086TGRYD	1	General Keowee Main Tx Lock Out Sensing Relay Fails To Operate	3.30E-05
29	AB0SWGRCOM	6.69E-04	Common Cause Failure Of All Keowee Auxiliary Power Breakers	6.69E-04
30	AB0SWGRRHE	1.0	Failure To Recover Keowee Aux Power Breakers by Manual Control	1.00E+00
31	AB152TCSVO	1	Air Circuit Breaker 1 Trip Coil Fails To Operate	2.90E-05
32	AB1ACCUDEX	3.51E-05	Air Circuit Breaker 1 Accumulator Air Pressure Low	3.51E-05
33	AB1FALTDEX	1.75E-05	Fault Occurs at ACB-1 When The BReaker Trips	1.75E-05
34	AB1MECHDEX	1.51E-4	Air Circuit Breaker 1 Fails To Open Due To Mechanical Failure	1.51E-04
35	AB1OPENLHE	2.60E-4	Air Circuit Breaker 1 Fails To Open Due To A Latent Human Error	2.60E-04
36	AB1PS02PST	12	Air Circuit Breaker 1 Accumulator Pressure Switch PS2 Fails Low	5.16E-06
37	AB1PSWTPST	24	Air Circuit Breaker 1 Accumulator Pressure Switch Fails Low	1.03E-05

Table E-6

Keowee PRA Basic Event Data
Two Unit Generation - Bayesian Update/Unrecovered

	NAME	FACTOR	DESCRIPTION	PROBABILITY
38	AB1R52ZR6D	1	Air Circuit Breaker 1 Relay 52Z Fails To Operate	2.49E-04
39	AB21521SWT	30	Control Switch 152-2 Spurious Operation	2.10E-06
40	AB22BV1RYT	24	Backup Undervoltage Relay 2BV1 Spurious Operation	8.64E-06
41	AB23BKRCOM	1.12e-04	Common Cause Failure Of Air Circuit Breakers 2 And 3 To Close	1.12E-04
42	AB24BKRCOM	1.12E-04	Common Cause Failure Of Air Circuit Breakers 2 And 4 To Close	1.12E-04
43	AB251G2RYT	24	Air Circuit Breaker 2 Overcurrent Ground Relay 51G-2 Spurious Operation	8.64E-06
44	AB252CCSVO	1	Air Circuit Breaker 2 Close Coil Fails To Operate	2.90E-05
45	AB252TCSVO	1	Air Circuit Breaker 2 Trip Coil Fails To Operate	2.90E-05
46	AB252TCSVT	36	Air Circuit Breaker 2 Trip Coil Spurious Operation	1.40E-05
47	AB252Y2R6D	1	Air Circuit Breaker 2 Relay 52Y Failed To Drop Out Following Last Demand	2.49E-04
48	AB252Y2R6T	12	Air Circuit Breaker 2 Y-relay Spurious Operation	4.36E-06
49	AB2ACCUDEX	3.51E-05	Air Circuit Breaker 2 Accumulator Air Pressure Low	3.51E-05
50	AB2CLOSLHE	2.60E-4	Air Circuit Breaker 2 Fails To Close Due To A Latent Human Error	2.60E-04
51	AB2KEYISWT	12	Air Circuit Breaker 2 Key Interlock Switch Transfers Open	8.40E-07
52	AB2MCH2DEX	3.02E-4	Air Circuit Breaker 2 Fails To Close Due To Mechanical Failure	3.02E-04
53	AB2MECHDEX	1.51E-4	Air Circuit Breaker 2 Fails To Open Due To Mechanical Failure	1.51E-04
54	AB2OPENLHE	2.60E-4	Air Circuit Breaker 2 Fails To Open Due To A Latent Human Error	2.60E-04
55	AB2PS02PST	12	Air Circuit Breaker 2 Accumulator Pressure Switch PS2 Fails Low	5.16E-06
56	AB2PSWTPST	24	Air Circuit Breaker 2 Accumulator Pressure Switch Fails Low	1.03E-05
57	AB2PUSHPBT	36	Trip Pushbutton On ACB2 Spurious Operation	8.64E-06
58	AB2R462RYT	24	Air Circuit Breaker 2 Negative Sequence Relay 46-2 Spurious Operation	8.64E-06
59	AB2R52XR6D	1	Air Circuit Breaker 2 Relay 52X Fails To Operate	2.49E-04
60	AB2R52ZR6D	1	Air Circuit Breaker 2 Relay 52Z Fails To Operate	2.49E-04
61	AB2R52ZR6T	36	Air Circuit Breaker 2 Relay 52Z Spurious Operation	1.31E-05
62	AB31523SWT	24	Control Switch 152-3 Spurious Operation	1.68E-06
63	AB352CCSVO	1	Air Circuit Breaker 3 Close Coil Fails To Operate	2.90E-05
64	AB352TCSVO	1	Air Circuit Breaker 3 Trip Coil Fails To Operate	2.90E-05
65	AB352TCSVT	24	Air Circuit Breaker 3 Trip Coil Spurious Operation	9.36E-06
66	AB352Y2R6D	1	Air Circuit Breaker 3 Relay 52Y Failed To Drop Out Following Last Demand	2.49E-04
67	AB352Y2R6T	360	Air Circuit Breaker 3 Y-relay Spurious Operation	1.31E-04
68	AB3ACCUDEX	3.51E-05	Air Circuit Breaker 3 Accumulator Air Pressure Low	3.51E-05
69	AB3CLOSLHE	2.60e-04	Air Circuit Breaker 3 Fails To Close Due To Latent Human Error	2.60E-04
70	AB3MCH2DEX	3.02E-04	Air Circuit Breaker 3 Fails To Close Due To Mechanical Failure	3.02E-04
71	AB3MECHDEX	1.51E-04	Air Circuit Breaker 3 Fails To Open Due To Mechanical Failure	1.51E-04
72	AB3PS02PST	372	Air Circuit Breaker 3 Accumulator Pressure Switch PS2 Fails Low	1.60E-04
73	AB3PSWTPST	24	Air Circuit Breaker 3 Accumulator Pressure Switch Fails Low	1.03E-05
74	AB3PUSHPBT	24	Trip Pushbutton On ACB3 Spurious Operation	5.76E-06

Table E-6

Keowee PRA Basic Event Data
Two Unit Generation - Bayesian Update/Unrecovered

	NAME	FACTOR	DESCRIPTION	PROBABILITY
75	AB3R52XR6D	1	Air Circuit Breaker 3 Relay 52X Fails To Operate	2.49E-04
76	AB3R52ZR6D	1	Air Circuit Breaker 3 Relay 52Z Fails To Operate	2.49E-04
77	AB3R52ZR6T	24	Air Circuit Breaker 3 Relay 52Z Spurious Operation	8.71E-06
78	AB41523SWT	24	Control Switch 152-4 Spurious Operation	1.68E-06
79	AB452CCSVO	1	Air Circuit Breaker 4 Close Coil Fails To Operate	2.90E-05
80	AB452TCSVT	24	Air Circuit Breaker 4 Trip Coil Spurious Operation	9.36E-06
81	AB452Y2R6D	1	Air Circuit Breaker 4 Relay 52Y Failed To Drop Out Following Last Demand	2.49E-04
82	AB452Y2R6T	372	Air Circuit Breaker 4 Y-relay Spurious Operation	1.35E-04
83	AB4ACCUDEX	3.51E-05	Air Circuit Breaker 4 Accumulator Air Pressure Low	3.51E-05
84	AB4CLOSLHE	2.60E-4	Air Circuit Breaker 4 Fails To Close Due To A Latent Human Error	2.60E-04
85	AB4CLSESWC	1	Air Circuit Breaker 4 Close Switch Fails To Close On Demand	1.00E-05
86	AB4KEYISWT	372	Air Circuit Breaker 4 Key Interlock Switch Transfers Open	2.60E-05
87	AB4LORESWT	372	Air Circuit Breaker 4 Local/Remote Switch Contact Transfers Position	2.60E-05
88	AB4MCH2DEX	3.02E-04	Air Circuit Breaker 4 Fails To Close Due To Mechanical Failure	3.02E-04
89	AB4PS02PST	372	Air Circuit Breaker 4 Accumulator Pressure Switch PS2 Indicates Low Pressure	1.60E-04
90	AB4PSWTPST	12	Air Circuit Breaker 4 Accumulator Pressure Switch Indicates Low Air Pressure	5.16E-06
91	AB4PUSHPBT	24	Trip Pushbutton On ACB-4 Spurious Operation	5.76E-06
92	AB4R52XR6D	1	Air Circuit Breaker 4 Relay 52X Fails To Operate	2.49E-04
93	AB4R52ZR6T	24	Air Circuit Breaker 4 Relay 52Z Spurious Operation	8.71E-06
94	AB510A1FUF	6	One Or More Control Power Fuses For X, Y And CC Fail	2.16E-05
95	AB51431LHE	3.20E-4	Manual/Auto Control Switch 143/1 Left In Manual	3.20E-04
96	AB51431RYT	360	Auxiliary Relay 143X/1 Spuriously Energizes	1.30E-04
97	AB51431SWT	360	Manual/Auto Control Switch 143/1 Spuriously Transfers Into Manual	2.52E-05
98	AB552CCRYD	1	Air Circuit Breaker 5 Close Coil CC Fails On Demand	3.30E-05
99	AB552TCRYT	384	Air Circuit Breaker 5 Trip Coil 52TC Spurious Operation	1.38E-04
100	AB552Y2RYT	360	Air Circuit Breaker 5 Y-relay Spurious Operation	1.30E-04
101	AB583S5RYD	1	Time Delay Relay 83S5 Fails To Pick Up	3.30E-05
102	AB5CLOSLHE	2.60E-4	Air Circuit Breaker 5 Fails To Close Due To A Latent Human Error	2.60E-04
103	AB5KEYISWT	360	Air Circuit Breaker 5 Key Interlock Switch Transfers Open	2.52E-05
104	AB5MCH2DEX	7.04E-03	Air Circuit Breaker 5 Fails To Close Due To Mechanical Failure	7.04E-03
105	AB5PUSHPBT	384	Trip Pushbutton On ACB5 Spurious Operation	9.22E-05
106	AB5R52XRYD	1	Air Circuit Breaker 5 Relay 52X Fails To Operate	3.30E-05
107	AB5R52YRYD	1	Air Circuit Breaker 5 Relay 52Y Failed To Drop Out At Last Demand	3.30E-05
108	AB610A1FUF	6	One Or More Control Power Fuses For X, Y And CC Fail	2.16E-05
109	AB610AFFUF	6	One Or More Control Power Fuses For Relay 27X/2X Fail	2.16E-05
110	AB61432LHE	3.20E-4	Manual/Auto Control Switch 143/2 Left In Manual	3.20E-04
111	AB61432SWT	360	Manual/Auto Control Switch 143/2 Spuriously Transfers Into Manual	2.52E-05

Table E-6

Keowee PRA Basic Event Data
Two Unit Generation - Bayesian Update/Unrecovered

	NAME	FACTOR	DESCRIPTION	PROBABILITY
112	AB652CCRYD	1	Air Circuit Breaker 6 Close Coil CC Fails On Demand	3.30E-05
113	AB652TCRYD	1	Air Circuit Breaker 6 Trip Coil 52TC Fails Fails To Operate	3.30E-05
114	AB652TCRYT	24	Air Circuit Breaker 6 Trip Coil 52TC Spurious Operation	8.64E-06
115	AB652Y2RYT	360	Air Circuit Breaker 6 Y-relay Spurious Operation	1.30E-04
116	AB6CLOSLHE	2.60E-4	Air Circuit Breaker 6 Fails To Close Due To A Latent Human Error	2.60E-04
117	AB6KEYISWT	360	Air Circuit Breaker 6 Key Interlock Switch Transfers Open	2.52E-05
118	AB6MCH2DEX	7.04E-03	Air Circuit Breaker 6 Fails To Close Due To Mechanical Failure	7.04E-03
119	AB6MECHDEX	8.01E-04	Air Circuit Breaker 6 Fails To Open Due To Mechanical Failure	8.01E-04
120	AB6OPENLHE	3.20E-3	Air Circuit Breaker 6 Fails To Open Due To A Latent Human Error	3.20E-03
121	AB6PUSHPBT	24	Trip Pushbutton On ACB6 Spurious Operation	5.76E-06
122	AB6R52XRYD	1	Air Circuit Breaker 6 Relay 52X Fails To Operate	3.30E-05
123	AB6R52YRYD	1	Air Circuit Breaker 6 Relay 52Y Failed To Drop Out At Last Demand	3.30E-05
124	AB710A1FUF	6	One Or More Control Power Fuses For X, Y And CC Fail	2.16E-05
125	AB710AFFUF	6	One Or More Air Circuit Breaker 7 Control Power Fuses Fail	2.16E-05
126	AB752CCRYD	1	Air Circuit Breaker 7 Close Coil CC Fails On Demand	3.30E-05
127	AB752TCRYD	1	Air Circuit Breaker 7 Trip Coil CC Fails On Demand	3.30E-05
128	AB752TCRYT	24	Air Circuit Breaker 7 Trip Coil 52TC Spurious Operation	8.64E-06
129	AB752Y2RYT	360	Air Circuit Breaker 7 Y-relay Spurious Operation	1.30E-04
130	AB7CLOSLHE	2.60E-4	Air Circuit Breaker 7 Fails To Close Due To A Latent Human Error	2.60E-04
131	AB7KEYISWT	360	Air Circuit Breaker 7 Key Interlock Switch Transfers Open	2.52E-05
132	AB7MCH2DEX	7.04E-03	Air Circuit Breaker 7 Fails To Close Due To Mechanical Failure	7.04E-03
133	AB7MECHDEX	8.01E-04	Air Circuit Breaker 7 Fails To Open Due To Mechanical Failure	8.01E-04
134	AB7OPENLHE	3.20E-3	Air Circuit Breaker 7 Fails To Open Due To A Latent Human Error	3.20E-03
135	AB7PUSHPBT	30	Trip Pushbutton On ACB7 Spurious Operation	7.20E-06
136	AB7R52XRYD	1	Air Circuit Breaker 7 Relay 52X Fails To Operate	3.30E-05
137	AB7R52YRYD	1	Air Circuit Breaker 7 Relay 52Y Failed To Drop Out At Last Demand	3.30E-05
138	AB810A1FUF	6	One Or More Control Power Fuses For X, Y And CC Fail	2.16E-05
139	AB81432RYT	360	Auxiliary Relay 143X/2 Spuriously Energizes	1.30E-04
140	AB852CCRYD	1	Air Circuit Breaker 8 Close Coil CC Fails On Demand	3.30E-05
141	AB852TCRYT	384	Air Circuit Breaker 8 Trip Coil 52TC Spurious Operation	1.38E-04
142	AB852Y2RYT	360	Air Circuit Breaker 8 Y-relay Spurious Operation	1.30E-04
143	AB86E1ARYD	1	Emergency Lock Out Aux. Relay 86E-1a Fails To Operate On Demand	3.30E-05
144	AB86E1GRYD	1	Keowee Unit 1 Emergency Lock Out Sensing Relay Fails To Operate	3.30E-05
145	AB883S8RYD	1	Time Delay Relay 83S8 Fails To Pick Up	3.30E-05
146	AB8KEYISWT	360	Air Circuit Breaker 8 Key Interlock Switch Transfers Open	2.52E-05
147	AB8MCH2DEX	7.04E-03	Air Circuit Breaker 8 Fails To Close Due To Mechanical Failure	7.04E-03
148	AB8PUSHPBT	384	Trip Pushbutton On ACB8 Spurious Operation	9.22E-05

Table E-6

Keowee PRA Basic Event Data
Two Unit Generation - Bayesian Update/Unrecovered

	NAME	FACTOR	DESCRIPTION	PROBABILITY
149	AB8R52XRYD	1	Air Circuit Breaker 8 Relay 52X Fails To Operate	3.30E-05
150	AB8R52YRYD	1	Air Circuit Breaker 8 Relay 52Y Failed To Drop Out At Last Demand	3.30E-05
151	ABEOPRCDHE	1.0	Operators Fail To Close Air Circuit Breaker 2	1.00E+00
152	ABEOPRCRHE	1	Operators Fail To Close Air Circuit Breaker 2	1.00E+00
153	ABPOPRCRHE	1.0	Operators Fail To Close Air Circuit Breaker 4	1.00E+00
154	ACB4MOD	0	NSM-ON-52966 Is Not In Service	0.00E+00
155	ACBAIRPDEX	2.00E-03	ACB Air Supply Fails Causing Low Pressure In All ACB Accumulators	2.00E-03
156	ACBTRIPCHE	0.0	Operators Trip Generator Output ACBs	0.00E+00
157	ACBXFERCOM	1.28E-06	Common Cause Failure That Results In ACBs 2 & 3 Transfering Open	1.28E-06
158	AD1B4ALCDT	30	Breaker 4AL In 125 V dc Distribution Center 1DA Transfers Open	2.25E-06
159	AD1C3CCCDT	24	Breaker 3CC In 125V dc Distribution Center 1DA Transfers Position	1.80E-06
160	AD1C3CLCDT	24	Breaker 3CL In 125V dc Distribution Center 1DA Transfers Position	1.80E-06
161	AD1SCLRCDT	12	Breaker 3CL In 125V dc Distribution Center 1DA Transfers Position (Rec)	9.00E-07
162	AD2B2ALCDT	30	Breaker 2AL In 125V dc Distribution Center 2DA Transfers Open	2.25E-06
163	AD2B3CCCDT	12	Breaker 3CC In 125V dc Distribution Center 2DA Transfers Position	9.00E-07
164	AD2C3CCCDT	24	Breaker 3CC In 125V dc Distribution Center 2DA Transfers Position	1.80E-06
165	AD2C3CLCDT	24	Breaker 3CL In 125V dc Distribution Center 2DA Transfers Position	1.80E-06
166	AK1141XRYD	1	Auxiliary Relay 14GOV/1X Fails To Pick-up	3.30E-05
167	AK114GVDEX	1.00e-04	KU1 Magnetic Speed Switch System Fails	1.00E-04
168	AK121TDRYD	1	Time Delay Relay 2-1TD Fails To Pick-up	3.30E-05
169	AK152TDRYD	1	Time Delay Relay 52-1TD Fails To Pick-up	3.30E-05
170	AK152TDRYT	4380	Time Delay Relay 52-1TD Spurious Operation	1.58E-03
171	AK152XGRYD	1	Relay 52XG/1 Fails To Pick Up When The Unit Is Started	3.30E-05
172	AK152XGRYT	2	Relay 52XG/1 Spuriously Drops Out While The Unit Is Running	7.20E-07
173	AK1AX34RYT	6	Relay 52AX/34 Spuriously Drops-out	2.16E-06
174	AK1GV1XRYD	1	Relay 14GOV/1X Fails To Pick-up	3.30E-05
175	AK1OFRQCOM	3.30E-06	KU1 CCF Of 2/3 Overfrequency Relays To Reset When Frequency Drops	3.30E-06
176	AK1X34XRYT	6	Relay 52AX/34X Spuriously Drops-out	2.16E-06
177	AK212OSSST	36	Turbine Overspeed Switch Indicates Overspeed	1.51E-04
178	AK2142XRYD	1	Auxiliary Relay 14GOV/2X Fails To Pick Up	3.30E-05
179	AK214GVDEX	1.00e-4	KU2 Magnetic Speed Switch System Fails	1.00E-04
180	AK222TDRYD	1	Time Delay Relay 2-2TD Fails To Pick-up	3.30E-05
181	AK252TDRYD	1	Time Delay Relay 52-2TD Fails To Operate	3.30E-05
182	AK252TDRYT	4380	Time Delay Relay 52-2TD Spurious Operation	1.58E-03
183	AK252W0RYD	1	KU2 Relay 52W Fails To Pick Up	3.30E-05
184	AK252XGRYD	1	Auxiliary Relay 52XG/2 Fails To Pick -up	3.30E-05
185	AK2GATEDEX	2.11E-5	Wicket Gate Limit Switch Indicates Gate Position Is Below No-load Setting	2.11E-05

Table E-6

Keowee PRA Basic Event Data
Two Unit Generation - Bayesian Update/Unrecovered

	NAME	FACTOR	DESCRIPTION	PROBABILITY
186	AK2GV2XRYD	1	Relay 14GOV/2X Fails To Pick-up	3.30E-05
187	AK2OFRQCOM	3.30E-06	KU2 CCF Of 2/3 Overfrequency Relays To Reset When Frequency Drops	3.30E-06
188	BK1088XRYD	1	Keowee 1 Turbine Guide Bearing Oil Relay 88X Fails to Drop Out	3.30E-05
189	BK1088XRYT	24	Keowee 1 Turbine Guide Bearing Oil Relay 88X Spurious Operation	8.64E-06
190	BK114/2SSD	1	Keowee 1 Speed Switch 14/2 Fails On Demand	1.80E-05
191	BK114/2SST	24	Keowee 1 Speed Switch 14/2 Spuriously Transfers Closed	1.01E-04
192	BK114DXRYD	1	Keowee 1 Rotation Sensing Aux. Relay 14DX Fails to Energize	3.30E-05
193	BK114DXRYT	24	Keowee 1 Rotation Sensing Aux. Relay 14DX Spuriously Drops Out	8.64E-06
194	BK114T2RYD	1	Keowee 1 Rotation Sensing Timer 14T2 Fails to De-energize	3.30E-05
195	BK114T2RYT	24	Keowee 1 Rotation Sensing Timer 14T2 Spurious Operation	8.64E-06
196	BK1188ASWT	24	Keowee 1 AC GBO Pump Control Switch S188A Spurious Operation	1.68E-06
197	BK1188DSWT	108	Unit 1 DC GBO Pump Control Switch S188D Spurious Operation	7.56E-06
198	BK1631XRYD	1	Keowee 1 Relay 63TA/1X Fails to De-energize	3.30E-05
199	BK1631XRYT	24	Keowee 1 GBO Level Relay 63TA/1X Spurious Operation	8.64E-06
200	BK1632XRYD	1	Keowee 1 Brng. Low Oil Level Aux. Relay 63TA/2X Fails To Operate On Demand	3.30E-05
201	BK1632XRYT	24	Keowee 1 Turb. Brng. Low Oil Level Aux. Rly 63TA/2X Spurious Operation	8.64E-06
202	BK163TALSD	1	Turbine No. 1 Bearing Oil Level Switch 63TA Fails on Demand	1.60E-03
203	BK163TALST	24	Turbine No. 1 Bearing Oil Level Switch 63TA Spurious Operation	7.44E-06
204	BK188AXRYD	1	Unit 1 AC Bearing Oil Pump Aux. Relay 88AX Fails to Drop Out	3.30E-05
205	BK188AXRYT	24	Unit 1 AC Bearing Oil Pump Aux. Relay 88AX Fails to Remain De-energized	8.64E-06
206	BK1DA5BCDT	24	DC Circuit Breaker 1DA-5B Transfers Position	1.80E-06
207	BK1GBDCGPR	12	Unit 1 DC Turbine GBO Pump Fails To Run	1.68E-04
208	BK1GBDCGPS	1	Unit 1 DC Turbine GBO Pump Fails To Start On Demand	9.70E-05
209	BK1GBDCLHE	3.2E-3	Latent Human Error Fails Unit 1 DC Guide Bearing Oil Pump Discharge Path	3.20E-03
210	BK1GBO1CVC	1	Check Valve 1GBO-1 Fails to Close on Demand	3.50E-04
211	BK1GBO1CVO	1	Check Valve 1GBO-1 Fails To Open On Demand	2.30E-06
212	BK1GBO1CVT	24	Check Valve 1GBO-1 Transfers Closed	3.12E-06
213	BK1GBO1FTC	24	Filter 1GBOFL-1 Becomes Clogged	4.32E-05
214	BK1GBO2VVT	24	Manual Valve 1GBO-2 Transfers Position	4.08E-07
215	BK1GBO3CVO	1	Check Valve 1GBO-3 Fails To Open On Demand	2.30E-06
216	BK1GBO3CVT	12	Check Valve 1GBO-3 Transfers Closed	1.56E-06
217	BK1GBO4VVT	108	Manual Valve 1GBO-4 Transfers Position	1.84E-06
218	BK1GBO5VVT	24	Manual Valve 1GBO-5 Transfers Position	4.08E-07
219	BK1GBO6VVT	24	Manual Valve 1GBO-6 Transfers Position	4.08E-07
220	BK1GBO8VVT	24	Manual Valve 1GBO-8 Transfers Position	4.08E-07
221	BK1GBO9VVT	24	Manual Valve 1GBO-9 Transfers Position	4.08E-07
222	BK1GOACGPR	24	Unit 1 AC Turbine GBO Pump Fails To Run	3.36E-04

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	NAME	FACTOR	DESCRIPTION	PROBABILITY
223	BK1GOACGPS	1	Unit 1 AC Turbine GBO Pump Fails To Start	9.70E-05
224	BK1GODCTRM	1.14E-3	Unit 1 DC Turbine GBO Pump Train In Maintenance	1.14E-03
225	BK1XA1CCLT	24	600 V Circuit Breaker 1XA-1C Transfers Position	2.18E-05
226	BK2088XRYD	1	Keowee 2 Turbine.Guide Bearing Oil Relay 88X Fails to Drop Out.	3.30E-05
227	BK2088XRYT	24	Keowee 2 Turbine Guide Bearing Oil Relay 88X Spurious Operation	8.64E-06
228	BK214/2SSD	1	Keowee 2 Speed Switch 14/2 Fails On Demand	1.80E-05
229	BK214/2SST	24	Keowee 2 Speed Switch 14/2 Spuriously Transfers Closed	1.01E-04
230	BK214DXRYD	1	Keowee 2 Rotation Sensing Aux. Relay 14DX Fails to Energize	3.30E-05
231	BK214DXRYT	24	Keowee 2 Rotation Sensing Aux. Relay 14DX Spurious Operation	8.64E-06
232	BK214T2RYD	1	Keowee 2 Rotation Sensing Timer 14T2 Fails to De-energize	3.30E-05
233	BK214T2RYT	24	Keowee Rotation Sensing Timer 14T2 Fails to Remain De-energized	8.64E-06
234	BK2188ASWT	24	Unit 2 AC GBO Pump Control Switch S188A Spurious Operation	1.68E-06
235	BK2188DSWT	108	Unit 2 DC GBO Pump Control Switch S188D Spurious Operation	7.56E-06
236	BK2631XRYD	1	Keowee 2 Relay 63TA/1X Fails to De-energize	3.30E-05
237	BK2631XRYT	24	Keowee 2 GBO Level Relay 63TA/1X Spurious Operation	8.64E-06
238	BK2632XRYD	1	Keowee 2 Brng. Low Oil Level Aux. Relay 63TA/2X Fails To Operate On Demand	3.30E-05
239	BK2632XRYT	24	Keowee 2 Turb. Brng. Low Oil Level Aux. Relay 63TA/2X Spurious Operation	8.64E-06
240	BK263TALSD	1	Turbine No. 2 Bearing Oil Level Switch 63TA Fails on Demand	1.60E-03
241	BK263TALST	24	Turbine No. 2 Bearing Oil Level Switch 63TA Spurious Operation	7.44E-06
242	BK288AXRYD	1	Unit 2 AC Bearing Oil Pump Aux. Relay 88AX Fails to Drop Out	3.30E-05
243	BK288AXRYT	24	Unit 2 AC Bearing Oil Pump Aux. Relay 88AX Fails to Remain De-energized	8.64E-06
244	BK2DA1BCDT	24	DC Circuit Breaker 2DA-1B Transfers Position	1.80E-06
245	BK2GBDCGPR	12	Unit 2 DC Turbine GBO Pump Fails To Run	1.68E-04
246	BK2GBDCGPS	1	Unit 2 DC Turbine GBO Pump Fails To Start On Demand	9.70E-05
247	BK2GBDCLHE	3.2E-3	Latent Human Error Fails Unit 2 DC Guide Bearing Oil Pump Discharge Path	3.20E-03
248	BK2GBO1CVC	1	Check Valve 2GBO-1 Fails to Close on Demand	3.50E-04
249	BK2GBO1CVO	1	Check Valve 2GBO-1 Fails To Open On Demand	2.30E-06
250	BK2GBO1CVT	24	Check Valve 2GBO-1 Transfers Closed	3.12E-06
251	BK2GBO1FTC	24	Filter 2GBOFL-1 Becomes Clogged	4.32E-05
252	BK2GBO2VVT	24	Manual Valve 2GBO-2 Transfers Position	4.08E-07
253	BK2GBO3CVO	1	Check Valve 2GBO-3 Fails To Open On Demand	2.30E-06
254	BK2GBO3CVT	12	Check Valve 2GBO-3 Transfers Closed	1.56E-06
255	BK2GBO4VVT	108	Manual Valve 2GBO-4 Transfers Position	1.84E-06
256	BK2GBO5VVT	24	Manual Valve 2GBO-5 Transfers Position	4.08E-07
257	BK2GBO6VVT	24	Manual Valve 2GBO-6 Transfers Position	4.08E-07
258	BK2GBO8VVT	24	Manual Valve 2GBO-8 Transfers Position	4.08E-07
259	BK2GBO9VVT	24	Manual Valve 2GBO-9 Transfers Position	4.08E-07

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	NAME	FACTOR	DESCRIPTION		PROBABILITY
260	BK2GOACGPR	24	Unit 2 AC Turbine GBO Pump Fails To Run		3.36E-04
261	BK2GOACGPS	1	Unit 2 AC Turbine GBO Pump Fails To Start		9.70E-05
262	BK2GODCTRM	1.14E-3	Unit 2 DC Turbine GBO Pump Train In Maintenance		1.14E-03
263	BK2XA1CCLT	24	600 V Circuit Breaker 2XA-1C Transfers Position		2.18E-05
264	BKGBOILCOM	1.94E-06	Common Cause Failure Of Turbine Guide Bearing Oil System		1.94E-06
265	D1DIAXXDEX	6.50E-06	Loss Of Power On 125 V dc Panelboard 1DIA	OEE-120, O-705	6.50E-06
266	D1DIBXXDEX	6.50E-06	Loss Of Power On 125 V dc Panelboard 1DIB	OEE-120-1, O-705	6.50E-06
267	D2DIAXXDEX	6.50E-06	Loss Of Power On 125 V dc Panelboard 2DIA		6.50E-06
268	D2DIBXXDEX	6.50E-06	Loss of Power on 125 V dc Panelboard 2DIB		6.50E-06
269	D3DIAXXDEX	6.50E-06	Loss Of Power On 125 V dc Panelboard 3DIA		6.50E-06
270	D3DIBXXDEX	6.50E-06	Loss Of Power On 125 Vdc Panelboard 3DIB		6.50E-06
271	DDC11BXCDT	24	125 Vdc Battery Breaker SY-DC1-1B Transfers Open		1.80E-06
272	DDC11CXCDT	24	125 Vdc Breaker SY-DC1-1C Transfers Open		1.80E-06
273	DDC11DCCDT	24	125 Vdc Breaker SY-DC1-1DC Transfers Open		1.80E-06
274	DDC11DLCDT	24	125 Vdc Breaker SY-DC1-1DL Transfers Open		1.80E-06
275	DDC11DRCDT	24	125 Vdc Breaker SY-DC1-1DR Transfers Open		1.80E-06
276	DDC1ALXBYM	1.14E-02	Test and Maintenance Weighting Factor		1.14E-02
277	DDC1BATBYF	1	Battery SY-1 Fails During Discharge		9.30E-04
278	DDC1FLTBDF	24	SY-DC1 Is Faulted		7.68E-06
279	DDC21BXCDT	24	125 Vdc Battery Breaker SY-DC2-1B Transfers Open		1.80E-06
280	DDC21CXCDT	24	125 Vdc Breaker SY-DC2-1C Transfers Open		1.80E-06
281	DDC21DCCDT	24	125 Vdc Breaker SY-DC2-1DC Transfers Open		1.80E-06
282	DDC21DLCDT	24	125 Vdc Breaker SY-DC2-1DL Transfers Open		1.80E-06
283	DDC21DRCDT	24	125 Vdc Breaker SY-DC2-1DR Transfers Open		1.80E-06
284	DDC2BATBYF	1	Battery SY-2 Fails During Discharge		9.30E-04
285	DDC2FLTBDF	24	SY-DC2 Is Faulted		7.68E-06
286	DDCBATTCOM	2.70E-05	Common Cause Failure of Switchyard Batteries		2.70E-05
287	DDCDYAXBDF	24	125 Vdc Switchyard DC Panelboard DYA Is Faulted		7.68E-06
288	DDCDYBXBDF	24	125 Vdc Switchyard DC Panelboard DYB Is Faulted		7.68E-06
289	DDCDYCXBDF	24	125 Vdc Switchyard DC Panelboard DYC Is Faulted		7.68E-06
290	DDCDYEXBDF	24	125 Vdc Switchyard DC Panelboard DYE Is Faulted		7.68E-06
291	DDCDYFXBDF	24	125 Vdc Switchyard DC Panelboard DYF Is Faulted		7.68E-06
292	DDCDYGXBDF	24	125 Vdc Switchyard DC Panelboard DYG Is Faulted		7.68E-06
293	E12EXCTCOM	5.31E-05	Units 1 & 2 Excit Fail Due To Common Cause Failure Of The Breakers		5.31E-05
294	ED11D3DCDT	12	Breaker 3D In 125V dc Distribution Center 1DA Transfers Open		9.00E-07
295	ED13BR2CDT	24	Breaker 3BR In 125V dc Distribution Center 1DA Transfers Open		1.80E-06
296	ED22D3DCDT	12	Breaker 2D In 125V dc Distribution Center 2DA Transfers Open		9.00E-07

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	NAME	FACTOR	DESCRIPTION	PROBABILITY
297	ED23BR2CDT	24	Breaker 3BR In 125V dc Distribution Center 2DA Transfers Open	1.80E-06
298	EK00RUNCOM	1.24E-4	Common Cause Failure Of Both Units Voltage Regulators To Run	1.24E-04
299	EK0BASERHE	1.0	Failure To Recover From Keowee Base Adjust LHE	1.00E+00
300	EK131TDRYD	1	Keowee Unit 1 Field Flashing Breaker Time Delay Relay 31/TD Fails To Operate	3.30E-05
301	EK131TDRYT	12	Keowee Unit 1 Field Flashing Breaker Time Delay Relay 31/TD Spurious Operation	4.32E-06
302	EK14152SWT	12	KHU1 Generator Supply Breaker Trip Control Switch 141-52/T Spurious Operation	8.40E-07
303	EK1415TSWT	24	Spurious Operation Of The KHU1 Supply Breaker Trip Switch	1.68E-06
304	EK1415YRYD	1	KHU1 Generator Supply Breaker Y-relay Failed To Drop-out At Last Operation	3.30E-05
305	EK1415YRYT	12	KHU1 Generator Supply Breaker Y-relay Spurious Operation	4.32E-06
306	EK141AXR6D	1	Keowee Unit 1 Relay 41/AX Fails To Pick-up And Latch	2.49E-04
307	EK141AXR6T	24	Keowee Unit 1 Relay 41/AX Spuriously Resets	8.71E-06
308	EK141CFRYD	1	Keowee Unit 1 Field Flashing Breaker Close Coil Fails To Operate On Demand	3.30E-05
309	EK186E2RYT	6	Keowee Unit 1 Lockout Auxiliary Relay 86EX-2 Is Picked-up	2.16E-06
310	EK186EXRYT	12	Keowee Unit 1 Gen Lockout Auxiliary Relay 86EX-1 Spurious Actuation	4.32E-06
311	EK186X2RYT	24	Keowee Unit 1 Generator Lockout Auxiliary Relay 86EX-1 Spurious Actuation	8.64E-06
312	EK188SVRYD	1	Keowee Unit 1 Fan Control Relay 88SV Fails On Demand	3.30E-05
313	EK188SVRYT	36	Keowee Unit 1 Fan Control Relay 88SV Prior To Or During The Run	1.30E-05
314	EK1901ARYT	12	Keowee Unit 1 Relay 90X1A Spurious Operation	4.32E-06
315	EK199SXRYD	1	Auxiliary Relay 99SX1 Fails To Pick-up	3.30E-05
316	EK199SYRYD	1	Keowee Unit 1 Relay 99SY Fails To Pick-up	3.30E-05
317	EK199SYRYT	24	Keowee Unit 1 Relay 99SY Drops Out	8.64E-06
318	EK1BAS2DEX	1.24E-3	KHU-1 Base Adjust Fails To Maintain Generator Output Within Acceptable Range	1.24E-03
319	EK1BASEDEX	6.17E-4	Keowee Unit 1 Base Adjust Fails To Establish Correct Unit Voltage	6.17E-04
320	EK1BASELHE	3.20E-3	Keowee Unit 1 Base Adjust Is Set Incorrectly	3.20E-03
321	EK1DIODDEX	2.88E-4	Keowee Unit 1 Exciter Fan Supply Diode Bridge Fails	2.88E-04
322	EK1EXC1TGF	12	Keowee Unit 1 Gen Excitation Transformer Is Failed	1.18E-05
323	EK1EXC2TGF	24	Keowee Unit 1 Generator Excitation Transformer Fails	2.35E-05
324	EK1F30AFUF	24	Keowee Unit 1 Excitation Cabinet Fan Fuses Fail	8.64E-05
325	EK1F31XRYD	1	Keowee Unit 1 Field Flashing Breaker Relay 31/X Fails To Pick-up On Demand	3.30E-05
326	EK1F41CRYD	1	Keowee Unit 1 Field Breaker Close Coil Fails To Operate On Demand	3.30E-05
327	EK1FAN1TLF	24	Keowee Unit 1 Generator Excitation Fan Power Transformer Fails	1.80E-05
328	EK1FLDCLHE	2.60E-4	Keowee Unit 1 Field Breaker Fails To Close Due To Latent Human Error	2.60E-04
329	EK1FLDMDEX	7.71E-5	Keowee Unit 1 Field Breaker Fails To Close Due To Mechanical Failure	7.71E-05
330	EK1FLSCLHE	2.60E-4	Keowee Unit 1 Field Flashing Breaker Fails To Close Due To Latent Human Error	2.60E-04
331	EK1FLSMDEX	7.71E-5	Keowee Unit 1 Field Flashing Breaker Fails To Close Due To Mechanical Failure	7.71E-05
332	EK1FLSOLHE	2.60E-4	Keowee Unit 1 Field Flashing Breaker Fails To Open Due To Latent Human Error	2.60E-04
333	EK1R31TRYD	1	Keowee Unit 1 Field Flashing Breaker Trip Coil 31/T Fails To Operate	3.30E-05

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	NAME	FACTOR	DESCRIPTION	PROBABILITY
334	EK1R31YRYD	1	KHU1 Gen Field Flashing Breaker Y-relay Failed To Drop Out At Last Operation	3.30E-05
335	EK1R31YRYT	12	KHU1 Generator Field Flashing Breaker Y-relay Spurious Operation	4.32E-06
336	EK1R41XRYD	1	Keowee Unit 1 Field Breaker Relay 41/X Fails To Pick-up On Demand	3.30E-05
337	EK1R41YRYD	1	KHU1 Generator Field Breaker Y-relay Failed To Drop-out At Last Operation	3.30E-05
338	EK1R41YRYT	12	Keowee Unit 1 Generator Field Breaker Y-relay Spurious Operation	4.32E-06
339	EK1R9A1RYT	12	Keowee Unit 1 Relay 90X1A/TD Spurious Operation	4.32E-06
340	EK1R9C1R6T	12	Keowee Unit 1 Relay 90X1C Spurious Operation	4.36E-06
341	EK1S141SWT	12	KHU1 Field Breaker Trip Control Switch 141/T Spurious Operation	8.40E-07
342	EK1S31TSWT	12	KHU1 Field Flashing Breaker Trip Control Switch 131/T Spurious Operation	8.40E-07
343	EK1S41CRYD	1	Keowee Unit 1 Supply Breaker Close Coil Fails To Operate On Demand	3.30E-05
344	EK1S41TSWT	24	Keowee Unit 1 Field Breaker Trip Control Switch Transfers Position	1.68E-06
345	EK1S41XRYD	1	Keowee Unit 1 Supply Breaker Relay 41-52X Fails To Pick-up On Demand	3.30E-05
346	EK1SPYCLHE	2.60E-4	Keowee Unit 1 Supply Breaker Fails To Close Due To Latent Human Error	2.60E-04
347	EK1SPYMDEX	4.62E-4	Keowee Unit 1 Supply Breaker Fails To Close Due To Mehanical Failure	4.62E-04
348	EK1VHSVRYD	1	Keowee Unit 1 Volts/Hertz Relay SV Fails To Trip Field Flashing Breaker	3.30E-05
349	EK1VREGDEX	2.47E-3	KHU-1 Voltage Adjust Failure Drives Generator Output Too High/Low	2.47E-03
350	EK231TDRYD	1	Keowee Unit 2 Field Flashing Breaker Time Delay Relay 31/TD Fails To Operate	3.30E-05
351	EK231TDRYT	12	Keowee Unit 2 Field Flashing Breaker Time Delay Relay 31/TD Spurious Operation	4.32E-06
352	EK24152SWT	12	KHU2 Generator Supply Breaker Trip Control Switch Spurious Operation	8.40E-07
353	EK2415TSWT	24	Spurious Operation Of The KHU2 Supply Breaker Trip Switch	1.68E-06
354	EK2415YRYD	1	KHU2 Gen Supply Breaker Y-relay Failed To Drop-out At Last Operation	3.30E-05
355	EK2415YRYT	12	KHU2 Generator Supply Breaker Y-relay Spurious Operation	4.32E-06
356	EK241AXR6D	1	Keowee Unit 2 Relay 41/AX Fails To Pick-up And Latch	2.49E-04
357	EK241AXR6T	24	Keowee Unit 2 Relay 41/AX Spuriously Resets	8.71E-06
358	EK241CFRYD	1	Keowee Unit 2 Field Flashing Breaker Close Coil Fails To Operat On Demand	3.30E-05
359	EK286E2RYT	6	Keowee Unit 2 Lockout Auxiliary Relay 86EX-2 Is Picked-up	2.16E-06
360	EK286EXRYT	12	Keowee Unit 2 Generator Lockout Auxiliary Relay 86EX-1 Spurious Actuation	4.32E-06
361	EK286X2RYT	24	Keowee Unit 2 Generator Lockout Auxiliary Relay 86EX-1 Spurious Actuation	8.64E-06
362	EK288SVRYD	1	Keowee Unit 2 Fan Control Relay 88SV Fails On Demand	3.30E-05
363	EK288SVRYT	36	Keowee Unit 2 Fan Control Relay 88SV Prior To Or During The Run	1.30E-05
364	EK2901ARYT	12	Keowee Unit 2 Relay 90X1A Spurious Operation	4.32E-06
365	EK299SXRYD	1	Auxiliary Relay 99SX2 Fails To Pick-up	3.30E-05
366	EK299SYRYD	1	Keowee Unit 2 Relay 99SY Fails To Pick-up	3.30E-05
367	EK299SYRYT	24	Keowee Unit 2 Relay 99SY Drops Out	8.64E-06
368	EK2BAS2DEX	1.24E-3	KHU-2 Base Adjust Fails To Maintain Generator Output Within Acceptable Range	1.24E-03
369	EK2BASEDEX	6.17E-4	Keowee Unit 2 Base Adjust Fails To Establish Correct Unit Voltage	6.17E-04
370	EK2BASELHE	3.20E-3	Keowee Unit 2 Base Adjust Is Set Incorrectly	3.20E-03

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	NAME	FACTOR	DESCRIPTION		PROBABILITY
371	EK2DIODDEX	2.88E-4	Keowee Unit 2 Exciter Fan Supply Diode Bridge Fails		2.88E-04
372	EK2EXC1TGF	12	Keowee Unit 2 Generator Excitation Transformer Is Failed		1.18E-05
373	EK2EXC2TGF	24	Keowee Unit 2 Generator Excitation Transformer Fails		2.35E-05
374	EK2F30AFUF	24	Keowee Unit 2 Excitation Cabinet Fan Fuses Fail		8.64E-05
375	EK2F31XRYD	1	Keowee Unit 2 Field Flashing Breaker Relay 31/X Fails To Pick-up On Demand		3.30E-05
376	EK2F41CRYD	1	Keowee Unit 2 Field Breaker Close Coil Fails To Operate On Demand		3.30E-05
377	EK2FAN1TLF	24	Keowee Unit 2 Generator Excitation Fan Power Transformer Fails		1.80E-05
378	EK2FLDCLHE	2.60E-4	Keowee Unit 2 Field Breaker Fails To Close Due To Latent Human Error		2.60E-04
379	EK2FLDMDEX	7.71E-5	Keowee Unit 2 Field Breaker Fails To Close Due To Mechanical Failure		7.71E-05
380	EK2FLSCLHE	2.60E-4	Keowee Unit 2 Field Flashing Breaker Fails To Close Due To Latent Human Error		2.60E-04
381	EK2FLSMDEX	7.71E-5	Keowee Unit 2 Field Flashing Breaker Fails To Close Due To Mechanical Failure		7.71E-05
382	EK2FLSOLHE	2.60E-4	Keowee Unit 2 Field Flashing Breaker Fails To Open Due To Latent Human Error		2.60E-04
383	EK2R31TRYD	1	Keowee Unit 2 Field Flashing Breaker Trip Coil 31/T Fails To Operate		3.30E-05
384	EK2R31YRYD	1	KHU2 Gen Field Flashing Breaker Y-relay Failed To Drop At Last Operation		3.30E-05
385	EK2R31YRYT	12	KHU2 Generator Field Flashing Breaker Y-relay Spurious Operation		4.32E-06
386	EK2R41XRYD	1	Keowee Unit 2 Field Breaker Relay 41/X Fails To Pick-up On Demand		3.30E-05
387	EK2R41YRYD	1	KHU2 Generator Field Breaker Y-relay Failed To Drop-out At Last Operation		3.30E-05
388	EK2R41YRYT	12	KHU2 Generator Field Breaker Y-relay Spurious Operation		4.32E-06
389	EK2R9A2RYT	12	Keowee Unit 2 Relay 90X1A/TD Spurious Operation		4.32E-06
390	EK2R9C2R6T	12	Keowee Unit 2 Relay 90X1C Spurious Operation		4.36E-06
391	EK2S141SWT	12	KHU2 Field Breaker Trip Control Switch Spurious Operation		8.40E-07
392	EK2S31TSWT	12	KHU2 Field Flashing Breaker Trip Control Switch 131/T Spurious Operation		8.40E-07
393	EK2S41CRYD	1	Keowee Unit 2 Supply Breaker Close Coil Fails To Operate On Demand		3.30E-05
394	EK2S41TSWT	24	Keowee Unit 2 Field Breaker Trip Control Switch Transfers Position		1.68E-06
395	EK2S41XRYD	1	Keowee Unit 2 Supply Breaker Relay 41-52X Fails To Pick-up On Demand		3.30E-05
396	EK2SPYCLHE	2.60E-4	Keowee Unit 2 Supply Breaker Fails To Close Due To Latent Human Error		2.60E-04
397	EK2SPYMDEX	4.62E-4	Keowee Unit 2 Supply Breaker Fails To Close Due To Mehanical Failure		4.62E-04
398	EK2VHSVRYD	1	Keowee Unit 2 Volts/Hertz Relay SV Fails To Trip Field Flashing Breaker		3.30E-05
399	EK2VREGDEX	2.47E-3	KHU-2 Voltage Adjust Failure Drives Generator Output Too High/Low		2.47E-03
400	EKSTARTCOM	6.17E-5	Common Cause Failure Of Both Units Voltage Regulators To Start		6.17E-05
401	ESCONDNOT	1	An Engineered Safeguards Condition Does Not Exist		1.00E+00
402	EU1C1RORYD	1	ONS1 ESG Chan. 1 Ro Relay Fails To Pick Up	OEE-120	1.00E+00
403	EU1C2RORYD	1	ONS1 ESG Chan. 2 Ro Relay Fails to Pick Up		1.00E+00
404	EU2C1RORYD	1	ONS2 ESG Chan. 1 Ro Relay Fails to Pick Up	OEE-220	1.00E+00
405	EU2C2RORYD	1	ONS2 ESG Chan. 2 Ro Relay Fails to Pick Up	OEE-220-1	1.00E+00
406	EU3C1RORYD	1	ONS3 ESG Chan. 1 Ro Relay Fails to Pick Up	OEE-320	1.00E+00
407	EU3C2RORYD	1	ONS3 ESG Chan. 2 Ro Relay Fails to Pick Up	OEE-320-1	1.00E+00

Table E-6

Keowee PRA Basic Event Data
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	NAME	FACTOR	DESCRIPTION	PROBABILITY
408	FK0FISHCOM	2.55E-3	Common Cause Failure Of Both Unit s WL Filters Due To Intake Debris	2.55E-03
409	FK0FISHDHE	1.0	Failure To Recover From MainTure WL Strainer Clogging	1.00E+00
410	FK0FL00DHE	1.0	Failure To Recover From Turbine Guide Bearing or Packing WL Filter Clogging	1.00E+00
411	FK0WL01VVT	24	Locked-Open Manual Valve 0WL-1 Transfers Position	4.08E-07
412	FK1120GLHE	3.2E-3	Unit 1 Control Switch S120G Left in OFF Position	3.20E-03
413	FK1120GSWT	36	Unit 1 Control Switch S120G Spurious Operation	2.52E-06
414	FK1FL01FRF	24	Filter 1WLFL-1 Becomes Clogged	2.35E-05
415	FK1FL02FRF	24	Filter 1WLFL-2 Becomes Clogged	2.35E-05
416	FK1TRHXHXF	24	Turbine Packing Box Heat Exchanger 1TRHX-1 Fails	1.54E-05
417	FK1WL03VVT	24	Manual Valve 1WL-3 Transfers Position	4.08E-07
418	FK1WL04VVT	24	Manual Valve 1WL-4 Transfers Position	4.08E-07
419	FK1WL05VVT	24	Manual Valve 1WL-5 Transfers Position	4.08E-07
420	FK1WL06VVT	24	Manual Valve 1WL-6 Transfers Position	4.08E-07
421	FK1WL07VVT	24	Manual Valve 1WL-7 Transfers Position	4.08E-07
422	FK1WL08VVT	24	Manual Valve 1WL-8 Transfers Position	4.08E-07
423	FK1WL09VVT	24	Manual Valve 1WL-9 Transfers Position	4.08E-07
424	FK1WL11AVO	1	Cooling Water Control Valve 1WL-11 Fails To Open On Demand	2.80E-04
425	FK1WL11AVT	24	Cooling Water Control Valve 1WL-11 Transfers Closed	5.52E-05
426	FK1WL12VVT	36	Manual Valve 1WL-12 Transfers Position	6.12E-07
427	FK1WL15VVT	36	Manual Valve 1WL-15 Transfers Position	6.12E-07
428	FK1WL42VVT	36	Manual Valve 1WL-42 Transfers Position	6.12E-07
429	FK1WL43VVT	36	Manual Valve 1WL-43 Transfers Position	6.12E-07
430	FK2120GLHE	2.6E-4	Unit 2 Control Switch S120G Left in OFF Position	2.60E-04
431	FK2120GSWT	36	Unit 2 Control Switch S120G Spurious Operation	2.52E-06
432	FK2FL01FRF	24	Filter 2WLFL-1 Becomes Clogged	2.35E-05
433	FK2FL02FRF	24	Filter 2WLFL-2 Becomes Clogged	2.35E-05
434	FK2TRHXHXF	24	Turbine Packing Box Heat Exchanger 2TRHX-1 Fails	1.54E-05
435	FK2WL03VVT	24	Manual Valve 2WL-3 Transfers Position	4.08E-07
436	FK2WL04VVT	24	Manual Valve 2WL-4 Transfers Position	4.08E-07
437	FK2WL05VVT	24	Manual Valve 2WL-5 Transfers Position	4.08E-07
438	FK2WL06VVT	24	Manual Valve 2WL-6 Transfers Position	4.08E-07
439	FK2WL07VVT	24	Manual Valve 2WL-7 Transfers Position	4.08E-07
440	FK2WL08VVT	24	Manual Valve 2WL-8 Transfers Position	4.08E-07
441	FK2WL09VVT	24	Manual Valve 2WL-9 Transfers Position	4.08E-07
442	FK2WL11AVO	1	Cooling Water Control Valve 2WL-11 Fails To Open On Demand	2.80E-04
443	FK2WL11AVT	24	Cooling Water Control Valve 2WL-11 Transfers Closed	5.52E-05
444	FK2WL12VVT	36	Manual Valve 2WL-12 Transfers Position	6.12E-07

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	NAME	FACTOR	DESCRIPTION	PROBABILITY
445	FK2WL15VVT	36	Manual Valve 2WL-15 Transfers Position	6.12E-07
446	FK2WL42VVT	36	Manual Valve 2WL-42 Transfers Position	6.12E-07
447	FK2WL43VVT	36	Manual Valve 2WL-43 Transfers Position	6.12E-07
448	FKVALVECOM	2.46E-5	Common Cause Failure Of Cooling Water Control Valves	2.46E-05
449	GK0COOLCOM	4.61E-07	Common Cause Failure of Generator Air Cooling	4.61E-07
450	GK0LOCKCOM	4.06E-06	Common Cause Actuation of Generator Lockouts	4.06E-06
451	GK10001HGR	24	Keowee Unit 1 Generator Fault While the Unit Runs	2.27E-03
452	GK10001HGS	1	Keowee Unit 1 Generator Fault Causes Unit Start Failure	1.54E-04
453	GK1063FPST	24	Keowee 1 Gen CO2 Sys Press Switch 63F Spurious Operation	1.03E-05
454	GK112TDRYT	24	Time Delay Relay 12XTD/1 Spuriously Picks-up	8.64E-06
455	GK112X1RYT	24	Relay 12X/1 Spuriously Picks-up	8.64E-06
456	GK13SUIRYT	24	Keowee Unit 1 Startup Inhibit Switch Auxiliary Relay S3SUIX Spurious Actuation	8.64E-06
457	GK13SUISWT	24	Keowee Unit 1 Startup Inhibit Switch 3SUI Spurious Operation	1.68E-06
458	GK140G1RYT	24	Keowee Unit 1 Loss Of Generator Field Relay 40G1 Spurious Actuation	8.64E-06
459	GK159GNRYT	24	Keowee Unit 1 Generator Ground Fault Relay 59GN1 Spurious Actuation	8.64E-06
460	GK162TDRYT	24	Keowee Unit 1 Generator Backup Trip Timer 62-1TD Spurious Operation	8.64E-06
461	GK163FXRYT	24	Keowee Unit 1 Generator Fire Relay 63FX Spurious Actuation	8.64E-06
462	GK186E1RYT	24	Keowee 1 Emergency Lockout Relay 86E-1 Spuriously Picks Up	8.64E-06
463	GK187G1RYT	24	Keowee Unit 1 Generator Differential Relay 87G-1 Spurious Actuation	8.64E-06
464	GK187GBRYT	24	Keowee Unit 1 Generator Bus Differential Relay 87GB Spurious Actuation	8.64E-06
465	GK187TERYT	24	Keowee Unit 1 Exitation Transformer Differential Relay 87T-1E Spur. Actuation	8.64E-06
466	GK1BRGVLHE	2.60E-04	Keowee 1 Gen. Brng Oil Cooling Flow Path Vlvs Mispositioned After Maintenance	2.60E-04
467	GK1COOLLHE	2.60E-04	Keowee 1 Gen. Air Cooler WL Flow Path Vlvs Mispositioned After Maintenance	2.60E-04
468	GK1FIREDEX	3.19E-05	Spurious Actuation of Unit 1 Gen. CO2 Fire Supression System	3.19E-05
469	GK1GAC1HXF	24	Generator Air Cooler 1GAHW-1 Fails	1.54E-05
470	GK1GAC1HXL	36	Heat Exchanger 1GAC1 Leaks	3.60E-06
471	GK1GAC2HXF	24	Generator Air Cooler 1GAHW-2 Fails	1.54E-05
472	GK1GAC2HXL	36	Heat Exchanger 1GAC2 Leaks	3.60E-06
473	GK1GAC3HXF	24	Generator Air Cooler 1GAHW-3 Fails	1.54E-05
474	GK1GAC3HXL	36	Heat Exchanger 1GAC3 Leaks	3.60E-06
475	GK1GAC4HXF	24	Generator Air Cooler 1GAHW-4 Fails	1.54E-05
476	GK1GAC4HXL	36	Heat Exchanger 1GAC4 Leaks	3.60E-06
477	GK1GAC5HXF	24	Generator Air Cooler 1GAHW-5 Fails	1.54E-05
478	GK1GAC5HXL	36	Heat Exchanger 1GAC5 Leaks	3.60E-06
479	GK1GAC6HXF	24	Generator Air Cooler 1GAHW-6 Fails	1.54E-05
480	GK1GAC6HXL	36	Heat Exchanger 1GAC6 Leaks	3.60E-06
481	GK1HPO1HXF	24	Generator Thrust Bearing Cooler 1HPOHX-1 Fails	1.54E-05

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Keowee PRA Basic Event Data
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	NAME	FACTOR	DESCRIPTION	PROBABILITY
482	GK1HPO2HXF	24	Generator Thrust Bearing Cooler 1HPOHX-2 Fails	1.54E-05
483	GK1HPO3HXF	24	Generator Thrust Bearing Cooler 1HPOHX-3 Fails	1.54E-05
484	GK1HPO4HXF	24	Generator Thrust Bearing Cooler 1HPOHX-4 Fails	1.54E-05
485	GK1HPO5HXF	24	Generator Thrust Bearing Cooler 1HPOHX-5 Fails	1.54E-05
486	GK1HPO6HXF	24	Generator Thrust Bearing Cooler 1HPOHX-6 Fails	1.54E-05
487	GK1HPO6VVT	24	Genrator Bearing Oil Leak Because Manual Valve 1HPO-6 Transfers Position	4.08E-07
488	GK1HPO7HXF	24	Generator Thrust Bearing Cooler 1HPOHX-7 Fails	1.54E-05
489	GK1HPO8HXF	24	Generator Thrust Bearing Cooler 1HPOHX-8 Fails	1.54E-05
490	GK1NGDCLHE	5.20E-05	Failure to Close the Unit 1 Neutral Ground Disconnect Following Maintenance	5.20E-05
491	GK1O121SST	24	Speed Switch 12/1 Falsely Indicates High Speed	1.01E-04
492	GK1WL16VVT	36	Manual Valve 1WL-16 Transfers Position	6.12E-07
493	GK1WL17VVT	36	Manual Valve 1WL-17 Transfers Position	6.12E-07
494	GK1WL18VVT	36	Manual Valve 1WL18 Transfers Position	6.12E-07
495	GK1WL19VVT	36	Manual Valve 1WL19 Transfers Position	6.12E-07
496	GK1WL20VVT	36	Manual Valve 1WL-20 Transfers Position	6.12E-07
497	GK1WL21VVT	36	Manual Valve 1WL-21 Transfers Position	6.12E-07
498	GK1WL22VVT	36	Manual Valve 1WL22 Transfers Position	6.12E-07
499	GK1WL23VVT	36	Manual Valve 1WL23 Transfers.Position	6.12E-07
500	GK1WL24VVT	36	Manual Valve 1WL-24 Transfers Position	6.12E-07
501	GK1WL25VVT	36	Manual Valve 1WL-25 Transfers Position	6.12E-07
502	GK1WL26VVT	36	Manual Valve 1WL26 Transfers Position	6.12E-07
503	GK1WL27VVT	36	Manual Valve 1WL27 Transfers Position	6.12E-07
504	GK1WL28VVT	36	Manual Valve 1WL-28 Transfers Position	6.12E-07
505	GK1WL29VVT	36	Manual Valve 1WL-29 Transfers Position	6.12E-07
506	GK1WL30VVT	36	Manual Valve 1WL30 Transfers Position	6.12E-07
507	GK1WL31VVT	36	Manual Valve 1WL31 Transfers Position	6.12E-07
508	GK1WL32VVT	36	Manual Valve 1WL-32 Transfers Position	6.12E-07
509	GK1WL33VVT	36	Manual Valve 1WL-33 Transfers Position	6.12E-07
510	GK1WL34VVT	36	Manual Valve 1WL34 Transfers Position	6.12E-07
511	GK1WL35VVT	36	Manual Valve 1WL35 Transfers Position	6.12E-07
512	GK1WL36VVT	36	Manual Valve 1WL-36 Transfers Position	6.12E-07
513	GK1WL37VVT	36	Manual Valve 1WL-37 Transfers Position	6.12E-07
514	GK1WL38VVT	36	Manual Valve 1WL38 Transfers Position	6.12E-07
515	GK1WL39VVT	36	Manual Valve 1WL39 Transfers Position	6.12E-07
516	GK1WL41VVT	36	Keowee 1 Manual Valve 1WL-41 Transfers Position to Block Discharge Path	6.12E-07
517	GK1WL44VVT	36	Manual Valve 1WL-44 Transfers Position	6.12E-07
518	GK1WL45VVT	36	Manual Valve 1WL-45 Transfers Position	6.12E-07

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Keowee PRA Basic Event Data
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	NAME	FACTOR	DESCRIPTION	PROBABILITY
519	GK1WL46VVT	36	Manual Valve 1WL-46 Transfers Position	6.12E-07
520	GK1WL47VVT	36	Manual Valve 1WL-47 Transfers Position	6.12E-07
521	GK1WL48VVT	36	Manual Valve 1WL-48 Transfers Position	6.12E-07
522	GK1WL49VVT	36	Manual Valve 1WL-49 Transfers Position	6.12E-07
523	GK1WL50VVT	36	Manual Valve 1WL-50 Transfers Position	6.12E-07
524	GK1WL51VVT	36	Manual Valve 1WL-51 Transfers Position	6.12E-07
525	GK1WL52VVT	36	Manual Valve 1WL-52 Transfers Position	6.12E-07
526	GK1WL53VVT	36	Manual Valve 1WL-53 Transfers Position	6.12E-07
527	GK1WL54VVT	36	Manual Valve 1WL-54 Transfers Position	6.12E-07
528	GK1WL55VVT	36	Manual Valve 1WL-55 Transfers Position	6.12E-07
529	GK1WL56VVT	36	Manual Valve 1WL-56 Transfers Position	6.12E-07
530	GK1WL57VVT	36	Manual Valve 1WL-57 Transfers Position	6.12E-07
531	GK1WL58VVT	36	Manual Valve 1WL-58 Transfers Position	6.12E-07
532	GK1WL59VVT	36	Manual Valve 1WL-59 Transfers Position	6.12E-07
533	GK1WL60VVT	36	Manual Valve 1WL-60 Transfers Position	6.12E-07
534	GK1WL61VVT	36	Manual Valve 1WL-61 Transfers Position	6.12E-07
535	GK1WL62VVT	36	Manual Valve 1WL-62 Transfers Position	6.12E-07
536	GK1WL63VVT	36	Manual Valve 1WL-63 Transfers Position	6.12E-07
537	GK1WL64VVT	36	Manual Valve 1WL-64 Transfers Position	6.12E-07
538	GK1WL65VVT	36	Manual Valve 1WL-65 Transfers Position	6.12E-07
539	GK1WL66VVT	36	Manual Valve 1WL-66 Transfers Position	6.12E-07
540	GK1WL67VVT	36	Manual Valve 1WL-67 Transfers Position	6.12E-07
541	GK1WL68VVT	36	Manual Valve 1WL-68 Transfers Position	6.12E-07
542	GK1WL69VVT	36	Manual Valve 1WL-69 Transfers Position	6.12E-07
543	GK1WL70VVT	36	Manual Valve 1WL-70 Transfers Position	6.12E-07
544	GK1WL71VVT	36	Manual Valve 1WL-71 Transfers Position	6.12E-07
545	GK1WL72VVT	36	Manual Valve 1WL-72 Transfers Position	6.12E-07
546	GK1WL73VVT	36	Manual Valve 1WL-73 Transfers Position	6.12E-07
547	GK1WL74VVT	36	Manual Valve 1WL-74 Transfers Position	6.12E-07
548	GK1WL75VVT	36	Manual Valve 1WL-75 Transfers Position	6.12E-07
549	GK1WL76VVT	36	Manual Valve 1WL76 Transfers Position and Blocks Discharge Path	6.12E-07
550	GK1WL78VVT	36	Manual Valve 1WL78 Transfers Position and Blocks Discharge Path	6.12E-07
551	GK20001HGR	24	Keowee Unit 2 Generator Fault While the Unit Runs	2.27E-03
552	GK20002HGS	1	Keowee Unit 2 Generator Fault Causes Unit Start Failure	1.54E-04
553	GK2063FPST	24	Keowee 2 Gen CO2 Sys Press Switch 63F Spurious Operation	1.03E-05
554	GK212TDRYT	24	Time Delay Relay 12XTD/2 Spuriously Picks-up	8.64E-06
555	GK212X2RYT	24	Relay 12X/2 Spuriously Picks-up	8.64E-06

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Keowee PRA Basic Event Data
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	NAME	FACTOR	DESCRIPTION	PROBABILITY
556	GK23SUIRYT	24	Keowee Unit 2 Startup Inhibit Switch Auxiliary Relay S3SUIX Spurious Actuation	8.64E-06
557	GK23SUISWT	24	Keowee Unit 2 Startup Inhibit Swtich 3SUI Spurious Operation	1.68E-06
558	GK240G1RYT	24	Keowee Unit 2 Loss Of Generator Field Relay 40G1 Spurious Actuation	8.64E-06
559	GK259GNRYT	24	Keowee Unit 2 Generator Ground Fault Relay 59GN2 Spurious Actuation	8.64E-06
560	GK262TDRYT	24	Keowee Unit 2 Generator Backup Trip Timer 62-2TD Spurious Operation	8.64E-06
561	GK263FXRYT	24	Keowee Unit 2 Generator Fire Relay 63FX Spurious Actuation	8.64E-06
562	GK286E2RYT	24	Keowee 2 Emergency Lockout Relay 86E-2 Spuriously Picks Up	8.64E-06
563	GK287G2RYT	24	Keowee Unit 2 Generator Differential Relay 87G-2 Spurious Actuation	8.64E-06
564	GK287GBRYT	24	Keowee Unit 2 Generator Bus Differential Relay 87GB Spurious Actuation	8.64E-06
565	GK287TERYT	24	Keowee Unit 2 Excitation Transformer Differential Relay 87T-2E Spur. Actuation	8.64E-06
566	GK2BRGVLHE	2.60E-04	Keowee 2 Gen. Brng Oil Cooling Flow Path Vlvs Mispositioned After Maintenance	2.60E-04
567	GK2COOLLHE	2.60E-04	Keowee 2 Gen. Air Cooler WL Flow Path Vlvs Mispositioned After Maintenance	2.60E-04
568	GK2FIREDEX	7.00E-05	Spurious Actuation of Unit 2 Gen. CO2 Fire Supression System	7.00E-05
569	GK2GAC1HXF	24	Generator Air Cooler 2GAHW-1 Fails	1.54E-05
570	GK2GAC1HXL	36	Heat Exchanger 2GAC1 Leaks	3.60E-06
571	GK2GAC2HXF	24	Generator Air Cooler 2GAHW-2 Fails	1.54E-05
572	GK2GAC2HXL	36	Heat Exchanger 2GAC2 Leaks	3.60E-06
573	GK2GAC3HXF	24	Generator Air Cooler 2GAHW-3 Fails	1.54E-05
574	GK2GAC3HXL	36	Heat Exchanger 2GAC3 Leaks	3.60E-06
575	GK2GAC4HXF	24	Generator Air Cooler 2GAHW-4 Fails	1.54E-05
576	GK2GAC4HXL	36	Heat Exchanger 2GAC4 Leaks	3.60E-06
577	GK2GAC5HXF	24	Generator Air Cooler 2GAHW-5 Fails	1.54E-05
578	GK2GAC5HXL	36	Heat Exchanger 2GAC5 Leaks	3.60E-06
579	GK2GAC6HXF	24	Generator Air Cooler 2GAHW-6 Fails	1.54E-05
580	GK2GAC6HXL	36	Heat Exchanger 2GAC6 Leaks	3.60E-06
581	GK2HPO1HXF	24	Generator Thrust Bearing Cooler 2HPOHX-1 Fails	1.54E-05
582	GK2HPO2HXF	24	Generator Thrust Bearing Cooler 2HPOHX-2 Fails	1.54E-05
583	GK2HPO3HXF	24	Generator Thrust Bearing Cooler 2HPOHX-3 Fails	1.54E-05
584	GK2HPO4HXF	24	Generator Thrust Bearing Cooler 2HPOHX-4 Fails	1.54E-05
585	GK2HPO5HXF	24	Generator Thrust Bearing Cooler 2HPOHX-5 Fails	1.54E-05
586	GK2HPO6HXF	24	Generator Thrust Bearing Cooler 2HPOHX-6 Fails	1.54E-05
587	GK2HPO6VVT	24	Genrator Bearing Oil Leak Because Manual Valve 2HPO-6 Transfers Position	4.08E-07
588	GK2HPO7HXF	24	Generator Thrust Bearing Cooler 2HPOHX-7 Fails	1.54E-05
589	GK2HPO8HXF	24	Generator Thrust Bearing Cooler 2HPOHX-8 Fails	1.54E-05
590	GK2NGDCLHE	5.20E-05	Failure to Close the Unit 2 Neutral Ground Disconnect Following Maintenance	5.20E-05
591	GK2O121SST	24	Speed Switch 12/2 Falsely Indicates High Speed	1.01E-04
592	GK2WL16VVT	36	Manual Valve 2WL-16 Transfers Position	6.12E-07

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Keowee PRA Basic Event Data
Two Unit Generation - Bayesian Update/Unrecovered

	NAME	FACTOR	DESCRIPTION	PROBABILITY
593	GK2WL17VVT	36	Manual Valve 2WL-17 Transfers Position	6.12E-07
594	GK2WL18VVT	36	Manual Valve 2WL18 Transfers Position	6.12E-07
595	GK2WL19VVT	36	Manual Valve 2WL19 Transfers Position	6.12E-07
596	GK2WL20VVT	36	Manual Valve 2WL-20 Transfers Position	6.12E-07
597	GK2WL21VVT	36	Manual Valve 2WL-21 Transfers Position	6.12E-07
598	GK2WL22VVT	36	Manual Valve 2WL22 Transfers Position	6.12E-07
599	GK2WL23VVT	36	Manual Valve 2WL23 Transfers Position	6.12E-07
600	GK2WL24VVT	36	Manual Valve 2WL-24 Transfers Position	6.12E-07
601	GK2WL25VVT	36	Manual Valve 2WL-25 Transfers Position	6.12E-07
602	GK2WL26VVT	36	Manual Valve 2WL26 Transfers Position	6.12E-07
603	GK2WL27VVT	36	Manual Valve 2WL27 Transfers Position	6.12E-07
604	GK2WL28VVT	36	Manual Valve 2WL-28 Transfers Position	6.12E-07
605	GK2WL29VVT	36	Manual Valve 2WL-29 Transfers Position	6.12E-07
606	GK2WL30VVT	36	Manual Valve 2WL30 Transfers Position	6.12E-07
607	GK2WL31VVT	36	Manual Valve 2WL31 Transfers Position	6.12E-07
608	GK2WL32VVT	36	Manual Valve 2WL-32 Transfers Position	6.12E-07
609	GK2WL33VVT	36	Manual Valve 2WL-33 Transfers Position	6.12E-07
610	GK2WL34VVT	36	Manual Valve 2WL34 Transfers Position	6.12E-07
611	GK2WL35VVT	36	Manual Valve 2WL35 Transfers Position	6.12E-07
612	GK2WL36VVT	36	Manual Valve 2WL-36 Transfers Position	6.12E-07
613	GK2WL37VVT	36	Manual Valve 2WL-37 Transfers Position	6.12E-07
614	GK2WL38VVT	36	Manual Valve 2WL38 Transfers Position	6.12E-07
615	GK2WL39VVT	36	Manual Valve 2WL39 Transfers Position	6.12E-07
616	GK2WL41VVT	36	Keowee 2 Manual Valve 2WL-41 Transfers Position to Block Discharge Path	6.12E-07
617	GK2WL44VVT	36	Manual Valve 2WL-44 Transfers Position	6.12E-07
618	GK2WL45VVT	36	Manual Valve 2WL-45 Transfers Position	6.12E-07
619	GK2WL46VVT	36	Manual Valve 2WL-46 Transfers Position	6.12E-07
620	GK2WL47VVT	36	Manual Valve 2WL-47 Transfers Position	6.12E-07
621	GK2WL48VVT	36	Manual Valve 2WL-48 Transfers Position	6.12E-07
622	GK2WL49VVT	36	Manual Valve 2WL-49 Transfers Position	6.12E-07
623	GK2WL50VVT	36	Manual Valve 2WL-50 Transfers Position	6.12E-07
624	GK2WL51VVT	36	Manual Valve 2WL-51 Transfers Position	6.12E-07
625	GK2WL52VVT	36	Manual Valve 2WL-52 Transfers Position	6.12E-07
626	GK2WL53VVT	36	Manual Valve 2WL-53 Transfers Position	6.12E-07
627	GK2WL54VVT	36	Manual Valve 2WL-54 Transfers Position	6.12E-07
628	GK2WL55VVT	36	Manual Valve 2WL-55 Transfers Position	6.12E-07
629	GK2WL56VVT	36	Manual Valve 2WL-56 Transfers Position	6.12E-07

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Keowee PRA Basic Event Data
Two Unit Generation - Bayesian Update/Unrecovered

NAME	FACTOR	DESCRIPTION	PROBABILITY
630 GK2WL57VVT	36	Manual Valve 2WL-57 Transfers Position	6.12E-07
631 GK2WL58VVT	36	Manual Valve 2WL-58 Transfers Position	6.12E-07
632 GK2WL59VVT	36	Manual Valve 2WL-59 Transfers Position	6.12E-07
633 GK2WL60VVT	36	Manual Valve 2WL-60 Transfers Position	6.12E-07
634 GK2WL61VVT	36	Manual Valve 2WL-61 Transfers Position	6.12E-07
635 GK2WL62VVT	36	Manual Valve 2WL-62 Transfers Position	6.12E-07
636 GK2WL63VVT	36	Manual Valve 2WL-63 Transfers Position	6.12E-07
637 GK2WL64VVT	36	Manual Valve 2WL-64 Transfers Position	6.12E-07
638 GK2WL65VVT	36	Manual Valve 2WL-65 Transfers Position	6.12E-07
639 GK2WL66VVT	36	Manual Valve 2WL-66 Transfers Position	6.12E-07
640 GK2WL67VVT	36	Manual Valve 2WL-67 Transfers Position	6.12E-07
641 GK2WL68VVT	36	Manual Valve 2WL-68 Transfers Position	6.12E-07
642 GK2WL69VVT	36	Manual Valve 2WL-69 Transfers Position	6.12E-07
643 GK2WL70VVT	36	Manual Valve 2WL-70 Transfers Position	6.12E-07
644 GK2WL71VVT	36	Manual Valve 2WL-71 Transfers Position	6.12E-07
645 GK2WL72VVT	36	Manual Valve 2WL-72 Transfers Position	6.12E-07
646 GK2WL73VVT	36	Manual Valve 2WL-73 Transfers Position	6.12E-07
647 GK2WL74VVT	36	Manual Valve 2WL-74 Transfers Position	6.12E-07
648 GK2WL75VVT	36	Manual Valve 2WL-75 Transfers Position	6.12E-07
649 GK2WL76VVT	36	Manual Valve 2WL76 Transfers Position and Blocks Discharge Path	6.12E-07
650 GK2WL78VVT	36	Manual Valve 2WL78 Transfers Position and Blocks Discharge Path	6.12E-07
651 GKHPOILCOM	4.61E-07	Common Cause Failure of Generator Thrust Bearings	4.61E-07
652 K12COM1DEX	1.00E-06	Grid Degradation Occurs And Causes Failure Of Both Keowee Units	1.00E-06
653 KA127T1R6D	1	Xfrmr 1X UV Relay 27T/1X Fails To Pick-up	2.49E-04
654 KA127T1R6T	360	Xfrmr 1X UV Relay 27T/1X Spuriously De-energizes	1.31E-04
655 KA227T2R6T	360	Xfmr 2X UV Relay 27T/2x Spuriously De-energizes	1.31E-04
656 KB4CONNDEX	1.1E-7	Air Circuit Breaker 4 Connects Unit 2 To The Underground Path	1.10E-07
657 KK1BOTHDEX	0.034	Keowee Units 1 And 2 Are Supplying The Grid	3.40E-02
658 KK1BOTHHYM	5.23E-3	Both Keowee Units Unavailable Due To Common Maintenance	5.23E-03
659 KK1OVERBHF	24	Fault Occurs On The Overhead Power Path	9.60E-06
660 KK1RUNSDEX	0.024	Keowee Unit 1 Only Is Supplying The Grid	2.40E-02
661 KK1UNDRBHF	24	Fault Occurs On The Underground Power Path	9.60E-06
662 KK2RUNSDEX	0.024	Keowee Unit 2 Only Is Supplying The Grid	2.40E-02
663 KK2UNITHYM	3.80E-2	A Single Keowee Unit Is Unavailable Due To Maintenance	3.80E-02
664 KU2CREDIT	0	Take No Credit For Keowee Unit 2 Supplying Auxiliary ac Power To Unit 1	0.00E+00
665 L0EGTPSCOM	1.78E-06	Common Cause Failure of UV And UF Detection Circuits	1.78E-06
666 L27BRX1RYD	1	Snsng Rly 27B/RX1 Fails to Drop Out on Undervoltage OEE-76-3, -4	3.30E-05

Table E-6

Keowee PRA Basic Event Data
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	NAME	FACTOR	DESCRIPTION	PROBABILITY
667	L27BRX2RYD	1	Snsng Rly 27B/RX2 Fails to Drop Out on Undervoltage OEE-76-3, -8	3.30E-05
668	L27BRY1RYD	1	Snsng Rly 27B/RY1 Fails to Drop Out on Undervoltage OEE-76-3, -4	3.30E-05
669	L27BRY2RYD	1	Snsng Rly 27B/RY2 Fails to Drop Out on Undervoltage OEE-76-3, -8	3.30E-05
670	L27BRZ1RYD	1	Snsng Rly 27B/RZ1 Fails to Drop Out on Undervoltage OEE-76-3, -4	3.30E-05
671	L27BRZ2RYD	1	Snsng Rly 27B/RZ2 Fails to Drop Out on Undervoltage OEE-76-3, -8	3.30E-05
672	L27BYX1RYD	1	Snsng Rly 27B/YX1 Fails to Drop Out on Undervoltage OEE-76-3, -4	3.30E-05
673	L27BYX2RYD	1	Snsng Rly 27B/YX2 Fails to Drop Out on Undervoltage OEE-76-3, -8	3.30E-05
674	L27BYY1RYD	1	Snsng Rly 27B/YY1 Fails to Drop Out on Undervoltage OEE-76-3, -4	3.30E-05
675	L27BYY2RYD	1	Snsng Rly 27B/YY2 Fails to Drop Out on Undervoltage OEE-76-3, -8	3.30E-05
676	L27BYZ1RYD	1	Snsng Rly 27B/YZ1 Fails to Drop Out on Undervoltage OEE-76-3, -4	3.30E-05
677	L27BYZ2RYD	1	Snsng Rly 27B/YZ2 Fails to Drop Out on Undervoltage OEE-76-3, -8	3.30E-05
678	L27XPX1RYD	1	Ch 1 Phase X UV Aux. Relay Fails To Pick Up OEE-76-4	3.30E-05
679	L27XPX2RYD	1	Ch 2 Phase X UV Aux. Relay Fails To Pick Up OEE-76-8	3.30E-05
680	L27XPY1RYD	1	Ch 1 Phase Y UV Aux. Relay Fails to Pick Up OEE-76-4	3.30E-05
681	L27XPY2RYD	1	Ch 2 Phase Y UV Aux. Relay Fails to Pick Up OEE-76-8	3.30E-05
682	L27XPZ1RYD	1	Ch 1 Phase Z UV Aux. Relay Fails To Pick Up OEE-76-4	3.30E-05
683	L27XPZ2RYD	1	Ch 2 Phase Z UV Aux. Relay Fails To Pick Up OEE-76-8	3.30E-05
684	L27XRX1RYD	1	Red Bus Phase X1 Undervoltage Aux. Relay Fails To Pick Up OEE-76-4	3.30E-05
685	L27XRX2RYD	1	Red Bus Phase X2 Undervoltage Aux. Relay Fails To Pick Up OEE-76-8	3.30E-05
686	L27XRY1RYD	1	Red Bus Phase Y1 Undervoltage Aux. Relay Fails To Pick Up OEE-76-4	3.30E-05
687	L27XRY2RYD	1	Red Bus Phase Y2 Undervoltage Aux. Relay Fails to Pick Up OEE-76-8	3.30E-05
688	L27XRZ1RYD	1	Red Bus Phase Z1 Undervoltage Aux. Relay Fails To Pick Up OEE-76-4	3.30E-05
689	L27XRZ2RYD	1	Red Bus Phase Z2 Undervoltage Aux. Relay Fails To Pick Up OEE-76-8	3.30E-05
690	L27XSTARYD	1	Keowee Start Relay 27X/STA Fails To Pick Up OEE-76-4-A	3.30E-05
691	L27XSTBRYD	1	Keowee Start Relay 27X/STB Fails To Pick Up	3.30E-05
692	L27XYX1RYD	1	Yellow Bus Phase X1 Undervoltage Aux. Relay Fails To Pick Up OEE-76-4	3.30E-05
693	L27XYX2RYD	1	Yellow Bus Phase X2 Undervoltage Aux. Relay Fails To Pick Up OEE-76-8	3.30E-05
694	L27XYY1RYD	1	Yellow Bus Phase Y1 Undervoltage Aux. Relay Fails To Pick Up OEE-76-4	3.30E-05
695	L27XYY2RYD	1	Yellow Bus Phase Y2 Undervoltage Aux. Relay Fails to Pick Up OEE-76-8	3.30E-05
696	L27XYZ1RYD	1	Yellow Bus Phase Z1 Undervoltage Aux. Relay Fails To Pick Up OEE-76-4	3.30E-05
697	L27XYZ2RYD	1	Yellow Bus Phase Z2 Undervoltage Aux. Relay Fails to Pick Up OEE-76-8	3.30E-05
698	L81BRX1RYD	1	Sensing Relay 81BL/RX1 Fails to Drop Out on Underfrequency	3.30E-05
699	L81BRX2RYD	1	Sensing Relay 81BL/RX2 Fails to Drop Out on Underfrequency	3.30E-05
700	L81BRY1RYD	1	Sensing Relay 81BL/RY1 Fails to Drop Out on Underfrequency	3.30E-05
701	L81BRY2RYD	1	Sensing Relay 81BL/RY2 Fails to Drop Out on Underfrequency	3.30E-05
702	L81BRZ1RYD	1	Sensing Relay 81BL/RZ1 Fails to Drop Out on Underfrequency	3.30E-05
703	L81BRZ2RYD	1	Sensing Relay 81BL/RZ2 Fails to Drop Out on Underfrequency	3.30E-05

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	NAME	FACTOR	DESCRIPTION		PROBABILITY
704	L81BYX1RYD	1	Sensing Relay 81BL/YX1 Fails to Drop Out on Underfrequency		3.30E-05
705	L81BYX2RYD	1	Sensing Relay 81BL/YX2 Fails to Drop Out on Underfrequency		3.30E-05
706	L81BYY1RYD	1	Sensing Relay 81BL/YY1 Fails to Drop Out on Underfrequency		3.30E-05
707	L81BYY2RYD	1	Sensing Relay 81BL/YY2 Fails to Drop Out on Underfrequency		3.30E-05
708	L81BYZ1RYD	1	Sensing Relay 81BL/YZ1 Fails to Drop Out on Underfrequency		3.30E-05
709	L81BYZ2RYD	1	Sensing Relay 81BL/YZ2 Fails to Drop Out On Underfrequency		3.30E-05
710	L81XPX1RYD	1	Ch 1 Phase X Underfrequency Aux. Rly Fails to Pick Up		3.30E-05
711	L81XPX2RYD	1	Ch 2 Phase X Underfrequency Aux. Rly Fails to Pick Up		3.30E-05
712	L81XPY1RYD	1	Ch 1 Phase Y Underfrequency Aux. Rly Fails to Pick Up		3.30E-05
713	L81XPY2RYD	1	Ch 2 Phase Y Underfrequency Aux. Rly Fails to Pick Up		3.30E-05
714	L81XPZ1RYD	1	Ch 1 Phase Z Underfrequency Aux. Rly Fails to Pick Up		3.30E-05
715	L81XPZ2RYD	1	Ch 2 Phase Z Underfrequency Aux. Rly Fails to Pick up		3.30E-05
716	L81XRX1RYD	1	Red Bus Phase X1 Underfrequency Aux. Rly Fails to Pick Up		3.30E-05
717	L81XRX2RYD	1	Red Bus Phase X2 Underfrequency Aux. Rly Fails to Pick Up		3.30E-05
718	L81XRY1RYD	1	Red Bus Phase Y1 Underfrequency Aux. Rly Fails to Pick Up		3.30E-05
719	L81XRY2RYD	1	Red Bus Phase Y2 Underfrequency Aux. Rly Fails to Pick Up		3.30E-05
720	L81XRZ1RYD	1	Red Bus Phase Z1 Underfrequency Aux. Rly Fails to Pick Up		3.30E-05
721	L81XRZ2RYD	1	Red Bus Phase Z2 Underfrequency Aux. Rly Fails to Pick Up		3.30E-05
722	L81XYX1RYD	1	Yellow Bus Phase X1 Underfrequency Aux. Rly Fails to Pick Up		3.30E-05
723	L81XYX2RYD	1	Yellow Bus Phase X2 Underfrequency Aux. Rly Fails to Pick Up		3.30E-05
724	L81XYY1RYD	1	Yellow Bus Phase Y1 Underfrequency Aux. Rly Fails to Pick Up		3.30E-05
725	L81XYY2RYD	1	Yellow Bus Phase Y2 Underfrequency Aux. Rly Fails to Pick Up		3.30E-05
726	L81XYZ1RYD	1	Yellow Bus Phase Z1 Underfrequency Aux. Rly Fails to Pick Up		3.30E-05
727	L81XYZ2RYD	1	Yellow Bus Phase Z2 Underfrequency Aux. Rly Fails to Pick Up		3.30E-05
728	LC94F1ARYD	1	EGTPS Underfrequency Relay 94/F1A Fails to Pick Up		3.30E-05
729	LC94F1BRYD	1	EGTPS Underfrequency Relay 94/F1B Fails to Pick Up		3.30E-05
730	LC94F1DRYD	1	EGTPS Underfrequency Relay 94/F1D Fails to Pick Up		3.30E-05
731	LC94F2ARYD	1	EGTPS Underfrequency Relay 94/F2A Fails to Pick Up		3.30E-05
732	LC94F2BRYD	1	EGTPS Underfrequency Relay 94/F2B Fails to Pick Up		3.30E-05
733	LC94F2CRYD	1	EGTPS Underfrequency Relay 94/F2C Fails to Pick Up		3.30E-05
734	LC94F2DRYD	1	EGTPS Underfrequency Relay 94/F2D Fails to Pick Up		3.30E-05
735	LC94V1ARYD	1	EGTPS Undervoltage Relay 94/V1A Fails to Pick Up		3.30E-05
736	LC94V1BRYD	1	EGTPS Undervoltage Relay 94/V1B Fails To Pick Up	OEE-76-4	3.30E-05
737	LC94V1DRYD	1	EGTPS Undervoltage Relay 94/V1D Fails to Pick Up	OEE-76-4	3.30E-05
738	LC94V2ARYD	1	EGTPS Undervoltage Relay 94/V2A Fails to Pick Up		3.30E-05
739	LC94V2BRYD	1	EGTPS Undervoltage Relay 94/V2B Fails To Pick Up		3.30E-05
740	LC94V2CRYD	1	EGTPS Undervoltage Relay 94/V2C Fails to Pick Up		3.30E-05

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	NAME	FACTOR	DESCRIPTION	PROBABILITY
741	LDCYC13CDT	24	Switchyard 125 Vdc Panelboard DYC Breaker 13 Transfers Open OEE-76-4 / O-802	1.80E-06
742	LDCYC14CDT	24	Switchyard 125 Vdc Panelboard DYC Breaker 14 Transfers Open OEE-76-4 / O-802	1.80E-06
743	LDCYG12CDT	24	Switchyard 125 Vdc Panelboard DYG Breaker 12 Transfers Open	1.80E-06
744	LDCYG18CDT	24	Switchyard 125 Vdc Panelboard DYG Breaker 18 Transfers Open	1.80E-06
745	OFACTORDEX	1.0	Overload Susceptibility Factor	1.00E+00
746	OK0PRUNCOM	1.46E-05	Common Cause Failure Of Both Governor Oil Systems To Run	1.46E-05
747	OK10001PSC	15	Pressure Switch 1OGPS-1 Fails to Close (Normal Control Signal)	4.35E-05
748	OK10002PSC	8	Pressure Switch 1OGPS-2 Fails to Close	2.32E-05
749	OK10003PSC	4	Pressure Switch 1OGPS-3 Fails to Close	1.16E-05
750	OK10003RVT	24	Safety Relief Valve 1OG-3 Spurious Operation	1.34E-04
751	OK10003TKF	24	Unit 1 Governor Oil Pressure Tank Fails	1.10E-05
752	OK10004PSC	1	Pressure Switch 1OGPS-4 Fails to Close	2.90E-06
753	OK10007FVT	24	Float Valve 1OG-7 Transfers Closed	1.40E-04
754	OK10009VVT	24	Manual Valve 1OG-9 Transfers Closed	4.08E-07
755	OK10011CVO	15	Check Valve 1OG-11 Fails to Open	3.45E-05
756	OK10011CVT	0.75	Check Valve 1OG-11 Transfers Closed	9.75E-08
757	OK10012VVT	30	Manual Globe Valve 1OG-12 Transfers Closed	5.10E-07
758	OK10013RVT	0.75	Relief Valve 1OG-13 Spurious Operation	4.20E-06
759	OK10014CVO	8	Check Valve 1OG-14 Fails to Open	1.84E-05
760	OK10014CVT	0.5	Check Valve 1OG-14 Transfers Closed	6.50E-08
761	OK10015VVT	192	Manual Globe Valve 1OG-15 Transfers Closed	3.26E-06
762	OK10016RVT	0.5	Relief Valve 1OG-16 Transfers Open	2.80E-06
763	OK10017CVO	4	Check Valve 1OG-17 Fails to Open	9.20E-06
764	OK10017CVT	0.25	Check Valve 1OG-17 Transfers Closed	3.25E-08
765	OK10018VVT	108	Manual Globe Valve 1OG-18 Transfers Closed	1.84E-06
766	OK10019RVT	0.25	Relief Valve 1OG-19 Spurious Operation	1.40E-06
767	OK1001AGPR	0.75	OG Pump 1A Fails to Run	1.05E-05
768	OK1001AGPS	15	OG Pump 1A Fails to Start	1.45E-03
769	OK1001BGPR	0.5	OG Pump 1B Fails to Run	7.00E-06
770	OK1001BGPS	8	OG Pump 1B Fails to Start	7.76E-04
771	OK1001BLHE	3.2E-3	Latent Human Error Fails OG Pump 1B	3.20E-03
772	OK1001CGPR	0.25	OG Pump 1C Fails to Run	3.50E-06
773	OK1001CGPS	4	OG Pump 1C Fails to Start	3.88E-04
774	OK1001CLHE	3.2E-3	Latent Human Error Fails OG Pump 1C	3.20E-03
775	OK188GASWT	30	Keowee 1 Governor Oil Control Switch 188GA Spurious Operation	2.10E-06
776	OK188GBSWT	192	Keowee 1 Control Switch 188GB Spurious Operation	1.34E-05
777	OK188GCSWT	108	Keowee 1 Control Switch 188GC Spurious Operation	7.56E-06

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Keowee PRA Basic Event Data
Two Unit Generation - Bayesian Update/Unrecovered

	NAME	FACTOR	DESCRIPTION	PROBABILITY
778	OK199K1RYD	1	Keowee 1 Relay 99K1 Fails To Operate On Demand	3.30E-05
779	OK199K1RYT	24	Keowee Unit 1 Relay 99K1 Spurious Operation	8.64E-06
780	OK199K2RYD	1	Keowee 1 Relay 99K2 Fails To Operate On Demand	3.30E-05
781	OK1AG01TKF	24	Air Receiver Tank 1AGTK-1 Fails	1.10E-05
782	OK1AG04RVT	24	Safety Relief Valve 1AG-4 Spurious Operation	1.34E-04
783	OK1AG05VVT	24	Manual Valve 1AG-5 Transfers Position	4.08E-07
784	OK1OG1CTRM	3.42E-3	OG Pump 1C Train In Maintenance Or Testing	3.42E-03
785	OK1PRUNCOM	1.12E-07	Common Cause Failure of Unit 1 OG Pumps to Run	1.12E-07
786	OK1PSTRCOM	2.04E-05	Common Cause Failure of Unit 1 OG Pumps to Start	2.04E-05
787	OK1XA1DCLT	30	Low Voltage Circuit Breaker 1XA-1D Transfers Position	2.73E-05
788	OK1XA2ECLT	30	Low Voltage Circuit Breaker 1XA-2E Transfers Position	2.73E-05
789	OK1XA4DCLT	30	Low Voltage Circuit Breaker 1XA-4D Transfers Position	2.73E-05
790	OK20001PSC	15	Pressure Switch 2OGPS-1 Fails to Close (Normal Control Signal)	4.35E-05
791	OK20002PSC	8	Pressure Switch 2OGPS-2 Fails to Close	2.32E-05
792	OK20003PSC	4	Pressure Switch 2OGPS-3 Fails to Close	1.16E-05
793	OK20003RVT	24	Safety Relief Valve 2OG-3 Spurious Operation	1.34E-04
794	OK20003TKF	24	Unit 2 Governor Oil Pressure Tank Fails	1.10E-05
795	OK20004PSC	1	Pressure Switch 2OGPS-4 Fails to Close	2.90E-06
796	OK20007FVT	24	Float Valve 2OG-7 Transfers Closed	1.40E-04
797	OK20009VVT	24	Manual Valve 2OG-9 Transfers Closed	4.08E-07
798	OK20011CVO	15	Check Valve 2OG-11 Fails to Open	3.45E-05
799	OK20011CVT	0.75	Check Valve 2OG-11 Transfers Closed	9.75E-08
800	OK20012VVT	30	Manual Globe Valve 2OG-12 Transfers Closed	5.10E-07
801	OK20013RVT	0.75	Relief Valve 2OG-13 Spurious Operation	4.20E-06
802	OK20014CVO	8	Check Valve 2OG-14 Fails to Open	1.84E-05
803	OK20014CVT	0.5	Check Valve 2OG-14 Transfers Closed	6.50E-08
804	OK20015VVT	192	Manual Globe Valve 2OG-15 Transfers Closed	3.26E-06
805	OK20016RVT	0.5	Relief Valve 2OG-16 Transfers Open	2.80E-06
806	OK20017CVO	4	Check Valve 2OG-17 Fails to Open	9.20E-06
807	OK20017CVT	0.25	Check Valve 2OG-17 Transfers Closed	3.25E-08
808	OK20018VVT	108	Manual Globe Valve 2OG-18 Transfers Closed	1.84E-06
809	OK20019RVT	0.25	Relief Valve 2OG-19 Spurious Operation	1.40E-06
810	OK2002AGPR	0.75	OG Pump 2A Fails to Run	1.05E-05
811	OK2002AGPS	15	OG Pump 2A Fails to Start	1.45E-03
812	OK2002BGPR	0.5	OG Pump 2B Fails to Run	7.00E-06
813	OK2002BGPS	8	OG Pump 2B Fails to Start	7.76E-04
814	OK2002BLHE	3.2E-3	Latent Human Error Fails OG Pump 2B	3.20E-03

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Keowee PRA Basic Event Data
Two Unit Generation - Bayesian Update/Unrecovered

	NAME	FACTOR	DESCRIPTION	PROBABILITY
815	OK2002CGPR	0.25	OG Pump 2C Fails to Run	3.50E-06
816	OK2002CGPS	4	OG Pump 2C Fails to Start	3.88E-04
817	OK2002CLHE	3.2E-3	Latent Human Error Fails OG Pump 2C	3.20E-03
818	OK288GASWT	30	Keowee 2 Governor Oil Control Switch 188GA Spurious Operation	2.10E-06
819	OK288GBSWT	192	Keowee 2 Control Switch 188GB Spurious Operation	1.34E-05
820	OK288GCSWT	108	Keowee 2 Control Switch 188GC Spurious Operation	7.56E-06
821	OK299K1RYD	1	Keowee 2 Relay 99K1 Fails To Operate On Demand	3.30E-05
822	OK299K1RYT	24	Keowee Unit 2 Relay 99K1 Spurious Operation	8.64E-06
823	OK299K2RYD	1	Relay 99K2 Fails To Operate On Demand	3.30E-05
824	OK2AG04RVT	24	Safety Relief Valve 2AG-4 Spurious Operation	1.34E-04
825	OK2AG05VVT	24	Manual Valve 2AG-5 Transfers Position	4.08E-07
826	OK2AGO1TKF	24	Air Receiver Tank 2AGTK-1 Fails	1.10E-05
827	OK2OG2CTRM	3.42E-3	OG Pump 2C Train In Maintenance Or Testing	3.42E-03
828	OK2PRUNCOM	1.12E-07	Common Cause Failure of Unit 2 OG Pumps to Run	1.12E-07
829	OK2PSTRCOM	2.04E-05	Common Cause Failure of Unit 2 OG Pumps to Start	2.04E-05
830	OK2XA1DCLT	30	Low Voltage Circuit Breaker 2XA-1D Transfers Position	2.73E-05
831	OK2XA2ECLT	30	Low Voltage Circuit Breaker 2XA-2E Transfers Position	2.73E-05
832	OK2XA4DCLT	30	Low Voltage Circuit Breaker 2XA-4D Transfers Position	2.73E-05
833	OMOD	0	Startup Bus UV Sensing Mod Is In Service	0.00E+00
834	PAC1TC4C4T	24	4160 Vac Breaker 1TC-4 Transfers Open	2.26E-05
835	PACTC01C4T	24	4160 Vac Breaker 1TC-1 Transfers Open	2.26E-05
836	PACTC14C4T	24	4160 Vac Breaker 1TC-14 Transfers Open	2.26E-05
837	PACX1TCBHF	24	4160 Vac Switchgear 1TC Fails	9.60E-06
838	PK0SUMPCOM	2.44E-06	Common Cause Failure Of Turbine Sump Pump System	2.44E-06
839	PK163SALST	30	Unit 1 AC Turbine Sump Pump Float Switch 63SA Fails	9.30E-06
840	PK163SBLST	15	Unit 1 DC Turbine Sump Pump Float Switch 63SB Transfers	4.65E-06
841	PK1ACDCCOM	2.77E-05	Common Cause Failure of Unit 1 Turbine Sump Pump System	2.77E-05
842	PK1DA5CCDT	24	125 Vdc Circuit Breaker 1DA-5C Transfers Position	1.80E-06
843	PK1PACKDEX	3.1E-5	Turbine No. 1 Packing Fails	3.10E-05
844	PK1TS01VVT	30	Manual Valve 1TS-1 Transfers Position	5.10E-07
845	PK1TS02CVT	30	Check Valve 1TS-2 Fails to Open or Transfers Closed	3.90E-06
846	PK1TS03VVT	108	Manual Valve 1TS-3 Transfers Position	1.84E-06
847	PK1TS04CVT	15	Check Valve 1TS-4 Fails to Open or Transfers Closed	1.95E-06
848	PK1TSACGPR	30	AC Sump Pump 1TSPU-1 Fails To Start Or Run	4.20E-04
849	PK1TSDCGPR	15	DC Sump Pump 1TSPU-2 Fails To Start Or Run	2.10E-04
850	PK1TSDCLHE	3.2E-3	Latent Human Error Fails Turbine No. 1 DC Sump Pump	3.20E-03
851	PK1TSDCTRM	6.85E-4	Turbine No. 1 DC Pump Train In Maintenance Or Testing	6.85E-04

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	NAME	FACTOR	DESCRIPTION		PROBABILITY
852	PK1XA2CCLT	30	600 V Circuit Breaker 1XA-2C Transfers Position		2.73E-05
853	PK263SALST	30	Unit 2 AC Turbine Sump Pump Float Switch 63SA Fails		9.30E-06
854	PK263SBLST	15	Unit 2 DC Turbine Sump Pump Float Switch 63SB Transfers		4.65E-06
855	PK2ACDCCOM	2.77E-05	Common Cause Failure of Unit 2 Turbine Sump Pump System		2.77E-05
856	PK2DA1CCDT	24	125 Vdc Circuit Breaker 2DA-1C Transfers Position		1.80E-06
857	PK2PACKDEX	3.1E-5	Turbine No. 2 Packing Fails		3.10E-05
858	PK2TS01VVT	30	Manual Valve 2TS-1 Transfers Position		5.10E-07
859	PK2TS02CVT	30	Check Valve 2TS-2 Fails to Open or Transfers Closed		3.90E-06
860	PK2TS03VVT	108	Manual Valve 2TS-3 Transfers Position		1.84E-06
861	PK2TS04CVT	15	Check Valve 2TS-4 Fails to Open or Transfers Closed		1.95E-06
862	PK2TSACGPR	30	AC Sump Pump 2TSPU-1 Fails To Start Or Run		4.20E-04
863	PK2TSDCGPR	15	DC Sump Pump 2TSPU-2 Fails To Start Or Run		2.10E-04
864	PK2TSDCLHE	3.2E-3	Latent Human Error Fails Turbine No. 2 DC Sump Pump		3.20E-03
865	PK2TSDCTRM	6.85E-4	Turbine No. 2 DC Pump Train In Maintenance Or Testing		6.85E-04
866	PK2XA2CCLT	30	Low Voltage Circuit Breaker 2XA-2C Transfers Position		2.73E-05
867	PMFB1	5.60E-03	Loss of Power on Main Feeder Bus 1		5.60E-03
868	PMFB2	5.60E-03	Loss of Power on Main Feeder Bus 2		5.60E-03
869	S127E1VRYT	9	Unit 1 Startup Bus Undervoltage Relay 27E1 Fails		2.33E-03
870	S127EUVRYT	9	Unit 1 Startup Bus Undervoltage Relay 27E Fails		2.33E-03
871	S127EX1RYD	1	Unit 1 Startup Bus UV Aux Relay 27EX1 Fails to Pick Up		3.30E-05
872	S127EXVRYD	1	Unit 1 Startup Bus UV Aux Relay 27EX Fails to Pick Up		3.30E-05
873	S227E1VRYT	9	Unit 2 Startup Bus Undervoltage Relay 27E1 Fails		2.33E-03
874	S227EUVRYT	9	Unit 2 Startup Bus Undervoltage Relay 27E Fails		2.33E-03
875	S227EX1RYD	1	Unit 2 Startup Bus UV Aux Relay 27EX1 Fails to Pick Up		3.30E-05
876	S227EXVRYD	1	Unit 2 Startup Bus UV Aux Relay 27EX Fails to Pick Up		3.30E-05
877	S27XSC1RYD	1	Channel 1 Swyd Isolated Rly, 27X/SC1, Fails to Pick Up	OEE-76-12	3.30E-05
878	S27XSC2RYD	1	Channel 2 Swyd Isolated Rly, 27X/SC2, Fails to Pick Up	OEE-76-12A	3.30E-05
879	S27XTD1RYD	1	Channel 1 Swyd Isolated Time Delay Rly, 27XTD/SC1, Fails	OEE-76-12	3.30E-05
880	S27XTD2RYD	1	Channel 2 Swyd Isolated Time Delay Rly, 27XTD/SC2, Fails	OEE-76-12A	3.30E-05
881	S327E1VRYT	9	Unit 3 Startup Bus Undervoltage Trip Relay 27E1 Fails		2.33E-03
882	S327EUVRYT	9	Unit 3 Startup Bus Undervoltage Trip Relay 27E Fails		2.33E-03
883	S327EX1RYD	1	Unit 3 Standby Bus UV Aux Relay 27EX1 Fails to Pick Up		3.30E-05
884	S327EXVRYD	1	Unit 3 Startup Bus UV Trip Aux Relay 27EX Fails to Pick Up		3.30E-05
885	SB18UX1RYT	24	Auxiliary Relay 8UX-1 Spurious Operation		8.64E-06
886	SB28UX2RYT	24	Auxiliary Relay 8UX-2 Spurious Operation		8.64E-06
887	SB38UX3RYT	24	Auxiliary Relay 8UX-3 Spurious Operation		8.64E-06
888	SB48UX4RYT	24	Auxiliary Relay 8UX-4 Spurious Operation		8.64E-06

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	NAME	FACTOR	DESCRIPTION		PROBABILITY
889	SDCAIDDDIF	24	Control Power From DYA To PCB 9 Isolating Diode Fails		9.12E-05
890	SDCDA12CDT	24	125 Vdc Swyd Control Power Pnlbd DYA Bkr 12 Xfrs Open		1.80E-06
891	SDCDA15CDT	24	125 Vdc Swyd Control Power Pnlbd DYA Bkr 15 Xfrs Open		1.80E-06
892	SDCDA17CDT	24	125 Vdc Swyd Control Power Pnlbd DYA Bkr 17 Xfrs Open		1.80E-06
893	SDCDB01CDT	24	125 Vdc Swyd Control Power Pnlbd DYB Bkr 1 Xfrs Open		1.80E-06
894	SDCDB13CDT	24	125 Vdc Swyd Control Power Pnlbd DYB Bkr 13 Xfrs Open		1.80E-06
895	SDCDC12CDT	24	125 Vdc Swyd Control Power Pnlbd DYC Bkr 12 Xfrs Open		1.80E-06
896	SDCDE12CDT	24	125 Vdc Swyd Control Power Pnlbd DYE Bkr 12 Xfrs Open		1.80E-06
897	SDCDE15CDT	24	125 Vdc Swyd Control Power Pnlbd DYE Bkr 15 Xfrs Open		1.80E-06
898	SDCDE17CDT	24	125 Vdc Swyd Control Power Pnlbd DYE Bkr 17 Xfrs Open		1.80E-06
899	SDCDF01CDT	24	125 Vdc Swyd Control Power Pnlbd DYF Bkr 1 Xfrs Open		1.80E-06
900	SDCDF13CDT	24	125 Vdc Swyd Control Power Pnlbd DYF Bkr 13 Xfrs Open		1.80E-06
901	SDCDG16CDT	24	125 Vdc Swyd Control Power Pnlbd DYG Bkr 16 Xfrs Open		1.80E-06
902	SDCDYA8CDT	24	125 Vdc Swyd Control Power Pnlbd DYA Bkr 8 Xfrs Open	OEE-38	1.80E-06
903	SDCDYA9CDT	24	125 Vdc Swyd Control Power Pnlbd DYA Bkr 9 Xfrs Open	OEE-39B	1.80E-06
904	SDCDYB4CDT	24	125 Vdc Swyd Control Power Pnlbd DYB Bkr 4 Xfrs Open		1.80E-06
905	SDCDYB6CDT	24	125 Vdc Swyd Control Power Pnlbd DYB Bkr 6 Xfrs Open		1.80E-06
906	SDCDYB8CDT	24	125 Vdc Swyd Control Power Pnlbd DYB Bkr 8 Xfrs Open		1.80E-06
907	SDCDYE8CDT	24	125 Vdc Swyd Control Power Pnlbd DYE Bkr 8 Xfrs Open		1.80E-06
908	SDCDYE9CDT	24	125 Vdc Swyd Control Power Pnlbd DYE Bkr 9 Xfrs Open	OEE-39B	1.80E-06
909	SDCDYF4CDT	24	125 Vdc Swyd Control Power Pnlbd DYF Bkr 4 Xfrs Open		1.80E-06
910	SDCDYF6CDT	24	125 Vdc Swyd Control Power Pnlbd DYF Bkr 6 Xfrs Open		1.80E-06
911	SDCDYF8CDT	24	125 Vdc Swyd Control Power Pnlbd DYF Bkr 8 Xfrs Open		1.80E-06
912	SDCEIDDDIF	24	Control Power From DYE To PCB-9 Isolating Diode Fails		9.12E-05
913	SK194GBRYT	24	Keowee Unit 1 94GB Auxiliary Relay Spurious Operation		8.64E-06
914	SK294GBRYT	24	Keowee Unit 2 94GB Auxiliary Relay Spurious Operation		8.64E-06
915	SKXFMR1THF	24	Keowee Transformer 1 Fails		7.44E-05
916	SPC14KVBHF	24	13.8 kV Bus Faulted		9.60E-06
917	SPC51TNRYT	24	Main Step Up Transformer Neutral Ground Relay 51TN Spurious Operation		8.64E-06
918	SPC62ABRYT	24	ACB Back-up Trip Timer 62AB Spurious Operation		8.64E-06
919	SPC631XRYT	24	Auxiliary Relay 63H1X Spurious Operation		8.64E-06
920	SPC871XRYT	72	Transformer 1X Differential Relay 87T-1X Spurious Operation		2.59E-05
921	SPC872XRYT	72	Transformer 2X Differential Relay 87T-2X Spurious Operation		2.59E-05
922	SPC87T1RYT	72	Main Step Up Transformer Differential Relay 87T Spurious Operation		2.59E-05
923	SPC94TKRYT	24	Auxiliary Relay 94T/K Spurious Operation		8.64E-06
924	SPCB008CHO	1	SWYD PCB-8 Fails to Trip		2.60E-05
925	SPCB009CHC	1	SWYD PCB-9 Fails To Close On Demand		2.60E-04

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	NAME	FACTOR	DESCRIPTION	PROBABILITY
926	SPCB009CHO	1	SWYD PCB-9 Fails To Trip	2.60E-05
927	SPCB012CHO	1	SWYD PCB-12 Fails To Trip	2.60E-05
928	SPCB015CHO	1	SWYD PCB-15 Fails To Trip On Demand	2.60E-05
929	SPCB017CHO	1	SWYD PCB-17 Fails To Trip On Demand	2.60E-05
930	SPCB021CHO	1	SWYD PCB-21 Fails To Trip On Demand	2.60E-05
931	SPCB024CHO	1	SWYD PCB-24 Fails To Trip On Demand	2.60E-05
932	SPCB026CHO	1	SWYD PCB-26 Fails To Trip On Demand	2.60E-05
933	SPCB028CHO	1	SWYD PCB-28 Fails To Trip On Demand	2.60E-05
934	SPCB033CHO	1	SWYD PCB-33 Fails To Open On Demand	2.60E-05
935	SPCD87LRYT	24	Line Differential Relay 87L Spurious Operation	8.64E-06
936	SPCGLASSWT	24	Break Glass Switch Spurious Operation	1.68E-06
937	SPCR86TRYT	24	Lock Out Relay 86T Spurious Operation	8.64E-06
938	SU127UVCOM	1.18E-04	Common Cause Failure of Unit 1 SU Bus Undervoltage Relays	1.18E-04
939	SU227UVCOM	1.18E-04	Common Cause Failure of Unit 2 SU Bus Undervoltage Relays	1.18E-04
940	SU327UVCOM	1.18E-04	Common Cause Failure of Unit 3 SU Bus Undervoltage Relays	1.18E-04
941	SXFRCT3THF	24	Transformer CT3 Faulted	7.44E-05
942	SXFRCT3THM	1.74E-04	Transformer CT3 Is In Maintenance	1.74E-04
943	SXFRCT4LHE	6.40E-05	Latent Human Error on CT4 Maintenance	6.40E-05
944	SXFRCT4THM	9.13E-04	Transformer CT4 Is In Maintenance	9.13E-04
945	SY30R94RYT	24	PCB 30 Relay 94 Spuriously Picks Up	8.64E-06
946	SY51TN2RYT	24	230kV Neutral Ground Relay Spuriously Picks Up	8.64E-06
947	SY51TN4RYT	24	4.16kV Neutral Ground Relay Spuriously Picks Up	8.64E-06
948	SY51TN6RYT	24	6.9kV Neutral Ground Relay 51TN Spuriously Picks Up	8.64E-06
949	SY62X1FRYT	24	Breaker Failure Relay 62X1 Spuriously Picks Up	8.64E-06
950	SY62X2FRYT	24	Breaker Failure Relay 62X2 Spuriously Picks Up	8.64E-06
951	SY62XXFRYT	24	Breaker Failure Relay 62X Spuriously Picks Up	8.64E-06
952	SY86BUIRYT	24	CT3 6.9kV Start Up Bus Lockout Relay Spuriously Picks Up	8.64E-06
953	SY86CT3RYT	24	Transformer CT3 Lockout Relay Spuriously Picks Up	8.64E-06
954	SY86YA9RYT	24	Yellow Bus Lockout Auxiliary Relay 86YA9 Spuriously Picks Up	8.64E-06
955	SY86YJ3RYT	24	Yellow Bus Lockout Auxiliary Relay 86YJ30 Spuriously Picks Up	8.64E-06
956	SY87BYXRYT	24	Yellow Bus X Phase Differential Relay 87BYX Spuriously Picks Up	8.64E-06
957	SY87BYYRYT	24	Yellow Bus Y Phase Differential Relay 87BYY Spuriously Picks Up	8.64E-06
958	SY87BYZRYT	24	Yellow Bus Z Phase Differential Relay 86BYZ Spuriously Picks Up	8.64E-06
959	SY87LXXRYT	24	Differential Auxiliary Relay 87LX Spuriously Picks Up	8.64E-06
960	SY94L1XRYT	24	Protective Relay 94L Spuriously Picks Up	8.64E-06
961	SYE1362RYT	24	E13 Bkr Failure Relay 62B Spuriously Picks Up	8.64E-06
962	SYE2362RYT	24	E23 Bkr Failure Relay 62B Spuriously Picks Up	8.64E-06

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	NAME	FACTOR	DESCRIPTION	PROBABILITY
963	SYP2862RYT	24	PCB 28 Breaker Failure Relay 62B Spuriously Picks Up	8.64E-06
964	SYP3062RYT	24	PCB 30 Breaker Failure Relay 62B Spuriously Picks Up	8.64E-06
965	SYP86TXRYT	24	PCB 30 LOR 86TX Spuriously Picks Up	8.64E-06
966	SYPCB09CHT	24	Switchyard Power Circuit Breaker 9 Transfers Open	4.56E-05
967	SYPCB30CHT	24	Switchyard Power Circuit Breaker 30 Transfers Open	4.56E-05
968	SYPL86TRYT	24	PCB 30 LOR 86T Spuriously Picks Up	8.64E-06
969	SYPL87LRYT	24	Differential Relay 87L Spuriously Picks Up	8.64E-06
970	SYR86BYRYT	24	Yellow Bus Lockout Relay 86BY Spuriously Picks Up	8.64E-06
971	SYS63FPRYT	24	Fault Pressure Relay 63FP Spuriously Picks Up	8.64E-06
972	SYSX50BRYT	24	Transformer CT3 Fault Detector Relay 50B Spuriously Picks Up	8.64E-06
973	SYX87TBRYT	24	Differential Relay 87B Spuriously Picks Up	8.64E-06
974	SYXX87TRYT	24	Differential Relay 87T Spuriously Picks Up	8.64E-06
975	U5086EFRYT	24	Overcurrent Relay 50 Spuriously Actuates Lockout Rly 86EF	8.64E-06
976	U5186EFRYT	24	Time Delay Overcurrent Relay 51 Actuates Lockout Relay 86EF	8.64E-06
977	U51TNC4RYT	24	CT4 Neutral Ground Rly Actuates CT4 LOR 86T/CT4	8.64E-06
978	U62BSK1RYT	24	SK1 Breaker Failure Relay 62BXSK1 Spuriously Picks Up	8.64E-06
979	U62BSK2RYT	24	SK2 Breaker Failure Relay 62BXSK2 Spuriously Picks Up	8.64E-06
980	U86CT4XRYT	24	Auxiliary Lockout Relay 86CT4X Spuriously Picks Up	8.64E-06
981	U86TCT4RYT	24	CT4 Lockout Relay 86T/CT4 Spuriously Picks Up	8.64E-06
982	U87TCT4RYT	24	Spurious Op of CT4 Differential Rly 87T Actuates LOR 86EF	8.64E-06
983	UACXCT4THF	24	Transformer CT4 Failed	7.44E-05
984	UXX86EFRYT	24	Lockout Relay 86EF Spuriously Picks Up	8.64E-06
985	WK00RUNCOM	2.09E-05	Common Cause Failure of Keowee Governors to Run	2.09E-05
986	WK1GVCDDEX	3.5E-05	Keowee Unit 1 Gov. Fails to Position Wicket Gates During a Cold Start	3.50E-05
987	WK1GVCDLHE	2.6E-4	Latent Human Error Fails Keowee 1 Governor During Cold Start	2.60E-04
988	WK1GVHTDEX	3.5E-04	Keowee Unit 1 Gov. Fails to Position Wicket Gates During Hot Start	3.50E-04
989	WK1GVRNDEX	5.6E-4	Keowee Unit 1 Gov. Fails to Position Wicket Gates With Unit Running	5.60E-04
990	WK1SPD1DEX	1.0	Potentially Damaging Overspeed Condition Occures At Load Rejection	1.00E+00
991	WK1SPD2DEX	5.6E-05	Keowee Unit 1 Governor Failure Creates Overspeed Condition	5.60E-05
992	WK1TBCDDEX	3.5E-5	Keowee Unit 1 Turbine Fails During a Cold Start	3.50E-05
993	WK1TBHTDEX	3.5E-4	Keowee Unit 1 Turbine Fails During a Hot Start	3.50E-04
994	WK1TBRNDEX	5.6e-4	Keowee Unit 1 Turbine Fails With the Unit Running	5.60E-04
995	WK2GVCDDEX	3.5E-05	Keowee Unit 2 Gov. Fails to Position Wicket Gates During Cold Start	3.50E-05
996	WK2GVCDLHE	2.6E-4	Latent Human Error Fails Keowee 2 Governor During Cold Start	2.60E-04
997	WK2GVHTDEX	3.5E-04	Keowee Unit 2 Gov. Fails to Position Wicket Gates During Hot Start	3.50E-04
998	WK2GVRNDEX	5.6E-4	Keowee Unit 2 Gov. Fails to Position Wicket Gates With Unit Running	5.60E-04
999	WK2SPD2DEX	5.6E-05	Keowee Unit 2 Governor Failure Creates Overspeed Condition	5.60E-05

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	NAME	FACTOR	DESCRIPTION		PROBABILITY
1000	WK2TBCDDEX	3.5E-5	Keowee Unit 2 Turbine Fails During a Cold Start		3.50E-05
1001	WK2TBHTDEX	3.5E-4	Keowee Unit 2 Turbine Fails During a Hot Start		3.50E-04
1002	WK2TBRNDEX	5.6E-4	Keowee Unit 2 Turbine Fails With the Unit Running		5.60E-04
1003	WKCSTRTCOM	1.12E-05	Common Cause Failure of Keowee Governors to Cold Start		1.12E-05
1004	WKHSTRTCOM	3.50E-6	Common Cause Failure of Keowee Governors to Hot Start		3.50E-06
1005	XA0SWGRCOM	1.22E-06	Common Cause Failure Of Transformers 1X, 2X, And CX		1.22E-06
1006	XA1A2BTCDT	24	600 Vac Breaker 1XA-2BT Transfers Position	K-704	1.80E-06
1007	XA1BKRSCOM	3.10E-04	CCF of 1X Aux Power Breakers ACB-5 & -7		3.10E-04
1008	XA1TR1XTLF	24	Keowee Transformer 1X Fails		1.80E-05
1009	XA1X2AXCLT	24	600 Vac Breaker 1X-2A Transfers Position		2.18E-05
1010	XA1X2CCCLT	24	600 Vac Breaker 1X-2C Transfers Position		2.18E-05
1011	XA1XA1ACLT	24	600 Vac Breaker 1XA-1A Transfers Open		2.18E-05
1012	XA1XAALBLM	2.74E-03	MCC 1XA Is Connected to Its Alternate Source of Power		2.74E-03
1013	XA1XAMCBLF	24	600 Vac MCC 1XA Fault		6.48E-06
1014	XA1XCXXTHM	4.57E-04	4160/600 Vac Transformer CX Is In Maintenance		4.57E-04
1015	XA1XCXXTLF	24	4160/600 Vac Transformer CX Fails		1.80E-05
1016	XA1XXXXBLF	24	600 Vac Switchgear 1X Fault		6.48E-06
1017	XA2A2BTCDT	24	600 Vac Breaker 2XA-2BT Transfers Position		1.80E-06
1018	XA2BKRSCOM	3.10E-04	CCF of Aux Power Breakers ACB-6 & -8		3.10E-04
1019	XA2TR2XTLF	24	Keowee Transformer 2X Fails		1.80E-05
1020	XA2X2BXCLT	24	600 Vac Breaker 2X-2B Transfers Position		2.18E-05
1021	XA2X2DXCLT	24	600 Vac Breaker 2X-2D Transfers Open		2.18E-05
1022	XA2X4AXCLT	24	600 Vac Breaker 2XA-4A Transfers Position		2.18E-05
1023	XA2XAALBLM	2.74E-03	MCC 2XA Is Connected to Its Alternate Power Source		2.74E-03
1024	XA2XAMCBLF	24	600 Vac MCC-2XA Fault		6.48E-06
1025	XA2XXXXBLF	24	600 Vac Switchgear 2X Fault		6.48E-06
1026	XA56BKRCOM	3.10E-04	Common Cause Failure Of ACB-5 And ACB-6 To Close		3.10E-04
1027	XA78BKRCOM	3.10E-04	Common Cause Failure Of ACB-7 And ACB-8 To Close		3.10E-04
1028	XD0BATTCOM	2.70E-05	Common Cause Failure Of Keowee I&C Power Batteries		2.70E-05
1029	XD0CHRGCOM	3.48E-05	Common Cause Failure Of Keowee Battery Chargers		3.48E-05
1030	XD104CCCDT	24	Breaker 1DA-4CC Transfers Open		1.80E-06
1031	XD104CRCDT	6	Breaker 1DA-4CR Transfers Open		4.50E-07
1032	XD1BK1ACDT	24	Battery No. 1 Breaker 1A Transfers Position	run time dependent	1.80E-06
1033	XD1CKC1BCF	24	Battery Charger KC1 Fails		6.96E-04
1034	XD1DA1CCDT	24	125 Vdc Breaker 1C (from charger KC1) Transfers Position		1.80E-06
1035	XD1DA3BCDT	24	125 Vdc Breaker 1DA-3BR Transfers Open		1.80E-06
1036	XD1DA4ACDT	24	DC Circuit Breaker 1DA-4AR Transfers Position		1.80E-06

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	NAME	FACTOR	DESCRIPTION		PROBABILITY
1037	XD1DALTBYM	5.48E-03	Normal Power To Dist. Center 1DA Is In Test and Maintenance		5.48E-03
1038	XD1DARXBDF	24	DC Distribution Center 1DA Faulted during Run		7.68E-06
1039	XD1KB1XDHE	1	Keowee Standby Battery Charger SBC Not Lined Up in 1 Hour		1.00E+00
1040	XD1KB1XRHE	1	Keowee Standby Battery Charger SBC Not Lined Up in 1 Hour		1.00E+00
1041	XD1KBATBYF	1	Keowee Battery No. 1 Fails During Discharge		9.30E-04
1042	XD1TIE1CDT	24	Keowee 125V dc Dist Cntr 1DA Tie Breaker 1 Transfers Position		1.80E-06
1043	XD202CCCDT	6	Breaker 2DA-2CC Transfers Open		4.50E-07
1044	XD204CCCDT	24	Breaker 2DA-4CC Transfers Open	K-704	1.80E-06
1045	XD2BK1ACDT	24	Battery No. 2 Breaker 1A Transfers Position		1.80E-06
1046	XD2CKC2BCF	24	Battery Charger KC2 Fails		6.96E-04
1047	XD2DA2ACDT	24	DC Circuit Breaker 2DA-2AR Transfers Position		1.80E-06
1048	XD2DA3BCDT	24	125 Vdc Circuit Breaker 2DA-3BR Transfers Position		1.80E-06
1049	XD2DA5CCDT	24	125 Vdc Breaker 2DA-5C (from Charger KC2) Transfers Open		1.80E-06
1050	XD2DALTBYM	5.48E-03	Normal Power To Dist Cntr 2DA Is In Test and Maintenance		5.48E-03
1051	XD2DARXBDF	24	DC Distribution Center 2DA Faulted During Run		7.68E-06
1052	XD2KB2XDHE	1	Keowee Standby Battery Charger SBC Not Lined Up in 1 Hour		1.00E+00
1053	XD2KB2XRHE	1	Keowee Standby Battery Charger SBC Not Lined Up in 1 Hour		1.00E+00
1054	XD2KBATBYF	1	Keowee Battery No. 2 Fails during Discharge		9.30E-04
1055	XD2TIE2CDT	24	Keowee 125V dc Dist Cntr 2DA Tie Breaker 2 Transfers Position		1.80E-06
1056	Y0STARTCOM	7.26E-06	Common Cause Failure Of Emergency Start Signal		7.26E-06
1057	YK114X3SSD	1	Keowee 1 Speed Switch 14-3 Fails to Open at 65 rpm	KEE-111	1.80E-05
1058	YK13SUISWT	24	KHU#1 Startup Inhibit Sw 3SUI Xfrs to Inhibit	KEE-111, -113	1.68E-06
1059	YK14AMRRYT	24	Keowee 1 Master Relay 4A Spuriously Drops Out		8.64E-06
1060	YK14BMRRYT	24	Keowee 1 Master Relay 4B Spuriously Drops Out		8.64E-06
1061	YK163BHLST	24	Keowee 1 Gen Thrst Brng Oil Lvl Hi Sw 63BL/H Sprsly Clsd	KEE-111, -113-3	7.44E-06
1062	YK163BHRYT	24	Keowee 1 Gen Thrst Brng Oil Lvl Hi Rly 63BL/HX Sprsly Picks Up	KEE-111,-113-	8.64E-06
1063	YK163BLLST	24	Keowee 1 Gen Thrst Brng Oil Lvl Lo Sw 63BL/L Spuriously Operates	KEE-111,-113-	7.44E-06
1064	YK163BLRYT	24	Keowee 1 Gen Thrst Brng Oil Lvl Lo Rly 63BL/LXTD Sprsly Pcks Up	KEE-111, -113-	8.64E-06
1065	YK163TBLST	24	Keowee 1 Turb Guide Brng Lo Lvl Sensor Sw Spuriously Closes	KEE-113-4	7.44E-06
1066	YK163TBRYT	24	Keowee 1 Turb Gd Brng Oil Lvl Lo Rly 63TB/1X Sprsly Picks Up	KEE-111,-113-4	8.64E-06
1067	YK186N1DEX	9.89E-03	Keowee 1 Normal Lockout Actuates		9.89E-03
1068	YK199SDRYD	1	Keowee 1 Shutdown Solenoid 99SD Fails To Pick Up		3.30E-05
1069	YK199SDRYT	24	Keowee 1 Shutdown Solenoid Spuriously Drops Out		8.64E-06
1070	YK199SNRYD	1	K1 Emergency Load Solenoid 99SN Fails To Pick Up/Drop Out		3.30E-05
1071	YK199SNRYT	24	Emergency Load Solenoid 99SN Spuriously Drops Out		8.64E-06
1072	YK199SXRYD	1	Keowee 1 Shutdown Solenoid Aux Relay 99SX Fails to Pick Up	KEE-111	3.30E-05
1073	YK199SXRYT	24	Shutdown Auxiliary Relay 99SX Spuriously Drops Out		8.64E-06

Table E-6

Keowee PRA Basic Event Data
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	NAME	FACTOR	DESCRIPTION	PROBABILITY
1074	YK1D4CRFUF	6	Fuse 1DA-4CR Fails	2.16E-05
1075	YK1ES1ARYD	1	Keowee 1 Emergency Start Aux Relay 1ESRX/1A Fails To Pick Up OEE-120	3.30E-05
1076	YK1ES1BRYD	1	Keowee 1 Emergency Start Aux Relay 1ESRX/1B Fails To Pick Up OEE-120-1	3.30E-05
1077	YK1ES2ARYD	1	Keowee 1 Emergency Start Aux Relay 1ESRX/2A Fails To Pick Up OEE-120	3.30E-05
1078	YK1ES2BRYD	1	Keowee 1 Emergency Start Aux Relay 1ESRX/2B Fails To Pick Up OEE-120-1	3.30E-05
1079	YK1MR4ARYD	1	Keowee 1 Start Master Relay 4A Fails To Pick Up KEE-113	3.30E-05
1080	YK1MR4BRYD	1	Keowee 1 Start Master Relay 4B Fails To Pick Up KEE-113	3.30E-05
1081	YK1SS12SST	24	Keowee 1 Overspeed Switch 12 Spuriously Picks Up KEE-111	1.01E-04
1082	YK1SS13SSD	1	Keowee 1 Speed Switch 13 Fails to Close at 122 rpm KEE-111	1.80E-05
1083	YK214X3SSD	1	KHU#2 Speed Switch 14-3 Fails to Open at 65 rpm KEE-211	1.80E-05
1084	YK23SUISWT	24	KHU#2 Startup Inhbt Sw 3SUI Sprsly Xfrs to Inhibit KEE-211, -213	1.68E-06
1085	YK24AMRRYT	24	Keowee 2 Master Relay 4A Spuriously Drops Out	8.64E-06
1086	YK24BMRRYT	24	Keowee 2 Master Relay 4B Spuriously Drops Out	8.64E-06
1087	YK263BHLST	24	Keowee 2 Gen Thrst Brng Oil Lvl Hi Sw 63BL/H Sprsly Clsd	7.44E-06
1088	YK263BHRYT	24	Keowee 2 Gen Thrst Brng Oil Lvl Hi Rly 63BL/HX Sprsly Picks Up KEE-211	8.64E-06
1089	YK263BLLST	24	Keowee 2 Gen Thrst Brng Oil Lvl Lo Sw 63BL/L Sprsly Opn	7.44E-06
1090	YK263BLRYT	24	Keowee 2 Gen Thrst Brng Oil Lvl Lo Rly 63BL/LXTD Sprsly Pcks Up KEE-211	8.64E-06
1091	YK263TBLST	24	Keowee 2 Turb Guide Brng Lo Lvl Sensor Sw Sprsly Closes	7.44E-06
1092	YK263TBRYT	24	Keowee 2 Turb Gd Brng Oil Lvl Lo Rly 63TB/1X Sprsly Picks Up KEE-211	8.64E-06
1093	YK286N2DEX	7.41E-03	Keowee Unit 2 Normal Lockout Activates	7.41E-03
1094	YK299SDRYD	1	Keowee 2 Shutdown Solenoid 99SD Fails To Pick Up	3.30E-05
1095	YK299SDRYT	24	Keowee 2 Shutdown Solenoid Spuriously Drops Out	8.64E-06
1096	YK299SNRYD	1	Keowee 2 Emergency Load Solenoid 99SN Fails To Operate	3.30E-05
1097	YK299SNRYT	24	Emergency Load Solenoid 99SN Spuriously Drops Out	8.64E-06
1098	YK299SXRYD	1	Keowee 2 Shutdown Solenoid Aux Relay 99SX Fails to Pick Up KEE-211	3.30E-05
1099	YK299SXRYT	24	Shutdown Auxiliary Relay 99SX Spuriously Drops Out s	8.64E-06
1100	YK2D2CCFUF	6	Fuse 2DA-2CC Fails	2.16E-05
1101	YK2ES1ARYD	1	Keowee 2 Emergency Start Aux Relay 2ESRX/1A Fails To Pick Up OEE-120	3.30E-05
1102	YK2ES1BRYD	1	Keowee 2 Emergency Start Aux Relay 2ESRX/1B Fails to Pick Up OEE-120-1	3.30E-05
1103	YK2ES2ARYD	1	Keowee 2 Emergency Start Aux Relay 2ESRX/2A Fails to Pick Up OEE-120	3.30E-05
1104	YK2ES2BRYD	1	Keowee 2 Emergency Start Aux Relay 2ESRX/2B Fails to Pick Up OEE-120-1	3.30E-05
1105	YK2MR4ARYD	1	Keowee 2 Start Master Relay 4A Fails To Pick Up KEE-213	3.30E-05
1106	YK2MR4BRYD	1	Keowee 2 Start Master Relay 4B Fails to Pick Up KEE-213	3.30E-05
1107	YK2SS12SST	24	Keowee 2 Overspeed Switch 12 Spuriously Picks Up KEE-211	1.01E-04
1108	YK2SS13SSD	1	Keowee 2 Speed Switch 13 Fails to Close at 122 rpm KEE-211	1.80E-05
1109	YKEMSRTCHE	0	Operator Incorrectly Resets Keowee Emergency Start Signals	0.00E+00
1110	YO1DIA2CDT	30	DC Circuit Breaker 1DIA-2 Transfers Position	2.25E-06

Table E-6

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	NAME	FACTOR	DESCRIPTION	PROBABILITY
1111	YO1DIB2CDT	30	DC Circuit Breaker 1DIB-2 Transfers Position	2.25E-06
1112	YO1MFBMA	1	ONS1 MFB Monitor Channel A Keowee Start Signal Fails	1.00E+00
1113	YO1MFBMB	1	ONS1 MFB Monitor Channel B Keowee Start Signal Fails	1.00E+00
1114	YO1OPSARHE	1	Operator fails to operate Keowee start switch S1A	1.00E+00
1115	YO1OPSBRHE	1	Operator fails to operate Keowee start switch S1B	1.00E+00
1116	YO1S1AFSWC	1	Control Switch S1A Fails To Close On Demand	1.00E-05
1117	YO1S1BFSWC	1	Control Switch S1B Fails To Close On Demand	1.00E-05
1118	YO1XXKARYD	1	ONS1 Ch A Keowee Emergency Start Relay KA Fails to Pick Up OEE-120	3.30E-05
1119	YO1XXKBRYD	1	Oconee Unit 1 Chan. B Keowee Emergency Start Relay Fails OEE-120-1	3.30E-05
1120	YO2CR2ARYD	1	ONS2 Ch A Keowee Emergency Start Relay CR2A Fails to Pick Up OEE-220	3.30E-05
1121	YO2CR2BRYD	1	ONS2 Keowee Emergency Start Relay CR2B Fails to Pick Up OEE-220-1	3.30E-05
1122	YO2DIA2CDT	30	Breaker 2DIA-2 Transfers Position	2.25E-06
1123	YO2DIB2CDT	30	Breaker 2DIB-2 Transfers Position	2.25E-06
1124	YO2MFBMA	1	ONS2 MFB Monitor CH A Keowee Start Sig Fails	1.00E+00
1125	YO2MFBMB	1	ONS2 MFB Monitor Ch B Keowee Start Sig Fails	1.00E+00
1126	YO2SSWARHE	1	Operator Fails to Operate Keowee Start Switch 2SSW'A'	1.00E+00
1127	YO2SSWASWC	1	Control Switch 2SSW'A' Fails To Close On Demand	1.00E-05
1128	YO2SSWBRHE	1	Operator Fails to Operate Keowee Start Switch 2SSW'B'	1.00E+00
1129	YO2SSWBSWC	1	Control Switch 2SSW'B' Fails To Close On Demand	1.00E-05
1130	YO3CR3ARYD	1	ONS3 Ch A Keowee Emergency Start Relay CR3A Fails To Pick Up OEE-320	3.30E-05
1131	YO3CR3BRYD	1	ONS3 Keowee Emer Start Relay CR3B Fails to Pick Up OEE-320-1	3.30E-05
1132	YO3DIA2CDT	30	Breaker 3DIA-2 Transfers Open OEE-320, O-2705	2.25E-06
1133	YO3DIB2CDT	30	Breaker 3DIB-2 Transfers Open OEE-320-1, O-2705	2.25E-06
1134	YO3MFBMA	3.96E-03	ONS3 MFB Monitor Ch A Keowee Start Sig Fails	3.96E-03
1135	YO3MFBMB	3.96E-03	ONS3 MFB Monitor Ch B Keowee Start Sig Fails	3.96E-03
1136	YO3OPFARHE	1	Operator fails to operate Keowee Start Switch 3S1A	1.00E+00
1137	YO3OPFBRHE	1	Operator Fails to Operate Keowee Start Switch 3S1B	1.00E+00
1138	YO3S1AFSWC	1	Control Switch S1A Fails To Close On Demand	1.00E-05
1139	YO3S1BFSWC	1	Control Switch S1B Fails To Close On Demand	1.00E-05
1140	YO3SSWARHE	1	Operator fails to operate Keowee Start Switch 3SSW'A'	1.00E+00
1141	YO3SSWASWC	1	Control Switch 3SSW'A' Fails To Close On Demand	1.00E-05
1142	YO3SSWBRHE	1	Operator Fails to Operate Keowee Start Switch 3SSW'B'	1.00E+00
1143	YO3SSWBSWC	1	Control Switch 3SSW'B' Fails To Close On Demand	1.00E-05

Table E-7

Keowee PRA Basic Event Data
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	NAME	FACTOR	DESCRIPTION	PROBABILITY
1	AA1271PR6D	1	Transformer 1X Undervoltage Relay 27/1X Fails To Pick Up	2.49E-04
2	AA1271XR6T	30	Transformer 1X Undervoltage Relay 27/1X Spuriously De-energizes	1.09E-05
3	AA127C1R6T	24	Transformer CX Undervoltage Relay 27/CX1 Spuriously De-energizes	8.71E-06
4	AA127CPR6D	1	Transformer CX Undervoltage Relay 27/CX1 Fails To Pick Up	2.49E-04
5	AA127R1RYT	24	Auxiliary Relay 27X/CX1 Spurious Operation	8.64E-06
6	AA127X1RYD	1	Auxiliary Relay 27X/1X Fails To Operate On Demand	3.30E-05
7	AA127X1RYT	384	Auxiliary Relay 27X/1X Spurious Operation	1.38E-04
8	AA127X2R6D	1	Transformer CX Undervoltage Relay 27/CX1 Fails To Drop Out	2.49E-04
9	AA127XCRYD	1	Auxiliary Relay 27/CX1 Fails To Operate On Demand	3.30E-05
10	AA186CXRYT	24	Transformer CX Differential Lock Out Relay 86CX Spurious Operation	8.64E-06
11	AA186S1RYT	24	Switchgear 1X Lockout Relay 86S/1X Spurious Operation	8.64E-06
12	AA187CXRYT	24	Transformer CX Differential Relay 87CX Spurious Operation	8.64E-06
13	AA2272PR6D	1	Transformer 2X Undervoltage Relay 27/2X Fails To Pick Up	2.49E-04
14	AA2272XR6D	1	Transformer 2X Undervoltage Relay 27/2X Fails To Drop Out	2.49E-04
15	AA2272XR6T	24	Transformer 2X Undervoltage Relay 27/2X Spuriously De-energizes	8.71E-06
16	AA227C2R6T	30	Transformer CX Undervoltage Relay 27/CX2 Spuriously De-energizes	1.09E-05
17	AA227C2RYD	1	Auxiliary Relay 27X/CX2 Fails To Operate On Demand	3.30E-05
18	AA227CPR6D	1	Transformer CX Undervoltage Relay 27/CX2 Fails To Pick Up	2.49E-04
19	AA227R2RYT	384	Auxiliary Relay 27X/CX2 Spurious Operation	1.38E-04
20	AA227T2R6D	1	Transformer 2X Undervoltage Relay (27T/2X) Fails To Drop Out	2.49E-04
21	AA227X2RYD	1	Auxiliary Relay 27X/2X Fails To Operate On Demand	3.30E-05
22	AA227X2RYT	24	Auxiliary Relay 27X/2X Spurious Operation	8.64E-06
23	AA286S2RYT	24	Switchgear 2X Lockout Relay 86S/2X Spurious Operation	8.64E-06
24	AB004ECCDT	30	DC Circuit Breaker 1DA-4EC Transfers Position	2.25E-06
25	AB0086TRYD	1	Keowee Main Tx Lock Out Relay 86T Fails To Operate On Demand	3.30E-05
26	AB0624CRYD	1	Time Delay Relay 62-4c Fails To Operate On Demand	3.30E-05
27	AB086E1RYD	1	Emergency Lock Out Relay 86E-1 Fails To Operate On Demand	3.30E-05
28	AB086TGRYD	1	General Keowee Main Tx Lock Out Sensing Relay Fails To Operate	3.30E-05
29	AB0SWGRCOM	6.69E-04	Common Cause Failure Of All Keowee Auxiliary Power Breakers	6.69E-04
30	AB0SWGRRHE	5.0E-01	Recovery of Keowee Aux Power Breakers by Manual Control	5.00E-01
31	AB152TCSVO	1	Air Circuit Breaker 1 Trip Coil Fails To Operate	2.90E-05
32	AB1ACCUDEX	3.51E-05	Air Circuit Breaker 1 Accumulator Air Pressure Low	3.51E-05
33	AB1FALTDEX	1.75E-05	Fault Occurs at ACB-1 When The BReaker Trips	1.75E-05
34	AB1MECHDEX	1.51E-4	Air Circuit Breaker 1 Fails To Open Due To Mechanical Failure	1.51E-04
35	AB1OPENLHE	2.60E-4	Air Circuit Breaker 1 Fails To Open Due To A Latent Human Error	2.60E-04
36	AB1PS02PST	12	Air Circuit Breaker 1 Accumulator Pressure Switch PS2 Fails Low	5.16E-06
37	AB1PSWTPST	24	Air Circuit Breaker 1 Accumulator Pressure Switch Fails Low	1.03E-05

Table E-7

Keowee PRA Basic Event Data
Two Unit Generation - Bayesian Update/Recovered

	NAME	FACTOR	DESCRIPTION	PROBABILITY
38	AB1R52ZR6D	1	Air Circuit Breaker 1 Relay 52Z Fails To Operate	2.49E-04
39	AB21521SWT	30	Control Switch 152-2 Spurious Operation	2.10E-06
40	AB22BV1RYT	24	Backup Undervoltage Relay 2BV1 Spurious Operation	8.64E-06
41	AB23BKRCOM	1.12e-04	Common Cause Failure Of Air Circuit Breakers 2 And 3 To Close	1.12E-04
42	AB24BKRCOM	1.12E-04	Common Cause Failure Of Air Circuit Breakers 2 And 4 To Close	1.12E-04
43	AB251G2RYT	24	Air Circuit Breaker 2 Overcurrent Ground Relay 51G-2 Spurious Operation	8.64E-06
44	AB252CCSVO	1	Air Circuit Breaker 2 Close Coil Fails To Operate	2.90E-05
45	AB252TCSVO	1	Air Circuit Breaker 2 Trip Coil Fails To Operate	2.90E-05
46	AB252TCSVT	36	Air Circuit Breaker 2 Trip Coil Spurious Operation	1.40E-05
47	AB252Y2R6D	1	Air Circuit Breaker 2 Relay 52Y Failed To Drop Out Following Last Demand	2.49E-04
48	AB252Y2R6T	12	Air Circuit Breaker 2 Y-relay Spurious Operation	4.36E-06
49	AB2ACCUDEX	3.51E-05	Air Circuit Breaker 2 Accumulator Air Pressure Low	3.51E-05
50	AB2CLOSLHE	2.60E-4	Air Circuit Breaker 2 Fails To Close Due To A Latent Human Error	2.60E-04
51	AB2KEYISWT	12	Air Circuit Breaker 2 Key Interlock Switch Transfers Open	8.40E-07
52	AB2MCH2DEX	3.02E-4	Air Circuit Breaker 2 Fails To Close Due To Mechanical Failure	3.02E-04
53	AB2MECHDEX	1.51E-4	Air Circuit Breaker 2 Fails To Open Due To Mechanical Failure	1.51E-04
54	AB2OPENLHE	2.60E-4	Air Circuit Breaker 2 Fails To Open Due To A Latent Human Error	2.60E-04
55	AB2PS02PST	12	Air Circuit Breaker 2 Accumulator Pressure Switch PS2 Fails Low	5.16E-06
56	AB2PSWTPST	24	Air Circuit Breaker 2 Accumulator Pressure Switch Fails Low	1.03E-05
57	AB2PUSHPBT	36	Trip Pushbutton On ACB2 Spurious Operation	8.64E-06
58	AB2R462RYT	24	Air Circuit Breaker 2 Negative Sequence Relay 46-2 Spurious Operation	8.64E-06
59	AB2R52XR6D	1	Air Circuit Breaker 2 Relay 52X Fails To Operate	2.49E-04
60	AB2R52ZR6D	1	Air Circuit Breaker 2 Relay 52Z Fails To Operate	2.49E-04
61	AB2R52ZR6T	36	Air Circuit Breaker 2 Relay 52Z Spurious Operation	1.31E-05
62	AB31523SWT	24	Control Switch 152-3 Spurious Operation	1.68E-06
63	AB352CCSVO	1	Air Circuit Breaker 3 Close Coil Fails To Operate	2.90E-05
64	AB352TCSVO	1	Air Circuit Breaker 3 Trip Coil Fails To Operate	2.90E-05
65	AB352TCSVT	24	Air Circuit Breaker 3 Trip Coil Spurious Operation	9.36E-06
66	AB352Y2R6D	1	Air Circuit Breaker 3 Relay 52Y Failed To Drop Out Following Last Demand	2.49E-04
67	AB352Y2R6T	360	Air Circuit Breaker 3 Y-relay Spurious Operation	1.31E-04
68	AB3ACCUDEX	3.51E-05	Air Circuit Breaker 3 Accumulator Air Pressure Low	3.51E-05
69	AB3CLOSLHE	2.60e-04	Air Circuit Breaker 3 Fails To Close Due To Latent Human Error	2.60E-04
70	AB3MCH2DEX	3.02E-04	Air Circuit Breaker 3 Fails To Close Due To Mechanical Failure	3.02E-04
71	AB3MECHDEX	1.51E-04	Air Circuit Breaker 3 Fails To Open Due To Mechanical Failure	1.51E-04
72	AB3PS02PST	372	Air Circuit Breaker 3 Accumulator Pressure Switch PS2 Fails Low	1.60E-04
73	AB3PSWTPST	24	Air Circuit Breaker 3 Accumulator Pressure Switch Fails Low	1.03E-05
74	AB3PUSHPBT	24	Trip Pushbutton On ACB3 Spurious Operation	5.76E-06

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Keowee PRA Basic Event Data
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	NAME	FACTOR	DESCRIPTION	PROBABILITY
75	AB3R52XR6D	1	Air Circuit Breaker 3 Relay 52X Fails To Operate	2.49E-04
76	AB3R52ZR6D	1	Air Circuit Breaker 3 Relay 52Z Fails To Operate	2.49E-04
77	AB3R52ZR6T	24	Air Circuit Breaker 3 Relay 52Z Spurious Operation	8.71E-06
78	AB41523SWT	24	Control Switch 152-4 Spurious Operation	1.68E-06
79	AB452CCSVO	1	Air Circuit Breaker 4 Close Coil Fails To Operate	2.90E-05
80	AB452TCSVT	24	Air Circuit Breaker 4 Trip Coil Spurious Operation	9.36E-06
81	AB452Y2R6D	1	Air Circuit Breaker 4 Relay 52Y Failed To Drop Out Following Last Demand	2.49E-04
82	AB452Y2R6T	372	Air Circuit Breaker 4 Y-relay Spurious Operation	1.35E-04
83	AB4ACCUDEX	3.51E-05	Air Circuit Breaker 4 Accumulator Air Pressure Low	3.51E-05
84	AB4CLOSLHE	2.60E-4	Air Circuit Breaker 4 Fails To Close Due To A Latent Human Error	2.60E-04
85	AB4CLSESWC	1	Air Circuit Breaker 4 Close Switch Fails To Close On Demand	1.00E-05
86	AB4KEYISWT	372	Air Circuit Breaker 4 Key Interlock Switch Transfers Open	2.60E-05
87	AB4LORESWT	372	Air Circuit Breaker 4 Local/Remote Switch Contact Transfers Position	2.60E-05
88	AB4MCH2DEX	3.02E-04	Air Circuit Breaker 4 Fails To Close Due To Mechanical Failure	3.02E-04
89	AB4PS02PST	372	Air Circuit Breaker 4 Accumulator Pressure Switch PS2 Indicates Low Pressure	1.60E-04
90	AB4PSWTPST	12	Air Circuit Breaker 4 Accumulator Pressure Switch Indicates Low Air Pressure	5.16E-06
91	AB4PUSHPBT	24	Trip Pushbutton On ACB-4 Spurious Operation	5.76E-06
92	AB4R52XR6D	1	Air Circuit Breaker 4 Relay 52X Fails To Operate	2.49E-04
93	AB4R52ZR6T	24	Air Circuit Breaker 4 Relay 52Z Spurious Operation	8.71E-06
94	AB510A1FUF	6	One Or More Control Power Fuses For X, Y And CC Fail	2.16E-05
95	AB51431LHE	3.20E-4	Manual/Auto Control Switch 143/1 Left In Manual	3.20E-04
96	AB51431RYT	360	Auxiliary Relay 143X/1 Spuriously Energizes	1.30E-04
97	AB51431SWT	360	Manual/Auto Control Switch 143/1 Spuriously Transfers Into Manual	2.52E-05
98	AB552CCRYD	1	Air Circuit Breaker 5 Close Coil CC Fails On Demand	3.30E-05
99	AB552TCRYT	384	Air Circuit Breaker 5 Trip Coil 52TC Spurious Operation	1.38E-04
100	AB552Y2RYT	360	Air Circuit Breaker 5 Y-relay Spurious Operation	1.30E-04
101	AB583S5RYD	1	Time Delay Relay 83S5 Fails To Pick Up	3.30E-05
102	AB5CLOSLHE	2.60E-4	Air Circuit Breaker 5 Fails To Close Due To A Latent Human Error	2.60E-04
103	AB5KEYISWT	360	Air Circuit Breaker 5 Key Interlock Switch Transfers Open	2.52E-05
104	AB5MCH2DEX	7.04E-03	Air Circuit Breaker 5 Fails To Close Due To Mechanical Failure	7.04E-03
105	AB5PUSHPBT	384	Trip Pushbutton On ACB5 Spurious Operation	9.22E-05
106	AB5R52XRYD	1	Air Circuit Breaker 5 Relay 52X Fails To Operate	3.30E-05
107	AB5R52YRYD	1	Air Circuit Breaker 5 Relay 52Y Failed To Drop Out At Last Demand	3.30E-05
108	AB610A1FUF	6	One Or More Control Power Fuses For X, Y And CC Fail	2.16E-05
109	AB610AFFUF	6	One Or More Control Power Fuses For Relay 27X/2X Fail	2.16E-05
110	AB61432LHE	3.20E-4	Manual/Auto Control Switch 143/2 Left In Manual	3.20E-04
111	AB61432SWT	360	Manual/Auto Control Switch 143/2 Spuriously Transfers Into Manual	2.52E-05

Table E-7

Keowee PRA Basic Event Data
Two Unit Generation - Bayesian Update/Recovered

	NAME	FACTOR	DESCRIPTION	PROBABILITY
112	AB652CCRYD	1	Air Circuit Breaker 6 Close Coil CC Fails On Demand	3.30E-05
113	AB652TCRYD	1	Air Circuit Breaker 6 Trip Coil 52TC Fails Fails To Operate	3.30E-05
114	AB652TCRYT	24	Air Circuit Breaker 6 Trip Coil 52TC Spurious Operation	8.64E-06
115	AB652Y2RYT	360	Air Circuit Breaker 6 Y-relay Spurious Operation	1.30E-04
116	AB6CLOSLHE	2.60E-4	Air Circuit Breaker 6 Fails To Close Due To A Latent Human Error	2.60E-04
117	AB6KEYISWT	360	Air Circuit Breaker 6 Key Interlock Switch Transfers Open	2.52E-05
118	AB6MCH2DEX	7.04E-03	Air Circuit Breaker 6 Fails To Close Due To Mechanical Failure	7.04E-03
119	AB6MECHDEX	8.01E-04	Air Circuit Breaker 6 Fails To Open Due To Mechanical Failure	8.01E-04
120	AB6OPENLHE	3.20E-3	Air Circuit Breaker 6 Fails To Open Due To A Latent Human Error	3.20E-03
121	AB6PUSHPBT	24	Trip Pushbutton On ACB6 Spurious Operation	5.76E-06
122	AB6R52XRYD	1	Air Circuit Breaker 6 Relay 52X Fails To Operate	3.30E-05
123	AB6R52YRYD	1	Air Circuit Breaker 6 Relay 52Y Failed To Drop Out At Last Demand	3.30E-05
124	AB710A1FUF	6	One Or More Control Power Fuses For X, Y And CC Fail	2.16E-05
125	AB710AFFUF	6	One Or More Air Circuit Breaker 7 Control Power Fuses Fail	2.16E-05
126	AB752CCRYD	1	Air Circuit Breaker 7 Close Coil CC Fails On Demand	3.30E-05
127	AB752TCRYD	1	Air Circuit Breaker 7 Trip Coil CC Fails On Demand	3.30E-05
128	AB752TCRYT	24	Air Circuit Breaker 7 Trip Coil 52TC Spurious Operation	8.64E-06
129	AB752Y2RYT	360	Air Circuit Breaker 7 Y-relay Spurious Operation	1.30E-04
130	AB7CLOSLHE	2.60E-4	Air Circuit Breaker 7 Fails To Close Due To A Latent Human Error	2.60E-04
131	AB7KEYISWT	360	Air Circuit Breaker 7 Key Interlock Switch Transfers Open	2.52E-05
132	AB7MCH2DEX	7.04E-03	Air Circuit Breaker 7 Fails To Close Due To Mechanical Failure	7.04E-03
133	AB7MECHDEX	8.01E-04	Air Circuit Breaker 7 Fails To Open Due To Mechanical Failure	8.01E-04
134	AB7OPENLHE	3.20E-3	Air Circuit Breaker 7 Fails To Open Due To A Latent Human Error	3.20E-03
135	AB7PUSHPBT	30	Trip Pushbutton On ACB7 Spurious Operation	7.20E-06
136	AB7R52XRYD	1	Air Circuit Breaker 7 Relay 52X Fails To Operate	3.30E-05
137	AB7R52YRYD	1	Air Circuit Breaker 7 Relay 52Y Failed To Drop Out At Last Demand	3.30E-05
138	AB810A1FUF	6	One Or More Control Power Fuses For X, Y And CC Fail	2.16E-05
139	AB81432RYT	360	Auxiliary Relay 143X/2 Spuriously Energizes	1.30E-04
140	AB852CCRYD	1	Air Circuit Breaker 8 Close Coil CC Fails On Demand	3.30E-05
141	AB852TCRYT	384	Air Circuit Breaker 8 Trip Coil 52TC Spurious Operation	1.38E-04
142	AB852Y2RYT	360	Air Circuit Breaker 8 Y-relay Spurious Operation	1.30E-04
143	AB86E1ARYD	1	Emergency Lock Out Aux. Relay 86E-1a Fails To Operate On Demand	3.30E-05
144	AB86E1GRYD	1	Keowee Unit 1 Emergency Lock Out Sensing Relay Fails To Operate	3.30E-05
145	AB883S8RYD	1	Time Delay Relay 83S8 Fails To Pick Up	3.30E-05
146	AB8KEYISWT	360	Air Circuit Breaker 8 Key Interlock Switch Transfers Open	2.52E-05
147	AB8MCH2DEX	7.04E-03	Air Circuit Breaker 8 Fails To Close Due To Mechanical Failure	7.04E-03
148	AB8PUSHPBT	384	Trip Pushbutton On ACB8 Spurious Operation	9.22E-05

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	NAME	FACTOR	DESCRIPTION	PROBABILITY
149	AB8R52XRYD	1	Air Circuit Breaker 8 Relay 52X Fails To Operate	3.30E-05
150	AB8R52YRYD	1	Air Circuit Breaker 8 Relay 52Y Failed To Drop Out At Last Demand	3.30E-05
151	ABEOPRCDHE	9.0E-03	Operators Fail To Close Air Circuit Breaker 2	9.00E-03
152	ABEOPRCRHE	1	Operators Fail To Close Air Circuit Breaker 2	1.00E+00
153	ABPOPRCRHE	9.0E-03	Operators Fail To Close Air Circuit Breaker 4	9.00E-03
154	ACB4MOD	0	NSM-ON-52966 Is Not In Service	0.00E+00
155	ACBAIRPDEX	2.00E-03	ACB Air Supply Fails Causing Low Pressure In All ACB Accumulators	2.00E-03
156	ACBTRIPCHE	0.0	Operators Trip Generator Output ACBs	0.00E+00
157	ACBXFERCOM	1.28E-06	Common Cause Failure That Results In ACBs 2 & 3 Transfering Open	1.28E-06
158	AD1B4ALCDT	30	Breaker 4AL In 125 V dc Distribution Center 1DA Transfers Open	2.25E-06
159	AD1C3CCCDT	24	Breaker 3CC In 125V dc Distribution Center 1DA Transfers Position	1.80E-06
160	AD1C3CLCDT	24	Breaker 3CL In 125V dc Distribution Center 1DA Transfers Position	1.80E-06
161	AD1SCLRCDT	12	Breaker 3CL In 125V dc Distribution Center 1DA Transfers Position (Rec)	9.00E-07
162	AD2B2ALCDT	30	Breaker 2AL In 125V dc Distribution Center 2DA Transfers Open	2.25E-06
163	AD2B3CCCDT	12	Breaker 3CC In 125V dc Distribution Center 2DA Transfers Position	9.00E-07
164	AD2C3CCCDT	24	Breaker 3CC In 125V dc Distribution Center 2DA Transfers Position	1.80E-06
165	AD2C3CLCDT	24	Breaker 3CL In 125V dc Distribution Center 2DA Transfers Position	1.80E-06
166	AK1141XRYD	1	Auxiliary Relay 14GOV/1X Fails To Pick-up	3.30E-05
167	AK114GVDEX	1.00e-04	KU1 Magnetic Speed Switch System Fails	1.00E-04
168	AK121TDRYD	1	Time Delay Relay 2-1TD Fails To Pick-up	3.30E-05
169	AK152TDRYD	1	Time Delay Relay 52-1TD Fails To Pick-up	3.30E-05
170	AK152TDRYT	4380	Time Delay Relay 52-1TD Spurious Operation	1.58E-03
171	AK152XGRYD	1	Relay 52XG/1 Fails To Pick Up When The Unit Is Started	3.30E-05
172	AK152XGRYT	2	Relay 52XG/1 Spuriously Drops Out While The Unit Is Running	7.20E-07
173	AK1AX34RYT	6	Relay 52AX/34 Spuriously Drops-out	2.16E-06
174	AK1GV1XRYD	1	Relay 14GOV/1X Fails To Pick-up	3.30E-05
175	AK1OFRQCOM	3.30E-06	KU1 CCF Of 2/3 Overfrequency Relays To Reset When Frequency Drops	3.30E-06
176	AK1X34XRYT	6	Relay 52AX/34X Spuriously Drops-out	2.16E-06
177	AK212OSSST	36	Turbine Overspeed Switch Indicates Overspeed	1.51E-04
178	AK2142XRYD	1	Auxiliary Relay 14GOV/2X Fails To Pick-up	3.30E-05
179	AK214GVDEX	1.00e-4	KU2 Magnetic Speed Switch System Fails	1.00E-04
180	AK222TDRYD	1	Time Delay Relay 2-2TD Fails To Pick-up	3.30E-05
181	AK252TDRYD	1	Time Delay Relay 52-2TD Fails To Operate	3.30E-05
182	AK252TDRYT	4380	Time Delay Relay 52-2TD Spurious Operation	1.58E-03
183	AK252W0RYD	1	KU2 Relay 52W Fails To Pick-up	3.30E-05
184	AK252XGRYD	1	Auxiliary Relay 52XG/2 Fails To Pick-up	3.30E-05
185	AK2GATEDEX	2.11E-5	Wicket Gate Limit Switch Indicates Gate Position Is Below No-load Setting	2.11E-05

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	NAME	FACTOR	DESCRIPTION	PROBABILITY
186	AK2GV2XRYD	1	Relay 14GOV/2X Fails To Pick-up	3.30E-05
187	AK2OFRQCOM	3.30E-06	KU2 CCF Of 2/3 Overfrequency Relays To Reset When Frequency Drops	3.30E-06
188	BK1088XRYD	1	Keowee 1 Turbine Guide Bearing Oil Relay 88X Fails to Drop Out	3.30E-05
189	BK1088XRYT	24	Keowee 1 Turbine Guide Bearing Oil Relay 88X Spurious Operation	8.64E-06
190	BK114/2SSD	1	Keowee 1 Speed Switch 14/2 Fails On Demand	1.80E-05
191	BK114/2SST	24	Keowee 1 Speed Switch 14/2 Spuriously Transfers Closed	1.01E-04
192	BK114DXRYD	1	Keowee 1 Rotation Sensing Aux. Relay 14DX Fails to Energize	3.30E-05
193	BK114DXRYT	24	Keowee 1 Rotation Sensing Aux. Relay 14DX Spuriously Drops Out	8.64E-06
194	BK114T2RYD	1	Keowee 1 Rotation Sensing Timer 14T2 Fails to De-energize	3.30E-05
195	BK114T2RYT	24	Keowee 1 Rotation Sensing Timer 14T2 Spurious Operation	8.64E-06
196	BK1188ASWT	24	Keowee 1 AC GBO Pump Control Switch S188A Spurious Operation	1.68E-06
197	BK1188DSWT	108	Unit 1 DC GBO Pump Control Switch S188D Spurious Operation	7.56E-06
198	BK1631XRYD	1	Keowee 1 Relay 63TA/1X Fails to De-energize	3.30E-05
199	BK1631XRYT	24	Keowee 1 GBO Level Relay 63TA/1X Spurious Operation	8.64E-06
200	BK1632XRYD	1	Keowee 1 Brng. Low Oil Level Aux. Relay 63TA/2X Fails To Operate On Demand	3.30E-05
201	BK1632XRYT	24	Keowee 1 Turb. Brng. Low Oil Level Aux. Rly 63TA/2X Spurious Operation	8.64E-06
202	BK163TALSD	1	Turbine No. 1 Bearing Oil Level Switch 63TA Fails on Demand	1.60E-03
203	BK163TALST	24	Turbine No. 1 Bearing Oil Level Switch 63TA Spurious Operation	7.44E-06
204	BK188AXRYD	1	Unit 1 AC Bearing Oil Pump Aux. Relay 88AX Fails to Drop Out	3.30E-05
205	BK188AXRYT	24	Unit 1 AC Bearing Oil Pump Aux. Relay 88AX Fails to Remain De-energized	8.64E-06
206	BK1DA5BCDT	24	DC Circuit Breaker 1DA-5B Transfers Position	1.80E-06
207	BK1GBDCGPR	12	Unit 1 DC Turbine GBO Pump Fails To Run	1.68E-04
208	BK1GBDCGPS	1	Unit 1 DC Turbine GBO Pump Fails To Start On Demand	9.70E-05
209	BK1GBDCLHE	3.2E-3	Latent Human Error Fails Unit 1 DC Guide Bearing Oil Pump Discharge Path	3.20E-03
210	BK1GBO1CVC	1	Check Valve 1GBO-1 Fails to Close on Demand	3.50E-04
211	BK1GBO1CVO	1	Check Valve 1GBO-1 Fails To Open On Demand	2.30E-06
212	BK1GBO1CVT	24	Check Valve 1GBO-1 Transfers Closed	3.12E-06
213	BK1GBO1FTC	24	Filter 1GBOFL-1 Becomes Clogged	4.32E-05
214	BK1GBO2VVT	24	Manual Valve 1GBO-2 Transfers Position	4.08E-07
215	BK1GBO3CVO	1	Check Valve 1GBO-3 Fails To Open On Demand	2.30E-06
216	BK1GBO3CVT	12	Check Valve 1GBO-3 Transfers Closed	1.56E-06
217	BK1GBO4VVT	108	Manual Valve 1GBO-4 Transfers Position	1.84E-06
218	BK1GBO5VVT	24	Manual Valve 1GBO-5 Transfers Position	4.08E-07
219	BK1GBO6VVT	24	Manual Valve 1GBO-6 Transfers Position	4.08E-07
220	BK1GBO8VVT	24	Manual Valve 1GBO-8 Transfers Position	4.08E-07
221	BK1GBO9VVT	24	Manual Valve 1GBO-9 Transfers Position	4.08E-07
222	BK1GOACGPR	24	Unit 1 AC Turbine GBO Pump Fails To Run	3.36E-04

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	NAME	FACTOR	DESCRIPTION	PROBABILITY
223	BK1GOACGPS	1	Unit 1 AC Turbine GBO Pump Fails To Start	9.70E-05
224	BK1GODCTRM	1.14E-3	Unit 1 DC Turbine GBO Pump Train In Maintenance	1.14E-03
225	BK1XA1CCLT	24	600 V Circuit Breaker 1XA-1C Transfers Position	2.18E-05
226	BK2088XRYD	1	Keowee 2 Turbine Guide Bearing Oil Relay 88X Fails to Drop Out	3.30E-05
227	BK2088XRYT	24	Keowee 2 Turbine Guide Bearing Oil Relay 88X Spurious Operation	8.64E-06
228	BK214/2SSD	1	Keowee 2 Speed Switch 14/2 Fails On Demand	1.80E-05
229	BK214/2SST	24	Keowee 2 Speed Switch 14/2 Spuriously Transfers Closed	1.01E-04
230	BK214DXRYD	1	Keowee 2 Rotation Sensing Aux. Relay 14DX Fails to Energize	3.30E-05
231	BK214DXRYT	24	Keowee 2 Rotation Sensing Aux. Relay 14DX Spurious Operation	8.64E-06
232	BK214T2RYD	1	Keowee 2 Rotation Sensing Timer 14T2 Fails to De-energize	3.30E-05
233	BK214T2RYT	24	Keowee Rotation Sensing Timer 14T2 Fails to Remain De-energized	8.64E-06
234	BK2188ASWT	24	Unit 2 AC GBO Pump Control Switch S188A Spurious Operation	1.68E-06
235	BK2188DSWT	108	Unit 2 DC GBO Pump Control Switch S188D Spurious Operation	7.56E-06
236	BK2631XRYD	1	Keowee 2 Relay 63TA/1X Fails to De-energize	3.30E-05
237	BK2631XRYT	24	Keowee 2 GBO Level Relay 63TA/1X Spurious Operation	8.64E-06
238	BK2632XRYD	1	Keowee 2 Brng. Low Oil Level Aux. Relay 63TA/2X Fails To Operate On Demand	3.30E-05
239	BK2632XRYT	24	Keowee 2 Turb. Brng. Low Oil Level Aux. Relay 63TA/2X Spurious Operation	8.64E-06
240	BK263TALSD	1	Turbine No. 2 Bearing Oil Level Switch 63TA Fails on Demand	1.60E-03
241	BK263TALST	24	Turbine No. 2 Bearing Oil Level Switch 63TA Spurious Operation	7.44E-06
242	BK288AXRYD	1	Unit 2 AC Bearing Oil Pump Aux. Relay 88AX Fails to Drop Out	3.30E-05
243	BK288AXRYT	24	Unit 2 AC Bearing Oil Pump Aux. Relay 88AX Fails to Remain De-energized	8.64E-06
244	BK2DA1BCDT	24	DC Circuit Breaker 2DA-1B Transfers Position	1.80E-06
245	BK2GBDCGPR	12	Unit 2 DC Turbine GBO Pump Fails To Run	1.68E-04
246	BK2GBDCGPS	1	Unit 2 DC Turbine GBO Pump Fails To Start On Demand	9.70E-05
247	BK2GBDCLHE	3.2E-3	Latent Human Error Fails Unit 2 DC Guide Bearing Oil Pump Discharge Path	3.20E-03
248	BK2GBO1CVC	1	Check Valve 2GBO-1 Fails to Close on Demand	3.50E-04
249	BK2GBO1CVO	1	Check Valve 2GBO-1 Fails To Open On Demand	2.30E-06
250	BK2GBO1CVT	24	Check Valve 2GBO-1 Transfers Closed	3.12E-06
251	BK2GBO1FTC	24	Filter 2GBOFL-1 Becomes Clogged	4.32E-05
252	BK2GBO2VVT	24	Manual Valve 2GBO-2 Transfers Position	4.08E-07
253	BK2GBO3CVO	1	Check Valve 2GBO-3 Fails To Open On Demand	2.30E-06
254	BK2GBO3CVT	12	Check Valve 2GBO-3 Transfers Closed	1.56E-06
255	BK2GBO4VVT	108	Manual Valve 2GBO-4 Transfers Position	1.84E-06
256	BK2GBO5VVT	24	Manual Valve 2GBO-5 Transfers Position	4.08E-07
257	BK2GBO6VVT	24	Manual Valve 2GBO-6 Transfers Position	4.08E-07
258	BK2GBO8VVT	24	Manual Valve 2GBO-8 Transfers Position	4.08E-07
259	BK2GBO9VVT	24	Manual Valve 2GBO-9 Transfers Position	4.08E-07

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	NAME	FACTOR	DESCRIPTION		PROBABILITY
260	BK2GOACGPR	24	Unit 2 AC Turbine GBO Pump Fails To Run		3.36E-04
261	BK2GOACGPS	1	Unit 2 AC Turbine GBO Pump Fails To Start		9.70E-05
262	BK2GODCTRM	1.14E-3	Unit 2 DC Turbine GBO Pump Train In Maintenance		1.14E-03
263	BK2XA1CCLT	24	600 V Circuit Breaker 2XA-1C Transfers Position		2.18E-05
264	BKGBOILCOM	1.94E-06	Common Cause Failure Of Turbine Guide Bearing Oil System		1.94E-06
265	D1DIAXXDEX	6.50E-06	Loss Of Power On 125 V dc Panelboard 1DIA	OEE-120, O-705	6.50E-06
266	D1DIBXXDEX	6.50E-06	Loss Of Power On 125 V dc Panelboard 1DIB	OEE-120-1, O-705	6.50E-06
267	D2DIAXXDEX	6.50E-06	Loss Of Power On 125 V dc Panelboard 2DIA		6.50E-06
268	D2DIBXXDEX	6.50E-06	Loss of Power on 125 V dc Panelboard 2DIB		6.50E-06
269	D3DIAXXDEX	6.50E-06	Loss Of Power On 125 V dc Panelboard 3DIA		6.50E-06
270	D3DIBXXDEX	6.50E-06	Loss Of Power On 125 Vdc Panelboard 3DIB		6.50E-06
271	DDC11BXCDT	24	125 Vdc Battery Breaker SY-DC1-1B Transfers Open		1.80E-06
272	DDC11CXCDT	24	125 Vdc Breaker SY-DC1-1C Transfers Open		1.80E-06
273	DDC11DCCDT	24	125 Vdc Breaker SY-DC1-1DC Transfers Open		1.80E-06
274	DDC11DLCDT	24	125 Vdc Breaker SY-DC1-1DL Transfers Open		1.80E-06
275	DDC11DRCDT	24	125 Vdc Breaker SY-DC1-1DR Transfers Open		1.80E-06
276	DDC1ALXBYM	1.14E-02	Test and Maintenance Weighting Factor		1.14E-02
277	DDC1BATBYF	1	Battery SY-1 Fails During Discharge		9.30E-04
278	DDC1FLTBDF	24	SY-DC1 Is Faulted		7.68E-06
279	DDC21BXCDT	24	125 Vdc Battery Breaker SY-DC2-1B Transfers Open		1.80E-06
280	DDC21CXCDT	24	125 Vdc Breaker SY-DC2-1C Transfers Open		1.80E-06
281	DDC21DCCDT	24	125 Vdc Breaker SY-DC2-1DC Transfers Open		1.80E-06
282	DDC21DLCDT	24	125 Vdc Breaker SY-DC2-1DL Transfers Open		1.80E-06
283	DDC21DRCDT	24	125 Vdc Breaker SY-DC2-1DR Transfers Open		1.80E-06
284	DDC2BATBYF	1	Battery SY-2 Fails During Discharge		9.30E-04
285	DDC2FLTBDF	24	SY-DC2 Is Faulted		7.68E-06
286	DDCBATTCOM	2.70E-05	Common Cause Failure of Switchyard Batteries		2.70E-05
287	DDCDYAXBDF	24	125 Vdc Switchyard DC Panelboard DYA Is Faulted		7.68E-06
288	DDCDYBXBDF	24	125 Vdc Switchyard DC Panelboard DYB Is Faulted		7.68E-06
289	DDCDYCXBDF	24	125 Vdc Switchyard DC Panelboard DYC Is Faulted		7.68E-06
290	DDCDYEXBDF	24	125 Vdc Switchyard DC Panelboard DYE Is Faulted		7.68E-06
291	DDCDYFXBDF	24	125 Vdc Switchyard DC Panelboard DYF Is Faulted		7.68E-06
292	DDCDYGXBDF	24	125 Vdc Switchyard DC Panelboard DYG Is Faulted		7.68E-06
293	E12EXCTCOM	5.31E-05	Units 1 & 2 Excit Fail Due To Common Cause Failure Of The Breakers		5.31E-05
294	ED11D3DCDT	12	Breaker 3D In 125V dc Distribution Center 1DA Transfers Open		9.00E-07
295	ED13BR2CDT	24	Breaker 3BR In 125V dc Distribution Center 1DA Transfers Open		1.80E-06
296	ED22D3DCDT	12	Breaker 2D In 125V dc Distribution Center 2DA Transfers Open		9.00E-07

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	NAME	FACTOR	DESCRIPTION	PROBABILITY
297	ED23BR2CDT	24	Breaker 3BR In 125V dc Distribution Center 2DA Transfers Open	1.80E-06
298	EK00RUNCOM	1.24E-4	Common Cause Failure Of Both Units Voltage Regulators To Run	1.24E-04
299	EK0BASERHE	1.9E-02	Recovery of Keowee Base Adjust LHE	1.90E-02
300	EK131TDRYD	1	Keowee Unit 1 Field Flashing Breaker Time Delay Relay 31/TD Fails To Operate	3.30E-05
301	EK131TDRYT	12	Keowee Unit 1 Field Flashing Breaker Time Delay Relay 31/TD Spurious Operation	4.32E-06
302	EK14152SWT	12	KHU1 Generator Supply Breaker Trip Control Switch 141-52/T Spurious Operation	8.40E-07
303	EK1415TSWT	24	Spurious Operation Of The KHU1 Supply Breaker Trip Switch	1.68E-06
304	EK1415YRYD	1	KHU1 Generator Supply Breaker Y-relay Failed To Drop-out At Last Operation	3.30E-05
305	EK1415YRYT	12	KHU1 Generator Supply Breaker Y-relay Spurious Operation	4.32E-06
306	EK141AXR6D	1	Keowee Unit 1 Relay 41/AX Fails To Pick-up And Latch	2.49E-04
307	EK141AXR6T	24	Keowee Unit 1 Relay 41/AX Spuriously Resets	8.71E-06
308	EK141CFRYD	1	Keowee Unit 1 Field Flashing Breaker Close Coil Fails To Operate On Demand	3.30E-05
309	EK186E2RYT	6	Keowee Unit 1 Lockout Auxiliary Relay 86EX-2 Is Picked-up	2.16E-06
310	EK186EXRYT	12	Keowee Unit 1 Gen Lockout Auxiliary Relay 86EX-1 Spurious Actuation	4.32E-06
311	EK186X2RYT	24	Keowee Unit 1 Generator Lockout Auxiliary Relay 86EX-1 Spurious Actuation	8.64E-06
312	EK188SVRYD	1	Keowee Unit 1 Fan Control Relay 88SV Fails On Demand	3.30E-05
313	EK188SVRYT	36	Keowee Unit 1 Fan Control Relay 88SV Prior To Or During The Run	1.30E-05
314	EK1901ARYT	12	Keowee Unit 1 Relay 90X1A Spurious Operation	4.32E-06
315	EK199SXRYD	1	Auxiliary Relay 99SX1 Fails To Pick-up	3.30E-05
316	EK199SYRYD	1	Keowee Unit 1 Relay 99SY Fails To Pick-up	3.30E-05
317	EK199SYRYT	24	Keowee Unit 1 Relay 99SY Drops Out	8.64E-06
318	EK1BAS2DEX	1.24E-3	KHU-1 Base Adjust Fails To Maintain Generator Output Within Acceptable Range	1.24E-03
319	EK1BASEDEX	6.17E-4	Keowee Unit 1 Base Adjust Fails To Establish Correct Unit Voltage	6.17E-04
320	EK1BASELHE	3.20E-3	Keowee Unit 1 Base Adjust Is Set Incorrectly	3.20E-03
321	EK1DIODDEX	2.88E-4	Keowee Unit 1 Exciter Fan Supply Diode Bridge Fails	2.88E-04
322	EK1EXC1TGF	12	Keowee Unit 1 Gen Excitation Transformer Is Failed	1.18E-05
323	EK1EXC2TGF	24	Keowee Unit 1 Generator Excitation Transformer Fails	2.35E-05
324	EK1F30AFUF	24	Keowee Unit 1 Excitation Cabinet Fan Fuses Fail	8.64E-05
325	EK1F31XRYD	1	Keowee Unit 1 Field Flashing Breaker Relay 31/X Fails To Pick-up On Demand	3.30E-05
326	EK1F41CRYD	1	Keowee Unit 1 Field Breaker Close Coil Fails To Operate On Demand	3.30E-05
327	EK1FAN1TLF	24	Keowee Unit 1 Generator Excitation Fan Power Transformer Fails	1.80E-05
328	EK1FLDCLHE	2.60E-4	Keowee Unit 1 Field Breaker Fails To Close Due To Latent Human Error	2.60E-04
329	EK1FLDMDEX	7.71E-5	Keowee Unit 1 Field Breaker Fails To Close Due To Mechanical Failure	7.71E-05
330	EK1FLSCLHE	2.60E-4	Keowee Unit 1 Field Flashing Breaker Fails To Close Due To Latent Human Error	2.60E-04
331	EK1FLSMDEX	7.71E-5	Keowee Unit 1 Field Flashing Breaker Fails To Close Due To Mechanical Failure	7.71E-05
332	EK1FLSOLHE	2.60E-4	Keowee Unit 1 Field Flashing Breaker Fails To Open Due To Latent Human Error	2.60E-04
333	EK1R31TRYD	1	Keowee Unit 1 Field Flashing Breaker Trip Coil 31/T Fails To Operate	3.30E-05

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	NAME	FACTOR	DESCRIPTION	PROBABILITY
334	EK1R31YRYD	1	KHU1 Gen Field Flashing Breaker Y-relay Failed To Drop Out At Last Operation	3.30E-05
335	EK1R31YRYT	12	KHU1 Generator Field Flashing Breaker Y-relay Spurious Operation	4.32E-06
336	EK1R41XRYD	1	Keowee Unit 1 Field Breaker Relay 41/X Fails To Pick-up On Demand	3.30E-05
337	EK1R41YRYD	1	KHU1 Generator Field Breaker Y-relay Failed To Drop-out At Last Operation	3.30E-05
338	EK1R41YRYT	12	Keowee Unit 1 Generator Field Breaker Y-relay Spurious Operation	4.32E-06
339	EK1R9A1RYT	12	Keowee Unit 1 Relay 90X1A/TD Spurious Operation	4.32E-06
340	EK1R9C1R6T	12	Keowee Unit 1 Relay 90X1C Spurious Operation	4.36E-06
341	EK1S141SWT	12	KHU1 Field Breaker Trip Control Switch 141/T Spurious Operation	8.40E-07
342	EK1S31TSWT	12	KHU1 Field Flashing Breaker Trip Control Switch 131/T Spurious Operation	8.40E-07
343	EK1S41CRYD	1	Keowee Unit 1 Supply Breaker Close Coil Fails To Operate On Demand	3.30E-05
344	EK1S41TSWT	24	Keowee Unit 1 Field Breaker Trip Control Switch Transfers Position	1.68E-06
345	EK1S41XRYD	1	Keowee Unit 1 Supply Breaker Relay 41-52X Fails To Pick-up On Demand	3.30E-05
346	EK1SPYCLHE	2.60E-4	Keowee Unit 1 Supply Breaker Fails To Close Due To Latent Human Error	2.60E-04
347	EK1SPYMDEX	4.62E-4	Keowee Unit 1 Supply Breaker Fails To Close Due To Mehanical Failure	4.62E-04
348	EK1VHSVRYD	1	Keowee Unit 1 Volts/Hertz Relay SV Fails To Trip Field Flashing Breaker	3.30E-05
349	EK1VREGDEX	2.47E-3	KHU-1 Voltage Adjust Failure Drives Generator Output Too High/Low	2.47E-03
350	EK231TDRYD	1	Keowee Unit 2 Field Flashing Breaker Time Delay Relay 31/TD Fails To Operate	3.30E-05
351	EK231TDRYT	12	Keowee Unit 2 Field Flashing Breaker Time Delay Relay 31/TD Spurious Operation	4.32E-06
352	EK24152SWT	12	KHU2 Generator Supply Breaker Trip Control Switch Spurious Operation	8.40E-07
353	EK2415TSWT	24	Spurious Operation Of The KHU2 Supply Breaker Trip Switch	1.68E-06
354	EK2415YRYD	1	KHU2 Gen Supply Breaker Y-relay Failed To Drop-out At Last Operation	3.30E-05
355	EK2415YRYT	12	KHU2 Generator Supply Breaker Y-relay Spurious Operation	4.32E-06
356	EK241AXR6D	1	Keowee Unit 2 Relay 41/AX Fails To Pick-up And Latch	2.49E-04
357	EK241AXR6T	24	Keowee Unit 2 Relay 41/AX Spuriously Resets	8.71E-06
358	EK241CFRYD	1	Keowee Unit 2 Field Flashing Breaker Close Coil Fails To Operat On Demand	3.30E-05
359	EK286E2RYT	6	Keowee Unit 2 Lockout Auxiliary Relay 86EX-2 Is Picked-up	2.16E-06
360	EK286EXRYT	12	Keowee Unit 2 Generator Lockout Auxiliary Relay 86EX-1 Spurious Actuation	4.32E-06
361	EK286X2RYT	24	Keowee Unit 2 Generator Lockout Auxiliary Relay 86EX-1 Spurious Actuation	8.64E-06
362	EK288SVRYD	1	Keowee Unit 2 Fan Control Relay 88SV Fails On Demand	3.30E-05
363	EK288SVRYT	36	Keowee Unit 2 Fan Control Relay 88SV Prior To Or During The Run	1.30E-05
364	EK2901ARYT	12	Keowee Unit 2 Relay 90X1A Spurious Operation	4.32E-06
365	EK299SXRYD	1	Auxiliary Relay 99SX2 Fails To Pick-up	3.30E-05
366	EK299SYRYD	1	Keowee Unit 2 Relay 99SY Fails To Pick-up	3.30E-05
367	EK299SYRYT	24	Keowee Unit 2 Relay 99SY Drops Out	8.64E-06
368	EK2BAS2DEX	1.24E-3	KHU-2 Base Adjust Fails To Maintain Generator Output Within Acceptable Range	1.24E-03
369	EK2BASEDEX	6.17E-4	Keowee Unit 2 Base Adjust Fails To Establish Correct Unit Voltage	6.17E-04
370	EK2BASELHE	3.20E-3	Keowee Unit 2 Base Adjust Is Set Incorrectly	3.20E-03

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Keowee PRA Basic Event Data
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	NAME	FACTOR	DESCRIPTION		PROBABILITY
371	EK2DIODDEX	2.88E-4	Keowee Unit 2 Exciter Fan Supply Diode Bridge Fails		2.88E-04
372	EK2EXC1TGF	12	Keowee Unit 2 Generator Excitation Transformer Is Failed		1.18E-05
373	EK2EXC2TGF	24	Keowee Unit 2 Generator Excitation Transformer Fails		2.35E-05
374	EK2F30AFUF	24	Keowee Unit 2 Excitation Cabinet Fan Fuses Fail		8.64E-05
375	EK2F31XRYD	1	Keowee Unit 2 Field Flashing Breaker Relay 31/X Fails To Pick-up On Demand		3.30E-05
376	EK2F41CRYD	1	Keowee Unit 2 Field Breaker Close Coil Fails To Operate On Demand		3.30E-05
377	EK2FAN1TLF	24	Keowee Unit 2 Generator Excitation Fan Power Transformer Fails		1.80E-05
378	EK2FLDCLHE	2.60E-4	Keowee Unit 2 Field Breaker Fails To Close Due To Latent Human Error		2.60E-04
379	EK2FLDMDEX	7.71E-5	Keowee Unit 2 Field Breaker Fails To Close Due To Mechanical Failure		7.71E-05
380	EK2FLSCLHE	2.60E-4	Keowee Unit 2 Field Flashing Breaker Fails To Close Due To Latent Human Error		2.60E-04
381	EK2FLSMDEX	7.71E-5	Keowee Unit 2 Field Flashing Breaker Fails To Close Due To Mechanical Failure		7.71E-05
382	EK2FLSOLHE	2.60E-4	Keowee Unit 2 Field Flashing Breaker Fails To Open Due To Latent Human Error		2.60E-04
383	EK2R31TRYD	1	Keowee Unit 2 Field Flashing Breaker Trip Coil 31/T Fails To Operate		3.30E-05
384	EK2R31YRYD	1	KHU2 Gen Field Flashing Breaker Y-relay Failed To Drop At Last Operation		3.30E-05
385	EK2R31YRYT	12	KHU2 Generator Field Flashing Breaker Y-relay Spurious Operation		4.32E-06
386	EK2R41XRYD	1	Keowee Unit 2 Field Breaker Relay 41/X Fails To Pick-up On Demand		3.30E-05
387	EK2R41YRYD	1	KHU2 Generator Field Breaker Y-relay Failed To Drop-out At Last Operation		3.30E-05
388	EK2R41YRYT	12	KHU2 Generator Field Breaker Y-relay Spurious Operation		4.32E-06
389	EK2R9A2RYT	12	Keowee Unit 2 Relay 90X1A/TD Spurious Operation		4.32E-06
390	EK2R9C2R6T	12	Keowee Unit 2 Relay 90X1C Spurious Operation		4.36E-06
391	EK2S141SWT	12	KHU2 Field Breaker Trip Control Switch Spurious Operation		8.40E-07
392	EK2S31TSWT	12	KHU2 Field Flashing Breaker Trip Control Switch 131/T Spurious Operation		8.40E-07
393	EK2S41CRYD	1	Keowee Unit 2 Supply Breaker Close Coil Fails To Operate On Demand		3.30E-05
394	EK2S41TSWT	24	Keowee Unit 2 Field Breaker Trip Control Switch Transfers Position		1.68E-06
395	EK2S41XRYD	1	Keowee Unit 2 Supply Breaker Relay 41-52X Fails To Pick-up On Demand		3.30E-05
396	EK2SPYCLHE	2.60E-4	Keowee Unit 2 Supply Breaker Fails To Close Due To Latent Human Error		2.60E-04
397	EK2SPYMDEX	4.62E-4	Keowee Unit 2 Supply Breaker Fails To Close Due To Mehanical Failure		4.62E-04
398	EK2VHSVRYD	1	Keowee Unit 2 Volts/Hertz Relay SV Fails To Trip Field Flashing Breaker		3.30E-05
399	EK2VREGDEX	2.47E-3	KHU-2 Voltage Adjust Failure Drives Generator Output Too High/Low		2.47E-03
400	EKSTARTCOM	6.17E-5	Common Cause Failure Of Both Units Voltage Regulators To Start		6.17E-05
401	ESCONDNOT	1	An Engineered Safeguards Condition Does Not Exist		1.00E+00
402	EU1C1RORYD	1	ONS1 ESG Chan. 1 Ro Relay Fails To Pick Up	OEE-120	1.00E+00
403	EU1C2RORYD	1	ONS1 ESG Chan. 2 Ro Relay Fails to Pick Up		1.00E+00
404	EU2C1RORYD	1	ONS2 ESG Chan. 1 Ro Relay Fails to Pick Up	OEE-220	1.00E+00
405	EU2C2RORYD	1	ONS2 ESG Chan. 2 Ro Relay Fails to Pick Up	OEE-220-1	1.00E+00
406	EU3C1RORYD	1	ONS3 ESG Chan. 1 Ro Relay Fails to Pick Up	OEE-320	1.00E+00
407	EU3C2RORYD	1	ONS3 ESG Chan. 2 Ro Relay Fails to Pick Up	OEE-320-1	1.00E+00

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	NAME	FACTOR	DESCRIPTION	PROBABILITY
408	FK0FISHCOM	2.55E-3	Common Cause Failure Of Both Unit s WL Filters Due To Intake Debris	2.55E-03
409	FK0FISHDHE	6.3E-02	Recovery of Main WL Strainer Clogging	6.30E-02
410	FK0FL00DHE	6.3E-02	Recovery of Trubine Guide Bearing or Packing WL Filter Clogging	6.30E-02
411	FK0WL01VVT	24	Locked-Open Manual Valve 0WL-1 Transfers Position	4.08E-07
412	FK1120GLHE	3.2E-3	Unit 1 Control Switch S120G Left in OFF Position	3.20E-03
413	FK1120GSWT	36	Unit 1 Control Switch S120G Spurious Operation	2.52E-06
414	FK1FL01FRF	24	Filter 1WLFL-1 Becomes Clogged	2.35E-05
415	FK1FL02FRF	24	Filter 1WLFL-2 Becomes Clogged	2.35E-05
416	FK1TRHXHXF	24	Turbine Packing Box Heat Exchanger 1TRHX-1 Fails	1.54E-05
417	FK1WL03VVT	24	Manual Valve 1WL-3 Transfers Position	4.08E-07
418	FK1WL04VVT	24	Manual Valve 1WL-4 Transfers Position	4.08E-07
419	FK1WL05VVT	24	Manual Valve 1WL-5 Transfers Position	4.08E-07
420	FK1WL06VVT	24	Manual Valve 1WL-6 Transfers Position	4.08E-07
421	FK1WL07VVT	24	Manual Valve 1WL-7 Transfers Position	4.08E-07
422	FK1WL08VVT	24	Manual Valve 1WL-8 Transfers Position	4.08E-07
423	FK1WL09VVT	24	Manual Valve 1WL-9 Transfers Position	4.08E-07
424	FK1WL11AVO	1	Cooling Water Control Valve 1WL-11 Fails To Open On Demand	2.80E-04
425	FK1WL11AVT	24	Cooling Water Control Valve 1WL-11 Transfers Closed	5.52E-05
426	FK1WL12VVT	36	Manual Valve 1WL-12 Transfers Position	6.12E-07
427	FK1WL15VVT	36	Manual Valve 1WL-15 Transfers Position	6.12E-07
428	FK1WL42VVT	36	Manual Valve 1WL-42 Transfers Position	6.12E-07
429	FK1WL43VVT	36	Manual Valve 1WL-43 Transfers Position	6.12E-07
430	FK2120GLHE	2.6E-4	Unit 2 Control Switch S120G Left in OFF Position	2.60E-04
431	FK2120GSWT	36	Unit 2 Control Switch S120G Spurious Operation	2.52E-06
432	FK2FL01FRF	24	Filter 2WLFL-1 Becomes Clogged	2.35E-05
433	FK2FL02FRF	24	Filter 2WLFL-2 Becomes Clogged	2.35E-05
434	FK2TRHXHXF	24	Turbine Packing Box Heat Exchanger 2TRHX-1 Fails	1.54E-05
435	FK2WL03VVT	24	Manual Valve 2WL-3 Transfers Position	4.08E-07
436	FK2WL04VVT	24	Manual Valve 2WL-4 Transfers Position	4.08E-07
437	FK2WL05VVT	24	Manual Valve 2WL-5 Transfers Position	4.08E-07
438	FK2WL06VVT	24	Manual Valve 2WL-6 Transfers Position	4.08E-07
439	FK2WL07VVT	24	Manual Valve 2WL-7 Transfers Position	4.08E-07
440	FK2WL08VVT	24	Manual Valve 2WL-8 Transfers Position	4.08E-07
441	FK2WL09VVT	24	Manual Valve 2WL-9 Transfers Position	4.08E-07
442	FK2WL11AVO	1	Cooling Water Control Valve 2WL-11 Fails To Open On Demand	2.80E-04
443	FK2WL11AVT	24	Cooling Water Control Valve 2WL-11 Transfers Closed	5.52E-05
444	FK2WL12VVT	36	Manual Valve 2WL-12 Transfers Position	6.12E-07

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	NAME	FACTOR	DESCRIPTION	PROBABILITY
445	FK2WL15VVT	36	Manual Valve 2WL-15 Transfers Position	6.12E-07
446	FK2WL42VVT	36	Manual Valve 2WL-42 Transfers Position	6.12E-07
447	FK2WL43VVT	36	Manual Valve 2WL-43 Transfers Position	6.12E-07
448	FKVALVECOM	2.46E-5	Common Cause Failure Of Cooling Water Control Valves	2.46E-05
449	GK0BRGVRHE	1.00E+00	Failure To Recover Thrust Bearing Cooling	1.00E+00
450	GK0COOLCOM	4.61E-07	Common Cause Failure of Generator Air Cooling	4.61E-07
451	GK0LOCKCOM	4.06E-06	Common Cause Actuation of Generator Lockouts	4.06E-06
452	GK10001HGR	24	Keowee Unit 1 Generator Fault While the Unit Runs	2.27E-03
453	GK10001HGS	1	Keowee Unit 1 Generator Fault Causes Unit Start Failure	1.54E-04
454	GK1063FPST	24	Keowee 1 Gen CO2 Sys Press Switch 63F Spurious Operation	1.03E-05
455	GK112TDRYT	24	Time Delay Relay 12XTD/1 Spuriously Picks-up	8.64E-06
456	GK112X1RYT	24	Relay 12X/1 Spuriously Picks-up	8.64E-06
457	GK13SUIRYT	24	Keowee Unit 1 Startup Inhibit Switch Auxiliary Relay S3SUIX Spurious Actuation	8.64E-06
458	GK13SUISWT	24	Keowee Unit 1 Startup Inhibit Switch 3SUI Spurious Operation	1.68E-06
459	GK140G1RYT	24	Keowee Unit 1 Loss Of Generator Field Relay 40G1 Spurious Actuation	8.64E-06
460	GK159GNRYT	24	Keowee Unit 1 Generator Ground Fault Relay 59GN1 Spurious Actuation	8.64E-06
461	GK162TDRYT	24	Keowee Unit 1 Generator Backup Trip Timer 62-1TD Spurious Operation	8.64E-06
462	GK163FXRYT	24	Keowee Unit 1 Generator Fire Relay 63FX Spurious Actuation	8.64E-06
463	GK186E1RYT	24	Keowee 1 Emergency Lockout Relay 86E-1 Spuriously Picks Up	8.64E-06
464	GK187G1RYT	24	Keowee Unit 1 Generator Differential Relay 87G-1 Spurious Actuation	8.64E-06
465	GK187GBRYT	24	Keowee Unit 1 Generator Bus Differential Relay 87GB Spurious Actuation	8.64E-06
466	GK187TERYT	24	Keowee Unit 1 Exitation Transformer Differential Relay 87T-1E Spur. Actuation	8.64E-06
467	GK1BRGVLHE	2.60E-04	Keowee 1 Gen. Brng Oil Cooling Flow Path Vlvs Mispositioned After Maintenance	2.60E-04
468	GK1COOLLHE	2.60E-04	Keowee 1 Gen. Air Cooler WL Flow Path Vlvs Mispositioned After Maintenance	2.60E-04
469	GK1FIREDEX	3.19E-05	Spurious Actuation of Unit 1 Gen. CO2 Fire Supression System	3.19E-05
470	GK1GAC1HXF	24	Generator Air Cooler 1GAHW-1 Fails	1.54E-05
471	GK1GAC1HXL	36	Heat Exchanger 1GAC1 Leaks	3.60E-06
472	GK1GAC2HXF	24	Generator Air Cooler 1GAHW-2 Fails	1.54E-05
473	GK1GAC2HXL	36	Heat Exchanger 1GAC2 Leaks	3.60E-06
474	GK1GAC3HXF	24	Generator Air Cooler 1GAHW-3 Fails	1.54E-05
475	GK1GAC3HXL	36	Heat Exchanger 1GAC3 Leaks	3.60E-06
476	GK1GAC4HXF	24	Generator Air Cooler 1GAHW-4 Fails	1.54E-05
477	GK1GAC4HXL	36	Heat Exchanger 1GAC4 Leaks	3.60E-06
478	GK1GAC5HXF	24	Generator Air Cooler 1GAHW-5 Fails	1.54E-05
479	GK1GAC5HXL	36	Heat Exchanger 1GAC5 Leaks	3.60E-06
480	GK1GAC6HXF	24	Generator Air Cooler 1GAHW-6 Fails	1.54E-05
481	GK1GAC6HXL	36	Heat Exchanger 1GAC6 Leaks	3.60E-06

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Keowee PRA Basic Event Data
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	NAME	FACTOR	DESCRIPTION	PROBABILITY
482	GK1HPO1HXF	24	Generator Thrust Bearing Cooler 1HPOHX-1 Fails	1.54E-05
483	GK1HPO2HXF	24	Generator Thrust Bearing Cooler 1HPOHX-2 Fails	1.54E-05
484	GK1HPO3HXF	24	Generator Thrust Bearing Cooler 1HPOHX-3 Fails	1.54E-05
485	GK1HPO4HXF	24	Generator Thrust Bearing Cooler 1HPOHX-4 Fails	1.54E-05
486	GK1HPO5HXF	24	Generator Thrust Bearing Cooler 1HPOHX-5 Fails	1.54E-05
487	GK1HPO6HXF	24	Generator Thrust Bearing Cooler 1HPOHX-6 Fails	1.54E-05
488	GK1HPO6VVT	24	Genrator Bearing Oil Leak Because Manual Valve 1HPO-6 Transfers Position	4.08E-07
489	GK1HPO7HXF	24	Generator Thrust Bearing Cooler 1HPOHX-7 Fails	1.54E-05
490	GK1HPO8HXF	24	Generator Thrust Bearing Cooler 1HPOHX-8 Fails	1.54E-05
491	GK1NGDCLHE	5.20E-05	Failure to Close the Unit 1 Neutral Ground Disconnect Following Maintenance	5.20E-05
492	GK1O121SST	24	Speed Switch 12/1 Falsely Indicates High Speed	1.01E-04
493	GK1WL16VVT	36	Manual Valve 1WL-16 Transfers Position	6.12E-07
494	GK1WL17VVT	36	Manual Valve 1WL-17 Transfers Position	6.12E-07
495	GK1WL18VVT	36	Manual Valve 1WL18 Transfers Position	6.12E-07
496	GK1WL19VVT	36	Manual Valve 1WL19 Transfers Position	6.12E-07
497	GK1WL20VVT	36	Manual Valve 1WL-20 Transfers Position	6.12E-07
498	GK1WL21VVT	36	Manual Valve 1WL-21 Transfers Position	6.12E-07
499	GK1WL22VVT	36	Manual Valve 1WL22 Transfers Position	6.12E-07
500	GK1WL23VVT	36	Manual Valve 1WL23 Transfers Position	6.12E-07
501	GK1WL24VVT	36	Manual Valve 1WL-24 Transfers Position	6.12E-07
502	GK1WL25VVT	36	Manual Valve 1WL-25 Transfers Position	6.12E-07
503	GK1WL26VVT	36	Manual Valve 1WL26 Transfers Position	6.12E-07
504	GK1WL27VVT	36	Manual Valve 1WL27 Transfers Position	6.12E-07
505	GK1WL28VVT	36	Manual Valve 1WL-28 Transfers Position	6.12E-07
506	GK1WL29VVT	36	Manual Valve 1WL-29 Transfers Position	6.12E-07
507	GK1WL30VVT	36	Manual Valve 1WL30 Transfers Position	6.12E-07
508	GK1WL31VVT	36	Manual Valve 1WL31 Transfers Position	6.12E-07
509	GK1WL32VVT	36	Manual Valve 1WL-32 Transfers Position	6.12E-07
510	GK1WL33VVT	36	Manual Valve 1WL-33 Transfers Position	6.12E-07
511	GK1WL34VVT	36	Manual Valve 1WL34 Transfers Position	6.12E-07
512	GK1WL35VVT	36	Manual Valve 1WL35 Transfers Position	6.12E-07
513	GK1WL36VVT	36	Manual Valve 1WL-36 Transfers Position	6.12E-07
514	GK1WL37VVT	36	Manual Valve 1WL-37 Transfers Position	6.12E-07
515	GK1WL38VVT	36	Manual Valve 1WL38 Transfers Position	6.12E-07
516	GK1WL39VVT	36	Manual Valve 1WL39 Transfers Position	6.12E-07
517	GK1WL41VVT	36	Keowee 1 Manual Valve 1WL-41 Transfers Position to Block Discharge Path	6.12E-07
518	GK1WL44VVT	36	Manual Valve 1WL-44 Transfers Position	6.12E-07

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Keowee PRA Basic Event Data
Two Unit Generation - Bayesian Update/Recovered

	NAME	FACTOR	DESCRIPTION	PROBABILITY
519	GK1WL45VVT	36	Manual Valve 1WL-45 Transfers Position	6.12E-07
520	GK1WL46VVT	36	Manual Valve 1WL-46 Transfers Position	6.12E-07
521	GK1WL47VVT	36	Manual Valve 1WL-47 Transfers Position	6.12E-07
522	GK1WL48VVT	36	Manual Valve 1WL-48 Transfers Position	6.12E-07
523	GK1WL49VVT	36	Manual Valve 1WL-49 Transfers Position	6.12E-07
524	GK1WL50VVT	36	Manual Valve 1WL-50 Transfers Position	6.12E-07
525	GK1WL51VVT	36	Manual Valve 1WL-51 Transfers Position	6.12E-07
526	GK1WL52VVT	36	Manual Valve 1WL-52 Transfers Position	6.12E-07
527	GK1WL53VVT	36	Manual Valve 1WL-53 Transfers Position	6.12E-07
528	GK1WL54VVT	36	Manual Valve 1WL-54 Transfers Position	6.12E-07
529	GK1WL55VVT	36	Manual Valve 1WL-55 Transfers Position	6.12E-07
530	GK1WL56VVT	36	Manual Valve 1WL-56 Transfers Position	6.12E-07
531	GK1WL57VVT	36	Manual Valve 1WL-57 Transfers Position	6.12E-07
532	GK1WL58VVT	36	Manual Valve 1WL-58 Transfers Position	6.12E-07
533	GK1WL59VVT	36	Manual Valve 1WL-59 Transfers Position	6.12E-07
534	GK1WL60VVT	36	Manual Valve 1WL-60 Transfers Position	6.12E-07
535	GK1WL61VVT	36	Manual Valve 1WL-61 Transfers Position	6.12E-07
536	GK1WL62VVT	36	Manual Valve 1WL-62 Transfers Position	6.12E-07
537	GK1WL63VVT	36	Manual Valve 1WL-63 Transfers Position	6.12E-07
538	GK1WL64VVT	36	Manual Valve 1WL-64 Transfers Position	6.12E-07
539	GK1WL65VVT	36	Manual Valve 1WL-65 Transfers Position	6.12E-07
540	GK1WL66VVT	36	Manual Valve 1WL-66 Transfers Position	6.12E-07
541	GK1WL67VVT	36	Manual Valve 1WL-67 Transfers Position	6.12E-07
542	GK1WL68VVT	36	Manual Valve 1WL-68 Transfers Position	6.12E-07
543	GK1WL69VVT	36	Manual Valve 1WL-69 Transfers Position	6.12E-07
544	GK1WL70VVT	36	Manual Valve 1WL-70 Transfers Position	6.12E-07
545	GK1WL71VVT	36	Manual Valve 1WL-71 Transfers Position	6.12E-07
546	GK1WL72VVT	36	Manual Valve 1WL-72 Transfers Position	6.12E-07
547	GK1WL73VVT	36	Manual Valve 1WL-73 Transfers Position	6.12E-07
548	GK1WL74VVT	36	Manual Valve 1WL-74 Transfers Position	6.12E-07
549	GK1WL75VVT	36	Manual Valve 1WL-75 Transfers Position	6.12E-07
550	GK1WL76VVT	36	Manual Valve 1WL76 Transfers Position and Blocks Discharge Path	6.12E-07
551	GK1WL78VVT	36	Manual Valve 1WL78 Transfers Position and Blocks Discharge Path	6.12E-07
552	GK20001HGR	24	Keowee Unit 2 Generator Fault While the Unit Runs	2.27E-03
553	GK20002HGS	1	Keowee Unit 2 Generator Fault Causes Unit Start Failure	1.54E-04
554	GK2063FPST	24	Keowee 2 Gen CO2 Sys Press Switch 63F Spurious Operation	1.03E-05
555	GK212TDRYT	24	Time Delay Relay 12XTD/2 Spuriously Picks-up	8.64E-06

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Keowee PRA Basic Event Data
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	NAME	FACTOR	DESCRIPTION	PROBABILITY
556	GK212X2RYT	24	Relay 12X/2 Spuriously Picks-up	8.64E-06
557	GK23SUIRYT	24	Keowee Unit 2 Startup Inhibit Switch Auxiliary Relay S3SUIX Spurious Actuation	8.64E-06
558	GK23SUISWT	24	Keowee Unit 2 Startup Inhibit Swtich 3SUI Spurious Operation	1.68E-06
559	GK240G1RYT	24	Keowee Unit 2 Loss Of Generator Field Relay 40G1 Spurious Actuation	8.64E-06
560	GK259GNRYT	24	Keowee Unit 2 Generator Ground Fault Relay 59GN2 Spurious Actuation	8.64E-06
561	GK262TDRYT	24	Keowee Unit 2 Generator Backup Trip Timer 62-2TD Spurious Operation	8.64E-06
562	GK263FXRYT	24	Keowee Unit 2 Generator Fire Relay 63FX Spurious Actuation	8.64E-06
563	GK286E2RYT	24	Keowee 2 Emergency Lockout Relay 86E-2 Spuriously Picks Up	8.64E-06
564	GK287G2RYT	24	Keowee Unit 2 Generator Differential Relay 87G-2 Spurious Actuation	8.64E-06
565	GK287GBRYT	24	Keowee Unit 2 Generator Bus Differential Relay 87GB Spurious Actuation	8.64E-06
566	GK287TERYT	24	Keowee Unit 2 Excitation Transformer Differential Relay 87T-2E Spur. Actuation	8.64E-06
567	GK2BRGVLHE	2.60E-04	Keowee 2 Gen. Brng Oil Cooling Flow Path Vlvs Mispositioned After Maintenance	2.60E-04
568	GK2COOLLHE	2.60E-04	Keowee 2 Gen. Air Cooler WL Flow Path Vlvs Mispositioned After Maintenance	2.60E-04
569	GK2FIREDEX	7.00E-05	Spurious Actuation of Unit 2 Gen. CO2 Fire Supression System	7.00E-05
570	GK2GAC1HXF	24	Generator Air Cooler 2GAHW-1 Fails	1.54E-05
571	GK2GAC1HXL	36	Heat Exchanger 2GAC1 Leaks	3.60E-06
572	GK2GAC2HXF	24	Generator Air Cooler 2GAHW-2 Fails	1.54E-05
573	GK2GAC2HXL	36	Heat Exchanger 2GAC2 Leaks	3.60E-06
574	GK2GAC3HXF	24	Generator Air Cooler 2GAHW-3 Fails	1.54E-05
575	GK2GAC3HXL	36	Heat Exchanger 2GAC3 Leaks	3.60E-06
576	GK2GAC4HXF	24	Generator Air Cooler 2GAHW-4 Fails	1.54E-05
577	GK2GAC4HXL	36	Heat Exchanger 2GAC4 Leaks	3.60E-06
578	GK2GAC5HXF	24	Generator Air Cooler 2GAHW-5 Fails	1.54E-05
579	GK2GAC5HXL	36	Heat Exchanger 2GAC5 Leaks	3.60E-06
580	GK2GAC6HXF	24	Generator Air Cooler 2GAHW-6 Fails	1.54E-05
581	GK2GAC6HXL	36	Heat Exchanger 2GAC6 Leaks	3.60E-06
582	GK2HPO1HXF	24	Generator Thrust Bearing Cooler 2HPOHX-1 Fails	1.54E-05
583	GK2HPO2HXF	24	Generator Thrust Bearing Cooler 2HPOHX-2 Fails	1.54E-05
584	GK2HPO3HXF	24	Generator Thrust Bearing Cooler 2HPOHX-3 Fails	1.54E-05
585	GK2HPO4HXF	24	Generator Thrust Bearing Cooler 2HPOHX-4 Fails	1.54E-05
586	GK2HPO5HXF	24	Generator Thrust Bearing Cooler 2HPOHX-5 Fails	1.54E-05
587	GK2HPO6HXF	24	Generator Thrust Bearing Cooler 2HPOHX-6 Fails	1.54E-05
588	GK2HPO6VVT	24	Genrator Bearing Oil Leak Because Manual Valve 2HPO-6 Transfers Position	4.08E-07
589	GK2HPO7HXF	24	Generator Thrust Bearing Cooler 2HPOHX-7 Fails	1.54E-05
590	GK2HPO8HXF	24	Generator Thrust Bearing Cooler 2HPOHX-8 Fails	1.54E-05
591	GK2NGDCLHE	5.20E-05	Failure to Close the Unit 2 Neutral Ground Disconnect Following Maintenance	5.20E-05
592	GK2O121SST	24	Speed Switch 12/2 Falsely Indicates High Speed	1.01E-04

Table E-7

Keowee PRA Basic Event Data
Two Unit Generation - Bayesian Update/Recovered

	NAME	FACTOR	DESCRIPTION	PROBABILITY
593	GK2WL16VVT	36	Manual Valve 2WL-16 Transfers Position	6.12E-07
594	GK2WL17VVT	36	Manual Valve 2WL-17 Transfers Position	6.12E-07
595	GK2WL18VVT	36	Manual Valve 2WL18 Transfers Position	6.12E-07
596	GK2WL19VVT	36	Manual Valve 2WL19 Transfers Position	6.12E-07
597	GK2WL20VVT	36	Manual Valve 2WL-20 Transfers Position	6.12E-07
598	GK2WL21VVT	36	Manual Valve 2WL-21 Transfers Position	6.12E-07
599	GK2WL22VVT	36	Manual Valve 2WL22 Transfers Position	6.12E-07
600	GK2WL23VVT	36	Manual Valve 2WL23 Transfers Position	6.12E-07
601	GK2WL24VVT	36	Manual Valve 2WL-24 Transfers Position	6.12E-07
602	GK2WL25VVT	36	Manual Valve 2WL-25 Transfers Position	6.12E-07
603	GK2WL26VVT	36	Manual Valve 2WL26 Transfers Position	6.12E-07
604	GK2WL27VVT	36	Manual Valve 2WL27 Transfers Position	6.12E-07
605	GK2WL28VVT	36	Manual Valve 2WL-28 Transfers Position	6.12E-07
606	GK2WL29VVT	36	Manual Valve 2WL-29 Transfers Position	6.12E-07
607	GK2WL30VVT	36	Manual Valve 2WL30 Transfers Position	6.12E-07
608	GK2WL31VVT	36	Manual Valve 2WL31 Transfers Position	6.12E-07
609	GK2WL32VVT	36	Manual Valve 2WL-32 Transfers Position	6.12E-07
610	GK2WL33VVT	36	Manual Valve 2WL-33 Transfers Position	6.12E-07
611	GK2WL34VVT	36	Manual Valve 2WL34 Transfers Position	6.12E-07
612	GK2WL35VVT	36	Manual Valve 2WL35 Transfers Position	6.12E-07
613	GK2WL36VVT	36	Manual Valve 2WL-36 Transfers Position	6.12E-07
614	GK2WL37VVT	36	Manual Valve 2WL-37 Transfers Position	6.12E-07
615	GK2WL38VVT	36	Manual Valve 2WL38 Transfers Position	6.12E-07
616	GK2WL39VVT	36	Manual Valve 2WL39 Transfers Position	6.12E-07
617	GK2WL41VVT	36	Keowee 2 Manual Valve 2WL-41 Transfers Position to Block Discharge Path	6.12E-07
618	GK2WL44VVT	36	Manual Valve 2WL-44 Transfers Position	6.12E-07
619	GK2WL45VVT	36	Manual Valve 2WL-45 Transfers Position	6.12E-07
620	GK2WL46VVT	36	Manual Valve 2WL-46 Transfers Position	6.12E-07
621	GK2WL47VVT	36	Manual Valve 2WL-47 Transfers Position	6.12E-07
622	GK2WL48VVT	36	Manual Valve 2WL-48 Transfers Position	6.12E-07
623	GK2WL49VVT	36	Manual Valve 2WL-49 Transfers Position	6.12E-07
624	GK2WL50VVT	36	Manual Valve 2WL-50 Transfers Position	6.12E-07
625	GK2WL51VVT	36	Manual Valve 2WL-51 Transfers Position	6.12E-07
626	GK2WL52VVT	36	Manual Valve 2WL-52 Transfers Position	6.12E-07
627	GK2WL53VVT	36	Manual Valve 2WL-53 Transfers Position	6.12E-07
628	GK2WL54VVT	36	Manual Valve 2WL-54 Transfers Position	6.12E-07
629	GK2WL55VVT	36	Manual Valve 2WL-55 Transfers Position	6.12E-07

Table E-7

Keowee PRA Basic Event Data
Two Unit Generation - Bayesian Update/Recovered

	NAME	FACTOR	DESCRIPTION	PROBABILITY
630	GK2WL56VVT	36	Manual Valve 2WL-56 Transfers Position	6.12E-07
631	GK2WL57VVT	36	Manual Valve 2WL-57 Transfers Position	6.12E-07
632	GK2WL58VVT	36	Manual Valve 2WL-58 Transfers Position	6.12E-07
633	GK2WL59VVT	36	Manual Valve 2WL-59 Transfers Position	6.12E-07
634	GK2WL60VVT	36	Manual Valve 2WL-60 Transfers Position	6.12E-07
635	GK2WL61VVT	36	Manual Valve 2WL-61 Transfers Position	6.12E-07
636	GK2WL62VVT	36	Manual Valve 2WL-62 Transfers Position	6.12E-07
637	GK2WL63VVT	36	Manual Valve 2WL-63 Transfers Position	6.12E-07
638	GK2WL64VVT	36	Manual Valve 2WL-64 Transfers Position	6.12E-07
639	GK2WL65VVT	36	Manual Valve 2WL-65 Transfers Position	6.12E-07
640	GK2WL66VVT	36	Manual Valve 2WL-66 Transfers Position	6.12E-07
641	GK2WL67VVT	36	Manual Valve 2WL-67 Transfers Position	6.12E-07
642	GK2WL68VVT	36	Manual Valve 2WL-68 Transfers Position	6.12E-07
643	GK2WL69VVT	36	Manual Valve 2WL-69 Transfers Position	6.12E-07
644	GK2WL70VVT	36	Manual Valve 2WL-70 Transfers Position	6.12E-07
645	GK2WL71VVT	36	Manual Valve 2WL-71 Transfers Position	6.12E-07
646	GK2WL72VVT	36	Manual Valve 2WL-72 Transfers Position	6.12E-07
647	GK2WL73VVT	36	Manual Valve 2WL-73 Transfers Position	6.12E-07
648	GK2WL74VVT	36	Manual Valve 2WL-74 Transfers Position	6.12E-07
649	GK2WL75VVT	36	Manual Valve 2WL-75 Transfers Position	6.12E-07
650	GK2WL76VVT	36	Manual Valve 2WL76 Transfers Position and Blocks Discharge Path	6.12E-07
651	GK2WL78VVT	36	Manual Valve 2WL78 Transfers Position and Blocks Discharge Path	6.12E-07
652	GKHPOILCOM	4.61E-07	Common Cause Failure of Generator Thrust Bearings	4.61E-07
653	K12COM1DEX	1.00E-06	Grid Degradation Occurs And Causes Failure Of Both Keowee Units	1.00E-06
654	KA127T1R6D	1	Xfrmr 1X UV Relay 27T/1X Fails To Pick-up	2.49E-04
655	KA127T1R6T	360	Xfrmr 1X UV Relay 27T/1X Spuriously De-energizes	1.31E-04
656	KA227T2R6T	360	Xfmr 2X UV Relay 27T/2x Spuriously De-energizes	1.31E-04
657	KB4CONNDEX	1.1E-7	Air Circuit Breaker 4 Connects Unit 2 To The Underground Path	1.10E-07
658	KK1BOTHDEX	0.034	Keowee Units 1 And 2 Are Supplying The Grid	3.40E-02
659	KK1BOTHHYM	5.23E-3	Both Keowee Units Unavailable Due To Common Maintenance	5.23E-03
660	KK1OVERBHF	24	Fault Occurs On The Overhead Power Path	9.60E-06
661	KK1RUNSDEX	0.024	Keowee Unit 1 Only Is Supplying The Grid	2.40E-02
662	KK1UNDRBHF	24	Fault Occurs On The Underground Power Path	9.60E-06
663	KK2RUNSDEX	0.024	Keowee Unit 2 Only Is Supplying The Grid	2.40E-02
664	KK2UNITHYM	3.80E-2	A Single Keowee Unit Is Unavailable Due To Maintenance	3.80E-02
665	KU2CREDIT	0	No Credit For Keowee Unit 2 Supplying Auxiliary ac Power To Unit 1	0.00E+00
666	L0EGTPSCOM	1.78E-06	Common Cause Failure of UV And UF Detection Circuits	1.78E-06

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Keowee PRA Basic Event Data
Two Unit Generation - Bayesian Update/Recovered

	NAME	FACTOR	DESCRIPTION		PROBABILITY
667	L27BRX1RYD	1	Snsng Rly 27B/RX1 Fails to Drop Out on Undervoltage	OEE-76-3, -4	3.30E-05
668	L27BRX2RYD	1	Snsng Rly 27B/RX2 Fails to Drop Out on Undervoltage	OEE-76-3, -8	3.30E-05
669	L27BRY1RYD	1	Snsng Rly 27B/RY1 Fails to Drop Out on Undervoltage	OEE-76-3, -4	3.30E-05
670	L27BRY2RYD	1	Snsng Rly 27B/RY2 Fails to Drop Out on Undervoltage	OEE-76-3, -8	3.30E-05
671	L27BRZ1RYD	1	Snsng Rly 27B/RZ1 Fails to Drop Out on Undervoltage	OEE-76-3, -4	3.30E-05
672	L27BRZ2RYD	1	Snsng Rly 27B/RZ2 Fails to Drop Out on Undervoltage	OEE-76-3, -8	3.30E-05
673	L27BYX1RYD	1	Snsng Rly 27B/YX1 Fails to Drop Out on Undervoltage	OEE-76-3, -4	3.30E-05
674	L27BYX2RYD	1	Snsng Rly 27B/YX2 Fails to Drop Out on Undervoltage	OEE-76-3, -8	3.30E-05
675	L27BYY1RYD	1	Snsng Rly 27B/YY1 Fails to Drop Out on Undervoltage	OEE-76-3, -4	3.30E-05
676	L27BYY2RYD	1	Snsng Rly 27B/YY2 Fails to Drop Out on Undervoltage	OEE-76-3, -8	3.30E-05
677	L27BYZ1RYD	1	Snsng Rly 27B/YZ1 Fails to Drop Out on Undervoltage	OEE-76-3, -4	3.30E-05
678	L27BYZ2RYD	1	Snsng Rly 27B/YZ2 Fails to Drop Out on Undervoltage	OEE-76-3, -8	3.30E-05
679	L27XPX1RYD	1	Ch 1 Phase X UV Aux. Relay Fails To Pick Up	OEE-76-4	3.30E-05
680	L27XPX2RYD	1	Ch 2 Phase X UV Aux. Relay Fails To Pick Up	OEE-76-8	3.30E-05
681	L27XPY1RYD	1	Ch 1 Phase Y UV Aux. Relay Fails to Pick Up	OEE-76-4	3.30E-05
682	L27XPY2RYD	1	Ch 2 Phase Y UV Aux. Relay Fails to Pick Up	OEE-76-8	3.30E-05
683	L27XPZ1RYD	1	Ch 1 Phase Z UV Aux. Relay Fails To Pick Up	OEE-76-4	3.30E-05
684	L27XPZ2RYD	1	Ch 2 Phase Z UV Aux. Relay Fails To Pick Up	OEE-76-8	3.30E-05
685	L27XRX1RYD	1	Red Bus Phase X1 Undervoltage Aux. Relay Fails To Pick Up	OEE-76-4	3.30E-05
686	L27XRX2RYD	1	Red Bus Phase X2 Undervoltage Aux. Relay Fails To Pick Up	OEE-76-8	3.30E-05
687	L27XRY1RYD	1	Red Bus Phase Y1 Undervoltage Aux. Relay Fails To Pick Up	OEE-76-4	3.30E-05
688	L27XRY2RYD	1	Red Bus Phase Y2 Undervoltage Aux. Relay Fails to Pick Up	OEE-76-8	3.30E-05
689	L27XRZ1RYD	1	Red Bus Phase Z1 Undervoltage Aux. Relay Fails To Pick Up	OEE-76-4	3.30E-05
690	L27XRZ2RYD	1	Red Bus Phase Z2 Undervoltage Aux. Relay Fails To Pick Up	OEE-76-8	3.30E-05
691	L27XSTARYD	1	Keowee Start Relay 27X/STA Fails To Pick Up	OEE-76-4-A	3.30E-05
692	L27XSTBRYD	1	Keowee Start Relay 27X/STB Fails To Pick Up		3.30E-05
693	L27XYX1RYD	1	Yellow Bus Phase X1 Undervoltage Aux. Relay Fails To Pick Up	OEE-76-4	3.30E-05
694	L27XYX2RYD	1	Yellow Bus Phase X2 Undervoltage Aux. Relay Fails To Pick Up	OEE-76-8	3.30E-05
695	L27XYY1RYD	1	Yellow Bus Phase Y1 Undervoltage Aux. Relay Fails To Pick Up	OEE-76-4	3.30E-05
696	L27XYY2RYD	1	Yellow Bus Phase Y2 Undervoltage Aux. Relay Fails to Pick Up	OEE-76-8	3.30E-05
697	L27XYZ1RYD	1	Yellow Bus Phase Z1 Undervoltage Aux. Relay Fails To Pick Up	OEE-76-4	3.30E-05
698	L27XYZ2RYD	1	Yellow Bus Phase Z2 Undervoltage Aux. Relay Fails to Pick Up	OEE-76-8	3.30E-05
699	L81BRX1RYD	1	Sensing Relay 81BL/RX1 Fails to Drop Out on Underfrequency		3.30E-05
700	L81BRX2RYD	1	Sensing Relay 81BL/RX2 Fails to Drop Out on Underfrequency		3.30E-05
701	L81BRY1RYD	1	Sensing Relay 81BL/RY1 Fails to Drop Out on Underfrequency		3.30E-05
702	L81BRY2RYD	1	Sensing Relay 81BL/RY2 Fails to Drop Out on Underfrequency		3.30E-05
703	L81BRZ1RYD	1	Sensing Relay 81BL/RZ1 Fails to Drop Out on Underfrequency		3.30E-05

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Keowee PRA Basic Event Data
Two Unit Generation - Bayesian Update/Recovered

	NAME	FACTOR	DESCRIPTION		PROBABILITY
704	L81BRZ2RYD	1	Sensing Relay 81BL/RZ2 Fails to Drop Out on Underfrequency		3.30E-05
705	L81BYX1RYD	1	Sensing Relay 81BL/YX1 Fails to Drop Out on Underfrequency		3.30E-05
706	L81BYX2RYD	1	Sensing Relay 81BL/YX2 Fails to Drop Out on Underfrequency		3.30E-05
707	L81BYY1RYD	1	Sensing Relay 81BL/YY1 Fails to Drop Out on Underfrequency		3.30E-05
708	L81BYY2RYD	1	Sensing Relay 81BL/YY2 Fails to Drop Out on Underfrequency		3.30E-05
709	L81BYZ1RYD	1	Sensing Relay 81BL/YZ1 Fails to Drop Out on Underfrequency		3.30E-05
710	L81BYZ2RYD	1	Sensing Relay 81BL/YZ2 Fails to Drop Out On Underfrequency		3.30E-05
711	L81XPX1RYD	1	Ch 1 Phase X Underfrequency Aux. Rly Fails to Pick Up		3.30E-05
712	L81XPX2RYD	1	Ch 2 Phase X Underfrequency Aux. Rly Fails to Pick Up		3.30E-05
713	L81XPY1RYD	1	Ch 1 Phase Y Underfrequency Aux. Rly Fails to Pick Up		3.30E-05
714	L81XPY2RYD	1	Ch 2 Phase Y Underfrequency Aux. Rly Fails to Pick Up		3.30E-05
715	L81XPZ1RYD	1	Ch 1 Phase Z Underfrequency Aux. Rly Fails to Pick Up		3.30E-05
716	L81XPZ2RYD	1	Ch 2 Phase Z Underfrequency Aux. Rly Fails to Pick up		3.30E-05
717	L81XRX1RYD	1	Red Bus Phase X1 Underfrequency Aux. Rly Fails to Pick Up		3.30E-05
718	L81XRX2RYD	1	Red Bus Phase X2 Underfrequency Aux. Rly Fails to Pick Up		3.30E-05
719	L81XRY1RYD	1	Red Bus Phase Y1 Underfrequency Aux. Rly Fails to Pick Up		3.30E-05
720	L81XRY2RYD	1	Red Bus Phase Y2 Underfrequency Aux. Rly Fails to Pick Up		3.30E-05
721	L81XRZ1RYD	1	Red Bus Phase Z1 Underfrequency Aux. Rly Fails to Pick Up		3.30E-05
722	L81XRZ2RYD	1	Red Bus Phase Z2 Underfrequency Aux. Rly Fails to Pick Up		3.30E-05
723	L81XYX1RYD	1	Yellow Bus Phase X1 Underfrequency Aux. Rly Fails to Pick Up		3.30E-05
724	L81XYX2RYD	1	Yellow Bus Phase X2 Underfrequency Aux. Rly Fails to Pick Up		3.30E-05
725	L81XYY1RYD	1	Yellow Bus Phase Y1 Underfrequency Aux. Rly Fails to Pick Up		3.30E-05
726	L81XYY2RYD	1	Yellow Bus Phase Y2 Underfrequency Aux. Rly Fails to Pick Up		3.30E-05
727	L81XYZ1RYD	1	Yellow Bus Phase Z1 Underfrequency Aux. Rly Fails to Pick Up		3.30E-05
728	L81XYZ2RYD	1	Yellow Bus Phase Z2 Underfrequency Aux. Rly Fails to Pick Up		3.30E-05
729	LC94F1ARYD	1	EGTPS Underfrequency Relay 94/F1A Fails to Pick Up		3.30E-05
730	LC94F1BRYD	1	EGTPS Underfrequency Relay 94/F1B Fails to Pick Up		3.30E-05
731	LC94F1DRYD	1	EGTPS Underfrequency Relay 94/F1D Fails to Pick Up		3.30E-05
732	LC94F2ARYD	1	EGTPS Underfrequency Relay 94/F2A Fails to Pick Up		3.30E-05
733	LC94F2BRYD	1	EGTPS Underfrequency Relay 94/F2B Fails to Pick Up		3.30E-05
734	LC94F2CRYD	1	EGTPS Underfrequency Relay 94/F2C Fails to Pick Up		3.30E-05
735	LC94F2DRYD	1	EGTPS Underfrequency Relay 94/F2D Fails to Pick Up		3.30E-05
736	LC94V1ARYD	1	EGTPS Undervoltage Relay 94/V1A Fails to Pick Up		3.30E-05
737	LC94V1BRYD	1	EGTPS Undervoltage Relay 94/V1B Fails To Pick Up	OEE-76-4	3.30E-05
738	LC94V1DRYD	1	EGTPS Undervoltage Relay 94/V1D Fails to Pick Up	OEE-76-4	3.30E-05
739	LC94V2ARYD	1	EGTPS Undervoltage Relay 94/V2A Fails to Pick Up		3.30E-05
740	LC94V2BRYD	1	EGTPS Undervoltage Relay 94/V2B Fails To Pick Up		3.30E-05

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Keowee PRA Basic Event Data
Two Unit Generation - Bayesian Update/Recovered

	NAME	FACTOR	DESCRIPTION	PROBABILITY
741	LC94V2CRYD	1	EGTPS Undervoltage Relay 94/V2C Fails to Pick Up	3.30E-05
742	LDCYC13CDT	24	Switchyard 125 Vdc Panelboard DYC Breaker 13 Transfers Open OEE-76-4 / O-802	1.80E-06
743	LDCYC14CDT	24	Switchyard 125 Vdc Panelboard DYC Breaker 14 Transfers Open OEE-76-4 / O-802	1.80E-06
744	LDCYG12CDT	24	Switchyard 125 Vdc Panelboard DYG Breaker 12 Transfers Open	1.80E-06
745	LDCYG18CDT	24	Switchyard 125 Vdc Panelboard DYG Breaker 18 Transfers Open	1.80E-06
746	OFACTORDEX	1.0	Overload Susceptibility Factor	1.00E+00
747	OK0PRUNCOM	1.46E-05	Common Cause Failure Of Both Governor Oil Systems To Run	1.46E-05
748	OK10001PSC	15	Pressure Switch 1OGPS-1 Fails to Close (Normal Control Signal)	4.35E-05
749	OK10002PSC	8	Pressure Switch 1OGPS-2 Fails to Close	2.32E-05
750	OK10003PSC	4	Pressure Switch 1OGPS-3 Fails to Close	1.16E-05
751	OK10003RVT	24	Safety Relief Valve 1OG-3 Spurious Operation	1.34E-04
752	OK10003TKF	24	Unit 1 Governor Oil Pressure Tank Fails	1.10E-05
753	OK10004PSC	1	Pressure Switch 1OGPS-4 Fails to Close	2.90E-06
754	OK10007FVT	24	Float Valve 1OG-7 Transfers Closed	1.40E-04
755	OK10009VVT	24	Manual Valve 1OG-9 Transfers Closed	4.08E-07
756	OK10011CVO	15	Check Valve 1OG-11 Fails to Open	3.45E-05
757	OK10011CVT	0.75	Check Valve 1OG-11 Transfers Closed	9.75E-08
758	OK10012VVT	30	Manual Globe Valve 1OG-12 Transfers Closed	5.10E-07
759	OK10013RVT	0.75	Relief Valve 1OG-13 Spurious Operation	4.20E-06
760	OK10014CVO	8	Check Valve 1OG-14 Fails to Open	1.84E-05
761	OK10014CVT	0.5	Check Valve 1OG-14 Transfers Closed	6.50E-08
762	OK10015VVT	192	Manual Globe Valve 1OG-15 Transfers Closed	3.26E-06
763	OK10016RVT	0.5	Relief Valve 1OG-16 Transfers Open	2.80E-06
764	OK10017CVO	4	Check Valve 1OG-17 Fails to Open	9.20E-06
765	OK10017CVT	0.25	Check Valve 1OG-17 Transfers Closed	3.25E-08
766	OK10018VVT	108	Manual Globe Valve 1OG-18 Transfers Closed	1.84E-06
767	OK10019RVT	0.25	Relief Valve 1OG-19 Spurious Operation	1.40E-06
768	OK1001AGPR	0.75	OG Pump 1A Fails to Run	1.05E-05
769	OK1001AGPS	15	OG Pump 1A Fails to Start	1.45E-03
770	OK1001BGPR	0.5	OG Pump 1B Fails to Run	7.00E-06
771	OK1001BGPS	8	OG Pump 1B Fails to Start	7.76E-04
772	OK1001BLHE	3.2E-3	Latent Human Error Fails OG Pump 1B	3.20E-03
773	OK1001CGPR	0.25	OG Pump 1C Fails to Run	3.50E-06
774	OK1001CGPS	4	OG Pump 1C Fails to Start	3.88E-04
775	OK1001CLHE	3.2E-3	Latent Human Error Fails OG Pump 1C	3.20E-03
776	OK188GASWT	30	Keowee 1 Governor Oil Control Switch 188GA Spurious Operation	2.10E-06
777	OK188GBSWT	192	Keowee 1 Control Switch 188GB Spurious Operation	1.34E-05

Table E-7

Keowee PRA Basic Event Data
Two Unit Generation - Bayesian Update/Recovered

	NAME	FACTOR	DESCRIPTION	PROBABILITY
778	OK188GCSWT	108	Keowee 1 Control Switch 188GC Spurious Operation	7.56E-06
779	OK199K1RYD	1	Keowee 1 Relay 99K1 Fails To Operate On Demand	3.30E-05
780	OK199K1RYT	24	Keowee Unit 1 Relay 99K1 Spurious Operation	8.64E-06
781	OK199K2RYD	1	Keowee 1 Relay 99K2 Fails To Operate On Demand	3.30E-05
782	OK1AG01TKF	24	Air Receiver Tank 1AGTK-1 Fails	1.10E-05
783	OK1AG04RVT	24	Safety Relief Valve 1AG-4 Spurious Operation	1.34E-04
784	OK1AG05VVT	24	Manual Valve 1AG-5 Transfers Position	4.08E-07
785	OK1OG1CTRM	3.42E-3	OG Pump 1C Train In Maintenance Or Testing	3.42E-03
786	OK1PRUNCOM	1.12E-07	Common Cause Failure of Unit 1 OG Pumps to Run	1.12E-07
787	OK1PSTRCOM	2.04E-05	Common Cause Failure of Unit 1 OG Pumps to Start	2.04E-05
788	OK1XA1DCLT	30	Low Voltage Circuit Breaker 1XA-1D Transfers Position	2.73E-05
789	OK1XA2ECLT	30	Low Voltage Circuit Breaker 1XA-2E Transfers Position	2.73E-05
790	OK1XA4DCLT	30	Low Voltage Circuit Breaker 1XA-4D Transfers Position	2.73E-05
791	OK20001PSC	15	Pressure Switch 2OGPS-1 Fails to Close (Normal Control Signal)	4.35E-05
792	OK20002PSC	8	Pressure Switch 2OGPS-2 Fails to Close	2.32E-05
793	OK20003PSC	4	Pressure Switch 2OGPS-3 Fails to Close	1.16E-05
794	OK20003RVT	24	Safety Relief Valve 2OG-3 Spurious Operation	1.34E-04
795	OK20003TKF	24	Unit 2 Governor Oil Pressure Tank Fails	1.10E-05
796	OK20004PSC	1	Pressure Switch 2OGPS-4 Fails to Close	2.90E-06
797	OK20007FVT	24	Float Valve 2OG-7 Transfers Closed	1.40E-04
798	OK20009VVT	24	Manual Valve 2OG-9 Transfers Closed	4.08E-07
799	OK20011CVO	15	Check Valve 2OG-11 Fails to Open	3.45E-05
800	OK20011CVT	0.75	Check Valve 2OG-11 Transfers Closed	9.75E-08
801	OK20012VVT	30	Manual Globe Valve 2OG-12 Transfers Closed	5.10E-07
802	OK20013RVT	0.75	Relief Valve 2OG-13 Spurious Operation	4.20E-06
803	OK20014CVO	8	Check Valve 2OG-14 Fails to Open	1.84E-05
804	OK20014CVT	0.5	Check Valve 2OG-14 Transfers Closed	6.50E-08
805	OK20015VVT	192	Manual Globe Valve 2OG-15 Transfers Closed	3.26E-06
806	OK20016RVT	0.5	Relief Valve 2OG-16 Transfers Open	2.80E-06
807	OK20017CVO	4	Check Valve 2OG-17 Fails to Open	9.20E-06
808	OK20017CVT	0.25	Check Valve 2OG-17 Transfers Closed	3.25E-08
809	OK20018VVT	108	Manual Globe Valve 2OG-18 Transfers Closed	1.84E-06
810	OK20019RVT	0.25	Relief Valve 2OG-19 Spurious Operation	1.40E-06
811	OK2002AGPR	0.75	OG Pump 2A Fails to Run	1.05E-05
812	OK2002AGPS	15	OG Pump 2A Fails to Start	1.45E-03
813	OK2002BGPR	0.5	OG Pump 2B Fails to Run	7.00E-06
814	OK2002BGPS	8	OG Pump 2B Fails to Start	7.76E-04

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	NAME	FACTOR	DESCRIPTION	PROBABILITY
815	OK2002BLHE	3.2E-3	Latent Human Error Fails OG Pump 2B	3.20E-03
816	OK2002CGPR	0.25	OG Pump 2C Fails to Run	3.50E-06
817	OK2002CGPS	4	OG Pump 2C Fails to Start	3.88E-04
818	OK2002CLHE	3.2E-3	Latent Human Error Fails OG Pump 2C	3.20E-03
819	OK288GASWT	30	Keowee 2 Governor Oil Control Switch 188GA Spurious Operation	2.10E-06
820	OK288GBSWT	192	Keowee 2 Control Switch 188GB Spurious Operation	1.34E-05
821	OK288GCSWT	108	Keowee 2 Control Switch 188GC Spurious Operation	7.56E-06
822	OK299K1RYD	1	Keowee 2 Relay 99K1 Fails To Operate On Demand	3.30E-05
823	OK299K1RYT	24	Keowee Unit 2 Relay 99K1 Spurious Operation	8.64E-06
824	OK299K2RYD	1	Relay 99K2 Fails To Operate On Demand	3.30E-05
825	OK2AG04RVT	24	Safety Relief Valve 2AG-4 Spurious Operation	1.34E-04
826	OK2AG05VVT	24	Manual Valve 2AG-5 Transfers Position	4.08E-07
827	OK2AGO1TKF	24	Air Receiver Tank 2AGTK-1 Fails	1.10E-05
828	OK2OG2CTRM	3.42E-3	OG Pump 2C Train In Maintenance Or Testing	3.42E-03
829	OK2PRUNCOM	1.12E-07	Common Cause Failure of Unit 2 OG Pumps to Run	1.12E-07
830	OK2PSTRCOM	2.04E-05	Common Cause Failure of Unit 2 OG Pumps to Start	2.04E-05
831	OK2XA1DCLT	30	Low Voltage Circuit Breaker 2XA-1D Transfers Position	2.73E-05
832	OK2XA2ECLT	30	Low Voltage Circuit Breaker 2XA-2E Transfers Position	2.73E-05
833	OK2XA4DCLT	30	Low Voltage Circuit Breaker 2XA-4D Transfers Position	2.73E-05
834	OMOD	1	Startup Bus UV Sensing Mod Is In Service	1.00E+00
835	PAC1TC4C4T	24	4160 Vac Breaker 1TC-4 Transfers Open	2.26E-05
836	PACTC01C4T	24	4160 Vac Breaker 1TC-1 Transfers Open	2.26E-05
837	PACTC14C4T	24	4160 Vac Breaker 1TC-14 Transfers Open	2.26E-05
838	PACX1TCBHF	24	4160 Vac Switchgear 1TC Fails	9.60E-06
839	PK0SUMPCOM	2.44E-06	Common Cause Failure Of Turbine Sump Pump System	2.44E-06
840	PK163SALST	30	Unit 1 AC Turbine Sump Pump Float Switch 63SA Fails	9.30E-06
841	PK163SBLST	15	Unit 1 DC Turbine Sump Pump Float Switch 63SB Transfers	4.65E-06
842	PK1ACDCCOM	2.77E-05	Common Cause Failure of Unit 1 Turbine Sump Pump System	2.77E-05
843	PK1DA5CCDT	24	125 Vdc Circuit Breaker 1DA-5C Transfers Position	1.80E-06
844	PK1PACKDEX	3.1E-5	Turbine No. 1 Packing Fails	3.10E-05
845	PK1TS01VVT	30	Manual Valve 1TS-1 Transfers Position	5.10E-07
846	PK1TS02CVT	30	Check Valve 1TS-2 Fails to Open or Transfers Closed	3.90E-06
847	PK1TS03VVT	108	Manual Valve 1TS-3 Transfers Position	1.84E-06
848	PK1TS04CVT	15	Check Valve 1TS-4 Fails to Open or Transfers Closed	1.95E-06
849	PK1TSACGPR	30	AC Sump Pump 1TSPU-1 Fails To Start Or Run	4.20E-04
850	PK1TSDCGPR	15	DC Sump Pump 1TSPU-2 Fails To Start Or Run	2.10E-04
851	PK1TSDCLHE	3.2E-3	Latent Human Error Fails Turbine No. 1 DC Sump Pump	3.20E-03

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	NAME	FACTOR	DESCRIPTION		PROBABILITY
852	PK1TSDCTRM	6.85E-4	Turbine No. 1 DC Pump Train In Maintenance Or Testing		6.85E-04
853	PK1XA2CCLT	30	600 V Circuit Breaker 1XA-2C Transfers Position		2.73E-05
854	PK263SALST	30	Unit 2 AC Turbine Sump Pump Float Switch 63SA Fails		9.30E-06
855	PK263SBLST	15	Unit 2 DC Turbine Sump Pump Float Switch 63SB Transfers		4.65E-06
856	PK2ACDCCOM	2.77E-05	Common Cause Failure of Unit 2 Turbine Sump Pump System		2.77E-05
857	PK2DA1CCDT	24	125 Vdc Circuit Breaker 2DA-1C Transfers Position		1.80E-06
858	PK2PACKDEX	3.1E-5	Turbine No. 2 Packing Fails		3.10E-05
859	PK2TS01VVT	30	Manual Valve 2TS-1 Transfers Position		5.10E-07
860	PK2TS02CVT	30	Check Valve 2TS-2 Fails to Open or Transfers Closed		3.90E-06
861	PK2TS03VVT	108	Manual Valve 2TS-3 Transfers Position		1.84E-06
862	PK2TS04CVT	15	Check Valve 2TS-4 Fails to Open or Transfers Closed		1.95E-06
863	PK2TSACGPR	30	AC Sump Pump 2TSPU-1 Fails To Start Or Run		4.20E-04
864	PK2TSDCGPR	15	DC Sump Pump 2TSPU-2 Fails To Start Or Run		2.10E-04
865	PK2TSDCLHE	3.2E-3	Latent Human Error Fails Turbine No. 2 DC Sump Pump		3.20E-03
866	PK2TSDCTRM	6.85E-4	Turbine No. 2 DC Pump Train In Maintenance Or Testing		6.85E-04
867	PK2XA2CCLT	30	Low Voltage Circuit Breaker 2XA-2C Transfers Position		2.73E-05
868	PMFB1	5.60E-03	Loss of Power on Main Feeder Bus 1		5.60E-03
869	PMFB2	5.60E-03	Loss of Power on Main Feeder Bus 2		5.60E-03
870	S127E1VRYT	9	Unit 1 Startup Bus Undervoltage Relay 27E1 Fails		2.33E-03
871	S127EUVRYT	9	Unit 1 Startup Bus Undervoltage Relay 27E Fails		2.33E-03
872	S127EX1RYD	1	Unit 1 Startup Bus UV Aux Relay 27EX1 Fails to Pick Up		3.30E-05
873	S127EXVRYD	1	Unit 1 Startup Bus UV Aux Relay 27EX Fails to Pick Up		3.30E-05
874	S227E1VRYT	9	Unit 2 Startup Bus Undervoltage Relay 27E1 Fails		2.33E-03
875	S227EUVRYT	9	Unit 2 Startup Bus Undervoltage Relay 27E Fails		2.33E-03
876	S227EX1RYD	1	Unit 2 Startup Bus UV Aux Relay 27EX1 Fails to Pick Up		3.30E-05
877	S227EXVRYD	1	Unit 2 Startup Bus UV Aux Relay 27EX Fails to Pick Up		3.30E-05
878	S27XSC1RYD	1	Channel 1 Swyd Isolated Rly, 27X/SC1, Fails to Pick Up	OEE-76-12	3.30E-05
879	S27XSC2RYD	1	Channel 2 Swyd Isolated Rly, 27X/SC2, Fails to Pick Up	OEE-76-12A	3.30E-05
880	S27XTD1RYD	1	Channel 1 Swyd Isolated Time Delay Rly, 27XTD/SC1, Fails	OEE-76-12	3.30E-05
881	S27XTD2RYD	1	Channel 2 Swyd Isolated Time Delay Rly, 27XTD/SC2, Fails	OEE-76-12A	3.30E-05
882	S327E1VRYT	9	Unit 3 Startup Bus Undervoltage Trip Relay 27E1 Fails		2.33E-03
883	S327EUVRYT	9	Unit 3 Startup Bus Undervoltage Trip Relay 27E Fails		2.33E-03
884	S327EX1RYD	1	Unit 3 Standby Bus UV Aux Relay 27EX1 Fails to Pick Up		3.30E-05
885	S327EXVRYD	1	Unit 3 Startup Bus UV Trip Aux Relay 27EX Fails to Pick Up		3.30E-05
886	SB18UX1RYT	24	Auxiliary Relay 8UX-1 Spurious Operation		8.64E-06
887	SB28UX2RYT	24	Auxiliary Relay 8UX-2 Spurious Operation		8.64E-06
888	SB38UX3RYT	24	Auxiliary Relay 8UX-3 Spurious Operation		8.64E-06

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	NAME	FACTOR	DESCRIPTION		PROBABILITY
889	SB48UX4RYT	24	Auxiliary Relay 8UX-4 Spurious Operation		8.64E-06
890	SDCAIDDDIF	24	Control Power From DYA To PCB 9 Isolating Diode Fails		9.12E-05
891	SDCDA12CDT	24	125 Vdc Swyd Control Power Pnlbd DYA Bkr 12 Xfrs Open		1.80E-06
892	SDCDA15CDT	24	125 Vdc Swyd Control Power Pnlbd DYA Bkr 15 Xfrs Open		1.80E-06
893	SDCDA17CDT	24	125 Vdc Swyd Control Power Pnlbd DYA Bkr 17 Xfrs Open		1.80E-06
894	SDCDB01CDT	24	125 Vdc Swyd Control Power Pnlbd DYB Bkr 1 Xfrs Open		1.80E-06
895	SDCDB13CDT	24	125 Vdc Swyd Control Power Pnlbd DYB Bkr 13 Xfrs Open		1.80E-06
896	SDCDC12CDT	24	125 Vdc Swyd Control Power Pnlbd DYC Bkr 12 Xfrs Open		1.80E-06
897	SDCDE12CDT	24	125 Vdc Swyd Control Power Pnlbd DYE Bkr 12 Xfrs Open		1.80E-06
898	SDCDE15CDT	24	125 Vdc Swyd Control Power Pnlbd DYE Bkr 15 Xfrs Open		1.80E-06
899	SDCDE17CDT	24	125 Vdc Swyd Control Power Pnlbd DYE Bkr 17 Xfrs Open		1.80E-06
900	SDCDF01CDT	24	125 Vdc Swyd Control Power Pnlbd DYF Bkr 1 Xfrs Open		1.80E-06
901	SDCDF13CDT	24	125 Vdc Swyd Control Power Pnlbd DYF Bkr 13 Xfrs Open		1.80E-06
902	SDCDG16CDT	24	125 Vdc Swyd Control Power Pnlbd DYG Bkr 16 Xfrs Open		1.80E-06
903	SDCDYA8CDT	24	125 Vdc Swyd Control Power Pnlbd DYA Bkr 8 Xfrs Open	OEE-38	1.80E-06
904	SDCDYA9CDT	24	125 Vdc Swyd Control Power Pnlbd DYA Bkr 9 Xfrs Open	OEE-39B	1.80E-06
905	SDCDYB4CDT	24	125 Vdc Swyd Control Power Pnlbd DYB Bkr 4 Xfrs Open		1.80E-06
906	SDCDYB6CDT	24	125 Vdc Swyd Control Power Pnlbd DYB Bkr 6 Xfrs Open		1.80E-06
907	SDCDYB8CDT	24	125 Vdc Swyd Control Power Pnlbd DYB Bkr 8 Xfrs Open		1.80E-06
908	SDCDYE8CDT	24	125 Vdc Swyd Control Power Pnlbd DYE Bkr 8 Xfrs Open		1.80E-06
909	SDCDYE9CDT	24	125 Vdc Swyd Control Power Pnlbd DYE Bkr 9 Xfrs Open	OEE-39B	1.80E-06
910	SDCDYF4CDT	24	125 Vdc Swyd Control Power Pnlbd DYF Bkr 4 Xfrs Open		1.80E-06
911	SDCDYF6CDT	24	125 Vdc Swyd Control Power Pnlbd DYF Bkr 6 Xfrs Open		1.80E-06
912	SDCDYF8CDT	24	125 Vdc Swyd Control Power Pnlbd DYF Bkr 8 Xfrs Open		1.80E-06
913	SDCEIDDDIF	24	Control Power From DYE To PCB-9 Isolating Diode Fails		9.12E-05
914	SK194GBRYT	24	Keowee Unit 1 94GB Auxiliary Relay Spurious Operation		8.64E-06
915	SK294GBRYT	24	Keowee Unit 2 94GB Auxiliary Relay Spurious Operation		8.64E-06
916	SKXFMR1THF	24	Keowee Transformer 1 Fails		7.44E-05
917	SPC14KVBHF	24	13.8 kV Bus Faulted		9.60E-06
918	SPC51TNRYT	24	Main Step Up Transformer Neutral Ground Relay 51TN Spurious Operation		8.64E-06
919	SPC62ABRYT	24	ACB Back-up Trip Timer 62AB Spurious Operation		8.64E-06
920	SPC631XRYT	24	Auxiliary Relay 63H1X Spurious Operation		8.64E-06
921	SPC871XRYT	72	Transformer 1X Differential Relay 87T-1X Spurious Operation		2.59E-05
922	SPC872XRYT	72	Transformer 2X Differential Relay 87T-2X Spurious Operation		2.59E-05
923	SPC87T1RYT	72	Main Step Up Transformer Differential Relay 87T Spurious Operation		2.59E-05
924	SPC94TKRYT	24	Auxiliary Relay 94T/K Spurious Operation		8.64E-06
925	SPCB008CHO	1	SWYD PCB-8 Fails to Trip		2.60E-05

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	NAME	FACTOR	DESCRIPTION	PROBABILITY
926	SPCB009CHC	1	SWYD PCB-9 Fails To Close On Demand	2.60E-04
927	SPCB009CHO	1	SWYD PCB-9 Fails To Trip	2.60E-05
928	SPCB012CHO	1	SWYD PCB-12 Fails To Trip	2.60E-05
929	SPCB015CHO	1	SWYD PCB-15 Fails To Trip On Demand	2.60E-05
930	SPCB017CHO	1	SWYD PCB-17 Fails To Trip On Demand	2.60E-05
931	SPCB021CHO	1	SWYD PCB-21 Fails To Trip On Demand	2.60E-05
932	SPCB024CHO	1	SWYD PCB-24 Fails To Trip On Demand	2.60E-05
933	SPCB026CHO	1	SWYD PCB-26 Fails To Trip On Demand	2.60E-05
934	SPCB028CHO	1	SWYD PCB-28 Fails To Trip On Demand	2.60E-05
935	SPCB033CHO	1	SWYD PCB-33 Fails To Open On Demand	2.60E-05
936	SPCD87LRYT	24	Line Differential Relay 87L Spurious Operation	8.64E-06
937	SPCGLASSWT	24	Break Glass Switch Spurious Operation	1.68E-06
938	SPCR86TRYT	24	Lock Out Relay 86T Spurious Operation	8.64E-06
939	SU127UVCOM	1.18E-04	Common Cause Failure of Unit 1 SU Bus Undervoltage Relays	1.18E-04
940	SU227UVCOM	1.18E-04	Common Cause Failure of Unit 2 SU Bus Undervoltage Relays	1.18E-04
941	SU327UVCOM	1.18E-04	Common Cause Failure of Unit 3 SU Bus Undervoltage Relays	1.18E-04
942	SXFRCT3THF	24	Transformer CT3 Faulted	7.44E-05
943	SXFRCT3THM	1.74E-04	Transformer CT3 Is In Maintenance	1.74E-04
944	SXFRCT4LHE	6.40E-05	Latent Human Error on CT4 Maintenance	6.40E-05
945	SXFRCT4THM	9.13E-04	Transformer CT4 Is In Maintenance	9.13E-04
946	SY30R94RYT	24	PCB 30 Relay 94 Spuriously Picks Up	8.64E-06
947	SY51TN2RYT	24	230kV Neutral Ground Relay Spuriously Picks Up	8.64E-06
948	SY51TN4RYT	24	4.16kV Neutral Ground Relay Spuriously Picks Up	8.64E-06
949	SY51TN6RYT	24	6.9kV Neutral Ground Relay 51TN Spuriously Picks Up	8.64E-06
950	SY62X1FRYT	24	Breaker Failure Relay 62X1 Spuriously Picks Up	8.64E-06
951	SY62X2FRYT	24	Breaker Failure Relay 62X2 Spuriously Picks Up	8.64E-06
952	SY62XXFRYT	24	Breaker Failure Relay 62X Spuriously Picks Up	8.64E-06
953	SY86BUIRYT	24	CT3 6.9kV Start Up Bus Lockout Relay Spuriously Picks Up	8.64E-06
954	SY86CT3RYT	24	Transformer CT3 Lockout Relay Spuriously Picks Up	8.64E-06
955	SY86YA9RYT	24	Yellow Bus Lockout Auxiliary Relay 86YA9 Spuriously Picks Up	8.64E-06
956	SY86YJ3RYT	24	Yellow Bus Lockout Auxiliary Relay 86YJ30 Spuriously Picks Up	8.64E-06
957	SY87BYXRYT	24	Yellow Bus X Phase Differential Relay 87BYX Spuriously Picks Up	8.64E-06
958	SY87BYYRYT	24	Yellow Bus Y Phase Differential Relay 87BYY Spuriously Picks Up	8.64E-06
959	SY87BYZRYT	24	Yellow Bus Z Phase Differential Relay 86BYZ Spuriously Picks Up	8.64E-06
960	SY87LXXRYT	24	Differential Auxiliary Relay 87LX Spuriously Picks Up	8.64E-06
961	SY94L1XRYT	24	Protective Relay 94L Spuriously Picks Up	8.64E-06
962	SYE1362RYT	24	E13 Bkr Failure Relay 62B Spuriously Picks Up	8.64E-06

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	NAME	FACTOR	DESCRIPTION	PROBABILITY
963	SYE2362RYT	24	E23 Bkr Failure Relay 62B Spuriously Picks Up	8.64E-06
964	SYP2862RYT	24	PCB 28 Breaker Failure Relay 62B Spuriously Picks Up	8.64E-06
965	SYP3062RYT	24	PCB 30 Breaker Failure Relay 62B Spuriously Picks Up	8.64E-06
966	SYP86TXRYT	24	PCB 30 LOR 86TX Spuriously Picks Up	8.64E-06
967	SYPCB09CHT	24	Switchyard Power Circuit Breaker 9 Transfers Open	4.56E-05
968	SYPCB30CHT	24	Switchyard Power Circuit Breaker 30 Transfers Open	4.56E-05
969	SYPL86TRYT	24	PCB 30 LOR 86T Spuriously Picks Up	8.64E-06
970	SYPL87LRYT	24	Differential Relay 87L Spuriously Picks Up	8.64E-06
971	SYR86BYRYT	24	Yellow Bus Lockout Relay 86BY Spuriously Picks Up	8.64E-06
972	SYS63FPRYT	24	Fault Pressure Relay 63FP Spuriously Picks Up	8.64E-06
973	SYSX50BRYT	24	Transformer CT3 Fault Detector Relay 50B Spuriously Picks Up	8.64E-06
974	SYX87TBRYT	24	Differential Relay 87B Spuriously Picks Up	8.64E-06
975	SYXX87TRYT	24	Differential Relay 87T Spuriously Picks Up	8.64E-06
976	U5086EFRYT	24	Overcurrent Relay 50 Spuriously Actuates Lockout Rly 86EF	8.64E-06
977	U5186EFRYT	24	Time Delay Overcurrent Relay 51 Actuates Lockout Relay 86EF	8.64E-06
978	U51TNC4RYT	24	CT4 Neutral Ground Rly Actuates CT4 LOR 86T/CT4	8.64E-06
979	U62BSK1RYT	24	SK1 Breaker Failure Relay 62BXSK1 Spuriously Picks Up	8.64E-06
980	U62BSK2RYT	24	SK2 Breaker Failure Relay 62BXSK2 Spuriously Picks Up	8.64E-06
981	U86CT4XRYT	24	Auxiliary Lockout Relay 86CT4X Spuriously Picks Up	8.64E-06
982	U86TCT4RYT	24	CT4 Lockout Relay 86T/CT4 Spuriously Picks Up	8.64E-06
983	U87TCT4RYT	24	Spurious Op of CT4 Differential Rly 87T Actuates LOR 86EF	8.64E-06
984	UACXCT4THF	24	Transformer CT4 Failed	7.44E-05
985	UXX86EFRYT	24	Lockout Relay 86EF Spuriously Picks Up	8.64E-06
986	WK00RUNCOM	2.09E-05	Common Cause Failure of Keowee Governors to Run	2.09E-05
987	WK1GVCDDEX	3.5E-05	Keowee Unit 1 Gov. Fails to Position Wicket Gates During a Cold Start	3.50E-05
988	WK1GVCDLHE	2.6E-4	Latent Human Error Fails Keowee 1 Governor During Cold Start	2.60E-04
989	WK1GVHTDEX	3.5E-04	Keowee Unit 1 Gov. Fails to Position Wicket Gates During Hot Start	3.50E-04
990	WK1GVRNDEX	5.6E-4	Keowee Unit 1 Gov. Fails to Position Wicket Gates With Unit Running	5.60E-04
991	WK1SPD1DEX	1.0	Potentially Damaging Overspeed Condition Occures At Load Rejection	1.00E+00
992	WK1SPD2DEX	5.6E-05	Keowee Unit 1 Governor Failure Creates Overspeed Condition	5.60E-05
993	WK1TBCDDEX	3.5E-5	Keowee Unit 1 Turbine Fails During a Cold Start	3.50E-05
994	WK1TBHTDEX	3.5E-4	Keowee Unit 1 Turbine Fails During a Hot Start	3.50E-04
995	WK1TBRNDEX	5.6e-4	Keowee Unit 1 Turbine Fails With the Unit Running	5.60E-04
996	WK2GVCDDEX	3.5E-05	Keowee Unit 2 Gov. Fails to Position Wicket Gates During Cold Start	3.50E-05
997	WK2GVCDLHE	2.6E-4	Latent Human Error Fails Keowee 2 Governor During Cold Start	2.60E-04
998	WK2GVHTDEX	3.5E-04	Keowee Unit 2 Gov. Fails to Position Wicket Gates During Hot Start	3.50E-04
999	WK2GVRNDEX	5.6E-4	Keowee Unit 2 Gov. Fails to Position Wicket Gates With Unit Running	5.60E-04

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	NAME	FACTOR	DESCRIPTION		PROBABILITY
1000	WK2SPD2DEX	5.6E-05	Keowee Unit 2 Governor Failure Creates Overspeed Condition		5.60E-05
1001	WK2TBCDDEX	3.5E-5	Keowee Unit 2 Turbine Fails During a Cold Start		3.50E-05
1002	WK2TBHTDEX	3.5E-4	Keowee Unit 2 Turbine Fails During a Hot Start		3.50E-04
1003	WK2TBRNDEX	5.6E-4	Keowee Unit 2 Turbine Fails With the Unit Running		5.60E-04
1004	WKCSTRTCOM	1.12E-05	Common Cause Failure of Keowee Governors to Cold Start		1.12E-05
1005	WKHSTRTCOM	3.50E-6	Common Cause Failure of Keowee Governors to Hot Start		3.50E-06
1006	XA0SWGRCOM	1.22E-06	Common Cause Failure Of Transformers 1X, 2X, And CX		1.22E-06
1007	XA1A2BTCDT	24	600 Vac Breaker 1XA-2BT Transfers Position	K-704	1.80E-06
1008	XA1BKRSCOM	3.10E-04	CCF of 1X Aux Power Breakers ACB-5 & -7		3.10E-04
1009	XA1TR1XTLF	24	Keowee Transformer 1X Fails		1.80E-05
1010	XA1X2AXCLT	24	600 Vac Breaker 1X-2A Transfers Position		2.18E-05
1011	XA1X2CCCLT	24	600 Vac Breaker 1X-2C Transfers Position		2.18E-05
1012	XA1XA1ACLT	24	600 Vac Breaker 1XA-1A Transfers Open		2.18E-05
1013	XA1XAALBLM	2.74E-03	MCC 1XA Is Connected to Its Alternate Source of Power		2.74E-03
1014	XA1XAMCBLF	24	600 Vac MCC 1XA Fault		6.48E-06
1015	XA1XCXXTHM	4.57E-04	4160/600 Vac Transformer CX Is In Maintenance		4.57E-04
1016	XA1XCXXTLF	24	4160/600 Vac Transformer CX Fails		1.80E-05
1017	XA1XXXXBLF	24	600 Vac Switchgear 1X Fault		6.48E-06
1018	XA2A2BTCDT	24	600 Vac Breaker 2XA-2BT Transfers Position		1.80E-06
1019	XA2BKRSCOM	3.10E-04	CCF of Aux Power Breakers ACB-6 & -8		3.10E-04
1020	XA2TR2XTLF	24	Keowee Transformer 2X Fails		1.80E-05
1021	XA2X2BXCLT	24	600 Vac Breaker 2X-2B Transfers Position		2.18E-05
1022	XA2X2DXCLT	24	600 Vac Breaker 2X-2D Transfers Open		2.18E-05
1023	XA2X4AXCLT	24	600 Vac Breaker 2XA-4A Transfers Position		2.18E-05
1024	XA2XAALBLM	2.74E-03	MCC 2XA Is Connected to Its Alternate Power Source		2.74E-03
1025	XA2XAMCBLF	24	600 Vac MCC-2XA Fault		6.48E-06
1026	XA2XXXXBLF	24	600 Vac Switchgear 2X Fault		6.48E-06
1027	XA56BKRCOM	3.10E-04	Common Cause Failure Of ACB-5 And ACB-6 To Close		3.10E-04
1028	XA78BKRCOM	3.10E-04	Common Cause Failure Of ACB-7 And ACB-8 To Close		3.10E-04
1029	XD0BATTCOM	2.70E-05	Common Cause Failure Of Keowee I&C Power Batteries		2.70E-05
1030	XD0CHRGCOM	3.48E-05	Common Cause Failure Of Keowee Battery Chargers		3.48E-05
1031	XD0KBATRHE	1.00E+00	Failure To Recover DC Power By Cross-Cennecting The DC Distribution Centers		1.00E+00
1032	XD104CCCDT	24	Breaker 1DA-4CC Transfers Open		1.80E-06
1033	XD104CRCDT	6	Breaker 1DA-4CR Transfers Open		4.50E-07
1034	XD1BK1ACDT	24	Battery No. 1 Breaker 1A Transfers Position	run time dependent	1.80E-06
1035	XD1CKC1BCF	24	Battery Charger KC1 Fails		6.96E-04
1036	XD1DA1CCDT	24	125 Vdc Breaker 1C (from charger KC1) Transfers Position		1.80E-06

Table E-7

Keowee PRA Basic Event Data
Two Unit Generation - Bayesian Update/Recovered

	NAME	FACTOR	DESCRIPTION	PROBABILITY
1037	XD1DA3BCDT	24	125 Vdc Breaker 1DA-3BR Transfers Open	1.80E-06
1038	XD1DA4ACDT	24	DC Circuit Breaker 1DA-4AR Transfers Position	1.80E-06
1039	XD1DALTBYM	5.48E-03	Normal Power To Dist. Center 1DA Is In Test and Maintenance	5.48E-03
1040	XD1DARXBDF	24	DC Distribution Center 1DA Faulted during Run	7.68E-06
1041	XD1KB1XDHE	1	Keowee Standby Battery Charger SBC Not Lined Up in 1 Hour	1.00E+00
1042	XD1KB1XRHE	1	Keowee Standby Battery Charger SBC Not Lined Up in 1 Hour	1.00E+00
1043	XD1KBATBYF	1	Keowee Battery No. 1 Fails During Discharge	9.30E-04
1044	XD1TIE1CDT	24	Keowee 125V dc Dist Cntr 1DA Tie Breaker 1 Transfers Position	1.80E-06
1045	XD202CCCDT	6	Breaker 2DA-2CC Transfers Open	4.50E-07
1046	XD204CCCDT	24	Breaker 2DA-4CC Transfers Open K-704	1.80E-06
1047	XD2BK1ACDT	24	Battery No. 2 Breaker 1A Transfers Position	1.80E-06
1048	XD2CKC2BCF	24	Battery Charger KC2 Fails	6.96E-04
1049	XD2DA2ACDT	24	DC Circuit Breaker 2DA-2AR Transfers Position	1.80E-06
1050	XD2DA3BCDT	24	125 Vdc Circuit Breaker 2DA-3BR Transfers Position	1.80E-06
1051	XD2DA5CCDT	24	125 Vdc Breaker 2DA-5C (from Charger KC2) Transfers Open	1.80E-06
1052	XD2DALTBYM	5.48E-03	Normal Power To Dist Cntr 2DA Is In Test and Maintenance	5.48E-03
1053	XD2DARXBDF	24	DC Distribution Center 2DA Faulted During Run	7.68E-06
1054	XD2KB2XDHE	1	Keowee Standby Battery Charger SBC Not Lined Up in 1 Hour	1.00E+00
1055	XD2KB2XRHE	1	Keowee Standby Battery Charger SBC Not Lined Up in 1 Hour	1.00E+00
1056	XD2KBATBYF	1	Keowee Battery No. 2 Fails during Discharge	9.30E-04
1057	XD2TIE2CDT	24	Keowee 125V dc Dist Cntr 2DA Tie Breaker 2 Transfers Position	1.80E-06
1058	Y0STARTCOM	7.26E-06	Common Cause Failure Of Emergency Start Signal	7.26E-06
1059	Y0STARTRHE	1.00E+00	Operators Fail To Manually Start Keowee	1.00E+00
1060	YK114X3SSD	1	Keowee 1 Speed Switch 14-3 Fails to Open at 65 rpm KEE-111	1.80E-05
1061	YK13SUISWT	24	KHU#1 Startup Inhibit Sw 3SUI Xfrs to Inhibit KEE-111, -113	1.68E-06
1062	YK14AMRRYT	24	Keowee 1 Master Relay 4A Spuriously Drops Out	8.64E-06
1063	YK14BMRRYT	24	Keowee 1 Master Relay 4B Spuriously Drops Out	8.64E-06
1064	YK163BHLST	24	Keowee 1 Gen Thrst Brng Oil Lvl Hi Sw 63BL/H Sprsly Clsd KEE-111, -113-3	7.44E-06
1065	YK163BHRYT	24	Keowee 1 Gen Thrst Brng Oil Lvl Hi Rly 63BL/HX Sprsly Picks Up KEE-111,-113-	8.64E-06
1066	YK163BLLST	24	Keowee 1 Gen Thrst Brng Oil Lvl Lo Sw 63BL/L Spuriously Operates KEE-111,-113-	7.44E-06
1067	YK163BLRYT	24	Keowee 1 Gen Thrst Brng Oil Lvl Lo Rly 63BL/LXTD Sprsly Pcks Up KEE-111, -113-	8.64E-06
1068	YK163TBLST	24	Keowee 1 Turb Guide Brng Lo Lvl Sensor Sw Spuriously Closes KEE-113-4	7.44E-06
1069	YK163TBRYT	24	Keowee 1 Turb Gd Brng Oil Lvl Lo Rly 63TB/1X Sprsly Picks Up KEE-111,-113-4	8.64E-06
1070	YK186N1DEX	9.89E-03	Keowee 1 Normal Lockout Actuates	9.89E-03
1071	YK199SDRYD	1	Keowee 1 Shutdown Solenoid 99SD Fails To Pick Up	3.30E-05
1072	YK199SDRYT	24	Keowee 1 Shutdown Solenoid Spuriously Drops Out	8.64E-06
1073	YK199SNRYD	1	K1 Emergency Load Solenoid 99SN Fails To Pick Up/Drop Out	3.30E-05

Table E-7

Keowee PRA Basic Event Data
Two Unit Generation - Bayesian Update/Recovered

	NAME	FACTOR	DESCRIPTION		PROBABILITY
1074	YK199SNRYT	24	Emergency Load Solenoid 99SN Spuriously Drops Out		8.64E-06
1075	YK199SXRYD	1	Keowee 1 Shutdown Solenoid Aux Relay 99SX Fails to Pick Up	KEE-111	3.30E-05
1076	YK199SXRYT	24	Shutdown Auxiliary Relay 99SX Spuriously Drops Out		8.64E-06
1077	YK1D4CRFUF	6	Fuse 1DA-4CR Fails		2.16E-05
1078	YK1ES1ARYD	1	Keowee 1 Emergency Start Aux Relay 1ESRX/1A Fails To Pick Up	OEE-120	3.30E-05
1079	YK1ES1BRYD	1	Keowee 1 Emergency Start Aux Relay 1ESRX/1B Fails To Pick Up	OEE-120-1	3.30E-05
1080	YK1ES2ARYD	1	Keowee 1 Emergency Start Aux Relay 1ESRX/2A Fails To Pick Up	OEE-120	3.30E-05
1081	YK1ES2BRYD	1	Keowee 1 Emergency Start Aux Relay 1ESRX/2B Fails To Pick Up	OEE-120-1	3.30E-05
1082	YK1MR4ARYD	1	Keowee 1 Start Master Relay 4A Fails To Pick Up	KEE-113	3.30E-05
1083	YK1MR4BRYD	1	Keowee 1 Start Master Relay 4B Fails To Pick Up	KEE-113	3.30E-05
1084	YK1SS12SST	24	Keowee 1 Overspeed Switch 12 Spuriously Picks Up	KEE-111	1.01E-04
1085	YK1SS13SSD	1	Keowee 1 Speed Switch 13 Fails to Close at 122 rpm	KEE-111	1.80E-05
1086	YK214X3SSD	1	KHU#2 Speed Switch 14-3 Fails to Open at 65 rpm	KEE-211	1.80E-05
1087	YK23SUISWT	24	KHU#2 Startup Inhbt Sw 3SUI Sprsly Xfrs to Inhibit	KEE-211, -213	1.68E-06
1088	YK24AMRRYT	24	Keowee 2 Master Relay 4A Spuriously Drops Out		8.64E-06
1089	YK24BMRRYT	24	Keowee 2 Master Relay 4B Spuriously Drops Out		8.64E-06
1090	YK263BHLST	24	Keowee 2 Gen Thrst Brng Oil Lvl Hi Sw 63BL/H Sprsly Clsd		7.44E-06
1091	YK263BHRYT	24	Keowee 2 Gen Thrst Brng Oil Lvl Hi Rly 63BL/HX Sprsly Picks Up	KEE-211	8.64E-06
1092	YK263BLLST	24	Keowee 2 Gen Thrst Brng Oil Lvl Lo Sw 63BL/L Sprsly Opn		7.44E-06
1093	YK263BLRYT	24	Keowee 2 Gen Thrst Brng Oil Lvl Lo Rly 63BL/LXTD Sprsly Pcks Up	KEE-211	8.64E-06
1094	YK263TBLST	24	Keowee 2 Turb Guide Brng Lo Lvl Sensor Sw Sprsly Closes		7.44E-06
1095	YK263TBRYT	24	Keowee 2 Turb Gd Brng Oil Lvl Lo Rly 63TB/1X Sprsly Picks Up	KEE-211	8.64E-06
1096	YK286N2DEX	7.41E-03	Keowee Unit 2 Normal Lockout Activates		7.41E-03
1097	YK299SDRYD	1	Keowee 2 Shutdown Solenoid 99SD Fails To Pick Up		3.30E-05
1098	YK299SDRYT	24	Keowee 2 Shutdown Solenoid Spuriously Drops Out		8.64E-06
1099	YK299SNRYD	1	Keowee 2 Emergency Load Solenoid 99SN Fails To Operate		3.30E-05
1100	YK299SNRYT	24	Emergency Load Solenoid 99SN Spuriously Drops Out		8.64E-06
1101	YK299SXRYD	1	Keowee 2 Shutdown Solenoid Aux Relay 99SX Fails to Pick Up	KEE-211	3.30E-05
1102	YK299SXRYT	24	Shutdown Auxiliary Relay 99SX Spuriously Drops Out	s	8.64E-06
1103	YK2D2CCFUF	6	Fuse 2DA-2CC Fails		2.16E-05
1104	YK2ES1ARYD	1	Keowee 2 Emergency Start Aux Relay 2ESRX/1A Fails To Pick Up	OEE-120	3.30E-05
1105	YK2ES1BRYD	1	Keowee 2 Emergency.Start Aux Relay 2ESRX/1B Fails to Pick Up	OEE-120-1	3.30E-05
1106	YK2ES2ARYD	1	Keowee 2 Emergency Start Aux Relay 2ESRX/2A Fails to Pick Up	OEE-120	3.30E-05
1107	YK2ES2BRYD	1	Keowee 2 Emergency Start Aux Relay 2ESRX/2B Fails to Pick Up	OEE-120-1	3.30E-05
1108	YK2MR4ARYD	1	Keowee 2 Start Master Relay 4A Fails To Pick Up	KEE-213	3.30E-05
1109	YK2MR4BRYD	1	Keowee 2 Start Master Relay 4B Fails to Pick Up	KEE-213	3.30E-05
1110	YK2SS12SST	24	Keowee 2 Overspeed Switch 12 Spuriously Picks Up	KEE-211	1.01E-04

Table E-7

Keowee PRA Basic Event Data
Two Unit Generation - Bayesian Update/Recovered

	NAME	FACTOR	DESCRIPTION		PROBABILITY
1111	YK2SS13SSD	1	Keowee 2 Speed Switch 13 Fails to Close at 122 rpm	KEE-211	1.80E-05
1112	YKEMSRTCHE	0	Operator Incorrectly Resets Keowee Emergency Start Signals		0.00E+00
1113	YO1DIA2CDT	30	DC Circuit Breaker 1DIA-2 Transfers Position		2.25E-06
1114	YO1DIB2CDT	30	DC Circuit Breaker 1DIB-2 Transfers Position		2.25E-06
1115	YO1MFBMA	1	ONS1 MFB Monitor Channel A Keowee Start Signal Fails		1.00E+00
1116	YO1MFBMB	1	ONS1 MFB Monitor Channel B Keowee Start Signal Fails		1.00E+00
1117	YO1OPSARHE	1	Operator fails to operate Keowee start switch S1A		1.00E+00
1118	YO1OPSBRHE	1	Operator fails to operate Keowee start switch S1B		1.00E+00
1119	YO1S1AFSWC	1	Control Switch S1A Fails To Close On Demand		1.00E-05
1120	YO1S1BFSWC	1	Control Switch S1B Fails To Close On Demand		1.00E-05
1121	YO1XXKARYD	1	ONS1 Ch A Keowee Emergency Start Relay KA Fails to Pick Up	OEE-120	3.30E-05
1122	YO1XXKBRYD	1	Oconee Unit 1 Chan. B Keowee Emergency Start Relay Fails	OEE-120-1	3.30E-05
1123	YO2CR2ARYD	1	ONS2 Ch A Keowee Emergency Start Relay CR2A Fails to Pick Up	OEE-220	3.30E-05
1124	YO2CR2BRYD	1	ONS2 Keowee Emergency Start Relay CR2B Fails to Pick Up	OEE-220-1	3.30E-05
1125	YO2DIA2CDT	30	Breaker 2DIA-2 Transfers Position		2.25E-06
1126	YO2DIB2CDT	30	Breaker 2DIB-2 Transfers Position		2.25E-06
1127	YO2MFBMA	1	ONS2 MFB Monitor CH A Keowee Start Sig Fails		1.00E+00
1128	YO2MFBMB	1	ONS2 MFB Monitor Ch B Keowee Start Sig Fails		1.00E+00
1129	YO2SSWARHE	1	Operator Fails to Operate Keowee Start Switch 2SSW'A'		1.00E+00
1130	YO2SSWASWC	1	Control Switch 2SSW'A' Fails To Close On Demand		1.00E-05
1131	YO2SSWBRHE	1	Operator Fails to Operate Keowee Start Switch 2SSW'B'		1.00E+00
1132	YO2SSWBSWC	1	Control Switch 2SSW'B' Fails To Close On Demand		1.00E-05
1133	YO3CR3ARYD	1	ONS3 Ch A Keowee Emergency Start Relay CR3A Fails To Pick Up	OEE-320	3.30E-05
1134	YO3CR3BRYD	1	ONS3 Keowee Emer Start Relay CR3B Fails to Pick Up	OEE-320-1	3.30E-05
1135	YO3DIA2CDT	30	Breaker 3DIA-2 Transfers Open	OEE-320, O-2705	2.25E-06
1136	YO3DIB2CDT	30	Breaker 3DIB-2 Transfers Open	OEE-320-1, O-2705	2.25E-06
1137	YO3MFBMA	3.96E-03	ONS3 MFB Monitor Ch A Keowee Start Sig Fails		3.96E-03
1138	YO3MFBMB	3.96E-03	ONS3 MFB Monitor Ch B Keowee Start Sig Fails		3.96E-03
1139	YO3OPFARHE	1	Operator fails to operate Keowee Start Switch 3S1A		1.00E+00
1140	YO3OPFBRHE	1	Operator Fails to Operate Keowee Start Switch 3S1B		1.00E+00
1141	YO3S1AFSWC	1	Control Switch S1A Fails To Close On Demand		1.00E-05
1142	YO3S1BFSWC	1	Control Switch S1B Fails To Close On Demand		1.00E-05
1143	YO3SSWARHE	1	Operator fails to operate Keowee Start Switch 3SSW'A'		1.00E+00
1144	YO3SSWASWC	1	Control Switch 3SSW'A' Fails To Close On Demand		1.00E-05
1145	YO3SSWBRHE	1	Operator Fails to Operate Keowee Start Switch 3SSW'B'		1.00E+00
1146	YO3SSWBSWC	1	Control Switch 3SSW'B' Fails To Close On Demand		1.00E-05

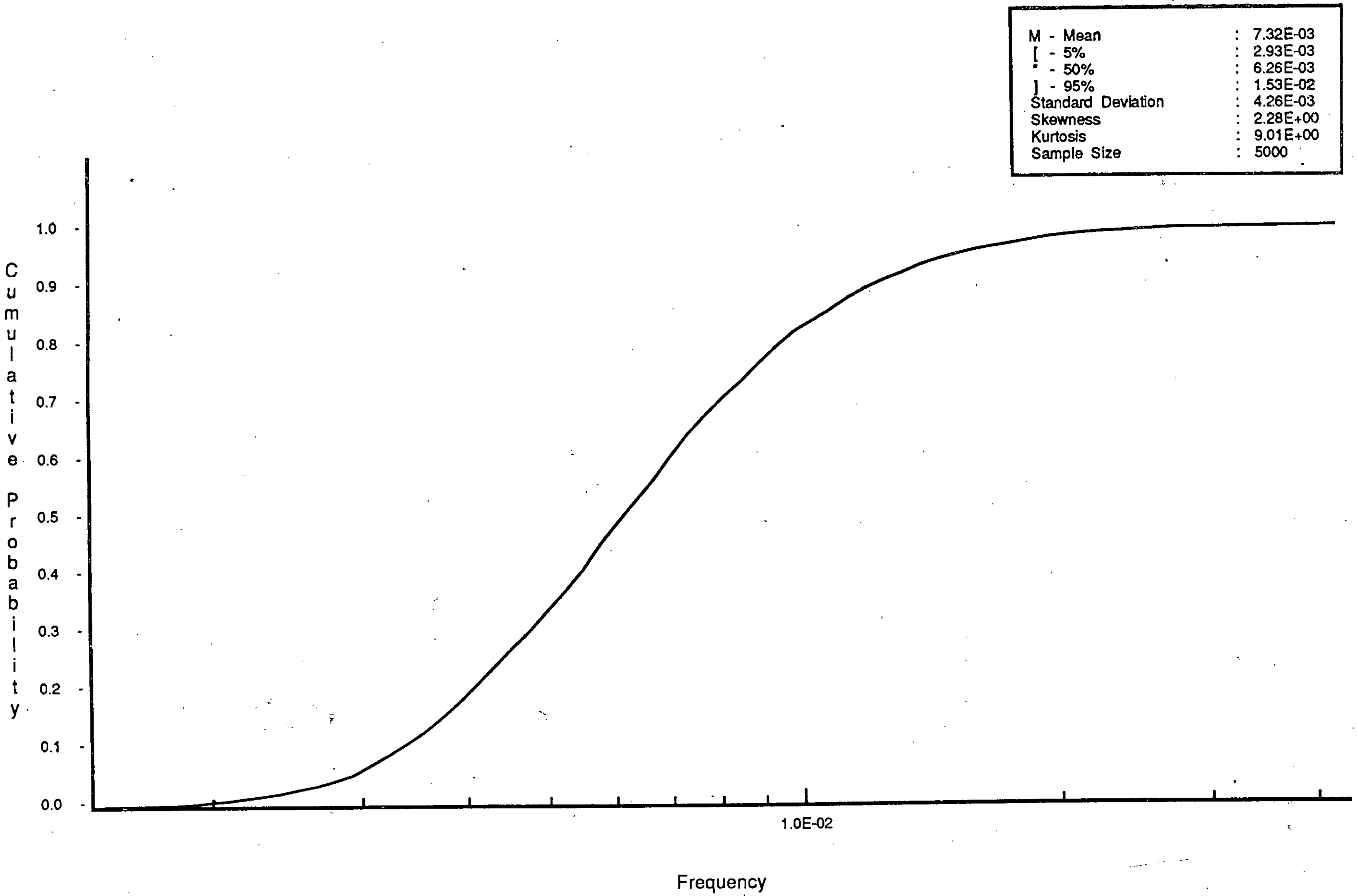


Figure E-2: Cumalative Probability For Model Top Gate KEOWTOP

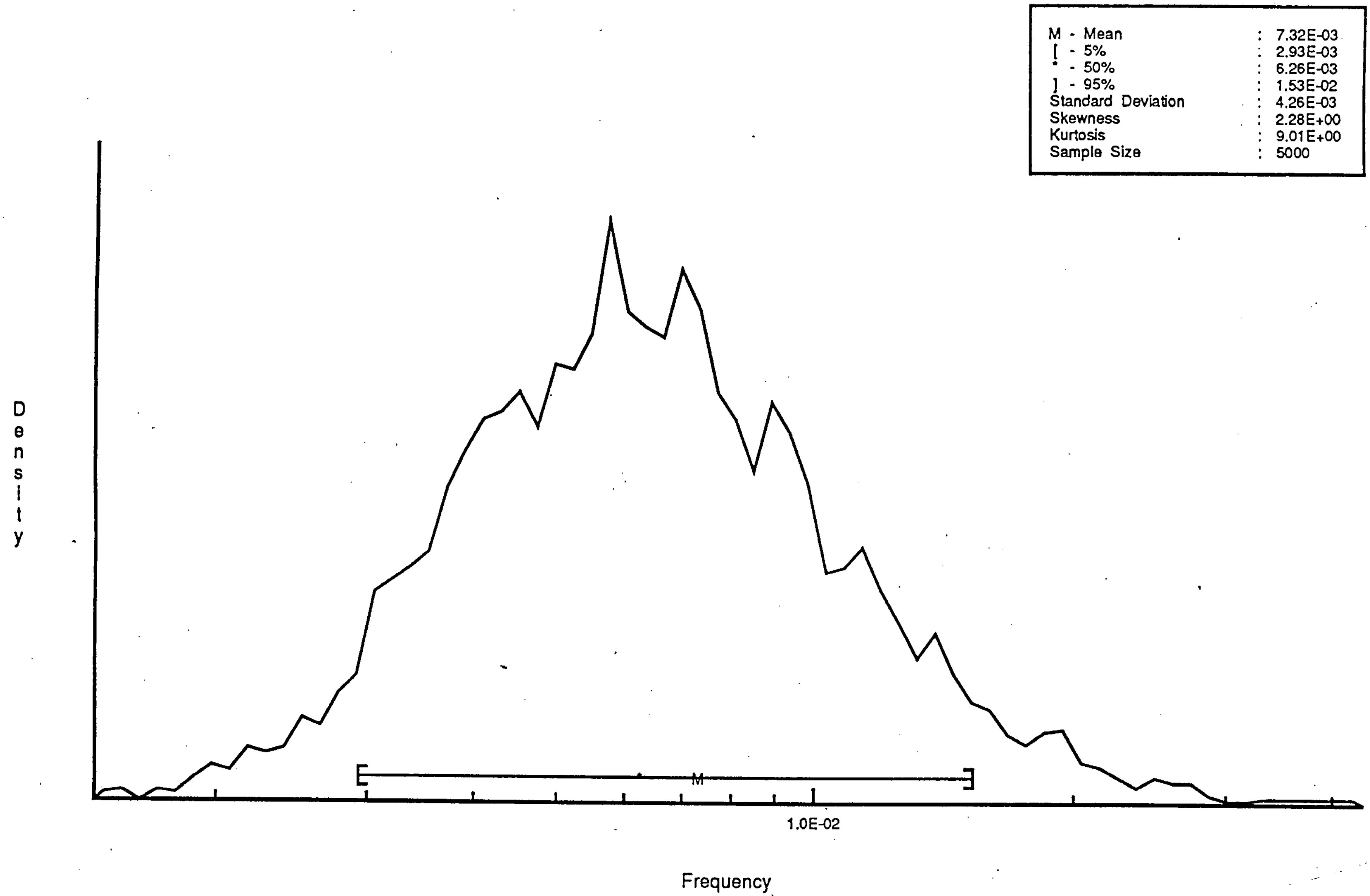


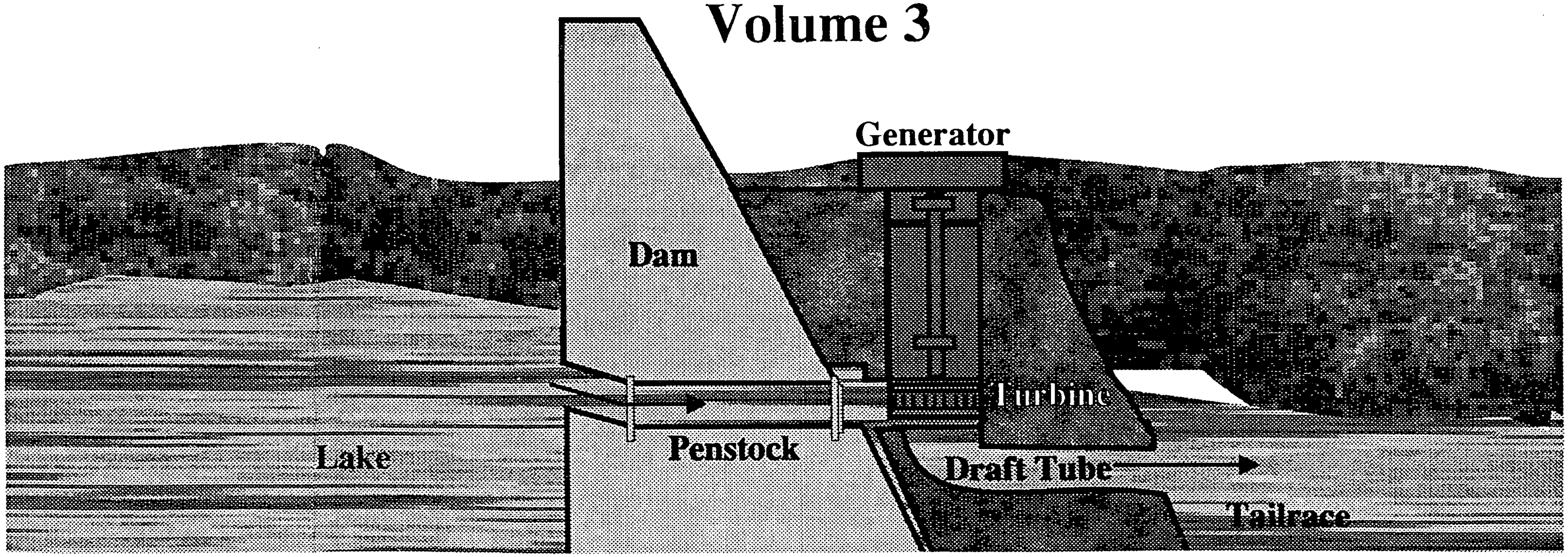
Figure E-1: Probability Distribution For Model Top Gate KEOWTOP

OCONEE NUCLEAR STATION

KEOWEE RELIABILITY ANALYSIS

DUKE POWER COMPANY

Volume 3



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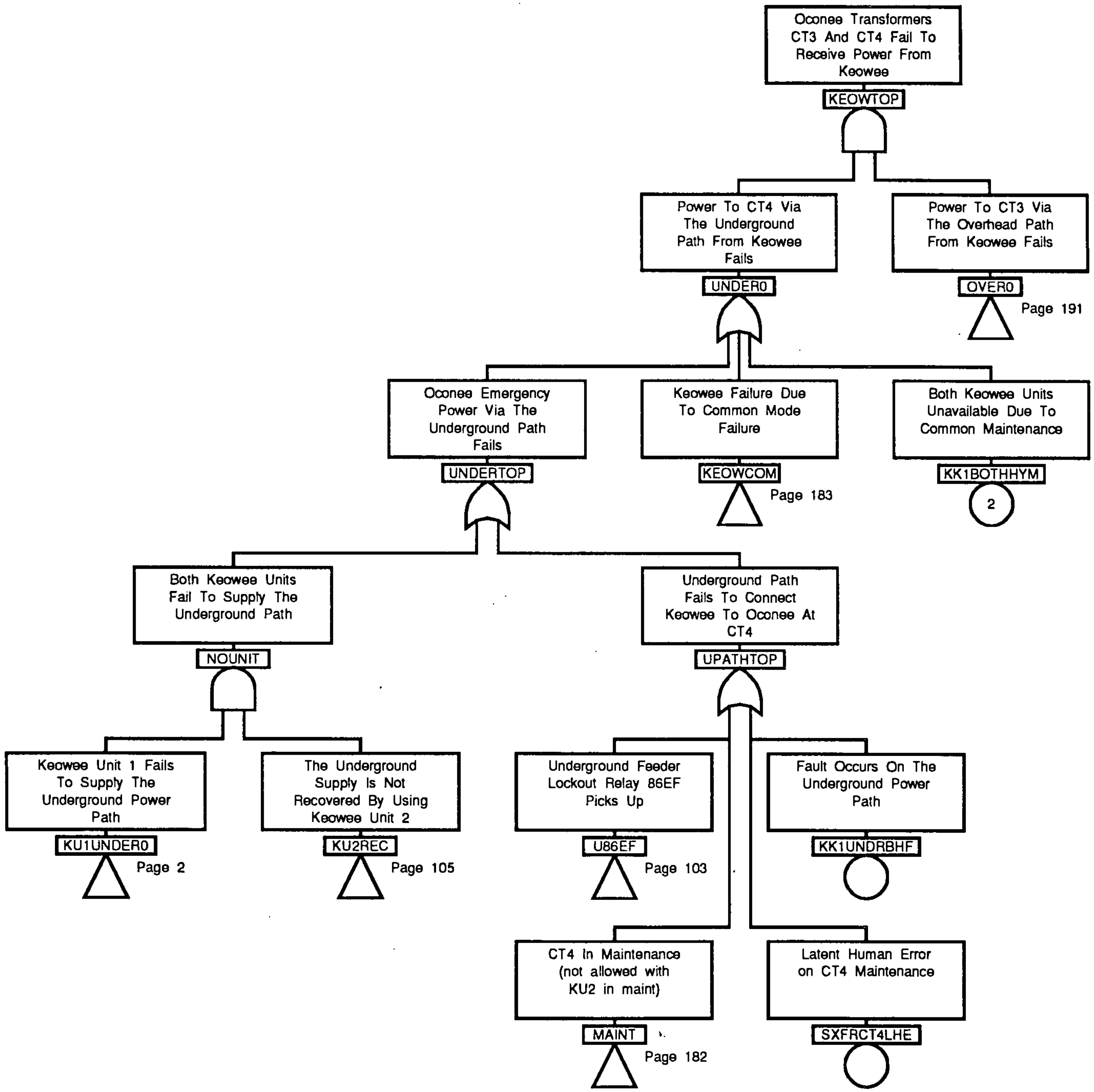

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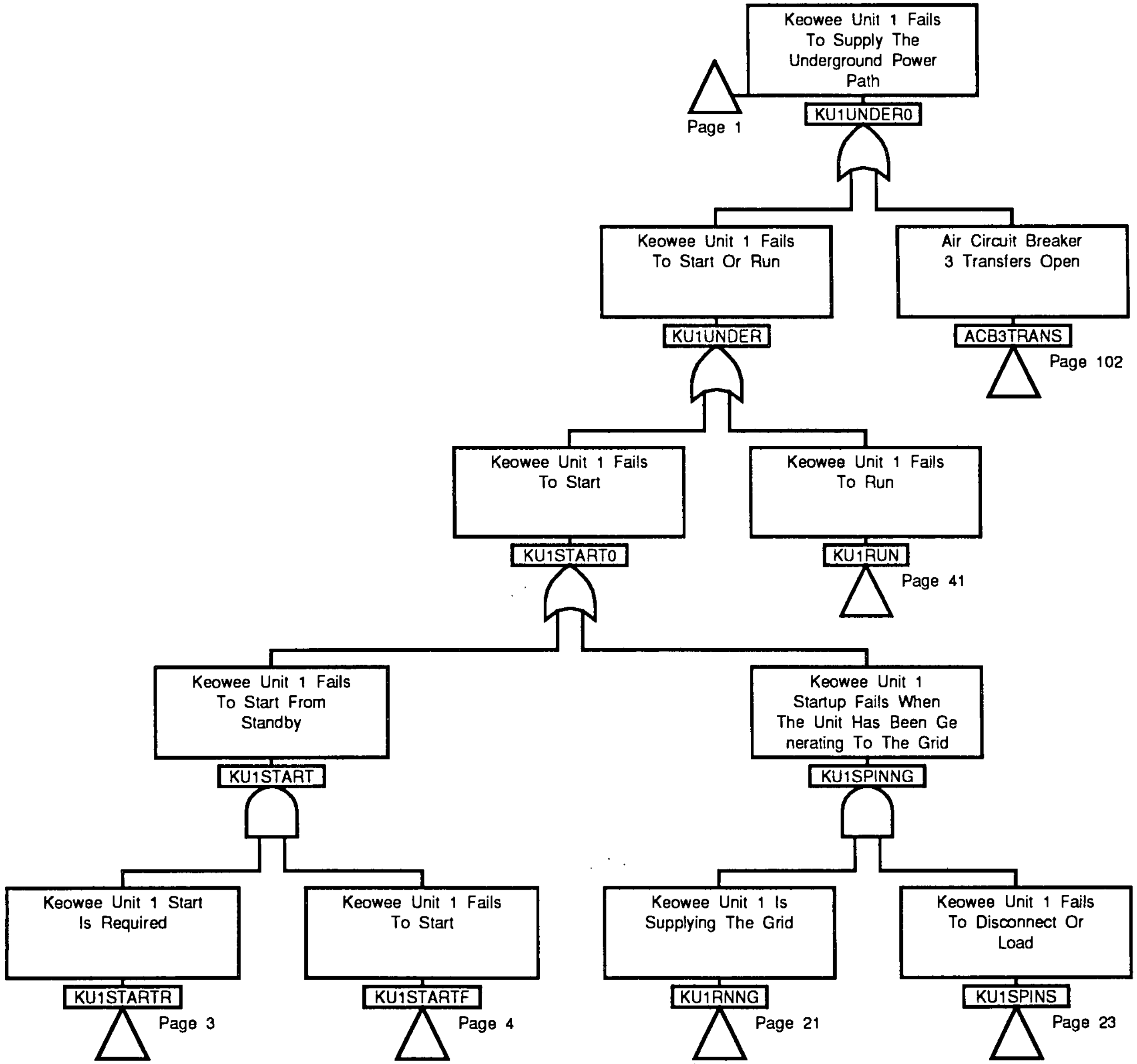
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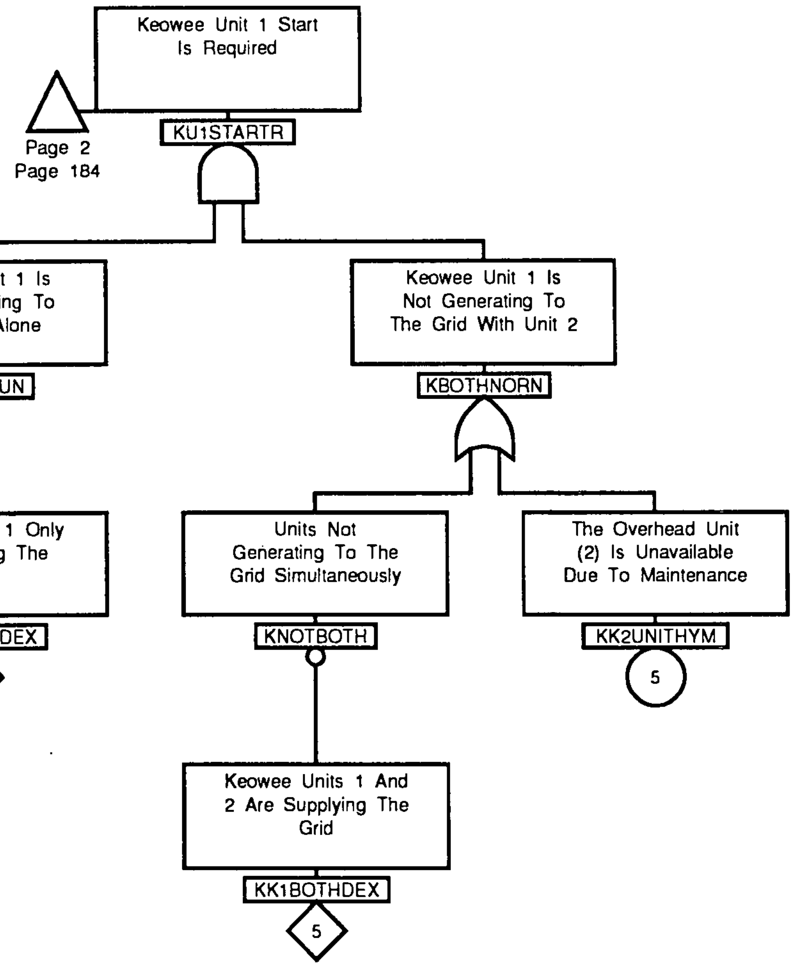
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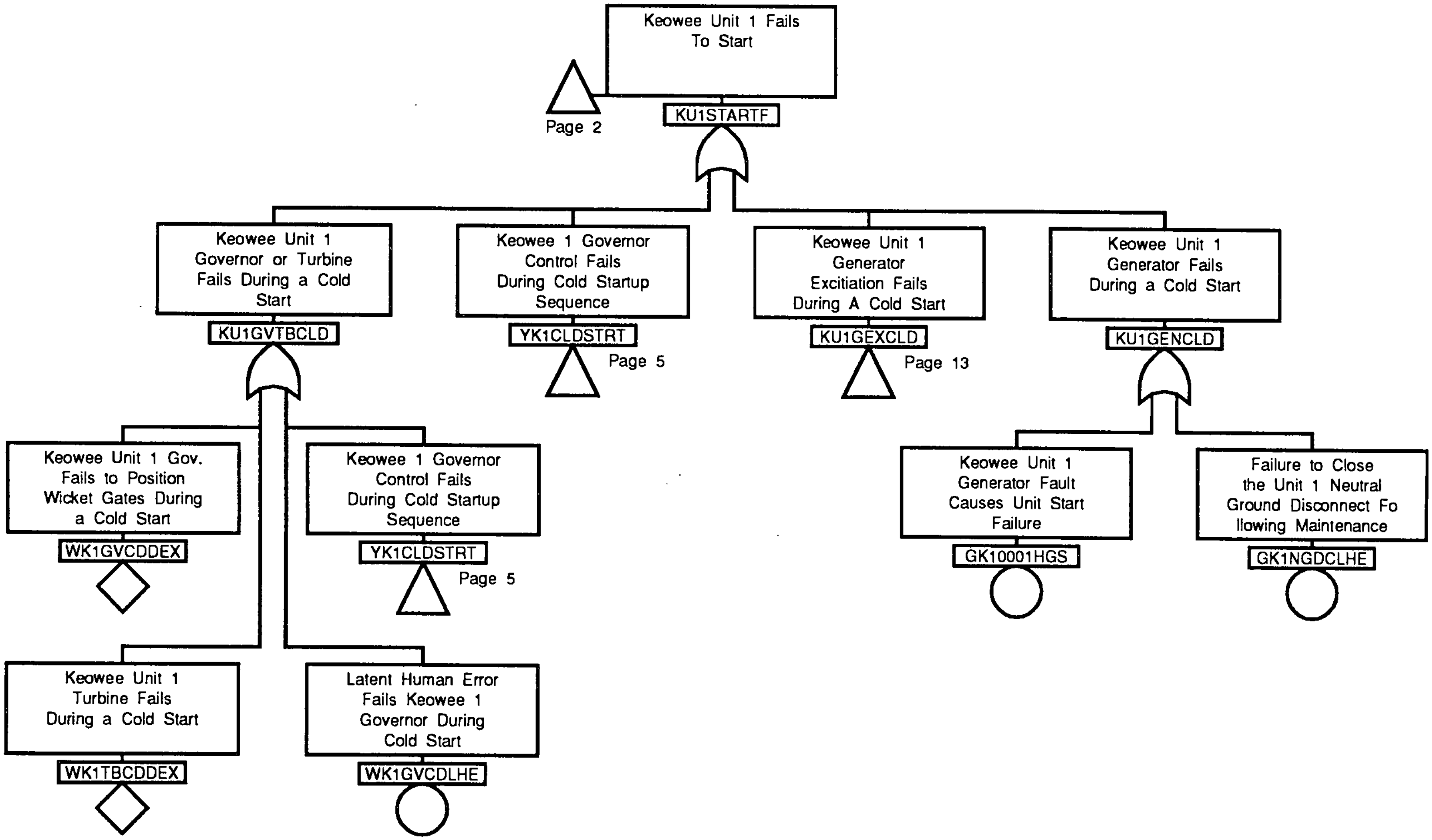
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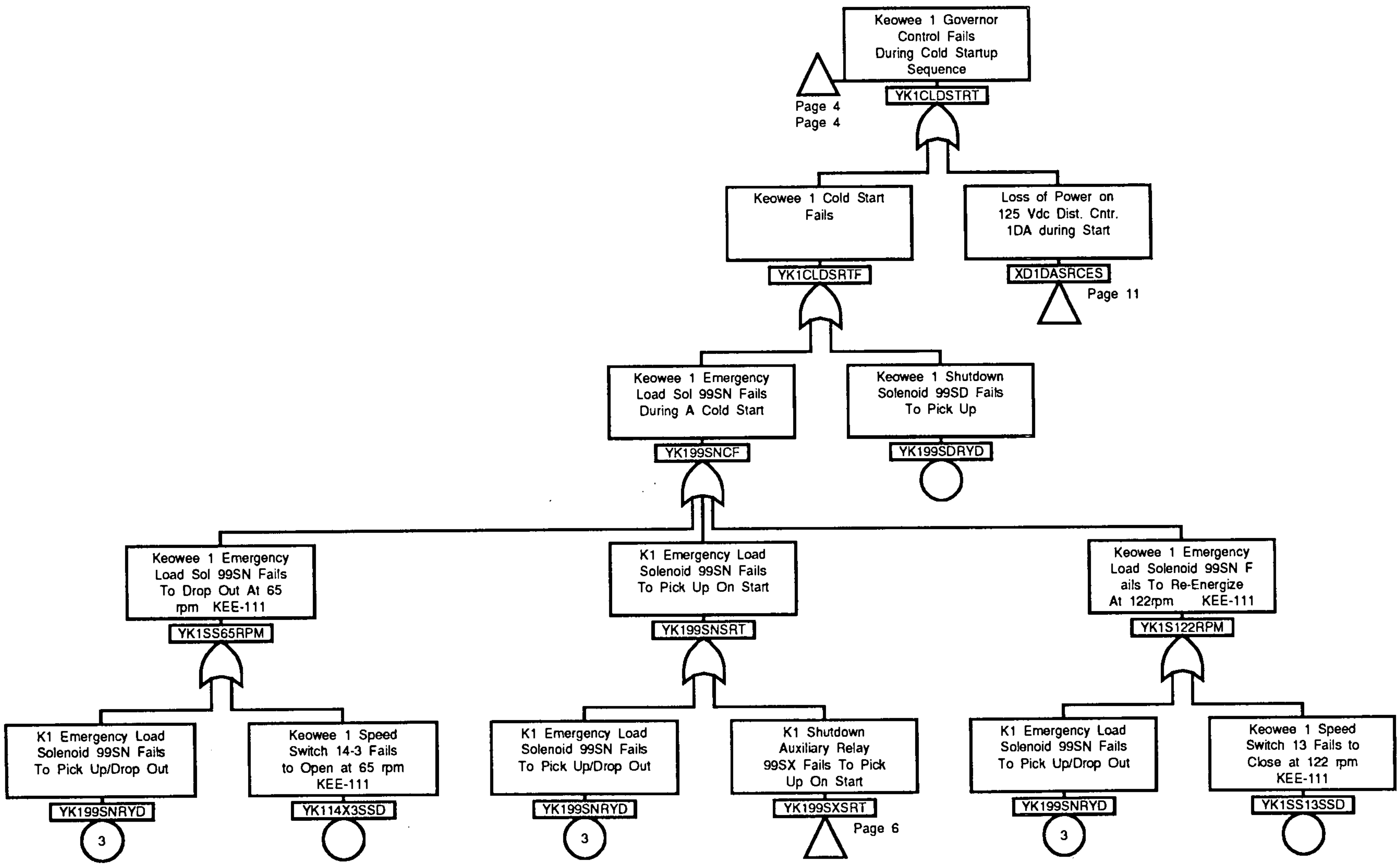
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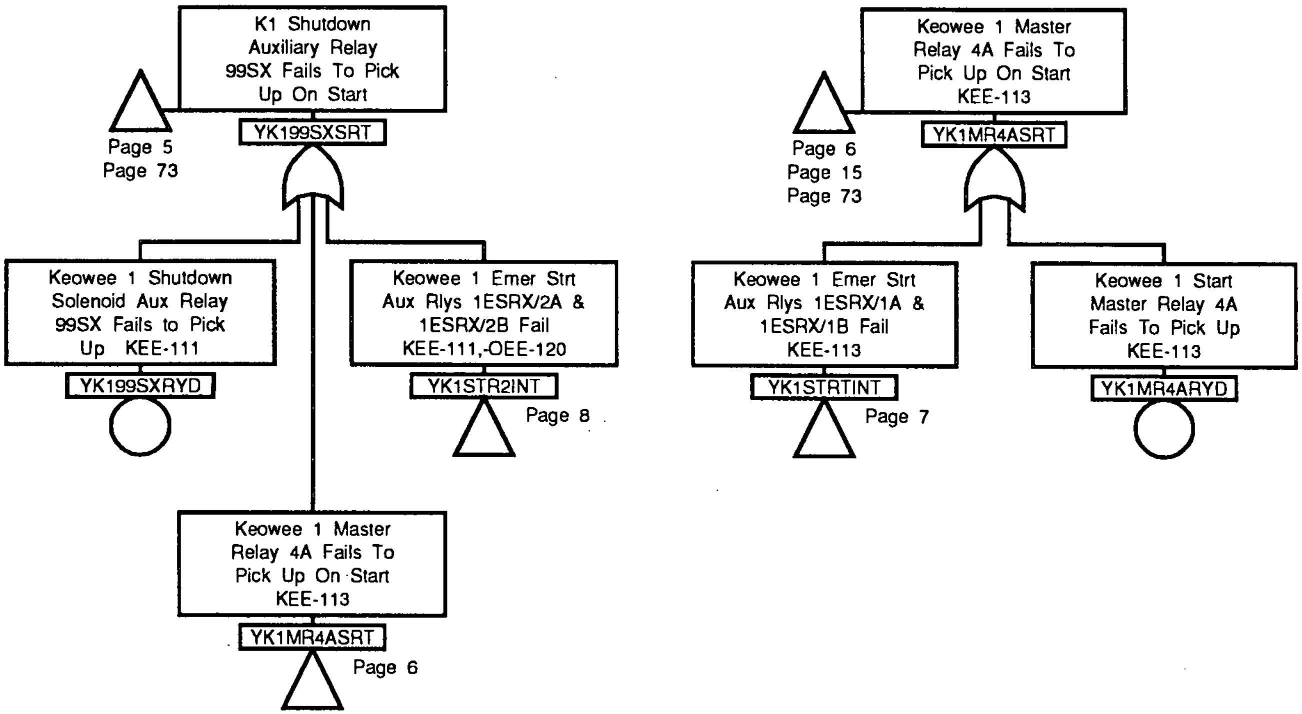
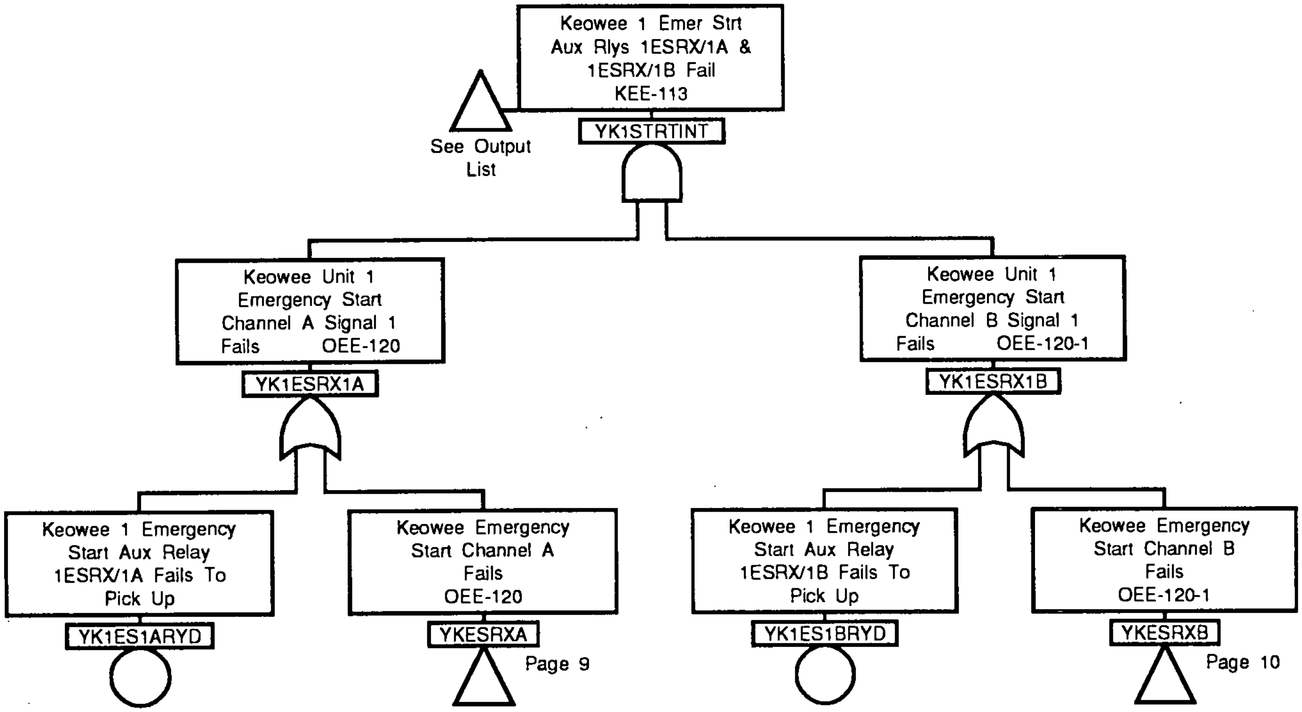
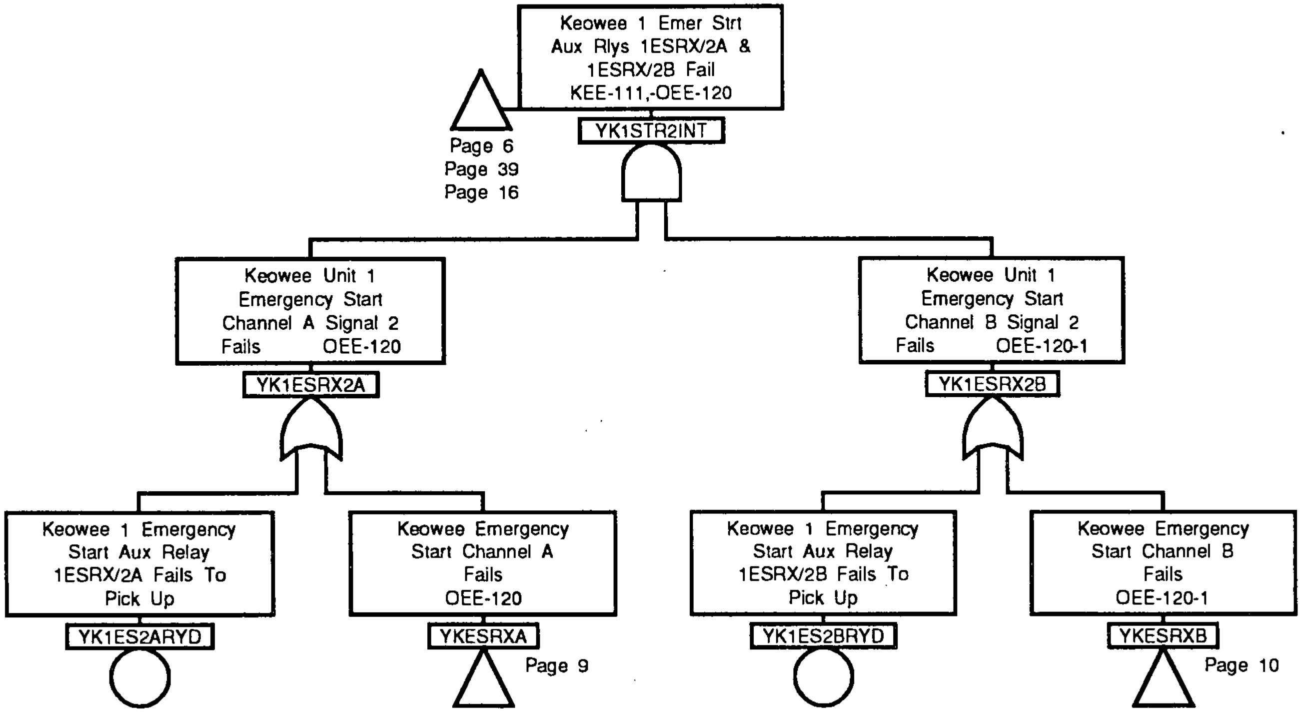
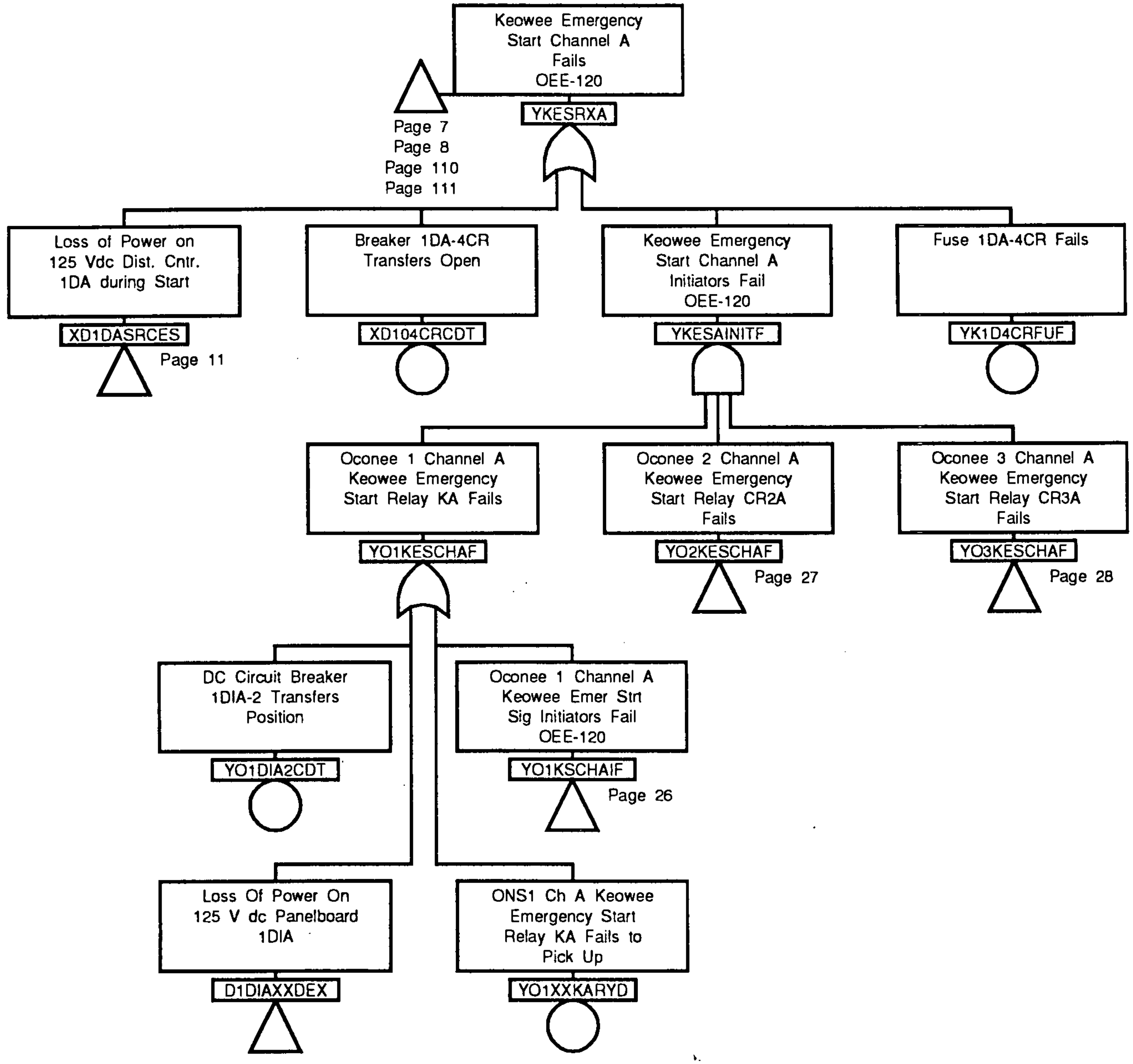
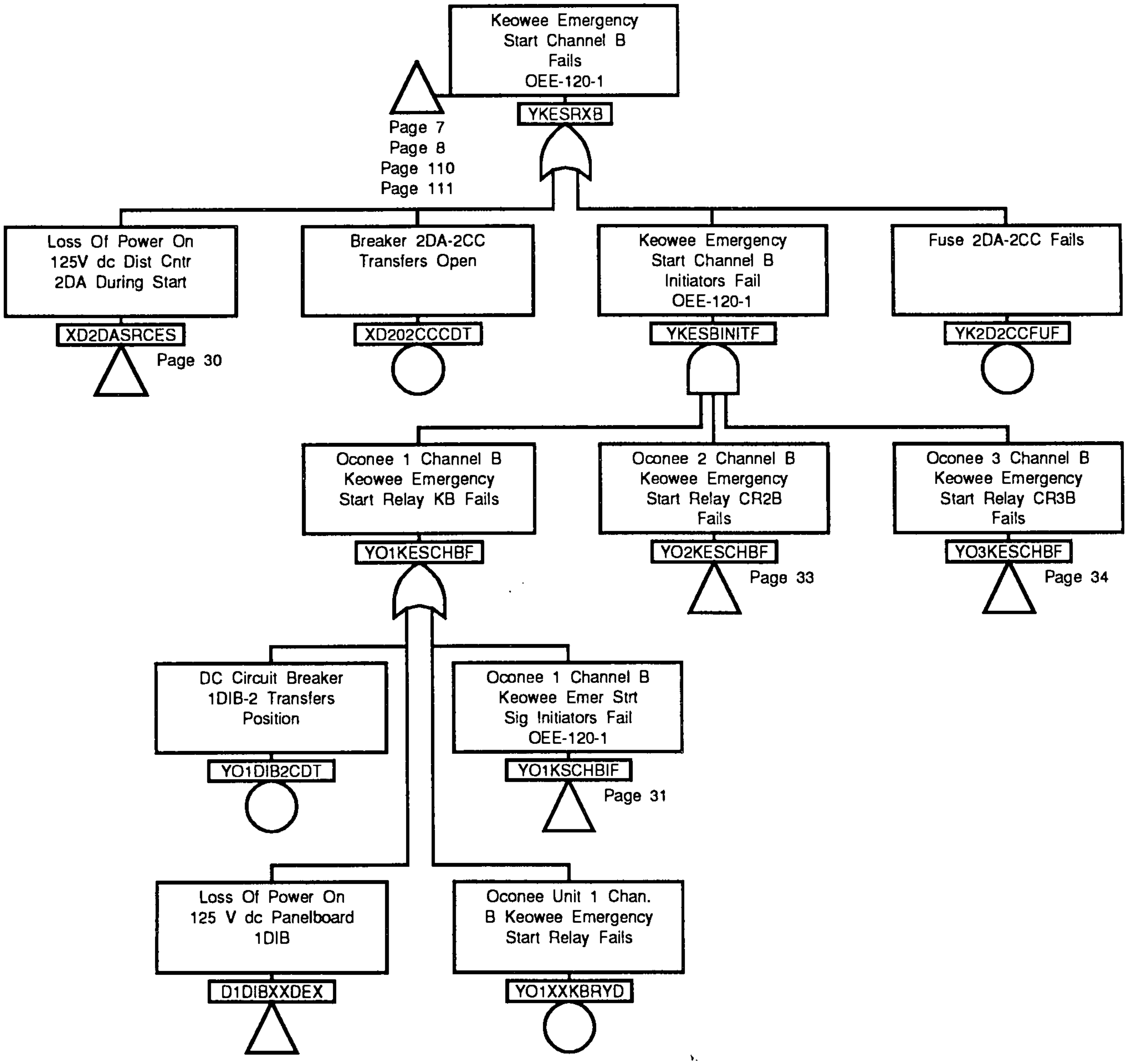
K1 Emergency Load Solenoid 99SN Fails To Pick Up On Start
YK199SNSRT
Keowee 1 Emergency Load Solenoid 99SN F ails To Re-Energize At 122rpm KEE-111
YK1S122RPM
K1 Emergency Load Solenoid 99SN Fails To Pick Up/Drop Out
YK199SNRYD
3
Keowee 1 Speed Switch 14-3 Fails to Open at 65 rpm KEE-111
YK114X3SSD
K1 Emergency Load Solenoid 99SN Fails To Pick Up/Drop Out
YK199SNRYD
3
K1 Shutdown Auxiliary Relay 99SX Fails To Pick Up On Start
YK199SXSRT
Page 6
K1 Emergency Load Solenoid 99SN Fails To Pick Up/Drop Out
YK199SNRYD
3
Keowee 1 Speed Switch 13 Fails to Close at 122 rpm KEE-111
YK1SS13SSD


K1 Shutdown Auxiliary Relay 99SX Fails To Pick Up On Start
YK199SXSRT
Page 5
Page 73
Keowee 1 Shutdown Solenoid Aux Relay 99SX Fails to Pick Up KEE-111
YK199SXRYD
Keowee 1 Emer Strt Aux Rlys 1ESRX/2A & 1ESRX/2B Fail KEE-111,-OEE-120
YK1STR2INT
Page 8
Keowee 1 Master Relay 4A Fails To Pick Up On Start KEE-113
YK1MR4ASRT
Page 6
Keowee 1 Master Relay 4A Fails To Pick Up On Start KEE-113
YK1MR4ASRT
Page 6
Page 15
Page 73
Keowee 1 Emer Strt Aux Rlys 1ESRX/1A & 1ESRX/1B Fail KEE-113
YK1STRTINT
Page 7
Keowee 1 Start Master Relay 4A Fails To Pick Up KEE-113
YK1MR4ARYD

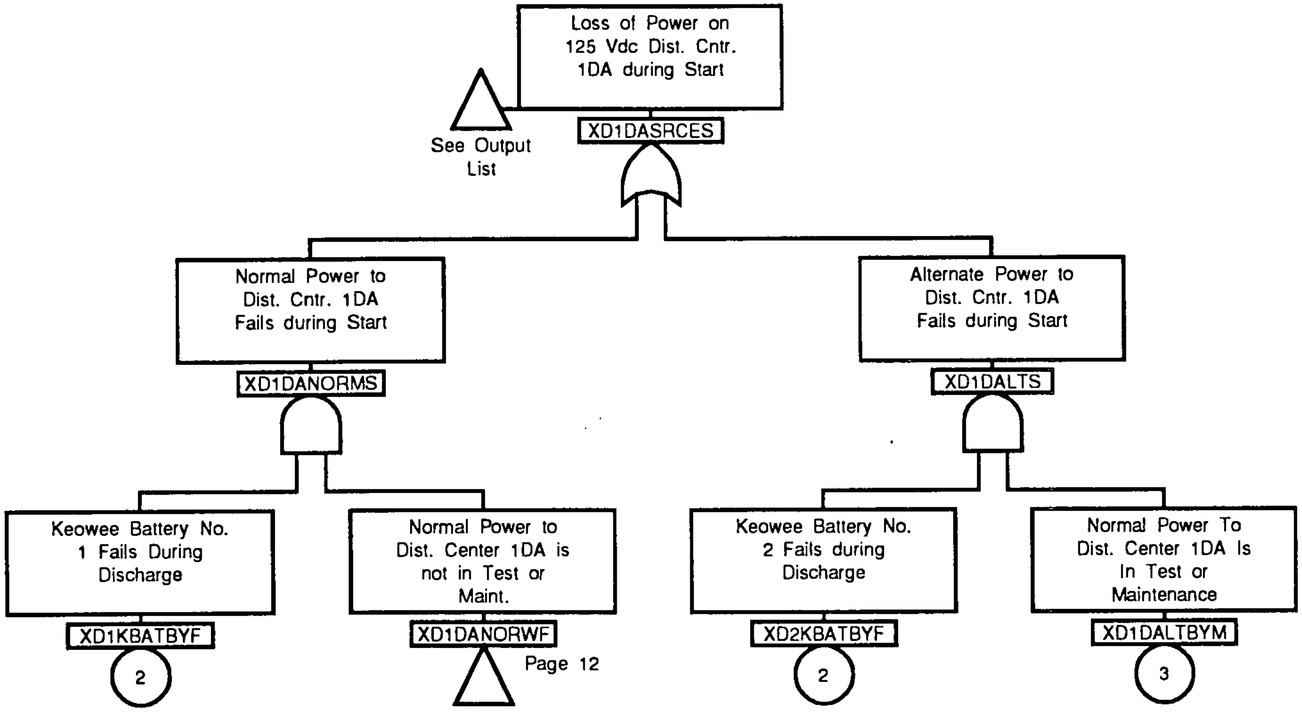

Keowee 1 Emer Strt Aux Rlys 1ESRX/1A & 1ESRX/1B Fail KEE-113
YK1STRTINT
See Output List
Keowee Unit 1 Emergency Start Channel A Signal 1 Fails OEE-120
YK1ESRX1A
Keowee Unit 1 Emergency Start Channel B Signal 1 Fails OEE-120-1
YK1ESRX1B
Keowee 1 Emergency Start Aux Relay 1ESRX/1A Fails To Pick Up
YK1ES1ARYD
Keowee Emergency Start Channel A Fails OEE-120
YKESRXA
Page 9
Keowee 1 Emergency Start Aux Relay 1ESRX/1B Fails To Pick Up
YK1ES1BRYD
Keowee Emergency Start Channel B Fails OEE-120-1
YKESRXB
Page 10


Keowee 1 Emer Strt Aux Rlys 1ESRX/2A & 1ESRX/2B Fail KEE-111,-OEE-120
YK1STR2INT
Page 6
Page 39
Page 16
Keowee Unit 1 Emergency Start Channel A Signal 2 Fails OEE-120
YK1ESRX2A
Keowee Unit 1 Emergency Start Channel B Signal 2 Fails OEE-120-1
YK1ESRX2B
Keowee 1 Emergency Start Aux Relay 1ESRX/2A Fails To Pick Up
YK1ES2ARYD
Keowee Emergency Start Channel A Fails OEE-120
YKESRXA
Page 9
Keowee 1 Emergency Start Aux Relay 1ESRX/2B Fails To Pick Up
YK1ES2BRYD
Keowee Emergency Start Channel B Fails OEE-120-1
YKESRXB
Page 10

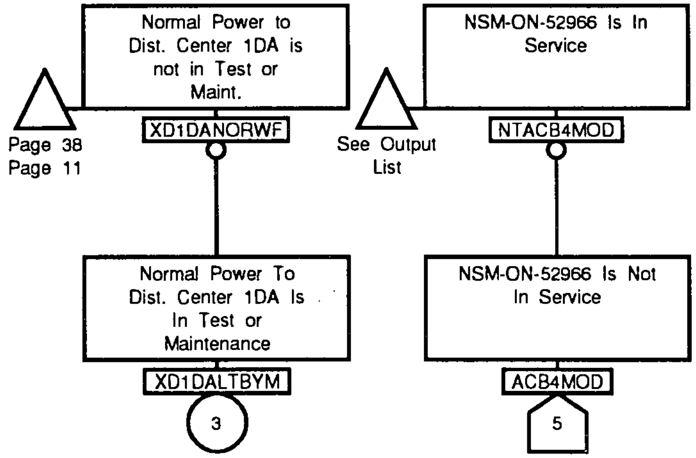

Keewee Emergency Start Channel A Fails OEE-120
YKESRXA
Page 7
Page 8
Page 110
Page 111
Loss of Power on 125 Vdc Dist. Cntr. 1DA during Start
XD1DASRCES
Page 11
Breaker 1DA-4CR Transfers Open
XD104CRCDT
Keowee Emergency Start Channel A Initiators Fail OEE-120
YKESAINITF
Fuse 1DA-4CR Fails
YK1D4CRFUF
Oconee 1 Channel A Keowee Emergency Start Relay KA Fails
YO1KESCHAF
Oconee 2 Channel A Keowee Emergency Start Relay CR2A Fails
YO2KESCHAF
Page 27
Oconee 3 Channel A Keowee Emergency Start Relay CR3A Fails
YO3KESCHAF
Page 28
DC Circuit Breaker 1DIA-2 Transfers Position
YO1DIA2CDT
Oconee 1 Channel A Keowee Emer Strt Sig Initiators Fail OEE-120
YO1KSCHAIF
Page 26
Loss Of Power On 125 V dc Panelboard 1DIA
D1DIAXXDEX
ONS1 Ch A Keowee Emergency Start Relay KA Fails to Pick Up
YO1XXKARYD

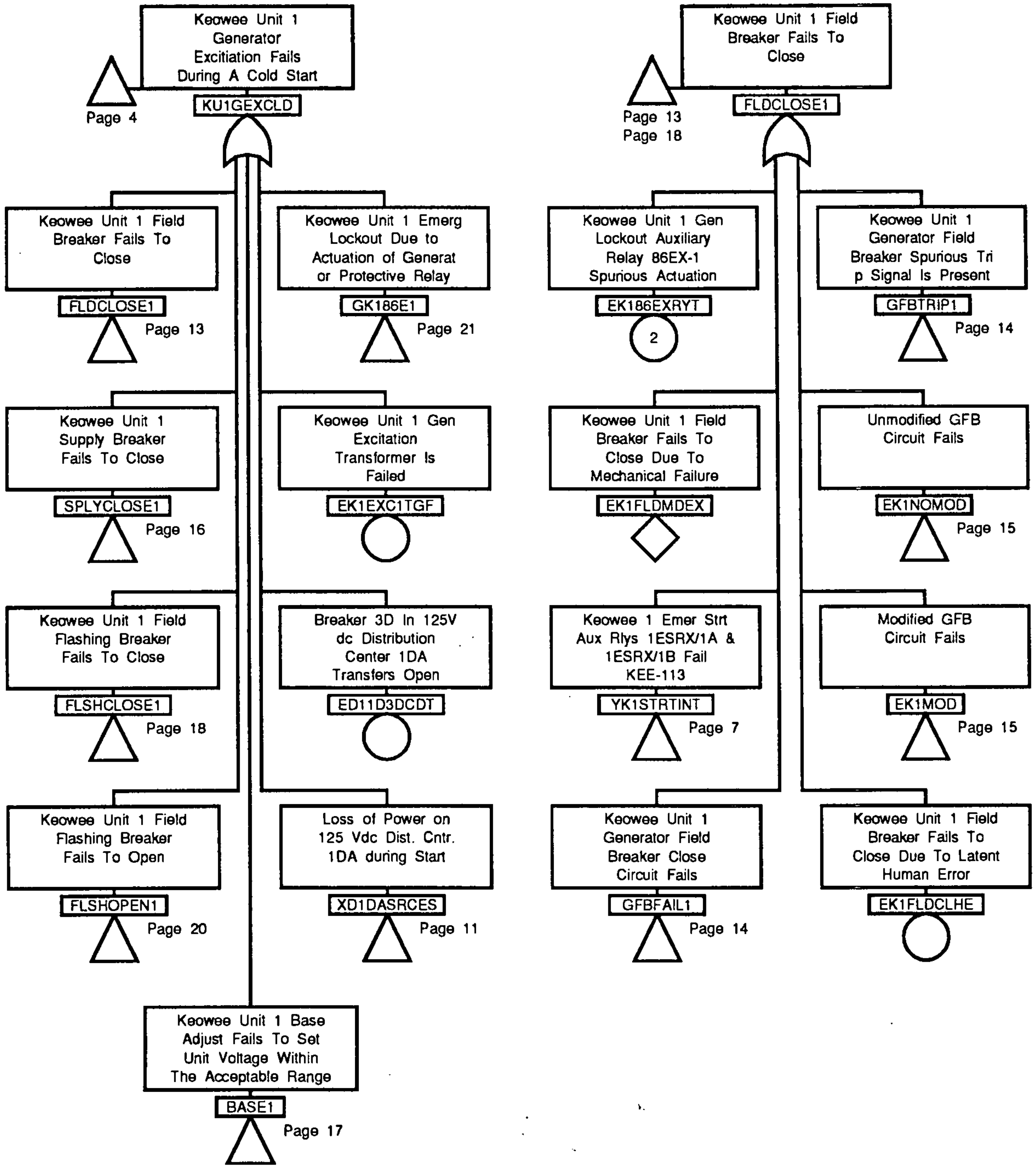

Keowee Emergency Start Channel B Fails OEE-120-1
YKESRXB
Page 7
Page 8
Page 110
Page 111
Loss Of Power On 125V dc Dist Cntr 2DA During Start
XD2DASRCES
Page 30
Breaker 2DA-2CC Transfers Open
XD202CCCDT
Keowee Emergency Start Channel B Initiators Fail OEE-120-1
YKESBINITF
Fuse 2DA-2CC Fails
YK2D2CCFUF
Oconee 1 Channel B Keowee Emergency Start Relay KB Fails
YO1KESCHBF
Oconee 2 Channel B Keowee Emergency Start Relay CR2B Fails
YO2KESCHBF
Page 33
Oconee 3 Channel B Keowee Emergency Start Relay CR3B Fails
YO3KESCHBF
Page 34
DC Circuit Breaker 1DIB-2 Transfers Position
YO1DIB2CDT
Oconee 1 Channel B Keowee Emer Strt Sig Initiators Fail OEE-120-1
YO1KSCHBIF
Page 31
Loss Of Power On 125 V dc Panelboard 1DIB
D1DIBXXDEX
Oconee Unit 1 Chan. B Keowee Emergency Start Relay Fails
YO1XXKBRYD

XD1DASRCES Outputs:
Page 5, Page 23, Page 9, Page 25, Page 109, Page 13

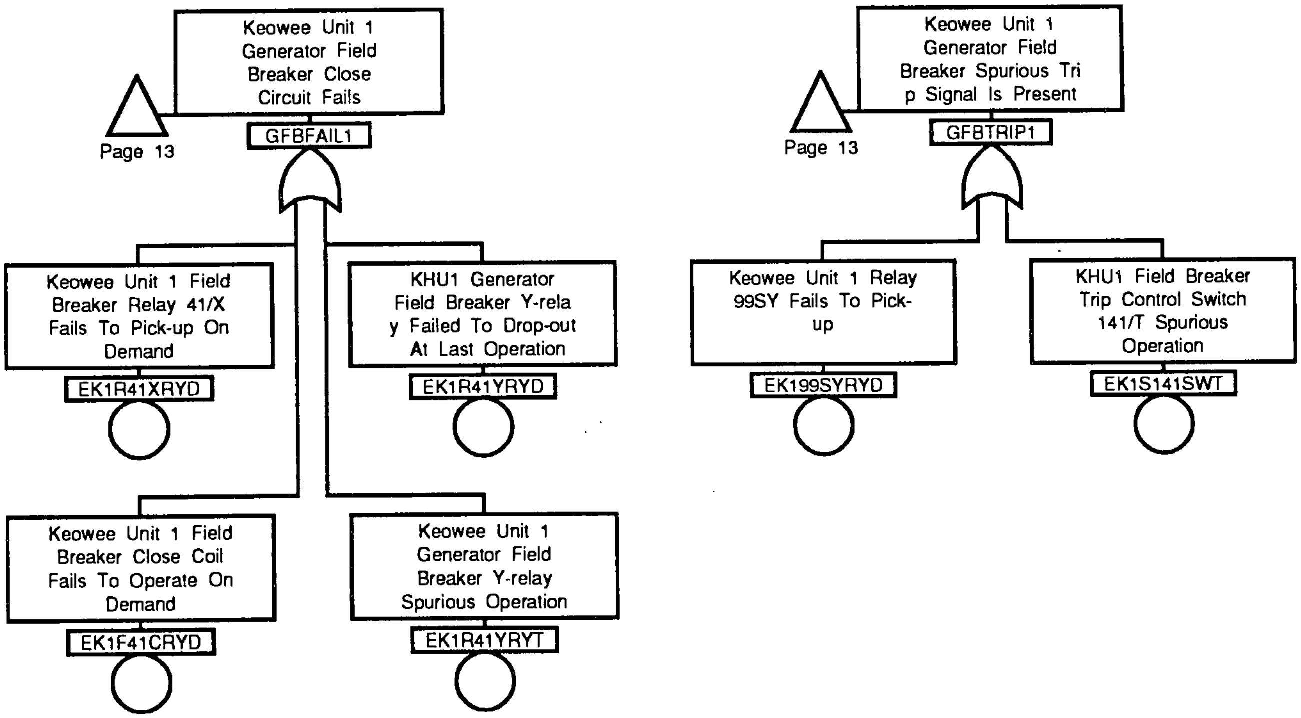


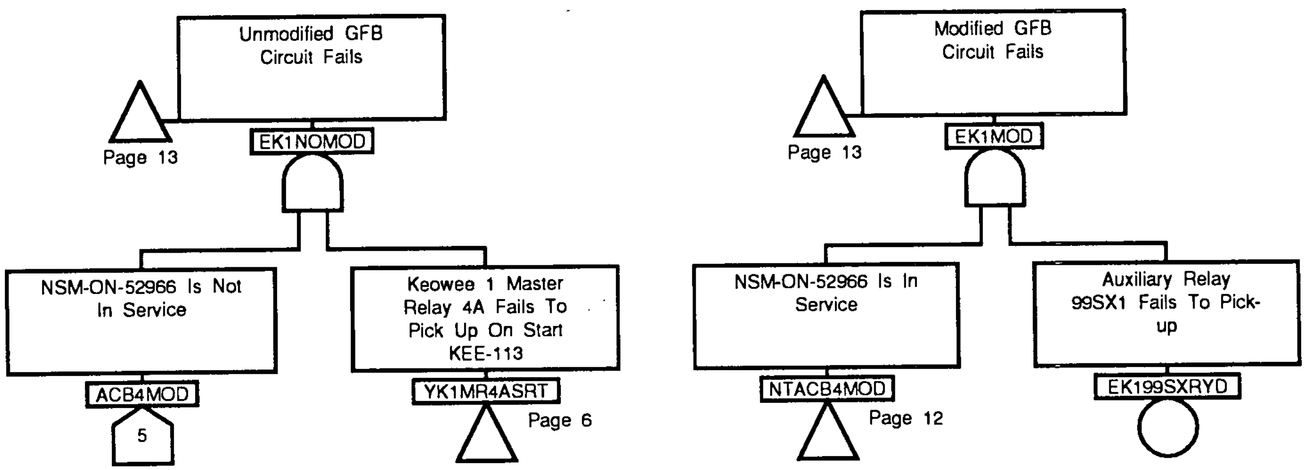
NTACB4MOD Outputs:
Page 23, Page 37, Page 35, Page 196, Page 102, Page 181, Page 106, Page 15
Page 194, Page 108, Page 201



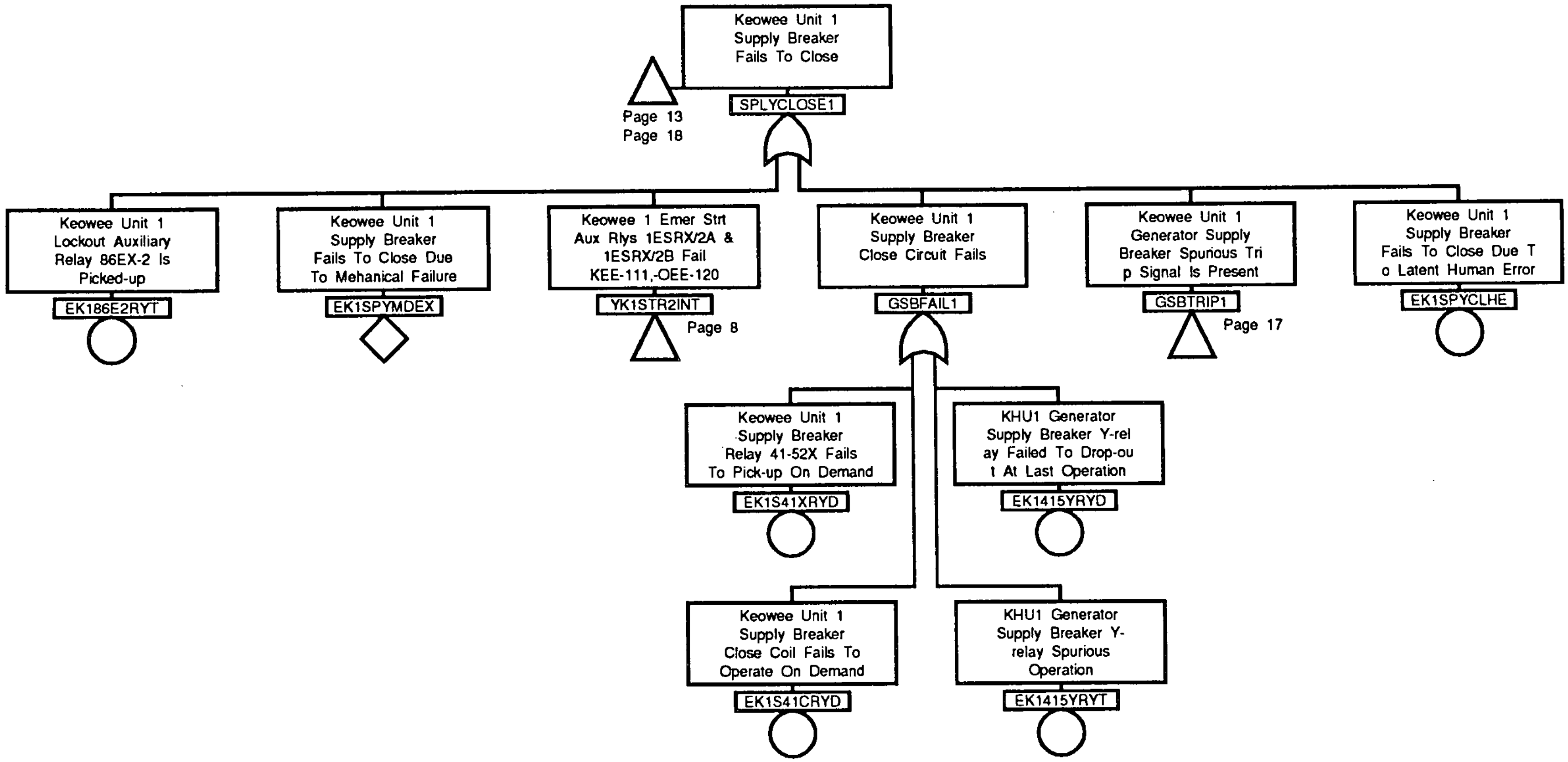


Keowee Unit 1 Generator Excitiation Fails During A Cold Start
KU1GEXCLD
Page 4
Keowee Unit 1 Field Breaker Fails To Close
FLDCLOSE1
Page 13
Keowee Unit 1 Emerg Lockout Due to Actuation of Generat or Protective Relay
GK186E1
Page 21
Keowee Unit 1 Supply Breaker Fails To Close
SPLYCLOSE1
Page 16
Keowee Unit 1 Gen Excitation Transformer Is Failed
EK1EXC1TGF
Keowee Unit 1 Field Flashing Breaker Fails To Close
FLSHCLOSE1
Page 18
Breaker 3D In 125V dc Distribution Center 1DA Transfers Open
ED11D3DCDT
Keowee Unit 1 Field Flashing Breaker Fails To Open
FLSHOPEN1
Page 20
Loss of Power on 125 Vdc Dist. Cntr. 1DA during Start
XD1DASRCES
Page 11
Keowee Unit 1 Base Adjust Fails To Set Unit Voltage Within The Acceptable Range
BASE1
Page 17
Keowee Unit 1 Field Breaker Fails To Close
FLDCLOSE1
Page 13
Page 18
Keowee Unit 1 Gen Lockout Auxiliary Relay 86EX-1 Spurious Actuation
EK186EXRYT
2
Keowee Unit 1 Generator Field Breaker Spurious Tri p Signal Is Present
GFBTRIP1
Page 14
Keowee Unit 1 Field Breaker Fails To Close Due To Mechanical Failure
EK1FLDMDEX
Unmodified GFB Circuit Fails
EK1NOMOD
Page 15
Keowee 1 Emer Strt Aux Rlys 1ESRX/1A & 1ESRX/1B Fail KEE-113
YK1STRTINT
Page 7
Modified GFB Circuit Fails
EK1MOD
Page 15
Keowee Unit 1 Generator Field Breaker Close Circuit Fails
GFBFAIL1
Page 14
Keowee Unit 1 Field Breaker Fails To Close Due To Latent Human Error
EK1FLDCLHE

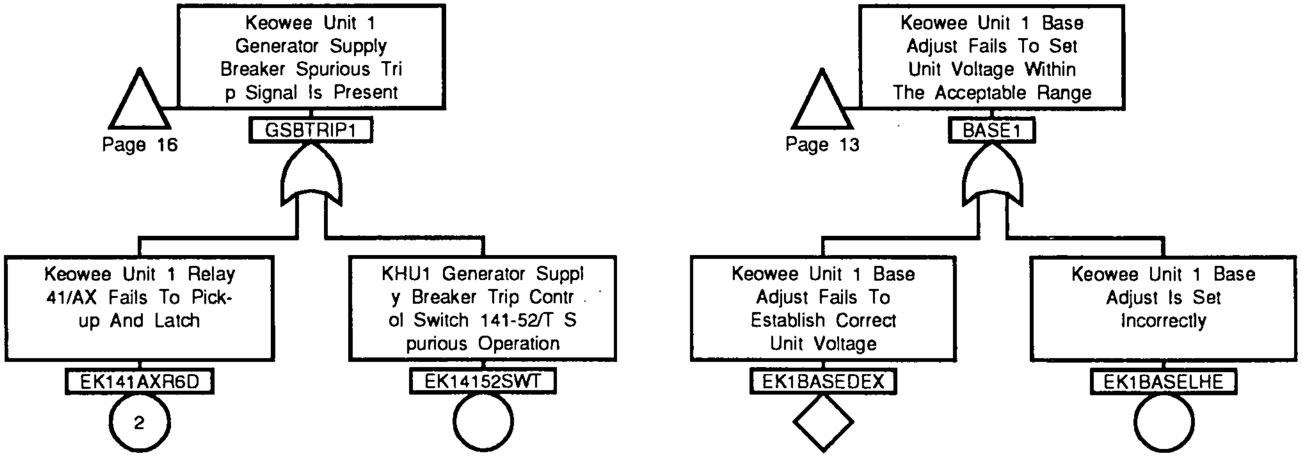

Keowee Unit 1 Generator Field Breaker Close Circuit Fails
Page 13
GFBFAIL1
Keowee Unit 1 Field Breaker Relay 41/X Fails To Pick-up On Demand
EK1R41XRYD
KHU1 Generator Field Breaker Y-rela y Failed To Drop-out At Last Operation
EK1R41YRYD
Keowee Unit 1 Field Breaker Close Coil Fails To Operate On Demand
EK1F41CRYD
Keowee Unit 1 Generator Field Breaker Y-relay Spurious Operation
EK1R41YRYT
Keowee Unit 1 Generator Field Breaker Spurious Tri p Signal Is Present
Page 13
GFBTRIP1
Keowee Unit 1 Relay 99SY Fails To Pick- up
EK199SYRYD
KHU1 Field Breaker Trip Control Switch 141/T Spurious Operation
EK1S141SWT



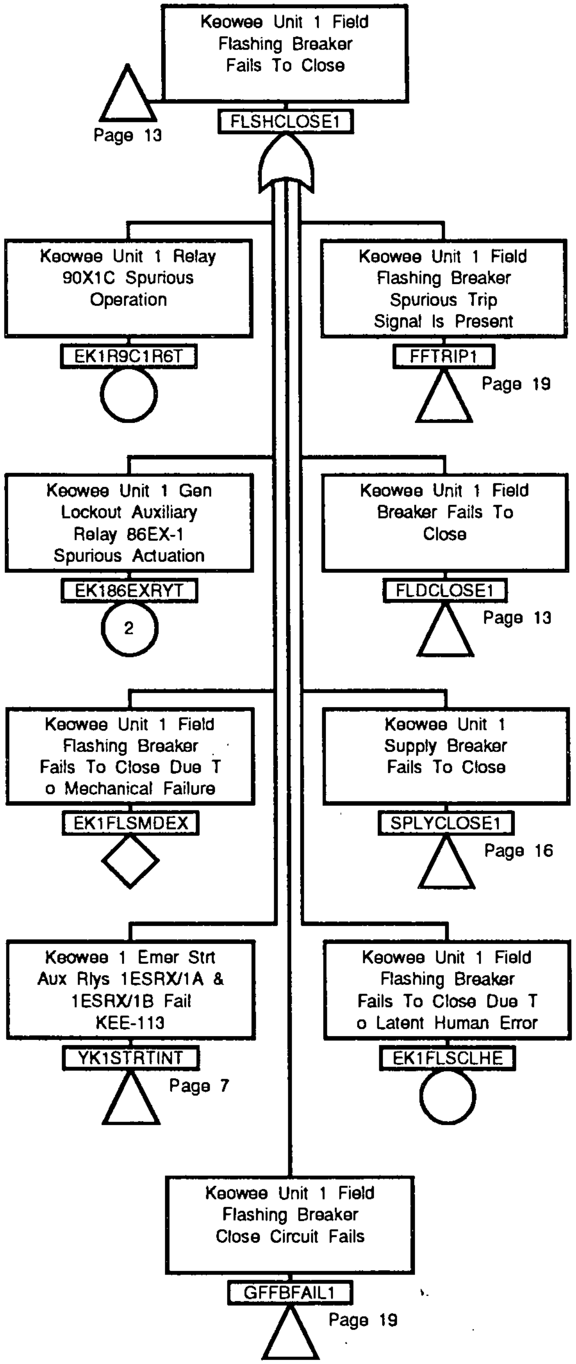
Unmodified GFB Circuit Fails
Page 13
EK1NOMOD
NSM-ON-52966 Is Not In Service
ACB4MOD
5
Keowee 1 Master Relay 4A Fails To Pick Up On Start KEE-113
YK1MR4ASRT
Page 6
Modified GFB Circuit Fails
Page 13
EK1MOD
NSM-ON-52966 Is In Service
NTACB4MOD
Page 12
Auxiliary Relay 99SX1 Fails To Pick-up
EK199SXRYD



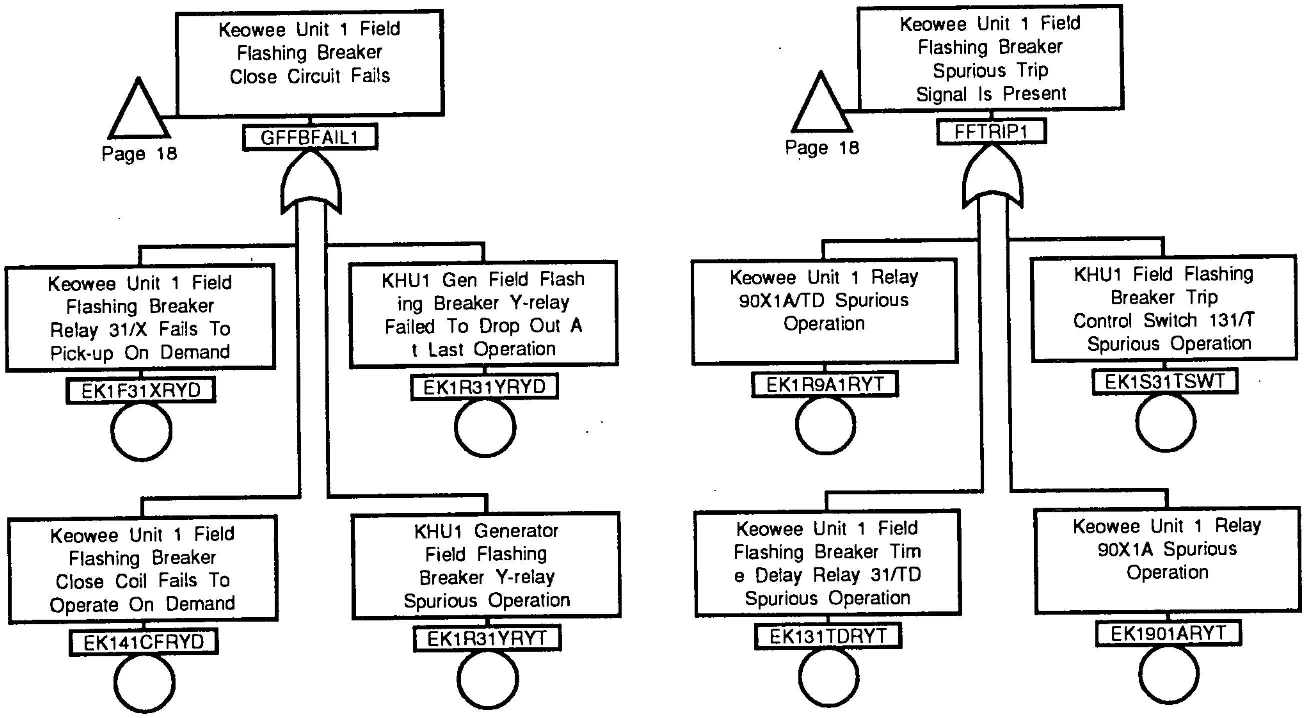
Keowee Unit 1 Supply Breaker Fails To Close
SPLYCLOSE1
Page 13
Page 18
Keowee Unit 1 Lockout Auxiliary Relay 86EX-2 Is Picked-up
EK186E2RYT
Keowee Unit 1 Supply Breaker Fails To Close Due To Mehanical Failure
EK1SPYMDEX
Keowee 1 Emer Strt Aux Rlys 1ESRX/2A & 1ESRX/2B Fail KEE-111,-OEE-120
YK1STR2INT
Page 8
Keowee Unit 1 Supply Breaker Close Circuit Fails
GSBFAIL1
Keowee Unit 1 Generator Supply Breaker Spurious Tri p Signal Is Present
GSBTRIP1
Page 17
Keowee Unit 1 Supply Breaker Fails To Close Due T o Latent Human Error
EK1SPYCLHE
Keowee Unit 1 Supply Breaker Relay 41-52X Fails To Pick-up On Demand
EK1S41XRYD
KHU1 Generator Supply Breaker Y-rel ay Failed To Drop-ou t At Last Operation
EK1415YRYD
Keowee Unit 1 Supply Breaker Close Coil Fails To Operate On Demand
EK1S41CRYD
KHU1 Generator Supply Breaker Y-relay Spurious Operation
EK1415YRYT



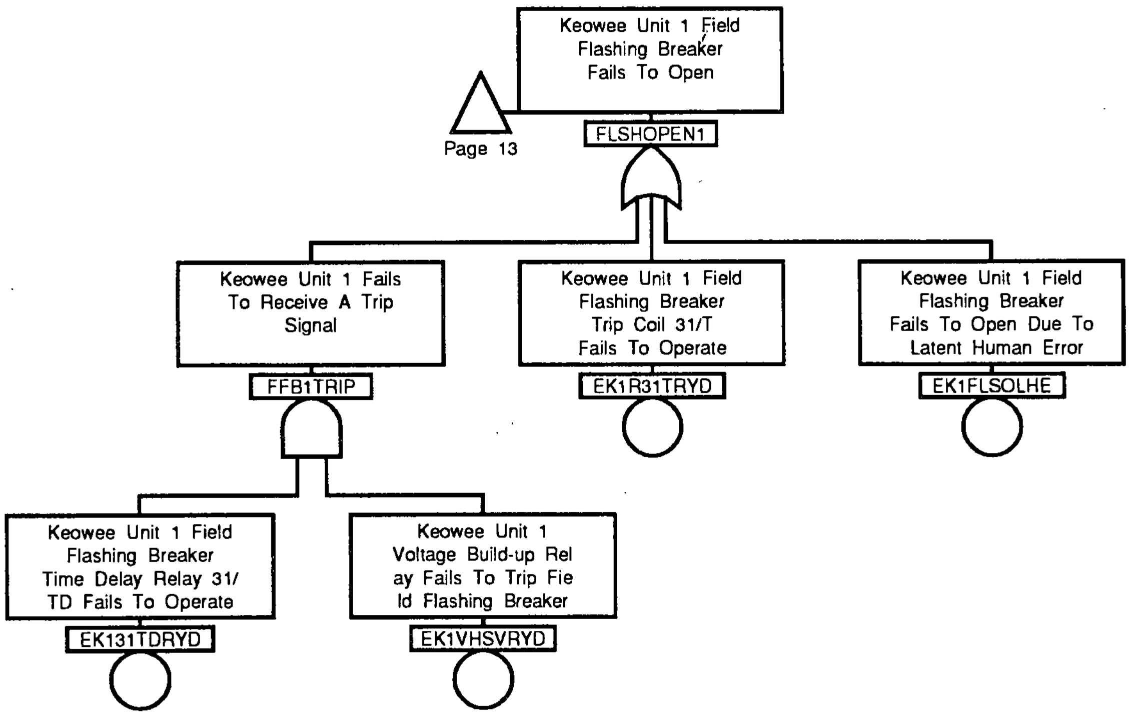
Keowee Unit 1 Generator Supply Breaker Spurious Trip Signal Is Present
GSBTRIP1
Page 16
Keowee Unit 1 Relay 41/AX Fails To Pick-up And Latch
EK141AXR6D
2
KHU1 Generator Supply Breaker Trip Control Switch 141-52/T Spurious Operation
EK14152SWT
Keowee Unit 1 Base Adjust Fails To Set Unit Voltage Within The Acceptable Range
BASE1
Page 13
Keowee Unit 1 Base Adjust Fails To Establish Correct Unit Voltage
EK1BASEDEX
Keowee Unit 1 Base Adjust Is Set Incorrectly
EK1BASELHE



Keowee Unit 1 Field Flashing Breaker Fails To Close
FLSHCLOSE1
Page 13
Keowee Unit 1 Relay 90X1C Spurious Operation
EK1R9C1R6T
Keowee Unit 1 Field Flashing Breaker Spurious Trip Signal Is Present
FFTRIP1
Page 19
Keowee Unit 1 Gen Lockout Auxiliary Relay 86EX-1 Spurious Actuation
EK186EXRYT
2
Keowee Unit 1 Field Breaker Fails To Close
FLDCLOSE1
Page 13
Keowee Unit 1 Field Flashing Breaker Fails To Close Due T o Mechanical Failure
EK1FLSMDEX
Keowee Unit 1 Supply Breaker Fails To Close
SPLYCLOSE1
Page 16
Keowee 1 Emer Strt Aux Rlys 1ESRX/1A & 1ESRX/1B Fail KEE-113
YK1STRTINT
Page 7
Keowee Unit 1 Field Flashing Breaker Fails To Close Due T o Latent Human Error
EK1FLSCLHE
Keowee Unit 1 Field Flashing Breaker Close Circuit Fails
GFFBFAIL1
Page 19

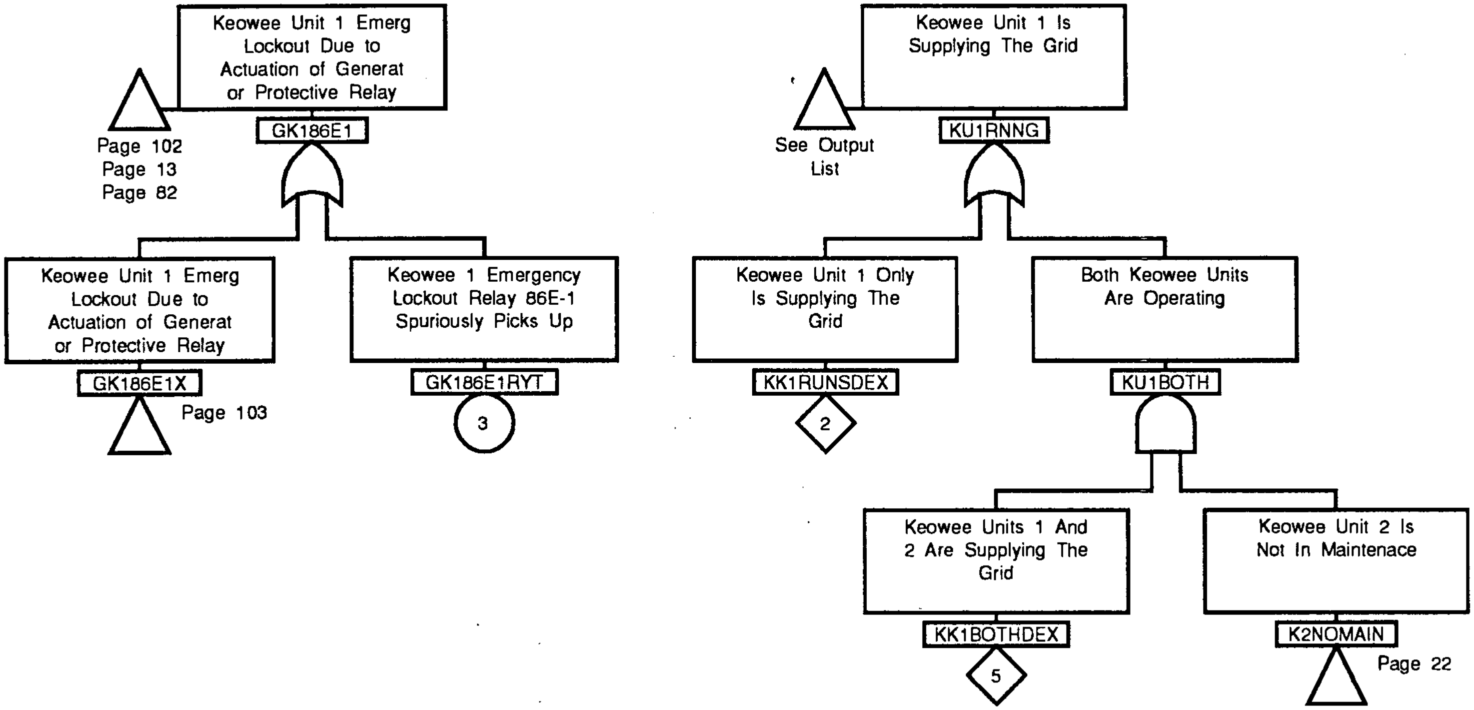


Keowee Unit 1 Field Flashing Breaker Close Circuit Fails
GFFBFAIL1
Page 18
Keowee Unit 1 Field Flashing Breaker Relay 31/X Fails To Pick-up On Demand
EK1F31XRYD
KHU1 Gen Field Flash ing Breaker Y-relay Failed To Drop Out A t Last Operation
EK1R31YRYD
Keowee Unit 1 Field Flashing Breaker Close Coil Fails To Operate On Demand
EK141CFRYD
KHU1 Generator Field Flashing Breaker Y-relay Spurious Operation
EK1R31YRYT
Keowee Unit 1 Field Flashing Breaker Spurious Trip Signal Is Present
FFTRIP1
Page 18
Keowee Unit 1 Relay 90X1A/TD Spurious Operation
EK1R9A1RYT
KHU1 Field Flashing Breaker Trip Control Switch 131/T Spurious Operation
EK1S31TSWT
Keowee Unit 1 Field Flashing Breaker Tim e Delay Relay 31/TD Spurious Operation
EK131TDRYT
Keowee Unit 1 Relay 90X1A Spurious Operation
EK1901ARYT

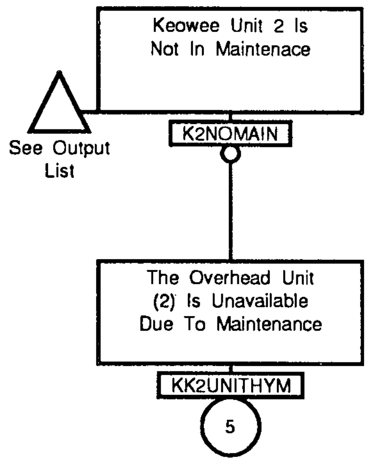


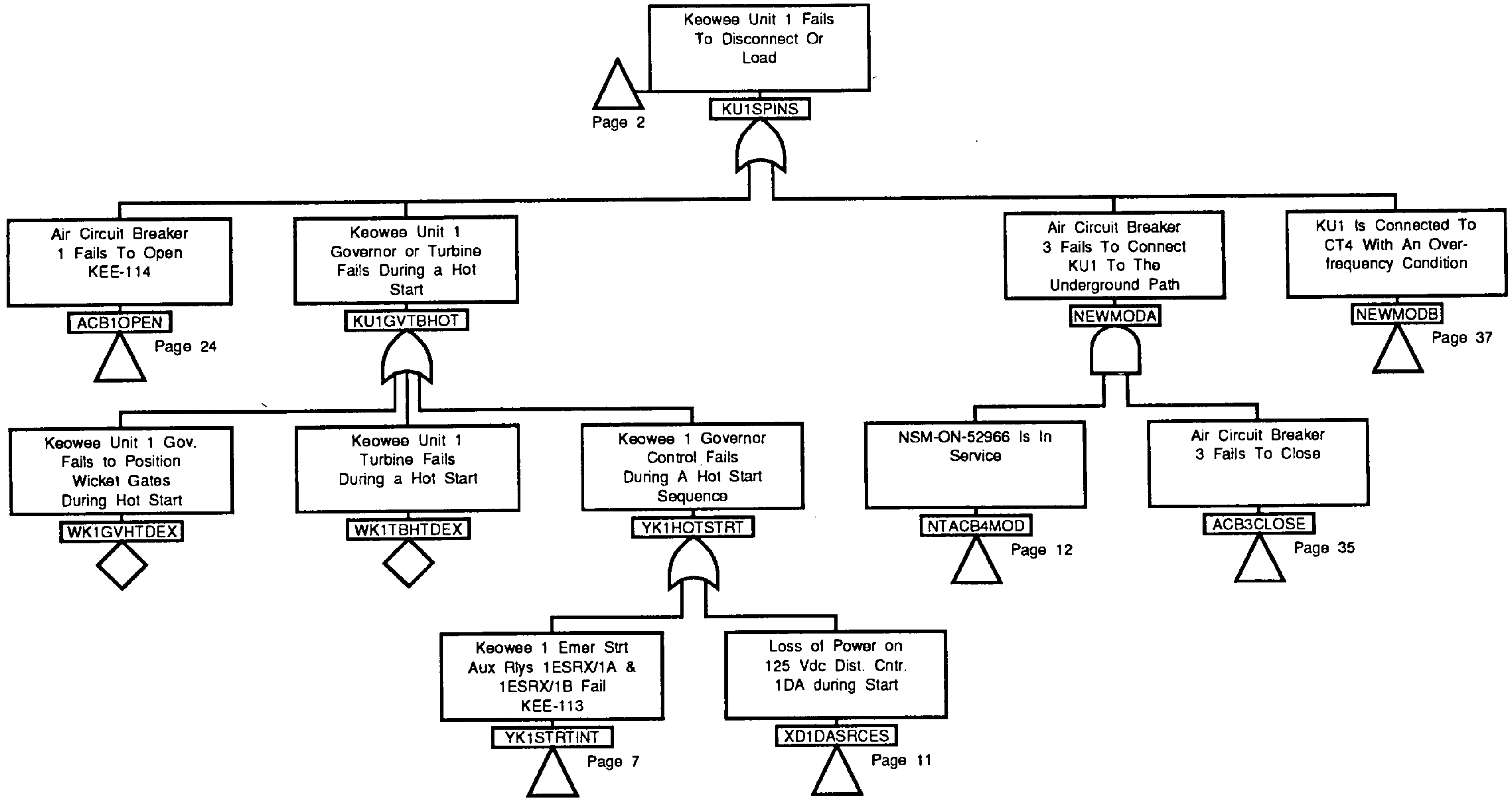
Keowee Unit 1 Field Flashing Breaker Fails To Open
FLSHOPEN1
Page 13
Keowee Unit 1 Fails To Receive A Trip Signal
FFB1TRIP
Keowee Unit 1 Field Flashing Breaker Trip Coil 31/T Fails To Operate
EK1R31TRYD
Keowee Unit 1 Field Flashing Breaker Fails To Open Due To Latent Human Error
EK1FLSOLHE
Keowee Unit 1 Field Flashing Breaker Time Delay Relay 31/ TD Fails To Operate
EK131TDRYD
Keowee Unit 1 Voltage Build-up Rel ay Fails To Trip Fie ld Flashing Breaker
EK1VHSVRYD

KU1RNNG Outputs:
Page 2, Page 188, Page 204, Page 35, Page 39, Page 107

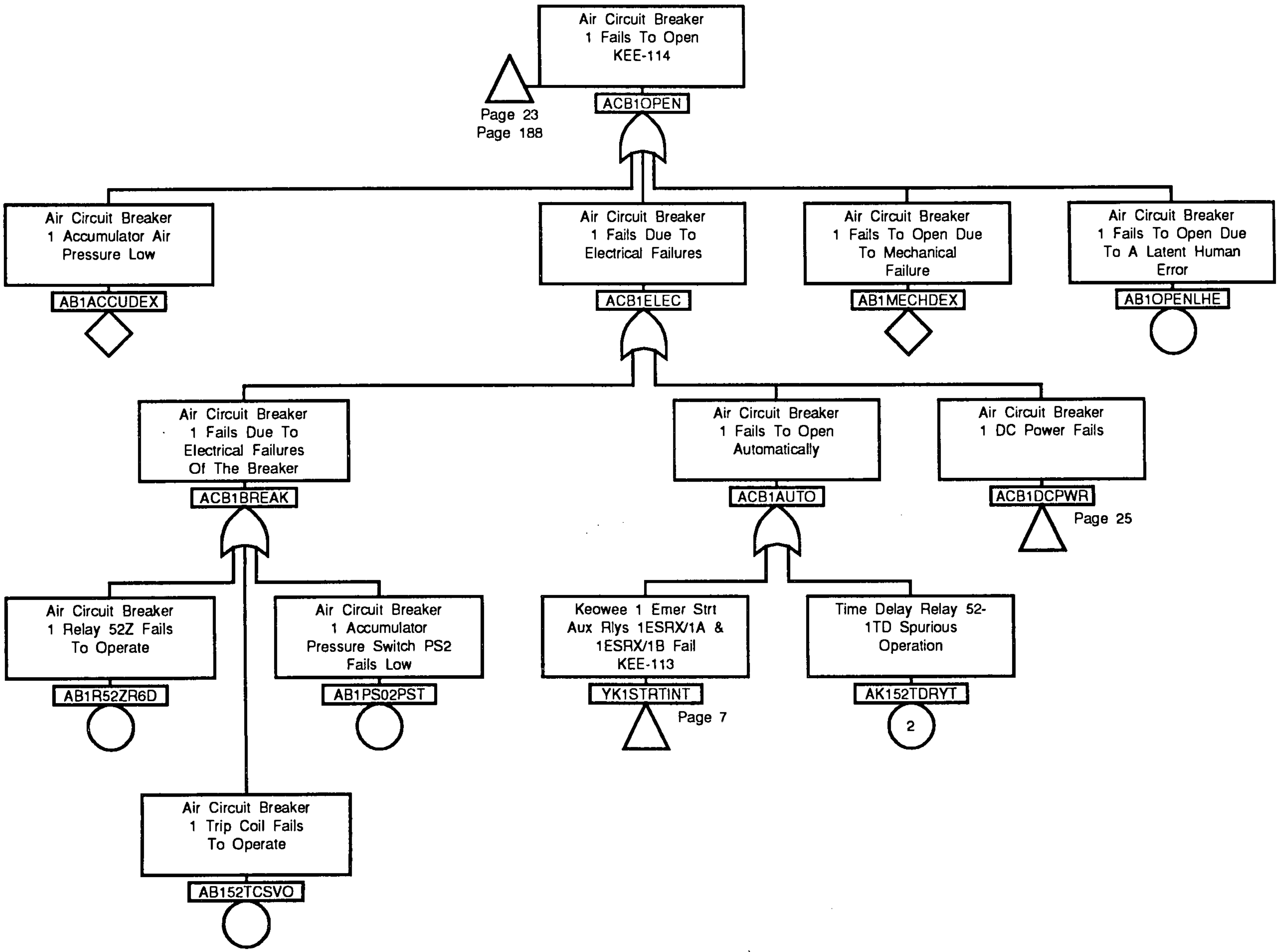


K2NOMAIN Outputs:
Page 183, Page 21, Page 185, Page 188, Page 188, Page 189, Page 182, Page 35
Page 113

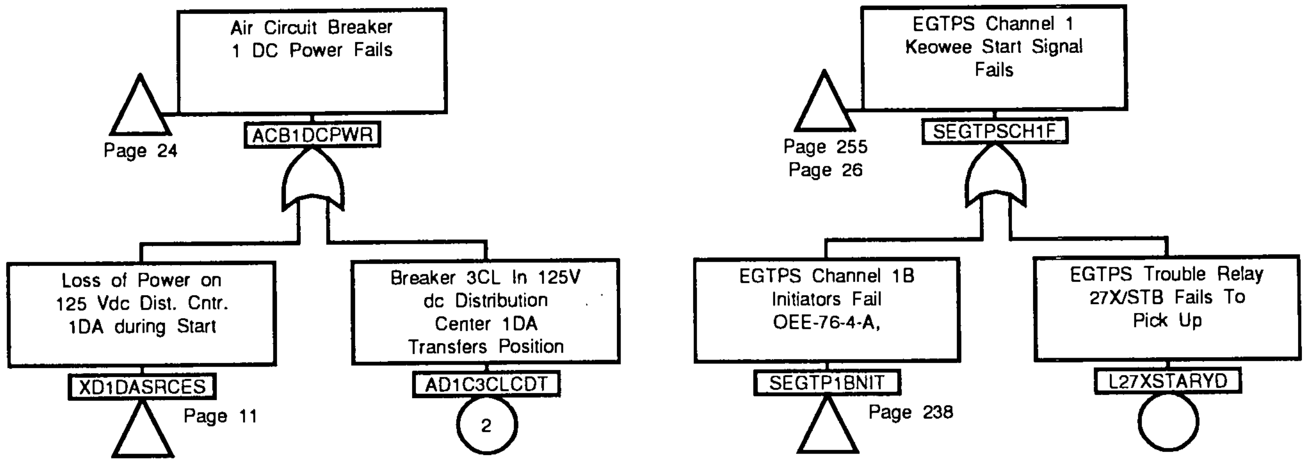




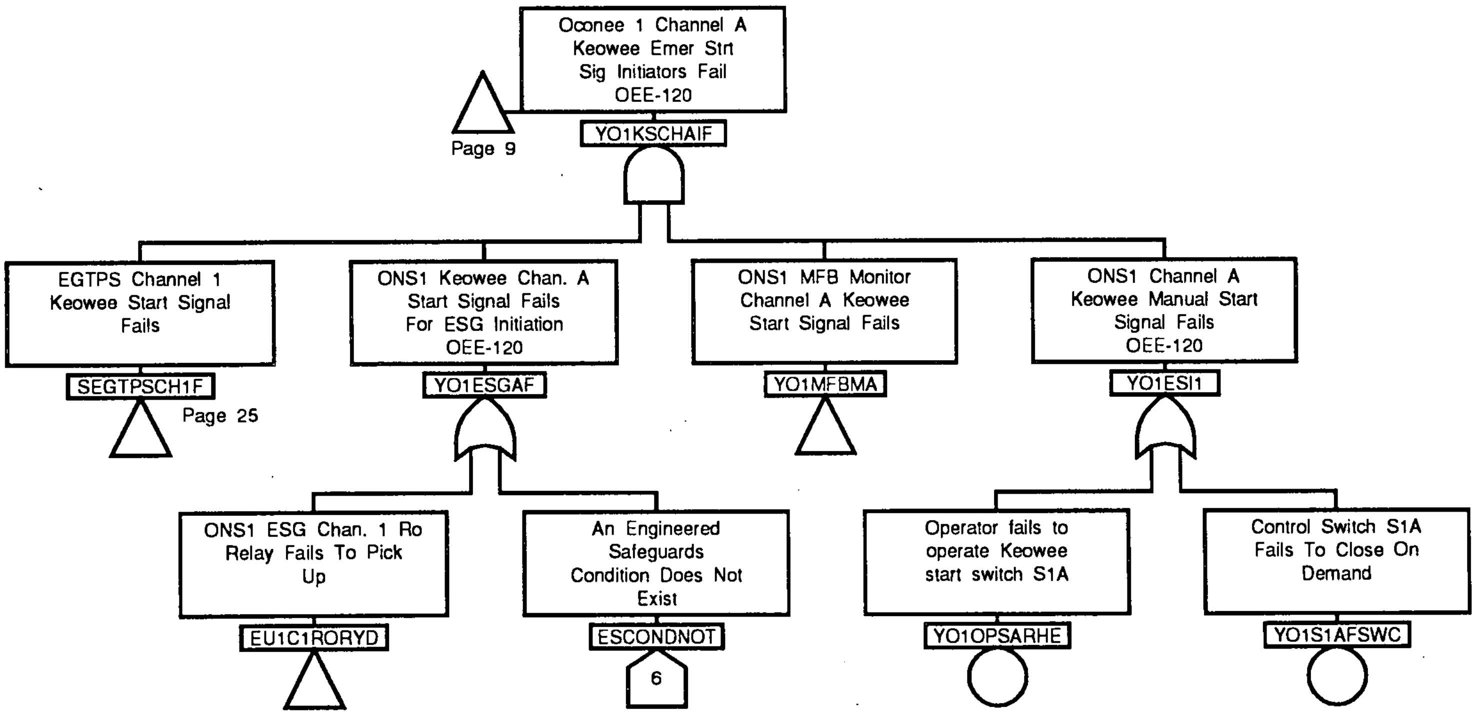
Keowee Unit 1 Fails To Disconnect Or Load
KU1SPINS
Page 2
Air Circuit Breaker 1 Fails To Open KEE-114
ACB1OPEN
Page 24
Keowee Unit 1 Governor or Turbine Fails During a Hot Start
KU1GVTBHOT
Keowee Unit 1 Gov. Fails to Position Wicket Gates During Hot Start
WK1GVHTDEX
Keowee Unit 1 Turbine Fails During a Hot Start
WK1TBHTDEX
Keowee 1 Governor Control Fails During A Hot Start Sequence
YK1HOTSTRT
Keowee 1 Emer Strt Aux Rlys 1ESRX/1A & 1ESRX/1B Fail KEE-113
YK1STRTINT
Page 7
Loss of Power on 125 Vdc Dist. Cntr. 1DA during Start
XD1DASRCES
Page 11
Air Circuit Breaker 3 Fails To Connect KU1 To The Underground Path
NEWMODA
NSM-ON-52966 Is In Service
NTACB4MOD
Page 12
Air Circuit Breaker 3 Fails To Close
ACB3CLOSE
Page 35
KU1 Is Connected To CT4 With An Over-frequency Condition
NEWMODB
Page 37

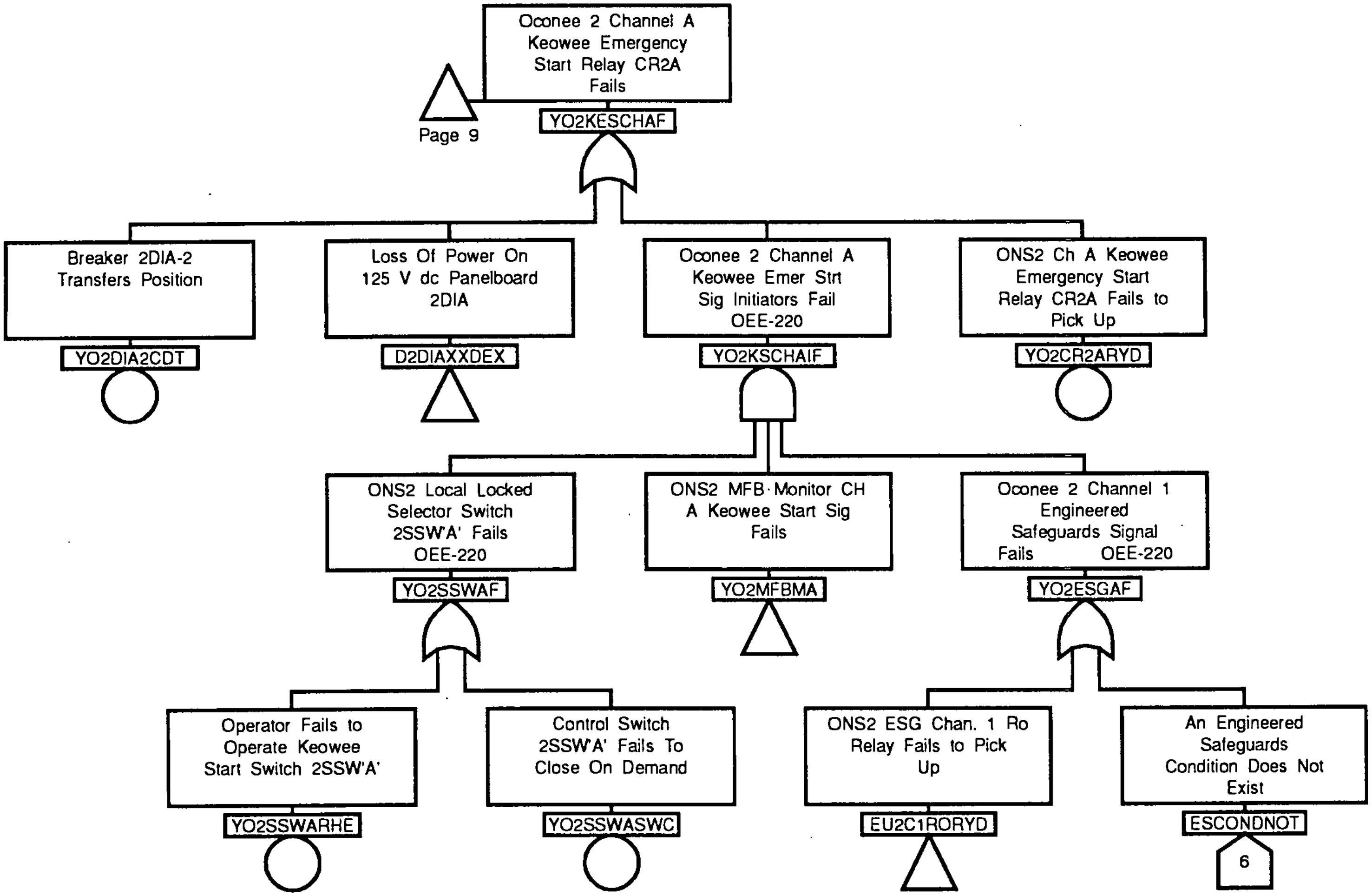


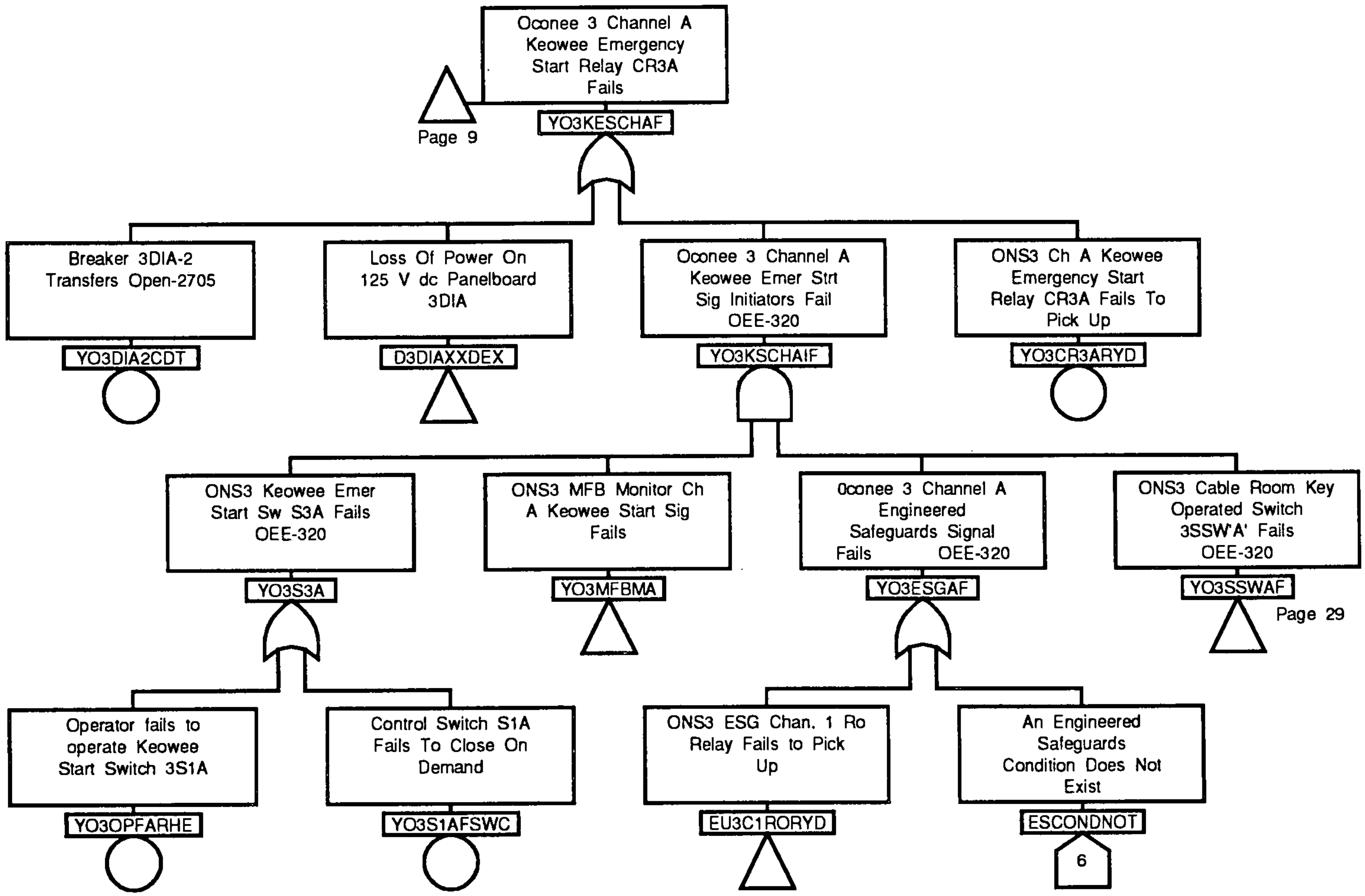
Air Circuit Breaker 1 Fails To Open KEE-114
ACB1OPEN
Page 23
Page 188
Air Circuit Breaker 1 Accumulator Air Pressure Low
AB1ACCUDEX
Air Circuit Breaker 1 Fails Due To Electrical Failures
ACB1ELEC
Air Circuit Breaker 1 Fails To Open Due To Mechanical Failure
AB1MECHDEX
Air Circuit Breaker 1 Fails To Open Due To A Latent Human Error
AB1OPENLHE
Air Circuit Breaker 1 Fails Due To Electrical Failures Of The Breaker
ACB1BREAK
Air Circuit Breaker 1 Fails To Open Automatically
ACB1AUTO
Air Circuit Breaker 1 DC Power Fails
ACB1DCPWR
Page 25
Air Circuit Breaker 1 Relay 52Z Fails To Operate
AB1R52ZR6D
Air Circuit Breaker 1 Accumulator Pressure Switch PS2 Fails Low
AB1PS02PST
Keowee 1 Emer Strt Aux Rlys 1ESRX/1A & 1ESRX/1B Fail KEE-113
YK1STRTINT
Page 7
Time Delay Relay 52-1TD Spurious Operation
AK152TDRYT
2
Air Circuit Breaker 1 Trip Coil Fails To Operate
AB152TCSVO



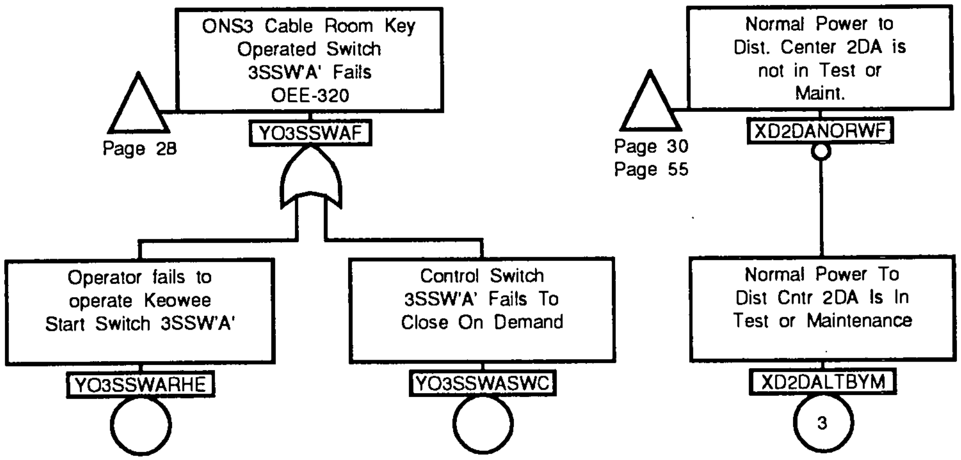
Air Circuit Breaker 1 DC Power Fails
ACB1DCPWR
Page 24
Loss of Power on 125 Vdc Dist. Cntr. 1DA during Start
XD1DASRCES
Page 11
Breaker 3CL In 125V dc Distribution Center 1DA Transfers Position
AD1C3CLCDT
2
EGTPS Channel 1 Keowee Start Signal Fails
SEGTPSCH1F
Page 255
Page 26
EGTPS Channel 1B Initiators Fail OEE-76-4-A,
SEGTP1BNIT
Page 238
EGTPS Trouble Relay 27X/STB Fails To Pick Up
L27XSTARYD


Oconee 1 Channel A Keowee Emer Strt Sig Initiators Fail OEE-120
YO1KSCHAIF
Page 9
EGTPS Channel 1 Keowee Start Signal Fails
SEGTPSCH1F
Page 25
ONS1 Keowee Chan. A Start Signal Fails For ESG Initiation OEE-120
YO1ESGAF
ONS1 MFB Monitor Channel A Keowee Start Signal Fails
YO1MFBMA
ONS1 Channel A Keowee Manual Start Signal Fails OEE-120
YO1ESI1
ONS1 ESG Chan. 1 Ro Relay Fails To Pick Up
EU1C1RORYD
An Engineered Safeguards Condition Does Not Exist
ESCONDNOT
6
Operator fails to operate Keowee start switch S1A
YO1OPSARHE
Control Switch S1A Fails To Close On Demand
YO1S1AFSWC


Oconee 2 Channel A Keowee Emergency Start Relay CR2A Fails
YO2KESCHAF
Page 9
Breaker 2DIA-2 Transfers Position
YO2DIA2CDT
Loss Of Power On 125 V dc Panelboard 2DIA
D2DIAXXDEX
Oconee 2 Channel A Keowee Emer Strt Sig Initiators Fail OEE-220
YO2KSCHAIF
ONS2 Ch A Keowee Emergency Start Relay CR2A Fails to Pick Up
YO2CR2ARYD
ONS2 Local Locked Selector Switch 2SSW'A' Fails OEE-220
YO2SSWAF
ONS2 MFB Monitor CH A Keowee Start Sig Fails
YO2MFBMA
Oconee 2 Channel 1 Engineered Safeguards Signal Fails OEE-220
YO2ESGAF
Operator Fails to Operate Keowee Start Switch 2SSW'A'
YO2SSWARHE
Control Switch 2SSW'A' Fails To Close On Demand
YO2SSWASWC
ONS2 ESG Chan. 1 Ro Relay Fails to Pick Up
EU2C1RORYD
An Engineered Safeguards Condition Does Not Exist
ESCONDNOT
6

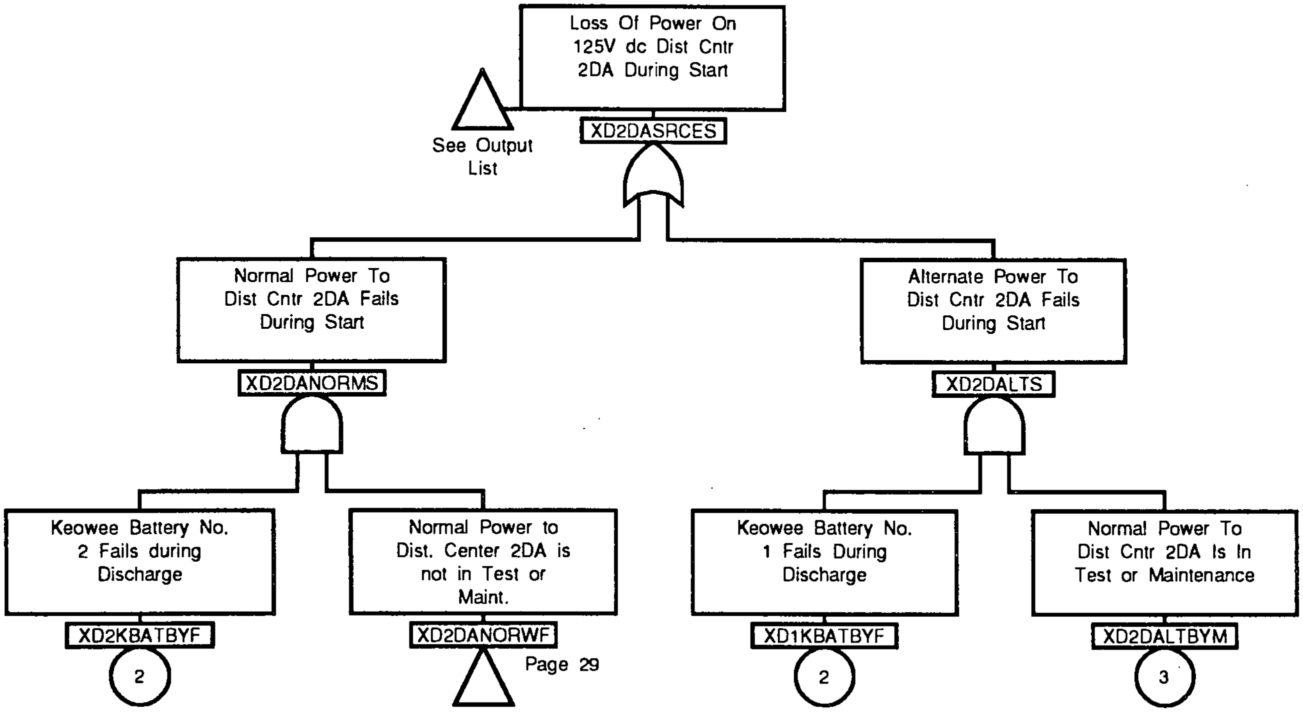


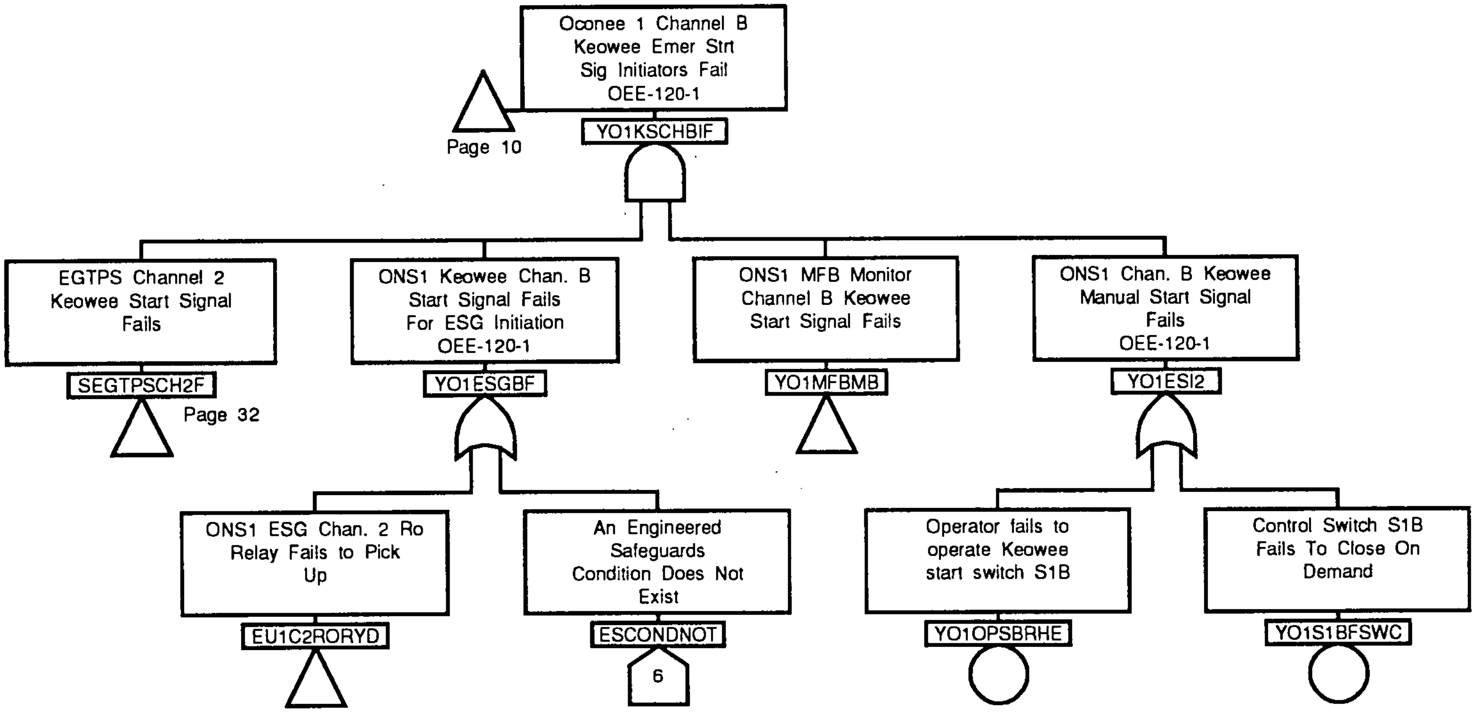
Oconee 3 Channel A Keowee Emergency Start Relay CR3A Fails
YO3KESCHAF
Page 9
Breaker 3DIA-2 Transfers Open-2705
YO3DIA2CDT
Loss Of Power On 125 V dc Panelboard 3DIA
D3DIAXXDEX
Oconee 3 Channel A Keowee Emer Strt Sig Initiators Fail OEE-320
YO3KSCHAIF
ONS3 Ch A Keowee Emergency Start Relay CR3A Fails To Pick Up
YO3CR3ARYD
ONS3 Keowee Emer Start Sw S3A Fails OEE-320
YO3S3A
ONS3 MFB Monitor Ch A Keowee Start Sig Fails
YO3MFBMA
Oconee 3 Channel A Engineered Safeguards Signal Fails OEE-320
YO3ESGAF
ONS3 Cable Room Key Operated Switch 3SSW'A' Fails OEE-320
YO3SSWAF
Page 29
Operator fails to operate Keowee Start Switch 3S1A
YO3OPFARHE
Control Switch S1A Fails To Close On Demand
YO3S1AFSWC
ONS3 ESG Chan. 1 Ro Relay Fails to Pick Up
EU3C1RORYD
An Engineered Safeguards Condition Does Not Exist
ESCONDNOT
6

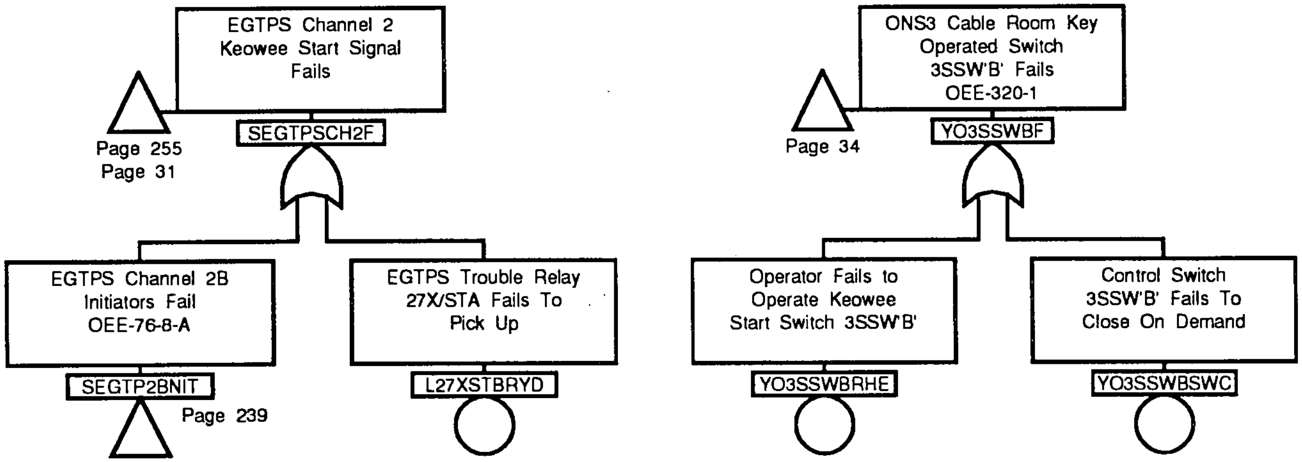


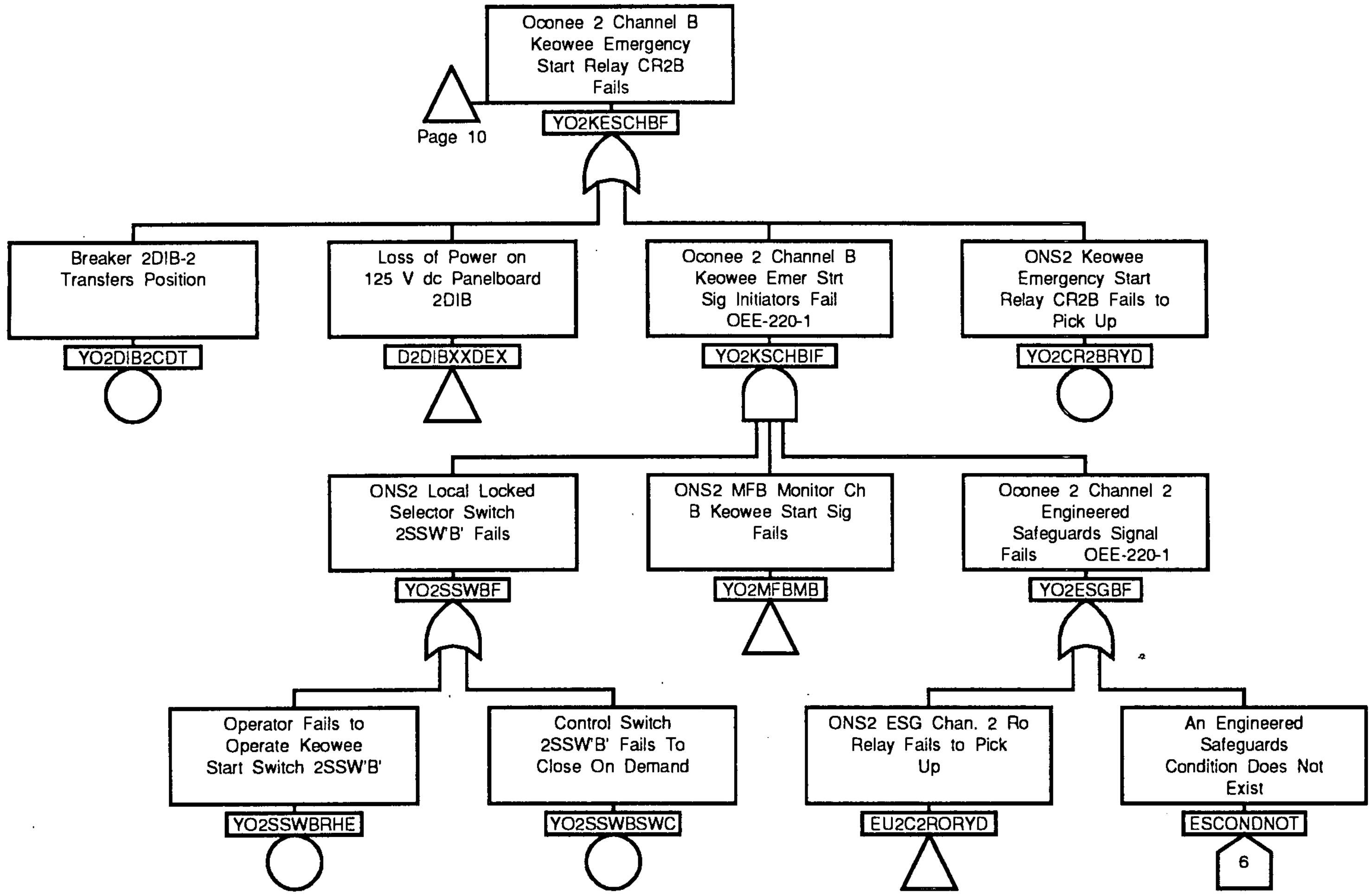
ONS3 Cable Room Key Operated Switch 3SSW'A' Fails OEE-320
YO3SSWAF
Page 28
Operator fails to operate Keowee Start Switch 3SSW'A'
YO3SSWARHE
Control Switch 3SSW'A' Fails To Close On Demand
YO3SSWASWC
Normal Power to Dist. Center 2DA is not in Test or Maint.
XD2DANORWF
Page 30
Page 55
Normal Power To Dist Cntr 2DA Is In Test or Maintenance
XD2DALTBYM
3

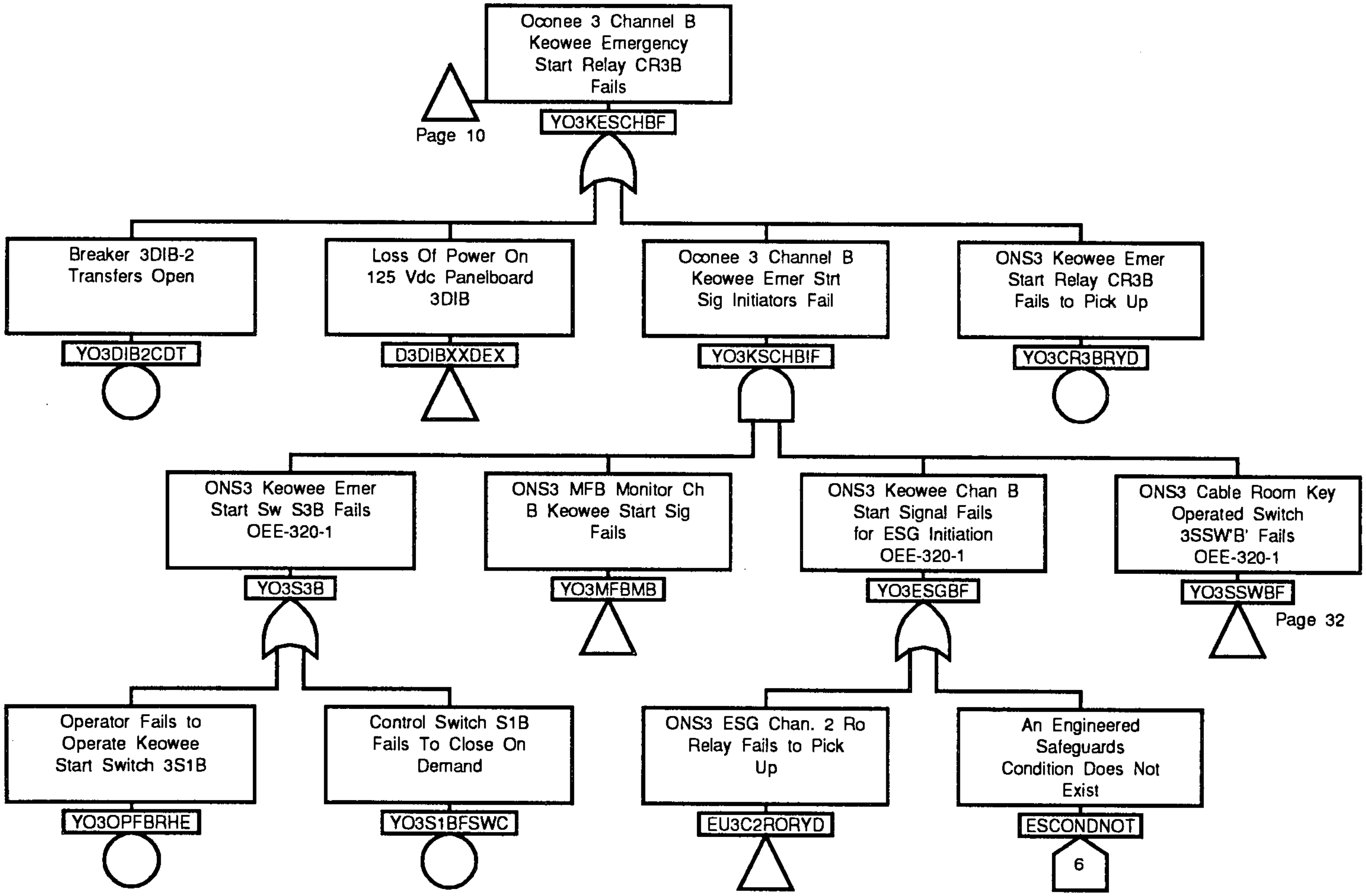
XD2DASRCES Outputs:
Page 10, Page 123, Page 114, Page 192, Page 112, Page 116

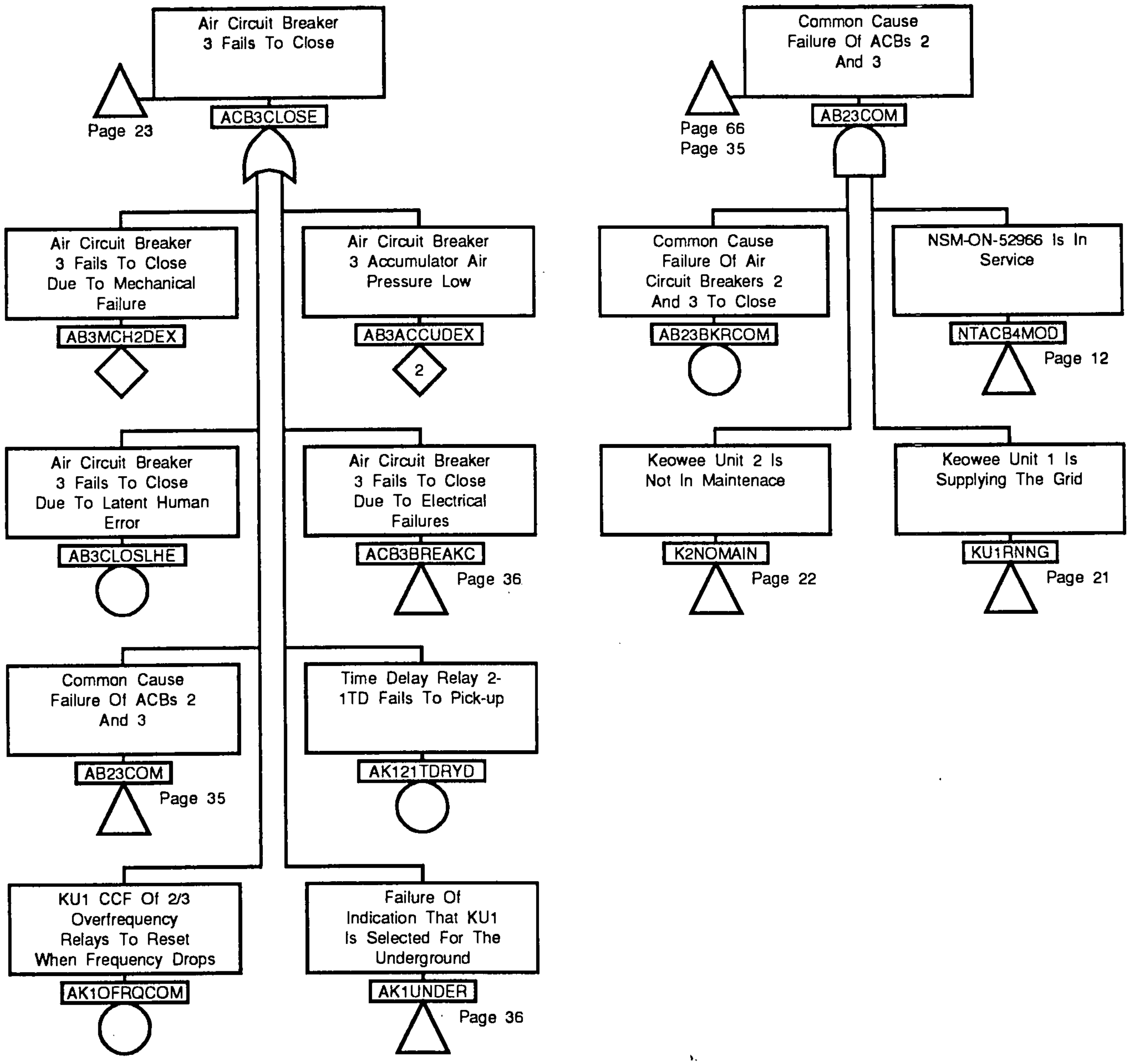


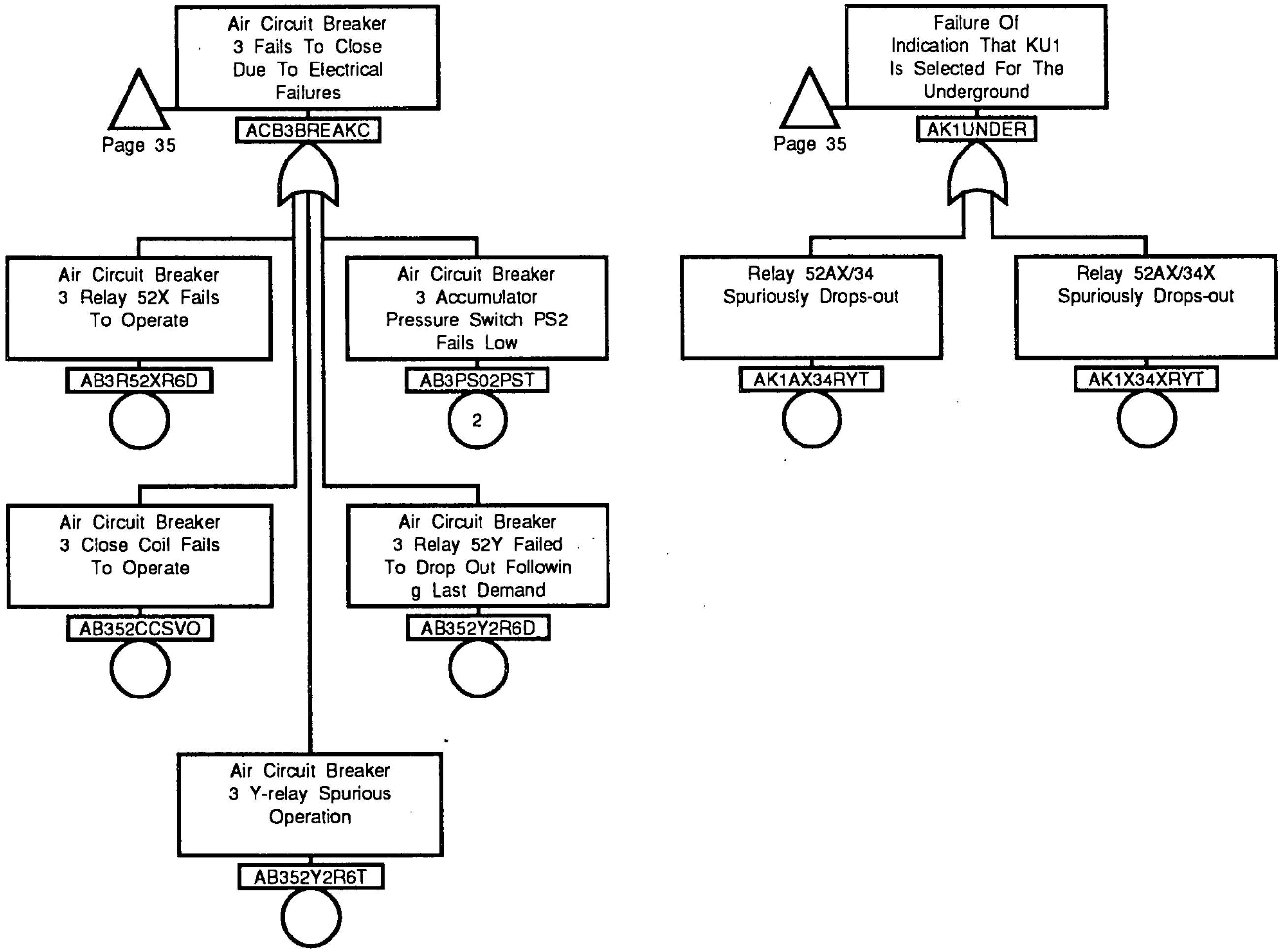

Oconee 1 Channel B Keowee Emer Strt Sig Initiators Fail OEE-120-1
YO1KSCHBIF
Page 10
EGTPS Channel 2 Keowee Start Signal Fails
SEGTPSCH2F
Page 32
ONS1 Keowee Chan. B Start Signal Fails For ESG Initiation OEE-120-1
YO1ESGBF
ONS1 MFB Monitor Channel B Keowee Start Signal Fails
YO1MFBMB
ONS1 Chan. B Keowee Manual Start Signal Fails OEE-120-1
YO1ESI2
ONS1 ESG Chan. 2 Ro Relay Fails to Pick Up
EU1C2RORYD
An Engineered Safeguards Condition Does Not Exist
ESCONDNOT
6
Operator fails to operate Keowee start switch S1B
YO1OPSBRHE
Control Switch S1B Fails To Close On Demand
YO1S1BFSWC

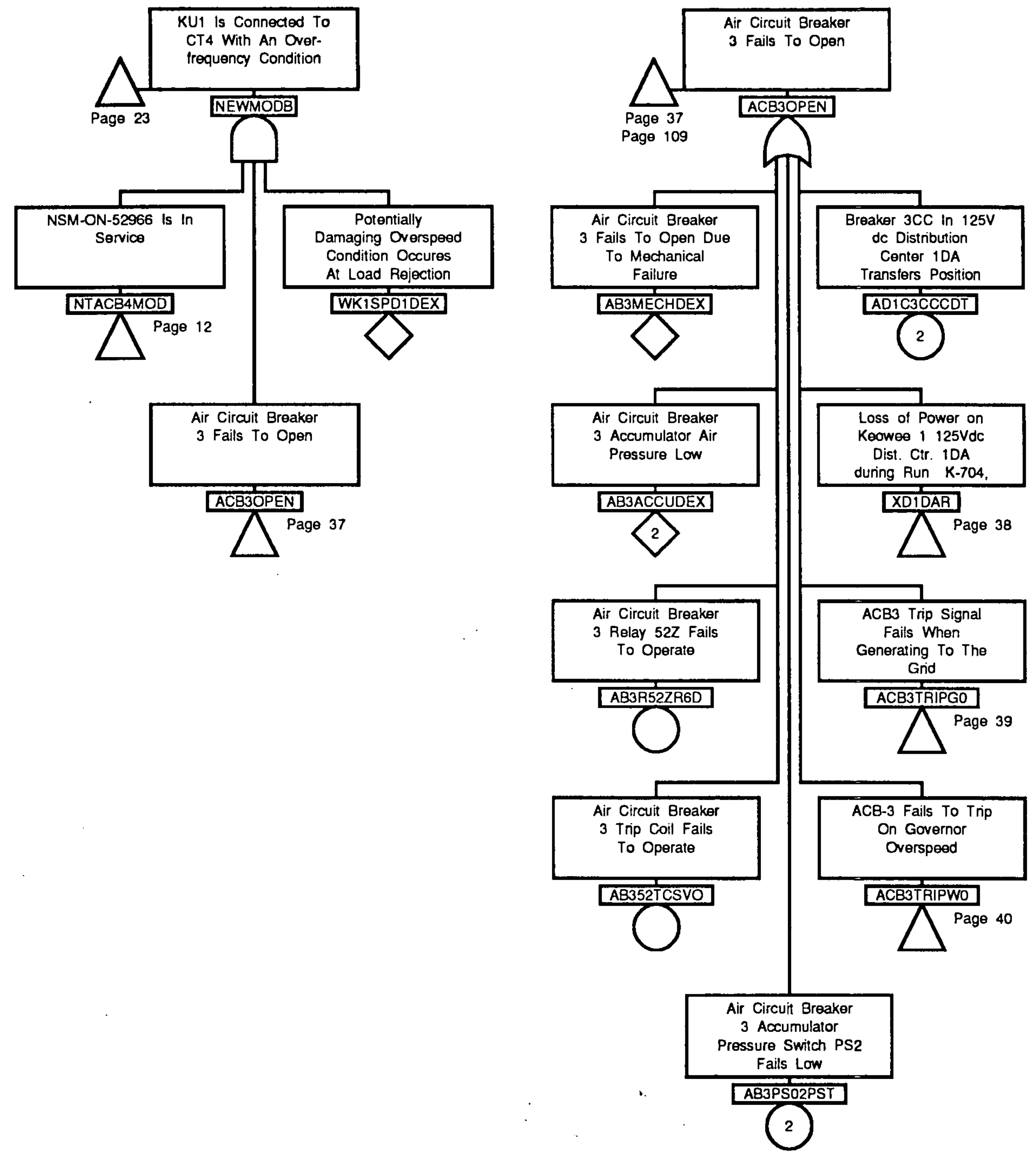

EGTPS Channel 2 Keowee Start Signal Fails
SEGTPSCH2F
Page 255
Page 31
EGTPS Channel 2B Initiators Fail OEE-76-8-A
SEGTP2BNIT
Page 239
EGTPS Trouble Relay 27X/STA Fails To Pick Up
L27XSTBRYD
ONS3 Cable Room Key Operated Switch 3SSW'B' Fails OEE-320-1
YO3SSWBF
Page 34
Operator Fails to Operate Keowee Start Switch 3SSW'B'
YO3SSWBRHE
Control Switch 3SSW'B' Fails To Close On Demand
YO3SSWBSWC

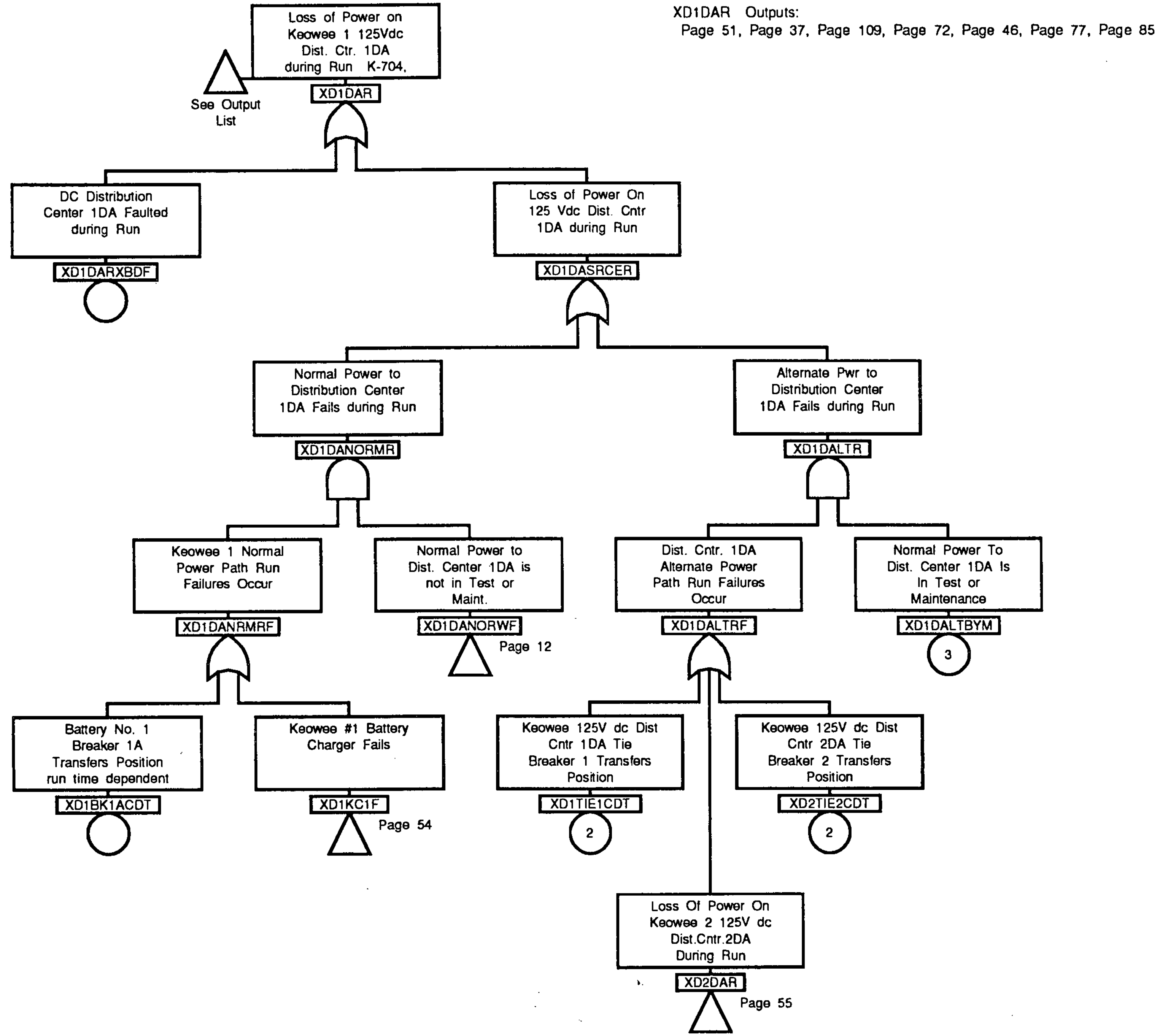

Oconee 2 Channel B Keowee Emergency Start Relay CR2B Fails
YO2KESCHBF
Page 10
Breaker 2DIB-2 Transfers Position
YO2DIB2CDT
Loss of Power on 125 V dc Panelboard 2DIB
D2DIBXXDEX
Oconee 2 Channel B Keowee Emer Strt Sig Initiators Fail OEE-220-1
YO2KSCHBIF
ONS2 Keowee Emergency Start Relay CR2B Fails to Pick Up
YO2CR2BRYD
ONS2 Local Locked Selector Switch 2SSW'B' Fails
YO2SSWBF
ONS2 MFB Monitor Ch B Keowee Start Sig Fails
YO2MFBMB
Oconee 2 Channel 2 Engineered Safeguards Signal Fails OEE-220-1
YO2ESGBF
Operator Fails to Operate Keowee Start Switch 2SSW'B'
YO2SSWBRHE
Control Switch 2SSW'B' Fails To Close On Demand
YO2SSWBSWC
ONS2 ESG Chan. 2 Ro Relay Fails to Pick Up
EU2C2RORYD
An Engineered Safeguards Condition Does Not Exist
ESCONDNOT
6

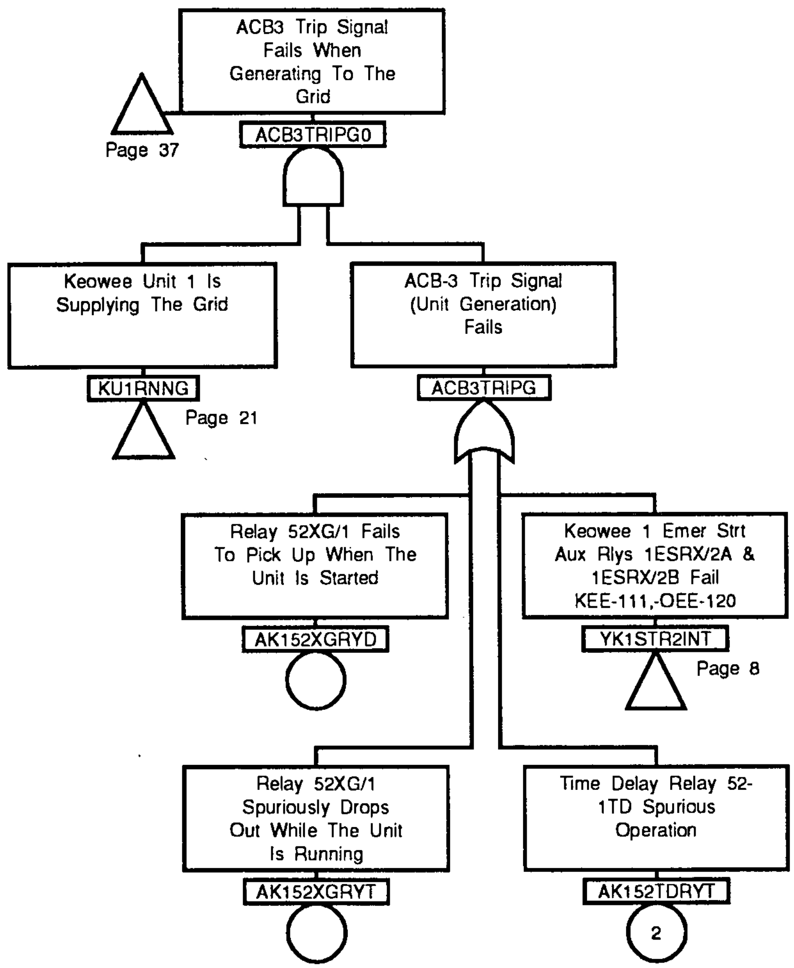

Oconee 3 Channel B Keowee Emergency Start Relay CR3B Fails
YO3KESCHBF
Page 10
Breaker 3DIB-2 Transfers Open
YO3DIB2CDT
Loss Of Power On 125 Vdc Panelboard 3DIB
D3DIBXXDEX
Oconee 3 Channel B Keowee Emer Strt Sig Initiators Fail
YO3KSCHBIF
ONS3 Keowee Emer Start Relay CR3B Fails to Pick Up
YO3CR3BRYD
ONS3 Keowee Emer Start Sw S3B Fails OEE-320-1
YO3S3B
ONS3 MFB Monitor Ch B Keowee Start Sig Fails
YO3MFBMB
ONS3 Keowee Chan B Start Signal Fails for ESG Initiation OEE-320-1
YO3ESGBF
ONS3 Cable Room Key Operated Switch 3SSW'B' Fails OEE-320-1
YO3SSWBF
Page 32
Operator Fails to Operate Keowee Start Switch 3S1B
YO3OPFBRHE
Control Switch S1B Fails To Close On Demand
YO3S1BFSWC
ONS3 ESG Chan. 2 Ro Relay Fails to Pick Up
EU3C2RORYD
An Engineered Safeguards Condition Does Not Exist
ESCONDNOT
6


Air Circuit Breaker 3 Fails To Close
ACB3CLOSE
Page 23
Air Circuit Breaker 3 Fails To Close Due To Mechanical Failure
AB3MCH2DEX
Air Circuit Breaker 3 Accumulator Air Pressure Low
AB3ACCUDEX
2
Air Circuit Breaker 3 Fails To Close Due To Latent Human Error
AB3CLOSLHE
Air Circuit Breaker 3 Fails To Close Due To Electrical Failures
ACB3BREAKC
Page 36
Common Cause Failure Of ACBs 2 And 3
AB23COM
Page 35
Time Delay Relay 2-1TD Fails To Pick-up
AK121TDRYD
KU1 CCF Of 2/3 Overfrequency Relays To Reset When Frequency Drops
AK1OFRQCOM
Failure Of Indication That KU1 Is Selected For The Underground
AK1UNDER
Page 36
Common Cause Failure Of ACBs 2 And 3
AB23COM
Page 66
Page 35
Common Cause Failure Of Air Circuit Breakers 2 And 3 To Close
AB23BKRCOM
NSM-ON-52966 Is In Service
NTACB4MOD
Page 12
Keowee Unit 2 Is Not In Maintenace
K2NOMAIN
Page 22
Keowee Unit 1 Is Supplying The Grid
KU1RNNG
Page 21

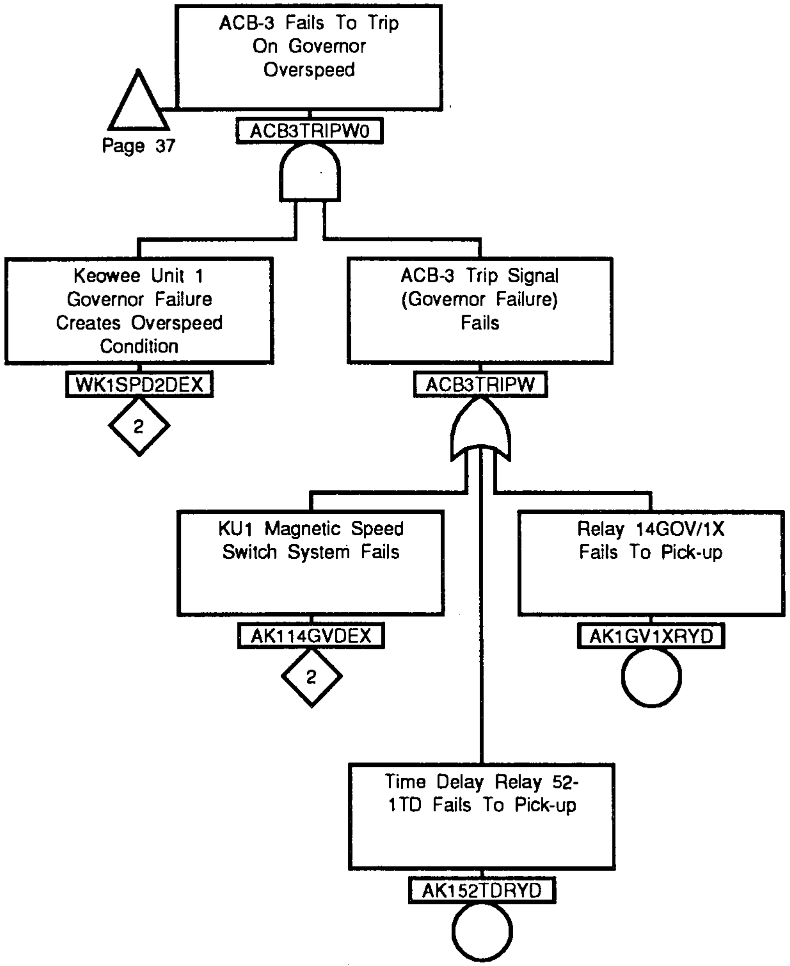

Air Circuit Breaker 3 Fails To Close Due To Electrical Failures
ACB3BREAKC
Page 35
Air Circuit Breaker 3 Relay 52X Fails To Operate
AB3R52XR6D
Air Circuit Breaker 3 Accumulator Pressure Switch PS2 Fails Low
AB3PS02PST
2
Air Circuit Breaker 3 Close Coil Fails To Operate
AB352CCSVO
Air Circuit Breaker 3 Relay 52Y Failed To Drop Out Followin g Last Demand
AB352Y2R6D
Air Circuit Breaker 3 Y-relay Spurious Operation
AB352Y2R6T
Failure Of Indication That KU1 Is Selected For The Underground
AK1UNDER
Page 35
Relay 52AX/34 Spuriously Drops-out
AK1AX34RYT
Relay 52AX/34X Spuriously Drops-out
AK1X34XRYT

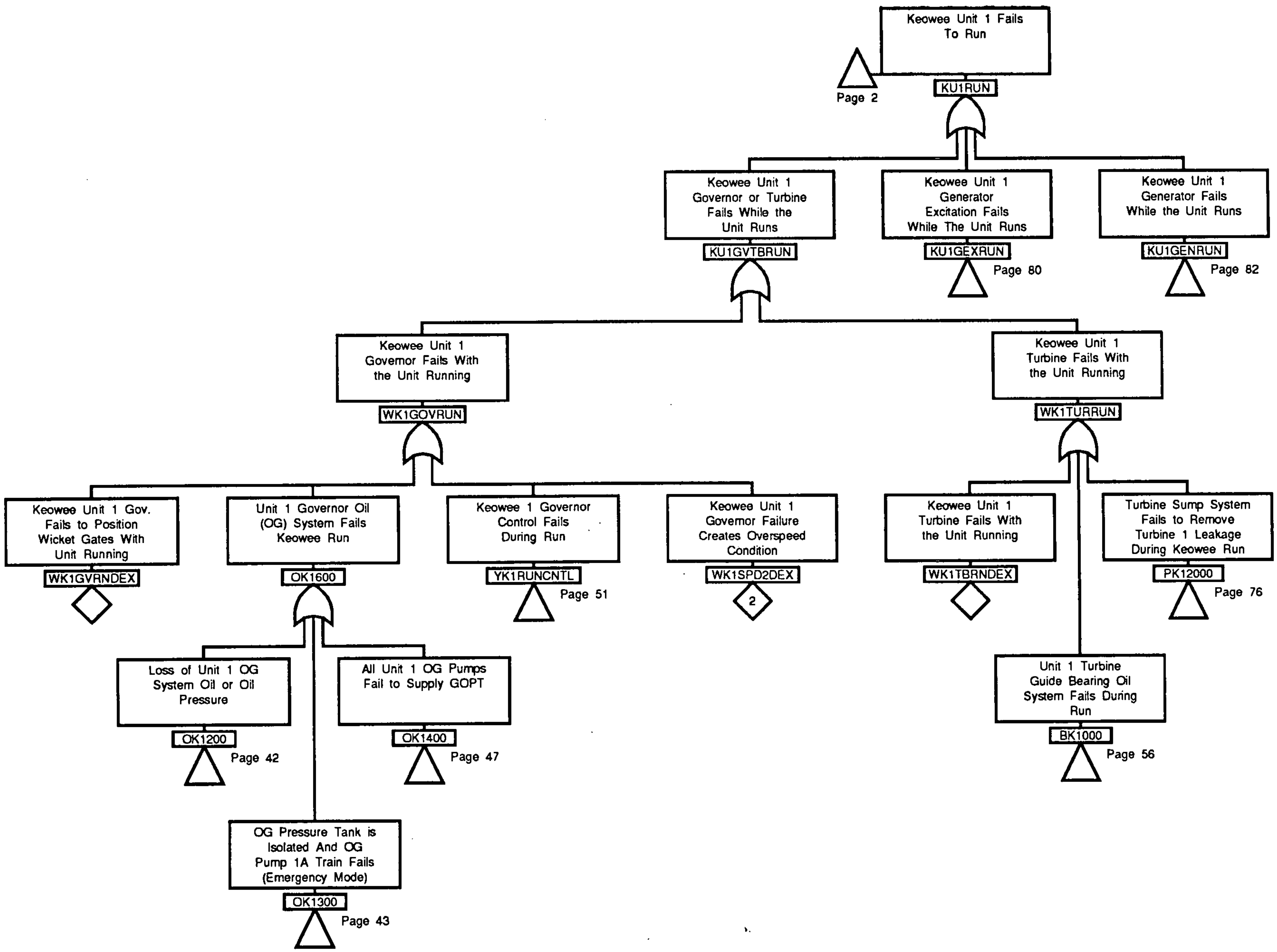

KU1 Is Connected To CT4 With An Over-frequency Condition
NEWMODB
Page 23
NSM-ON-52966 Is In Service
NTACB4MOD
Page 12
Potentially Damaging Overspeed Condition Occures At Load Rejection
WK1SPD1DEX
Air Circuit Breaker 3 Fails To Open
ACB3OPEN
Page 37
Air Circuit Breaker 3 Fails To Open
ACB3OPEN
Page 37
Page 109
Air Circuit Breaker 3 Fails To Open Due To Mechanical Failure
AB3MECHDEX
Breaker 3CC In 125V dc Distribution Center 1DA Transfers Position
AD1C3CCCDT
2
Air Circuit Breaker 3 Accumulator Air Pressure Low
AB3ACCUDEX
2
Loss of Power on Keowee 1 125Vdc Dist. Ctr. 1DA during Run K-704,
XD1DAR
Page 38
Air Circuit Breaker 3 Relay 52Z Fails To Operate
AB3R52ZR6D
ACB3 Trip Signal Fails When Generating To The Grid
ACB3TRIPG0
Page 39
Air Circuit Breaker 3 Trip Coil Fails To Operate
AB352TCSVO
ACB-3 Fails To Trip On Governor Overspeed
ACB3TRIPW0
Page 40
Air Circuit Breaker 3 Accumulator Pressure Switch PS2 Fails Low
AB3PS02PST
2


XD1DAR Outputs:
Page 51, Page 37, Page 109, Page 72, Page 46, Page 77, Page 85
Loss of Power on Keowee 1 125Vdc Dist. Ctr. 1DA during Run K-704,
XD1DAR
See Output List
DC Distribution Center 1DA Faulted during Run
XD1DARXBDF
Loss of Power On 125 Vdc Dist. Cntr 1DA during Run
XD1DASRCER
Normal Power to Distribution Center 1DA Fails during Run
XD1DANORMR
Alternate Pwr to Distribution Center 1DA Fails during Run
XD1DALTR
Keowee 1 Normal Power Path Run Failures Occur
XD1DANRMRF
Normal Power to Dist. Center 1DA is not in Test or Maint.
XD1DANORWF
Page 12
Dist. Cntr. 1DA Alternate Power Path Run Failures Occur
XD1DALTRF
Normal Power To Dist. Center 1DA Is In Test or Maintenance
XD1DALTBYM
3
Battery No. 1 Breaker 1A Transfers Position run time dependent
XD1BK1ACDT
Keowee #1 Battery Charger Fails
XD1KC1F
Page 54
Keowee 125V dc Dist Cntr 1DA Tie Breaker 1 Transfers Position
XD1TIE1CDT
2
Keowee 125V dc Dist Cntr 2DA Tie Breaker 2 Transfers Position
XD2TIE2CDT
2
Loss Of Power On Keowee 2 125V dc Dist.Cntr.2DA During Run
XD2DAR
Page 55

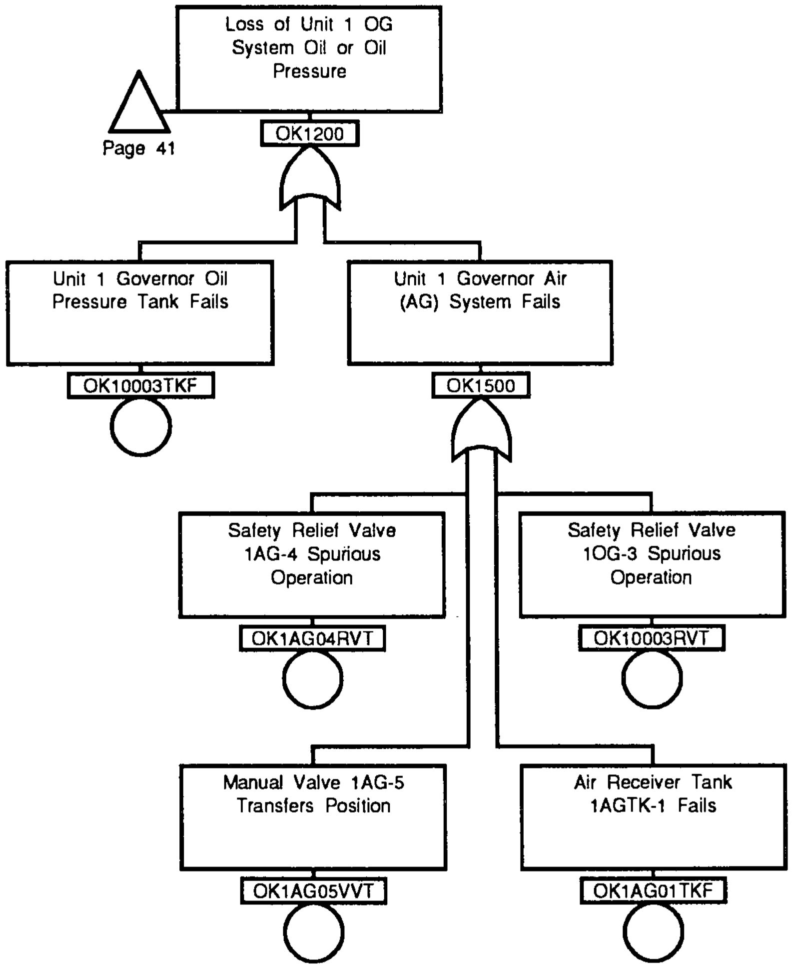


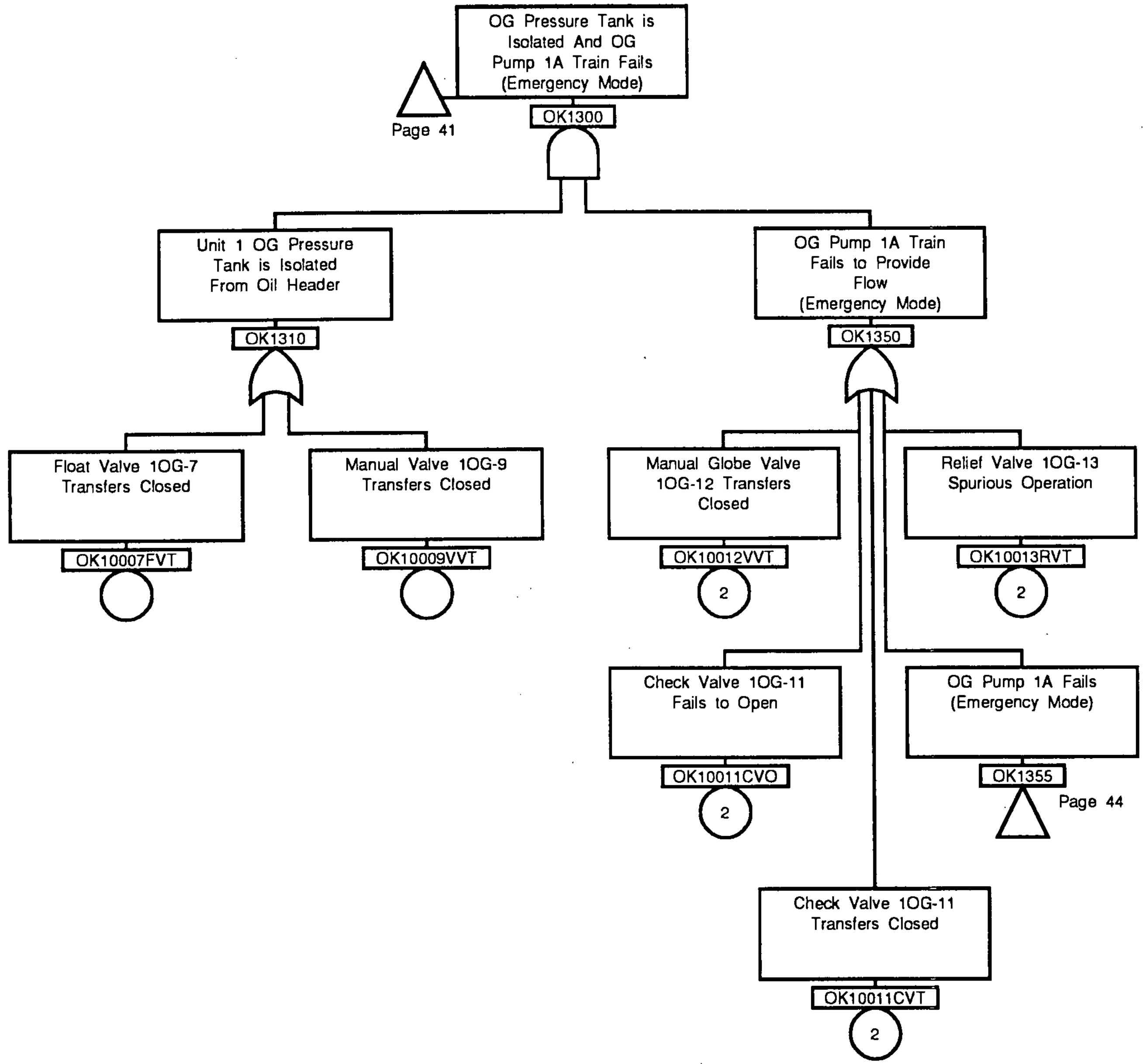
ACB3 Trip Signal Fails When Generating To The Grid
ACB3TRIPG0
Page 37
Keowee Unit 1 Is Supplying The Grid
KU1RNNG
Page 21
ACB-3 Trip Signal (Unit Generation) Fails
ACB3TRIPG
Relay 52XG/1 Fails To Pick Up When The Unit Is Started
AK152XGRYD
Keowee 1 Emer Strt Aux Rlys 1ESRX/2A & 1ESRX/2B Fail KEE-111,-OEE-120
YK1STR2INT
Page 8
Relay 52XG/1 Spuriously Drops Out While The Unit Is Running
AK152XGRYT
Time Delay Relay 52-1TD Spurious Operation
AK152TDRYT
2

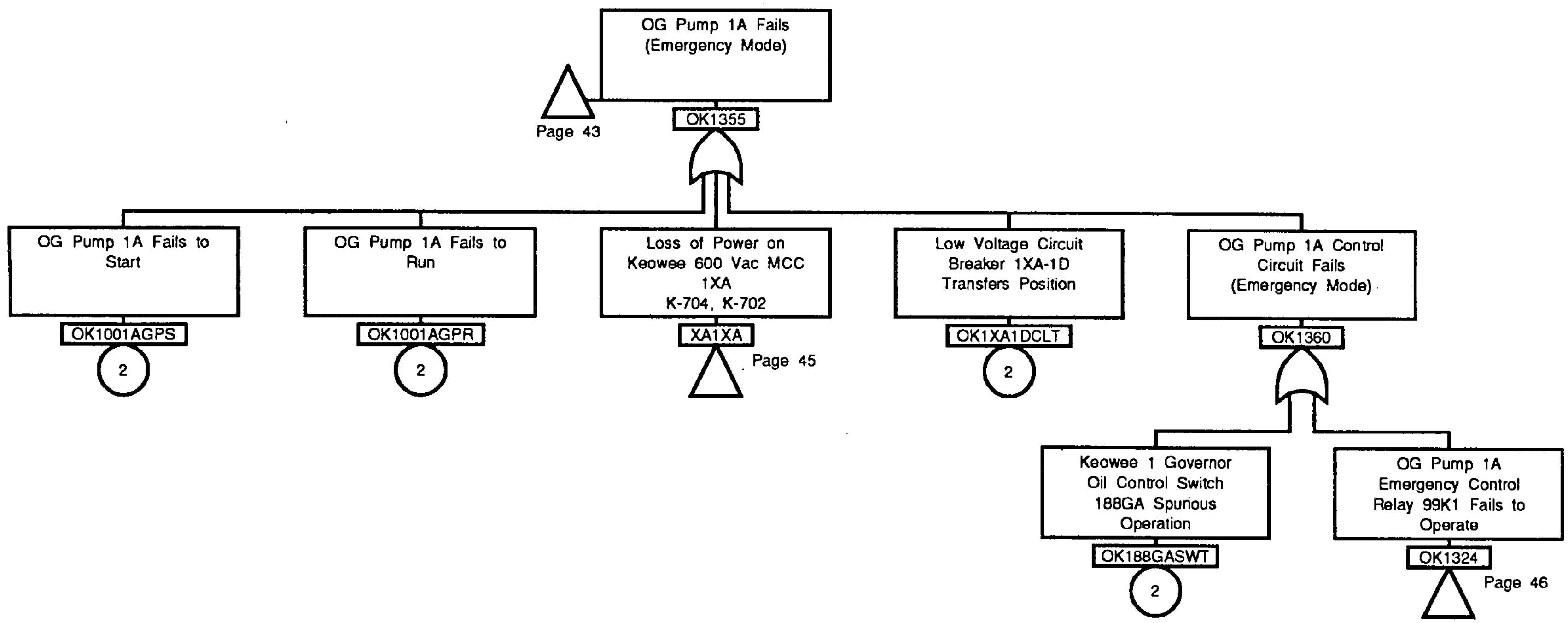

ACB-3 Fails To Trip On Governor Overspeed
ACB3TRIPW0
Page 37
Keowee Unit 1 Governor Failure Creates Overspeed Condition
WK1SPD2DEX
2
ACB-3 Trip Signal (Governor Failure) Fails
ACB3TRIPW
KU1 Magnetic Speed Switch System Fails
AK114GVDEX
2
Relay 14GOV/1X Fails To Pick-up
AK1GV1XRYD
Time Delay Relay 52-1TD Fails To Pick-up
AK152TDRYD



Keowee Unit 1 Fails To Run
Page 2
KU1RUN
Keowee Unit 1 Governor or Turbine Fails While the Unit Runs
KU1GVTBRUN
Keowee Unit 1 Generator Excitation Fails While The Unit Runs
KU1GEXRUN
Page 80
Keowee Unit 1 Generator Fails While the Unit Runs
KU1GENRUN
Page 82
Keowee Unit 1 Governor Fails With the Unit Running
WK1GOVRUN
Keowee Unit 1 Turbine Fails With the Unit Running
WK1TURRUN
Keowee Unit 1 Gov. Fails to Position Wicket Gates With Unit Running
WK1GVRNDEX
Unit 1 Governor Oil (OG) System Fails Keowee Run
OK1600
Keowee 1 Governor Control Fails During Run
YK1RUNCNTL
Page 51
Keowee Unit 1 Governor Failure Creates Overspeed Condition
WK1SPD2DEX
2
Keowee Unit 1 Turbine Fails With the Unit Running
WK1TBRNDEX
Turbine Sump System Fails to Remove Turbine 1 Leakage During Keowee Run
PK12000
Page 76
Loss of Unit 1 OG System Oil or Oil Pressure
OK1200
Page 42
All Unit 1 OG Pumps Fail to Supply GOPT
OK1400
Page 47
Unit 1 Turbine Guide Bearing Oil System Fails During Run
BK1000
Page 56
OG Pressure Tank is Isolated And OG Pump 1A Train Fails (Emergency Mode)
OK1300
Page 43

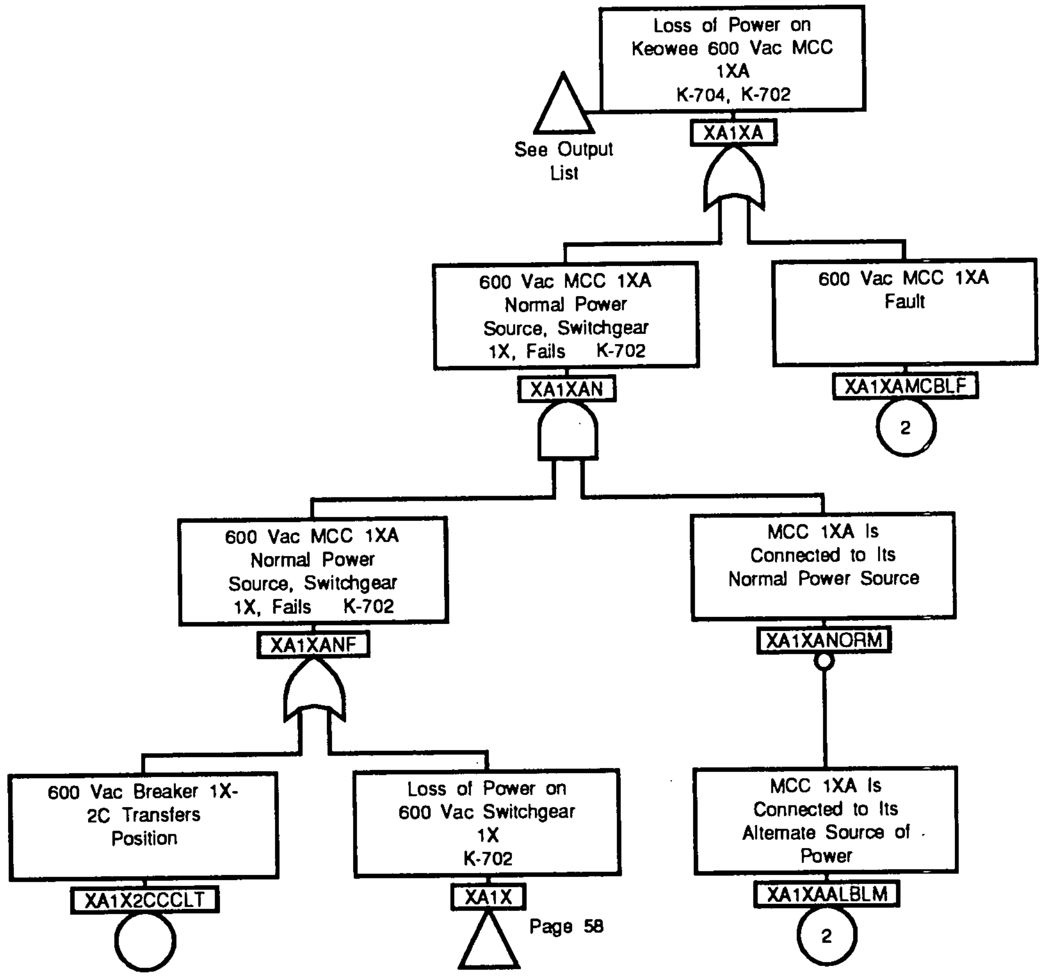

Loss of Unit 1 OG System Oil or Oil Pressure
OK1200
Page 41
Unit 1 Governor Oil Pressure Tank Fails
OK10003TKF
Unit 1 Governor Air (AG) System Fails
OK1500
Safety Relief Valve 1AG-4 Spurious Operation
OK1AG04RVT
Safety Relief Valve 1OG-3 Spurious Operation
OK10003RVT
Manual Valve 1AG-5 Transfers Position
OK1AG05VVT
Air Receiver Tank 1AGTK-1 Fails
OK1AG01TKF

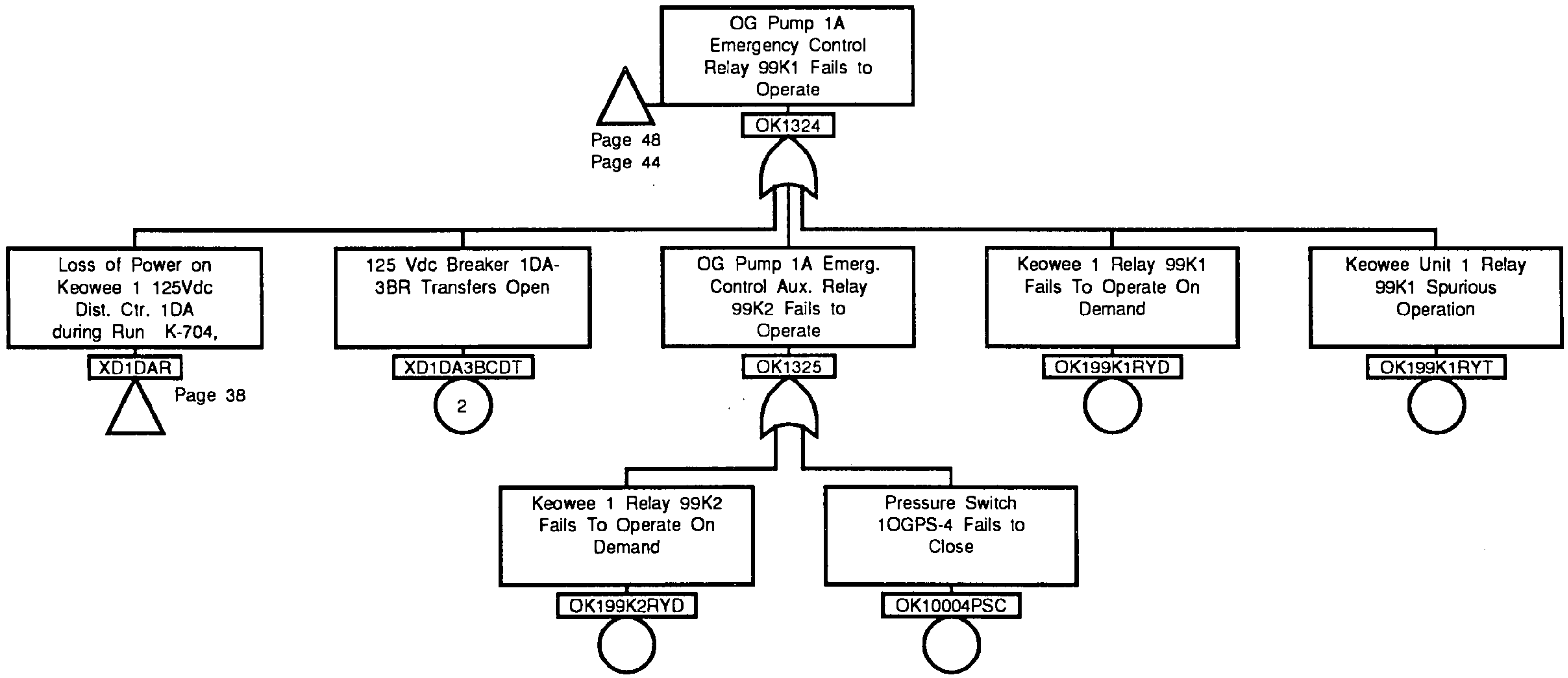

OG Pressure Tank is Isolated And OG Pump 1A Train Fails (Emergency Mode)
OK1300
Page 41
Unit 1 OG Pressure Tank is Isolated From Oil Header
OK1310
OG Pump 1A Train Fails to Provide Flow (Emergency Mode)
OK1350
Float Valve 1OG-7 Transfers Closed
OK10007FVT
Manual Valve 1OG-9 Transfers Closed
OK10009VVT
Manual Globe Valve 1OG-12 Transfers Closed
OK10012VVT
2
Relief Valve 1OG-13 Spurious Operation
OK10013RVT
2
Check Valve 1OG-11 Fails to Open
OK10011CVO
2
OG Pump 1A Fails (Emergency Mode)
OK1355
Page 44
Check Valve 1OG-11 Transfers Closed
OK10011CVT
2



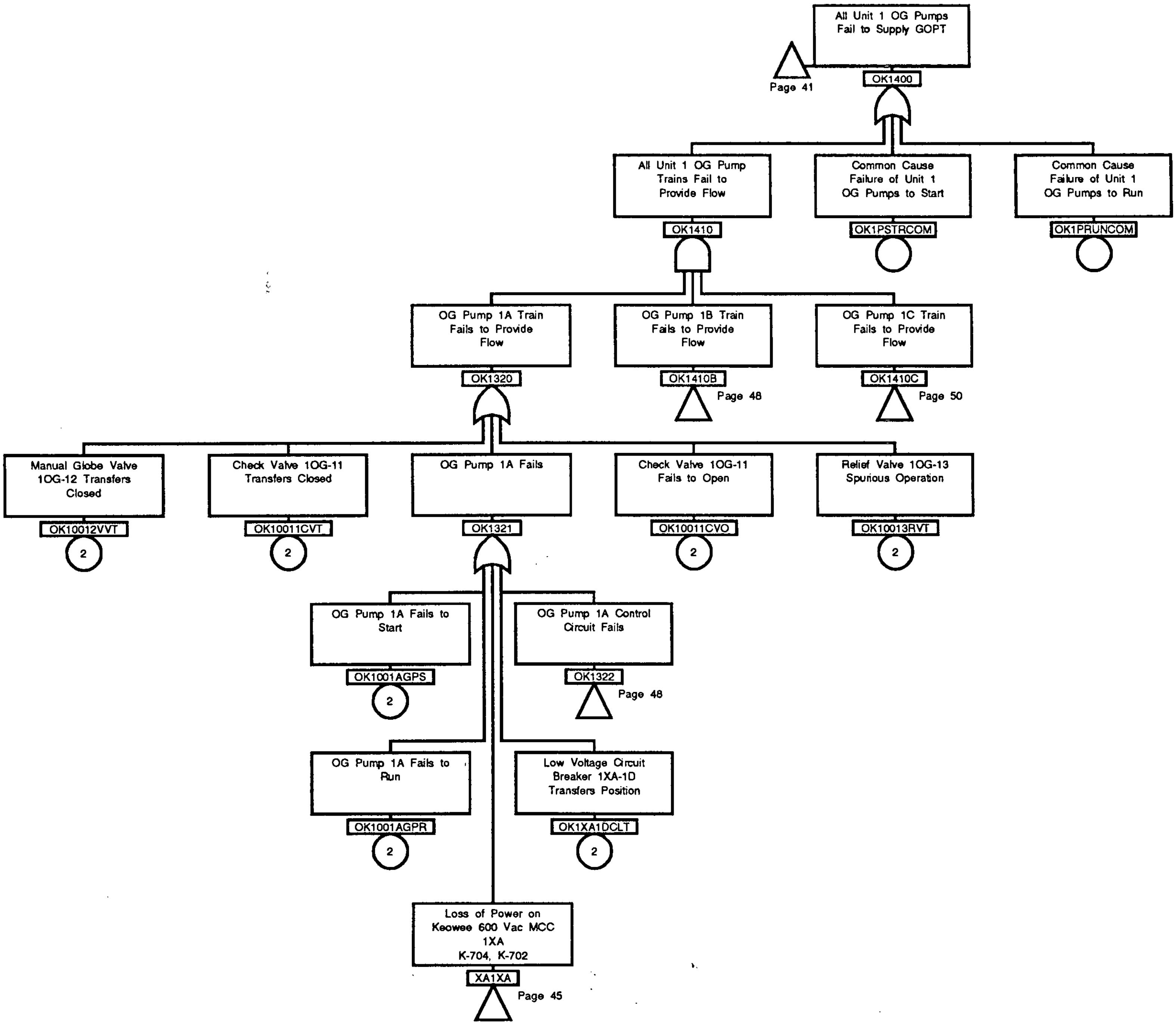
OG Pump 1A Fails (Emergency Mode)
Page 43
OK1355
OG Pump 1A Fails to Start
OK1001AGPS
2
OG Pump 1A Fails to Run
OK1001AGPR
2
Loss of Power on Keowee 600 Vac MCC 1XA K-704, K-702
XA1XA
Page 45
Low Voltage Circuit Breaker 1XA-1D Transfers Position
OK1XA1DCLT
2
OG Pump 1A Control Circuit Fails (Emergency Mode)
OK1360
Keowee 1 Governor Oil Control Switch 188GA Spurious Operation
OK188GASWT
2
OG Pump 1A Emergency Control Relay 99K1 Fails to Operate
OK1324
Page 46

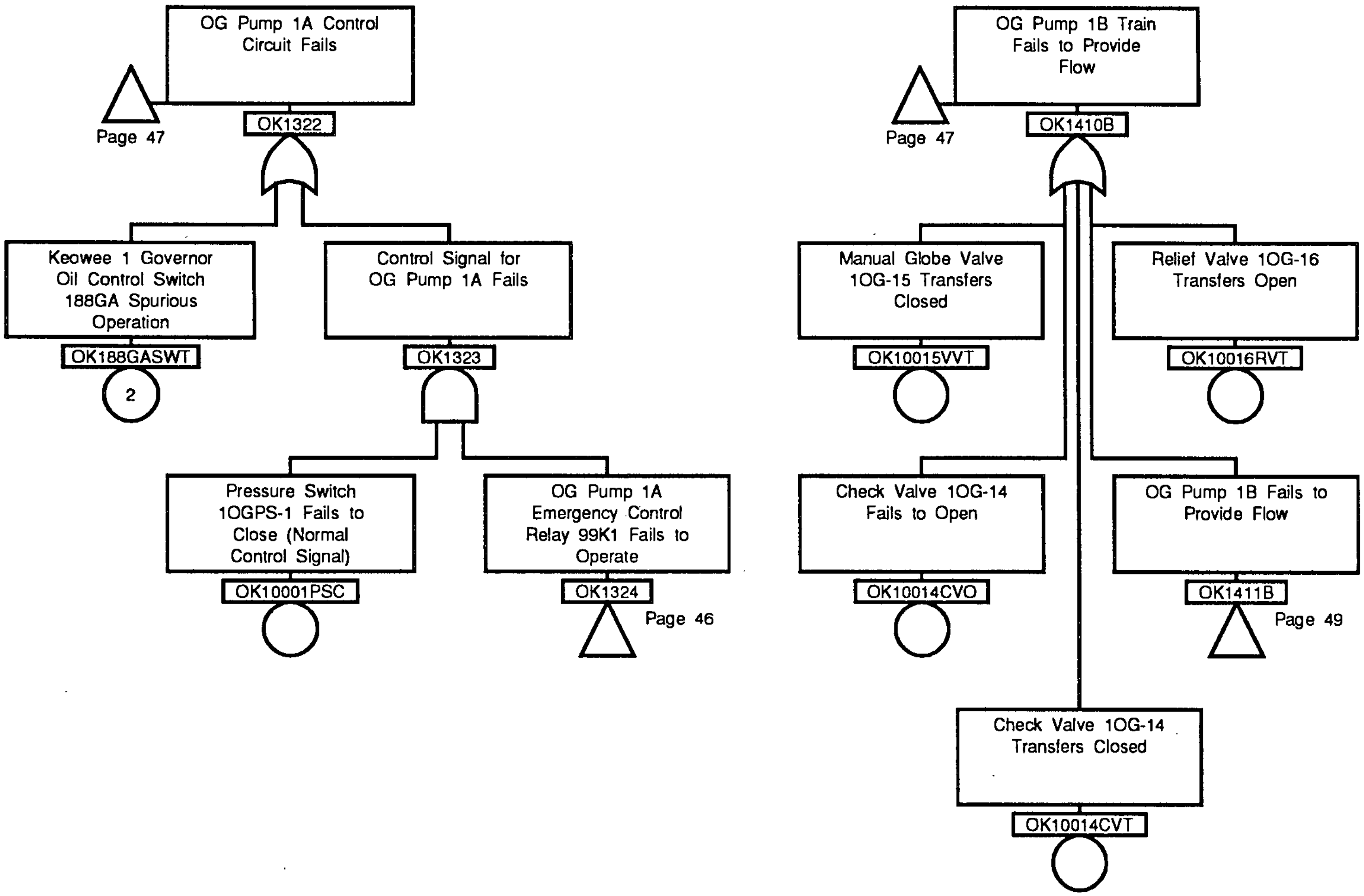
XA1XA Outputs:
Page 57, Page 47, Page 44, Page 49, Page 52, Page 76



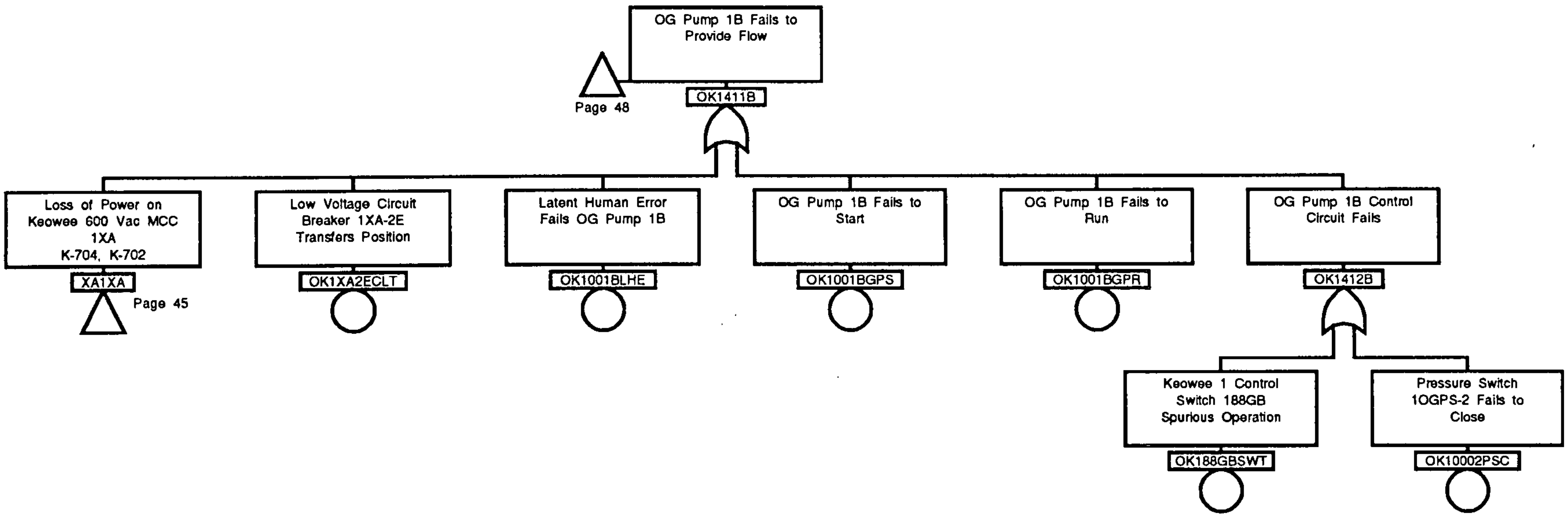


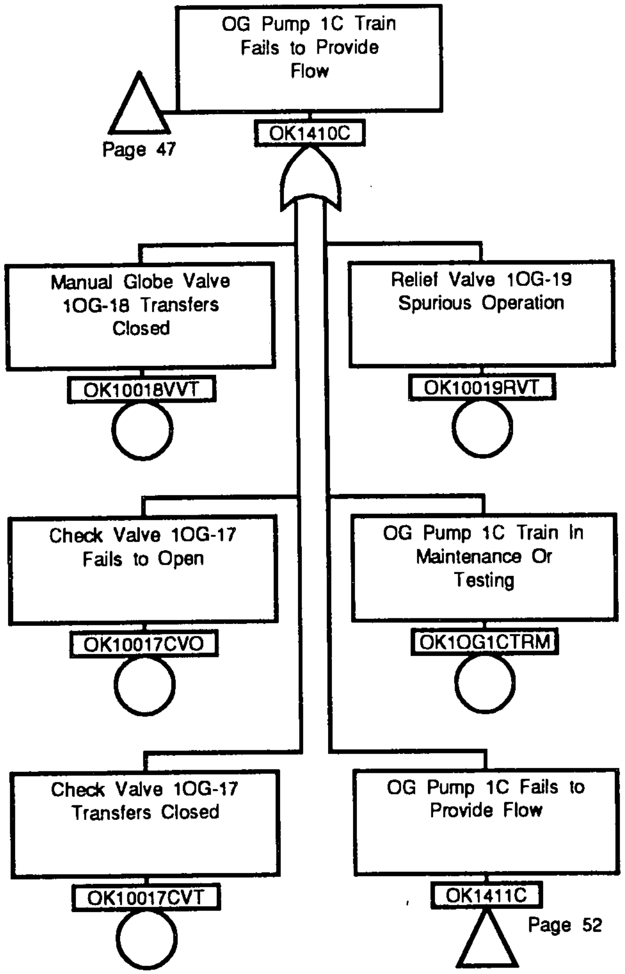
OG Pump 1A Emergency Control Relay 99K1 Fails to Operate
OK1324
Page 48
Page 44
Loss of Power on Keowee 1 125Vdc Dist. Ctr. 1DA during Run K-704,
XD1DAR
Page 38
125 Vdc Breaker 1DA-3BR Transfers Open
XD1DA3BCDT
2
OG Pump 1A Emerg. Control Aux. Relay 99K2 Fails to Operate
OK1325
Keowee 1 Relay 99K1 Fails To Operate On Demand
OK199K1RYD
Keowee Unit 1 Relay 99K1 Spurious Operation
OK199K1RYT
Keowee 1 Relay 99K2 Fails To Operate On Demand
OK199K2RYD
Pressure Switch 1OGPS-4 Fails to Close
OK10004PSC

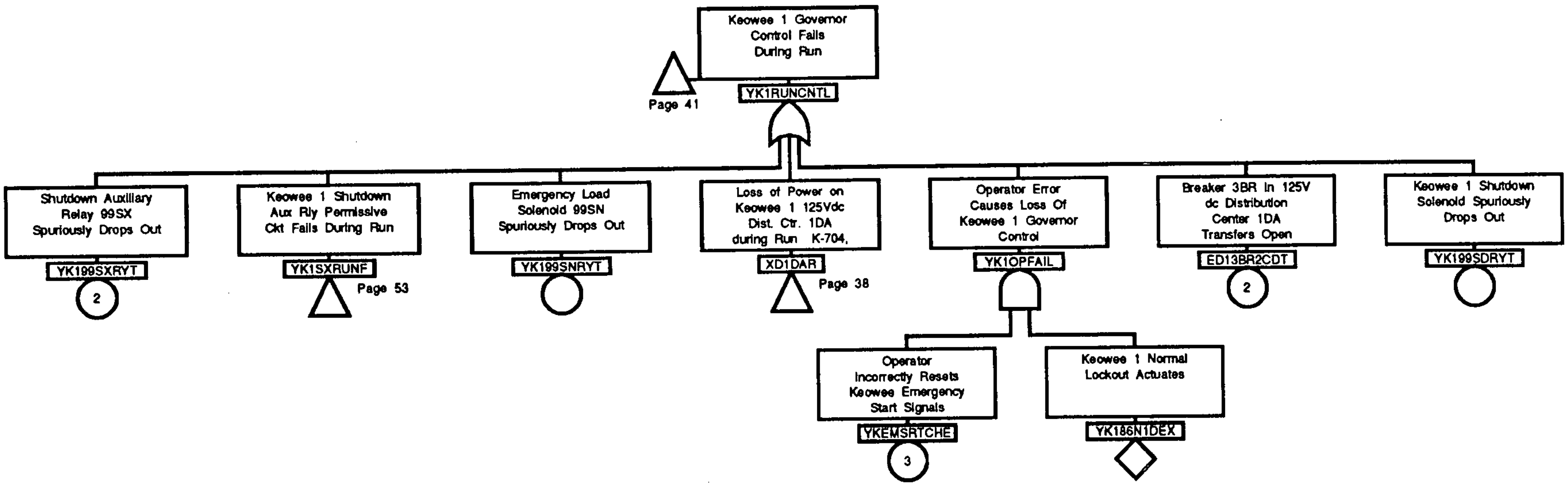

All Unit 1 OG Pumps Fail to Supply GOPT
OK1400
Page 41
All Unit 1 OG Pump Trains Fail to Provide Flow
OK1410
Common Cause Failure of Unit 1 OG Pumps to Start
OK1PSTRCOM
Common Cause Failure of Unit 1 OG Pumps to Run
OK1PRUNCOM
OG Pump 1A Train Fails to Provide Flow
OK1320
OG Pump 1B Train Fails to Provide Flow
OK1410B
Page 48
OG Pump 1C Train Fails to Provide Flow
OK1410C
Page 50
Manual Globe Valve 1OG-12 Transfers Closed
OK10012VVT
2
Check Valve 1OG-11 Transfers Closed
OK10011CVT
2
OG Pump 1A Fails
OK1321
Check Valve 1OG-11 Fails to Open
OK10011CVO
2
Relief Valve 1OG-13 Spurious Operation
OK10013RVT
2
OG Pump 1A Fails to Start
OK1001AGPS
2
OG Pump 1A Control Circuit Fails
OK1322
Page 48
OG Pump 1A Fails to Run
OK1001AGPR
2
Low Voltage Circuit Breaker 1XA-1D Transfers Position
OK1XA1DCLT
2
Loss of Power on Keowee 600 Vac MCC 1XA K-704, K-702
XA1XA
Page 45



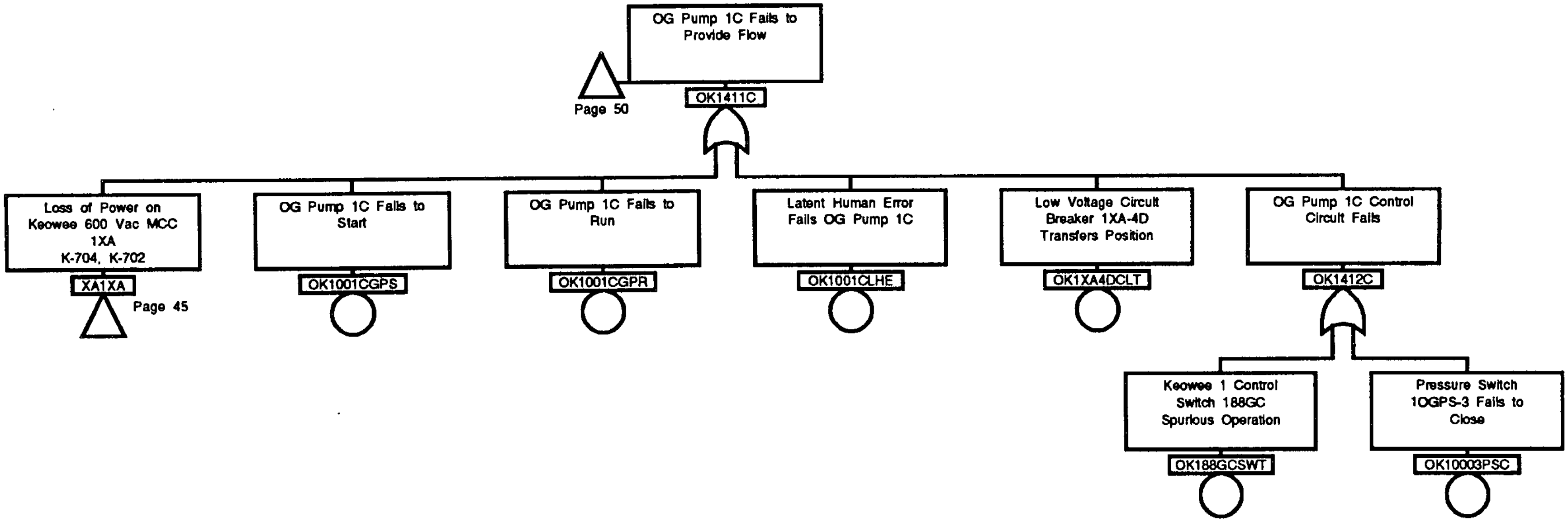
OG Pump 1A Control Circuit Fails
OK1322
Page 47
Keowee 1 Governor Oil Control Switch 188GA Spurious Operation
OK188GASWT
2
Control Signal for OG Pump 1A Fails
OK1323
Pressure Switch 1OGPS-1 Fails to Close (Normal Control Signal)
OK10001PSC
OG Pump 1A Emergency Control Relay 99K1 Fails to Operate
OK1324
Page 46
OG Pump 1B Train Fails to Provide Flow
OK1410B
Page 47
Manual Globe Valve 1OG-15 Transfers Closed
OK10015VVT
Relief Valve 1OG-16 Transfers Open
OK10016RVT
Check Valve 1OG-14 Fails to Open
OK10014CVO
OG Pump 1B Fails to Provide Flow
OK1411B
Page 49
Check Valve 1OG-14 Transfers Closed
OK10014CVT


OG Pump 1B Fails to Provide Flow
OK1411B
Page 48
Loss of Power on Keowee 600 Vac MCC 1XA K-704, K-702
XA1XA
Page 45
Low Voltage Circuit Breaker 1XA-2E Transfers Position
OK1XA2ECLT
Latent Human Error Fails OG Pump 1B
OK1001BLHE
OG Pump 1B Fails to Start
OK1001BGPS
OG Pump 1B Fails to Run
OK1001BGPR
OG Pump 1B Control Circuit Fails
OK1412B
Keowee 1 Control Switch 188GB Spurious Operation
OK188GBSWT
Pressure Switch 1OGPS-2 Fails to Close
OK10002PSC

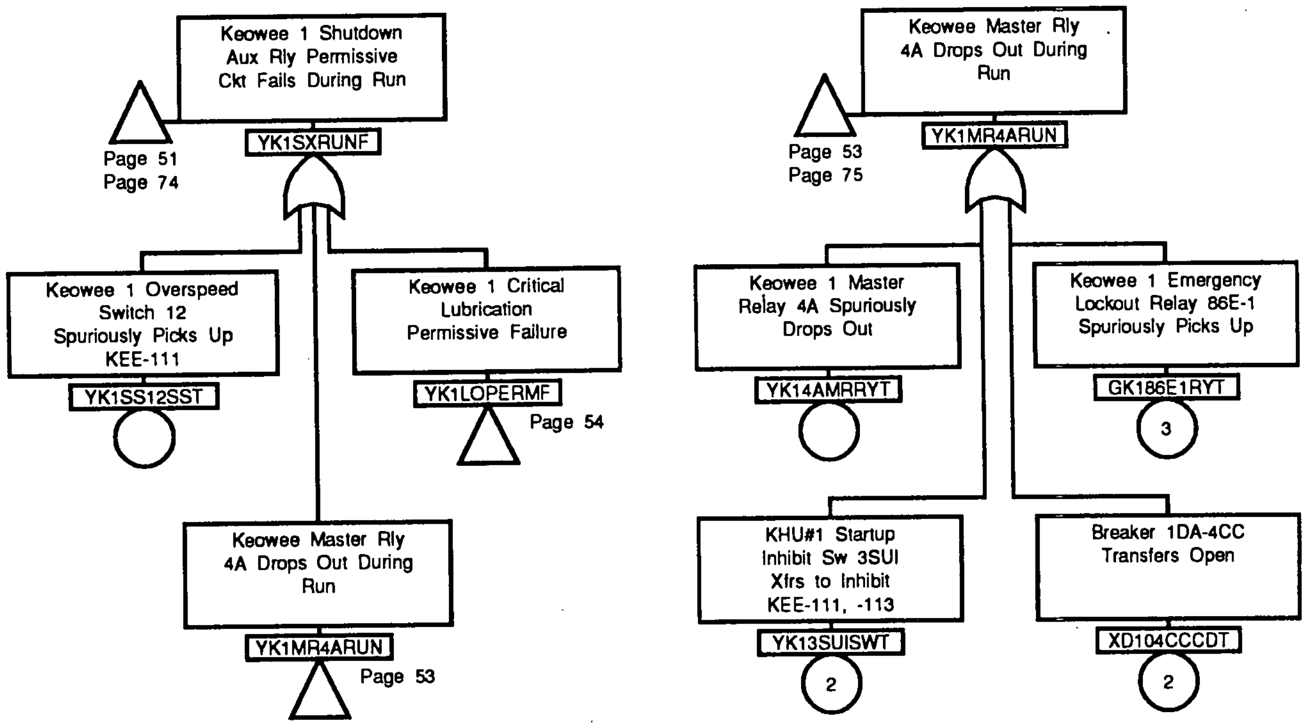

OG Pump 1C Train Fails to Provide Flow
OK1410C
Page 47
Manual Globe Valve 1OG-18 Transfers Closed
OK10018VVT
Relief Valve 1OG-19 Spurious Operation
OK10019RVT
Check Valve 1OG-17 Fails to Open
OK10017CVO
OG Pump 1C Train In Maintenance Or Testing
OK1OG1CTRM
Check Valve 1OG-17 Transfers Closed
OK10017CVT
OG Pump 1C Fails to Provide Flow
OK1411C
Page 52



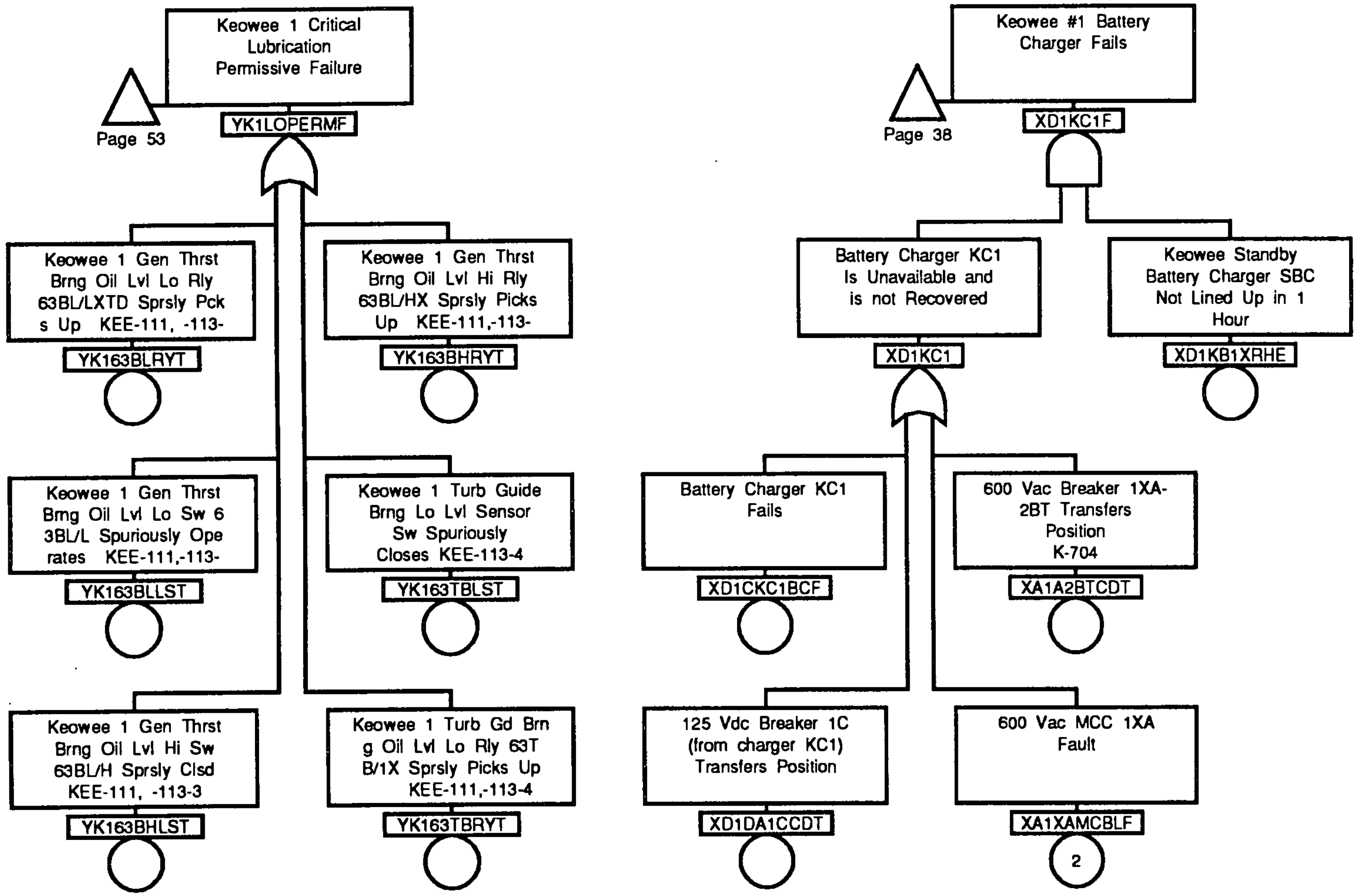
Keowee 1 Governor Control Fails During Run
YK1RUNCNTL
Page 41
Shutdown Auxiliary Relay 99SX Spuriously Drops Out
YK199SXRYT
2
Keowee 1 Shutdown Aux Rly Permissive Ckt Fails During Run
YK1SXRUNF
Page 53
Emergency Load Solenoid 99SN Spuriously Drops Out
YK199SNRYT
Loss of Power on Keowee 1 125Vdc Dist. Ctr. 1DA during Run K-704,
XD1DAR
Page 38
Operator Error Causes Loss Of Keowee 1 Governor Control
YK1OPFAIL
Breaker 3BR In 125V dc Distribution Center 1DA Transfers Open
ED13BR2CDT
2
Keowee 1 Shutdown Solenoid Spuriously Drops Out
YK199SDRYT
Operator Incorrectly Resets Keowee Emergency Start Signals
YKEMSRTCHE
3
Keowee 1 Normal Lockout Actuates
YK186N1DEX



OG Pump 1C Fails to Provide Flow
OK1411C
Page 50
Loss of Power on Keowee 600 Vac MCC 1XA K-704, K-702
XA1XA
Page 45
OG Pump 1C Fails to Start
OK1001CGPS
OG Pump 1C Fails to Run
OK1001CGPR
Latent Human Error Fails OG Pump 1C
OK1001CLHE
Low Voltage Circuit Breaker 1XA-4D Transfers Position
OK1XA4DCLT
OG Pump 1C Control Circuit Fails
OK1412C
Keowee 1 Control Switch 188GC Spurious Operation
OK188GCSWT
Pressure Switch 1OGPS-3 Fails to Close
OK10003PSC

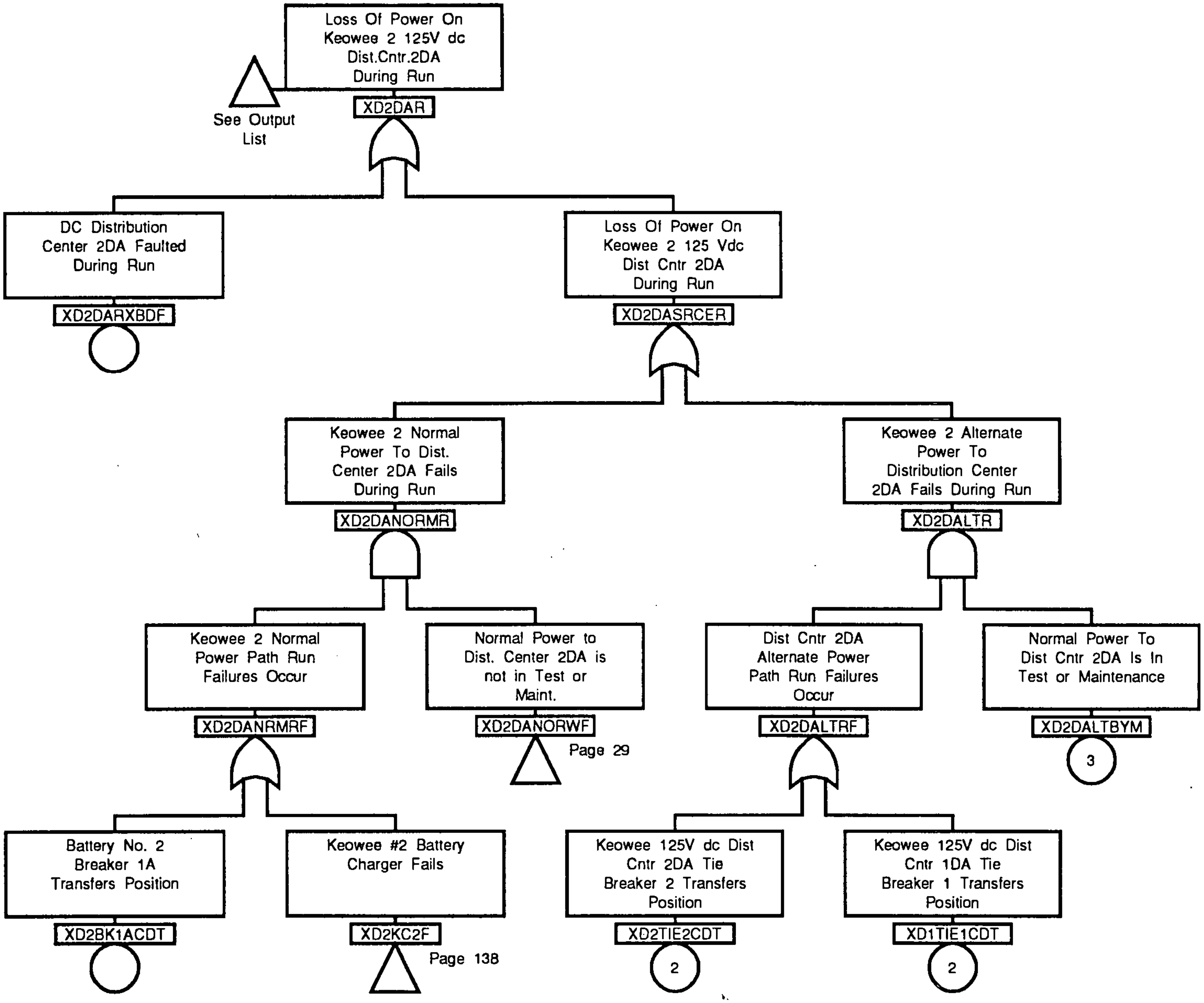


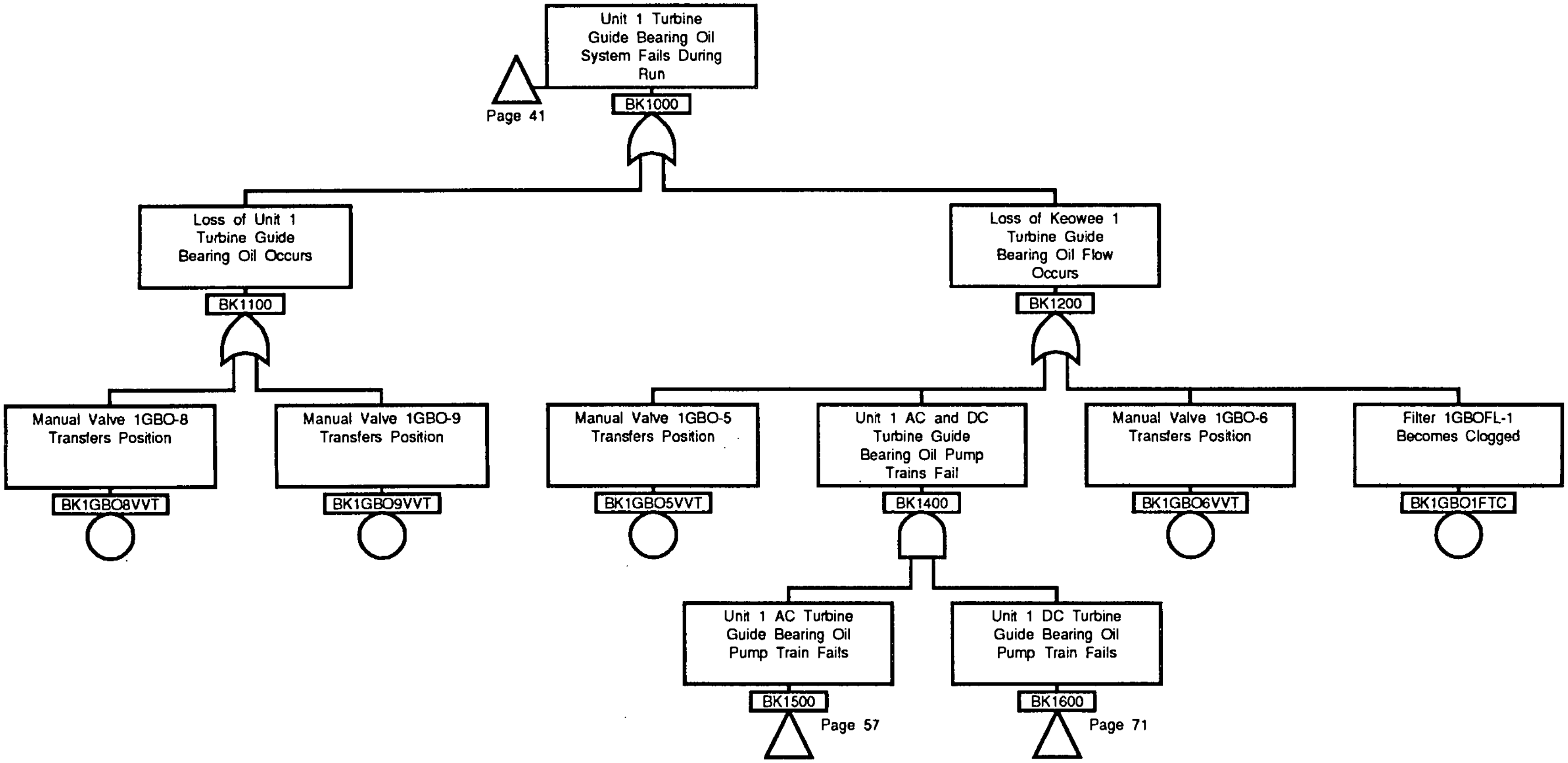
Keowee 1 Shutdown Aux Rly Permissive Ckt Fails During Run
YK1SXRUNF
Page 51
Page 74
Keowee 1 Overspeed Switch 12 Spuriously Picks Up KEE-111
YK1SS12SST
Keowee 1 Critical Lubrication Permissive Failure
YK1LOPERMF
Page 54
Keowee Master Rly 4A Drops Out During Run
YK1MR4ARUN
Page 53
Keowee Master Rly 4A Drops Out During Run
YK1MR4ARUN
Page 53
Page 75
Keowee 1 Master Relay 4A Spuriously Drops Out
YK14AMRRYT
Keowee 1 Emergency Lockout Relay 86E-1 Spuriously Picks Up
GK186E1RYT
3
KHU#1 Startup Inhibit Sw 3SUI Xfrs to Inhibit KEE-111, -113
YK13SUISWT
2
Breaker 1DA-4CC Transfers Open
XD104CCCDT
2



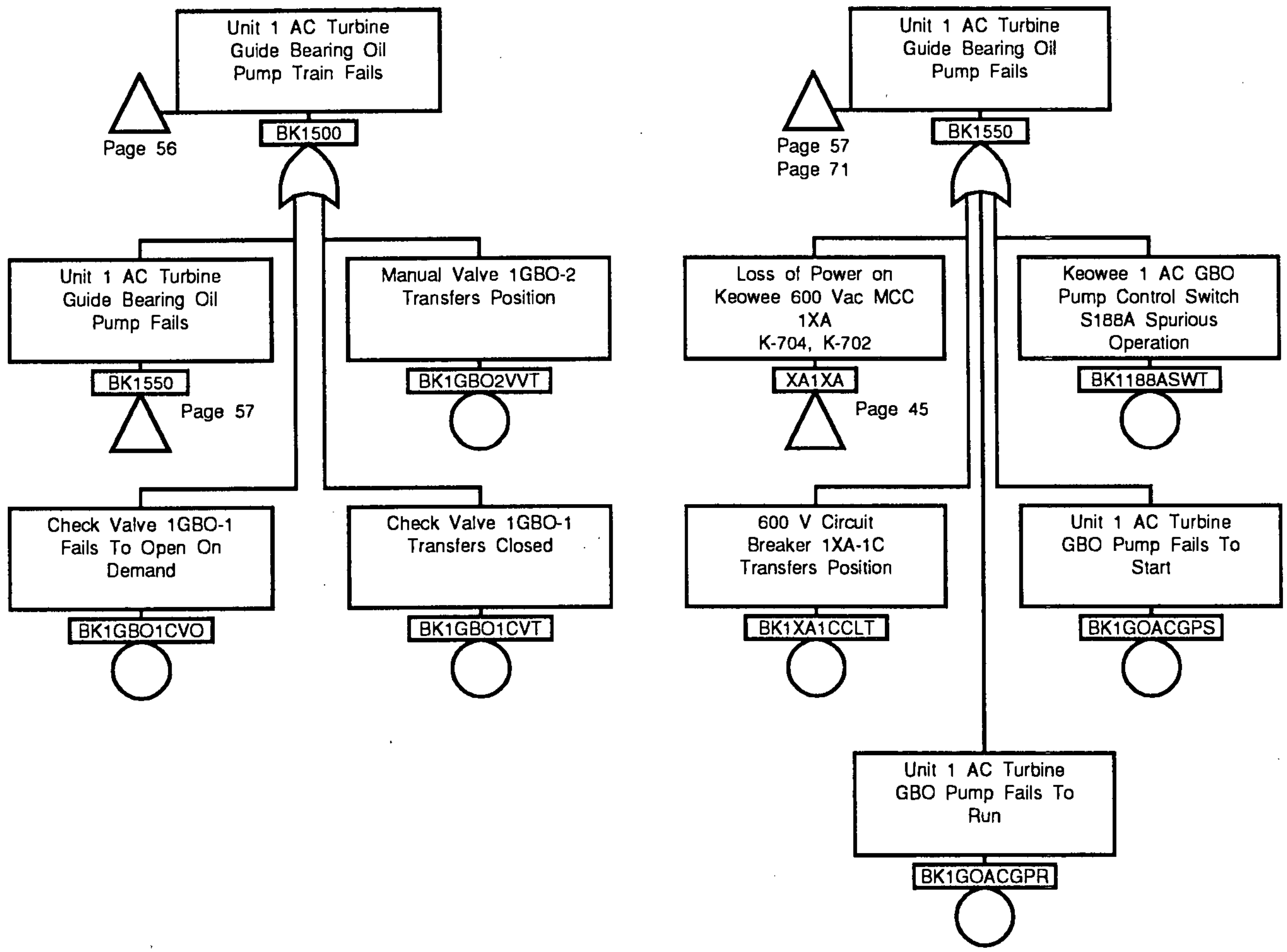
Keowee 1 Critical Lubrication Permissive Failure
YK1LOPERMF
Page 53
Keowee 1 Gen Thrst Brng Oil Lvl Lo Rly 63BL/LXTD Sprsly Pck s Up KEE-111, -113-
YK163BLRYT
Keowee 1 Gen Thrst Brng Oil Lvl Hi Rly 63BL/HX Sprsly Picks Up KEE-111,-113-
YK163BHRYT
Keowee 1 Gen Thrst Brng Oil Lvl Lo Sw 6 3BL/L Spuriously Ope rates KEE-111,-113-
YK163BLLST
Keowee 1 Turb Guide Brng Lo Lvl Sensor Sw Spuriously Closes KEE-113-4
YK163TBLST
Keowee 1 Gen Thrst Brng Oil Lvl Hi Sw 63BL/H Sprsly Clsd KEE-111, -113-3
YK163BHLST
Keowee 1 Turb Gd Brn g Oil Lvl Lo Rly 63T B/1X Sprsly Picks Up KEE-111,-113-4
YK163TBRYT
Keowee #1 Battery Charger Fails
XD1KC1F
Page 38
Battery Charger KC1 Is Unavailable and is not Recovered
XD1KC1
Keowee Standby Battery Charger SBC Not Lined Up in 1 Hour
XD1KB1XRHE
Battery Charger KC1 Fails
XD1CKC1BCF
600 Vac Breaker 1XA-2BT Transfers Position K-704
XA1A2BTCDT
125 Vdc Breaker 1C (from charger KC1) Transfers Position
XD1DA1CCDT
600 Vac MCC 1XA Fault
XA1XAMCBLF
2

XD2DAR Outputs:
Page 135, Page 38, Page 112, Page 150, Page 129, Page 156, Page 163

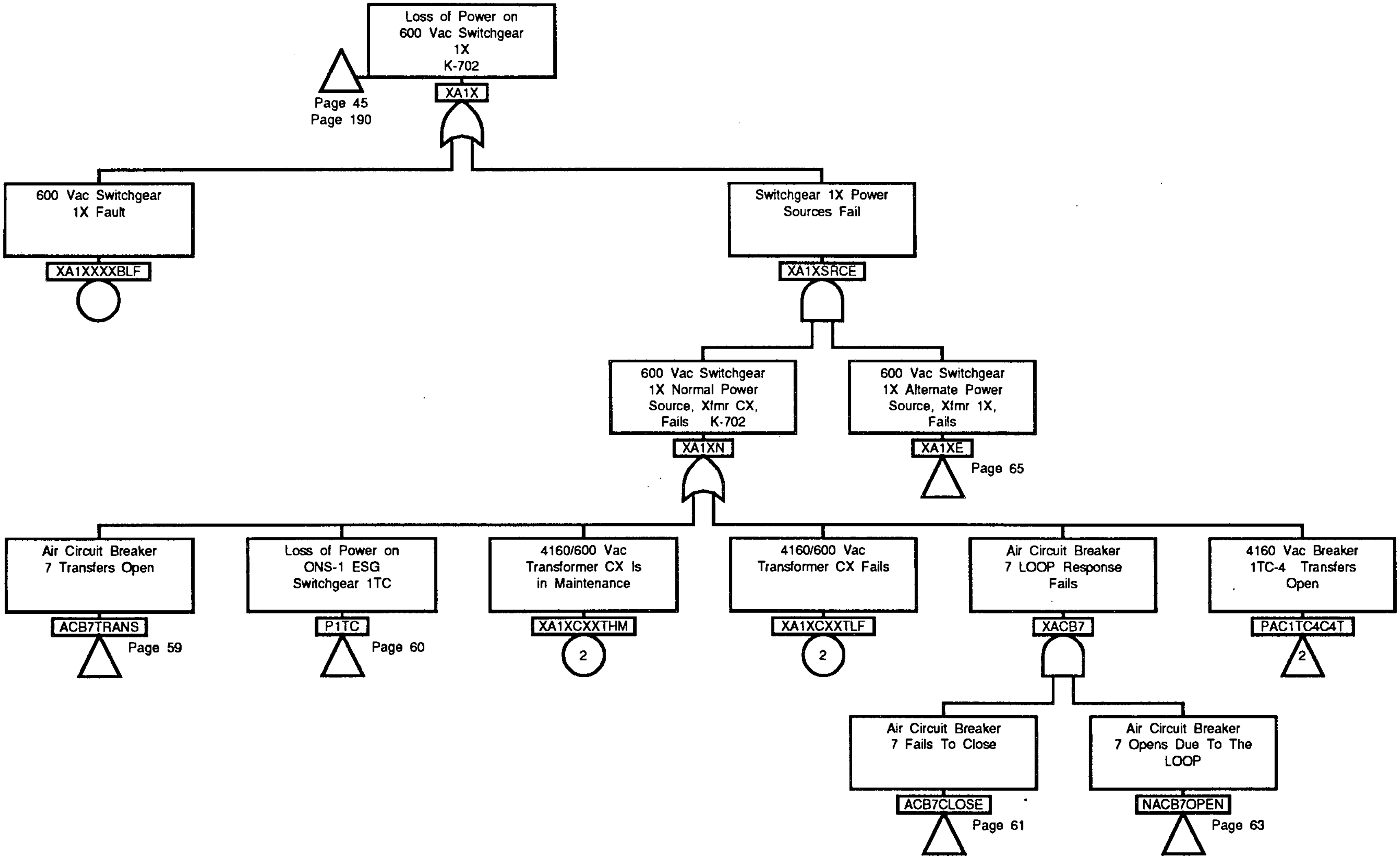




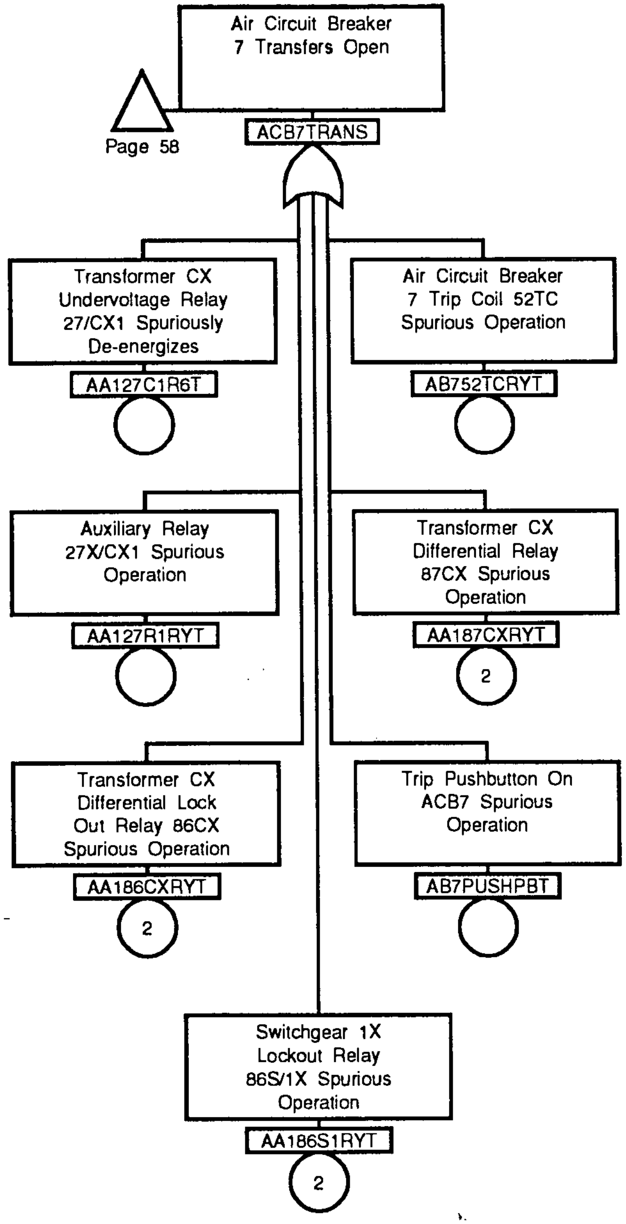
Unit 1 Turbine Guide Bearing Oil System Fails During Run
BK1000
Page 41
Loss of Unit 1 Turbine Guide Bearing Oil Occurs
BK1100
Loss of Keowee 1 Turbine Guide Bearing Oil Flow Occurs
BK1200
Manual Valve 1GBO-8 Transfers Position
BK1GBO8VVT
Manual Valve 1GBO-9 Transfers Position
BK1GBO9VVT
Manual Valve 1GBO-5 Transfers Position
BK1GBO5VVT
Unit 1 AC and DC Turbine Guide Bearing Oil Pump Trains Fail
BK1400
Manual Valve 1GBO-6 Transfers Position
BK1GBO6VVT
Filter 1GBOFL-1 Becomes Clogged
BK1GBO1FTC
Unit 1 AC Turbine Guide Bearing Oil Pump Train Fails
BK1500
Page 57
Unit 1 DC Turbine Guide Bearing Oil Pump Train Fails
BK1600
Page 71

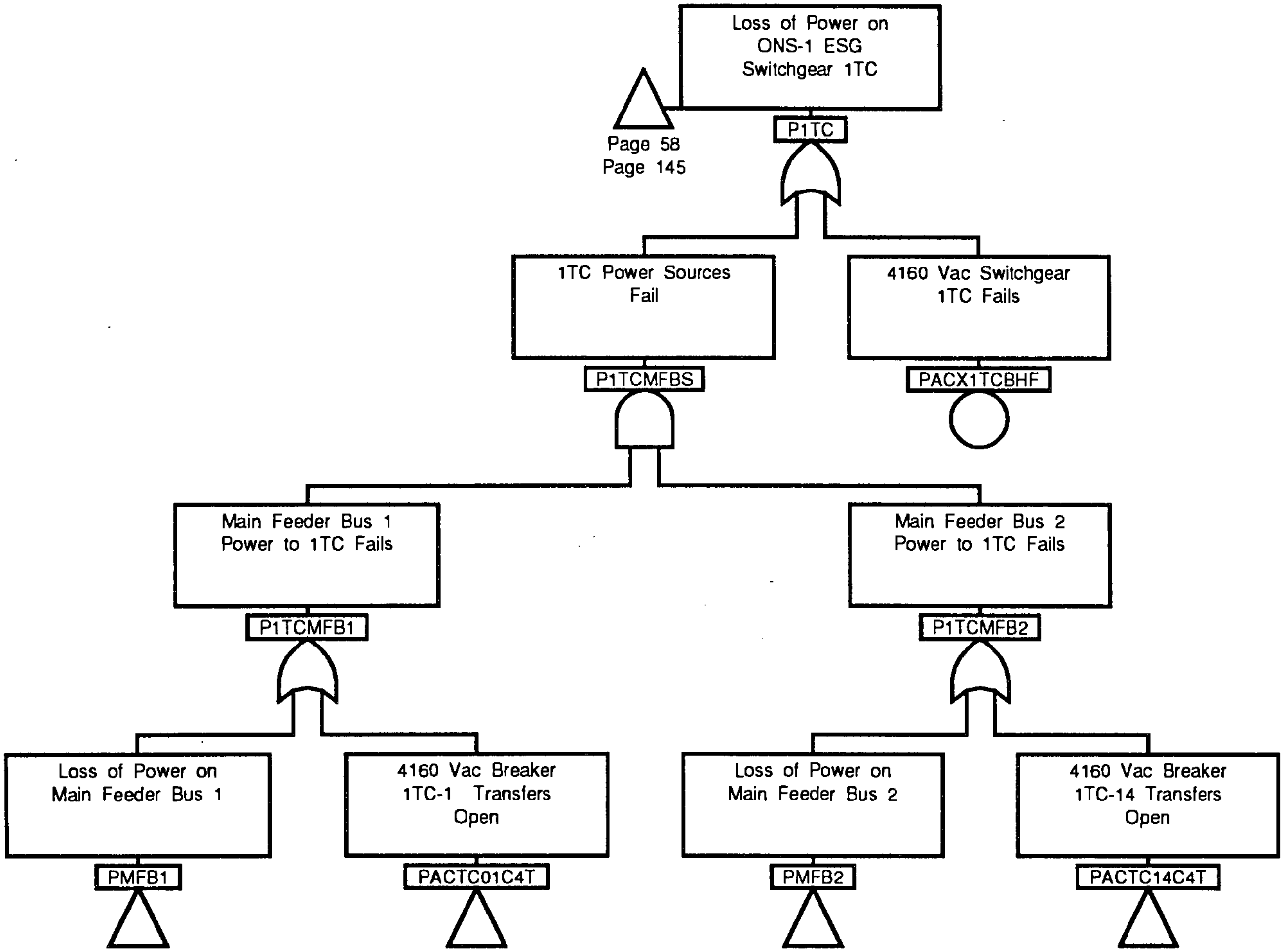


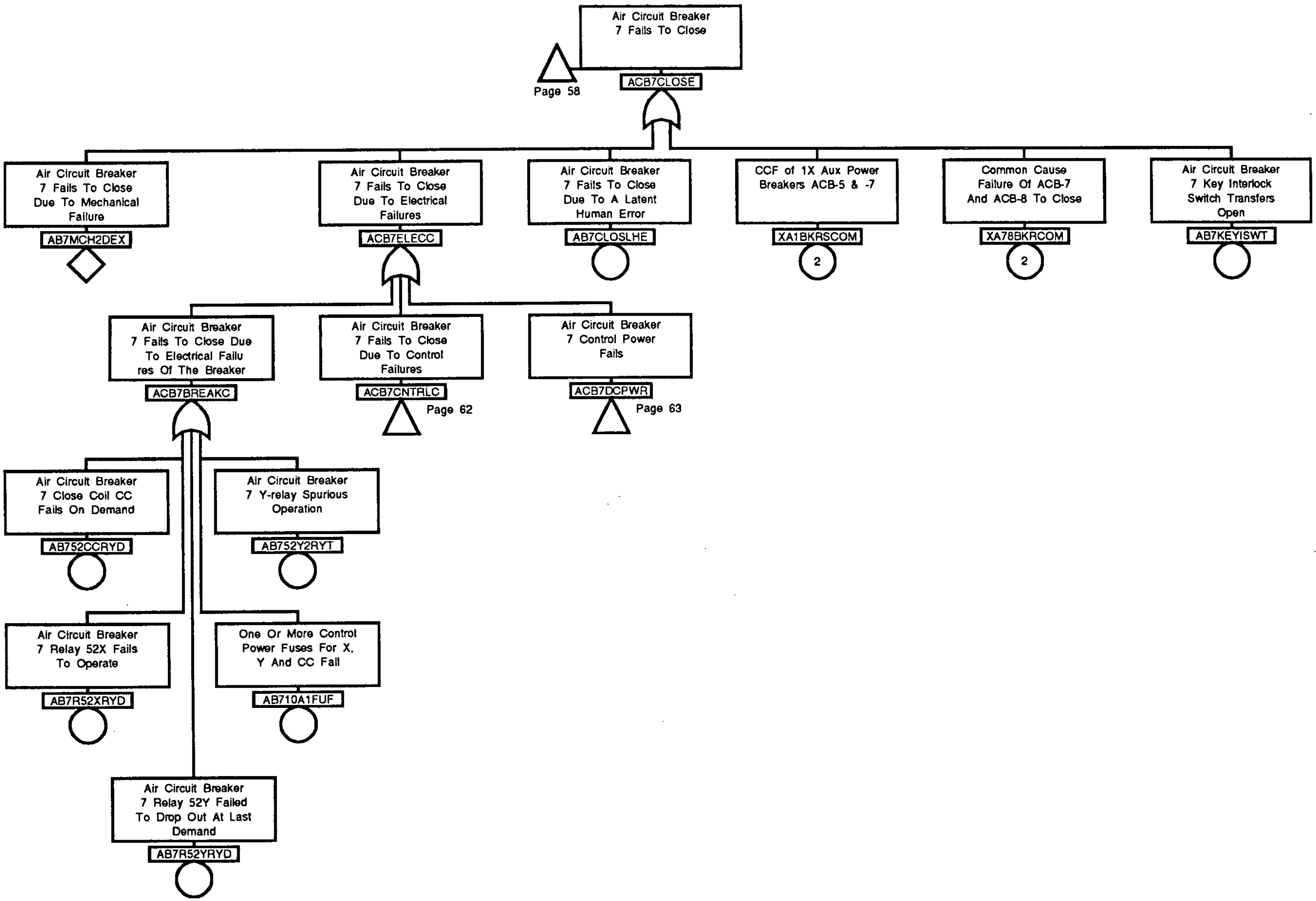
Unit 1 AC Turbine Guide Bearing Oil Pump Train Fails
BK1500
Page 56
Unit 1 AC Turbine Guide Bearing Oil Pump Fails
BK1550
Page 57
Manual Valve 1GBO-2 Transfers Position
BK1GBO2VVT
Check Valve 1GBO-1 Fails To Open On Demand
BK1GBO1CVO
Check Valve 1GBO-1 Transfers Closed
BK1GBO1CVT
Unit 1 AC Turbine Guide Bearing Oil Pump Fails
BK1550
Page 57
Page 71
Loss of Power on Keowee 600 Vac MCC 1XA K-704, K-702
XA1XA
Page 45
Keowee 1 AC GBO Pump Control Switch S188A Spurious Operation
BK1188ASWT
600 V Circuit Breaker 1XA-1C Transfers Position
BK1XA1CCLT
Unit 1 AC Turbine GBO Pump Fails To Start
BK1GOACGPS
Unit 1 AC Turbine GBO Pump Fails To Run
BK1GOACGPR

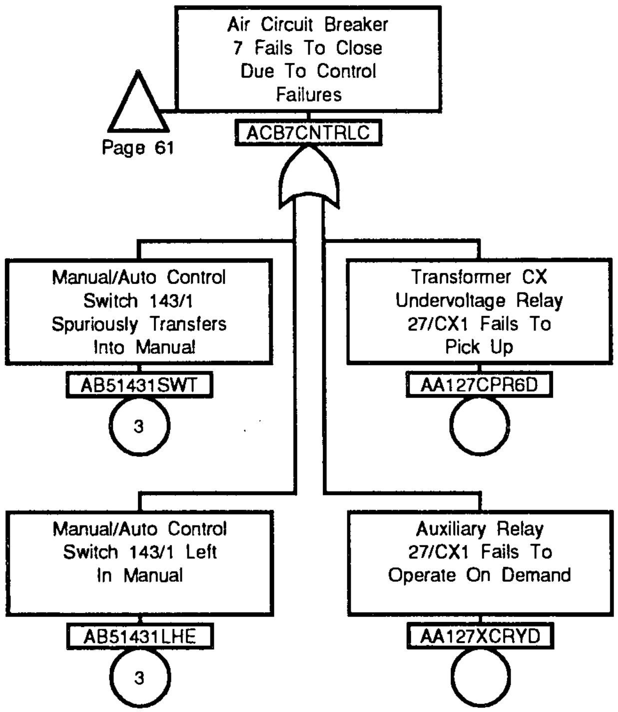


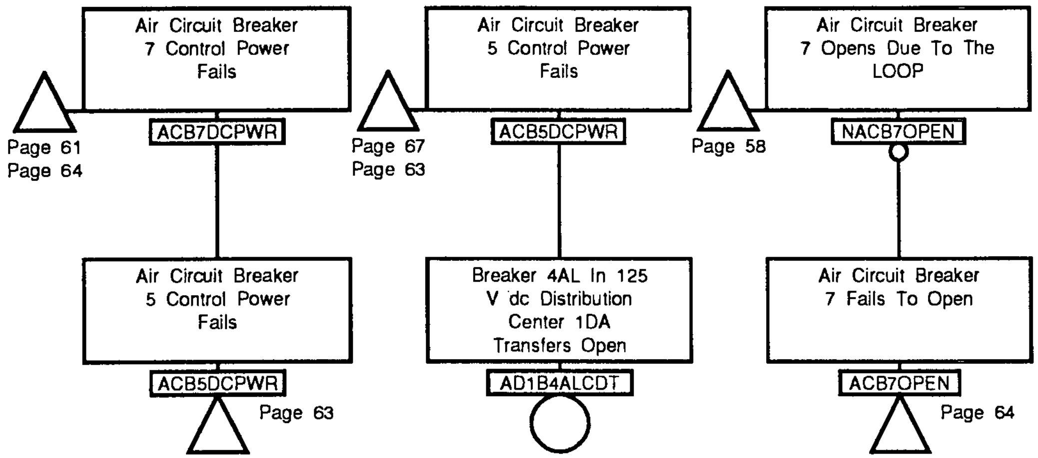
Loss of Power on 600 Vac Switchgear 1X K-702
XA1X
Page 45
Page 190
600 Vac Switchgear 1X Fault
XA1XXXXBLF
Switchgear 1X Power Sources Fail
XA1XSRCE
600 Vac Switchgear 1X Normal Power Source, Xfmr CX, Fails K-702
XA1XN
600 Vac Switchgear 1X Alternate Power Source, Xfmr 1X, Fails
XA1XE
Page 65
Air Circuit Breaker 7 Transfers Open
ACB7TRANS
Page 59
Loss of Power on ONS-1 ESG Switchgear 1TC
P1TC
Page 60
4160/600 Vac Transformer CX Is in Maintenance
XA1XCXXTHM
2
4160/600 Vac Transformer CX Fails
XA1XCXXTLF
2
Air Circuit Breaker 7 LOOP Response Fails
XACB7
4160 Vac Breaker 1TC-4 Transfers Open
PAC1TC4C4T
2
Air Circuit Breaker 7 Fails To Close
ACB7CLOSE
Page 61
Air Circuit Breaker 7 Opens Due To The LOOP
NACB7OPEN
Page 63

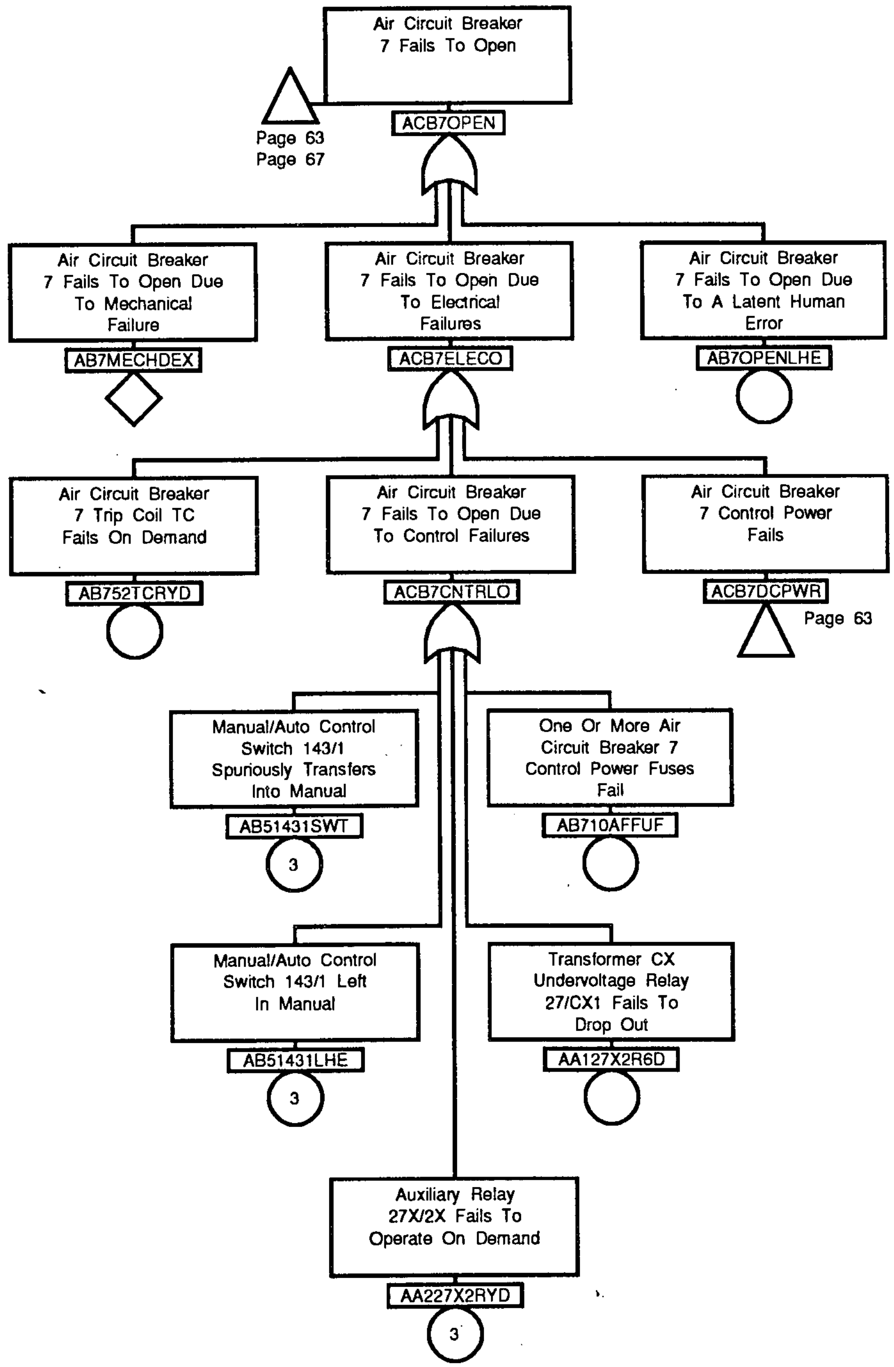

Air Circuit Breaker 7 Transfers Open
ACB7TRANS
Page 58
Transformer CX Undervoltage Relay 27/CX1 Spuriously De-energizes
AA127C1R6T
Air Circuit Breaker 7 Trip Coil 52TC Spurious Operation
AB752TCRYT
Auxiliary Relay 27X/CX1 Spurious Operation
AA127R1RYT
Transformer CX Differential Relay 87CX Spurious Operation
AA187CXRYT
2
Transformer CX Differential Lock Out Relay 86CX Spurious Operation
AA186CXRYT
2
Trip Pushbutton On ACB7 Spurious Operation
AB7PUSHPBT
Switchgear 1X Lockout Relay 86S/1X Spurious Operation
AA186S1RYT
2


Loss of Power on
ONS-1 ESG
Switchgear 1TC
P1TC
Page 58
Page 145
1TC Power Sources
Fail
P1TCMFBS
4160 Vac Switchgear
1TC Fails
PACX1TCBHF
Main Feeder Bus 1
Power to 1TC Fails
P1TCMFB1
Main Feeder Bus 2
Power to 1TC Fails
P1TCMFB2
Loss of Power on
Main Feeder Bus 1
PMFB1
4160 Vac Breaker
1TC-1 Transfers
Open
PACTC01C4T
Loss of Power on
Main Feeder Bus 2
PMFB2
4160 Vac Breaker
1TC-14 Transfers
Open
PACTC14C4T

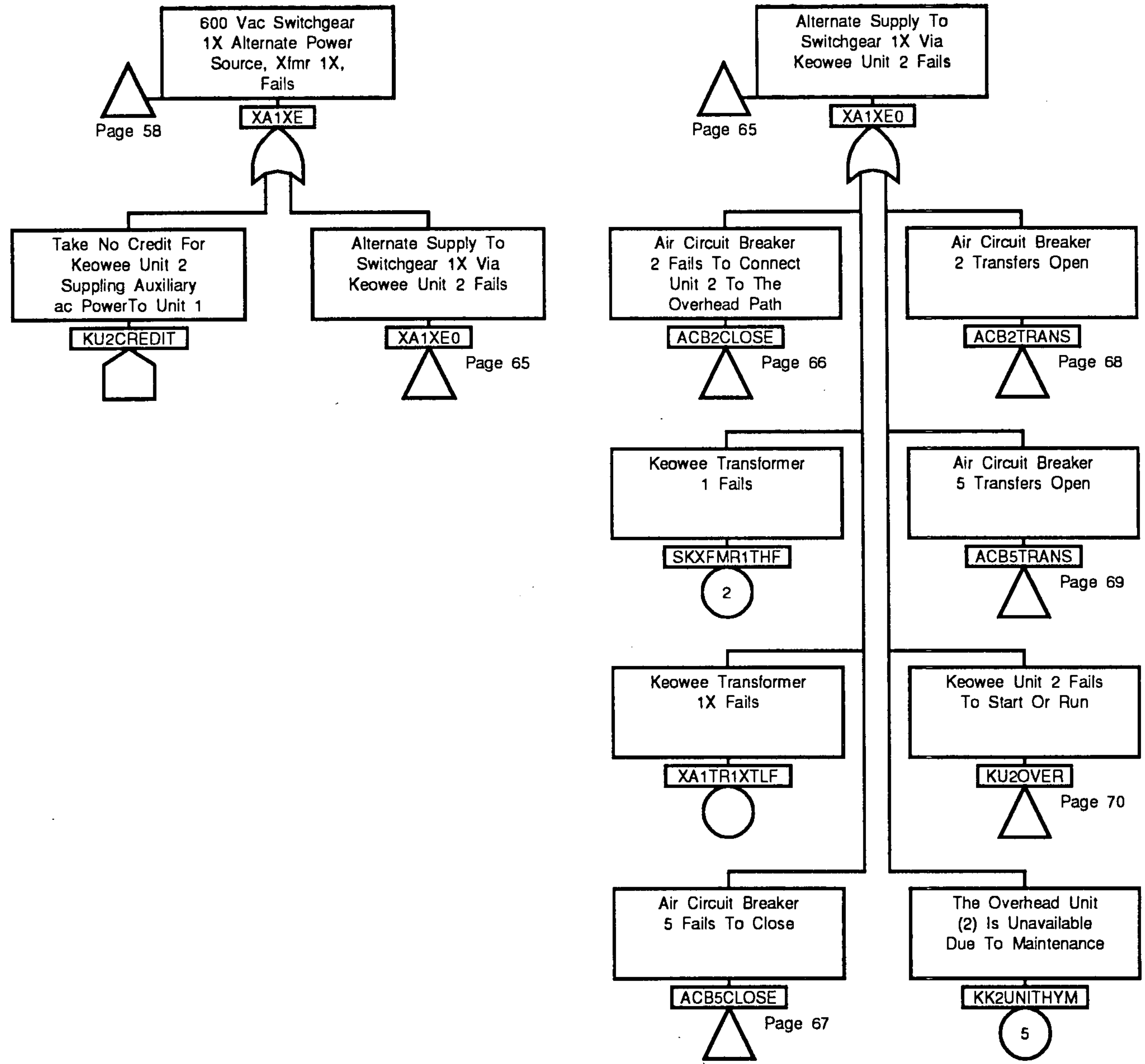

Air Circuit Breaker 7 Fails To Close
ACB7CLOSE
Page 58
Air Circuit Breaker 7 Fails To Close Due To Mechanical Failure
AB7MCH2DEX
Air Circuit Breaker 7 Fails To Close Due To Electrical Failures
ACB7ELECC
Air Circuit Breaker 7 Fails To Close Due To A Latent Human Error
AB7CLOSLHE
CCF of 1X Aux Power Breakers ACB-5 & -7
XA1BKRSCOM
2
Common Cause Failure Of ACB-7 And ACB-8 To Close
XA78BKRCOM
2
Air Circuit Breaker 7 Key Interlock Switch Transfers Open
AB7KEYISWT
Air Circuit Breaker 7 Fails To Close Due To Electrical Failu res Of The Breaker
ACB7BREAKC
Air Circuit Breaker 7 Fails To Close Due To Control Failures
ACB7CNTRLC
Page 62
Air Circuit Breaker 7 Control Power Fails
ACB7DCPWR
Page 63
Air Circuit Breaker 7 Close Coil CC Fails On Demand
AB752CCRYD
Air Circuit Breaker 7 Y-relay Spurious Operation
AB752Y2RYT
Air Circuit Breaker 7 Relay 52X Fails To Operate
AB7R52XRYD
One Or More Control Power Fuses For X, Y And CC Fail
AB710A1FUF
Air Circuit Breaker 7 Relay 52Y Failed To Drop Out At Last Demand
AB7R52YRYD

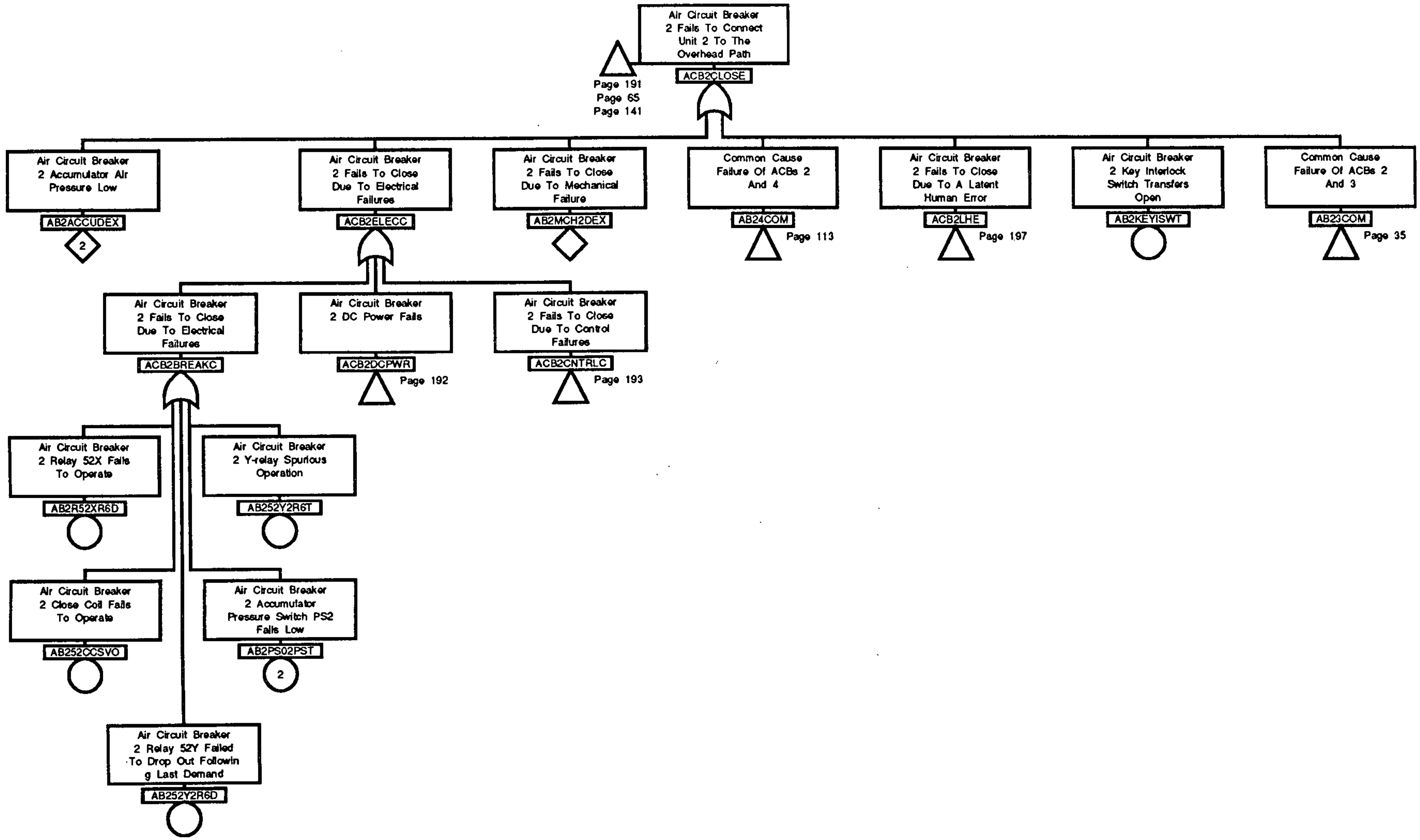

Air Circuit Breaker 7 Fails To Close Due To Control Failures
ACB7CNTRLC
Page 61
Manual/Auto Control Switch 143/1 Spuriously Transfers Into Manual
AB51431SWT
3
Transformer CX Undervoltage Relay 27/CX1 Fails To Pick Up
AA127CPR6D
Manual/Auto Control Switch 143/1 Left In Manual
AB51431LHE
3
Auxiliary Relay 27/CX1 Fails To Operate On Demand
AA127XCRYD


Air Circuit Breaker 7 Control Power Fails
ACB7DCPWR
Page 61
Page 64
Air Circuit Breaker 5 Control Power Fails
ACB5DCPWR
Page 67
Page 63
Air Circuit Breaker 7 Opens Due To The LOOP
NACB7OPEN
Page 58
Air Circuit Breaker 5 Control Power Fails
ACB5DCPWR
Page 63
Breaker 4AL In 125 V dc Distribution Center 1DA Transfers Open
AD1B4ALCDT
Air Circuit Breaker 7 Fails To Open
ACB7OPEN
Page 64

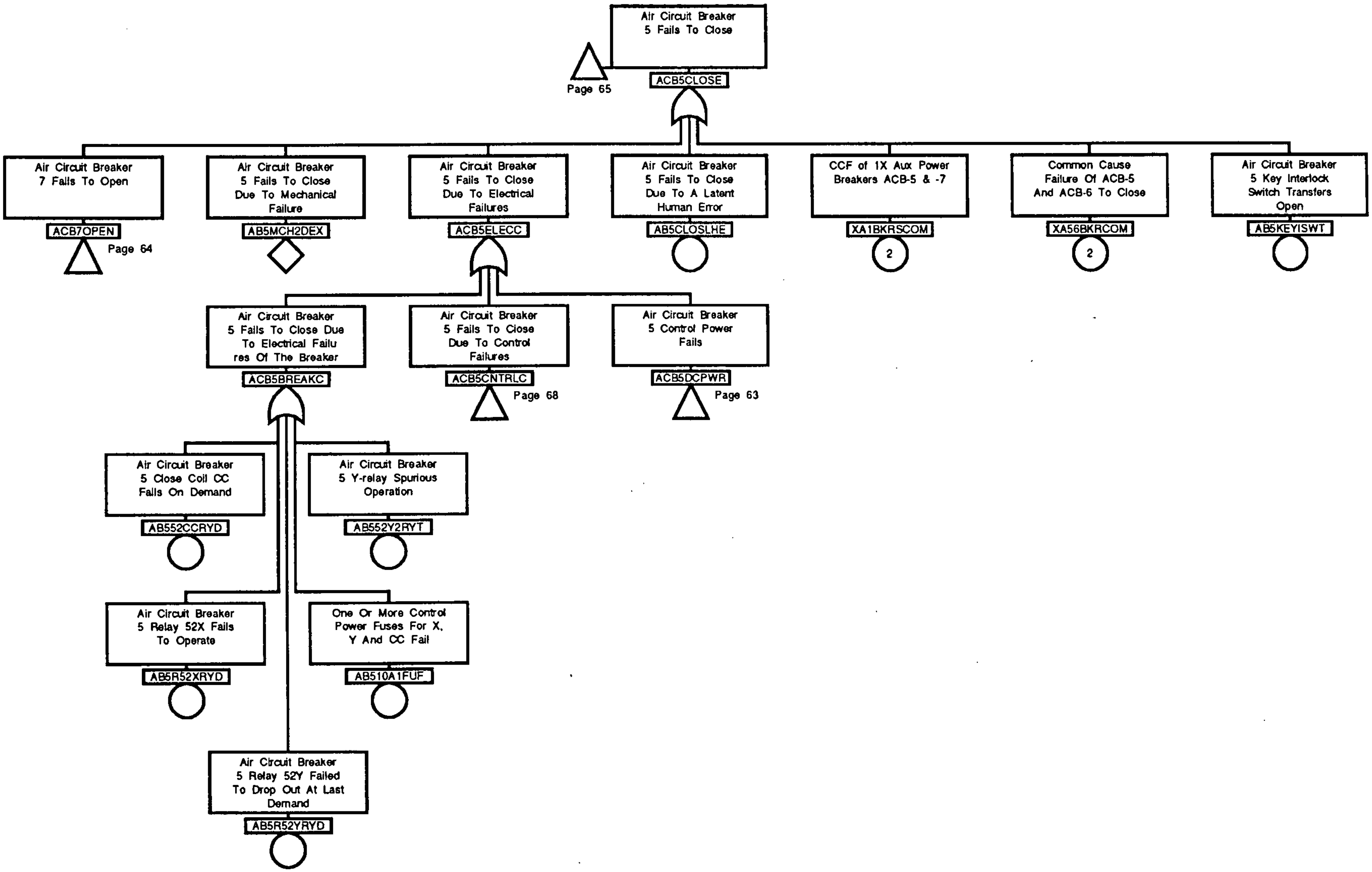


Air Circuit Breaker 7 Fails To Open
ACB7OPEN
Page 63
Page 67
Air Circuit Breaker 7 Fails To Open Due To Mechanical Failure
AB7MECHDEX
Air Circuit Breaker 7 Fails To Open Due To Electrical Failures
ACB7ELECO
Air Circuit Breaker 7 Fails To Open Due To A Latent Human Error
AB7OPENLHE
Air Circuit Breaker 7 Trip Coil TC Fails On Demand
AB752TCRYD
Air Circuit Breaker 7 Fails To Open Due To Control Failures
ACB7CNTRLO
Air Circuit Breaker 7 Control Power Fails
ACB7DCPWR
Page 63
Manual/Auto Control Switch 143/1 Spuriously Transfers Into Manual
AB51431SWT
3
One Or More Air Circuit Breaker 7 Control Power Fuses Fail
AB710AFFUF
Manual/Auto Control Switch 143/1 Left In Manual
AB51431LHE
3
Transformer CX Undervoltage Relay 27/CX1 Fails To Drop Out
AA127X2R6D
Auxiliary Relay 27X/2X Fails To Operate On Demand
AA227X2RYD
3

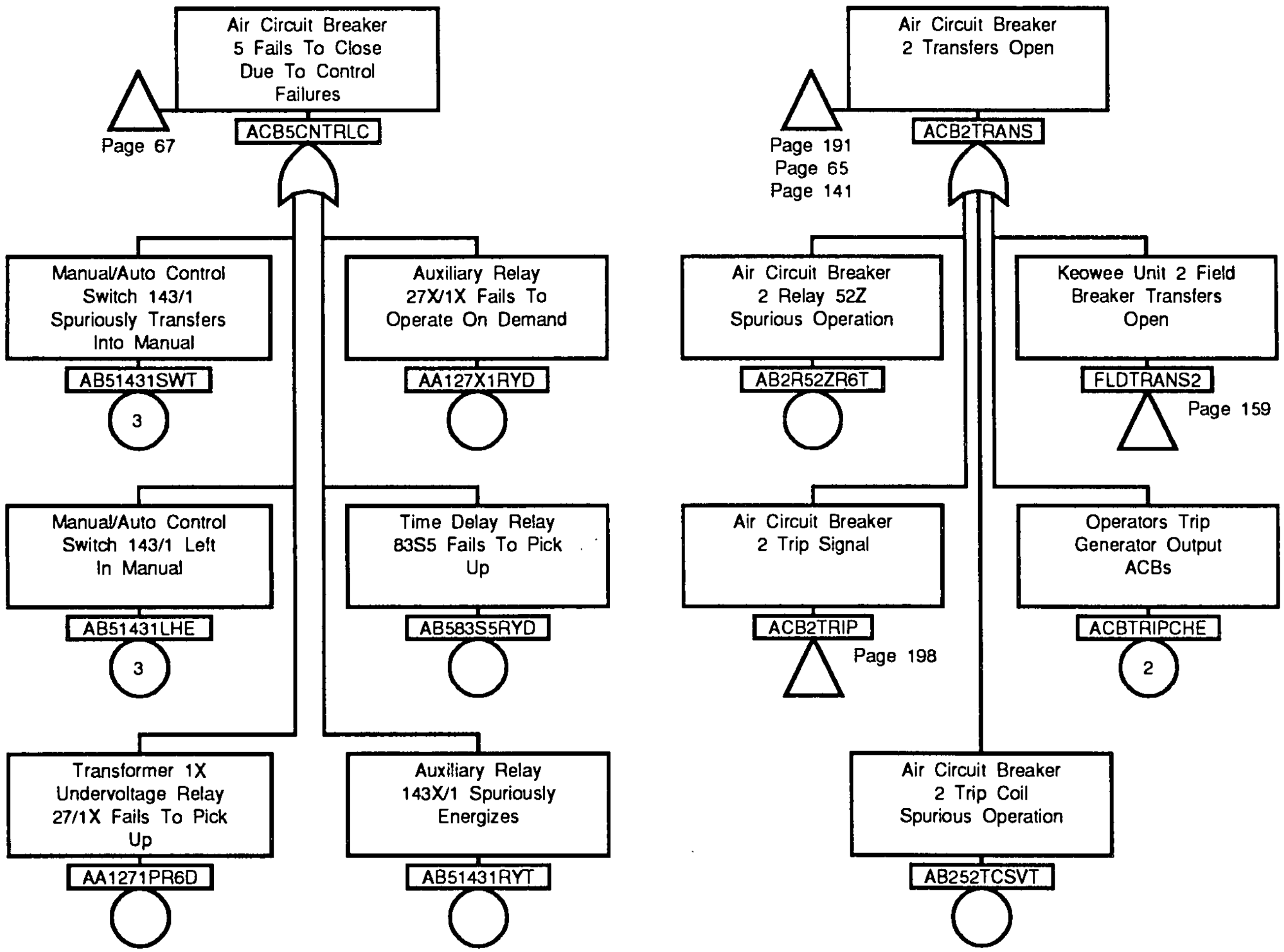

600 Vac Switchgear 1X Alternate Power Source, Xfmr 1X, Fails
Page 58
XA1XE
Take No Credit For Keowee Unit 2 Suppling Auxiliary ac PowerTo Unit 1
KU2CREDIT
Alternate Supply To Switchgear 1X Via Keowee Unit 2 Fails
XA1XE0
Page 65
Alternate Supply To Switchgear 1X Via Keowee Unit 2 Fails
Page 65
XA1XE0
Air Circuit Breaker 2 Fails To Connect Unit 2 To The Overhead Path
ACB2CLOSE
Page 66
Air Circuit Breaker 2 Transfers Open
ACB2TRANS
Page 68
Keowee Transformer 1 Fails
SKXFMR1THF
2
Air Circuit Breaker 5 Transfers Open
ACB5TRANS
Page 69
Keowee Transformer 1X Fails
XA1TR1XTLF
Keowee Unit 2 Fails To Start Or Run
KU2OVER
Page 70
Air Circuit Breaker 5 Fails To Close
ACB5CLOSE
Page 67
The Overhead Unit (2) Is Unavailable Due To Maintenance
KK2UNITHYM
5



Air Circuit Breaker 2 Fails To Connect Unit 2 To The Overhead Path
ACB2CLOSE
Page 191
Page 65
Page 141
Air Circuit Breaker 2 Accumulator Air Pressure Low
AB2ACCUDEX
2
Air Circuit Breaker 2 Fails To Close Due To Electrical Failures
ACB2ELECC
Air Circuit Breaker 2 Fails To Close Due To Mechanical Failure
AB2MCH2DEX
Common Cause Failure Of ACBs 2 And 4
AB24COM
Page 113
Air Circuit Breaker 2 Fails To Close Due To A Latent Human Error
ACB2LHE
Page 197
Air Circuit Breaker 2 Key Interlock Switch Transfers Open
AB2KEYISWT
Common Cause Failure Of ACBs 2 And 3
AB23COM
Page 35
Air Circuit Breaker 2 Fails To Close Due To Electrical Failures
ACB2BREAKC
Air Circuit Breaker 2 DC Power Fails
ACB2DCPWR
Page 192
Air Circuit Breaker 2 Fails To Close Due To Control Failures
ACB2CNTRLC
Page 193
Air Circuit Breaker 2 Relay 52X Fails To Operate
AB2R52XR6D
Air Circuit Breaker 2 Y-relay Spurious Operation
AB252Y2R6T
Air Circuit Breaker 2 Close Coil Fails To Operate
AB252CCSVO
Air Circuit Breaker 2 Accumulator Pressure Switch PS2 Fails Low
AB2PS02PST
2
Air Circuit Breaker 2 Relay 52Y Failed To Drop Out Followin g Last Demand
AB252Y2R6D

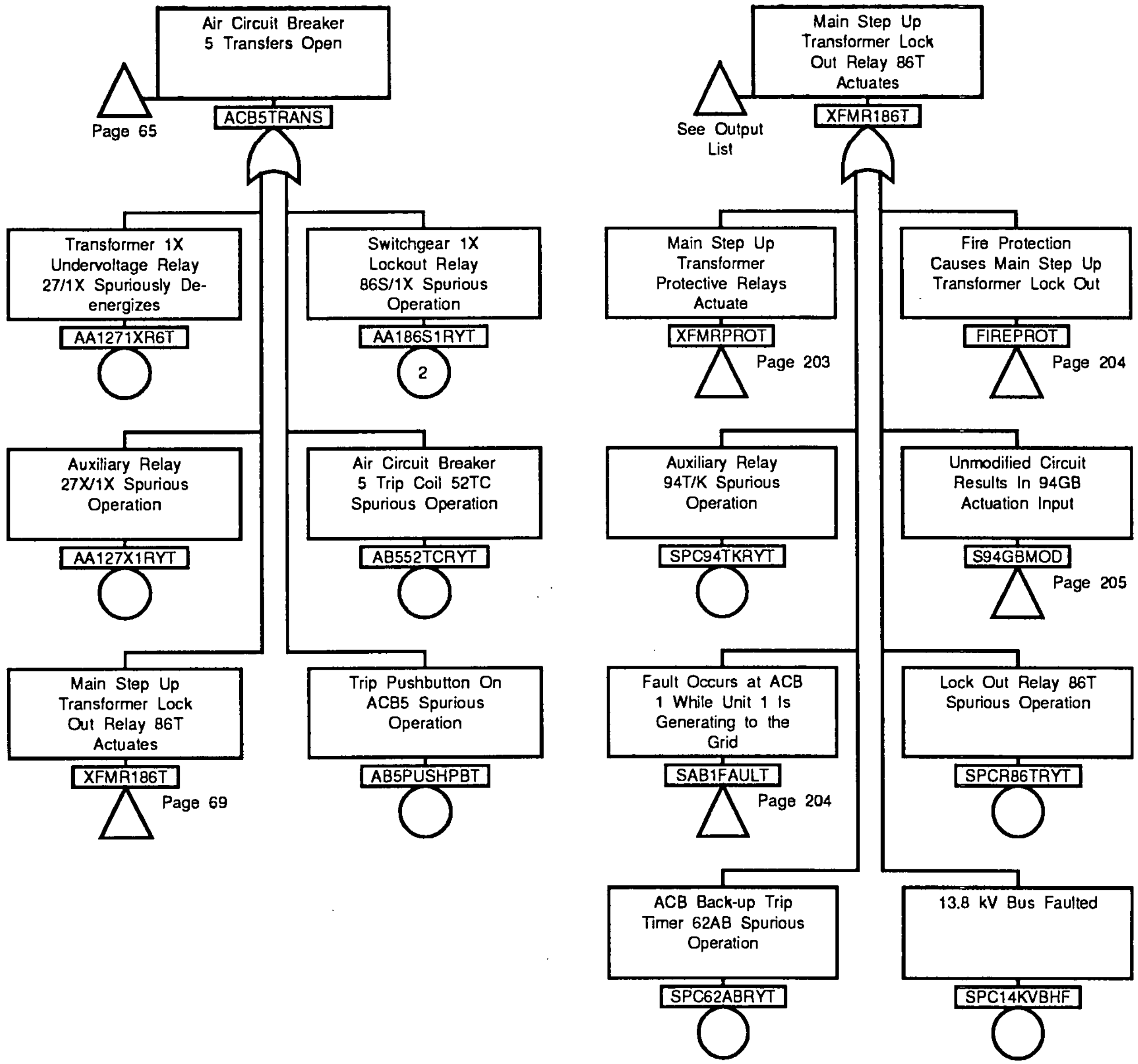


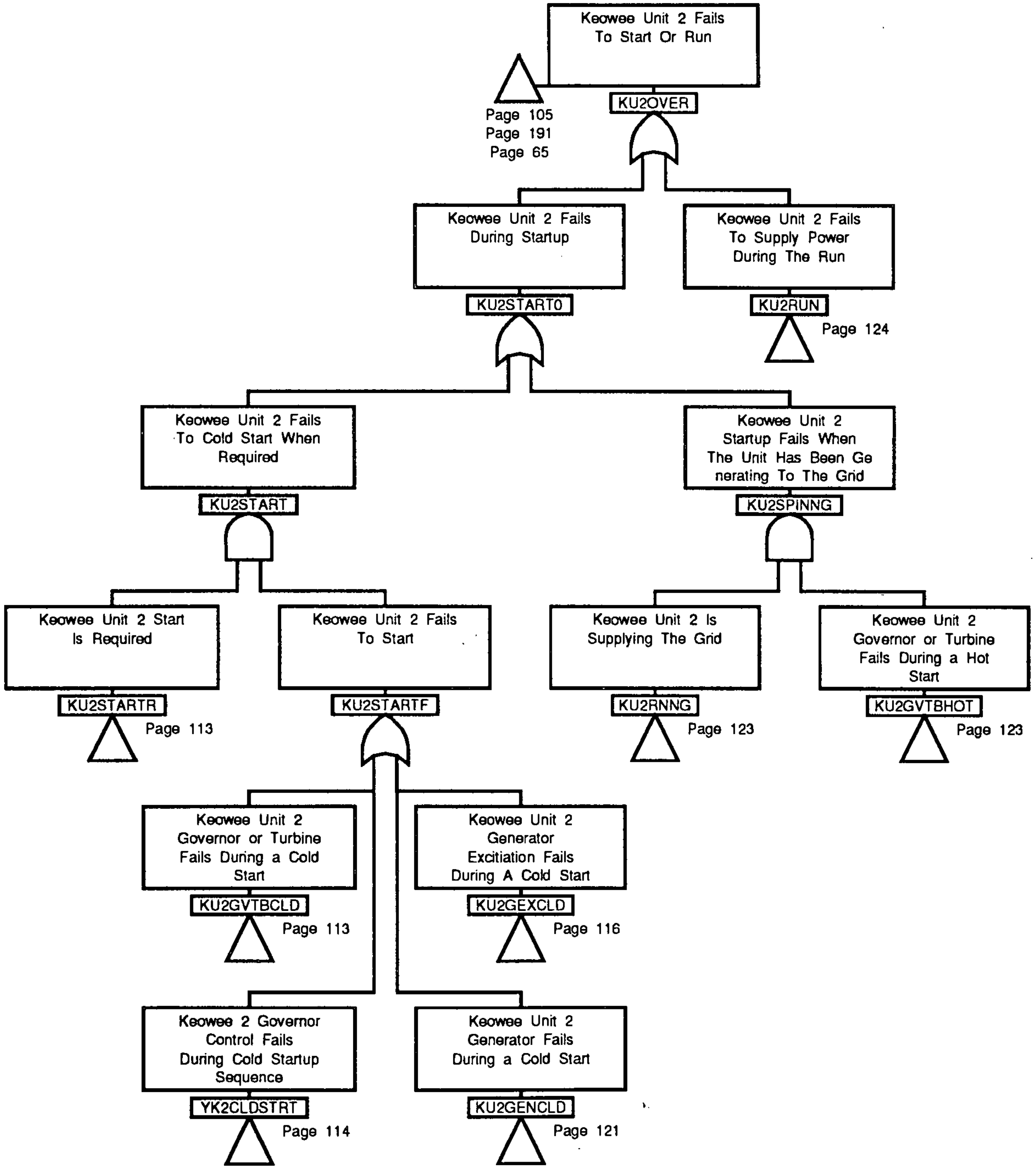
Air Circuit Breaker 5 Fails To Close
ACB5CLOSE
Page 65
Air Circuit Breaker 7 Fails To Open
ACB7OPEN
Page 64
Air Circuit Breaker 5 Fails To Close Due To Mechanical Failure
AB5MCH2DEX
Air Circuit Breaker 5 Fails To Close Due To Electrical Failures
ACB5ELECC
Air Circuit Breaker 5 Fails To Close Due To A Latent Human Error
AB5CLOSLHE
CCF of 1X Aux Power Breakers ACB-5 & -7
XA1BKRSCOM
2
Common Cause Failure Of ACB-5 And ACB-6 To Close
XA56BKRCOM
2
Air Circuit Breaker 5 Key Interlock Switch Transfers Open
AB5KEYISWT
Air Circuit Breaker 5 Fails To Close Due To Electrical Failu res Of The Breaker
ACB5BREAKC
Air Circuit Breaker 5 Fails To Close Due To Control Failures
ACB5CNTRLC
Page 68
Air Circuit Breaker 5 Control Power Fails
ACB5DCPWR
Page 63
Air Circuit Breaker 5 Close Coil CC Fails On Demand
AB552CCRYD
Air Circuit Breaker 5 Y-relay Spurious Operation
AB552Y2RYT
Air Circuit Breaker 5 Relay 52X Fails To Operate
AB5R52XRYD
One Or More Control Power Fuses For X, Y And CC Fail
AB510A1FUF
Air Circuit Breaker 5 Relay 52Y Failed To Drop Out At Last Demand
AB5R52YRYD

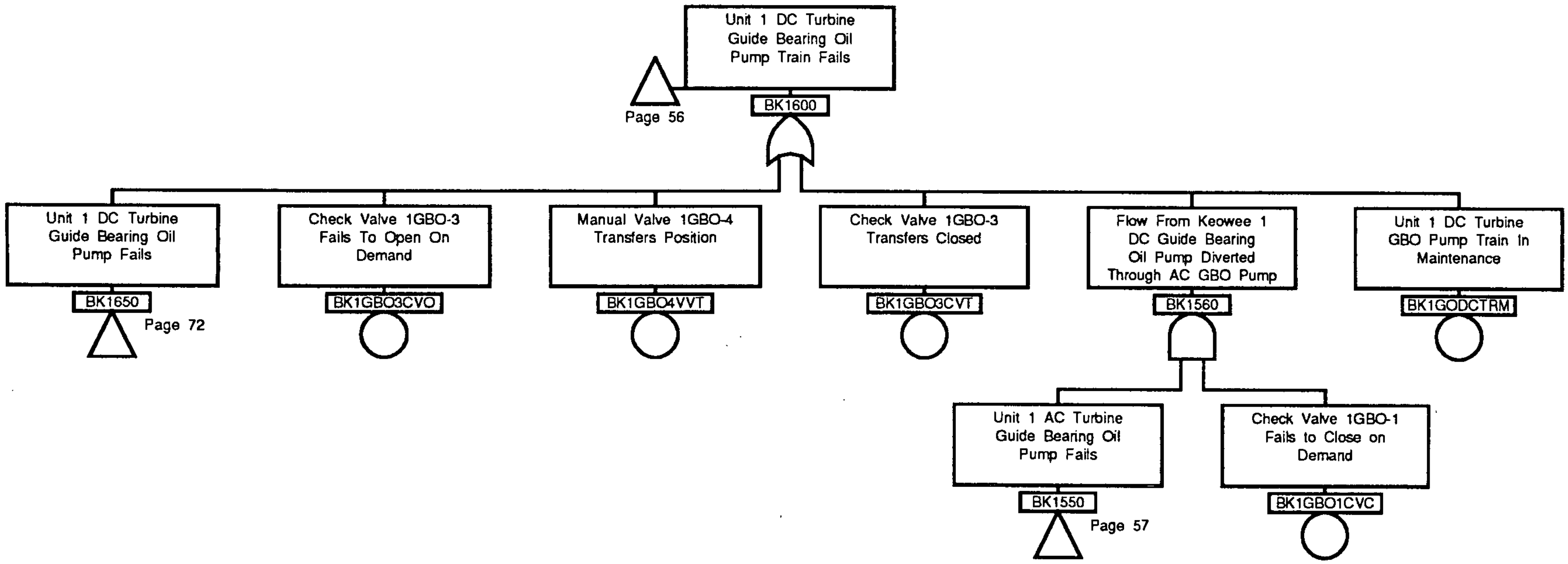


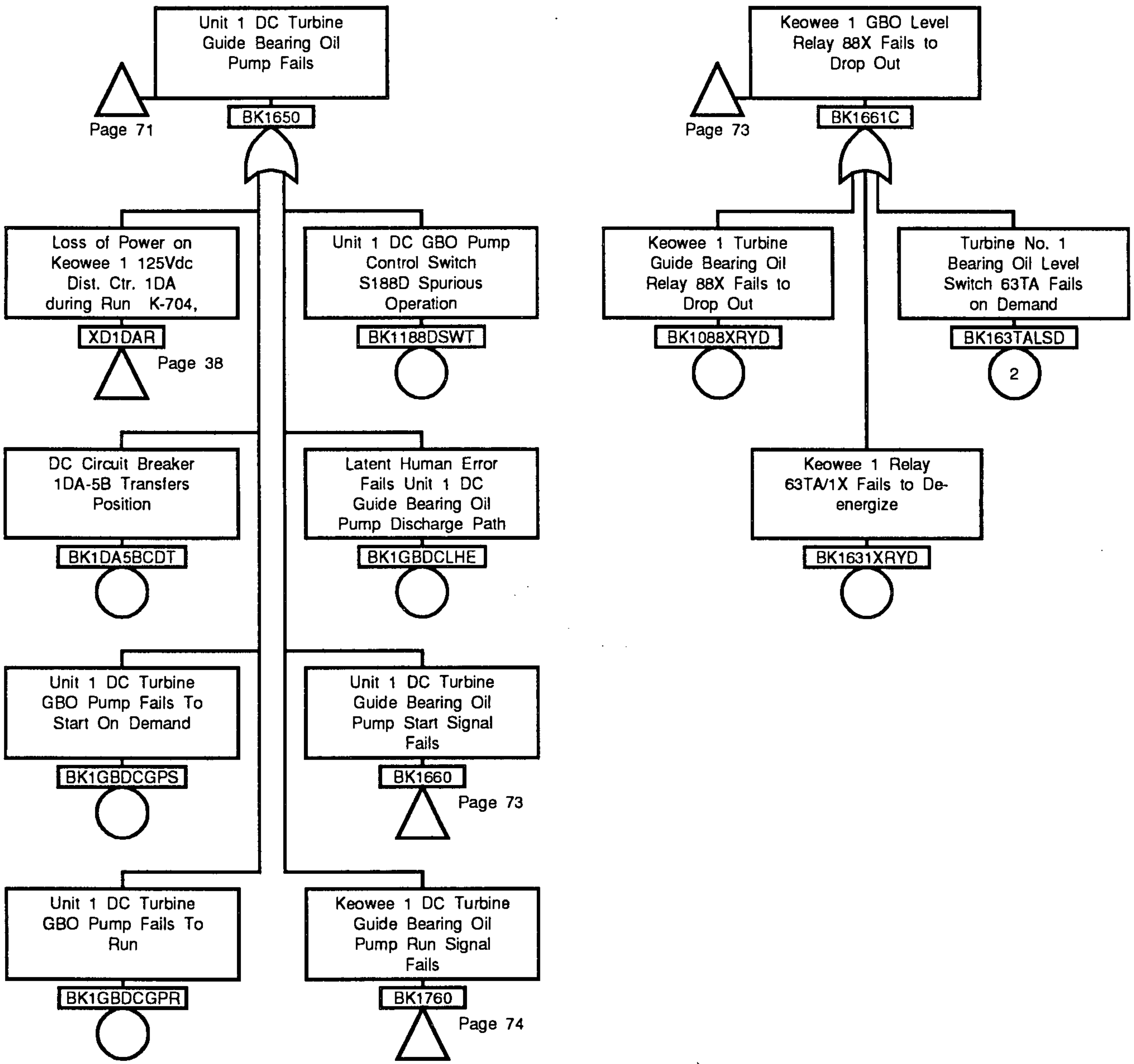
Air Circuit Breaker 5 Fails To Close Due To Control Failures
ACB5CNTRLC
Page 67
Manual/Auto Control Switch 143/1 Spuriously Transfers Into Manual
AB51431SWT
3
Auxiliary Relay 27X/1X Fails To Operate On Demand
AA127X1RYD
Manual/Auto Control Switch 143/1 Left In Manual
AB51431LHE
3
Time Delay Relay 83S5 Fails To Pick Up
AB583S5RYD
Transformer 1X Undervoltage Relay 27/1X Fails To Pick Up
AA1271PR6D
Auxiliary Relay 143X/1 Spuriously Energizes
AB51431RYT
Air Circuit Breaker 2 Transfers Open
ACB2TRANS
Page 191
Page 65
Page 141
Air Circuit Breaker 2 Relay 52Z Spurious Operation
AB2R52ZR6T
Keowee Unit 2 Field Breaker Transfers Open
FLDTRANS2
Page 159
Air Circuit Breaker 2 Trip Signal
ACB2TRIP
Page 198
Operators Trip Generator Output ACBs
ACBTRIPCHE
2
Air Circuit Breaker 2 Trip Coil Spurious Operation
AB252TCSVT

XFMR186T Outputs:
Page 202, Page 193, Page 197, Page 106, Page 69, Page 145

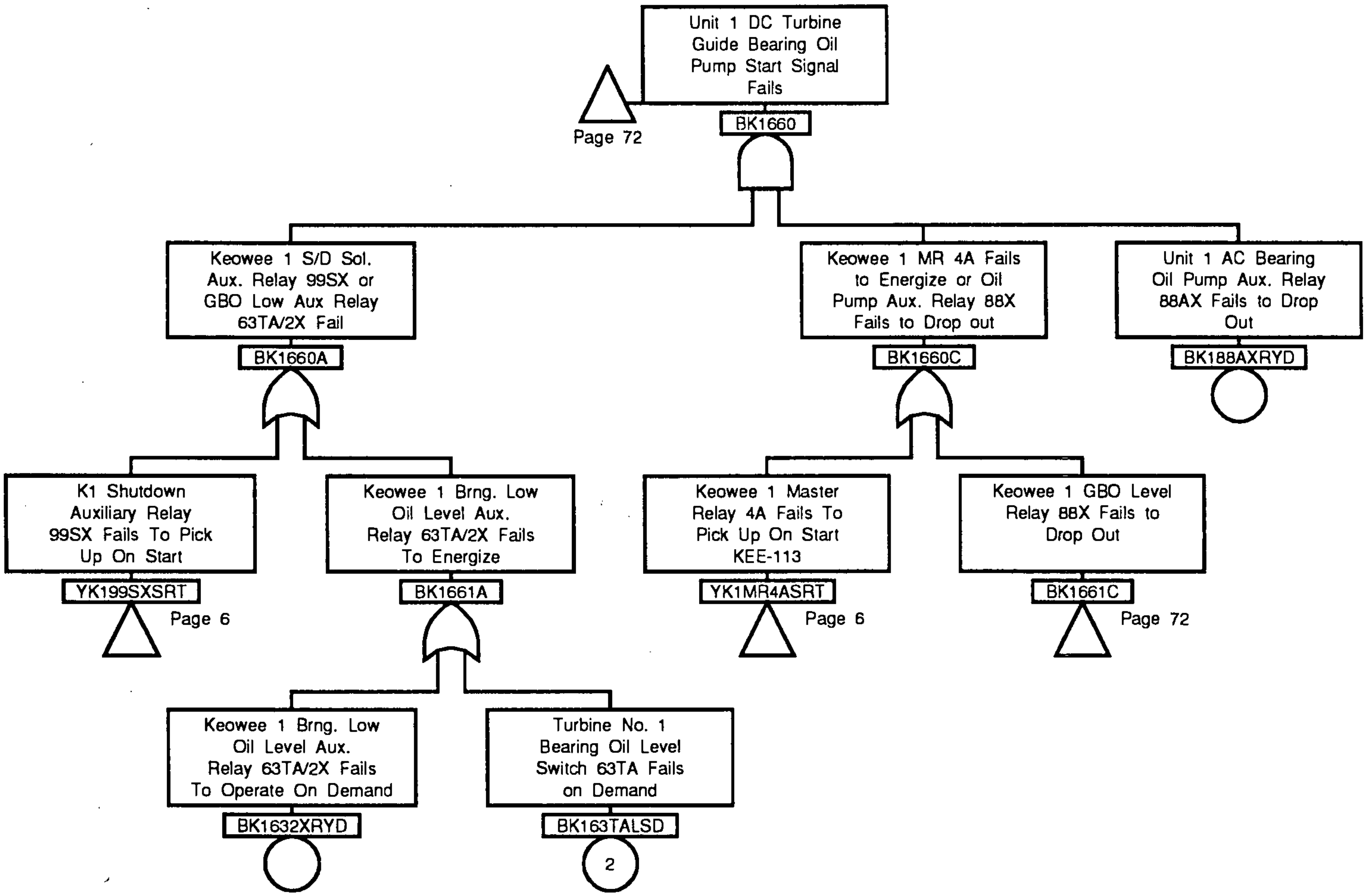



Keowee Unit 2 Fails To Start Or Run
KU2OVER
Page 105
Page 191
Page 65
Keowee Unit 2 Fails During Startup
KU2STARTO
Keowee Unit 2 Fails To Supply Power During The Run
KU2RUN
Page 124
Keowee Unit 2 Fails To Cold Start When Required
KU2START
Keowee Unit 2 Startup Fails When The Unit Has Been Ge nerating To The Grid
KU2SPINNG
Keowee Unit 2 Start Is Required
KU2STARTR
Page 113
Keowee Unit 2 Fails To Start
KU2STARTF
Keowee Unit 2 Is Supplying The Grid
KU2RNNG
Page 123
Keowee Unit 2 Governor or Turbine Fails During a Hot Start
KU2GVTBHOT
Page 123
Keowee Unit 2 Governor or Turbine Fails During a Cold Start
KU2GVTBCLD
Page 113
Keowee Unit 2 Generator Excitiation Fails During A Cold Start
KU2GEXCLD
Page 116
Keowee 2 Governor Control Fails During Cold Startup Sequence
YK2CLDSTRT
Page 114
Keowee Unit 2 Generator Fails During a Cold Start
KU2GENCLD
Page 121

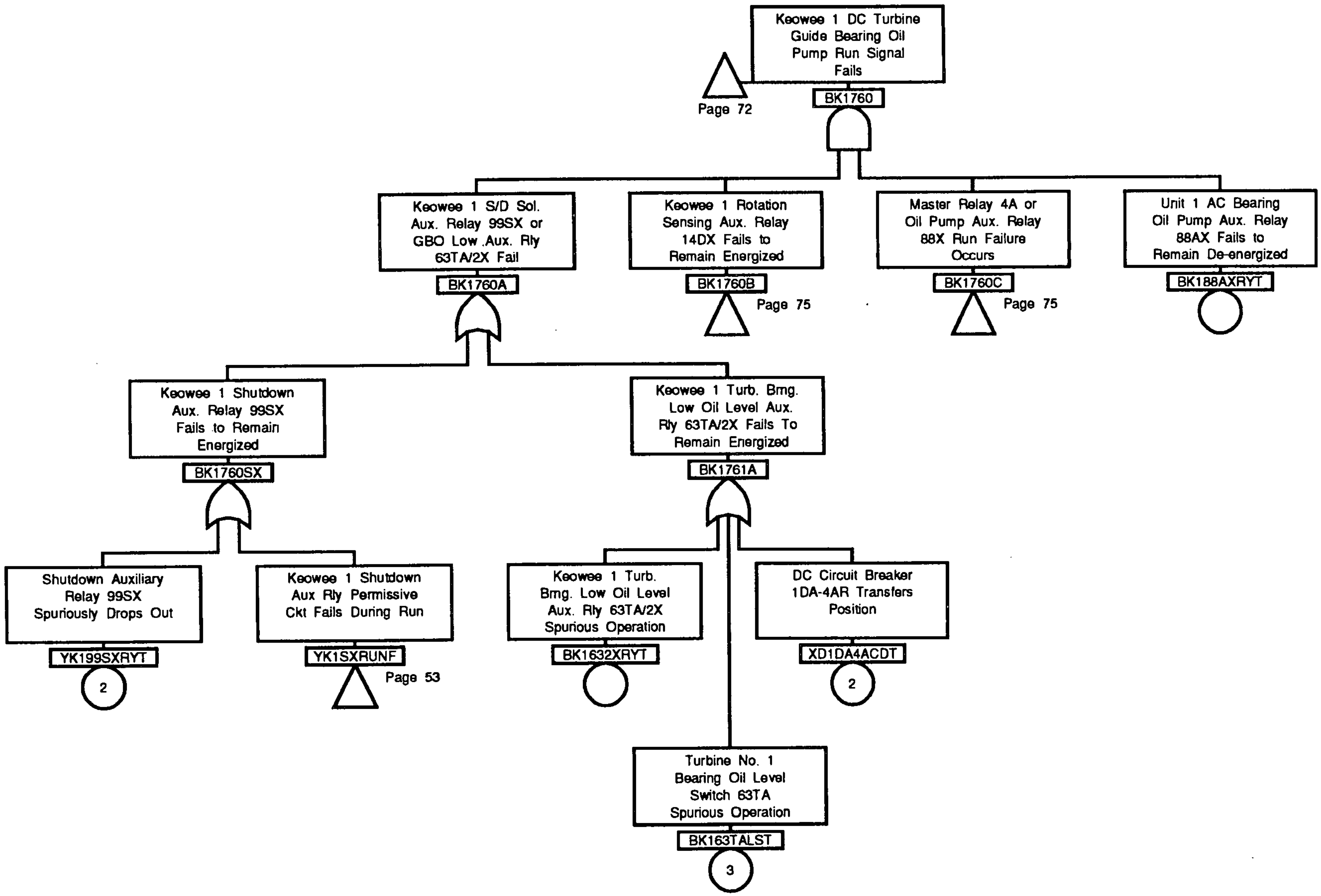

Unit 1 DC Turbine Guide Bearing Oil Pump Train Fails
BK1600
Page 56
Unit 1 DC Turbine Guide Bearing Oil Pump Fails
BK1650
Page 72
Check Valve 1GBO-3 Fails To Open On Demand
BK1GBO3CVO
Manual Valve 1GBO-4 Transfers Position
BK1GBO4VVT
Check Valve 1GBO-3 Transfers Closed
BK1GBO3CVT
Flow From Keowee 1 DC Guide Bearing Oil Pump Diverted Through AC GBO Pump
BK1560
Unit 1 DC Turbine GBO Pump Train In Maintenance
BK1GODCTRM
Unit 1 AC Turbine Guide Bearing Oil Pump Fails
BK1550
Page 57
Check Valve 1GBO-1 Fails to Close on Demand
BK1GBO1CVC

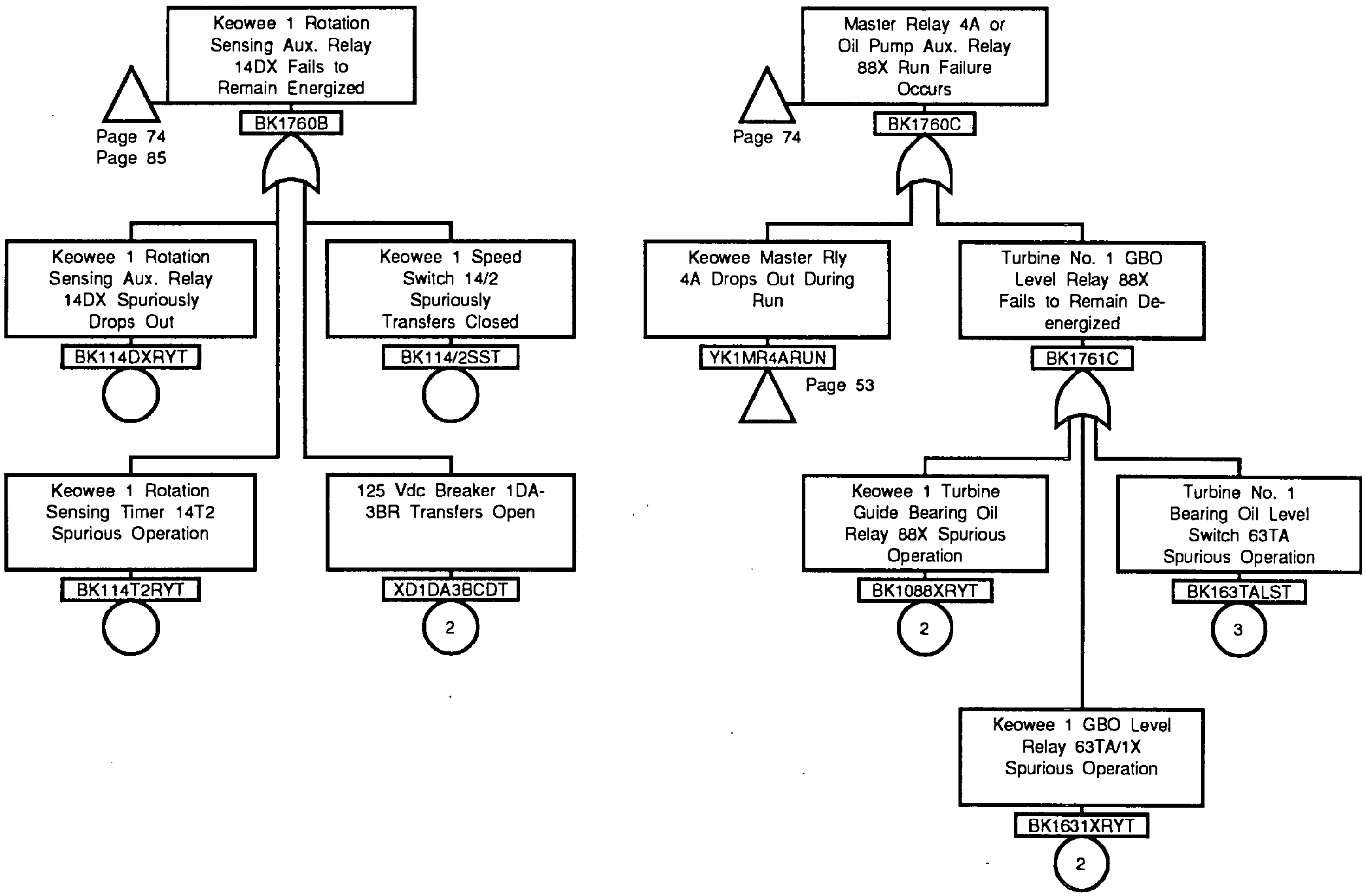


Unit 1 DC Turbine Guide Bearing Oil Pump Fails
BK1650
Page 71
Loss of Power on Keowee 1 125Vdc Dist. Ctr. 1DA during Run K-704,
XD1DAR
Page 38
Unit 1 DC GBO Pump Control Switch S188D Spurious Operation
BK1188DSWT
DC Circuit Breaker 1DA-5B Transfers Position
BK1DA5BCDT
Latent Human Error Fails Unit 1 DC Guide Bearing Oil Pump Discharge Path
BK1GBDCLHE
Unit 1 DC Turbine GBO Pump Fails To Start On Demand
BK1GBDCGPS
Unit 1 DC Turbine Guide Bearing Oil Pump Start Signal Fails
BK1660
Page 73
Unit 1 DC Turbine GBO Pump Fails To Run
BK1GBDCGPR
Keowee 1 DC Turbine Guide Bearing Oil Pump Run Signal Fails
BK1760
Page 74
Keowee 1 GBO Level Relay 88X Fails to Drop Out
BK1661C
Page 73
Keowee 1 Turbine Guide Bearing Oil Relay 88X Fails to Drop Out
BK1088XRYD
Turbine No. 1 Bearing Oil Level Switch 63TA Fails on Demand
BK163TALSD
2
Keowee 1 Relay 63TA/1X Fails to De-energize
BK1631XRYD

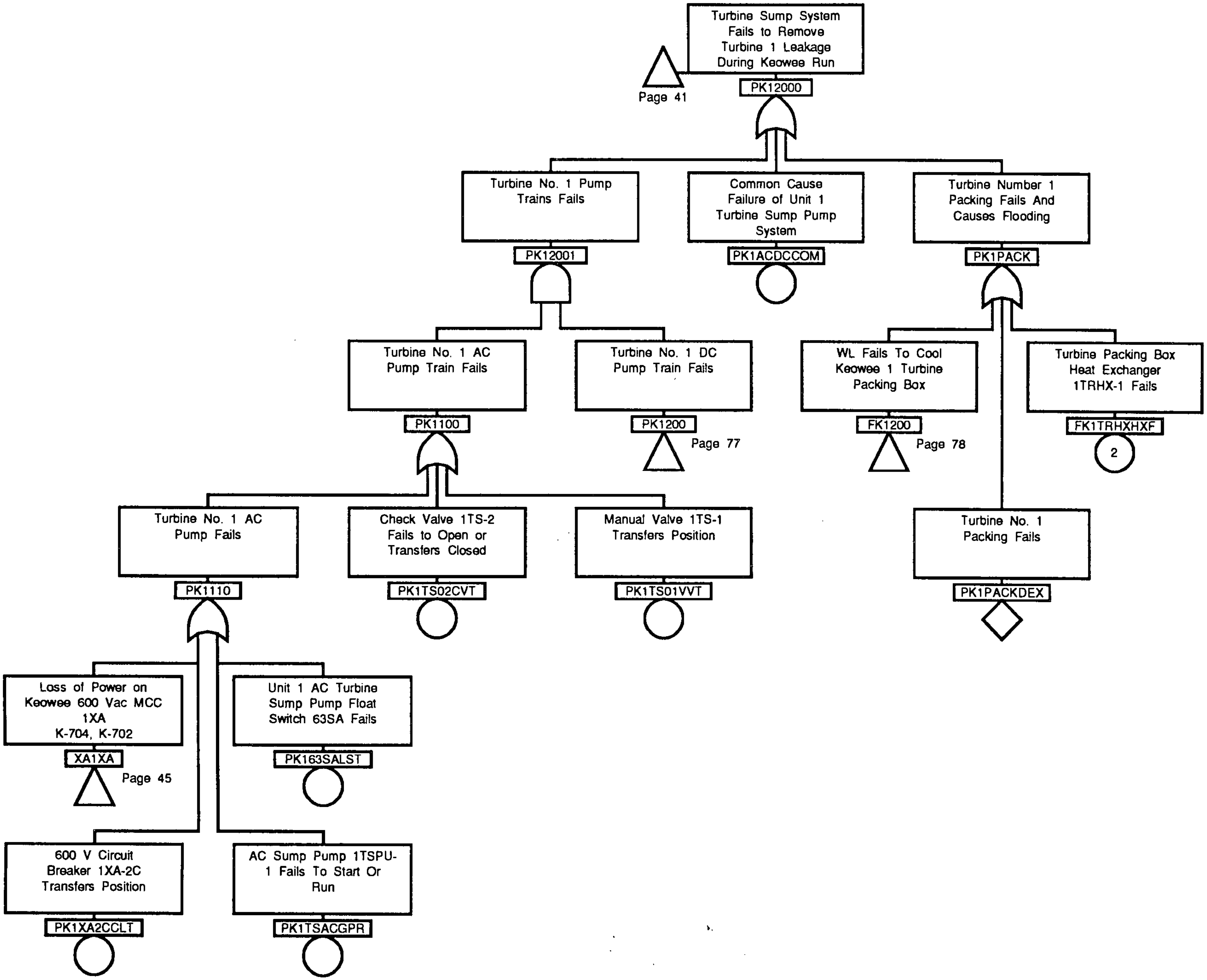


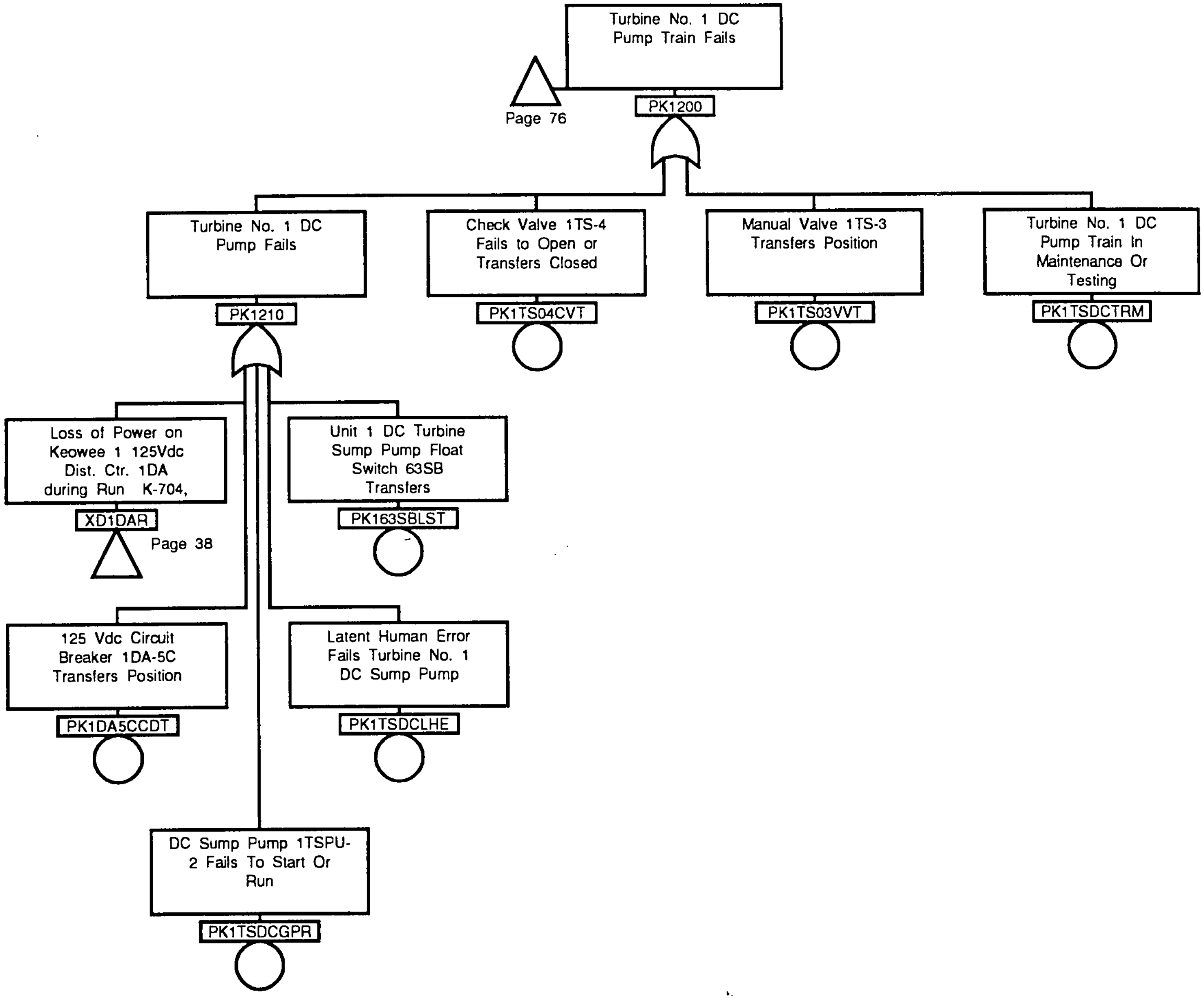
Unit 1 DC Turbine Guide Bearing Oil Pump Start Signal Fails
BK1660
Page 72
Keowee 1 S/D Sol. Aux. Relay 99SX or GBO Low Aux Relay 63TA/2X Fail
BK1660A
Keowee 1 MR 4A Fails to Energize or Oil Pump Aux. Relay 88X Fails to Drop out
BK1660C
Unit 1 AC Bearing Oil Pump Aux. Relay 88AX Fails to Drop Out
BK188AXRYD
K1 Shutdown Auxiliary Relay 99SX Fails To Pick Up On Start
YK199SXSRT
Page 6
Keowee 1 Brng. Low Oil Level Aux. Relay 63TA/2X Fails To Energize
BK1661A
Keowee 1 Master Relay 4A Fails To Pick Up On Start KEE-113
YK1MR4ASRT
Page 6
Keowee 1 GBO Level Relay 88X Fails to Drop Out
BK1661C
Page 72
Keowee 1 Brng. Low Oil Level Aux. Relay 63TA/2X Fails To Operate On Demand
BK1632XRYD
Turbine No. 1 Bearing Oil Level Switch 63TA Fails on Demand
BK163TALSD
2

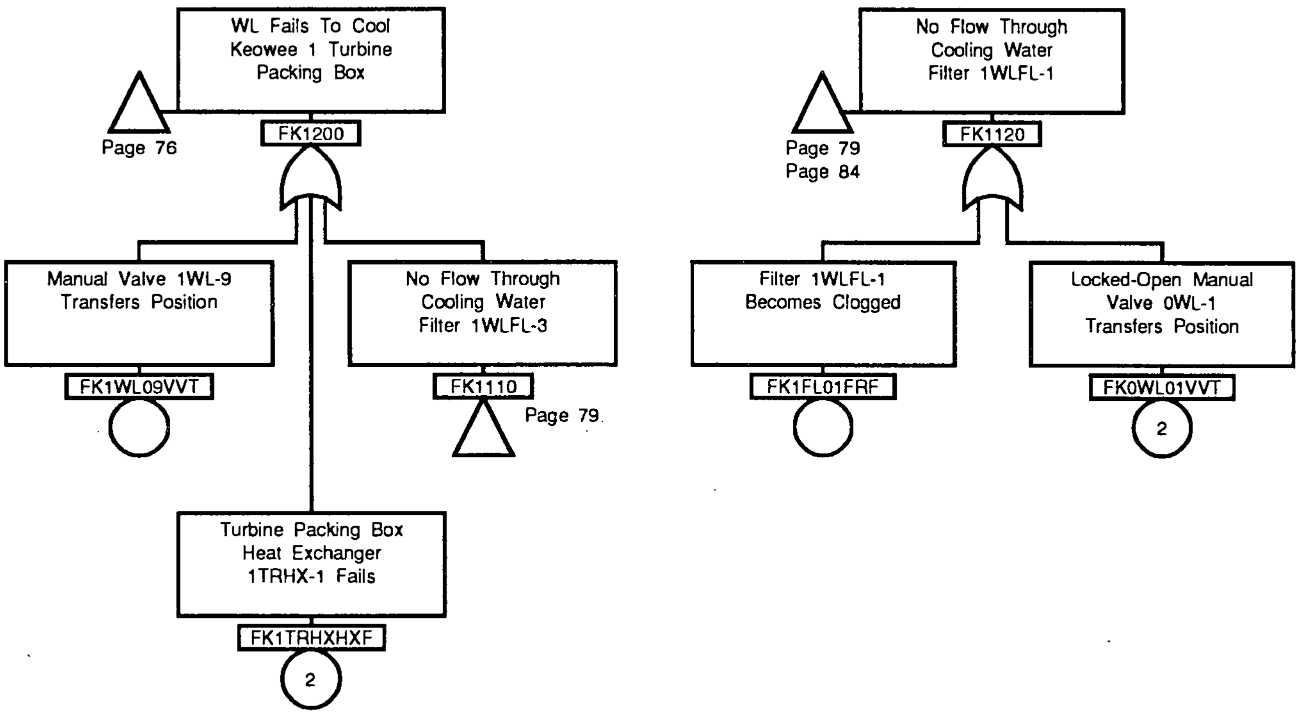

Keowee 1 DC Turbine Guide Bearing Oil Pump Run Signal Fails
BK1760
Page 72
Keowee 1 S/D Sol. Aux. Relay 99SX or GBO Low Aux. Rly 63TA/2X Fail
BK1760A
Keowee 1 Rotation Sensing Aux. Relay 14DX Fails to Remain Energized
BK1760B
Page 75
Master Relay 4A or Oil Pump Aux. Relay 88X Run Failure Occurs
BK1760C
Page 75
Unit 1 AC Bearing Oil Pump Aux. Relay 88AX Fails to Remain De-energized
BK188AXRYT
Keowee 1 Shutdown Aux. Relay 99SX Fails to Remain Energized
BK1760SX
Keowee 1 Turb. Brng. Low Oil Level Aux. Rly 63TA/2X Fails To Remain Energized
BK1761A
Shutdown Auxiliary Relay 99SX Spuriously Drops Out
YK199SXRYT
2
Keowee 1 Shutdown Aux Rly Permissive Ckt Fails During Run
YK1SXRUNF
Page 53
Keowee 1 Turb. Brng. Low Oil Level Aux. Rly 63TA/2X Spurious Operation
BK1632XRYT
DC Circuit Breaker 1DA-4AR Transfers Position
XD1DA4ACDT
2
Turbine No. 1 Bearing Oil Level Switch 63TA Spurious Operation
BK163TALST
3

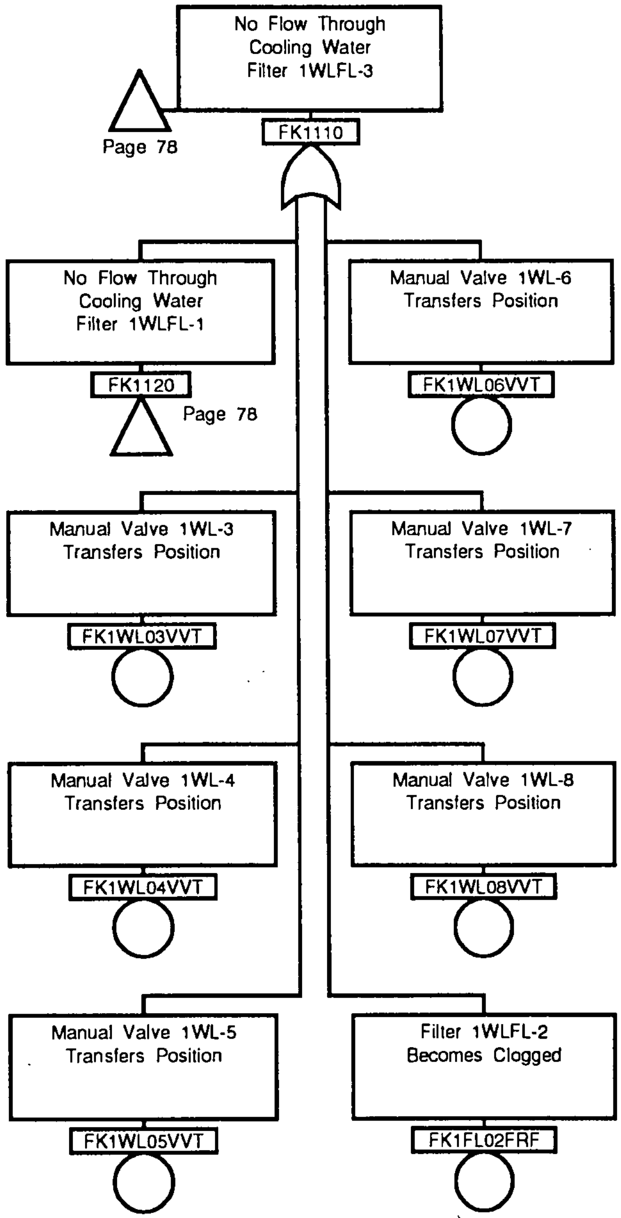


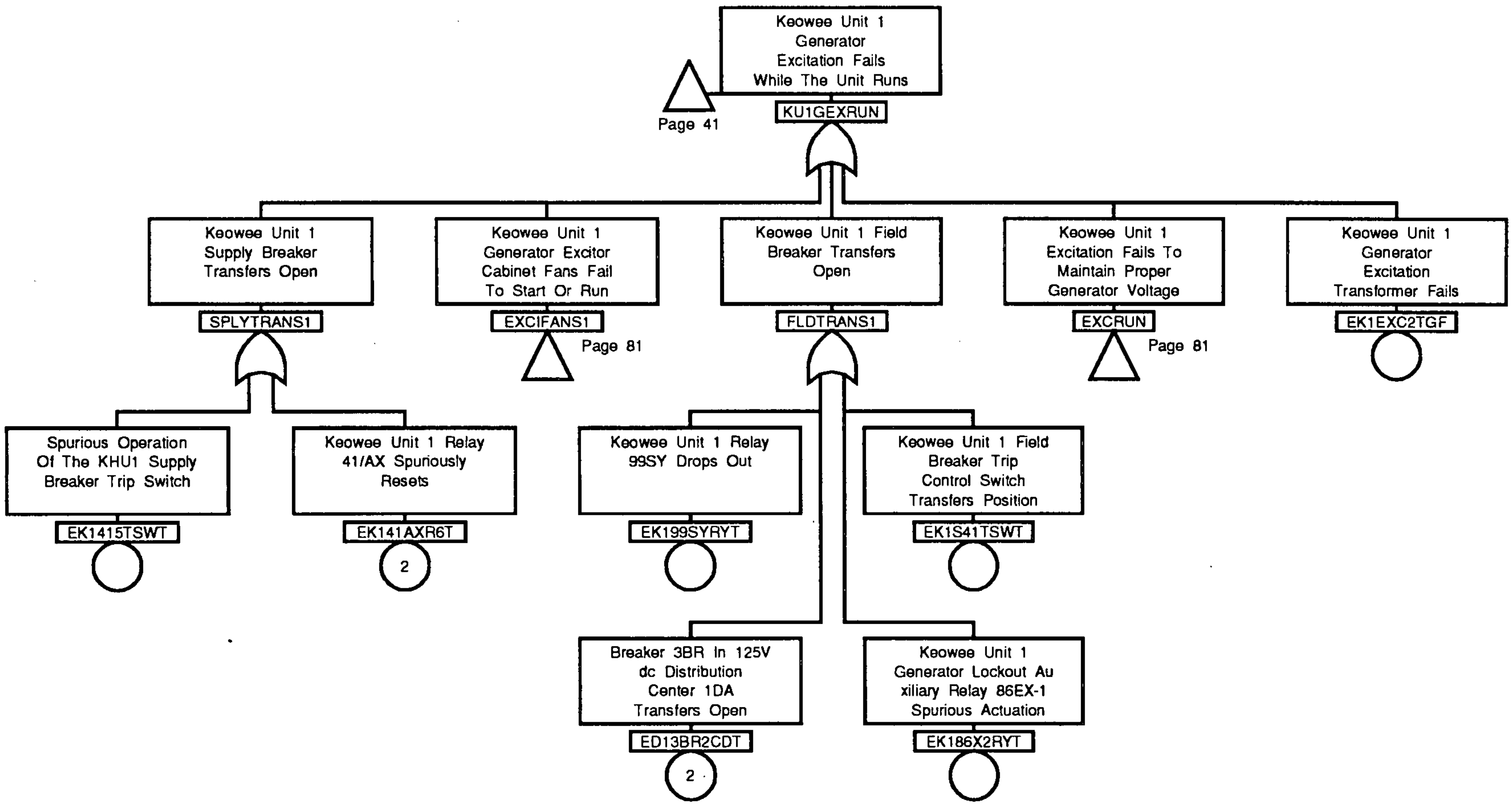
Keowee 1 Rotation Sensing Aux. Relay 14DX Fails to Remain Energized
BK1760B
Page 74
Page 85
Keowee 1 Rotation Sensing Aux. Relay 14DX Spuriously Drops Out
BK114DXRYT
Keowee 1 Speed Switch 14/2 Spuriously Transfers Closed
BK114/2SST
Keowee 1 Rotation Sensing Timer 14T2 Spurious Operation
BK114T2RYT
125 Vdc Breaker 1DA-3BR Transfers Open
XD1DA3BCDT
2
Master Relay 4A or Oil Pump Aux. Relay 88X Run Failure Occurs
BK1760C
Page 74
Keowee Master Rly 4A Drops Out During Run
YK1MR4ARUN
Page 53
Turbine No. 1 GBO Level Relay 88X Fails to Remain De-energized
BK1761C
Keowee 1 Turbine Guide Bearing Oil Relay 88X Spurious Operation
BK1088XRYT
2
Turbine No. 1 Bearing Oil Level Switch 63TA Spurious Operation
BK163TALST
3
Keowee 1 GBO Level Relay 63TA/1X Spurious Operation
BK1631XRYT
2

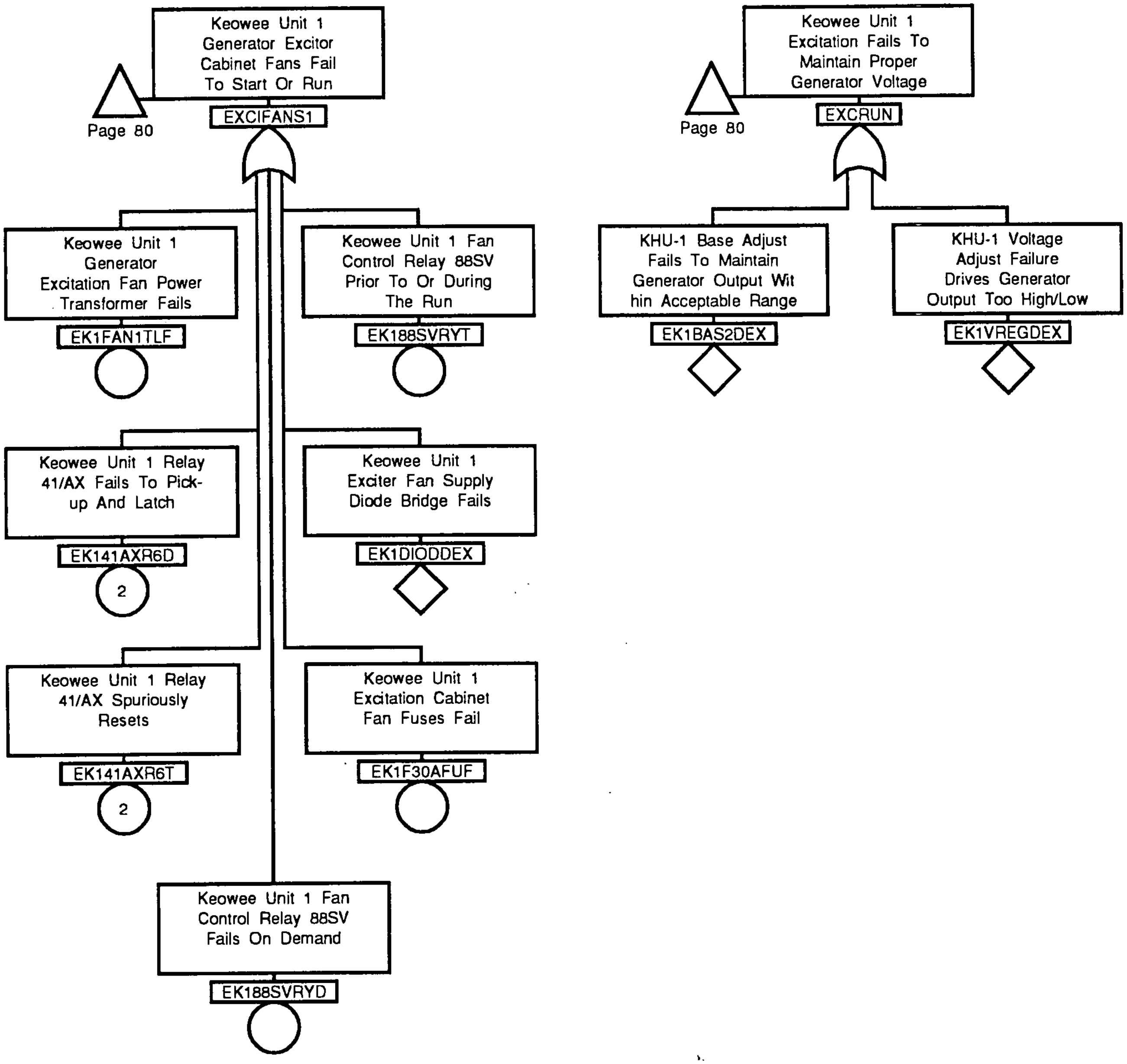

Turbine Sump System Fails to Remove Turbine 1 Leakage During Keowee Run
PK12000
Page 41
Turbine No. 1 Pump Trains Fails
PK12001
Common Cause Failure of Unit 1 Turbine Sump Pump System
PK1ACDCCOM
Turbine Number 1 Packing Fails And Causes Flooding
PK1PACK
Turbine No. 1 AC Pump Train Fails
PK1100
Turbine No. 1 DC Pump Train Fails
PK1200
Page 77
WL Fails To Cool Keowee 1 Turbine Packing Box
FK1200
Page 78
Turbine Packing Box Heat Exchanger 1TRHX-1 Fails
FK1TRHXHXF
2
Turbine No. 1 AC Pump Fails
PK1110
Check Valve 1TS-2 Fails to Open or Transfers Closed
PK1TS02CVT
Manual Valve 1TS-1 Transfers Position
PK1TS01VVT
Turbine No. 1 Packing Fails
PK1PACKDEX
Loss of Power on Keowee 600 Vac MCC 1XA K-704, K-702
XA1XA
Page 45
Unit 1 AC Turbine Sump Pump Float Switch 63SA Fails
PK163SALST
600 V Circuit Breaker 1XA-2C Transfers Position
PK1XA2CCLT
AC Sump Pump 1TSPU-1 Fails To Start Or Run
PK1TSACGPR


Turbine No. 1 DC Pump Train Fails
PK1200
Page 76
Turbine No. 1 DC Pump Fails
PK1210
Check Valve 1TS-4 Fails to Open or Transfers Closed
PK1TS04CVT
Manual Valve 1TS-3 Transfers Position
PK1TS03VVT
Turbine No. 1 DC Pump Train In Maintenance Or Testing
PK1TSDCTRM
Loss of Power on Keowee 1 125Vdc Dist. Ctr. 1DA during Run K-704,
XD1DAR
Page 38
Unit 1 DC Turbine Sump Pump Float Switch 63SB Transfers
PK163SBLST
125 Vdc Circuit Breaker 1DA-5C Transfers Position
PK1DA5CCDT
Latent Human Error Fails Turbine No. 1 DC Sump Pump
PK1TSDCLHE
DC Sump Pump 1TSPU-2 Fails To Start Or Run
PK1TSDCGPR

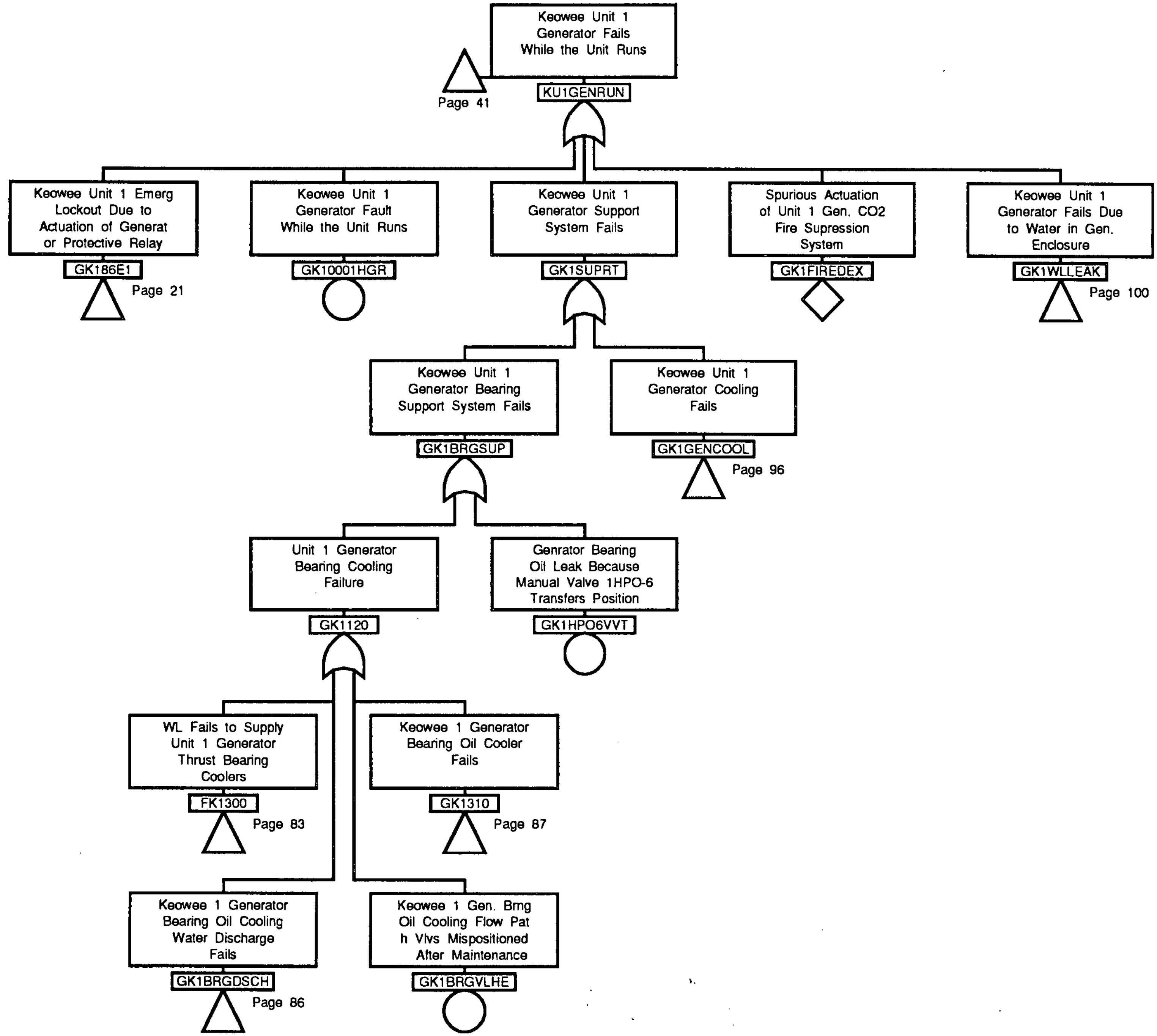

WL Fails To Cool Keowee 1 Turbine Packing Box
FK1200
Page 76
Manual Valve 1WL-9 Transfers Position
FK1WL09VVT
No Flow Through Cooling Water Filter 1WLFL-3
FK1110
Page 79
Turbine Packing Box Heat Exchanger 1TRHX-1 Fails
FK1TRHXHXF
2
No Flow Through Cooling Water Filter 1WLFL-1
FK1120
Page 79
Page 84
Filter 1WLFL-1 Becomes Clogged
FK1FL01FRF
Locked-Open Manual Valve 0WL-1 Transfers Position
FK0WL01VVT
2

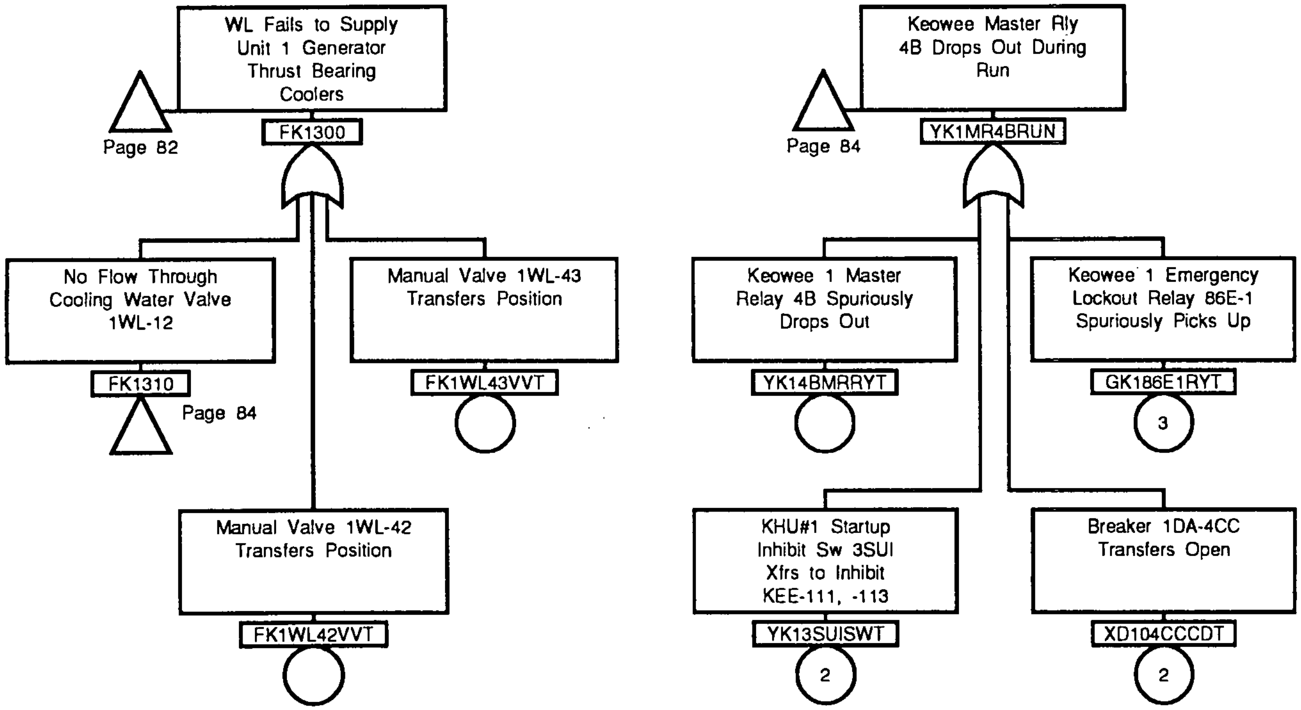

No Flow Through Cooling Water Filter 1WLFL-3
FK1110
Page 78
No Flow Through Cooling Water Filter 1WLFL-1
FK1120
Page 78
Manual Valve 1WL-6 Transfers Position
FK1WL06VVT
Manual Valve 1WL-3 Transfers Position
FK1WL03VVT
Manual Valve 1WL-7 Transfers Position
FK1WL07VVT
Manual Valve 1WL-4 Transfers Position
FK1WL04VVT
Manual Valve 1WL-8 Transfers Position
FK1WL08VVT
Manual Valve 1WL-5 Transfers Position
FK1WL05VVT
Filter 1WLFL-2 Becomes Clogged
FK1FL02FRF


Keowee Unit 1 Generator Excitation Fails While The Unit Runs
KU1GEXRUN
Page 41
Keowee Unit 1 Supply Breaker Transfers Open
SPLYTRANS1
Keowee Unit 1 Generator Excitor Cabinet Fans Fail To Start Or Run
EXCIFANS1
Page 81
Keowee Unit 1 Field Breaker Transfers Open
FLDTRANS1
Keowee Unit 1 Excitation Fails To Maintain Proper Generator Voltage
EXCRUN
Page 81
Keowee Unit 1 Generator Excitation Transformer Fails
EK1EXC2TGF
Spurious Operation Of The KHU1 Supply Breaker Trip Switch
EK1415TSWT
Keowee Unit 1 Relay 41/AX Spuriously Resets
EK141AXR6T
2
Keowee Unit 1 Relay 99SY Drops Out
EK199SYRYT
Keowee Unit 1 Field Breaker Trip Control Switch Transfers Position
EK1S41TSWT
Breaker 3BR In 125V dc Distribution Center 1DA Transfers Open
ED13BR2CDT
2
Keowee Unit 1 Generator Lockout Au xiliary Relay 86EX-1 Spurious Actuation
EK186X2RYT



Keowee Unit 1 Generator Excitor Cabinet Fans Fail To Start Or Run
Page 80
EXCIFANS1
Keowee Unit 1 Generator Excitation Fan Power Transformer Fails
EK1FAN1TLF
Keowee Unit 1 Fan Control Relay 88SV Prior To Or During The Run
EK188SVRYT
Keowee Unit 1 Relay 41/AX Fails To Pick-up And Latch
EK141AXR6D
2
Keowee Unit 1 Exciter Fan Supply Diode Bridge Fails
EK1DIODDEX
Keowee Unit 1 Relay 41/AX Spuriously Resets
EK141AXR6T
2
Keowee Unit 1 Excitation Cabinet Fan Fuses Fail
EK1F30AFUF
Keowee Unit 1 Fan Control Relay 88SV Fails On Demand
EK188SVRYD
Keowee Unit 1 Excitation Fails To Maintain Proper Generator Voltage
Page 80
EXCRUN
KHU-1 Base Adjust Fails To Maintain Generator Output Wit hin Acceptable Range
EK1BAS2DEX
KHU-1 Voltage Adjust Failure Drives Generator Output Too High/Low
EK1VREGDEX


Keowee Unit 1 Generator Fails While the Unit Runs
KU1GENRUN
Page 41
Keowee Unit 1 Emerg Lockout Due to Actuation of Generat or Protective Relay
GK186E1
Page 21
Keowee Unit 1 Generator Fault While the Unit Runs
GK10001HGR
Keowee Unit 1 Generator Support System Fails
GK1SUPRT
Spurious Actuation of Unit 1 Gen. CO2 Fire Supression System
GK1FIREDEX
Keowee Unit 1 Generator Fails Due to Water in Gen. Enclosure
GK1WLLEAK
Page 100
Keowee Unit 1 Generator Bearing Support System Fails
GK1BRGSUP
Keowee Unit 1 Generator Cooling Fails
GK1GENCOOL
Page 96
Unit 1 Generator Bearing Cooling Failure
GK1120
Genrator Bearing Oil Leak Because Manual Valve 1HPO-6 Transfers Position
GK1HPO6VVT
WL Fails to Supply Unit 1 Generator Thrust Bearing Coolers
FK1300
Page 83
Keowee 1 Generator Bearing Oil Cooler Fails
GK1310
Page 87
Keowee 1 Generator Bearing Oil Cooling Water Discharge Fails
GK1BRGDSCH
Page 86
Keowee 1 Gen. Brng Oil Cooling Flow Pat h Vlvs Mispositioned After Maintenance
GK1BRGVLHE



WL Fails to Supply Unit 1 Generator Thrust Bearing Coolers
FK1300
Page 82
No Flow Through Cooling Water Valve 1WL-12
FK1310
Page 84
Manual Valve 1WL-43 Transfers Position
FK1WL43VVT
Manual Valve 1WL-42 Transfers Position
FK1WL42VVT
Keowee Master Rly 4B Drops Out During Run
YK1MR4BRUN
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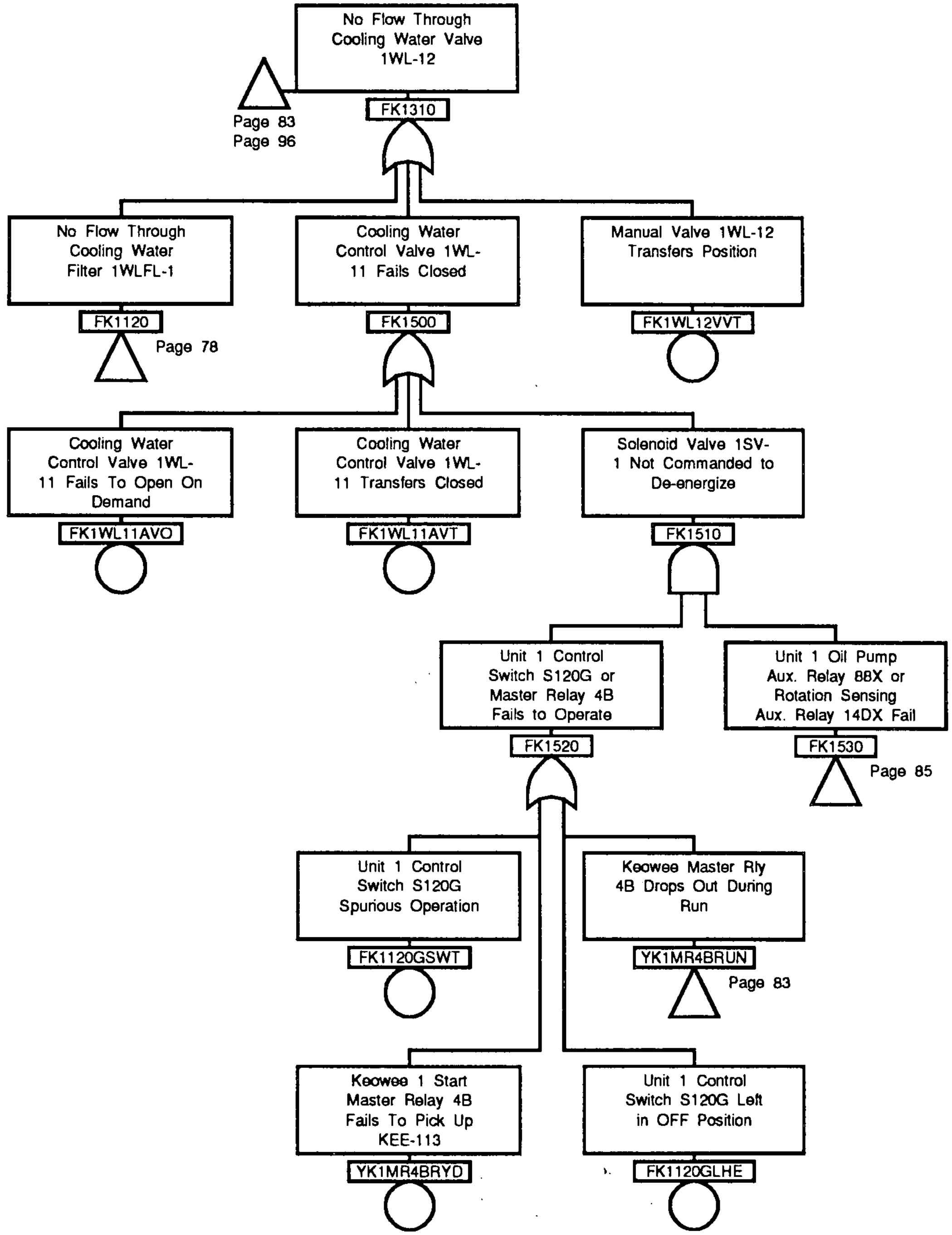
Keowee 1 Master Relay 4B Spuriously Drops Out
YK14BMRRYT
Keowee 1 Emergency Lockout Relay 86E-1 Spuriously Picks Up
GK186E1RYT
3
KHU#1 Startup Inhibit Sw 3SUI Xfrs to Inhibit KEE-111, -113
YK13SUISWT
2
Breaker 1DA-4CC Transfers Open
XD104CCCDT
2



No Flow Through Cooling Water Valve 1WL-12
FK1310
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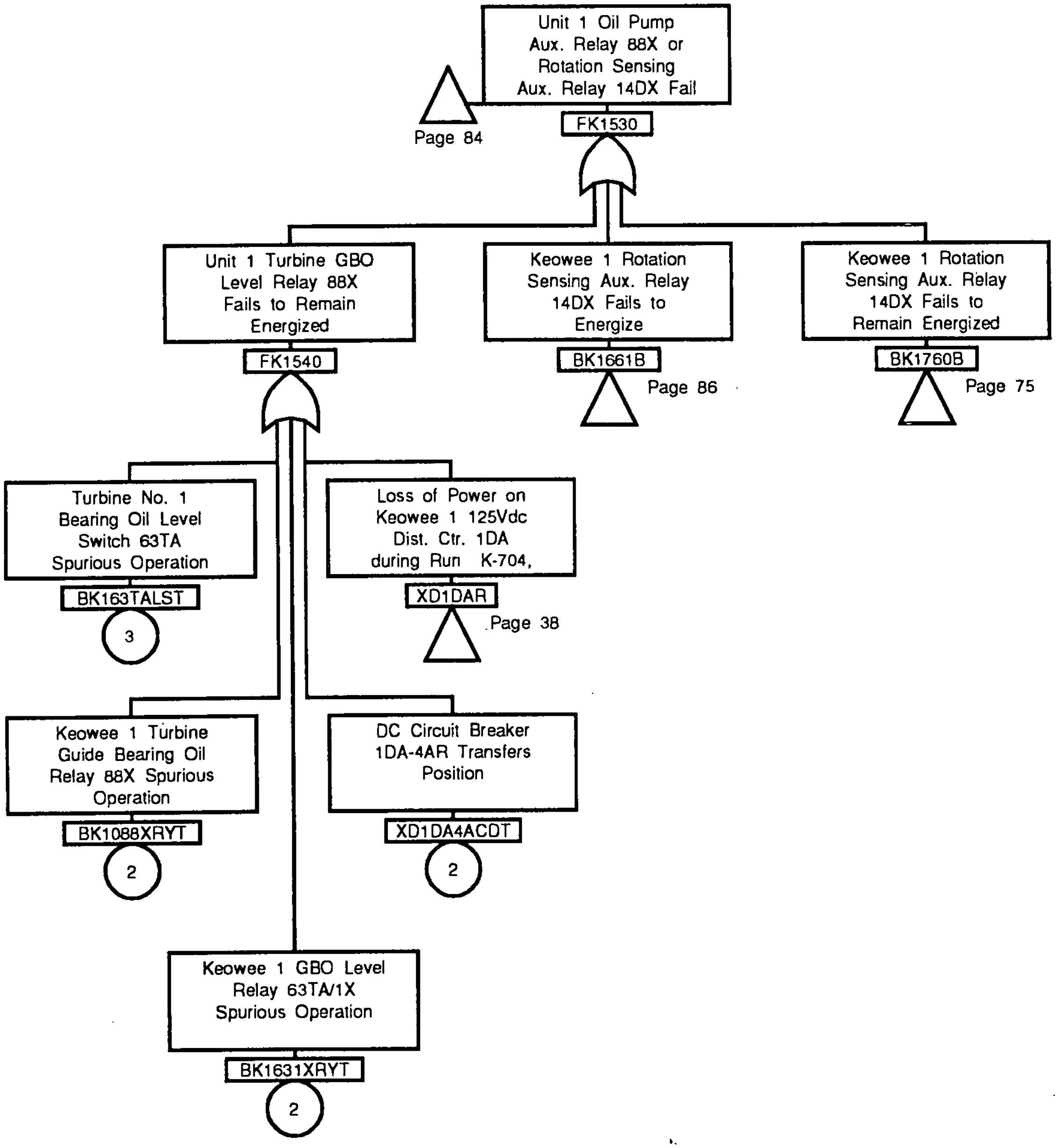
No Flow Through Cooling Water Filter 1WLFL-1
FK1120
Page 78
Cooling Water Control Valve 1WL-11 Fails Closed
FK1500
Manual Valve 1WL-12 Transfers Position
FK1WL12VVT
Cooling Water Control Valve 1WL-11 Fails To Open On Demand
FK1WL11AVO
Cooling Water Control Valve 1WL-11 Transfers Closed
FK1WL11AVT
Solenoid Valve 1SV-1 Not Commanded to De-energize
FK1510
Unit 1 Control Switch S120G or Master Relay 4B Fails to Operate
FK1520
Unit 1 Oil Pump Aux. Relay 88X or Rotation Sensing Aux. Relay 14DX Fail
FK1530
Page 85
Unit 1 Control Switch S120G Spurious Operation
FK1120GSWT
Keowee Master Rly 4B Drops Out During Run
YK1MR4BRUN
Page 83
Keowee 1 Start Master Relay 4B Fails To Pick Up KEE-113
YK1MR4BRYD
Unit 1 Control Switch S120G Left in OFF Position
FK1120GLHE



Unit 1 Oil Pump Aux. Relay 88X or Rotation Sensing Aux. Relay 14DX Fail
FK1530
Page 84
Unit 1 Turbine GBO Level Relay 88X Fails to Remain Energized
FK1540
Keowee 1 Rotation Sensing Aux. Relay 14DX Fails to Energize
BK1661B
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Keowee 1 Rotation Sensing Aux. Relay 14DX Fails to Remain Energized
BK1760B
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Turbine No. 1 Bearing Oil Level Switch 63TA Spurious Operation
BK163TALST
3
Loss of Power on Keowee 1 125Vdc Dist. Ctr. 1DA during Run K-704,
XD1DAR
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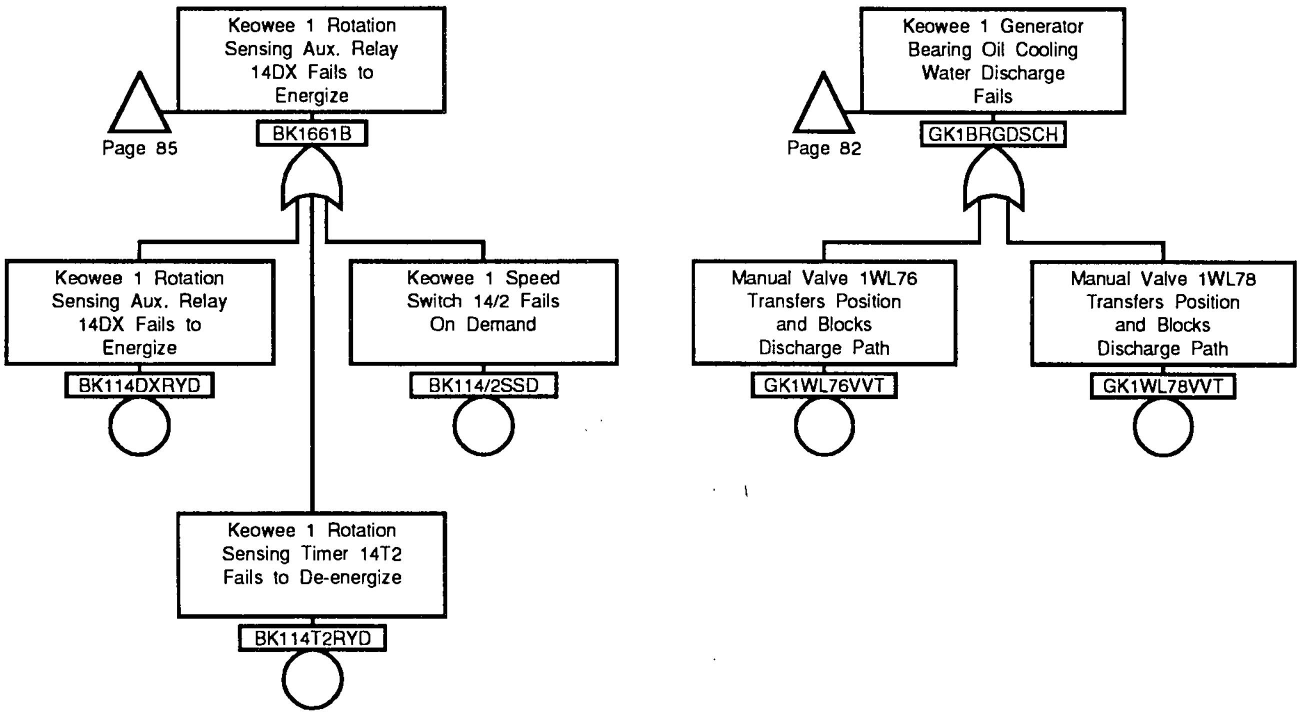
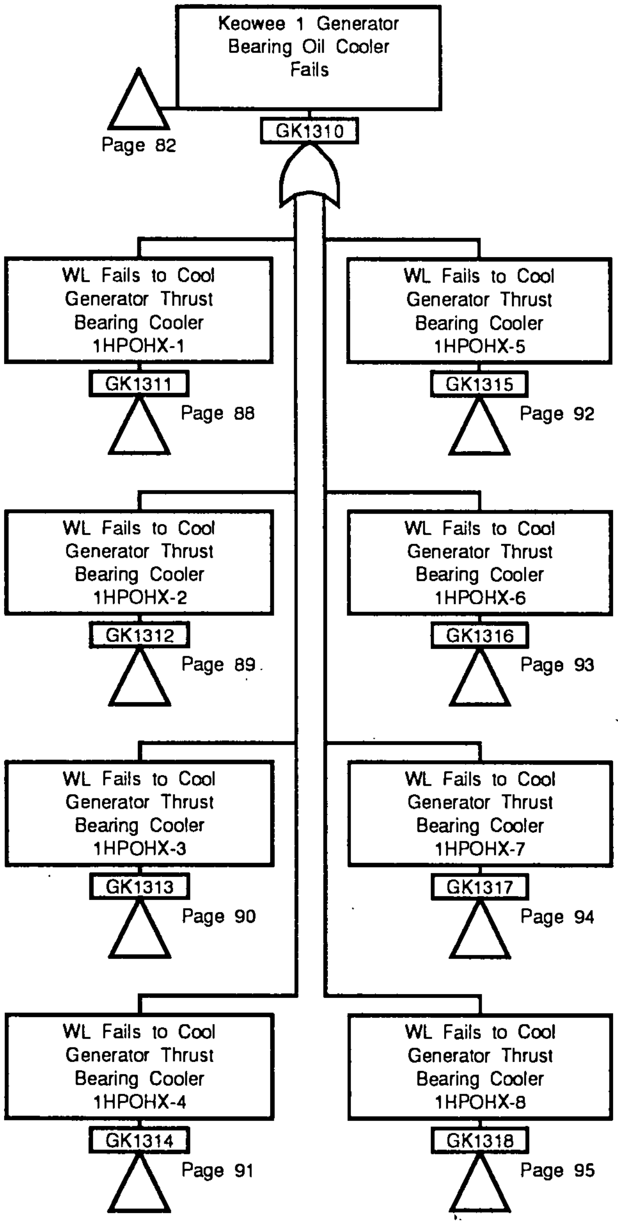
Keowee 1 Turbine Guide Bearing Oil Relay 88X Spurious Operation
BK1088XRYT
2
DC Circuit Breaker 1DA-4AR Transfers Position
XD1DA4ACDT
2
Keowee 1 GBO Level Relay 63TA/1X Spurious Operation
BK1631XRYT
2


Keowee 1 Rotation Sensing Aux. Relay 14DX Fails to Energize
BK1661B
Page 85
Keowee 1 Rotation Sensing Aux. Relay 14DX Fails to Energize
BK114DXRYD
Keowee 1 Speed Switch 14/2 Fails On Demand
BK114/2SSD
Keowee 1 Rotation Sensing Timer 14T2 Fails to De-energize
BK114T2RYD
Keowee 1 Generator Bearing Oil Cooling Water Discharge Fails
GK1BRGDSCH
Page 82
Manual Valve 1WL76 Transfers Position and Blocks Discharge Path
GK1WL76VVT
Manual Valve 1WL78 Transfers Position and Blocks Discharge Path
GK1WL78VVT


Keowee 1 Generator Bearing Oil Cooler Fails
Page 82
GK1310
WL Fails to Cool Generator Thrust Bearing Cooler 1HPOHX-1
GK1311
Page 88
WL Fails to Cool Generator Thrust Bearing Cooler 1HPOHX-5
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WL Fails to Cool Generator Thrust Bearing Cooler 1HPOHX-2
GK1312
Page 89
WL Fails to Cool Generator Thrust Bearing Cooler 1HPOHX-6
GK1316
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WL Fails to Cool Generator Thrust Bearing Cooler 1HPOHX-3
GK1313
Page 90
WL Fails to Cool Generator Thrust Bearing Cooler 1HPOHX-7
GK1317
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WL Fails to Cool Generator Thrust Bearing Cooler 1HPOHX-4
GK1314
Page 91
WL Fails to Cool Generator Thrust Bearing Cooler 1HPOHX-8
GK1318
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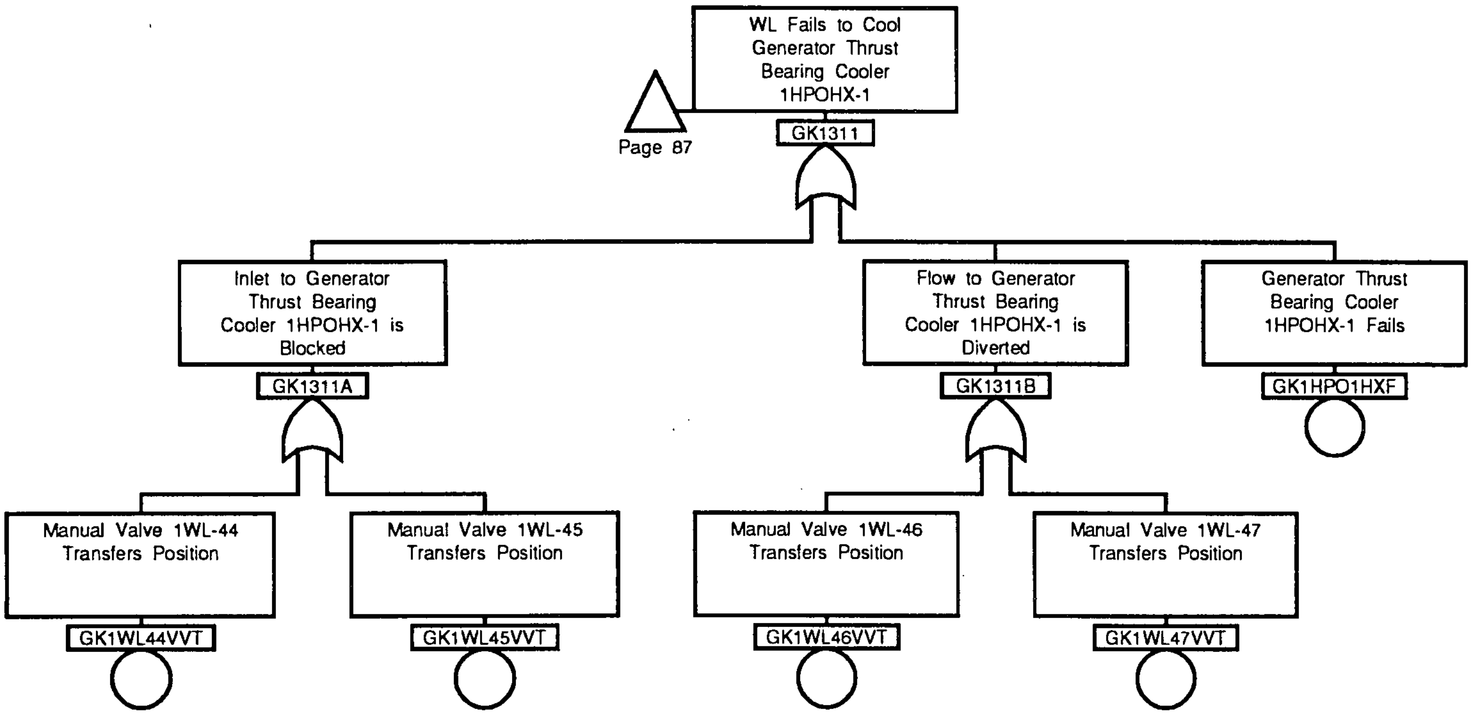
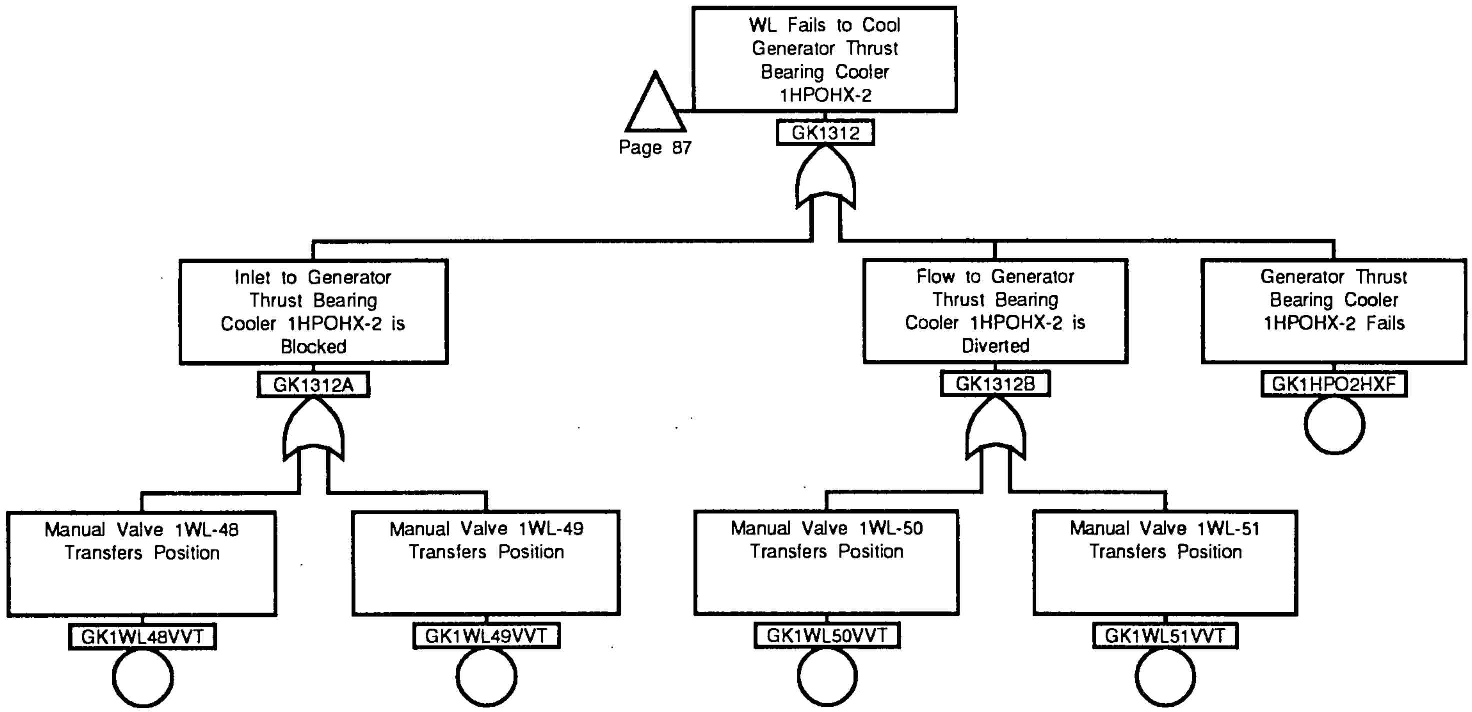
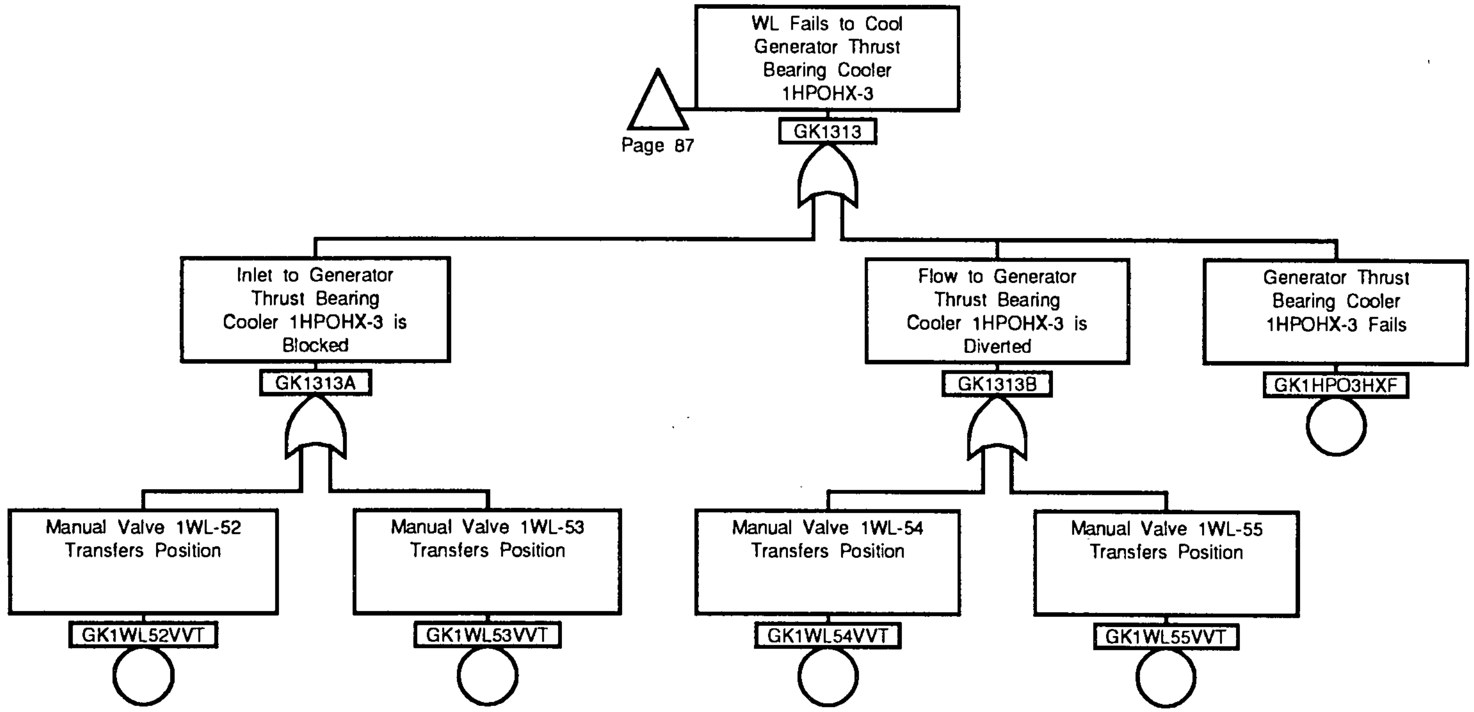
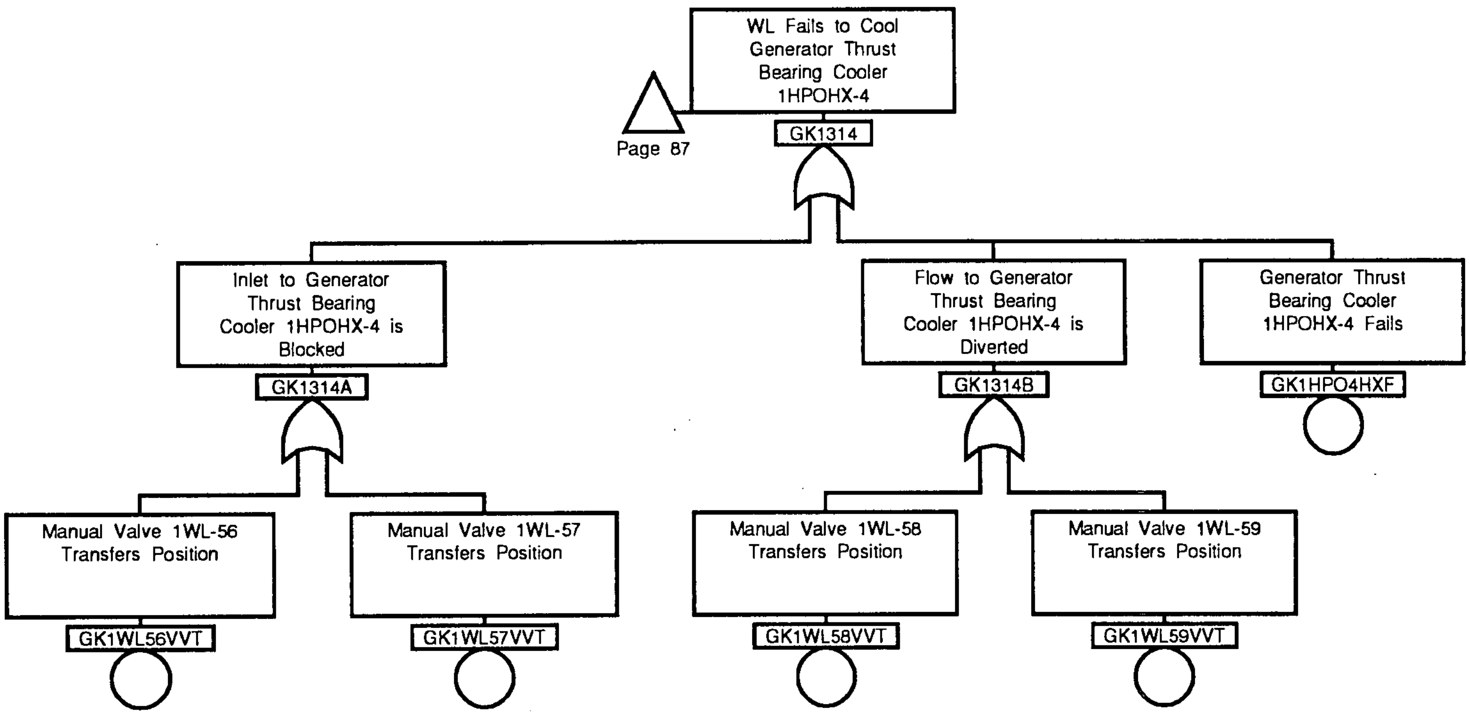
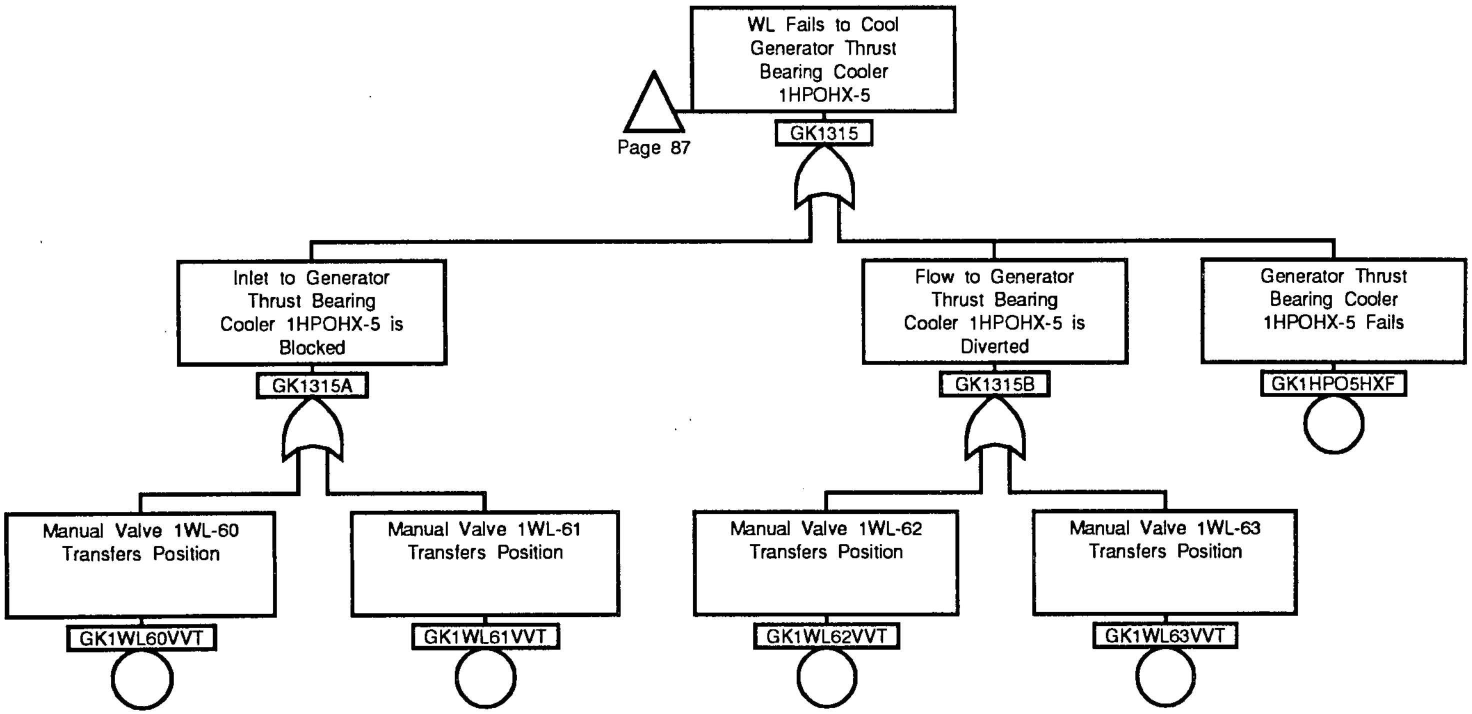


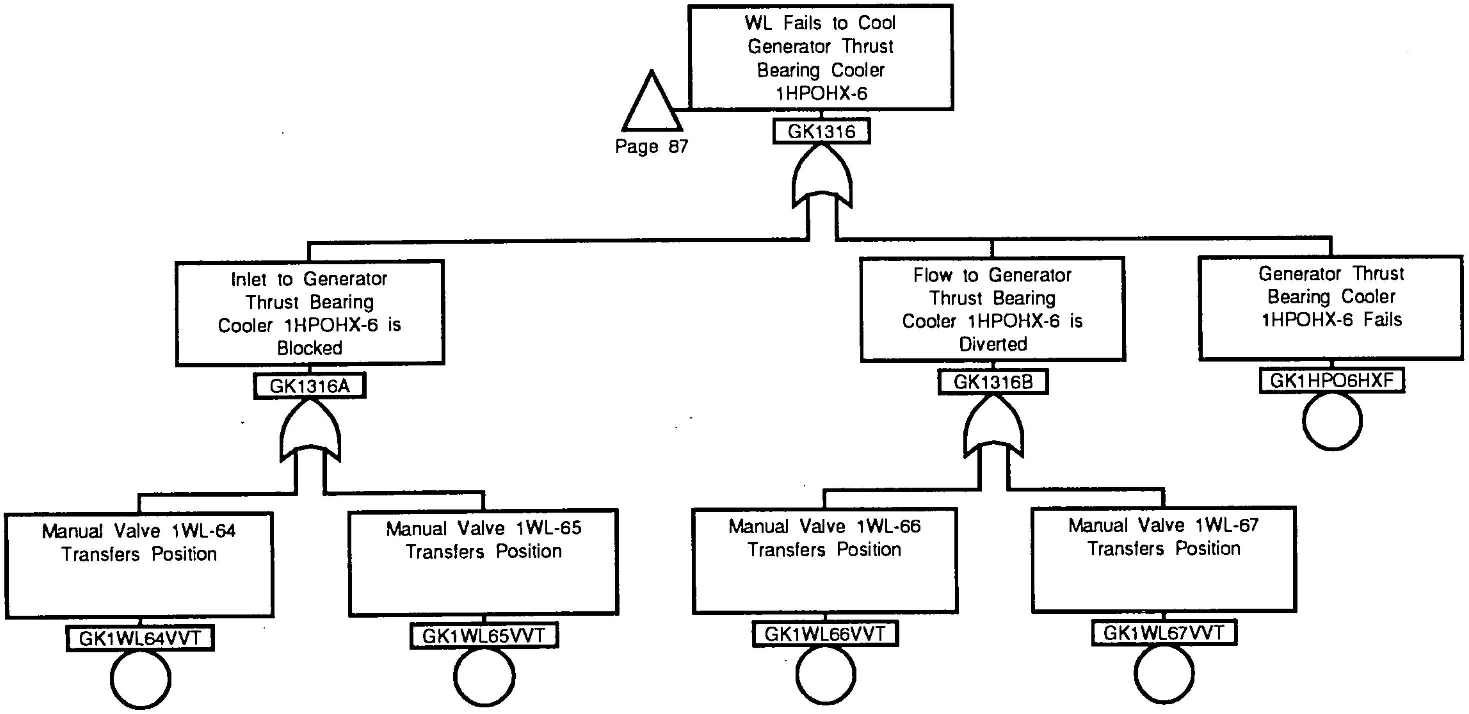
WL Fails to Cool Generator Thrust Bearing Cooler 1HPOHX-1
GK1311
Page 87
Inlet to Generator Thrust Bearing Cooler 1HPOHX-1 is Blocked
GK1311A
Flow to Generator Thrust Bearing Cooler 1HPOHX-1 is Diverted
GK1311B
Generator Thrust Bearing Cooler 1HPOHX-1 Fails
GK1HPO1HXF
Manual Valve 1WL-44 Transfers Position
GK1WL44VVT
Manual Valve 1WL-45 Transfers Position
GK1WL45VVT
Manual Valve 1WL-46 Transfers Position
GK1WL46VVT
Manual Valve 1WL-47 Transfers Position
GK1WL47VVT

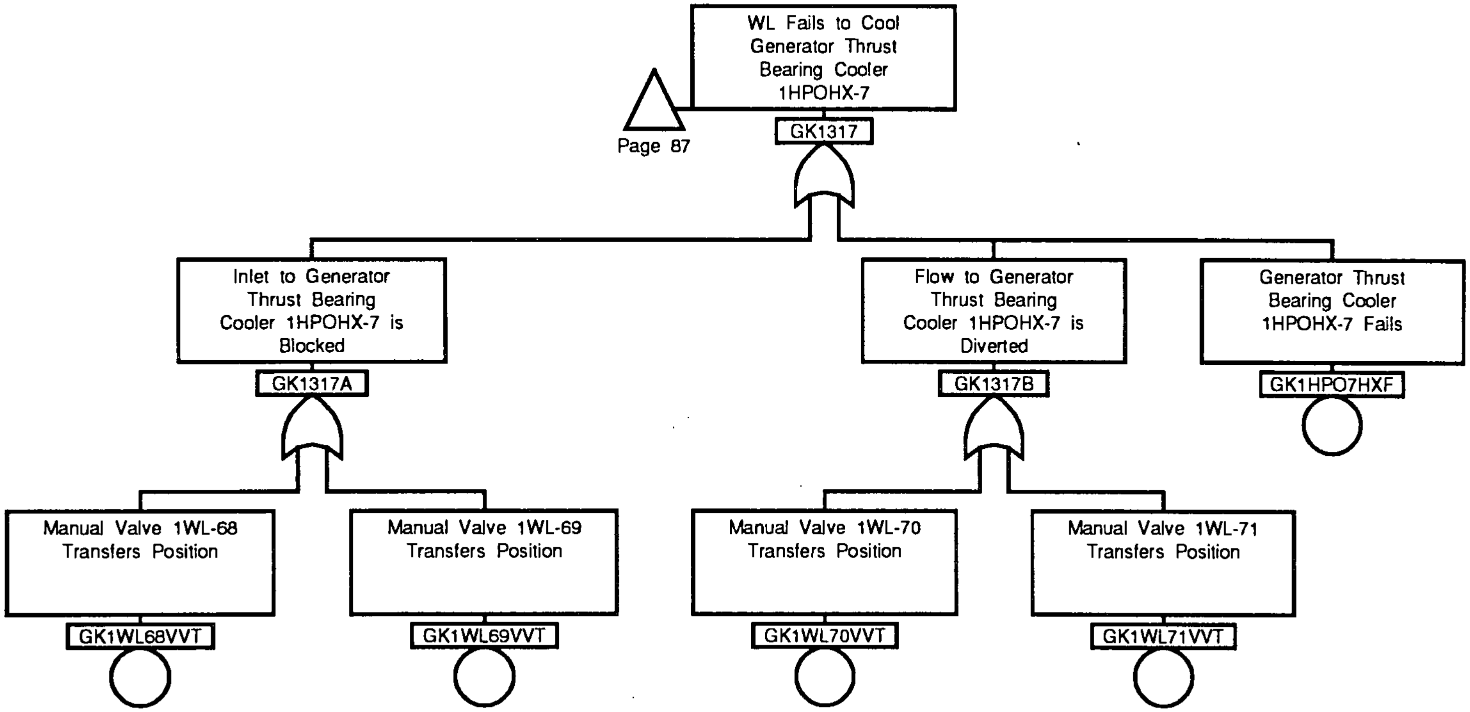

WL Fails to Cool Generator Thrust Bearing Cooler 1HPOHX-2
GK1312
Page 87
Inlet to Generator Thrust Bearing Cooler 1HPOHX-2 is Blocked
GK1312A
Flow to Generator Thrust Bearing Cooler 1HPOHX-2 is Diverted
GK1312B
Generator Thrust Bearing Cooler 1HPOHX-2 Fails
GK1HPO2HXF
Manual Valve 1WL-48 Transfers Position
GK1WL48VVT
Manual Valve 1WL-49 Transfers Position
GK1WL49VVT
Manual Valve 1WL-50 Transfers Position
GK1WL50VVT
Manual Valve 1WL-51 Transfers Position
GK1WL51VVT

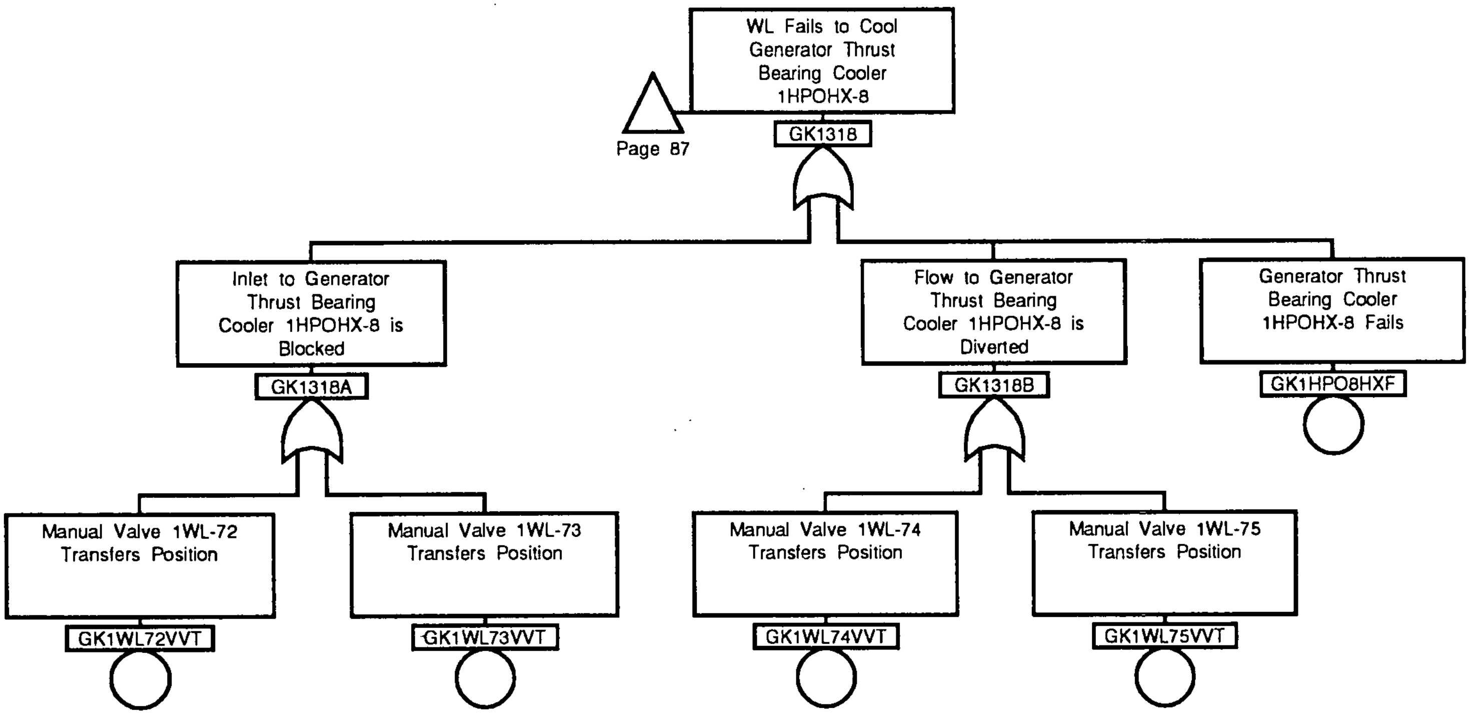

WL Fails to Cool Generator Thrust Bearing Cooler 1HPOHX-3
GK1313
Page 87
Inlet to Generator Thrust Bearing Cooler 1HPOHX-3 is Blocked
GK1313A
Flow to Generator Thrust Bearing Cooler 1HPOHX-3 is Diverted
GK1313B
Generator Thrust Bearing Cooler 1HPOHX-3 Fails
GK1HPO3HXF
Manual Valve 1WL-52 Transfers Position
GK1WL52VVT
Manual Valve 1WL-53 Transfers Position
GK1WL53VVT
Manual Valve 1WL-54 Transfers Position
GK1WL54VVT
Manual Valve 1WL-55 Transfers Position
GK1WL55VVT


WL Fails to Cool Generator Thrust Bearing Cooler 1HPOHX-4
GK1314
Page 87
Inlet to Generator Thrust Bearing Cooler 1HPOHX-4 is Blocked
GK1314A
Flow to Generator Thrust Bearing Cooler 1HPOHX-4 is Diverted
GK1314B
Generator Thrust Bearing Cooler 1HPOHX-4 Fails
GK1HPO4HXF
Manual Valve 1WL-56 Transfers Position
GK1WL56VVT
Manual Valve 1WL-57 Transfers Position
GK1WL57VVT
Manual Valve 1WL-58 Transfers Position
GK1WL58VVT
Manual Valve 1WL-59 Transfers Position
GK1WL59VVT

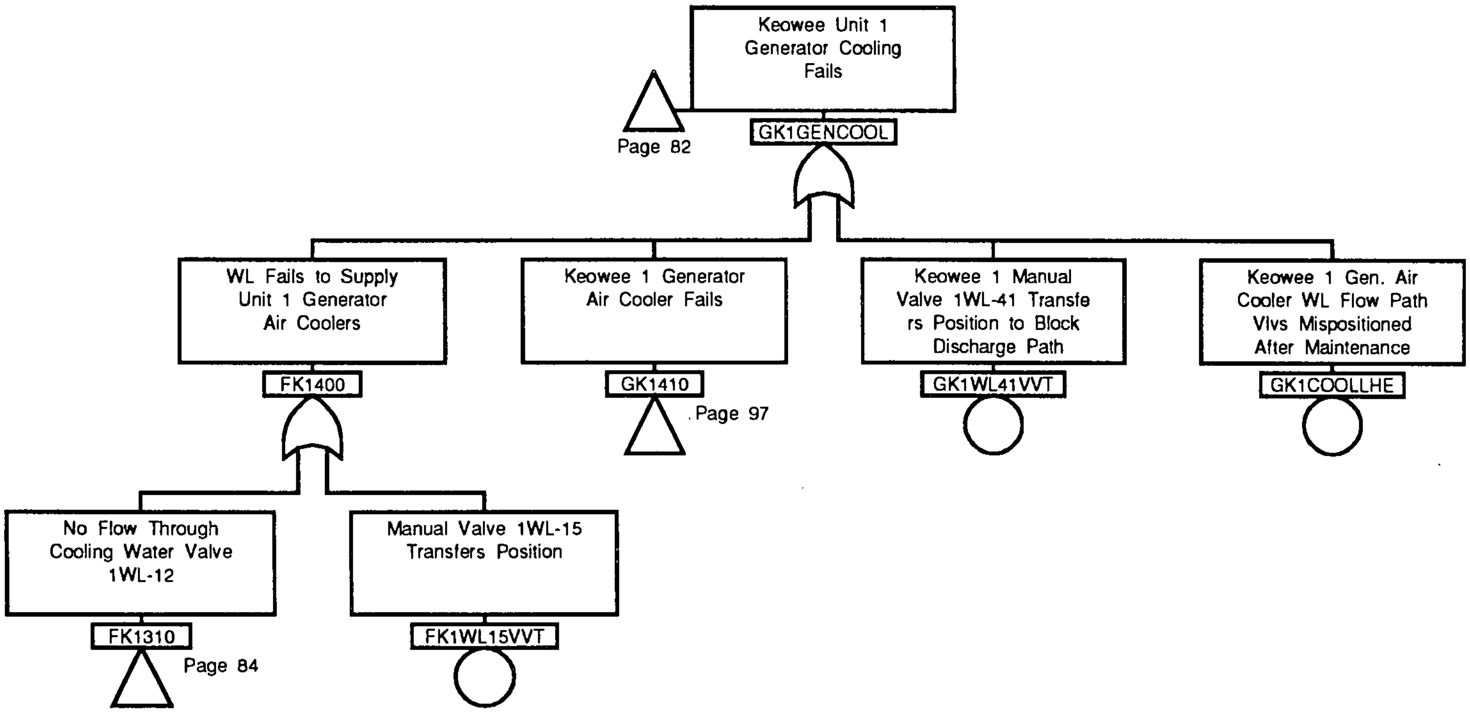

WL Fails to Cool Generator Thrust Bearing Cooler 1HPOHX-5
GK1315
Page 87
Inlet to Generator Thrust Bearing Cooler 1HPOHX-5 is Blocked
GK1315A
Flow to Generator Thrust Bearing Cooler 1HPOHX-5 is Diverted
GK1315B
Generator Thrust Bearing Cooler 1HPOHX-5 Fails
GK1HPO5HXF
Manual Valve 1WL-60 Transfers Position
GK1WL60VVT
Manual Valve 1WL-61 Transfers Position
GK1WL61VVT
Manual Valve 1WL-62 Transfers Position
GK1WL62VVT
Manual Valve 1WL-63 Transfers Position
GK1WL63VVT


WL Fails to Cool Generator Thrust Bearing Cooler 1HPOHX-6
GK1316
Page 87
Inlet to Generator Thrust Bearing Cooler 1HPOHX-6 is Blocked
GK1316A
Flow to Generator Thrust Bearing Cooler 1HPOHX-6 is Diverted
GK1316B
Generator Thrust Bearing Cooler 1HPOHX-6 Fails
GK1HPO6HXF
Manual Valve 1WL-64 Transfers Position
GK1WL64VVT
Manual Valve 1WL-65 Transfers Position
GK1WL65VVT
Manual Valve 1WL-66 Transfers Position
GK1WL66VVT
Manual Valve 1WL-67 Transfers Position
GK1WL67VVT


WL Fails to Cool Generator Thrust Bearing Cooler 1HPOHX-7
GK1317
Page 87
Inlet to Generator Thrust Bearing Cooler 1HPOHX-7 is Blocked
GK1317A
Flow to Generator Thrust Bearing Cooler 1HPOHX-7 is Diverted
GK1317B
Generator Thrust Bearing Cooler 1HPOHX-7 Fails
GK1HPO7HXF
Manual Valve 1WL-68 Transfers Position
GK1WL68VVT
Manual Valve 1WL-69 Transfers Position
GK1WL69VVT
Manual Valve 1WL-70 Transfers Position
GK1WL70VVT
Manual Valve 1WL-71 Transfers Position
GK1WL71VVT



WL Fails to Cool Generator Thrust Bearing Cooler 1HPOHX-8
Page 87
GK1318
Inlet to Generator Thrust Bearing Cooler 1HPOHX-8 is Blocked
GK1318A
Flow to Generator Thrust Bearing Cooler 1HPOHX-8 is Diverted
GK1318B
Generator Thrust Bearing Cooler 1HPOHX-8 Fails
GK1HPO8HXF
Manual Valve 1WL-72 Transfers Position
GK1WL72VVT
Manual Valve 1WL-73 Transfers Position
GK1WL73VVT
Manual Valve 1WL-74 Transfers Position
GK1WL74VVT
Manual Valve 1WL-75 Transfers Position
GK1WL75VVT



Keewee Unit 1
Generator Cooling
Fails
Page 82
GK1GENCOOL
WL Fails to Supply
Unit 1 Generator
Air Coolers
FK1400
Keowee 1 Generator
Air Cooler Fails
GK1410
Page 97
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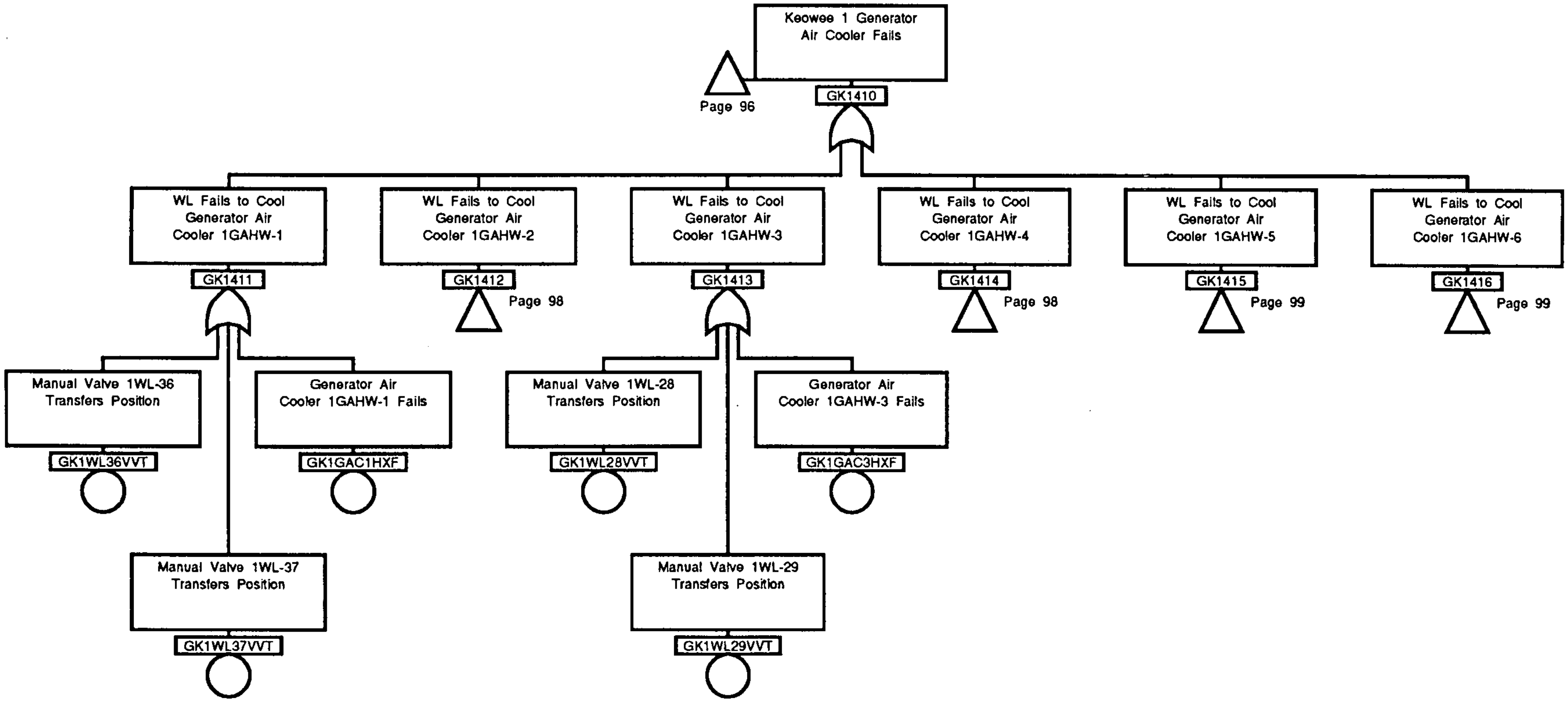
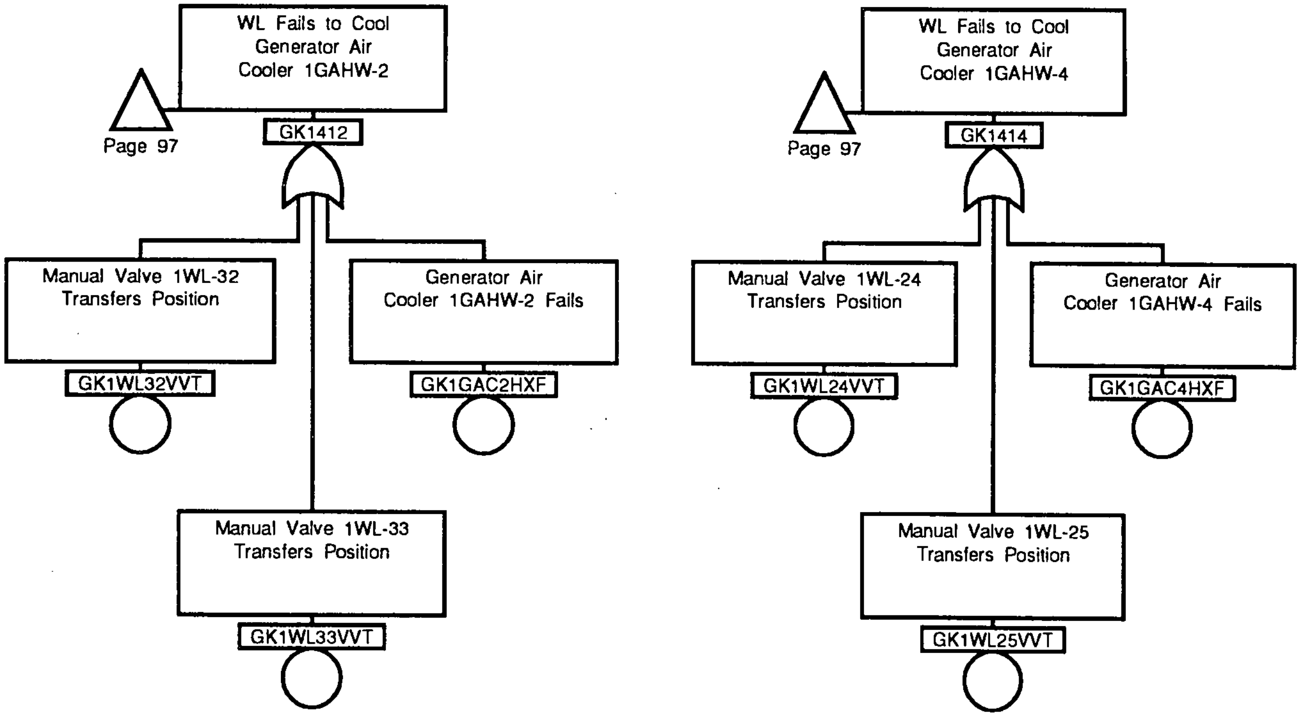
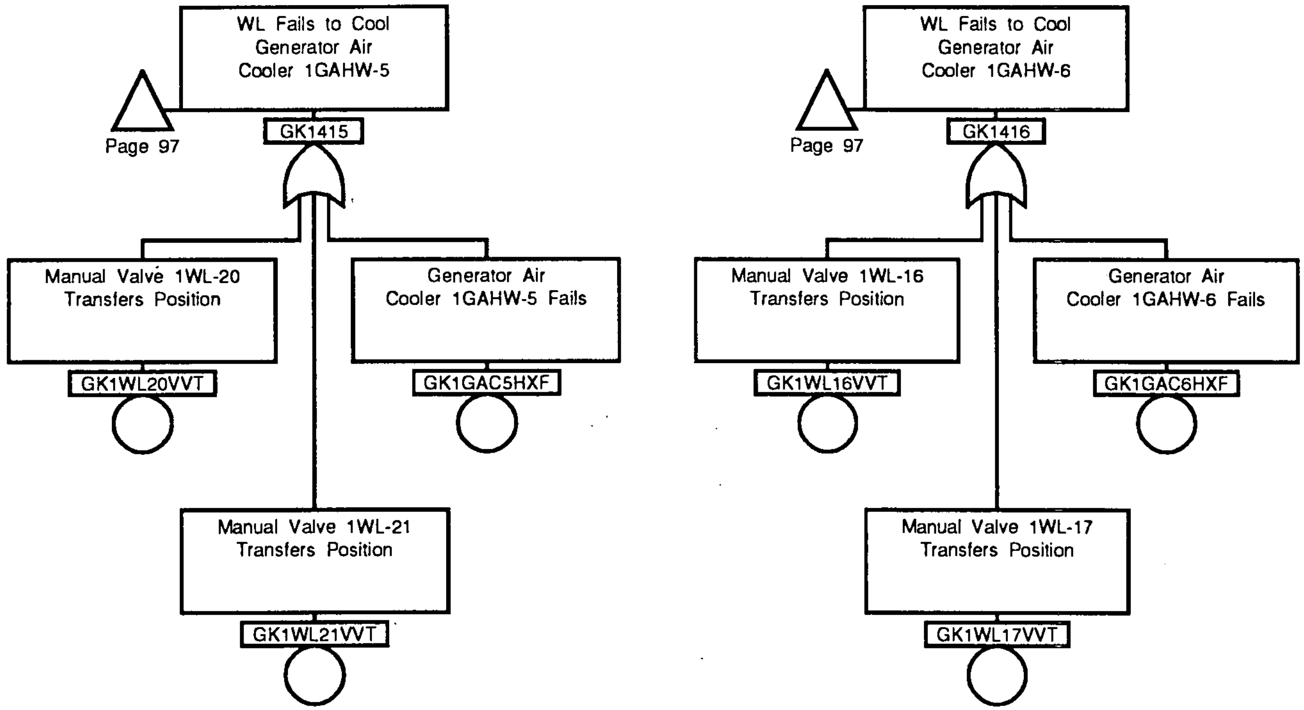
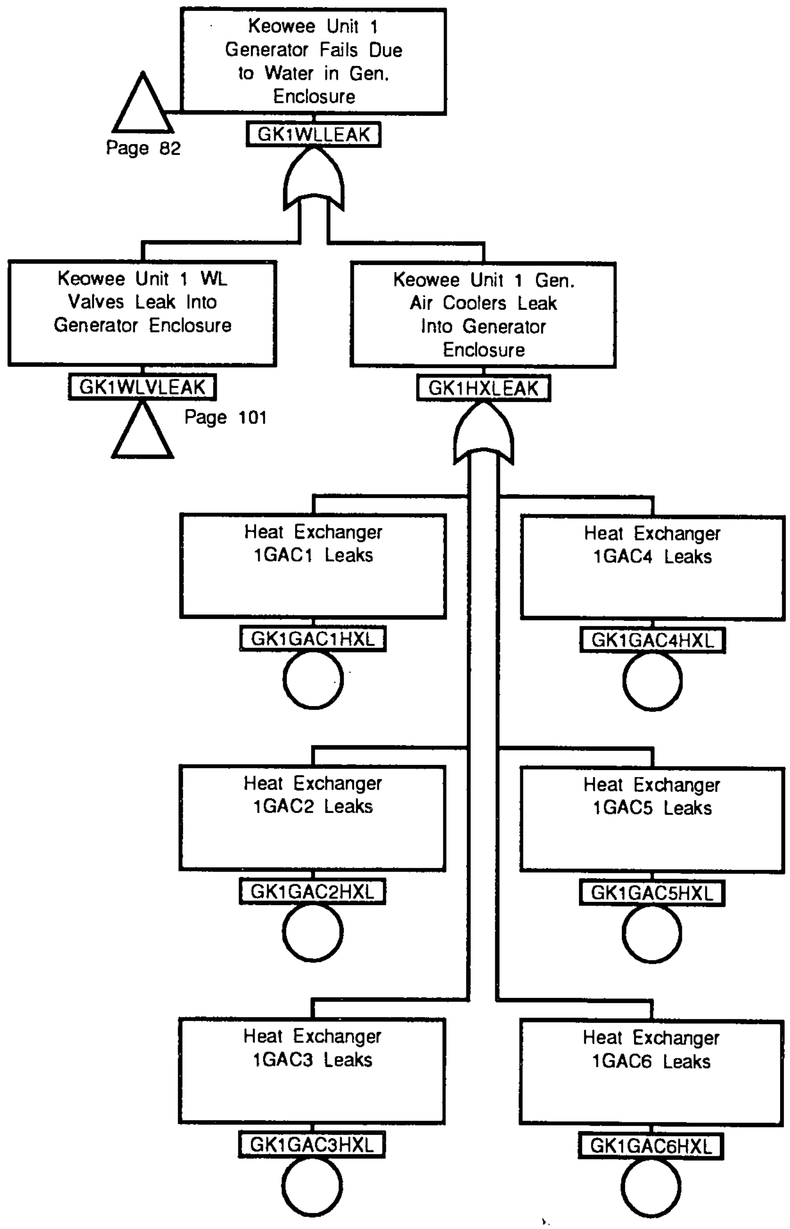
Valve 1WL-41 Transfe
rs Position to Block
Discharge Path
GK1WL41VVT
Keowee 1 Gen. Air
Cooler WL Flow Path
Vlvs Mispositioned
After Maintenance
GK1COOLLHE
No Flow Through
Cooling Water Valve
1WL-12
FK1310
Page 84
Manual Valve 1WL-15
Transfers Position
FK1WL15VVT



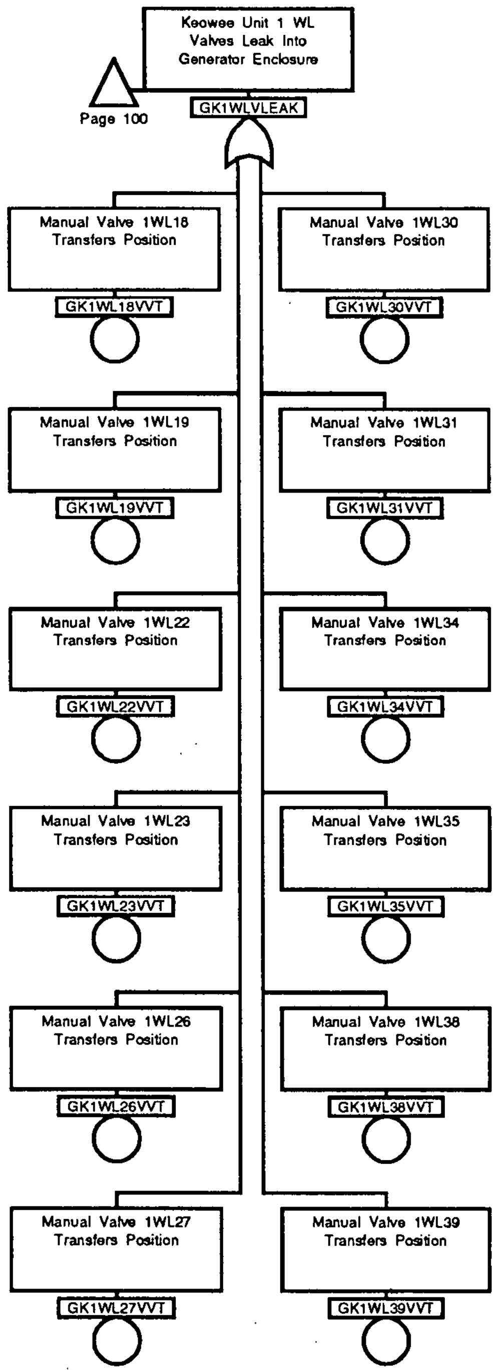
Keowee 1 Generator Air Cooler Fails
GK1410
Page 96
WL Fails to Cool Generator Air Cooler 1GAHW-1
GK1411
WL Fails to Cool Generator Air Cooler 1GAHW-2
GK1412
Page 98
WL Fails to Cool Generator Air Cooler 1GAHW-3
GK1413
WL Fails to Cool Generator Air Cooler 1GAHW-4
GK1414
Page 98
WL Fails to Cool Generator Air Cooler 1GAHW-5
GK1415
Page 99
WL Fails to Cool Generator Air Cooler 1GAHW-6
GK1416
Page 99
Manual Valve 1WL-36 Transfers Position
GK1WL36VVT
Generator Air Cooler 1GAHW-1 Fails
GK1GAC1HXF
Manual Valve 1WL-37 Transfers Position
GK1WL37VVT
Manual Valve 1WL-28 Transfers Position
GK1WL28VVT
Generator Air Cooler 1GAHW-3 Fails
GK1GAC3HXF
Manual Valve 1WL-29 Transfers Position
GK1WL29VVT


WL Fails to Cool Generator Air Cooler 1GAHW-2
Page 97
GK1412
Manual Valve 1WL-32 Transfers Position
GK1WL32VVT
Generator Air Cooler 1GAHW-2 Fails
GK1GAC2HXF
Manual Valve 1WL-33 Transfers Position
GK1WL33VVT
WL Fails to Cool Generator Air Cooler 1GAHW-4
Page 97
GK1414
Manual Valve 1WL-24 Transfers Position
GK1WL24VVT
Generator Air Cooler 1GAHW-4 Fails
GK1GAC4HXF
Manual Valve 1WL-25 Transfers Position
GK1WL25VVT

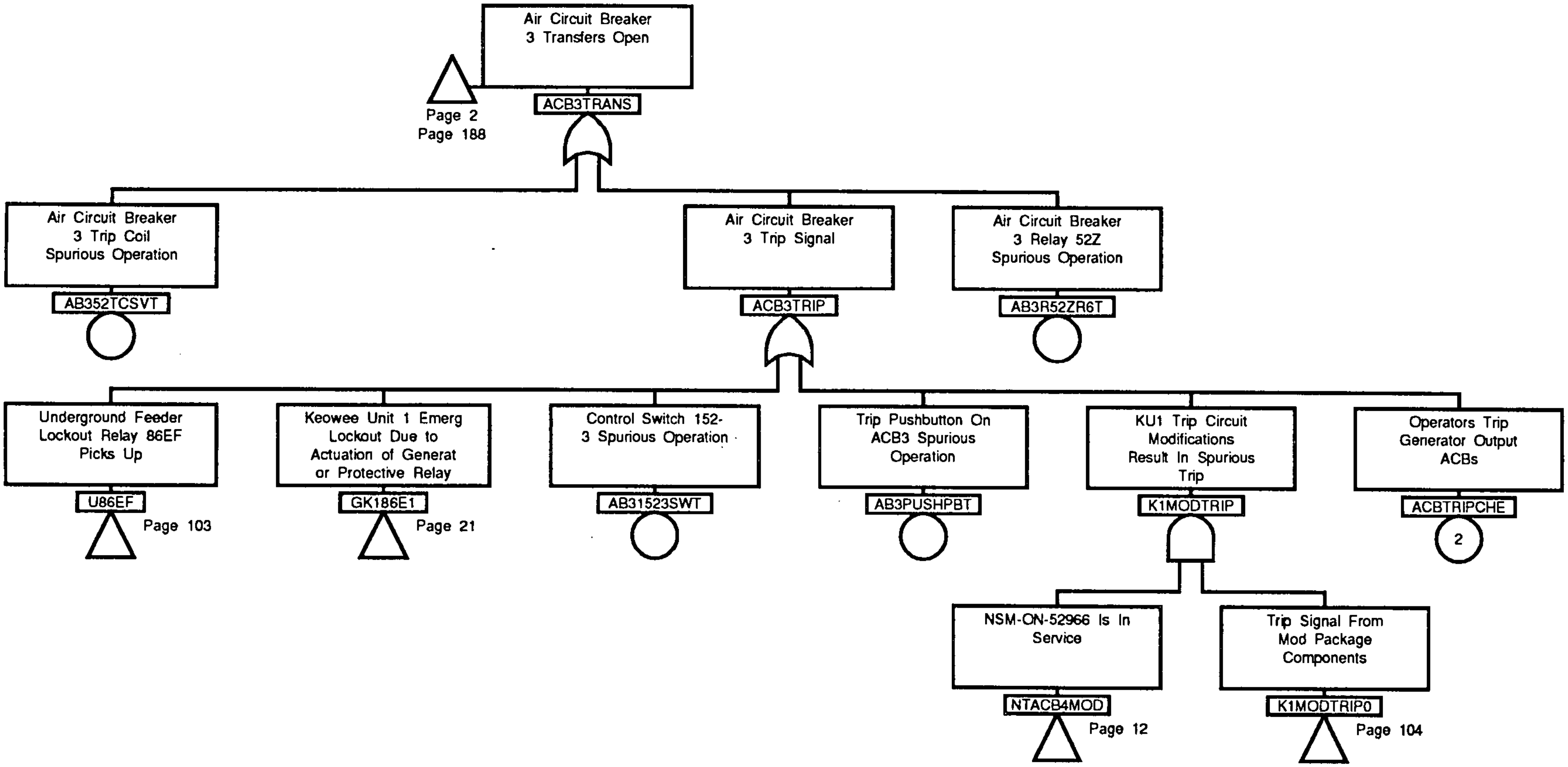

WL Fails to Cool Generator Air Cooler 1GAHW-5
GK1415
Page 97
Manual Valve 1WL-20 Transfers Position
GK1WL20VVT
Generator Air Cooler 1GAHW-5 Fails
GK1GAC5HXF
Manual Valve 1WL-21 Transfers Position
GK1WL21VVT
WL Fails to Cool Generator Air Cooler 1GAHW-6
GK1416
Page 97
Manual Valve 1WL-16 Transfers Position
GK1WL16VVT
Generator Air Cooler 1GAHW-6 Fails
GK1GAC6HXF
Manual Valve 1WL-17 Transfers Position
GK1WL17VVT



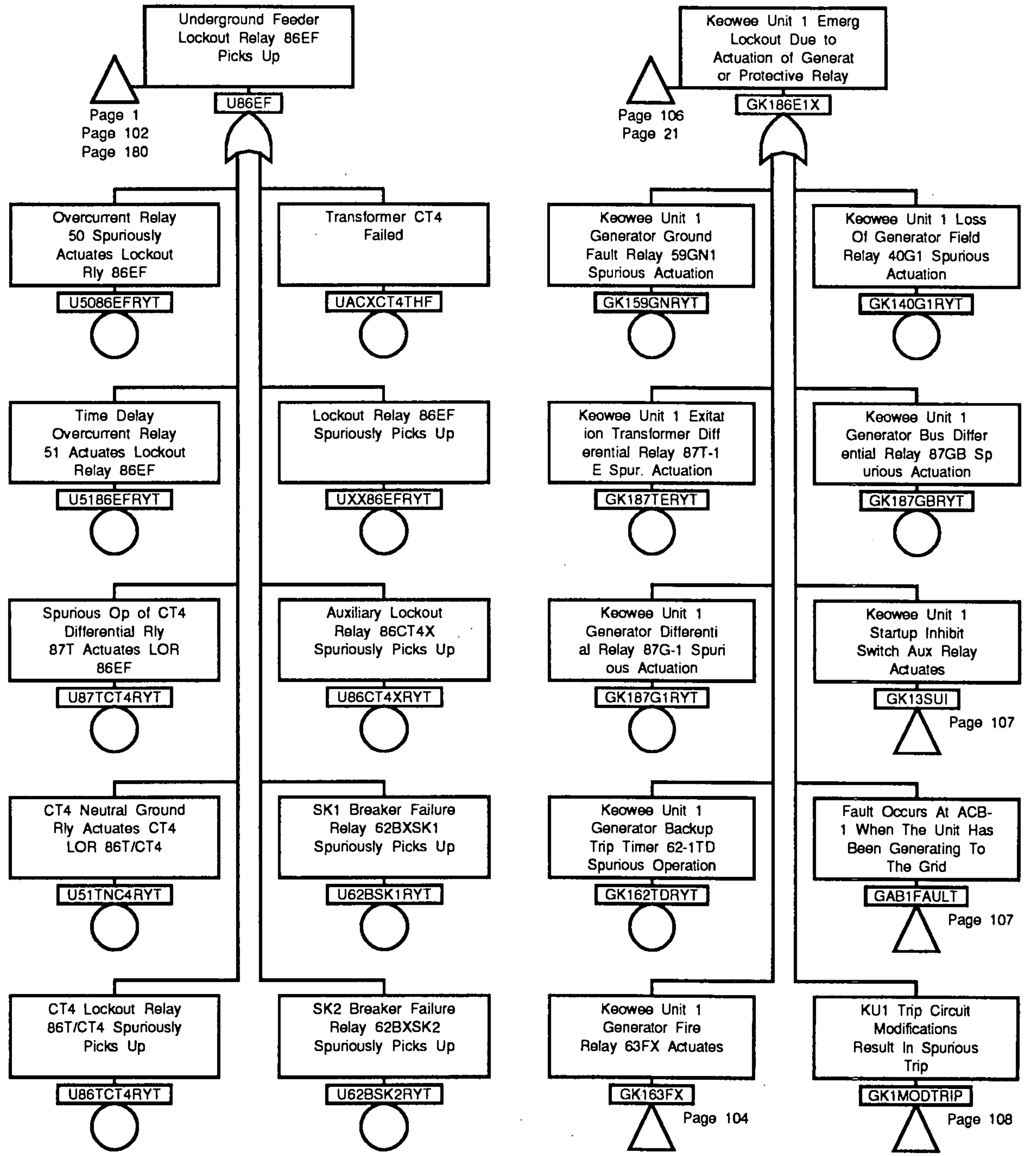
Keowee Unit 1 Generator Fails Due to Water in Gen. Enclosure
GK1WLLEAK
Page 82
Keowee Unit 1 WL Valves Leak Into Generator Enclosure
GK1WLVLEAK
Page 101
Keowee Unit 1 Gen. Air Coolers Leak Into Generator Enclosure
GK1HXLEAK
Heat Exchanger 1GAC1 Leaks
GK1GAC1HXL
Heat Exchanger 1GAC4 Leaks
GK1GAC4HXL
Heat Exchanger 1GAC2 Leaks
GK1GAC2HXL
Heat Exchanger 1GAC5 Leaks
GK1GAC5HXL
Heat Exchanger 1GAC3 Leaks
GK1GAC3HXL
Heat Exchanger 1GAC6 Leaks
GK1GAC6HXL

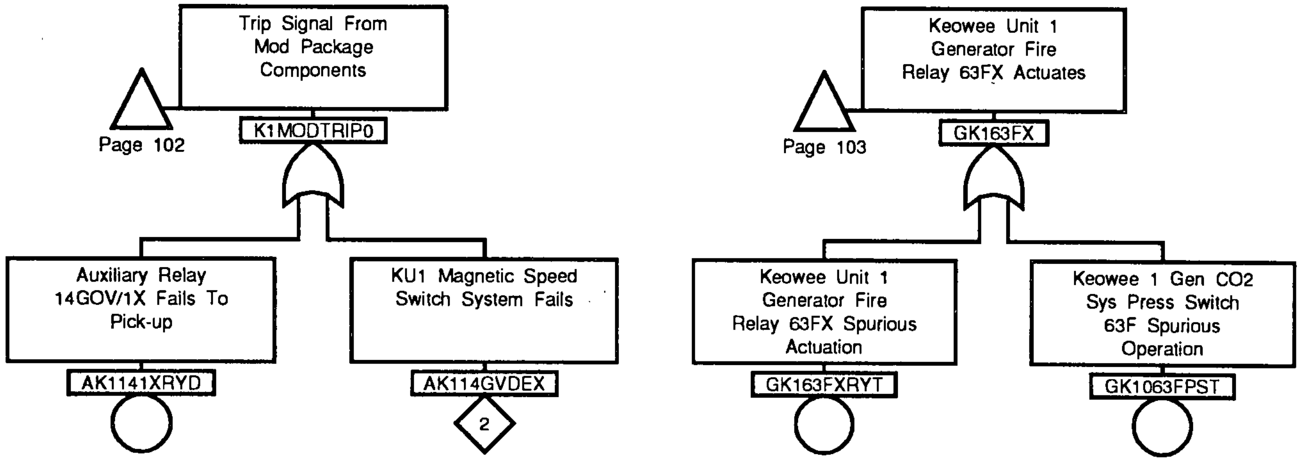


Keowee Unit 1 WL Valves Leak Into Generator Enclosure
GK1WLVLEAK
Page 100
Manual Valve 1WL18 Transfers Position
GK1WL18VVT
Manual Valve 1WL30 Transfers Position
GK1WL30VVT
Manual Valve 1WL19 Transfers Position
GK1WL19VVT
Manual Valve 1WL31 Transfers Position
GK1WL31VVT
Manual Valve 1WL22 Transfers Position
GK1WL22VVT
Manual Valve 1WL34 Transfers Position
GK1WL34VVT
Manual Valve 1WL23 Transfers Position
GK1WL23VVT
Manual Valve 1WL35 Transfers Position
GK1WL35VVT
Manual Valve 1WL26 Transfers Position
GK1WL26VVT
Manual Valve 1WL38 Transfers Position
GK1WL38VVT
Manual Valve 1WL27 Transfers Position
GK1WL27VVT
Manual Valve 1WL39 Transfers Position
GK1WL39VVT

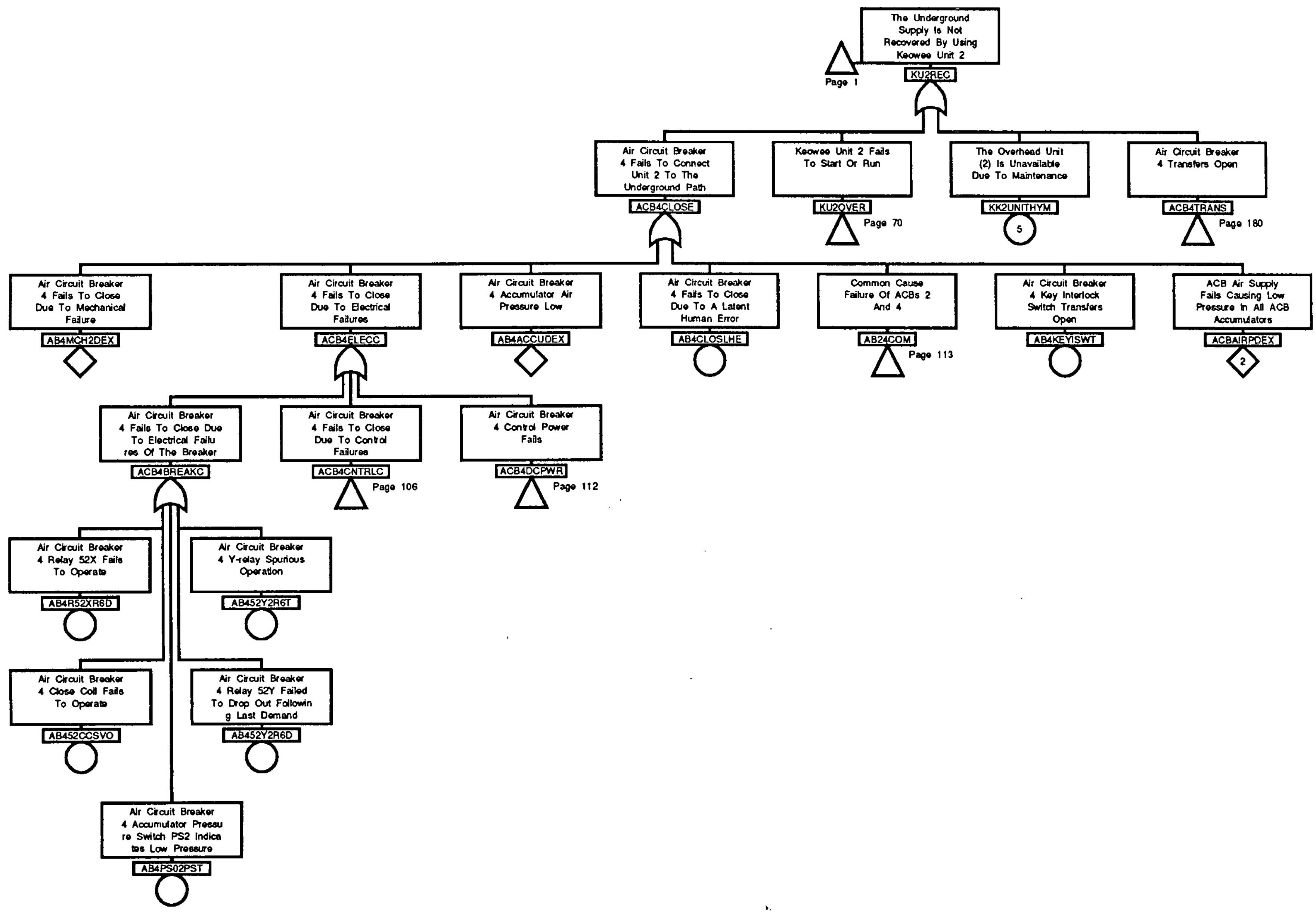


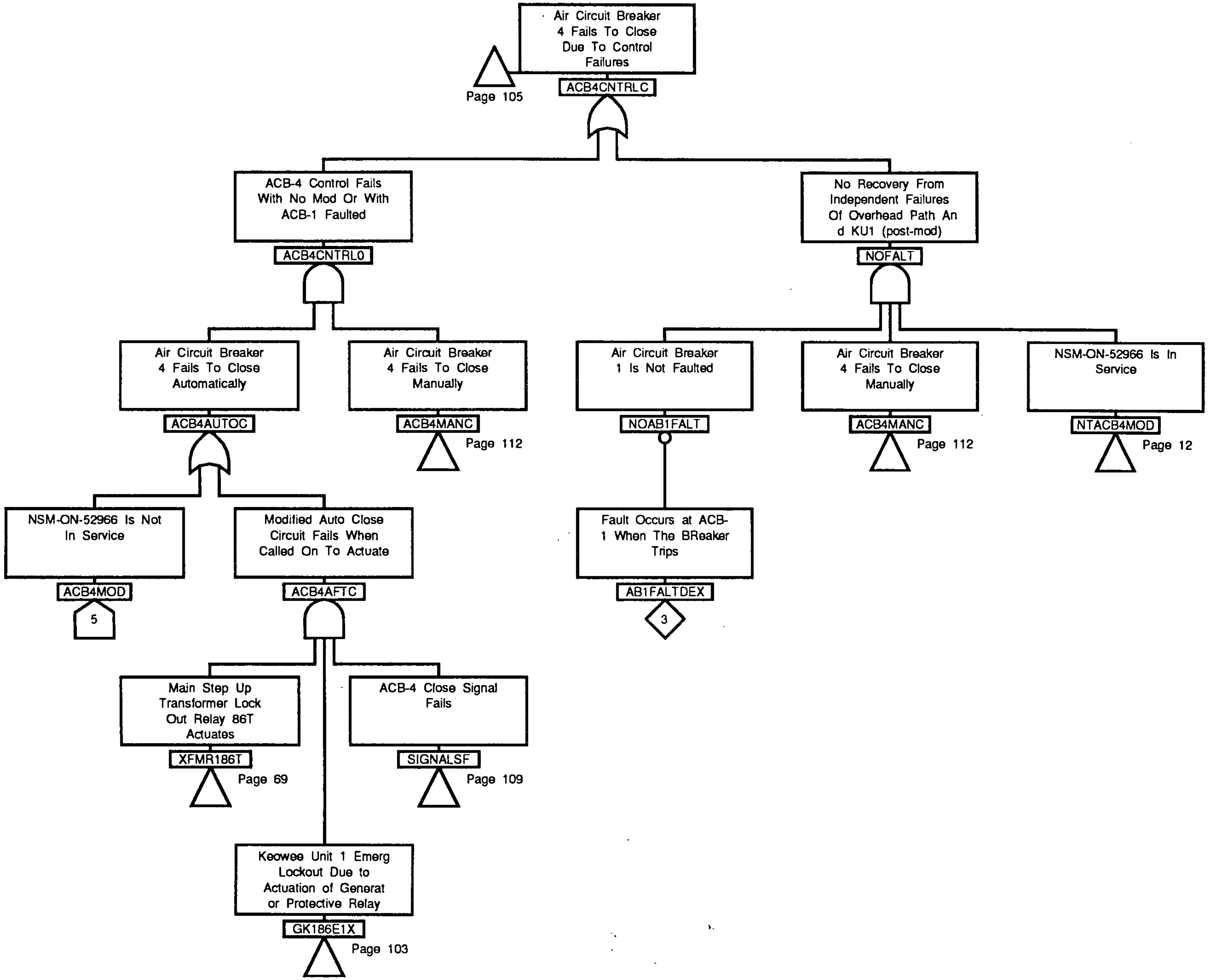
Air Circuit Breaker 3 Transfers Open
ACB3TRANS
Page 2
Page 188
Air Circuit Breaker 3 Trip Coil Spurious Operation
AB352TCSVT
Air Circuit Breaker 3 Trip Signal
ACB3TRIP
Air Circuit Breaker 3 Relay 52Z Spurious Operation
AB3R52ZR6T
Underground Feeder Lockout Relay 86EF Picks Up
U86EF
Page 103
Keowee Unit 1 Emerg Lockout Due to Actuation of Generat or Protective Relay
GK186E1
Page 21
Control Switch 152-3 Spurious Operation
AB31523SWT
Trip Pushbutton On ACB3 Spurious Operation
AB3PUSHPBT
KU1 Trip Circuit Modifications Result In Spurious Trip
K1MODTRIP
Operators Trip Generator Output ACBs
ACBTRIPCHE
2
NSM-ON-52966 Is In Service
NTACB4MOD
Page 12
Trip Signal From Mod Package Components
K1MODTRIP0
Page 104

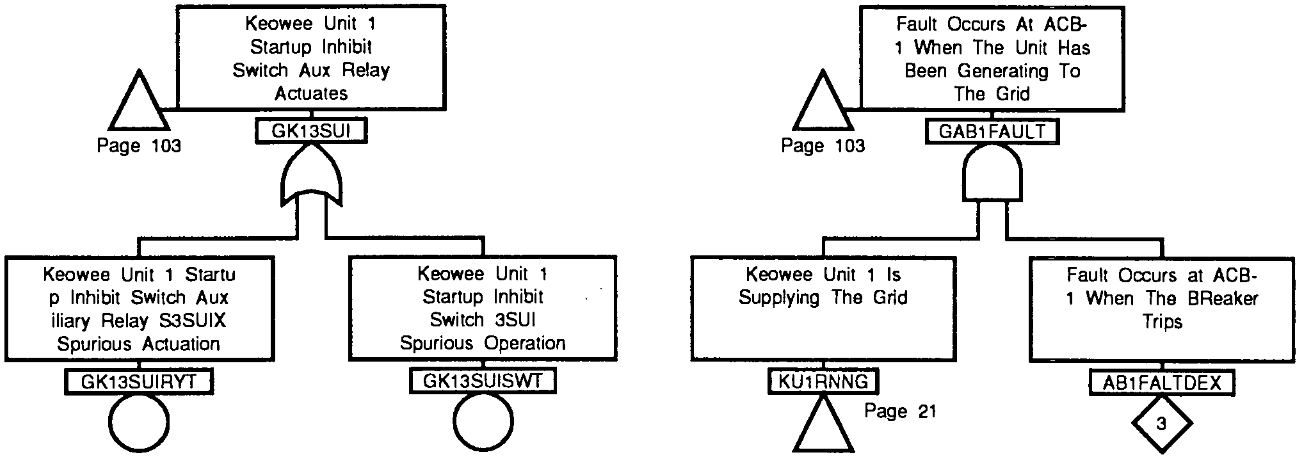

Underground Feeder Lockout Relay 86EF Picks Up
U86EF
Page 1
Page 102
Page 180
Overcurrent Relay 50 Spuriously Actuates Lockout Rly 86EF
U5086EFRYT
Transformer CT4 Failed
UACXCT4THF
Time Delay Overcurrent Relay 51 Actuates Lockout Relay 86EF
U5186EFRYT
Lockout Relay 86EF Spuriously Picks Up
UXX86EFRYT
Spurious Op of CT4 Differential Rly 87T Actuates LOR 86EF
U87TCT4RYT
Auxiliary Lockout Relay 86CT4X Spuriously Picks Up
U86CT4XRYT
CT4 Neutral Ground Rly Actuates CT4 LOR 86T/CT4
U51TNC4RYT
SK1 Breaker Failure Relay 62BXSK1 Spuriously Picks Up
U62BSK1RYT
CT4 Lockout Relay 86T/CT4 Spuriously Picks Up
U86TCT4RYT
SK2 Breaker Failure Relay 62BXSK2 Spuriously Picks Up
U62BSK2RYT
Keowee Unit 1 Emerg Lockout Due to Actuation of Generat or Protective Relay
GK186E1X
Page 106
Page 21
Keowee Unit 1 Generator Ground Fault Relay 59GN1 Spurious Actuation
GK159GNRYT
Keowee Unit 1 Loss Of Generator Field Relay 40G1 Spurious Actuation
GK140G1RYT
Keowee Unit 1 Exitat ion Transformer Diff erential Relay 87T-1 E Spur. Actuation
GK187TERYT
Keowee Unit 1 Generator Bus Differ ential Relay 87GB Sp urious Actuation
GK187GBRYT
Keowee Unit 1 Generator Differenti al Relay 87G-1 Spuri ous Actuation
GK187G1RYT
Keowee Unit 1 Startup Inhibit Switch Aux Relay Actuates
GK13SUI
Page 107
Keowee Unit 1 Generator Backup Trip Timer 62-1TD Spurious Operation
GK162TDRYT
Fault Occurs At ACB-1 When The Unit Has Been Generating To The Grid
GAB1FAULT
Page 107
Keowee Unit 1 Generator Fire Relay 63FX Actuates
GK163FX
Page 104
KU1 Trip Circuit Modifications Result In Spurious Trip
GK1MODTRIP
Page 108



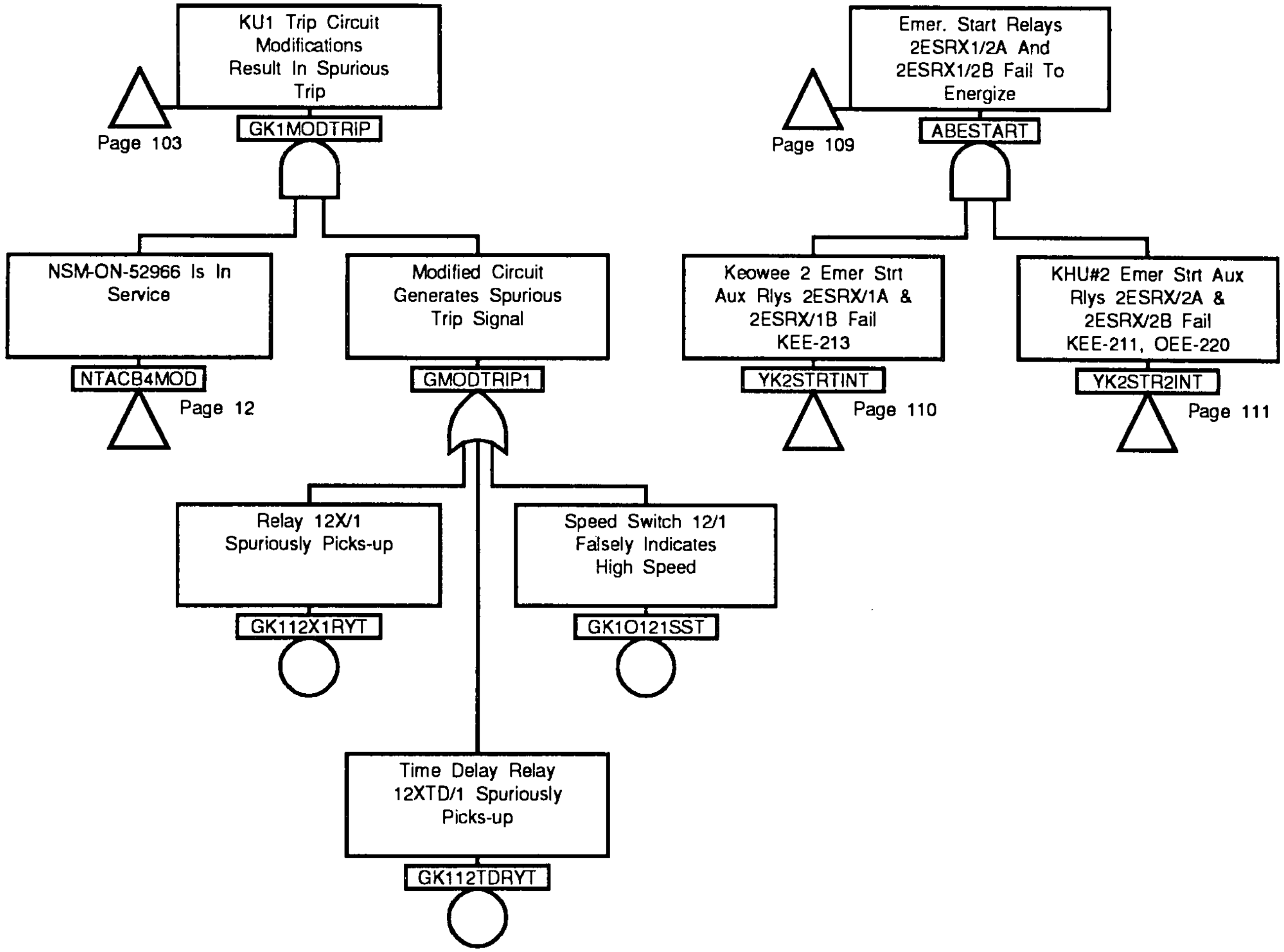
Trip Signal From Mod Package Components
K1MODTRIP0
Page 102
Auxiliary Relay 14GOV/1X Fails To Pick-up
AK1141XRYD
KU1 Magnetic Speed Switch System Fails
AK114GVDEX
2
Keowee Unit 1 Generator Fire Relay 63FX Actuates
GK163FX
Page 103
Keowee Unit 1 Generator Fire Relay 63FX Spurious Actuation
GK163FXRYT
Keowee 1 Gen CO2 Sys Press Switch 63F Spurious Operation
GK1063FPST

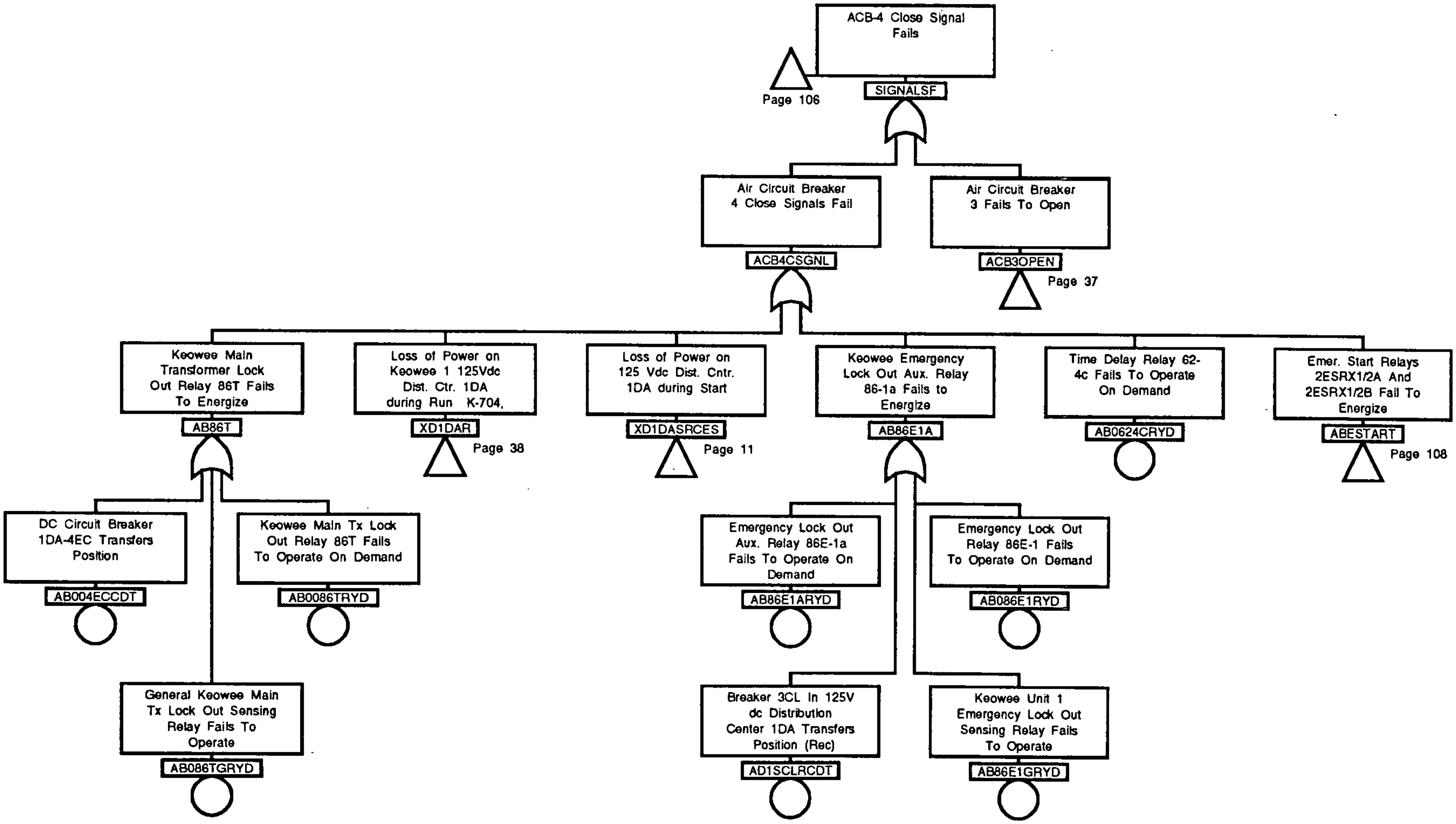

The Underground Supply Is Not Recovered By Using Keowee Unit 2
KU2REC
Page 1
Air Circuit Breaker 4 Fails To Connect Unit 2 To The Underground Path
ACB4CLOSE
Keowee Unit 2 Fails To Start Or Run
KU2OVER
Page 70
The Overhead Unit (2) Is Unavailable Due To Maintenance
KK2UNITHYM
5
Air Circuit Breaker 4 Transfers Open
ACB4TRANS
Page 180
Air Circuit Breaker 4 Fails To Close Due To Mechanical Failure
AB4MCH2DEX
Air Circuit Breaker 4 Fails To Close Due To Electrical Failures
ACB4ELECC
Air Circuit Breaker 4 Accumulator Air Pressure Low
AB4ACCUDEX
Air Circuit Breaker 4 Fails To Close Due To A Latent Human Error
AB4CLOSLHE
Common Cause Failure Of ACBs 2 And 4
AB24COM
Page 113
Air Circuit Breaker 4 Key Interlock Switch Transfers Open
AB4KEYISWT
ACB Air Supply Fails Causing Low Pressure In All ACB Accumulators
ACBAIRPDEX
2
Air Circuit Breaker 4 Fails To Close Due To Electrical Failures Of The Breaker
ACB4BREAKC
Air Circuit Breaker 4 Fails To Close Due To Control Failures
ACB4CNTRLC
Page 106
Air Circuit Breaker 4 Control Power Fails
ACB4DCPWR
Page 112
Air Circuit Breaker 4 Relay 52X Fails To Operate
AB4R52XR6D
Air Circuit Breaker 4 Y-relay Spurious Operation
AB452Y2R6T
Air Circuit Breaker 4 Close Coil Fails To Operate
AB452CCSVO
Air Circuit Breaker 4 Relay 52Y Failed To Drop Out Following Last Demand
AB452Y2R6D
Air Circuit Breaker 4 Accumulator Pressure Switch PS2 Indicates Low Pressure
AB4PS02PST


Air Circuit Breaker 4 Fails To Close Due To Control Failures
Page 105
ACB4CNTRLC
ACB-4 Control Fails With No Mod Or With ACB-1 Faulted
ACB4CNTRL0
No Recovery From Independent Failures Of Overhead Path An d KU1 (post-mod)
NOFALT
Air Circuit Breaker 4 Fails To Close Automatically
ACB4AUTOC
Air Circuit Breaker 4 Fails To Close Manually
ACB4MANC
Page 112
Air Circuit Breaker 1 Is Not Faulted
NOAB1FALT
Air Circuit Breaker 4 Fails To Close Manually
ACB4MANC
Page 112
NSM-ON-52966 Is In Service
NTACB4MOD
Page 12
NSM-ON-52966 Is Not In Service
ACB4MOD
5
Modified Auto Close Circuit Fails When Called On To Actuate
ACB4AFTC
Fault Occurs at ACB-1 When The BReaker Trips
AB1FALTDEX
3
Main Step Up Transformer Lock Out Relay 86T Actuates
XFMR186T
Page 69
ACB-4 Close Signal Fails
SIGNALSF
Page 109
Keowee Unit 1 Emerg Lockout Due to Actuation of Generat or Protective Relay
GK186E1X
Page 103

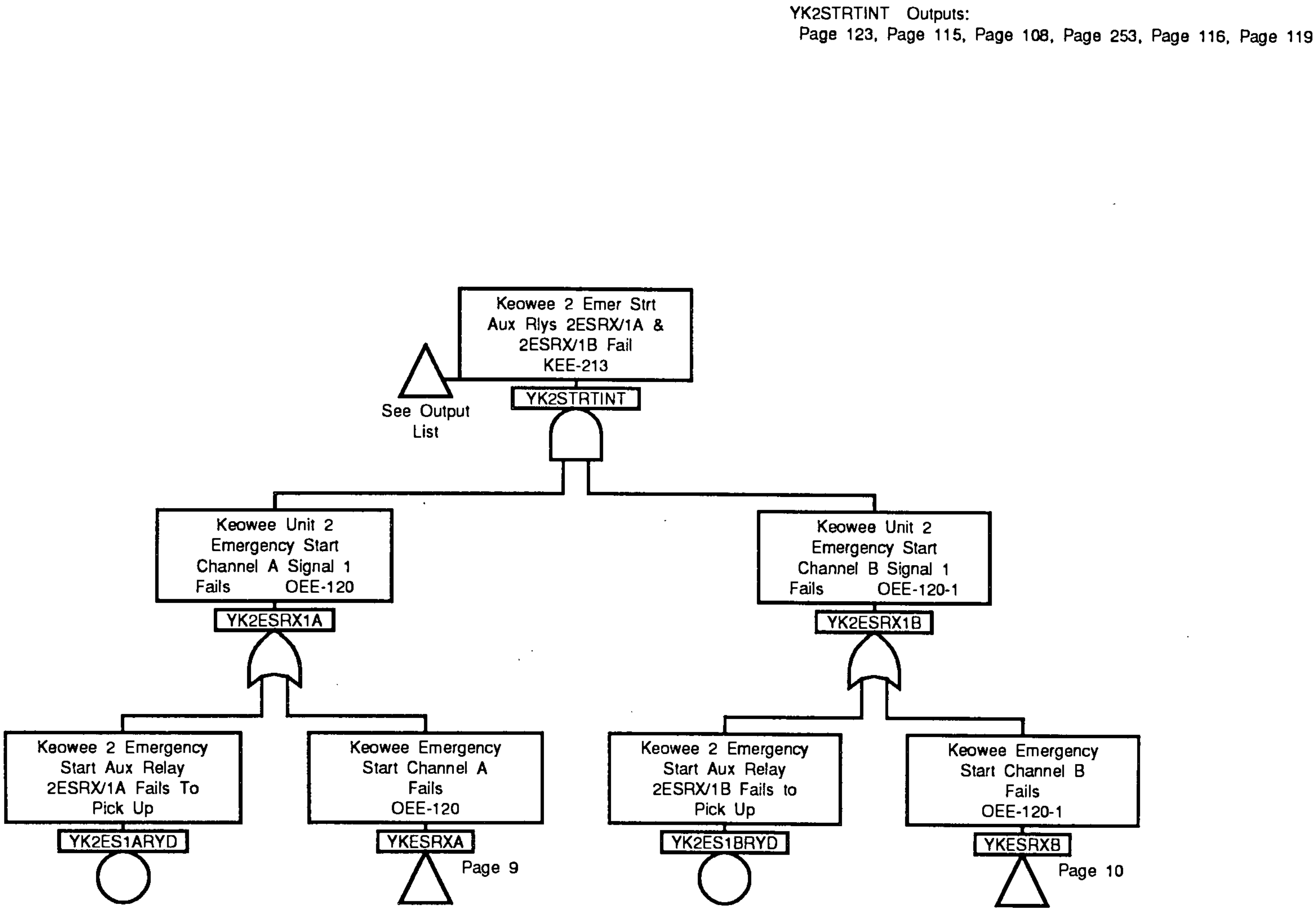


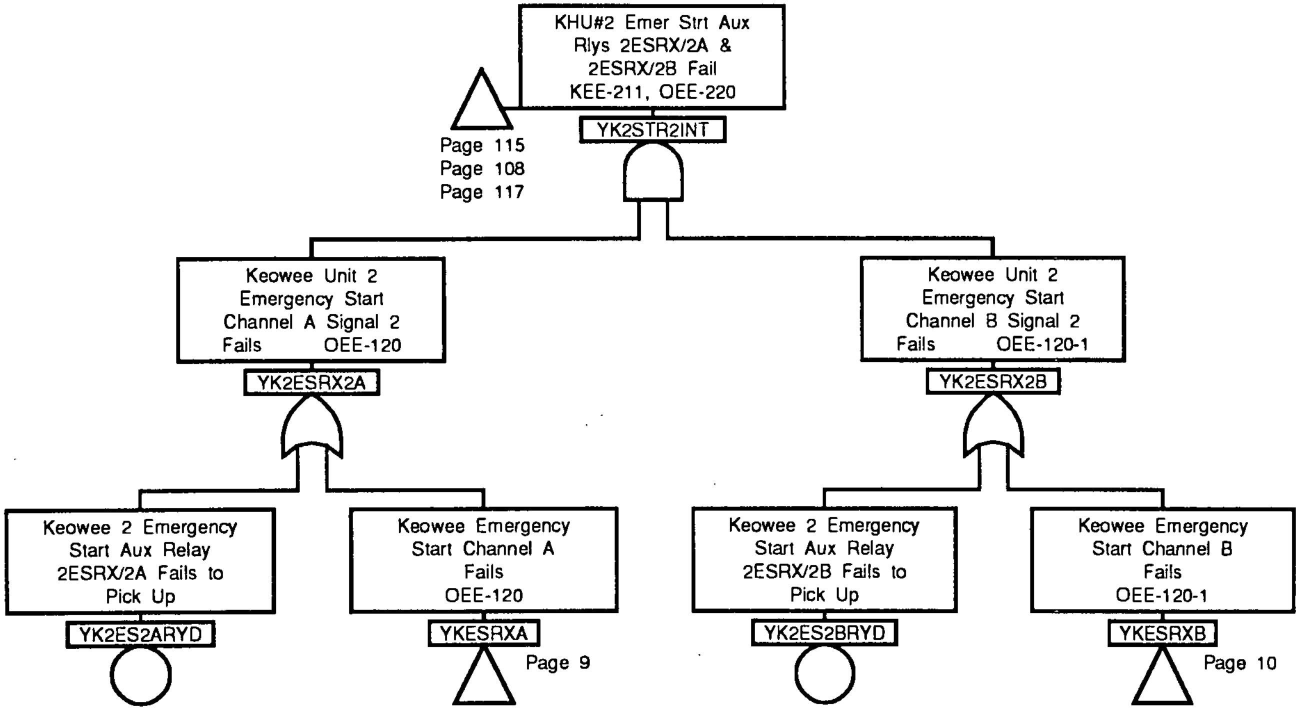
Keowee Unit 1 Startup Inhibit Switch Aux Relay Actuates
Page 103
GK13SUI
Keowee Unit 1 Startu p Inhibit Switch Aux iliary Relay S3SUIX Spurious Actuation
GK13SUIRYT
Keowee Unit 1 Startup Inhibit Switch 3SUI Spurious Operation
GK13SUISWT
Fault Occurs At ACB-1 When The Unit Has Been Generating To The Grid
Page 103
GAB1FAULT
Keowee Unit 1 Is Supplying The Grid
KU1RNNG
Page 21
Fault Occurs at ACB-1 When The BReaker Trips
AB1FALTDEX
3

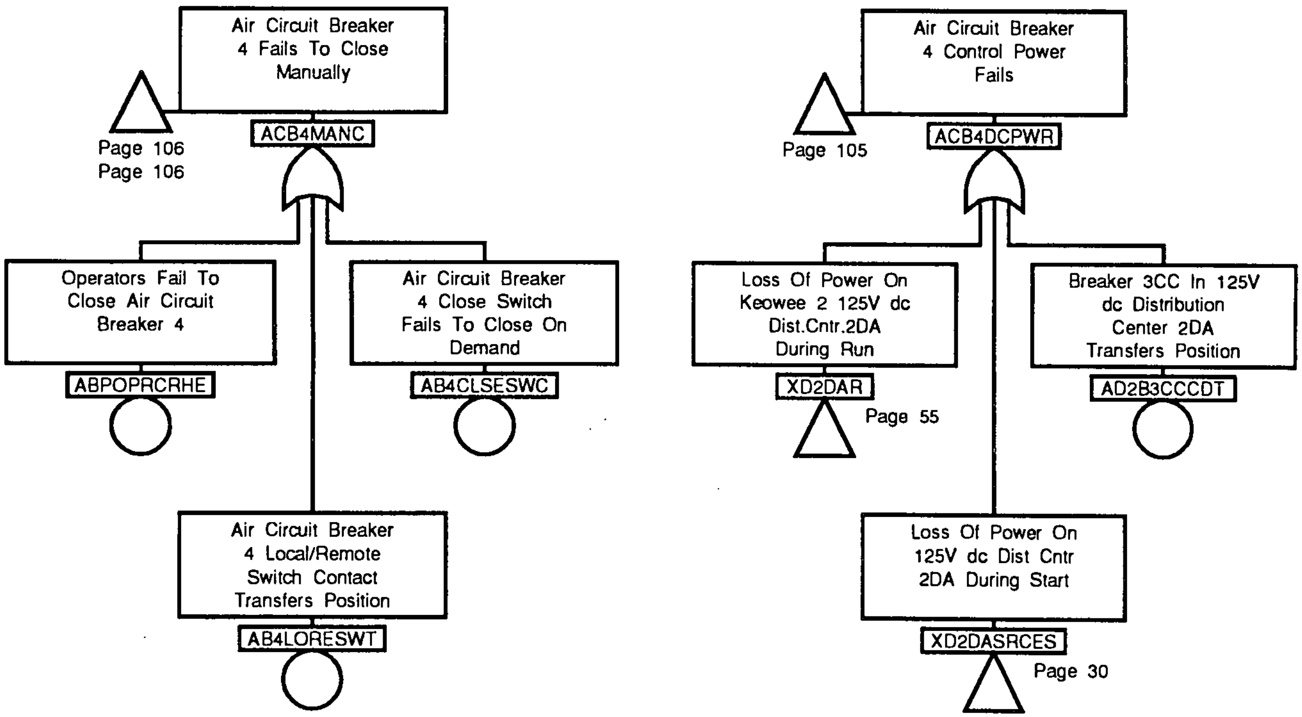

KU1 Trip Circuit Modifications Result In Spurious Trip
GK1MODTRIP
Page 103
Emer. Start Relays 2ESRX1/2A And 2ESRX1/2B Fail To Energize
ABESTART
Page 109
NSM-ON-52966 Is In Service
NTACB4MOD
Page 12
Modified Circuit Generates Spurious Trip Signal
GMODTRIP1
Keowee 2 Emer Strt Aux Rlys 2ESRX/1A & 2ESRX/1B Fail KEE-213
YK2STRTINT
Page 110
KHU#2 Emer Strt Aux Rlys 2ESRX/2A & 2ESRX/2B Fail KEE-211, OEE-220
YK2STR2INT
Page 111
Relay 12X/1 Spuriously Picks-up
GK112X1RYT
Speed Switch 12/1 Falsely Indicates High Speed
GK1O121SST
Time Delay Relay 12XTD/1 Spuriously Picks-up
GK112TDRYT

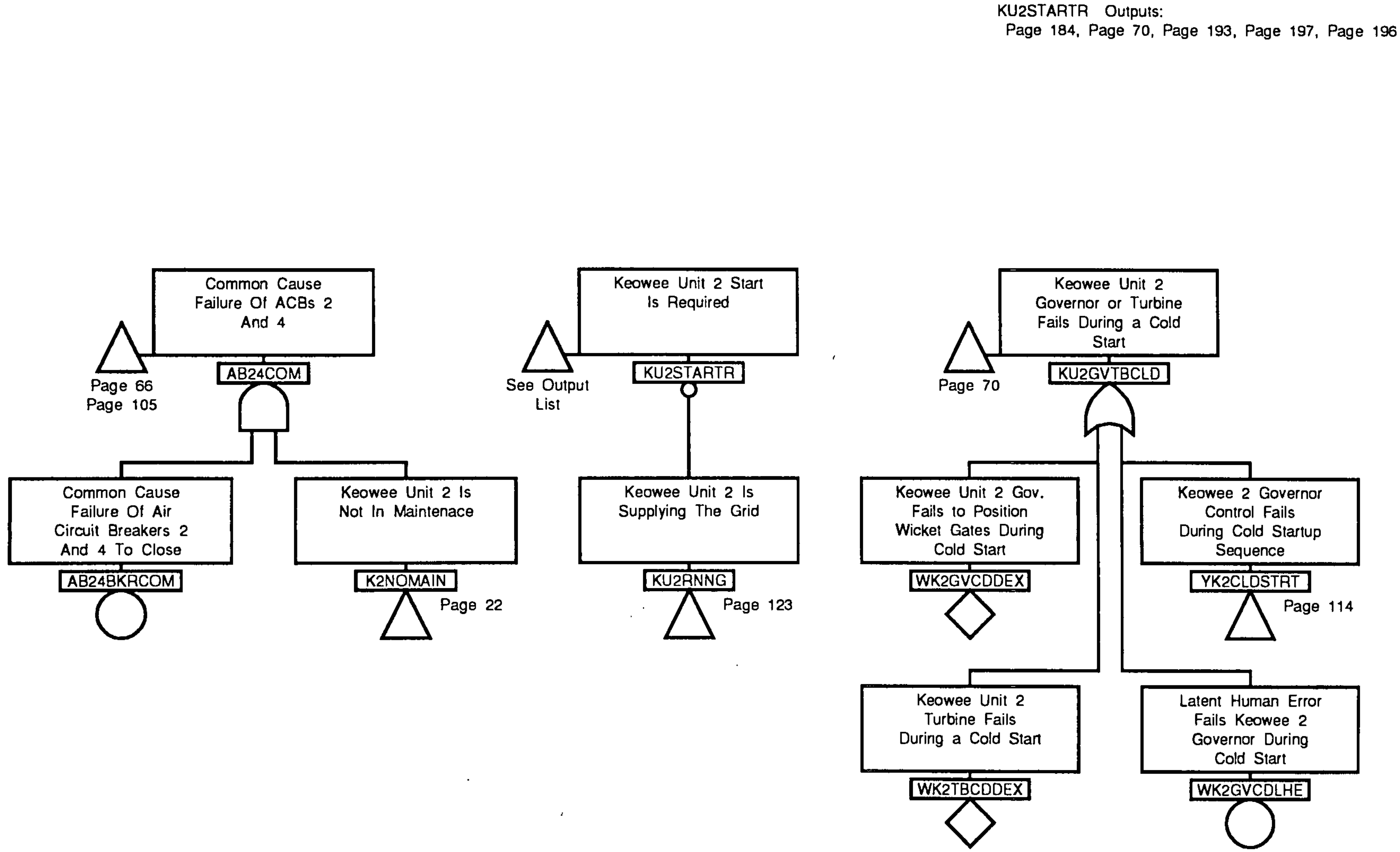


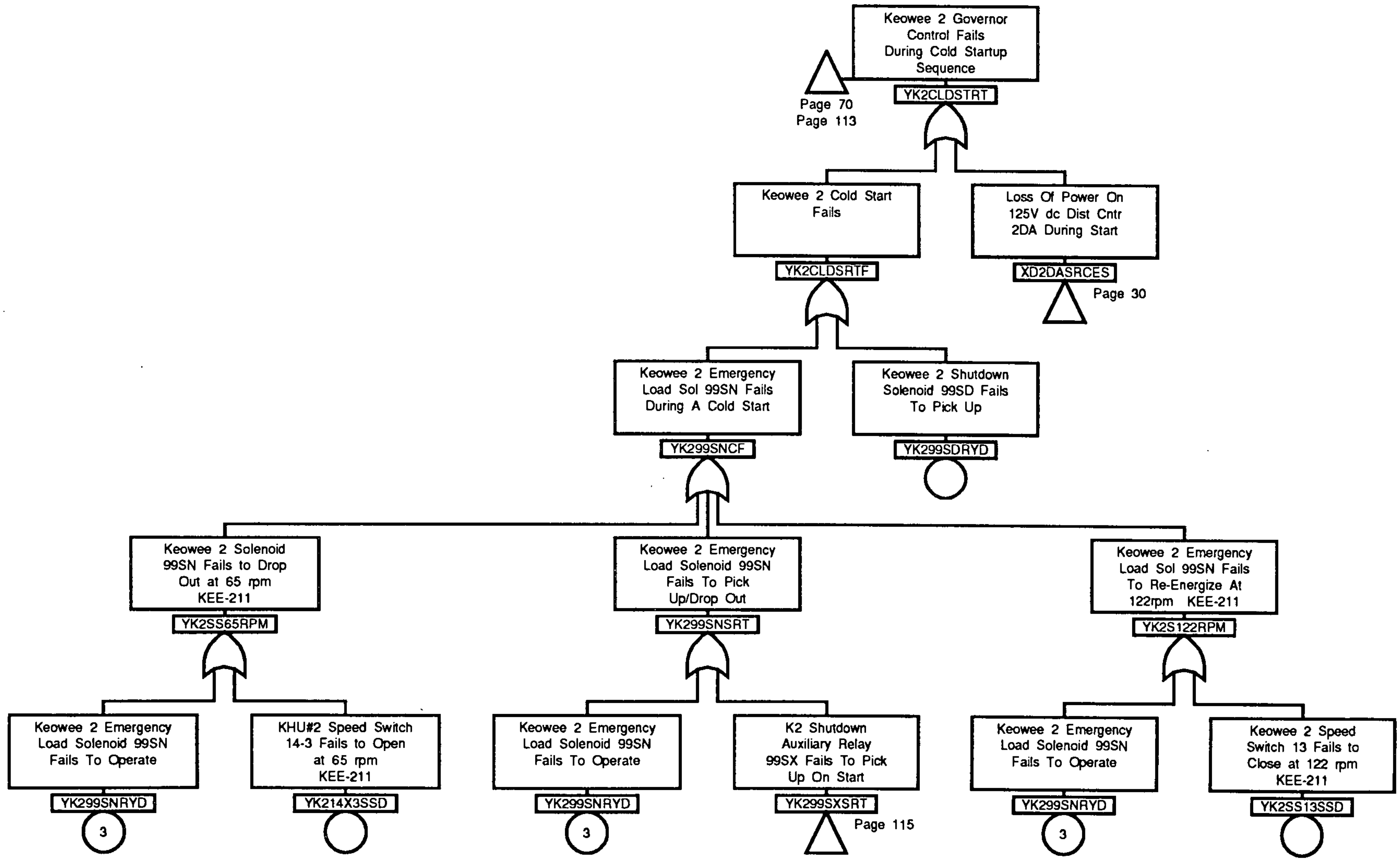
ACB-4 Close Signal Fails
SIGNALSF
Page 106
Air Circuit Breaker 4 Close Signals Fail
ACB4CSGNL
Air Circuit Breaker 3 Fails To Open
ACB3OPEN
Page 37
Keowee Main Transformer Lock Out Relay 86T Fails To Energize
AB86T
Loss of Power on Keowee 1 125Vdc Dist. Ctr. 1DA during Run K-704,
XD1DAR
Page 38
Loss of Power on 125 Vdc Dist. Cntr. 1DA during Start
XD1DASRCES
Page 11
Keowee Emergency Lock Out Aux. Relay 86-1a Fails to Energize
AB86E1A
Time Delay Relay 62-4c Fails To Operate On Demand
AB0624CRYD
Emer. Start Relays 2ESRX1/2A And 2ESRX1/2B Fail To Energize
ABESTART
Page 108
DC Circuit Breaker 1DA-4EC Transfers Position
AB004ECCDT
Keowee Main Tx Lock Out Relay 86T Fails To Operate On Demand
AB0086TRYD
General Keowee Main Tx Lock Out Sensing Relay Fails To Operate
AB086TGRYD
Emergency Lock Out Aux. Relay 86E-1a Fails To Operate On Demand
AB86E1ARYD
Emergency Lock Out Relay 86E-1 Fails To Operate On Demand
AB086E1RYD
Breaker 3CL In 125V dc Distribution Center 1DA Transfers Position (Rec)
AD1SCLRCDT
Keowee Unit 1 Emergency Lock Out Sensing Relay Fails To Operate
AB86E1GRYD


YK2STRTINT Outputs:
Page 123, Page 115, Page 108, Page 253, Page 116, Page 119
Keowee 2 Emer Strt Aux Rlys 2ESRX/1A & 2ESRX/1B Fail KEE-213
YK2STRTINT
See Output List
Keowee Unit 2 Emergency Start Channel A Signal 1 Fails OEE-120
YK2ESRX1A
Keowee Unit 2 Emergency Start Channel B Signal 1 Fails OEE-120-1
YK2ESRX1B
Keowee 2 Emergency Start Aux Relay 2ESRX/1A Fails To Pick Up
YK2ES1ARYD
Keowee Emergency Start Channel A Fails OEE-120
YKESRXA
Page 9
Keowee 2 Emergency Start Aux Relay 2ESRX/1B Fails to Pick Up
YK2ES1BRYD
Keowee Emergency Start Channel B Fails OEE-120-1
YKESRXB
Page 10

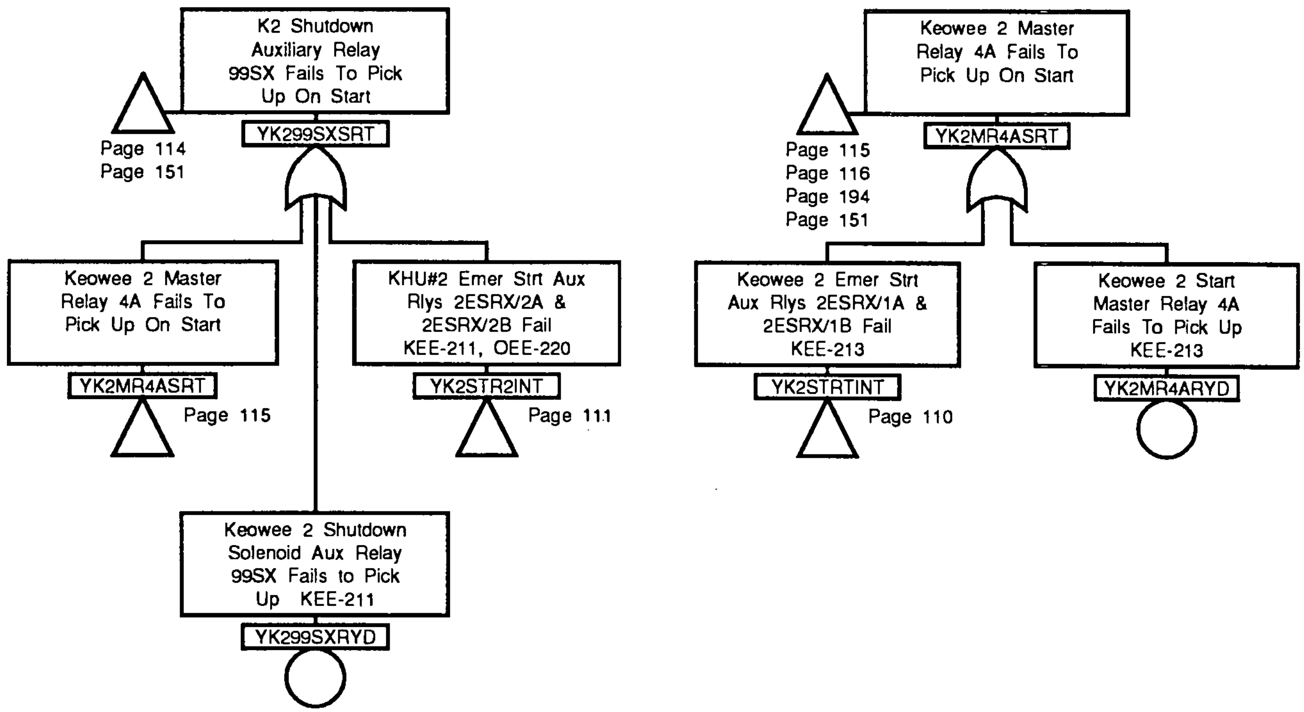

KHU#2 Emer Strt Aux Rlys 2ESRX/2A & 2ESRX/2B Fail KEE-211, OEE-220
YK2STR2INT
Page 115
Page 108
Page 117
Keowee Unit 2 Emergency Start Channel A Signal 2 Fails OEE-120
YK2ESRX2A
Keowee Unit 2 Emergency Start Channel B Signal 2 Fails OEE-120-1
YK2ESRX2B
Keowee 2 Emergency Start Aux Relay 2ESRX/2A Fails to Pick Up
YK2ES2ARYD
Keowee Emergency Start Channel A Fails OEE-120
YKESRXA
Page 9
Keowee 2 Emergency Start Aux Relay 2ESRX/2B Fails to Pick Up
YK2ES2BRYD
Keowee Emergency Start Channel B Fails OEE-120-1
YKESRXB
Page 10

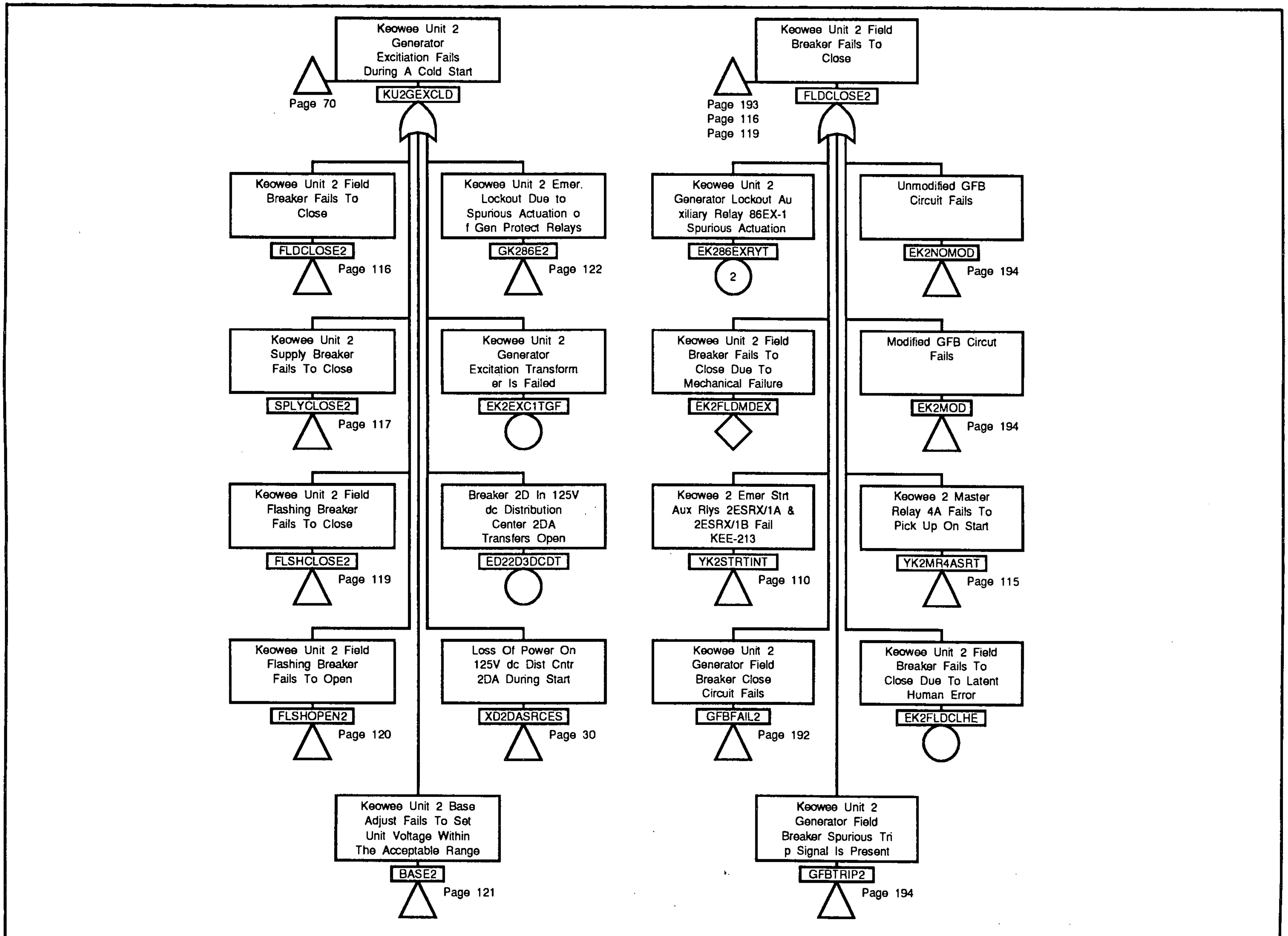

Air Circuit Breaker 4 Fails To Close Manually
ACB4MANC
Page 106
Page 106
Operators Fail To Close Air Circuit Breaker 4
ABPOPRCRHE
Air Circuit Breaker 4 Close Switch Fails To Close On Demand
AB4CLSESWC
Air Circuit Breaker 4 Local/Remote Switch Contact Transfers Position
AB4LORESWT
Air Circuit Breaker 4 Control Power Fails
ACB4DCPWR
Page 105
Loss Of Power On Keowee 2 125V dc Dist.Cntr.2DA During Run
XD2DAR
Page 55
Breaker 3CC In 125V dc Distribution Center 2DA Transfers Position
AD2B3CCCDT
Loss Of Power On 125V dc Dist Cntr 2DA During Start
XD2DASRCES
Page 30


KU2STARTR Outputs:
Page 184, Page 70, Page 193, Page 197, Page 196
Common Cause Failure Of ACBs 2 And 4
Page 66
Page 105
AB24COM
Common Cause Failure Of Air Circuit Breakers 2 And 4 To Close
AB24BKRCOM
Keowee Unit 2 Is Not In Maintenace
K2NOMAIN
Page 22
Keowee Unit 2 Start Is Required
See Output List
KU2STARTR
Keowee Unit 2 Is Supplying The Grid
KU2RNNG
Page 123
Keowee Unit 2 Governor or Turbine Fails During a Cold Start
Page 70
KU2GVTBCLD
Keowee Unit 2 Gov. Fails to Position Wicket Gates During Cold Start
WK2GVCDDEX
Keowee 2 Governor Control Fails During Cold Startup Sequence
YK2CLDSTRT
Page 114
Keowee Unit 2 Turbine Fails During a Cold Start
WK2TBCDDEX
Latent Human Error Fails Keowee 2 Governor During Cold Start
WK2GVCDLHE

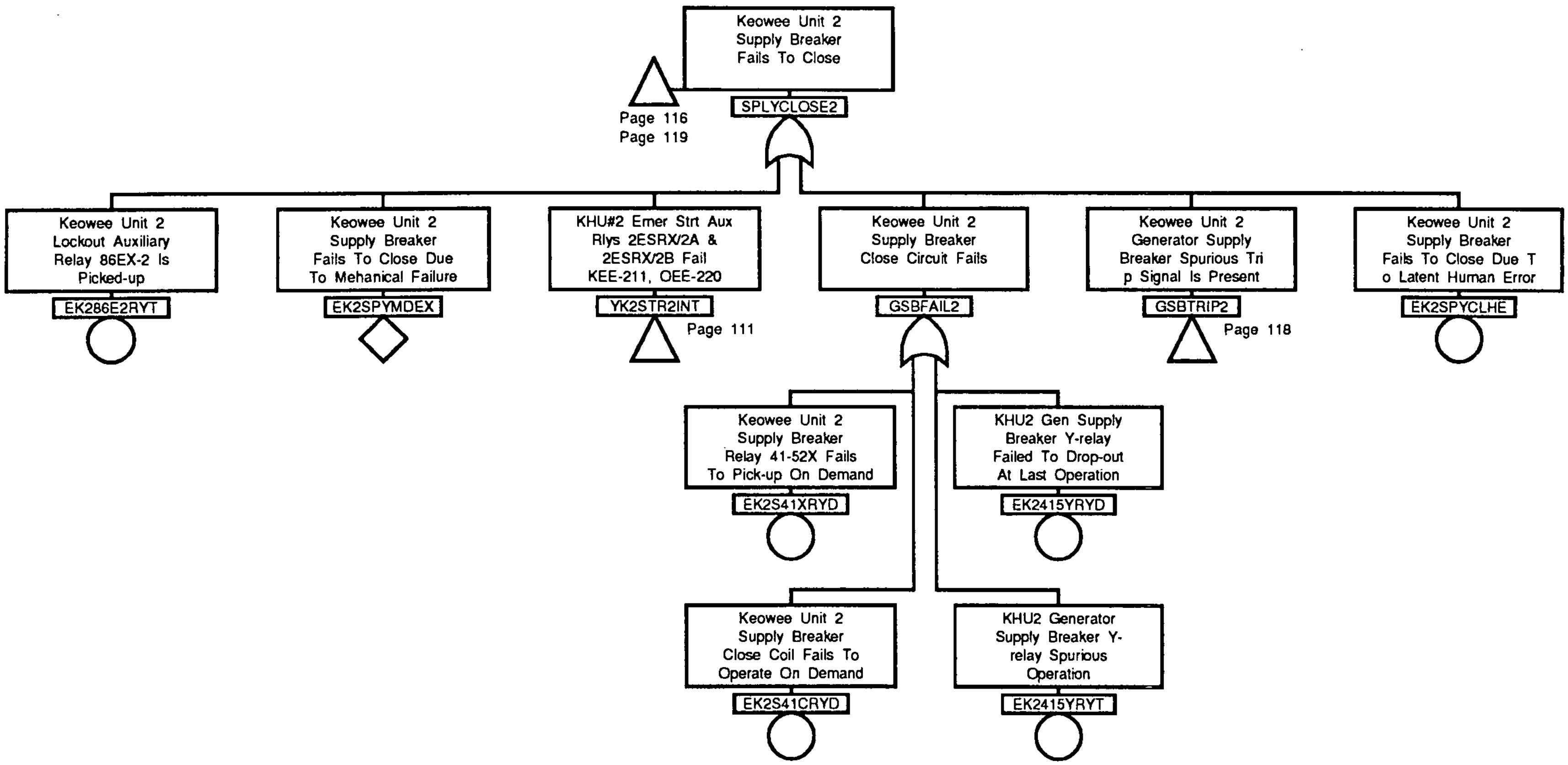


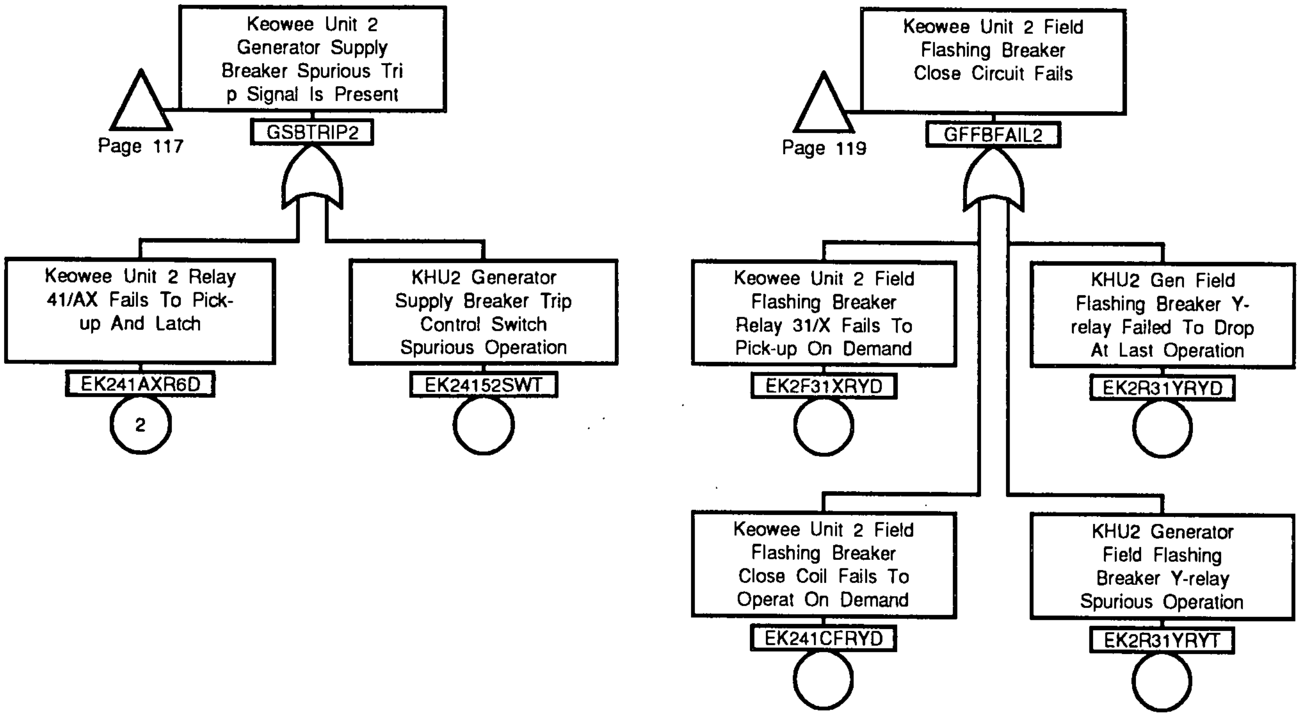
Keowee 2 Governor Control Fails During Cold Startup Sequence
YK2CLDSTRT
Page 70
Page 113
Keowee 2 Cold Start Fails
YK2CLDSRTF
Loss Of Power On 125V dc Dist Cntr 2DA During Start
XD2DASRCES
Page 30
Keowee 2 Emergency Load Sol 99SN Fails During A Cold Start
YK299SNCF
Keowee 2 Shutdown Solenoid 99SD Fails To Pick Up
YK299SDRYD
Keowee 2 Solenoid 99SN Fails to Drop Out at 65 rpm KEE-211
YK2SS65RPM
Keowee 2 Emergency Load Solenoid 99SN Fails To Pick Up/Drop Out
YK299SNSRT
Keowee 2 Emergency Load Sol 99SN Fails To Re-Energize At 122rpm KEE-211
YK2S122RPM
Keowee 2 Emergency Load Solenoid 99SN Fails To Operate
YK299SNRYD
3
KHU#2 Speed Switch 14-3 Fails to Open at 65 rpm KEE-211
YK214X3SSD
Keowee 2 Emergency Load Solenoid 99SN Fails To Operate
YK299SNRYD
3
K2 Shutdown Auxiliary Relay 99SX Fails To Pick Up On Start
YK299SXSRT
Page 115
Keowee 2 Emergency Load Solenoid 99SN Fails To Operate
YK299SNRYD
3
Keowee 2 Speed Switch 13 Fails to Close at 122 rpm KEE-211
YK2SS13SSD


K2 Shutdown Auxiliary Relay 99SX Fails To Pick Up On Start
YK299SXSRT
Page 114
Page 151
Keowee 2 Master Relay 4A Fails To Pick Up On Start
YK2MR4ASRT
Page 115
KHU#2 Emer Strt Aux Rlys 2ESRX/2A & 2ESRX/2B Fail KEE-211, OEE-220
YK2STR2INT
Page 111
Keowee 2 Shutdown Solenoid Aux Relay 99SX Fails to Pick Up KEE-211
YK299SXRYD
Keowee 2 Master Relay 4A Fails To Pick Up On Start
YK2MR4ASRT
Page 115
Page 116
Page 194
Page 151
Keowee 2 Emer Strt Aux Rlys 2ESRX/1A & 2ESRX/1B Fail KEE-213
YK2STRTINT
Page 110
Keowee 2 Start Master Relay 4A Fails To Pick Up KEE-213
YK2MR4ARYD

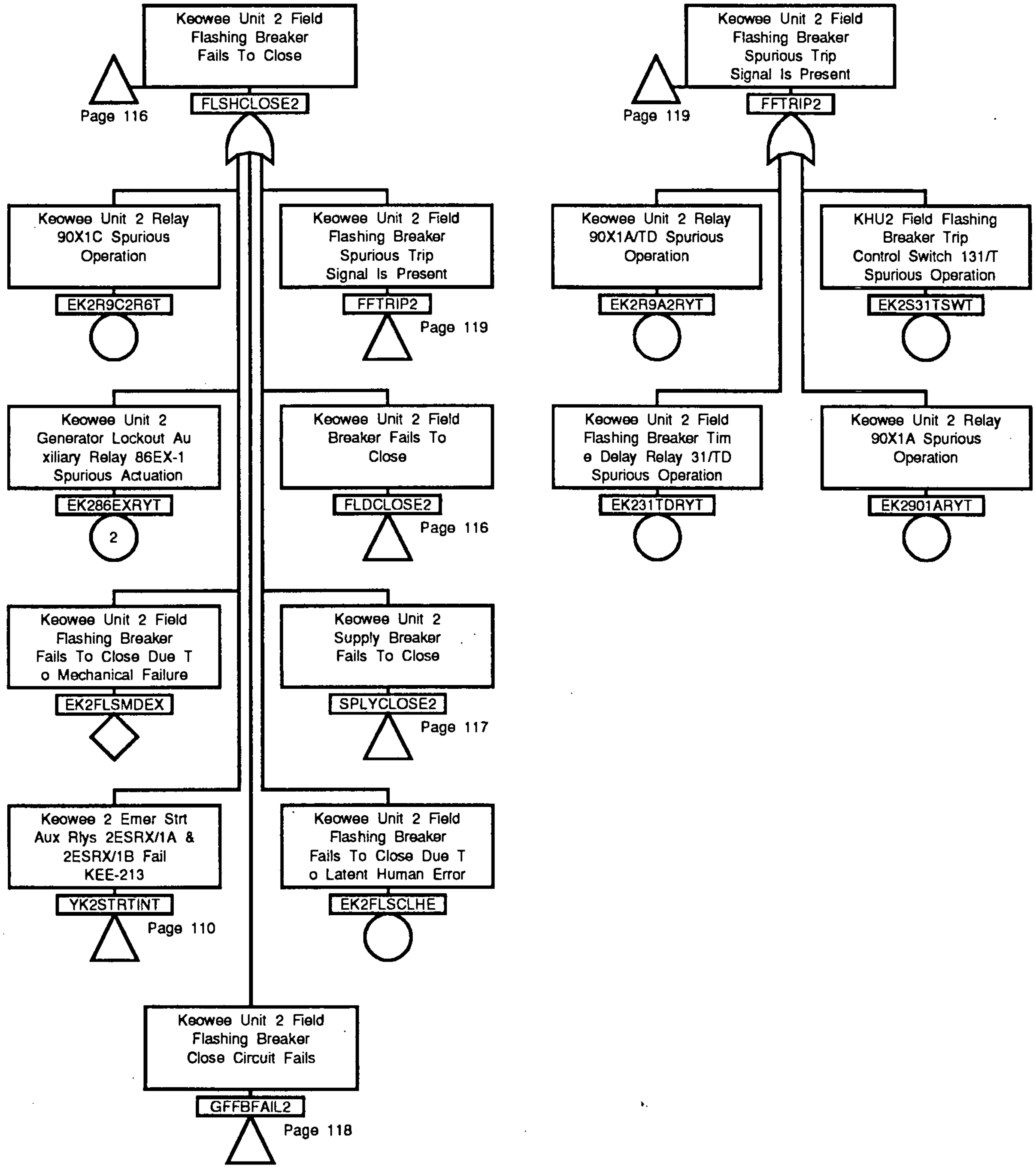


Keowee Unit 2 Generator Excitiation Fails During A Cold Start
KU2GEXCLD
Page 70
Keowee Unit 2 Field Breaker Fails To Close
FLDCLOSE2
Page 116
Keowee Unit 2 Emer. Lockout Due to Spurious Actuation of Gen Protect Relays
GK286E2
Page 122
Keowee Unit 2 Supply Breaker Fails To Close
SPLYCLOSE2
Page 117
Keowee Unit 2 Generator Excitation Transformer Is Failed
EK2EXC1TGF
Keowee Unit 2 Field Flashing Breaker Fails To Close
FLSHCLOSE2
Page 119
Breaker 2D In 125V dc Distribution Center 2DA Transfers Open
ED22D3DCDT
Keowee Unit 2 Field Flashing Breaker Fails To Open
FLSHOPEN2
Page 120
Loss Of Power On 125V dc Dist Cntr 2DA During Start
XD2DASRCES
Page 30
Keowee Unit 2 Base Adjust Fails To Set Unit Voltage Within The Acceptable Range
BASE2
Page 121
Keowee Unit 2 Field Breaker Fails To Close
FLDCLOSE2
Page 193
Page 116
Page 119
Keowee Unit 2 Generator Lockout Auxiliary Relay 86EX-1 Spurious Actuation
EK286EXRYT
2
Unmodified GFB Circuit Fails
EK2NOMOD
Page 194
Keowee Unit 2 Field Breaker Fails To Close Due To Mechanical Failure
EK2FLDMDEX
Modified GFB Circut Fails
EK2MOD
Page 194
Keowee 2 Emer Strt Aux Rlys 2ESRX/1A & 2ESRX/1B Fail KEE-213
YK2STRTINT
Page 110
Keowee 2 Master Relay 4A Fails To Pick Up On Start
YK2MR4ASRT
Page 115
Keowee Unit 2 Generator Field Breaker Close Circuit Fails
GFBFAIL2
Page 192
Keowee Unit 2 Field Breaker Fails To Close Due To Latent Human Error
EK2FLDCLHE
Keowee Unit 2 Generator Field Breaker Spurious Trip Signal Is Present
GFBTRIP2
Page 194

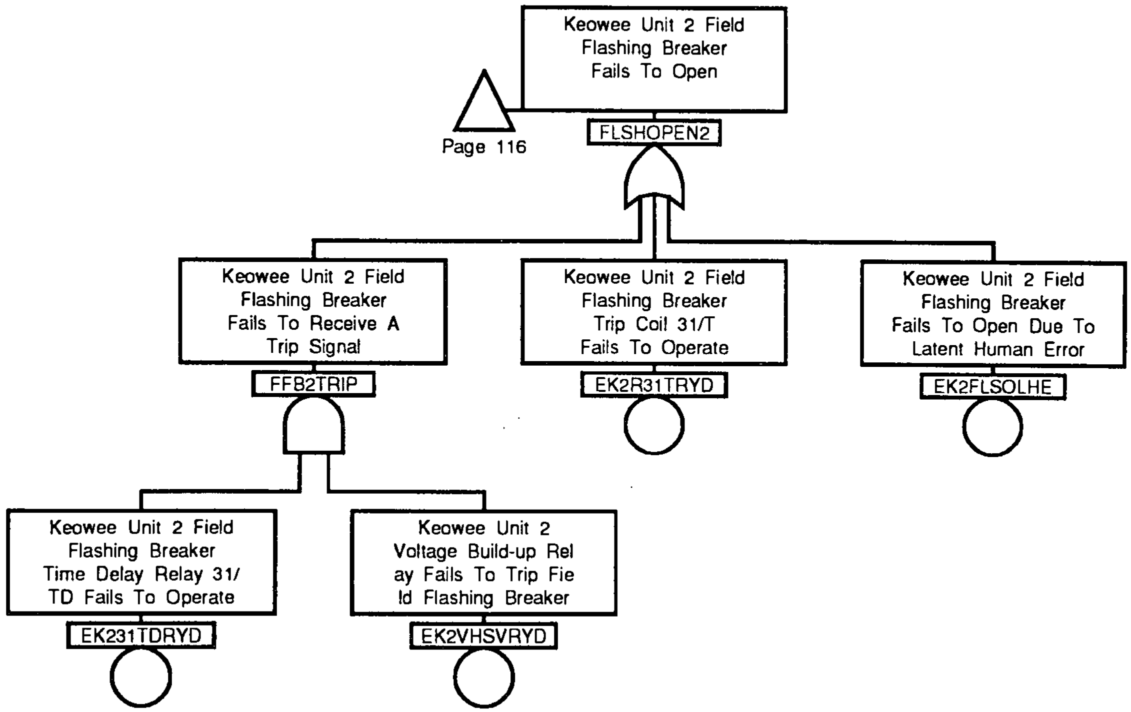

Keowee Unit 2 Supply Breaker Fails To Close
SPLYCLOSE2
Page 116
Page 119
Keowee Unit 2 Lockout Auxiliary Relay 86EX-2 Is Picked-up
EK286E2RYT
Keowee Unit 2 Supply Breaker Fails To Close Due To Mehanical Failure
EK2SPYMDEX
KHU#2 Emer Strt Aux Rlys 2ESRX/2A & 2ESRX/2B Fail KEE-211, OEE-220
YK2STR2INT
Page 111
Keowee Unit 2 Supply Breaker Close Circuit Fails
GSBFAIL2
Keowee Unit 2 Generator Supply Breaker Spurious Tri p Signal Is Present
GSBTRIP2
Page 118
Keowee Unit 2 Supply Breaker Fails To Close Due T o Latent Human Error
EK2SPYCLHE
Keowee Unit 2 Supply Breaker Relay 41-52X Fails To Pick-up On Demand
EK2S41XRYD
KHU2 Gen Supply Breaker Y-relay Failed To Drop-out At Last Operation
EK2415YRYD
Keowee Unit 2 Supply Breaker Close Coil Fails To Operate On Demand
EK2S41CRYD
KHU2 Generator Supply Breaker Y-relay Spurious Operation
EK2415YRYT



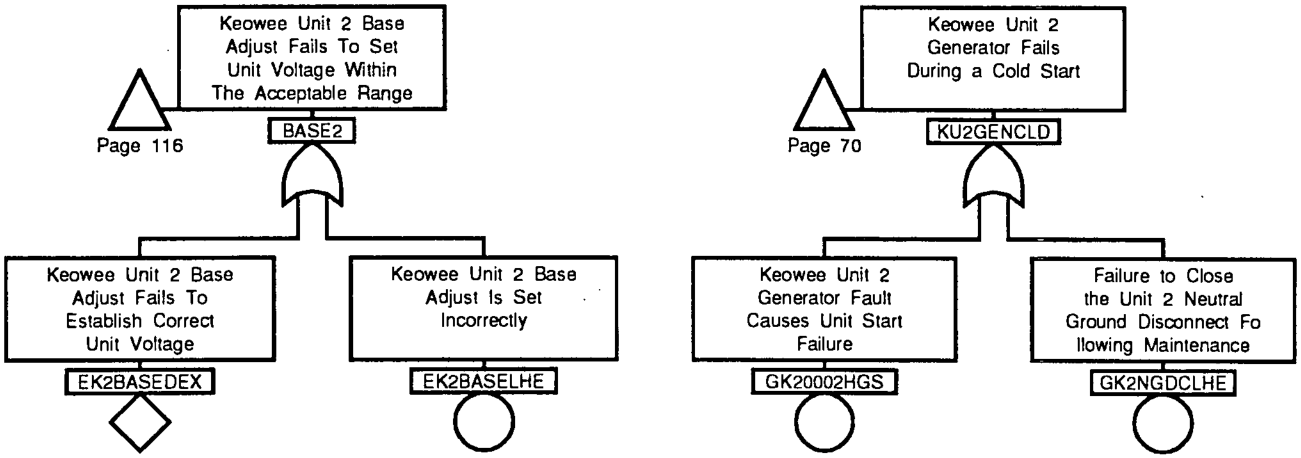
Keowee Unit 2 Generator Supply Breaker Spurious Tri p Signal Is Present
GSBTRIP2
Page 117
Keowee Unit 2 Relay 41/AX Fails To Pick-up And Latch
EK241AXR6D
2
KHU2 Generator Supply Breaker Trip Control Switch Spurious Operation
EK24152SWT
Keowee Unit 2 Field Flashing Breaker Close Circuit Fails
GFFBFAIL2
Page 119
Keowee Unit 2 Field Flashing Breaker Relay 31/X Fails To Pick-up On Demand
EK2F31XRYD
KHU2 Gen Field Flashing Breaker Y-relay Failed To Drop At Last Operation
EK2R31YRYD
Keowee Unit 2 Field Flashing Breaker Close Coil Fails To Operat On Demand
EK241CFRYD
KHU2 Generator Field Flashing Breaker Y-relay Spurious Operation
EK2R31YRYT

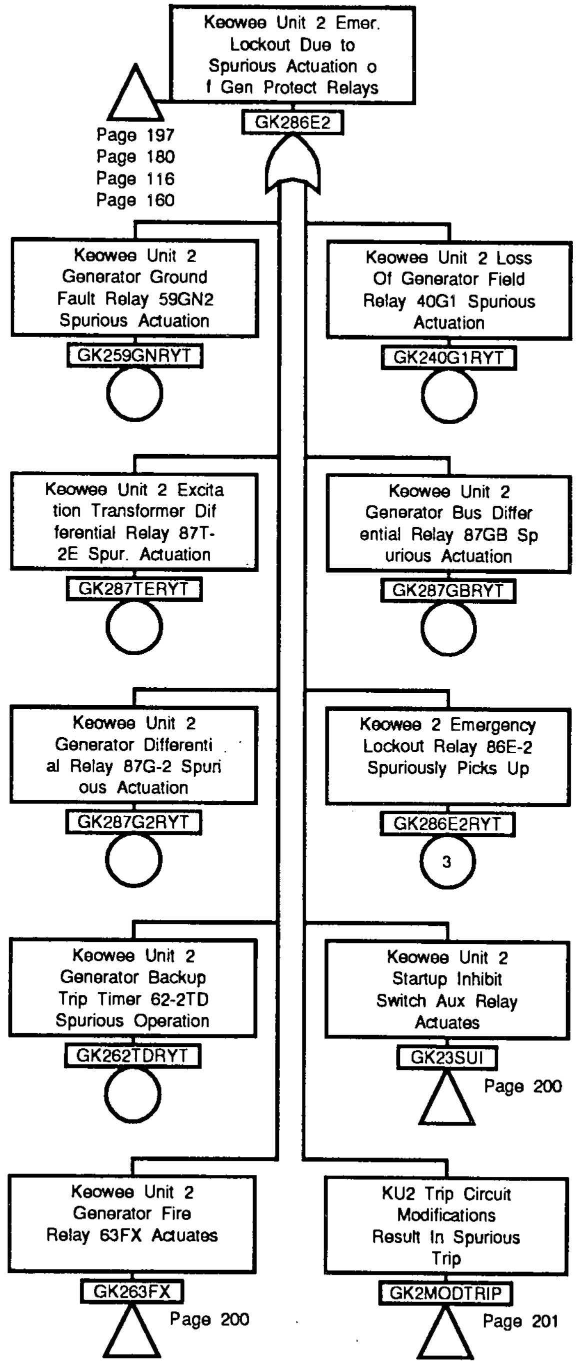


Keowee Unit 2 Field Flashing Breaker Fails To Close
FLSHCLOSE2
Page 116
Keowee Unit 2 Relay 90X1C Spurious Operation
EK2R9C2R6T
Keowee Unit 2 Field Flashing Breaker Spurious Trip Signal Is Present
FFTRIP2
Page 119
Keowee Unit 2 Generator Lockout Auxiliary Relay 86EX-1 Spurious Actuation
EK286EXRYT
2
Keowee Unit 2 Field Breaker Fails To Close
FLDCLOSE2
Page 116
Keowee Unit 2 Field Flashing Breaker Fails To Close Due To Mechanical Failure
EK2FLSMDEX
Keowee Unit 2 Supply Breaker Fails To Close
SPLYCLOSE2
Page 117
Keowee 2 Emer Strt Aux Rlys 2ESRX/1A & 2ESRX/1B Fail KEE-213
YK2STRTINT
Page 110
Keowee Unit 2 Field Flashing Breaker Fails To Close Due To Latent Human Error
EK2FLSCLHE
Keowee Unit 2 Field Flashing Breaker Close Circuit Fails
GFFBFAIL2
Page 118
Keowee Unit 2 Field Flashing Breaker Spurious Trip Signal Is Present
FFTRIP2
Page 119
Keowee Unit 2 Relay 90X1A/TD Spurious Operation
EK2R9A2RYT
KHU2 Field Flashing Breaker Trip Control Switch 131/T Spurious Operation
EK2S31TSWT
Keowee Unit 2 Field Flashing Breaker Time Delay Relay 31/TD Spurious Operation
EK231TDRYT
Keowee Unit 2 Relay 90X1A Spurious Operation
EK2901ARYT

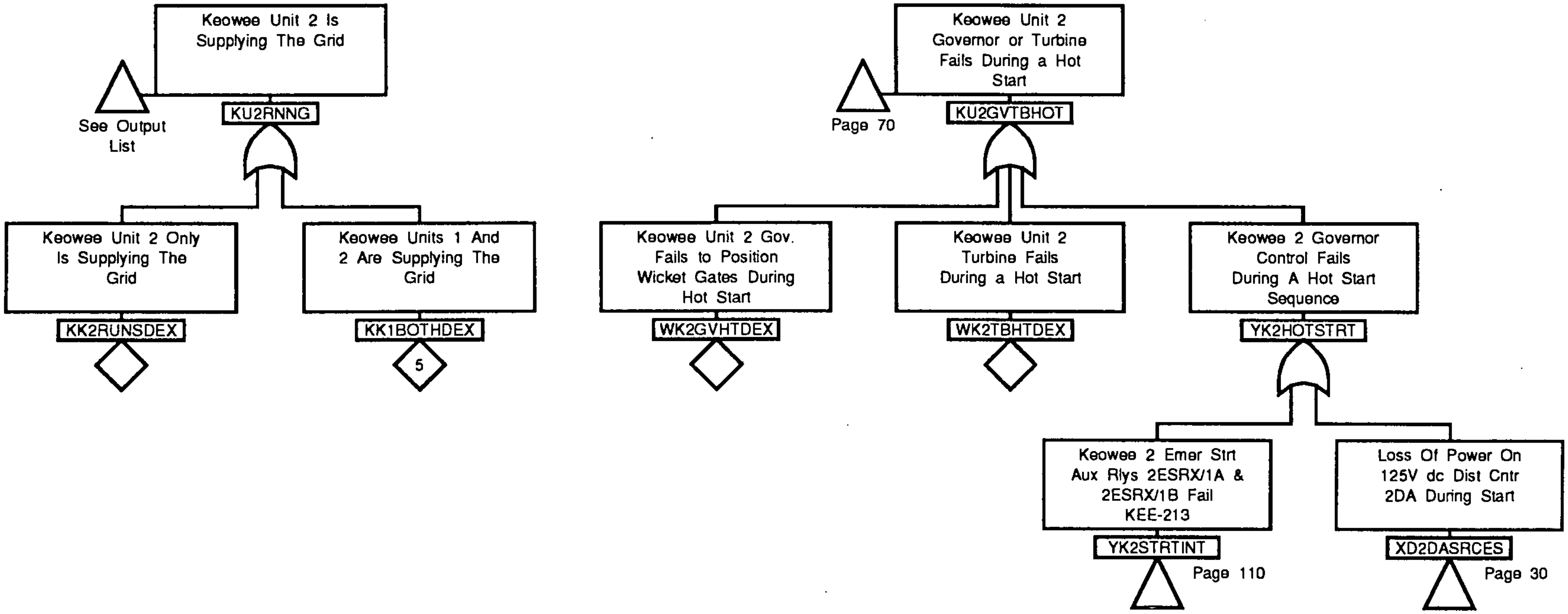


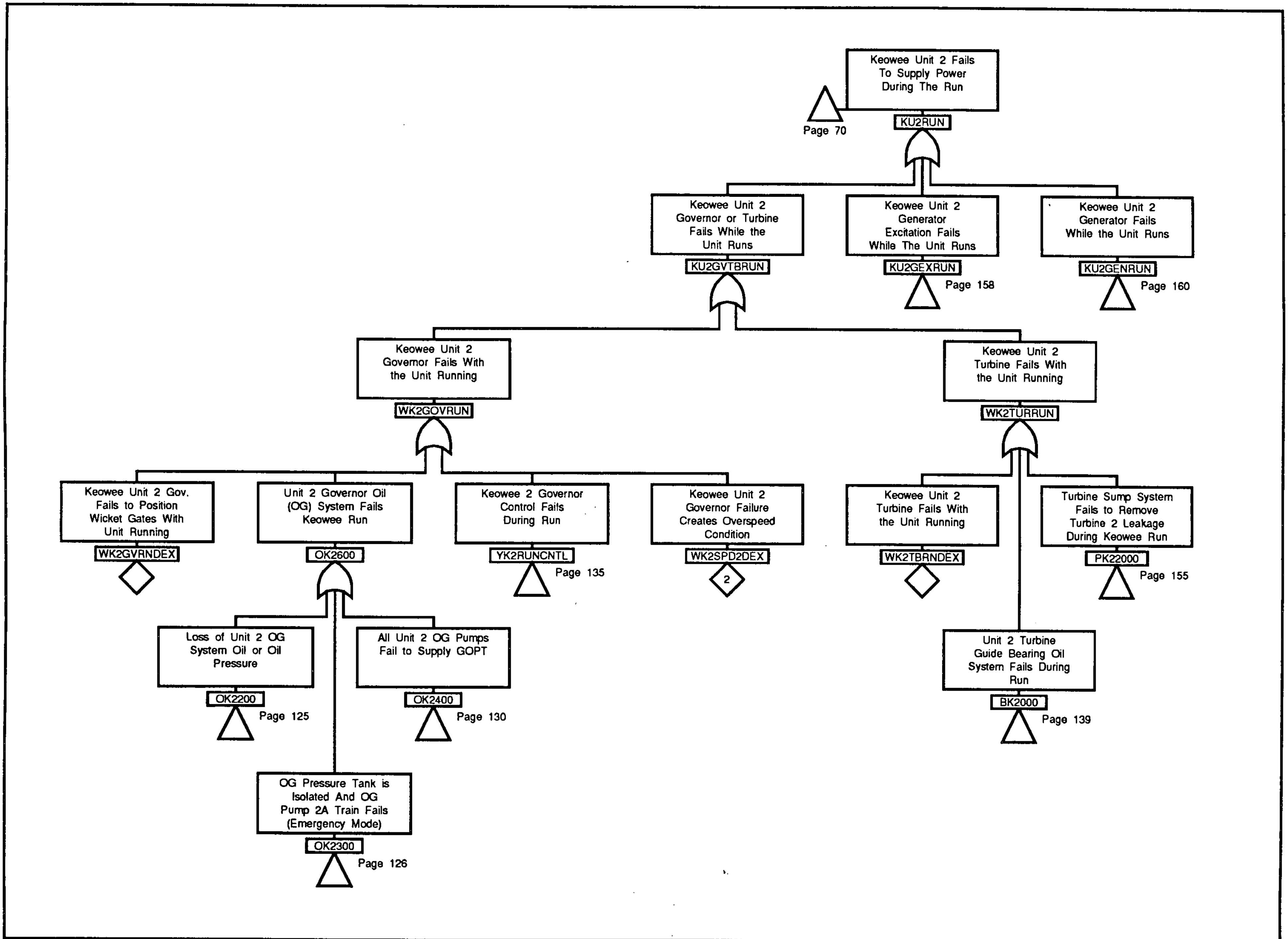
Keowee Unit 2 Field Flashing Breaker Fails To Open
FLSHOPEN2
Page 116
Keowee Unit 2 Field Flashing Breaker Fails To Receive A Trip Signal
FFB2TRIP
Keowee Unit 2 Field Flashing Breaker Trip Coil 31/T Fails To Operate
EK2R31TRYD
Keowee Unit 2 Field Flashing Breaker Fails To Open Due To Latent Human Error
EK2FLSOLHE
Keowee Unit 2 Field Flashing Breaker Time Delay Relay 31/ TD Fails To Operate
EK231TDRYD
Keowee Unit 2 Voltage Build-up Rel ay Fails To Trip Fie ld Flashing Breaker
EK2VHSVRYD

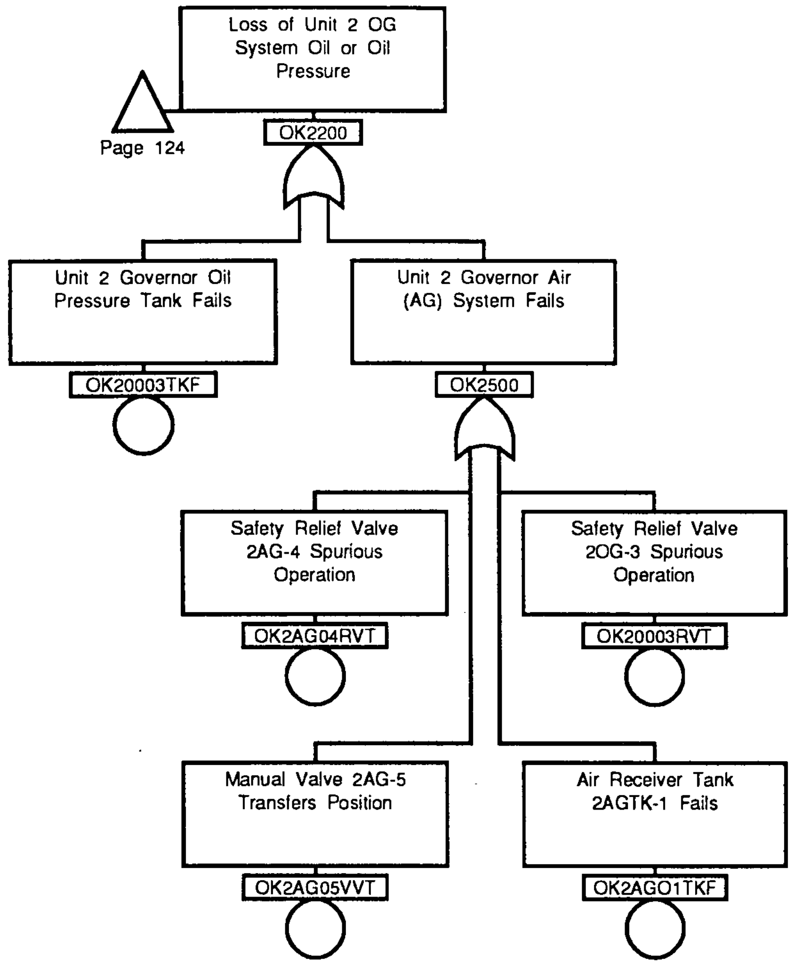

Keowee Unit 2 Base Adjust Fails To Set Unit Voltage Within The Acceptable Range
BASE2
Page 116
Keowee Unit 2 Base Adjust Fails To Establish Correct Unit Voltage
EK2BASEDEX
Keowee Unit 2 Base Adjust Is Set Incorrectly
EK2BASELHE
Keowee Unit 2 Generator Fails During a Cold Start
KU2GENCLD
Page 70
Keowee Unit 2 Generator Fault Causes Unit Start Failure
GK20002HGS
Failure to Close the Unit 2 Neutral Ground Disconnect Fo llowing Maintenance
GK2NGDCLHE


Keowee Unit 2 Emer. Lockout Due to Spurious Actuation o f Gen Protect Relays
GK286E2
Page 197
Page 180
Page 116
Page 160
Keowee Unit 2 Generator Ground Fault Relay 59GN2 Spurious Actuation
GK259GNRYT
Keowee Unit 2 Loss Of Generator Field Relay 40G1 Spurious Actuation
GK240G1RYT
Keowee Unit 2 Excita tion Transformer Dif ferential Relay 87T-2E Spur. Actuation
GK287TERYT
Keowee Unit 2 Generator Bus Differ ential Relay 87GB Sp urious Actuation
GK287GBRYT
Keowee Unit 2 Generator Differenti al Relay 87G-2 Spuri ous Actuation
GK287G2RYT
Keowee 2 Emergency Lockout Relay 86E-2 Spuriously Picks Up
GK286E2RYT
3
Keowee Unit 2 Generator Backup Trip Timer 62-2TD Spurious Operation
GK262TDRYT
Keowee Unit 2 Startup Inhibit Switch Aux Relay Actuates
GK23SUI
Page 200
Keowee Unit 2 Generator Fire Relay 63FX Actuates
GK263FX
Page 200
KU2 Trip Circuit Modifications Result In Spurious Trip
GK2MODTRIP
Page 201

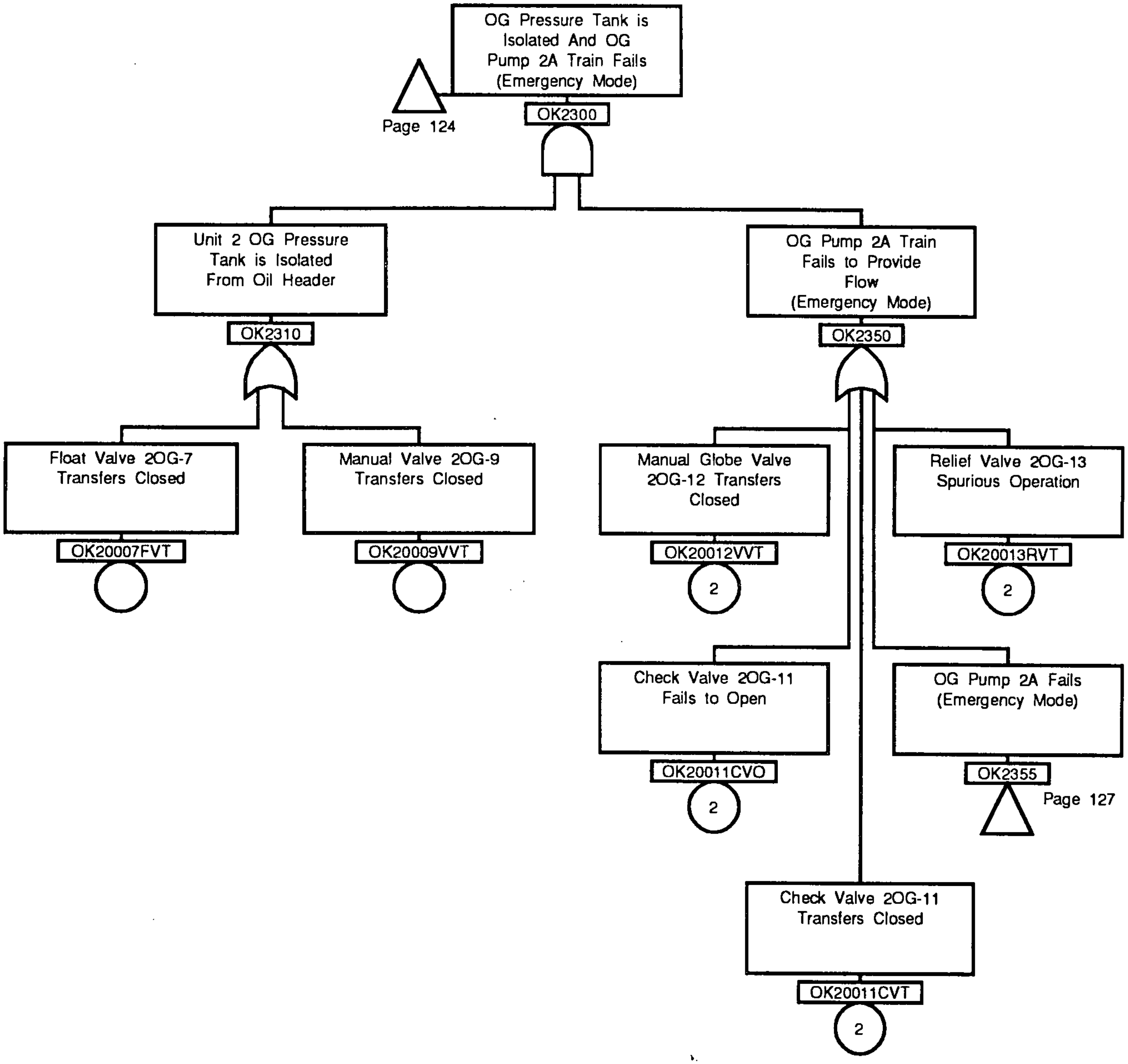
KU2RNNG Outputs:
Page 113, Page 70, Page 215, Page 253, Page 196



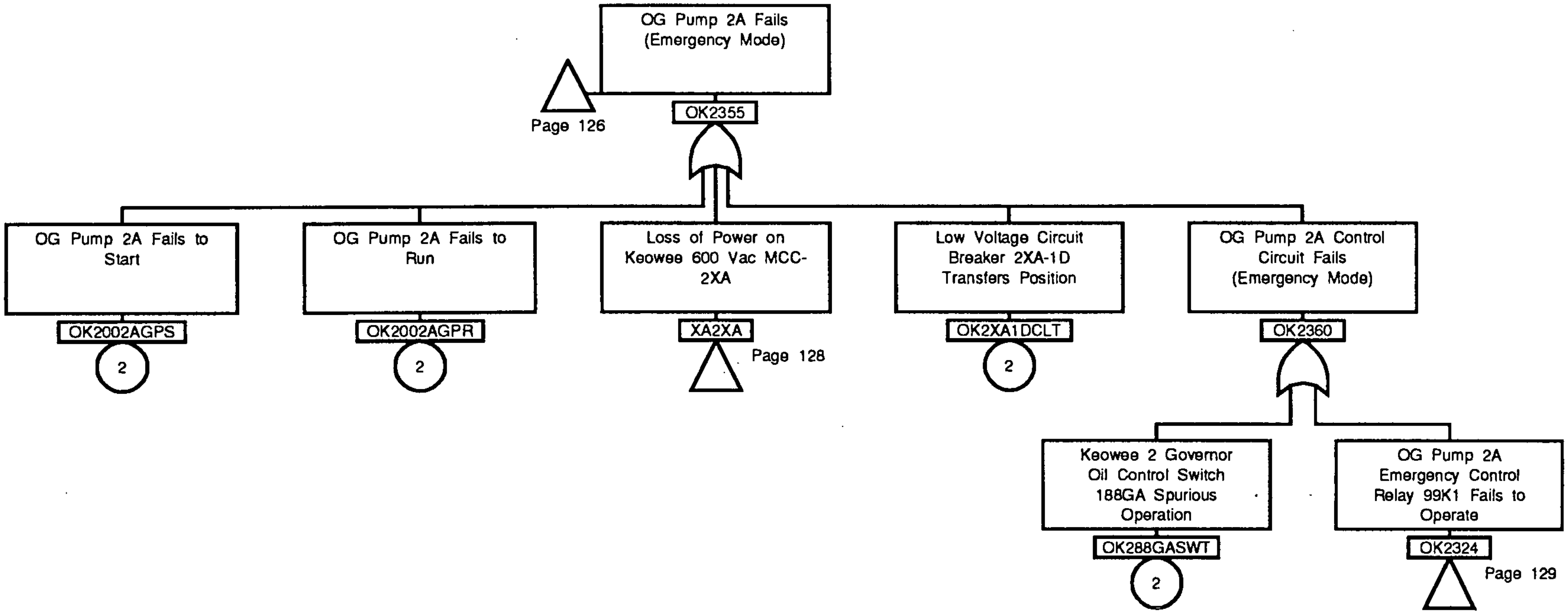

Keowee Unit 2 Fails To Supply Power During The Run
KU2RUN
Page 70
Keowee Unit 2 Governor or Turbine Fails While the Unit Runs
KU2GVTBRUN
Keowee Unit 2 Generator Excitation Fails While The Unit Runs
KU2GEXRUN
Page 158
Keowee Unit 2 Generator Fails While the Unit Runs
KU2GENRUN
Page 160
Keowee Unit 2 Governor Fails With the Unit Running
WK2GOVRUN
Keowee Unit 2 Turbine Fails With the Unit Running
WK2TURRUN
Keowee Unit 2 Gov. Fails to Position Wicket Gates With Unit Running
WK2GVRNDEX
Unit 2 Governor Oil (OG) System Fails Keowee Run
OK2600
Keowee 2 Governor Control Fails During Run
YK2RUNCNTL
Page 135
Keowee Unit 2 Governor Failure Creates Overspeed Condition
WK2SPD2DEX
2
Keowee Unit 2 Turbine Fails With the Unit Running
WK2TBRNDEX
Turbine Sump System Fails to Remove Turbine 2 Leakage During Keowee Run
PK22000
Page 155
Loss of Unit 2 OG System Oil or Oil Pressure
OK2200
Page 125
All Unit 2 OG Pumps Fail to Supply GOPT
OK2400
Page 130
Unit 2 Turbine Guide Bearing Oil System Fails During Run
BK2000
Page 139
OG Pressure Tank is Isolated And OG Pump 2A Train Fails (Emergency Mode)
OK2300
Page 126



Loss of Unit 2 OG System Oil or Oil Pressure
OK2200
Page 124
Unit 2 Governor Oil Pressure Tank Fails
OK20003TKF
Unit 2 Governor Air (AG) System Fails
OK2500
Safety Relief Valve 2AG-4 Spurious Operation
OK2AG04RVT
Safety Relief Valve 2OG-3 Spurious Operation
OK20003RVT
Manual Valve 2AG-5 Transfers Position
OK2AG05VVT
Air Receiver Tank 2AGTK-1 Fails
OK2AGO1TKF

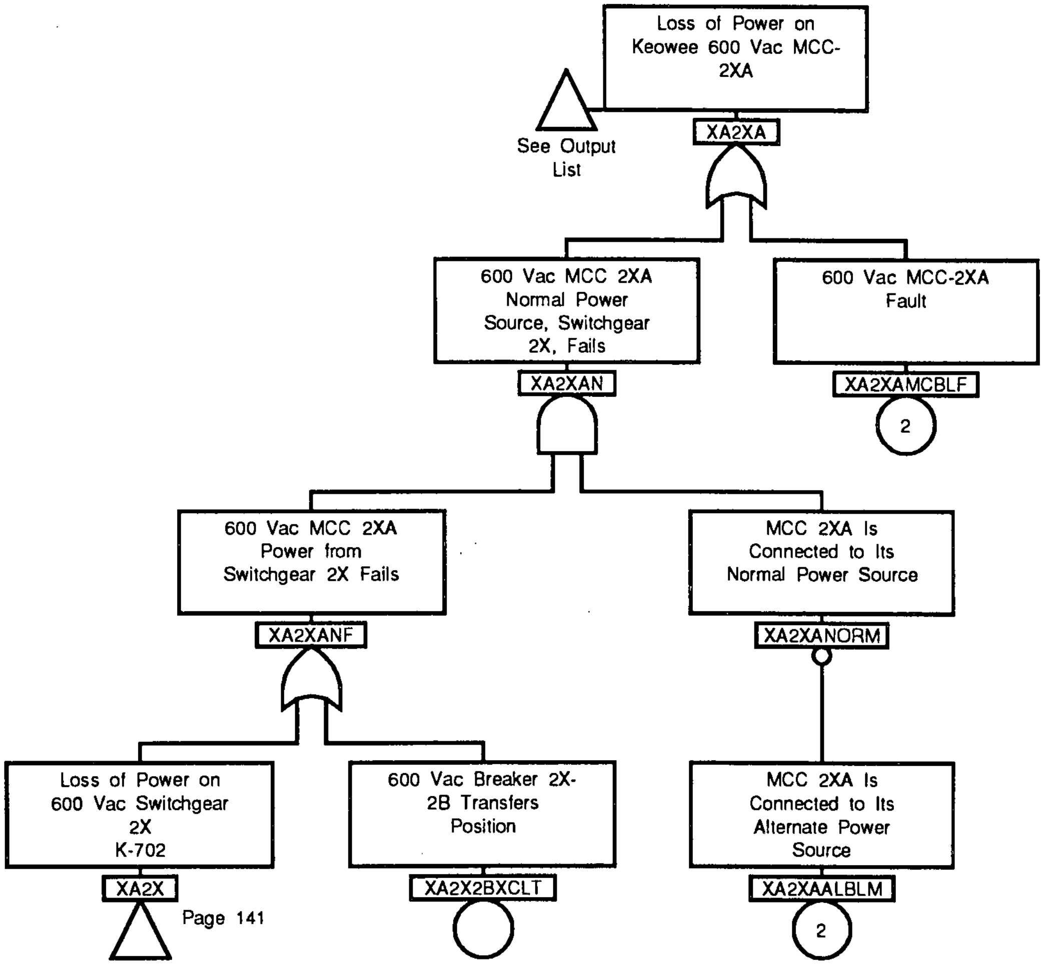


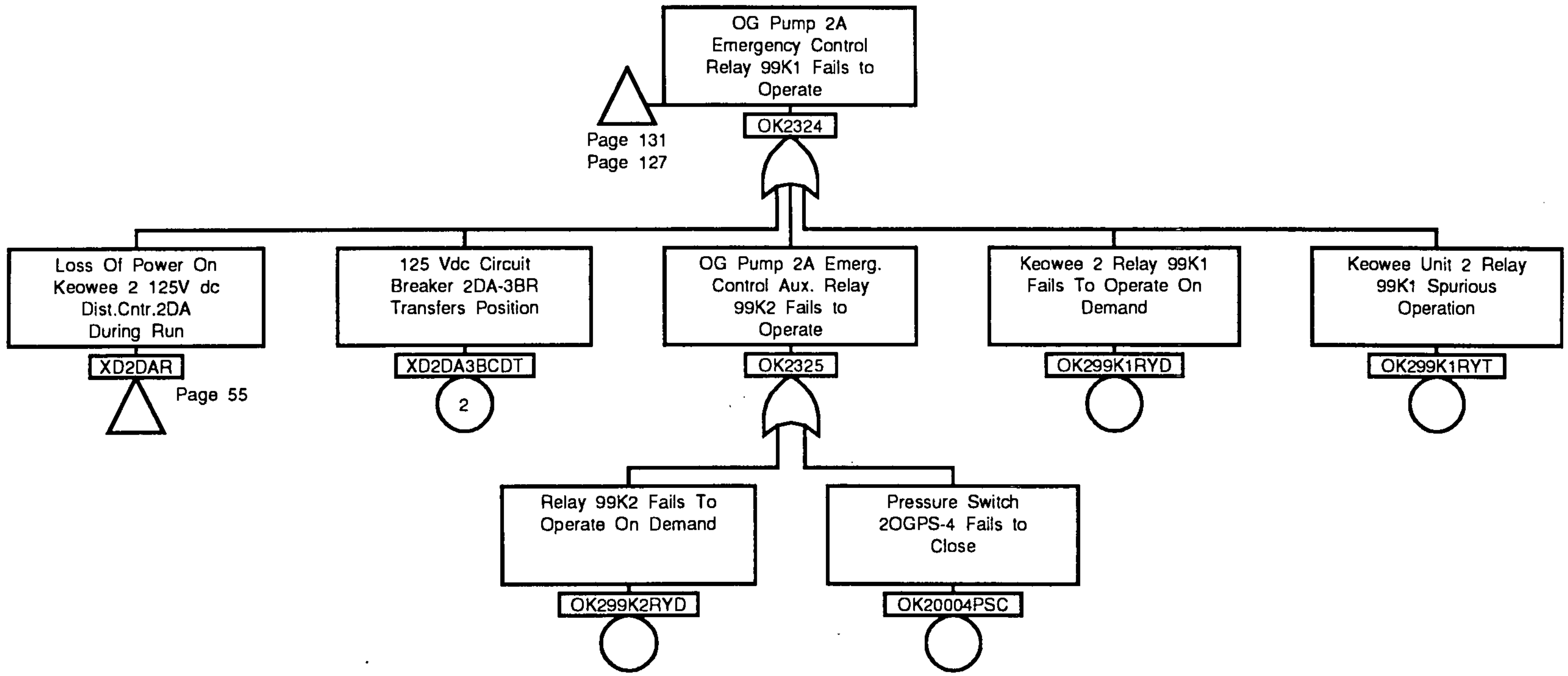
OG Pressure Tank is Isolated And OG Pump 2A Train Fails (Emergency Mode)
OK2300
Page 124
Unit 2 OG Pressure Tank is Isolated From Oil Header
OK2310
OG Pump 2A Train Fails to Provide Flow (Emergency Mode)
OK2350
Float Valve 2OG-7 Transfers Closed
OK20007FVT
Manual Valve 2OG-9 Transfers Closed
OK20009VVT
Manual Globe Valve 2OG-12 Transfers Closed
OK20012VVT
2
Relief Valve 2OG-13 Spurious Operation
OK20013RVT
2
Check Valve 2OG-11 Fails to Open
OK20011CVO
2
OG Pump 2A Fails (Emergency Mode)
OK2355
Page 127
Check Valve 2OG-11 Transfers Closed
OK20011CVT
2



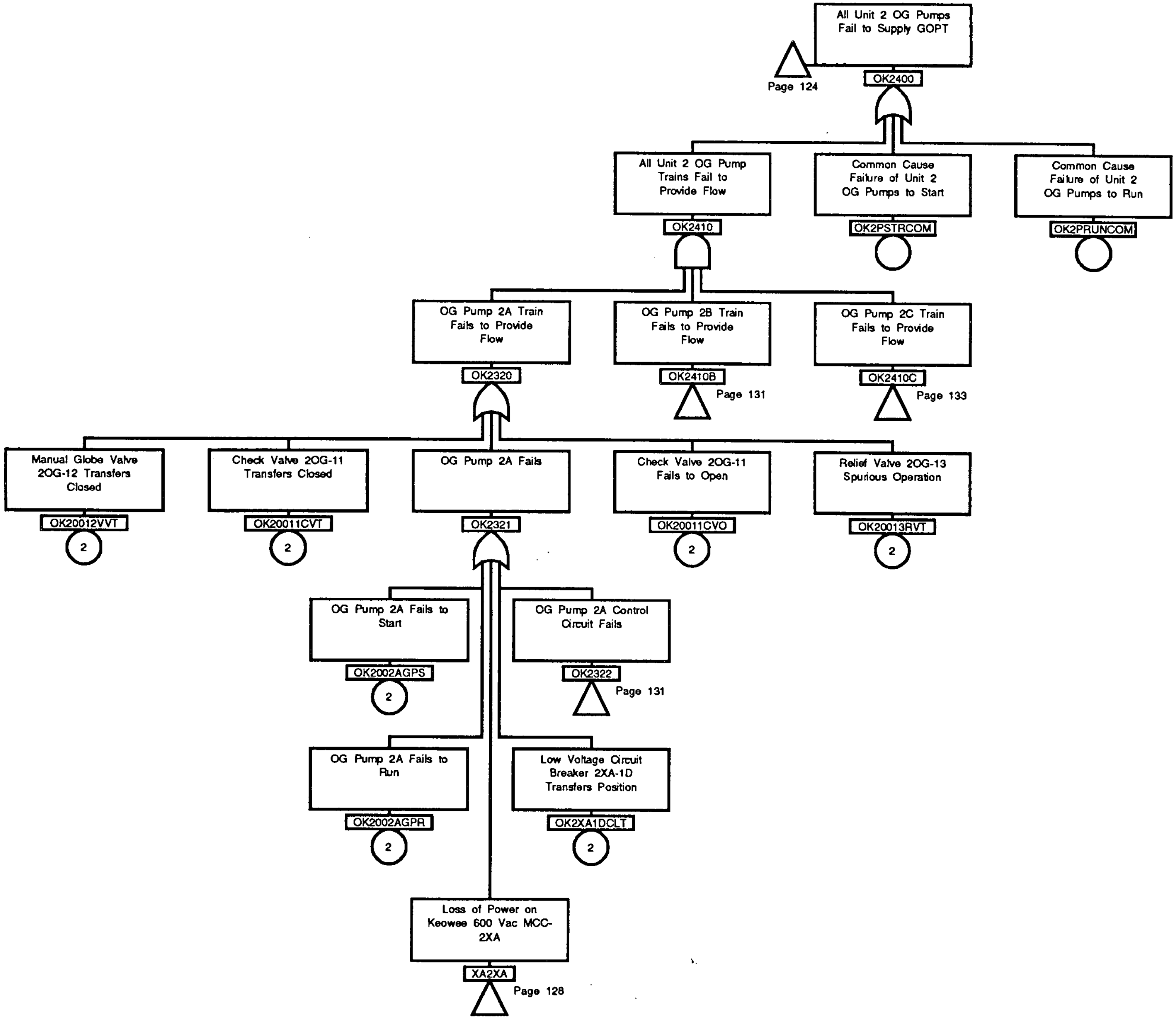
OG Pump 2A Fails (Emergency Mode)
Page 126
OK2355
OG Pump 2A Fails to Start
OK2002AGPS
2
OG Pump 2A Fails to Run
OK2002AGPR
2
Loss of Power on Keowee 600 Vac MCC-2XA
XA2XA
Page 128
Low Voltage Circuit Breaker 2XA-1D Transfers Position
OK2XA1DCLT
2
OG Pump 2A Control Circuit Fails (Emergency Mode)
OK2360
Keowee 2 Governor Oil Control Switch 188GA Spurious Operation
OK288GASWT
2
OG Pump 2A Emergency Control Relay 99K1 Fails to Operate
OK2324
Page 129

XA2XA Outputs:
Page 140, Page 130, Page 127, Page 132, Page 134, Page 155

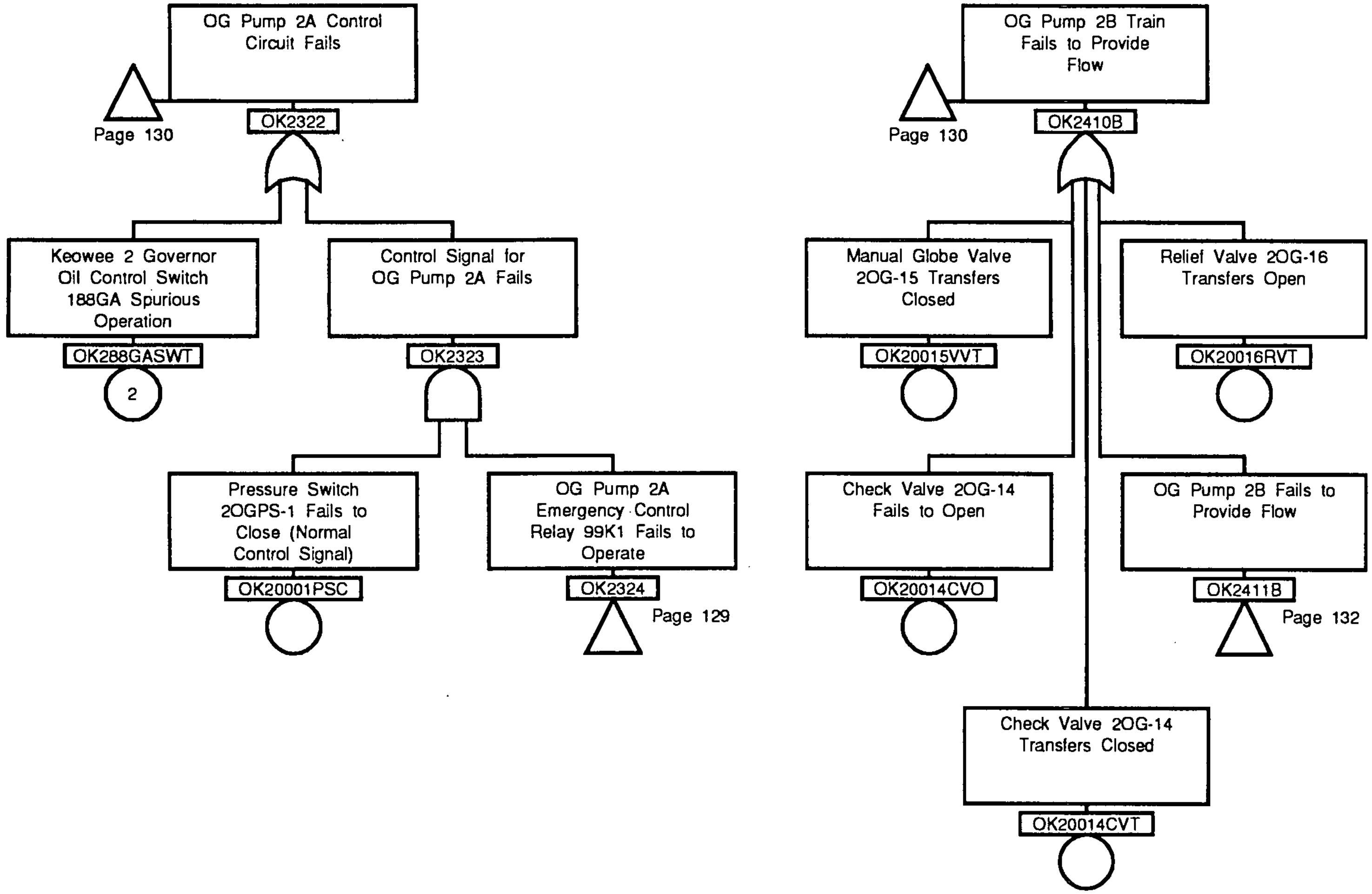




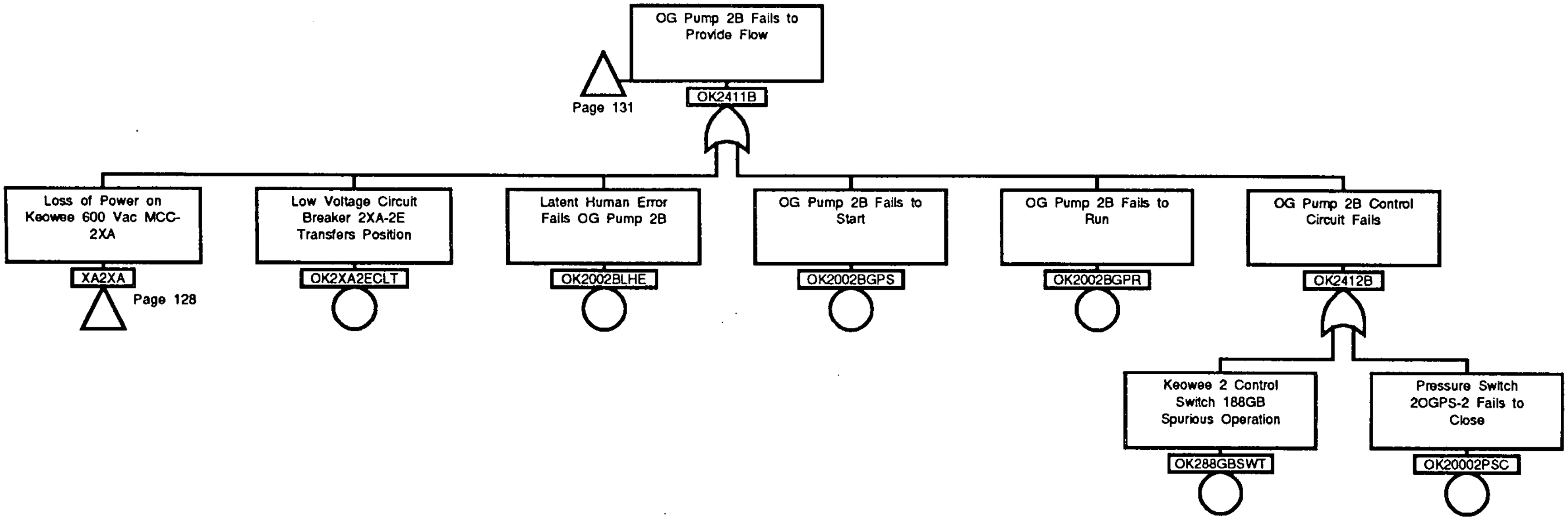
OG Pump 2A Emergency Control Relay 99K1 Fails to Operate
OK2324
Page 131
Page 127
Loss Of Power On Keowee 2 125V dc Dist.Cntr.2DA During Run
XD2DAR
Page 55
125 Vdc Circuit Breaker 2DA-3BR Transfers Position
XD2DA3BCDT
2
OG Pump 2A Emerg. Control Aux. Relay 99K2 Fails to Operate
OK2325
Keowee 2 Relay 99K1 Fails To Operate On Demand
OK299K1RYD
Keowee Unit 2 Relay 99K1 Spurious Operation
OK299K1RYT
Relay 99K2 Fails To Operate On Demand
OK299K2RYD
Pressure Switch 2OGPS-4 Fails to Close
OK20004PSC



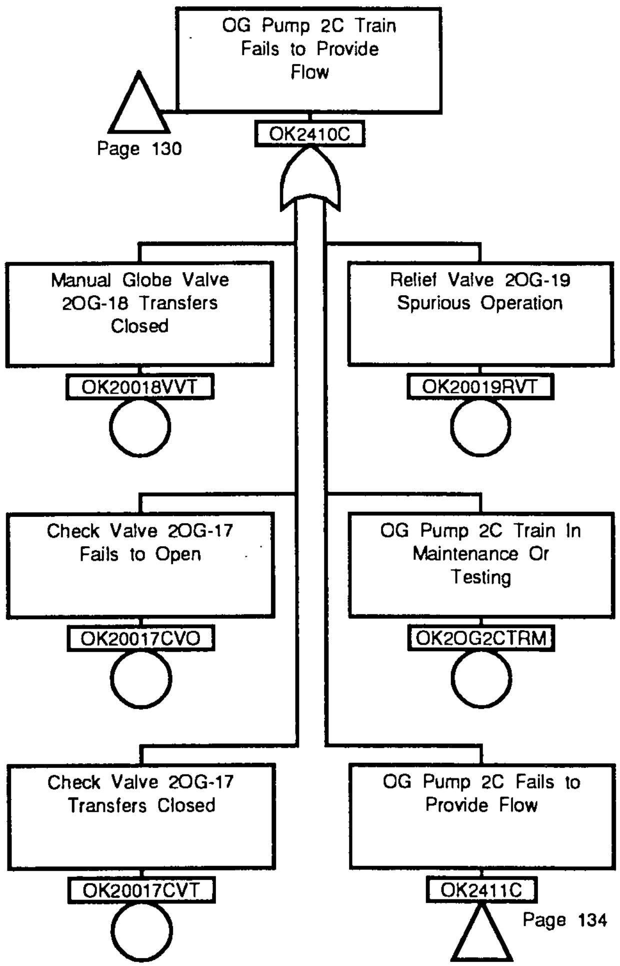
All Unit 2 OG Pumps Fail to Supply GOPT
Page 124
OK2400
All Unit 2 OG Pump Trains Fail to Provide Flow
OK2410
Common Cause Failure of Unit 2 OG Pumps to Start
OK2PSTRCOM
Common Cause Failure of Unit 2 OG Pumps to Run
OK2PRUNCOM
OG Pump 2A Train Fails to Provide Flow
OK2320
OG Pump 2B Train Fails to Provide Flow
OK2410B
Page 131
OG Pump 2C Train Fails to Provide Flow
OK2410C
Page 133
Manual Globe Valve 2OG-12 Transfers Closed
OK20012VVT
2
Check Valve 2OG-11 Transfers Closed
OK20011CVT
2
OG Pump 2A Fails
OK2321
Check Valve 2OG-11 Fails to Open
OK20011CVO
2
Relief Valve 2OG-13 Spurious Operation
OK20013RVT
2
OG Pump 2A Fails to Start
OK2002AGPS
2
OG Pump 2A Control Circuit Fails
OK2322
Page 131
OG Pump 2A Fails to Run
OK2002AGPR
2
Low Voltage Circuit Breaker 2XA-1D Transfers Position
OK2XA1DCLT
2
Loss of Power on Keowee 600 Vac MCC-2XA
XA2XA
Page 128

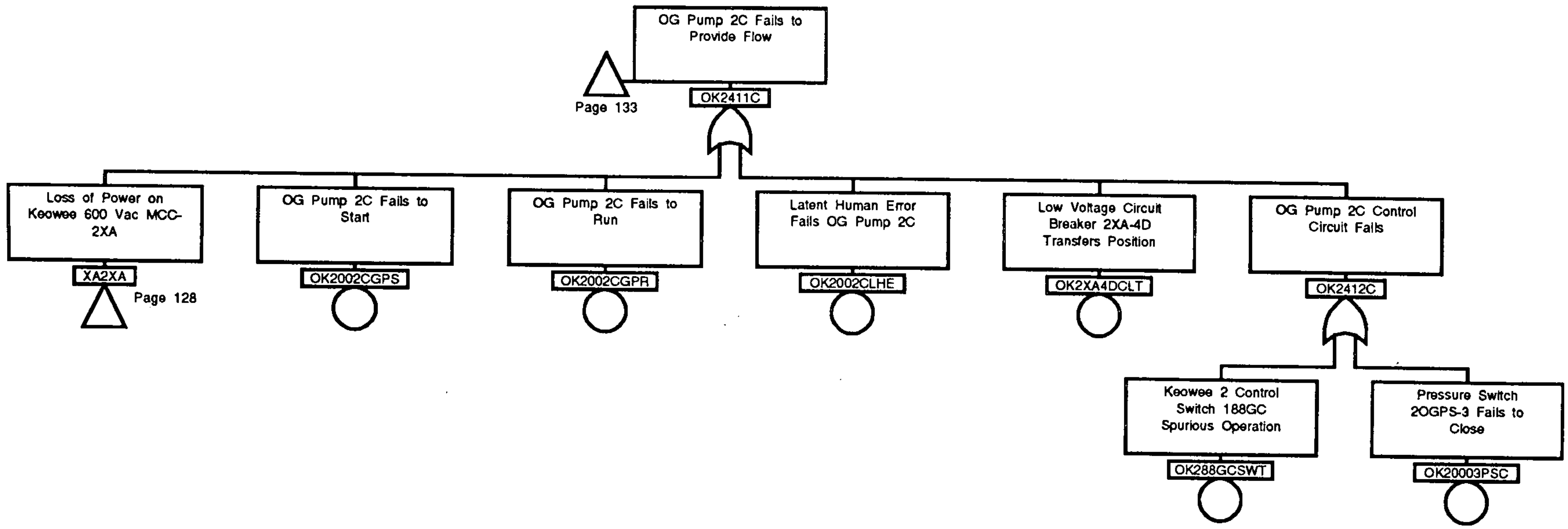


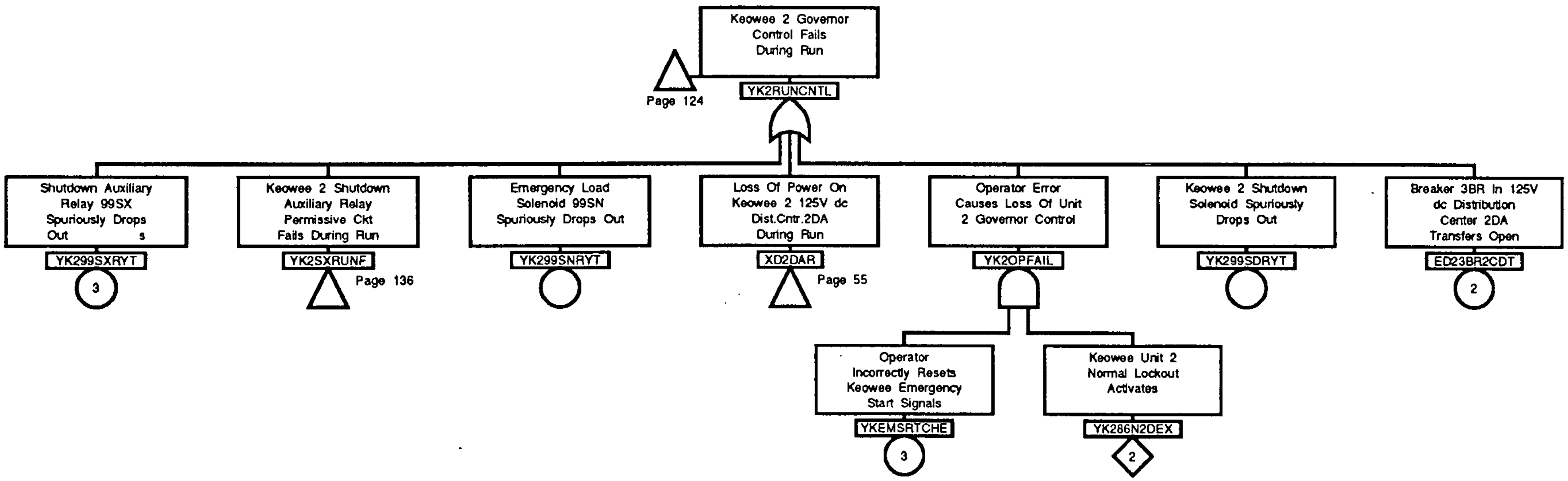
OG Pump 2A Control Circuit Fails
OK2322
Page 130
Keowee 2 Governor Oil Control Switch 188GA Spurious Operation
OK288GASWT
2
Control Signal for OG Pump 2A Fails
OK2323
Pressure Switch 2OGPS-1 Fails to Close (Normal Control Signal)
OK20001PSC
OG Pump 2A Emergency Control Relay 99K1 Fails to Operate
OK2324
Page 129
OG Pump 2B Train Fails to Provide Flow
OK2410B
Page 130
Manual Globe Valve 2OG-15 Transfers Closed
OK20015VVT
Relief Valve 2OG-16 Transfers Open
OK20016RVT
Check Valve 2OG-14 Fails to Open
OK20014CVO
OG Pump 2B Fails to Provide Flow
OK2411B
Page 132
Check Valve 2OG-14 Transfers Closed
OK20014CVT



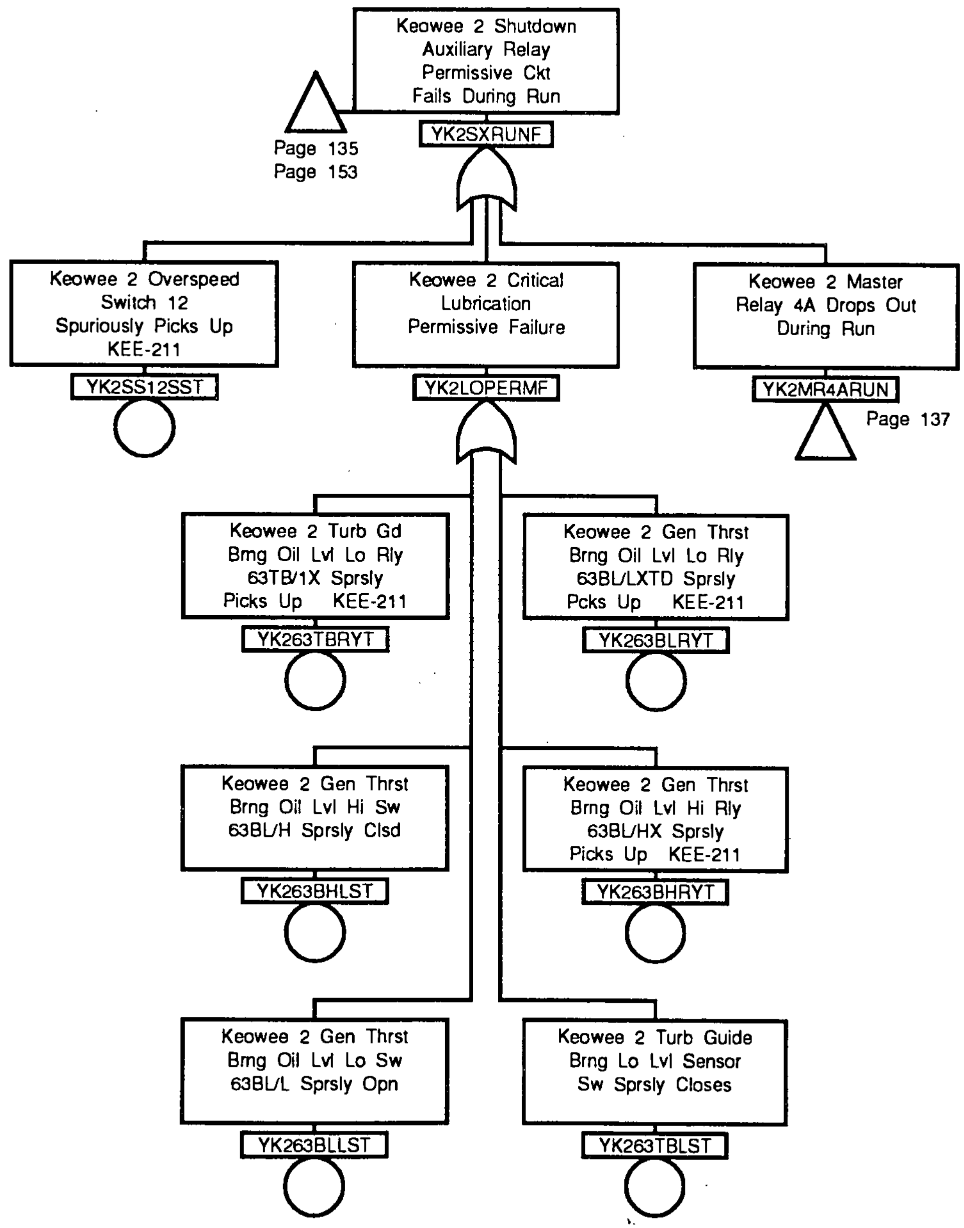
OG Pump 2B Fails to Provide Flow
OK2411B
Page 131
Loss of Power on Keowee 600 Vac MCC-2XA
XA2XA
Page 128
Low Voltage Circuit Breaker 2XA-2E Transfers Position
OK2XA2ECLT
Latent Human Error Fails OG Pump 2B
OK2002BLHE
OG Pump 2B Fails to Start
OK2002BGPS
OG Pump 2B Fails to Run
OK2002BGPR
OG Pump 2B Control Circuit Fails
OK2412B
Keowee 2 Control Switch 188GB Spurious Operation
OK288GBSWT
Pressure Switch 2OGPS-2 Fails to Close
OK20002PSC

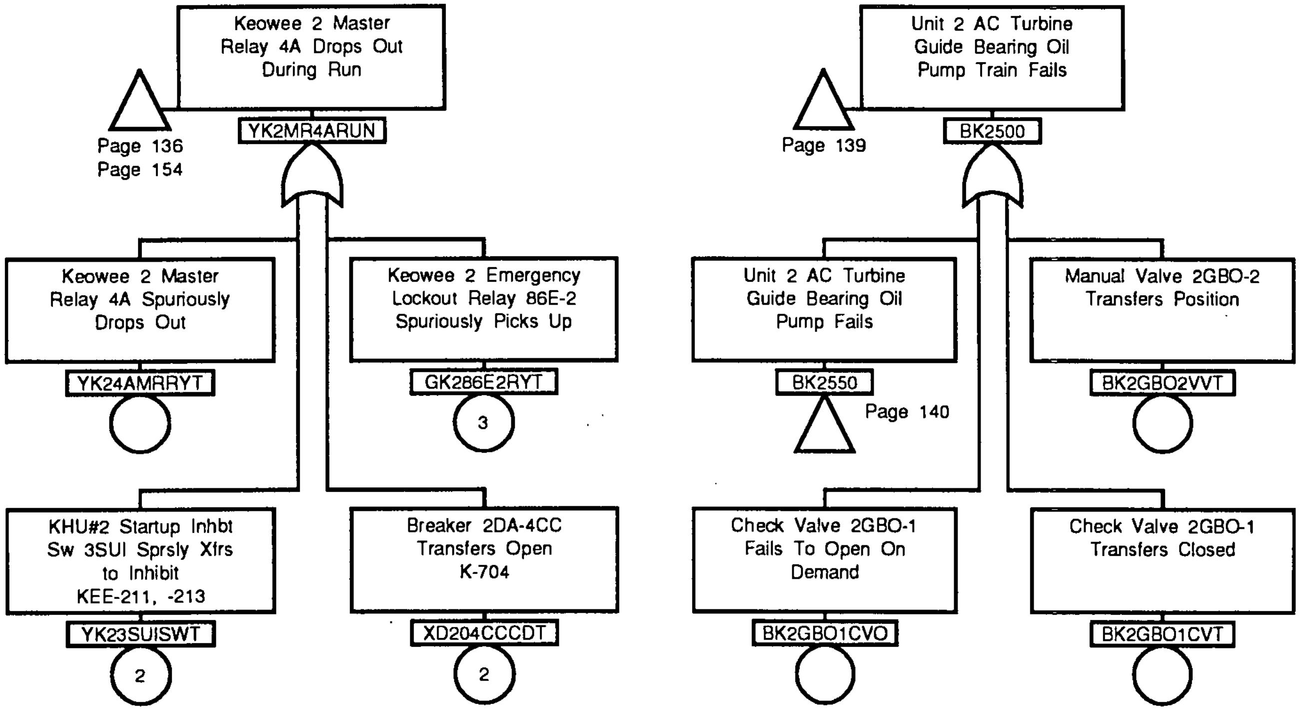

OG Pump 2C Train Fails to Provide Flow
OK2410C
Page 130
Manual Globe Valve 2OG-18 Transfers Closed
OK20018VVT
Relief Valve 2OG-19 Spurious Operation
OK20019RVT
Check Valve 2OG-17 Fails to Open
OK20017CVO
OG Pump 2C Train In Maintenance Or Testing
OK2OG2CTRM
Check Valve 2OG-17 Transfers Closed
OK20017CVT
OG Pump 2C Fails to Provide Flow
OK2411C
Page 134


OG Pump 2C Fails to Provide Flow
OK2411C
Page 133
Loss of Power on Keowee 600 Vac MCC-2XA
XA2XA
Page 128
OG Pump 2C Fails to Start
OK2002CGPS
OG Pump 2C Fails to Run
OK2002CGPR
Latent Human Error Fails OG Pump 2C
OK2002CLHE
Low Voltage Circuit Breaker 2XA-4D Transfers Position
OK2XA4DCLT
OG Pump 2C Control Circuit Fails
OK2412C
Keowee 2 Control Switch 188GC Spurious Operation
OK288GCSWT
Pressure Switch 2OGPS-3 Fails to Close
OK20003PSC

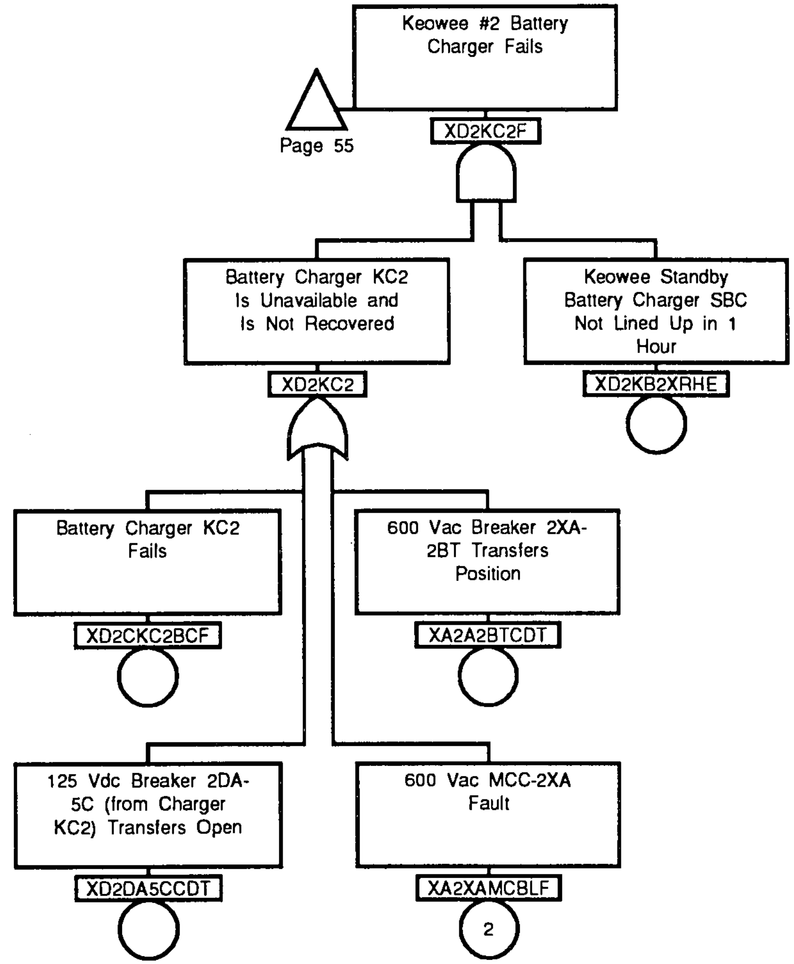


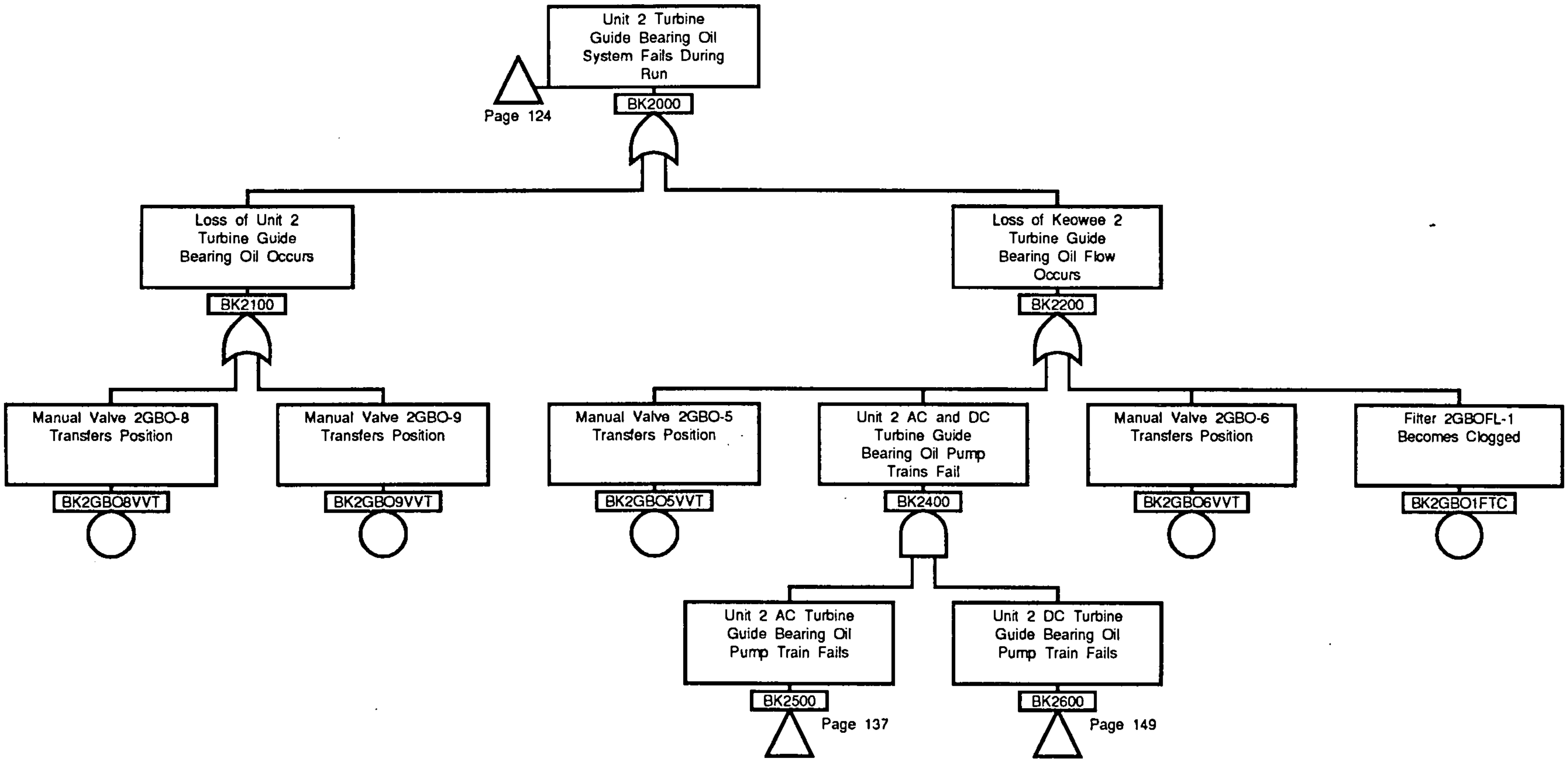
Keowee 2 Governor Control Fails During Run
YK2RUNCNTL
Page 124
Shutdown Auxiliary Relay 99SX Spuriously Drops Out s
YK299SXRYT
3
Keowee 2 Shutdown Auxiliary Relay Permissive Ckt Fails During Run
YK2SXRUNF
Page 136
Emergency Load Solenoid 99SN Spuriously Drops Out
YK299SNRYT
Loss Of Power On Keowee 2 125V dc Dist.Cntr.2DA During Run
XD2DAR
Page 55
Operator Error Causes Loss Of Unit 2 Governor Control
YK2OPFAIL
Keowee 2 Shutdown Solenoid Spuriously Drops Out
YK299SDRYT
Breaker 3BR In 125V dc Distribution Center 2DA Transfers Open
ED23BR2CDT
2
Operator Incorrectly Resets Keowee Emergency Start Signals
YKEMSRTCHE
3
Keowee Unit 2 Normal Lockout Activates
YK286N2DEX
2

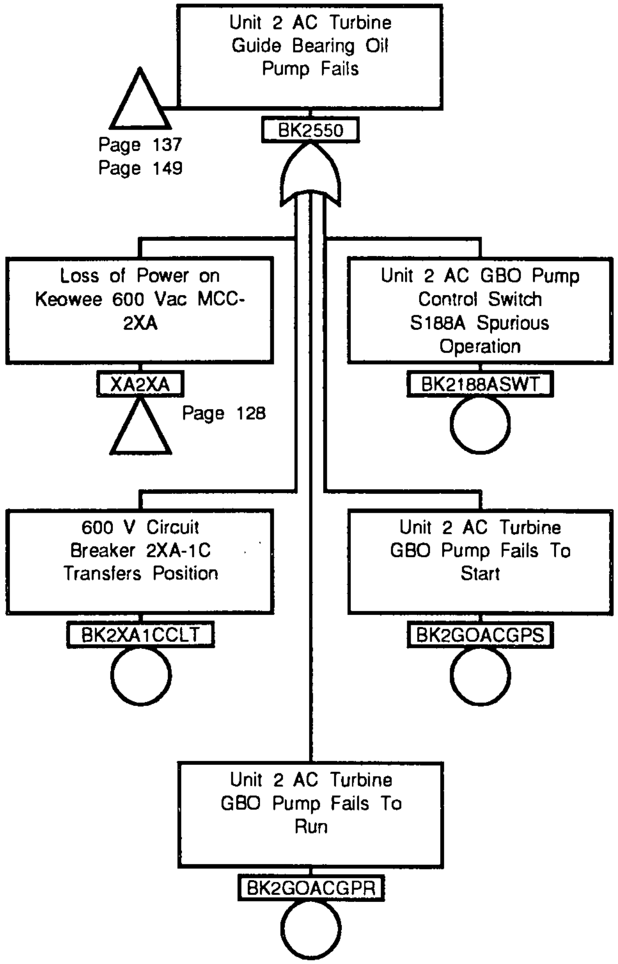

Keowee 2 Shutdown Auxiliary Relay Permissive Ckt Fails During Run
YK2SXRUNF
Page 135
Page 153
Keowee 2 Overspeed Switch 12 Spuriously Picks Up KEE-211
YK2SS12SST
Keowee 2 Critical Lubrication Permissive Failure
YK2LOPERMF
Keowee 2 Master Relay 4A Drops Out During Run
YK2MR4ARUN
Page 137
Keowee 2 Turb Gd Brng Oil Lvl Lo Rly 63TB/1X Sprsly Picks Up KEE-211
YK263TBRYT
Keowee 2 Gen Thrst Brng Oil Lvl Lo Rly 63BL/LXTD Sprsly Pcks Up KEE-211
YK263BLRYT
Keowee 2 Gen Thrst Brng Oil Lvl Hi Sw 63BL/H Sprsly Clsd
YK263BHLST
Keowee 2 Gen Thrst Brng Oil Lvl Hi Rly 63BL/HX Sprsly Picks Up KEE-211
YK263BHRYT
Keowee 2 Gen Thrst Brng Oil Lvl Lo Sw 63BL/L Sprsly Opn
YK263BLLST
Keowee 2 Turb Guide Brng Lo Lvl Sensor Sw Sprsly Closes
YK263TBLST

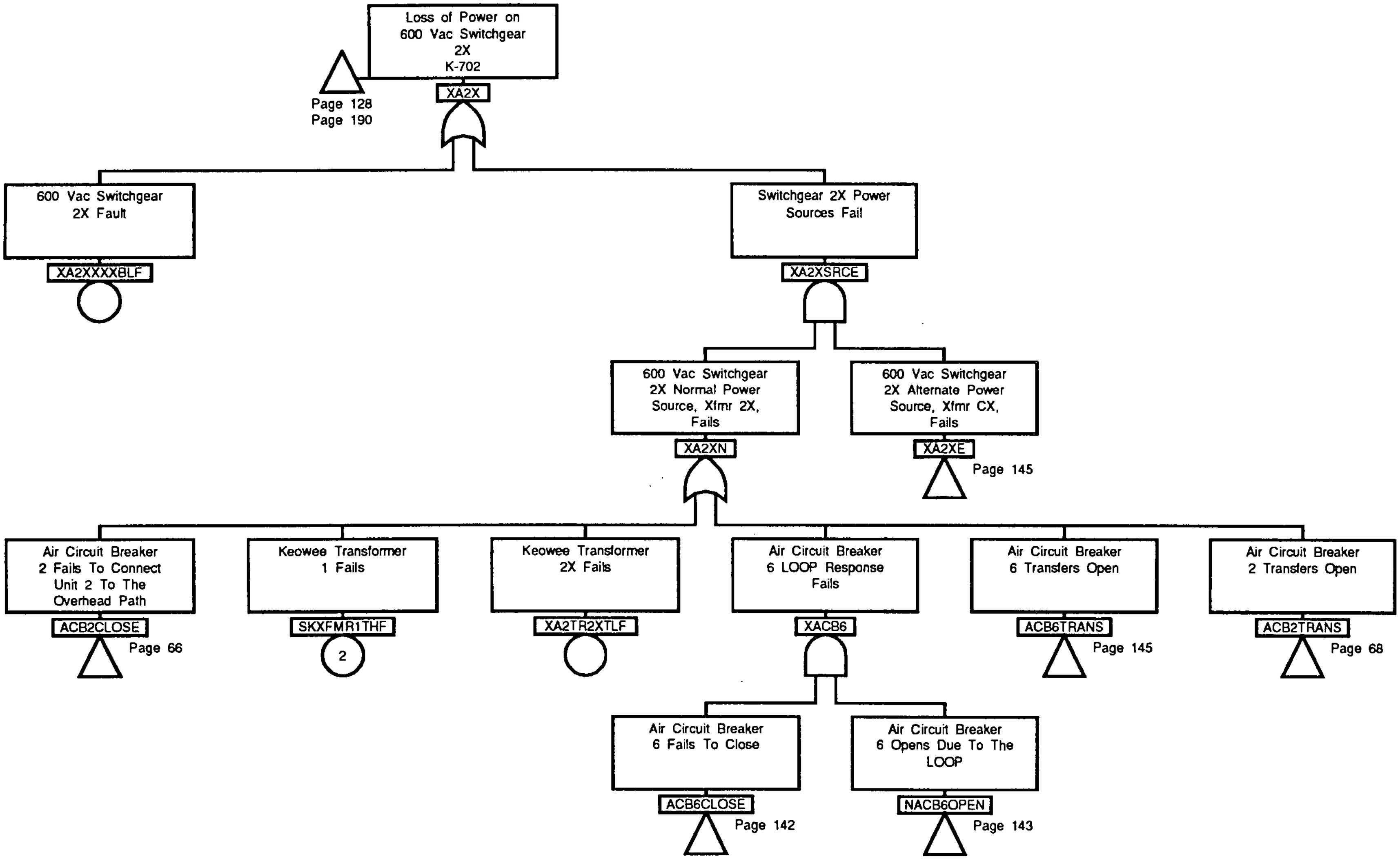


Keowee 2 Master Relay 4A Drops Out During Run
YK2MR4ARUN
Page 136
Page 154
Keowee 2 Master Relay 4A Spuriously Drops Out
YK24AMRRYT
Keowee 2 Emergency Lockout Relay 86E-2 Spuriously Picks Up
GK286E2RYT
3
KHU#2 Startup Inhbt Sw 3SUI Sprsly Xfrs to Inhibit KEE-211, -213
YK23SUISWT
2
Breaker 2DA-4CC Transfers Open K-704
XD204CCCDT
2
Unit 2 AC Turbine Guide Bearing Oil Pump Train Fails
BK2500
Page 139
Unit 2 AC Turbine Guide Bearing Oil Pump Fails
BK2550
Page 140
Manual Valve 2GBO-2 Transfers Position
BK2GBO2VVT
Check Valve 2GBO-1 Fails To Open On Demand
BK2GBO1CVO
Check Valve 2GBO-1 Transfers Closed
BK2GBO1CVT

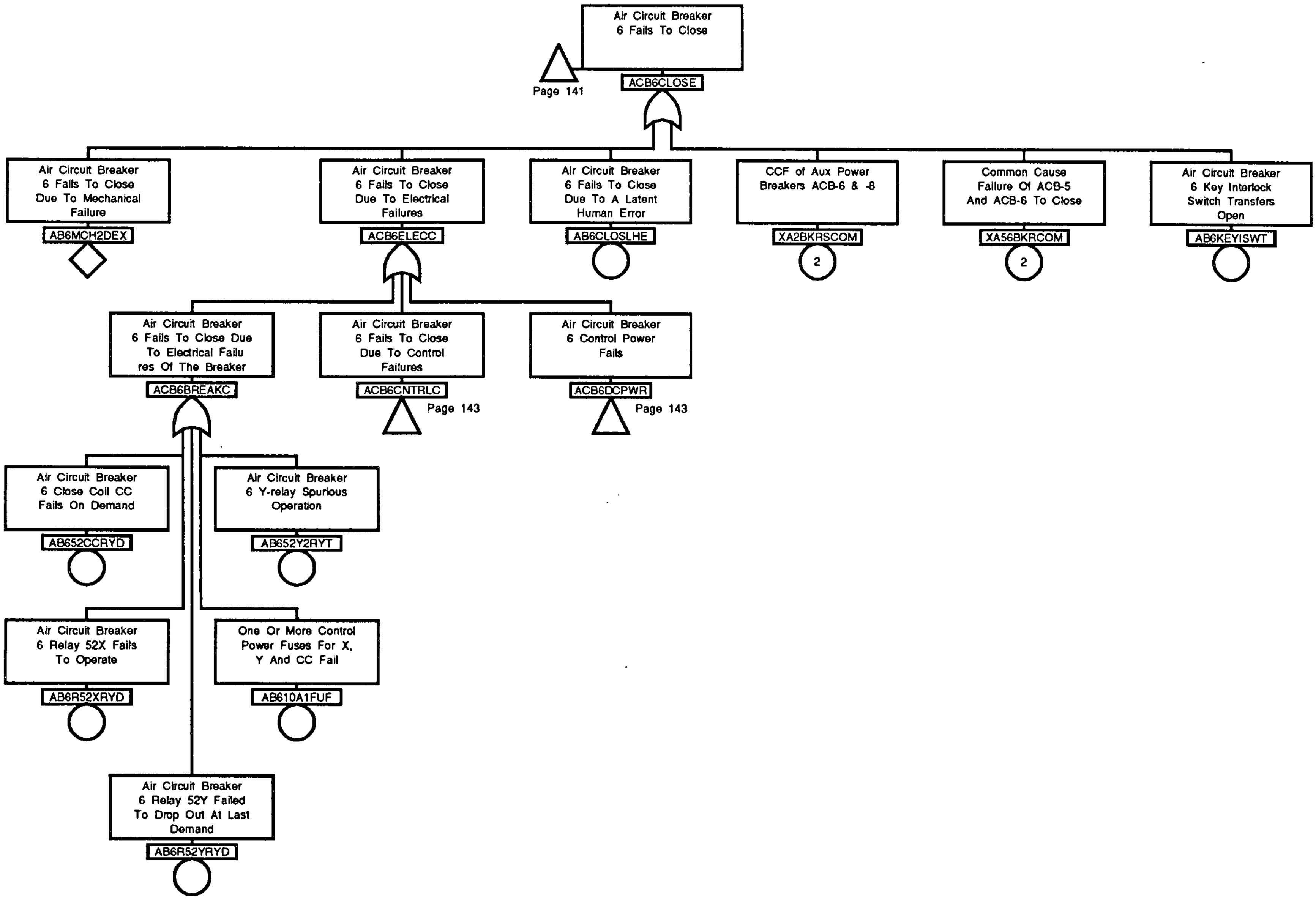

Keowee #2 Battery Charger Fails
Page 55
XD2KC2F
Battery Charger KC2 Is Unavailable and Is Not Recovered
XD2KC2
Keowee Standby Battery Charger SBC Not Lined Up in 1 Hour
XD2KB2XRHE
Battery Charger KC2 Fails
XD2CKC2BCF
600 Vac Breaker 2XA-2BT Transfers Position
XA2A2BTCDT
125 Vdc Breaker 2DA-5C (from Charger KC2) Transfers Open
XD2DA5CCDT
600 Vac MCC-2XA Fault
XA2XAMCBLF
2


Unit 2 Turbine Guide Bearing Oil System Fails During Run
BK2000
Page 124
Loss of Unit 2 Turbine Guide Bearing Oil Occurs
BK2100
Loss of Keowee 2 Turbine Guide Bearing Oil Flow Occurs
BK2200
Manual Valve 2GBO-8 Transfers Position
BK2GBO8VVT
Manual Valve 2GBO-9 Transfers Position
BK2GBO9VVT
Manual Valve 2GBO-5 Transfers Position
BK2GBO5VVT
Unit 2 AC and DC Turbine Guide Bearing Oil Pump Trains Fail
BK2400
Manual Valve 2GBO-6 Transfers Position
BK2GBO6VVT
Filter 2GBOFL-1 Becomes Clogged
BK2GBO1FTC
Unit 2 AC Turbine Guide Bearing Oil Pump Train Fails
BK2500
Page 137
Unit 2 DC Turbine Guide Bearing Oil Pump Train Fails
BK2600
Page 149

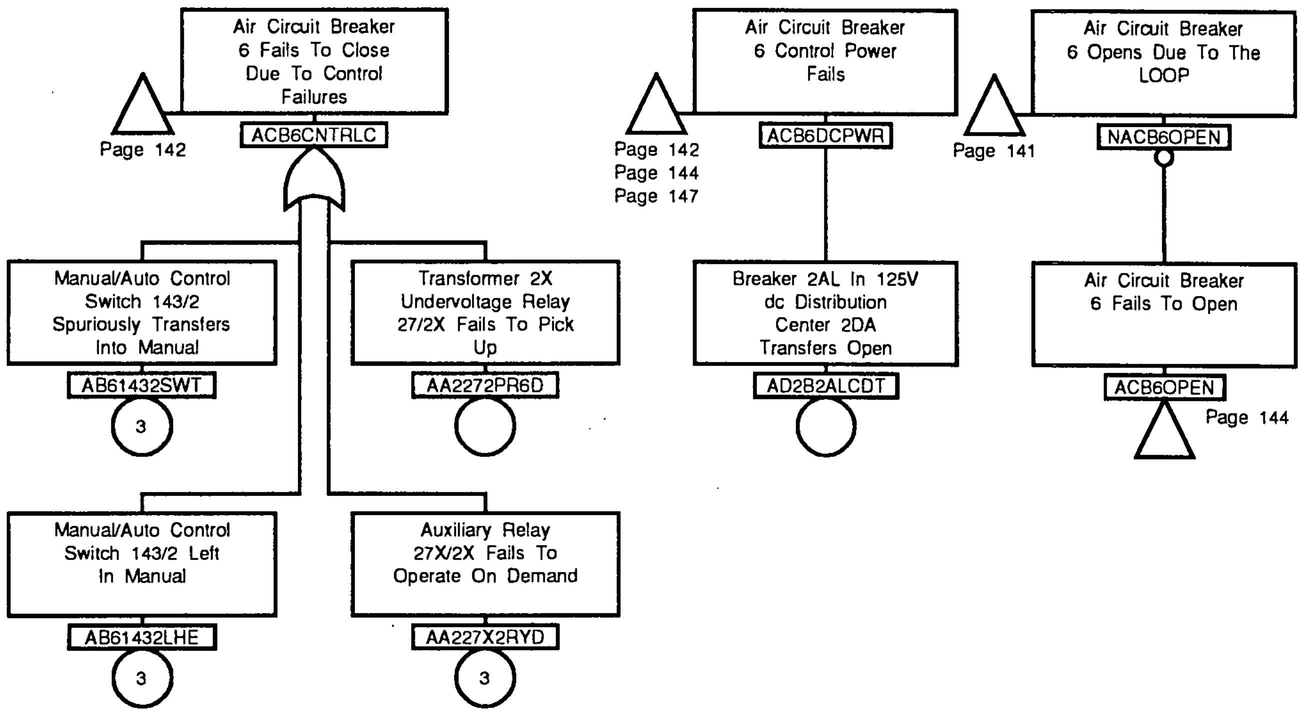

Unit 2 AC Turbine Guide Bearing Oil Pump Fails
BK2550
Page 137
Page 149
Loss of Power on Keowee 600 Vac MCC-2XA
XA2XA
Page 128
Unit 2 AC GBO Pump Control Switch S188A Spurious Operation
BK2188ASWT
600 V Circuit Breaker 2XA-1C Transfers Position
BK2XA1CCLT
Unit 2 AC Turbine GBO Pump Fails To Start
BK2GOACGPS
Unit 2 AC Turbine GBO Pump Fails To Run
BK2GOACGPR



Loss of Power on 600 Vac Switchgear 2X K-702
XA2X
Page 128
Page 190
600 Vac Switchgear 2X Fault
XA2XXXXBLF
Switchgear 2X Power Sources Fail
XA2XSRCE
600 Vac Switchgear 2X Normal Power Source, Xfmr 2X, Fails
XA2XN
600 Vac Switchgear 2X Alternate Power Source, Xfmr CX, Fails
XA2XE
Page 145
Air Circuit Breaker 2 Fails To Connect Unit 2 To The Overhead Path
ACB2CLOSE
Page 66
Keowee Transformer 1 Fails
SKXFMR1THF
2
Keowee Transformer 2X Fails
XA2TR2XTLF
Air Circuit Breaker 6 LOOP Response Fails
XACB6
Air Circuit Breaker 6 Transfers Open
ACB6TRANS
Page 145
Air Circuit Breaker 2 Transfers Open
ACB2TRANS
Page 68
Air Circuit Breaker 6 Fails To Close
ACB6CLOSE
Page 142
Air Circuit Breaker 6 Opens Due To The LOOP
NACB6OPEN
Page 143



Air Circuit Breaker 6 Fails To Close
ACB6CLOSE
Page 141
Air Circuit Breaker 6 Fails To Close Due To Mechanical Failure
AB6MCH2DEX
Air Circuit Breaker 6 Fails To Close Due To Electrical Failures
ACB6ELECC
Air Circuit Breaker 6 Fails To Close Due To A Latent Human Error
AB6CLOSLHE
CCF of Aux Power Breakers ACB-6 & -8
XA2BKRSCOM
2
Common Cause Failure Of ACB-5 And ACB-6 To Close
XA56BKRCOM
2
Air Circuit Breaker 6 Key Interlock Switch Transfers Open
AB6KEYISWT
Air Circuit Breaker 6 Fails To Close Due To Electrical Failu res Of The Breaker
ACB6BREAKC
Air Circuit Breaker 6 Fails To Close Due To Control Failures
ACB6CNTRLC
Page 143
Air Circuit Breaker 6 Control Power Fails
ACB6DCPWR
Page 143
Air Circuit Breaker 6 Close Coil CC Fails On Demand
AB652CCRYD
Air Circuit Breaker 6 Y-relay Spurious Operation
AB652Y2RYT
Air Circuit Breaker 6 Relay 52X Fails To Operate
AB6R52XRYD
One Or More Control Power Fuses For X, Y And CC Fail
AB610A1FUF
Air Circuit Breaker 6 Relay 52Y Failed To Drop Out At Last Demand
AB6R52YRYD


Air Circuit Breaker 6 Fails To Close Due To Control Failures
ACB6CNTRLC
Page 142
Manual/Auto Control Switch 143/2 Spuriously Transfers Into Manual
AB61432SWT
3
Transformer 2X Undervoltage Relay 27/2X Fails To Pick Up
AA2272PR6D
Manual/Auto Control Switch 143/2 Left In Manual
AB61432LHE
3
Auxiliary Relay 27X/2X Fails To Operate On Demand
AA227X2RYD
3
Air Circuit Breaker 6 Control Power Fails
ACB6DCPWR
Page 142
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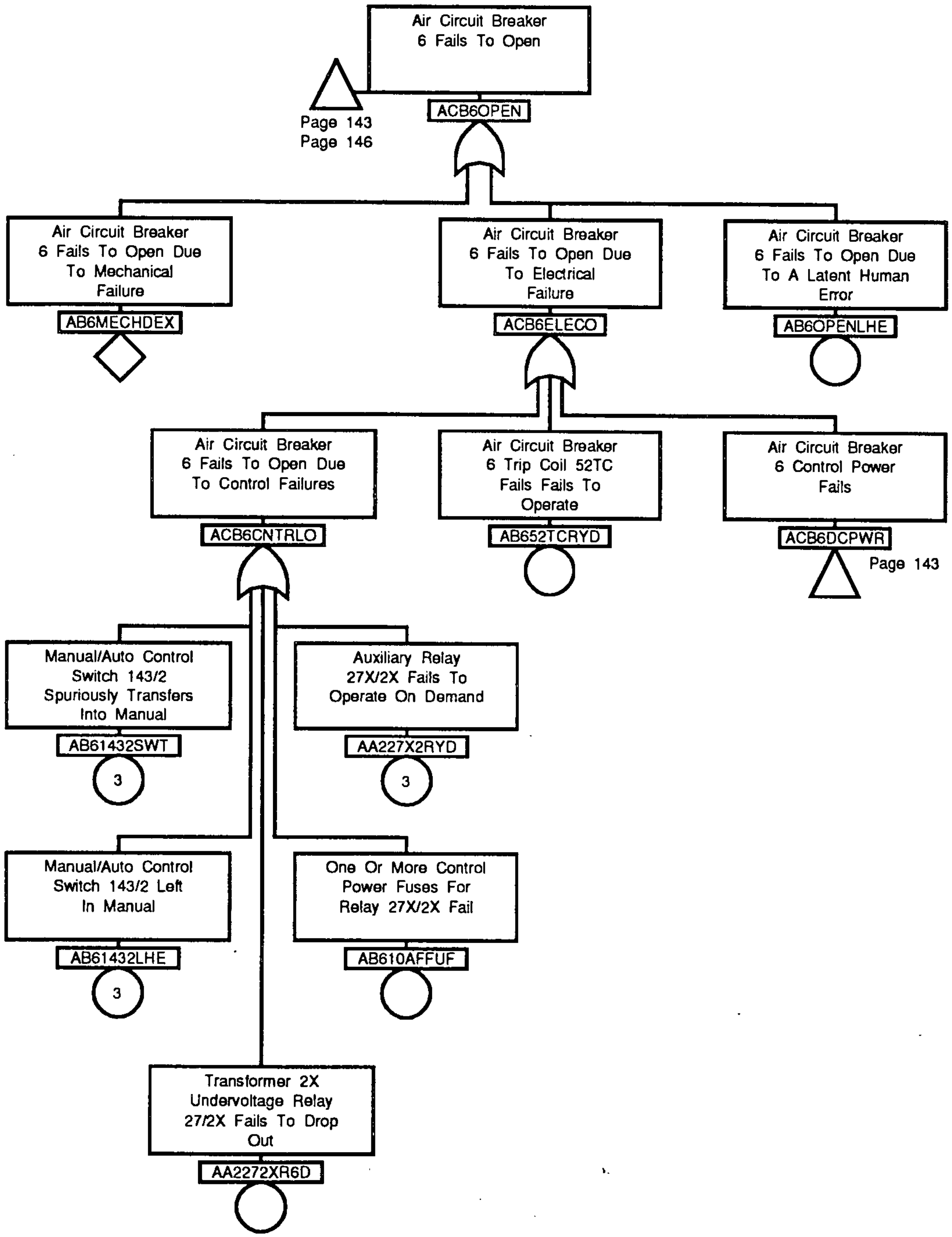
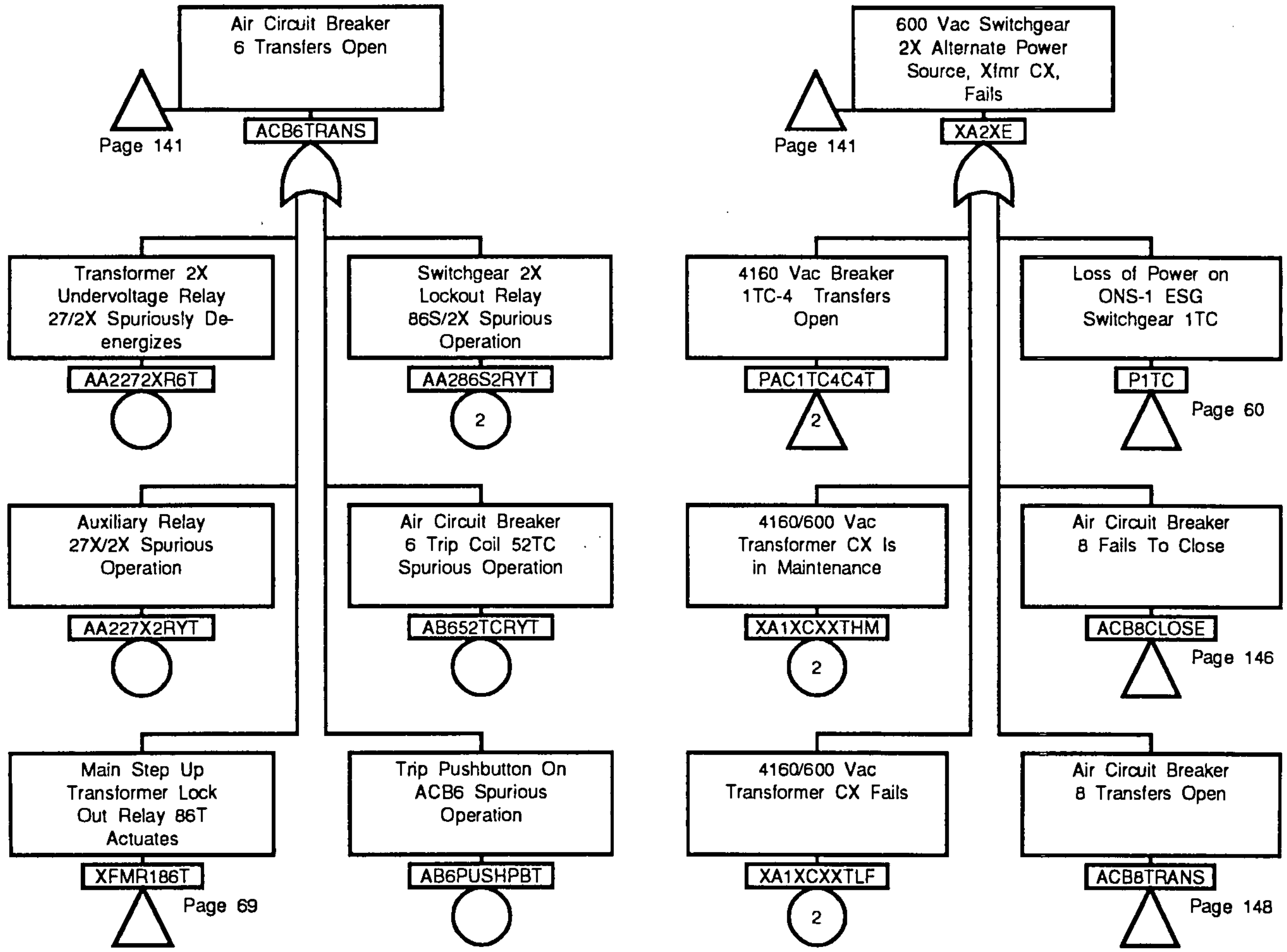
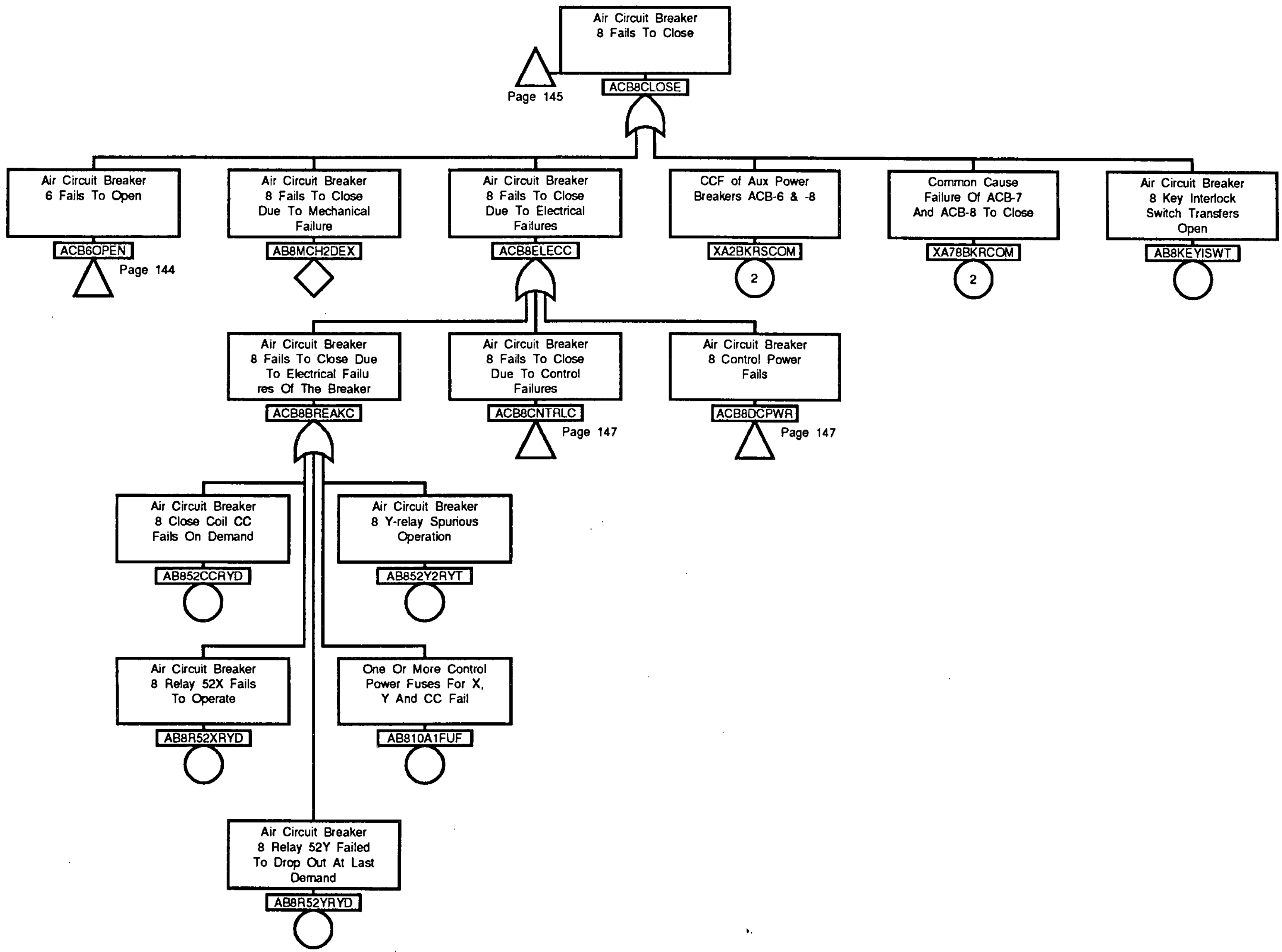
Page 147
Breaker 2AL In 125V dc Distribution Center 2DA Transfers Open
AD2B2ALCDT
Air Circuit Breaker 6 Opens Due To The LOOP
NACB6OPEN
Page 141
Air Circuit Breaker 6 Fails To Open
ACB6OPEN
Page 144



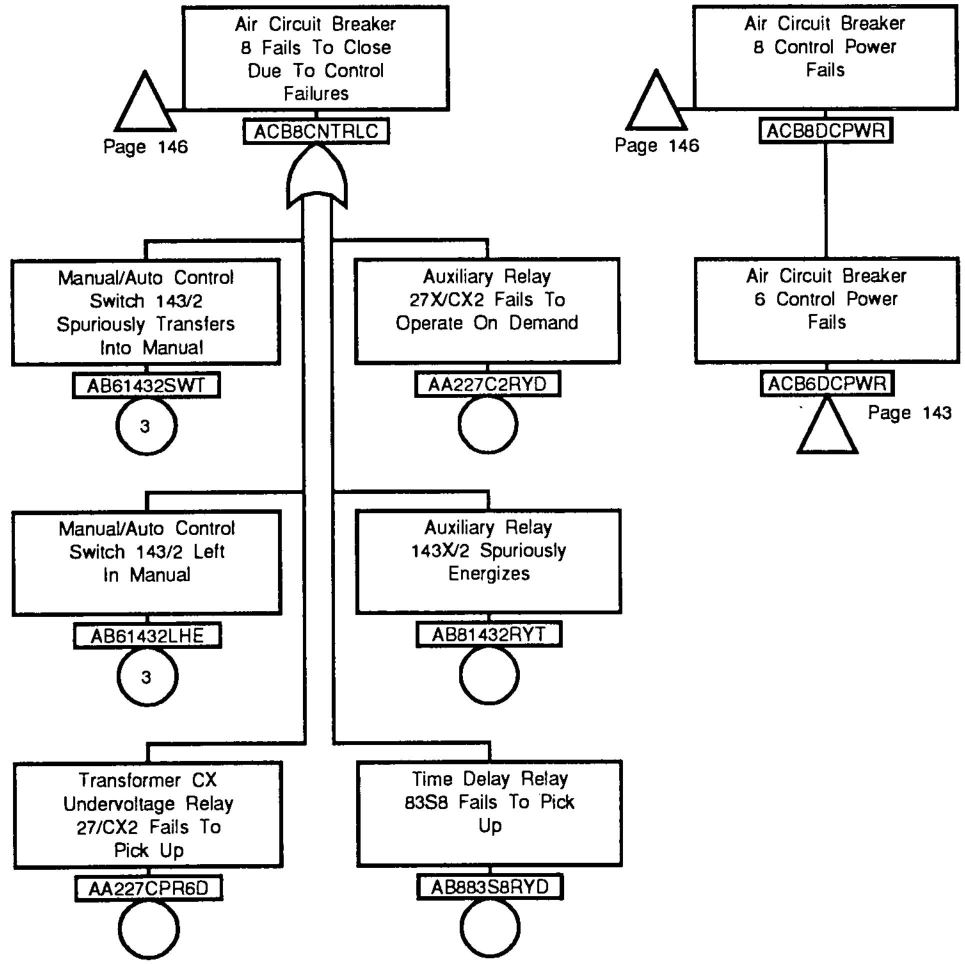
Air Circuit Breaker 6 Fails To Open
ACB6OPEN
Page 143
Page 146
Air Circuit Breaker 6 Fails To Open Due To Mechanical Failure
AB6MECHDEX
Air Circuit Breaker 6 Fails To Open Due To Electrical Failure
ACB6ELECO
Air Circuit Breaker 6 Fails To Open Due To A Latent Human Error
AB6OPENLHE
Air Circuit Breaker 6 Fails To Open Due To Control Failures
ACB6CNTRLO
Air Circuit Breaker 6 Trip Coil 52TC Fails Fails To Operate
AB652TCRYD
Air Circuit Breaker 6 Control Power Fails
ACB6DCPWR
Page 143
Manual/Auto Control Switch 143/2 Spuriously Transfers Into Manual
AB61432SWT
3
Auxiliary Relay 27X/2X Fails To Operate On Demand
AA227X2RYD
3
Manual/Auto Control Switch 143/2 Left In Manual
AB61432LHE
3
One Or More Control Power Fuses For Relay 27X/2X Fail
AB610AFFUF
Transformer 2X Undervoltage Relay 27/2X Fails To Drop Out
AA2272XR6D



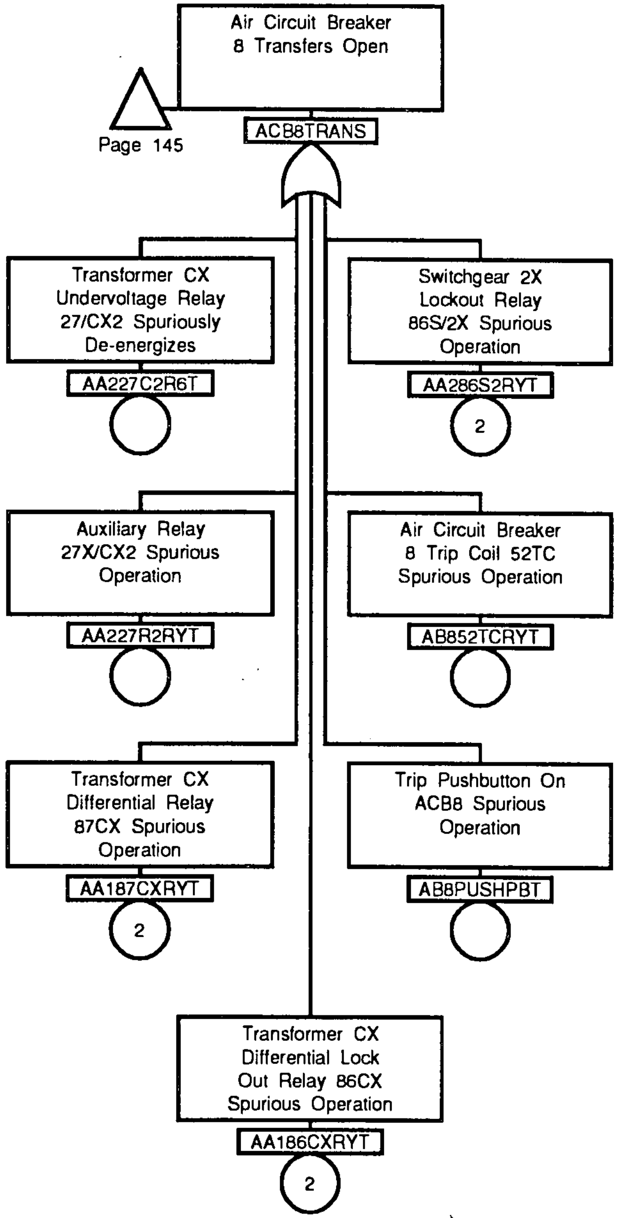
Air Circuit Breaker 6 Transfers Open
ACB6TRANS
Page 141
Transformer 2X Undervoltage Relay 27/2X Spuriously De-energizes
AA2272XR6T
Switchgear 2X Lockout Relay 86S/2X Spurious Operation
AA286S2RYT
2
Auxiliary Relay 27X/2X Spurious Operation
AA227X2RYT
Air Circuit Breaker 6 Trip Coil 52TC Spurious Operation
AB652TCRYT
Main Step Up Transformer Lock Out Relay 86T Actuates
XFMR186T
Page 69
Trip Pushbutton On ACB6 Spurious Operation
AB6PUSHPBT
600 Vac Switchgear 2X Alternate Power Source, Xfmr CX, Fails
XA2XE
Page 141
4160 Vac Breaker 1TC-4 Transfers Open
PAC1TC4C4T
2
Loss of Power on ONS-1 ESG Switchgear 1TC
P1TC
Page 60
4160/600 Vac Transformer CX Is in Maintenance
XA1XCXXTHM
2
Air Circuit Breaker 8 Fails To Close
ACB8CLOSE
Page 146
4160/600 Vac Transformer CX Fails
XA1XCXXTLF
2
Air Circuit Breaker 8 Transfers Open
ACB8TRANS
Page 148



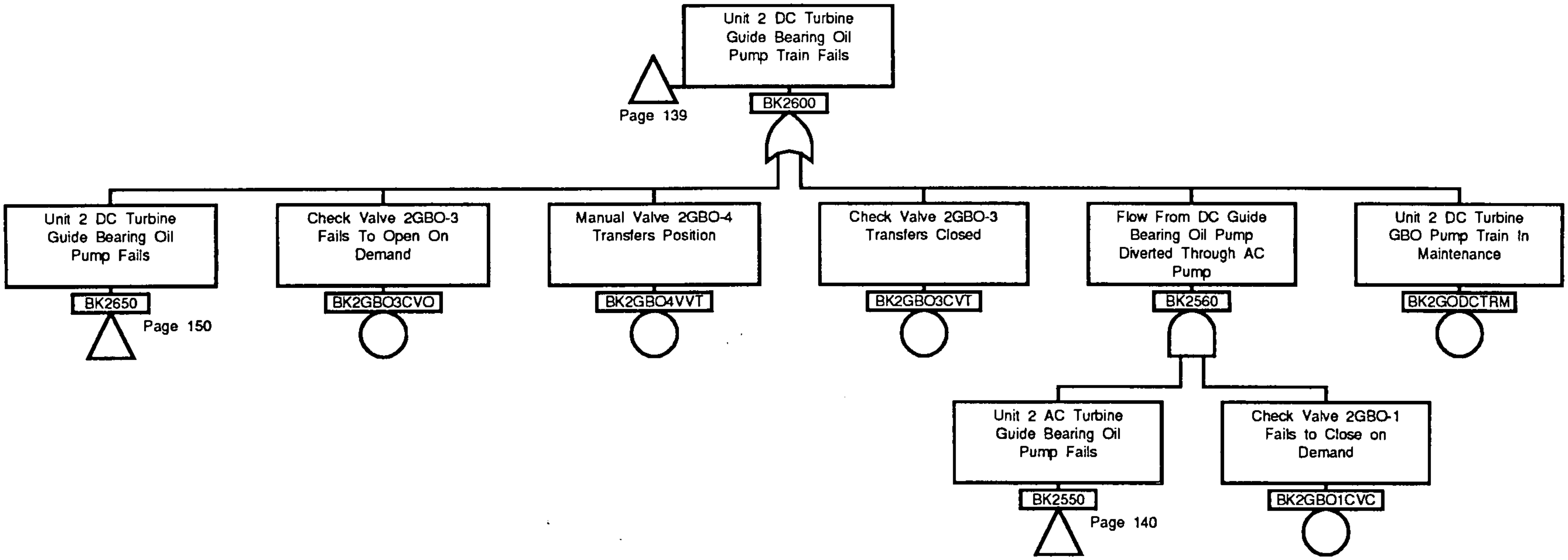
Air Circuit Breaker 8 Fails To Close
ACB8CLOSE
Page 145
Air Circuit Breaker 6 Fails To Open
ACB6OPEN
Page 144
Air Circuit Breaker 8 Fails To Close Due To Mechanical Failure
AB8MCH2DEX
Air Circuit Breaker 8 Fails To Close Due To Electrical Failures
ACB8ELECC
CCF of Aux Power Breakers ACB-6 & -8
XA2BKRSCOM
2
Common Cause Failure Of ACB-7 And ACB-8 To Close
XA78BKRCOM
2
Air Circuit Breaker 8 Key Interlock Switch Transfers Open
AB8KEYISWT
Air Circuit Breaker 8 Fails To Close Due To Electrical Failu res Of The Breaker
ACB8BREAKC
Air Circuit Breaker 8 Fails To Close Due To Control Failures
ACB8CNTRLC
Page 147
Air Circuit Breaker 8 Control Power Fails
ACB8DCPWR
Page 147
Air Circuit Breaker 8 Close Coil CC Fails On Demand
AB852CCRYD
Air Circuit Breaker 8 Y-relay Spurious Operation
AB852Y2RYT
Air Circuit Breaker 8 Relay 52X Fails To Operate
AB8R52XRYD
One Or More Control Power Fuses For X, Y And CC Fail
AB810A1FUF
Air Circuit Breaker 8 Relay 52Y Failed To Drop Out At Last Demand
AB8R52YRYD

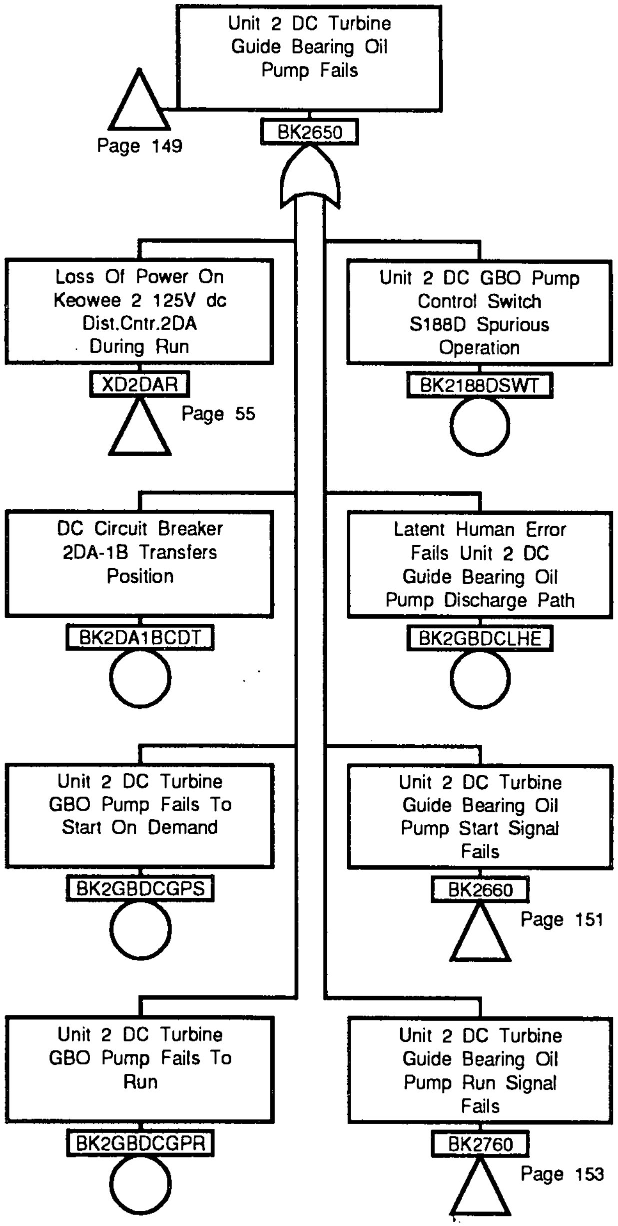


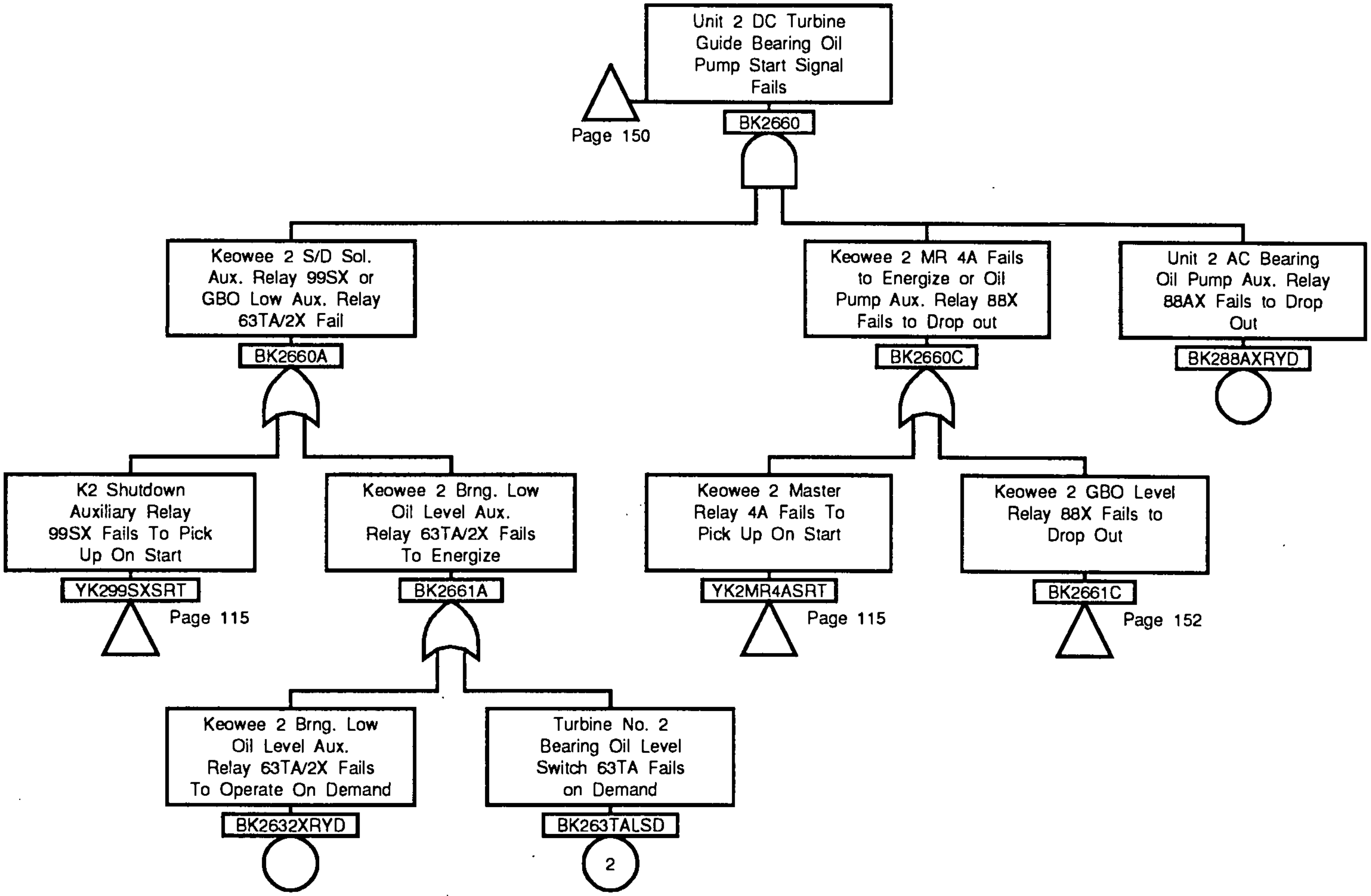
Air Circuit Breaker 8 Fails To Close Due To Control Failures
ACB8CNTRLC
Page 146
Manual/Auto Control Switch 143/2 Spuriously Transfers Into Manual
AB61432SWT
3
Auxiliary Relay 27X/CX2 Fails To Operate On Demand
AA227C2RYD
Manual/Auto Control Switch 143/2 Left In Manual
AB61432LHE
3
Auxiliary Relay 143X/2 Spuriously Energizes
AB81432RYT
Transformer CX Undervoltage Relay 27/CX2 Fails To Pick Up
AA227CPR6D
Time Delay Relay 83S8 Fails To Pick Up
AB883S8RYD
Air Circuit Breaker 8 Control Power Fails
ACB8DCPWR
Page 146
Air Circuit Breaker 6 Control Power Fails
ACB6DCPWR
Page 143

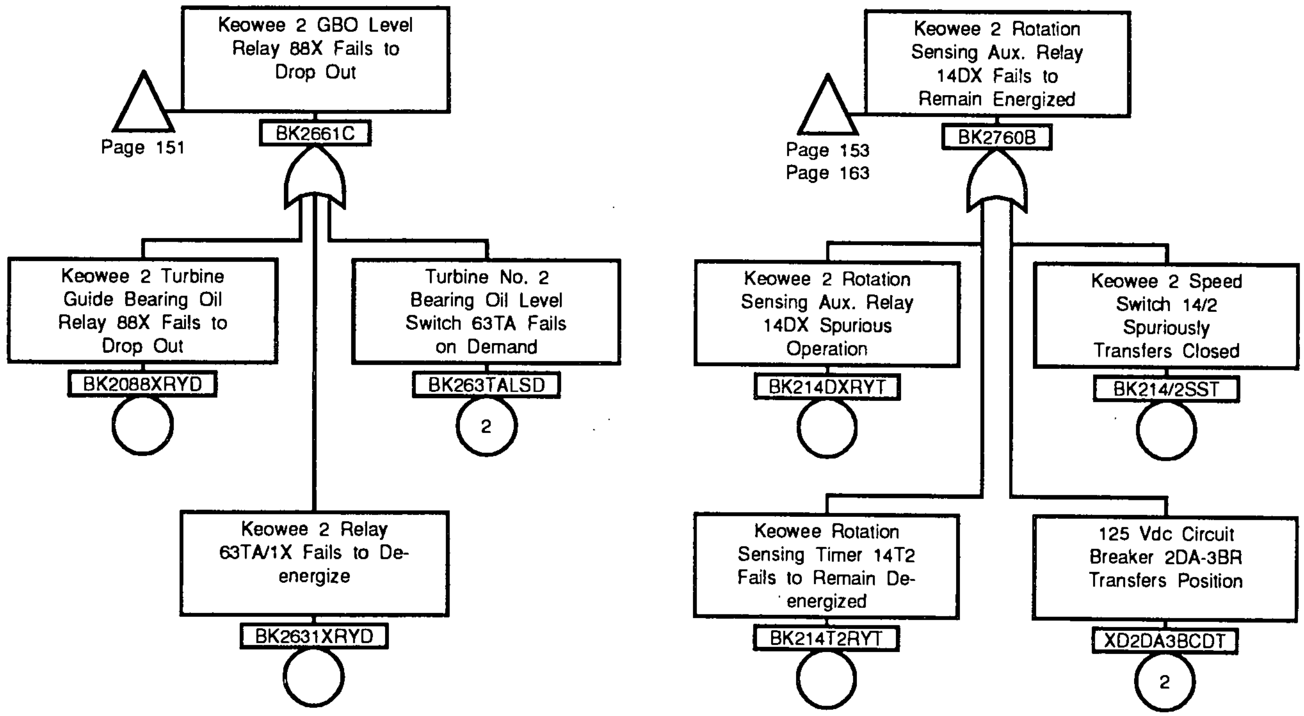


Air Circuit Breaker 8 Transfers Open
ACB8TRANS
Page 145
Transformer CX Undervoltage Relay 27/CX2 Spuriously De-energizes
AA227C2R6T
Switchgear 2X Lockout Relay 86S/2X Spurious Operation
AA286S2RYT
2
Auxiliary Relay 27X/CX2 Spurious Operation
AA227R2RYT
Air Circuit Breaker 8 Trip Coil 52TC Spurious Operation
AB852TCRYT
Transformer CX Differential Relay 87CX Spurious Operation
AA187CXRYT
2
Trip Pushbutton On ACB8 Spurious Operation
AB8PUSHPBT
Transformer CX Differential Lock Out Relay 86CX Spurious Operation
AA186CXRYT
2

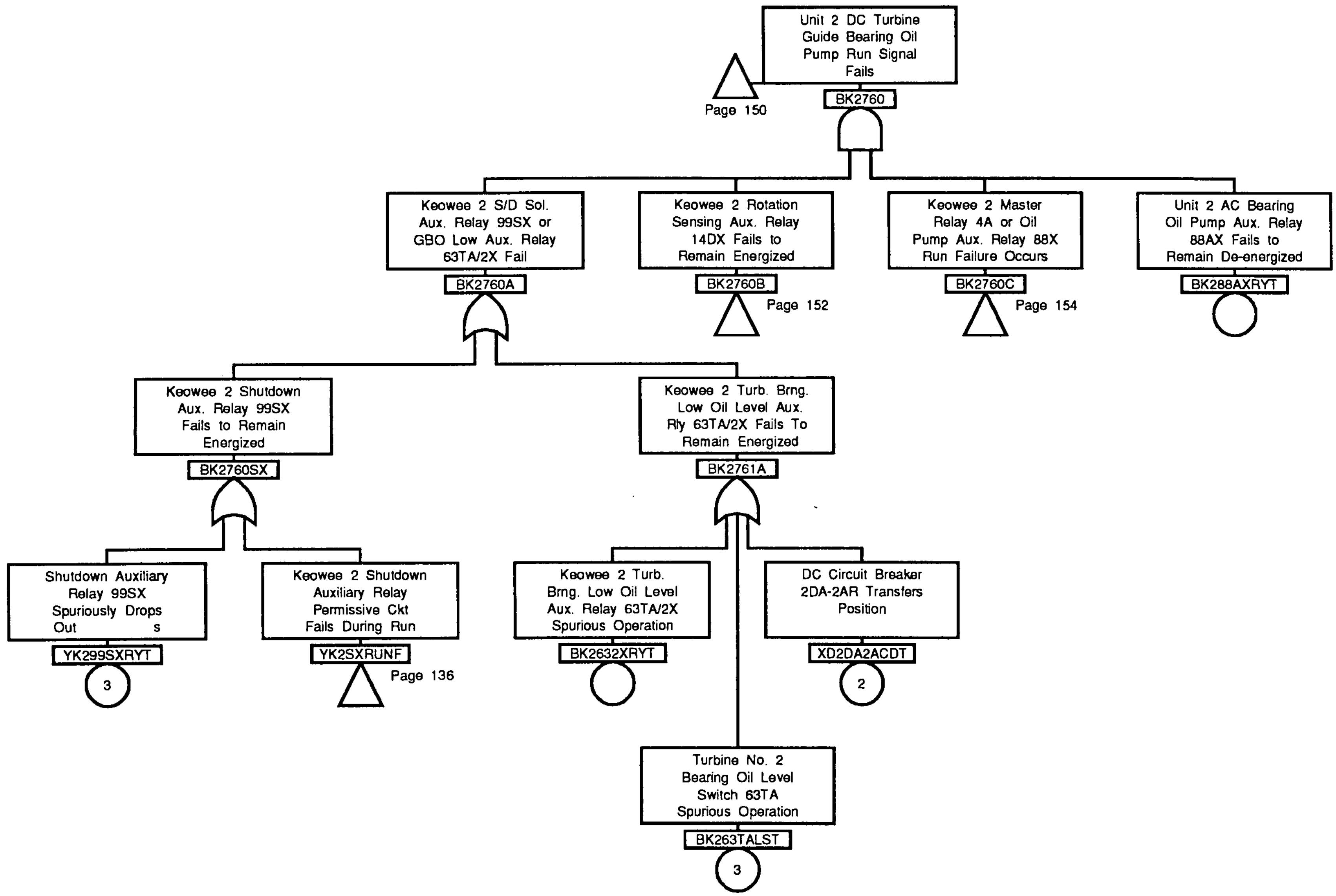

Unit 2 DC Turbine Guide Bearing Oil Pump Train Fails
BK2600
Page 139
Unit 2 DC Turbine Guide Bearing Oil Pump Fails
BK2650
Page 150
Check Valve 2GBO-3 Fails To Open On Demand
BK2GBO3CVO
Manual Valve 2GBO-4 Transfers Position
BK2GBO4VVT
Check Valve 2GBO-3 Transfers Closed
BK2GBO3CVT
Flow From DC Guide Bearing Oil Pump Diverted Through AC Pump
BK2560
Unit 2 DC Turbine GBO Pump Train In Maintenance
BK2GODCTRM
Unit 2 AC Turbine Guide Bearing Oil Pump Fails
BK2550
Page 140
Check Valve 2GBO-1 Fails to Close on Demand
BK2GBO1CVC

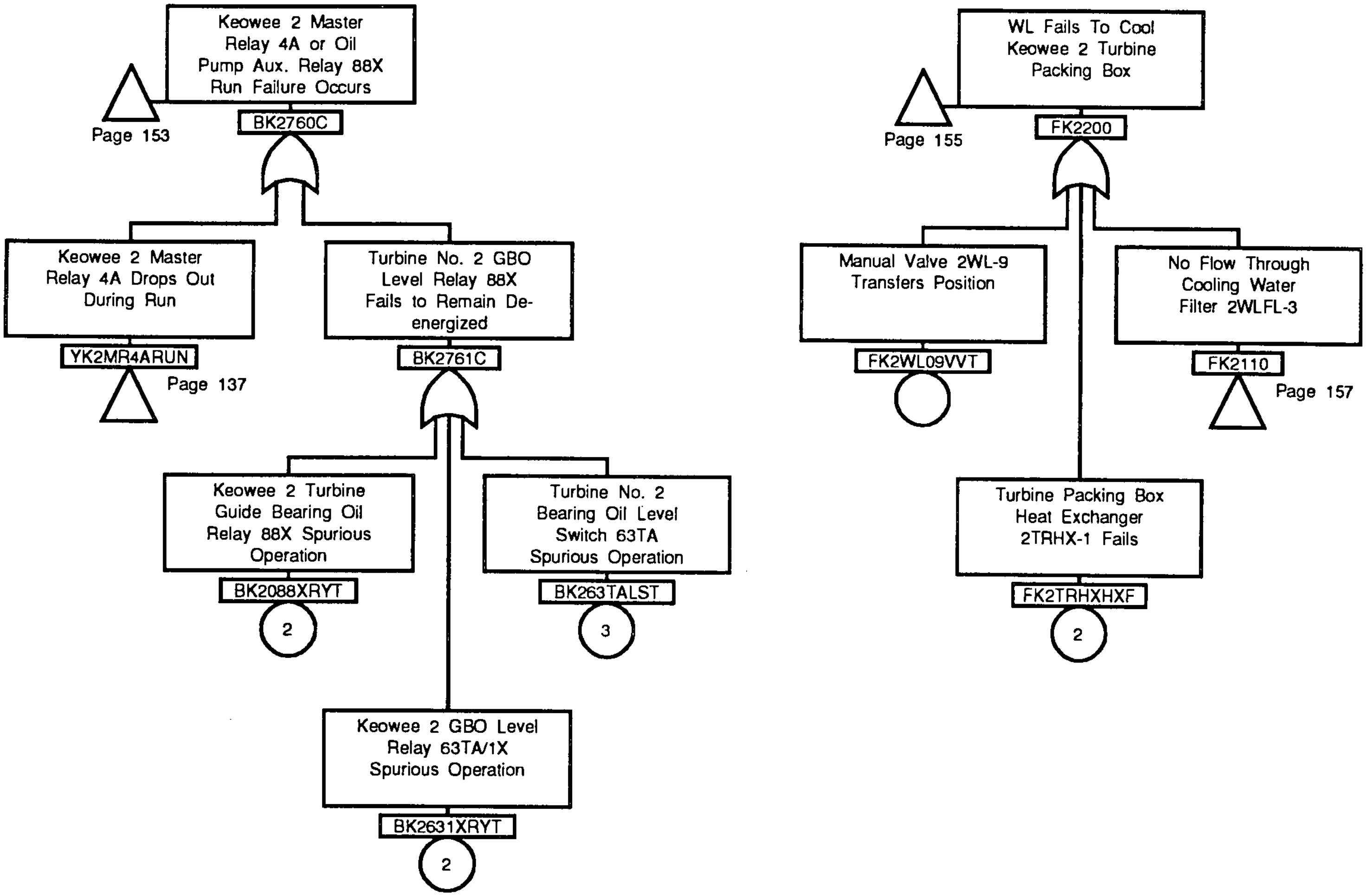

Unit 2 DC Turbine Guide Bearing Oil Pump Fails
Page 149
BK2650
Loss Of Power On Keowee 2 125V dc Dist.Cntr.2DA During Run
XD2DAR
Page 55
Unit 2 DC GBO Pump Control Switch S188D Spurious Operation
BK2188DSWT
DC Circuit Breaker 2DA-1B Transfers Position
BK2DA1BCDT
Latent Human Error Fails Unit 2 DC Guide Bearing Oil Pump Discharge Path
BK2GBDCLHE
Unit 2 DC Turbine GBO Pump Fails To Start On Demand
BK2GBDCGPS
Unit 2 DC Turbine Guide Bearing Oil Pump Start Signal Fails
BK2660
Page 151
Unit 2 DC Turbine GBO Pump Fails To Run
BK2GBDCGPR
Unit 2 DC Turbine Guide Bearing Oil Pump Run Signal Fails
BK2760
Page 153

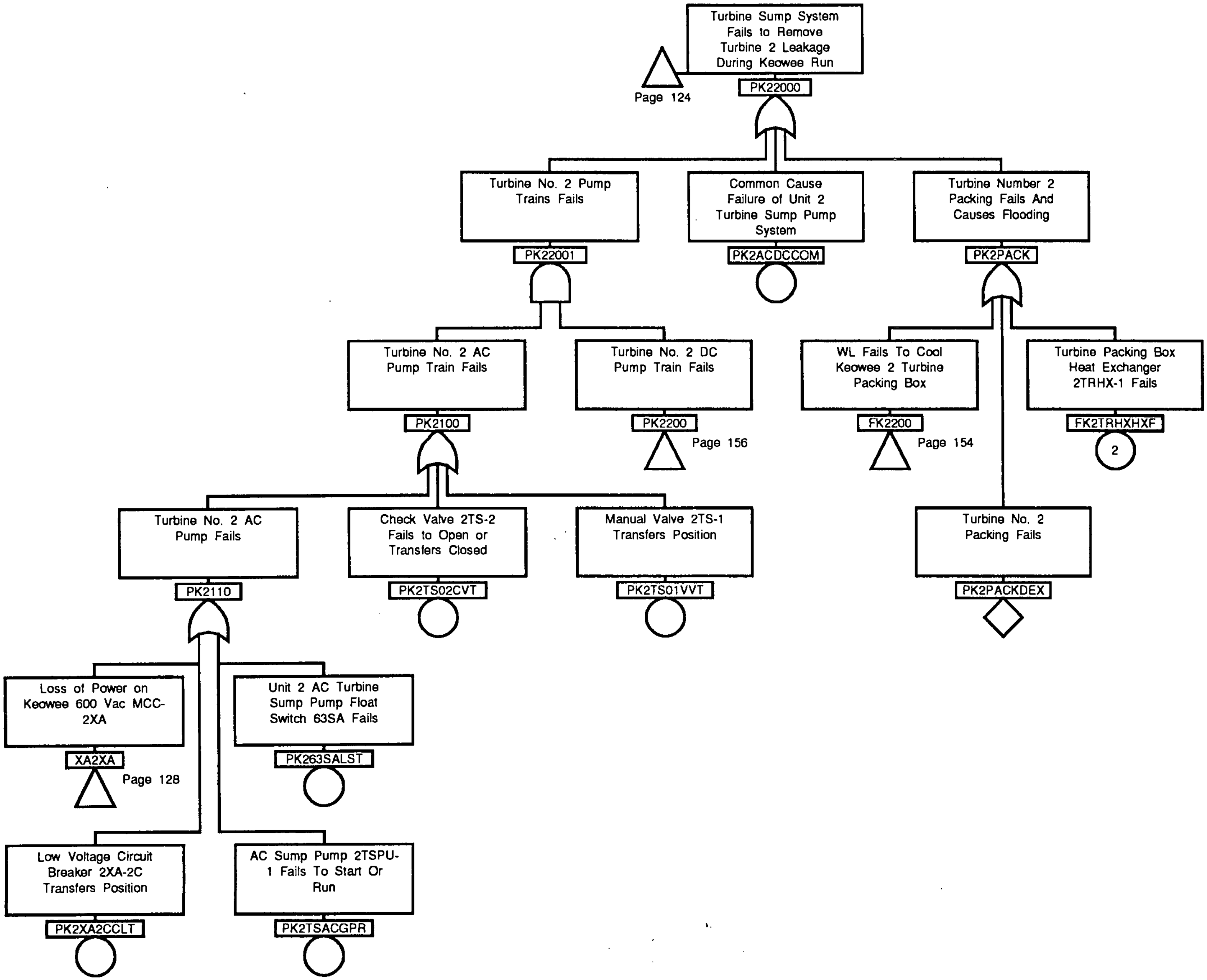

Unit 2 DC Turbine Guide Bearing Oil Pump Start Signal Fails
BK2660
Page 150
Keowee 2 S/D Sol. Aux. Relay 99SX or GBO Low Aux. Relay 63TA/2X Fail
BK2660A
Keowee 2 MR 4A Fails to Energize or Oil Pump Aux. Relay 88X Fails to Drop out
BK2660C
Unit 2 AC Bearing Oil Pump Aux. Relay 88AX Fails to Drop Out
BK288AXRYD
K2 Shutdown Auxiliary Relay 99SX Fails To Pick Up On Start
YK299SXSRT
Page 115
Keowee 2 Brng. Low Oil Level Aux. Relay 63TA/2X Fails To Energize
BK2661A
Keowee 2 Master Relay 4A Fails To Pick Up On Start
YK2MR4ASRT
Page 115
Keowee 2 GBO Level Relay 88X Fails to Drop Out
BK2661C
Page 152
Keowee 2 Brng. Low Oil Level Aux. Relay 63TA/2X Fails To Operate On Demand
BK2632XRYD
Turbine No. 2 Bearing Oil Level Switch 63TA Fails on Demand
BK263TALSD
2



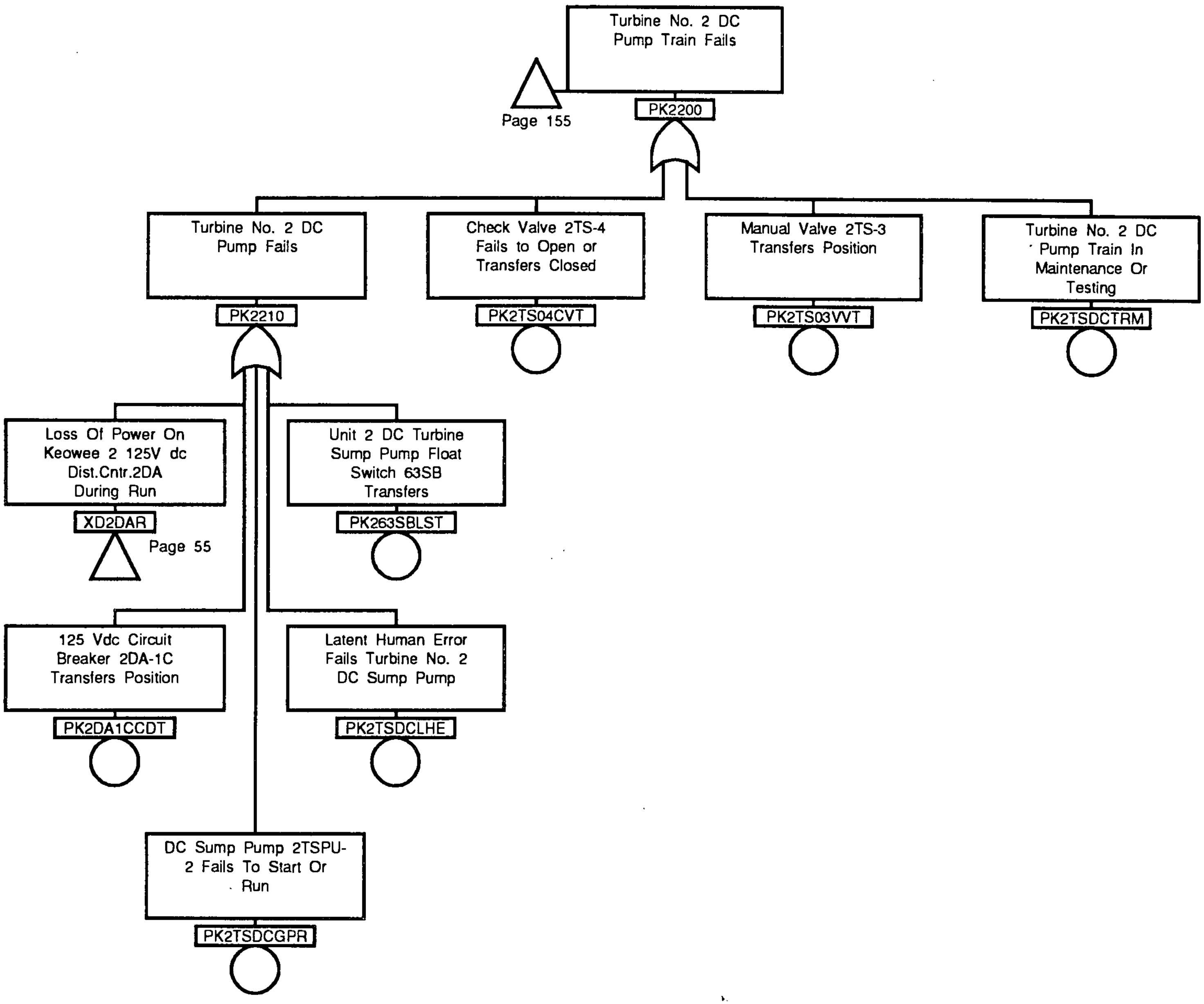
Keowee 2 GBO Level Relay 88X Fails to Drop Out
BK2661C
Page 151
Keowee 2 Turbine Guide Bearing Oil Relay 88X Fails to Drop Out
BK2088XRYD
Turbine No. 2 Bearing Oil Level Switch 63TA Fails on Demand
BK263TALSD
2
Keowee 2 Relay 63TA/1X Fails to De-energize
BK2631XRYD
Keowee 2 Rotation Sensing Aux. Relay 14DX Fails to Remain Energized
BK2760B
Page 153
Page 163
Keowee 2 Rotation Sensing Aux. Relay 14DX Spurious Operation
BK214DXRYT
Keowee 2 Speed Switch 14/2 Spuriously Transfers Closed
BK214/2SST
Keowee Rotation Sensing Timer 14T2 Fails to Remain De-energized
BK214T2RYT
125 Vdc Circuit Breaker 2DA-3BR Transfers Position
XD2DA3BCDT
2


Unit 2 DC Turbine Guide Bearing Oil Pump Run Signal Fails
BK2760
Page 150
Keowee 2 S/D Sol. Aux. Relay 99SX or GBO Low Aux. Relay 63TA/2X Fail
BK2760A
Keowee 2 Rotation Sensing Aux. Relay 14DX Fails to Remain Energized
BK2760B
Page 152
Keowee 2 Master Relay 4A or Oil Pump Aux. Relay 88X Run Failure Occurs
BK2760C
Page 154
Unit 2 AC Bearing Oil Pump Aux. Relay 88AX Fails to Remain De-energized
BK288AXRYT
Keowee 2 Shutdown Aux. Relay 99SX Fails to Remain Energized
BK2760SX
Keowee 2 Turb. Brng. Low Oil Level Aux. Rly 63TA/2X Fails To Remain Energized
BK2761A
Shutdown Auxiliary Relay 99SX Spuriously Drops Out s
YK299SXRYT
3
Keowee 2 Shutdown Auxiliary Relay Permissive Ckt Fails During Run
YK2SXRUNF
Page 136
Keowee 2 Turb. Brng. Low Oil Level Aux. Relay 63TA/2X Spurious Operation
BK2632XRYT
DC Circuit Breaker 2DA-2AR Transfers Position
XD2DA2ACDT
2
Turbine No. 2 Bearing Oil Level Switch 63TA Spurious Operation
BK263TALST
3

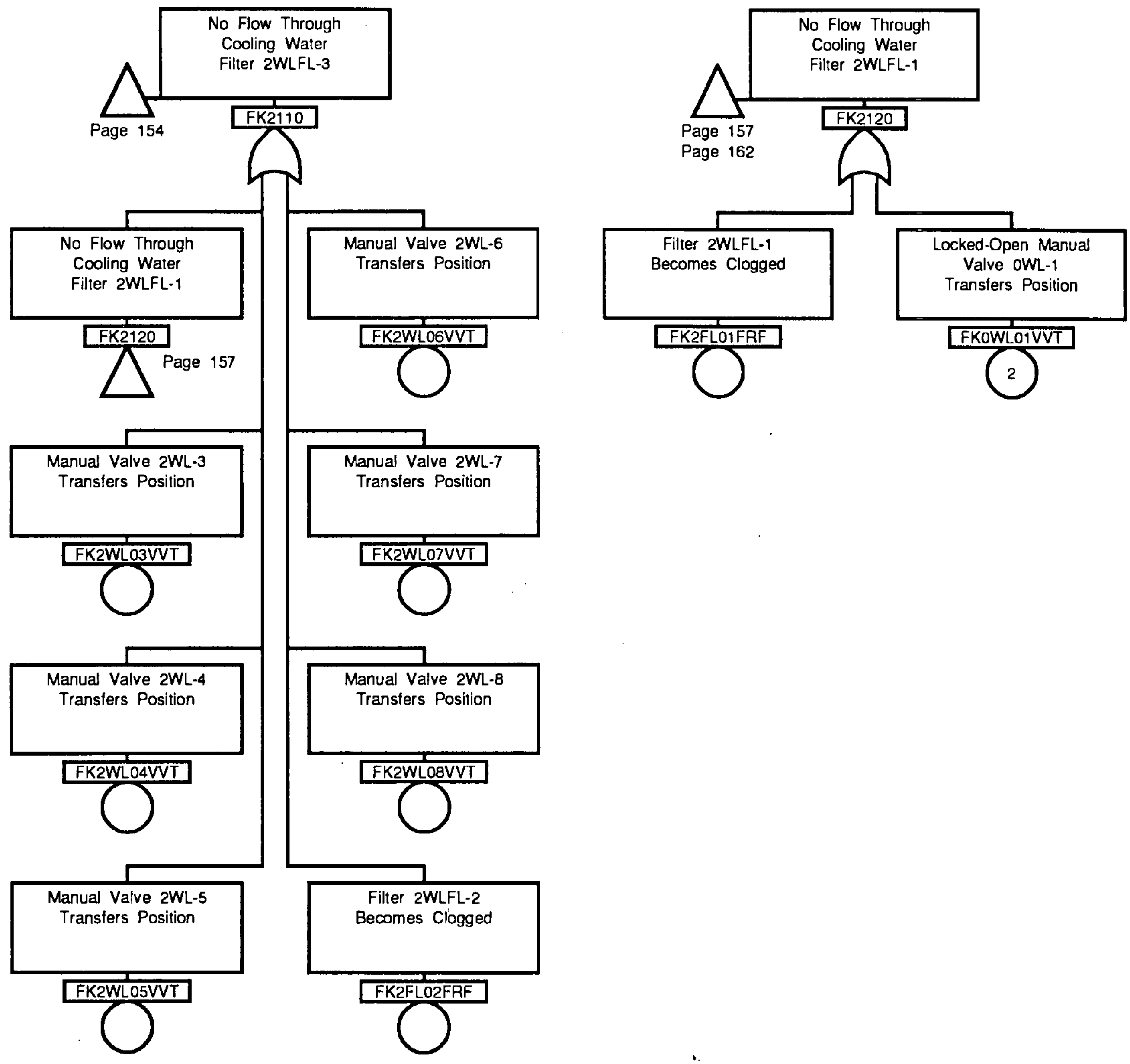

Keowee 2 Master Relay 4A or Oil Pump Aux. Relay 88X Run Failure Occurs
BK2760C
Page 153
Keowee 2 Master Relay 4A Drops Out During Run
YK2MR4ARUN
Page 137
Turbine No. 2 GBO Level Relay 88X Fails to Remain De-energized
BK2761C
Keowee 2 Turbine Guide Bearing Oil Relay 88X Spurious Operation
BK2088XRYT
2
Turbine No. 2 Bearing Oil Level Switch 63TA Spurious Operation
BK263TALST
3
Keowee 2 GBO Level Relay 63TA/1X Spurious Operation
BK2631XRYT
2
WL Fails To Cool Keowee 2 Turbine Packing Box
FK2200
Page 155
Manual Valve 2WL-9 Transfers Position
FK2WL09VVT
No Flow Through Cooling Water Filter 2WLFL-3
FK2110
Page 157
Turbine Packing Box Heat Exchanger 2TRHX-1 Fails
FK2TRHXHXF
2

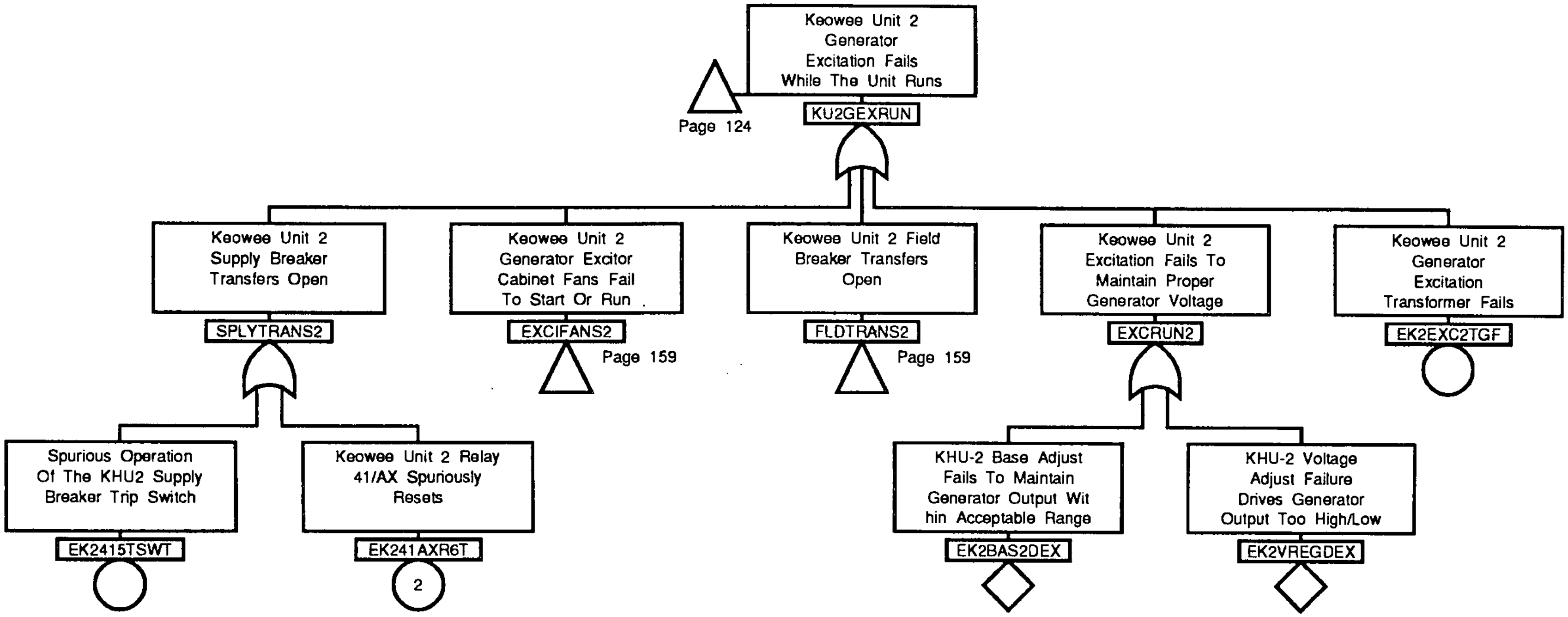


Turbine Sump System Fails to Remove Turbine 2 Leakage During Keowee Run
PK22000
Page 124
Turbine No. 2 Pump Trains Fails
PK22001
Common Cause Failure of Unit 2 Turbine Sump Pump System
PK2ACDCCOM
Turbine Number 2 Packing Fails And Causes Flooding
PK2PACK
Turbine No. 2 AC Pump Train Fails
PK2100
Turbine No. 2 DC Pump Train Fails
PK2200
Page 156
WL Fails To Cool Keowee 2 Turbine Packing Box
FK2200
Page 154
Turbine Packing Box Heat Exchanger 2TRHX-1 Fails
FK2TRHXHXF
2
Turbine No. 2 AC Pump Fails
PK2110
Check Valve 2TS-2 Fails to Open or Transfers Closed
PK2TS02CVT
Manual Valve 2TS-1 Transfers Position
PK2TS01VVT
Turbine No. 2 Packing Fails
PK2PACKDEX
Loss of Power on Keowee 600 Vac MCC-2XA
XA2XA
Page 128
Unit 2 AC Turbine Sump Pump Float Switch 63SA Fails
PK263SALST
Low Voltage Circuit Breaker 2XA-2C Transfers Position
PK2XA2CCLT
AC Sump Pump 2TSPU-1 Fails To Start Or Run
PK2TSACGPR

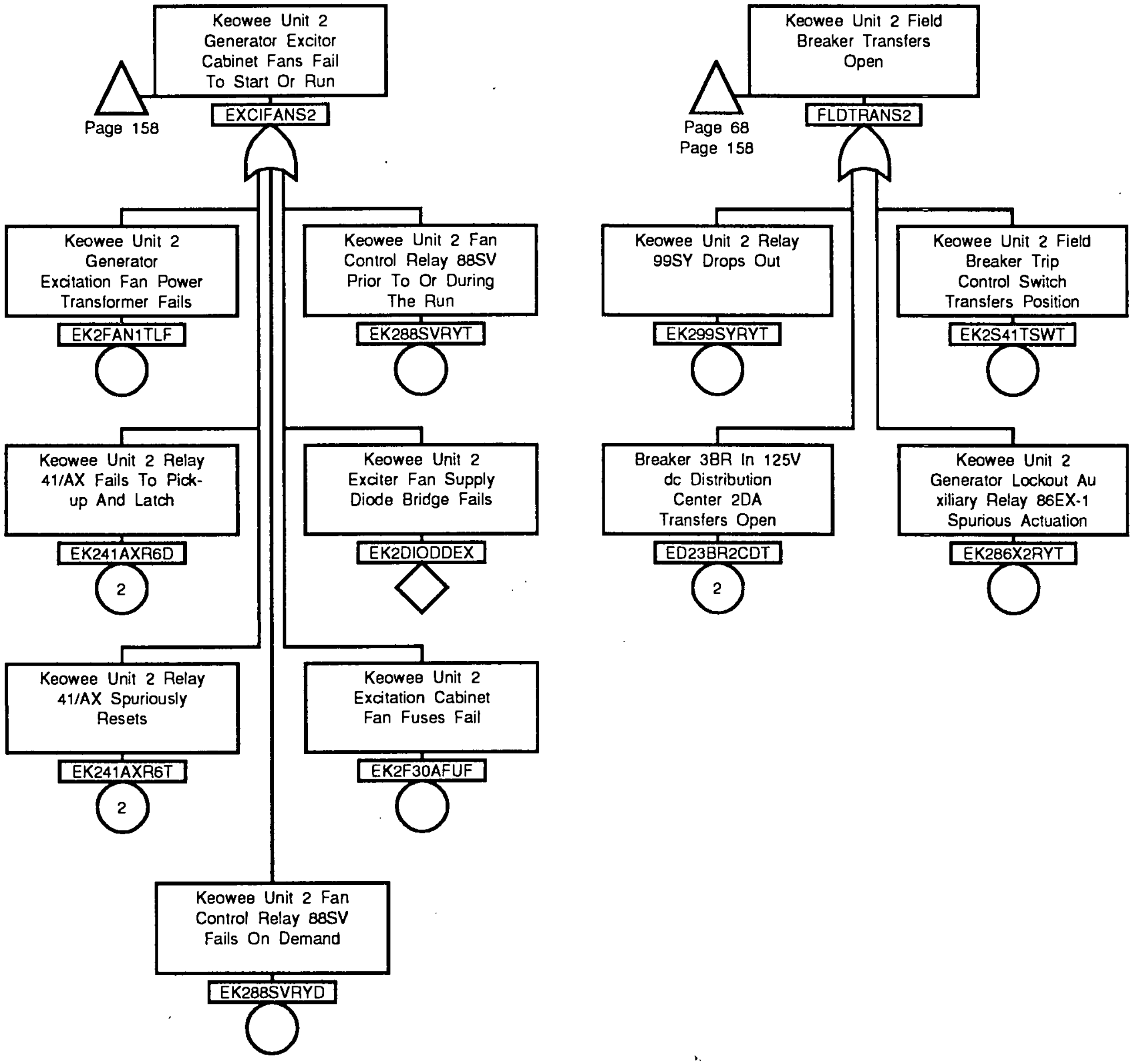


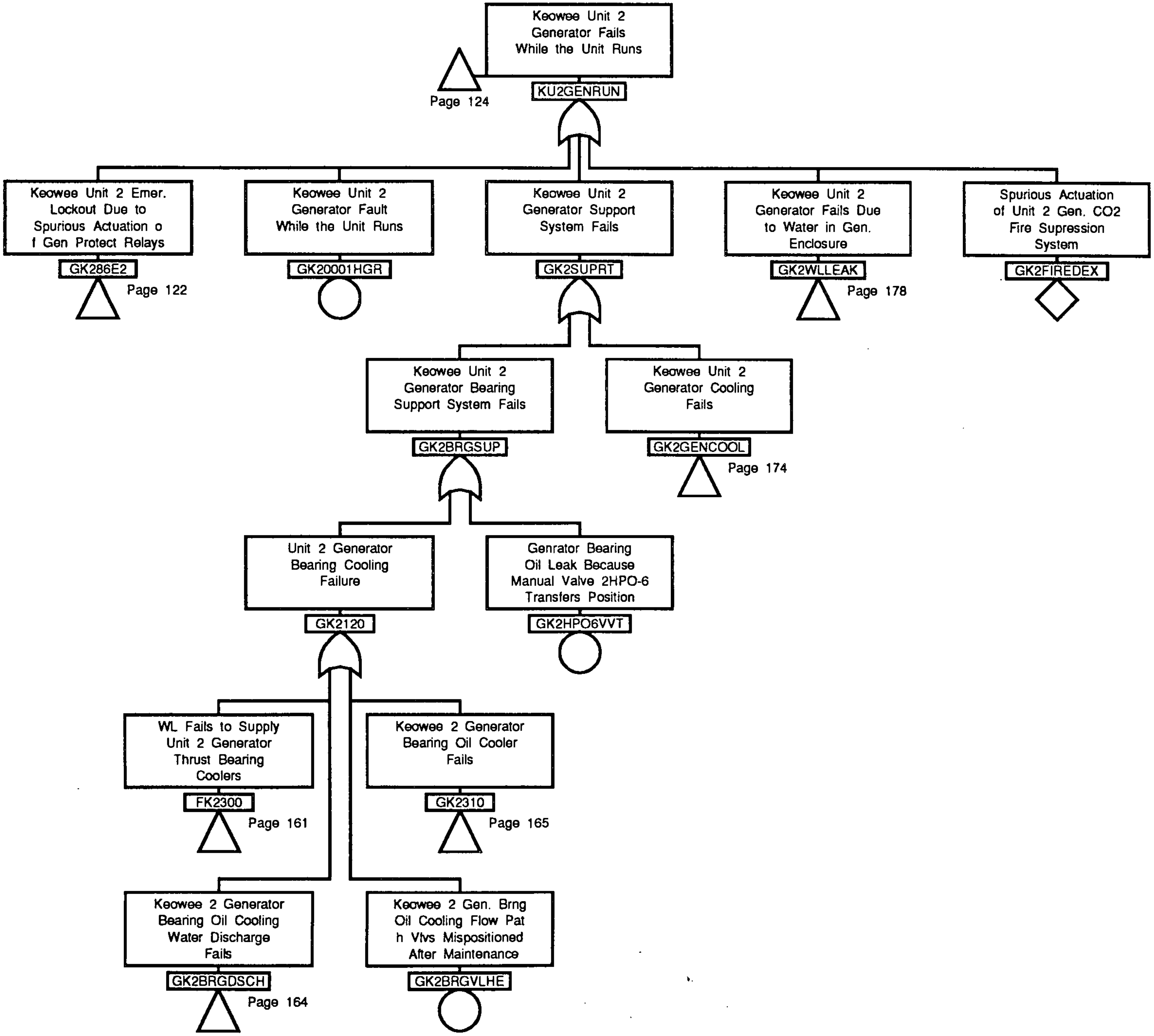
Turbine No. 2 DC Pump Train Fails
PK2200
Page 155
Turbine No. 2 DC Pump Fails
PK2210
Check Valve 2TS-4 Fails to Open or Transfers Closed
PK2TS04CVT
Manual Valve 2TS-3 Transfers Position
PK2TS03VVT
Turbine No. 2 DC Pump Train In Maintenance Or Testing
PK2TSDCTRM
Loss Of Power On Keowee 2 125V dc Dist.Cntr.2DA During Run
XD2DAR
Page 55
Unit 2 DC Turbine Sump Pump Float Switch 63SB Transfers
PK263SBLST
125 Vdc Circuit Breaker 2DA-1C Transfers Position
PK2DA1CCDT
Latent Human Error Fails Turbine No. 2 DC Sump Pump
PK2TSDCLHE
DC Sump Pump 2TSPU-2 Fails To Start Or Run
PK2TSDCGPR


No Flow Through Cooling Water Filter 2WLFL-3
FK2110
Page 154
No Flow Through Cooling Water Filter 2WLFL-1
FK2120
Page 157
Manual Valve 2WL-6 Transfers Position
FK2WL06VVT
Manual Valve 2WL-3 Transfers Position
FK2WL03VVT
Manual Valve 2WL-7 Transfers Position
FK2WL07VVT
Manual Valve 2WL-4 Transfers Position
FK2WL04VVT
Manual Valve 2WL-8 Transfers Position
FK2WL08VVT
Manual Valve 2WL-5 Transfers Position
FK2WL05VVT
Filter 2WLFL-2 Becomes Clogged
FK2FL02FRF
No Flow Through Cooling Water Filter 2WLFL-1
FK2120
Page 157
Page 162
Filter 2WLFL-1 Becomes Clogged
FK2FL01FRF
Locked-Open Manual Valve 0WL-1 Transfers Position
FK0WL01VVT
2

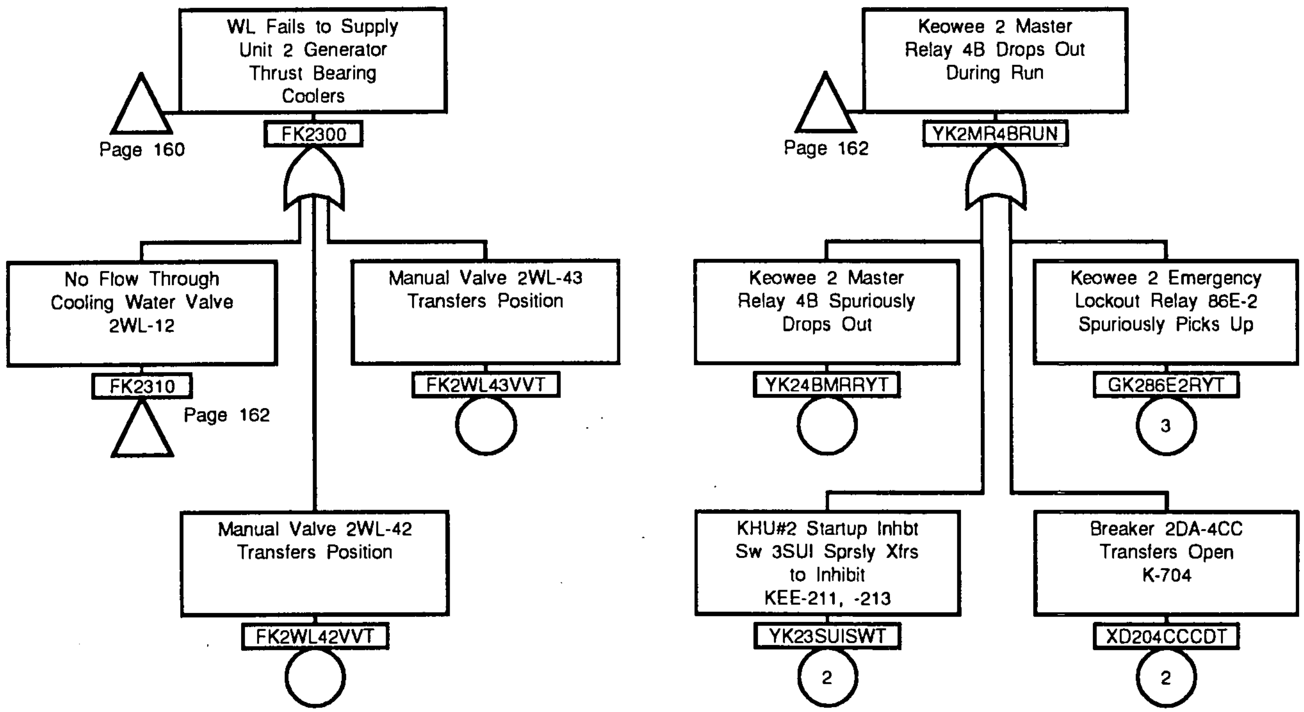


Keowee Unit 2 Generator Excitation Fails While The Unit Runs
KU2GEXRUN
Page 124
Keowee Unit 2 Supply Breaker Transfers Open
SPLYTRANS2
Keowee Unit 2 Generator Excitor Cabinet Fans Fail To Start Or Run
EXCIFANS2
Page 159
Keowee Unit 2 Field Breaker Transfers Open
FLDTRANS2
Page 159
Keowee Unit 2 Excitation Fails To Maintain Proper Generator Voltage
EXCRUN2
Keowee Unit 2 Generator Excitation Transformer Fails
EK2EXC2TGF
Spurious Operation Of The KHU2 Supply Breaker Trip Switch
EK2415TSWT
Keowee Unit 2 Relay 41/AX Spuriously Resets
EK241AXR6T
2
KHU-2 Base Adjust Fails To Maintain Generator Output Wit hin Acceptable Range
EK2BAS2DEX
KHU-2 Voltage Adjust Failure Drives Generator Output Too High/Low
EK2VREGDEX

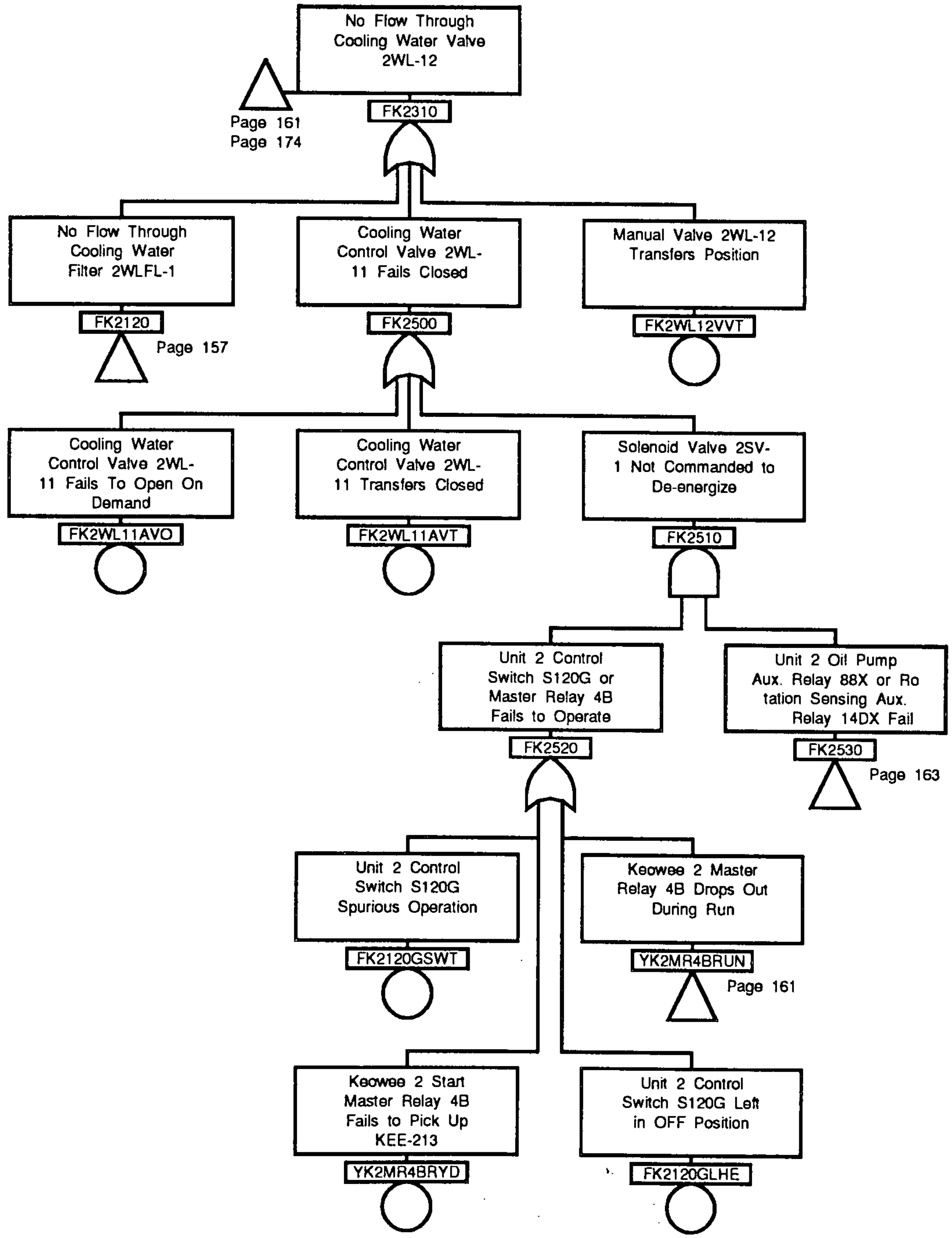

Keewee Unit 2 Generator Excitor Cabinet Fans Fail To Start Or Run
EXCIFANS2
Page 158
Keowee Unit 2 Generator Excitation Fan Power Transformer Fails
EK2FAN1TLF
Keowee Unit 2 Fan Control Relay 88SV Prior To Or During The Run
EK288SVRYT
Keowee Unit 2 Relay 41/AX Fails To Pick-up And Latch
EK241AXR6D
2
Keowee Unit 2 Exciter Fan Supply Diode Bridge Fails
EK2DIODDEX
Keowee Unit 2 Relay 41/AX Spuriously Resets
EK241AXR6T
2
Keowee Unit 2 Excitation Cabinet Fan Fuses Fail
EK2F30AFUF
Keowee Unit 2 Fan Control Relay 88SV Fails On Demand
EK288SVRYD
Keowee Unit 2 Field Breaker Transfers Open
FLDTRANS2
Page 68
Page 158
Keowee Unit 2 Relay 99SY Drops Out
EK299SYRYT
Keowee Unit 2 Field Breaker Trip Control Switch Transfers Position
EK2S41TSWT
Breaker 3BR In 125V dc Distribution Center 2DA Transfers Open
ED23BR2CDT
2
Keowee Unit 2 Generator Lockout Au xiliary Relay 86EX-1 Spurious Actuation
EK286X2RYT

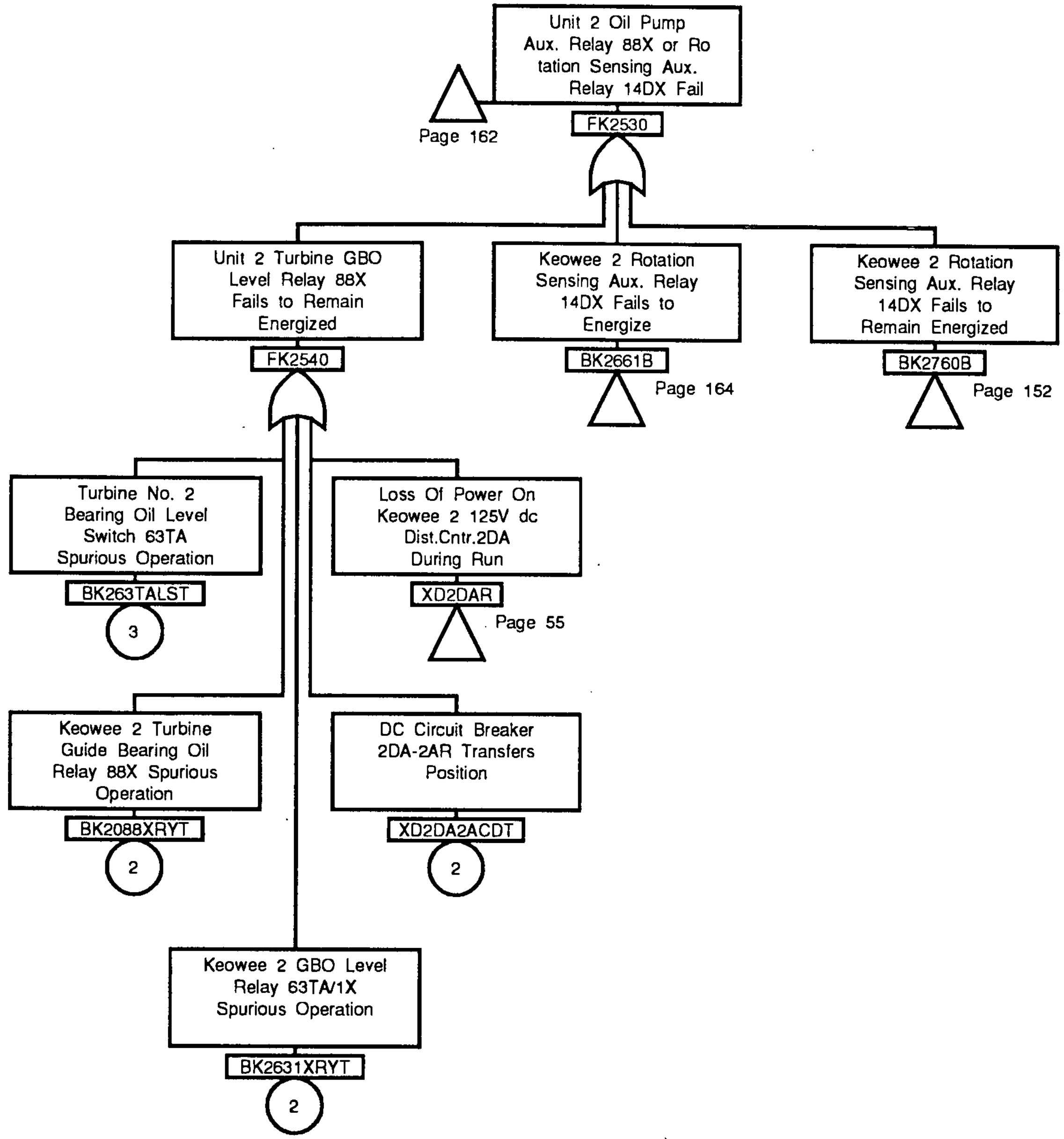


Keowee Unit 2 Generator Fails While the Unit Runs
KU2GENRUN
Page 124
Keowee Unit 2 Emer. Lockout Due to Spurious Actuation o f Gen Protect Relays
GK286E2
Page 122
Keowee Unit 2 Generator Fault While the Unit Runs
GK20001HGR
Keowee Unit 2 Generator Support System Fails
GK2SUPRT
Keowee Unit 2 Generator Fails Due to Water in Gen. Enclosure
GK2WLLEAK
Page 178
Spurious Actuation of Unit 2 Gen. CO2 Fire Supression System
GK2FIREDEX
Keowee Unit 2 Generator Bearing Support System Fails
GK2BRGSUP
Keowee Unit 2 Generator Cooling Fails
GK2GENCOOL
Page 174
Unit 2 Generator Bearing Cooling Failure
GK2120
Genrator Bearing Oil Leak Because Manual Valve 2HPO-6 Transfers Position
GK2HPO6VVT
WL Fails to Supply Unit 2 Generator Thrust Bearing Coolers
FK2300
Page 161
Keowee 2 Generator Bearing Oil Cooler Fails
GK2310
Page 165
Keowee 2 Generator Bearing Oil Cooling Water Discharge Fails
GK2BRGDSCH
Page 164
Keowee 2 Gen. Brng Oil Cooling Flow Pat h Vlvs Mispositioned After Maintenance
GK2BRGVLHE

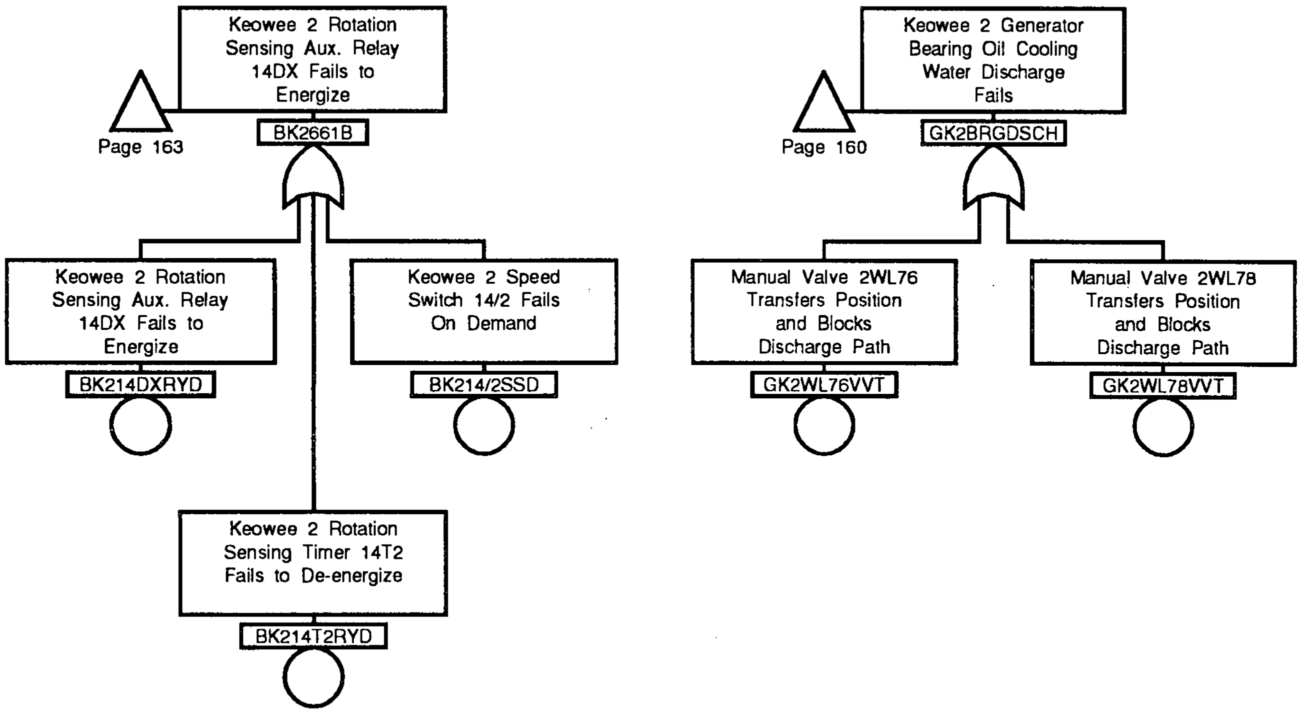


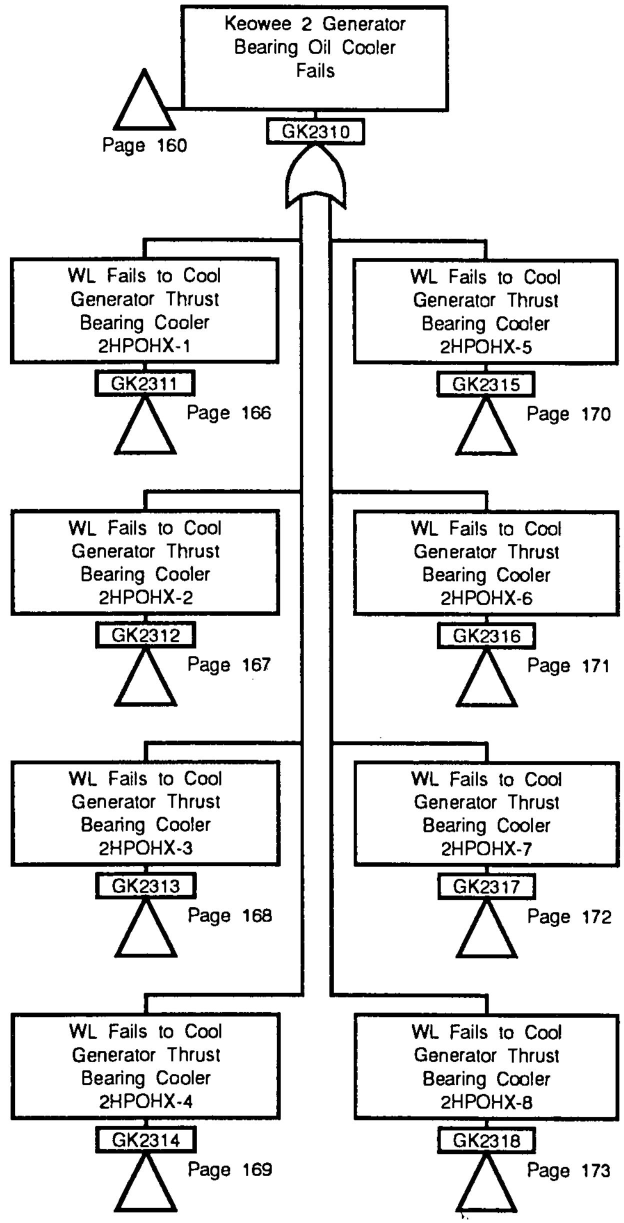
WL Fails to Supply Unit 2 Generator Thrust Bearing Coolers
FK2300
Page 160
No Flow Through Cooling Water Valve 2WL-12
FK2310
Page 162
Manual Valve 2WL-43 Transfers Position
FK2WL43VVT
Manual Valve 2WL-42 Transfers Position
FK2WL42VVT
Keowee 2 Master Relay 4B Drops Out During Run
YK2MR4BRUN
Page 162
Keowee 2 Master Relay 4B Spuriously Drops Out
YK24BMRRYT
Keowee 2 Emergency Lockout Relay 86E-2 Spuriously Picks Up
GK286E2RYT
3
KHU#2 Startup Inhbt Sw 3SUI Sprsly Xfrs to Inhibit KEE-211, -213
YK23SUISWT
2
Breaker 2DA-4CC Transfers Open K-704
XD204CCCDT
2


No Flow Through Cooling Water Valve 2WL-12
FK2310
Page 161
Page 174
No Flow Through Cooling Water Filter 2WLFL-1
FK2120
Page 157
Cooling Water Control Valve 2WL-11 Fails Closed
FK2500
Manual Valve 2WL-12 Transfers Position
FK2WL12VVT
Cooling Water Control Valve 2WL-11 Fails To Open On Demand
FK2WL11AVO
Cooling Water Control Valve 2WL-11 Transfers Closed
FK2WL11AVT
Solenoid Valve 2SV-1 Not Commanded to De-energize
FK2510
Unit 2 Control Switch S120G or Master Relay 4B Fails to Operate
FK2520
Unit 2 Oil Pump Aux. Relay 88X or Rotation Sensing Aux. Relay 14DX Fail
FK2530
Page 163
Unit 2 Control Switch S120G Spurious Operation
FK2120GSWT
Keowee 2 Master Relay 4B Drops Out During Run
YK2MR4BRUN
Page 161
Keowee 2 Start Master Relay 4B Fails to Pick Up KEE-213
YK2MR4BRYD
Unit 2 Control Switch S120G Left in OFF Position
FK2120GLHE

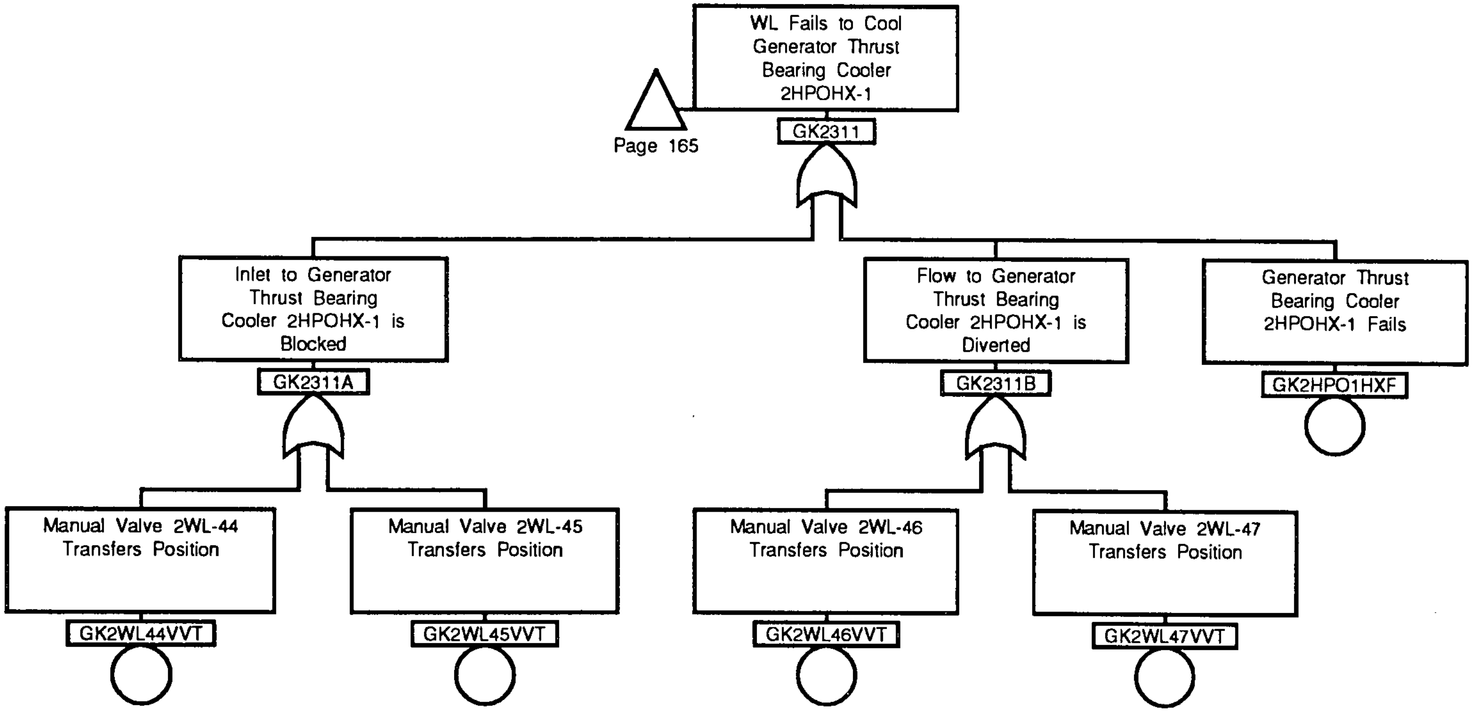


Unit 2 Oil Pump Aux. Relay 88X or Ro tation Sensing Aux. Relay 14DX Fail
FK2530
Page 162
Unit 2 Turbine GBO Level Relay 88X Fails to Remain Energized
FK2540
Keowee 2 Rotation Sensing Aux. Relay 14DX Fails to Energize
BK2661B
Page 164
Keowee 2 Rotation Sensing Aux. Relay 14DX Fails to Remain Energized
BK2760B
Page 152
Turbine No. 2 Bearing Oil Level Switch 63TA Spurious Operation
BK263TALST
3
Loss Of Power On Keowee 2 125V dc Dist.Cntr.2DA During Run
XD2DAR
Page 55
Keowee 2 Turbine Guide Bearing Oil Relay 88X Spurious Operation
BK2088XRYT
2
DC Circuit Breaker 2DA-2AR Transfers Position
XD2DA2ACDT
2
Keowee 2 GBO Level Relay 63TA/1X Spurious Operation
BK2631XRYT
2

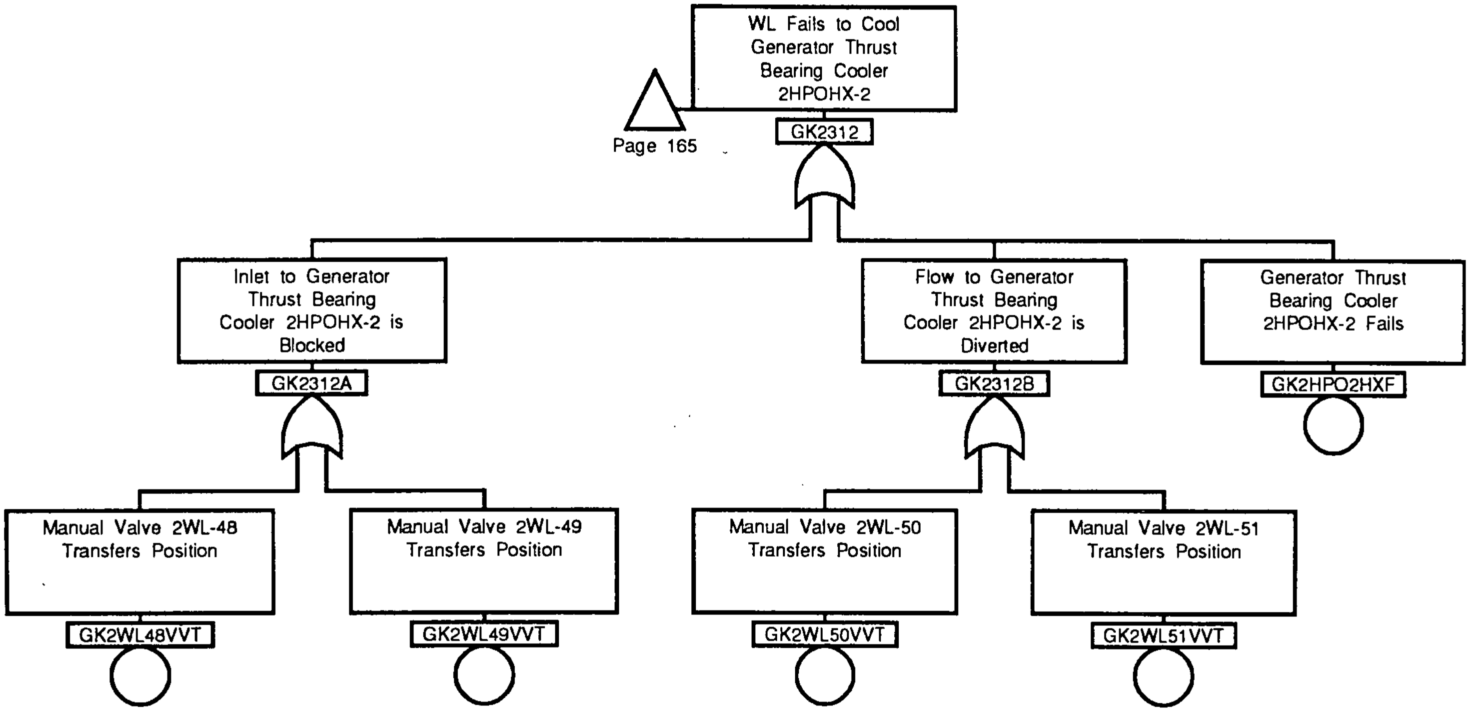

Keowee 2 Rotation Sensing Aux. Relay 14DX Fails to Energize
BK2661B
Page 163
Keowee 2 Rotation Sensing Aux. Relay 14DX Fails to Energize
BK214DXRYD
Keowee 2 Speed Switch 14/2 Fails On Demand
BK214/2SSD
Keowee 2 Rotation Sensing Timer 14T2 Fails to De-energize
BK214T2RYD
Keowee 2 Generator Bearing Oil Cooling Water Discharge Fails
GK2BRGDSCH
Page 160
Manual Valve 2WL76 Transfers Position and Blocks Discharge Path
GK2WL76VVT
Manual Valve 2WL78 Transfers Position and Blocks Discharge Path
GK2WL78VVT



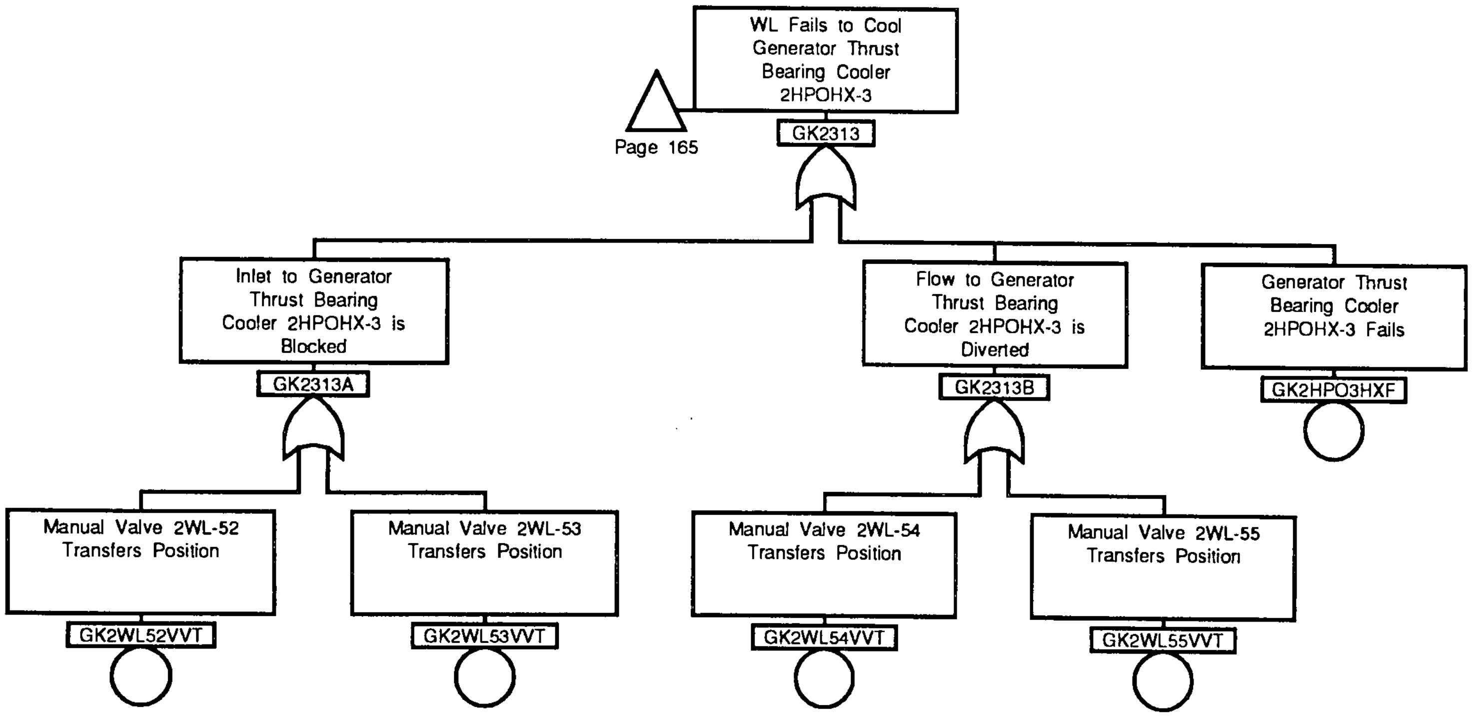
Keowee 2 Generator Bearing Oil Cooler Fails
GK2310
Page 160
WL Fails to Cool Generator Thrust Bearing Cooler 2HPOHX-1
GK2311
Page 166
WL Fails to Cool Generator Thrust Bearing Cooler 2HPOHX-5
GK2315
Page 170
WL Fails to Cool Generator Thrust Bearing Cooler 2HPOHX-2
GK2312
Page 167
WL Fails to Cool Generator Thrust Bearing Cooler 2HPOHX-6
GK2316
Page 171
WL Fails to Cool Generator Thrust Bearing Cooler 2HPOHX-3
GK2313
Page 168
WL Fails to Cool Generator Thrust Bearing Cooler 2HPOHX-7
GK2317
Page 172
WL Fails to Cool Generator Thrust Bearing Cooler 2HPOHX-4
GK2314
Page 169
WL Fails to Cool Generator Thrust Bearing Cooler 2HPOHX-8
GK2318
Page 173

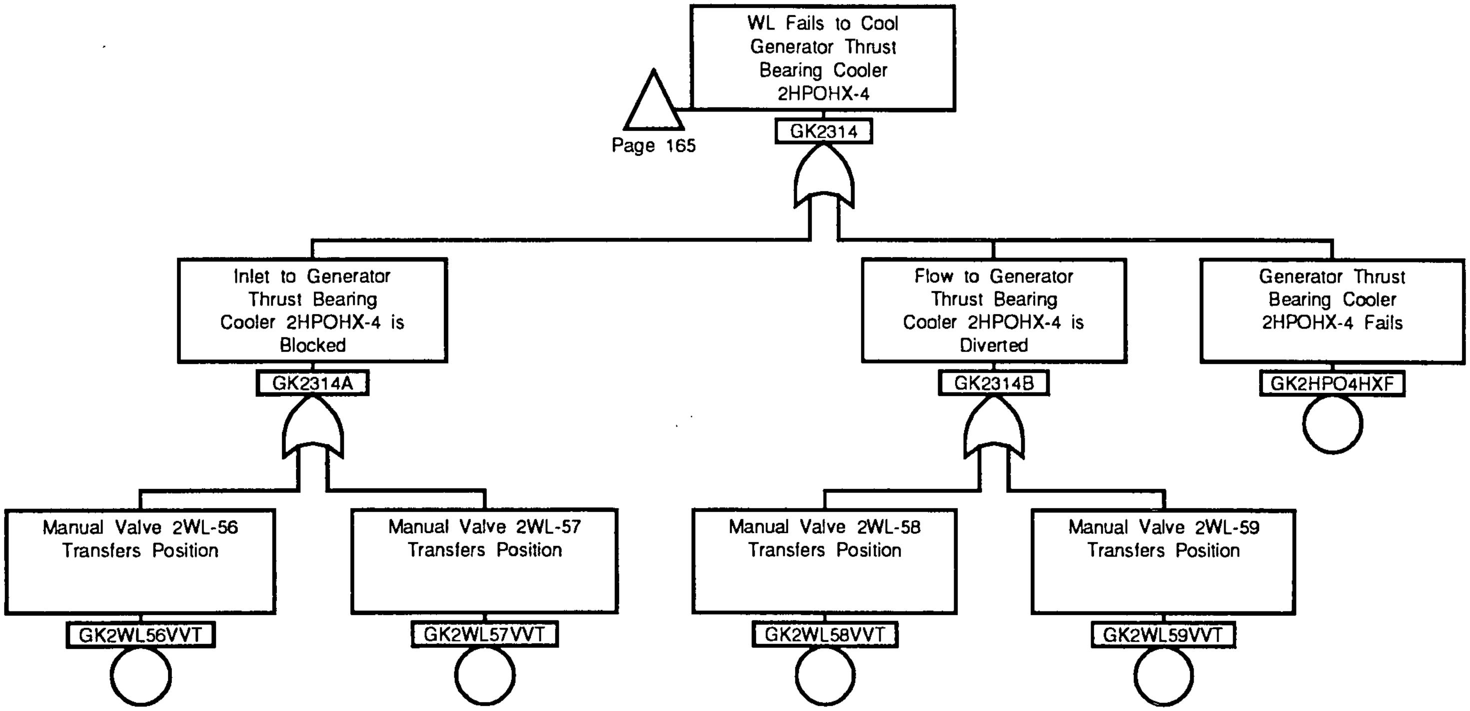


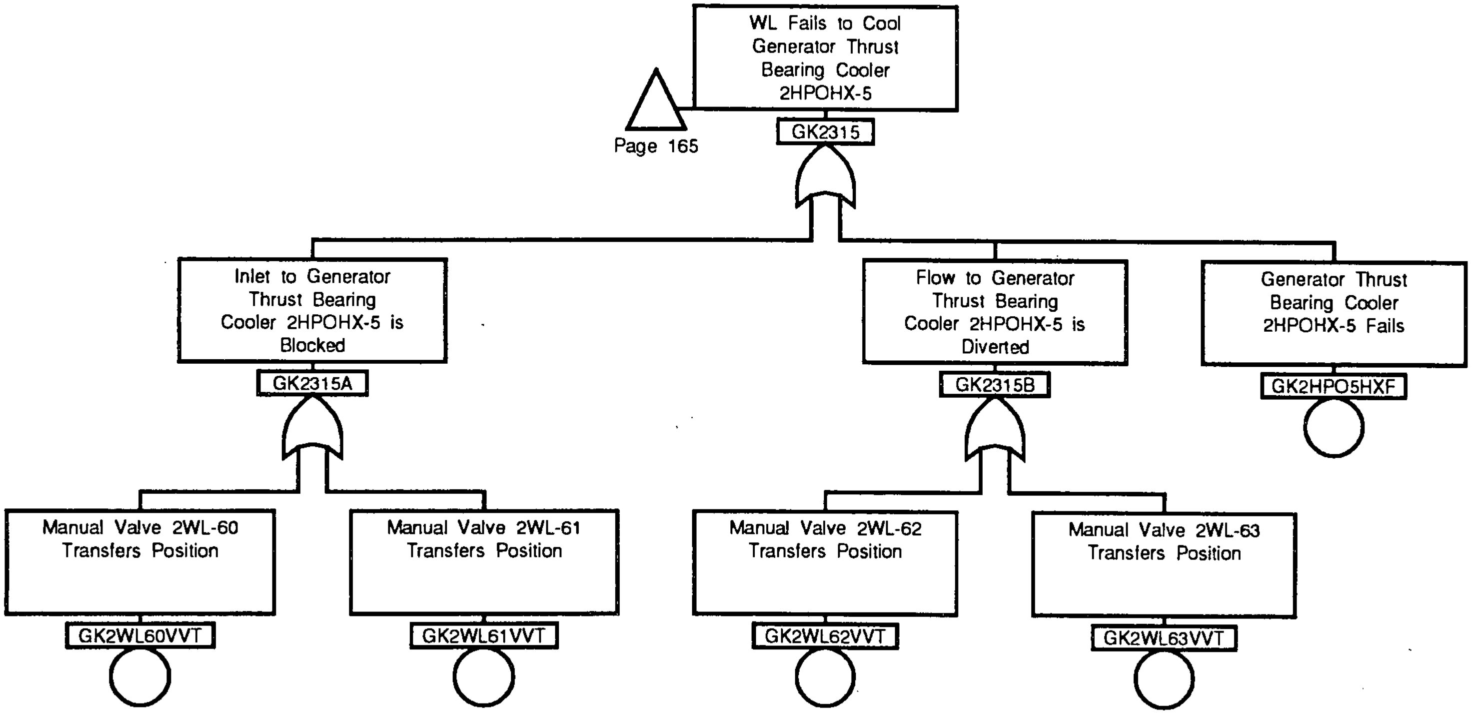
WL Fails to Cool Generator Thrust Bearing Cooler 2HPOHX-1
GK2311
Page 165
Inlet to Generator Thrust Bearing Cooler 2HPOHX-1 is Blocked
GK2311A
Flow to Generator Thrust Bearing Cooler 2HPOHX-1 is Diverted
GK2311B
Generator Thrust Bearing Cooler 2HPOHX-1 Fails
GK2HPO1HXF
Manual Valve 2WL-44 Transfers Position
GK2WL44VVT
Manual Valve 2WL-45 Transfers Position
GK2WL45VVT
Manual Valve 2WL-46 Transfers Position
GK2WL46VVT
Manual Valve 2WL-47 Transfers Position
GK2WL47VVT



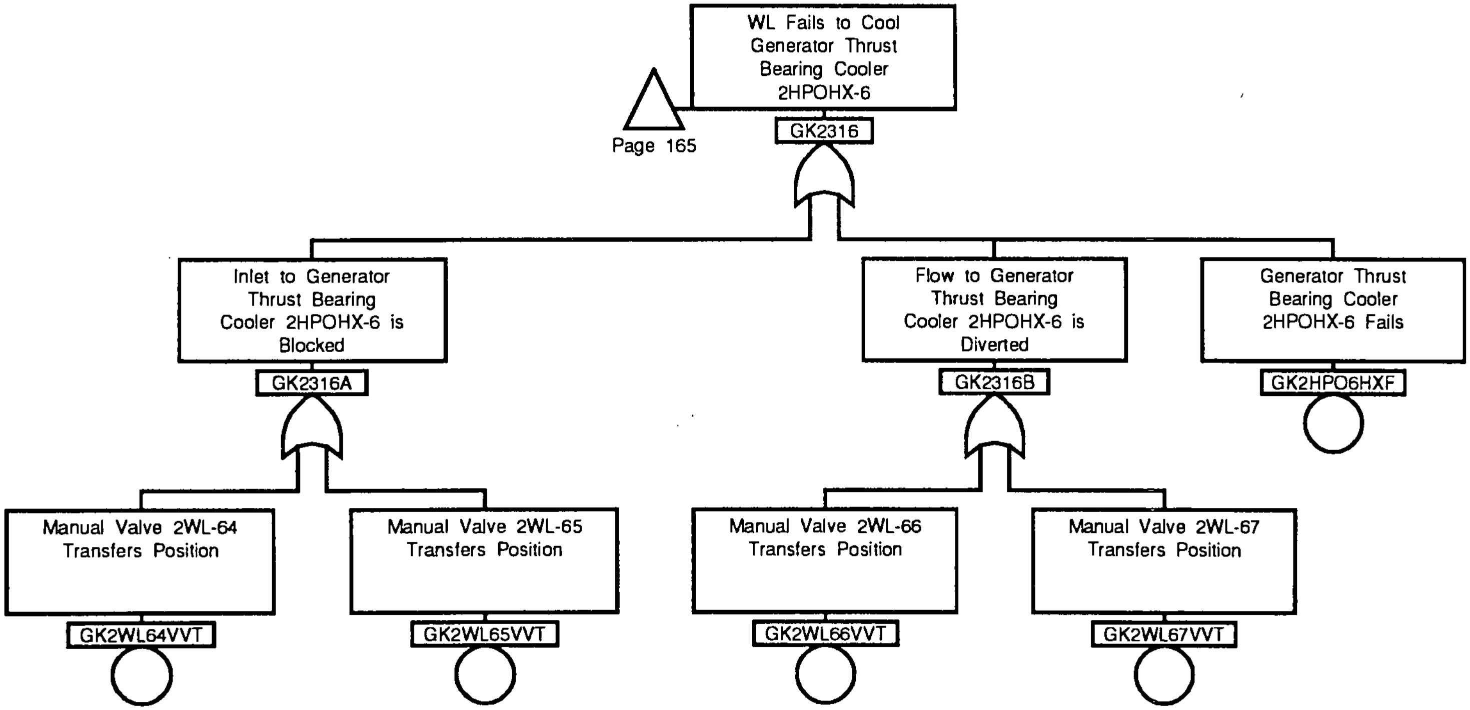
WL Fails to Cool Generator Thrust Bearing Cooler 2HPOHX-2
GK2312
Page 165
Inlet to Generator Thrust Bearing Cooler 2HPOHX-2 is Blocked
GK2312A
Flow to Generator Thrust Bearing Cooler 2HPOHX-2 is Diverted
GK2312B
Generator Thrust Bearing Cooler 2HPOHX-2 Fails
GK2HPO2HXF
Manual Valve 2WL-48 Transfers Position
GK2WL48VVT
Manual Valve 2WL-49 Transfers Position
GK2WL49VVT
Manual Valve 2WL-50 Transfers Position
GK2WL50VVT
Manual Valve 2WL-51 Transfers Position
GK2WL51VVT

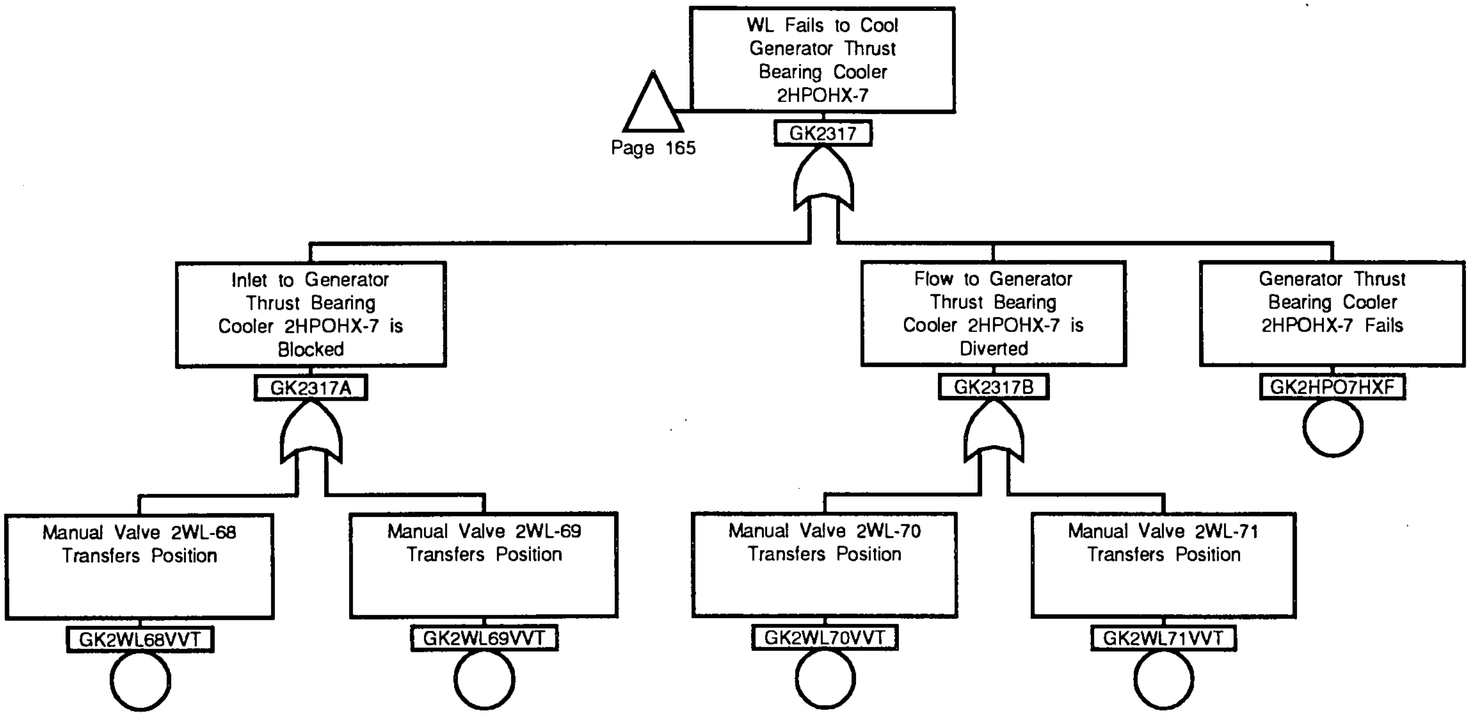

WL Fails to Cool Generator Thrust Bearing Cooler 2HPOHX-3
GK2313
Page 165
Inlet to Generator Thrust Bearing Cooler 2HPOHX-3 is Blocked
GK2313A
Flow to Generator Thrust Bearing Cooler 2HPOHX-3 is Diverted
GK2313B
Generator Thrust Bearing Cooler 2HPOHX-3 Fails
GK2HPO3HXF
Manual Valve 2WL-52 Transfers Position
GK2WL52VVT
Manual Valve 2WL-53 Transfers Position
GK2WL53VVT
Manual Valve 2WL-54 Transfers Position
GK2WL54VVT
Manual Valve 2WL-55 Transfers Position
GK2WL55VVT


WL Fails to Cool Generator Thrust Bearing Cooler 2HPOHX-4
GK2314
Page 165
Inlet to Generator Thrust Bearing Cooler 2HPOHX-4 is Blocked
GK2314A
Flow to Generator Thrust Bearing Cooler 2HPOHX-4 is Diverted
GK2314B
Generator Thrust Bearing Cooler 2HPOHX-4 Fails
GK2HPO4HXF
Manual Valve 2WL-56 Transfers Position
GK2WL56VVT
Manual Valve 2WL-57 Transfers Position
GK2WL57VVT
Manual Valve 2WL-58 Transfers Position
GK2WL58VVT
Manual Valve 2WL-59 Transfers Position
GK2WL59VVT

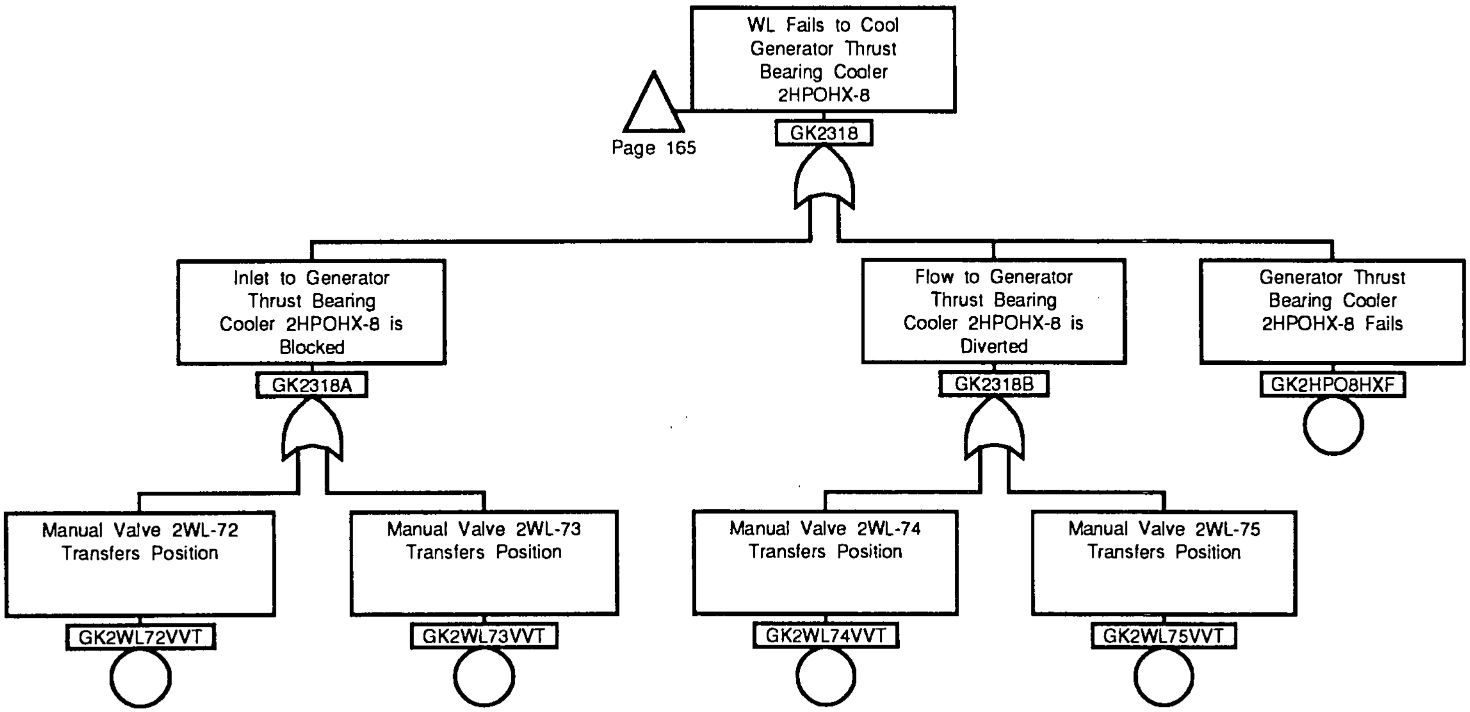


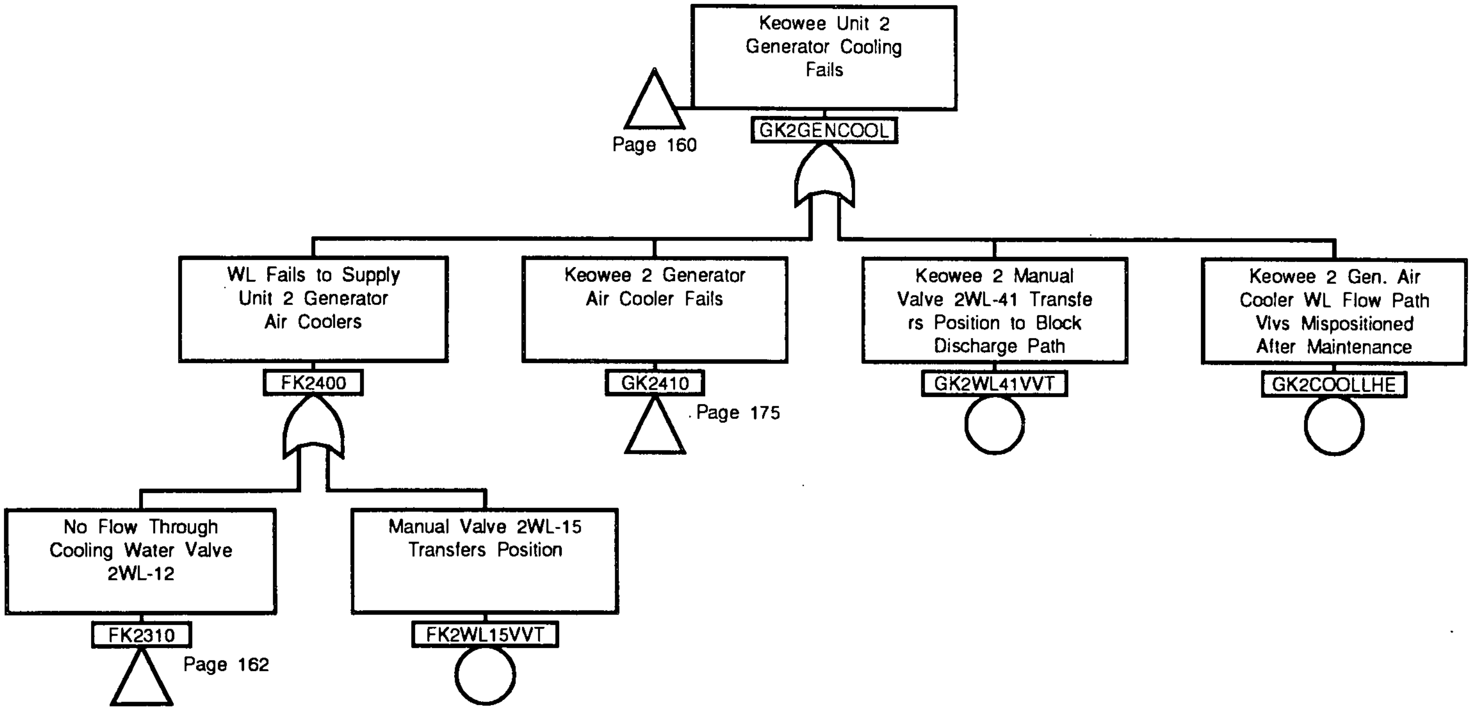
WL Fails to Cool Generator Thrust Bearing Cooler 2HPOHX-5
GK2315
Page 165
Inlet to Generator Thrust Bearing Cooler 2HPOHX-5 is Blocked
GK2315A
Flow to Generator Thrust Bearing Cooler 2HPOHX-5 is Diverted
GK2315B
Generator Thrust Bearing Cooler 2HPOHX-5 Fails
GK2HPO5HXF
Manual Valve 2WL-60 Transfers Position
GK2WL60VVT
Manual Valve 2WL-61 Transfers Position
GK2WL61VVT
Manual Valve 2WL-62 Transfers Position
GK2WL62VVT
Manual Valve 2WL-63 Transfers Position
GK2WL63VVT

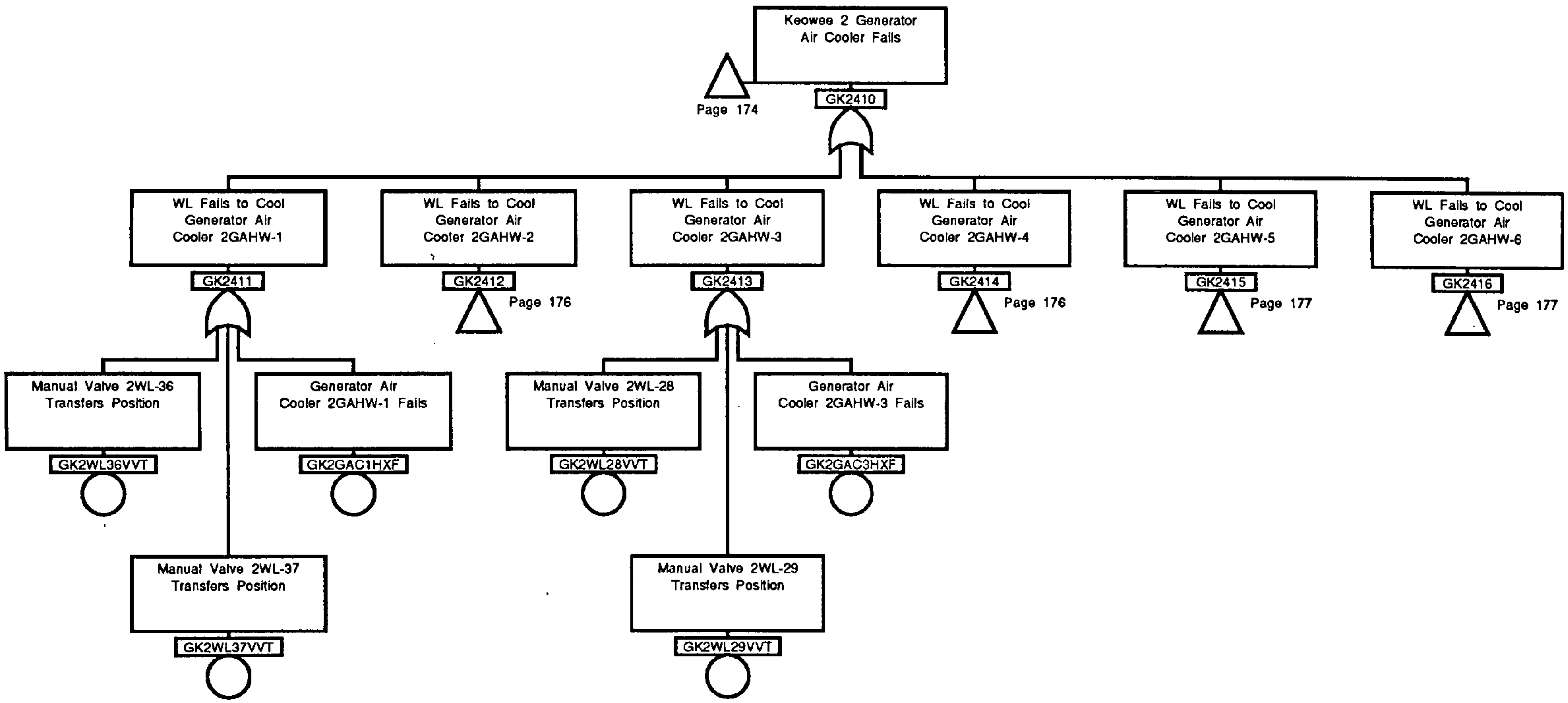

WL Fails to Cool Generator Thrust Bearing Cooler 2HPOHX-6
GK2316
Page 165
Inlet to Generator Thrust Bearing Cooler 2HPOHX-6 is Blocked
GK2316A
Flow to Generator Thrust Bearing Cooler 2HPOHX-6 is Diverted
GK2316B
Generator Thrust Bearing Cooler 2HPOHX-6 Fails
GK2HPO6HXF
Manual Valve 2WL-64 Transfers Position
GK2WL64VVT
Manual Valve 2WL-65 Transfers Position
GK2WL65VVT
Manual Valve 2WL-66 Transfers Position
GK2WL66VVT
Manual Valve 2WL-67 Transfers Position
GK2WL67VVT



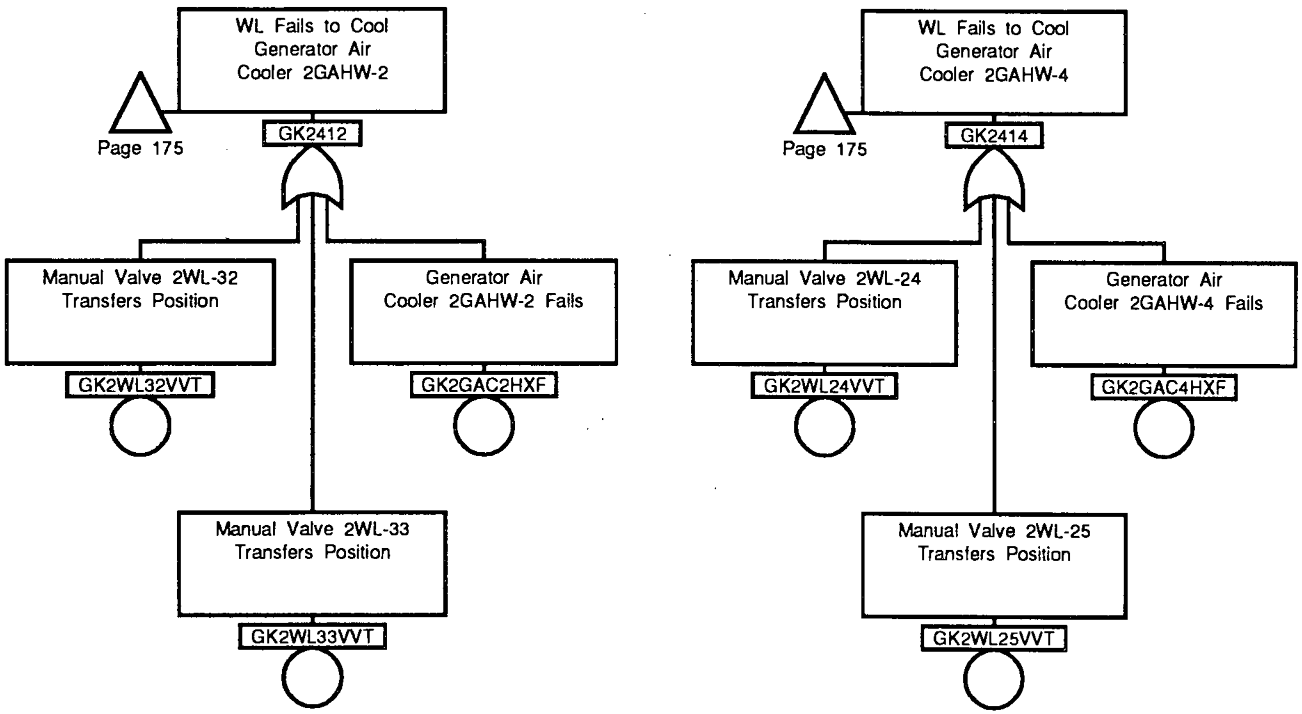
WL Fails to Cool Generator Thrust Bearing Cooler 2HPOHX-7
GK2317
Page 165
Inlet to Generator Thrust Bearing Cooler 2HPOHX-7 is Blocked
GK2317A
Flow to Generator Thrust Bearing Cooler 2HPOHX-7 is Diverted
GK2317B
Generator Thrust Bearing Cooler 2HPOHX-7 Fails
GK2HPO7HXF
Manual Valve 2WL-68 Transfers Position
GK2WL68VVT
Manual Valve 2WL-69 Transfers Position
GK2WL69VVT
Manual Valve 2WL-70 Transfers Position
GK2WL70VVT
Manual Valve 2WL-71 Transfers Position
GK2WL71VVT


WL Fails to Cool Generator Thrust Bearing Cooler 2HPOHX-8
GK2318
Page 165
Inlet to Generator Thrust Bearing Cooler 2HPOHX-8 is Blocked
GK2318A
Flow to Generator Thrust Bearing Cooler 2HPOHX-8 is Diverted
GK2318B
Generator Thrust Bearing Cooler 2HPOHX-8 Fails
GK2HPO8HXF
Manual Valve 2WL-72 Transfers Position
GK2WL72VVT
Manual Valve 2WL-73 Transfers Position
GK2WL73VVT
Manual Valve 2WL-74 Transfers Position
GK2WL74VVT
Manual Valve 2WL-75 Transfers Position
GK2WL75VVT

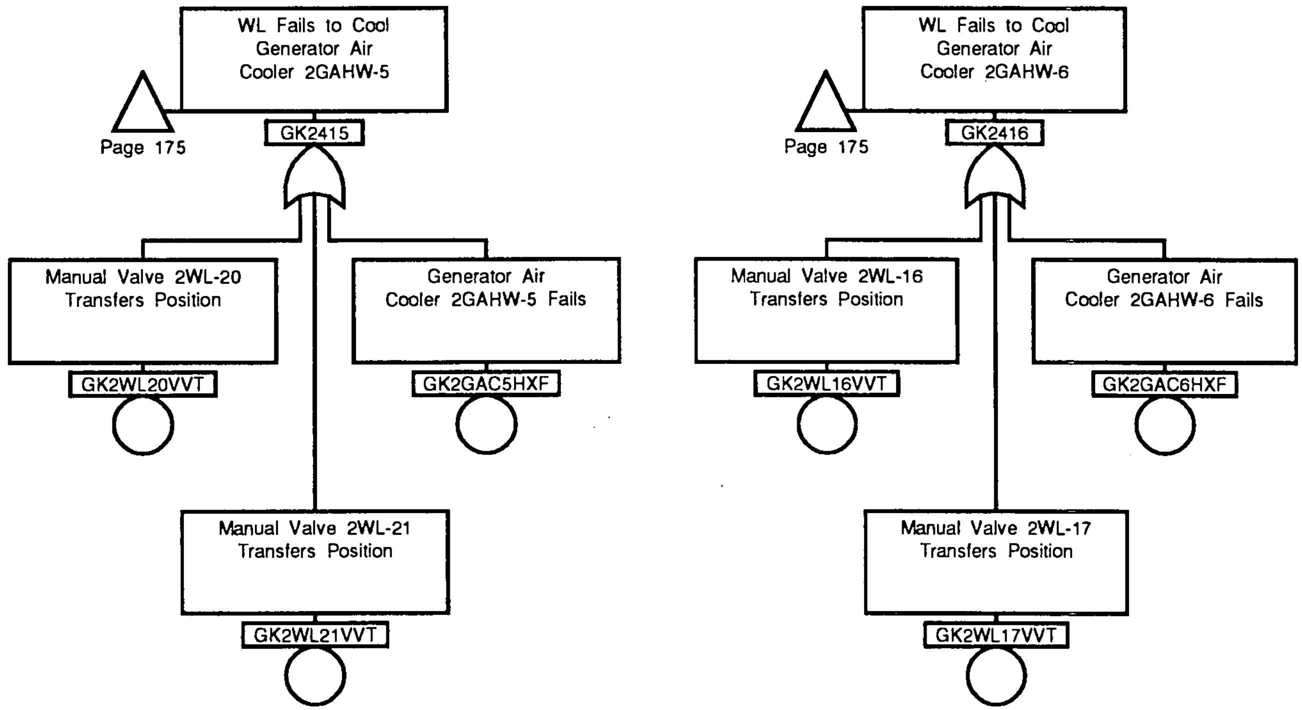

Keowee Unit 2 Generator Cooling Fails
GK2GENCOOL
Page 160
WL Fails to Supply Unit 2 Generator Air Coolers
FK2400
Keowee 2 Generator Air Cooler Fails
GK2410
Page 175
Keowee 2 Manual Valve 2WL-41 Transfe rs Position to Block Discharge Path
GK2WL41VVT
Keowee 2 Gen. Air Cooler WL Flow Path Vlvs Mispositioned After Maintenance
GK2COOLLHE
No Flow Through Cooling Water Valve 2WL-12
FK2310
Page 162
Manual Valve 2WL-15 Transfers Position
FK2WL15VVT

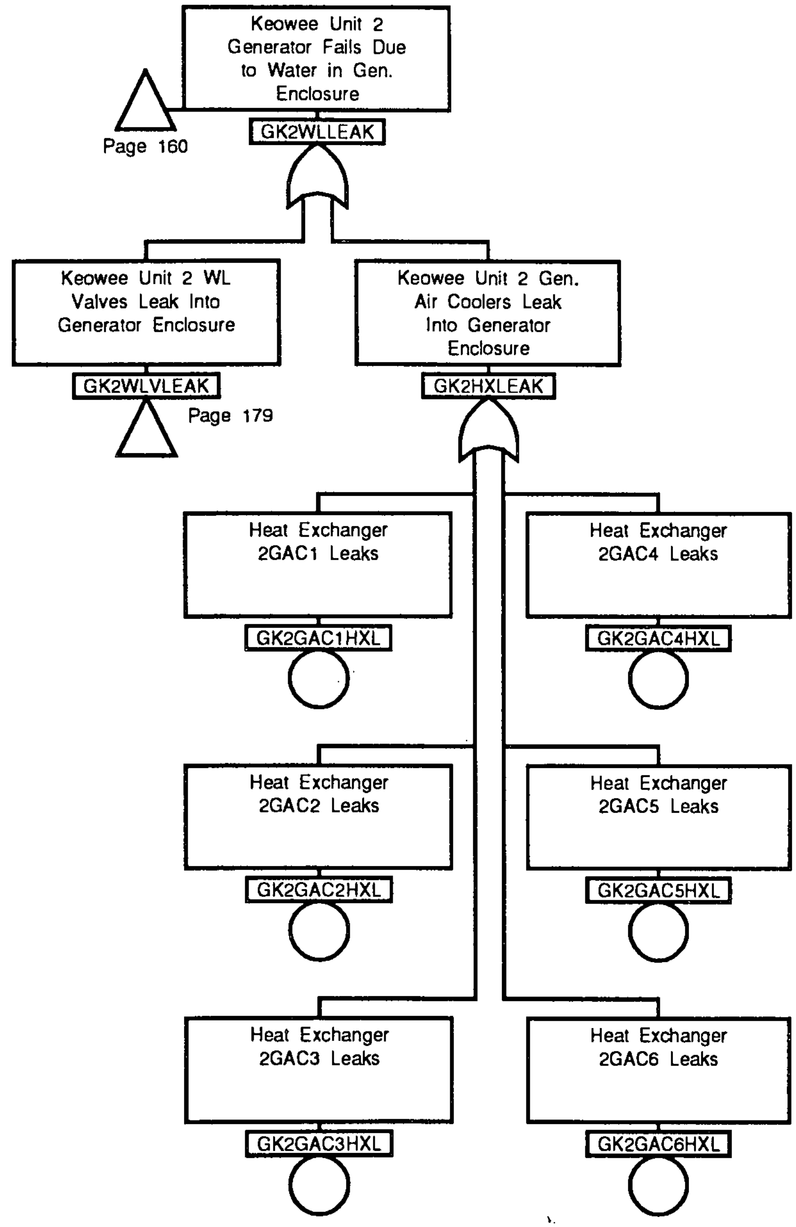


Keowee 2 Generator Air Cooler Fails
Page 174
GK2410
WL Fails to Cool Generator Air Cooler 2GAHW-1
GK2411
WL Fails to Cool Generator Air Cooler 2GAHW-2
GK2412
Page 176
WL Fails to Cool Generator Air Cooler 2GAHW-3
GK2413
WL Fails to Cool Generator Air Cooler 2GAHW-4
GK2414
Page 176
WL Fails to Cool Generator Air Cooler 2GAHW-5
GK2415
Page 177
WL Fails to Cool Generator Air Cooler 2GAHW-6
GK2416
Page 177
Manual Valve 2WL-36 Transfers Position
GK2WL36VVT
Generator Air Cooler 2GAHW-1 Fails
GK2GAC1HXF
Manual Valve 2WL-37 Transfers Position
GK2WL37VVT
Manual Valve 2WL-28 Transfers Position
GK2WL28VVT
Generator Air Cooler 2GAHW-3 Fails
GK2GAC3HXF
Manual Valve 2WL-29 Transfers Position
GK2WL29VVT

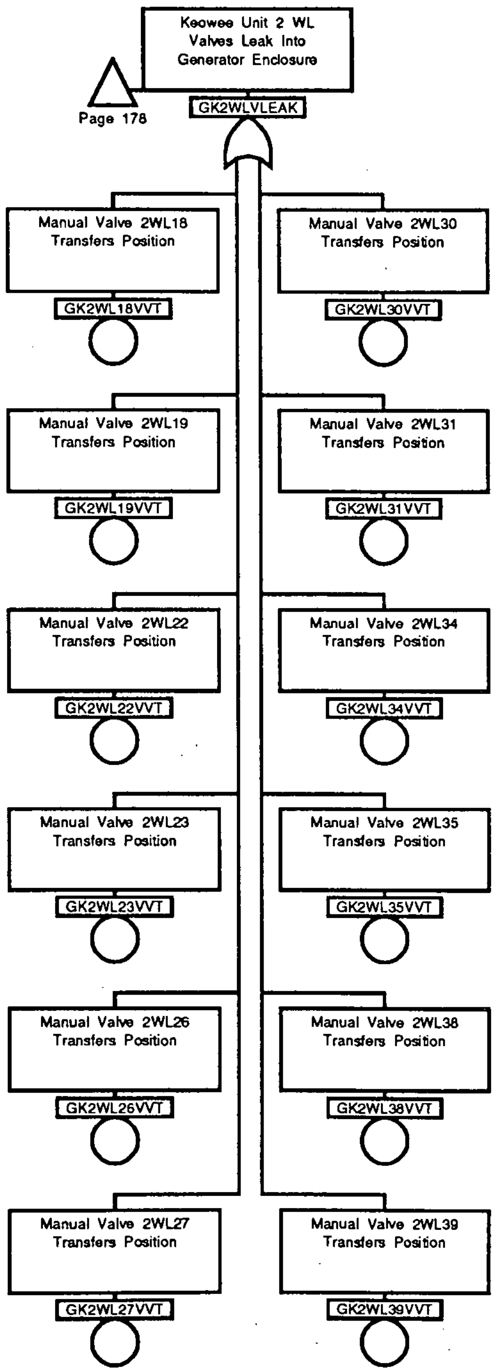


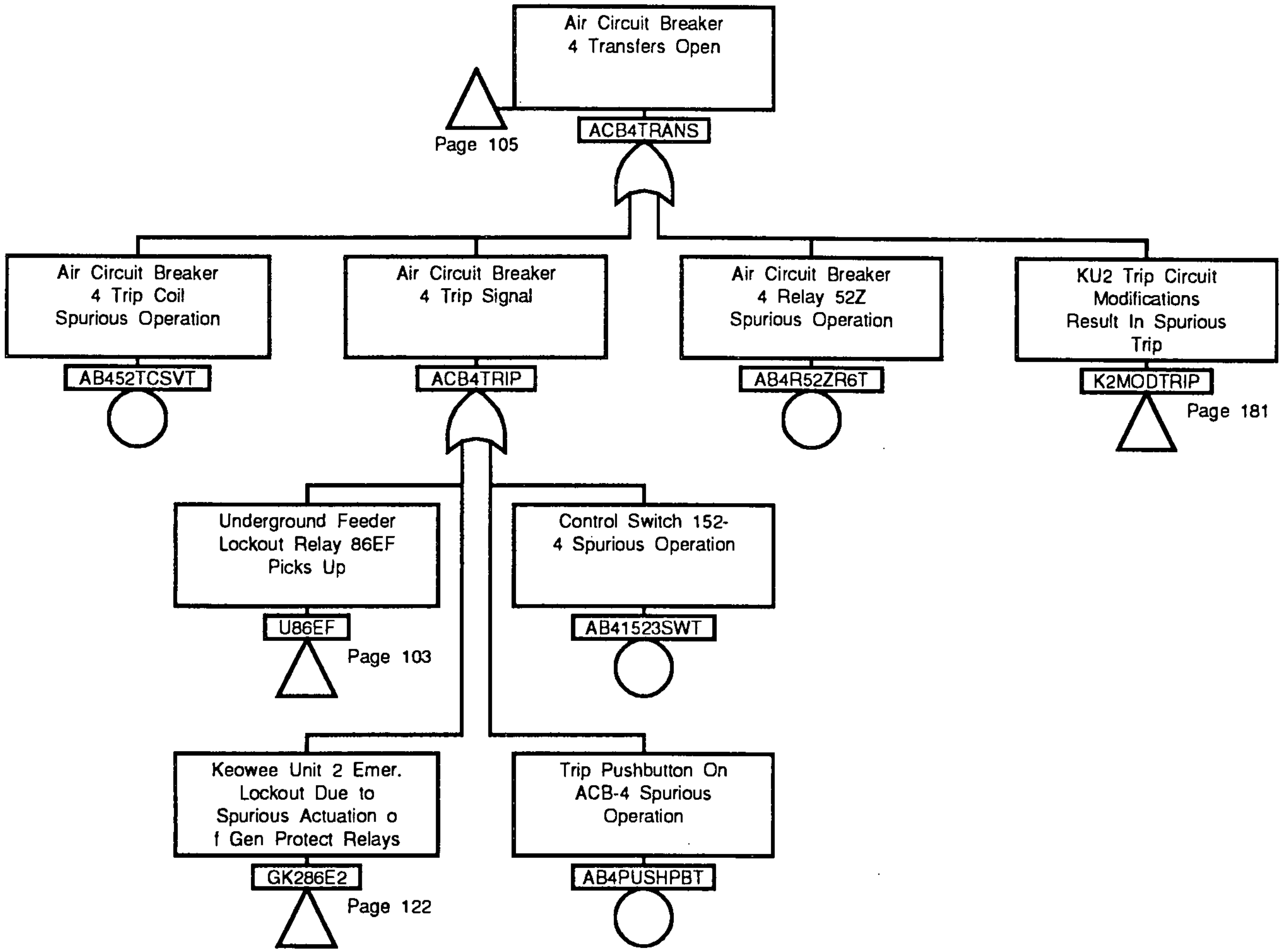
WL Fails to Cool Generator Air Cooler 2GAHW-2
Page 175
GK2412
Manual Valve 2WL-32 Transfers Position
GK2WL32VVT
Generator Air Cooler 2GAHW-2 Fails
GK2GAC2HXF
Manual Valve 2WL-33 Transfers Position
GK2WL33VVT
WL Fails to Cool Generator Air Cooler 2GAHW-4
Page 175
GK2414
Manual Valve 2WL-24 Transfers Position
GK2WL24VVT
Generator Air Cooler 2GAHW-4 Fails
GK2GAC4HXF
Manual Valve 2WL-25 Transfers Position
GK2WL25VVT

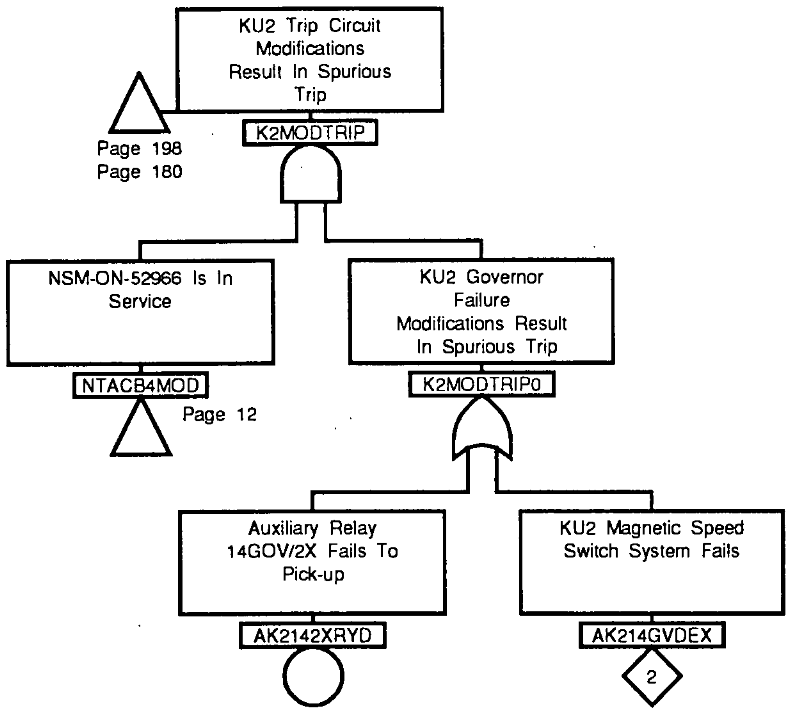

WL Fails to Cool Generator Air Cooler 2GAHW-5
Page 175
GK2415
Manual Valve 2WL-20 Transfers Position
GK2WL20VVT
Generator Air Cooler 2GAHW-5 Fails
GK2GAC5HXF
Manual Valve 2WL-21 Transfers Position
GK2WL21VVT
WL Fails to Cool Generator Air Cooler 2GAHW-6
Page 175
GK2416
Manual Valve 2WL-16 Transfers Position
GK2WL16VVT
Generator Air Cooler 2GAHW-6 Fails
GK2GAC6HXF
Manual Valve 2WL-17 Transfers Position
GK2WL17VVT

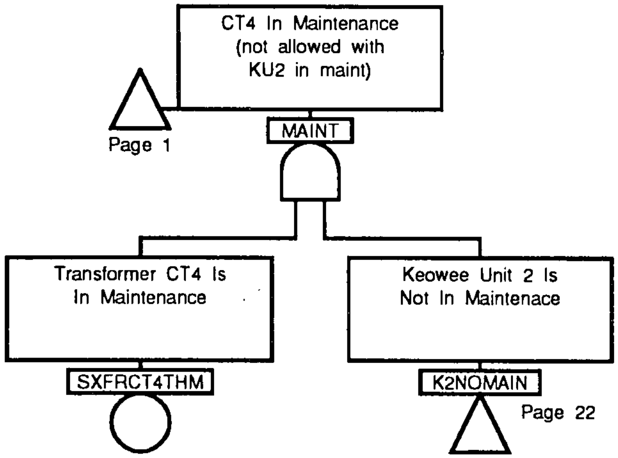


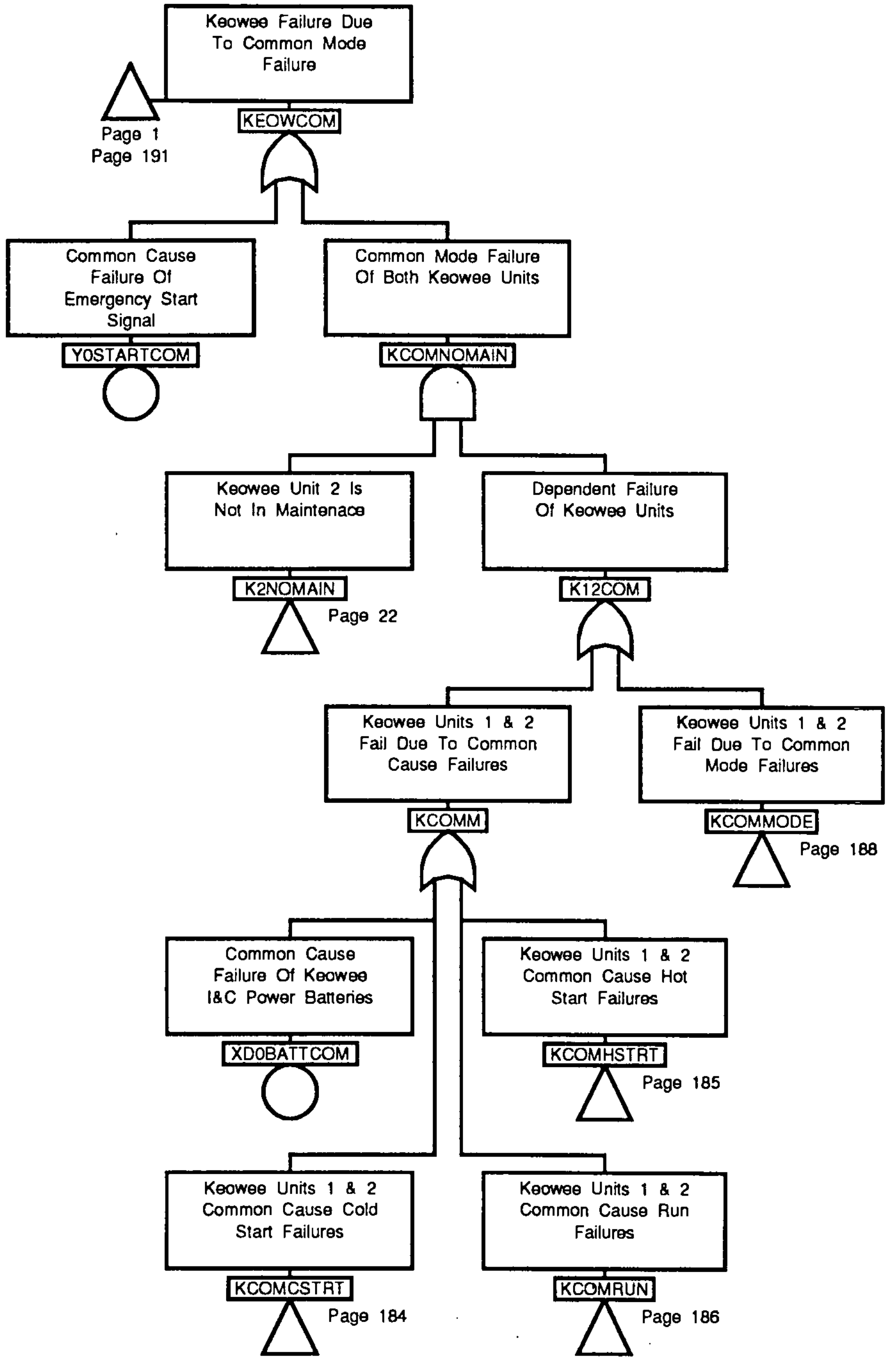
Keowee Unit 2 Generator Fails Due to Water in Gen. Enclosure
GK2WLLEAK
Page 160
Keowee Unit 2 WL Valves Leak Into Generator Enclosure
GK2WLVLEAK
Page 179
Keowee Unit 2 Gen. Air Coolers Leak Into Generator Enclosure
GK2HXLEAK
Heat Exchanger 2GAC1 Leaks
GK2GAC1HXL
Heat Exchanger 2GAC4 Leaks
GK2GAC4HXL
Heat Exchanger 2GAC2 Leaks
GK2GAC2HXL
Heat Exchanger 2GAC5 Leaks
GK2GAC5HXL
Heat Exchanger 2GAC3 Leaks
GK2GAC3HXL
Heat Exchanger 2GAC6 Leaks
GK2GAC6HXL


Keowee Unit 2 WL Valves Leak Into Generator Enclosure
Page 178
GK2WLVLEAK
Manual Valve 2WL18 Transfers Position
GK2WL18VVT
Manual Valve 2WL30 Transfers Position
GK2WL30VVT
Manual Valve 2WL19 Transfers Position
GK2WL19VVT
Manual Valve 2WL31 Transfers Position
GK2WL31VVT
Manual Valve 2WL22 Transfers Position
GK2WL22VVT
Manual Valve 2WL34 Transfers Position
GK2WL34VVT
Manual Valve 2WL23 Transfers Position
GK2WL23VVT
Manual Valve 2WL35 Transfers Position
GK2WL35VVT
Manual Valve 2WL26 Transfers Position
GK2WL26VVT
Manual Valve 2WL38 Transfers Position
GK2WL38VVT
Manual Valve 2WL27 Transfers Position
GK2WL27VVT
Manual Valve 2WL39 Transfers Position
GK2WL39VVT

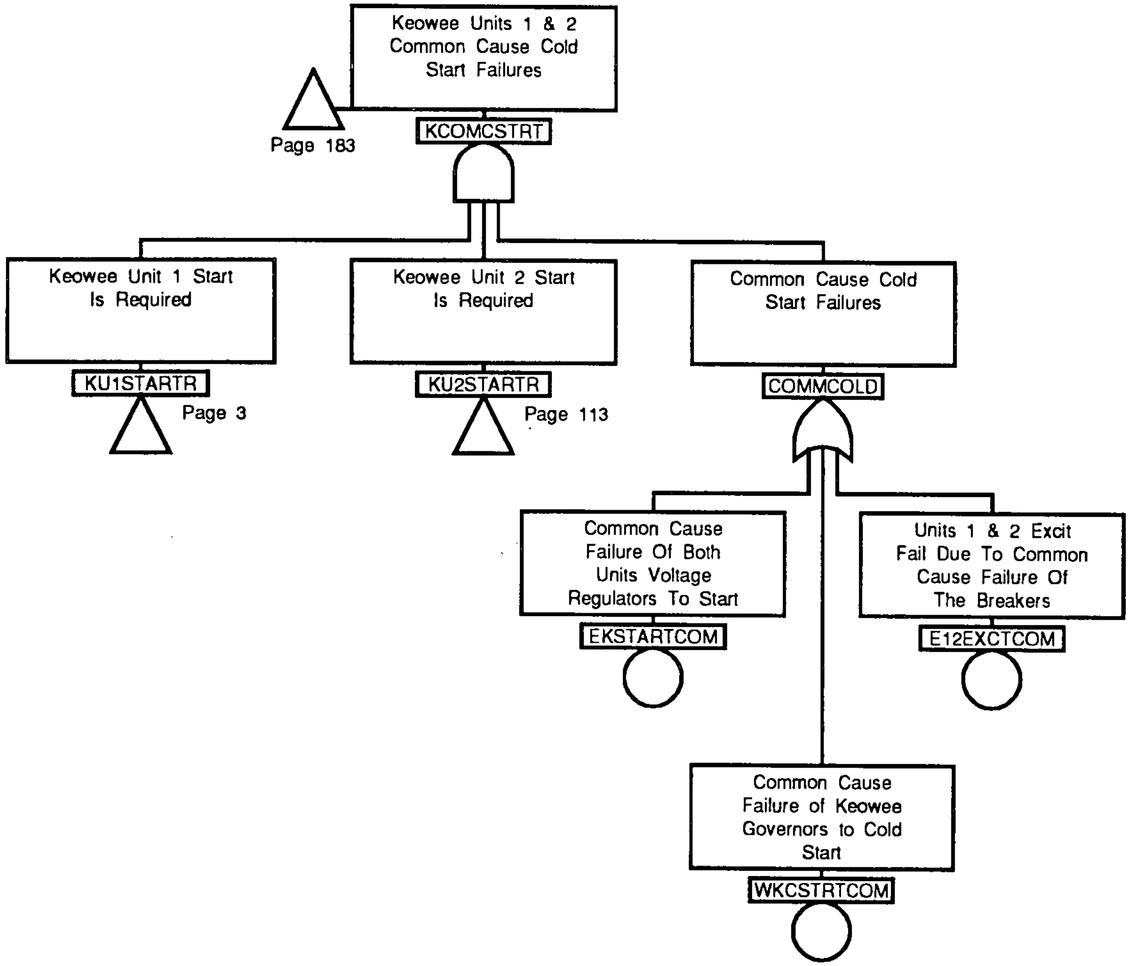

Air Circuit Breaker
4 Transfers Open
ACB4TRANS
Page 105
Air Circuit Breaker
4 Trip Coil
Spurious Operation
AB452TCSVT
Air Circuit Breaker
4 Trip Signal
ACB4TRIP
Air Circuit Breaker
4 Relay 52Z
Spurious Operation
AB4R52ZR6T
KU2 Trip Circuit
Modifications
Result In Spurious
Trip
K2MODTRIP
Page 181
Underground Feeder
Lockout Relay 86EF
Picks Up
U86EF
Page 103
Control Switch 152-
4 Spurious Operation
AB41523SWT
Keowee Unit 2 Emer.
Lockout Due to
Spurious Actuation o
f Gen Protect Relays
GK286E2
Page 122
Trip Pushbutton On
ACB-4 Spurious
Operation
AB4PUSHPBT


KU2 Trip Circuit Modifications Result In Spurious Trip
K2MODTRIP
Page 198
Page 180
NSM-ON-52966 Is In Service
NTACB4MOD
Page 12
KU2 Governor Failure Modifications Result In Spurious Trip
K2MODTRIP0
Auxiliary Relay 14GOV/2X Fails To Pick-up
AK2142XRYD
KU2 Magnetic Speed Switch System Fails
AK214GVDEX
2

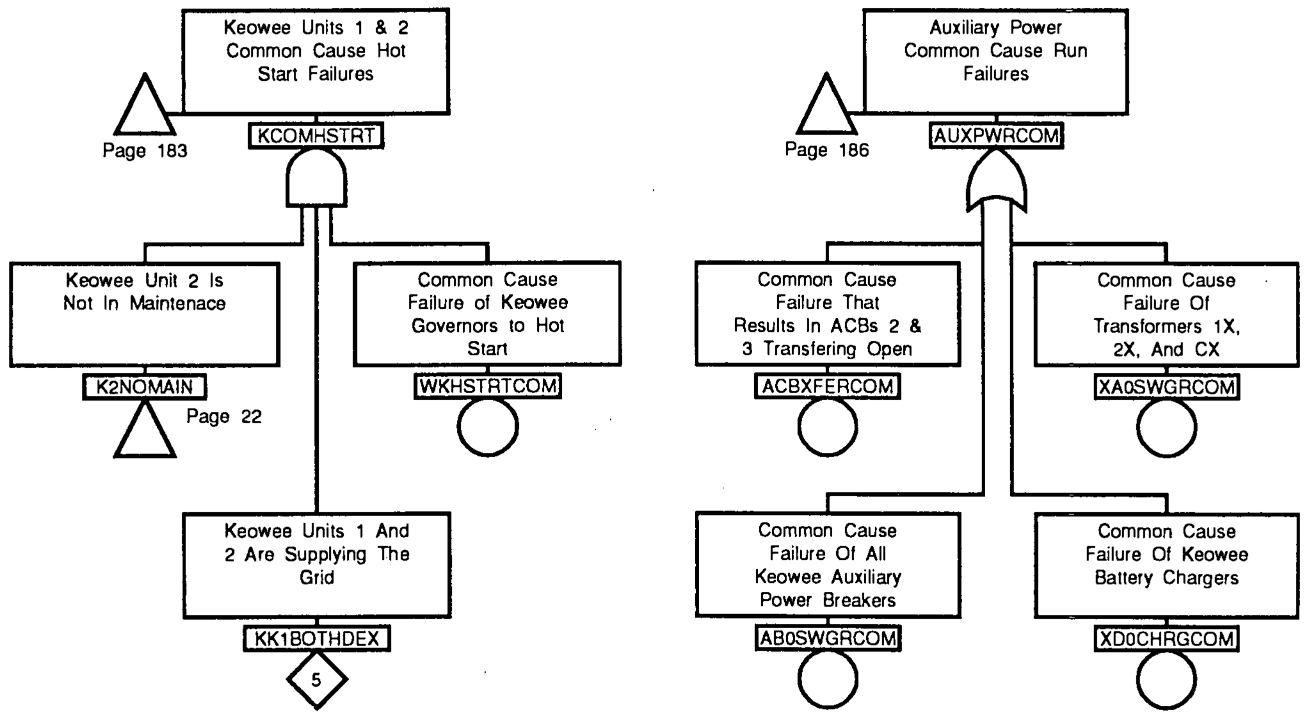

CT4 In Maintenance
(not allowed with
KU2 in maint)
Page 1
MAINT
Transformer CT4 Is
In Maintenance
Keowee Unit 2 Is
Not In Maintenace
SXFRCT4THM
K2NOMAIN
Page 22



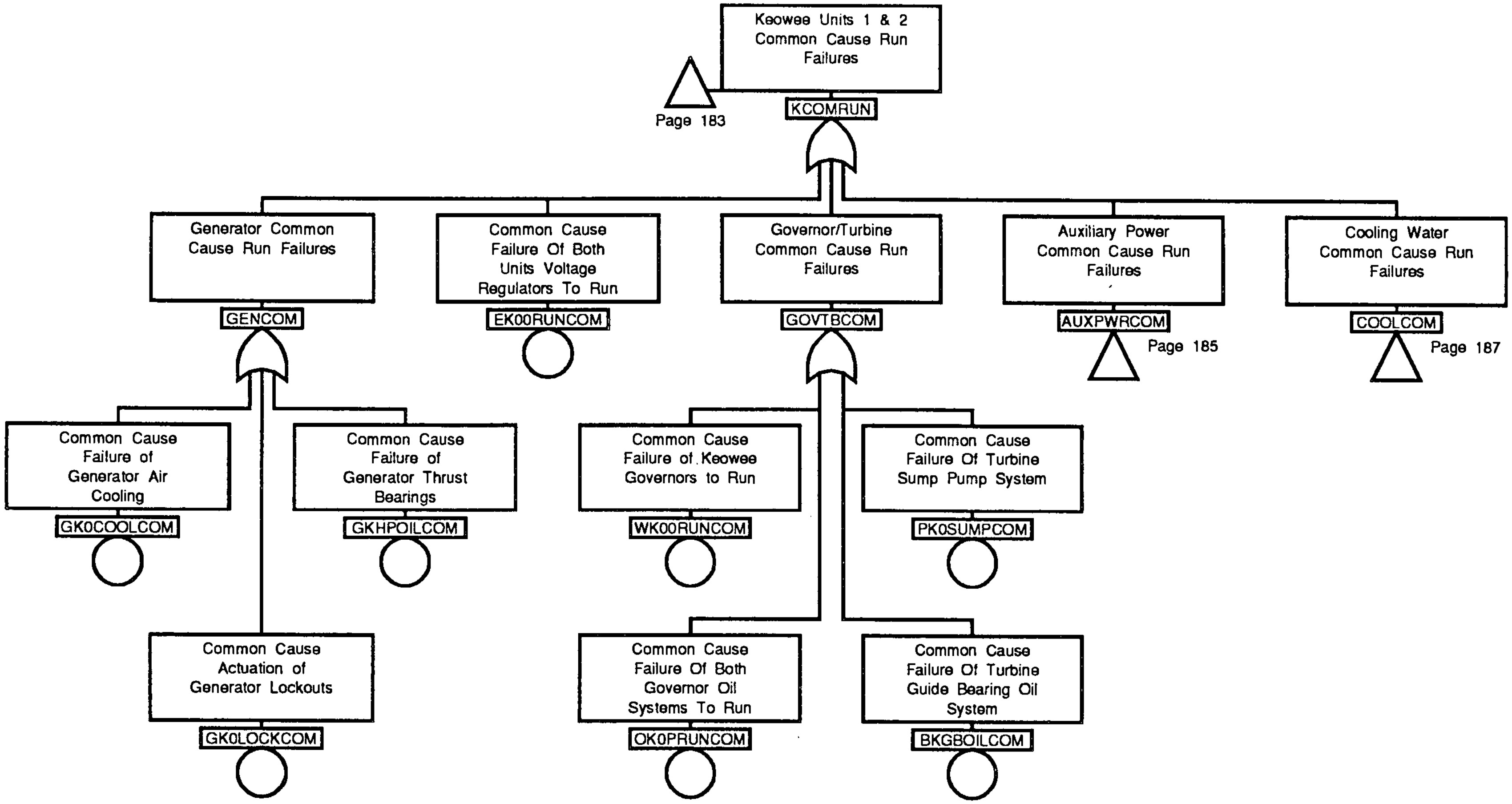
Keowee Failure Due To Common Mode Failure
KEOWCOM
Page 1
Page 191
Common Cause Failure Of Emergency Start Signal
Y0STARTCOM
Common Mode Failure Of Both Keowee Units
KCOMNOMAIN
Keowee Unit 2 Is Not In Maintenace
K2NOMAIN
Page 22
Dependent Failure Of Keowee Units
K12COM
Keowee Units 1 & 2 Fail Due To Common Cause Failures
KCOMM
Keowee Units 1 & 2 Fail Due To Common Mode Failures
KCOMMODE
Page 188
Common Cause Failure Of Keowee I&C Power Batteries
XD0BATTCOM
Keowee Units 1 & 2 Common Cause Hot Start Failures
KCOMHSTRT
Page 185
Keowee Units 1 & 2 Common Cause Cold Start Failures
KCOMCSTRT
Page 184
Keowee Units 1 & 2 Common Cause Run Failures
KCOMRUN
Page 186



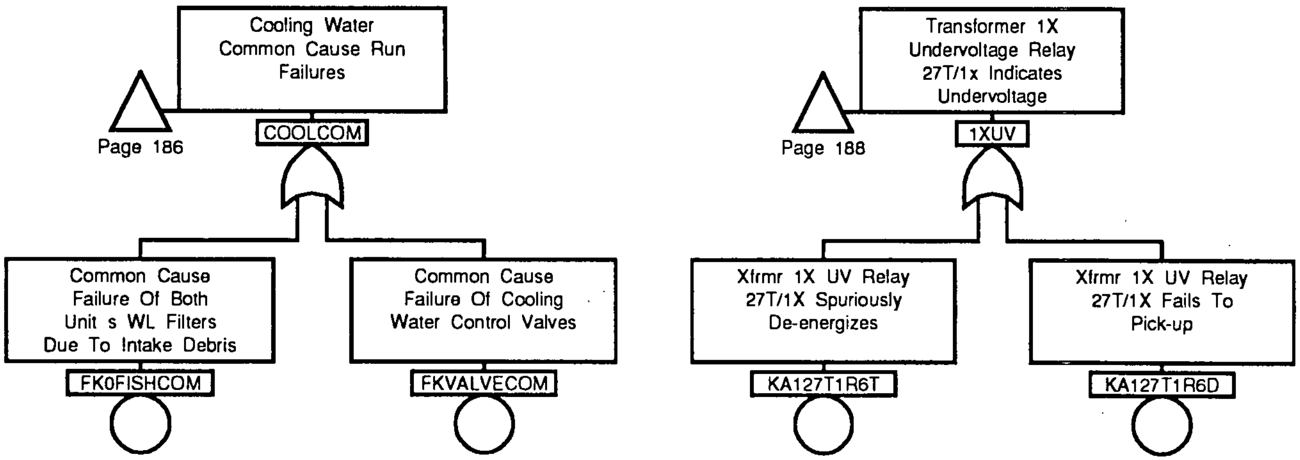
Keowee Units 1 & 2 Common Cause Cold Start Failures
KCOMCSTRT
Page 183
Keowee Unit 1 Start Is Required
KU1STARTR
Page 3
Keowee Unit 2 Start Is Required
KU2STARTR
Page 113
Common Cause Cold Start Failures
COMMCOLD
Common Cause Failure Of Both Units Voltage Regulators To Start
EKSTARTCOM
Units 1 & 2 Excit Fail Due To Common Cause Failure Of The Breakers
E12EXCTCOM
Common Cause Failure of Keowee Governors to Cold Start
WKCSTRTCOM



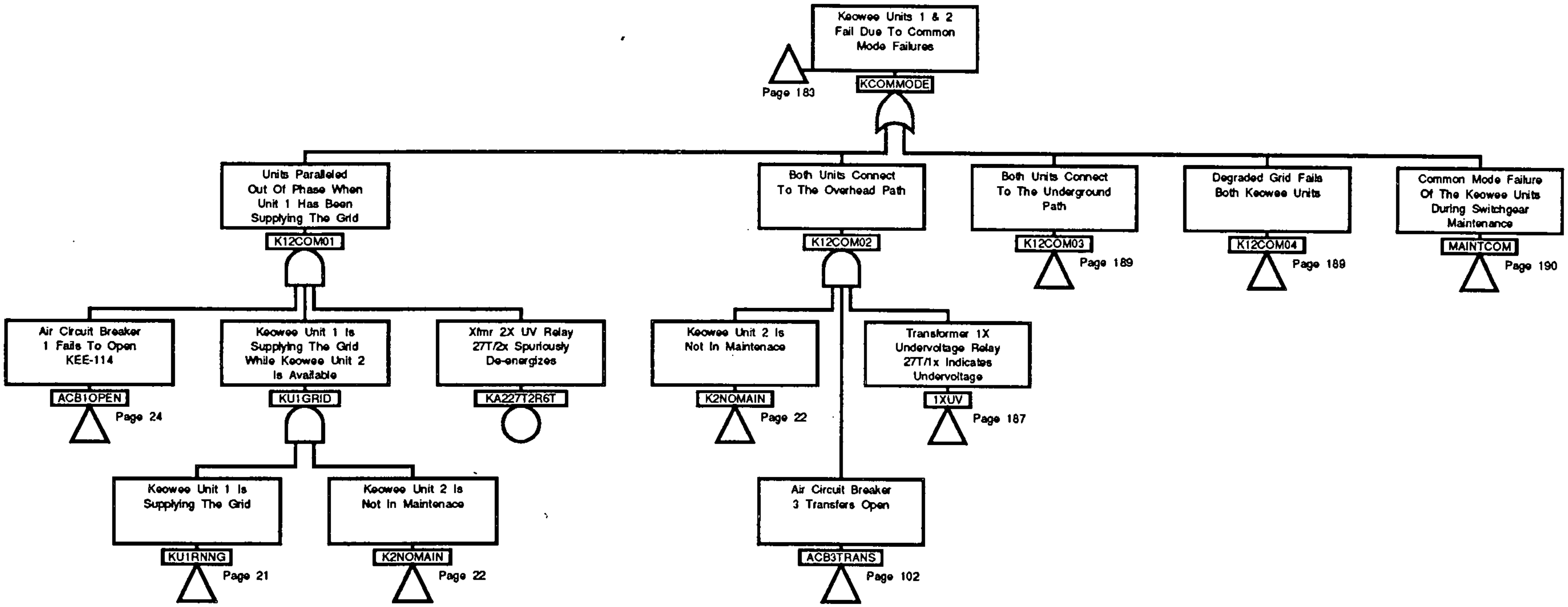
Keowee Units 1 & 2 Common Cause Hot Start Failures
Page 183
KCOMHSTRT
Keowee Unit 2 Is Not In Maintenace
K2NOMAIN
Page 22
Common Cause Failure of Keowee Governors to Hot Start
WKHSTRTCOM
Keowee Units 1 And 2 Are Supplying The Grid
KK1BOTHDEX
5
Auxiliary Power Common Cause Run Failures
Page 186
AUXPWRCOM
Common Cause Failure That Results In ACBs 2 & 3 Transfering Open
ACBXFERCOM
Common Cause Failure Of Transformers 1X, 2X, And CX
XA0SWGRCOM
Common Cause Failure Of All Keowee Auxiliary Power Breakers
AB0SWGRCOM
Common Cause Failure Of Keowee Battery Chargers
XD0CHRGCOM

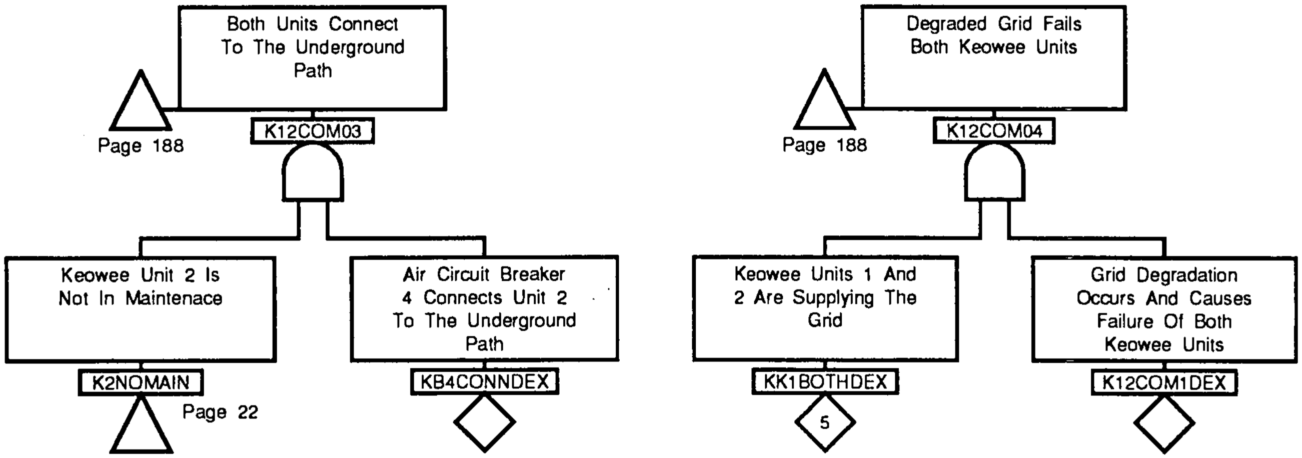


Keowee Units 1 & 2 Common Cause Run Failures
KCOMRUN
Page 183
Generator Common Cause Run Failures
GENCOM
Common Cause Failure Of Both Units Voltage Regulators To Run
EK00RUNCOM
Governor/Turbine Common Cause Run Failures
GOVTBCOM
Auxiliary Power Common Cause Run Failures
AUXPWRCOM
Page 185
Cooling Water Common Cause Run Failures
COOLCOM
Page 187
Common Cause Failure of Generator Air Cooling
GK0COOLCOM
Common Cause Failure of Generator Thrust Bearings
GKHPOILCOM
Common Cause Actuation of Generator Lockouts
GK0LOCKCOM
Common Cause Failure of Keowee Governors to Run
WK00RUNCOM
Common Cause Failure Of Turbine Sump Pump System
PK0SUMPCOM
Common Cause Failure Of Both Governor Oil Systems To Run
OK0PRUNCOM
Common Cause Failure Of Turbine Guide Bearing Oil System
BKGBOILCOM

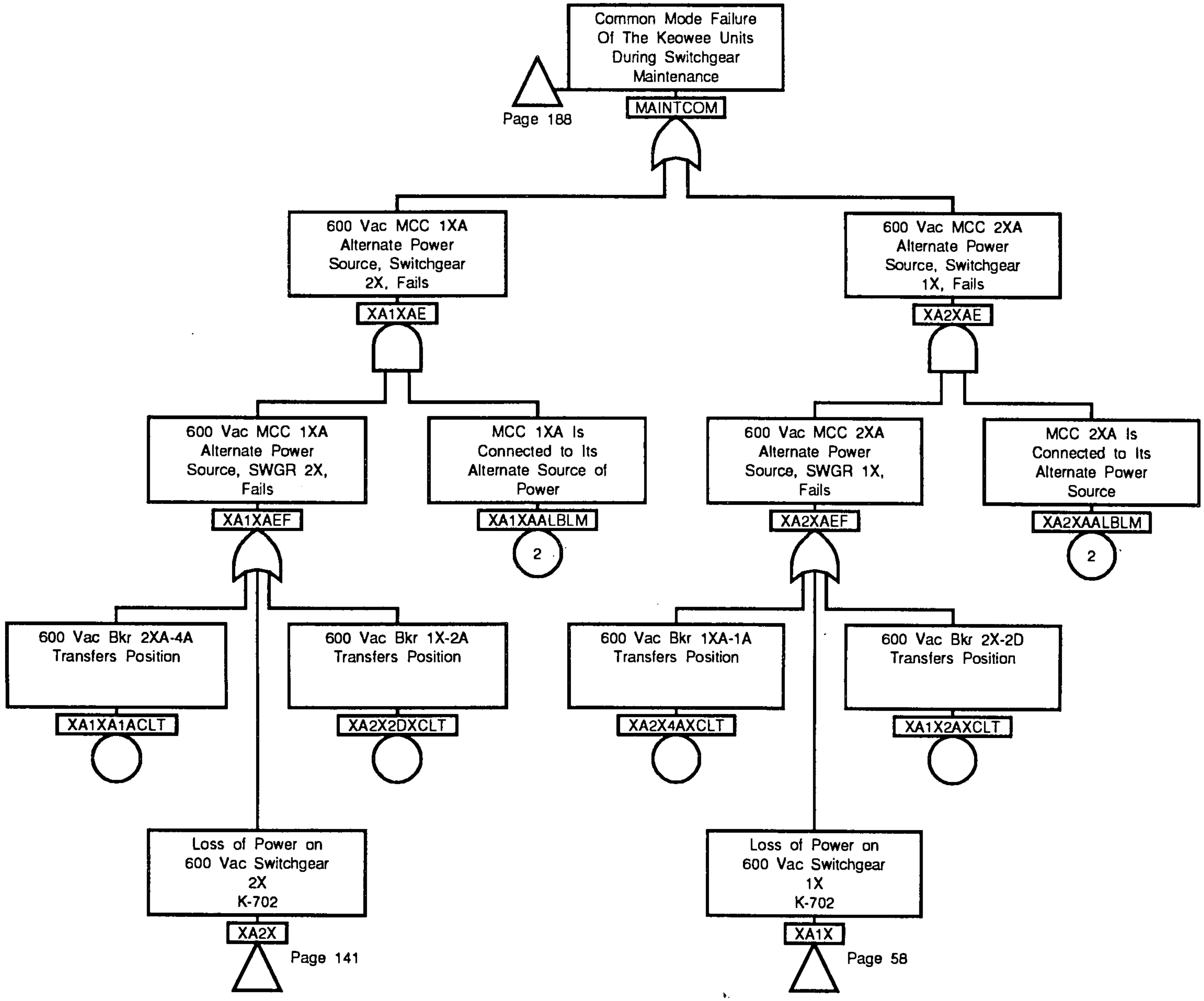


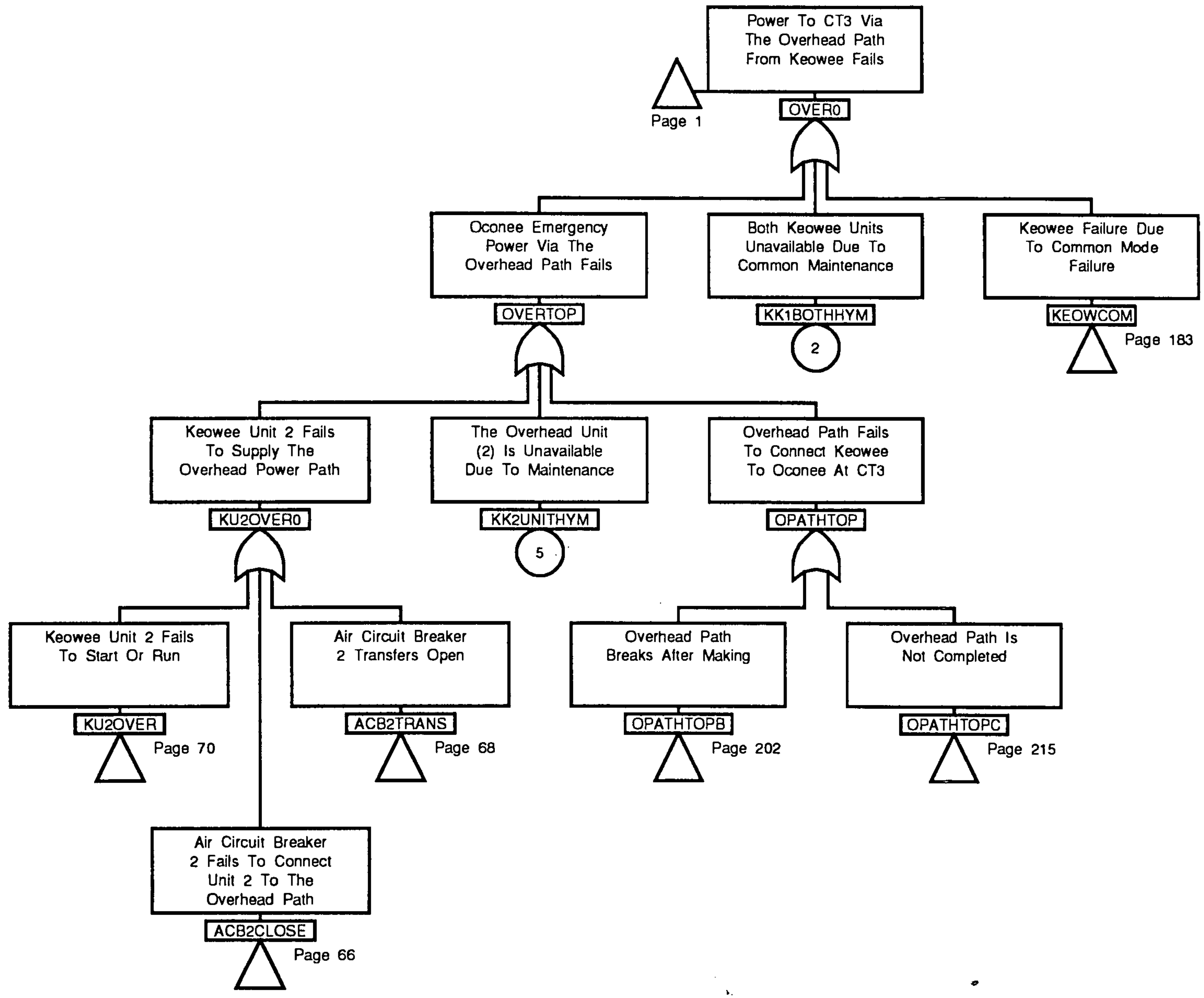
Cooling Water Common Cause Run Failures
COOLCOM
Page 186
Common Cause Failure Of Both Unit s WL Filters Due To Intake Debris
FK0FISHCOM
Common Cause Failure Of Cooling Water Control Valves
FKVALVECOM
Transformer 1X Undervoltage Relay 27T/1x Indicates Undervoltage
1XUV
Page 188
Xfrmr 1X UV Relay 27T/1X Spuriously De-energizes
KA127T1R6T
Xfrmr 1X UV Relay 27T/1X Fails To Pick-up
KA127T1R6D

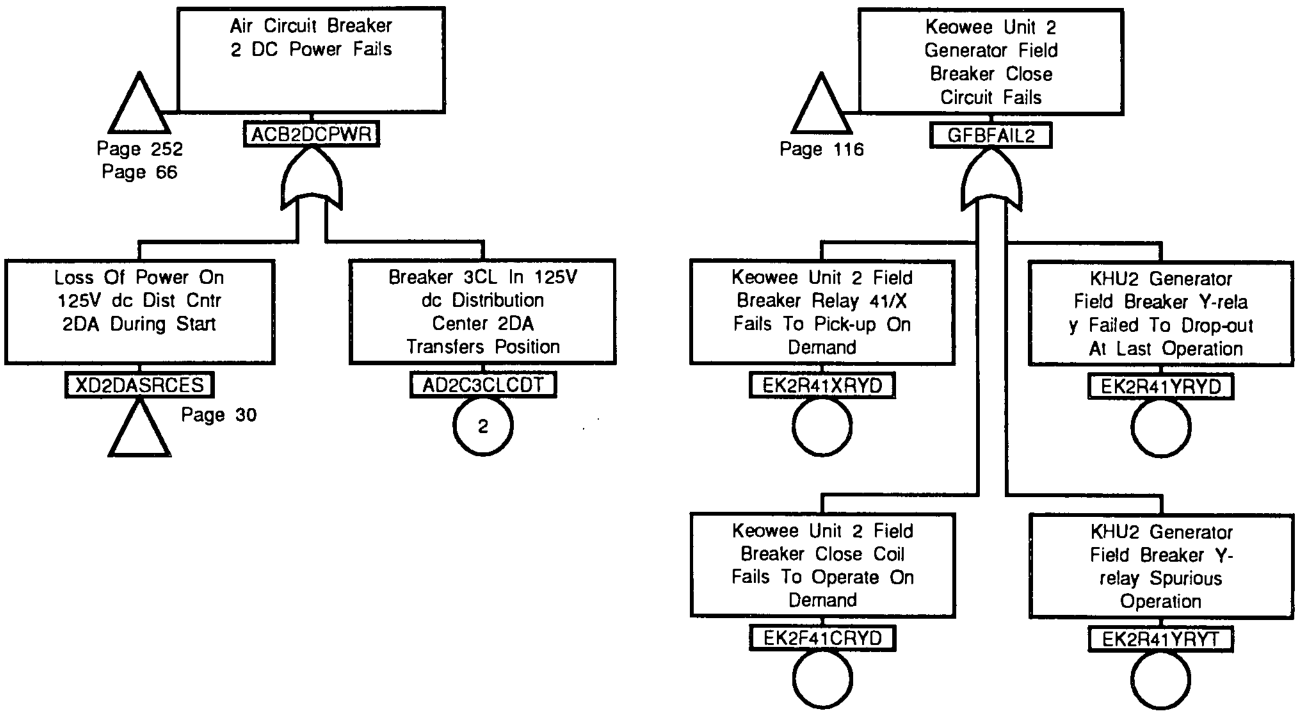

Keowee Units 1 & 2 Fail Due To Common Mode Failures
KCOMMODE
Page 183
Units Paralleled Out Of Phase When Unit 1 Has Been Supplying The Grid
K12COM01
Both Units Connect To The Overhead Path
K12COM02
Both Units Connect To The Underground Path
K12COM03
Page 189
Degraded Grid Fails Both Keowee Units
K12COM04
Page 189
Common Mode Failure Of The Keowee Units During Switchgear Maintenance
MAINTCOM
Page 190
Air Circuit Breaker 1 Fails To Open KEE-114
ACB1OPEN
Page 24
Keowee Unit 1 Is Supplying The Grid While Keowee Unit 2 Is Available
KU1GRID
Xfmr 2X UV Relay 27T/2x Spuriously De-energizes
KA227T2R6T
Keowee Unit 2 Is Not In Maintenace
K2NOMAIN
Page 22
Transformer 1X Undervoltage Relay 27T/1x Indicates Undervoltage
1XUV
Page 187
Keowee Unit 1 Is Supplying The Grid
KU1RNNG
Page 21
Keowee Unit 2 Is Not In Maintenace
K2NOMAIN
Page 22
Air Circuit Breaker 3 Transfers Open
ACB3TRANS
Page 102

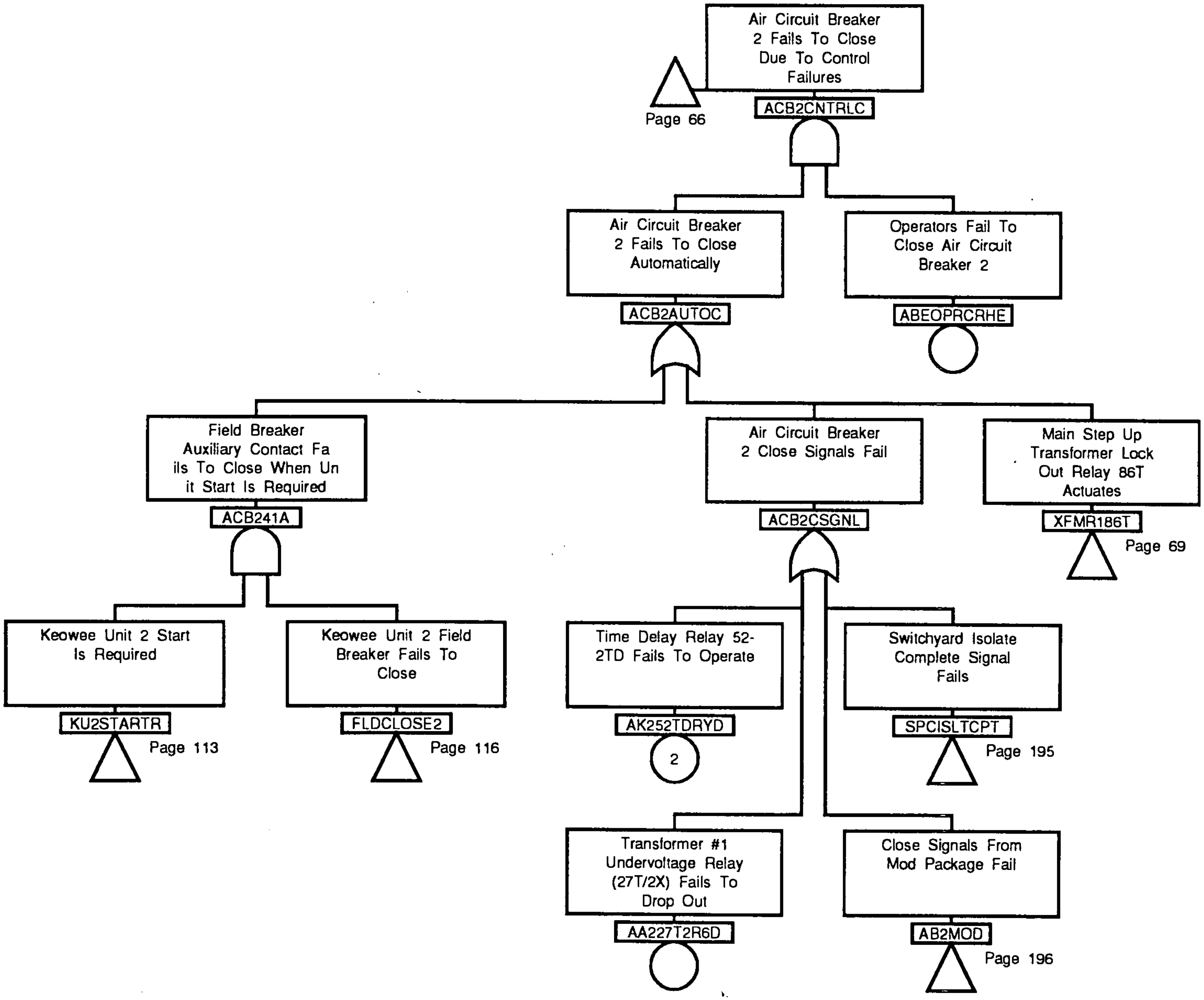


Both Units Connect To The Underground Path
K12COM03
Page 188
Keowee Unit 2 Is Not In Maintenace
K2NOMAIN
Page 22
Air Circuit Breaker 4 Connects Unit 2 To The Underground Path
KB4CONNDEX
Degraded Grid Fails Both Keowee Units
K12COM04
Page 188
Keowee Units 1 And 2 Are Supplying The Grid
KK1BOTHDEX
5
Grid Degradation Occurs And Causes Failure Of Both Keowee Units
K12COM1DEX

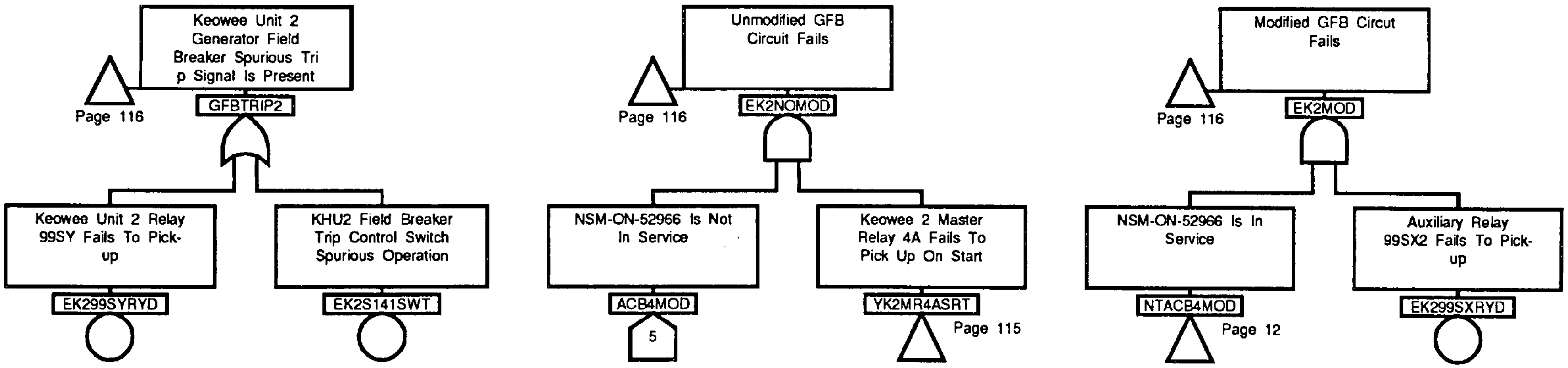

Common Mode Failure Of The Keowee Units During Switchgear Maintenance
MAINTCOM
Page 188
600 Vac MCC 1XA Alternate Power Source, Switchgear 2X, Fails
XA1XAE
600 Vac MCC 2XA Alternate Power Source, Switchgear 1X, Fails
XA2XAE
600 Vac MCC 1XA Alternate Power Source, SWGR 2X, Fails
XA1XAEF
MCC 1XA Is Connected to Its Alternate Source of Power
XA1XAALBLM
2
600 Vac MCC 2XA Alternate Power Source, SWGR 1X, Fails
XA2XAEF
MCC 2XA Is Connected to Its Alternate Power Source
XA2XAALBLM
2
600 Vac Bkr 2XA-4A Transfers Position
XA1XA1ACLT
600 Vac Bkr 1X-2A Transfers Position
XA2X2DXCLT
600 Vac Bkr 1XA-1A Transfers Position
XA2X4AXCLT
600 Vac Bkr 2X-2D Transfers Position
XA1X2AXCLT
Loss of Power on 600 Vac Switchgear 2X K-702
XA2X
Page 141
Loss of Power on 600 Vac Switchgear 1X K-702
XA1X
Page 58


Power To CT3 Via The Overhead Path From Keowee Fails
OVER0
Page 1
Oconee Emergency Power Via The Overhead Path Fails
OVERTOP
Both Keowee Units Unavailable Due To Common Maintenance
KK1BOTHHYM
2
Keowee Failure Due To Common Mode Failure
KEOWCOM
Page 183
Keowee Unit 2 Fails To Supply The Overhead Power Path
KU2OVER0
The Overhead Unit (2) Is Unavailable Due To Maintenance
KK2UNITHYM
5
Overhead Path Fails To Connect Keowee To Oconee At CT3
OPATHTOP
Keowee Unit 2 Fails To Start Or Run
KU2OVER
Page 70
Air Circuit Breaker 2 Transfers Open
ACB2TRANS
Page 68
Overhead Path Breaks After Making
OPATHTOPB
Page 202
Overhead Path Is Not Completed
OPATHTOPC
Page 215
Air Circuit Breaker 2 Fails To Connect Unit 2 To The Overhead Path
ACB2CLOSE
Page 66

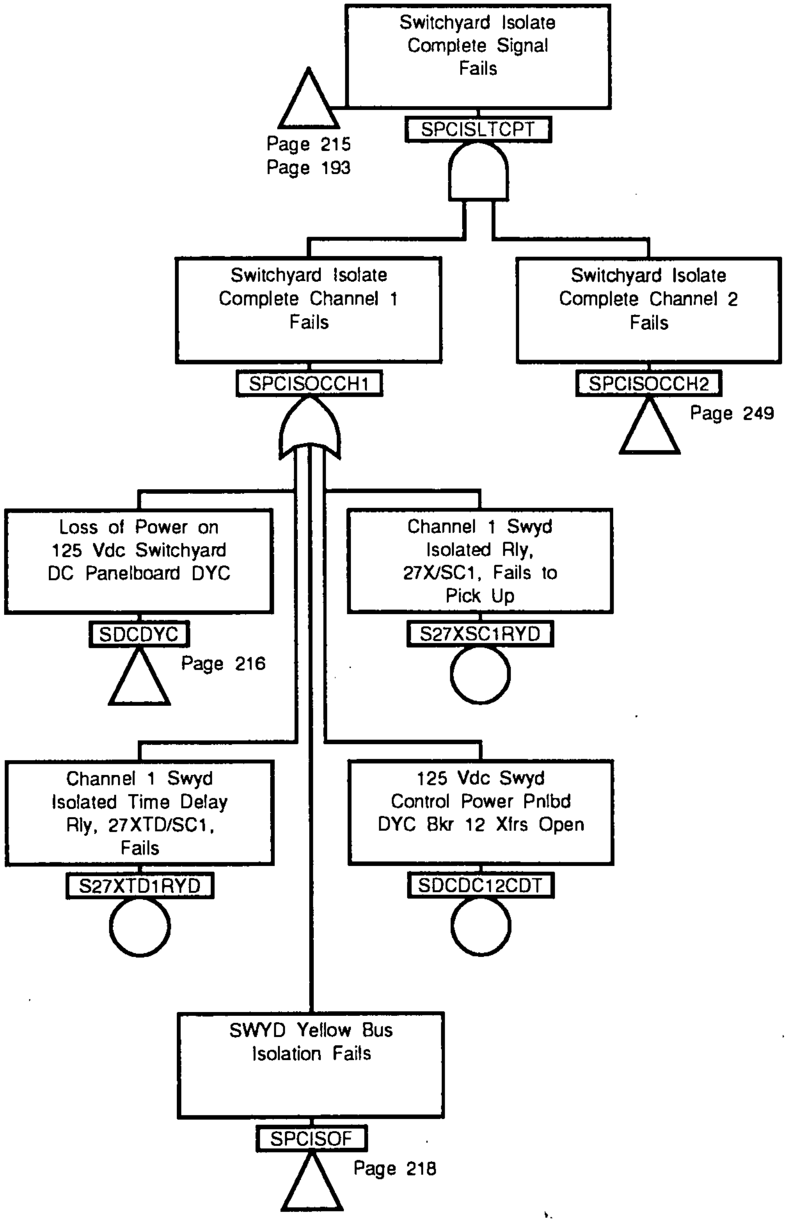

Air Circuit Breaker 2 DC Power Fails
ACB2DCPWR
Page 252
Page 66
Loss Of Power On 125V dc Dist Cntr 2DA During Start
XD2DASRCES
Page 30
Breaker 3CL In 125V dc Distribution Center 2DA Transfers Position
AD2C3CLCDT
2
Keowee Unit 2 Generator Field Breaker Close Circuit Fails
GFBFAIL2
Page 116
Keowee Unit 2 Field Breaker Relay 41/X Fails To Pick-up On Demand
EK2R41XRYD
KHU2 Generator Field Breaker Y-rela y Failed To Drop-out At Last Operation
EK2R41YRYD
Keowee Unit 2 Field Breaker Close Coil Fails To Operate On Demand
EK2F41CRYD
KHU2 Generator Field Breaker Y-relay Spurious Operation
EK2R41YRYT



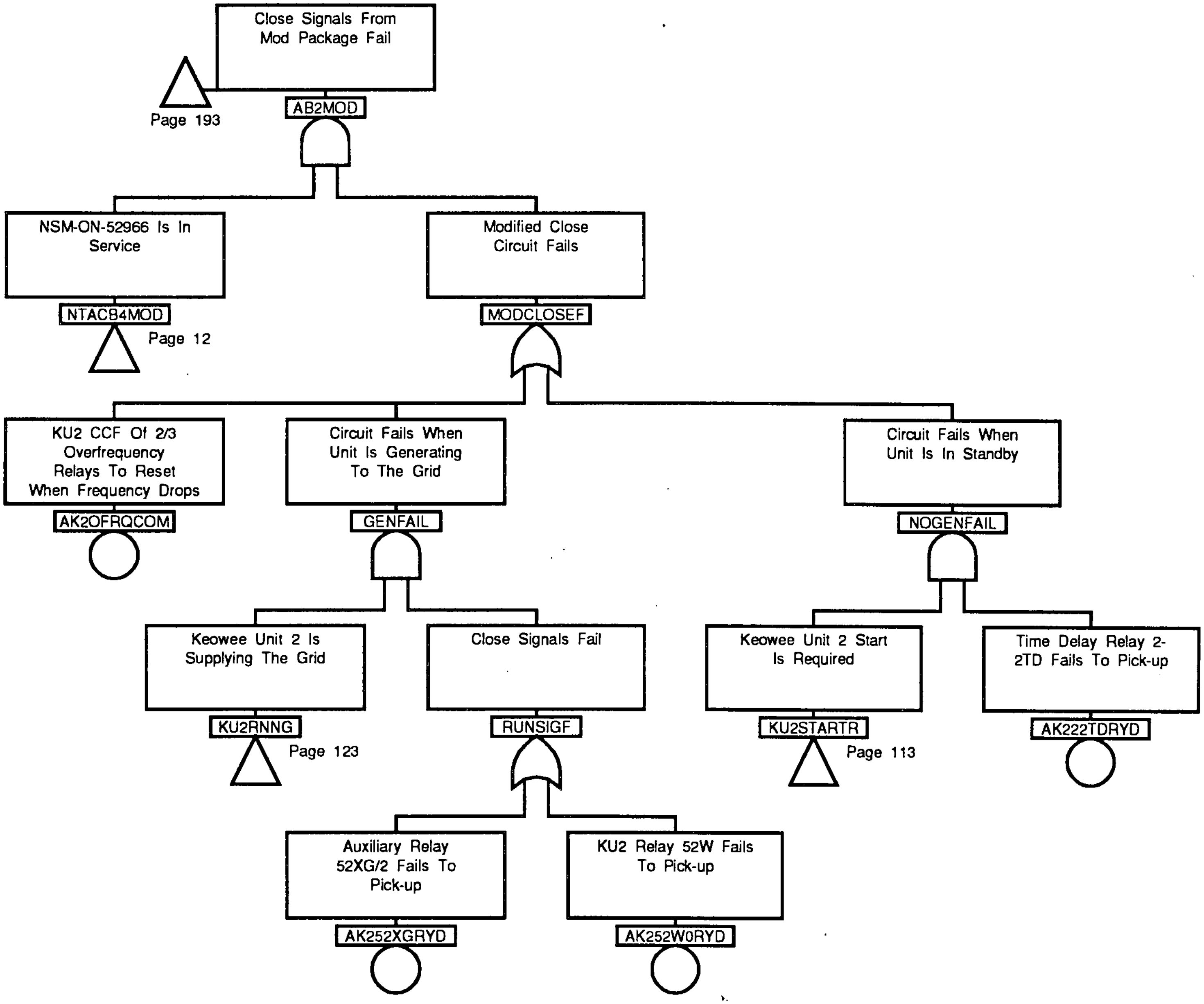
Air Circuit Breaker 2 Fails To Close Due To Control Failures
ACB2CNTRLC
Page 66
Air Circuit Breaker 2 Fails To Close Automatically
ACB2AUTOC
Operators Fail To Close Air Circuit Breaker 2
ABEOPRCRHE
Field Breaker Auxiliary Contact Fa ils To Close When Un it Start Is Required
ACB241A
Air Circuit Breaker 2 Close Signals Fail
ACB2CSGNL
Main Step Up Transformer Lock Out Relay 86T Actuates
XFMR186T
Page 69
Keowee Unit 2 Start Is Required
KU2STARTR
Page 113
Keowee Unit 2 Field Breaker Fails To Close
FLDCLOSE2
Page 116
Time Delay Relay 52-2TD Fails To Operate
AK252TDRYD
2
Switchyard Isolate Complete Signal Fails
SPCISLTCPT
Page 195
Transformer #1 Undervoltage Relay (27T/2X) Fails To Drop Out
AA227T2R6D
Close Signals From Mod Package Fail
AB2MOD
Page 196



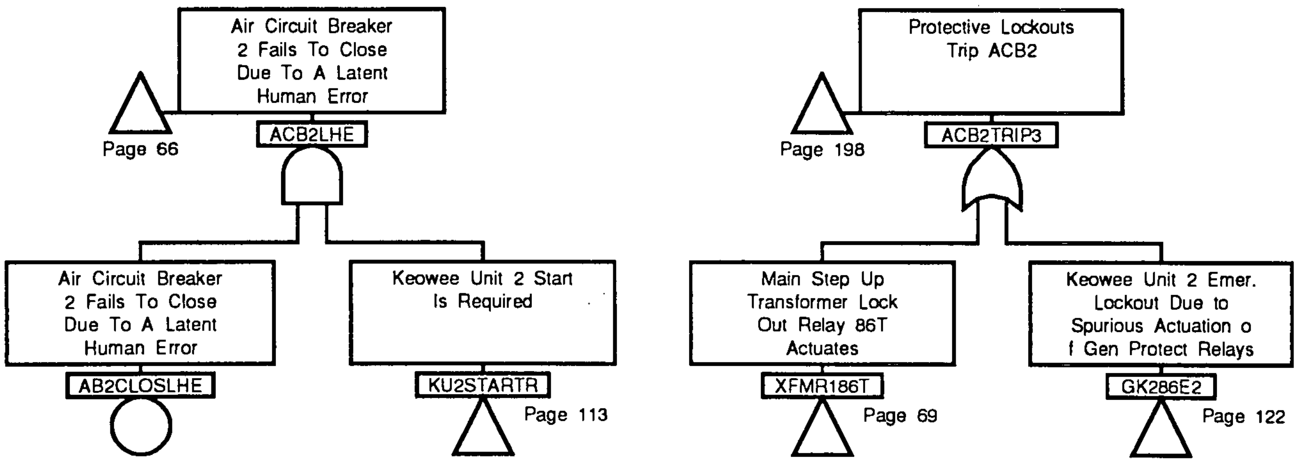
Keowee Unit 2 Generator Field Breaker Spurious Tri p Signal Is Present
GFBTRIP2
Page 116
Keowee Unit 2 Relay 99SY Fails To Pick-up
EK299SYRYD
KHU2 Field Breaker Trip Control Switch Spurious Operation
EK2S141SWT
Unmodified GFB Circuit Fails
EK2NOMOD
Page 116
NSM-ON-52966 Is Not In Service
ACB4MOD
5
Keowee 2 Master Relay 4A Fails To Pick Up On Start
YK2MR4ASRT
Page 115
Modified GFB Circut Fails
EK2MOD
Page 116
NSM-ON-52966 Is In Service
NTACB4MOD
Page 12
Auxiliary Relay 99SX2 Fails To Pick-up
EK299SXRYD



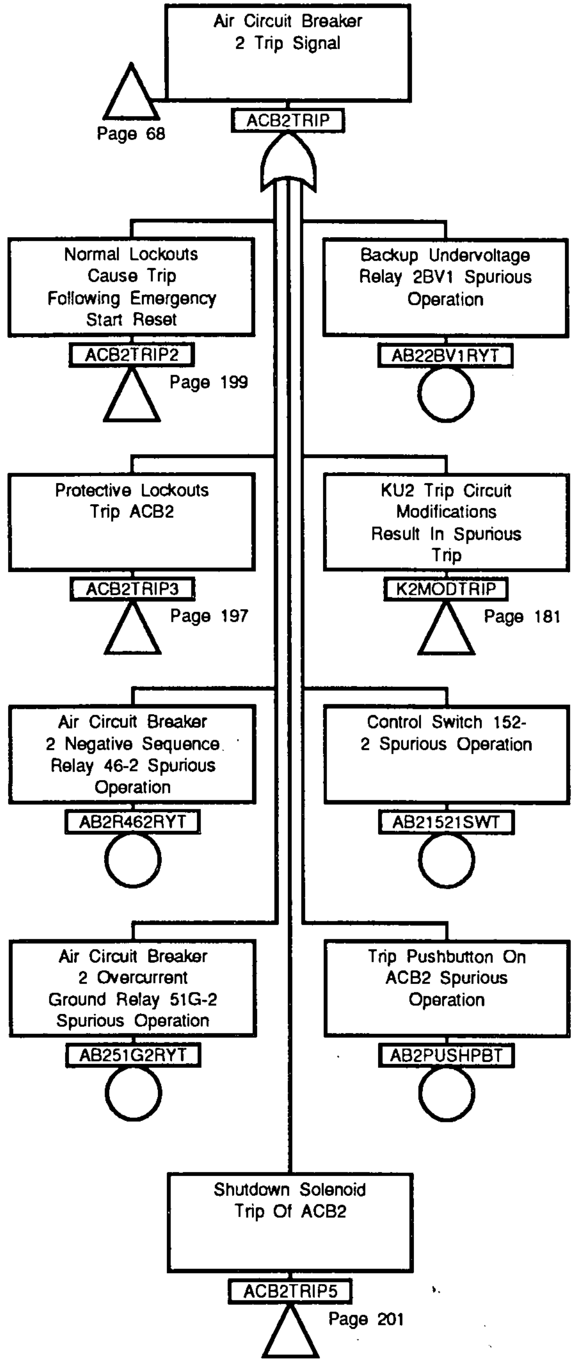
Switchyard Isolate Complete Signal Fails
SPCISLTCPT
Page 215
Page 193
Switchyard Isolate Complete Channel 1 Fails
SPCISOCCH1
Switchyard Isolate Complete Channel 2 Fails
SPCISOCCH2
Page 249
Loss of Power on 125 Vdc Switchyard DC Panelboard DYC
SDCDYC
Page 216
Channel 1 Swyd Isolated Rly, 27X/SC1, Fails to Pick Up
S27XSC1RYD
Channel 1 Swyd Isolated Time Delay Rly, 27XTD/SC1, Fails
S27XTD1RYD
125 Vdc Swyd Control Power Pnlbd DYC Bkr 12 Xfrs Open
SDCDC12CDT
SWYD Yellow Bus Isolation Fails
SPCISOF
Page 218

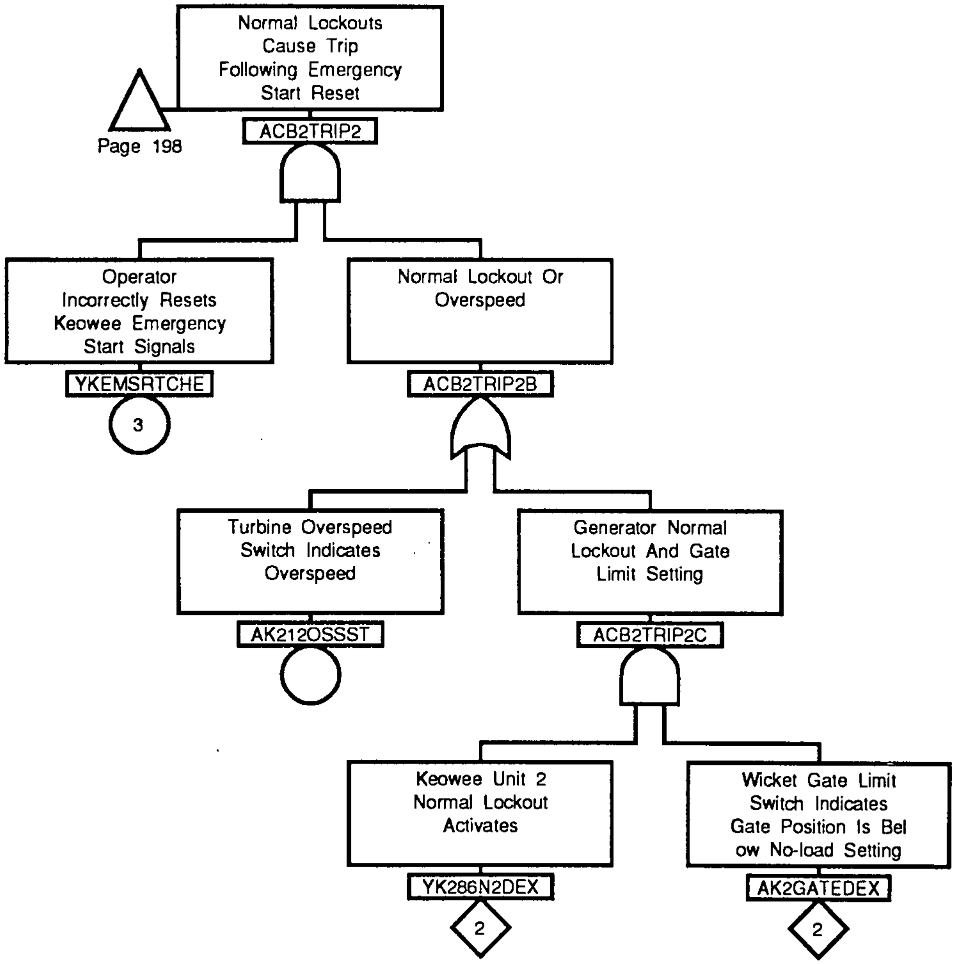


Close Signals From Mod Package Fail
Page 193
AB2MOD
NSM-ON-52966 Is In Service
NTACB4MOD
Page 12
Modified Close Circuit Fails
MODCLOSEF
KU2 CCF Of 2/3 Overfrequency Relays To Reset When Frequency Drops
AK2OFRQCOM
Circuit Fails When Unit Is Generating To The Grid
GENFAIL
Circuit Fails When Unit Is In Standby
NOGENFAIL
Keowee Unit 2 Is Supplying The Grid
KU2RNNG
Page 123
Close Signals Fail
RUNSIGF
Keowee Unit 2 Start Is Required
KU2STARTR
Page 113
Time Delay Relay 2-2TD Fails To Pick-up
AK222TDRYD
Auxiliary Relay 52XG/2 Fails To Pick-up
AK252XGRYD
KU2 Relay 52W Fails To Pick-up
AK252W0RYD

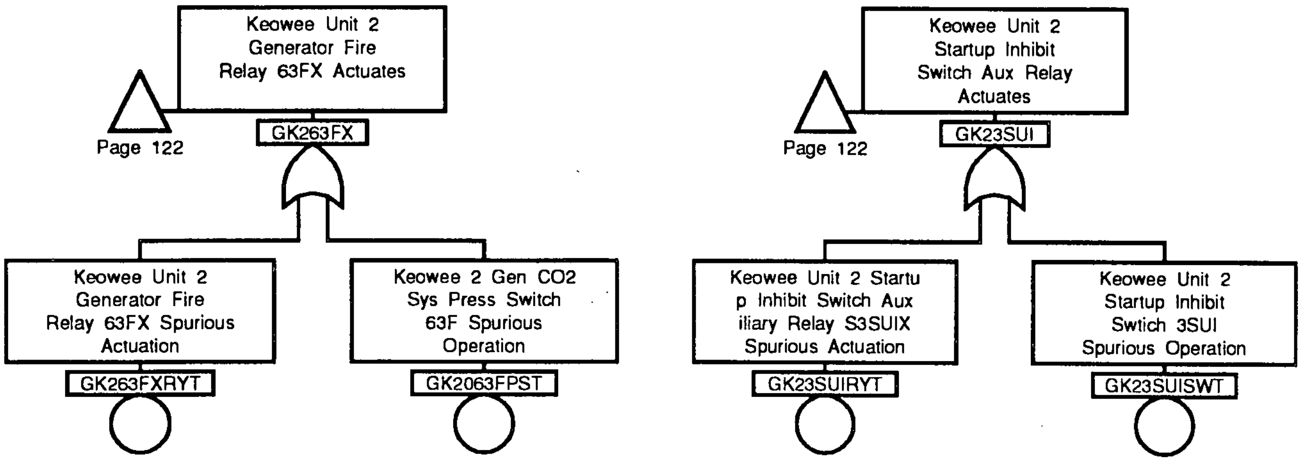


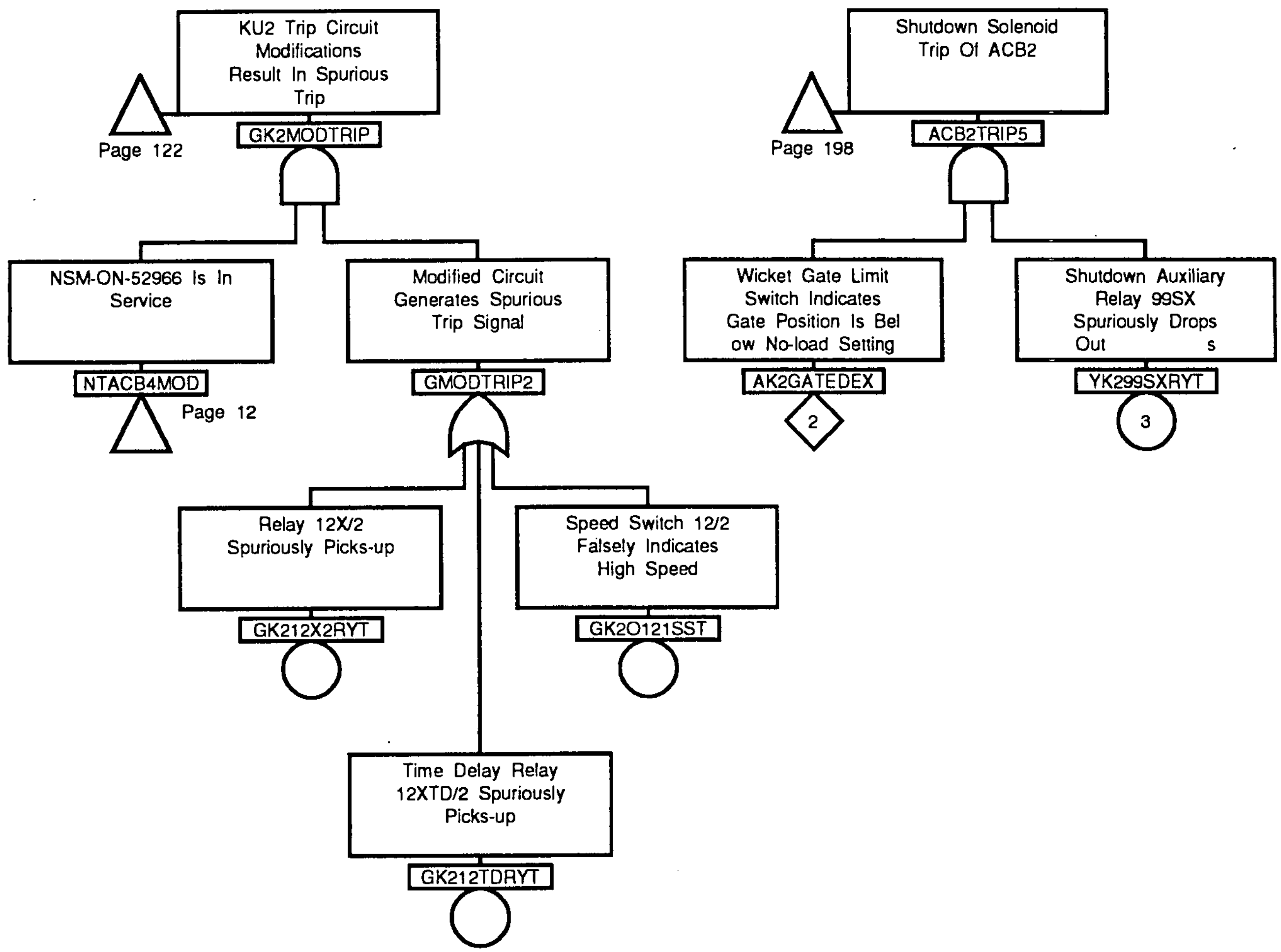
Air Circuit Breaker 2 Fails To Close Due To A Latent Human Error
ACB2LHE
Page 66
Air Circuit Breaker 2 Fails To Close Due To A Latent Human Error
AB2CLOSLHE
Keowee Unit 2 Start Is Required
KU2STARTR
Page 113
Protective Lockouts Trip ACB2
ACB2TRIP3
Page 198
Main Step Up Transformer Lock Out Relay 86T Actuates
XFMR186T
Page 69
Keowee Unit 2 Emer. Lockout Due to Spurious Actuation o f Gen Protect Relays
GK286E2
Page 122


Air Circuit Breaker 2 Trip Signal
ACB2TRIP
Page 68
Normal Lockouts Cause Trip Following Emergency Start Reset
ACB2TRIP2
Page 199
Backup Undervoltage Relay 2BV1 Spurious Operation
AB22BV1RYT
Protective Lockouts Trip ACB2
ACB2TRIP3
Page 197
KU2 Trip Circuit Modifications Result In Spurious Trip
K2MODTRIP
Page 181
Air Circuit Breaker 2 Negative Sequence Relay 46-2 Spurious Operation
AB2R462RYT
Control Switch 152-2 Spurious Operation
AB21521SWT
Air Circuit Breaker 2 Overcurrent Ground Relay 51G-2 Spurious Operation
AB251G2RYT
Trip Pushbutton On ACB2 Spurious Operation
AB2PUSHPBT
Shutdown Solenoid Trip Of ACB2
ACB2TRIP5
Page 201

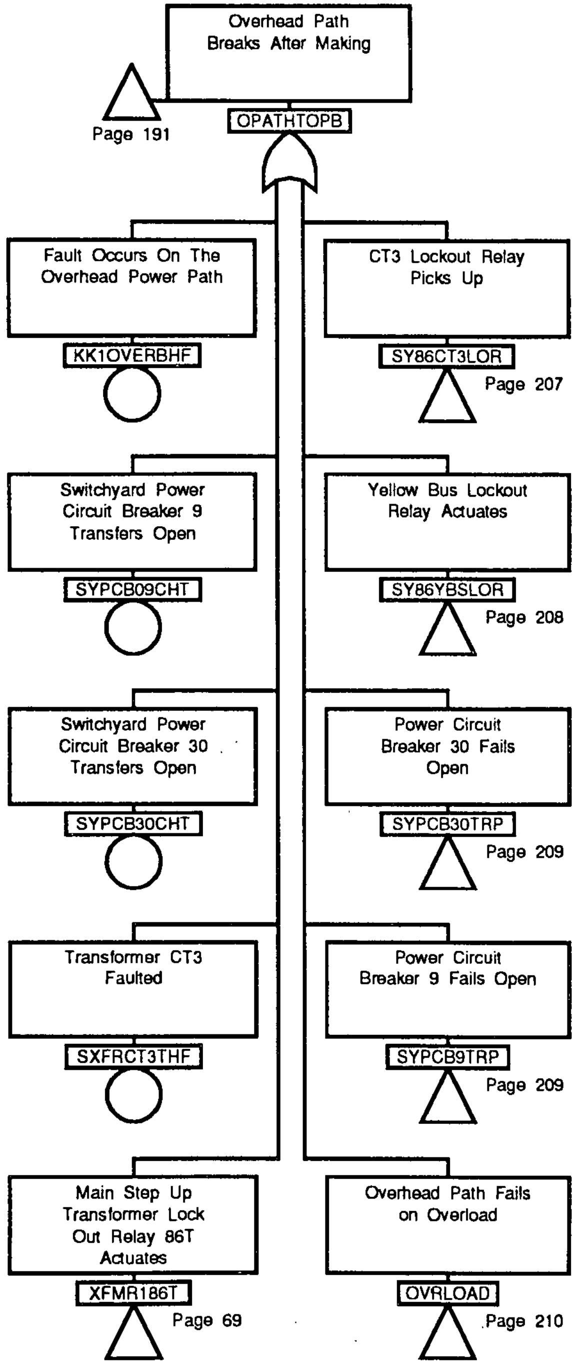


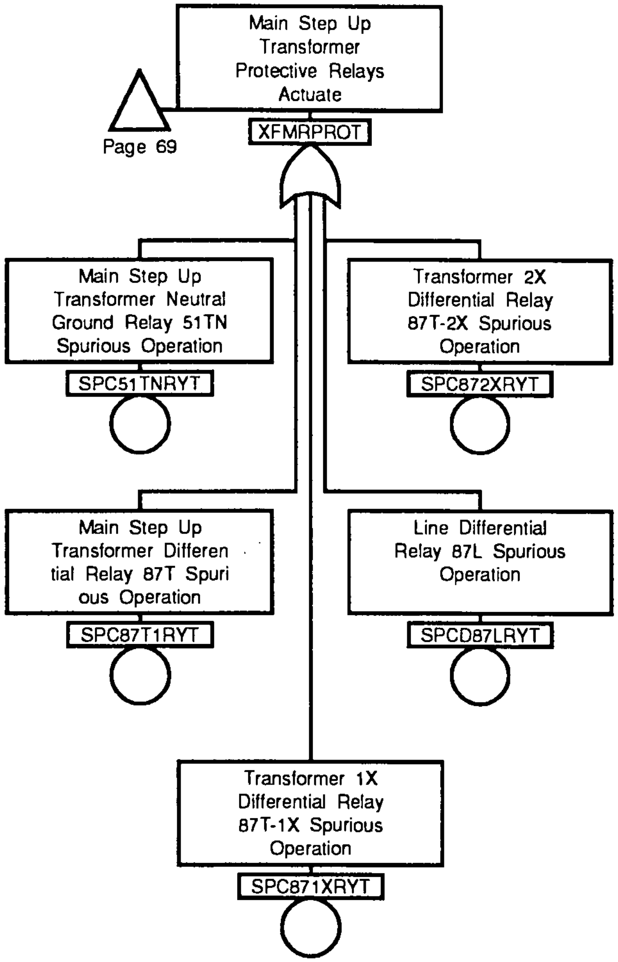
Normal Lockouts Cause Trip Following Emergency Start Reset
ACB2TRIP2
Page 198
Operator Incorrectly Resets Keowee Emergency Start Signals
YKEMSRTCHE
3
Normal Lockout Or Overspeed
ACB2TRIP2B
Turbine Overspeed Switch Indicates Overspeed
AK212OSSST
Generator Normal Lockout And Gate Limit Setting
ACB2TRIP2C
Keowee Unit 2 Normal Lockout Activates
YK286N2DEX
2
Wicket Gate Limit Switch Indicates Gate Position Is Bel ow No-load Setting
AK2GATEDEX
2

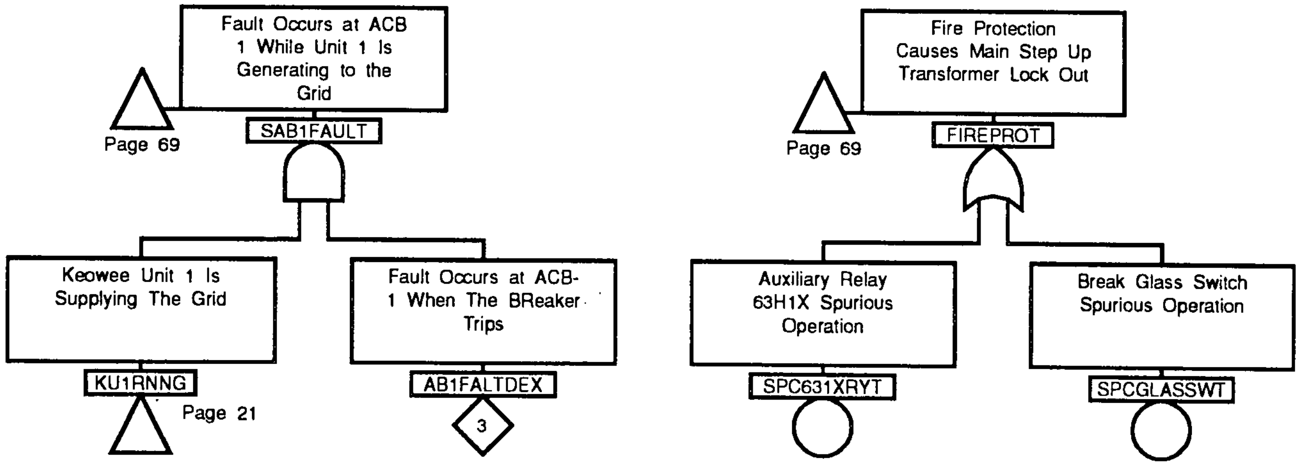

Keowee Unit 2 Generator Fire Relay 63FX Actuates
GK263FX
Page 122
Keowee Unit 2 Generator Fire Relay 63FX Spurious Actuation
GK263FXRYT
Keowee 2 Gen CO2 Sys Press Switch 63F Spurious Operation
GK2063FPST
Keowee Unit 2 Startup Inhibit Switch Aux Relay Actuates
GK23SUI
Page 122
Keowee Unit 2 Startu p Inhibit Switch Aux iliary Relay S3SUIX Spurious Actuation
GK23SUIRYT
Keowee Unit 2 Startup Inhibit Swtich 3SUI Spurious Operation
GK23SUISWT



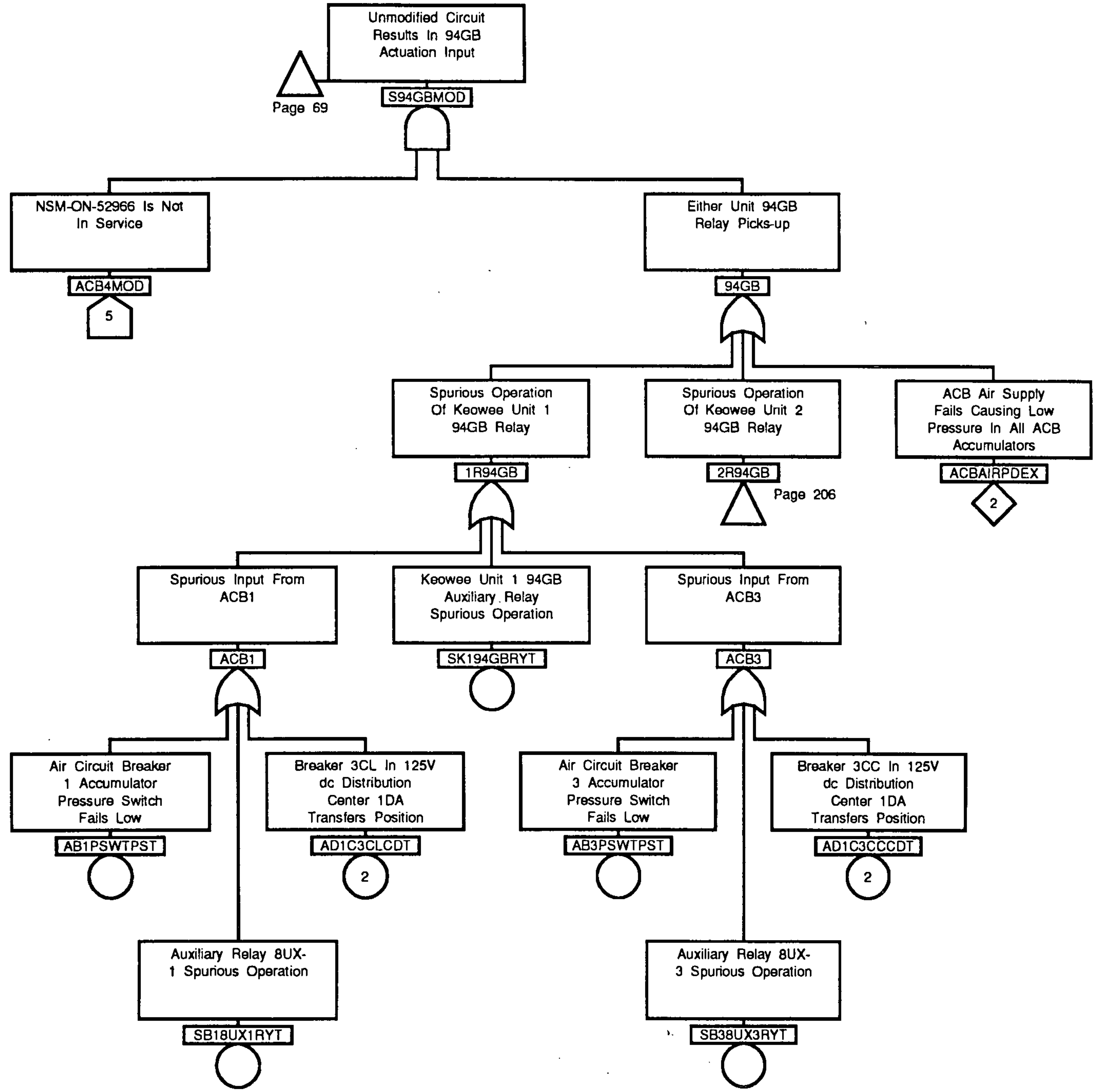
KU2 Trip Circuit Modifications Result In Spurious Trip
GK2MODTRIP
Page 122
NSM-ON-52966 Is In Service
NTACB4MOD
Page 12
Modified Circuit Generates Spurious Trip Signal
GMODTRIP2
Relay 12X/2 Spuriously Picks-up
GK212X2RYT
Speed Switch 12/2 Falsely Indicates High Speed
GK2O121SST
Time Delay Relay 12XTD/2 Spuriously Picks-up
GK212TDRYT
Shutdown Solenoid Trip Of ACB2
ACB2TRIP5
Page 198
Wicket Gate Limit Switch Indicates Gate Position Is Bel ow No-load Setting
AK2GATEDEX
2
Shutdown Auxiliary Relay 99SX Spuriously Drops Out s
YK299SXRYT
3


Overhead Path Breaks After Making
OPATHTOPB
Page 191
Fault Occurs On The Overhead Power Path
KK1OVERBHF
CT3 Lockout Relay Picks Up
SY86CT3LOR
Page 207
Switchyard Power Circuit Breaker 9 Transfers Open
SYPCB09CHT
Yellow Bus Lockout Relay Actuates
SY86YBSLOR
Page 208
Switchyard Power Circuit Breaker 30 Transfers Open
SYPCB30CHT
Power Circuit Breaker 30 Fails Open
SYPCB30TRP
Page 209
Transformer CT3 Faulted
SXFRCT3THF
Power Circuit Breaker 9 Fails Open
SYPCB9TRP
Page 209
Main Step Up Transformer Lock Out Relay 86T Actuates
XFMR186T
Page 69
Overhead Path Fails on Overload
OVRLOAD
Page 210

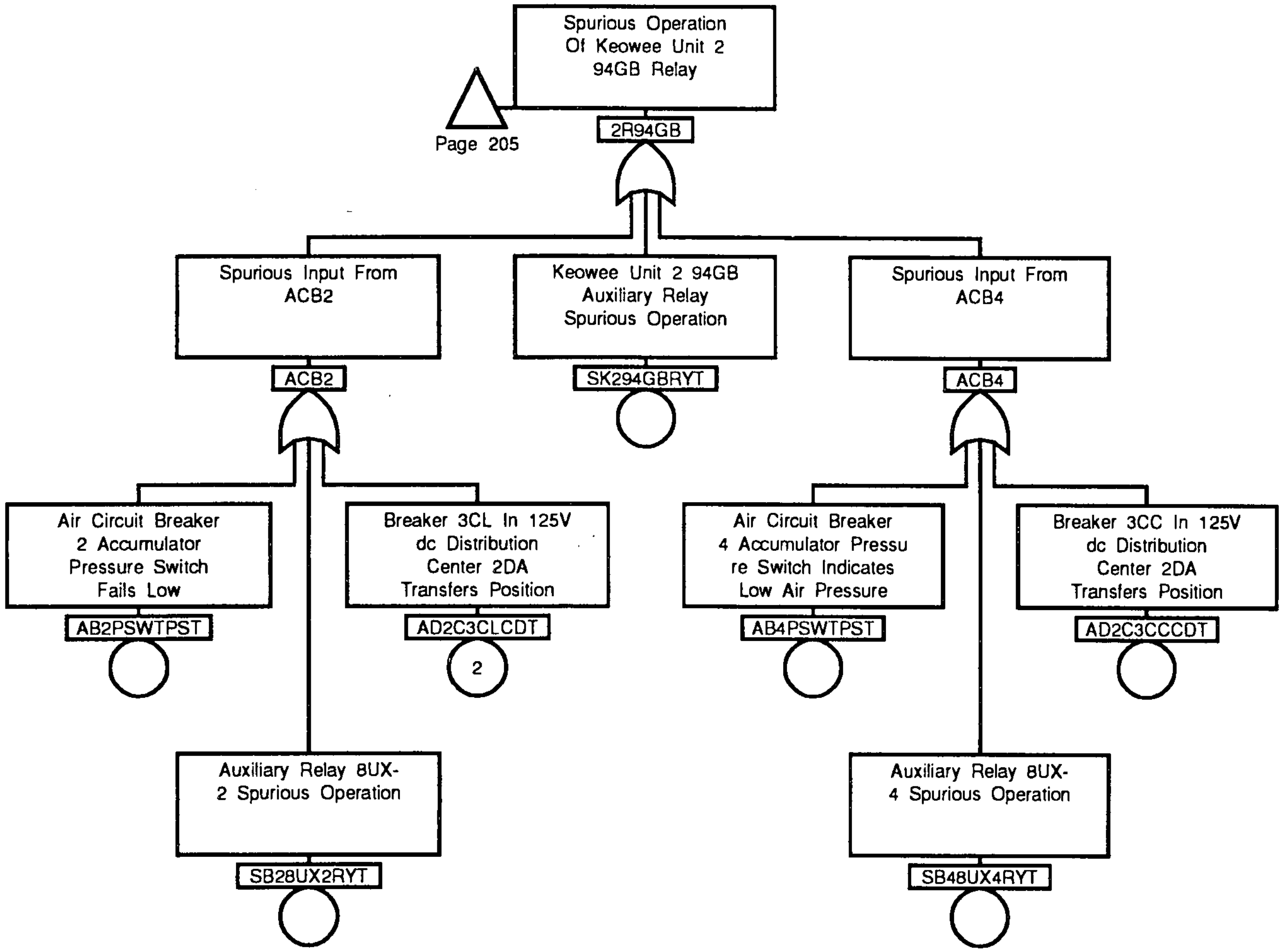

Main Step Up Transformer Protective Relays Actuate
XFMRPROT
Page 69
Main Step Up Transformer Neutral Ground Relay 51TN Spurious Operation
SPC51TNRYT
Transformer 2X Differential Relay 87T-2X Spurious Operation
SPC872XRYT
Main Step Up Transformer Differen tial Relay 87T Spuri ous Operation
SPC87T1RYT
Line Differential Relay 87L Spurious Operation
SPCD87LRYT
Transformer 1X Differential Relay 87T-1X Spurious Operation
SPC871XRYT

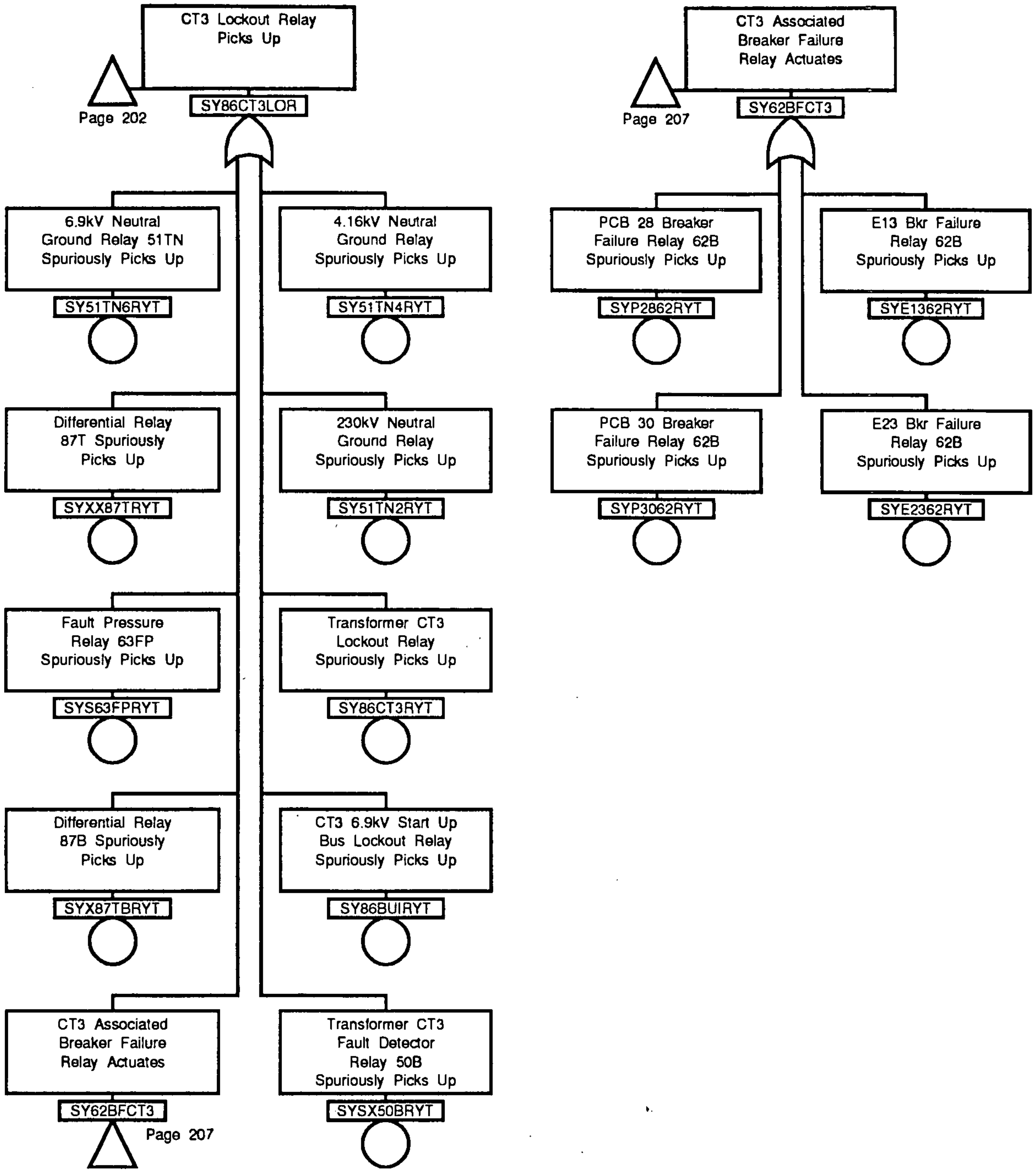


Fault Occurs at ACB 1 While Unit 1 Is Generating to the Grid
SAB1FAULT
Page 69
Keowee Unit 1 Is Supplying The Grid
KU1RNNG
Page 21
Fault Occurs at ACB-1 When The BReaker Trips
AB1FALTDEX
3
Fire Protection Causes Main Step Up Transformer Lock Out
FIREPROT
Page 69
Auxiliary Relay 63H1X Spurious Operation
SPC631XRYT
Break Glass Switch Spurious Operation
SPCGLASSWT

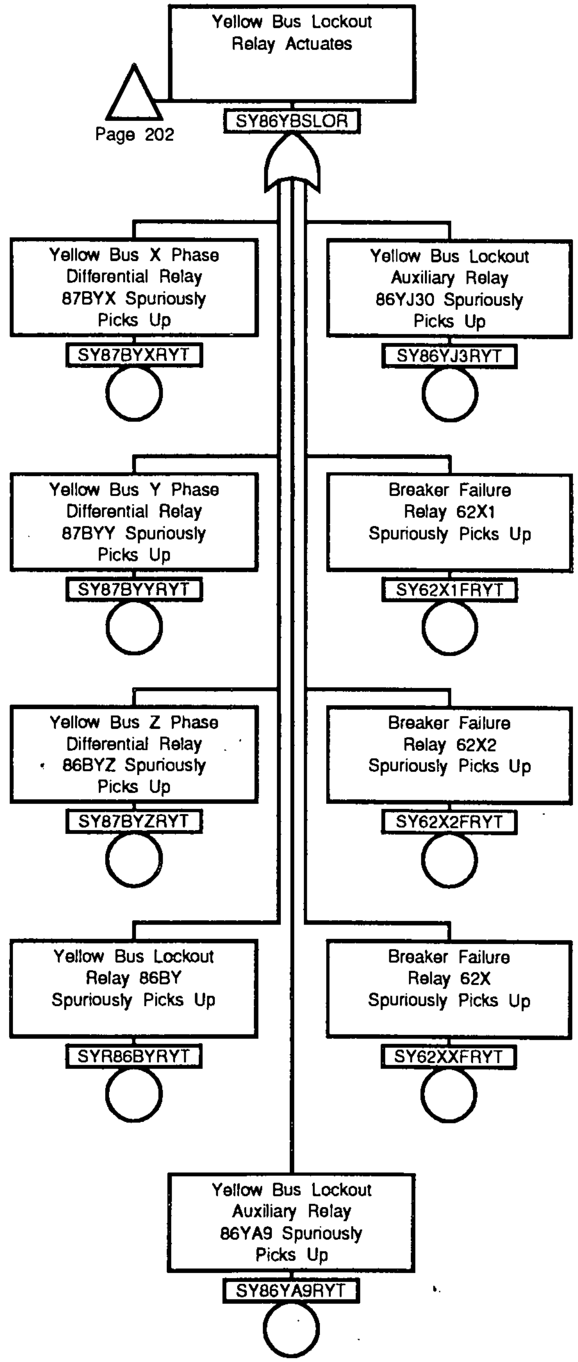


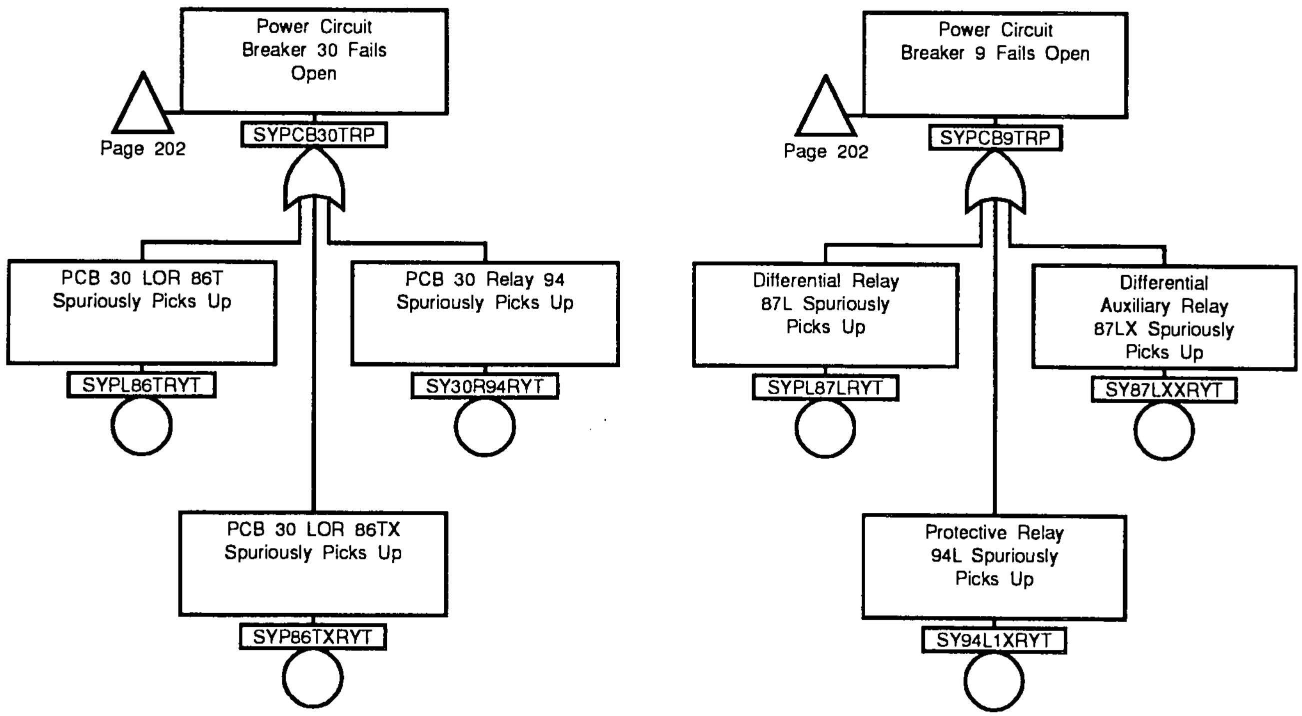
Unmodified Circuit Results In 94GB Actuation Input
S94GBMOD
Page 69
NSM-ON-52966 Is Not In Service
ACB4MOD
5
Either Unit 94GB Relay Picks-up
94GB
Spurious Operation Of Keowee Unit 1 94GB Relay
1R94GB
Spurious Operation Of Keowee Unit 2 94GB Relay
2R94GB
Page 206
ACB Air Supply Fails Causing Low Pressure In All ACB Accumulators
ACBAIRPDEX
2
Spurious Input From ACB1
ACB1
Keowee Unit 1 94GB Auxiliary Relay Spurious Operation
SK194GBRYT
Spurious Input From ACB3
ACB3
Air Circuit Breaker 1 Accumulator Pressure Switch Fails Low
AB1PSWTPST
Breaker 3CL In 125V dc Distribution Center 1DA Transfers Position
AD1C3CLCDT
2
Air Circuit Breaker 3 Accumulator Pressure Switch Fails Low
AB3PSWTPST
Breaker 3CC In 125V dc Distribution Center 1DA Transfers Position
AD1C3CCCDT
2
Auxiliary Relay 8UX-1 Spurious Operation
SB18UX1RYT
Auxiliary Relay 8UX-3 Spurious Operation
SB38UX3RYT


Spurious Operation Of Keowee Unit 2 94GB Relay
2R94GB
Page 205
Spurious Input From ACB2
ACB2
Keowee Unit 2 94GB Auxiliary Relay Spurious Operation
SK294GBRYT
Spurious Input From ACB4
ACB4
Air Circuit Breaker 2 Accumulator Pressure Switch Fails Low
AB2PSWTPST
Breaker 3CL In 125V dc Distribution Center 2DA Transfers Position
AD2C3CLCDT
2
Air Circuit Breaker 4 Accumulator Pressu re Switch Indicates Low Air Pressure
AB4PSWTPST
Breaker 3CC In 125V dc Distribution Center 2DA Transfers Position
AD2C3CCCDT
Auxiliary Relay 8UX-2 Spurious Operation
SB28UX2RYT
Auxiliary Relay 8UX-4 Spurious Operation
SB48UX4RYT

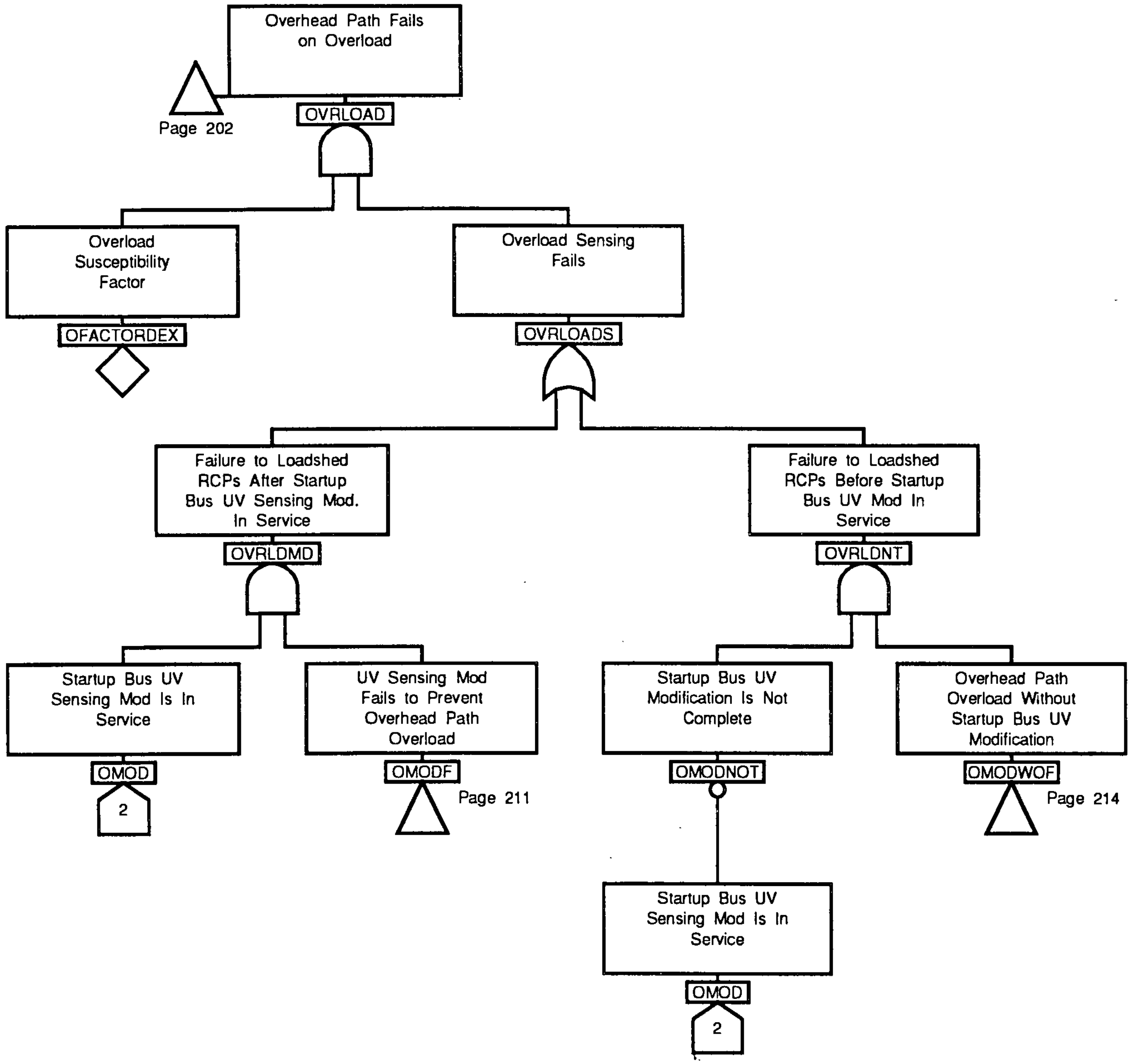


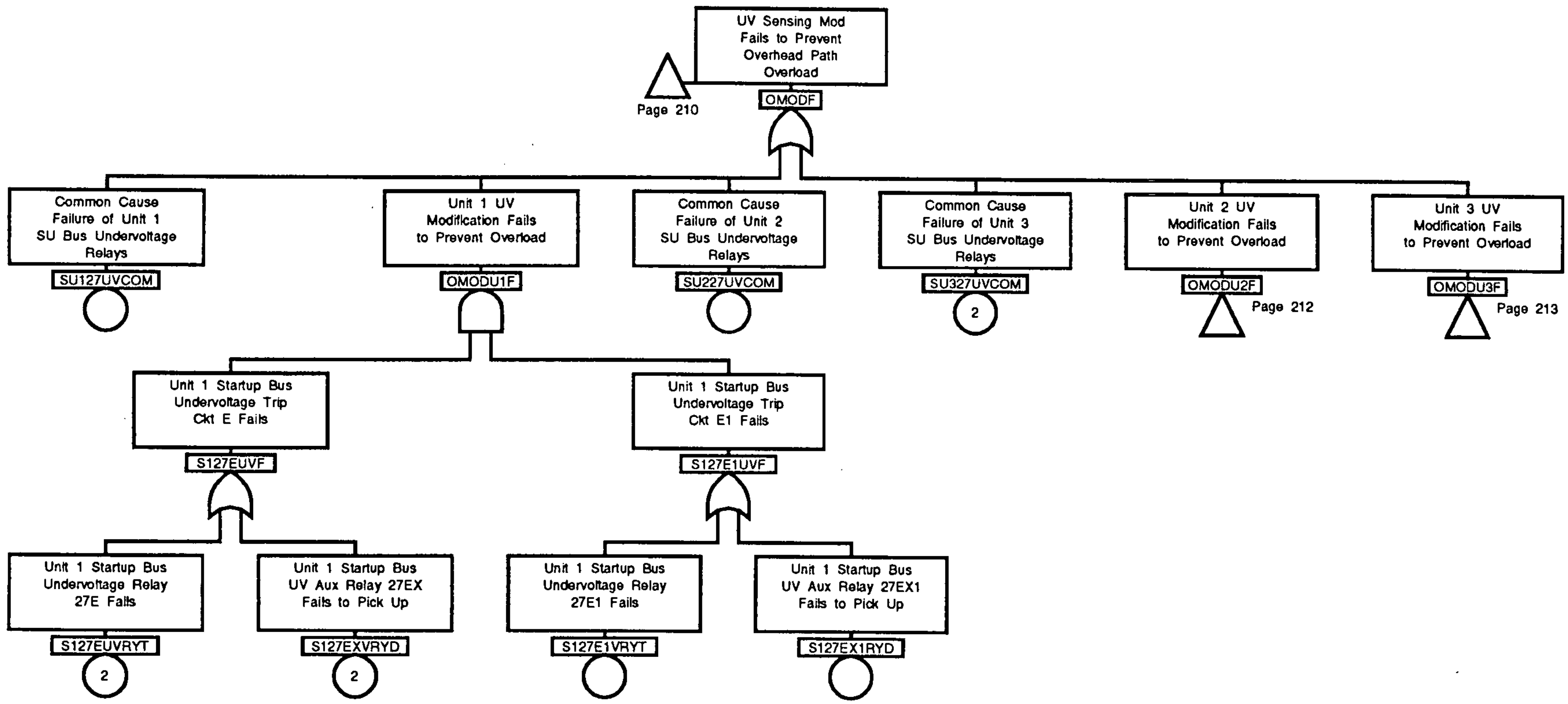
CT3 Lockout Relay Picks Up
SY86CT3LOR
Page 202
6.9kV Neutral Ground Relay 51TN Spuriously Picks Up
SY51TN6RYT
4.16kV Neutral Ground Relay Spuriously Picks Up
SY51TN4RYT
Differential Relay 87T Spuriously Picks Up
SYXX87TRYT
230kV Neutral Ground Relay Spuriously Picks Up
SY51TN2RYT
Fault Pressure Relay 63FP Spuriously Picks Up
SYS63FPRYT
Transformer CT3 Lockout Relay Spuriously Picks Up
SY86CT3RYT
Differential Relay 87B Spuriously Picks Up
SYX87TBRYT
CT3 6.9kV Start Up Bus Lockout Relay Spuriously Picks Up
SY86BUIRYT
CT3 Associated Breaker Failure Relay Actuates
SY62BFCT3
Page 207
Transformer CT3 Fault Detector Relay 50B Spuriously Picks Up
SYSX50BRYT
CT3 Associated Breaker Failure Relay Actuates
SY62BFCT3
Page 207
PCB 28 Breaker Failure Relay 62B Spuriously Picks Up
SYP2862RYT
E13 Bkr Failure Relay 62B Spuriously Picks Up
SYE1362RYT
PCB 30 Breaker Failure Relay 62B Spuriously Picks Up
SYP3062RYT
E23 Bkr Failure Relay 62B Spuriously Picks Up
SYE2362RYT

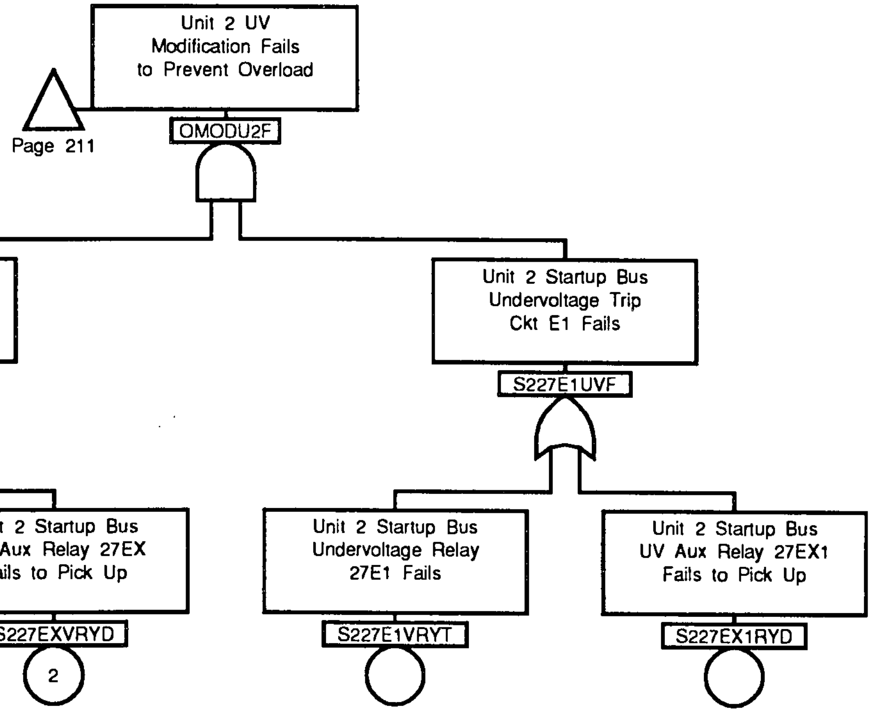

Yellow Bus Lockout Relay Actuates
SY86YBSLOR
Page 202
Yellow Bus X Phase Differential Relay 87BYX Spuriously Picks Up
SY87BYXRYT
Yellow Bus Lockout Auxiliary Relay 86YJ30 Spuriously Picks Up
SY86YJ3RYT
Yellow Bus Y Phase Differential Relay 87BYY Spuriously Picks Up
SY87BYYRYT
Breaker Failure Relay 62X1 Spuriously Picks Up
SY62X1FRYT
Yellow Bus Z Phase Differential Relay 86BYZ Spuriously Picks Up
SY87BYZRYT
Breaker Failure Relay 62X2 Spuriously Picks Up
SY62X2FRYT
Yellow Bus Lockout Relay 86BY Spuriously Picks Up
SYR86BYRYT
Breaker Failure Relay 62X Spuriously Picks Up
SY62XXFRYT
Yellow Bus Lockout Auxiliary Relay 86YA9 Spuriously Picks Up
SY86YA9RYT



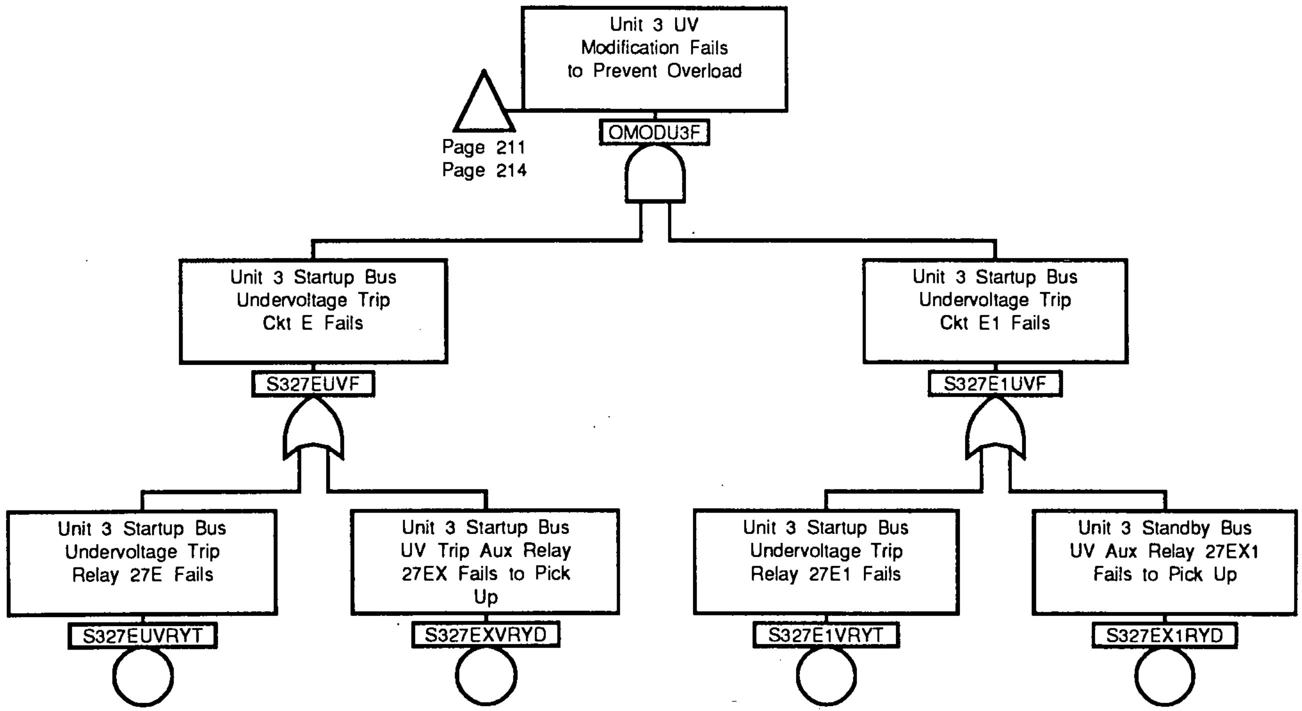
Power Circuit Breaker 30 Fails Open
Page 202
SYPCB30TRP
PCB 30 LOR 86T Spuriously Picks Up
SYPL86TRYT
PCB 30 Relay 94 Spuriously Picks Up
SY30R94RYT
PCB 30 LOR 86TX Spuriously Picks Up
SYP86TXRYT
Power Circuit Breaker 9 Fails Open
Page 202
SYPCB9TRP
Differential Relay 87L Spuriously Picks Up
SYPL87LRYT
Differential Auxiliary Relay 87LX Spuriously Picks Up
SY87LXXRYT
Protective Relay 94L Spuriously Picks Up
SY94L1XRYT

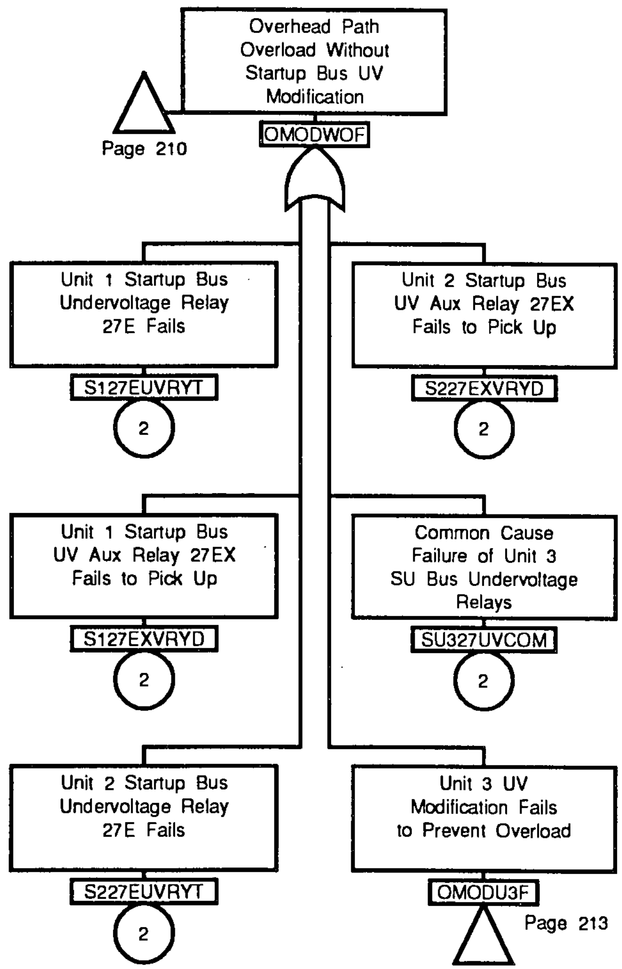

Overhead Path Fails on Overload
Page 202
OVRLOAD
Overload Susceptibility Factor
OFACTORDEX
Overload Sensing Fails
OVRLOADS
Failure to Loadshed RCPs After Startup Bus UV Sensing Mod. In Service
OVRLDMD
Failure to Loadshed RCPs Before Startup Bus UV Mod In Service
OVRLDNT
Startup Bus UV Sensing Mod Is In Service
OMOD
2
UV Sensing Mod Fails to Prevent Overhead Path Overload
OMODF
Page 211
Startup Bus UV Modification Is Not Complete
OMODNOT
Overhead Path Overload Without Startup Bus UV Modification
OMODWOF
Page 214
Startup Bus UV Sensing Mod Is In Service
OMOD
2


UV Sensing Mod Fails to Prevent Overhead Path Overload
OMODF
Page 210
Common Cause Failure of Unit 1 SU Bus Undervoltage Relays
SU127UVCOM
Unit 1 UV Modification Fails to Prevent Overload
OMODU1F
Common Cause Failure of Unit 2 SU Bus Undervoltage Relays
SU227UVCOM
Common Cause Failure of Unit 3 SU Bus Undervoltage Relays
SU327UVCOM
2
Unit 2 UV Modification Fails to Prevent Overload
OMODU2F
Page 212
Unit 3 UV Modification Fails to Prevent Overload
OMODU3F
Page 213
Unit 1 Startup Bus Undervoltage Trip Ckt E Fails
S127EUVF
Unit 1 Startup Bus Undervoltage Trip Ckt E1 Fails
S127E1UVF
Unit 1 Startup Bus Undervoltage Relay 27E Fails
S127EUVRYT
2
Unit 1 Startup Bus UV Aux Relay 27EX Fails to Pick Up
S127EXVRYD
2
Unit 1 Startup Bus Undervoltage Relay 27E1 Fails
S127E1VRYT
Unit 1 Startup Bus UV Aux Relay 27EX1 Fails to Pick Up
S127EX1RYD

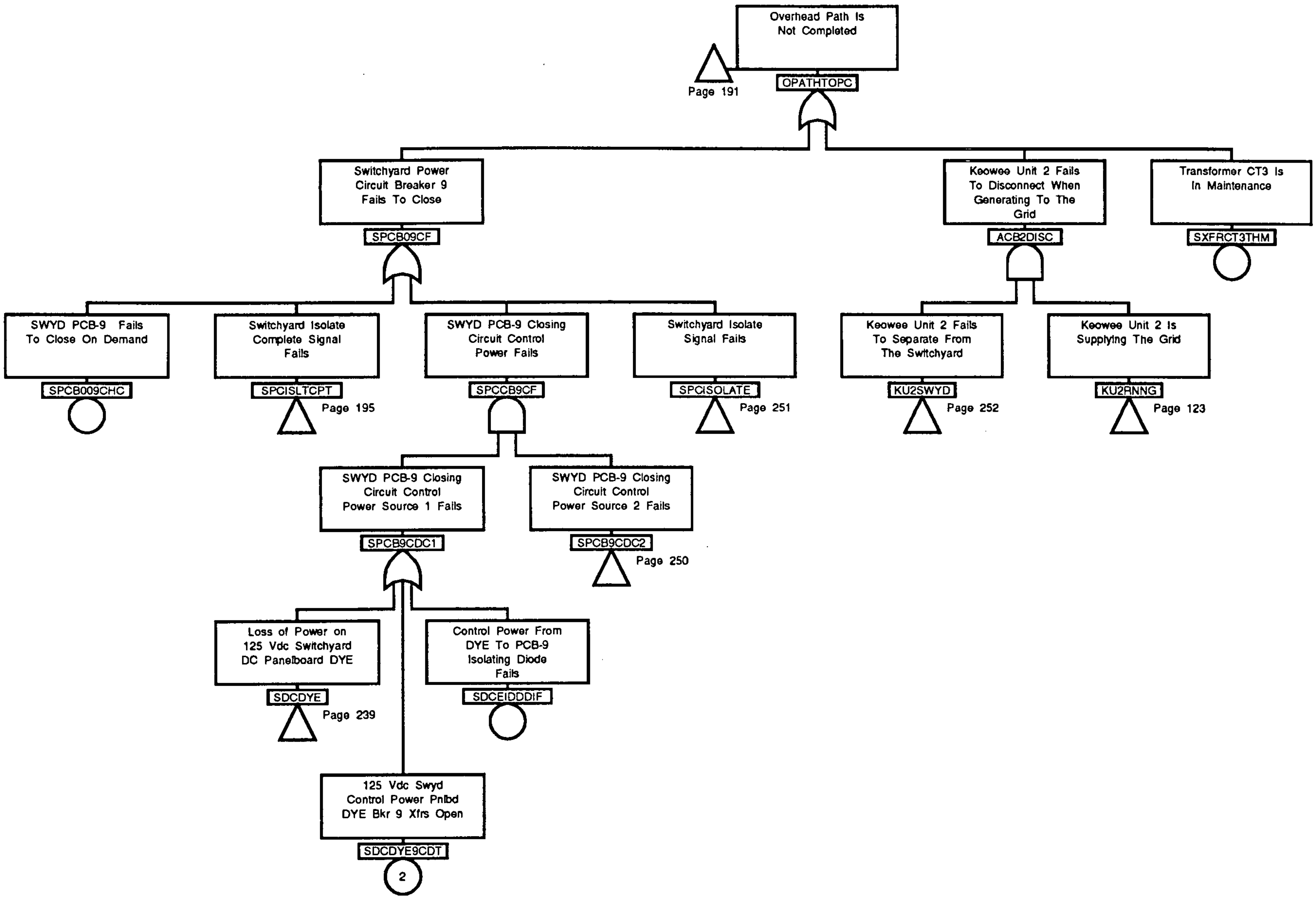


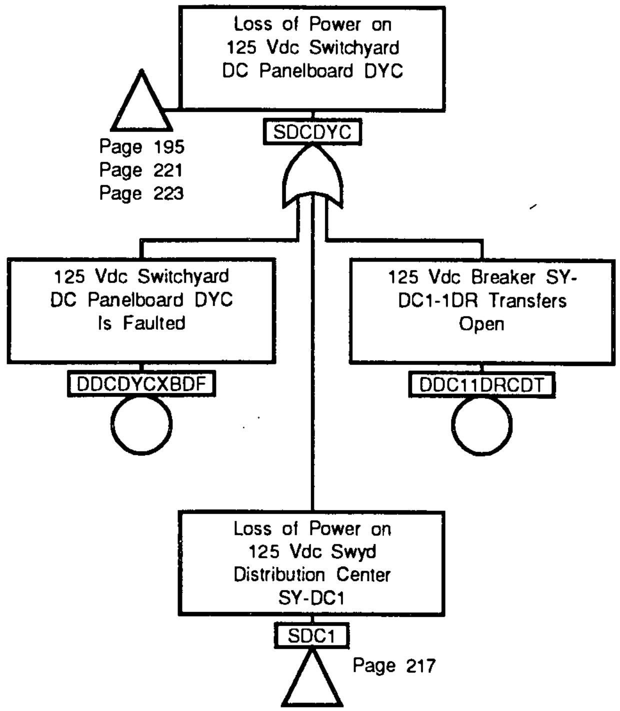
Unit 2 UV Modification Fails to Prevent Overload
Page 211
OMODU2F
Unit 2 Startup Bus Undervoltage Trip Ckt E Fails
S227EUVF
Unit 2 Startup Bus Undervoltage Trip Ckt E1 Fails
S227E1UVF
Unit 2 Startup Bus Undervoltage Relay 27E Fails
S227EUVRYT
2
Unit 2 Startup Bus UV Aux Relay 27EX Fails to Pick Up
S227EXVRYD
2
Unit 2 Startup Bus Undervoltage Relay 27E1 Fails
S227E1VRYT
Unit 2 Startup Bus UV Aux Relay 27EX1 Fails to Pick Up
S227EX1RYD


Unit 3 UV Modification Fails to Prevent Overload
OMODU3F
Page 211
Page 214
Unit 3 Startup Bus Undervoltage Trip Ckt E Fails
S327EUVF
Unit 3 Startup Bus Undervoltage Trip Ckt E1 Fails
S327E1UVF
Unit 3 Startup Bus Undervoltage Trip Relay 27E Fails
S327EUVRYT
Unit 3 Startup Bus UV Trip Aux Relay 27EX Fails to Pick Up
S327EXVRYD
Unit 3 Startup Bus Undervoltage Trip Relay 27E1 Fails
S327E1VRYT
Unit 3 Standby Bus UV Aux Relay 27EX1 Fails to Pick Up
S327EX1RYD

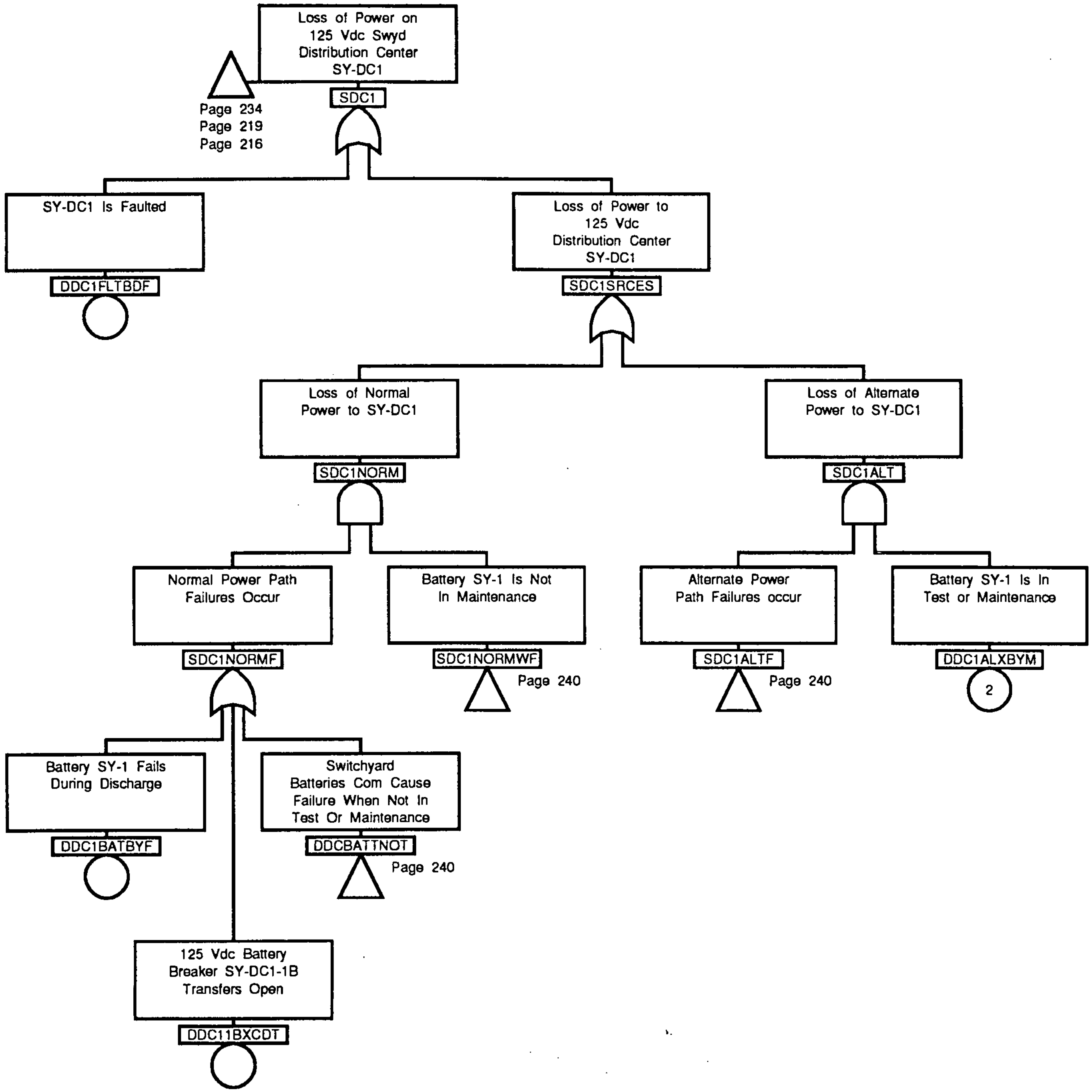


Overhead Path Overload Without Startup Bus UV Modification
OMODWOF
Page 210
Unit 1 Startup Bus Undervoltage Relay 27E Fails
S127EUVRYT
2
Unit 2 Startup Bus UV Aux Relay 27EX Fails to Pick Up
S227EXVRYD
2
Unit 1 Startup Bus UV Aux Relay 27EX Fails to Pick Up
S127EXVRYD
2
Common Cause Failure of Unit 3 SU Bus Undervoltage Relays
SU327UVCOM
2
Unit 2 Startup Bus Undervoltage Relay 27E Fails
S227EUVRYT
2
Unit 3 UV Modification Fails to Prevent Overload
OMODU3F
Page 213

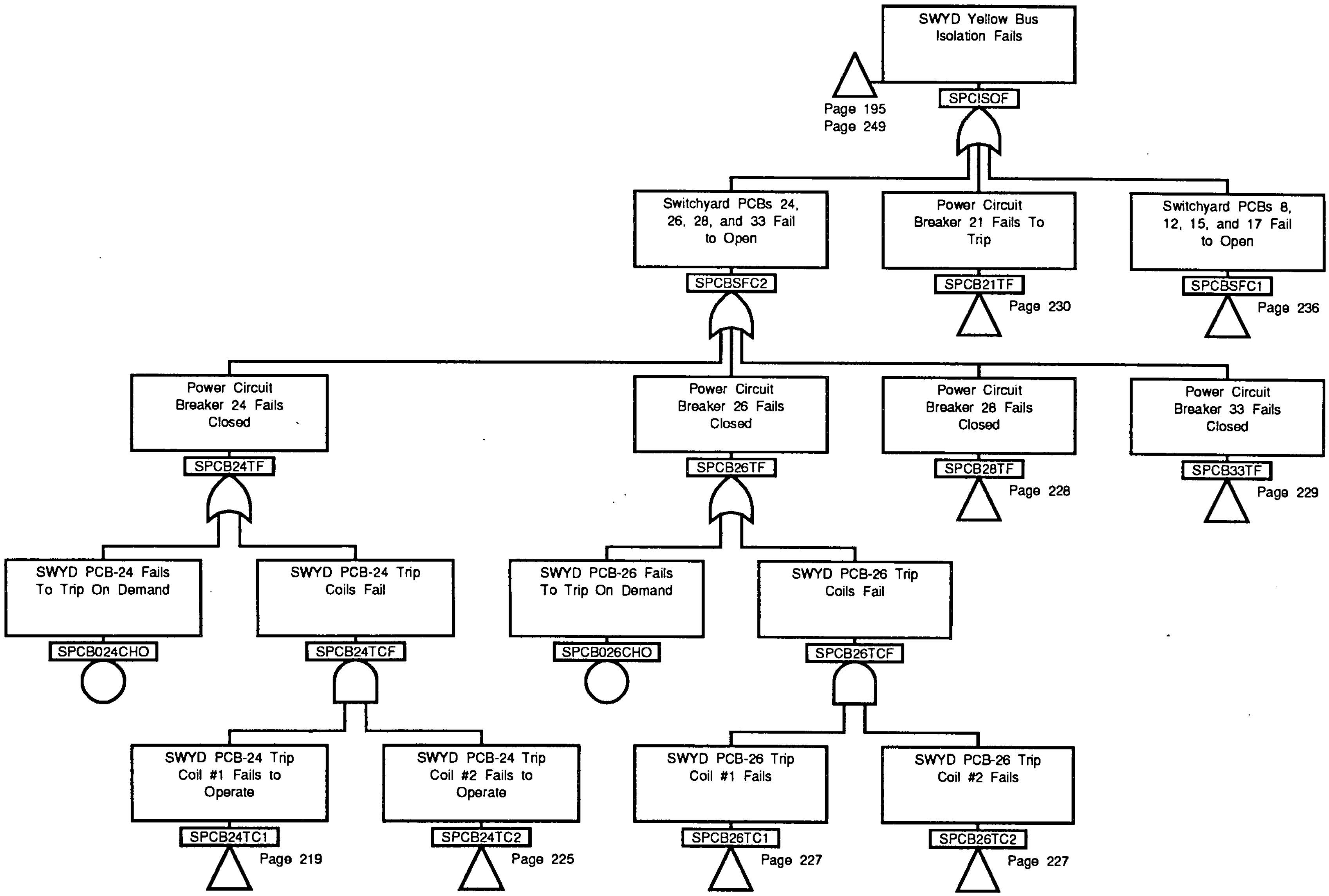

Overhead Path Is Not Completed
OPATHTOPC
Page 191
Switchyard Power Circuit Breaker 9 Fails To Close
SPCB09CF
Keowee Unit 2 Fails To Disconnect When Generating To The Grid
ACB2DISC
Transformer CT3 Is In Maintenance
SXFRCT3THM
SWYD PCB-9 Fails To Close On Demand
SPCB009CHC
Switchyard Isolate Complete Signal Fails
SPCISLTCPT
Page 195
SWYD PCB-9 Closing Circuit Control Power Fails
SPCCB9CF
Switchyard Isolate Signal Fails
SPCISOLATE
Page 251
Keowee Unit 2 Fails To Separate From The Switchyard
KU2SWYD
Page 252
Keowee Unit 2 Is Supplying The Grid
KU2RNNG
Page 123
SWYD PCB-9 Closing Circuit Control Power Source 1 Fails
SPCB9CDC1
SWYD PCB-9 Closing Circuit Control Power Source 2 Fails
SPCB9CDC2
Page 250
Loss of Power on 125 Vdc Switchyard DC Panelboard DYE
SDCDYE
Page 239
Control Power From DYE To PCB-9 Isolating Diode Fails
SDCEIDDDIF
125 Vdc Swyd Control Power Pnlbd DYE Bkr 9 Xfrs Open
SDCDYE9CDT
2



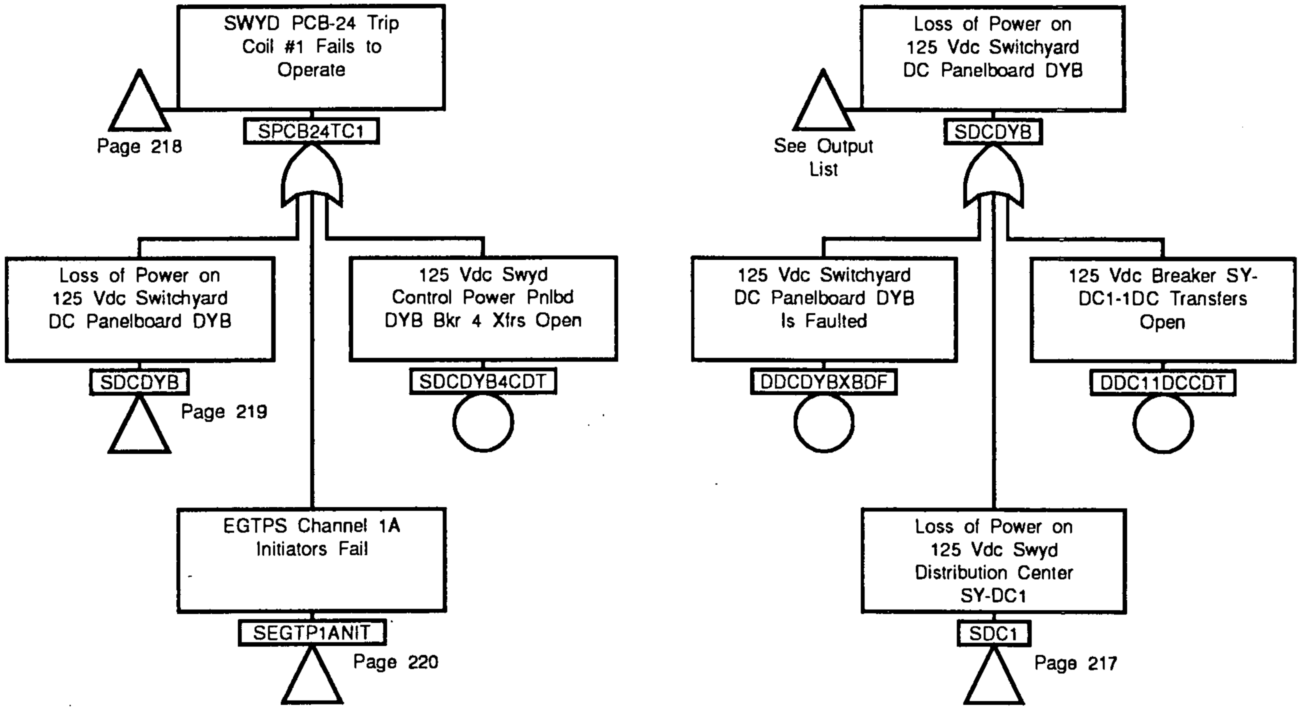
Loss of Power on
125 Vdc Switchyard
DC Panelboard DYC
SDCDYC
Page 195
Page 221
Page 223
125 Vdc Switchyard
DC Panelboard DYC
Is Faulted
DDCDYCXBDF
125 Vdc Breaker SY-
DC1-1DR Transfers
Open
DDC11DRCDT
Loss of Power on
125 Vdc Swyd
Distribution Center
SY-DC1
SDC1
Page 217

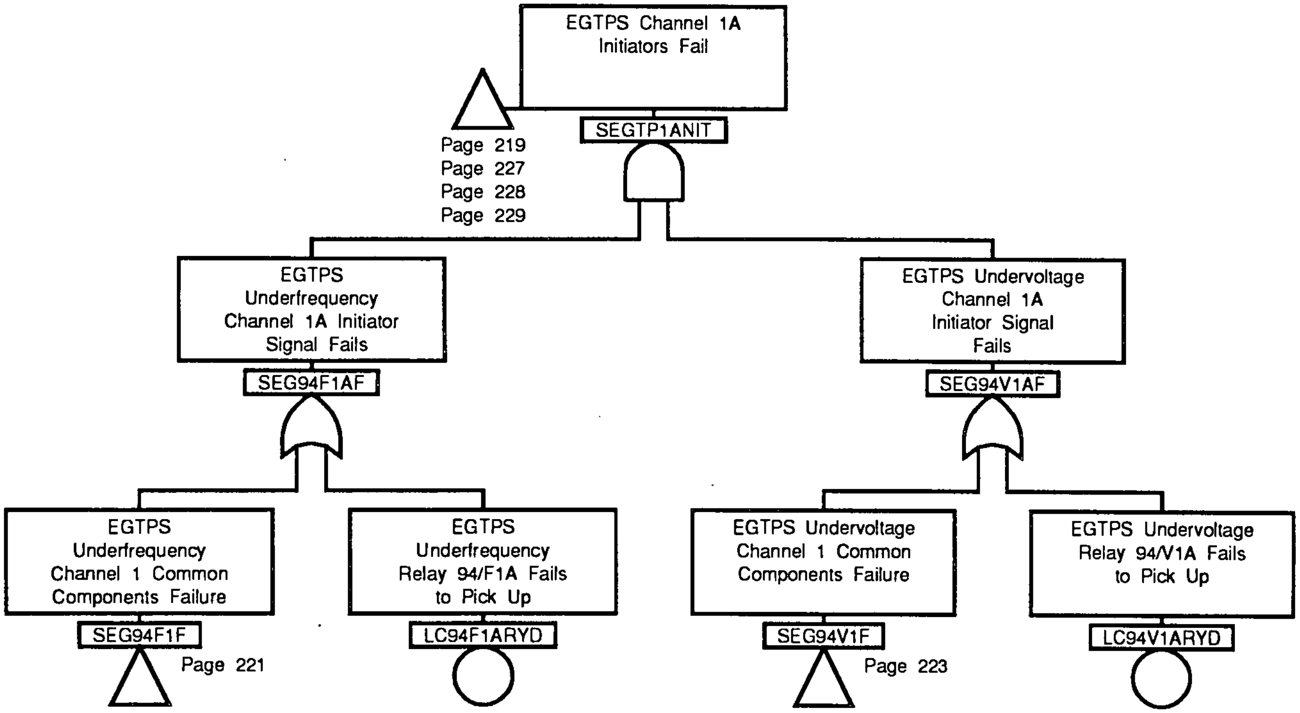


Loss of Power on 125 Vdc Swyd Distribution Center SY-DC1
SDC1
Page 234
Page 219
Page 216
SY-DC1 Is Faulted
DDC1FLTBDF
Loss of Power to 125 Vdc Distribution Center SY-DC1
SDC1SRCES
Loss of Normal Power to SY-DC1
SDC1NORM
Loss of Alternate Power to SY-DC1
SDC1ALT
Normal Power Path Failures Occur
SDC1NORMF
Battery SY-1 Is Not In Maintenance
SDC1NORMWF
Page 240
Alternate Power Path Failures occur
SDC1ALTF
Page 240
Battery SY-1 Is In Test or Maintenance
DDC1ALXBYM
2
Battery SY-1 Fails During Discharge
DDC1BATBYF
Switchyard Batteries Com Cause Failure When Not In Test Or Maintenance
DDCBATTNOT
Page 240
125 Vdc Battery Breaker SY-DC1-1B Transfers Open
DDC11BXCDT



SWYD Yellow Bus Isolation Fails
SPCISOF
Page 195
Page 249
Switchyard PCBs 24, 26, 28, and 33 Fail to Open
SPCBSFC2
Power Circuit Breaker 21 Fails To Trip
SPCB21TF
Page 230
Switchyard PCBs 8, 12, 15, and 17 Fail to Open
SPCBSFC1
Page 236
Power Circuit Breaker 24 Fails Closed
SPCB24TF
Power Circuit Breaker 26 Fails Closed
SPCB26TF
Power Circuit Breaker 28 Fails Closed
SPCB28TF
Page 228
Power Circuit Breaker 33 Fails Closed
SPCB33TF
Page 229
SWYD PCB-24 Fails To Trip On Demand
SPCB024CHO
SWYD PCB-24 Trip Coils Fail
SPCB24TCF
SWYD PCB-26 Fails To Trip On Demand
SPCB026CHO
SWYD PCB-26 Trip Coils Fail
SPCB26TCF
SWYD PCB-24 Trip Coil #1 Fails to Operate
SPCB24TC1
Page 219
SWYD PCB-24 Trip Coil #2 Fails to Operate
SPCB24TC2
Page 225
SWYD PCB-26 Trip Coil #1 Fails
SPCB26TC1
Page 227
SWYD PCB-26 Trip Coil #2 Fails
SPCB26TC2
Page 227


SWYD PCB-24 Trip Coil #1 Fails to Operate
SPCB24TC1
Page 218
Loss of Power on 125 Vdc Switchyard DC Panelboard DYB
SDCDYB
Page 219
125 Vdc Swyd Control Power Pnlbd DYB Bkr 4 Xfrs Open
SDCDYB4CDT
EGTPS Channel 1A Initiators Fail
SEGTP1ANIT
Page 220
Loss of Power on 125 Vdc Switchyard DC Panelboard DYB
SDCDYB
See Output List
125 Vdc Switchyard DC Panelboard DYB Is Faulted
DDCDYBXBDF
125 Vdc Breaker SY-DC1-1DC Transfers Open
DDC11DCCDT
Loss of Power on 125 Vdc Swyd Distribution Center SY-DC1
SDC1
Page 217


EGTPS Channel 1A Initiators Fail
SEGTP1ANIT
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Page 227
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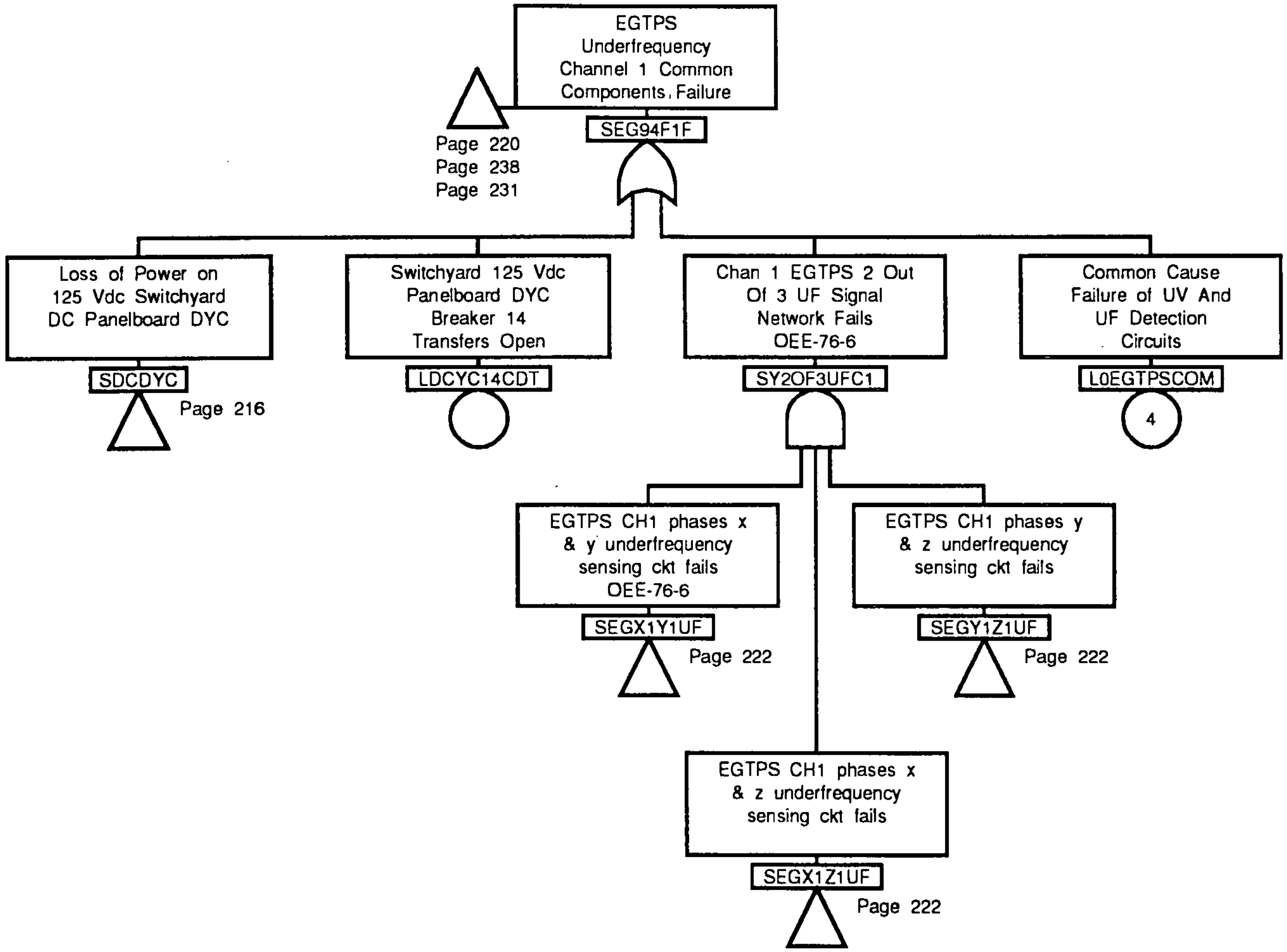
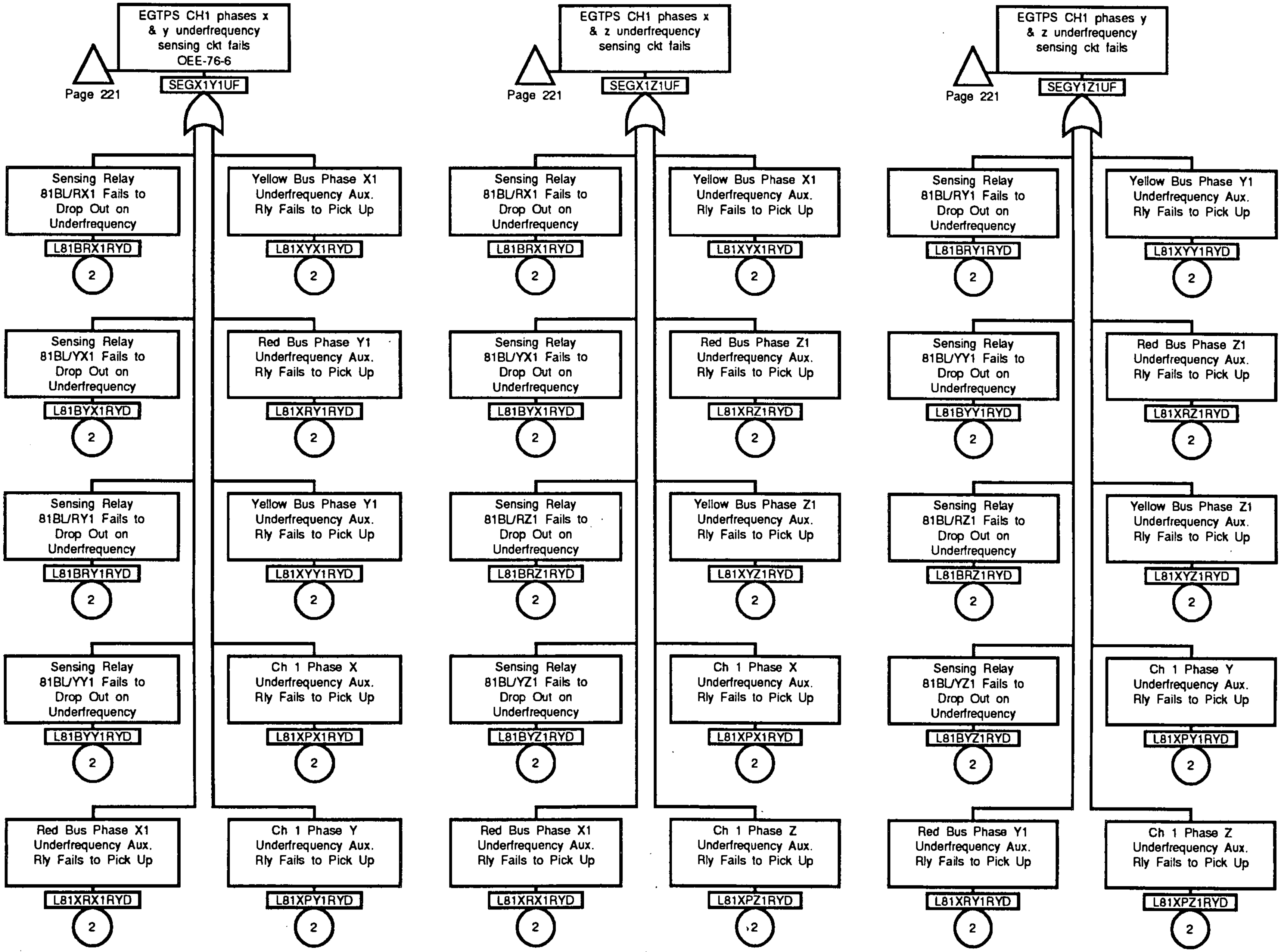
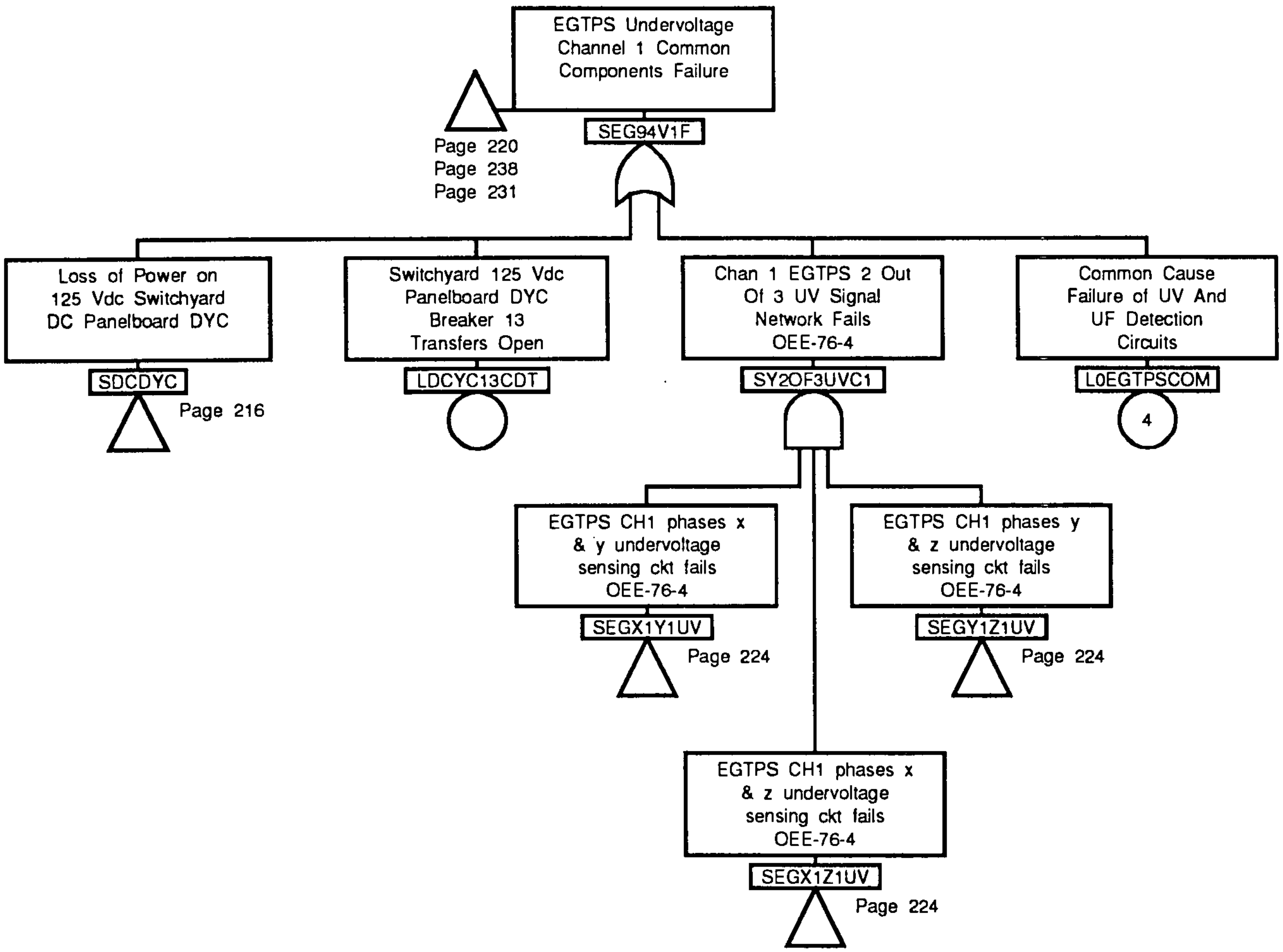
Page 229
EGTPS Underfrequency Channel 1A Initiator Signal Fails
SEG94F1AF
EGTPS Undervoltage Channel 1A Initiator Signal Fails
SEG94V1AF
EGTPS Underfrequency Channel 1 Common Components Failure
SEG94F1F
Page 221
EGTPS Underfrequency Relay 94/F1A Fails to Pick Up
LC94F1ARYD
EGTPS Undervoltage Channel 1 Common Components Failure
SEG94V1F
Page 223
EGTPS Undervoltage Relay 94/V1A Fails to Pick Up
LC94V1ARYD

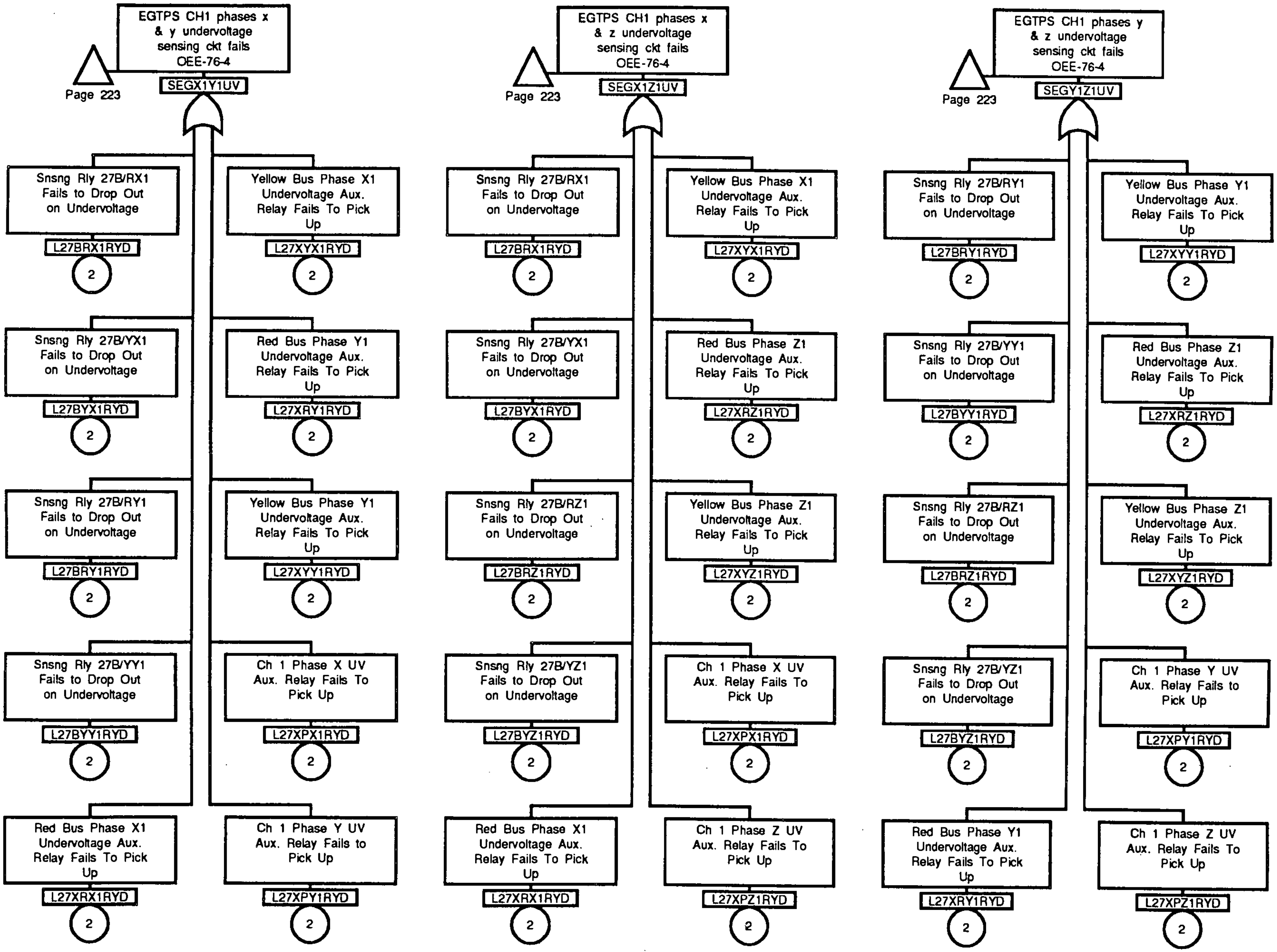

EGTPS
Underfrequency
Channel 1 Common
Components Failure
SEG94F1F
Page 220
Page 238
Page 231
Loss of Power on
125 Vdc Switchyard
DC Panelboard DYC
SDCDYC
Page 216
Switchyard 125 Vdc
Panelboard DYC
Breaker 14
Transfers Open
LDCYC14CDT
Chan 1 EGTPS 2 Out
Of 3 UF Signal
Network Fails
OEE-76-6
SY2OF3UFC1
Common Cause
Failure of UV And
UF Detection
Circuits
L0EGTPSCOM
4
EGTPS CH1 phases x
& y underfrequency
sensing ckt fails
OEE-76-6
SEGX1Y1UF
Page 222
EGTPS CH1 phases y
& z underfrequency
sensing ckt fails
SEGY1Z1UF
Page 222
EGTPS CH1 phases x
& z underfrequency
sensing ckt fails
SEGX1Z1UF
Page 222



EGTPS CH1 phases x & y underfrequency sensing ckt fails OEE-76-6
SEGX1Y1UF
Page 221
Sensing Relay 81BL/RX1 Fails to Drop Out on Underfrequency
L81BRX1RYD
Yellow Bus Phase X1 Underfrequency Aux. Rly Fails to Pick Up
L81XYX1RYD
Sensing Relay 81BL/YX1 Fails to Drop Out on Underfrequency
L81BYX1RYD
Red Bus Phase Y1 Underfrequency Aux. Rly Fails to Pick Up
L81XRY1RYD
Sensing Relay 81BL/RY1 Fails to Drop Out on Underfrequency
L81BRY1RYD
Yellow Bus Phase Y1 Underfrequency Aux. Rly Fails to Pick Up
L81XYY1RYD
Sensing Relay 81BL/YY1 Fails to Drop Out on Underfrequency
L81BYY1RYD
Ch 1 Phase X Underfrequency Aux. Rly Fails to Pick Up
L81XPX1RYD
Red Bus Phase X1 Underfrequency Aux. Rly Fails to Pick Up
L81XRX1RYD
Ch 1 Phase Y Underfrequency Aux. Rly Fails to Pick Up
L81XPY1RYD
EGTPS CH1 phases x & z underfrequency sensing ckt fails
SEGX1Z1UF
Page 221
Sensing Relay 81BL/RX1 Fails to Drop Out on Underfrequency
L81BRX1RYD
Yellow Bus Phase X1 Underfrequency Aux. Rly Fails to Pick Up
L81XYX1RYD
Sensing Relay 81BL/YX1 Fails to Drop Out on Underfrequency
L81BYX1RYD
Red Bus Phase Z1 Underfrequency Aux. Rly Fails to Pick Up
L81XRZ1RYD
Sensing Relay 81BL/RZ1 Fails to Drop Out on Underfrequency
L81BRZ1RYD
Yellow Bus Phase Z1 Underfrequency Aux. Rly Fails to Pick Up
L81XYZ1RYD
Sensing Relay 81BL/YZ1 Fails to Drop Out on Underfrequency
L81BYZ1RYD
Ch 1 Phase X Underfrequency Aux. Rly Fails to Pick Up
L81XPX1RYD
Red Bus Phase X1 Underfrequency Aux. Rly Fails to Pick Up
L81XRX1RYD
Ch 1 Phase Z Underfrequency Aux. Rly Fails to Pick Up
L81XPZ1RYD
EGTPS CH1 phases y & z underfrequency sensing ckt fails
SEGY1Z1UF
Page 221
Sensing Relay 81BL/RY1 Fails to Drop Out on Underfrequency
L81BRY1RYD
Yellow Bus Phase Y1 Underfrequency Aux. Rly Fails to Pick Up
L81XYY1RYD
Sensing Relay 81BL/YY1 Fails to Drop Out on Underfrequency
L81BYY1RYD
Red Bus Phase Z1 Underfrequency Aux. Rly Fails to Pick Up
L81XRZ1RYD
Sensing Relay 81BL/RZ1 Fails to Drop Out on Underfrequency
L81BRZ1RYD
Yellow Bus Phase Z1 Underfrequency Aux. Rly Fails to Pick Up
L81XYZ1RYD
Sensing Relay 81BL/YZ1 Fails to Drop Out on Underfrequency
L81BYZ1RYD
Ch 1 Phase Y Underfrequency Aux. Rly Fails to Pick Up
L81XPY1RYD
Red Bus Phase Y1 Underfrequency Aux. Rly Fails to Pick Up
L81XRY1RYD
Ch 1 Phase Z Underfrequency Aux. Rly Fails to Pick Up
L81XPZ1RYD

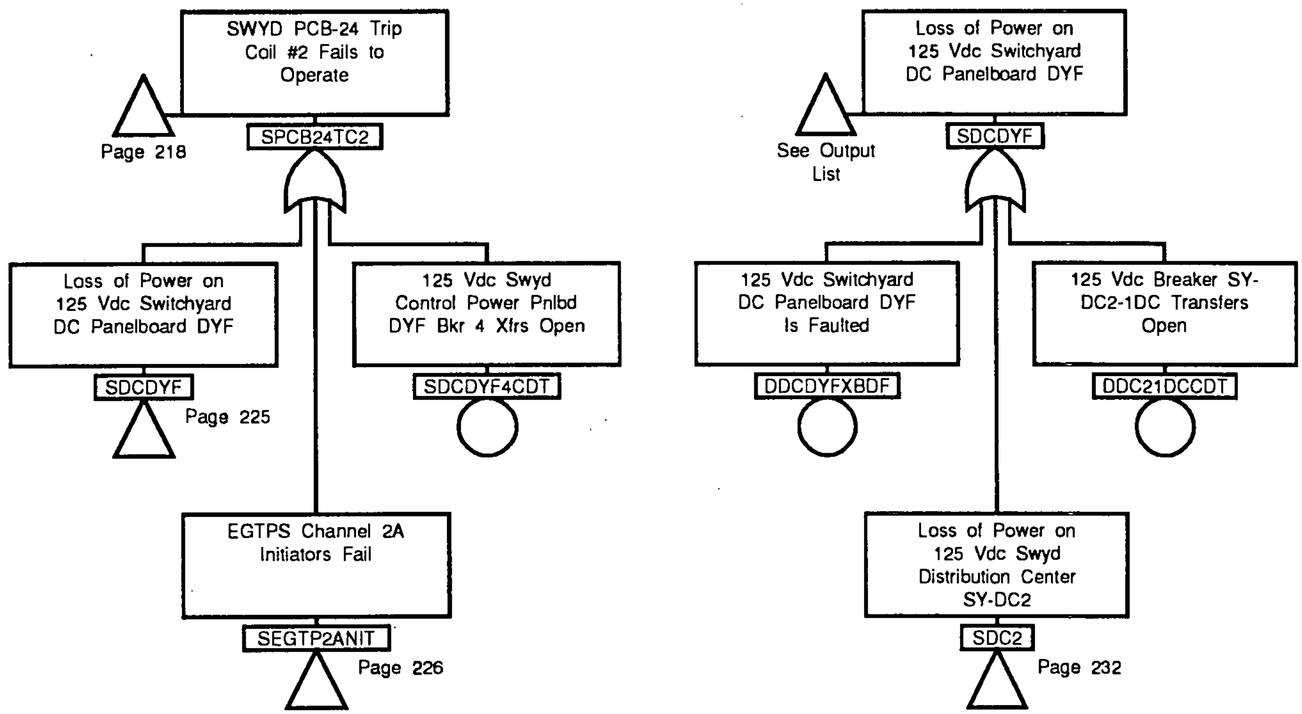


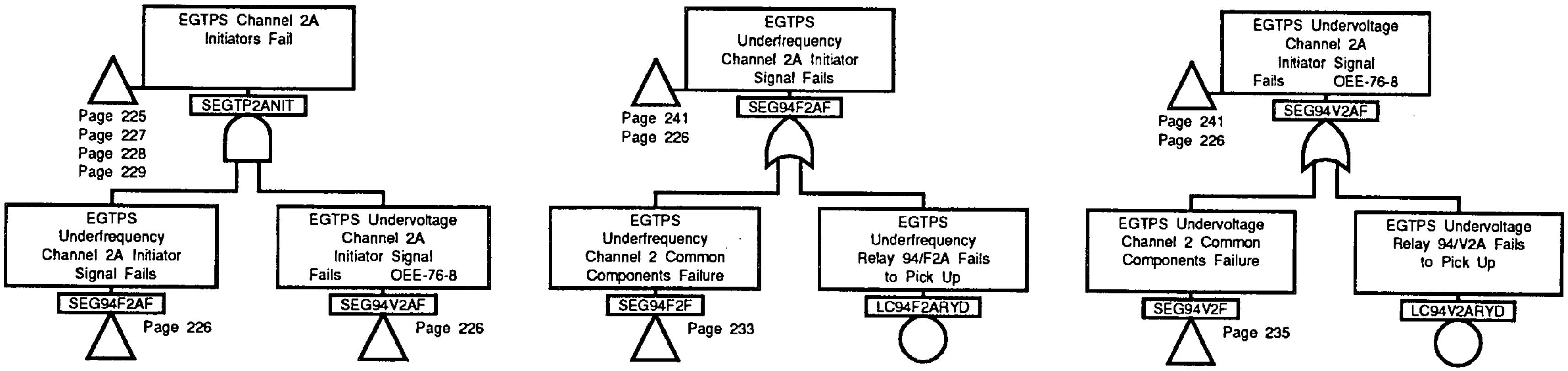
EGTPS Undervoltage Channel 1 Common Components Failure
SEG94V1F
Page 220
Page 238
Page 231
Loss of Power on 125 Vdc Switchyard DC Panelboard DYC
SDCDYC
Page 216
Switchyard 125 Vdc Panelboard DYC Breaker 13 Transfers Open
LDCYC13CDT
Chan 1 EGTPS 2 Out Of 3 UV Signal Network Fails OEE-76-4
SY2OF3UVC1
Common Cause Failure of UV And UF Detection Circuits
L0EGTPSCOM
4
EGTPS CH1 phases x & y undervoltage sensing ckt fails OEE-76-4
SEGX1Y1UV
Page 224
EGTPS CH1 phases y & z undervoltage sensing ckt fails OEE-76-4
SEGY1Z1UV
Page 224
EGTPS CH1 phases x & z undervoltage sensing ckt fails OEE-76-4
SEGX1Z1UV
Page 224



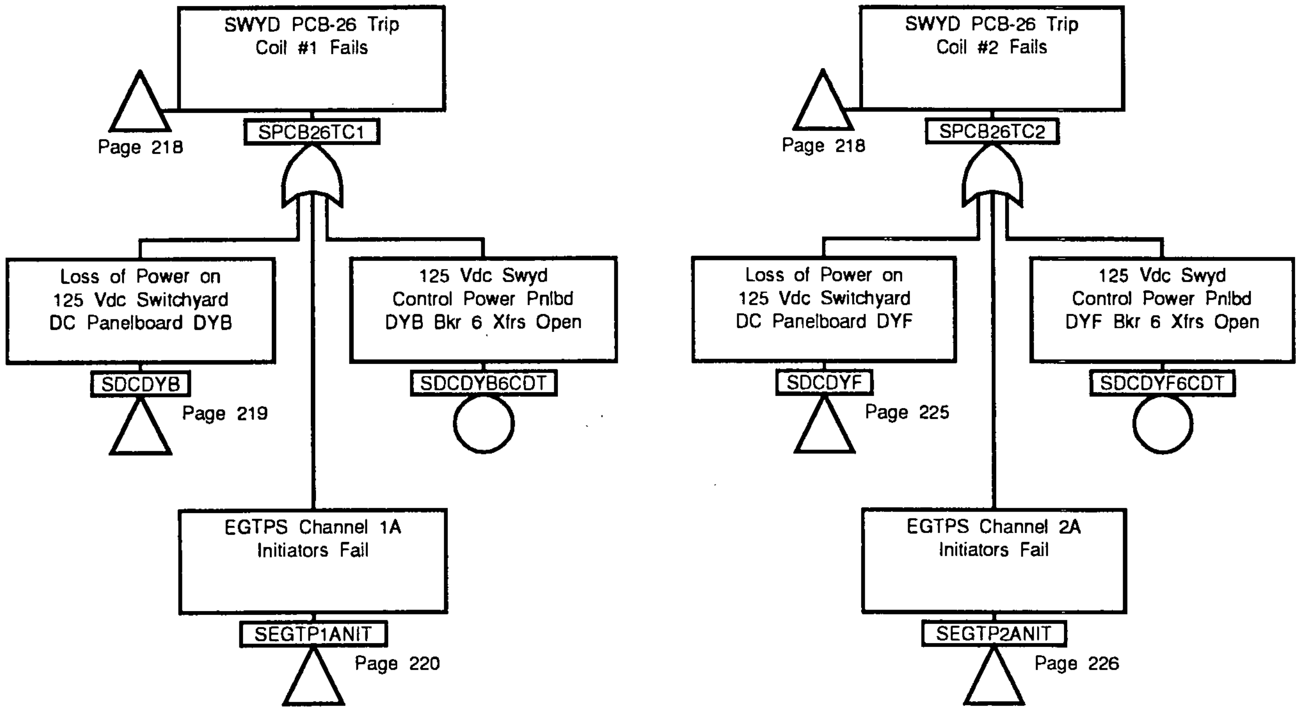
EGTPS CH1 phases x & y undervoltage sensing ckt fails OEE-76-4
SEGX1Y1UV
Page 223
Snsng Rly 27B/RX1 Fails to Drop Out on Undervoltage
L27BRX1RYD
Yellow Bus Phase X1 Undervoltage Aux. Relay Fails To Pick Up
L27XYX1RYD
Snsng Rly 27B/YX1 Fails to Drop Out on Undervoltage
L27BYX1RYD
Red Bus Phase Y1 Undervoltage Aux. Relay Fails To Pick Up
L27XRY1RYD
Snsng Rly 27B/RY1 Fails to Drop Out on Undervoltage
L27BRY1RYD
Yellow Bus Phase Y1 Undervoltage Aux. Relay Fails To Pick Up
L27XYY1RYD
Snsng Rly 27B/YY1 Fails to Drop Out on Undervoltage
L27BYY1RYD
Ch 1 Phase X UV Aux. Relay Fails To Pick Up
L27XPX1RYD
Red Bus Phase X1 Undervoltage Aux. Relay Fails To Pick Up
L27XRX1RYD
Ch 1 Phase Y UV Aux. Relay Fails to Pick Up
L27XPY1RYD
EGTPS CH1 phases x & z undervoltage sensing ckt fails OEE-76-4
SEGX1Z1UV
Page 223
Snsng Rly 27B/RX1 Fails to Drop Out on Undervoltage
L27BRX1RYD
Yellow Bus Phase X1 Undervoltage Aux. Relay Fails To Pick Up
L27XYX1RYD
Snsng Rly 27B/YX1 Fails to Drop Out on Undervoltage
L27BYX1RYD
Red Bus Phase Z1 Undervoltage Aux. Relay Fails To Pick Up
L27XRZ1RYD
Snsng Rly 27B/RZ1 Fails to Drop Out on Undervoltage
L27BRZ1RYD
Yellow Bus Phase Z1 Undervoltage Aux. Relay Fails To Pick Up
L27XYZ1RYD
Snsng Rly 27B/YZ1 Fails to Drop Out on Undervoltage
L27BYZ1RYD
Ch 1 Phase X UV Aux. Relay Fails To Pick Up
L27XPX1RYD
Red Bus Phase X1 Undervoltage Aux. Relay Fails To Pick Up
L27XRX1RYD
Ch 1 Phase Z UV Aux. Relay Fails To Pick Up
L27XPZ1RYD
EGTPS CH1 phases y & z undervoltage sensing ckt fails OEE-76-4
SEGY1Z1UV
Page 223
Snsng Rly 27B/RY1 Fails to Drop Out on Undervoltage
L27BRY1RYD
Yellow Bus Phase Y1 Undervoltage Aux. Relay Fails To Pick Up
L27XYY1RYD
Snsng Rly 27B/YY1 Fails to Drop Out on Undervoltage
L27BYY1RYD
Red Bus Phase Z1 Undervoltage Aux. Relay Fails To Pick Up
L27XRZ1RYD
Snsng Rly 27B/RZ1 Fails to Drop Out on Undervoltage
L27BRZ1RYD
Yellow Bus Phase Z1 Undervoltage Aux. Relay Fails To Pick Up
L27XYZ1RYD
Snsng Rly 27B/YZ1 Fails to Drop Out on Undervoltage
L27BYZ1RYD
Ch 1 Phase Y UV Aux. Relay Fails to Pick Up
L27XPY1RYD
Red Bus Phase Y1 Undervoltage Aux. Relay Fails To Pick Up
L27XRY1RYD
Ch 1 Phase Z UV Aux. Relay Fails To Pick Up
L27XPZ1RYD

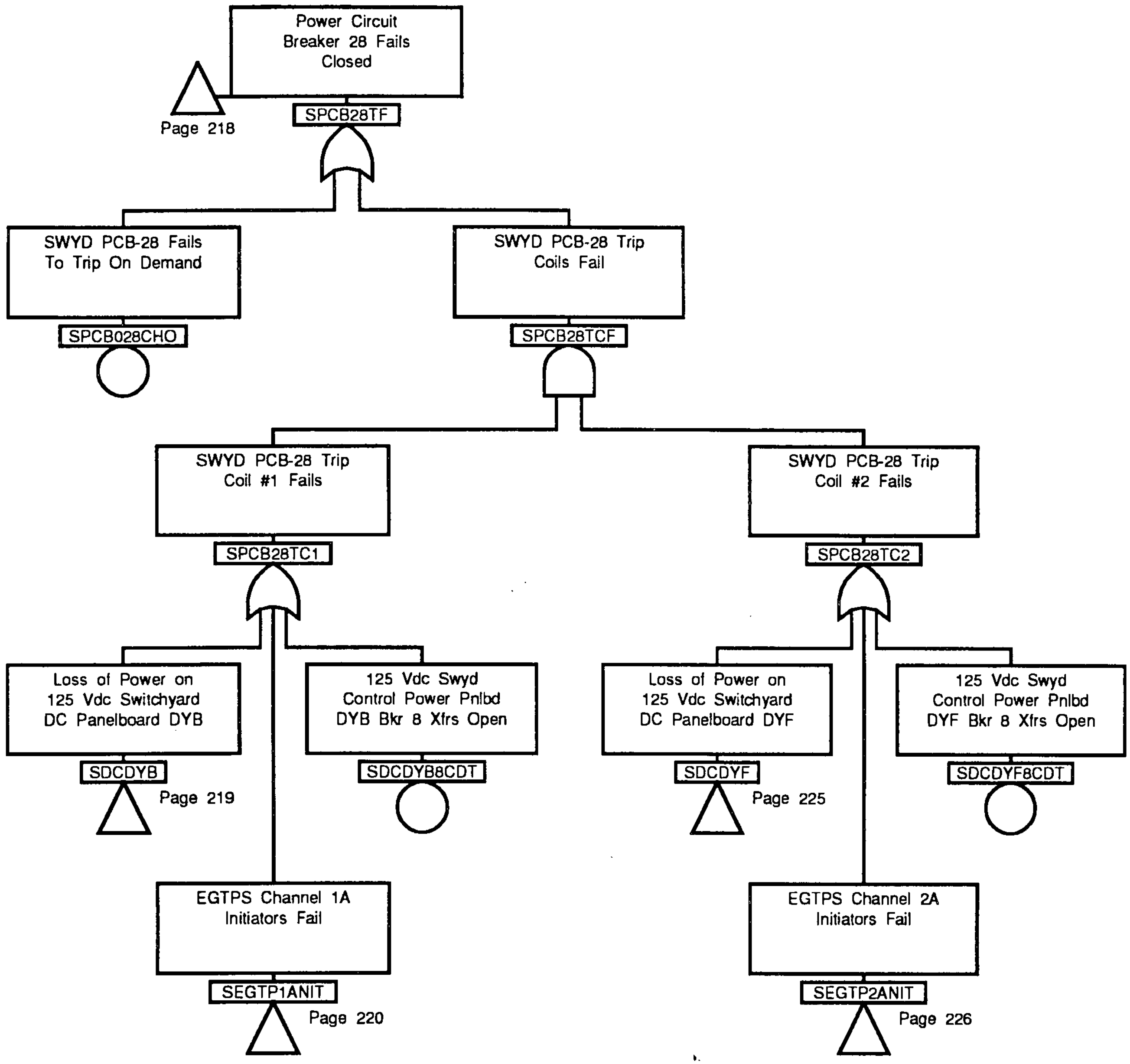
SDCDYF Outputs:
Page 230, Page 225, Page 227, Page 228, Page 229

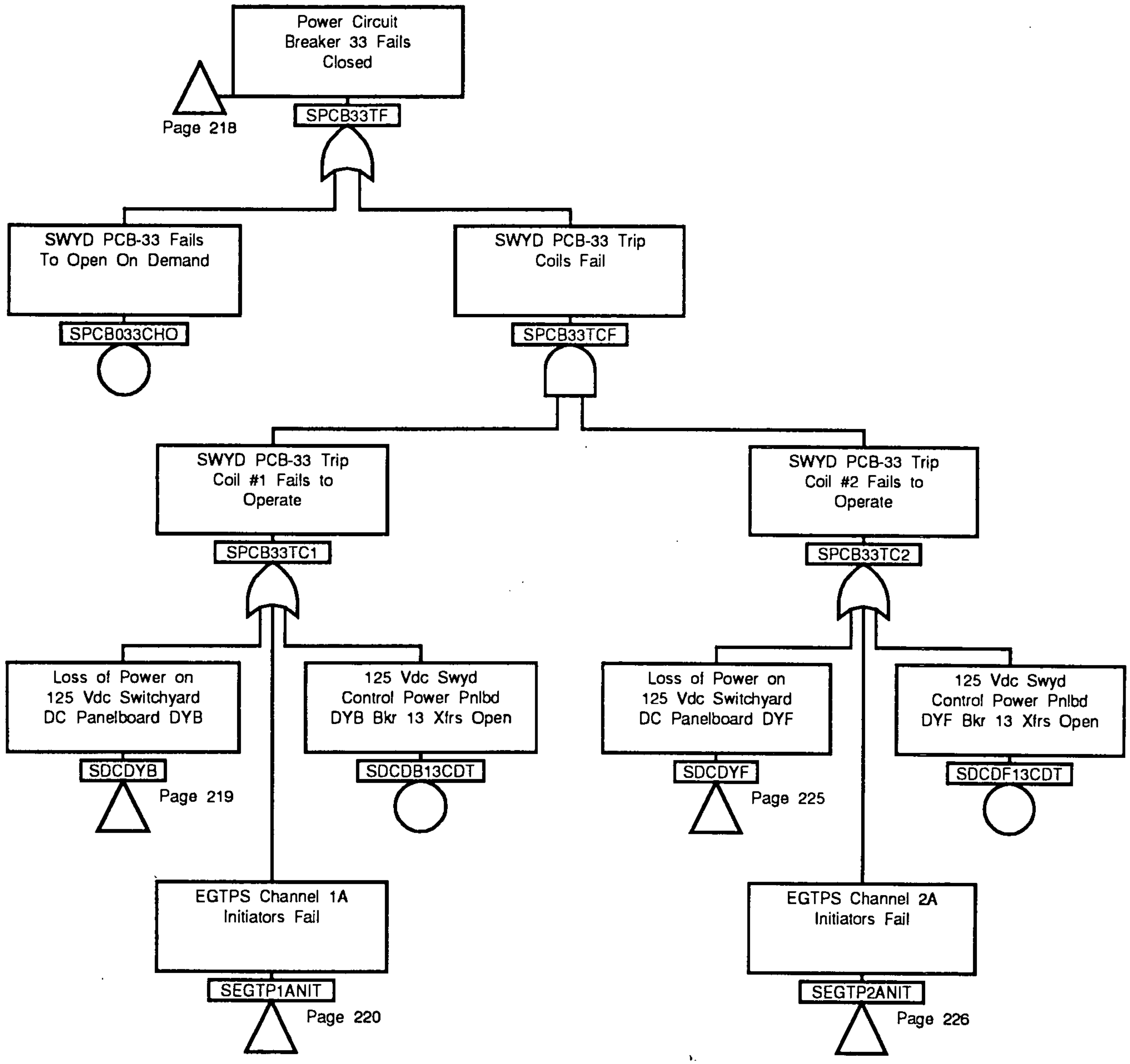


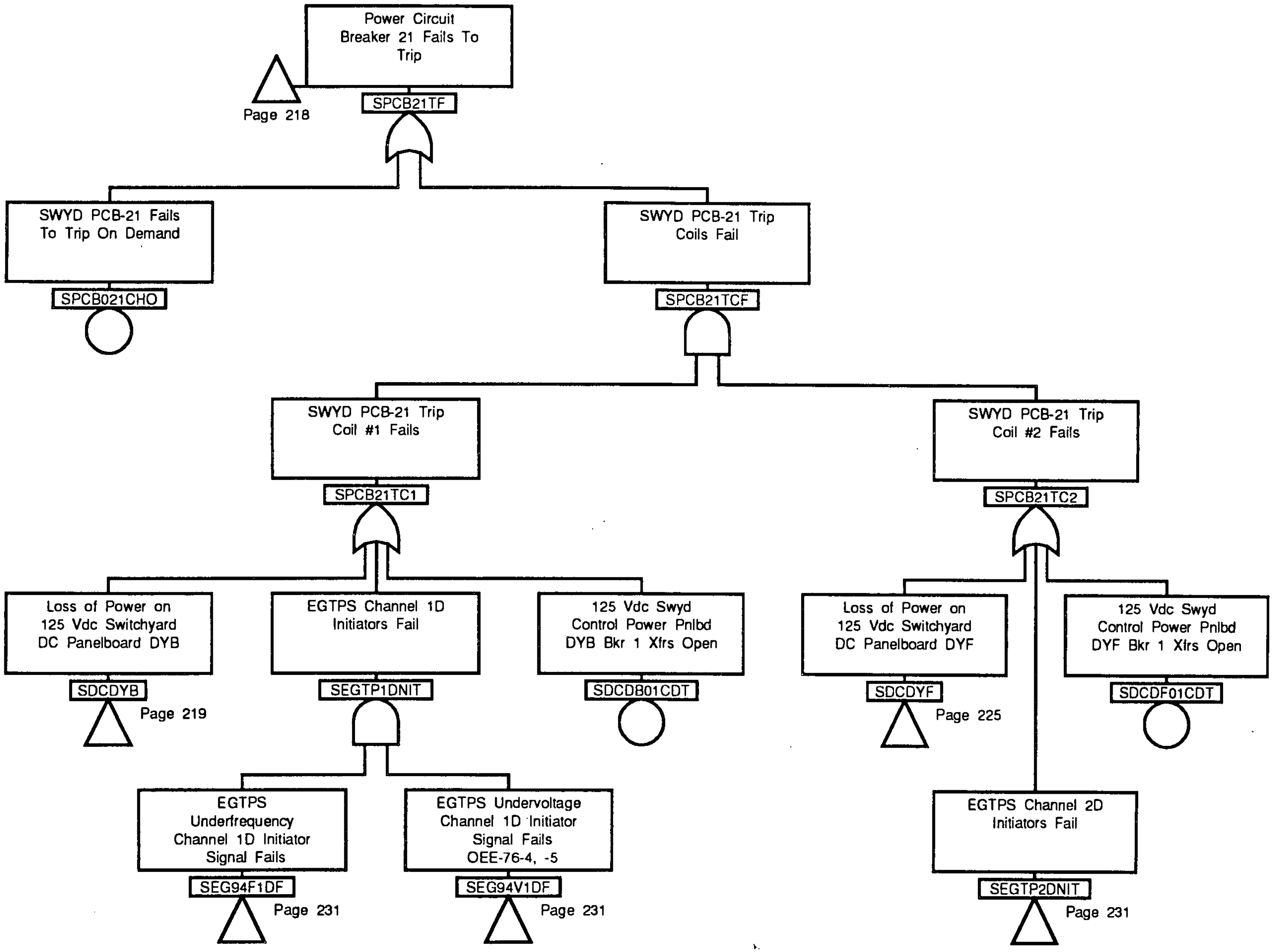


EGTPS Channel 2A Initiators Fail
SEGTP2ANIT
Page 225
Page 227
Page 228
Page 229
EGTPS Underfrequency Channel 2A Initiator Signal Fails
SEG94F2AF
Page 226
EGTPS Undervoltage Channel 2A Initiator Signal Fails OEE-76-8
SEG94V2AF
Page 226
EGTPS Underfrequency Channel 2A Initiator Signal Fails
SEG94F2AF
Page 241
Page 226
EGTPS Underfrequency Channel 2 Common Components Failure
SEG94F2F
Page 233
EGTPS Underfrequency Relay 94/F2A Fails to Pick Up
LC94F2ARYD
EGTPS Undervoltage Channel 2A Initiator Signal Fails OEE-76-8
SEG94V2AF
Page 241
Page 226
EGTPS Undervoltage Channel 2 Common Components Failure
SEG94V2F
Page 235
EGTPS Undervoltage Relay 94/V2A Fails to Pick Up
LC94V2ARYD

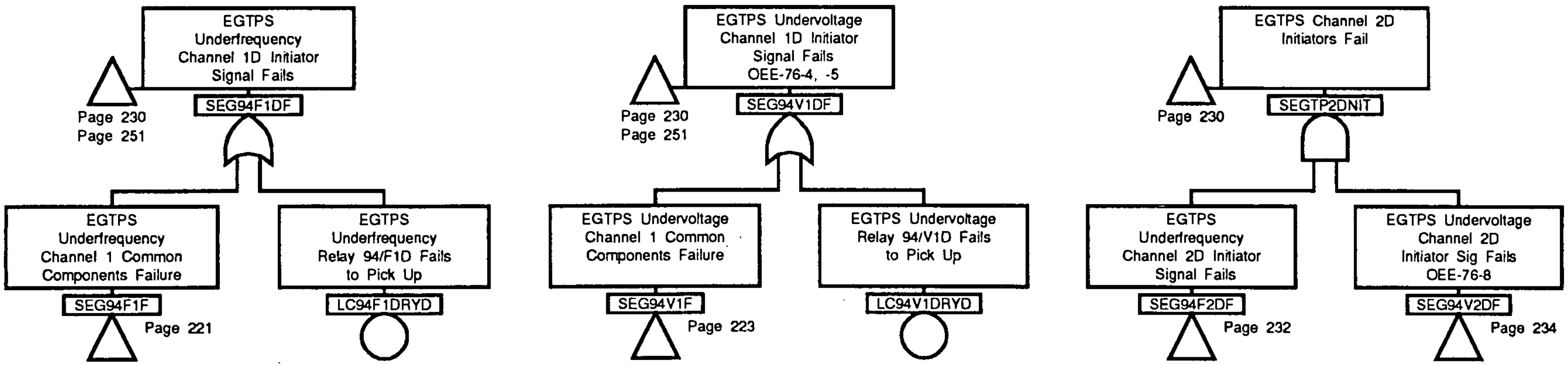

SWYD PCB-26 Trip Coil #1 Fails
SPCB26TC1
Page 218
Loss of Power on 125 Vdc Switchyard DC Panelboard DYB
SDCDYB
Page 219
125 Vdc Swyd Control Power Pnlbd DYB Bkr 6 Xfrs Open
SDCDYB6CDT
EGTPS Channel 1A Initiators Fail
SEGTP1ANIT
Page 220
SWYD PCB-26 Trip Coil #2 Fails
SPCB26TC2
Page 218
Loss of Power on 125 Vdc Switchyard DC Panelboard DYF
SDCDYF
Page 225
125 Vdc Swyd Control Power Pnlbd DYF Bkr 6 Xfrs Open
SDCDYF6CDT
EGTPS Channel 2A Initiators Fail
SEGTP2ANIT
Page 226


Power Circuit Breaker 28 Fails Closed
SPCB28TF
Page 218
SWYD PCB-28 Fails To Trip On Demand
SPCB028CHO
SWYD PCB-28 Trip Coils Fail
SPCB28TCF
SWYD PCB-28 Trip Coil #1 Fails
SPCB28TC1
SWYD PCB-28 Trip Coil #2 Fails
SPCB28TC2
Loss of Power on 125 Vdc Switchyard DC Panelboard DYB
SDCDYB
Page 219
125 Vdc Swyd Control Power Pnlbd DYB Bkr 8 Xfrs Open
SDCDYB8CDT
Loss of Power on 125 Vdc Switchyard DC Panelboard DYF
SDCDYF
Page 225
125 Vdc Swyd Control Power Pnlbd DYF Bkr 8 Xfrs Open
SDCDYF8CDT
EGTPS Channel 1A Initiators Fail
SEGTP1ANIT
Page 220
EGTPS Channel 2A Initiators Fail
SEGTP2ANIT
Page 226


Power Circuit Breaker 33 Fails Closed
SPCB33TF
Page 218
SWYD PCB-33 Fails To Open On Demand
SPCB033CHO
SWYD PCB-33 Trip Coils Fail
SPCB33TCF
SWYD PCB-33 Trip Coil #1 Fails to Operate
SPCB33TC1
SWYD PCB-33 Trip Coil #2 Fails to Operate
SPCB33TC2
Loss of Power on 125 Vdc Switchyard DC Panelboard DYB
SDCDYB
Page 219
125 Vdc Swyd Control Power Pnlbd DYB Bkr 13 Xfrs Open
SDCDB13CDT
Loss of Power on 125 Vdc Switchyard DC Panelboard DYF
SDCDYF
Page 225
125 Vdc Swyd Control Power Pnlbd DYF Bkr 13 Xfrs Open
SDCDF13CDT
EGTPS Channel 1A Initiators Fail
SEGTP1ANIT
Page 220
EGTPS Channel 2A Initiators Fail
SEGTP2ANIT
Page 226



Power Circuit Breaker 21 Fails To Trip
SPCB21TF
Page 218
SWYD PCB-21 Fails To Trip On Demand
SPCB021CHO
SWYD PCB-21 Trip Coils Fail
SPCB21TCF
SWYD PCB-21 Trip Coil #1 Fails
SPCB21TC1
SWYD PCB-21 Trip Coil #2 Fails
SPCB21TC2
Loss of Power on 125 Vdc Switchyard DC Panelboard DYB
SDCDYB
Page 219
EGTPS Channel 1D Initiators Fail
SEGTP1DNIT
125 Vdc Swyd Control Power Pnlbd DYB Bkr 1 Xfrs Open
SDCDB01CDT
Loss of Power on 125 Vdc Switchyard DC Panelboard DYF
SDCDYF
Page 225
125 Vdc Swyd Control Power Pnlbd DYF Bkr 1 Xfrs Open
SDCDF01CDT
EGTPS Underfrequency Channel 1D Initiator Signal Fails
SEG94F1DF
Page 231
EGTPS Undervoltage Channel 1D Initiator Signal Fails OEE-76-4, -5
SEG94V1DF
Page 231
EGTPS Channel 2D Initiators Fail
SEGTP2DNIT
Page 231


EGTPS Underfrequency Channel 1D Initiator Signal Fails
Page 230
Page 251
SEG94F1DF
EGTPS Underfrequency Channel 1 Common Components Failure
SEG94F1F
Page 221
EGTPS Underfrequency Relay 94/F1D Fails to Pick Up
LC94F1DRYD
EGTPS Undervoltage Channel 1D Initiator Signal Fails OEE-76-4, -5
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SEG94V1DF
EGTPS Undervoltage Channel 1 Common Components Failure
SEG94V1F
Page 223
EGTPS Undervoltage Relay 94/V1D Fails to Pick Up
LC94V1DRYD
EGTPS Channel 2D Initiators Fail
Page 230
SEGTP2DNIT
EGTPS Underfrequency Channel 2D Initiator Signal Fails
SEG94F2DF
Page 232
EGTPS Undervoltage Channel 2D Initiator Sig Fails OEE-76-8
SEG94V2DF
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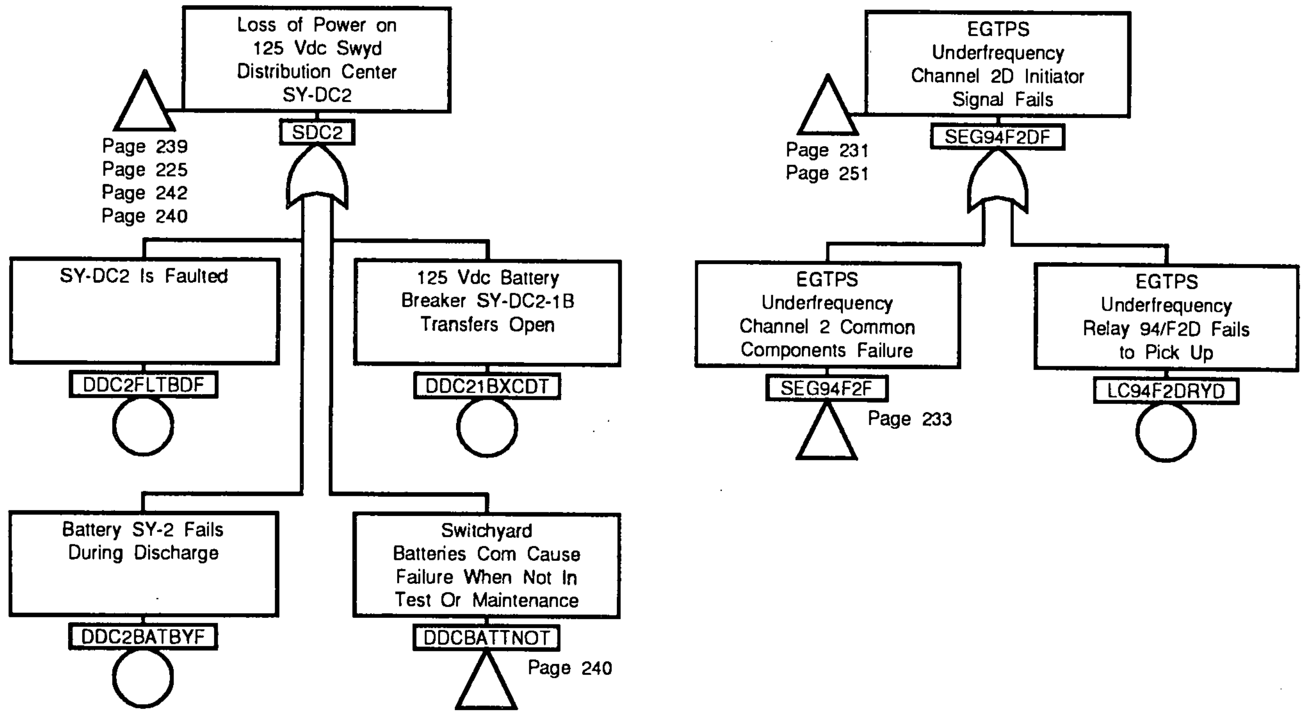
Loss of Power on 125 Vdc Swyd Distribution Center SY-DC2
SDC2
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Page 240
SY-DC2 Is Faulted
DDC2FLTBDF
125 Vdc Battery Breaker SY-DC2-1B Transfers Open
DDC21BXCDT
Battery SY-2 Fails During Discharge
DDC2BATBYF
Switchyard Batteries Com Cause Failure When Not In Test Or Maintenance
DDCBATTNOT
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EGTPS Underfrequency Channel 2D Initiator Signal Fails
SEG94F2DF
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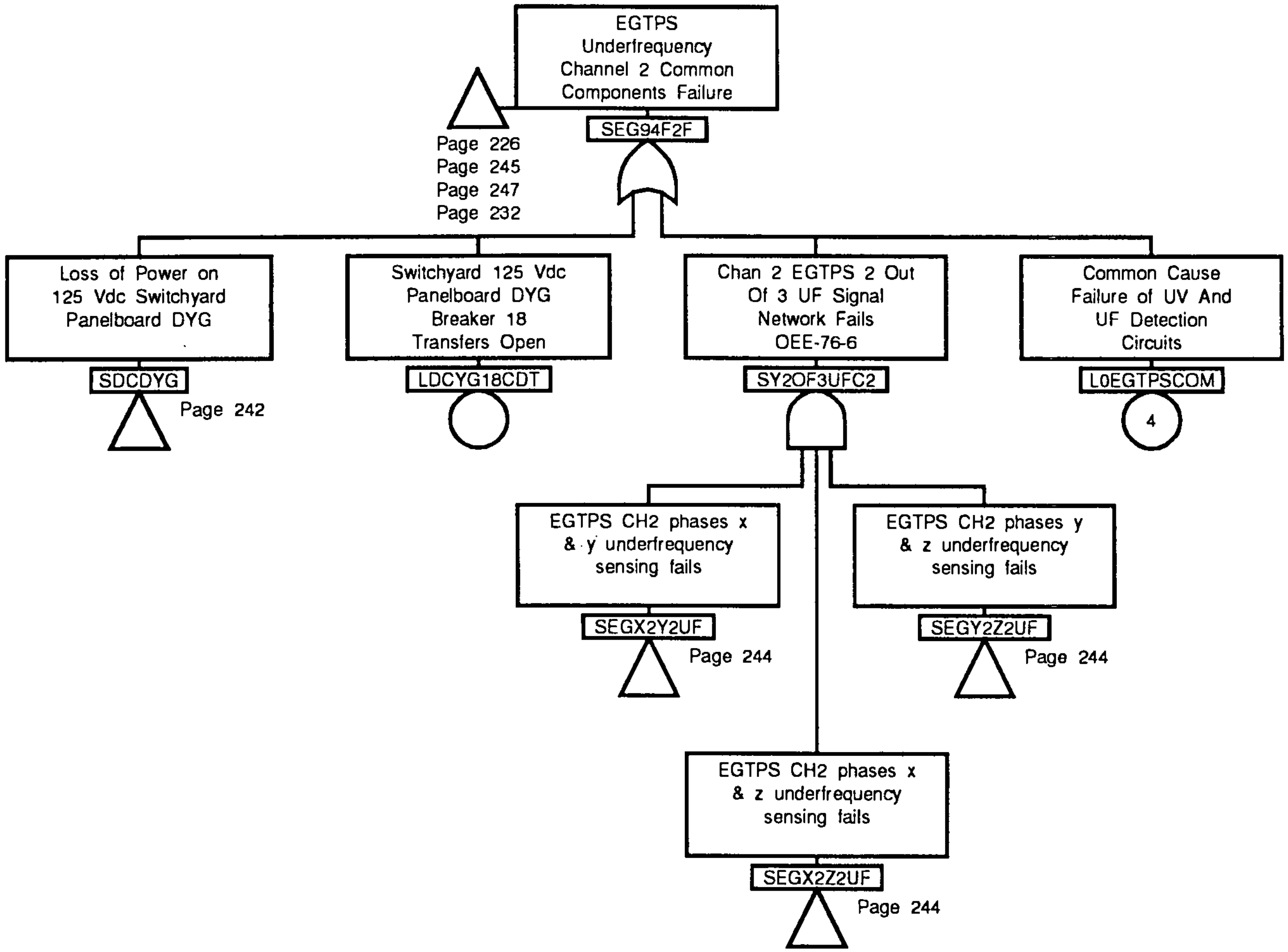
EGTPS Underfrequency Channel 2 Common Components Failure
SEG94F2F
Page 233
EGTPS Underfrequency Relay 94/F2D Fails to Pick Up
LC94F2DRYD


EGTPS
Underfrequency
Channel 2 Common
Components Failure
SEG94F2F
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Loss of Power on
125 Vdc Switchyard
Panelboard DYG
SDCDYG
Page 242
Switchyard 125 Vdc
Panelboard DYG
Breaker 18
Transfers Open
LDCYG18CDT
Chan 2 EGTPS 2 Out
Of 3 UF Signal
Network Fails
OEE-76-6
SY2OF3UFC2
Common Cause
Failure of UV And
UF Detection
Circuits
L0EGTPSCOM
4
EGTPS CH2 phases x
& y underfrequency
sensing fails
SEGX2Y2UF
Page 244
EGTPS CH2 phases y
& z underfrequency
sensing fails
SEGY2Z2UF
Page 244
EGTPS CH2 phases x
& z underfrequency
sensing fails
SEGX2Z2UF
Page 244

SDCDYA Outputs:
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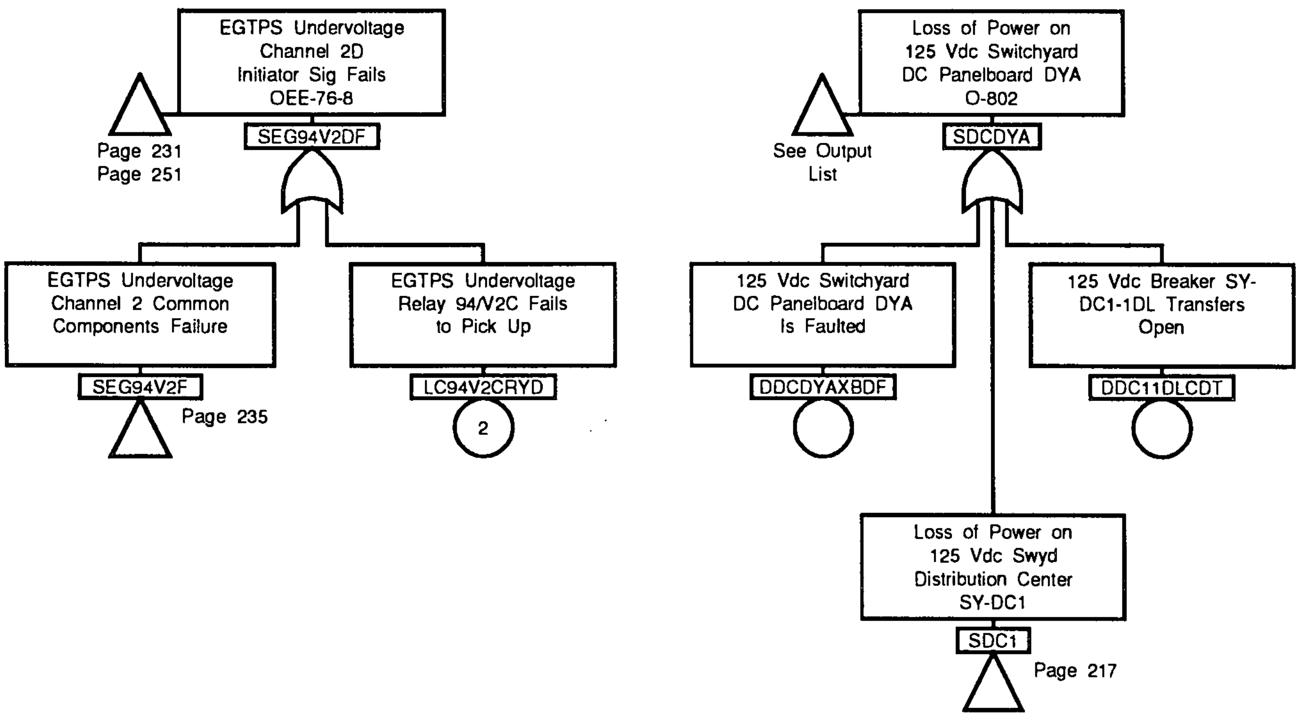

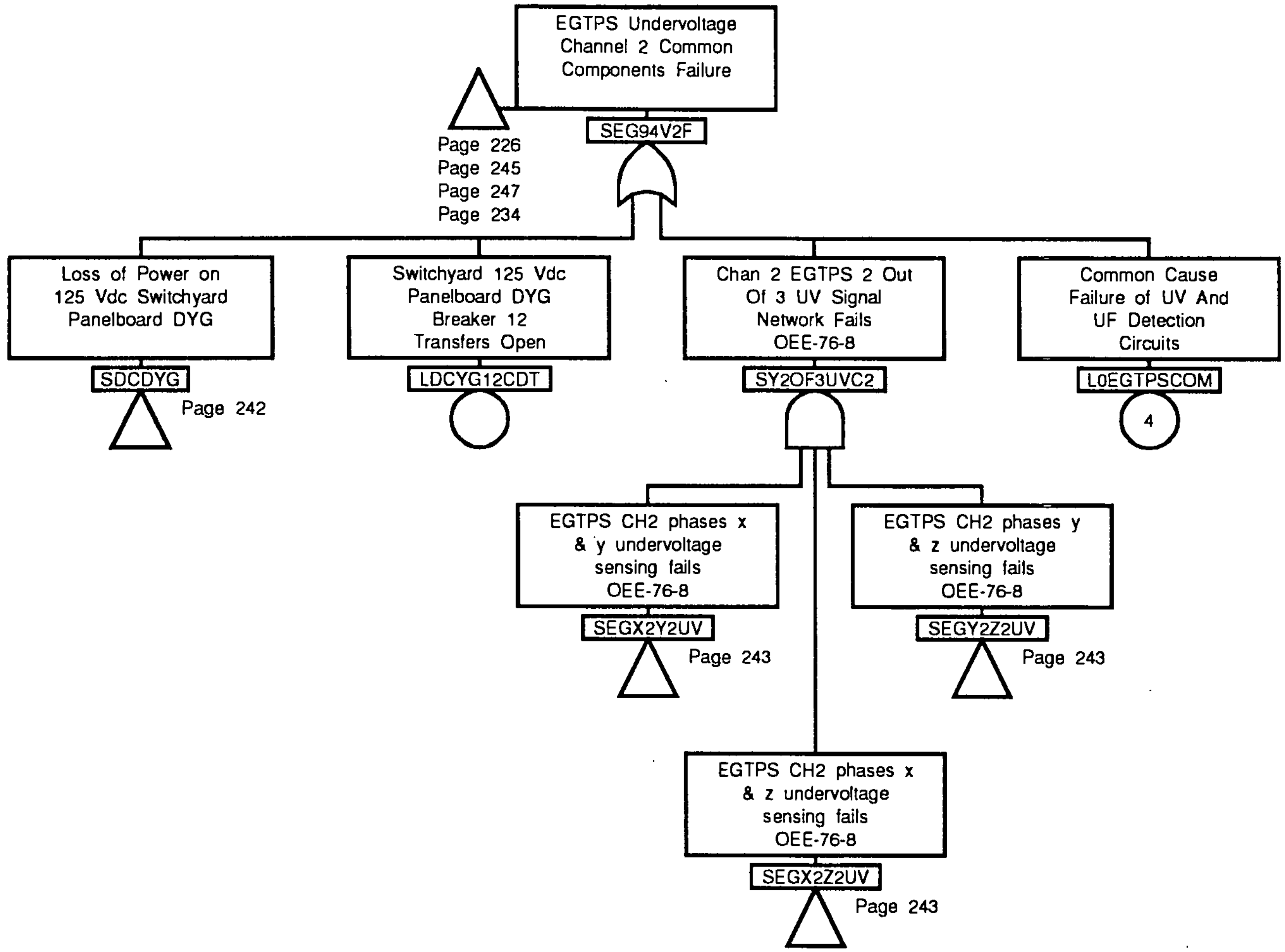
EGTPS Undervoltage Channel 2 Common Components Failure
SEG94V2F
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Loss of Power on 125 Vdc Switchyard Panelboard DYG
SDCDYG
Page 242
Switchyard 125 Vdc Panelboard DYG Breaker 12 Transfers Open
LDCYG12CDT
Chan 2 EGTPS 2 Out Of 3 UV Signal Network Fails OEE-76-8
SY2OF3UVC2
Common Cause Failure of UV And UF Detection Circuits
L0EGTPSCOM
4
EGTPS CH2 phases x & y undervoltage sensing fails OEE-76-8
SEGX2Y2UV
Page 243
EGTPS CH2 phases y & z undervoltage sensing fails OEE-76-8
SEGY2Z2UV
Page 243
EGTPS CH2 phases x & z undervoltage sensing fails OEE-76-8
SEGX2Z2UV
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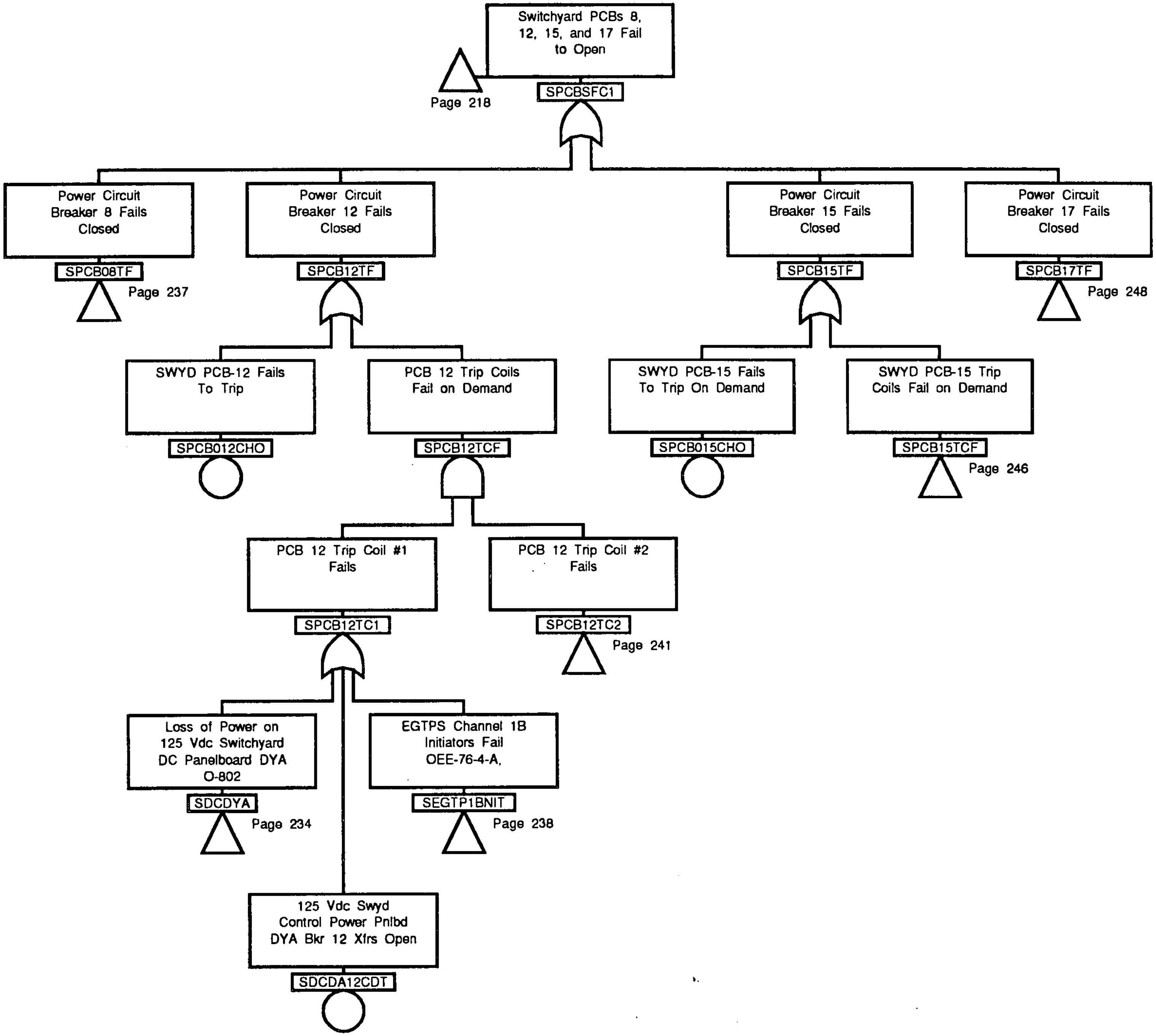
Switchyard PCBs 8, 12, 15, and 17 Fail to Open
SPCBSFC1
Page 218
Power Circuit Breaker 8 Fails Closed
SPCB08TF
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Power Circuit Breaker 12 Fails Closed
SPCB12TF
Power Circuit Breaker 15 Fails Closed
SPCB15TF
Power Circuit Breaker 17 Fails Closed
SPCB17TF
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SWYD PCB-12 Fails To Trip
SPCB012CHO
PCB 12 Trip Coils Fail on Demand
SPCB12TCF
SWYD PCB-15 Fails To Trip On Demand
SPCB015CHO
SWYD PCB-15 Trip Coils Fail on Demand
SPCB15TCF
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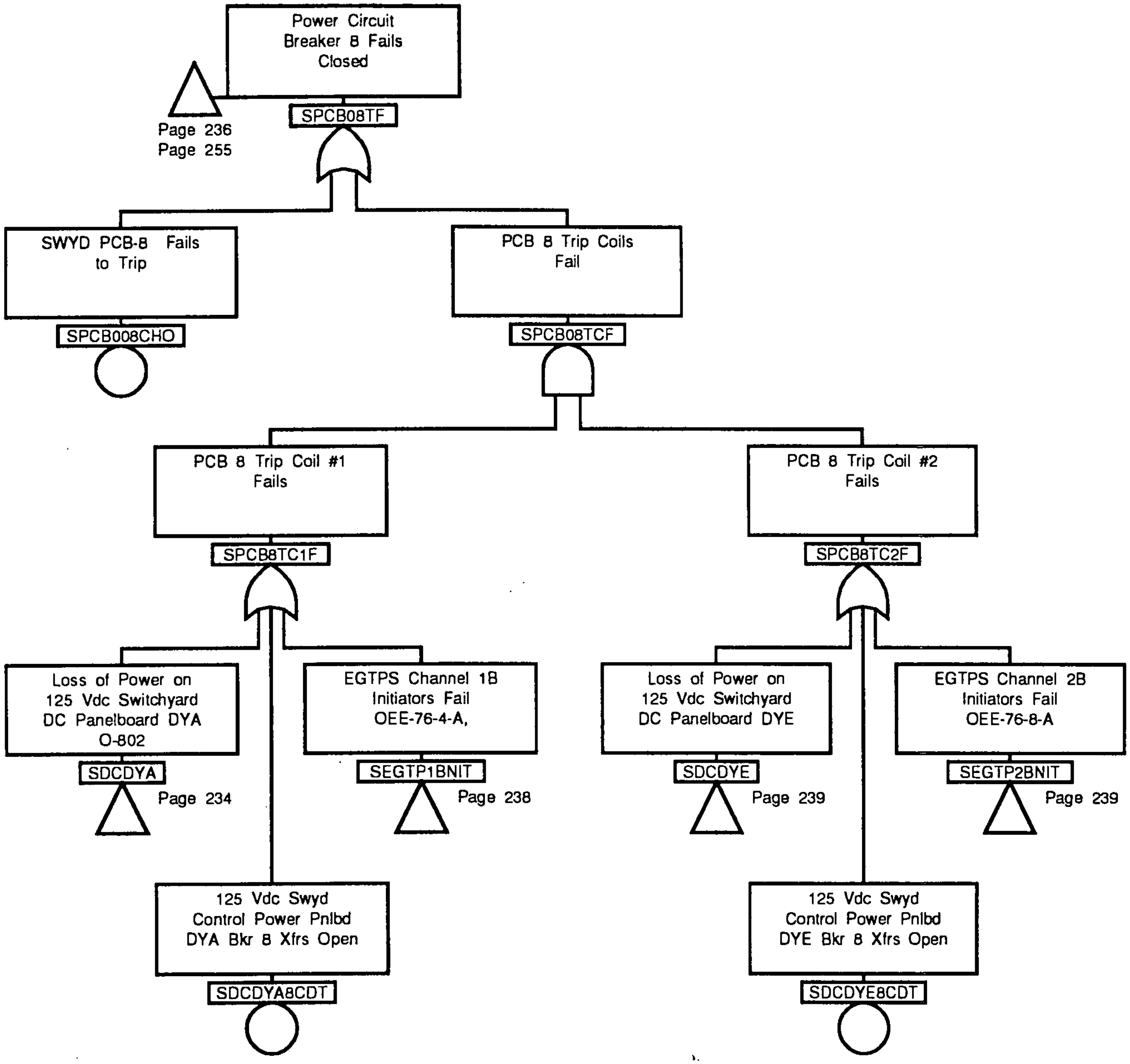
PCB 12 Trip Coil #1 Fails
SPCB12TC1
PCB 12 Trip Coil #2 Fails
SPCB12TC2
Page 241
Loss of Power on 125 Vdc Switchyard DC Panelboard DYA O-802
SDCDYA
Page 234
EGTPS Channel 1B Initiators Fail OEE-76-4-A.
SEGTP1BNIT
Page 238
125 Vdc Swyd Control Power Pnlbd DYA Bkr 12 Xfrs Open
SDCDA12CDT



Power Circuit Breaker 8 Fails Closed
SPCB08TF
Page 236
Page 255
SWYD PCB-8 Fails to Trip
SPCB008CHO
PCB 8 Trip Coils Fail
SPCB08TCF
PCB 8 Trip Coil #1 Fails
SPCB8TC1F
PCB 8 Trip Coil #2 Fails
SPCB8TC2F
Loss of Power on 125 Vdc Switchyard DC Panelboard DYA O-802
SDCDYA
Page 234
EGTPS Channel 1B Initiators Fail OEE-76-4-A,
SEGTP1BNIT
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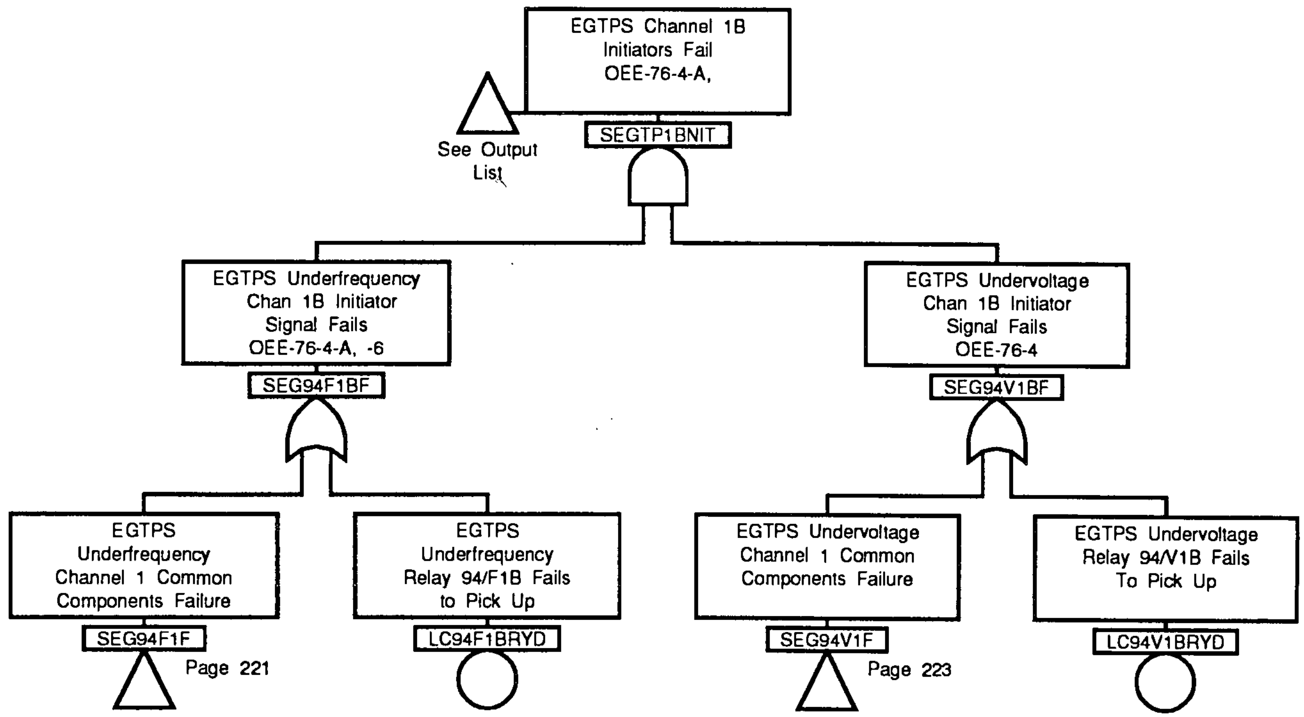
Loss of Power on 125 Vdc Switchyard DC Panelboard DYE
SDCDYE
Page 239
EGTPS Channel 2B Initiators Fail OEE-76-8-A
SEGTP2BNIT
Page 239
125 Vdc Swyd Control Power Pnlbd DYA Bkr 8 Xfrs Open
SDCDYA8CDT
125 Vdc Swyd Control Power Pnlbd DYE Bkr 8 Xfrs Open
SDCDYE8CDT


EGTPS Channel 1B
Initiators Fail
OEE-76-4-A,
SEGTP1BNIT
See Output
List
EGTPS Underfrequency
Chan 1B Initiator
Signal Fails
OEE-76-4-A, -6
SEG94F1BF
EGTPS Undervoltage
Chan 1B Initiator
Signal Fails
OEE-76-4
SEG94V1BF
EGTPS
Underfrequency
Channel 1 Common
Components Failure
SEG94F1F
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EGTPS
Underfrequency
Relay 94/F1B Fails
to Pick Up
LC94F1BRYD
EGTPS Undervoltage
Channel 1 Common
Components Failure
SEG94V1F
Page 223
EGTPS Undervoltage
Relay 94/V1B Fails
To Pick Up
LC94V1BRYD

SDCDYE Outputs:
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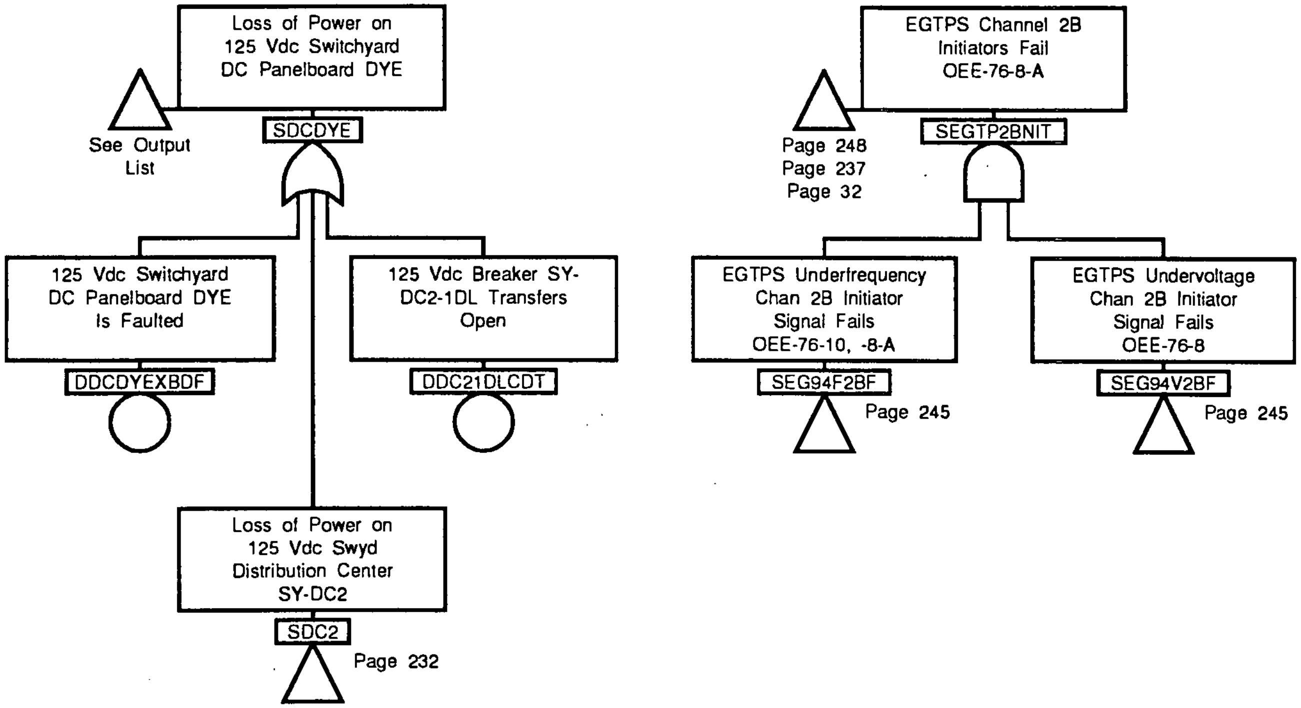

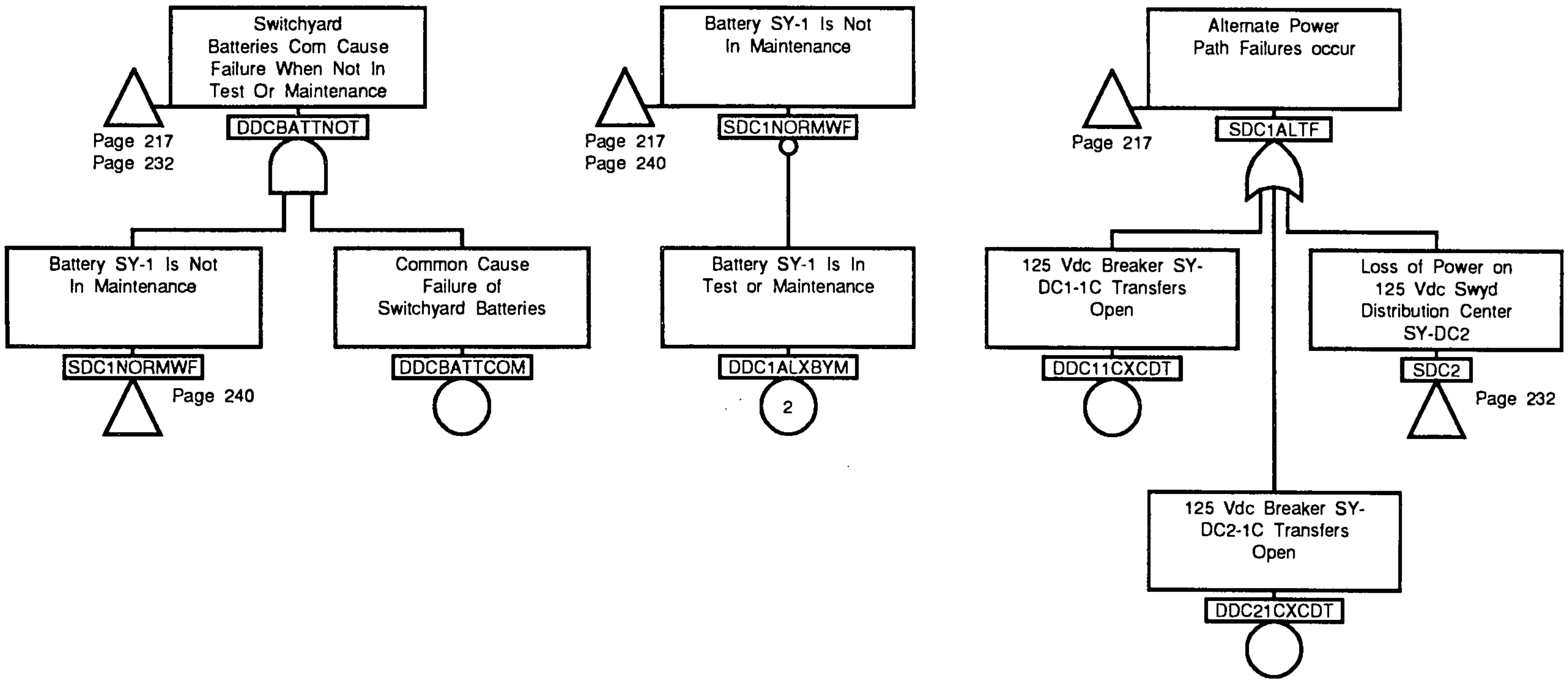
Switchyard Batteries Com Cause Failure When Not In Test Or Maintenance
DDCBATTNOT
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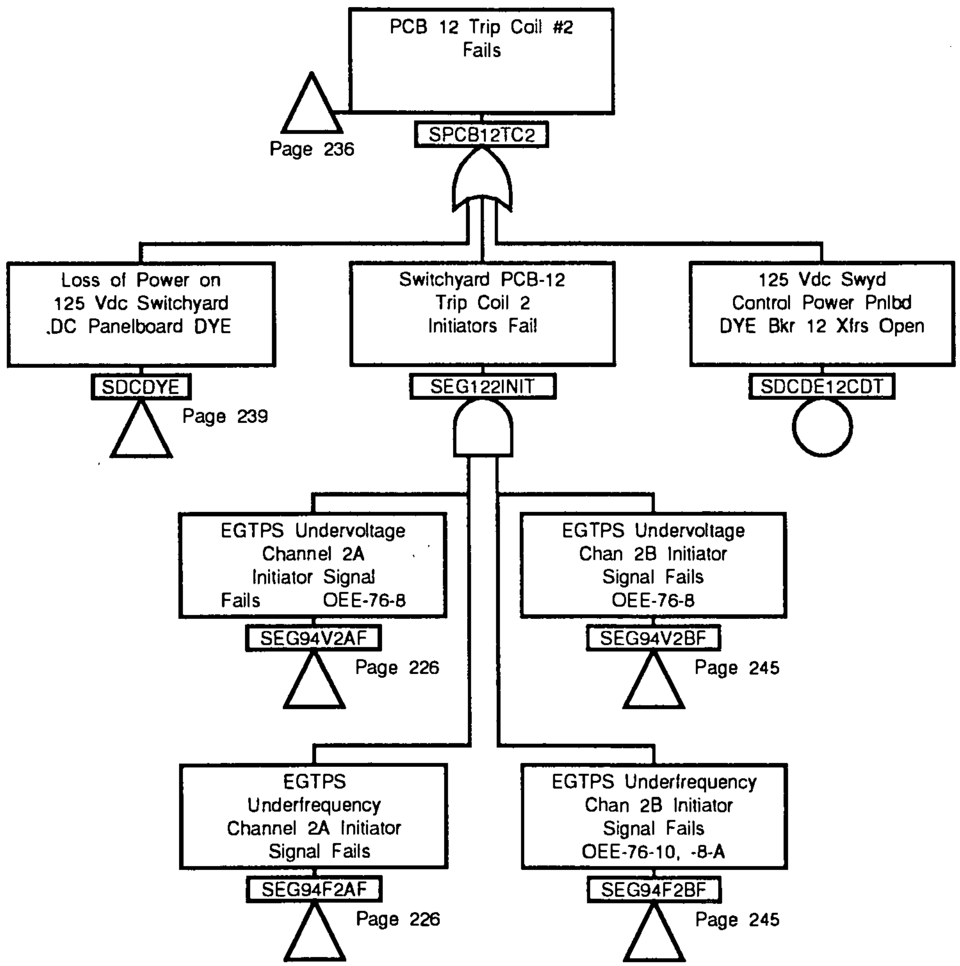
Battery SY-1 Is Not In Maintenance
SDC1NORMWF
Page 240
Common Cause Failure of Switchyard Batteries
DDCBATTCOM
Battery SY-1 Is Not In Maintenance
SDC1NORMWF
Page 217
Page 240
Battery SY-1 Is In Test or Maintenance
DDC1ALXBYM
2
Alternate Power Path Failures occur
SDC1ALTF
Page 217
125 Vdc Breaker SY-DC1-1C Transfers Open
DDC11CXCDT
Loss of Power on 125 Vdc Swyd Distribution Center SY-DC2
SDC2
Page 232
125 Vdc Breaker SY-DC2-1C Transfers Open
DDC21CXCDT


PCB 12 Trip Coil #2 Fails
SPCB12TC2
Page 236
Loss of Power on 125 Vdc Switchyard .DC Panelboard DYE
SDCDYE
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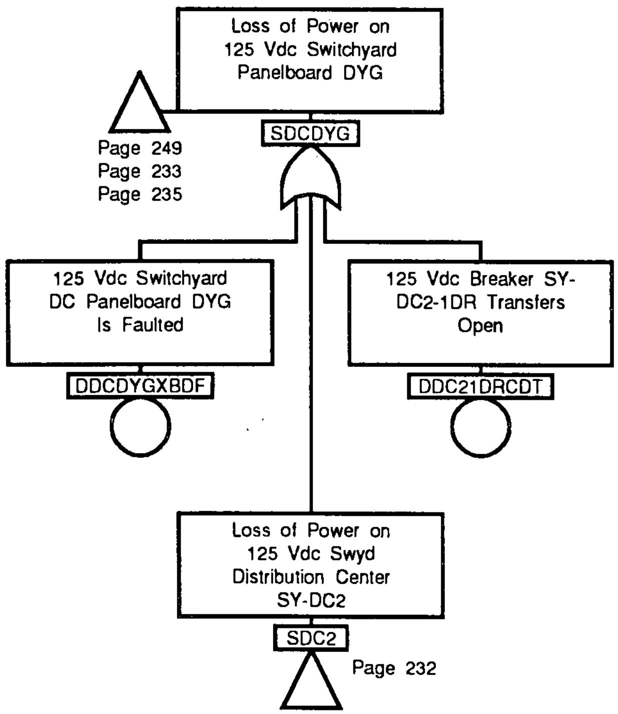
Switchyard PCB-12 Trip Coil 2 Initiators Fail
SEG122INIT
125 Vdc Swyd Control Power Pnlbd DYE Bkr 12 Xfrs Open
SDCDE12CDT
EGTPS Undervoltage Channel 2A Initiator Signal Fails OEE-76-8
SEG94V2AF
Page 226
EGTPS Undervoltage Chan 2B Initiator Signal Fails OEE-76-8
SEG94V2BF
Page 245
EGTPS Underfrequency Channel 2A Initiator Signal Fails
SEG94F2AF
Page 226
EGTPS Underfrequency Chan 2B Initiator Signal Fails OEE-76-10, -8-A
SEG94F2BF
Page 245



Loss of Power on 125 Vdc Switchyard Panelboard DYG
SDCDYG
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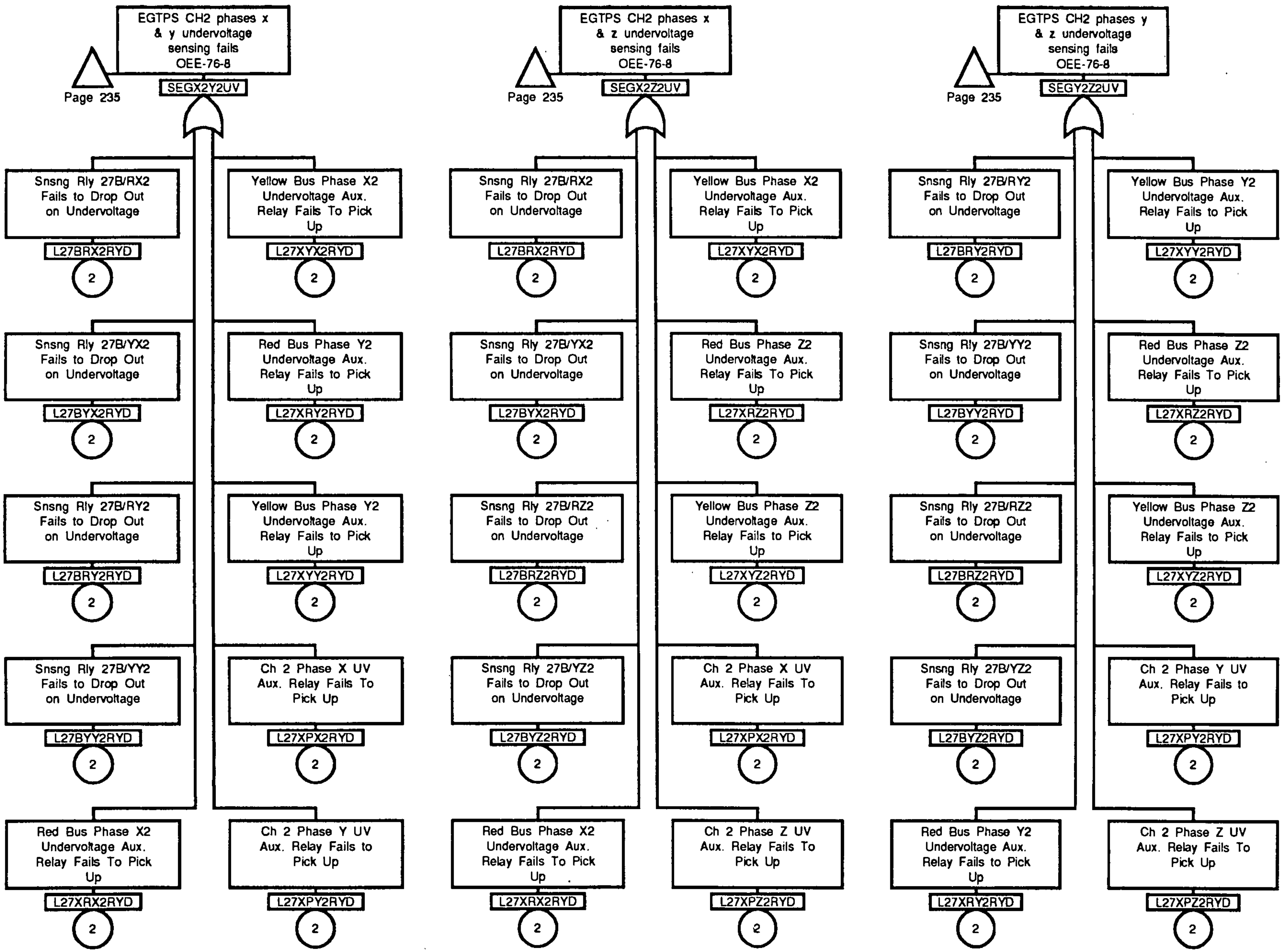
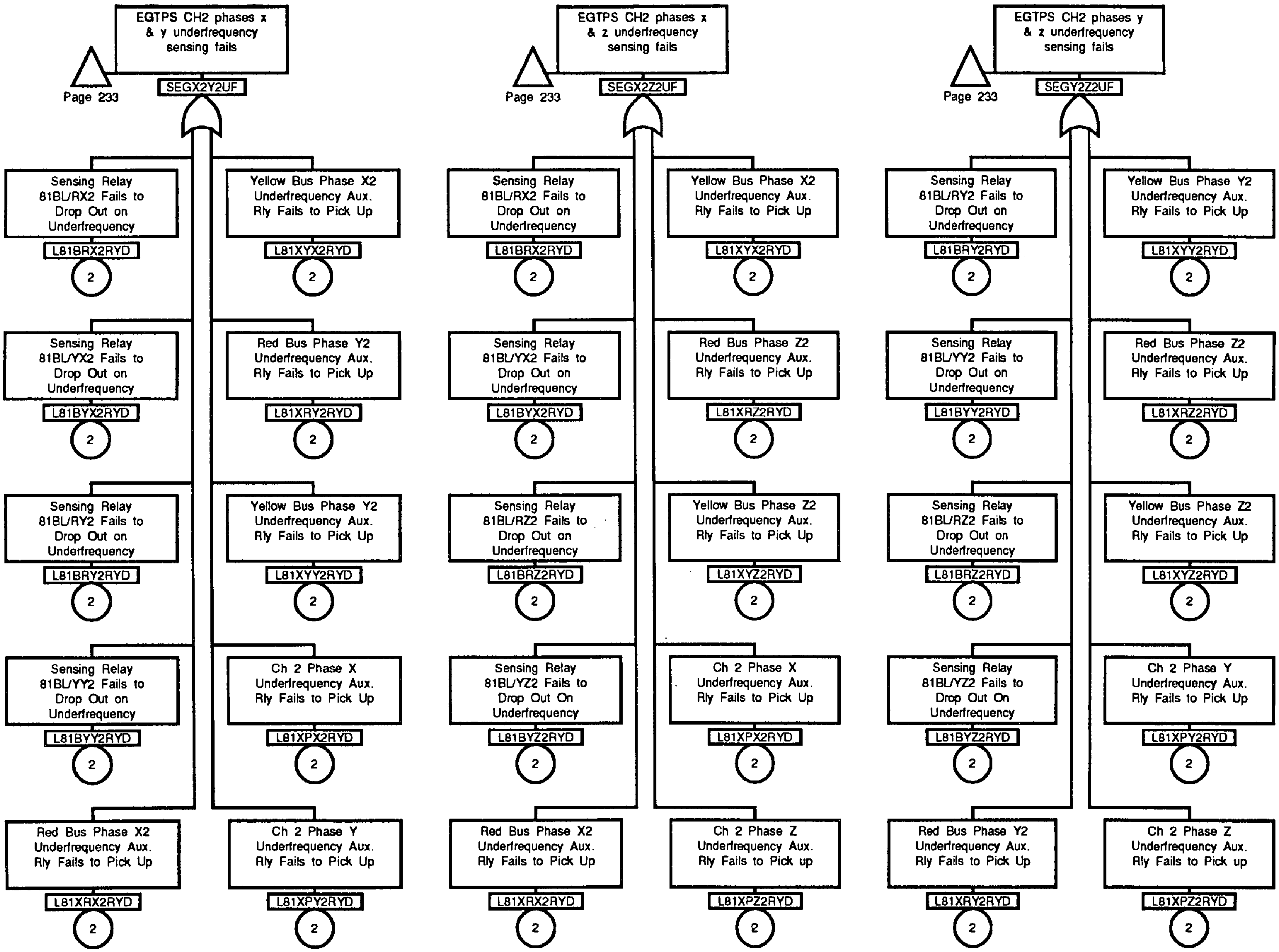
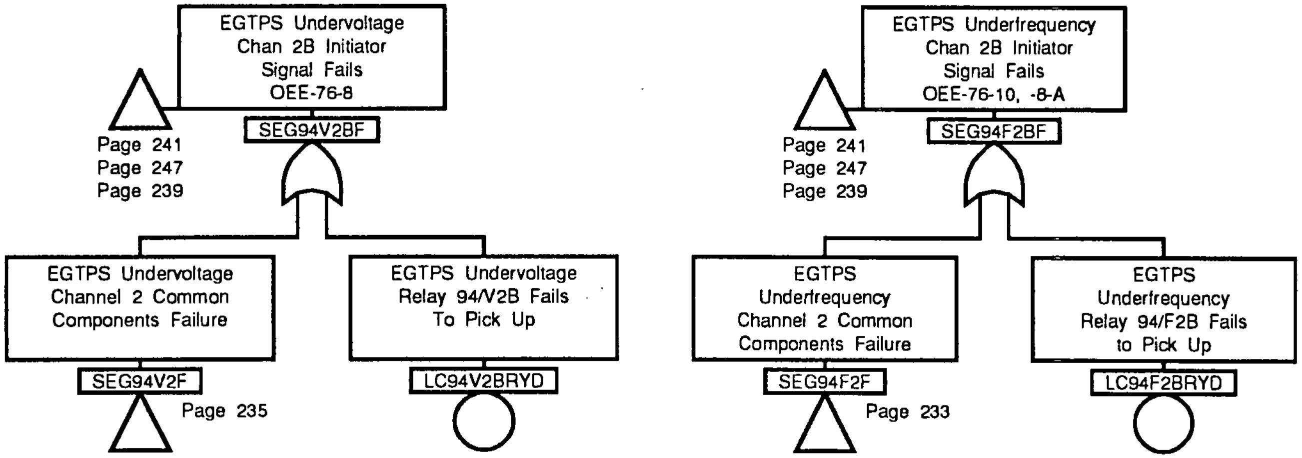
Page 235
125 Vdc Switchyard DC Panelboard DYG Is Faulted
DDCDYGXBDF
125 Vdc Breaker SY-DC2-1DR Transfers Open
DDC21DRCDT
Loss of Power on 125 Vdc Swyd Distribution Center SY-DC2
SDC2
Page 232



EGTPS CH2 phases x & y undervoltage sensing fails OEE-76-8
SEGX2Y2UV
Page 235
Snsng Rly 27B/RX2 Fails to Drop Out on Undervoltage
L27BRX2RYD
2
Yellow Bus Phase X2 Undervoltage Aux. Relay Fails To Pick Up
L27XYX2RYD
2
Snsng Rly 27B/YX2 Fails to Drop Out on Undervoltage
L27BYX2RYD
2
Red Bus Phase Y2 Undervoltage Aux. Relay Fails to Pick Up
L27XRY2RYD
2
Snsng Rly 27B/RY2 Fails to Drop Out on Undervoltage
L27BRY2RYD
2
Yellow Bus Phase Y2 Undervoltage Aux. Relay Fails to Pick Up
L27XYY2RYD
2
Snsng Rly 27B/YY2 Fails to Drop Out on Undervoltage
L27BYY2RYD
2
Ch 2 Phase X UV Aux. Relay Fails To Pick Up
L27XPX2RYD
2
Red Bus Phase X2 Undervoltage Aux. Relay Fails To Pick Up
L27XRX2RYD
2
Ch 2 Phase Y UV Aux. Relay Fails to Pick Up
L27XPY2RYD
2
EGTPS CH2 phases x & z undervoltage sensing fails OEE-76-8
SEGX2Z2UV
Page 235
Snsng Rly 27B/RX2 Fails to Drop Out on Undervoltage
L27BRX2RYD
2
Yellow Bus Phase X2 Undervoltage Aux. Relay Fails To Pick Up
L27XYX2RYD
2
Snsng Rly 27B/YX2 Fails to Drop Out on Undervoltage
L27BYX2RYD
2
Red Bus Phase Z2 Undervoltage Aux. Relay Fails To Pick Up
L27XRZ2RYD
2
Snsng Rly 27B/RZ2 Fails to Drop Out on Undervoltage
L27BRZ2RYD
2
Yellow Bus Phase Z2 Undervoltage Aux. Relay Fails to Pick Up
L27XYZ2RYD
2
Snsng Rly 27B/YZ2 Fails to Drop Out on Undervoltage
L27BYZ2RYD
2
Ch 2 Phase X UV Aux. Relay Fails To Pick Up
L27XPX2RYD
2
Red Bus Phase X2 Undervoltage Aux. Relay Fails To Pick Up
L27XRX2RYD
2
Ch 2 Phase Z UV Aux. Relay Fails To Pick Up
L27XPZ2RYD
2
EGTPS CH2 phases y & z undervoltage sensing fails OEE-76-8
SEGY2Z2UV
Page 235
Snsng Rly 27B/RY2 Fails to Drop Out on Undervoltage
L27BRY2RYD
2
Yellow Bus Phase Y2 Undervoltage Aux. Relay Fails to Pick Up
L27XYY2RYD
2
Snsng Rly 27B/YY2 Fails to Drop Out on Undervoltage
L27BYY2RYD
2
Red Bus Phase Z2 Undervoltage Aux. Relay Fails To Pick Up
L27XRZ2RYD
2
Snsng Rly 27B/RZ2 Fails to Drop Out on Undervoltage
L27BRZ2RYD
2
Yellow Bus Phase Z2 Undervoltage Aux. Relay Fails to Pick Up
L27XYZ2RYD
2
Snsng Rly 27B/YZ2 Fails to Drop Out on Undervoltage
L27BYZ2RYD
2
Ch 2 Phase Y UV Aux. Relay Fails to Pick Up
L27XPY2RYD
2
Red Bus Phase Y2 Undervoltage Aux. Relay Fails to Pick Up
L27XRY2RYD
2
Ch 2 Phase Z UV Aux. Relay Fails To Pick Up
L27XPZ2RYD
2



EGTPS CH2 phases x & y underfrequency sensing fails
SEGX2Y2UF
Page 233
Sensing Relay 81BL/RX2 Fails to Drop Out on Underfrequency
L81BRX2RYD
2
Yellow Bus Phase X2 Underfrequency Aux. Rly Fails to Pick Up
L81XYX2RYD
2
Sensing Relay 81BL/YX2 Fails to Drop Out on Underfrequency
L81BYX2RYD
2
Red Bus Phase Y2 Underfrequency Aux. Rly Fails to Pick Up
L81XRY2RYD
2
Sensing Relay 81BL/RY2 Fails to Drop Out on Underfrequency
L81BRY2RYD
2
Yellow Bus Phase Y2 Underfrequency Aux. Rly Fails to Pick Up
L81XYY2RYD
2
Sensing Relay 81BL/YY2 Fails to Drop Out on Underfrequency
L81BYY2RYD
2
Ch 2 Phase X Underfrequency Aux. Rly Fails to Pick Up
L81XPX2RYD
2
Red Bus Phase X2 Underfrequency Aux. Rly Fails to Pick Up
L81XRX2RYD
2
Ch 2 Phase Y Underfrequency Aux. Rly Fails to Pick Up
L81XPY2RYD
2
EGTPS CH2 phases x & z underfrequency sensing fails
SEGX2Z2UF
Page 233
Sensing Relay 81BL/RX2 Fails to Drop Out on Underfrequency
L81BRX2RYD
2
Yellow Bus Phase X2 Underfrequency Aux. Rly Fails to Pick Up
L81XYX2RYD
2
Sensing Relay 81BL/YX2 Fails to Drop Out on Underfrequency
L81BYX2RYD
2
Red Bus Phase Z2 Underfrequency Aux. Rly Fails to Pick Up
L81XRZ2RYD
2
Sensing Relay 81BL/RZ2 Fails to Drop Out on Underfrequency
L81BRZ2RYD
2
Yellow Bus Phase Z2 Underfrequency Aux. Rly Fails to Pick Up
L81XYZ2RYD
2
Sensing Relay 81BL/YZ2 Fails to Drop Out On Underfrequency
L81BYZ2RYD
2
Ch 2 Phase X Underfrequency Aux. Rly Fails to Pick Up
L81XPX2RYD
2
Red Bus Phase X2 Underfrequency Aux. Rly Fails to Pick Up
L81XRX2RYD
2
Ch 2 Phase Z Underfrequency Aux. Rly Fails to Pick up
L81XPZ2RYD
2
EGTPS CH2 phases y & z underfrequency sensing fails
SEGY2Z2UF
Page 233
Sensing Relay 81BL/RY2 Fails to Drop Out on Underfrequency
L81BRY2RYD
2
Yellow Bus Phase Y2 Underfrequency Aux. Rly Fails to Pick Up
L81XYY2RYD
2
Sensing Relay 81BL/YY2 Fails to Drop Out on Underfrequency
L81BYY2RYD
2
Red Bus Phase Z2 Underfrequency Aux. Rly Fails to Pick Up
L81XRZ2RYD
2
Sensing Relay 81BL/RZ2 Fails to Drop Out on Underfrequency
L81BRZ2RYD
2
Yellow Bus Phase Z2 Underfrequency Aux. Rly Fails to Pick Up
L81XYZ2RYD
2
Sensing Relay 81BL/YZ2 Fails to Drop Out On Underfrequency
L81BYZ2RYD
2
Ch 2 Phase Y Underfrequency Aux. Rly Fails to Pick Up
L81XPY2RYD
2
Red Bus Phase Y2 Underfrequency Aux. Rly Fails to Pick Up
L81XRY2RYD
2
Ch 2 Phase Z Underfrequency Aux. Rly Fails to Pick up
L81XPZ2RYD
2


EGTPS Undervoltage
Chan 2B Initiator
Signal Fails
OEE-76-8
SEG94V2BF
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Page 247
Page 239
EGTPS Undervoltage
Channel 2 Common
Components Failure
SEG94V2F
Page 235
EGTPS Undervoltage
Relay 94/V2B Fails
To Pick Up
LC94V2BRYD
EGTPS Underfrequency
Chan 2B Initiator
Signal Fails
OEE-76-10, -8-A
SEG94F2BF
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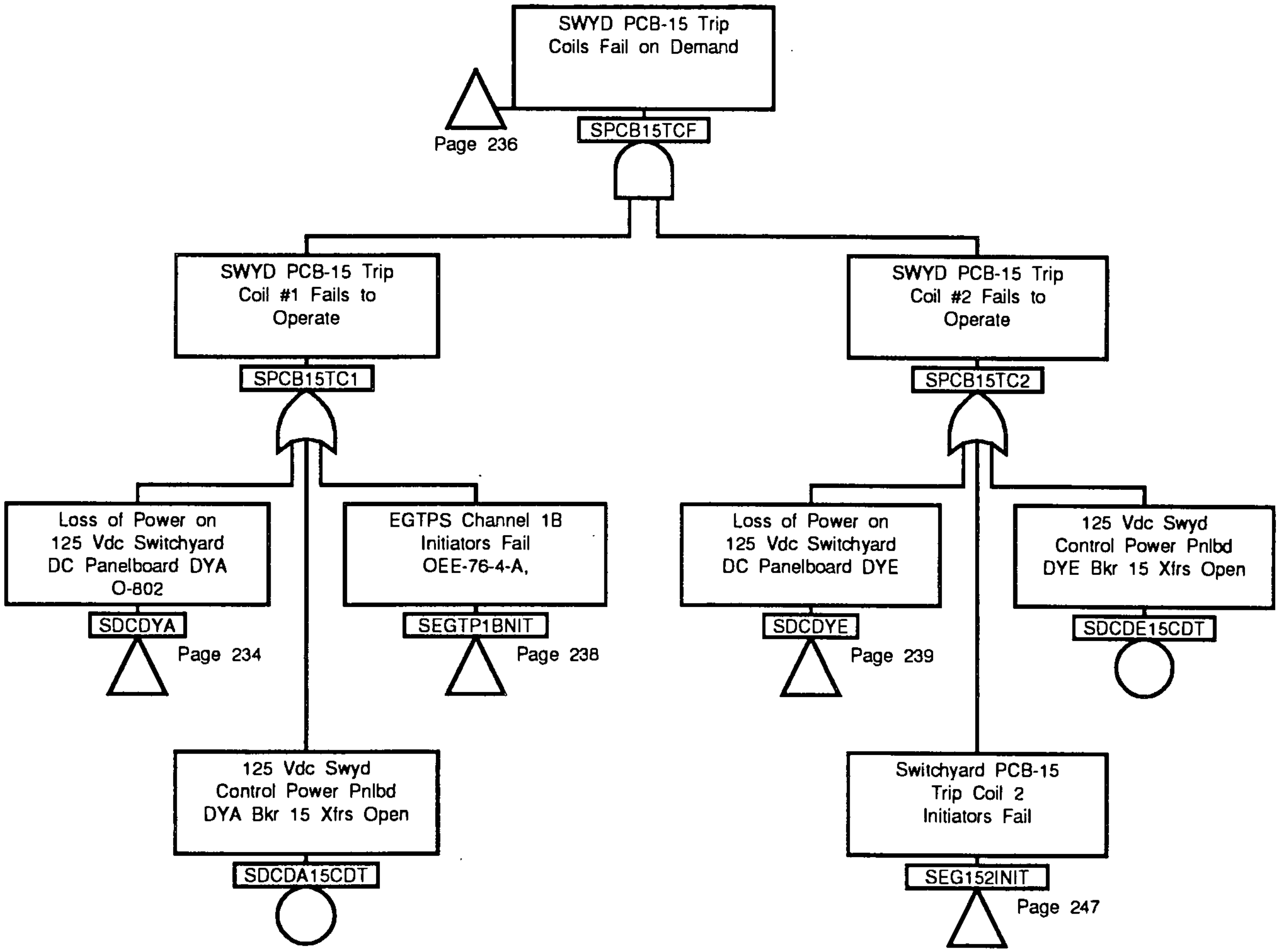
Page 247
Page 239
EGTPS
Underfrequency
Channel 2 Common
Components Failure
SEG94F2F
Page 233
EGTPS
Underfrequency
Relay 94/F2B Fails
to Pick Up
LC94F2BRYD


SWYD PCB-15 Trip Coils Fail on Demand
SPCB15TCF
Page 236
SWYD PCB-15 Trip Coil #1 Fails to Operate
SPCB15TC1
SWYD PCB-15 Trip Coil #2 Fails to Operate
SPCB15TC2
Loss of Power on 125 Vdc Switchyard DC Panelboard DYA O-802
SDCDYA
Page 234
EGTPS Channel 1B Initiators Fail OEE-76-4-A,
SEGTP1BNIT
Page 238
125 Vdc Swyd Control Power Pnlbd DYA Bkr 15 Xfrs Open
SDCDA15CDT
Loss of Power on 125 Vdc Switchyard DC Panelboard DYE
SDCDYE
Page 239
125 Vdc Swyd Control Power Pnlbd DYE Bkr 15 Xfrs Open
SDCDE15CDT
Switchyard PCB-15 Trip Coil 2 Initiators Fail
SEG152INIT
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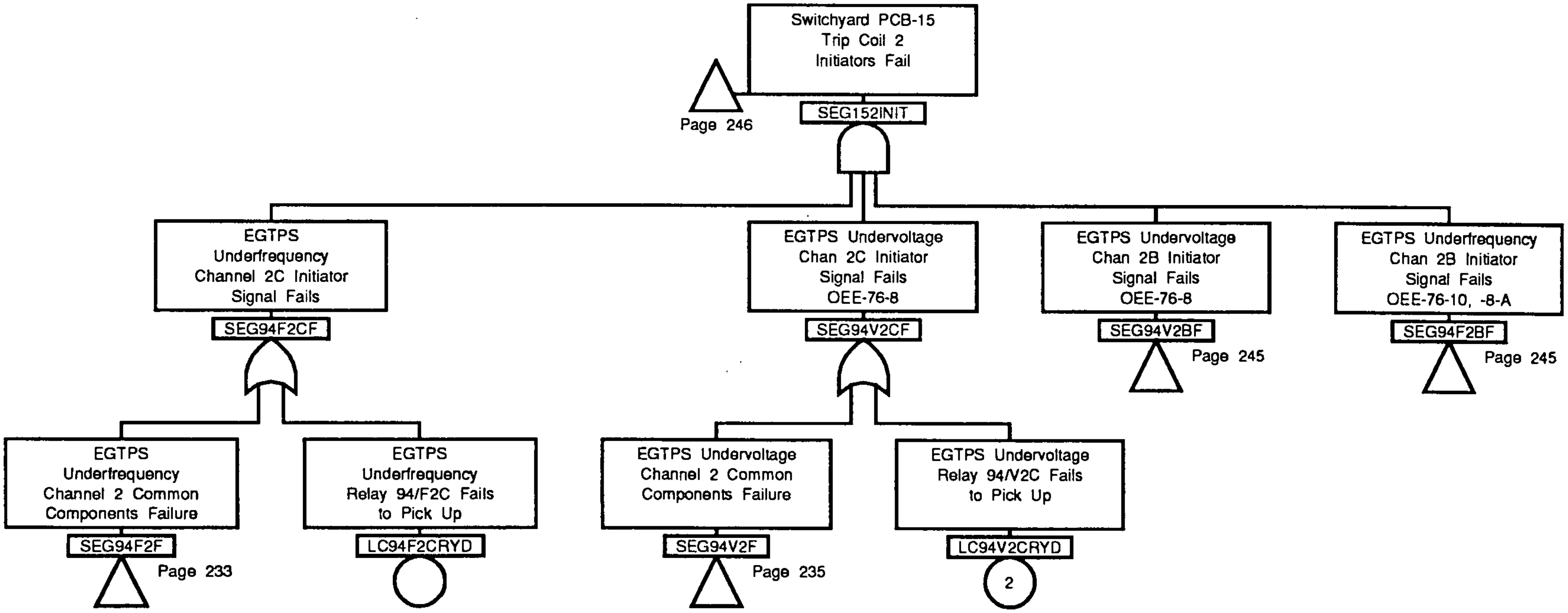
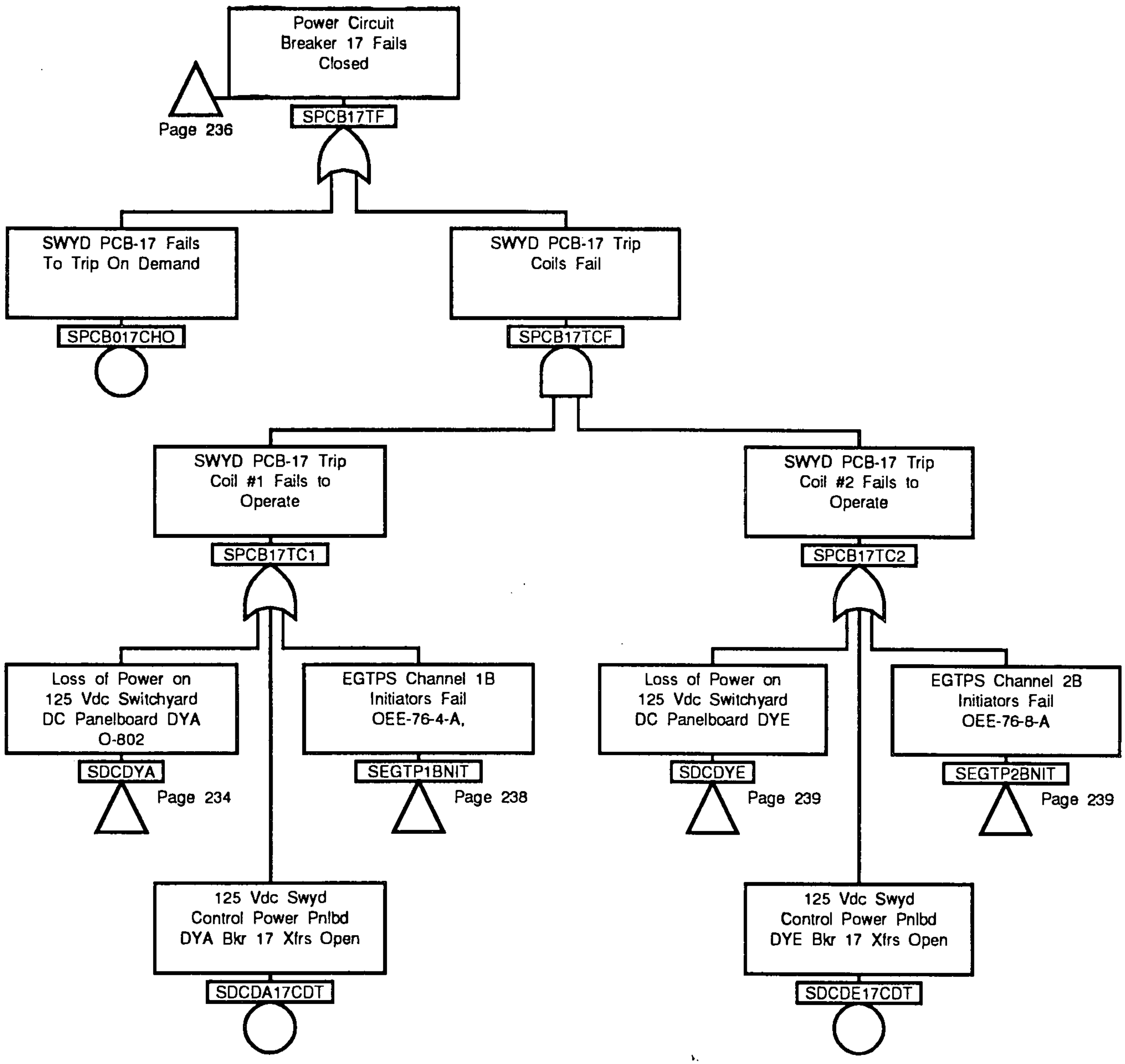


Switchyard PCB-15 Trip Coil 2 Initiators Fail
SEG152INIT
Page 246
EGTPS Underfrequency Channel 2C Initiator Signal Fails
SEG94F2CF
EGTPS Undervoltage Chan 2C Initiator Signal Fails OEE-76-8
SEG94V2CF
EGTPS Undervoltage Chan 2B Initiator Signal Fails OEE-76-8
SEG94V2BF
Page 245
EGTPS Underfrequency Chan 2B Initiator Signal Fails OEE-76-10, -8-A
SEG94F2BF
Page 245
EGTPS Underfrequency Channel 2 Common Components Failure
SEG94F2F
Page 233
EGTPS Underfrequency Relay 94/F2C Fails to Pick Up
LC94F2CRYD
EGTPS Undervoltage Channel 2 Common Components Failure
SEG94V2F
Page 235
EGTPS Undervoltage Relay 94/V2C Fails to Pick Up
LC94V2CRYD
2


Power Circuit Breaker 17 Fails Closed
Page 236
SPCB17TF
SWYD PCB-17 Fails To Trip On Demand
SPCB017CHO
SWYD PCB-17 Trip Coils Fail
SPCB17TCF
SWYD PCB-17 Trip Coil #1 Fails to Operate
SPCB17TC1
SWYD PCB-17 Trip Coil #2 Fails to Operate
SPCB17TC2
Loss of Power on 125 Vdc Switchyard DC Panelboard DYA O-802
SDCDYA
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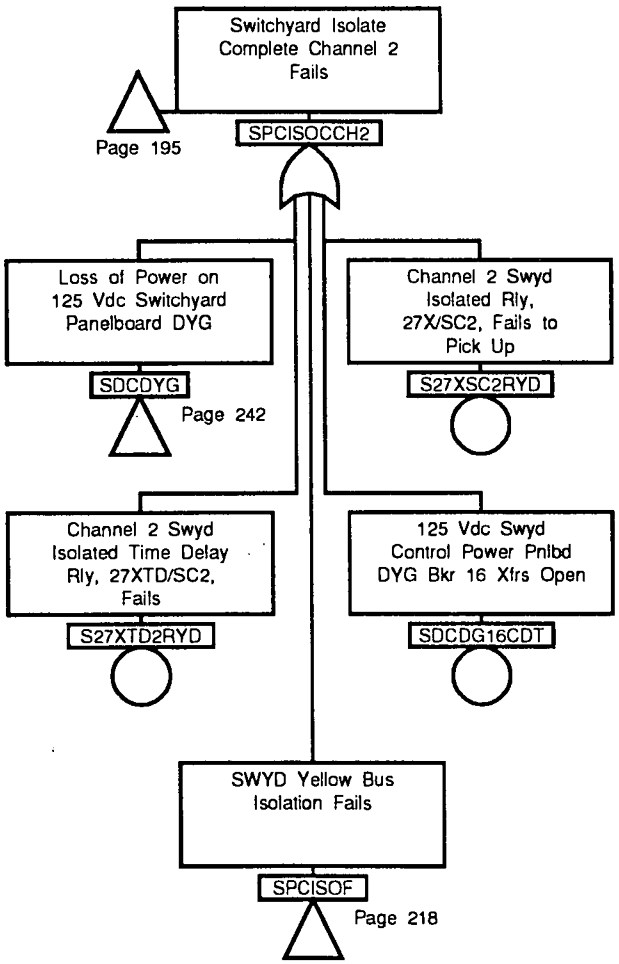
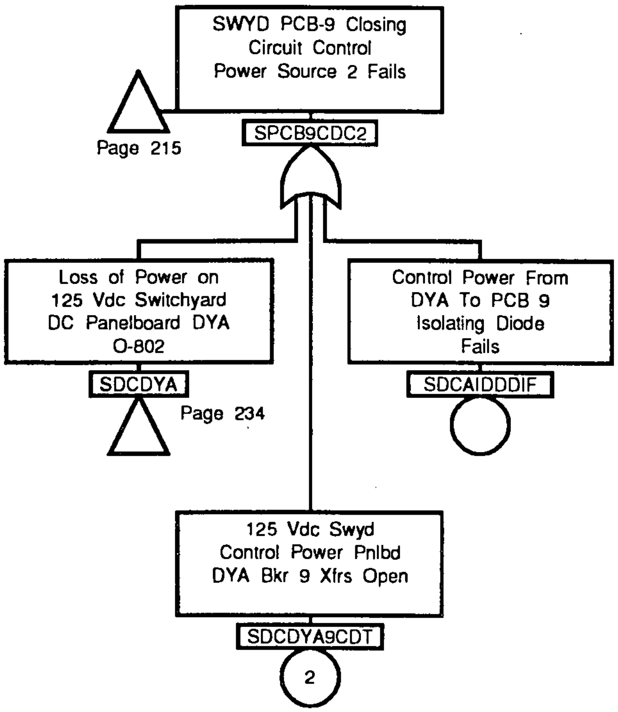
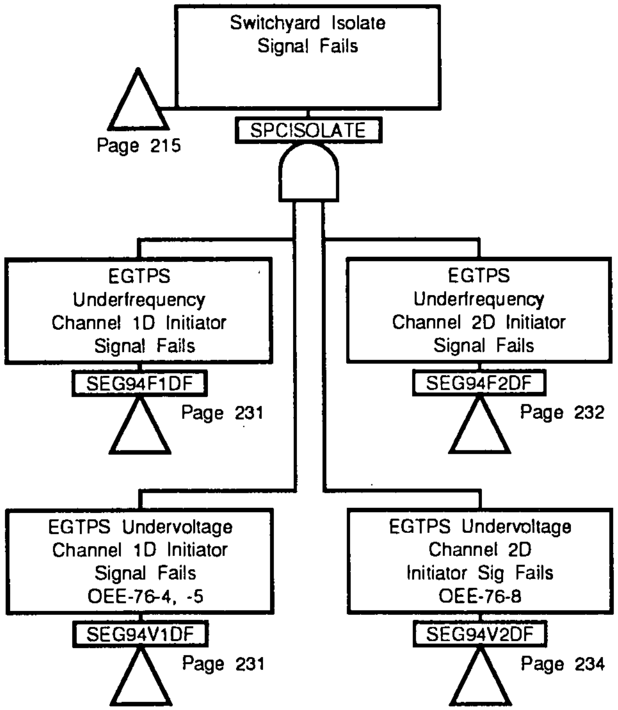
EGTPS Channel 1B Initiators Fail OEE-76-4-A,
SEGTP1BNIT
Page 238
Loss of Power on 125 Vdc Switchyard DC Panelboard DYE
SDCDYE
Page 239
EGTPS Channel 2B Initiators Fail OEE-76-8-A
SEGTP2BNIT
Page 239
125 Vdc Swyd Control Power Pnlbd DYA Bkr 17 Xfrs Open
SDCDA17CDT
125 Vdc Swyd Control Power Pnlbd DYE Bkr 17 Xfrs Open
SDCDE17CDT


Switchyard Isolate Complete Channel 2 Fails
SPCISOCCH2
Page 195
Loss of Power on 125 Vdc Switchyard Panelboard DYG
SDCDYG
Page 242
Channel 2 Swyd Isolated Rly, 27X/SC2, Fails to Pick Up
S27XSC2RYD
Channel 2 Swyd Isolated Time Delay Rly, 27XTD/SC2, Fails
S27XTD2RYD
125 Vdc Swyd Control Power Pnlbd DYG Bkr 16 Xfrs Open
SDCDG16CDT
SWYD Yellow Bus Isolation Fails
SPCISOF
Page 218



SWYD PCB-9 Closing Circuit Control Power Source 2 Fails
SPCB9CDC2
Page 215
Loss of Power on 125 Vdc Switchyard DC Panelboard DYA O-802
SDCDYA
Page 234
Control Power From DYA To PCB 9 Isolating Diode Fails
SDCAIDDDIF
125 Vdc Swyd Control Power Pnlbd DYA Bkr 9 Xfrs Open
SDCDYA9CDT
2


Switchyard Isolate Signal Fails
SPCISOLATE
Page 215
EGTPS Underfrequency Channel 1D Initiator Signal Fails
SEG94F1DF
Page 231
EGTPS Underfrequency Channel 2D Initiator Signal Fails
SEG94F2DF
Page 232
EGTPS Undervoltage Channel 1D Initiator Signal Fails OEE-76-4, -5
SEG94V1DF
Page 231
EGTPS Undervoltage Channel 2D Initiator Sig Fails OEE-76-8
SEG94V2DF
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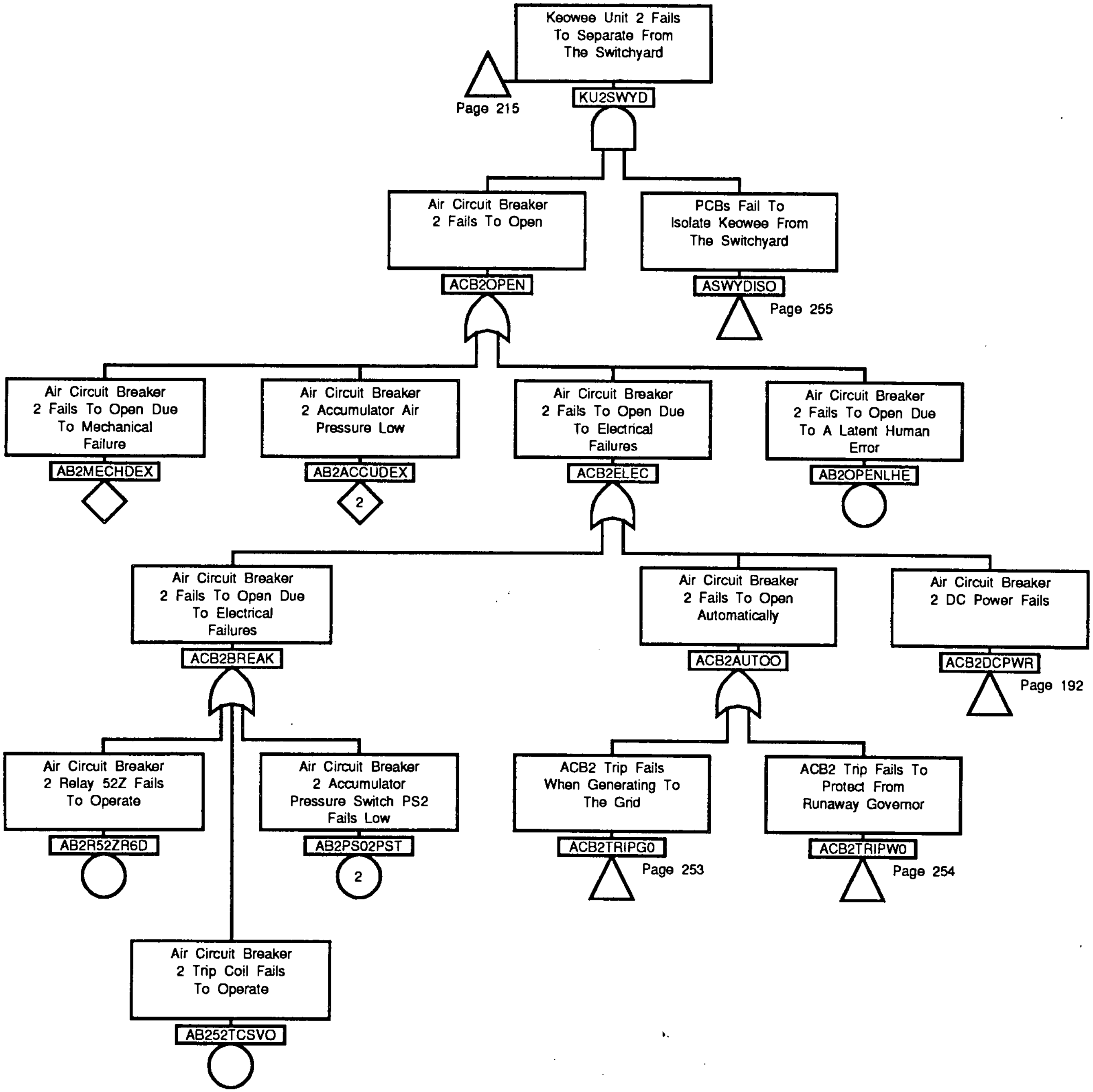
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Air Circuit Breaker 2 Fails To Open
ACB2OPEN
PCBs Fail To Isolate Keowee From The Switchyard
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ACB2ELEC
Air Circuit Breaker 2 Fails To Open Due To A Latent Human Error
AB2OPENLHE
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ACB2 Trip Fails To Protect From Runaway Governor
ACB2TRIPWO
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Air Circuit Breaker 2 Trip Coil Fails To Operate
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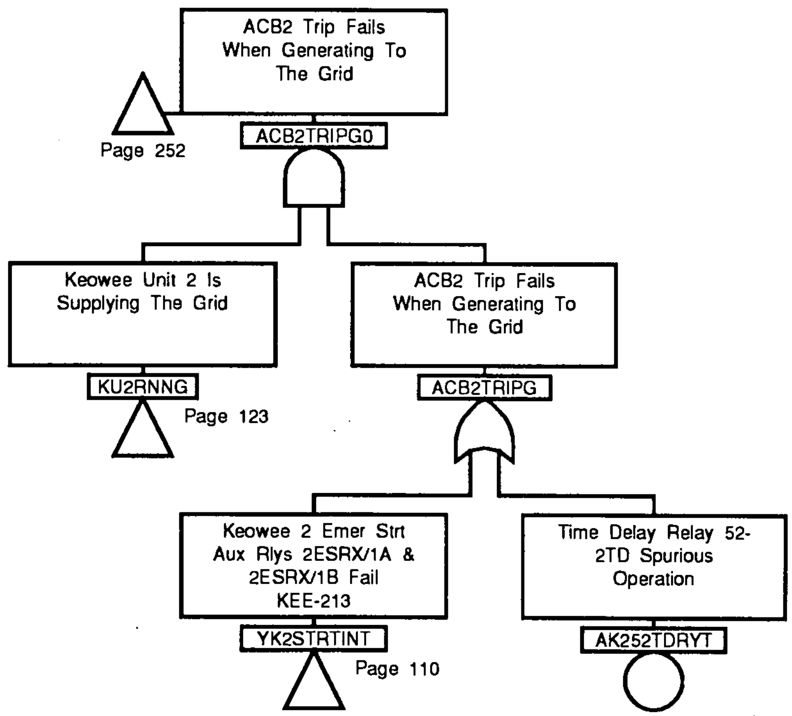
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Keowee Unit 2 Is Supplying The Grid
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ACB2 Trip Fails When Generating To The Grid
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Keowee 2 Emer Strt Aux Rlys 2ESRX/1A & 2ESRX/1B Fail KEE-213
YK2STRTINT
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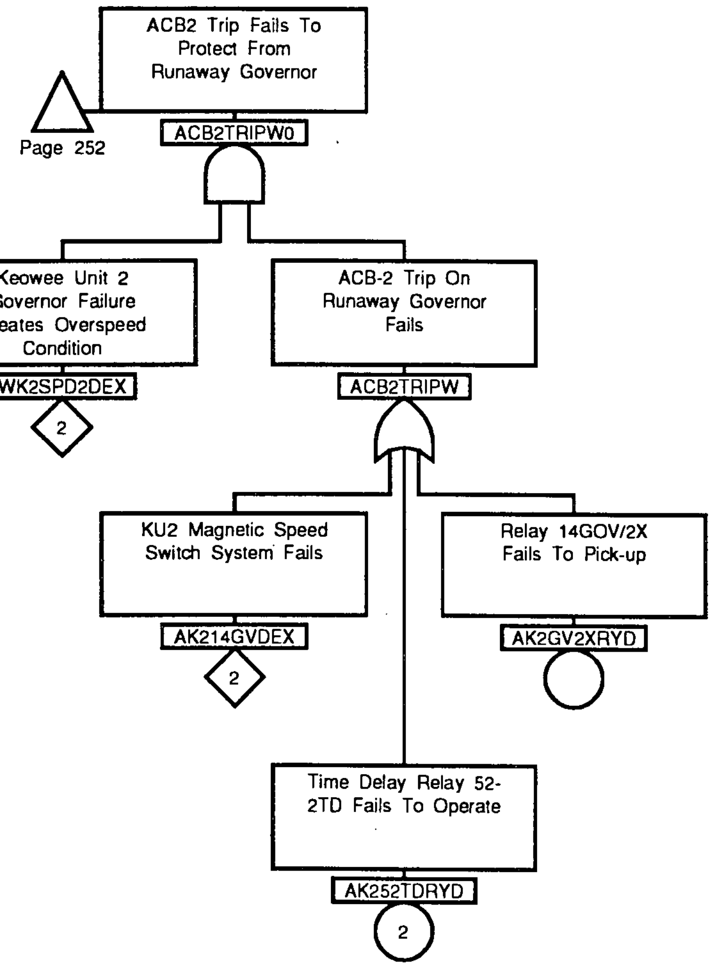
Time Delay Relay 52-2TD Spurious Operation
AK252TDRYT



ACB2 Trip Fails To Protect From Runaway Governor
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Keowee Unit 2 Governor Failure Creates Overspeed Condition
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2
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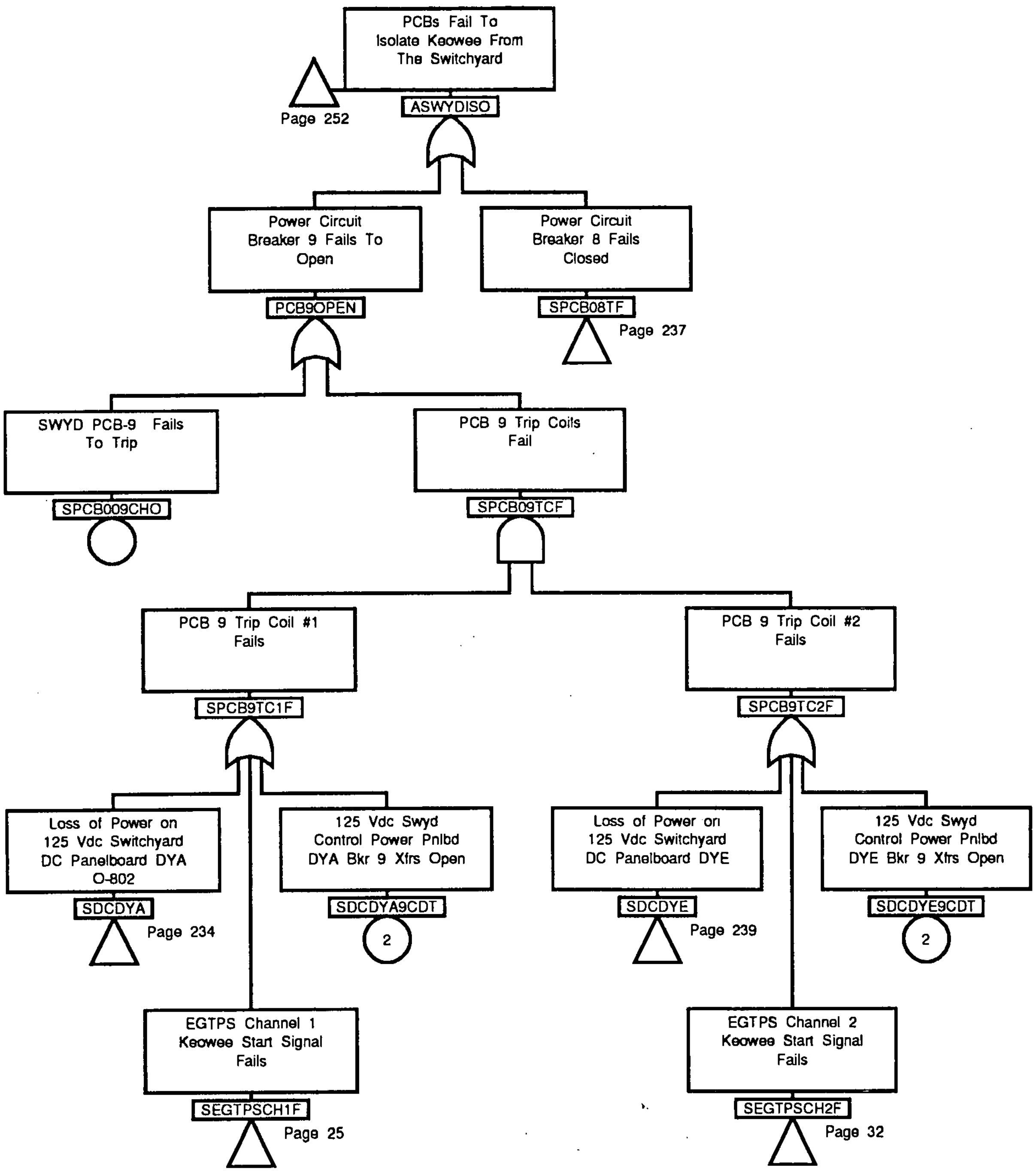
AK214GVDEX
2
Relay 14GOV/2X Fails To Pick-up
AK2GV2XRYD
Time Delay Relay 52-2TD Fails To Operate
AK252TDRYD
2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1R94GB	205		AB086E1RYD	109		AB2PS02PST	66		AB4PSWTPST	206	
1XUV	187		AB086TGRYD	109		AB2PS02PST	252		AB4PUSHPBT	180	
1XUV	188		AB0SWGRCOM	185		AB2PSWTPST	206		AB4R52XR6D	105	
2R94GB	205		AB152TCSVO	24		AB2PUSHPBT	198		AB4R52ZR6T	180	
2R94GB	206		AB1ACCUDEX	24		AB2R462RYT	198		AB510A1FUF	67	
94GB	205		AB1FALTDEX	106		AB2R52XR6D	66		AB51431LHE	62	
AA1271PR6D	68		AB1FALTDEX	107		AB2R52ZR6D	252		AB51431LHE	64	
AA1271XR6T	69		AB1FALTDEX	204		AB2R52ZR6T	68		AB51431LHE	68	
AA127C1R6T	59		AB1MECHDEX	24		AB31523SWT	102		AB51431RYT	68	
AA127CPR6D	62		AB1OPENLHE	24		AB352CCSVO	36		AB51431SWT	62	
AA127R1RYT	59		AB1PS02PST	24		AB352TCSVO	37		AB51431SWT	64	
AA127X1RYD	68		AB1PSWTPST	205		AB352TCSVT	102		AB51431SWT	68	
AA127X1RYT	69		AB1R52ZR6D	24		AB352Y2R6D	36		AB552CCRYD	67	
AA127X2R6D	64		AB21521SWT	198		AB352Y2R6T	36		AB552TCRYT	69	
AA127XCRYD	62		AB22BV1RYT	198		AB3ACCUDEX	35		AB552Y2RYT	67	
AA186CXRYT	59		AB23BKRCOM	35		AB3ACCUDEX	37		AB583S5RYD	68	
AA186CXRYT	148		AB23COM	35		AB3CLOSLHE	35		AB5CLOSLHE	67	
AA186S1RYT	59		AB23COM	35		AB3MCH2DEX	35		AB5KEYISWT	67	
AA186S1RYT	69		AB23COM	66		AB3MECHDEX	37		AB5MCH2DEX	67	
AA187CXRYT	59		AB24BKRCOM	113		AB3PS02PST	36		AB5PUSHPBT	69	
AA187CXRYT	148		AB24COM	66		AB3PS02PST	37		AB5R52XRYD	67	
AA2272PR6D	143		AB24COM	105		AB3PSWTPST	205		AB5R52YRYD	67	
AA2272XR6D	144		AB24COM	113		AB3PUSHPBT	102		AB610A1FUF	142	
AA2272XR6T	145		AB251G2RYT	198		AB3R52XR6D	36		AB610AFFUF	144	
AA227C2R6T	148		AB252CCSVO	66		AB3R52ZR6D	37		AB61432LHE	143	
AA227C2RYD	147		AB252TCSVO	252		AB3R52ZR6T	102		AB61432LHE	144	
AA227CPR6D	147		AB252TCSVT	68		AB41523SWT	180		AB61432LHE	147	
AA227R2RYT	148		AB252Y2R6D	66		AB452CCSVO	105		AB61432SWT	143	
AA227T2R6D	193		AB252Y2R6T	66		AB452TCSVT	180		AB61432SWT	144	
AA227X2RYD	64		AB2ACCUDEX	66		AB452Y2R6D	105		AB61432SWT	147	
AA227X2RYD	143		AB2ACCUDEX	252		AB452Y2R6T	105		AB652CCRYD	142	
AA227X2RYD	144		AB2CLOSLHE	197		AB4ACCUDEX	105		AB652TCRYD	144	
AA227X2RYT	145		AB2KEYISWT	66		AB4CLOSLHE	105		AB652TCRYT	145	
AA286S2RYT	145		AB2MCH2DEX	66		AB4CLSESWC	112		AB652Y2RYT	142	
AA286S2RYT	148		AB2MECHDEX	252		AB4KEYISWT	105		AB6CLOSLHE	142	
AB004ECCDT	109		AB2MOD	193		AB4LORESWT	112		AB6KEYISWT	142	
AB0086TRYD	109		AB2MOD	196		AB4MCH2DEX	105		AB6MCH2DEX	142	
AB0624CRYD	109		AB2OPENLHE	252		AB4PS02PST	105		AB6MECHDEX	144	

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BK1GBO3CVT	71		BK2632XRYT	153		BK2GBO2VVT	137		DDCBATTCOM	240	
BK1GBO4VVT	71		BK263TALSD	151		BK2GBO3CVO	149		DDCBATTNOT	217	
BK1GBO5VVT	56		BK263TALSD	152		BK2GBO3CVT	149		DDCBATTNOT	232	
BK1GBO6VVT	56		BK263TALST	153		BK2GBO4VVT	149		DDCBATTNOT	240	
BK1GBO8VVT	56		BK263TALST	154		BK2GBO5VVT	139		DDCDYAXBDF	234	
BK1GBO9VVT	56		BK263TALST	163		BK2GBO6VVT	139		DDCDYBXBDF	219	
BK1GOACGPR	57		BK2650	149		BK2GBO8VVT	139		DDCDYCXBDF	216	
BK1GOACGPS	57		BK2650	150		BK2GBO9VVT	139		DDCDYEXBDF	239	
BK1GODCTRM	71		BK2660	150		BK2GOACGPR	140		DDCDYFXBDF	225	
BK1XA1CCLT	57		BK2660	151		BK2GOACGPS	140		DDCDYGXBDF	242	
BK2000	124		BK2660A	151		BK2GODCTRM	149		E12EXCTCOM	184	
BK2000	139		BK2660C	151		BK2XA1CCLT	140		ED11D3DCDT	13	
BK2088XRYD	152		BK2661A	151		BKGBOILCOM	186		ED13BR2CDT	51	
BK2088XRYT	154		BK2661B	163		COMMCOLD	184		ED13BR2CDT	80	
BK2088XRYT	163		BK2661B	164		COOLCOM	186		ED22D3DCDT	116	
BK2100	139		BK2661C	151		COOLCOM	187		ED23BR2CDT	135	
BK214/2SSD	164		BK2661C	152		D1DIAXXDEX	9		ED23BR2CDT	159	
BK214/2SST	152		BK2760	150		D1DIBXXDEX	10		EK00RUNCOM	186	
BK214DXRYD	164		BK2760	153		D2DIAXXDEX	27		EK131TDRYD	20	
BK214DXRYT	152		BK2760A	153		D2DIBXXDEX	33		EK131TDRYT	19	
BK214T2RYD	164		BK2760B	152		D3DIAXXDEX	28		EK14152SWT	17	
BK214T2RYT	152		BK2760B	153		D3DIBXXDEX	34		EK1415TSWT	80	
BK2188ASWT	140		BK2760B	163		DDC11BXCDT	217		EK1415YRYD	16	
BK2188DSWT	150		BK2760C	153		DDC11CXCDT	240		EK1415YRYT	16	
BK2200	139		BK2760C	154		DDC11DCCDT	219		EK141AXR6D	17	
BK2400	139		BK2760SX	153		DDC11DLCDT	234		EK141AXR6D	81	
BK2500	137		BK2761A	153		DDC11DRCDT	216		EK141AXR6T	80	
BK2500	139		BK2761C	154		DDC1ALXBYM	217		EK141AXR6T	81	
BK2550	137		BK288AXRYD	151		DDC1ALXBYM	240		EK141CFRYD	19	
BK2550	140		BK288AXRYT	153		DDC1BATBYF	217		EK186E2RYT	16	
BK2550	149		BK2DA1BCDT	150		DDC1FLTBDF	217		EK186EXRYT	13	
BK2560	149		BK2GBDCGPR	150		DDC21BXCDT	232		EK186EXRYT	18	
BK2600	139		BK2GBDCGPS	150		DDC21CXCDT	240		EK186X2RYT	80	
BK2600	149		BK2GBDCLHE	150		DDC21DCCDT	225		EK188SVRYD	81	
BK2631XRYD	152		BK2GBO1CVC	149		DDC21DLCDT	239		EK188SVRYT	81	
BK2631XRYT	154		BK2GBO1CVO	137		DDC21DRCDT	242		EK1901ARYT	19	
BK2631XRYT	163		BK2GBO1CVT	137		DDC2BATBYF	232		EK199SXRYD	15	
BK2632XRYD	151		BK2GBO1FTC	139		DDC2FLTBDF	232		EK199SYRYD	14	

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FK1WL05VVT	79		FK2WL05VVT	157		GFBFAIL2	192		GK1315B	92	
FK1WL06VVT	79		FK2WL06VVT	157		GFBTRIP1	13		GK1316	87	
FK1WL07VVT	79		FK2WL07VVT	157		GFBTRIP1	14		GK1316	93	
FK1WL08VVT	79		FK2WL08VVT	157		GFBTRIP2	116		GK1316A	93	
FK1WL09VVT	78		FK2WL09VVT	154		GFBTRIP2	194		GK1316B	93	
FK1WL11AVO	84		FK2WL11AVO	162		GFFBFAIL1	18		GK1317	87	
FK1WL11AVT	84		FK2WL11AVT	162		GFFBFAIL1	19		GK1317	94	
FK1WL12VVT	84		FK2WL12VVT	162		GFFBFAIL2	118		GK1317A	94	
FK1WL15VVT	96		FK2WL15VVT	174		GFFBFAIL2	119		GK1317B	94	
FK1WL42VVT	83		FK2WL42VVT	161		GK0COOLCOM	186		GK1318	87	
FK1WL43VVT	83		FK2WL43VVT	161		GK0LOCKCOM	186		GK1318	95	
FK2110	154		FKVALVECOM	187		GK10001HGR	82		GK1318A	95	
FK2110	157		FLDCLOSE1	13		GK10001HGS	4		GK1318B	95	
FK2120	157		FLDCLOSE1	13		GK1063FPST	104		GK13SUI	103	
FK2120	157		FLDCLOSE1	18		GK1120	82		GK13SUI	107	
FK2120	162		FLDCLOSE2	116		GK112TDRYT	108		GK13SUIRYT	107	
FK2120GLHE	162		FLDCLOSE2	116		GK112X1RYT	108		GK13SUISWT	107	
FK2120GSWT	162		FLDCLOSE2	119		GK1310	82		GK140G1RYT	103	
FK2200	154		FLDCLOSE2	193		GK1310	87		GK1410	96	
FK2200	155		FLDTRANS1	80		GK1311	87		GK1410	97	
FK2300	160		FLDTRANS2	68		GK1311	88		GK1411	97	
FK2300	161		FLDTRANS2	158		GK1311A	88		GK1412	97	
FK2310	161		FLDTRANS2	159		GK1311B	88		GK1412	98	
FK2310	162		FLSHCLOSE1	13		GK1312	87		GK1413	97	
FK2310	174		FLSHCLOSE1	18		GK1312	89		GK1414	97	
FK2400	174		FLSHCLOSE2	116		GK1312A	89		GK1414	98	
FK2500	162		FLSHCLOSE2	119		GK1312B	89		GK1415	97	
FK2510	162		FLSHOPEN1	13		GK1313	87		GK1415	99	
FK2520	162		FLSHOPEN1	20		GK1313	90		GK1416	97	
FK2530	162		FLSHOPEN2	116		GK1313A	90		GK1416	99	
FK2530	163		FLSHOPEN2	120		GK1313B	90		GK159GNRYT	103	
FK2540	163		GAB1FAULT	103		GK1314	87		GK162TDRYT	103	
FK2FL01FRF	157		GAB1FAULT	107		GK1314	91		GK163FX	103	
FK2FL02FRF	157		GENCOM	186		GK1314A	91		GK163FX	104	
FK2TRHXHXF	154		GENFAIL	196		GK1314B	91		GK163FXRYT	104	
FK2TRHXHXF	155		GFBFAIL1	13		GK1315	87		GK186E1	13	
FK2WL03VVT	157		GFBFAIL1	14		GK1315	92		GK186E1	21	
FK2WL04VVT	157		GFBFAIL2	116		GK1315A	92		GK186E1	82	

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GK186E1	102		GK1HPO8HXF	95		GK1WL50VVT	89		GK2310	160	
GK186E1RYT	21		GK1HXLEAK	100		GK1WL51VVT	89		GK2310	165	
GK186E1RYT	53		GK1MODTRIP	103		GK1WL52VVT	90		GK2311	165	
GK186E1RYT	83		GK1MODTRIP	108		GK1WL53VVT	90		GK2311	166	
GK186E1X	21		GK1NGDCLHE	4		GK1WL54VVT	90		GK2311A	166	
GK186E1X	103		GK1O121SST	108		GK1WL55VVT	90		GK2311B	166	
GK186E1X	106		GK1SUPRT	82		GK1WL56VVT	91		GK2312	165	
GK187G1RYT	103		GK1WL16VVT	99		GK1WL57VVT	91		GK2312	167	
GK187GBRYT	103		GK1WL17VVT	99		GK1WL58VVT	91		GK2312A	167	
GK187TERYT	103		GK1WL18VVT	101		GK1WL59VVT	91		GK2312B	167	
GK1BRGDSCH	82		GK1WL19VVT	101		GK1WL60VVT	92		GK2313	165	
GK1BRGDSCH	86		GK1WL20VVT	99		GK1WL61VVT	92		GK2313	168	
GK1BRGSUP	82		GK1WL21VVT	99		GK1WL62VVT	92		GK2313A	168	
GK1BRGVLHE	82		GK1WL22VVT	101		GK1WL63VVT	92		GK2313B	168	
GK1COOLLHE	96		GK1WL23VVT	101		GK1WL64VVT	93		GK2314	165	
GK1FIREDEX	82		GK1WL24VVT	98		GK1WL65VVT	93		GK2314	169	
GK1GAC1HXF	97		GK1WL25VVT	98		GK1WL66VVT	93		GK2314A	169	
GK1GAC1HXL	100		GK1WL26VVT	101		GK1WL67VVT	93		GK2314B	169	
GK1GAC2HXF	98		GK1WL27VVT	101		GK1WL68VVT	94		GK2315	165	
GK1GAC2HXL	100		GK1WL28VVT	97		GK1WL69VVT	94		GK2315	170	
GK1GAC3HXF	97		GK1WL29VVT	97		GK1WL70VVT	94		GK2315A	170	
GK1GAC3HXL	100		GK1WL30VVT	101		GK1WL71VVT	94		GK2315B	170	
GK1GAC4HXF	98		GK1WL31VVT	101		GK1WL72VVT	95		GK2316	165	
GK1GAC4HXL	100		GK1WL32VVT	98		GK1WL73VVT	95		GK2316	171	
GK1GAC5HXF	99		GK1WL33VVT	98		GK1WL74VVT	95		GK2316A	171	
GK1GAC5HXL	100		GK1WL34VVT	101		GK1WL75VVT	95		GK2316B	171	
GK1GAC6HXF	99		GK1WL35VVT	101		GK1WL76VVT	86		GK2317	165	
GK1GAC6HXL	100		GK1WL36VVT	97		GK1WL78VVT	86		GK2317	172	
GK1GENCOOL	82		GK1WL37VVT	97		GK1WLLEAK	82		GK2317A	172	
GK1GENCOOL	96		GK1WL38VVT	101		GK1WLLEAK	100		GK2317B	172	
GK1HPO1HXF	88		GK1WL39VVT	101		GK1WLVLEAK	100		GK2318	165	
GK1HPO2HXF	89		GK1WL41VVT	96		GK1WLVLEAK	101		GK2318	173	
GK1HPO3HXF	90		GK1WL44VVT	88		GK20001HGR	160		GK2318A	173	
GK1HPO4HXF	91		GK1WL45VVT	88		GK20002HGS	121		GK2318B	173	
GK1HPO5HXF	92		GK1WL46VVT	88		GK2063FPST	200		GK23SUI	122	
GK1HPO6HXF	93		GK1WL47VVT	88		GK2120	160		GK23SUI	200	
GK1HPO6VVT	82		GK1WL48VVT	89		GK212TDRYT	201		GK23SUIRYT	200	
GK1HPO7HXF	94		GK1WL49VVT	89		GK212X2RYT	201		GK23SUISWT	200	

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GK240G1RYT	122		GK2GAC2HXL	178		GK2WL28VVT	175		GK2WL69VVT	172	
GK2410	174		GK2GAC3HXF	175		GK2WL29VVT	175		GK2WL70VVT	172	
GK2410	175		GK2GAC3HXL	178		GK2WL30VVT	179		GK2WL71VVT	172	
GK2411	175		GK2GAC4HXF	176		GK2WL31VVT	179		GK2WL72VVT	173	
GK2412	175		GK2GAC4HXL	178		GK2WL32VVT	176		GK2WL73VVT	173	
GK2412	176		GK2GAC5HXF	177		GK2WL33VVT	176		GK2WL74VVT	173	
GK2413	175		GK2GAC5HXL	178		GK2WL34VVT	179		GK2WL75VVT	173	
GK2414	175		GK2GAC6HXF	177		GK2WL35VVT	179		GK2WL76VVT	164	
GK2414	176		GK2GAC6HXL	178		GK2WL36VVT	175		GK2WL78VVT	164	
GK2415	175		GK2GENCOOL	160		GK2WL37VVT	175		GK2WLLEAK	160	
GK2415	177		GK2GENCOOL	174		GK2WL38VVT	179		GK2WLLEAK	178	
GK2416	175		GK2HPO1HXF	166		GK2WL39VVT	179		GK2WLVLEAK	178	
GK2416	177		GK2HPO2HXF	167		GK2WL41VVT	174		GK2WLVLEAK	179	
GK259GNRYT	122		GK2HPO3HXF	168		GK2WL44VVT	166		GKHPOILCOM	186	
GK262TDRYT	122		GK2HPO4HXF	169		GK2WL45VVT	166		GMODTRIP1	108	
GK263FX	122		GK2HPO5HXF	170		GK2WL46VVT	166		GMODTRIP2	201	
GK263FX	200		GK2HPO6HXF	171		GK2WL47VVT	166		GOVTBCOM	186	
GK263FXRYT	200		GK2HPO6VVT	160		GK2WL48VVT	167		GSBFAIL1	16	
GK286E2	116		GK2HPO7HXF	172		GK2WL49VVT	167		GSBFAIL2	117	
GK286E2	122		GK2HPO8HXF	173		GK2WL50VVT	167		GSBTRIP1	16	
GK286E2	160		GK2HXLEAK	178		GK2WL51VVT	167		GSBTRIP1	17	
GK286E2	180		GK2MODTRIP	122		GK2WL52VVT	168		GSBTRIP2	117	
GK286E2	197		GK2MODTRIP	201		GK2WL53VVT	168		GSBTRIP2	118	
GK286E2RYT	122		GK2NGDCLHE	121		GK2WL54VVT	168		K12COM	183	
GK286E2RYT	137		GK2O121SST	201		GK2WL55VVT	168		K12COM01	188	
GK286E2RYT	161		GK2SUPRT	160		GK2WL56VVT	169		K12COM02	188	
GK287G2RYT	122		GK2WL16VVT	177		GK2WL57VVT	169		K12COM03	188	
GK287GBRYT	122		GK2WL17VVT	177		GK2WL58VVT	169		K12COM03	189	
GK287TERYT	122		GK2WL18VVT	179		GK2WL59VVT	169		K12COM04	188	
GK2BRGDSCH	160		GK2WL19VVT	179		GK2WL60VVT	170		K12COM04	189	
GK2BRGDSCH	164		GK2WL20VVT	177		GK2WL61VVT	170		K12COM1DEX	189	
GK2BRGSUP	160		GK2WL21VVT	177		GK2WL62VVT	170		K1MODTRIP	102	
GK2BRGVLHE	160		GK2WL22VVT	179		GK2WL63VVT	170		K1MODTRIP0	102	
GK2COOLLHE	174		GK2WL23VVT	179		GK2WL64VVT	171		K1MODTRIP0	104	
GK2FIREDEX	160		GK2WL24VVT	176		GK2WL65VVT	171		K2MODTRIP	180	
GK2GAC1HXF	175		GK2WL25VVT	176		GK2WL66VVT	171		K2MODTRIP	181	
GK2GAC1HXL	178		GK2WL26VVT	179		GK2WL67VVT	171		K2MODTRIP	198	
GK2GAC2HXF	176		GK2WL27VVT	179		GK2WL68VVT	172		K2MODTRIP0	181	

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K2NOMAIN	22		KK1RUNSDEX	21		KU1STARTR	3		KU2STARTR	70	
K2NOMAIN	35		KK1UNDRBHF	1		KU1STARTR	184		KU2STARTR	113	
K2NOMAIN	113		KK2RUNSDEX	123		KU1UNDER	2		KU2STARTR	184	
K2NOMAIN	182		KK2UNITHYM	3		KU1UNDER0	1		KU2STARTR	193	
K2NOMAIN	183		KK2UNITHYM	22		KU1UNDER0	2		KU2STARTR	196	
K2NOMAIN	185		KK2UNITHYM	65		KU2CREDIT	65		KU2STARTR	197	
K2NOMAIN	188		KK2UNITHYM	105		KU2GENCLD	70		KU2SWYD	215	
K2NOMAIN	188		KK2UNITHYM	191		KU2GENCLD	121		KU2SWYD	252	
K2NOMAIN	189		KNOTBOTH	3		KU2GENRUN	124		L0EGTPSCOM	221	
KA127T1R6D	187		KU1BOTH	21		KU2GENRUN	160		L0EGTPSCOM	223	
KA127T1R6T	187		KU1GENCLD	4		KU2GEXCLD	70		L0EGTPSCOM	233	
KA227T2R6T	188		KU1GENRUN	41		KU2GEXCLD	116		L0EGTPSCOM	235	
KB4CONNDEX	189		KU1GENRUN	82		KU2GEXRUN	124		L27BRX1RYD	224	
KBOTHNORN	3		KU1GEXCLD	4		KU2GEXRUN	158		L27BRX1RYD	224	
KCOMCSTRT	183		KU1GEXCLD	13		KU2GVTBCLD	70		L27BRX2RYD	243	
KCOMCSTRT	184		KU1GEXRUN	41		KU2GVTBCLD	113		L27BRX2RYD	243	
KCOMHSTRT	183		KU1GEXRUN	80		KU2GVTBHOT	70		L27BRY1RYD	224	
KCOMHSTRT	185		KU1GRID	188		KU2GVTBHOT	123		L27BRY1RYD	224	
KCOMM	183		KU1GVTBCLD	4		KU2GVTBRUN	124		L27BRY2RYD	243	
KCOMMODE	183		KU1GVTBHOT	23		KU2OVER	65		L27BRY2RYD	243	
KCOMMODE	188		KU1GVTBRUN	41		KU2OVER	70		L27BRZ1RYD	224	
KCOMNOMAIN	183		KU1RNNG	2		KU2OVER	105		L27BRZ1RYD	224	
KCOMRUN	183		KU1RNNG	21		KU2OVER	191		L27BRZ2RYD	243	
KCOMRUN	186		KU1RNNG	35		KU2OVER0	191		L27BRZ2RYD	243	
KEOWCOM	1		KU1RNNG	39		KU2REC	1		L27BYX1RYD	224	
KEOWCOM	183		KU1RNNG	107		KU2REC	105		L27BYX1RYD	224	
KEOWCOM	191		KU1RNNG	188		KU2RNNG	70		L27BYX2RYD	243	
KEOWTOP	1		KU1RNNG	204		KU2RNNG	113		L27BYX2RYD	243	
KK1BOTHDEX	3		KU1RUN	2		KU2RNNG	123		L27BYY1RYD	224	
KK1BOTHDEX	21		KU1RUN	41		KU2RNNG	196		L27BYY1RYD	224	
KK1BOTHDEX	123		KU1SPINNG	2		KU2RNNG	215		L27BYY2RYD	243	
KK1BOTHDEX	185		KU1SPINS	2		KU2RNNG	253		L27BYY2RYD	243	
KK1BOTHDEX	189		KU1SPINS	23		KU2RUN	70		L27BYZ1RYD	224	
KK1BOTHHYM	1		KU1START	2		KU2RUN	124		L27BYZ1RYD	224	
KK1BOTHHYM	191		KU1START0	2		KU2SPINNG	70		L27BYZ2RYD	243	
KK1NORUN	3		KU1STARTF	2		KU2START	70		L27BYZ2RYD	243	
KK1OVERBHF	202		KU1STARTF	4		KU2START0	70		L27XPX1RYD	224	

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L27XPX2RYD	243		L81BRX2RYD	244		L81XRY1RYD	222		MAINT	182	
L27XPY1RYD	224		L81BRY1RYD	222		L81XRY2RYD	244		MAINTCOM	188	
L27XPY1RYD	224		L81BRY1RYD	222		L81XRY2RYD	244		MAINTCOM	190	
L27XPY2RYD	243		L81BRY2RYD	244		L81XRZ1RYD	222		MODCLOSEF	196	
L27XPY2RYD	243		L81BRY2RYD	244		L81XRZ1RYD	222		NACB6OPEN	141	
L27XPZ1RYD	224		L81BRZ1RYD	222		L81XRZ2RYD	244		NACB6OPEN	143	
L27XPZ1RYD	224		L81BRZ1RYD	222		L81XRZ2RYD	244		NACB7OPEN	58	
L27XPZ2RYD	243		L81BRZ2RYD	244		L81XYX1RYD	222		NACB7OPEN	63	
L27XPZ2RYD	243		L81BRZ2RYD	244		L81XYX1RYD	222		NEWMODA	23	
L27XRX1RYD	224		L81BYX1RYD	222		L81XYX2RYD	244		NEWMODB	23	
L27XRX1RYD	224		L81BYX1RYD	222		L81XYX2RYD	244		NEWMODB	37	
L27XRX2RYD	243		L81BYX2RYD	244		L81XYY1RYD	222		NOAB1FALT	106	
L27XRX2RYD	243		L81BYX2RYD	244		L81XYY1RYD	222		NOFALT	106	
L27XRY1RYD	224		L81BYY1RYD	222		L81XYY2RYD	244		NOGENFAIL	196	
L27XRY1RYD	224		L81BYY1RYD	222		L81XYY2RYD	244		NOUNIT	1	
L27XRY2RYD	243		L81BYY2RYD	244		L81XYZ1RYD	222		NTACB4MOD	12	
L27XRY2RYD	243		L81BYY2RYD	244		L81XYZ1RYD	222		NTACB4MOD	15	
L27XRZ1RYD	224		L81BYZ1RYD	222		L81XYZ2RYD	244		NTACB4MOD	23	
L27XRZ1RYD	224		L81BYZ1RYD	222		L81XYZ2RYD	244		NTACB4MOD	35	
L27XRZ2RYD	243		L81BYZ2RYD	244		LC94F1ARYD	220		NTACB4MOD	37	
L27XRZ2RYD	243		L81BYZ2RYD	244		LC94F1BRYD	238		NTACB4MOD	102	
L27XSTARYD	25		L81XPX1RYD	222		LC94F1DRYD	231		NTACB4MOD	106	
L27XSTBRYD	32		L81XPX1RYD	222		LC94F2ARYD	226		NTACB4MOD	108	
L27XYX1RYD	224		L81XPX2RYD	244		LC94F2BRYD	245		NTACB4MOD	181	
L27XYX1RYD	224		L81XPX2RYD	244		LC94F2CRYD	247		NTACB4MOD	194	
L27XYX2RYD	243		L81XPY1RYD	222		LC94F2DRYD	232		NTACB4MOD	196	
L27XYX2RYD	243		L81XPY1RYD	222		LC94V1ARYD	220		NTACB4MOD	201	
L27XYY1RYD	224		L81XPY2RYD	244		LC94V1BRYD	238		OFACTORDEX	210	
L27XYY1RYD	224		L81XPY2RYD	244		LC94V1DRYD	231		OK0PRUNCOM	186	
L27XYY2RYD	243		L81XPZ1RYD	222		LC94V2ARYD	226		OK10001PSC	48	
L27XYY2RYD	243		L81XPZ1RYD	222		LC94V2BRYD	245		OK10002PSC	49	
L27XYZ1RYD	224		L81XPZ2RYD	244		LC94V2CRYD	234		OK10003PSC	52	
L27XYZ1RYD	224		L81XPZ2RYD	244		LC94V2CRYD	247		OK10003RVT	42	
L27XYZ2RYD	243		L81XRX1RYD	222		LDCYC13CDT	223		OK10003TKF	42	
L27XYZ2RYD	243		L81XRX1RYD	222		LDCYC14CDT	221		OK10004PSC	46	
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OK10011CVO	43		OK1324	48		OK20001PSC	131		OK2310	126	
OK10011CVO	47		OK1325	46		OK20002PSC	132		OK2320	130	
OK10011CVT	43		OK1350	43		OK20003PSC	134		OK2321	130	
OK10011CVT	47		OK1355	43		OK20003RVT	125		OK2322	130	
OK10012VVT	43		OK1355	44		OK20003TKF	125		OK2322	131	
OK10012VVT	47		OK1360	44		OK20004PSC	129		OK2323	131	
OK10013RVT	43		OK1400	41		OK20007FVT	126		OK2324	127	
OK10013RVT	47		OK1400	47		OK20009VVT	126		OK2324	129	
OK10014CVO	48		OK1410	47		OK20011CVO	126		OK2324	131	
OK10014CVT	48		OK1410B	47		OK20011CVO	130		OK2325	129	
OK10015VVT	48		OK1410B	48		OK20011CVT	126		OK2350	126	
OK10016RVT	48		OK1410C	47		OK20011CVT	130		OK2355	126	
OK10017CVO	50		OK1410C	50		OK20012VVT	126		OK2355	127	
OK10017CVT	50		OK1411B	48		OK20012VVT	130		OK2360	127	
OK10018VVT	50		OK1411B	49		OK20013RVT	126		OK2400	124	
OK10019RVT	50		OK1411C	50		OK20013RVT	130		OK2400	130	
OK1001AGPR	44		OK1411C	52		OK20014CVO	131		OK2410	130	
OK1001AGPR	47		OK1412B	49		OK20014CVT	131		OK2410B	130	
OK1001AGPS	44		OK1412C	52		OK20015VVT	131		OK2410B	131	
OK1001AGPS	47		OK1500	42		OK20016RVT	131		OK2410C	130	
OK1001BGPR	49		OK1600	41		OK20017CVO	133		OK2410C	133	
OK1001BGPS	49		OK188GASWT	44		OK20017CVT	133		OK2411B	131	
OK1001BLHE	49		OK188GASWT	48		OK20018VVT	133		OK2411B	132	
OK1001CGPR	52		OK188GBSWT	49		OK20019RVT	133		OK2411C	133	
OK1001CGPS	52		OK188GCSWT	52		OK2002AGPR	127		OK2411C	134	
OK1001CLHE	52		OK199K1RYD	46		OK2002AGPR	130		OK2412B	132	
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OK1300	41		OK1AG01TKF	42		OK2002BGPR	132		OK2600	124	
OK1300	43		OK1AG04RVT	42		OK2002BGPS	132		OK288GASWT	127	
OK1310	43		OK1AG05VVT	42		OK2002BLHE	132		OK288GASWT	131	
OK1320	47		OK1OG1CTRM	50		OK2002CGPR	134		OK288GBSWT	132	
OK1321	47		OK1PRUNCOM	47		OK2002CGPS	134		OK288GCSWT	134	
OK1322	47		OK1PSTRCOM	47		OK2002CLHE	134		OK299K1RYD	129	
OK1322	48		OK1XA1DCLT	44		OK2200	124		OK299K1RYT	129	
OK1323	48		OK1XA1DCLT	47		OK2200	125		OK299K2RYD	129	
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SDCDB01CDT	230		SDCDYE	255		SEG94F2DF	231		SEGTP1BNIT	25	
SDCDB13CDT	229		SDCDYE8CDT	237		SEG94F2DF	232		SEGTP1BNIT	236	
SDCDC12CDT	195		SDCDYE9CDT	215		SEG94F2DF	251		SEGTP1BNIT	237	
SDCDE12CDT	241		SDCDYE9CDT	255		SEG94F2F	226		SEGTP1BNIT	238	
SDCDE15CDT	246		SDCDYF	225		SEG94F2F	232		SEGTP1BNIT	246	
SDCDE17CDT	248		SDCDYF	225		SEG94F2F	233		SEGTP1BNIT	248	
SDCDF01CDT	230		SDCDYF	227		SEG94F2F	245		SEGTP1DNIT	230	
SDCDF13CDT	229		SDCDYF	228		SEG94F2F	247		SEGTP2ANIT	225	
SDCDG16CDT	249		SDCDYF	229		SEG94V1AF	220		SEGTP2ANIT	226	
SDCDYA	234		SDCDYF	230		SEG94V1BF	238		SEGTP2ANIT	227	
SDCDYA	236		SDCDYF4CDT	225		SEG94V1DF	230		SEGTP2ANIT	228	
SDCDYA	237		SDCDYF6CDT	227		SEG94V1DF	231		SEGTP2ANIT	229	
SDCDYA	246		SDCDYF8CDT	228		SEG94V1DF	251		SEGTP2BNIT	32	
SDCDYA	248		SDCDYG	233		SEG94V1F	220		SEGTP2BNIT	237	
SDCDYA	250		SDCDYG	235		SEG94V1F	223		SEGTP2BNIT	239	
SDCDYA	255		SDCDYG	242		SEG94V1F	231		SEGTP2BNIT	248	
SDCDYA8CDT	237		SDCDYG	249		SEG94V1F	238		SEGTP2DNIT	230	
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SDCDYB	219		SEG152INIT	246		SEG94V2AF	241		SEGTPSCH1F	26	
SDCDYB	219		SEG152INIT	247		SEG94V2BF	239		SEGTPSCH1F	255	
SDCDYB	227		SEG94F1AF	220		SEG94V2BF	241		SEGTPSCH2F	31	
SDCDYB	228		SEG94F1BF	238		SEG94V2BF	245		SEGTPSCH2F	32	
SDCDYB	229		SEG94F1DF	230		SEG94V2BF	247		SEGTPSCH2F	255	
SDCDYB	230		SEG94F1DF	231		SEG94V2CF	247		SEGX1Y1UF	221	
SDCDYB4CDT	219		SEG94F1DF	251		SEG94V2DF	231		SEGX1Y1UF	222	
SDCDYB6CDT	227		SEG94F1F	220		SEG94V2DF	234		SEGX1Y1UV	223	
SDCDYB8CDT	228		SEG94F1F	221		SEG94V2DF	251		SEGX1Y1UV	224	
SDCDYC	195		SEG94F1F	231		SEG94V2F	226		SEGX1Z1UF	221	
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SDCDYC	221		SEG94F2AF	226		SEG94V2F	235		SEGX1Z1UV	223	
SDCDYC	223		SEG94F2AF	226		SEG94V2F	245		SEGX1Z1UV	224	
SDCDYE	215		SEG94F2AF	241		SEG94V2F	247		SEGX2Y2UF	233	
SDCDYE	237		SEG94F2BF	239		SEGTP1ANIT	219		SEGX2Y2UF	244	
SDCDYE	239		SEG94F2BF	241		SEGTP1ANIT	220		SEGX2Y2UV	235	
SDCDYE	241		SEG94F2BF	245		SEGTP1ANIT	227		SEGX2Y2UV	243	
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SEGX2Z2UV	243		SPCB09CF	215		SPCB28TF	228		SPLYTRANS2	158	
SEGY1Z1UF	221		SPCB09TCF	255		SPCB33TC1	229		SU127UVCOM	211	
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SEGY2Z2UF	233		SPCB12TCF	236		SPCB33TF	229		SXFRCT3THF	202	
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SKXFMR1THF	65		SPCB17TC2	248		SPCBSFC1	218		SY30R94RYT	209	
SKXFMR1THF	141		SPCB17TCF	248		SPCBSFC1	236		SY51TN2RYT	207	
SPC14KVBHF	69		SPCB17TF	236		SPCBSFC2	218		SY51TN4RYT	207	
SPC51TNRYT	203		SPCB17TF	248		SPCCB9CF	215		SY51TN6RYT	207	
SPC62ABRYT	69		SPCB21TC1	230		SPCD87LRYT	203		SY62BFCT3	207	
SPC631XRYT	204		SPCB21TC2	230		SPCGLASSWT	204		SY62BFCT3	207	
SPC871XRYT	203		SPCB21TCF	230		SPCISLTCPT	193		SY62X1FRYT	208	
SPC872XRYT	203		SPCB21TF	218		SPCISLTCPT	195		SY62X2FRYT	208	
SPC87T1RYT	203		SPCB21TF	230		SPCISLTCPT	215		SY62XXFRYT	208	
SPC94TKRYT	69		SPCB24TC1	218		SPCISOCCH1	195		SY86BUIRYT	207	
SPCB008CHO	237		SPCB24TC1	219		SPCISOCCH2	195		SY86CT3LOR	202	
SPCB009CHC	215		SPCB24TC2	218		SPCISOCCH2	249		SY86CT3LOR	207	
SPCB009CHO	255		SPCB24TC2	225		SPCISOF	195		SY86CT3RYT	207	
SPCB012CHO	236		SPCB24TCF	218		SPCISOF	218		SY86YA9RYT	208	
SPCB015CHO	236		SPCB24TF	218		SPCISOF	249		SY86YBSLOR	202	
SPCB017CHO	248		SPCB26TC1	218		SPCISOLATE	215		SY86YBSLOR	208	
SPCB021CHO	230		SPCB26TC1	227		SPCISOLATE	251		SY86YJ3RYT	208	
SPCB024CHO	218		SPCB26TC2	218		SPCR86TRYT	69		SY87BYXRYT	208	
SPCB026CHO	218		SPCB26TC2	227		SPLYCLOSE1	13		SY87BYYRYT	208	
SPCB028CHO	228		SPCB26TCF	218		SPLYCLOSE1	16		SY87BYZRYT	208	
SPCB033CHO	229		SPCB26TF	218		SPLYCLOSE1	18		SY87LXXRYT	209	
SPCB08TCF	237		SPCB28TC1	228		SPLYCLOSE2	116		SY94L1XRYT	209	
SPCB08TF	236		SPCB28TC2	228		SPLYCLOSE2	117		SYE1362RYT	207	

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SYP2862RYT	207		WK1GVRNDEX	41		XA1XA1ACLT	190		XA2XAALBLM	128	
SYP3062RYT	207		WK1SPD1DEX	37		XA1XAALBLM	45		XA2XAALBLM	190	
SYP86TXRYT	209		WK1SPD2DEX	40		XA1XAALBLM	190		XA2XAE	190	
SYPCB09CHT	202		WK1SPD2DEX	41		XA1XAE	190		XA2XAEF	190	
SYPCB30CHT	202		WK1TBCDDEX	4		XA1XAEF	190		XA2XAMCBLF	128	
SYPCB30TRP	202		WK1TBHTDEX	23		XA1XAMCBLF	45		XA2XAMCBLF	138	
SYPCB30TRP	209		WK1TBRNDEX	41		XA1XAMCBLF	54		XA2XAN	128	
SYPCB9TRP	202		WK1TURRUN	41		XA1XAN	45		XA2XANF	128	
SYPCB9TRP	209		WK2GOVRUN	124		XA1XANF	45		XA2XANORM	128	
SYPL86TRYT	209		WK2GVCDDEX	113		XA1XANORM	45		XA2XE	141	
SYPL87LRYT	209		WK2GVCDLHE	113		XA1XCXXTHM	58		XA2XE	145	
SYR86BYRYT	208		WK2GVHTDEX	123		XA1XCXXTHM	145		XA2XN	141	
SYS63FPRYT	207		WK2GVRNDEX	124		XA1XCXXTLF	58		XA2XSRCE	141	
SYSX50BRYT	207		WK2SPD2DEX	124		XA1XCXXTLF	145		XA2XXXXBLF	141	
SYX87TBRYT	207		WK2SPD2DEX	254		XA1XE	58		XA56BKRCOM	67	
SYXX87TRYT	207		WK2TBCDDEX	113		XA1XE	65		XA56BKRCOM	142	
U5086EFRYT	103		WK2TBHTDEX	123		XA1XE0	65		XA78BKRCOM	61	
U5186EFRYT	103		WK2TBRNDEX	124		XA1XE0	65		XA78BKRCOM	146	
U51TNC4RYT	103		WK2TURRUN	124		XA1XN	58		XACB6	141	
U62BSK1RYT	103		WKCSTRTCOM	184		XA1XSRCE	58		XACB7	58	
U62BSK2RYT	103		WKHSTRTCOM	185		XA1XXXXBLF	58		XD0BATTCOM	183	
U86CT4XRYT	103		XA0SWGRCOM	185		XA2A2BTCDT	138		XD0CHRGCOM	185	
U86EF	1		XA1A2BTCDT	54		XA2BKRSCOM	142		XD104CCCDT	53	
U86EF	102		XA1BKRSCOM	61		XA2BKRSCOM	146		XD104CCCDT	83	
U86EF	103		XA1BKRSCOM	67		XA2TR2XTLF	141		XD104CRCDT	9	
U86EF	180		XA1TR1XTLF	65		XA2X	128		XD1BK1ACDT	38	
U86TCT4RYT	103		XA1X	45		XA2X	141		XD1CKC1BCF	54	
U87TCT4RYT	103		XA1X	58		XA2X	190		XD1DA1CCDT	54	
UACXCT4THF	103		XA1X	190		XA2X2BXCLT	128		XD1DA3BCDT	46	
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UNDERTOP	1		XA1X2CCCLT	45		XA2X4AXCLT	190		XD1DA4ACDT	74	
UPATHTOP	1		XA1XA	44		XA2XA	127		XD1DA4ACDT	85	
UXX86EFRYT	103		XA1XA	45		XA2XA	128		XD1DALTBYM	11	
WK00RUNCOM	186		XA1XA	47		XA2XA	130		XD1DALTBYM	12	
WK1GOVRUN	41		XA1XA	49		XA2XA	132		XD1DALTBYM	38	
WK1GVCDDEX	4		XA1XA	52		XA2XA	134		XD1DALTR	38	
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YKESRXA	110	
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YO2KESCHBF	10	
YO2KESCHBF	33	
YO2KSCHAIF	27	
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XD2DA5CCDT	251		XD2TIE2CDT	252		YK1CLDSRTF	109		YK1STR2INT	113	
XD2DALTBYM	88		XFMR186T	9		YK1CLDSTRT	107		YK1STR2INT	122	
XD2DALTBYM	134		XFMR186T	17		YK1CLDSTRT	107		YK1STR2INT	143	
XD2DALTBYM	163		XFMR186T	23		YK1CLDSTRT	109		YK1STRTINT	111	
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XD2DALTRF	163		XFMR186T	177		YK1ES1ARYD	112		YK1STRTINT	119	
XD2DALTRF	252		XFMR186T	218		YK1ES1BRYD	112		YK1STRTINT	124	
XD2DALTS	88		XFMR186T	261		YK1ES2ARYD	113		YK1STRTINT	129	
XD2DANORMR	163		XFMRPROT	17		YK1ES2BRYD	113		YK1STRTINT	130	
XD2DANORMS	88		XFMRPROT	28		YK1ESRX1A	112		YK1SXRUNF	158	
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XD2DANORWF	134		YK114X3SSD	110		YK1ESRX2A	113		YK1SXRUNF	182	
XD2DANORWF	163		YK13SUISWT	160		YK1ESRX2B	113		YK214X3SSD	227	
XD2DANRMRF	163		YK13SUISWT	193		YK1HOTSTRT	128		YK23SUISWT	250	
XD2DANRMRF	251		YK14AMRRYT	160		YK1HOTSTRT	130		YK23SUISWT	282	
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XD2DAR	248		YK163BLRYT	160		YK1MR4ARUN	183		YK263BLLST	249	
XD2DAR	268		YK163TBLST	160		YK1MR4ARYD	111		YK263BLRYT	249	
XD2DAR	274		YK163TBRYT	160		YK1MR4ASRT	111		YK263TBLST	249	
XD2DAR	283		YK186N1DEX	159		YK1MR4ASRT	111		YK263TBRYT	249	
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XD2DASRCER	163		YK199SDRYT	158		YK1MR4ASRT	180		YK286N2DEX	248	
XD2DASRCES	8		YK199SNCF	109		YK1MR4BRUN	193		YK299SDRYD	226	
XD2DASRCES	88		YK199SNRYD	110		YK1MR4BRYD	193		YK299SDRYT	248	
XD2DASRCES	115		YK199SNRYD	110		YK1OPFAIL	158		YK299SNCF	226	
XD2DASRCES	224		YK199SNRYD	116		YK1OPFAIL	159		YK299SNRYD	227	
XD2DASRCES	226		YK199SNRYT	158		YK1RUNCNTL	144		YK299SNRYD	227	
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XD2DASRCES	235		YK199SNSRT	110		YK1S122RPM	109		YK299SNRYT	248	
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PMFB2M	310		S127EUVF	37		SDC1ALTF	72		SDCDYB	53	
PMFB2MN	103		S127EUVRYT	37		SDC1NORM	42		SDCDYB	54	
PMFB2MN	103		S127EUVRYT	40		SDC1NORMF	42		SDCDYB	56	
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PN1OPEN	309		S127EXVRYD	40		SDC1NORMWF	71		SDCDYB6CDT	53	
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PS1INIT	98		S227EUVRYT	38		SDC2	61		SDCDYC	47	
PS2CLOSE	315		S227EUVRYT	40		SDC2	69		SDCDYC	49	
PS2INIT	315		S227EX1RYD	38		SDC2	72		SDCDYE	69	
PS2INIT	316		S227EXVRYD	38		SDC2	74		SDCDYE	69	
PSB1	2		S227EXVRYD	40		SDCAIDDDIF	83		SDCDYE	73	
PSB1	98		S27XSC1RYD	14		SDCDA12CDT	70		SDCDYE	78	
PSB1S	98		S27XSC2RYD	82		SDCDA15CDT	78		SDCDYE	81	
PSB1S	104		S27XTD1RYD	14		SDCDA17CDT	80		SDCDYE	83	
PSB2	310		S27XTD2RYD	82		SDCDB01CDT	58		SDCDYE	90	
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OMODU3F	39		PACN1N2COM	310		PDC1D27CDT	315		PK22001	253	
OMODU3F	40		PACS1CSMOD	98		PDCA026CDT	92		PK2210	274	
OMODWOF	36		PACS1S2COM	98		PDCC027CDT	311		PK263SALST	273	
OMODWOF	40		PACS1S2COM	315		PE1CLOSE	2		PK263SBLST	274	
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OPATHTOPC	27		PACSK12COM	104		PK1100	164		PK2PACKDEX	275	
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OVRLDNT	36		PACTC14C4T	170		PK12000	164		PK2TSACGPR	273	
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OVRLOAD	36		PACXCT5THF	309		PK1210	185		PK2TSDCLHE	274	
OVRLOADS	36		PACXE01C4C	92		PK163SALST	184		PK2TSDCTRM	274	
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P1TC	170		PACXN01C4O	2		PK1ACDCCOM	164		PKEOSB1	104	
P1TC	262		PACXN02C4O	310		PK1DA5CCDT	185		PKEOSB2	104	
P1TCMFB1	170		PACXS01C4C	98		PK1PACK	164		PLEES	309	
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PAC1TC4C4T	262		PACXSB2BHM	103		PK1TS02CVT	184		PLEESB2	308	
PACE1CSMOD	92		PACXSB2BHM	103		PK1TS03VVT	185		PLEESB2CN	104	
PACE1E2COM	92		PACXSK1C4C	104		PK1TS04CVT	185		PLEESB2CN	308	
PACE1E2COM	311		PACXSK2C4C	104		PK1TSACGPR	184		PMFB1	1	
PACE2CSMOD	311		PACXSL1C4T	308		PK1TSDCGPR	185		PMFB1	2	
PACLEESCTR	309		PACXSL2C4T	308		PK1TSDCLHE	185		PMFB1A	2	
PACLINEDEX	309		PCB9OPEN	85		PK1TSDCTRM	185		PMFB1M	2	
PACMFB1BHF	2		PCB9OPEN	89		PK1XA2CCLT	184		PMFB1M	103	
PACMFB1BHM	103		PCT5	308		PK2100	253		PMFB1MN	310	
PACMFB1BHM	310		PCT5	308		PK2100	273		PMFB1SU	2	
PACMFB2BHF	310		PCT5	309		PK2110	273		PMFB2	1	

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OK1001BLHE	154		OK1500	145		OK20016RVT	245		OK2410C	243	
OK1001CGPR	157		OK1600	144		OK20017CVO	246		OK2410C	246	
OK1001CGPS	157		OK188GASWT	148		OK20017CVT	246		OK2411B	245	
OK1001CLHE	157		OK188GASWT	152		OK20018VVT	246		OK2411B	245	
OK1200	144		OK188GBSWT	155		OK20019RVT	246		OK2411C	246	
OK1200	145		OK188GCSWT	155		OK2002AGPR	240		OK2411C	247	
OK1300	144		OK199K1RYD	150		OK2002AGPR	244		OK2412B	245	
OK1300	146		OK199K1RYT	150		OK2002AGPS	240		OK2412B	246	
OK1310	146		OK199K2RYD	150		OK2002AGPS	244		OK2412C	247	
OK1320	151		OK1AG01TKF	145		OK2002BGPR	245		OK2412C	247	
OK1321	151		OK1AG04RVT	145		OK2002BGPS	245		OK2500	237	
OK1321	152		OK1AG05VVT	145		OK2002BLHE	245		OK2600	236	
OK1322	152		OK1OG1CTRM	156		OK2002CGPR	247		OK2600	237	
OK1323	152		OK1PRUNCOM	151		OK2002CGPS	247		OK288GASWT	240	
OK1324	148		OK1PSTRCOM	151		OK2002CLHE	247		OK288GASWT	244	
OK1324	150		OK1XA1DCLT	148		OK2200	237		OK288GBSWT	246	
OK1324	152		OK1XA1DCLT	152		OK2300	237		OK288GCSWT	247	
OK1325	150		OK1XA2ECLT	154		OK2300	238		OK299K1RYD	242	
OK1350	146		OK1XA4DCLT	157		OK2310	238		OK299K1RYT	242	
OK1350	147		OK20001PSC	244		OK2320	243		OK299K2RYD	242	
OK1355	147		OK20002PSC	246		OK2321	243		OK2AG04RVT	237	
OK1355	148		OK20003PSC	247		OK2321	244		OK2AG05VVT	237	
OK1360	148		OK20003RVT	237		OK2322	244		OK2AGO1TKF	237	
OK1400	144		OK20003TKF	237		OK2323	244		OK2OG2CTRM	246	
OK1400	151		OK20004PSC	242		OK2324	240		OK2PRUNCOM	243	
OK1410	151		OK20007FVT	238		OK2324	242		OK2PSTRCOM	243	
OK1410B	151		OK20009VVT	238		OK2324	244		OK2XA1DCLT	240	
OK1410B	153		OK20011CVO	239		OK2325	242		OK2XA1DCLT	244	
OK1410C	151		OK20011CVO	243		OK2350	238		OK2XA2ECLT	245	
OK1410C	156		OK20011CVT	239		OK2350	239		OK2XA4DCLT	247	
OK1411B	153		OK20011CVT	243		OK2355	239		OMOD	36	
OK1411B	154		OK20012VVT	239		OK2355	240		OMOD	40	
OK1411C	156		OK20012VVT	243		OK2360	240		OMODF	36	
OK1411C	157		OK20013RVT	239		OK2400	237		OMODF	37	
OK1412B	154		OK20013RVT	243		OK2400	243		OMODNOT	36	
OK1412B	155		OK20014CVO	245		OK2410	243		OMODNOT	40	
OK1412C	155		OK20014CVT	245		OK2410B	243		OMODU1F	37	

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L27XRZ2RYD	75		L81BYZ2RYD	76		LC94F1BRYD	68		NTACB4MOD	121	
L27XSTARYD	90		L81XPX1RYD	48		LC94F1DRYD	59		NTACB4MOD	138	
L27XSTBRYD	90		L81XPX1RYD	48		LC94F2ARYD	52		NTACB4MOD	140	
L27XYX1RYD	50		L81XPX2RYD	76		LC94F2BRYD	77		NTACB4MOD	212	
L27XYX1RYD	50		L81XPX2RYD	76		LC94F2CRYD	79		NTACB4MOD	217	
L27XYX2RYD	75		L81XPY1RYD	48		LC94F2DRYD	61		NTACB4MOD	220	
L27XYX2RYD	75		L81XPY1RYD	48		LC94V1ARYD	46		OFACTORDEX	36	
L27XYY1RYD	50		L81XPY2RYD	76		LC94V1BRYD	68		OK0PRUNCOM	302	
L27XYY1RYD	50		L81XPY2RYD	76		LC94V1DRYD	59		OK10001PSC	152	
L27XYY2RYD	75		L81XPZ1RYD	48		LC94V2ARYD	52		OK10002PSC	155	
L27XYY2RYD	75		L81XPZ1RYD	48		LC94V2BRYD	77		OK10003PSC	155	
L27XYZ1RYD	50		L81XPZ2RYD	76		LC94V2CRYD	63		OK10003RVT	145	
L27XYZ1RYD	50		L81XPZ2RYD	76		LC94V2CRYD	79		OK10003TKF	145	
L27XYZ2RYD	75		L81XRX1RYD	48		LDCYC13CDT	49		OK10004PSC	150	
L27XYZ2RYD	75		L81XRX1RYD	48		LDCYC14CDT	47		OK10007FVT	146	
L81BRX1RYD	48		L81XRX2RYD	76		LDCYG12CDT	64		OK10009VVT	146	
L81BRX1RYD	48		L81XRX2RYD	76		LDCYG18CDT	62		OK10011CVO	147	
L81BRX2RYD	76		L81XRY1RYD	48		MAINT	105		OK10011CVO	151	
L81BRX2RYD	76		L81XRY1RYD	48		MAINT	300		OK10011CVT	147	
L81BRY1RYD	48		L81XRY2RYD	76		MAINTCOM	305		OK10011CVT	151	
L81BRY1RYD	48		L81XRY2RYD	76		MAINTCOM	307		OK10012VVT	147	
L81BRY2RYD	76		L81XRZ1RYD	48		MODCLOSEF	15		OK10012VVT	151	
L81BRY2RYD	76		L81XRZ1RYD	48		NACB6OPEN	257		OK10013RVT	147	
L81BRZ1RYD	48		L81XRZ2RYD	76		NACB7OPEN	168		OK10013RVT	151	
L81BRZ1RYD	48		L81XRZ2RYD	76		NEWMODA	128		OK10014CVO	153	
L81BRZ2RYD	76		L81XYX1RYD	48		NEWMODA	138		OK10014CVT	153	
L81BRZ2RYD	76		L81XYX1RYD	48		NEWMODB	128		OK10015VVT	153	
L81BYX1RYD	48		L81XYX2RYD	76		NEWMODB	140		OK10016RVT	153	
L81BYX1RYD	48		L81XYX2RYD	76		NOAB1FALT	217		OK10017CVO	156	
L81BYX2RYD	76		L81XYY1RYD	48		NOFALT	217		OK10017CVT	156	
L81BYX2RYD	76		L81XYY1RYD	48		NOGENFAIL	15		OK10018VVT	156	
L81BYY1RYD	48		L81XYY2RYD	76		NOUNIT	105		OK10019RVT	156	
L81BYY1RYD	48		L81XYY2RYD	76		NTACB4MOD	13		OK1001AGPR	148	
L81BYY2RYD	76		L81XYZ1RYD	48		NTACB4MOD	13		OK1001AGPR	152	
L81BYY2RYD	76		L81XYZ1RYD	48		NTACB4MOD	15		OK1001AGPS	148	
L81BYZ1RYD	48		L81XYZ2RYD	76		NTACB4MOD	19		OK1001AGPS	152	
L81BYZ1RYD	48		L81XYZ2RYD	76		NTACB4MOD	25		OK1001BGPR	154	

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KCOMRUN	301		KU1GVTBRUN	106		KU2OVER	214		L27BRZ1RYD	50	
KCOMRUN	303		KU1GVTBRUN	144		KU2OVER0	3		L27BRZ2RYD	75	
KEOWCOM	3		KU1RNNG	19		KU2OVER0	4		L27BRZ2RYD	75	
KEOWCOM	91		KU1RNNG	20		KU2REC	105		L27BYX1RYD	50	
KEOWCOM	105		KU1RNNG	29		KU2REC	214		L27BYX1RYD	50	
KK1BOTHDEX	16		KU1RNNG	128		KU2RNNG	5		L27BYX2RYD	75	
KK1BOTHDEX	20		KU1RNNG	143		KU2RNNG	8		L27BYX2RYD	75	
KK1BOTHDEX	108		KU1RNNG	219		KU2RNNG	15		L27BYY1RYD	50	
KK1BOTHDEX	302		KU1RNNG	305		KU2RNNG	16		L27BYY1RYD	50	
KK1BOTHDEX	306		KU1RUN	106		KU2RNNG	85		L27BYY2RYD	75	
KK1BOTHHYM	3		KU1SPINNG	106		KU2RNNG	86		L27BYY2RYD	75	
KK1BOTHHYM	300		KU1SPINNG	128		KU2RUN	5		L27BYZ1RYD	50	
KK1BOTHHYM	308		KU1SPINS	128		KU2RUN	236		L27BYZ1RYD	50	
KK1BOTHHYM	308		KU1START	106		KU2SPINNG	5		L27BYZ2RYD	75	
KK1NORUN	108		KU1START	107		KU2START	5		L27BYZ2RYD	75	
KK1OVERBHF	28		KU1START0	106		KU2START0	5		L27XPX1RYD	50	
KK1RUNSDEX	20		KU1STARTF	107		KU2STARTF	5		L27XPX1RYD	50	
KK1RUNSDEX	108		KU1STARTR	107		KU2STARTF	225		L27XPX2RYD	75	
KK1UNDRBHF	105		KU1STARTR	108		KU2STARTR	5		L27XPX2RYD	75	
KK2RUNSDEX	16		KU1STARTR	301		KU2STARTR	8		L27XPY1RYD	50	
KK2UNITHYM	3		KU1UNDER	106		KU2STARTR	9		L27XPY1RYD	50	
KK2UNITHYM	18		KU1UNDER0	105		KU2STARTR	15		L27XPY2RYD	75	
KK2UNITHYM	108		KU1UNDER0	106		KU2STARTR	19		L27XPY2RYD	75	
KK2UNITHYM	175		KU2CREDIT	167		KU2STARTR	301		L27XPZ1RYD	50	
KK2UNITHYM	214		KU2GENCLD	225		KU2SWYD	85		L27XPZ1RYD	50	
KNOTBOTH	108		KU2GENRUN	236		L0EGTPSCOM	47		L27XPZ2RYD	75	
KU1BOTH	20		KU2GENRUN	279		L0EGTPSCOM	49		L27XPZ2RYD	75	
KU1GENCLD	107		KU2GEXCLD	225		L0EGTPSCOM	62		L27XRX1RYD	50	
KU1GENCLD	127		KU2GEXCLD	229		L0EGTPSCOM	64		L27XRX1RYD	50	
KU1GENRUN	106		KU2GEXRUN	236		L27BRX1RYD	50		L27XRX2RYD	75	
KU1GENRUN	190		KU2GEXRUN	278		L27BRX1RYD	50		L27XRX2RYD	75	
KU1GEXCLD	107		KU2GVTBCLD	225		L27BRX2RYD	75		L27XRY1RYD	50	
KU1GEXCLD	119		KU2GVTBHOT	5		L27BRX2RYD	75		L27XRY1RYD	50	
KU1GEXRUN	106		KU2GVTBHOT	235		L27BRY1RYD	50		L27XRY2RYD	75	
KU1GEXRUN	188		KU2GVTBRUN	236		L27BRY1RYD	50		L27XRY2RYD	75	
KU1GRID	305		KU2OVER	4		L27BRY2RYD	75		L27XRZ1RYD	50	
KU1GVTBCLD	107		KU2OVER	5		L27BRY2RYD	75		L27XRZ1RYD	50	

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GK286E2RYT	250		GK2O121SST	25		GK2WL55VVT	287		K12COM01	305	
GK286E2RYT	282		GK2SUPRT	279		GK2WL56VVT	288		K12COM02	304	
GK287G2RYT	23		GK2WL16VVT	296		GK2WL57VVT	288		K12COM02	305	
GK287GBRYT	23		GK2WL17VVT	296		GK2WL58VVT	288		K12COM03	305	
GK287TERYT	23		GK2WL18VVT	297		GK2WL59VVT	288		K12COM04	305	
GK2BRGDSCH	280		GK2WL19VVT	297		GK2WL60VVT	289		K12COM04	306	
GK2BRGSUP	279		GK2WL20VVT	296		GK2WL61VVT	289		K12COM1DEX	306	
GK2BRGVLHE	280		GK2WL21VVT	296		GK2WL62VVT	289		K12NOMAIN	300	
GK2COOLLHE	293		GK2WL22VVT	297		GK2WL63VVT	289		K1MODTRIP	212	
GK2FIREDEX	279		GK2WL23VVT	297		GK2WL64VVT	290		K1MODTRIP0	212	
GK2GAC1HXF	294		GK2WL24VVT	294		GK2WL65VVT	290		K1MODTRIP0	214	
GK2GAC1HXL	298		GK2WL25VVT	294		GK2WL66VVT	290		K2MODTRIP	21	
GK2GAC2HXF	295		GK2WL26VVT	297		GK2WL67VVT	290		K2MODTRIP	26	
GK2GAC2HXL	298		GK2WL27VVT	297		GK2WL68VVT	291		K2MODTRIP	299	
GK2GAC3HXF	295		GK2WL28VVT	295		GK2WL69VVT	291		K2MODTRIP0	26	
GK2GAC3HXL	298		GK2WL29VVT	295		GK2WL70VVT	291		K2NOMAIN	18	
GK2GAC4HXF	294		GK2WL30VVT	297		GK2WL71VVT	291		K2NOMAIN	18	
GK2GAC4HXL	298		GK2WL31VVT	297		GK2WL72VVT	292		K2NOMAIN	19	
GK2GAC5HXF	296		GK2WL32VVT	295		GK2WL73VVT	292		K2NOMAIN	20	
GK2GAC5HXL	298		GK2WL33VVT	295		GK2WL74VVT	292		K2NOMAIN	91	
GK2GAC6HXF	296		GK2WL34VVT	297		GK2WL75VVT	292		K2NOMAIN	300	
GK2GAC6HXL	298		GK2WL35VVT	297		GK2WL76VVT	280		K2NOMAIN	302	
GK2GENCOOL	279		GK2WL36VVT	294		GK2WL78VVT	280		K2NOMAIN	304	
GK2GENCOOL	293		GK2WL37VVT	294		GK2WLLEAK	279		K2NOMAIN	305	
GK2HPO1HXF	285		GK2WL38VVT	297		GK2WLVLEAK	279		K2NOMAIN	305	
GK2HPO2HXF	286		GK2WL39VVT	297		GK2WLVLEAK	297		KA127T1R6D	304	
GK2HPO3HXF	287		GK2WL41VVT	293		GKHPOILCOM	303		KA127T1R6T	304	
GK2HPO4HXF	288		GK2WL44VVT	285		GMODTRIP1	220		KA227T2R6T	305	
GK2HPO5HXF	289		GK2WL45VVT	285		GMODTRIP2	25		KB4CONNDEX	305	
GK2HPO6HXF	290		GK2WL46VVT	285		GOVTBCOM	302		KBOTHNORN	108	
GK2HPO6VVT	279		GK2WL47VVT	285		GOVTBCOM	303		KCOMCSTRT	301	
GK2HPO7HXF	291		GK2WL48VVT	286		GSBFAIL1	122		KCOMHSTRT	301	
GK2HPO8HXF	292		GK2WL49VVT	286		GSBFAIL1	123		KCOMHSTRT	302	
GK2HXLEAK	279		GK2WL50VVT	286		GSBFAIL2	230		KCOMM	91	
GK2HXLEAK	298		GK2WL51VVT	286		GSBFAIL2	231		KCOMM	301	
GK2MODTRIP	23		GK2WL52VVT	287		GSBTRIP1	122		KCOMMODE	91	
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GK1GAC5HXL	210		GK1WL33VVT	207		GK1WL74VVT	204		GK2316A	290	
GK1GAC6HXF	208		GK1WL34VVT	209		GK1WL75VVT	204		GK2316B	290	
GK1GAC6HXL	210		GK1WL35VVT	209		GK1WL76VVT	191		GK2317	284	
GK1GENCOOL	190		GK1WL36VVT	206		GK1WL78VVT	191		GK2317	291	
GK1GENCOOL	205		GK1WL37VVT	206		GK1WLLEAK	190		GK2317A	291	
GK1HPO1HXF	197		GK1WL38VVT	209		GK1WLVLEAK	190		GK2317B	291	
GK1HPO2HXF	198		GK1WL39VVT	209		GK1WLVLEAK	209		GK2318	284	
GK1HPO3HXF	199		GK1WL41VVT	205		GK20001HGR	279		GK2318	292	
GK1HPO4HXF	200		GK1WL44VVT	197		GK20002HGS	225		GK2318A	292	
GK1HPO5HXF	201		GK1WL45VVT	197		GK2063FPST	24		GK2318B	292	
GK1HPO6HXF	202		GK1WL46VVT	197		GK2120	279		GK23SUI	23	
GK1HPO6VVT	190		GK1WL47VVT	197		GK2120	280		GK23SUI	24	
GK1HPO7HXF	203		GK1WL48VVT	198		GK212TDRYT	25		GK23SUIRYT	24	
GK1HPO8HXF	204		GK1WL49VVT	198		GK212X2RYT	25		GK23SUISWT	24	
GK1HXLEAK	190		GK1WL50VVT	198		GK2310	280		GK240G1RYT	23	
GK1HXLEAK	210		GK1WL51VVT	198		GK2310	284		GK2410	293	
GK1MODTRIP	213		GK1WL52VVT	199		GK2311	284		GK2410	294	
GK1MODTRIP	220		GK1WL53VVT	199		GK2311	285		GK2411	294	
GK1NGDCLHE	127		GK1WL54VVT	199		GK2311A	285		GK2412	294	
GK1O121SST	220		GK1WL55VVT	199		GK2311B	285		GK2412	295	
GK1SUPRT	190		GK1WL56VVT	200		GK2312	284		GK2413	294	
GK1WL16VVT	208		GK1WL57VVT	200		GK2312	286		GK2413	295	
GK1WL17VVT	208		GK1WL58VVT	200		GK2312A	286		GK2414	294	
GK1WL18VVT	209		GK1WL59VVT	200		GK2312B	286		GK2415	294	
GK1WL19VVT	209		GK1WL60VVT	201		GK2313	284		GK2415	296	
GK1WL20VVT	208		GK1WL61VVT	201		GK2313	287		GK2416	294	
GK1WL21VVT	208		GK1WL62VVT	201		GK2313A	287		GK2416	296	
GK1WL22VVT	209		GK1WL63VVT	201		GK2313B	287		GK259GNRYT	23	
GK1WL23VVT	209		GK1WL64VVT	202		GK2314	284		GK262TDRYT	23	
GK1WL24VVT	206		GK1WL65VVT	202		GK2314	288		GK263FX	23	
GK1WL25VVT	206		GK1WL66VVT	202		GK2314A	288		GK263FX	24	
GK1WL26VVT	209		GK1WL67VVT	202		GK2314B	288		GK263FXRYT	24	
GK1WL27VVT	209		GK1WL68VVT	203		GK2315	284		GK286E2	23	
GK1WL28VVT	207		GK1WL69VVT	203		GK2315	289		GK286E2	23	
GK1WL29VVT	207		GK1WL70VVT	203		GK2315A	289		GK286E2	229	
GK1WL30VVT	209		GK1WL71VVT	203		GK2315B	289		GK286E2	279	
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FK2510	281		FLSHCLOSE2	231		GK1312A	198		GK1414	206	
FK2520	281		FLSHOPEN1	119		GK1312B	198		GK1415	206	
FK2520	282		FLSHOPEN1	126		GK1313	196		GK1415	208	
FK2530	281		FLSHOPEN2	229		GK1313	199		GK1416	206	
FK2530	283		FLSHOPEN2	233		GK1313A	199		GK1416	208	
FK2540	283		GAB1FAULT	213		GK1313B	199		GK159GNRYT	213	
FK2FL01FRF	277		GAB1FAULT	219		GK1314	196		GK162TDRYT	213	
FK2FL02FRF	276		GENCOM	303		GK1314	200		GK163FX	213	
FK2TRHXHXF	275		GENFAIL	15		GK1314A	200		GK163FX	219	
FK2TRHXHXF	275		GFBFAIL1	119		GK1314B	200		GK163FXRYT	219	
FK2WL03VVT	276		GFBFAIL1	120		GK1315	196		GK186E1	119	
FK2WL04VVT	276		GFBFAIL2	10		GK1315	201		GK186E1	127	
FK2WL05VVT	276		GFBFAIL2	10		GK1315A	201		GK186E1	190	
FK2WL06VVT	276		GFBTRIP1	119		GK1315B	201		GK186E1	212	
FK2WL07VVT	276		GFBTRIP1	120		GK1316	196		GK186E1RYT	127	
FK2WL08VVT	276		GFBTRIP2	10		GK1316	202		GK186E1RYT	160	
FK2WL09VVT	275		GFBTRIP2	12		GK1316A	202		GK186E1RYT	193	
FK2WL11AVO	281		GFFBFAIL1	124		GK1316B	202		GK186E1X	127	
FK2WL11AVT	281		GFFBFAIL1	125		GK1317	196		GK186E1X	213	
FK2WL12VVT	281		GFFBFAIL2	231		GK1317	203		GK186E1X	218	
FK2WL15VVT	293		GFFBFAIL2	232		GK1317A	203		GK187G1RYT	213	
FK2WL42VVT	280		GK0COOLCOM	303		GK1317B	203		GK187GBRYT	213	
FK2WL43VVT	280		GK0LOCKCOM	303		GK1318	196		GK187TERYT	213	
FKVALVECOM	303		GK10001HGR	190		GK1318	204		GK1BRGDSCH	191	
FLDCLOSE1	119		GK10001HGS	127		GK1318A	204		GK1BRGSUP	190	
FLDCLOSE1	119		GK1063FPST	219		GK1318B	204		GK1BRGVLHE	191	
FLDCLOSE1	124		GK1120	190		GK13SUI	213		GK1COOLLHE	205	
FLDCLOSE2	9		GK1120	191		GK13SUI	219		GK1FIREDEX	190	
FLDCLOSE2	10		GK112TDRYT	220		GK13SUIRYT	219		GK1GAC1HXF	206	
FLDCLOSE2	229		GK112X1RYT	220		GK13SUISWT	219		GK1GAC1HXL	210	
FLDCLOSE2	231		GK1310	191		GK140G1RYT	213		GK1GAC2HXF	207	
FLDTRANS1	188		GK1310	196		GK1410	205		GK1GAC2HXL	210	
FLDTRANS2	21		GK1311	196		GK1410	206		GK1GAC3HXF	207	
FLDTRANS2	26		GK1311	197		GK1411	206		GK1GAC3HXL	210	
FLDTRANS2	278		GK1311A	197		GK1412	206		GK1GAC4HXF	206	
FLSHCLOSE1	119		GK1311B	197		GK1412	207		GK1GAC4HXL	210	

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EK1R41XRYD	120		EK2DIODDEX	277		ESCONDNOT	136		FK1400	205	
EK1R41YRYD	120		EK2EXC1TGF	229		ESCONDNOT	137		FK1500	192	
EK1R41YRYT	120		EK2EXC2TGF	278		EU1C1RORYD	131		FK1510	192	
EK1R9A1RYT	125		EK2F30AFUF	277		EU1C2RORYD	135		FK1520	192	
EK1R9C1R6T	124		EK2F31XRYD	232		EU2C1RORYD	132		FK1520	193	
EK1S141SWT	120		EK2F41CRYD	10		EU2C2RORYD	136		FK1530	192	
EK1S31TSWT	125		EK2FAN1TLF	277		EU3C1RORYD	133		FK1530	194	
EK1S41CRYD	123		EK2FLDCLHE	10		EU3C2RORYD	137		FK1540	194	
EK1S41TSWT	188		EK2FLDMDEX	10		EXCIFANS1	188		FK1FL01FRF	187	
EK1S41XRYD	123		EK2FLSCLHE	231		EXCIFANS1	188		FK1FL02FRF	187	
EK1SPYCLHE	122		EK2FLSMDEX	231		EXCIFANS2	277		FK1TRHXHXF	186	
EK1SPYMDEX	122		EK2FLSOLHE	233		EXCIFANS2	278		FK1TRHXHXF	186	
EK1VHSVRYD	126		EK2MOD	10		EXCRUN	188		FK1WL03VVT	187	
EK1VREGDEX	189		EK2MOD	13		EXCRUN	189		FK1WL04VVT	187	
EK231TDRYD	233		EK2NOMOD	10		EXCRUN2	278		FK1WL05VVT	187	
EK231TDRYT	232		EK2NOMOD	12		FFB1TRIP	126		FK1WL06VVT	187	
EK24152SWT	230		EK2R31TRYD	233		FFB2TRIP	233		FK1WL07VVT	187	
EK2415TSWT	278		EK2R31YRYD	232		FFTRIP1	124		FK1WL08VVT	187	
EK2415YRYD	231		EK2R31YRYT	232		FFTRIP1	125		FK1WL09VVT	186	
EK2415YRYT	231		EK2R41XRYD	10		FFTRIP2	231		FK1WL11AVO	192	
EK241AXR6D	230		EK2R41YRYD	10		FFTRIP2	232		FK1WL11AVT	192	
EK241AXR6D	277		EK2R41YRYT	10		FIREPROT	17		FK1WL12VVT	192	
EK241AXR6T	277		EK2R9A2RYT	232		FIREPROT	29		FK1WL15VVT	205	
EK241AXR6T	278		EK2R9C2R6T	231		FK0FISHCOM	303		FK1WL42VVT	191	
EK241CFRYD	232		EK2S141SWT	12		FK0WL01VVT	187		FK1WL43VVT	191	
EK286E2RYT	230		EK2S31TSWT	232		FK0WL01VVT	277		FK2110	275	
EK286EXRYT	10		EK2S41CRYD	231		FK1110	186		FK2110	276	
EK286EXRYT	231		EK2S41TSWT	26		FK1110	187		FK2120	276	
EK286X2RYT	26		EK2S41XRYD	231		FK1120	187		FK2120	277	
EK288SVRYD	277		EK2SPYCLHE	230		FK1120	187		FK2120	281	
EK288SVRYT	277		EK2SPYMDEX	230		FK1120	192		FK2120GLHE	282	
EK2901ARYT	232		EK2VHSVRYD	233		FK1120GLHE	193		FK2120GSWT	282	
EK299SXRYD	13		EK2VREGDEX	278		FK1120GSWT	193		FK2200	275	
EK299SYRYD	12		EKSTARTCOM	301		FK1200	186		FK2300	280	
EK299SYRYT	26		ESCONDNOT	131		FK1300	191		FK2310	280	
EK2BAS2DEX	278		ESCONDNOT	132		FK1310	191		FK2310	281	
EK2BASEDEX	234		ESCONDNOT	133		FK1310	192		FK2310	293	

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D3DIA	92		DDC1DCBBDF	101		DDCADC2DIF	314		EK1415YRYT	123	
D3DIA	93		DDC1DCBBDM	101		DDCADD1DIF	316		EK141AXR6D	122	
D3DIA	98		DDC1DCBBYF	102		DDCADD2DIF	317		EK141AXR6D	188	
D3DIA	309		DDC1FLTBDF	42		DDCBATTCOM	71		EK141AXR6T	188	
D3DIA	316		DDC21BXCDT	61		DDCBATTDEX	95		EK141AXR6T	188	
D3DIAXXDEX	133		DDC21CXCDT	72		DDCBATTDEX	97		EK141CFRYD	125	
D3DIB	98		DDC21DCCDT	51		DDCBATTDEX	102		EK186E2RYT	122	
D3DIB	99		DDC21DLCDT	69		DDCBATTDEX	314		EK186EXRYT	119	
D3DIB	309		DDC21DRCDT	74		DDCBATTNOT	61		EK186EXRYT	124	
D3DIB	316		DDC2BATBYF	61		DDCBATTNOT	71		EK186X2RYT	188	
D3DIBXXDEX	137		DDC2FLTBDF	61		DDCBATTNOT	71		EK188SVRYD	188	
D3DIC	309		DDC3A1BCDT	94		DDCDYAXBDF	67		EK188SVRYT	188	
D3DIC	311		DDC3A2ACDT	95		DDCDYBXBDF	45		EK1901ARYT	125	
D3DIC	312		DDC3A3CCDT	93		DDCDYCXBDF	41		EK199SXRYD	121	
D3DID	309		DDC3A3DCDT	99		DDCDYEXBDF	69		EK199SYRYD	120	
DAC1F4ACLT	96		DDC3B1BCDT	313		DDCDYFXBDF	51		EK199SYRYT	188	
DAC2F4DCLT	101		DDC3B2ACDT	314		DDCDYGXBDF	74		EK1BAS2DEX	189	
DAC3F4ACLT	94		DDC3B3CCDT	312		DDCUN31DIM	95		EK1BASEDEX	127	
DAC3F4DCLT	313		DDC3B3DCDT	316		DDCUN31DIM	100		EK1BASELHE	127	
DDC11BXCDT	71		DDC3DCABDF	94		DDCUN31DIM	314		EK1DIODDEX	188	
DDC11CXCDT	72		DDC3DCABDM	94		DDCUN31DIM	317		EK1EXC1TGF	119	
DDC11DCCDT	45		DDC3DCABYF	95		DDCX1CABCF	96		EK1EXC2TGF	188	
DDC11DLCDT	67		DDC3DCBBDF	313		DDCX1CBBCF	101		EK1F30AFUF	188	
DDC11DRCDT	41		DDC3DCBBDM	313		DDCX3CABCF	94		EK1F31XRYD	125	
DDC1A1BCDT	96		DDC3DCBBYF	314		DDCX3CBBCF	313		EK1F41CRYD	120	
DDC1A2ACDT	97		DDC3DIABDF	93		E12EXCTCOM	301		EK1FAN1TLF	188	
DDC1A3CCDT	95		DDC3DIABDM	93		ED11D3DCDT	119		EK1FLDCLHE	119	
DDC1A3DCDT	314		DDC3DIBBDF	99		ED13BR2CDT	158		EK1FLDMDEX	119	
DDC1ALXBYM	42		DDC3DIBBDM	99		ED13BR2CDT	188		EK1FLSCLHE	124	
DDC1ALXBYM	71		DDC3DICBDF	312		ED22D3DCDT	229		EK1FLSMDEX	124	
DDC1B1BCDT	101		DDC3DICBDM	312		ED23BR2CDT	26		EK1FLSOLHE	126	
DDC1B2ACDT	102		DDC3DIDBDF	309		ED23BR2CDT	248		EK1MOD	119	
DDC1B3CCDT	100		DDC3DIDBDM	309		EK00RUNCOM	303		EK1MOD	121	
DDC1B3DCDT	317		DDCADA1DIF	93		EK131TDRYD	126		EK1NOMOD	119	
DDC1BATBYF	71		DDCADA2DIF	95		EK131TDRYT	125		EK1NOMOD	121	
DDC1DCABDF	96		DDCADB1DIF	99		EK14152SWT	122		EK1R31TRYD	126	
DDC1DCABDM	96		DDCADB2DIF	100		EK1415TSWT	188		EK1R31YRYD	125	

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BK1GBDCGPR	179		BK2550	267		BK2DA1BCDT	268		D1DIBXXDEX	115	
BK1GBDCGPS	179		BK2560	267		BK2GBDCGPR	268		D1DIC	98	
BK1GBDCLHE	179		BK2600	254		BK2GBDCGPS	268		D1DIC	104	
BK1GBO1CVC	178		BK2600	267		BK2GBDCLHE	268		D1DID	104	
BK1GBO1CVO	165		BK2631XRYD	270		BK2GBO1CVC	267		D1DID	315	
BK1GBO1CVT	165		BK2631XRYT	272		BK2GBO1CVO	254		D2DIAXXDEX	132	
BK1GBO1FTC	165		BK2631XRYT	283		BK2GBO1CVT	254		D2DIBXXDEX	136	
BK1GBO2VVT	165		BK2632XRYD	269		BK2GBO1FTC	254		D3ADA	93	
BK1GBO3CVO	178		BK2632XRYT	271		BK2GBO2VVT	254		D3ADA1	93	
BK1GBO3CVT	178		BK263TALSD	269		BK2GBO3CVO	267		D3ADA2	93	
BK1GBO4VVT	178		BK263TALSD	270		BK2GBO3CVT	267		D3ADA2	95	
BK1GBO5VVT	165		BK263TALST	271		BK2GBO4VVT	267		D3ADB	99	
BK1GBO6VVT	165		BK263TALST	272		BK2GBO5VVT	254		D3ADB1	99	
BK1GBO8VVT	164		BK263TALST	283		BK2GBO6VVT	254		D3ADB2	99	
BK1GBO9VVT	164		BK2650	267		BK2GBO8VVT	253		D3ADB2	100	
BK1GOACGPR	166		BK2650	268		BK2GBO9VVT	253		D3ADC	312	
BK1GOACGPS	166		BK2660	268		BK2GOACGPR	255		D3ADC1	312	
BK1GODCTRM	178		BK2660	269		BK2GOACGPS	255		D3ADC2	312	
BK1XA1CCLT	166		BK2660A	269		BK2GODCTRM	267		D3ADC2	314	
BK2000	253		BK2660C	269		BK2XA1CCLT	255		D3ADD	309	
BK2088XRYD	270		BK2661A	269		BKGBOILCOM	302		D3ADD1	309	
BK2088XRYT	272		BK2661B	283		COMMCOLD	301		D3ADD1	316	
BK2088XRYT	283		BK2661B	284		COOLCOM	303		D3ADD2	309	
BK2100	253		BK2661C	269		D1CABAT	96		D3ADD2	317	
BK214/2SSD	284		BK2661C	270		D1CABAT	97		D3CABAT	94	
BK214/2SST	270		BK2760	268		D1CACH	96		D3CABAT	95	
BK214DXRYD	284		BK2760	271		D1CBBAT	101		D3CACH	94	
BK214DXRYT	270		BK2760A	271		D1CBBAT	102		D3CBBAT	313	
BK214T2RYD	284		BK2760B	270		D1CBCH	101		D3CBBAT	314	
BK214T2RYT	270		BK2760B	271		D1DCA	95		D3CBCH	313	
BK2188ASWT	255		BK2760B	283		D1DCA	96		D3DCA	93	
BK2188DSWT	268		BK2760C	271		D1DCA	314		D3DCA	94	
BK2200	253		BK2760C	272		D1DCAPOW	96		D3DCA	99	
BK2200	254		BK2760SX	271		D1DCB	100		D3DCAPOW	94	
BK2400	254		BK2761A	271		D1DCB	101		D3DCB	312	
BK2500	254		BK2761C	272		D1DCB	317		D3DCB	313	
BK2550	254		BK288AXRYD	269		D1DCBPOW	101		D3DCB	316	

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ACB6CLOSE	258		ACB8DCPWR	263		AK214GVDEX	87		BK1560	178	
ACB6CNTRLC	258		ACB8ELECC	263		AK222TDRYD	15		BK1600	165	
ACB6CNTRLC	259		ACB8TRANS	262		AK252TDRYD	9		BK1600	178	
ACB6CNTRLO	260		ACB8TRANS	266		AK252TDRYD	87		BK1631XRYD	181	
ACB6DCPWR	258		ACBAIRPDEX	30		AK252TDRYT	87		BK1631XRYT	183	
ACB6DCPWR	259		ACBAIRPDEX	215		AK252W0RYD	16		BK1631XRYT	194	
ACB6DCPWR	260		ACBTRIPCHE	21		AK252XGRYD	16		BK1632XRYD	180	
ACB6DCPWR	263		ACBTRIPCHE	212		AK2GATEDEX	22		BK1632XRYT	182	
ACB6ELECC	258		ACBXFERCOM	304		AK2GATEDEX	25		BK163TALSD	180	
ACB6ELECO	260		AD1B4ALCDT	172		AK2GV2XRYD	87		BK163TALSD	181	
ACB6OPEN	257		AD1C3CCCDT	31		AK2OFRQCOM	15		BK163TALST	182	
ACB6OPEN	260		AD1C3CCCDT	141		ASWYDISO	85		BK163TALST	183	
ACB6OPEN	263		AD1C3CLCDT	31		AUXPWRCOM	303		BK163TALST	194	
ACB6TRANS	257		AD1C3CLCDT	130		AUXPWRCOM	304		BK1650	178	
ACB6TRANS	261		AD1SCLRCDT	222		BASE1	119		BK1650	179	
ACB7BREAKC	171		AD2B2ALCDT	259		BASE1	127		BK1660	179	
ACB7CLOSE	168		AD2B3CCCDT	224		BASE2	229		BK1660	180	
ACB7CLOSE	171		AD2C3CCCDT	32		BASE2	234		BK1660A	180	
ACB7CNTRLC	171		AD2C3CLCDT	8		BK1000	164		BK1660C	180	
ACB7CNTRLC	172		AD2C3CLCDT	32		BK1088XRYD	181		BK1661A	180	
ACB7CNTRLO	173		AK1141XRYD	214		BK1088XRYT	183		BK1661B	194	
ACB7CNTRLO	174		AK114GVDEX	143		BK1088XRYT	194		BK1661B	195	
ACB7DCPWR	171		AK114GVDEX	214		BK1100	164		BK1661C	180	
ACB7DCPWR	172		AK121TDRYD	139		BK114/2SSD	195		BK1661C	181	
ACB7DCPWR	173		AK152TDRYD	143		BK114/2SST	181		BK1760	179	
ACB7ELECC	171		AK152TDRYT	129		BK114DXRYD	195		BK1760	182	
ACB7ELECO	173		AK152TDRYT	143		BK114DXRYT	181		BK1760A	182	
ACB7OPEN	168		AK152XGRYD	143		BK114T2RYD	195		BK1760B	181	
ACB7OPEN	173		AK152XGRYT	143		BK114T2RYT	181		BK1760B	182	
ACB7OPEN	175		AK1AX34RYT	140		BK1188ASWT	166		BK1760B	194	
ACB7TRANS	168		AK1GV1XRYD	143		BK1188DSWT	179		BK1760C	182	
ACB7TRANS	169		AK1OFRQCOM	139		BK1200	164		BK1760C	183	
ACB8BREAKC	263		AK1UNDER	139		BK1200	165		BK1760SX	182	
ACB8BREAKC	264		AK1UNDER	140		BK1400	165		BK1761A	182	
ACB8CLOSE	262		AK1X34XRYT	140		BK1500	165		BK1761C	183	
ACB8CLOSE	263		AK212OSSST	22		BK1550	165		BK188AXRYD	180	
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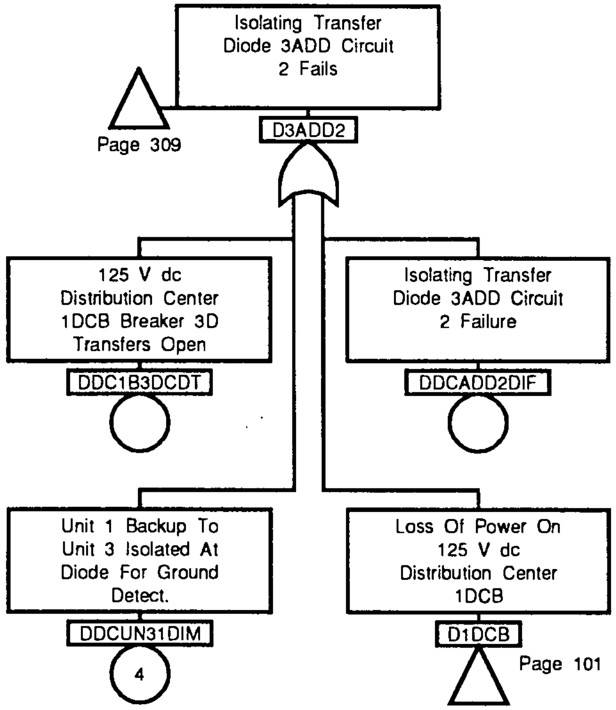
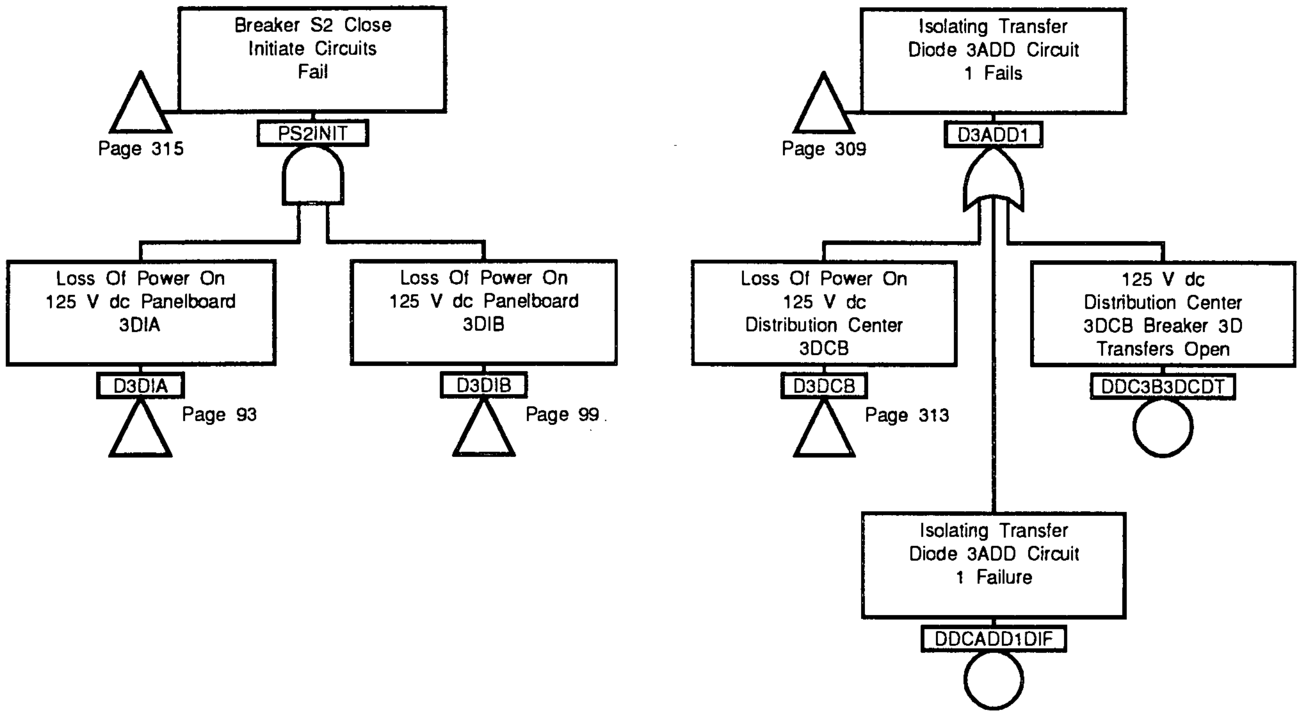
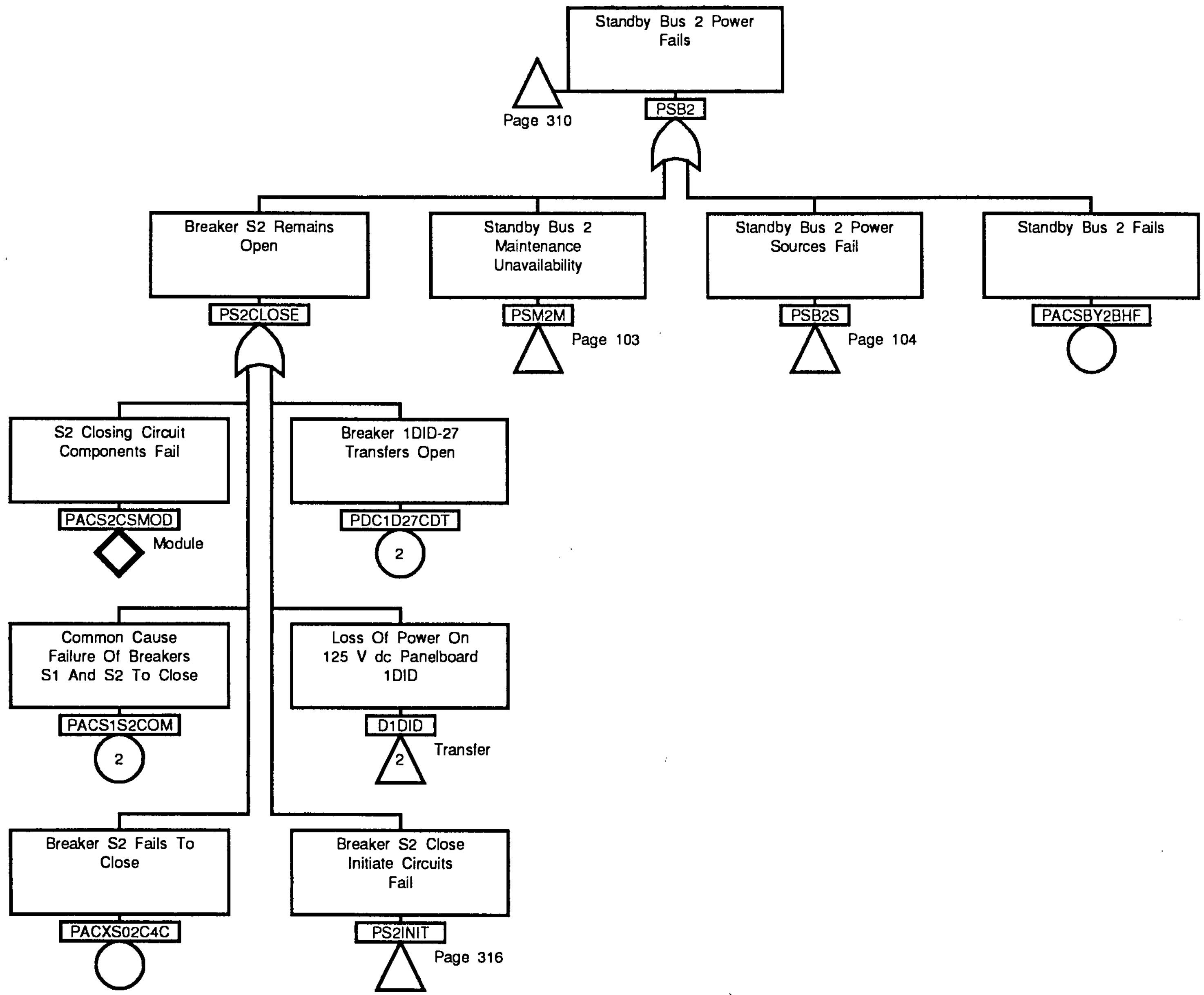
AB6R52XRYD	258		ACB1AUTO	129		ACB2TRIP	21		ACB4AUTOC	217	
AB6R52YRYD	258		ACB1BREAK	129		ACB2TRIP2	21		ACB4BREAKC	216	
AB710A1FUF	171		ACB1DCPWR	129		ACB2TRIP2	22		ACB4CLOSE	214	
AB710AFFUF	174		ACB1DCPWR	130		ACB2TRIP2B	22		ACB4CLOSE	215	
AB752CCRYD	171		ACB1ELEC	129		ACB2TRIP2C	22		ACB4CNTRL0	217	
AB752TCRYD	173		ACB1OPEN	128		ACB2TRIP3	21		ACB4CNTRLC	216	
AB752TCRYT	169		ACB1OPEN	129		ACB2TRIP3	23		ACB4CNTRLC	217	
AB752Y2RYT	171		ACB1OPEN	305		ACB2TRIP5	21		ACB4CSGNL	218	
AB7CLOSLHE	171		ACB2	32		ACB2TRIP5	25		ACB4CSGNL	221	
AB7KEYISWT	171		ACB241A	9		ACB2TRIPG	86		ACB4DCPWR	216	
AB7MCH2DEX	171		ACB2AUTOC	9		ACB2TRIPG	87		ACB4DCPWR	224	
AB7MECHDEX	173		ACB2AUTOO	86		ACB2TRIPG0	86		ACB4ELECC	215	
AB7OPENLHE	173		ACB2BREAK	86		ACB2TRIPW	87		ACB4ELECC	216	
AB7PUSHPBT	169		ACB2BREAKC	7		ACB2TRIPW0	86		ACB4MANC	217	
AB7R52XRYD	171		ACB2CLOSE	4		ACB2TRIPW0	87		ACB4MANC	217	
AB7R52YRYD	171		ACB2CLOSE	6		ACB3	30		ACB4MANC	224	
AB810A1FUF	264		ACB2CLOSE	175		ACB3	31		ACB4MOD	12	
AB81432RYT	265		ACB2CLOSE	257		ACB3BREAKC	139		ACB4MOD	13	
AB852CCRYD	264		ACB2CNTRLC	7		ACB3BREAKC	139		ACB4MOD	30	
AB852TCRYT	266		ACB2CNTRLC	9		ACB3CLOSE	138		ACB4MOD	121	
AB852Y2RYT	264		ACB2CSGNL	9		ACB3CLOSE	139		ACB4MOD	217	
AB86E1A	221		ACB2DCPWR	7		ACB3OPEN	140		ACB4TRANS	214	
AB86E1A	222		ACB2DCPWR	8		ACB3OPEN	141		ACB4TRANS	299	
AB86E1ARYD	222		ACB2DCPWR	86		ACB3OPEN	218		ACB4TRIP	299	
AB86E1GRYD	222		ACB2DISC	27		ACB3TRANS	106		ACB5BREAKC	176	
AB86T	221		ACB2DISC	85		ACB3TRANS	211		ACB5CLOSE	175	
AB883S8RYD	265		ACB2ELEC	85		ACB3TRANS	304		ACB5CLOSE	175	
AB8KEYISWT	263		ACB2ELEC	86		ACB3TRIP	211		ACB5CNTRLC	176	
AB8MCH2DEX	263		ACB2ELECC	6		ACB3TRIP	212		ACB5CNTRLC	177	
AB8PUSHPBT	266		ACB2ELECC	7		ACB3TRIPG	143		ACB5DCPWR	172	
AB8R52XRYD	264		ACB2LHE	6		ACB3TRIPG0	141		ACB5DCPWR	172	
AB8R52YRYD	264		ACB2LHE	19		ACB3TRIPG0	143		ACB5DCPWR	176	
ABEOPRCRHE	9		ACB2OPEN	85		ACB3TRIPW	143		ACB5ELECC	175	
ABESTART	221		ACB2TRANS	4		ACB3TRIPW0	141		ACB5ELECC	176	
ABESTART	222		ACB2TRANS	21		ACB3TRIPW0	143		ACB5TRANS	175	
ABPOPRCRHE	224		ACB2TRANS	175		ACB4	32		ACB5TRANS	177	
ACB1	30		ACB2TRANS	257		ACB4AFTC	217		ACB6BREAKC	258	



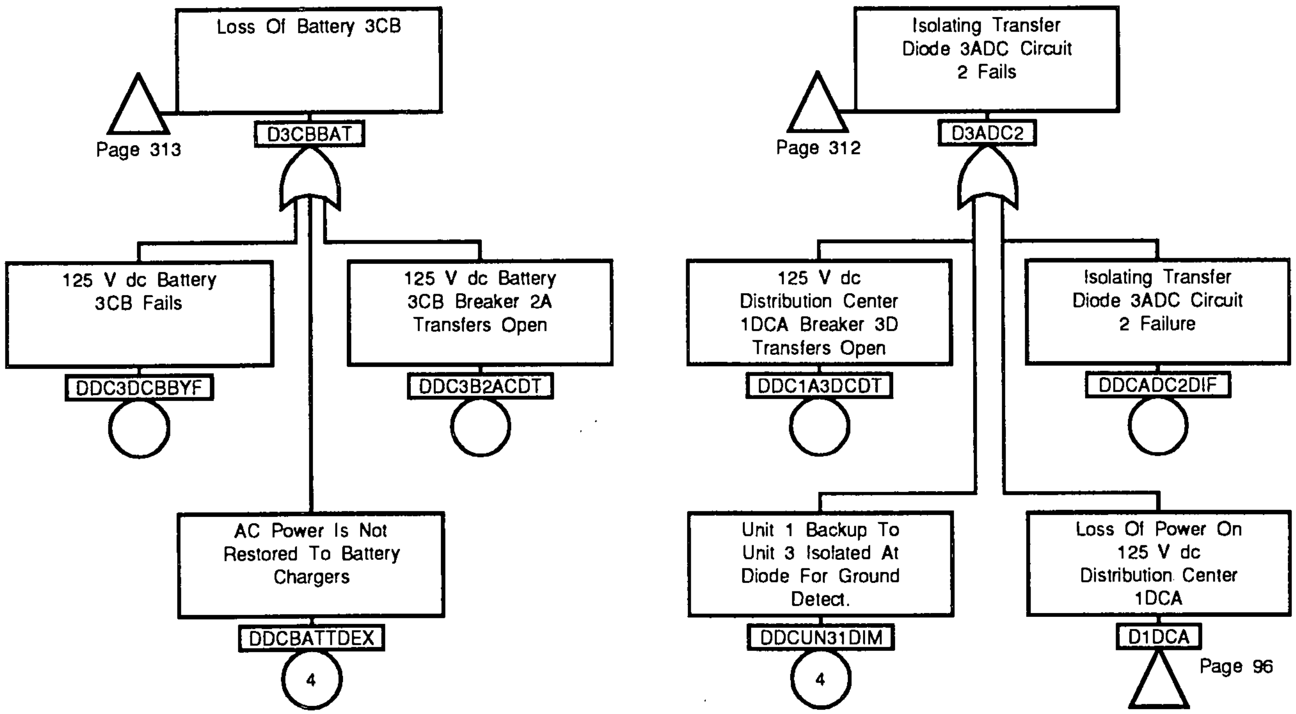
Isolating Transfer Diode 3ADD Circuit 2 Fails
D3ADD2
Page 309
125 V dc Distribution Center 1DCB Breaker 3D Transfers Open
DDC1B3DCDT
Isolating Transfer Diode 3ADD Circuit 2 Failure
DDCADD2DIF
Unit 1 Backup To Unit 3 Isolated At Diode For Ground Detect.
DDCUN31DIM
4
Loss Of Power On 125 V dc Distribution Center 1DCB
D1DCB
Page 101



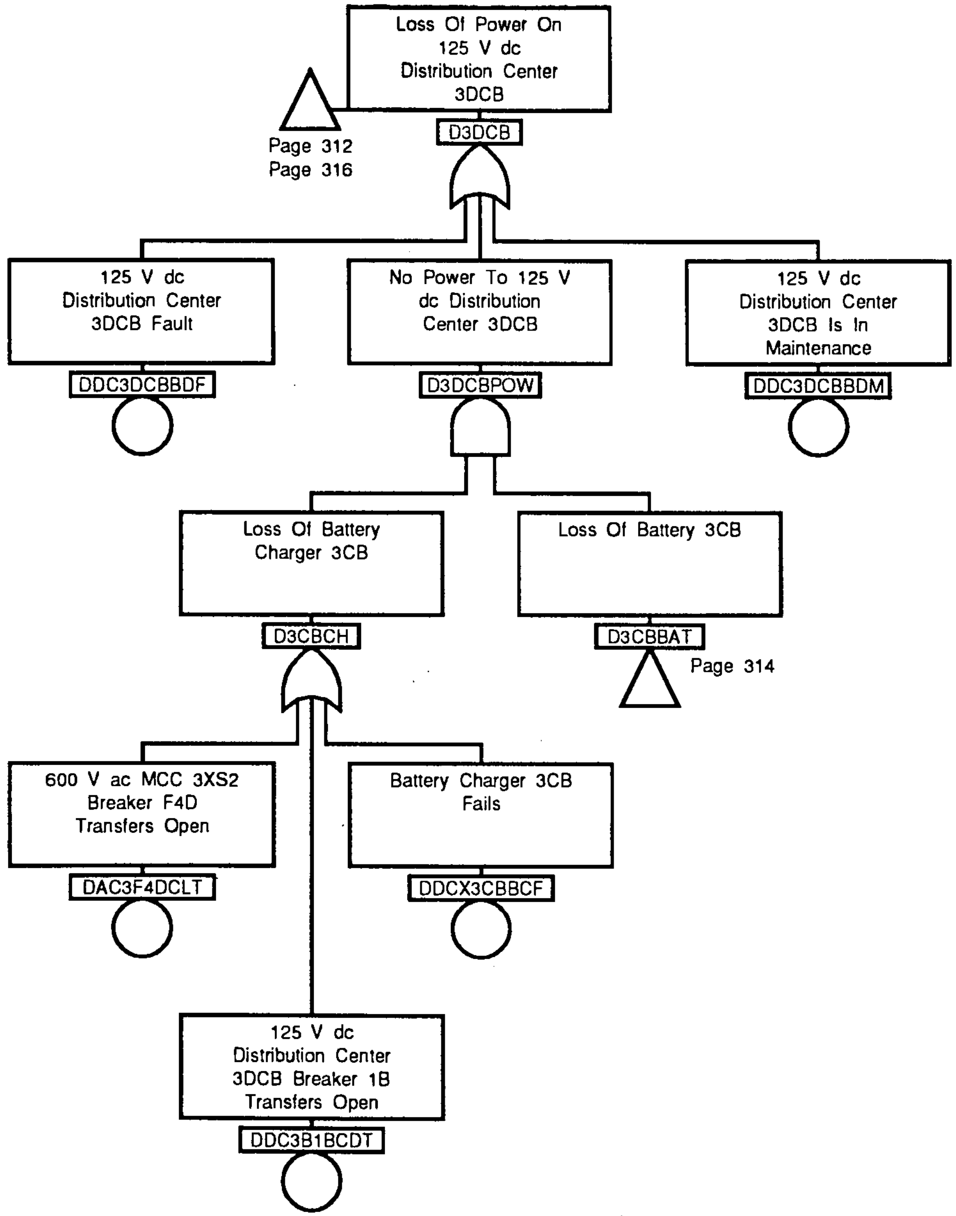
Breaker S2 Close Initiate Circuits Fail
PS2INIT
Page 315
Loss Of Power On 125 V dc Panelboard 3DIA
D3DIA
Page 93
Loss Of Power On 125 V dc Panelboard 3DIB
D3DIB
Page 99
Isolating Transfer Diode 3ADD Circuit 1 Fails
D3ADD1
Page 309
Loss Of Power On 125 V dc Distribution Center 3DCB
D3DCB
Page 313
125 V dc Distribution Center 3DCB Breaker 3D Transfers Open
DDC3B3DCDT
Isolating Transfer Diode 3ADD Circuit 1 Failure
DDCADD1DIF

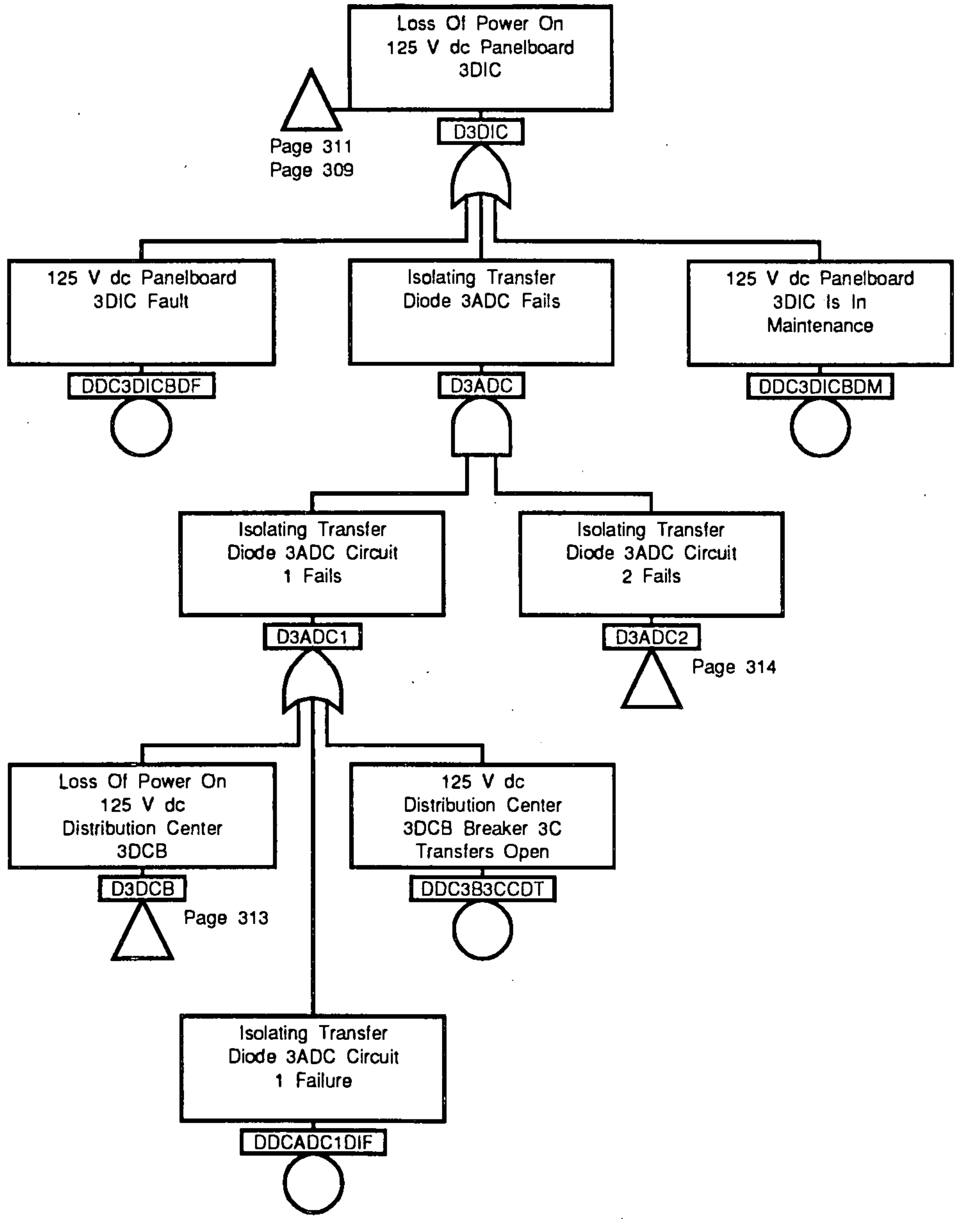


Standby Bus 2 Power Fails
PSB2
Page 310
Breaker S2 Remains Open
PS2CLOSE
Standby Bus 2 Maintenance Unavailability
PSM2M
Page 103
Standby Bus 2 Power Sources Fail
PSB2S
Page 104
Standby Bus 2 Fails
PACSBY2BHF
S2 Closing Circuit Components Fail
PACS2CSMOD
Module
Breaker 1DID-27 Transfers Open
PDC1D27CDT
2
Common Cause Failure Of Breakers S1 And S2 To Close
PACS1S2COM
2
Loss Of Power On 125 V dc Panelboard 1DID
D1DID
2
Transfer
Breaker S2 Fails To Close
PACXS02C4C
Breaker S2 Close Initiate Circuits Fail
PS2INIT
Page 316

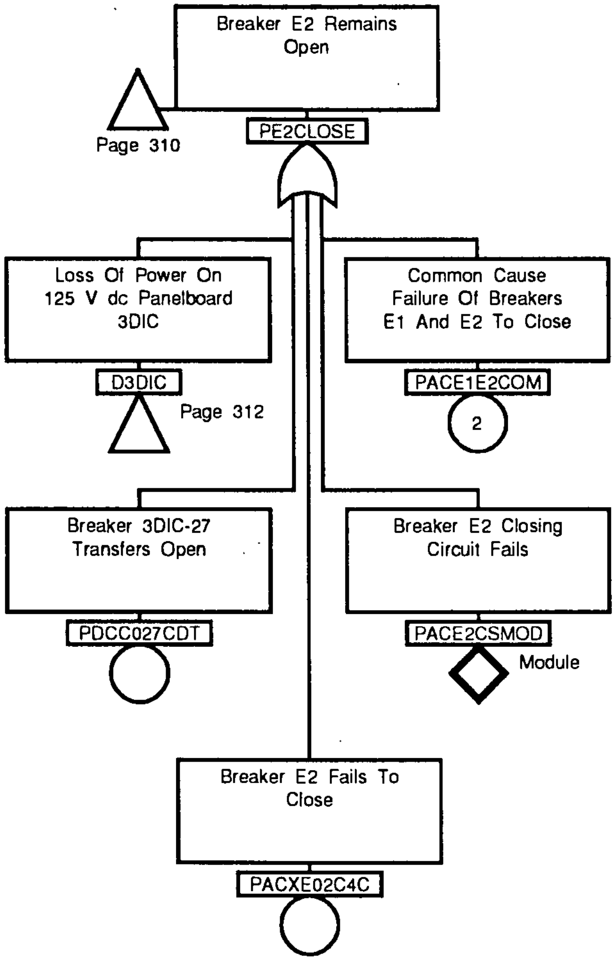


Loss Of Battery 3CB
Page 313
D3CBBAT
125 V dc Battery 3CB Fails
DDC3DCBBYF
125 V dc Battery 3CB Breaker 2A Transfers Open
DDC3B2ACDT
AC Power Is Not Restored To Battery Chargers
DDCBATTDEX
4
Isolating Transfer Diode 3ADC Circuit 2 Fails
Page 312
D3ADC2
125 V dc Distribution Center 1DCA Breaker 3D Transfers Open
DDC1A3DCDT
Isolating Transfer Diode 3ADC Circuit 2 Failure
DDCADC2DIF
Unit 1 Backup To Unit 3 Isolated At Diode For Ground Detect.
DDCUN31DIM
4
Loss Of Power On 125 V dc Distribution Center 1DCA
D1DCA
Page 96

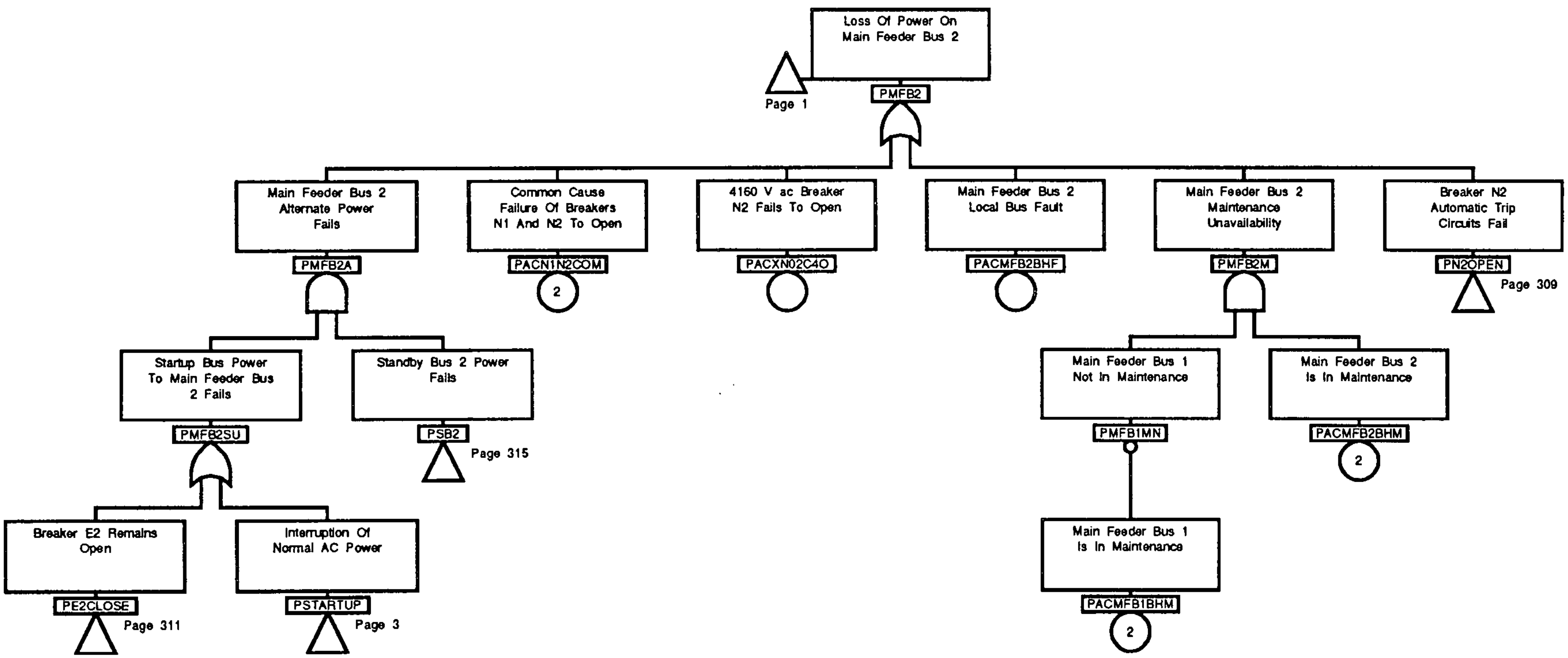

Loss Of Power On 125 V dc Distribution Center 3DCB
D3DCB
Page 312
Page 316
125 V dc Distribution Center 3DCB Fault
DDC3DCBBDF
No Power To 125 V dc Distribution Center 3DCB
D3DCBPOW
125 V dc Distribution Center 3DCB Is In Maintenance
DDC3DCBBDM
Loss Of Battery Charger 3CB
D3CBCH
Loss Of Battery 3CB
D3CBBAT
Page 314
600 V ac MCC 3XS2 Breaker F4D Transfers Open
DAC3F4DCLT
Battery Charger 3CB Fails
DDCX3CBBCF
125 V dc Distribution Center 3DCB Breaker 1B Transfers Open
DDC3B1BCDT



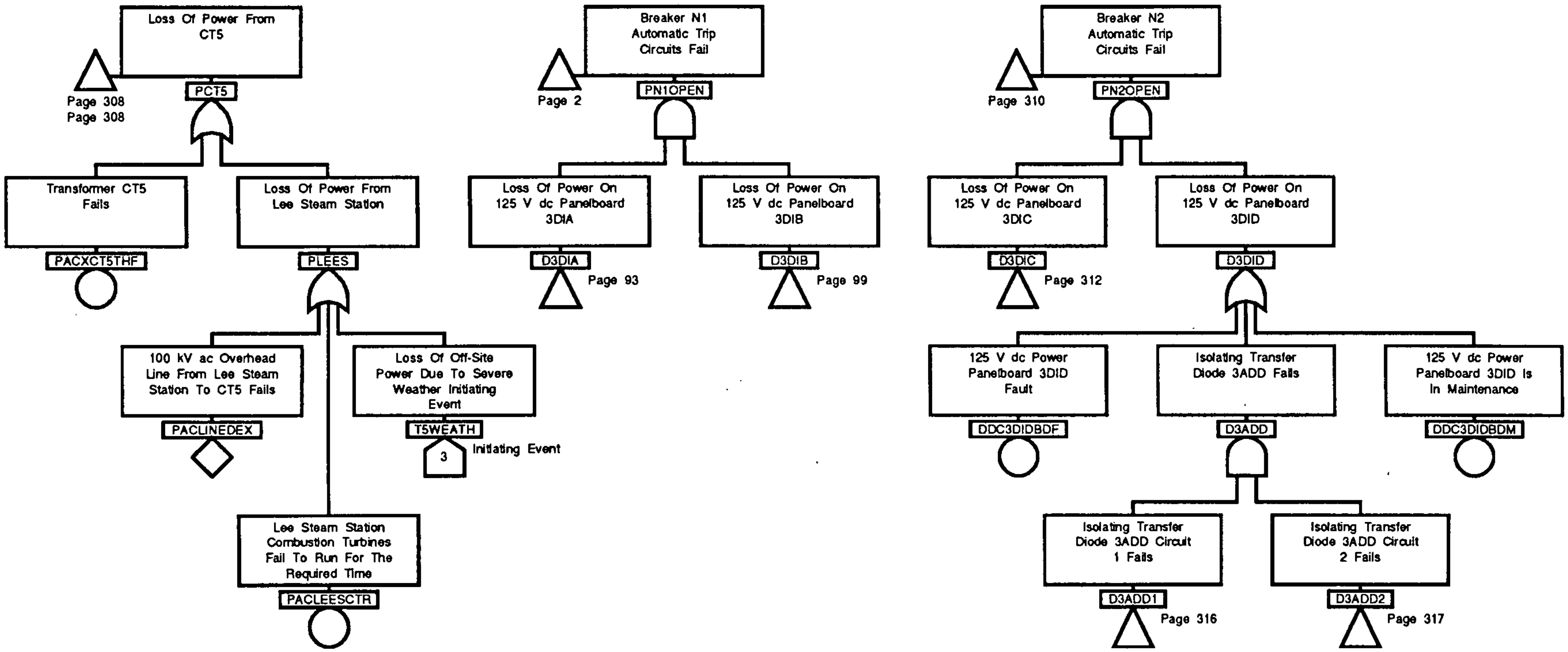
Loss Of Power On
125 V dc Panelboard
3DIC
D3DIC
Page 311
Page 309
125 V dc Panelboard
3DIC Fault
DDC3DICBDF
Isolating Transfer
Diode 3ADC Fails
D3ADC
125 V dc Panelboard
3DIC Is In
Maintenance
DDC3DICBDM
Isolating Transfer
Diode 3ADC Circuit
1 Fails
D3ADC1
Isolating Transfer
Diode 3ADC Circuit
2 Fails
D3ADC2
Page 314
Loss Of Power On
125 V dc
Distribution Center
3DCB
D3DCB
Page 313
125 V dc
Distribution Center
3DCB Breaker 3C
Transfers Open
DDC3B3CCDT
Isolating Transfer
Diode 3ADC Circuit
1 Failure
DDCADC1DIF



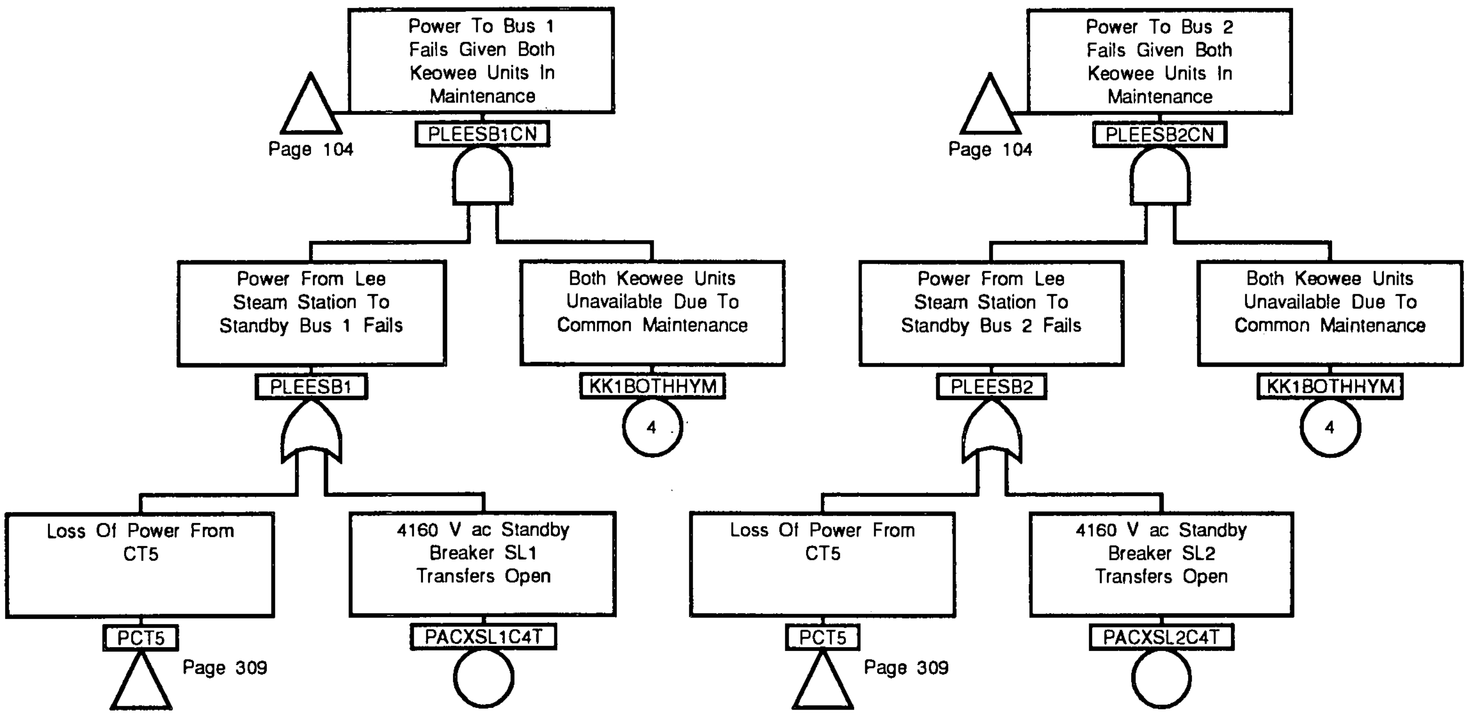
Breaker E2 Remains Open
PE2CLOSE
Page 310
Loss Of Power On 125 V dc Panelboard 3DIC
D3DIC
Page 312
Common Cause Failure Of Breakers E1 And E2 To Close
PACE1E2COM
2
Breaker 3DIC-27 Transfers Open
PDCC027CDT
Breaker E2 Closing Circuit Fails
PACE2CSMOD
Module
Breaker E2 Fails To Close
PACXE02C4C



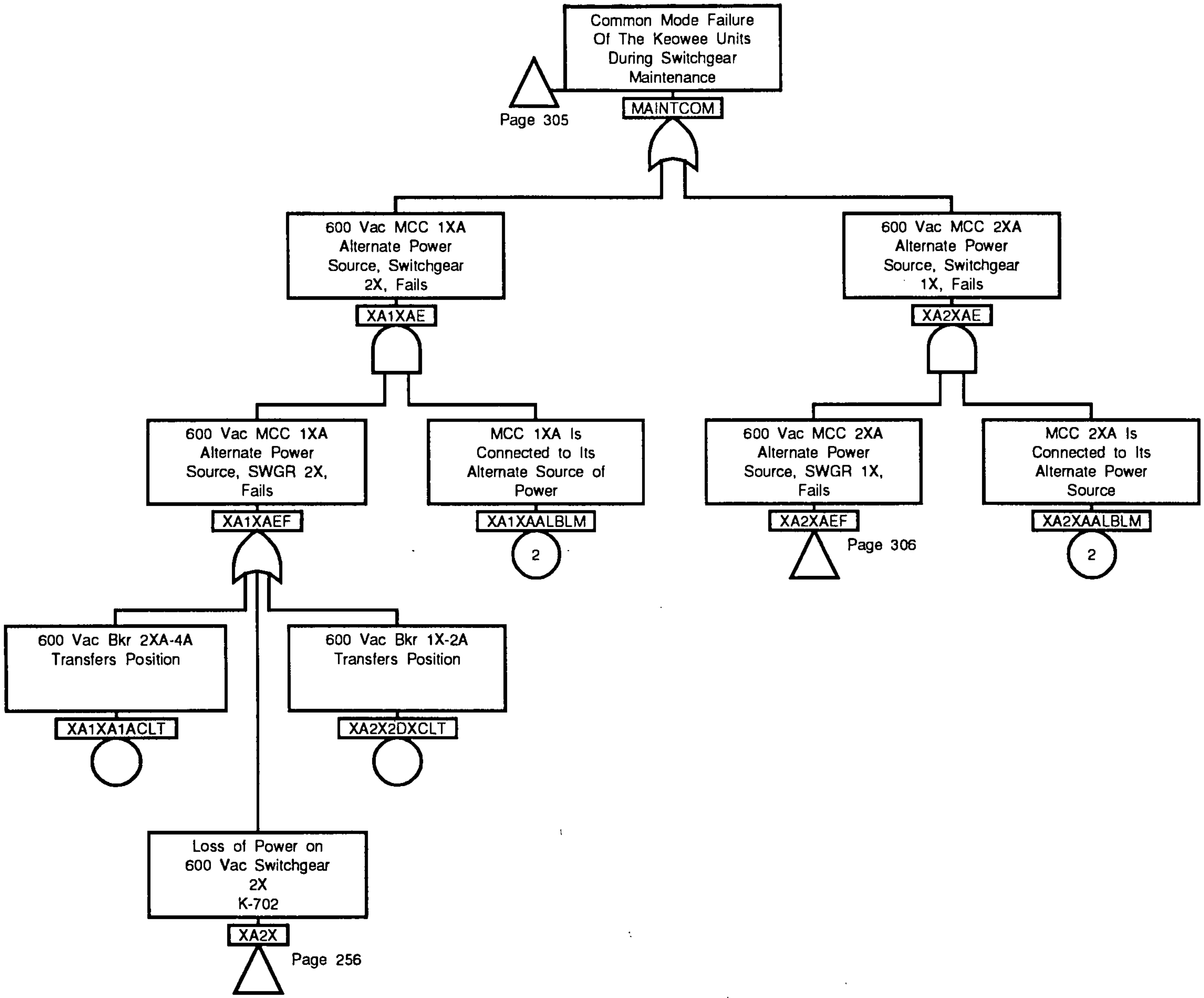
Loss Of Power On Main Feeder Bus 2
PMFB2
Page 1
Main Feeder Bus 2 Alternate Power Fails
PMFB2A
Common Cause Failure Of Breakers N1 And N2 To Open
PACN1N2COM
2
4160 V ac Breaker N2 Fails To Open
PACXN02C4O
Main Feeder Bus 2 Local Bus Fault
PACMFB2BHF
Main Feeder Bus 2 Maintenance Unavailability
PMFB2M
Breaker N2 Automatic Trip Circuits Fail
PN2OPEN
Page 309
Startup Bus Power To Main Feeder Bus 2 Fails
PMFB2SU
Standby Bus 2 Power Fails
PSB2
Page 315
Main Feeder Bus 1 Not In Maintenance
PMFB1MN
Main Feeder Bus 2 Is In Maintenance
PACMFB2BHM
2
Breaker E2 Remains Open
PE2CLOSE
Page 311
Interruption Of Normal AC Power
PSTARTUP
Page 3
Main Feeder Bus 1 Is In Maintenance
PACMFB1BHM
2



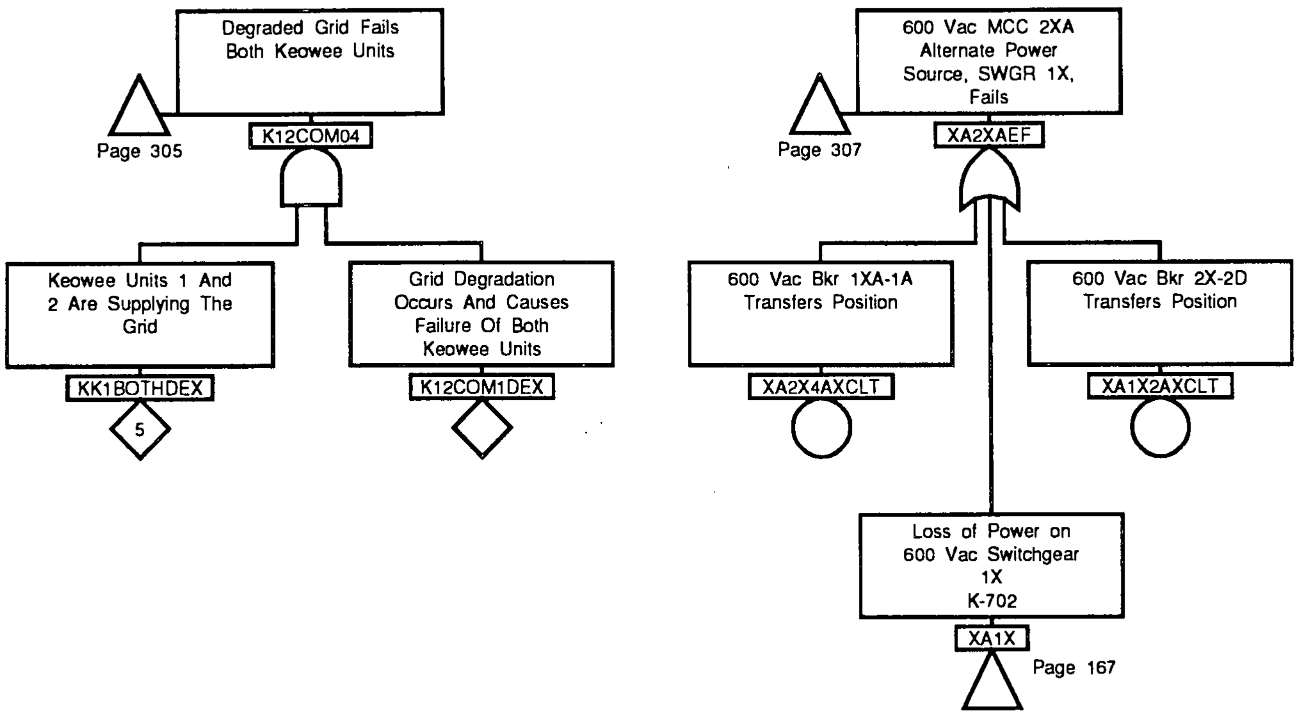
Loss Of Power From CT5
PCT5
Page 308
Page 308
Transformer CT5 Fails
PACXCT5THF
Loss Of Power From Lee Steam Station
PLEES
100 kV ac Overhead Line From Lee Steam Station To CT5 Fails
PACLINEDEX
Loss Of Off-Site Power Due To Severe Weather Initiating Event
T5WEATH
3
Initiating Event
Lee Steam Station Combustion Turbines Fail To Run For The Required Time
PACLEESCTR
Breaker N1 Automatic Trip Circuits Fail
Page 2
PN1OPEN
Loss Of Power On 125 V dc Panelboard 3DIA
D3DIA
Page 93
Loss Of Power On 125 V dc Panelboard 3DIB
D3DIB
Page 99
Breaker N2 Automatic Trip Circuits Fail
Page 310
PN2OPEN
Loss Of Power On 125 V dc Panelboard 3DIC
D3DIC
Page 312
Loss Of Power On 125 V dc Panelboard 3DID
D3DID
125 V dc Power Panelboard 3DID Fault
DDC3DIDBDF
Isolating Transfer Diode 3ADD Fails
D3ADD
125 V dc Power Panelboard 3DID Is In Maintenance
DDC3DIDBDM
Isolating Transfer Diode 3ADD Circuit 1 Fails
D3ADD1
Page 316
Isolating Transfer Diode 3ADD Circuit 2 Fails
D3ADD2
Page 317

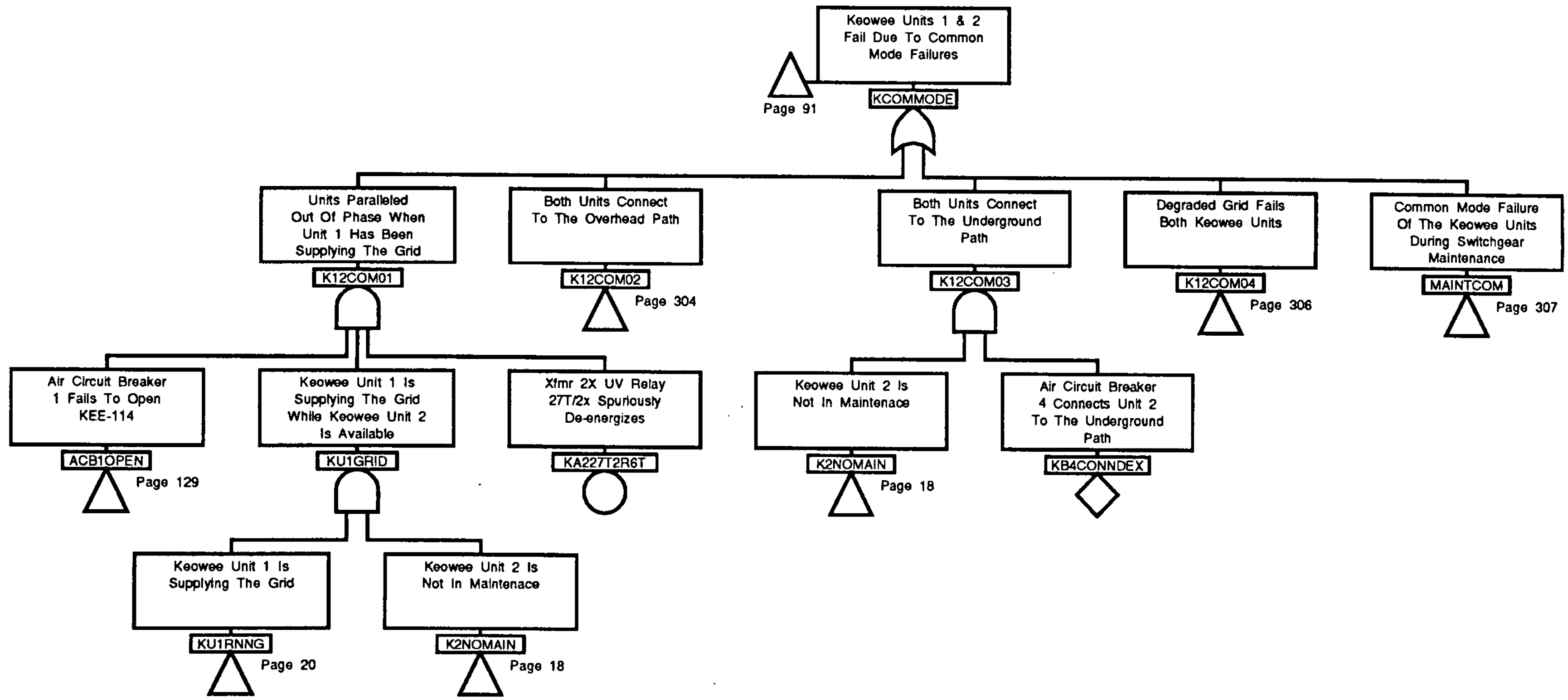


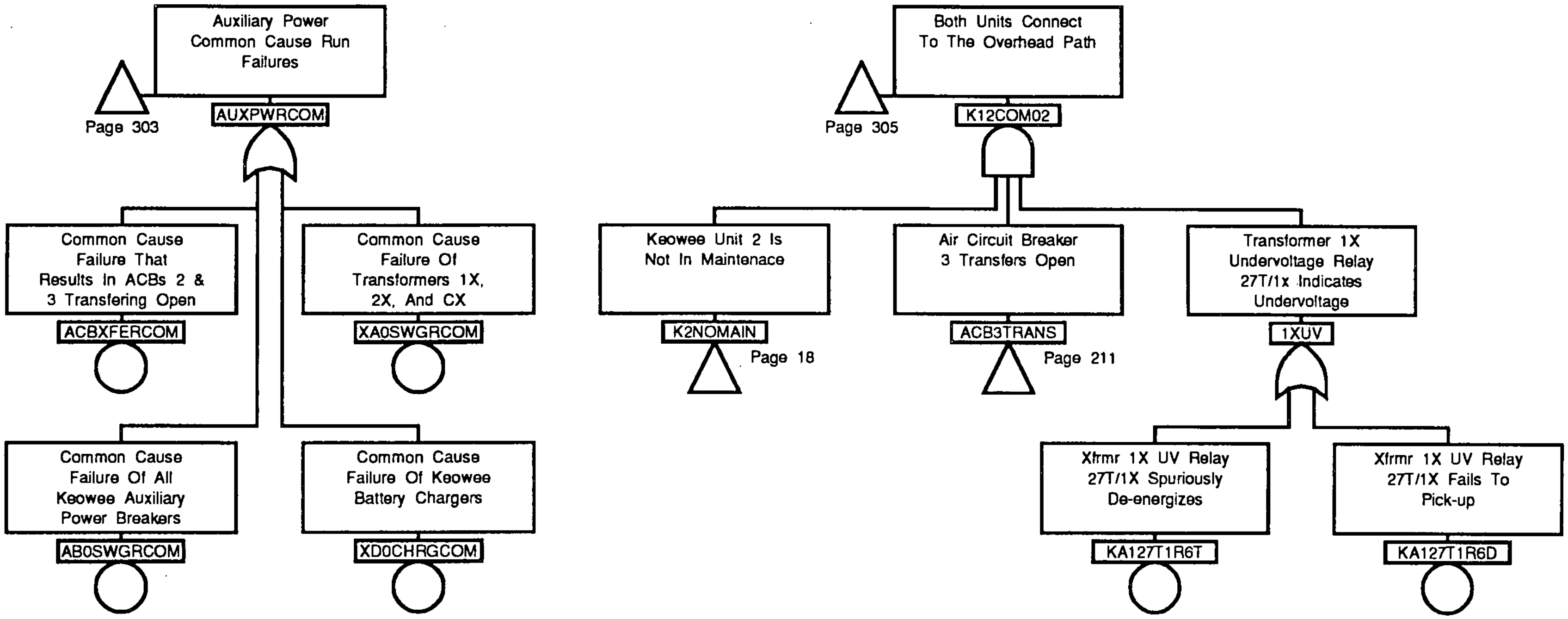
Power To Bus 1 Fails Given Both Keowee Units In Maintenance
PLEESB1CN
Page 104
Power From Lee Steam Station To Standby Bus 1 Fails
PLEESB1
Both Keowee Units Unavailable Due To Common Maintenance
KK1BOTHHYM
4
Loss Of Power From CT5
PCT5
Page 309
4160 V ac Standby Breaker SL1 Transfers Open
PACXSL1C4T
Power To Bus 2 Fails Given Both Keowee Units In Maintenance
PLEESB2CN
Page 104
Power From Lee Steam Station To Standby Bus 2 Fails
PLEESB2
Both Keowee Units Unavailable Due To Common Maintenance
KK1BOTHHYM
4
Loss Of Power From CT5
PCT5
Page 309
4160 V ac Standby Breaker SL2 Transfers Open
PACXSL2C4T

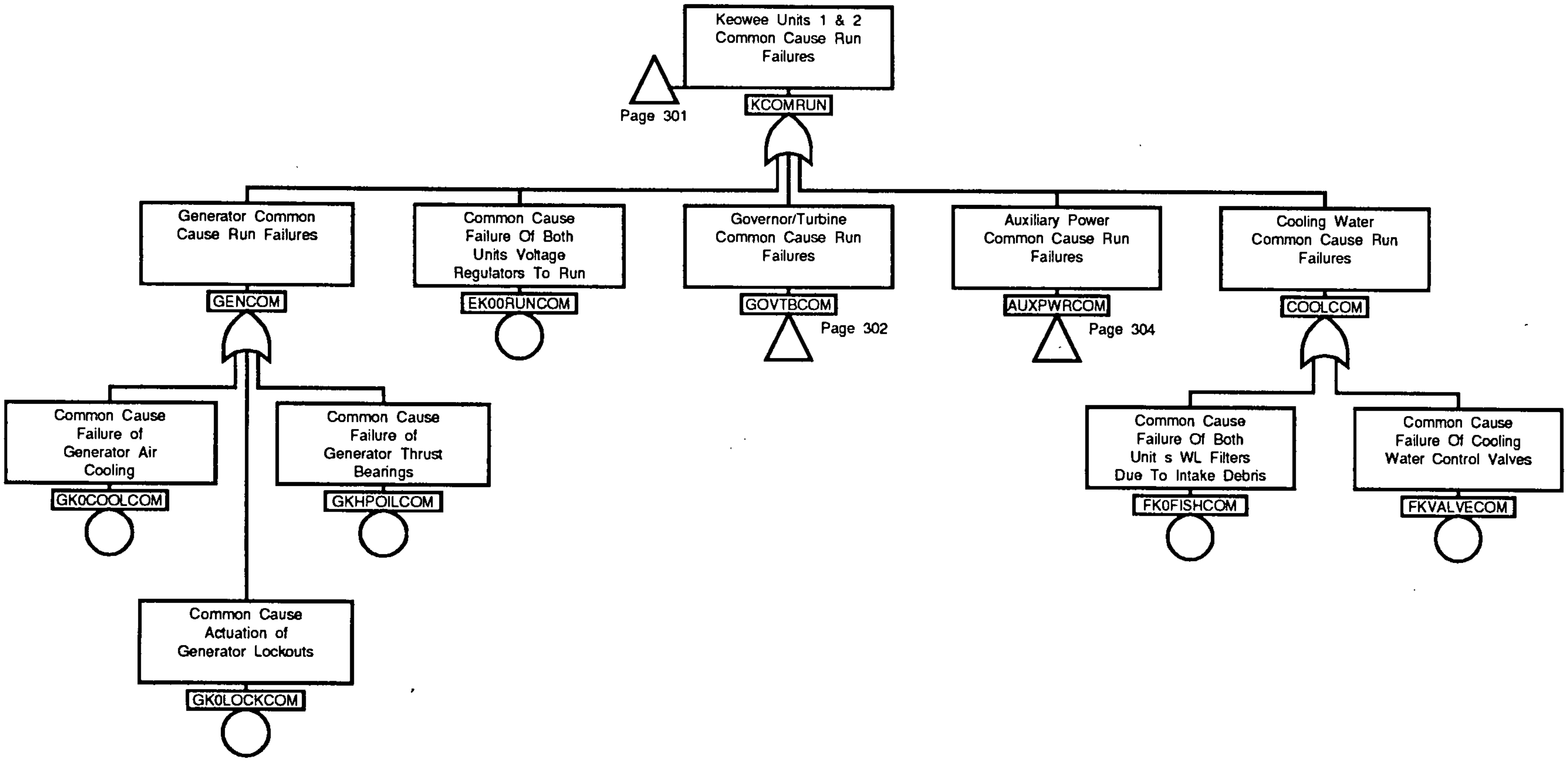


Common Mode Failure Of The Keowee Units During Switchgear Maintenance
MAINTCOM
Page 305
600 Vac MCC 1XA Alternate Power Source, Switchgear 2X, Fails
XA1XAE
600 Vac MCC 2XA Alternate Power Source, Switchgear 1X, Fails
XA2XAE
600 Vac MCC 1XA Alternate Power Source, SWGR 2X, Fails
XA1XAEF
MCC 1XA Is Connected to Its Alternate Source of Power
XA1XAALBLM
2
600 Vac MCC 2XA Alternate Power Source, SWGR 1X, Fails
XA2XAEF
Page 306
MCC 2XA Is Connected to Its Alternate Power Source
XA2XAALBLM
2
600 Vac Bkr 2XA-4A Transfers Position
XA1XA1ACLT
600 Vac Bkr 1X-2A Transfers Position
XA2X2DXCLT
Loss of Power on 600 Vac Switchgear 2X K-702
XA2X
Page 256

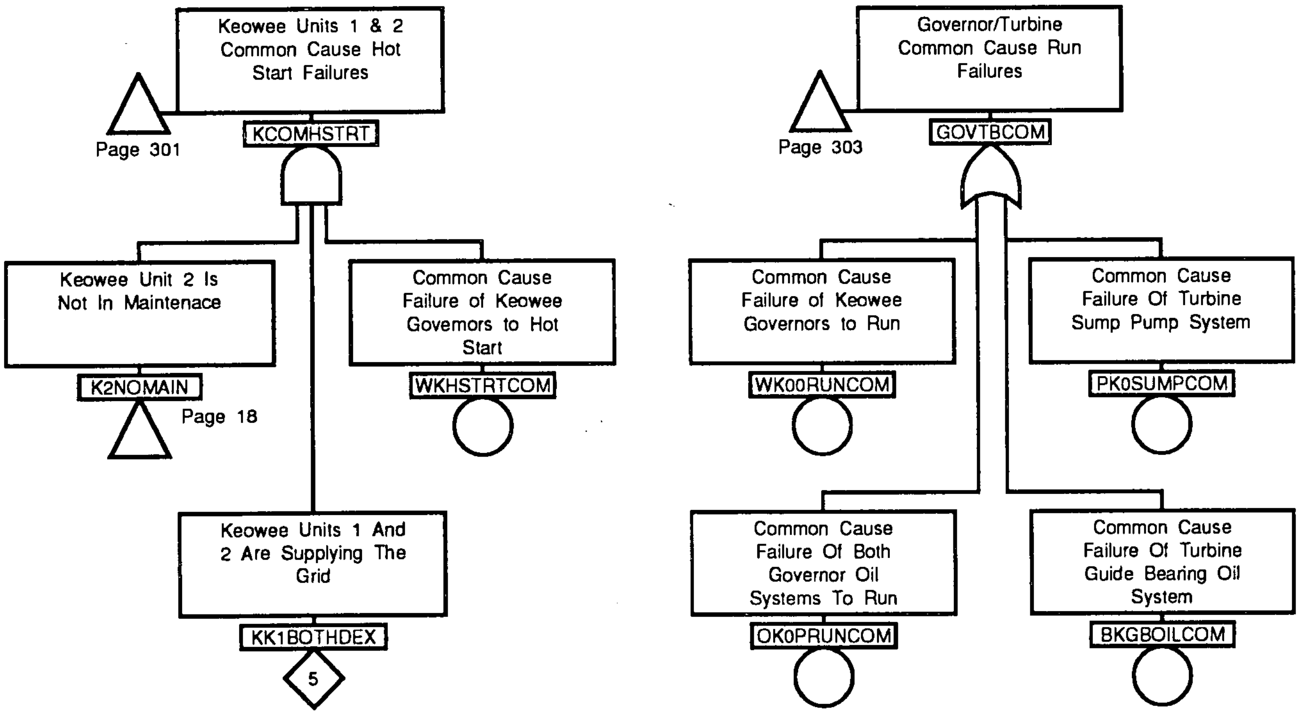

Degraded Grid Fails Both Keowee Units
K12COM04
Page 305
Keowee Units 1 And 2 Are Supplying The Grid
KK1BOTHDEX
5
Grid Degradation Occurs And Causes Failure Of Both Keowee Units
K12COM1DEX
600 Vac MCC 2XA Alternate Power Source, SWGR 1X, Fails
XA2XAEF
Page 307
600 Vac Bkr 1XA-1A Transfers Position
XA2X4AXCLT
600 Vac Bkr 2X-2D Transfers Position
XA1X2AXCLT
Loss of Power on 600 Vac Switchgear 1X K-702
XA1X
Page 167

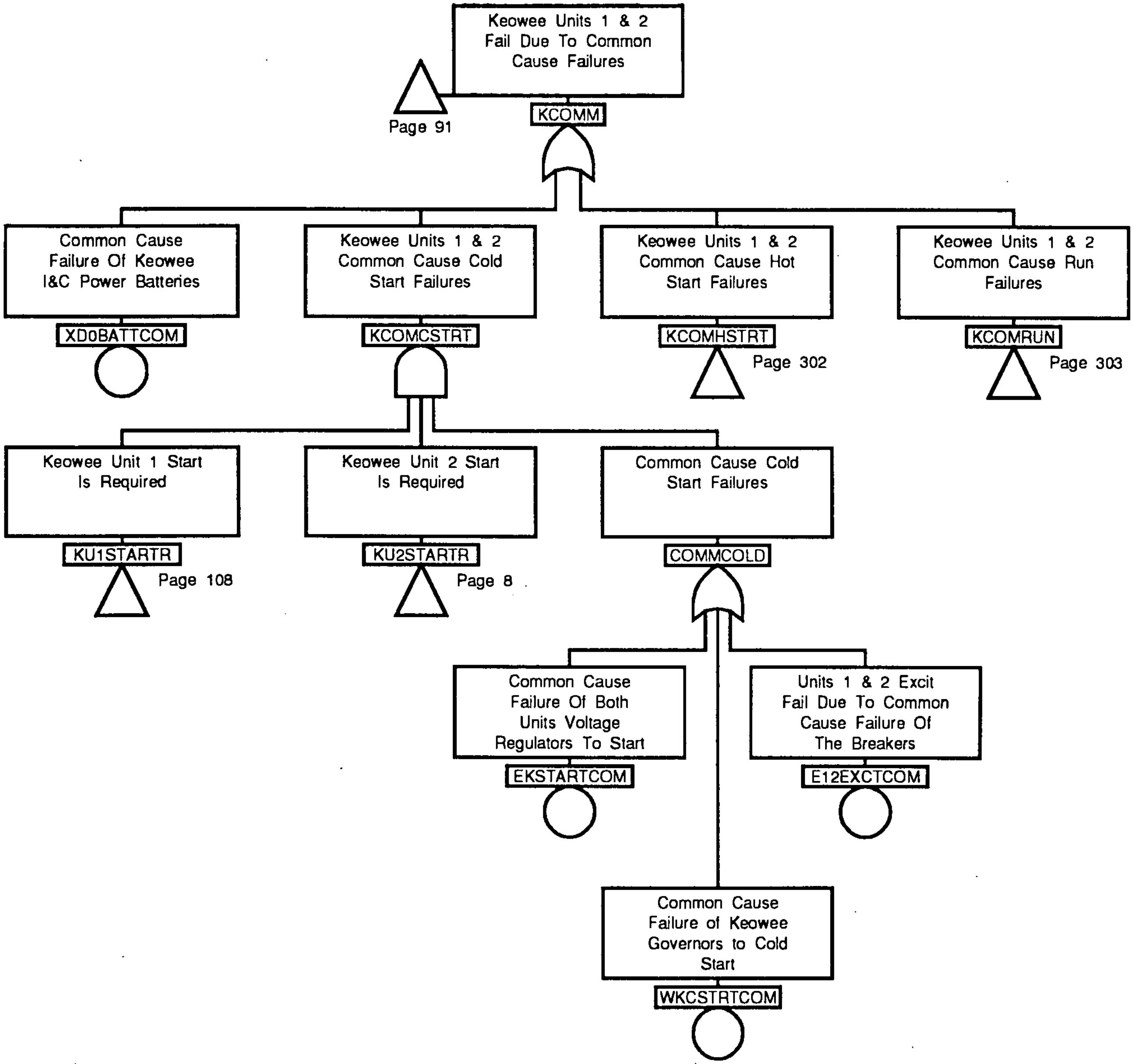

Keowee Units 1 & 2 Fail Due To Common Mode Failures
Page 91
KCOMMODE
Units Paralleled Out Of Phase When Unit 1 Has Been Supplying The Grid
K12COM01
Both Units Connect To The Overhead Path
K12COM02
Page 304
Both Units Connect To The Underground Path
K12COM03
Degraded Grid Fails Both Keowee Units
K12COM04
Page 306
Common Mode Failure Of The Keowee Units During Switchgear Maintenance
MAINTCOM
Page 307
Air Circuit Breaker 1 Fails To Open KEE-114
ACB1OPEN
Page 129
Keowee Unit 1 Is Supplying The Grid While Keowee Unit 2 Is Available
KU1GRID
Xfmr 2X UV Relay 27T/2x Spuriously De-energizes
KA227T2R6T
Keowee Unit 2 Is Not In Maintenace
K2NOMAIN
Page 18
Air Circuit Breaker 4 Connects Unit 2 To The Underground Path
KB4CONNDEX
Keowee Unit 1 Is Supplying The Grid
KU1RNNG
Page 20
Keowee Unit 2 Is Not In Maintenace
K2NOMAIN
Page 18


Auxiliary Power Common Cause Run Failures
AUXPWRCOM
Page 303
Common Cause Failure That Results In ACBs 2 & 3 Transfering Open
ACBXFERCOM
Common Cause Failure Of Transformers 1X, 2X, And CX
XA0SWGRCOM
Common Cause Failure Of All Keowee Auxiliary Power Breakers
AB0SWGRCOM
Common Cause Failure Of Keowee Battery Chargers
XD0CHRGCOM
Both Units Connect To The Overhead Path
K12COM02
Page 305
Keowee Unit 2 Is Not In Maintenace
K2NOMAIN
Page 18
Air Circuit Breaker 3 Transfers Open
ACB3TRANS
Page 211
Transformer 1X Undervoltage Relay 27T/1x Indicates Undervoltage
1XUV
Xfrmr 1X UV Relay 27T/1X Spuriously De-energizes
KA127T1R6T
Xfrmr 1X UV Relay 27T/1X Fails To Pick-up
KA127T1R6D

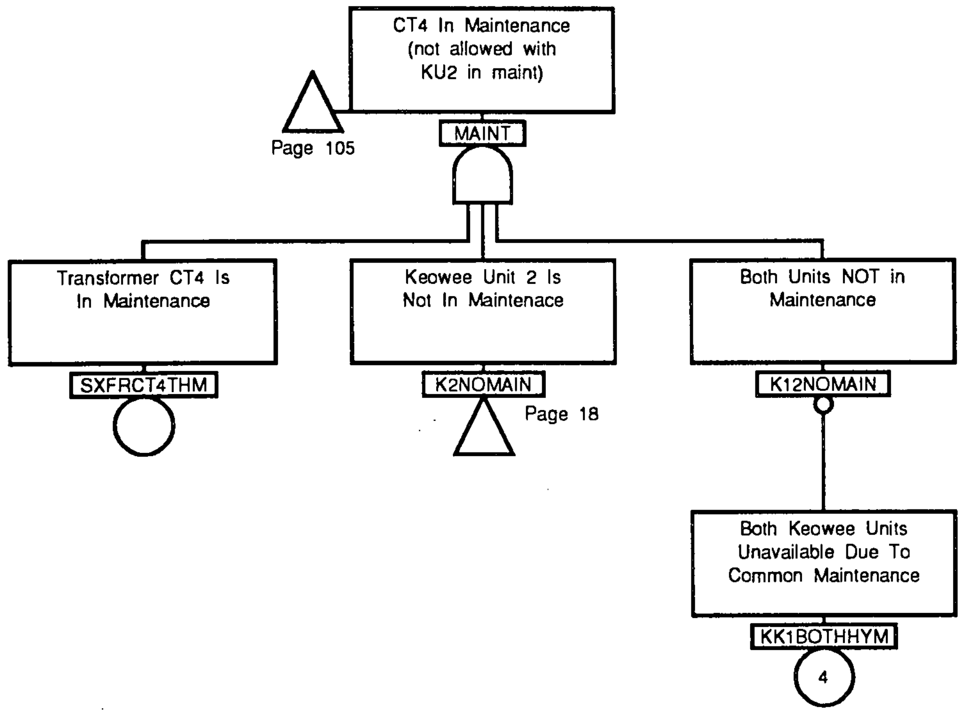


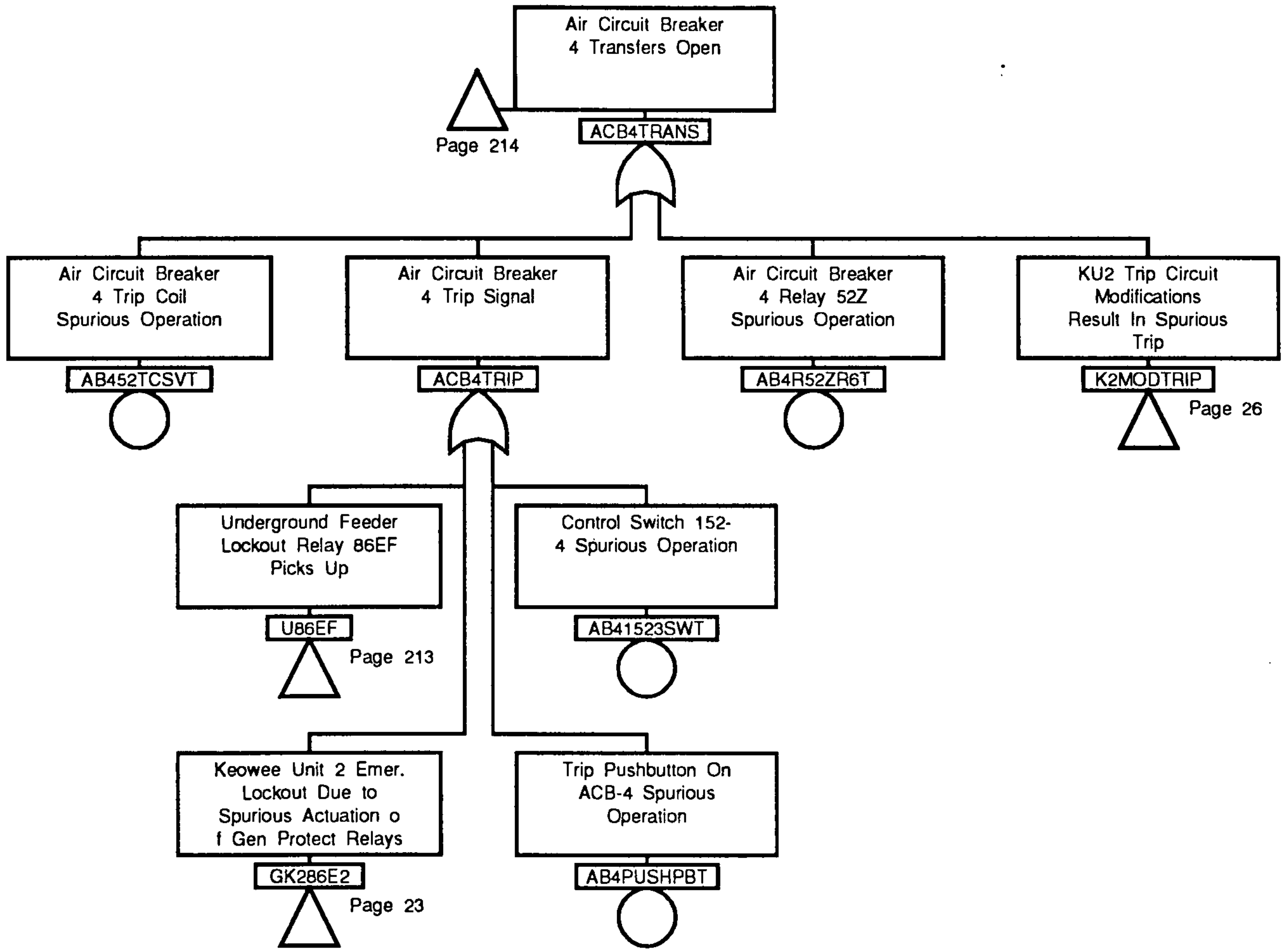
Keewee Units 1 & 2 Common Cause Run Failures
KCOMRUN
Page 301
Generator Common Cause Run Failures
GENCOM
Common Cause Failure Of Both Units Voltage Regulators To Run
EK00RUNCOM
Governor/Turbine Common Cause Run Failures
GOVTBCOM
Page 302
Auxiliary Power Common Cause Run Failures
AUXPWRCOM
Page 304
Cooling Water Common Cause Run Failures
COOLCOM
Common Cause Failure of Generator Air Cooling
GK0COOLCOM
Common Cause Failure of Generator Thrust Bearings
GKHPOILCOM
Common Cause Actuation of Generator Lockouts
GK0LOCKCOM
Common Cause Failure Of Both Unit s WL Filters Due To Intake Debris
FK0FISHCOM
Common Cause Failure Of Cooling Water Control Valves
FKVALVECOM

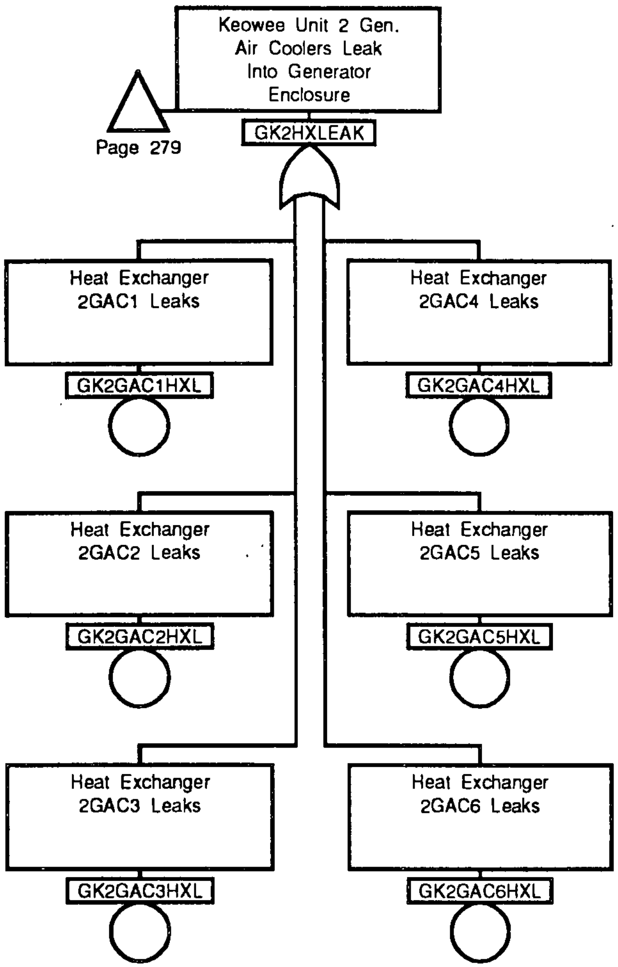

Keewee Units 1 & 2 Common Cause Hot Start Failures
KCOMHSTRT
Page 301
Keowee Unit 2 Is Not In Maintenace
K2NOMAIN
Page 18
Common Cause Failure of Keowee Governors to Hot Start
WKHSTRTCOM
Keowee Units 1 And 2 Are Supplying The Grid
KK1BOTHDEX
5
Governor/Turbine Common Cause Run Failures
GOVTBCOM
Page 303
Common Cause Failure of Keowee Governors to Run
WK00RUNCOM
Common Cause Failure Of Turbine Sump Pump System
PK0SUMPCOM
Common Cause Failure Of Both Governor Oil Systems To Run
OK0PRUNCOM
Common Cause Failure Of Turbine Guide Bearing Oil System
BKGBOILCOM

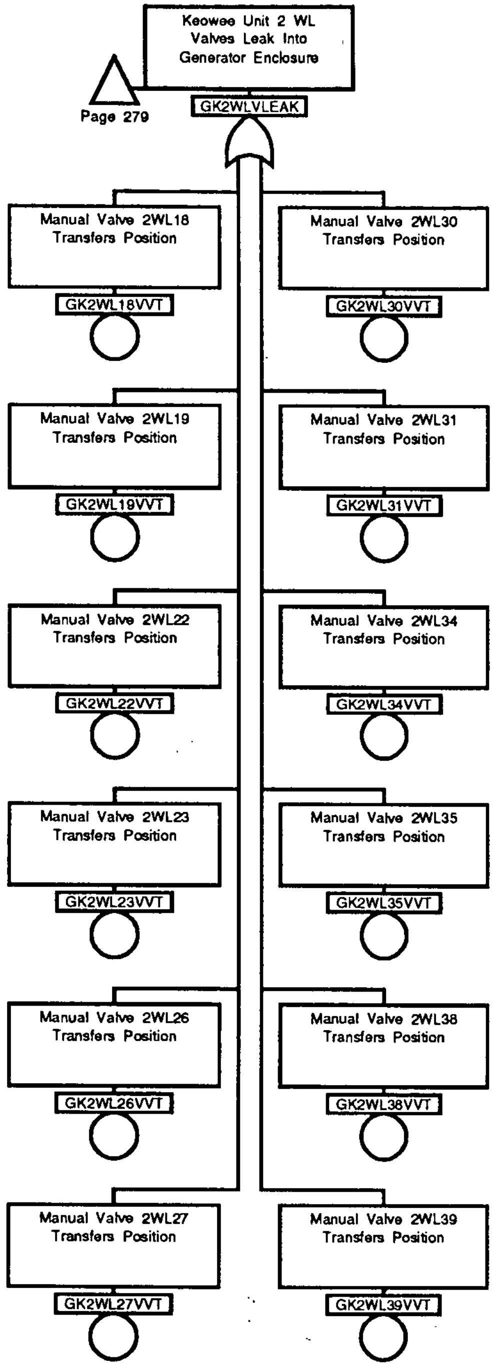


Keewee Units 1 & 2 Fail Due To Common Cause Failures
Page 91
KCOMM
Common Cause Failure Of Keowee I&C Power Batteries
XD0BATTCOM
Keowee Units 1 & 2 Common Cause Cold Start Failures
KCOMCSTRT
Keowee Units 1 & 2 Common Cause Hot Start Failures
KCOMHSTRT
Page 302
Keowee Units 1 & 2 Common Cause Run Failures
KCOMRUN
Page 303
Keowee Unit 1 Start Is Required
KU1STARTR
Page 108
Keowee Unit 2 Start Is Required
KU2STARTR
Page 8
Common Cause Cold Start Failures
COMMCOLD
Common Cause Failure Of Both Units Voltage Regulators To Start
EKSTARTCOM
Units 1 & 2 Excit Fail Due To Common Cause Failure Of The Breakers
E12EXCTCOM
Common Cause Failure of Keowee Governors to Cold Start
WKCSTRTCOM

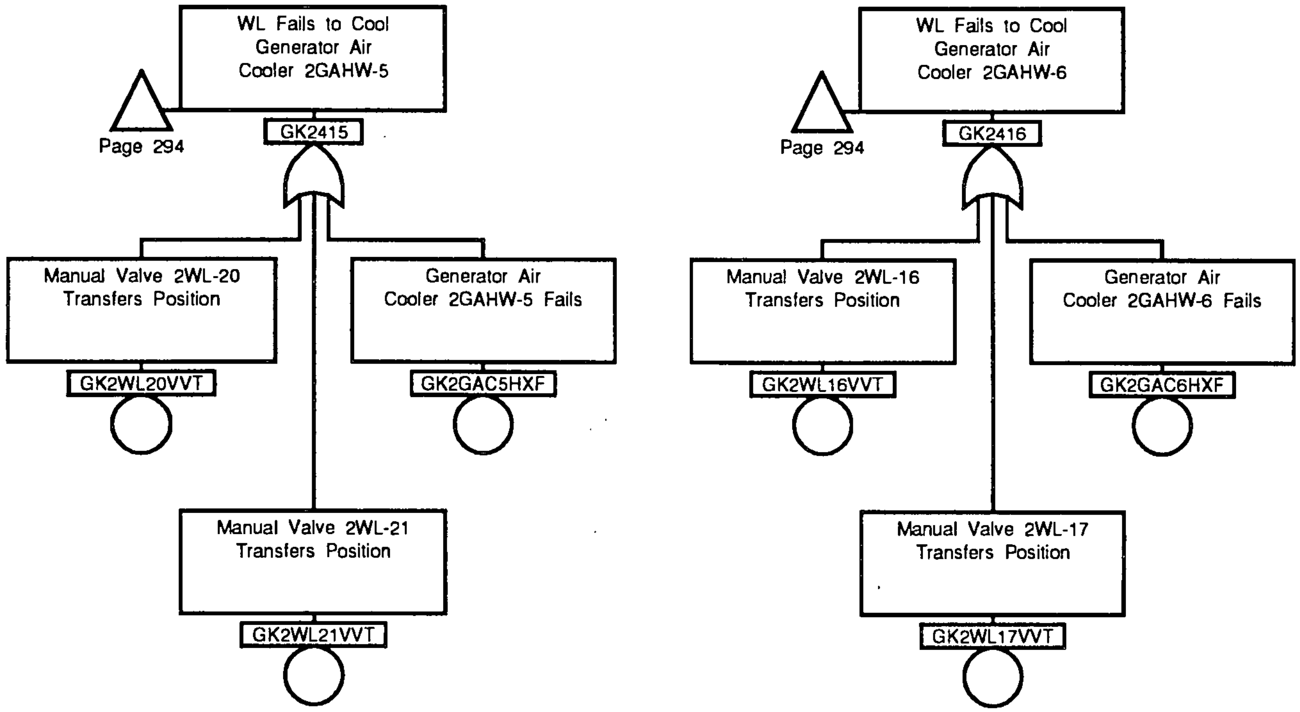

CT4 In Maintenance (not allowed with KU2 in maint)
MAINT
Page 105
Transformer CT4 Is In Maintenance
SXFRCT4THM
Keowee Unit 2 Is Not In Maintenace
K2NOMAIN
Page 18
Both Units NOT in Maintenance
K12NOMAIN
Both Keowee Units Unavailable Due To Common Maintenance
KK1BOTHHYM
4

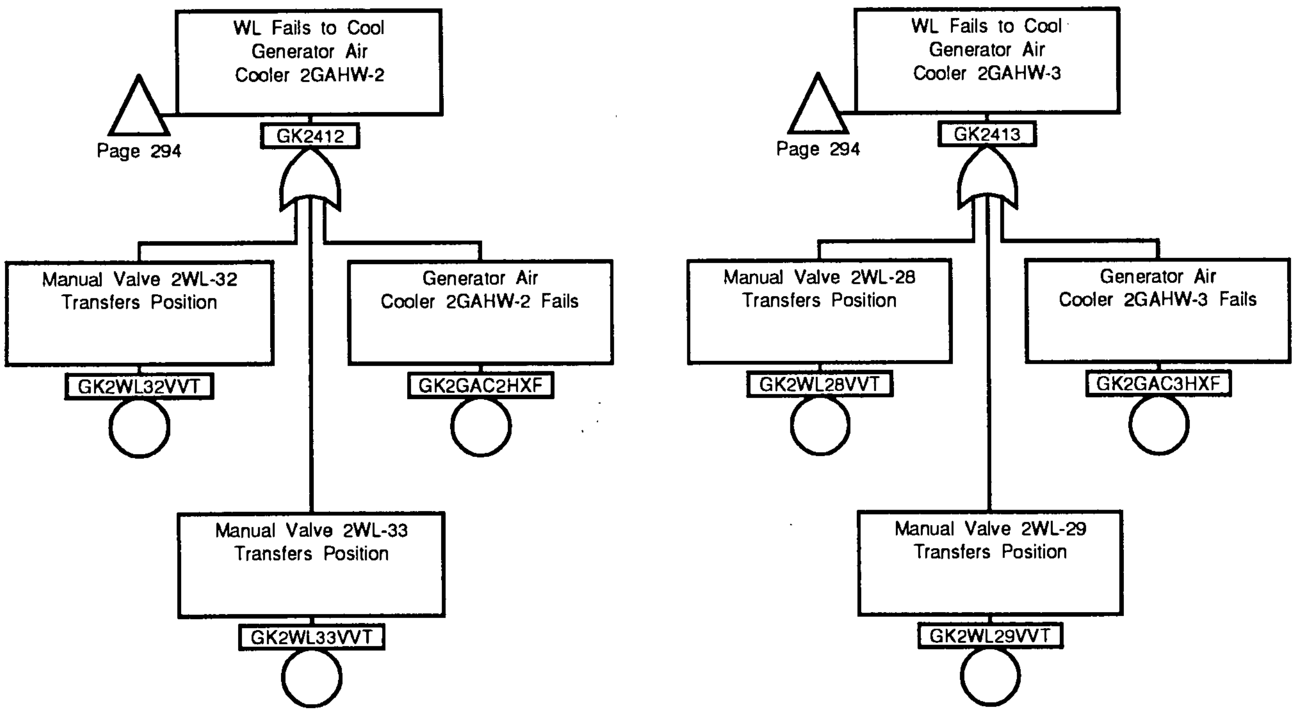

Air Circuit Breaker 4 Transfers Open
ACB4TRANS
Page 214
Air Circuit Breaker 4 Trip Coil Spurious Operation
AB452TCSVT
Air Circuit Breaker 4 Trip Signal
ACB4TRIP
Air Circuit Breaker 4 Relay 52Z Spurious Operation
AB4R52ZR6T
KU2 Trip Circuit Modifications Result In Spurious Trip
K2MODTRIP
Page 26
Underground Feeder Lockout Relay 86EF Picks Up
U86EF
Page 213
Control Switch 152-4 Spurious Operation
AB41523SWT
Keowee Unit 2 Emer. Lockout Due to Spurious Actuation o f Gen Protect Relays
GK286E2
Page 23
Trip Pushbutton On ACB-4 Spurious Operation
AB4PUSHPBT

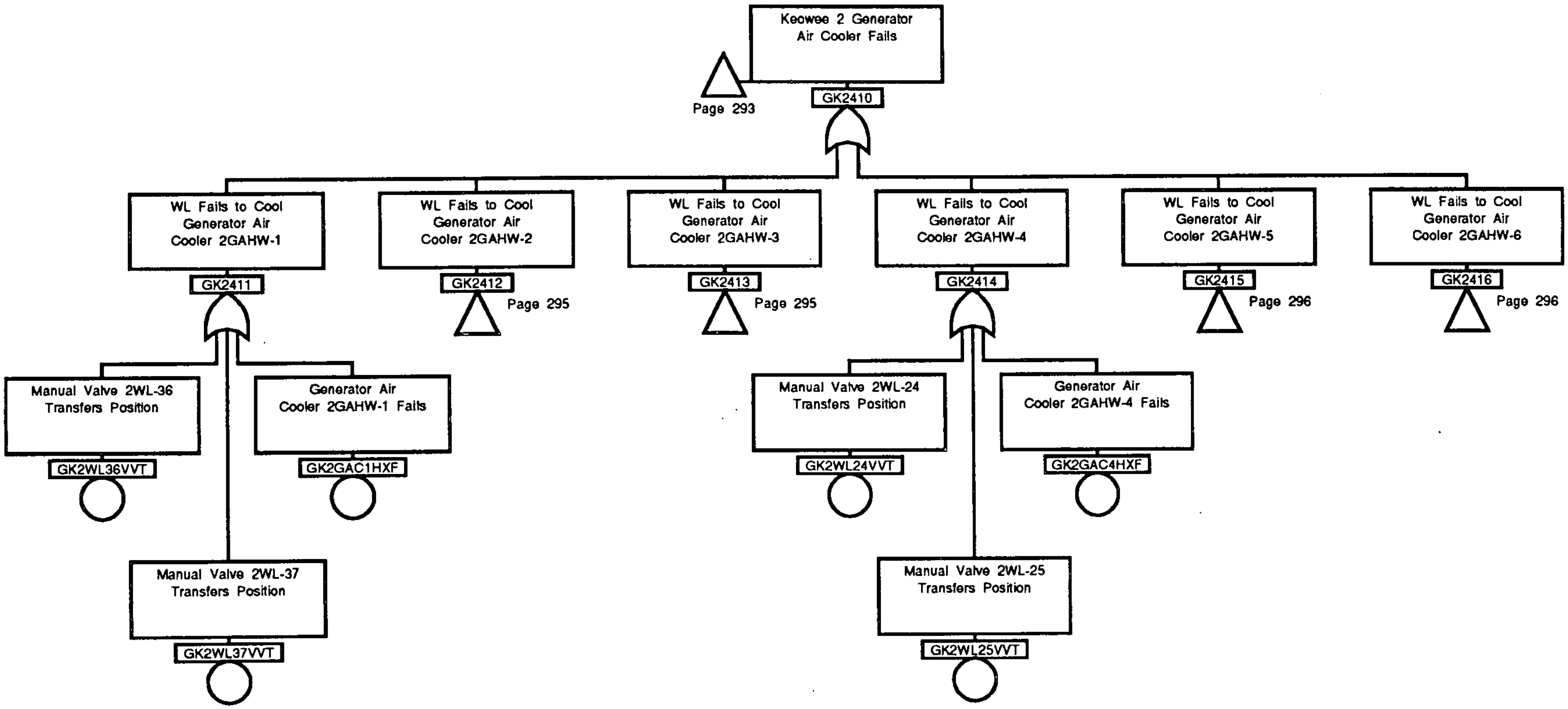

Keewee Unit 2 Gen.
Air Coolers Leak
Into Generator
Enclosure
GK2HXLEAK
Page 279
Heat Exchanger
2GAC1 Leaks
GK2GAC1HXL
Heat Exchanger
2GAC4 Leaks
GK2GAC4HXL
Heat Exchanger
2GAC2 Leaks
GK2GAC2HXL
Heat Exchanger
2GAC5 Leaks
GK2GAC5HXL
Heat Exchanger
2GAC3 Leaks
GK2GAC3HXL
Heat Exchanger
2GAC6 Leaks
GK2GAC6HXL



Keowee Unit 2 WL Valves Leak Into Generator Enclosure
GK2WLVLEAK
Page 279
Manual Valve 2WL18 Transfers Position
GK2WL18VVT
Manual Valve 2WL30 Transfers Position
GK2WL30VVT
Manual Valve 2WL19 Transfers Position
GK2WL19VVT
Manual Valve 2WL31 Transfers Position
GK2WL31VVT
Manual Valve 2WL22 Transfers Position
GK2WL22VVT
Manual Valve 2WL34 Transfers Position
GK2WL34VVT
Manual Valve 2WL23 Transfers Position
GK2WL23VVT
Manual Valve 2WL35 Transfers Position
GK2WL35VVT
Manual Valve 2WL26 Transfers Position
GK2WL26VVT
Manual Valve 2WL38 Transfers Position
GK2WL38VVT
Manual Valve 2WL27 Transfers Position
GK2WL27VVT
Manual Valve 2WL39 Transfers Position
GK2WL39VVT


WL Fails to Cool Generator Air Cooler 2GAHW-5
GK2415
Page 294
Manual Valve 2WL-20 Transfers Position
GK2WL20VVT
Generator Air Cooler 2GAHW-5 Fails
GK2GAC5HXF
Manual Valve 2WL-21 Transfers Position
GK2WL21VVT
WL Fails to Cool Generator Air Cooler 2GAHW-6
GK2416
Page 294
Manual Valve 2WL-16 Transfers Position
GK2WL16VVT
Generator Air Cooler 2GAHW-6 Fails
GK2GAC6HXF
Manual Valve 2WL-17 Transfers Position
GK2WL17VVT


WL Fails to Cool Generator Air Cooler 2GAHW-2
Page 294
GK2412
Manual Valve 2WL-32 Transfers Position
GK2WL32VVT
Generator Air Cooler 2GAHW-2 Fails
GK2GAC2HXF
Manual Valve 2WL-33 Transfers Position
GK2WL33VVT
WL Fails to Cool Generator Air Cooler 2GAHW-3
Page 294
GK2413
Manual Valve 2WL-28 Transfers Position
GK2WL28VVT
Generator Air Cooler 2GAHW-3 Fails
GK2GAC3HXF
Manual Valve 2WL-29 Transfers Position
GK2WL29VVT


Keowee 2 Generator Air Cooler Fails
GK2410
Page 293
WL Fails to Cool Generator Air Cooler 2GAHW-1
GK2411
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GK2412
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GK2414
WL Fails to Cool Generator Air Cooler 2GAHW-5
GK2415
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GK2416
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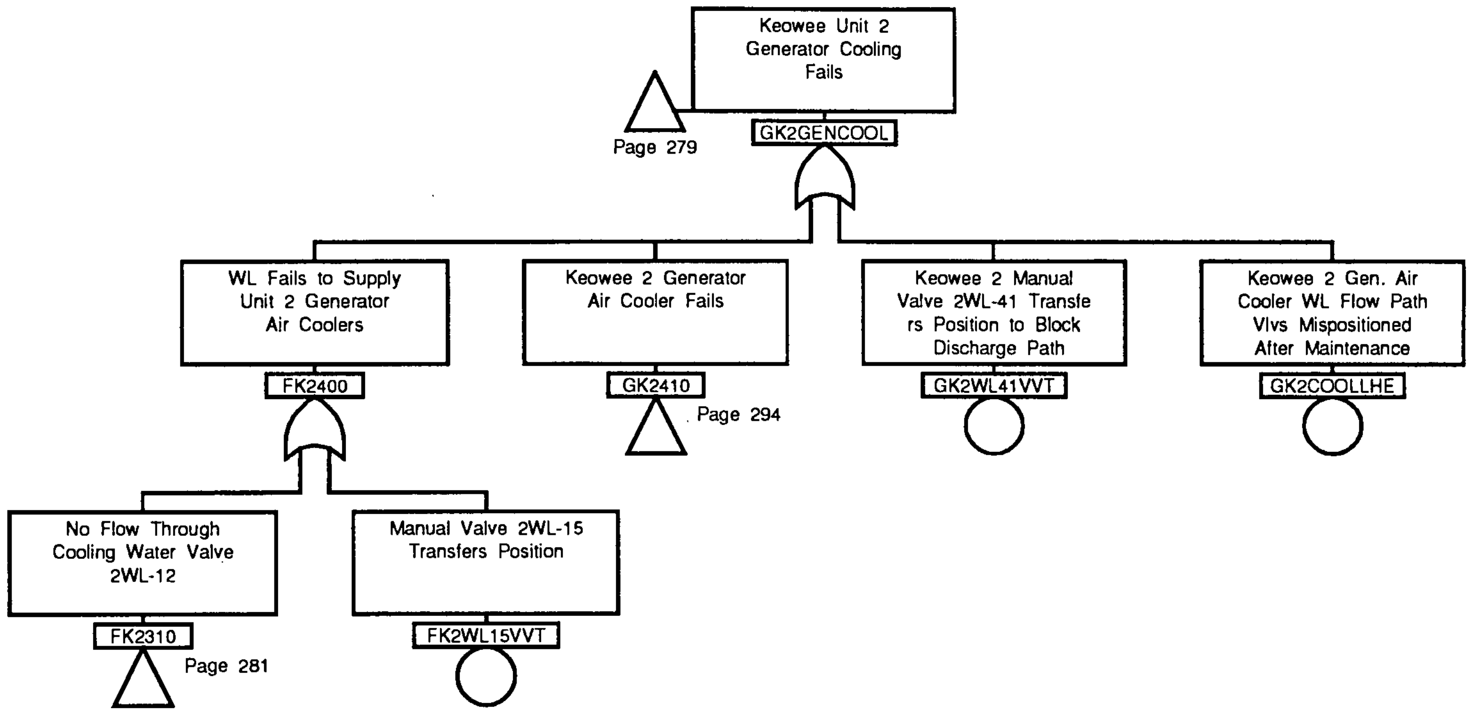
GK2WL36VVT
Generator Air Cooler 2GAHW-1 Fails
GK2GAC1HXF
Manual Valve 2WL-37 Transfers Position
GK2WL37VVT
Manual Valve 2WL-24 Transfers Position
GK2WL24VVT
Generator Air Cooler 2GAHW-4 Fails
GK2GAC4HXF
Manual Valve 2WL-25 Transfers Position
GK2WL25VVT


Keewee Unit 2 Generator Cooling Fails
GK2GENCOOL
Page 279
WL Fails to Supply Unit 2 Generator Air Coolers
FK2400
Keowee 2 Generator Air Cooler Fails
GK2410
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GK2WL41VVT
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GK2COOLLHE
No Flow Through Cooling Water Valve 2WL-12
FK2310
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Manual Valve 2WL-15 Transfers Position
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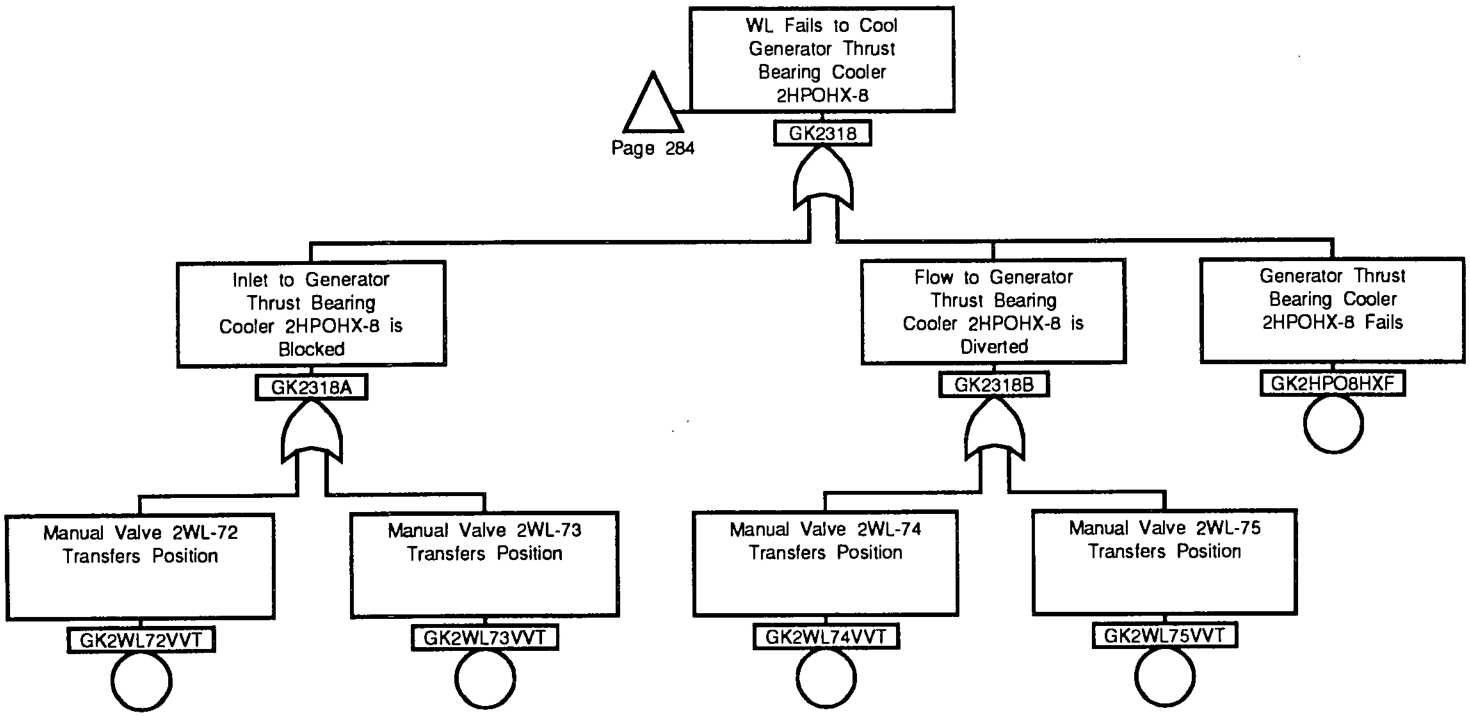

WL Fails to Cool Generator Thrust Bearing Cooler 2HPOHX-8
GK2318
Page 284
Inlet to Generator Thrust Bearing Cooler 2HPOHX-8 is Blocked
GK2318A
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GK2318B
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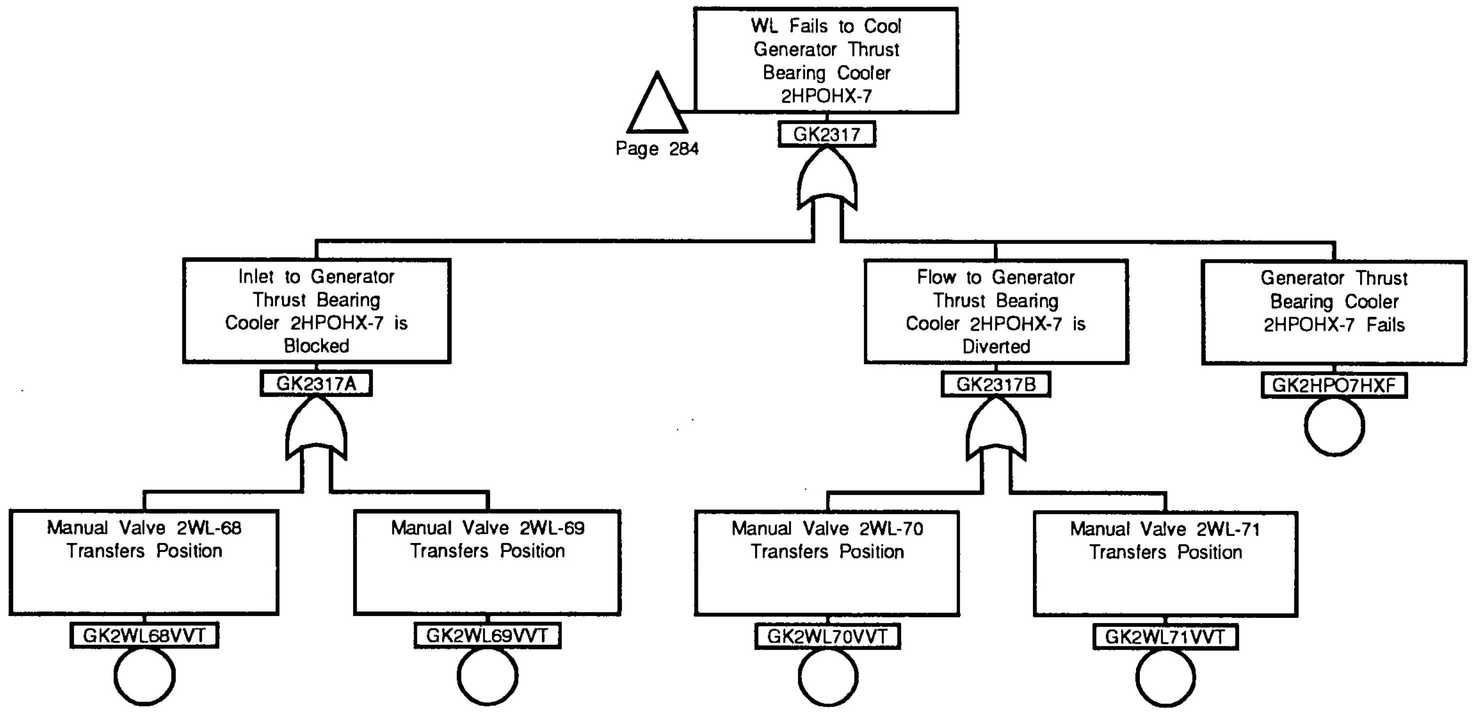
GK2WL73VVT
Manual Valve 2WL-74 Transfers Position
GK2WL74VVT
Manual Valve 2WL-75 Transfers Position
GK2WL75VVT



WL Fails to Cool Generator Thrust Bearing Cooler 2HPOHX-7
GK2317
Page 284
Inlet to Generator Thrust Bearing Cooler 2HPOHX-7 is Blocked
GK2317A
Flow to Generator Thrust Bearing Cooler 2HPOHX-7 is Diverted
GK2317B
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GK2HPO7HXF
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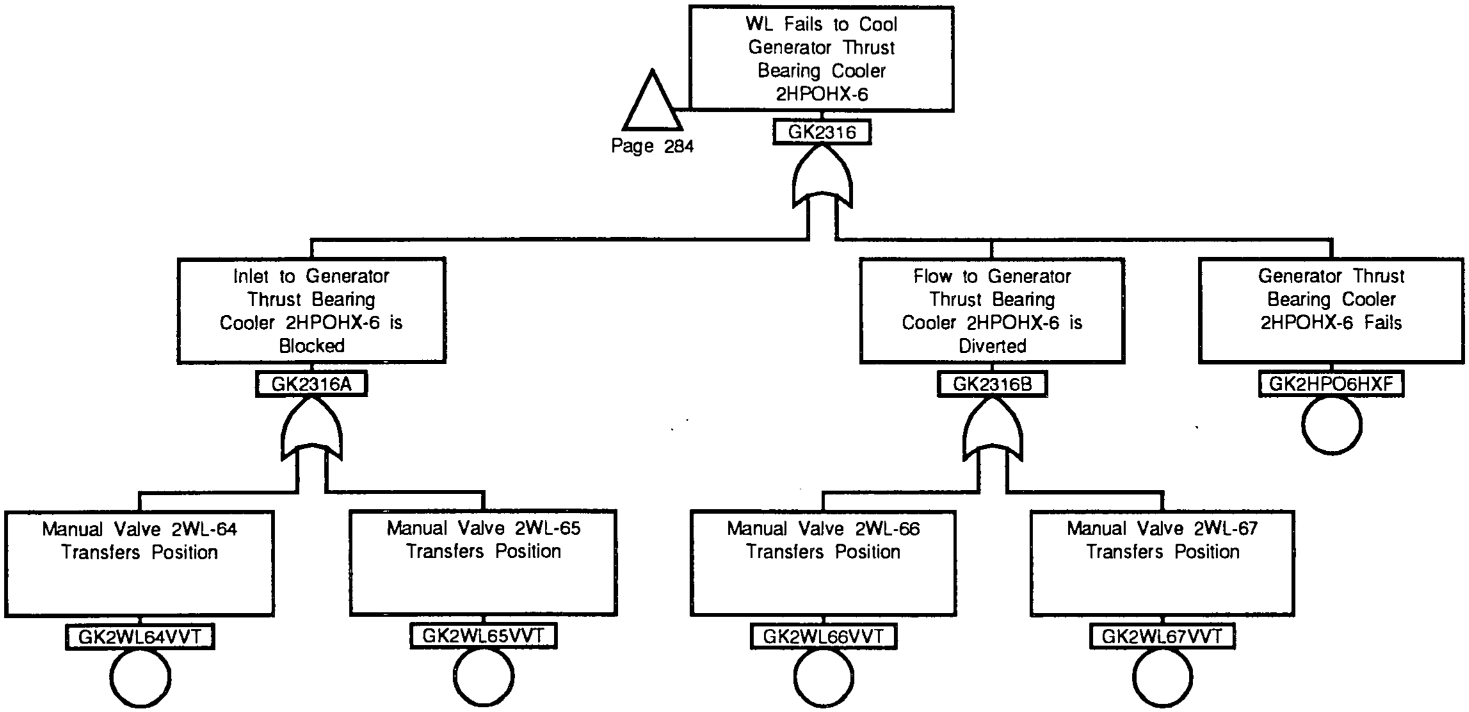
GK2WL69VVT
Manual Valve 2WL-70 Transfers Position
GK2WL70VVT
Manual Valve 2WL-71 Transfers Position
GK2WL71VVT



WL Fails to Cool Generator Thrust Bearing Cooler 2HPOHX-6
GK2316
Page 284
Inlet to Generator Thrust Bearing Cooler 2HPOHX-6 is Blocked
GK2316A
Flow to Generator Thrust Bearing Cooler 2HPOHX-6 is Diverted
GK2316B
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GK2HPO6HXF
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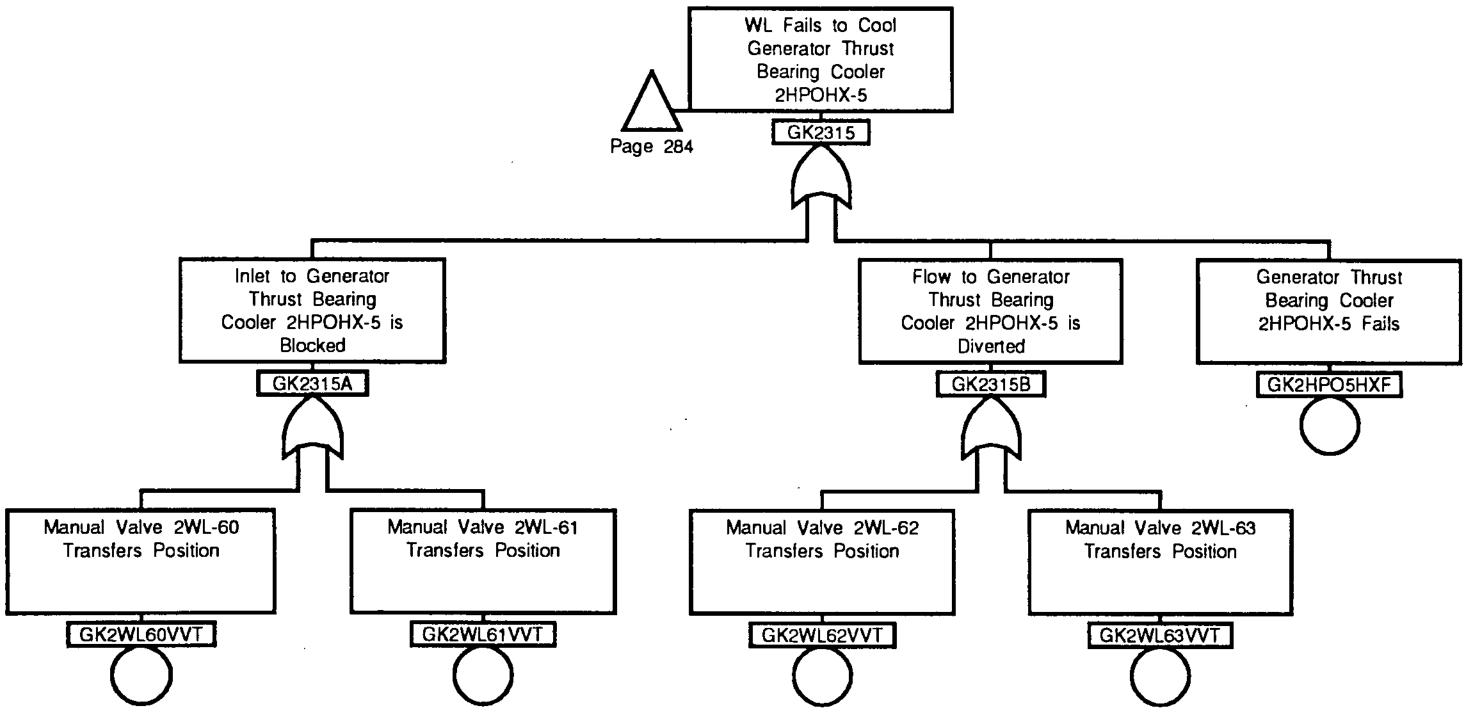
GK2WL65VVT
Manual Valve 2WL-66 Transfers Position
GK2WL66VVT
Manual Valve 2WL-67 Transfers Position
GK2WL67VVT



WL Fails to Cool Generator Thrust Bearing Cooler 2HPOHX-5
GK2315
Page 284
Inlet to Generator Thrust Bearing Cooler 2HPOHX-5 is Blocked
GK2315A
Flow to Generator Thrust Bearing Cooler 2HPOHX-5 is Diverted
GK2315B
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GK2HPO5HXF
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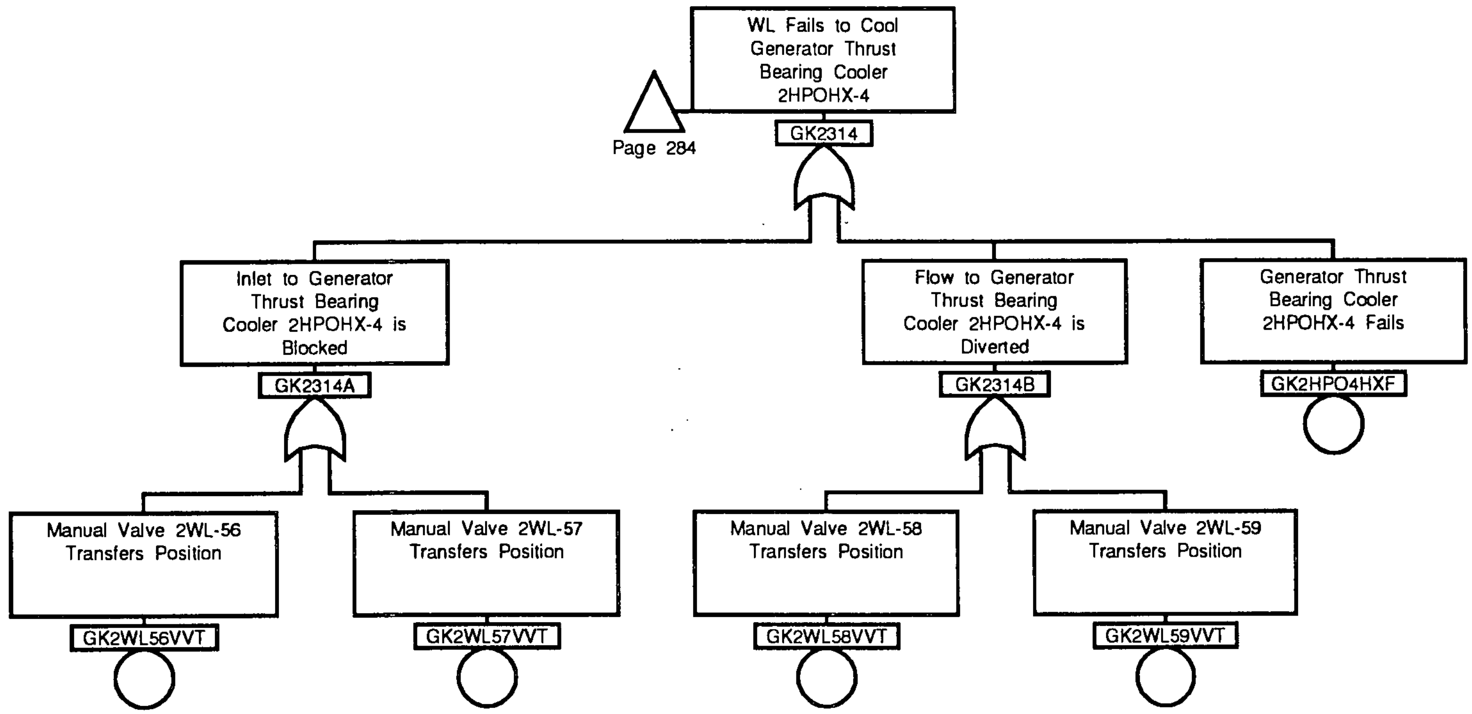
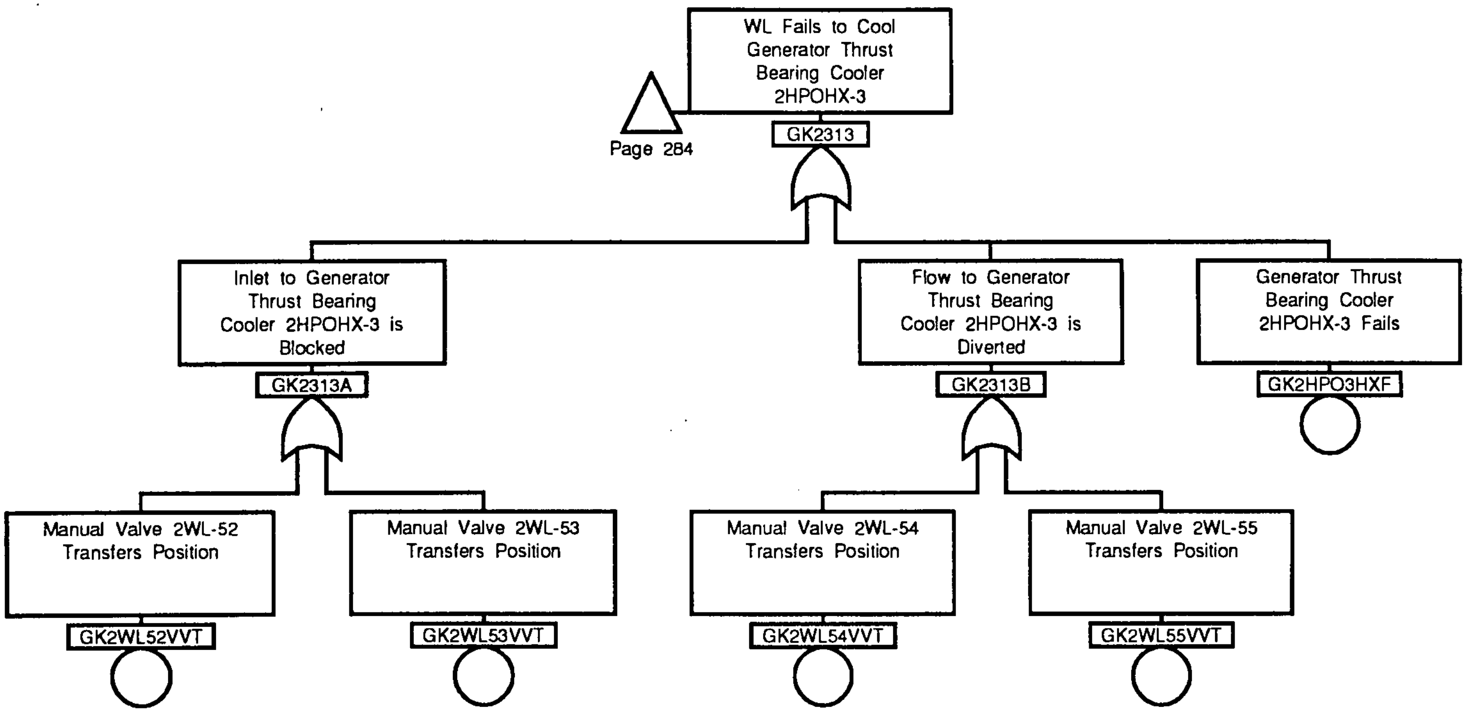
GK2WL61VVT
Manual Valve 2WL-62 Transfers Position
GK2WL62VVT
Manual Valve 2WL-63 Transfers Position
GK2WL63VVT


WL Fails to Cool Generator Thrust Bearing Cooler 2HPOHX-4
GK2314
Page 284
Inlet to Generator Thrust Bearing Cooler 2HPOHX-4 is Blocked
GK2314A
Flow to Generator Thrust Bearing Cooler 2HPOHX-4 is Diverted
GK2314B
Generator Thrust Bearing Cooler 2HPOHX-4 Fails
GK2HPO4HXF
Manual Valve 2WL-56 Transfers Position
GK2WL56VVT
Manual Valve 2WL-57 Transfers Position
GK2WL57VVT
Manual Valve 2WL-58 Transfers Position
GK2WL58VVT
Manual Valve 2WL-59 Transfers Position
GK2WL59VVT



WL Fails to Cool Generator Thrust Bearing Cooler 2HPOHX-3
GK2313
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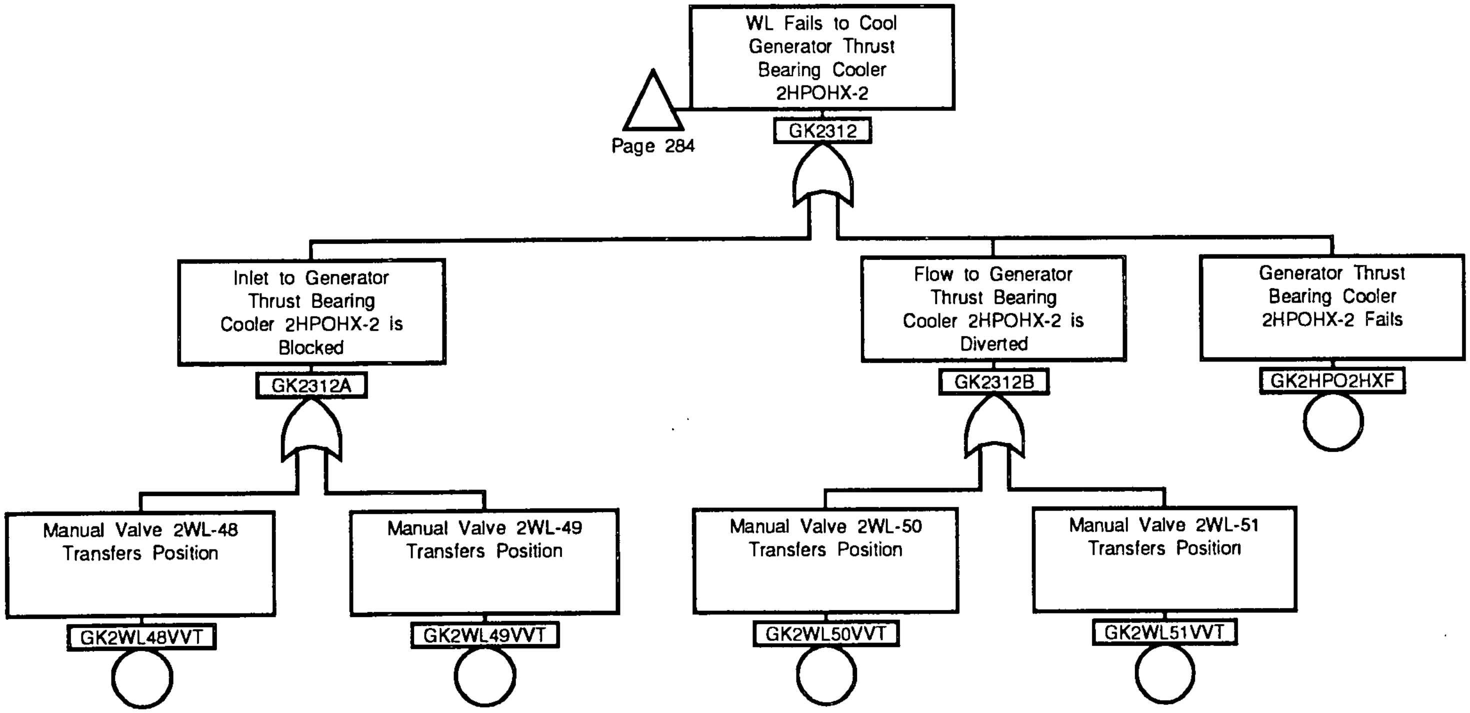
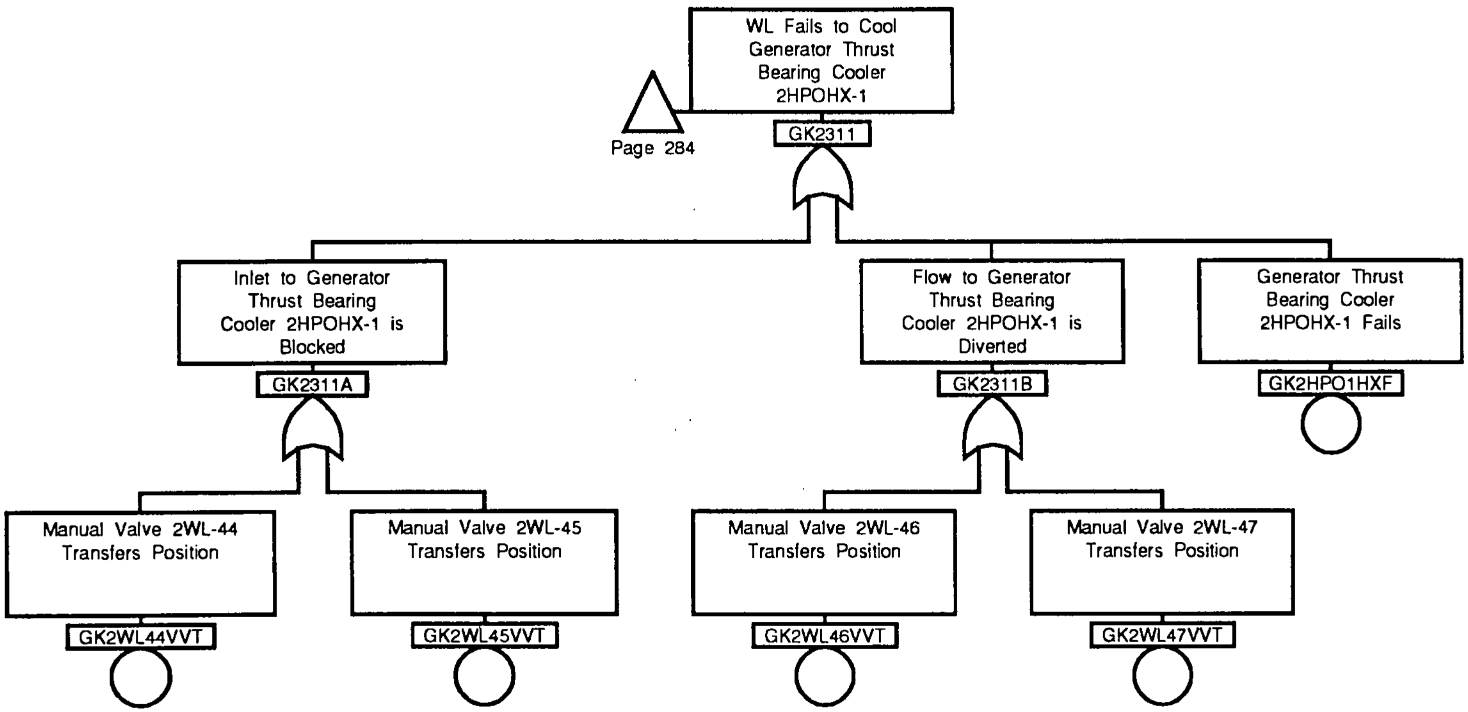
Inlet to Generator Thrust Bearing Cooler 2HPOHX-3 is Blocked
GK2313A
Flow to Generator Thrust Bearing Cooler 2HPOHX-3 is Diverted
GK2313B
Generator Thrust Bearing Cooler 2HPOHX-3 Fails
GK2HPO3HXF
Manual Valve 2WL-52 Transfers Position
GK2WL52VVT
Manual Valve 2WL-53 Transfers Position
GK2WL53VVT
Manual Valve 2WL-54 Transfers Position
GK2WL54VVT
Manual Valve 2WL-55 Transfers Position
GK2WL55VVT


WL Fails to Cool Generator Thrust Bearing Cooler 2HPOHX-2
GK2312
Page 284
Inlet to Generator Thrust Bearing Cooler 2HPOHX-2 is Blocked
GK2312A
Flow to Generator Thrust Bearing Cooler 2HPOHX-2 is Diverted
GK2312B
Generator Thrust Bearing Cooler 2HPOHX-2 Fails
GK2HPO2HXF
Manual Valve 2WL-48 Transfers Position
GK2WL48VVT
Manual Valve 2WL-49 Transfers Position
GK2WL49VVT
Manual Valve 2WL-50 Transfers Position
GK2WL50VVT
Manual Valve 2WL-51 Transfers Position
GK2WL51VVT


WL Fails to Cool Generator Thrust Bearing Cooler 2HPOHX-1
GK2311
Page 284
Inlet to Generator Thrust Bearing Cooler 2HPOHX-1 is Blocked
GK2311A
Flow to Generator Thrust Bearing Cooler 2HPOHX-1 is Diverted
GK2311B
Generator Thrust Bearing Cooler 2HPOHX-1 Fails
GK2HPO1HXF
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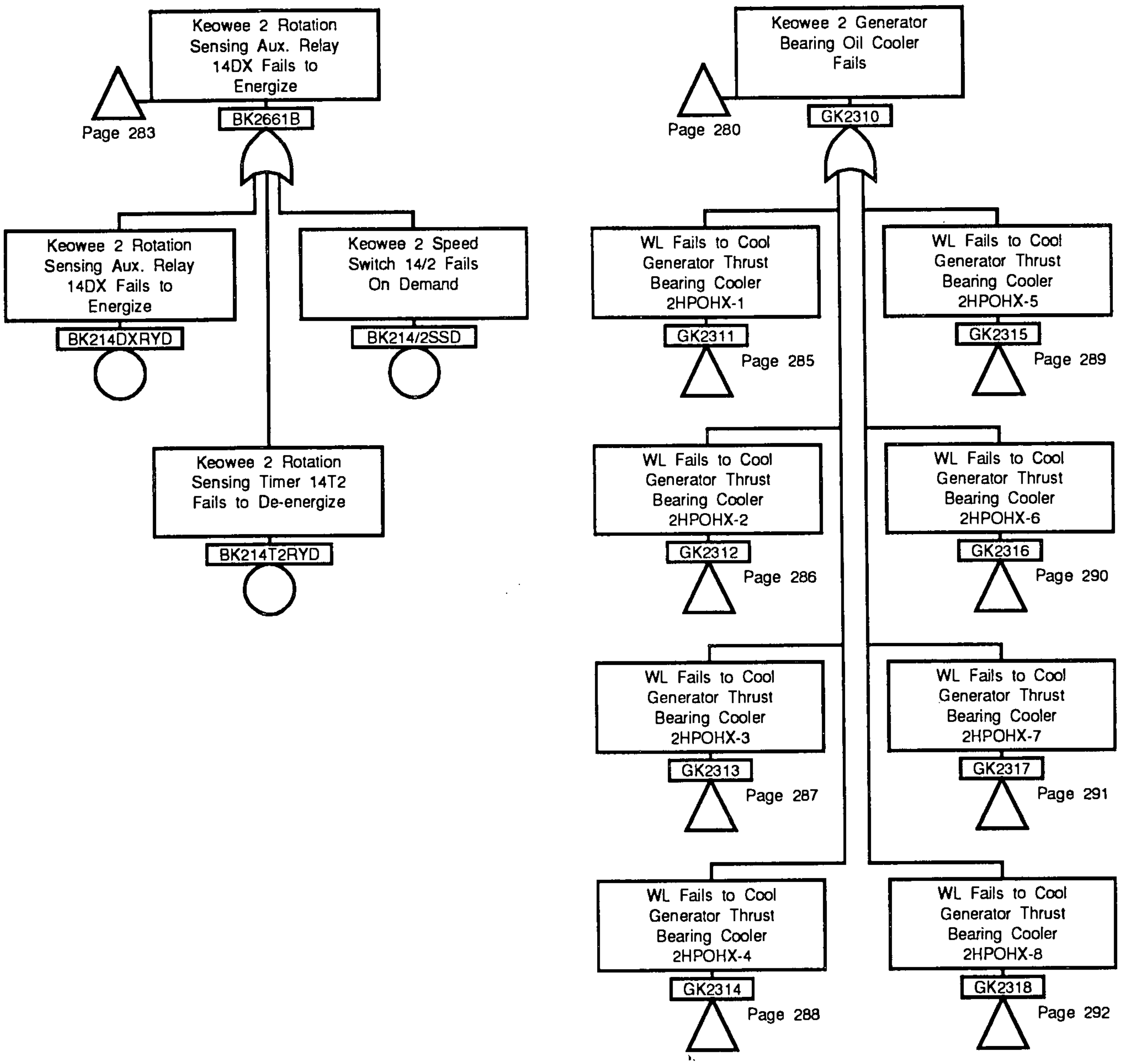
GK2WL44VVT
Manual Valve 2WL-45 Transfers Position
GK2WL45VVT
Manual Valve 2WL-46 Transfers Position
GK2WL46VVT
Manual Valve 2WL-47 Transfers Position
GK2WL47VVT



Keowee 2 Rotation Sensing Aux. Relay 14DX Fails to Energize
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BK2661B
Keowee 2 Rotation Sensing Aux. Relay 14DX Fails to Energize
BK214DXRYD
Keowee 2 Speed Switch 14/2 Fails On Demand
BK214/2SSD
Keowee 2 Rotation Sensing Timer 14T2 Fails to De-energize
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GK2311
Page 285
WL Fails to Cool Generator Thrust Bearing Cooler 2HPOHX-5
GK2315
Page 289
WL Fails to Cool Generator Thrust Bearing Cooler 2HPOHX-2
GK2312
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WL Fails to Cool Generator Thrust Bearing Cooler 2HPOHX-6
GK2316
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WL Fails to Cool Generator Thrust Bearing Cooler 2HPOHX-3
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WL Fails to Cool Generator Thrust Bearing Cooler 2HPOHX-4
GK2314
Page 288
WL Fails to Cool Generator Thrust Bearing Cooler 2HPOHX-8
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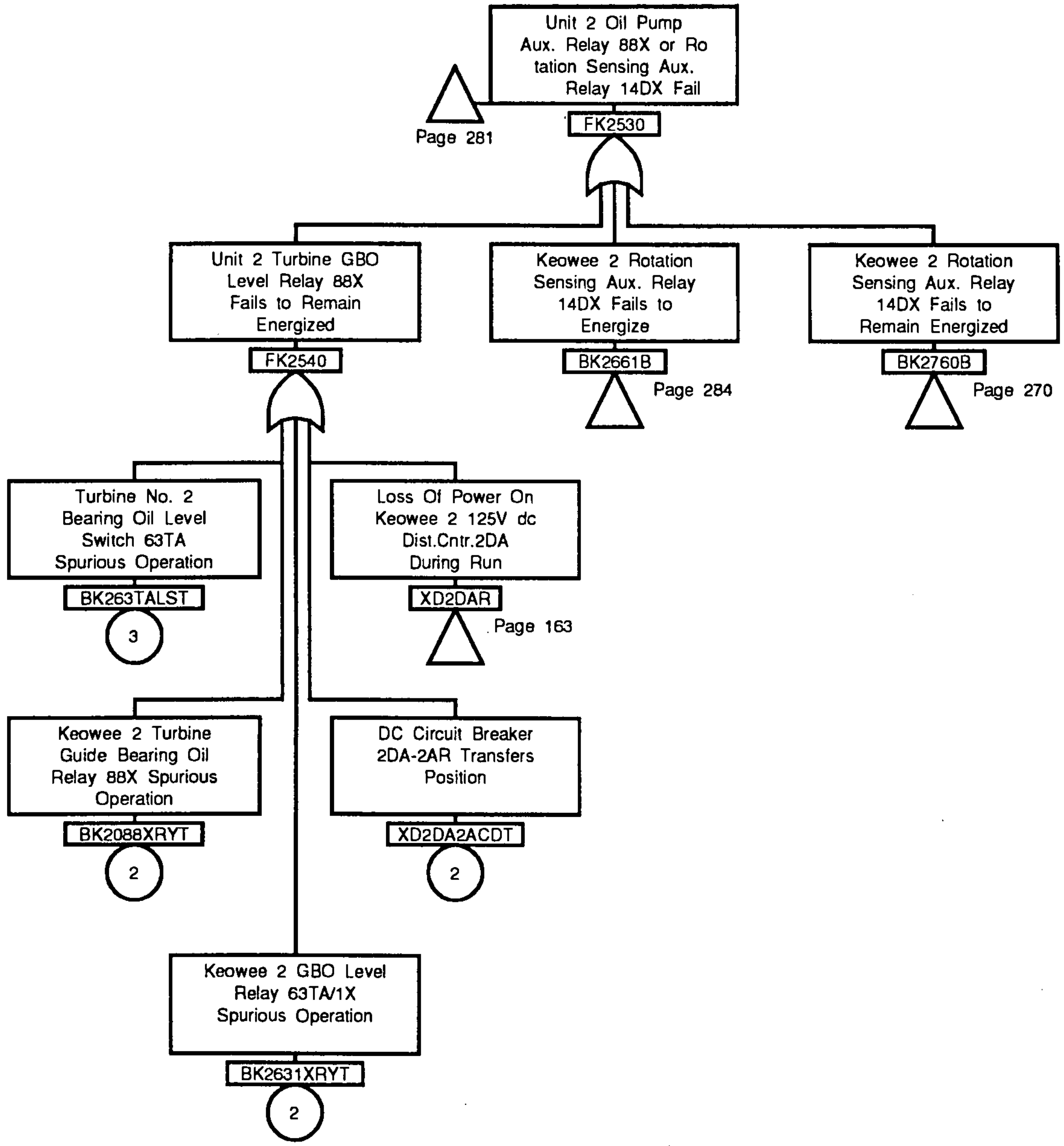
Unit 2 Oil Pump Aux. Relay 88X or Ro tation Sensing Aux. Relay 14DX Fail
FK2530
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Unit 2 Turbine GBO Level Relay 88X Fails to Remain Energized
FK2540
Keowee 2 Rotation Sensing Aux. Relay 14DX Fails to Energize
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Keowee 2 Rotation Sensing Aux. Relay 14DX Fails to Remain Energized
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Turbine No. 2 Bearing Oil Level Switch 63TA Spurious Operation
BK263TALST
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Loss Of Power On Keowee 2 125V dc Dist.Cntr.2DA During Run
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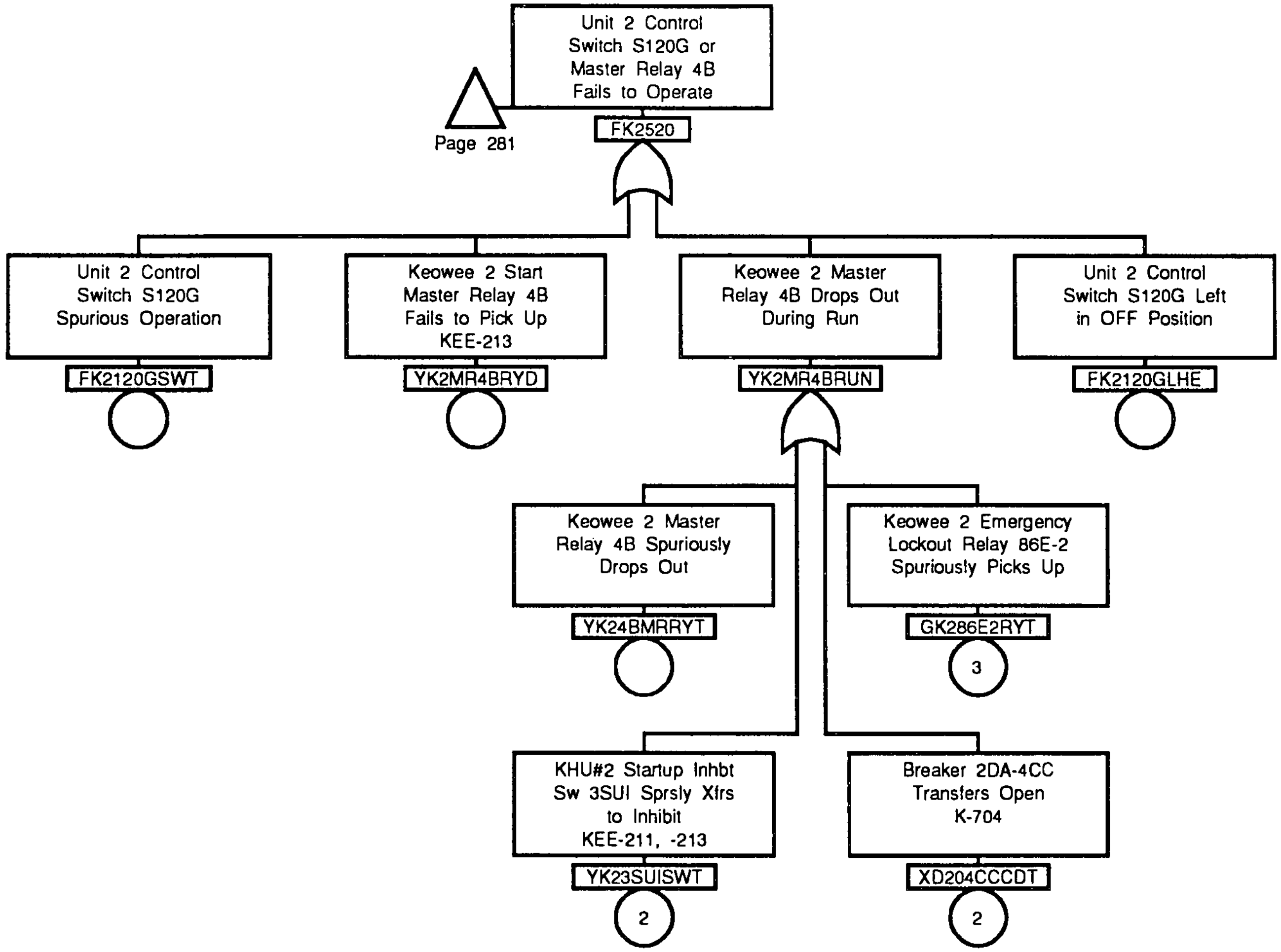
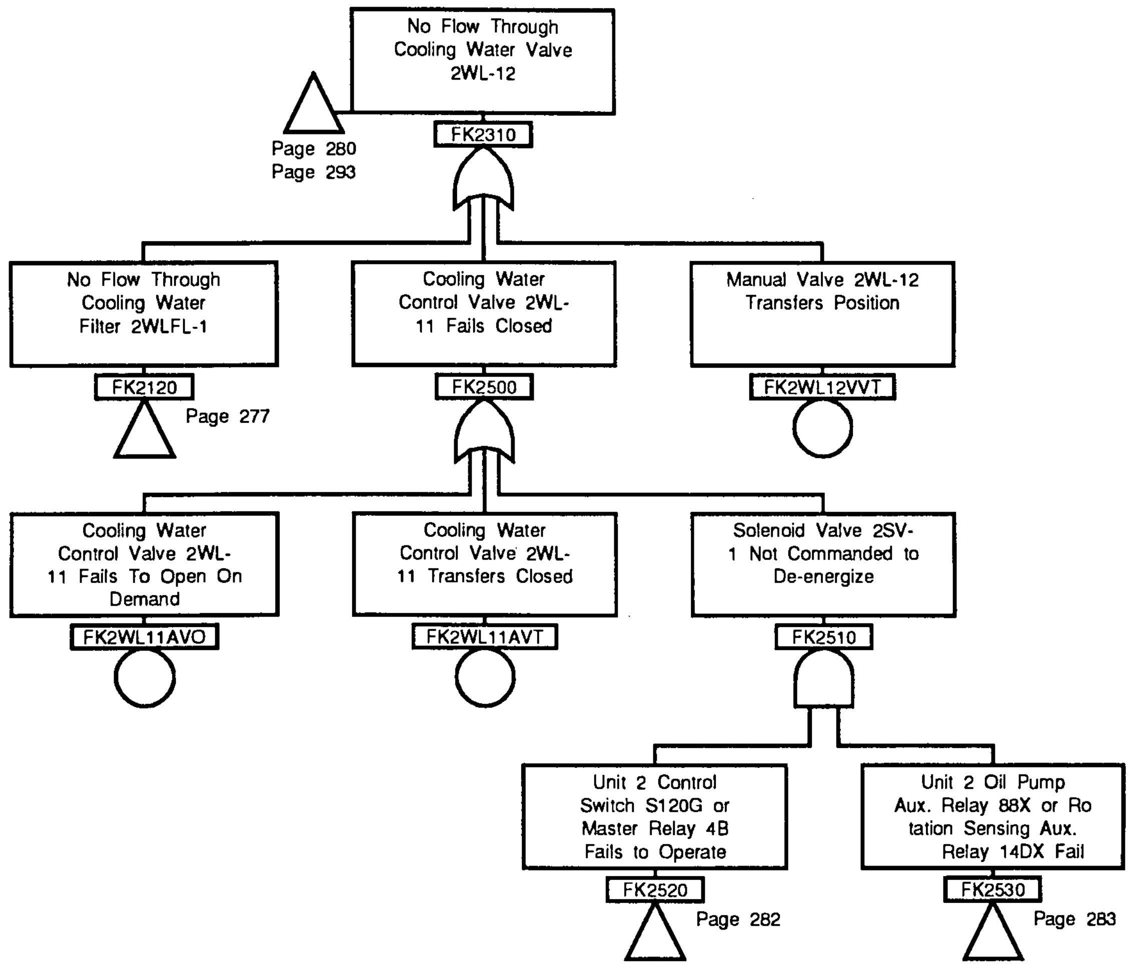
Keowee 2 Turbine Guide Bearing Oil Relay 88X Spurious Operation
BK2088XRYT
2
DC Circuit Breaker 2DA-2AR Transfers Position
XD2DA2ACDT
2
Keowee 2 GBO Level Relay 63TA/1X Spurious Operation
BK2631XRYT
2


Unit 2 Control Switch S120G or Master Relay 4B Fails to Operate
FK2520
Page 281
Unit 2 Control Switch S120G Spurious Operation
FK2120GSWT
Keowee 2 Start Master Relay 4B Fails to Pick Up KEE-213
YK2MR4BRYD
Keowee 2 Master Relay 4B Drops Out During Run
YK2MR4BRUN
Unit 2 Control Switch S120G Left in OFF Position
FK2120GLHE
Keowee 2 Master Relay 4B Spuriously Drops Out
YK24BMRRYT
Keowee 2 Emergency Lockout Relay 86E-2 Spuriously Picks Up
GK286E2RYT
3
KHU#2 Startup Inhbt Sw 3SUI Sprsly Xfrs to Inhibit KEE-211, -213
YK23SUISWT
2
Breaker 2DA-4CC Transfers Open K-704
XD204CCCDT
2



No Flow Through Cooling Water Valve 2WL-12
FK2310
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No Flow Through Cooling Water Filter 2WLFL-1
FK2120
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Cooling Water Control Valve 2WL-11 Fails Closed
FK2500
Manual Valve 2WL-12 Transfers Position
FK2WL12VVT
Cooling Water Control Valve 2WL-11 Fails To Open On Demand
FK2WL11AVO
Cooling Water Control Valve 2WL-11 Transfers Closed
FK2WL11AVT
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FK2510
Unit 2 Control Switch S120G or Master Relay 4B Fails to Operate
FK2520
Page 282
Unit 2 Oil Pump Aux. Relay 88X or Rotation Sensing Aux. Relay 14DX Fail
FK2530
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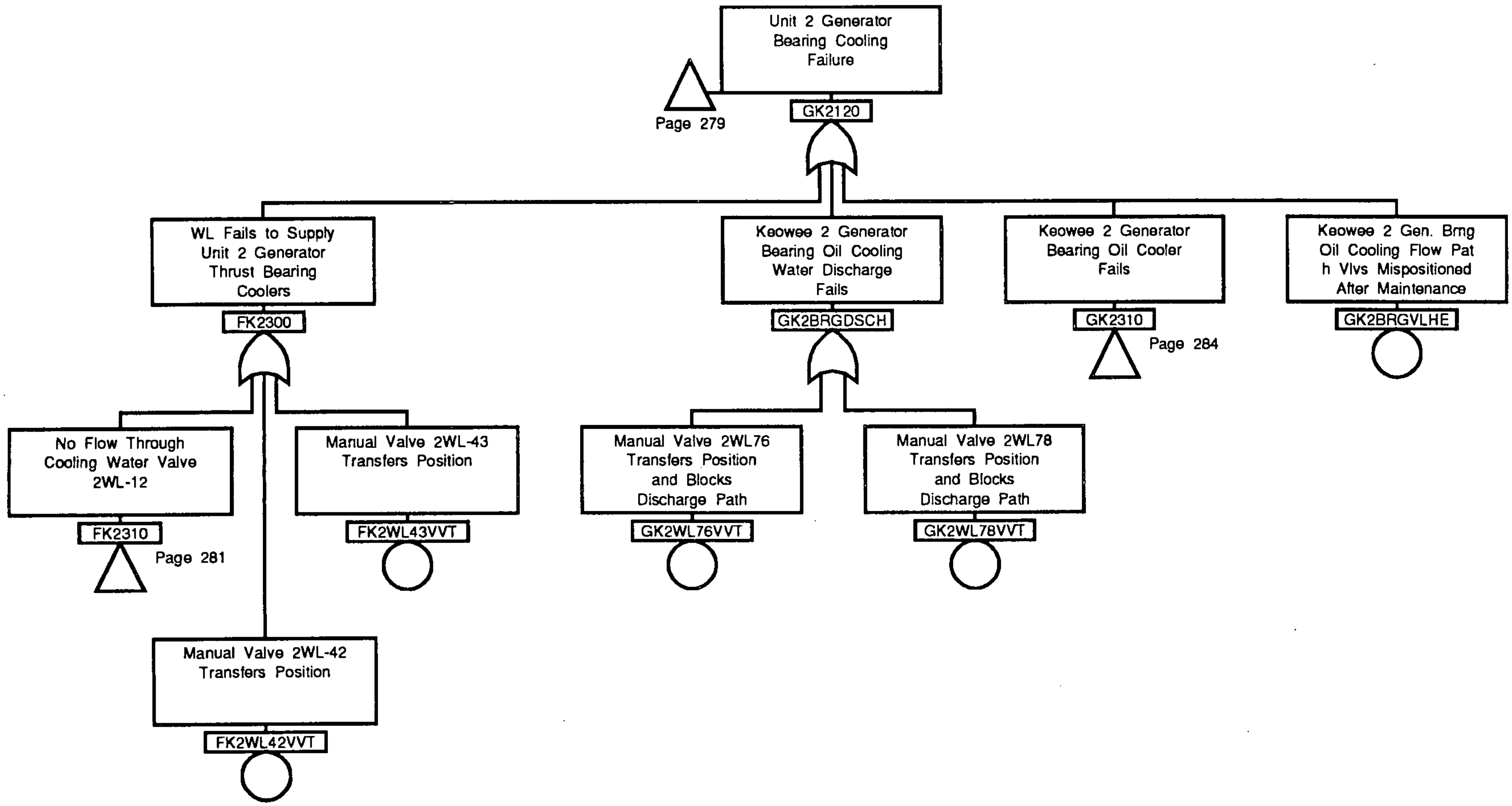
Unit 2 Generator Bearing Cooling Failure
GK2120
Page 279
WL Fails to Supply Unit 2 Generator Thrust Bearing Coolers
FK2300
Keowee 2 Generator Bearing Oil Cooling Water Discharge Fails
GK2BRGDSCH
Keowee 2 Generator Bearing Oil Cooler Fails
GK2310
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GK2BRGVLHE
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FK2310
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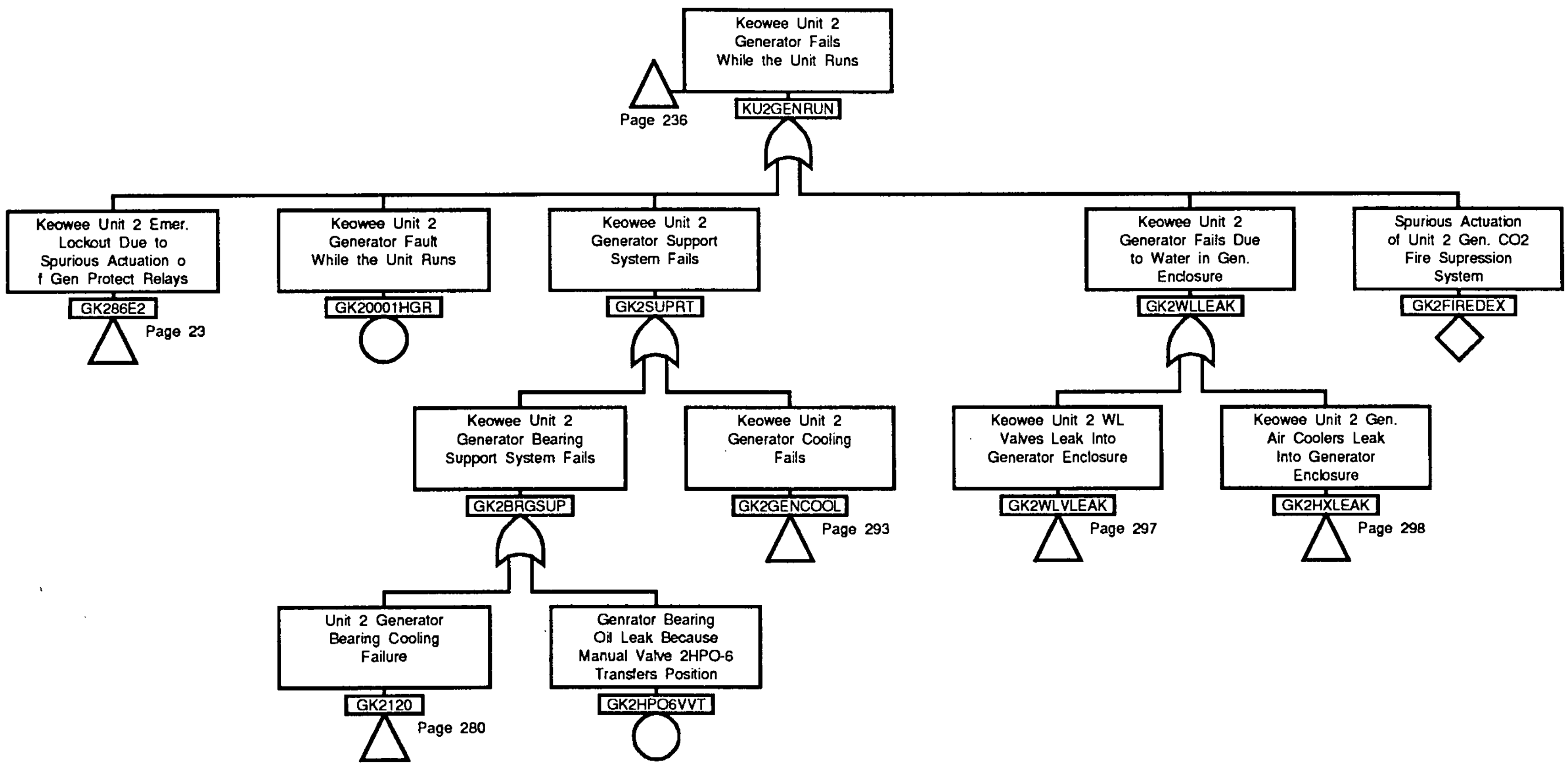
FK2WL43VVT
Manual Valve 2WL76 Transfers Position and Blocks Discharge Path
GK2WL76VVT
Manual Valve 2WL78 Transfers Position and Blocks Discharge Path
GK2WL78VVT
Manual Valve 2WL-42 Transfers Position
FK2WL42VVT


Keewee Unit 2 Generator Fails While the Unit Runs
KU2GENRUN
Page 236
Keowee Unit 2 Emer. Lockout Due to Spurious Actuation o f Gen Protect Relays
GK286E2
Page 23
Keowee Unit 2 Generator Fault While the Unit Runs
GK20001HGR
Keowee Unit 2 Generator Support System Fails
GK2SUPRT
Keowee Unit 2 Generator Fails Due to Water in Gen. Enclosure
GK2WLLEAK
Spurious Actuation of Unit 2 Gen. CO2 Fire Supression System
GK2FIREDEX
Keowee Unit 2 Generator Bearing Support System Fails
GK2BRGSUP
Keowee Unit 2 Generator Cooling Fails
GK2GENCOOL
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GK2WLVLEAK
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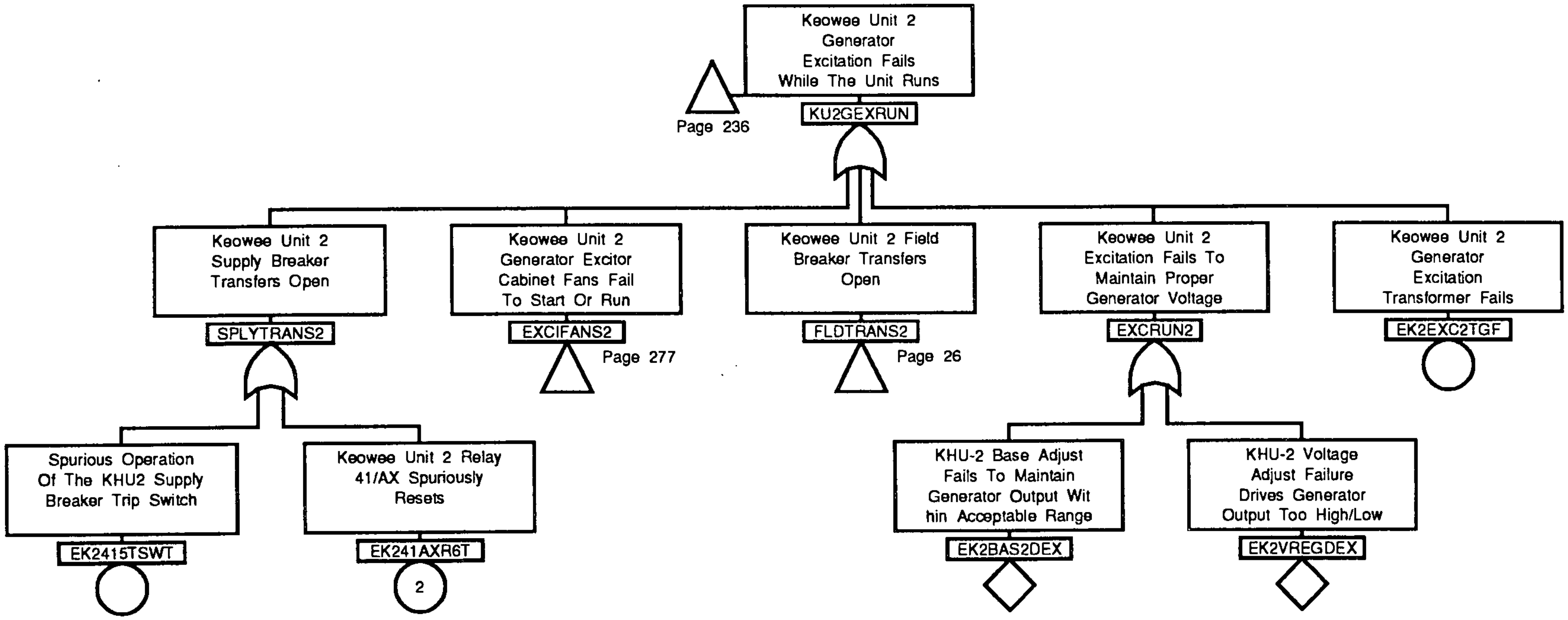
Keowee Unit 2 Gen. Air Coolers Leak Into Generator Enclosure
GK2HXLEAK
Page 298
Unit 2 Generator Bearing Cooling Failure
GK2120
Page 280
Genrator Bearing Oil Leak Because Manual Valve 2HPO-6 Transfers Position
GK2HPO6VVT


Keowee Unit 2 Generator Excitation Fails While The Unit Runs
KU2GEXRUN
Page 236
Keowee Unit 2 Supply Breaker Transfers Open
SPLYTRANS2
Keowee Unit 2 Generator Excitor Cabinet Fans Fail To Start Or Run
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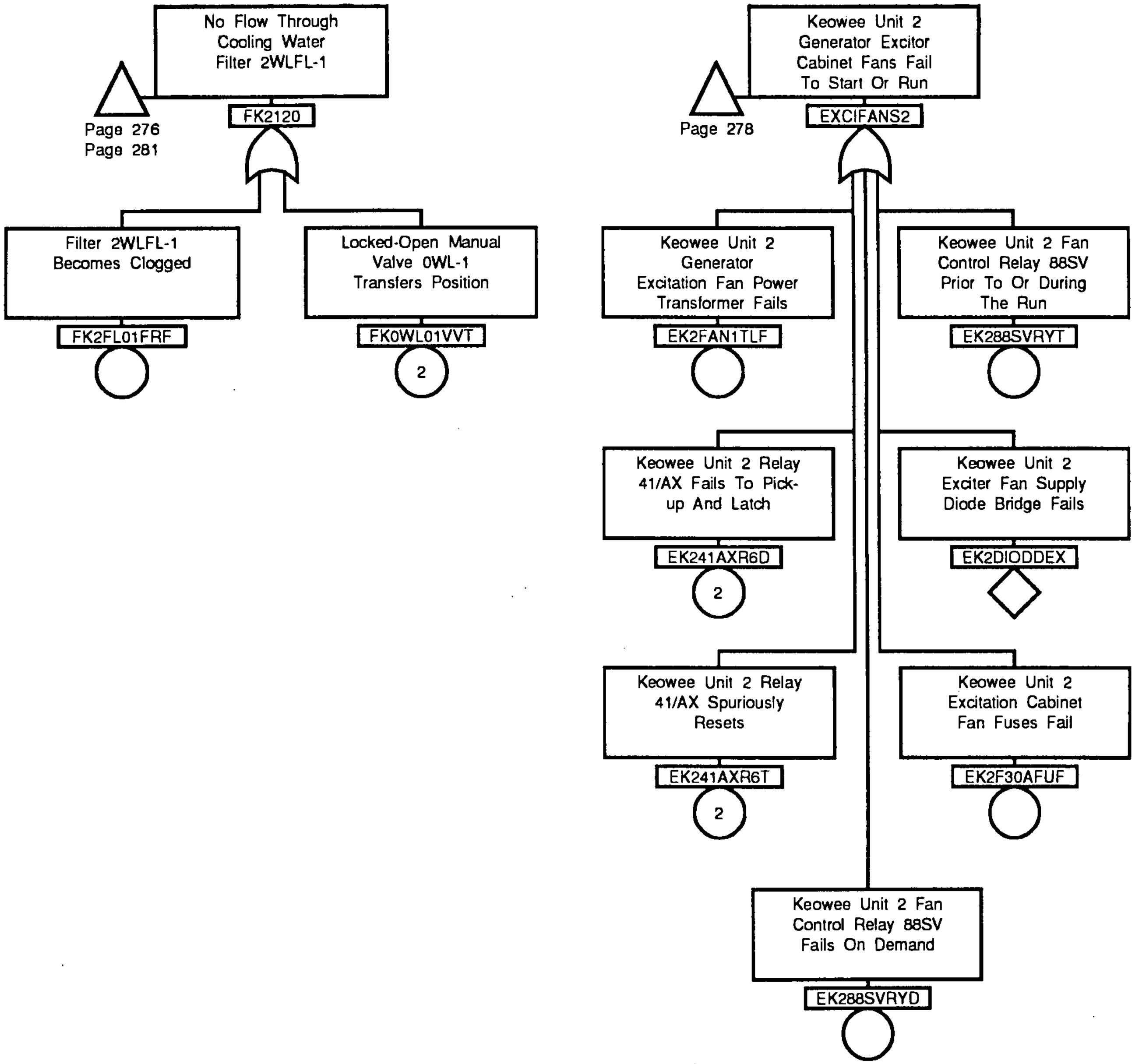
Keowee Unit 2 Excitation Fails To Maintain Proper Generator Voltage
EXCRUN2
Keowee Unit 2 Generator Excitation Transformer Fails
EK2EXC2TGF
Spurious Operation Of The KHU2 Supply Breaker Trip Switch
EK2415TSWT
Keowee Unit 2 Relay 41/AX Spuriously Resets
EK241AXR6T
2
KHU-2 Base Adjust Fails To Maintain Generator Output Wit hin Acceptable Range
EK2BAS2DEX
KHU-2 Voltage Adjust Failure Drives Generator Output Too High/Low
EK2VREGDEX


No Flow Through Cooling Water Filter 2WLFL-1
FK2120
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Filter 2WLFL-1 Becomes Clogged
FK2FL01FRF
Locked-Open Manual Valve 0WL-1 Transfers Position
FK0WL01VVT
2
Keowee Unit 2 Generator Excitor Cabinet Fans Fail To Start Or Run
EXCIFANS2
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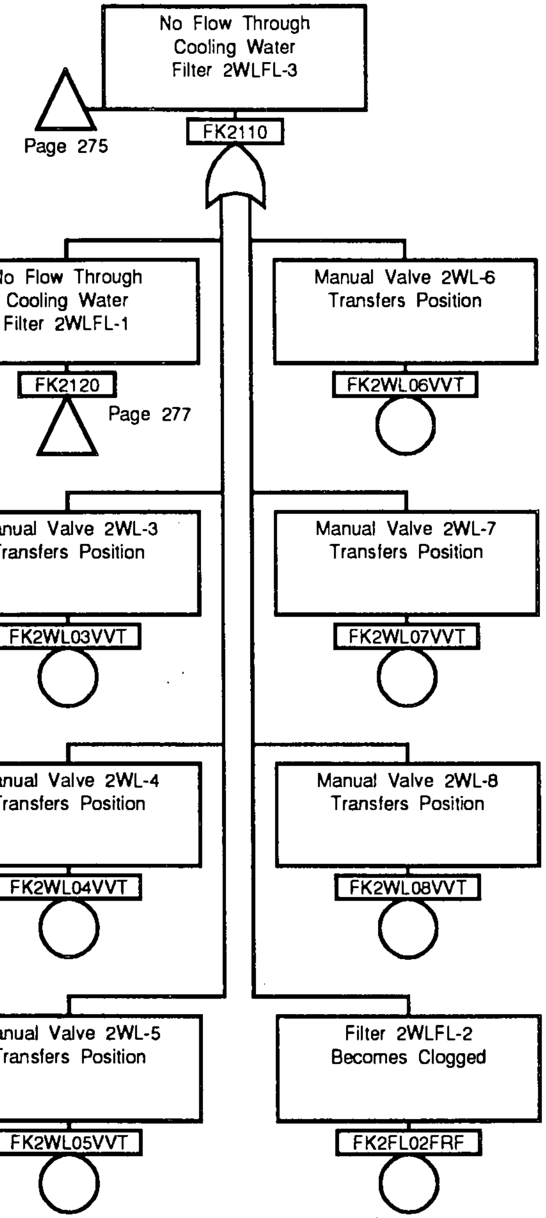
EK2FAN1TLF
Keowee Unit 2 Fan Control Relay 88SV Prior To Or During The Run
EK288SVRYT
Keowee Unit 2 Relay 41/AX Fails To Pick-up And Latch
EK241AXR6D
2
Keowee Unit 2 Exciter Fan Supply Diode Bridge Fails
EK2DIODDEX
Keowee Unit 2 Relay 41/AX Spuriously Resets
EK241AXR6T
2
Keowee Unit 2 Excitation Cabinet Fan Fuses Fail
EK2F30AFUF
Keowee Unit 2 Fan Control Relay 88SV Fails On Demand
EK288SVRYD


No Flow Through Cooling Water Filter 2WLFL-3
FK2110
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No Flow Through Cooling Water Filter 2WLFL-1
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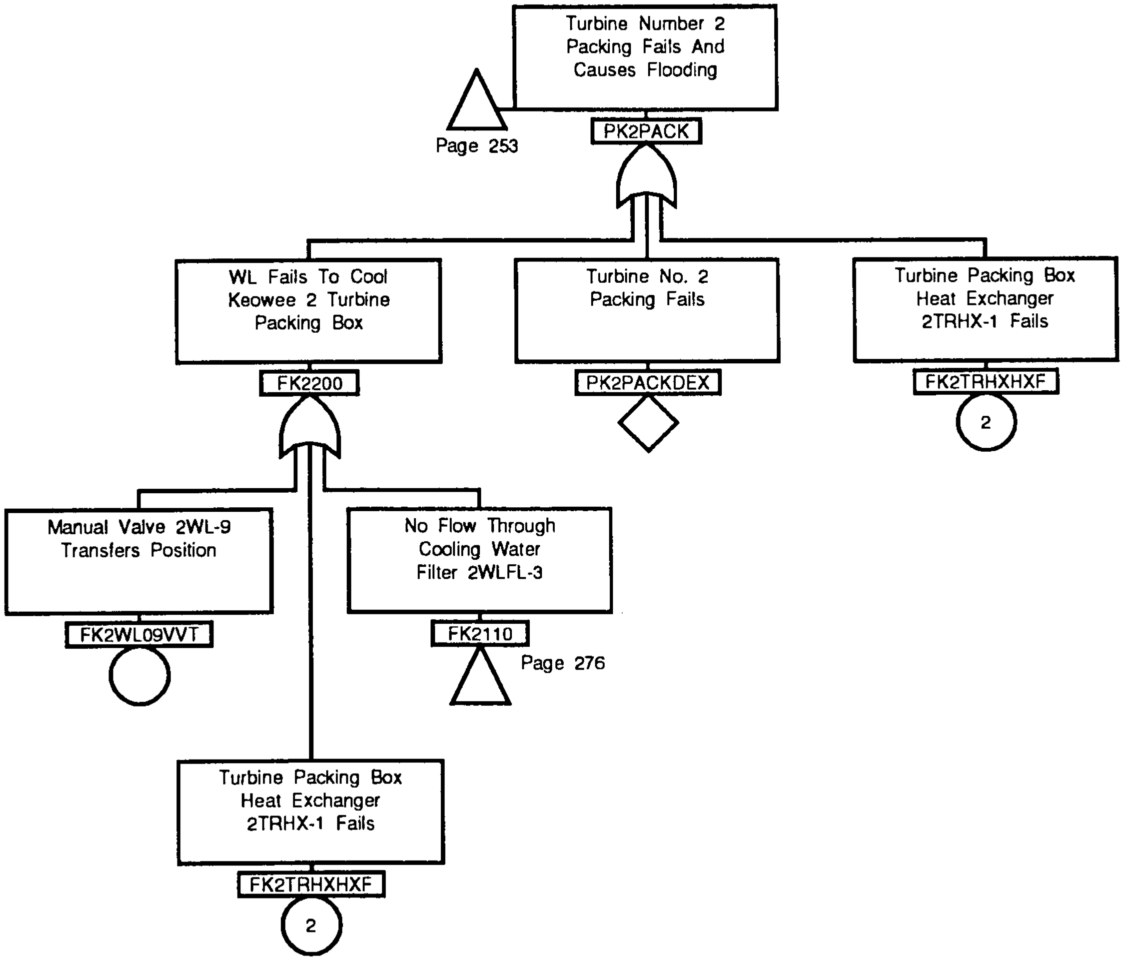
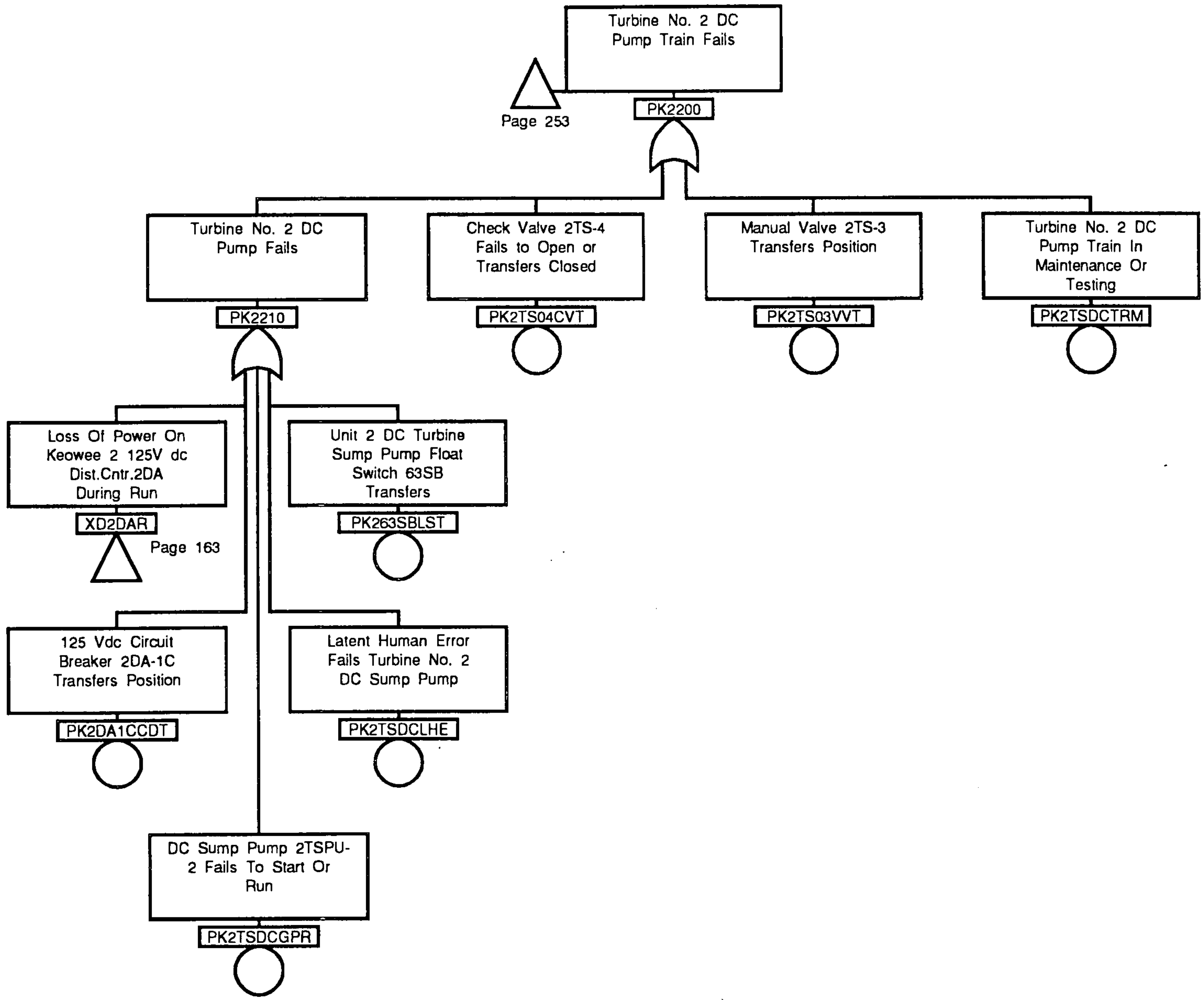
FK2WL06VVT
Manual Valve 2WL-3 Transfers Position
FK2WL03VVT
Manual Valve 2WL-7 Transfers Position
FK2WL07VVT
Manual Valve 2WL-4 Transfers Position
FK2WL04VVT
Manual Valve 2WL-8 Transfers Position
FK2WL08VVT
Manual Valve 2WL-5 Transfers Position
FK2WL05VVT
Filter 2WLFL-2 Becomes Clogged
FK2FL02FRF


Turbine Number 2 Packing Fails And Causes Flooding
PK2PACK
Page 253
WL Fails To Cool Keowee 2 Turbine Packing Box
FK2200
Turbine No. 2 Packing Fails
PK2PACKDEX
Turbine Packing Box Heat Exchanger 2TRHX-1 Fails
FK2TRHXHXF
2
Manual Valve 2WL-9 Transfers Position
FK2WL09VVT
No Flow Through Cooling Water Filter 2WLFL-3
FK2110
Page 276
Turbine Packing Box Heat Exchanger 2TRHX-1 Fails
FK2TRHXHXF
2



Turbine No. 2 DC Pump Train Fails
PK2200
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Turbine No. 2 DC Pump Fails
PK2210
Check Valve 2TS-4 Fails to Open or Transfers Closed
PK2TS04CVT
Manual Valve 2TS-3 Transfers Position
PK2TS03VVT
Turbine No. 2 DC Pump Train In Maintenance Or Testing
PK2TSDCTRM
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XD2DAR
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PK263SBLST
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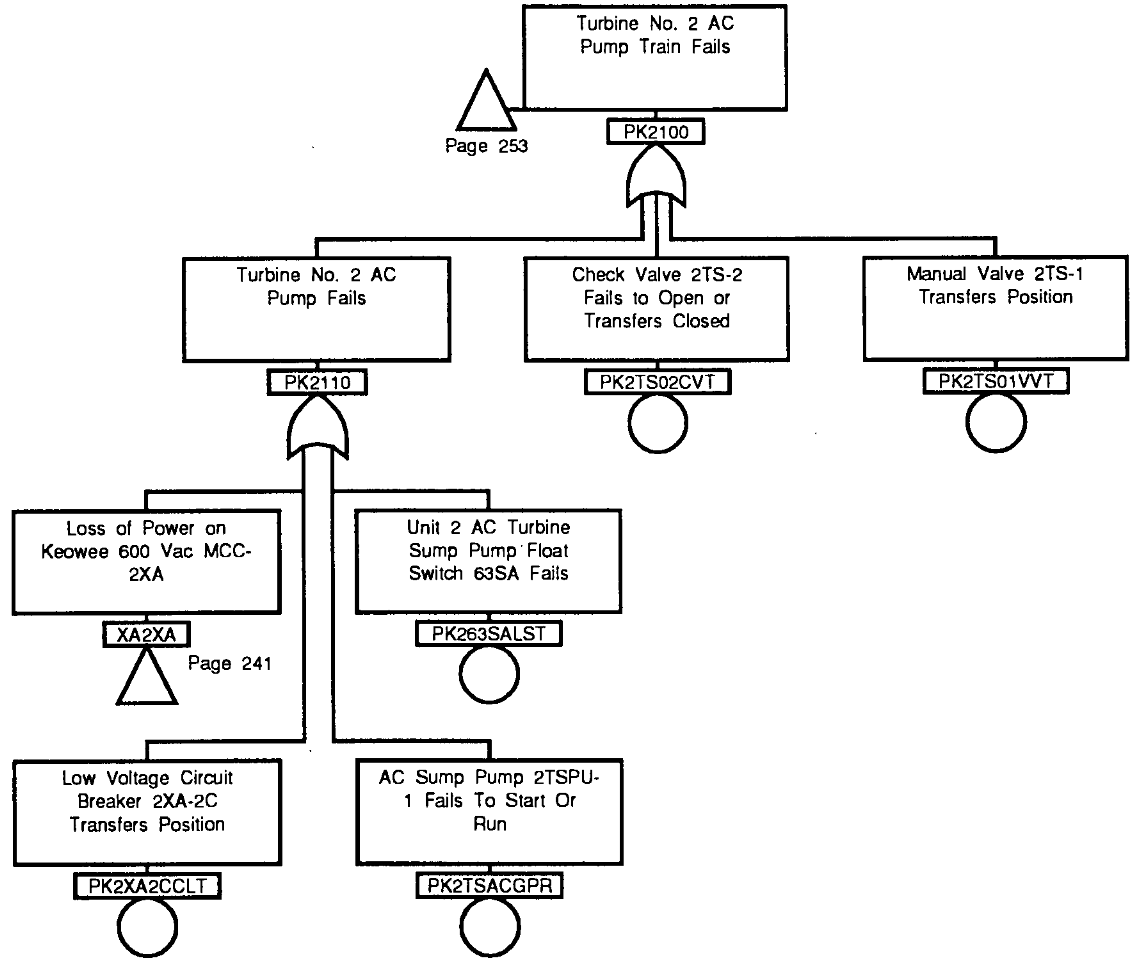
PK2DA1CCDT
Latent Human Error Fails Turbine No. 2 DC Sump Pump
PK2TSDCLHE
DC Sump Pump 2TSPU-2 Fails To Start Or Run
PK2TSDCGPR


Turbine No. 2 AC Pump Train Fails
PK2100
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Turbine No. 2 AC Pump Fails
PK2110
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PK2TS02CVT
Manual Valve 2TS-1 Transfers Position
PK2TS01VVT
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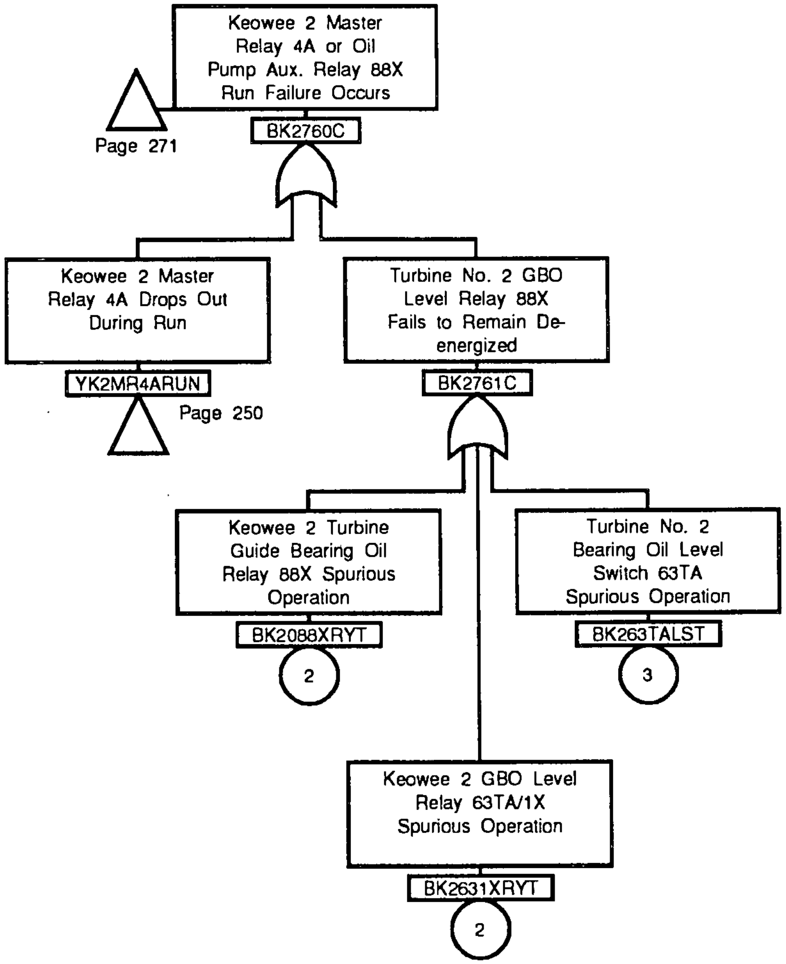
PK263SALST
Low Voltage Circuit Breaker 2XA-2C Transfers Position
PK2XA2CCLT
AC Sump Pump 2TSPU-1 Fails To Start Or Run
PK2TSACGPR


Keowee 2 Master Relay 4A or Oil Pump Aux. Relay 88X Run Failure Occurs
BK2760C
Page 271
Keowee 2 Master Relay 4A Drops Out During Run
YK2MR4ARUN
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BK2761C
Keowee 2 Turbine Guide Bearing Oil Relay 88X Spurious Operation
BK2088XRYT
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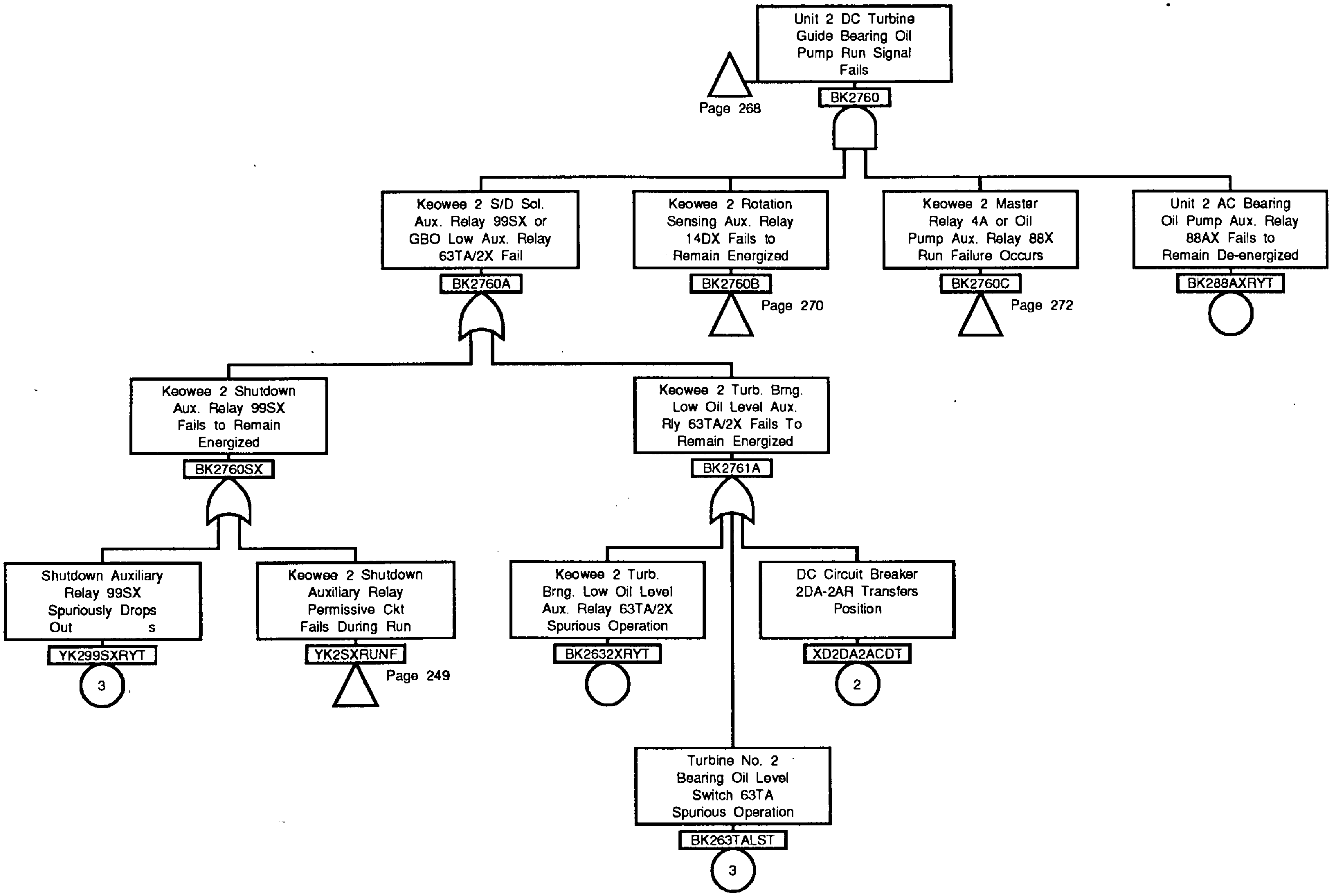
Turbine No. 2 Bearing Oil Level Switch 63TA Spurious Operation
BK263TALST
3
Keowee 2 GBO Level Relay 63TA/1X Spurious Operation
BK2631XRYT
2


Unit 2 DC Turbine Guide Bearing Oil Pump Run Signal Fails
BK2760
Page 268
Keowee 2 S/D Sol. Aux. Relay 99SX or GBO Low Aux. Relay 63TA/2X Fail
BK2760A
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BK2760SX
Keowee 2 Turb. Brng. Low Oil Level Aux. Rly 63TA/2X Fails To Remain Energized
BK2761A
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YK299SXRYT
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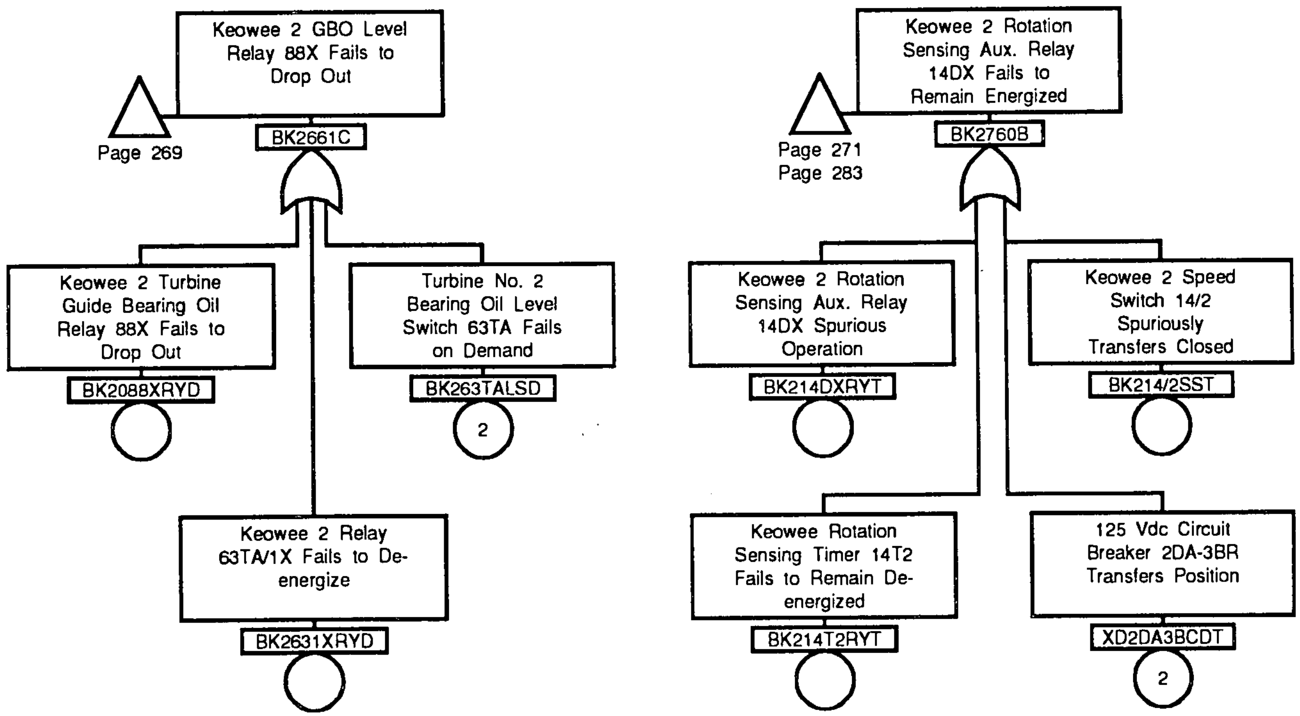
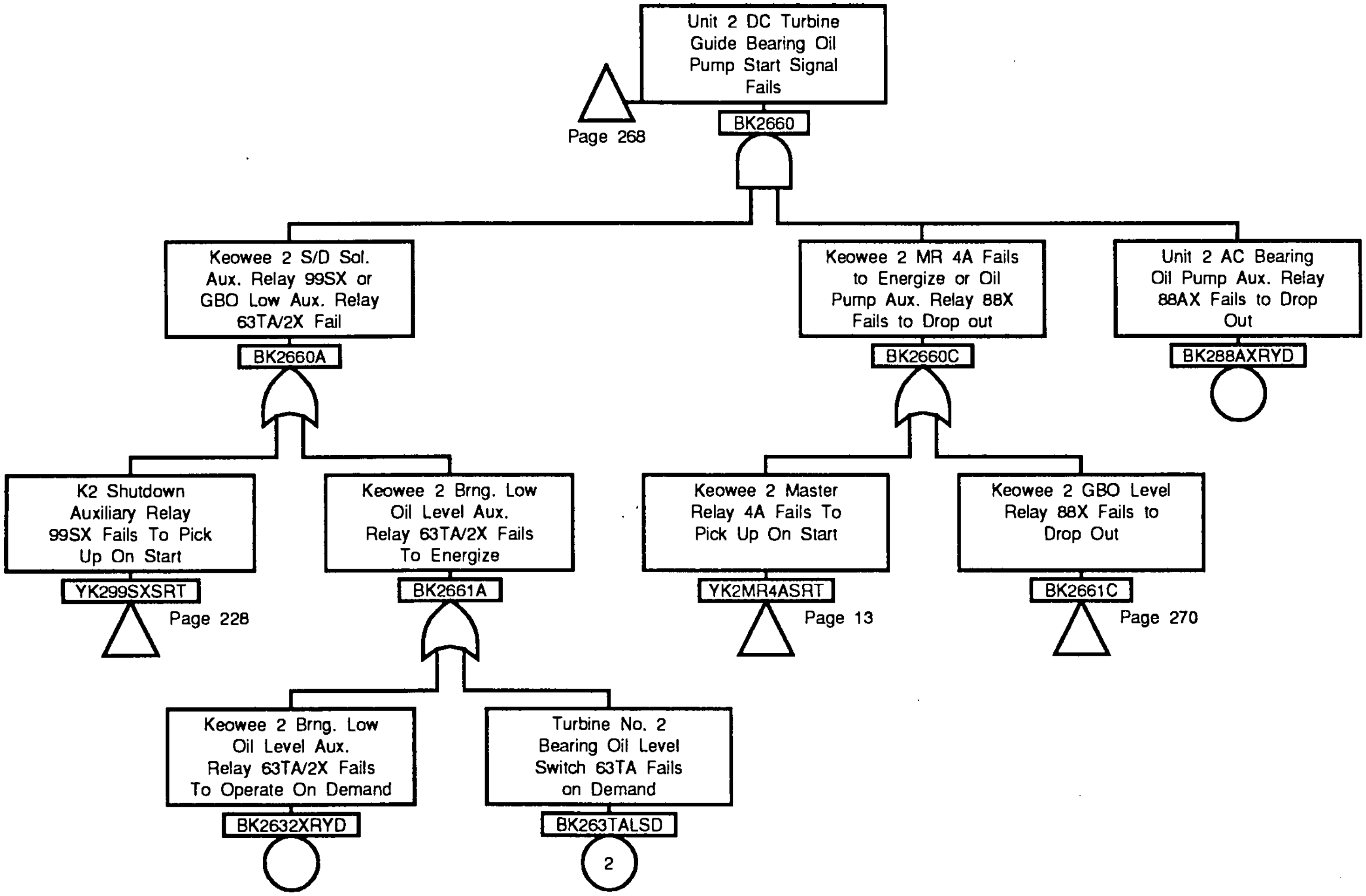
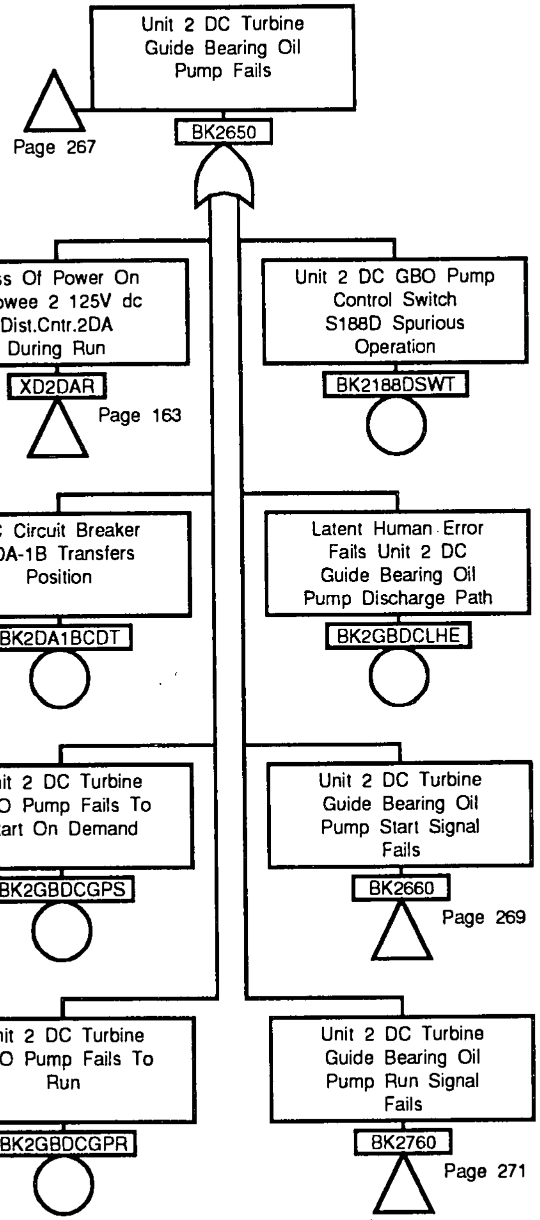
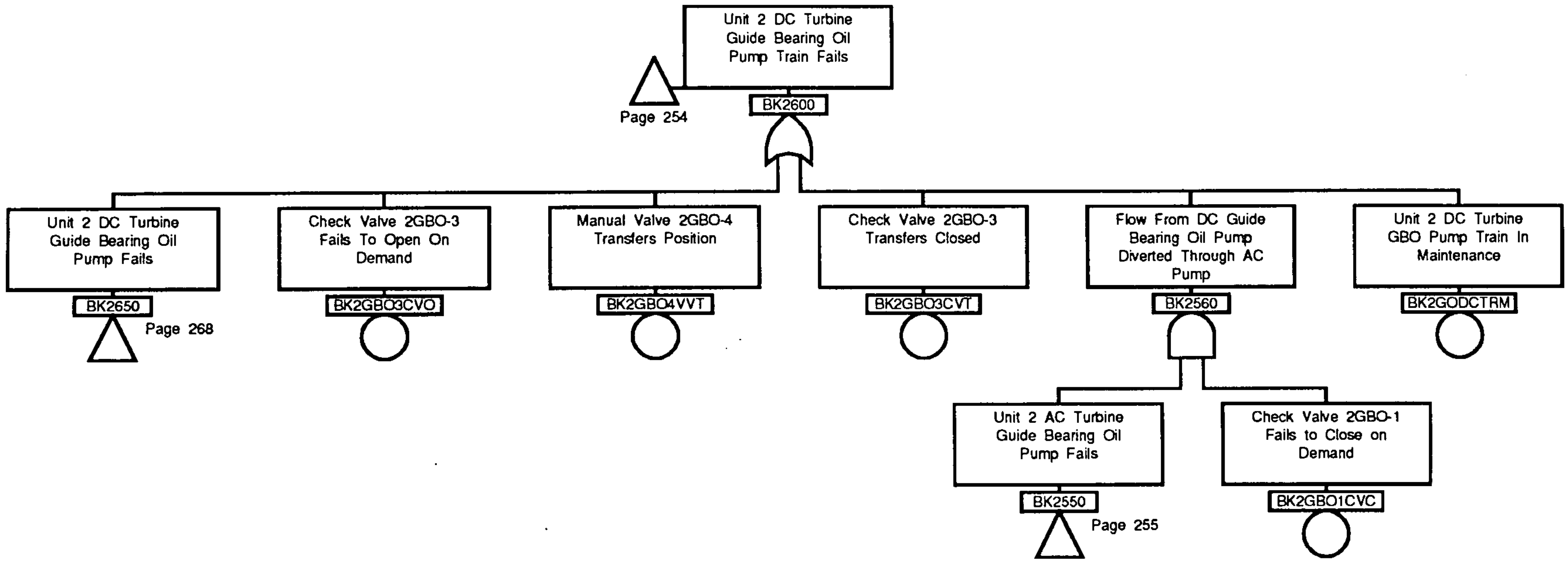
BK2632XRYT
DC Circuit Breaker 2DA-2AR Transfers Position
XD2DA2ACDT
2
Turbine No. 2 Bearing Oil Level Switch 63TA Spurious Operation
BK263TALST
3

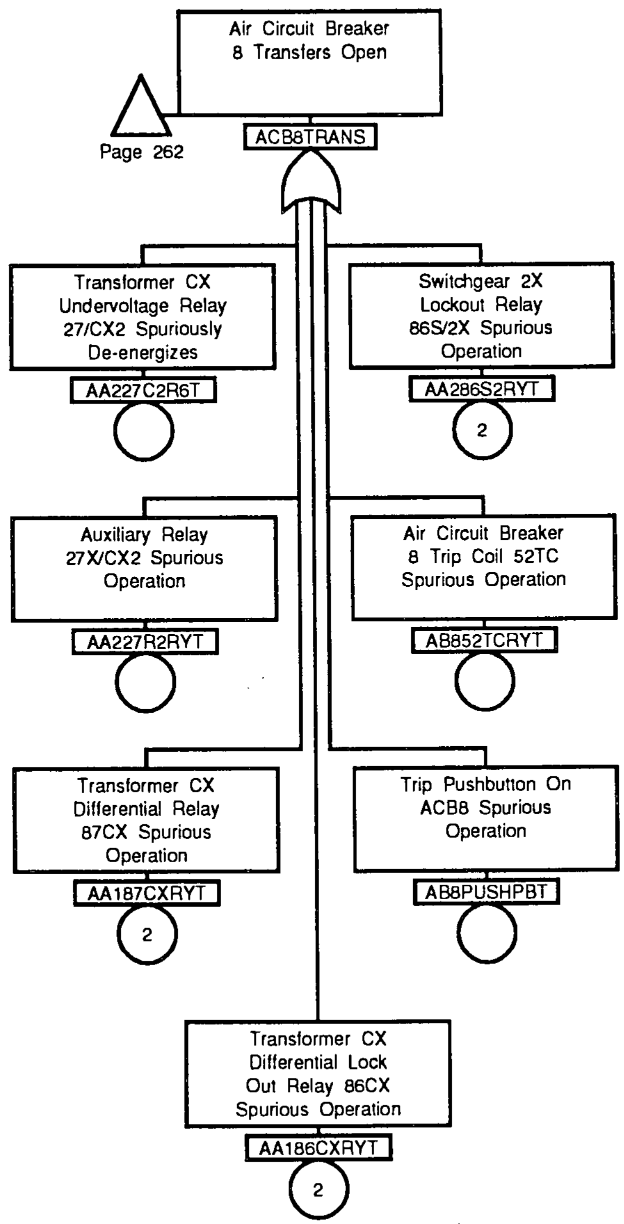

Keowee 2 GBO Level Relay 88X Fails to Drop Out
BK2661C
Page 269
Keowee 2 Turbine Guide Bearing Oil Relay 88X Fails to Drop Out
BK2088XRYD
Turbine No. 2 Bearing Oil Level Switch 63TA Fails on Demand
BK263TALSD
2
Keowee 2 Relay 63TA/1X Fails to De-energize
BK2631XRYD
Keowee 2 Rotation Sensing Aux. Relay 14DX Fails to Remain Energized
BK2760B
Page 271
Page 283
Keowee 2 Rotation Sensing Aux. Relay 14DX Spurious Operation
BK214DXRYT
Keowee 2 Speed Switch 14/2 Spuriously Transfers Closed
BK214/2SST
Keowee Rotation Sensing Timer 14T2 Fails to Remain De-energized
BK214T2RYT
125 Vdc Circuit Breaker 2DA-3BR Transfers Position
XD2DA3BCDT
2



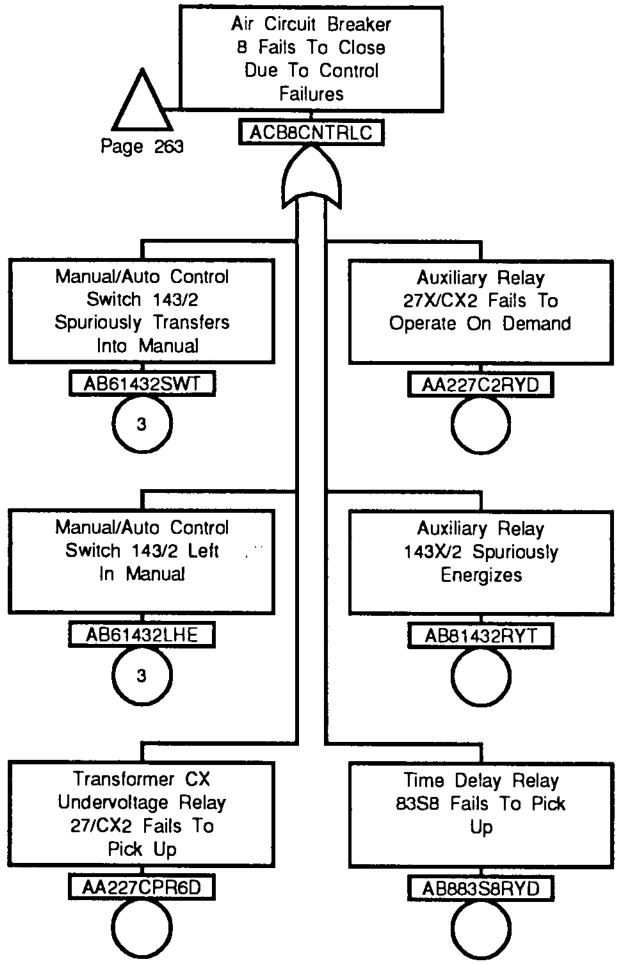
Unit 2 DC Turbine Guide Bearing Oil Pump Start Signal Fails
BK2660
Page 268
Keowee 2 S/D Sol. Aux. Relay 99SX or GBO Low Aux. Relay 63TA/2X Fail
BK2660A
Keowee 2 MR 4A Fails to Energize or Oil Pump Aux. Relay 88X Fails to Drop out
BK2660C
Unit 2 AC Bearing Oil Pump Aux. Relay 88AX Fails to Drop Out
BK288AXRYD
K2 Shutdown Auxiliary Relay 99SX Fails To Pick Up On Start
YK299SXSRT
Page 228
Keowee 2 Brng. Low Oil Level Aux. Relay 63TA/2X Fails To Energize
BK2661A
Keowee 2 Master Relay 4A Fails To Pick Up On Start
YK2MR4ASRT
Page 13
Keowee 2 GBO Level Relay 88X Fails to Drop Out
BK2661C
Page 270
Keowee 2 Brng. Low Oil Level Aux. Relay 63TA/2X Fails To Operate On Demand
BK2632XRYD
Turbine No. 2 Bearing Oil Level Switch 63TA Fails on Demand
BK263TALSD
2


Unit 2 DC Turbine Guide Bearing Oil Pump Fails
BK2650
Page 267
Loss Of Power On Keowee 2 125V dc Dist.Cntr.2DA During Run
XD2DAR
Page 163
Unit 2 DC GBO Pump Control Switch S188D Spurious Operation
BK2188DSWT
DC Circuit Breaker 2DA-1B Transfers Position
BK2DA1BCDT
Latent Human Error Fails Unit 2 DC Guide Bearing Oil Pump Discharge Path
BK2GBDCLHE
Unit 2 DC Turbine GBO Pump Fails To Start On Demand
BK2GBDCGPS
Unit 2 DC Turbine Guide Bearing Oil Pump Start Signal Fails
BK2660
Page 269
Unit 2 DC Turbine GBO Pump Fails To Run
BK2GBDCGPR
Unit 2 DC Turbine Guide Bearing Oil Pump Run Signal Fails
BK2760
Page 271

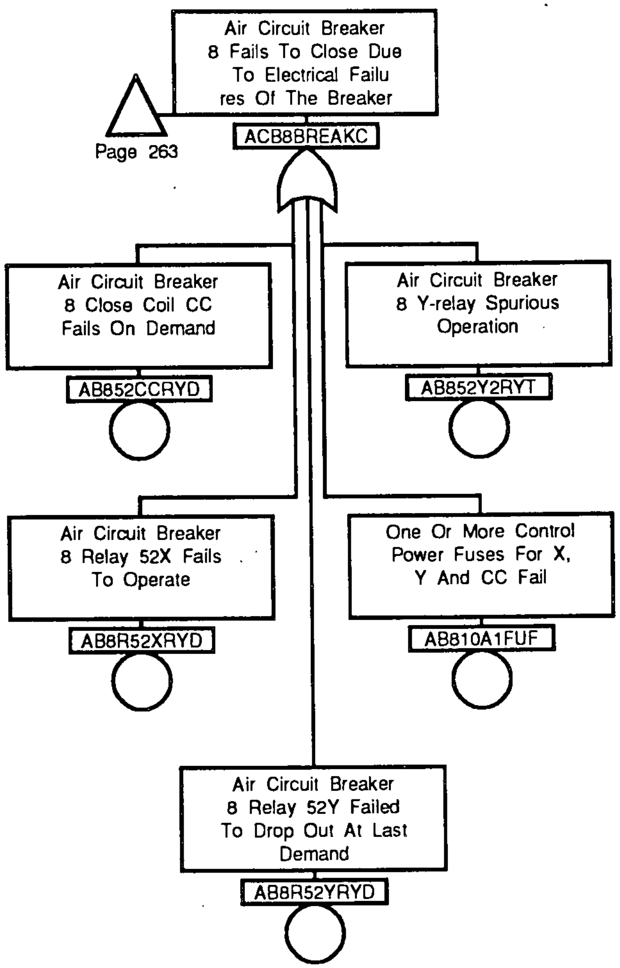

Unit 2 DC Turbine Guide Bearing Oil Pump Train Fails
BK2600
Page 254
Unit 2 DC Turbine Guide Bearing Oil Pump Fails
BK2650
Page 268
Check Valve 2GBO-3 Fails To Open On Demand
BK2GBO3CVO
Manual Valve 2GBO-4 Transfers Position
BK2GBO4VVT
Check Valve 2GBO-3 Transfers Closed
BK2GBO3CVT
Flow From DC Guide Bearing Oil Pump Diverted Through AC Pump
BK2560
Unit 2 DC Turbine GBO Pump Train In Maintenance
BK2GODCTRM
Unit 2 AC Turbine Guide Bearing Oil Pump Fails
BK2550
Page 255
Check Valve 2GBO-1 Fails to Close on Demand
BK2GBO1CVC



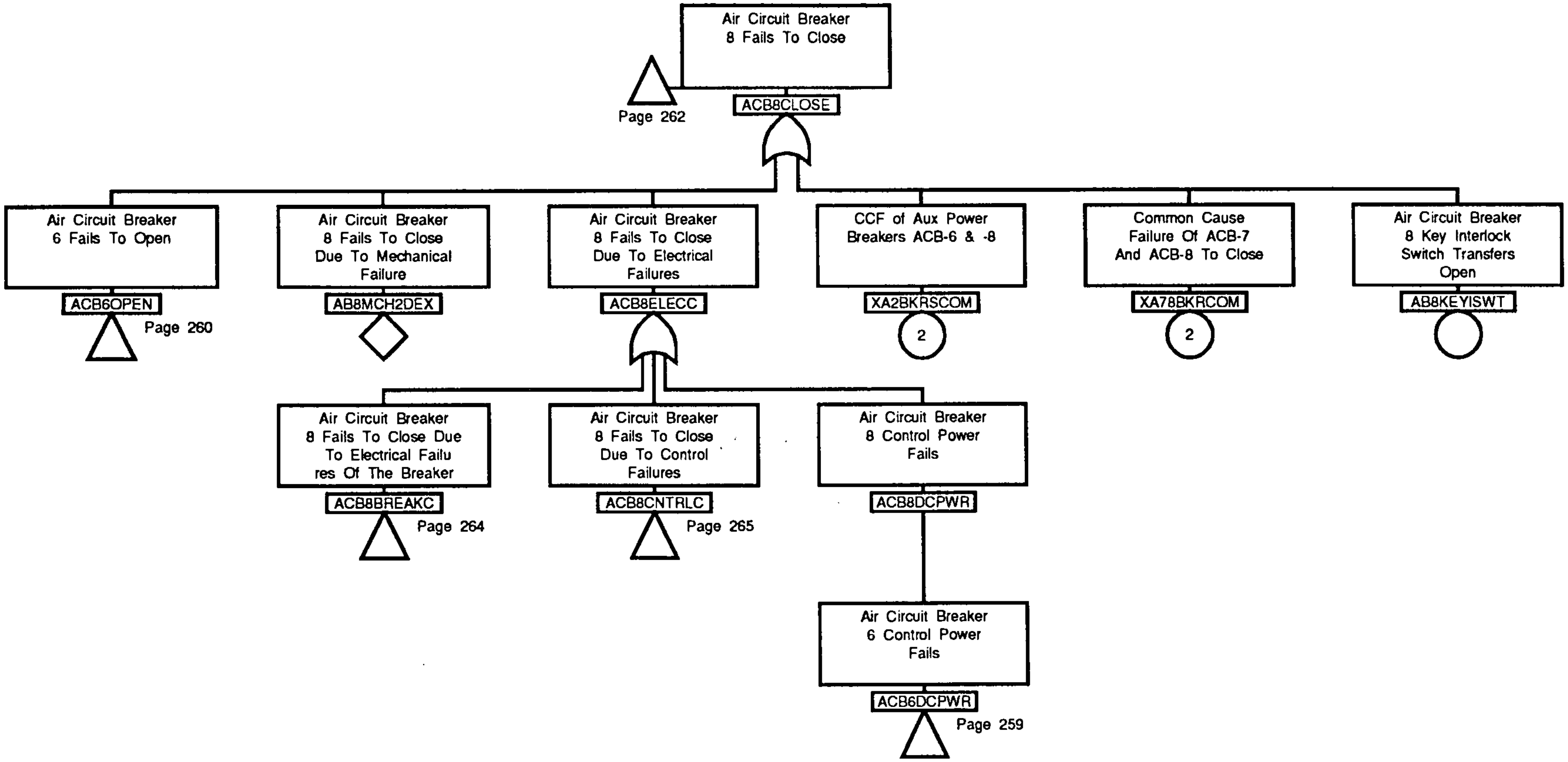
Air Circuit Breaker 8 Transfers Open
Page 262
ACB8TRANS
Transformer CX Undervoltage Relay 27/CX2 Spuriously De-energizes
AA227C2R6T
Switchgear 2X Lockout Relay 86S/2X Spurious Operation
AA286S2RYT
2
Auxiliary Relay 27X/CX2 Spurious Operation
AA227R2RYT
Air Circuit Breaker 8 Trip Coil 52TC Spurious Operation
AB852TCRYT
Transformer CX Differential Relay 87CX Spurious Operation
AA187CXRYT
2
Trip Pushbutton On ACB8 Spurious Operation
AB8PUSHPBT
Transformer CX Differential Lock Out Relay 86CX Spurious Operation
AA186CXRYT
2

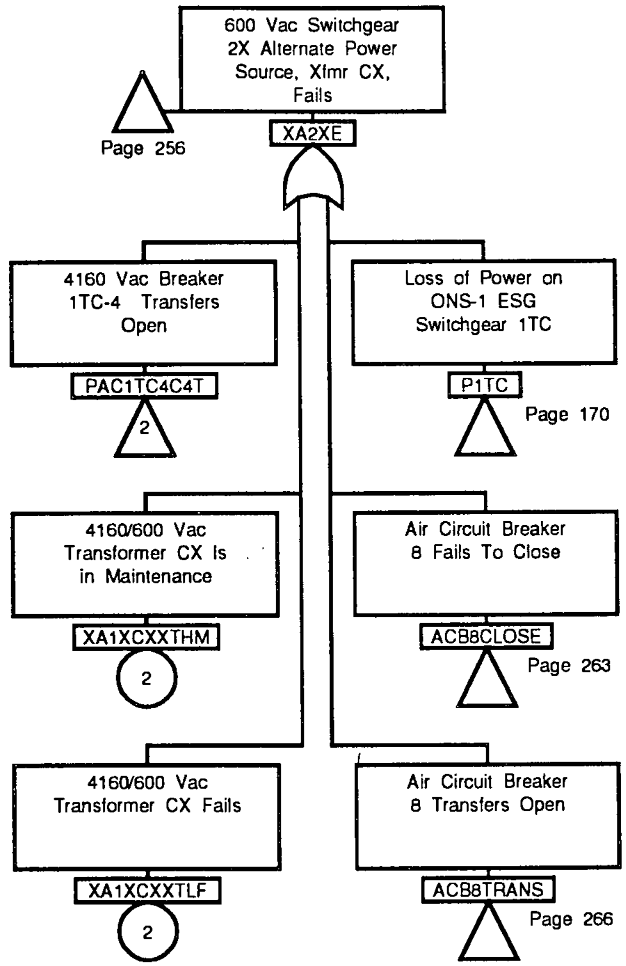


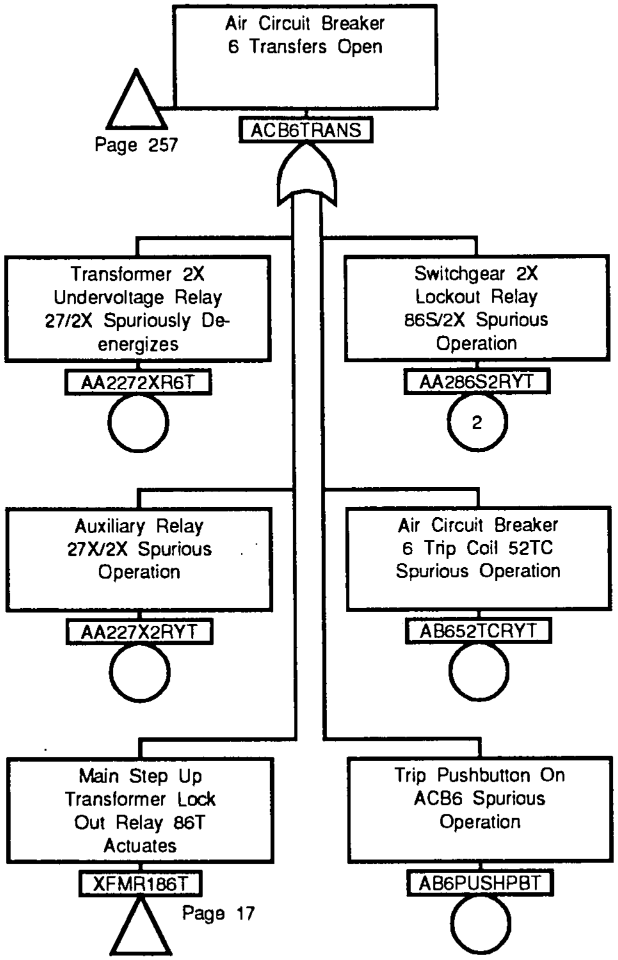
Air Circuit Breaker 8 Fails To Close Due To Control Failures
ACB8CNTRLC
Page 263
Manual/Auto Control Switch 143/2 Spuriously Transfers Into Manual
AB61432SWT
3
Auxiliary Relay 27X/CX2 Fails To Operate On Demand
AA227C2RYD
Manual/Auto Control Switch 143/2 Left In Manual
AB61432LHE
3
Auxiliary Relay 143X/2 Spuriously Energizes
AB81432RYT
Transformer CX Undervoltage Relay 27/CX2 Fails To Pick Up
AA227CPR6D
Time Delay Relay 83S8 Fails To Pick Up
AB883S8RYD



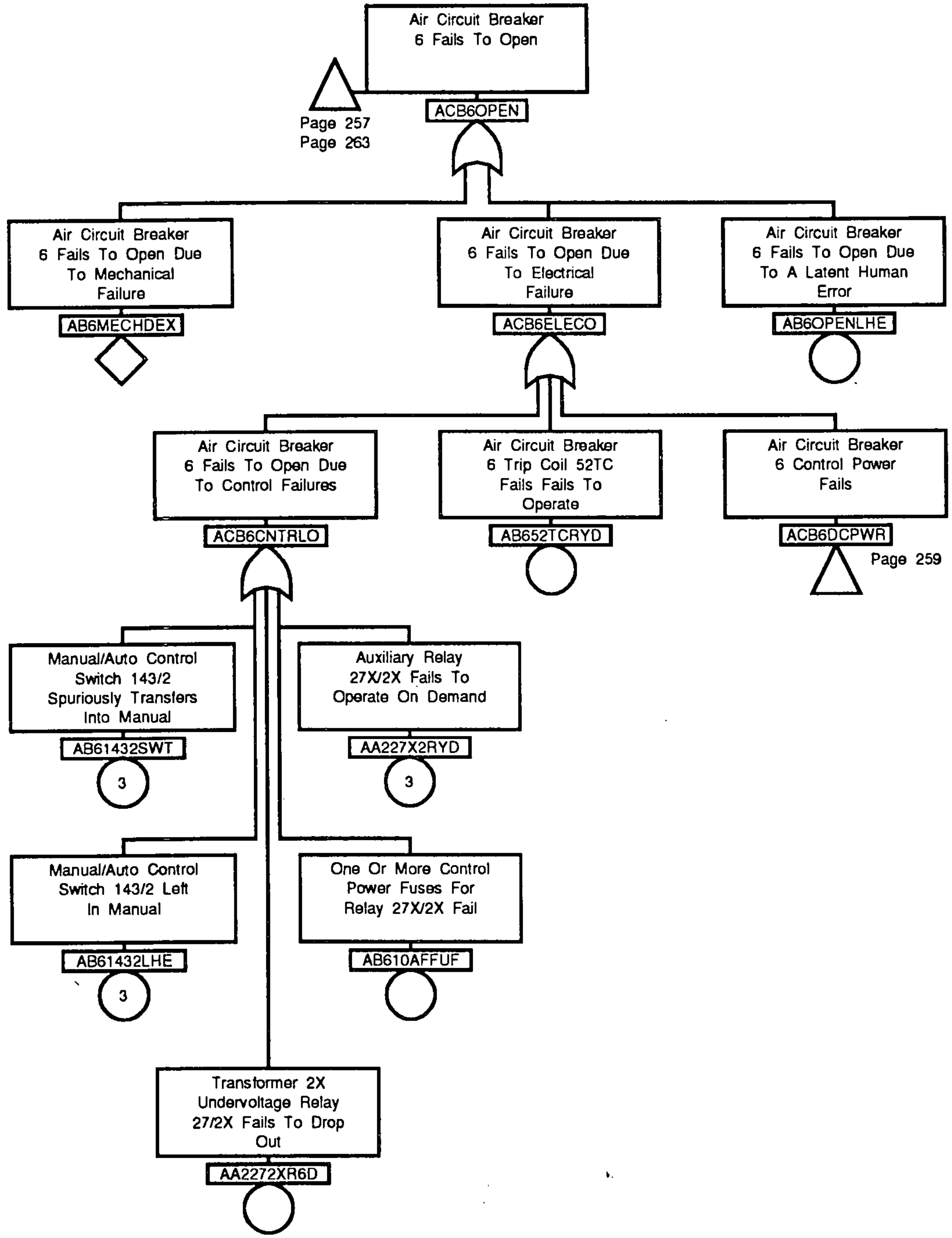
Air Circuit Breaker
8 Fails To Close Due
To Electrical Failu
res Of The Breaker
ACB8BREAKC
Page 263
Air Circuit Breaker
8 Close Coil CC
Fails On Demand
AB852CCRYD
Air Circuit Breaker
8 Y-relay Spurious
Operation
AB852Y2RYT
Air Circuit Breaker
8 Relay 52X Fails
To Operate
AB8R52XRYD
One Or More Control
Power Fuses For X,
Y And CC Fail
AB810A1FUF
Air Circuit Breaker
8 Relay 52Y Failed
To Drop Out At Last
Demand
AB8R52YRYD


Air Circuit Breaker 8 Fails To Close
ACB8CLOSE
Page 262
Air Circuit Breaker 6 Fails To Open
ACB6OPEN
Page 260
Air Circuit Breaker 8 Fails To Close Due To Mechanical Failure
AB8MCH2DEX
Air Circuit Breaker 8 Fails To Close Due To Electrical Failures
ACB8ELECC
CCF of Aux Power Breakers ACB-6 & -8
XA2BKRSCOM
2
Common Cause Failure Of ACB-7 And ACB-8 To Close
XA78BKRCOM
2
Air Circuit Breaker 8 Key Interlock Switch Transfers Open
AB8KEYISWT
Air Circuit Breaker 8 Fails To Close Due To Electrical Failu res Of The Breaker
ACB8BREAKC
Page 264
Air Circuit Breaker 8 Fails To Close Due To Control Failures
ACB8CNTRLC
Page 265
Air Circuit Breaker 8 Control Power Fails
ACB8DCPWR
Air Circuit Breaker 6 Control Power Fails
ACB6DCPWR
Page 259

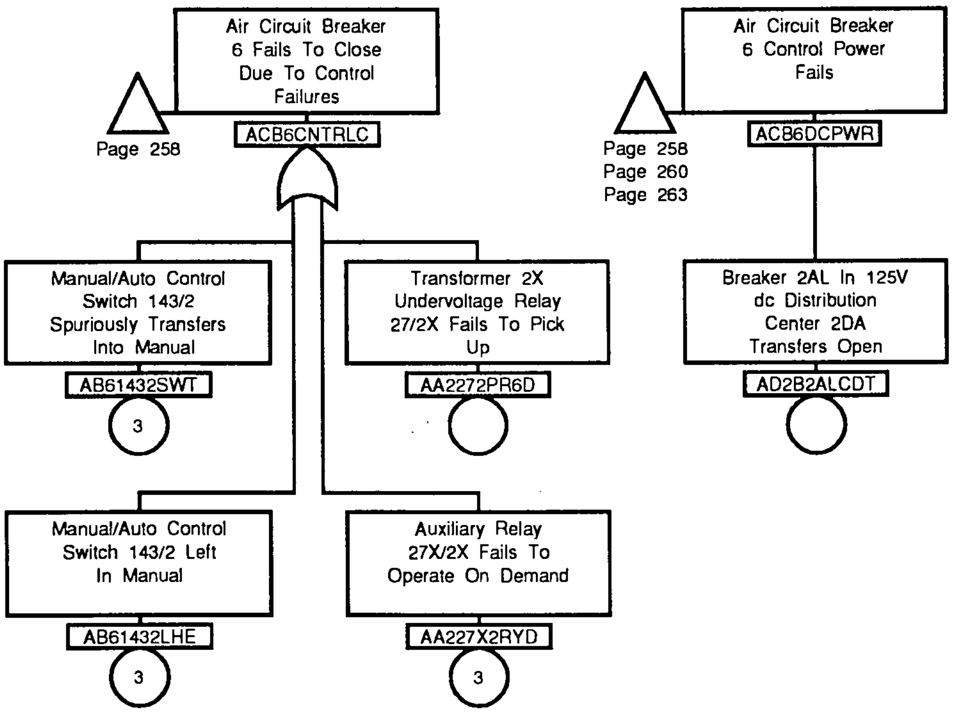

600 Vac Switchgear 2X Alternate Power Source, Xfmr CX, Fails
XA2XE
Page 256
4160 Vac Breaker 1TC-4 Transfers Open
PAC1TC4C4T
2
Loss of Power on ONS-1 ESG Switchgear 1TC
P1TC
Page 170
4160/600 Vac Transformer CX Is in Maintenance
XA1XCXXTHM
2
Air Circuit Breaker 8 Fails To Close
ACB8CLOSE
Page 263
4160/600 Vac Transformer CX Fails
XA1XCXXTLF
2
Air Circuit Breaker 8 Transfers Open
ACB8TRANS
Page 266



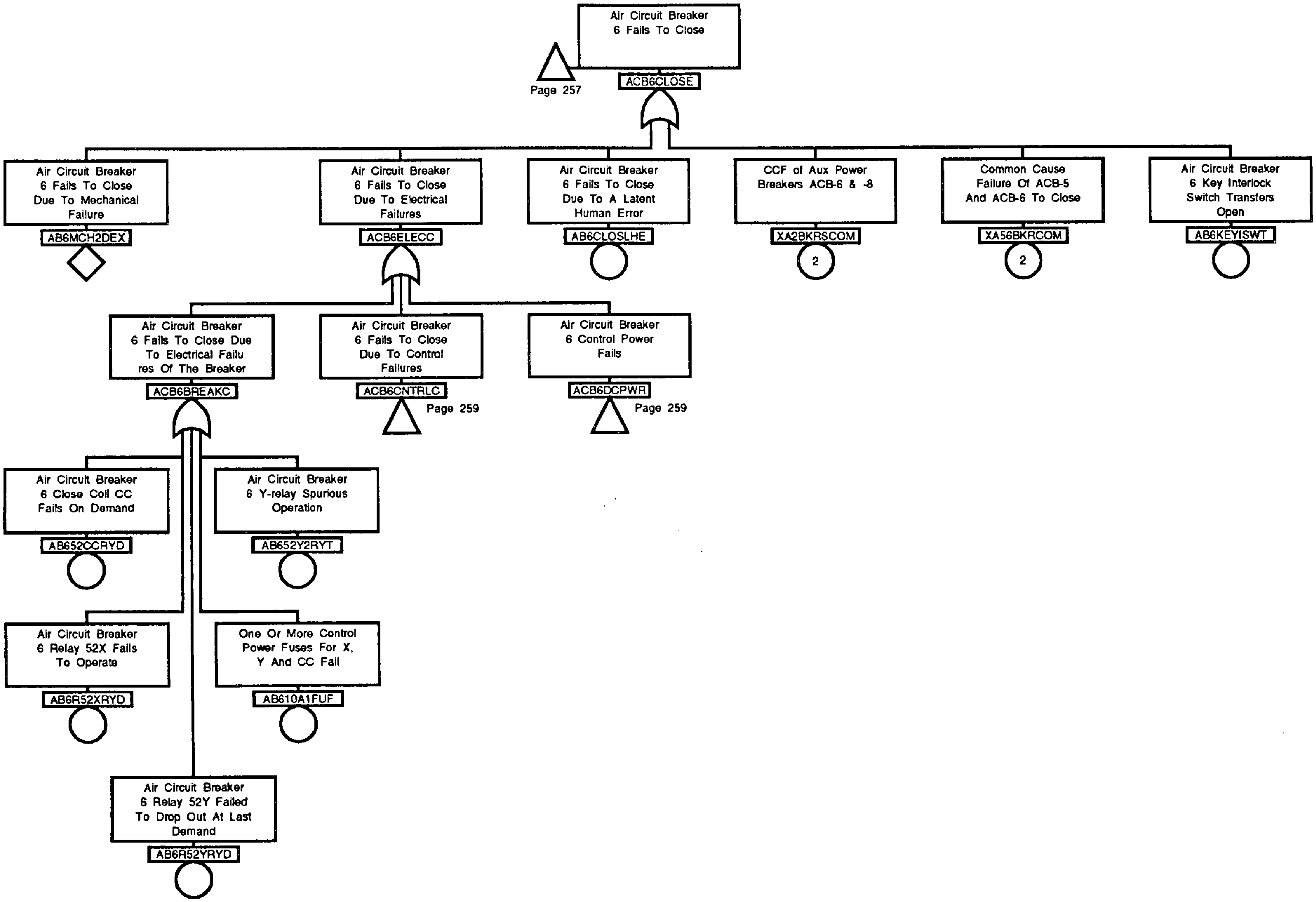
Air Circuit Breaker 6 Transfers Open
ACB6TRANS
Page 257
Transformer 2X Undervoltage Relay 27/2X Spuriously De-energizes
AA2272XR6T
Switchgear 2X Lockout Relay 86S/2X Spurious Operation
AA286S2RYT
2
Auxiliary Relay 27X/2X Spurious Operation
AA227X2RYT
Air Circuit Breaker 6 Trip Coil 52TC Spurious Operation
AB652TCRYT
Main Step Up Transformer Lock Out Relay 86T Actuates
XFMR186T
Page 17
Trip Pushbutton On ACB6 Spurious Operation
AB6PUSHPBT

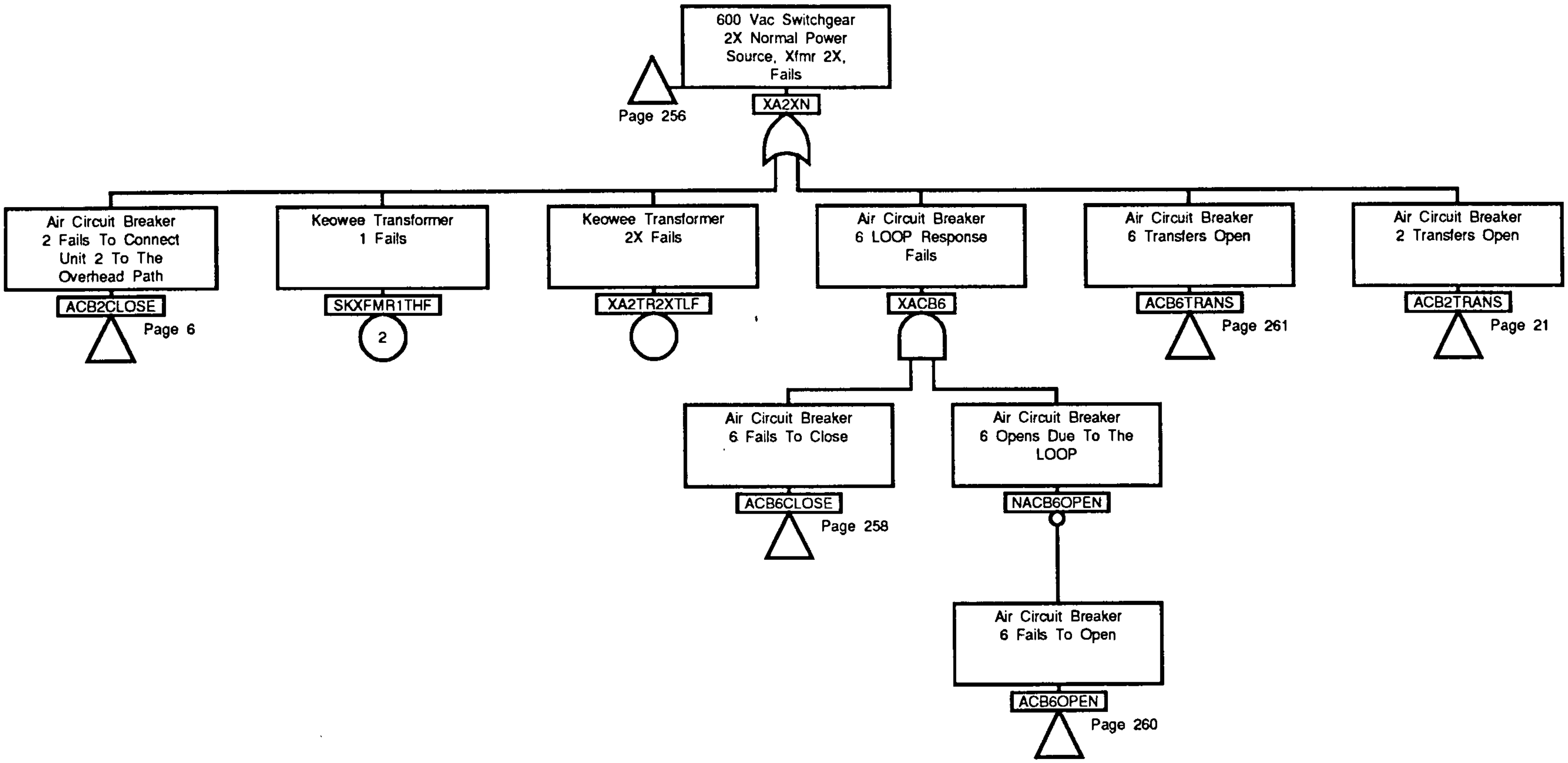


Air Circuit Breaker 6 Fails To Open
ACB6OPEN
Page 257
Page 263
Air Circuit Breaker 6 Fails To Open Due To Mechanical Failure
AB6MECHDEX
Air Circuit Breaker 6 Fails To Open Due To Electrical Failure
ACB6ELECO
Air Circuit Breaker 6 Fails To Open Due To A Latent Human Error
AB6OPENLHE
Air Circuit Breaker 6 Fails To Open Due To Control Failures
ACB6CNTRLO
Air Circuit Breaker 6 Trip Coil 52TC Fails Fails To Operate
AB652TCRYD
Air Circuit Breaker 6 Control Power Fails
ACB6DCPWR
Page 259
Manual/Auto Control Switch 143/2 Spuriously Transfers Into Manual
AB61432SWT
3
Auxiliary Relay 27X/2X Fails To Operate On Demand
AA227X2RYD
3
Manual/Auto Control Switch 143/2 Left In Manual
AB61432LHE
3
One Or More Control Power Fuses For Relay 27X/2X Fail
AB610AFFUF
Transformer 2X Undervoltage Relay 27/2X Fails To Drop Out
AA2272XR6D

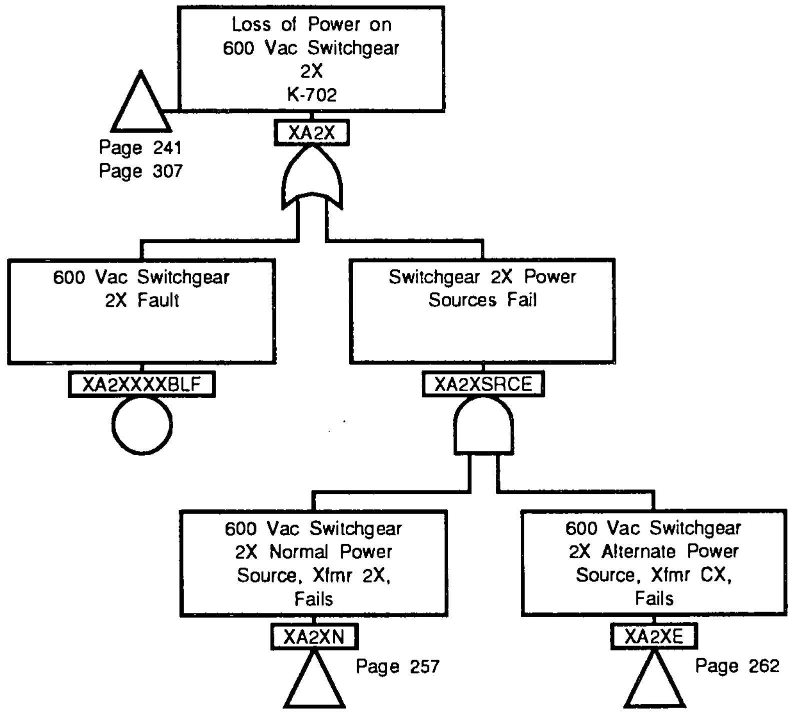


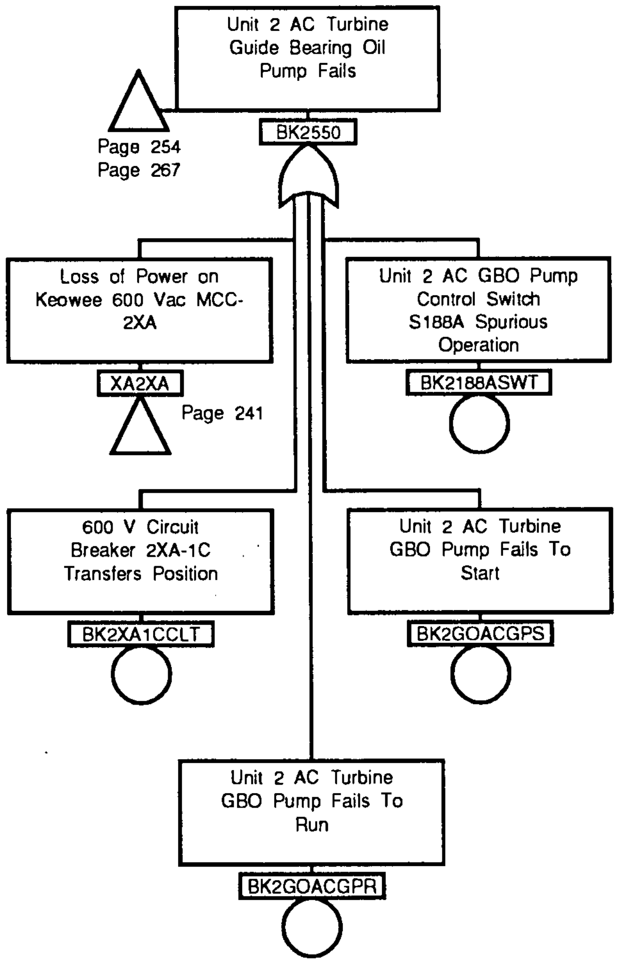
Air Circuit Breaker 6 Fails To Close Due To Control Failures
ACB6CNTRLC
Page 258
Manual/Auto Control Switch 143/2 Spuriously Transfers Into Manual
AB61432SWT
3
Transformer 2X Undervoltage Relay 27/2X Fails To Pick Up
AA2272PR6D
Manual/Auto Control Switch 143/2 Left In Manual
AB61432LHE
3
Auxiliary Relay 27X/2X Fails To Operate On Demand
AA227X2RYD
3
Air Circuit Breaker 6 Control Power Fails
ACB6DCPWR
Page 258
Page 260
Page 263
Breaker 2AL In 125V dc Distribution Center 2DA Transfers Open
AD2B2ALCDT

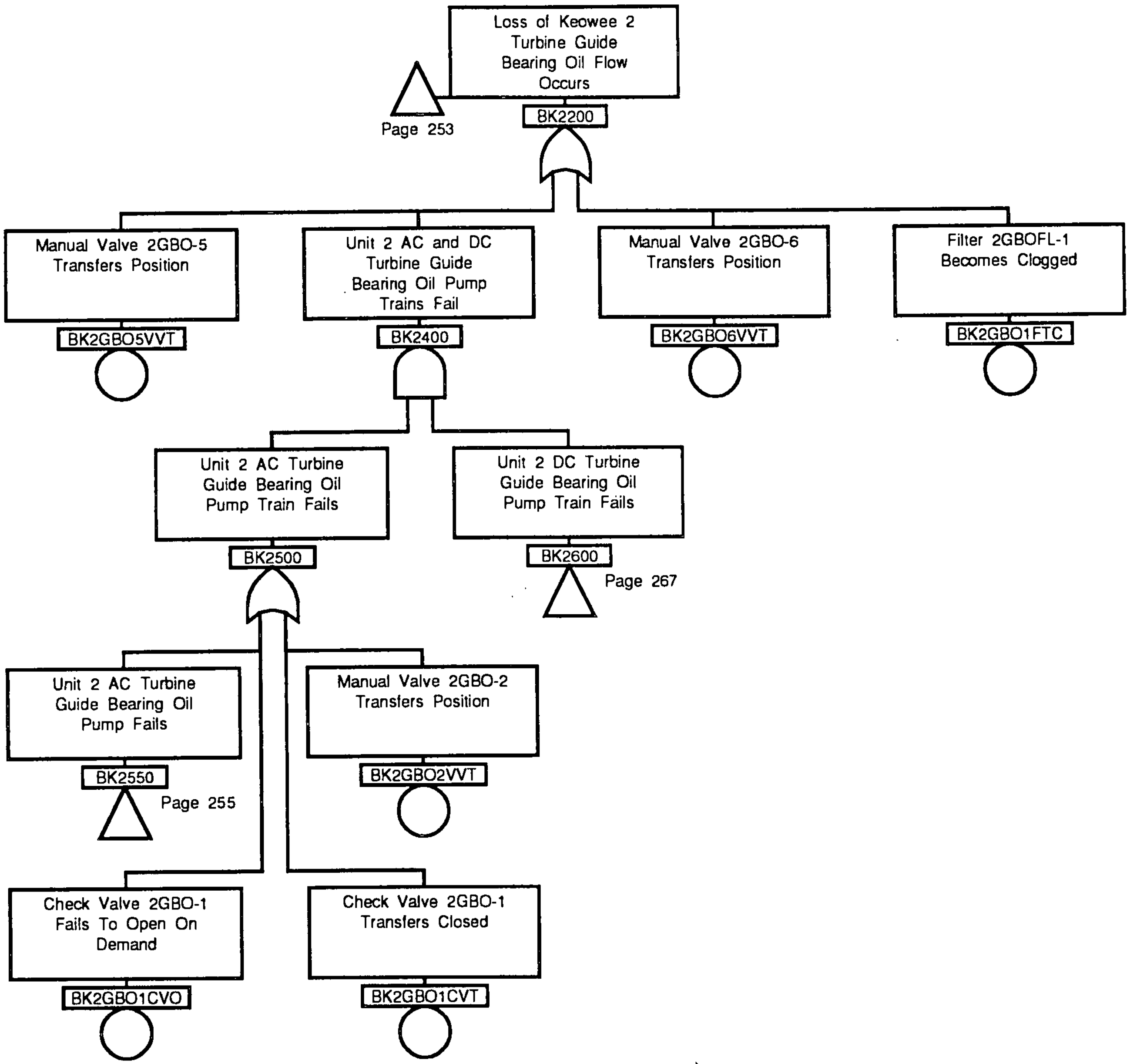

Air Circuit Breaker 6 Fails To Close
ACB6CLOSE
Page 257
Air Circuit Breaker 6 Fails To Close Due To Mechanical Failure
AB6MCH2DEX
Air Circuit Breaker 6 Fails To Close Due To Electrical Failures
ACB6ELECC
Air Circuit Breaker 6 Fails To Close Due To A Latent Human Error
AB6CLOSLHE
CCF of Aux Power Breakers ACB-6 & -8
XA2BKRSCOM
2
Common Cause Failure Of ACB-5 And ACB-6 To Close
XA56BKRCOM
2
Air Circuit Breaker 6 Key Interlock Switch Transfers Open
AB6KEYISWT
Air Circuit Breaker 6 Fails To Close Due To Electrical Failu res Of The Breaker
ACB6BREAKC
Air Circuit Breaker 6 Fails To Close Due To Control Failures
ACB6CNTRLC
Page 259
Air Circuit Breaker 6 Control Power Fails
ACB6DCPWR
Page 259
Air Circuit Breaker 6 Close Coil CC Fails On Demand
AB652CCRYD
Air Circuit Breaker 6 Y-relay Spurious Operation
AB652Y2RYT
Air Circuit Breaker 6 Relay 52X Fails To Operate
AB6R52XRYD
One Or More Control Power Fuses For X, Y And CC Fail
AB610A1FUF
Air Circuit Breaker 6 Relay 52Y Failed To Drop Out At Last Demand
AB6R52YRYD



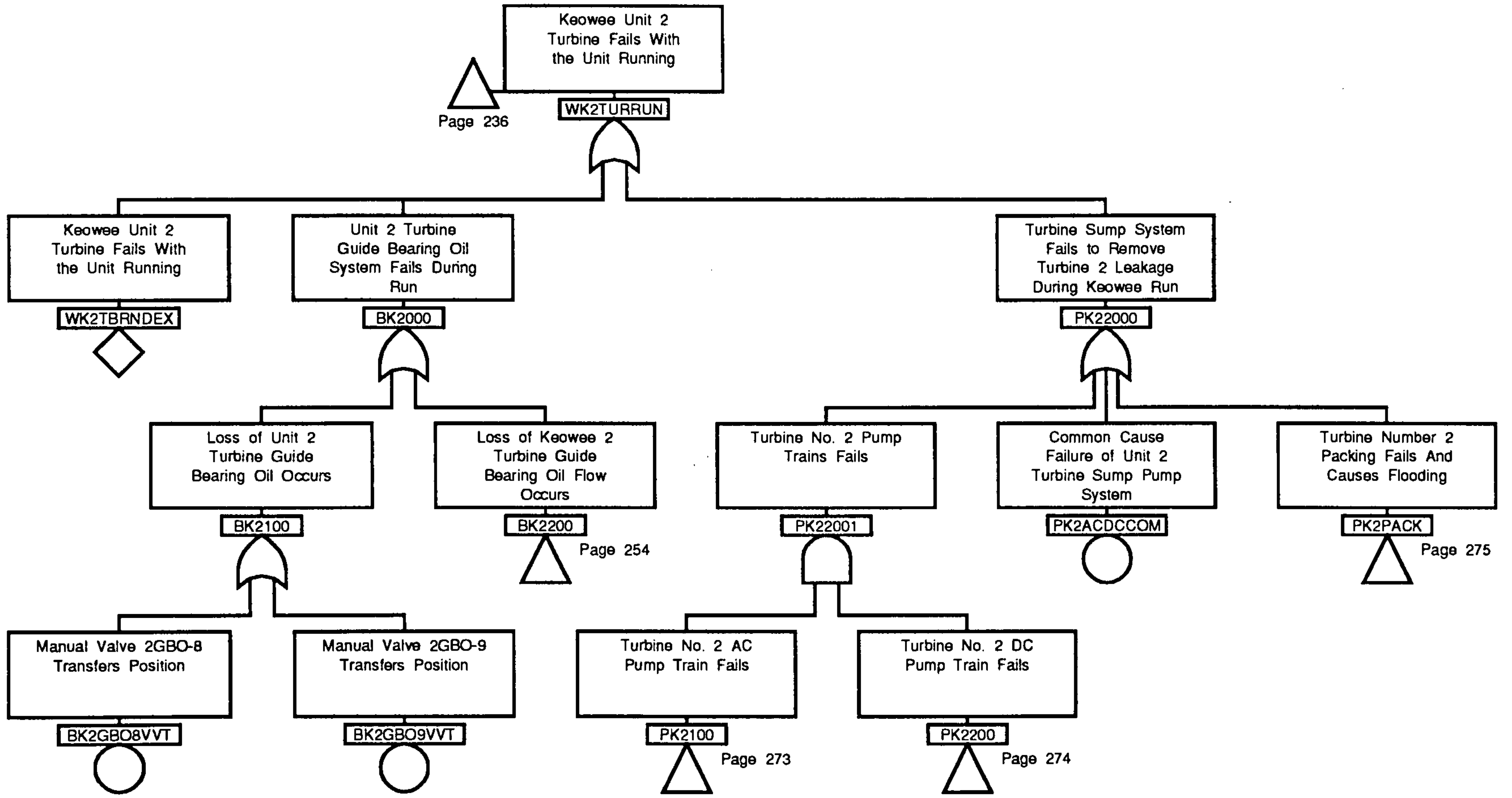
600 Vac Switchgear 2X Normal Power Source, Xfmr 2X, Fails
XA2XN
Page 256
Air Circuit Breaker 2 Fails To Connect Unit 2 To The Overhead Path
ACB2CLOSE
Page 6
Keowee Transformer 1 Fails
SKXFMR1THF
2
Keowee Transformer 2X Fails
XA2TR2XTLF
Air Circuit Breaker 6 LOOP Response Fails
XACB6
Air Circuit Breaker 6 Transfers Open
ACB6TRANS
Page 261
Air Circuit Breaker 2 Transfers Open
ACB2TRANS
Page 21
Air Circuit Breaker 6 Fails To Close
ACB6CLOSE
Page 258
Air Circuit Breaker 6 Opens Due To The LOOP
NACB6OPEN
Air Circuit Breaker 6 Fails To Open
ACB6OPEN
Page 260


Loss of Power on
600 Vac Switchgear
2X
K-702
XA2X
Page 241
Page 307
600 Vac Switchgear
2X Fault
XA2XXXXBLF
Switchgear 2X Power
Sources Fail
XA2XSRCE
600 Vac Switchgear
2X Normal Power
Source, Xfmr 2X,
Fails
XA2XN
Page 257
600 Vac Switchgear
2X Alternate Power
Source, Xfmr CX,
Fails
XA2XE
Page 262

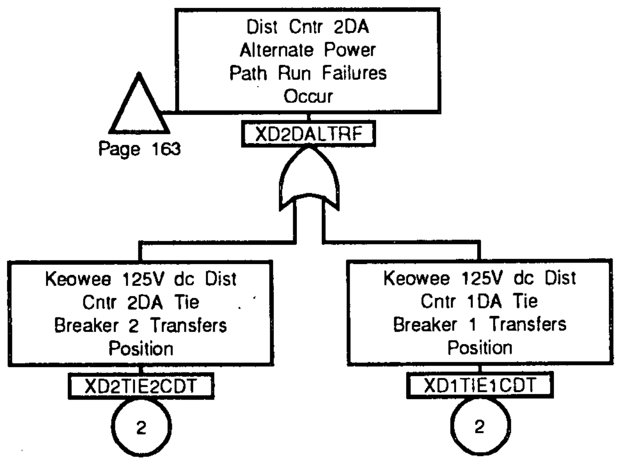

Unit 2 AC Turbine Guide Bearing Oil Pump Fails
BK2550
Page 254
Page 267
Loss of Power on Keowee 600 Vac MCC-2XA
XA2XA
Page 241
Unit 2 AC GBO Pump Control Switch S188A Spurious Operation
BK2188ASWT
600 V Circuit Breaker 2XA-1C Transfers Position
BK2XA1CCLT
Unit 2 AC Turbine GBO Pump Fails To Start
BK2GOACGPS
Unit 2 AC Turbine GBO Pump Fails To Run
BK2GOACGPR

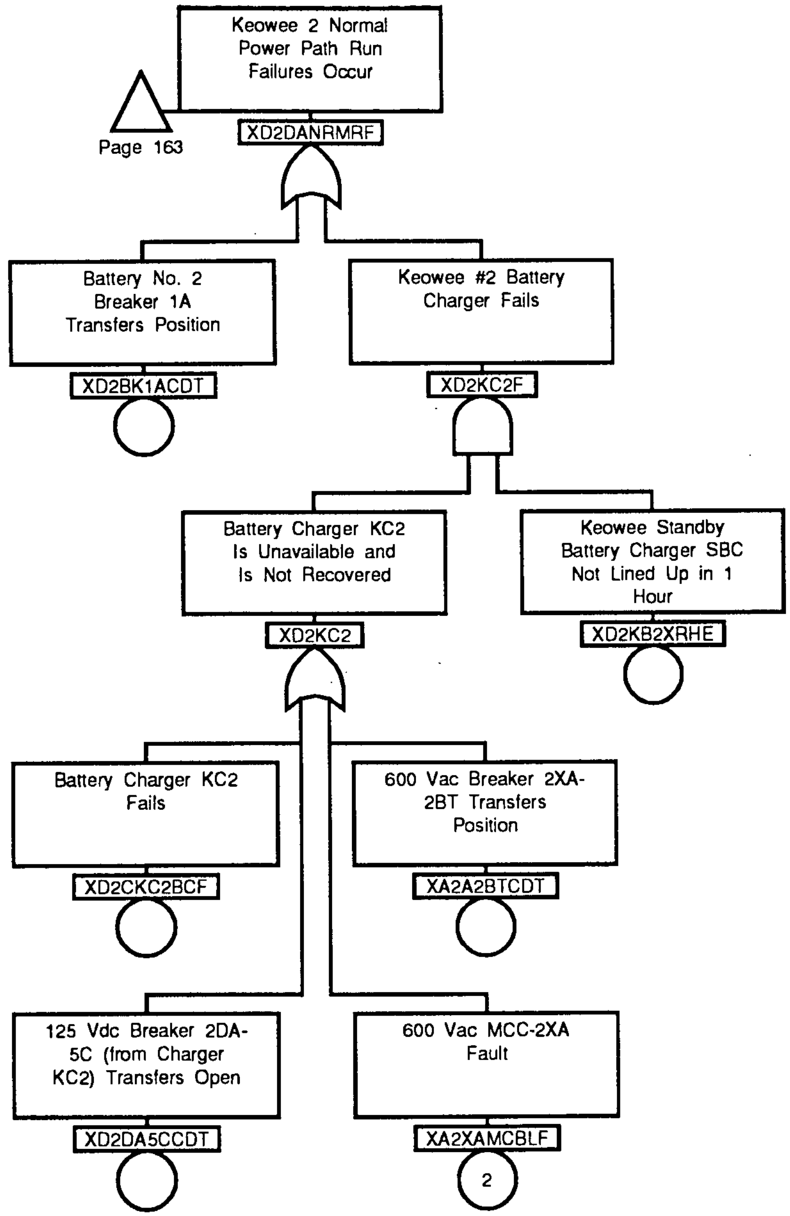


Loss of Keowee 2 Turbine Guide Bearing Oil Flow Occurs
BK2200
Page 253
Manual Valve 2GBO-5 Transfers Position
BK2GBO5VVT
Unit 2 AC and DC Turbine Guide Bearing Oil Pump Trains Fail
BK2400
Manual Valve 2GBO-6 Transfers Position
BK2GBO6VVT
Filter 2GBOFL-1 Becomes Clogged
BK2GBO1FTC
Unit 2 AC Turbine Guide Bearing Oil Pump Train Fails
BK2500
Unit 2 DC Turbine Guide Bearing Oil Pump Train Fails
BK2600
Page 267
Unit 2 AC Turbine Guide Bearing Oil Pump Fails
BK2550
Page 255
Manual Valve 2GBO-2 Transfers Position
BK2GBO2VVT
Check Valve 2GBO-1 Fails To Open On Demand
BK2GBO1CVO
Check Valve 2GBO-1 Transfers Closed
BK2GBO1CVT

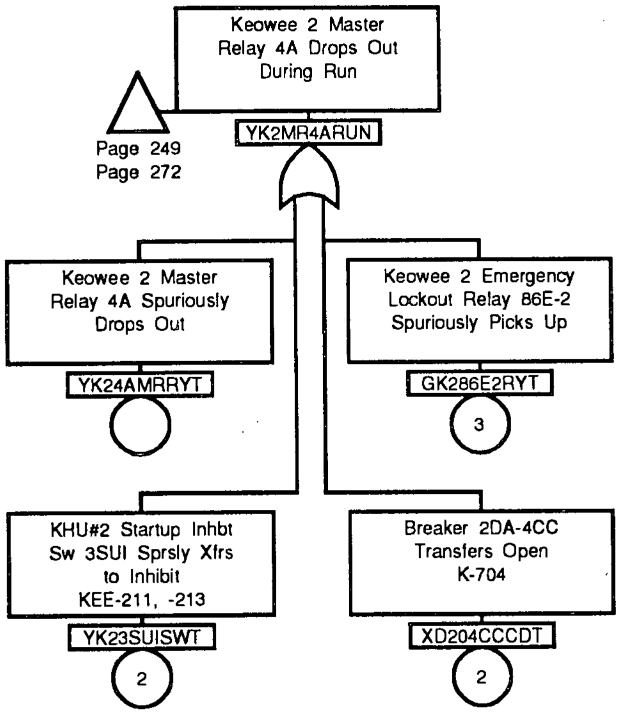


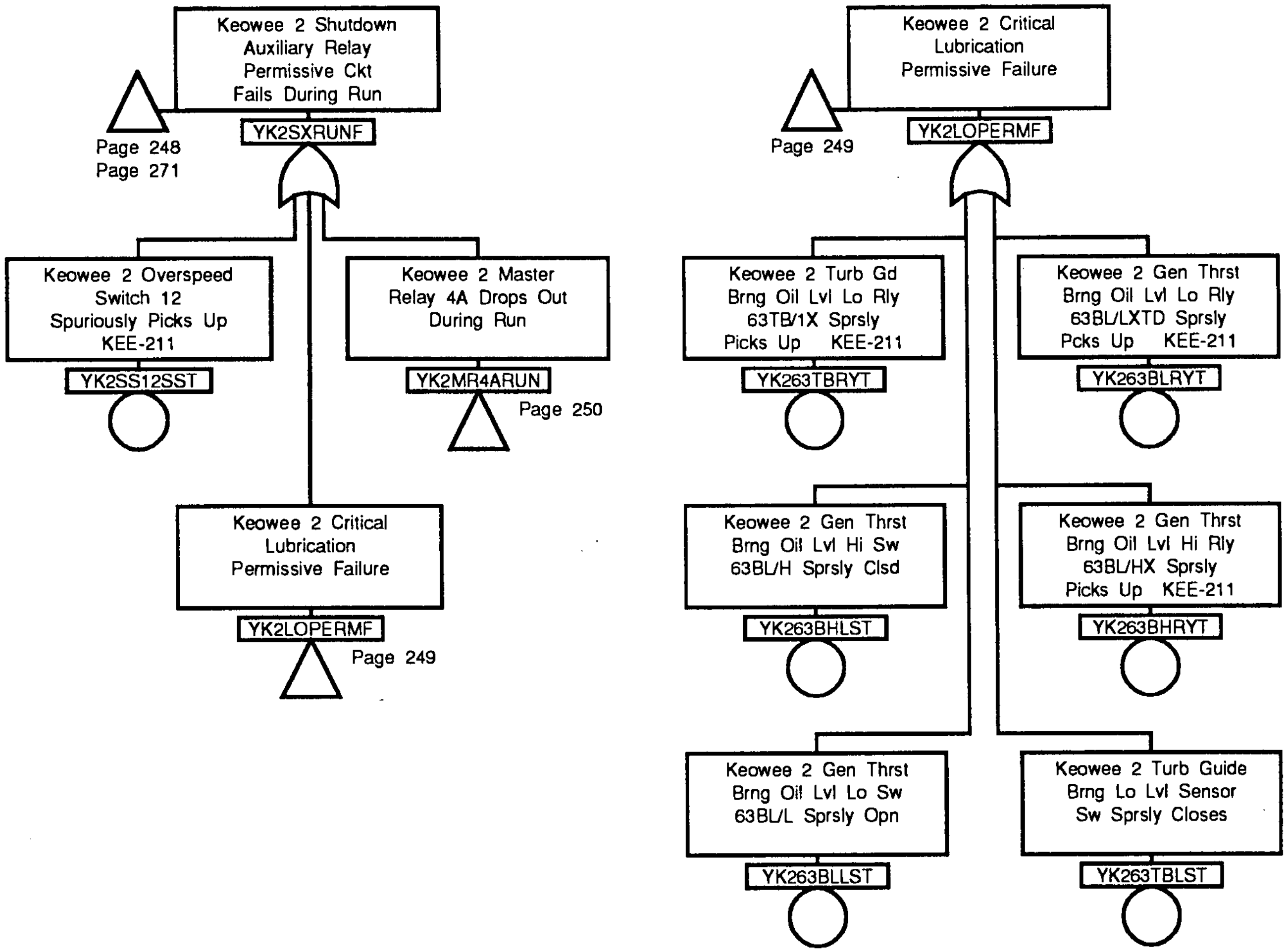
Keowee Unit 2 Turbine Fails With the Unit Running
WK2TURRUN
Page 236
Keowee Unit 2 Turbine Fails With the Unit Running
WK2TBRNDEX
Unit 2 Turbine Guide Bearing Oil System Fails During Run
BK2000
Turbine Sump System Fails to Remove Turbine 2 Leakage During Keowee Run
PK22000
Loss of Unit 2 Turbine Guide Bearing Oil Occurs
BK2100
Loss of Keowee 2 Turbine Guide Bearing Oil Flow Occurs
BK2200
Page 254
Turbine No. 2 Pump Trains Fails
PK22001
Common Cause Failure of Unit 2 Turbine Sump Pump System
PK2ACDCCOM
Turbine Number 2 Packing Fails And Causes Flooding
PK2PACK
Page 275
Manual Valve 2GBO-8 Transfers Position
BK2GBO8VVT
Manual Valve 2GBO-9 Transfers Position
BK2GBO9VVT
Turbine No. 2 AC Pump Train Fails
PK2100
Page 273
Turbine No. 2 DC Pump Train Fails
PK2200
Page 274

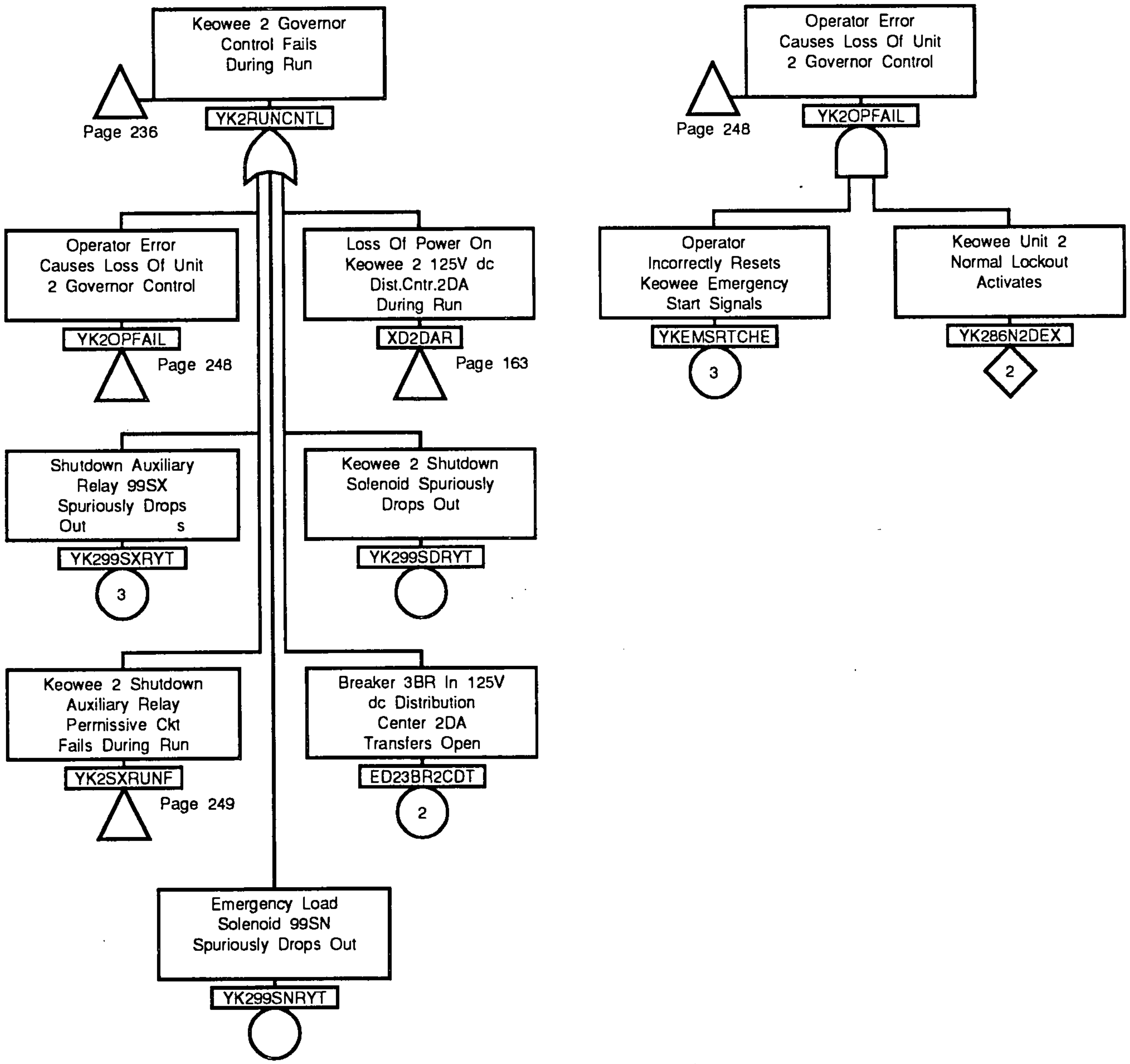

Dist Cntr 2DA
Alternate Power
Path Run Failures
Occur
XD2DALTRF
Page 163
Keowee 125V dc Dist
Cntr 2DA Tie
Breaker 2 Transfers
Position
XD2TIE2CDT
2
Keowee 125V dc Dist
Cntr 1DA Tie
Breaker 1 Transfers
Position
XD1TIE1CDT
2



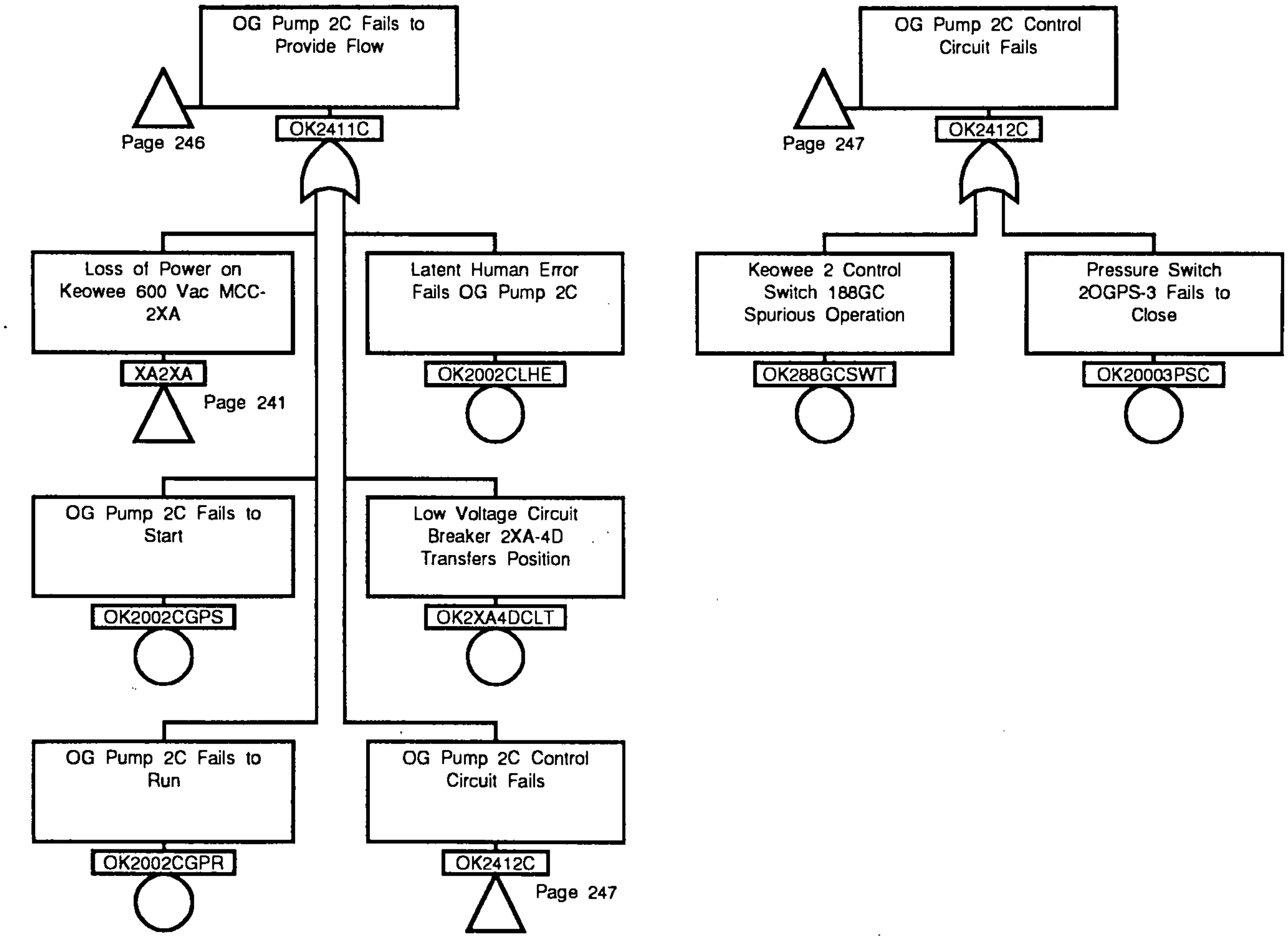
Keowee 2 Normal Power Path Run Failures Occur
XD2DANRMRF
Page 163
Battery No. 2 Breaker 1A Transfers Position
XD2BK1ACDT
Keowee #2 Battery Charger Fails
XD2KC2F
Battery Charger KC2 Is Unavailable and Is Not Recovered
XD2KC2
Keowee Standby Battery Charger SBC Not Lined Up in 1 Hour
XD2KB2XRHE
Battery Charger KC2 Fails
XD2CKC2BCF
600 Vac Breaker 2XA-2BT Transfers Position
XA2A2BTCDT
125 Vdc Breaker 2DA-5C (from Charger KC2) Transfers Open
XD2DA5CCDT
600 Vac MCC-2XA Fault
XA2XAMCBLF
2


Keowee 2 Master Relay 4A Drops Out During Run
YK2MR4ARUN
Page 249
Page 272
Keowee 2 Master Relay 4A Spuriously Drops Out
YK24AMRRYT
Keowee 2 Emergency Lockout Relay 86E-2 Spuriously Picks Up
GK286E2RYT
3
KHU#2 Startup Inhbt Sw 3SUI Sprsly Xfrs to Inhibit KEE-211, -213
YK23SUISWT
2
Breaker 2DA-4CC Transfers Open K-704
XD204CCCDT
2

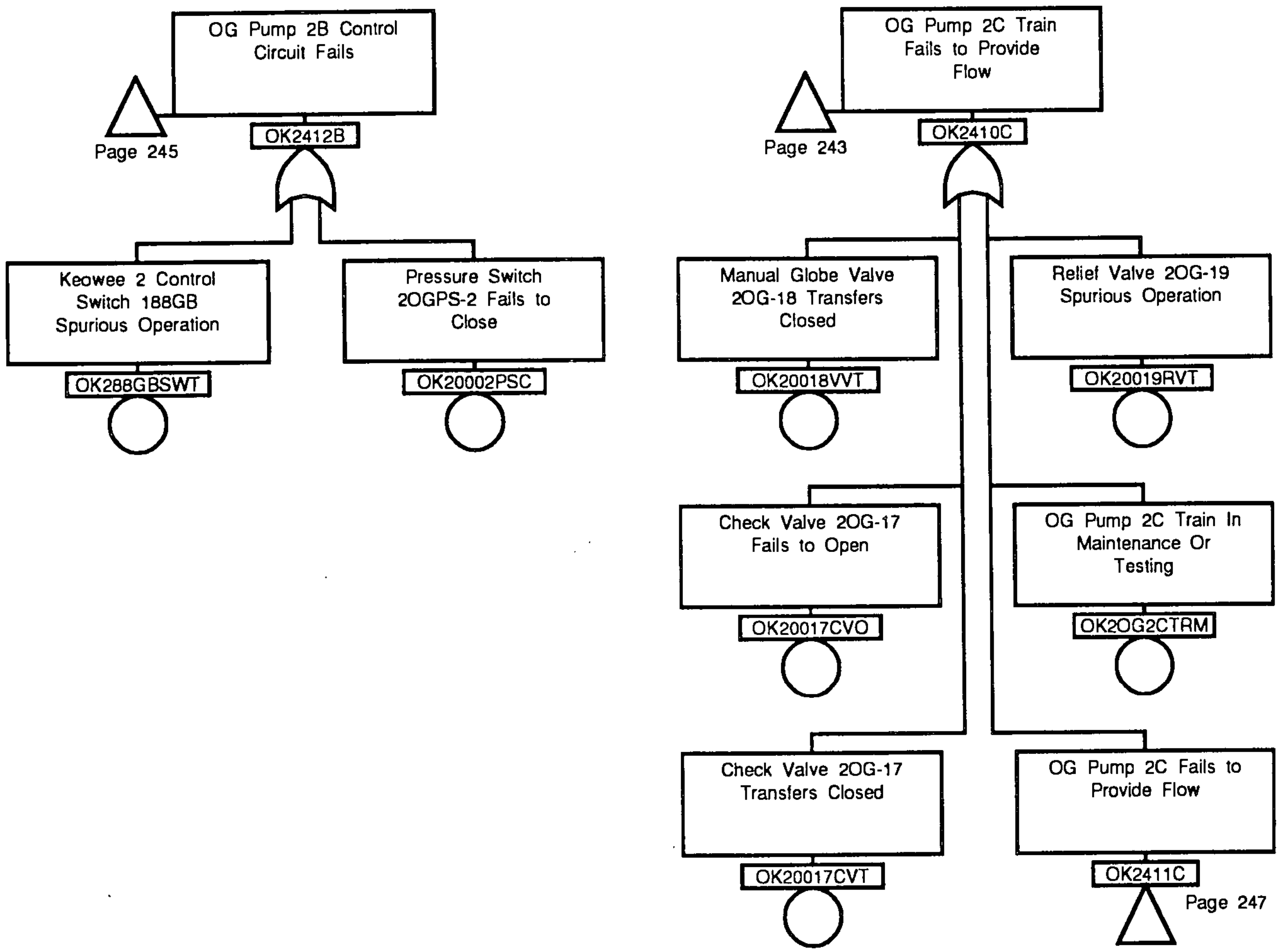

Keowee 2 Shutdown Auxiliary Relay Permissive Ckt Fails During Run
YK2SXRUNF
Page 248
Page 271
Keowee 2 Overspeed Switch 12 Spuriously Picks Up KEE-211
YK2SS12SST
Keowee 2 Master Relay 4A Drops Out During Run
YK2MR4ARUN
Page 250
Keowee 2 Critical Lubrication Permissive Failure
YK2LOPERMF
Page 249
Keowee 2 Critical Lubrication Permissive Failure
YK2LOPERMF
Page 249
Keowee 2 Turb Gd Brng Oil Lvl Lo Rly 63TB/1X Sprsly Picks Up KEE-211
YK263TBRYT
Keowee 2 Gen Thrst Brng Oil Lvl Lo Rly 63BL/LXTD Sprsly Pcks Up KEE-211
YK263BLRYT
Keowee 2 Gen Thrst Brng Oil Lvl Hi Sw 63BL/H Sprsly Clsd
YK263BHLST
Keowee 2 Gen Thrst Brng Oil Lvl Hi Rly 63BL/HX Sprsly Picks Up KEE-211
YK263BHRYT
Keowee 2 Gen Thrst Brng Oil Lvl Lo Sw 63BL/L Sprsly Opn
YK263BLLST
Keowee 2 Turb Guide Brng Lo Lvl Sensor Sw Sprsly Closes
YK263TBLST



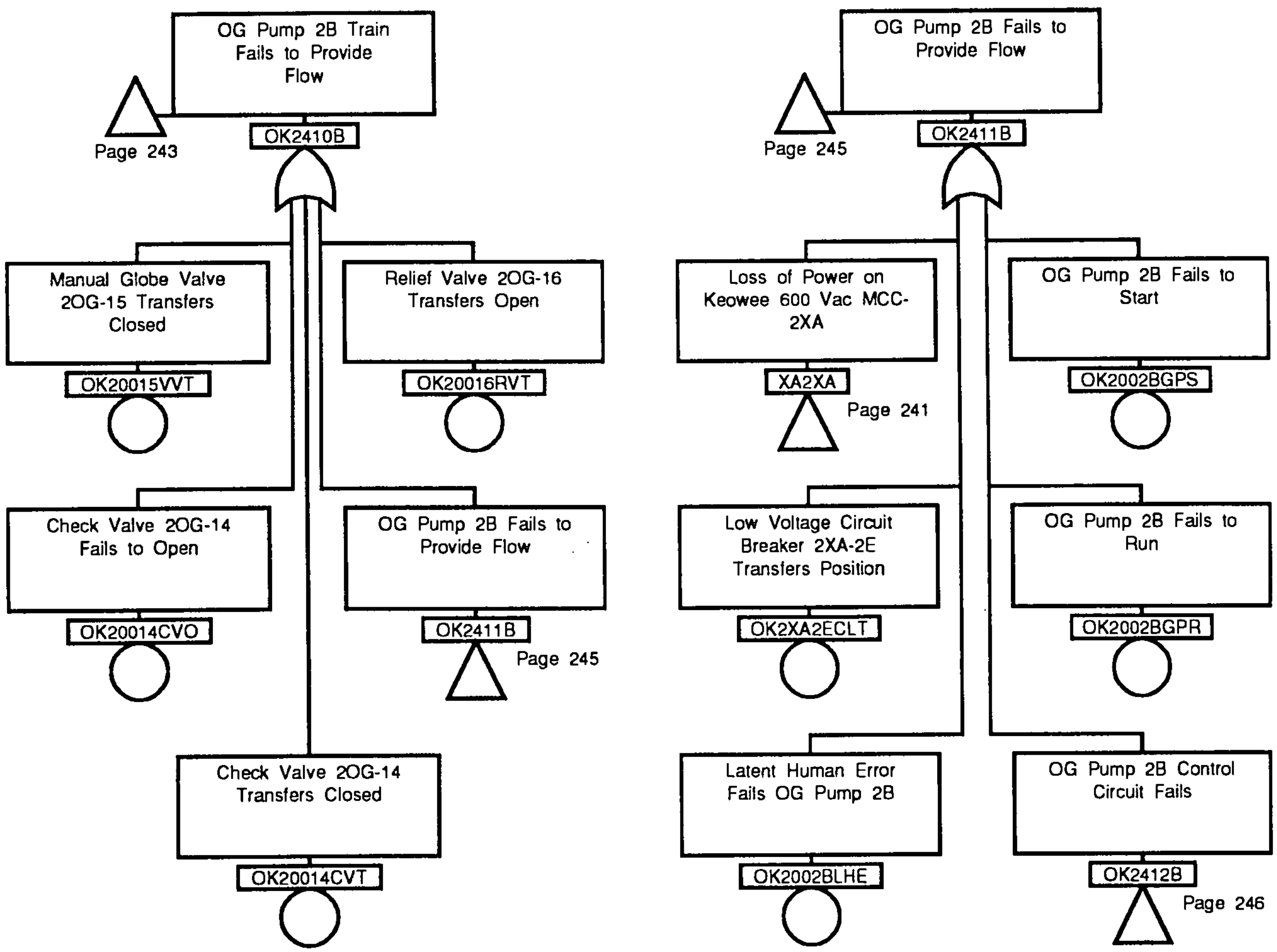
Keowee 2 Governor Control Fails During Run
YK2RUNCNTL
Page 236
Operator Error Causes Loss Of Unit 2 Governor Control
YK2OPFAIL
Page 248
Loss Of Power On Keowee 2 125V dc Dist.Cntr.2DA During Run
XD2DAR
Page 163
Shutdown Auxiliary Relay 99SX Spuriously Drops Out s
YK299SXRYT
3
Keowee 2 Shutdown Solenoid Spuriously Drops Out
YK299SDRYT
Keowee 2 Shutdown Auxiliary Relay Permissive Ckt Fails During Run
YK2SXRUNF
Page 249
Breaker 3BR In 125V dc Distribution Center 2DA Transfers Open
ED23BR2CDT
2
Emergency Load Solenoid 99SN Spuriously Drops Out
YK299SNRYT
Operator Error Causes Loss Of Unit 2 Governor Control
YK2OPFAIL
Page 248
Operator Incorrectly Resets Keowee Emergency Start Signals
YKEMSRTCHE
3
Keowee Unit 2 Normal Lockout Activates
YK286N2DEX
2



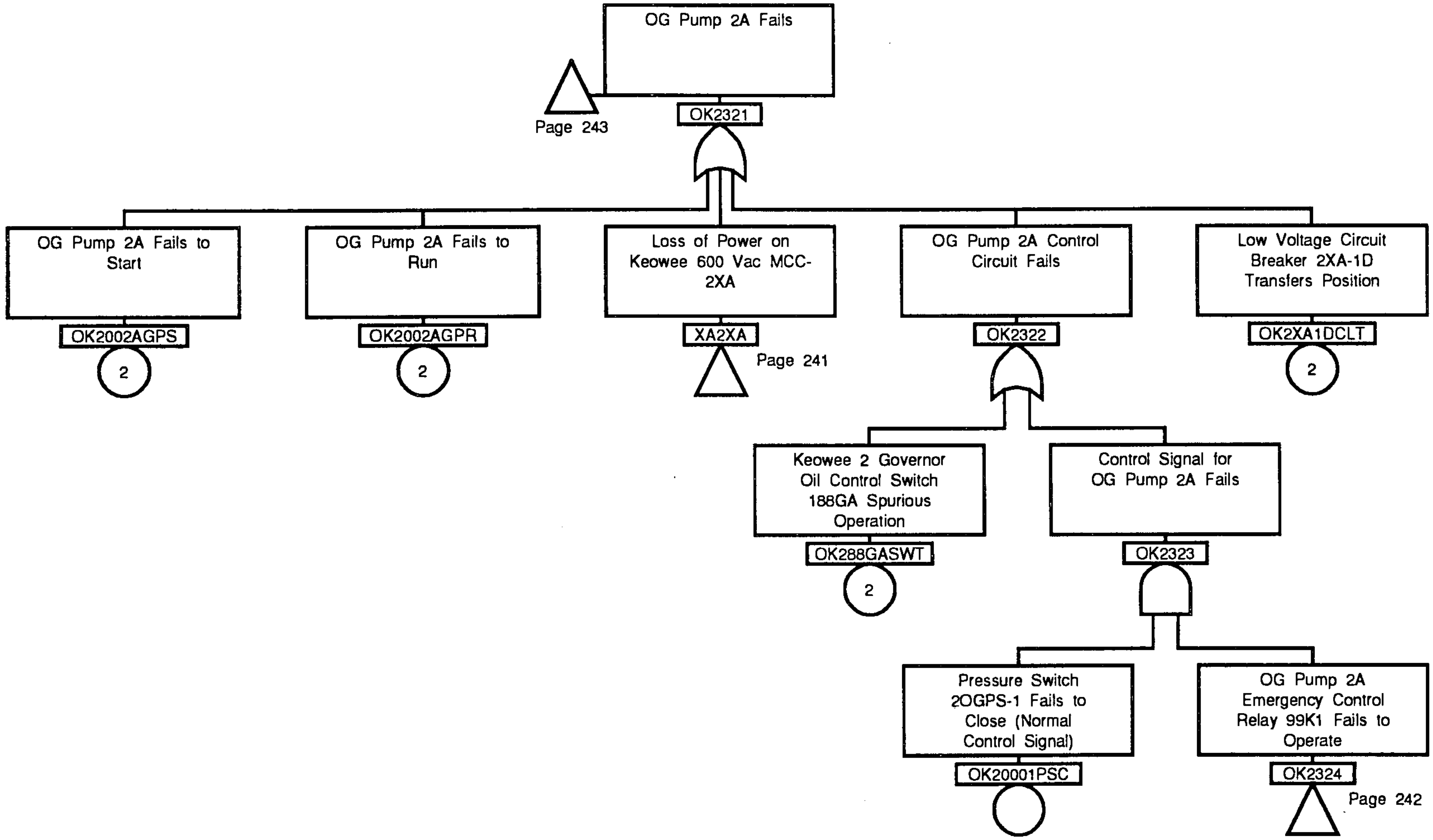
OG Pump 2C Fails to Provide Flow
Page 246
OK2411C
Loss of Power on Keowee 600 Vac MCC-2XA
XA2XA
Page 241
Latent Human Error Fails OG Pump 2C
OK2002CLHE
OG Pump 2C Fails to Start
OK2002CGPS
Low Voltage Circuit Breaker 2XA-4D Transfers Position
OK2XA4DCLT
OG Pump 2C Fails to Run
OK2002CGPR
OG Pump 2C Control Circuit Fails
OK2412C
Page 247
OG Pump 2C Control Circuit Fails
Page 247
OK2412C
Keowee 2 Control Switch 188GC Spurious Operation
OK288GCSWT
Pressure Switch 2OGPS-3 Fails to Close
OK20003PSC



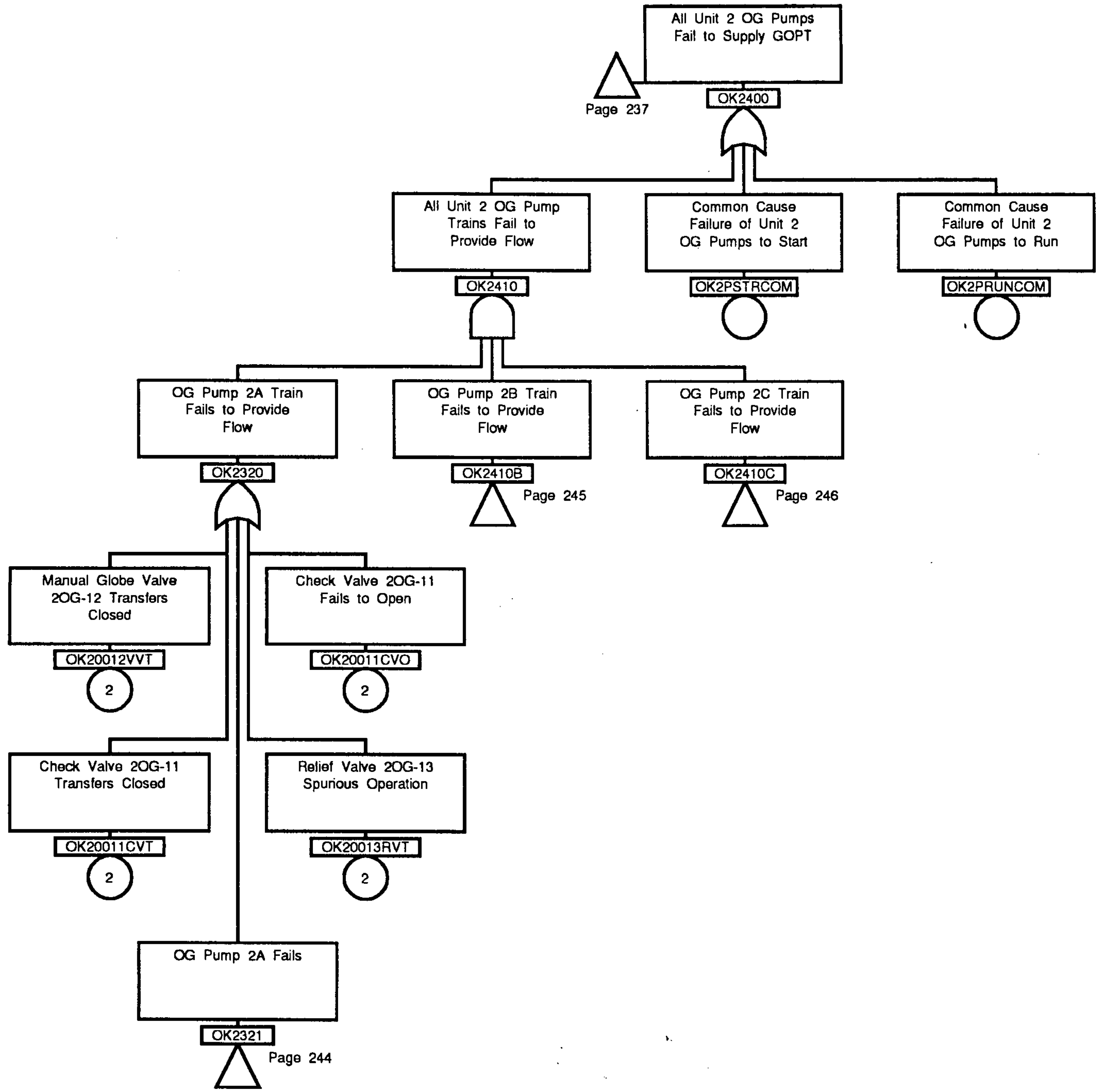
OG Pump 2B Control Circuit Fails
OK2412B
Page 245
Keowee 2 Control Switch 188GB Spurious Operation
OK288GBSWT
Pressure Switch 2OGPS-2 Fails to Close
OK20002PSC
OG Pump 2C Train Fails to Provide Flow
OK2410C
Page 243
Manual Globe Valve 2OG-18 Transfers Closed
OK20018VVT
Relief Valve 2OG-19 Spurious Operation
OK20019RVT
Check Valve 2OG-17 Fails to Open
OK20017CVO
OG Pump 2C Train In Maintenance Or Testing
OK2OG2CTRM
Check Valve 2OG-17 Transfers Closed
OK20017CVT
OG Pump 2C Fails to Provide Flow
OK2411C
Page 247

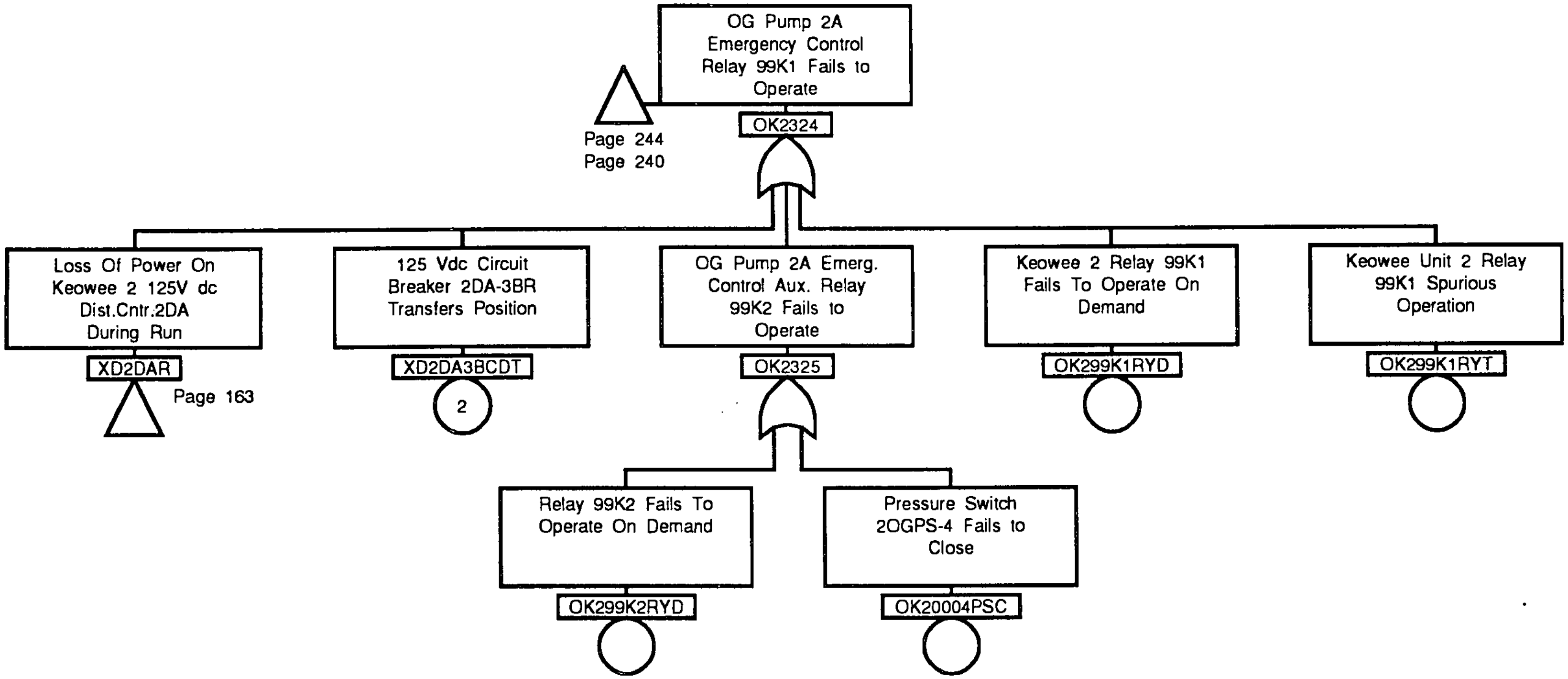


OG Pump 2B Train Fails to Provide Flow
OK2410B
Page 243
Manual Globe Valve 2OG-15 Transfers Closed
OK20015VVT
Relief Valve 2OG-16 Transfers Open
OK20016RVT
Check Valve 2OG-14 Fails to Open
OK20014CVO
OG Pump 2B Fails to Provide Flow
OK2411B
Page 245
Check Valve 2OG-14 Transfers Closed
OK20014CVT
OG Pump 2B Fails to Provide Flow
OK2411B
Page 245
Loss of Power on Keowee 600 Vac MCC-2XA
XA2XA
Page 241
OG Pump 2B Fails to Start
OK2002BGPS
Low Voltage Circuit Breaker 2XA-2E Transfers Position
OK2XA2ECLT
OG Pump 2B Fails to Run
OK2002BGPR
Latent Human Error Fails OG Pump 2B
OK2002BLHE
OG Pump 2B Control Circuit Fails
OK2412B
Page 246

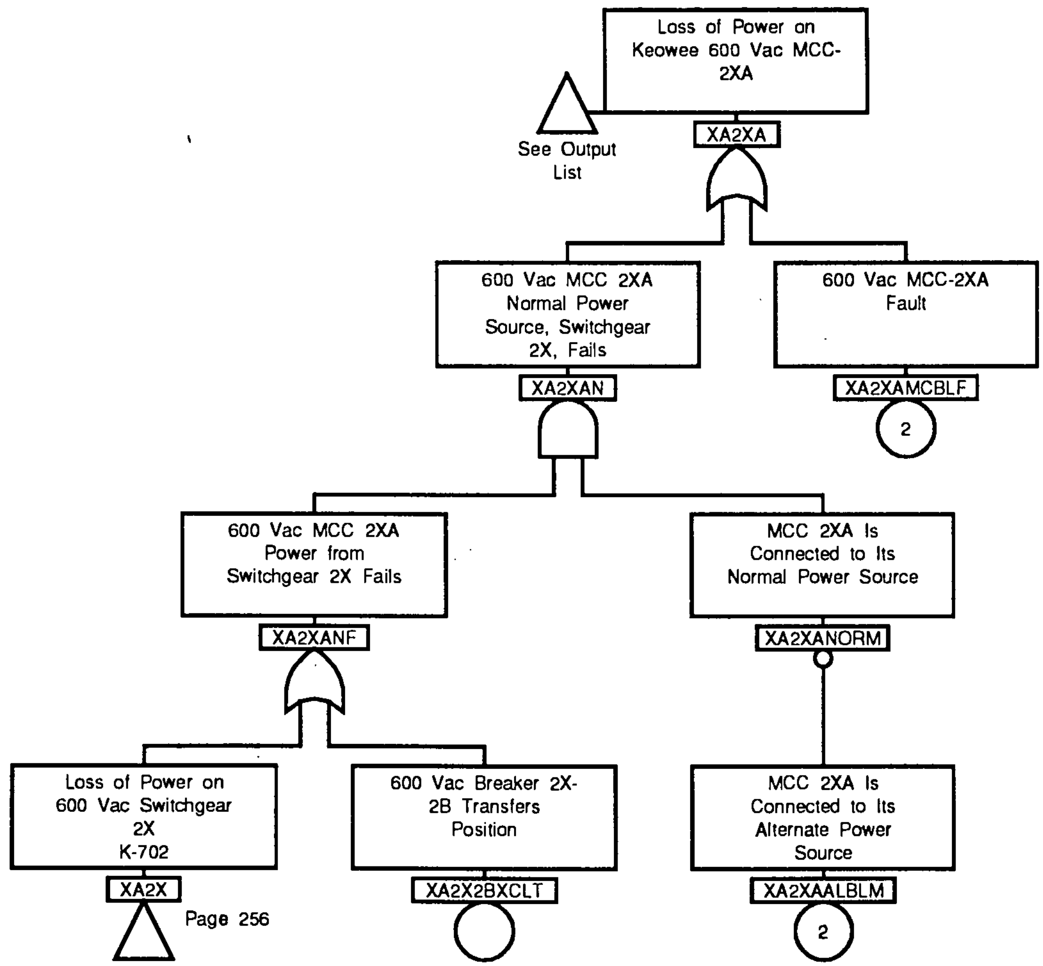


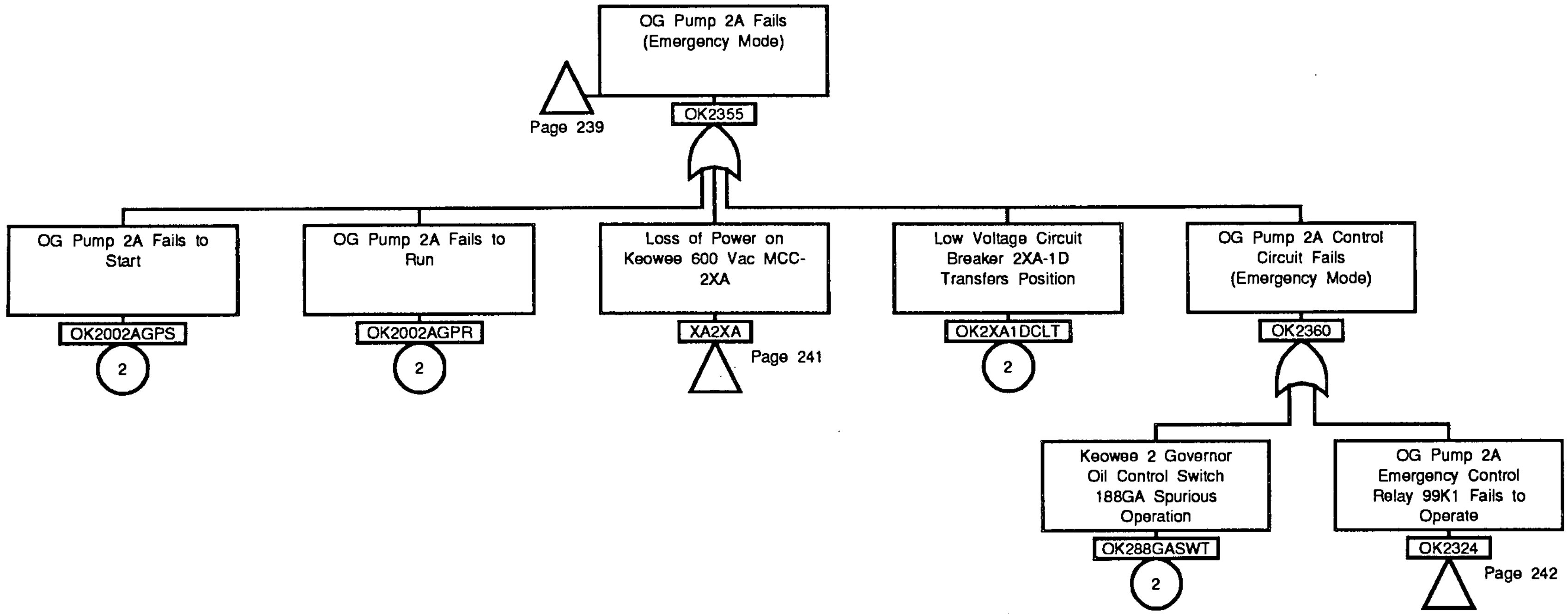
OG Pump 2A Fails
Page 243
OK2321
OG Pump 2A Fails to Start
OK2002AGPS
2
OG Pump 2A Fails to Run
OK2002AGPR
2
Loss of Power on Keowee 600 Vac MCC-2XA
XA2XA
Page 241
OG Pump 2A Control Circuit Fails
OK2322
Low Voltage Circuit Breaker 2XA-1D Transfers Position
OK2XA1DCLT
2
Keowee 2 Governor Oil Control Switch 188GA Spurious Operation
OK288GASWT
2
Control Signal for OG Pump 2A Fails
OK2323
Pressure Switch 2OGPS-1 Fails to Close (Normal Control Signal)
OK20001PSC
OG Pump 2A Emergency Control Relay 99K1 Fails to Operate
OK2324
Page 242


All Unit 2 OG Pumps Fail to Supply GOPT
OK2400
Page 237
All Unit 2 OG Pump Trains Fail to Provide Flow
OK2410
Common Cause Failure of Unit 2 OG Pumps to Start
OK2PSTRCOM
Common Cause Failure of Unit 2 OG Pumps to Run
OK2PRUNCOM
OG Pump 2A Train Fails to Provide Flow
OK2320
OG Pump 2B Train Fails to Provide Flow
OK2410B
Page 245
OG Pump 2C Train Fails to Provide Flow
OK2410C
Page 246
Manual Globe Valve 2OG-12 Transfers Closed
OK20012VVT
2
Check Valve 2OG-11 Fails to Open
OK20011CVO
2
Check Valve 2OG-11 Transfers Closed
OK20011CVT
2
Relief Valve 2OG-13 Spurious Operation
OK20013RVT
2
OG Pump 2A Fails
OK2321
Page 244

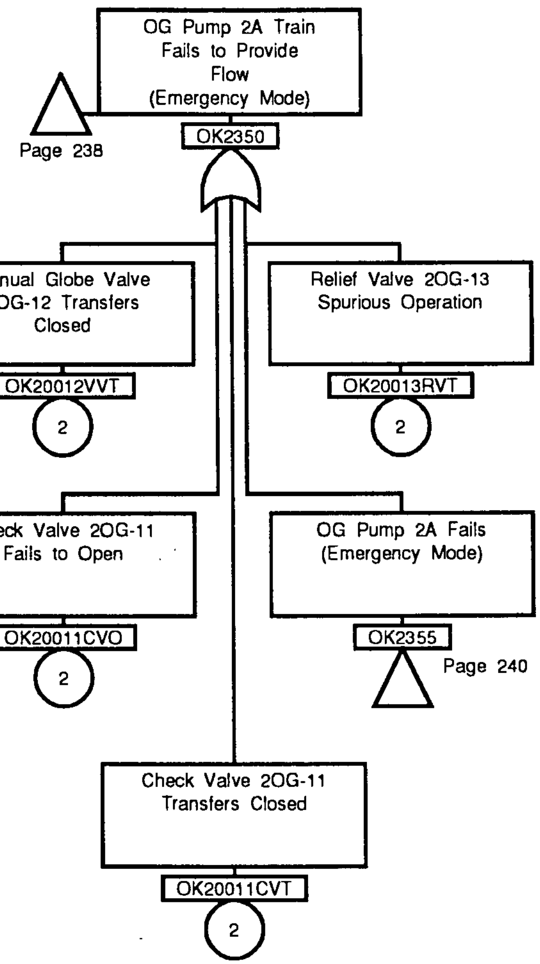

OG Pump 2A Emergency Control Relay 99K1 Fails to Operate
OK2324
Page 244
Page 240
Loss Of Power On Keowee 2 125V dc Dist.Cntr.2DA During Run
XD2DAR
Page 163
125 Vdc Circuit Breaker 2DA-3BR Transfers Position
XD2DA3BCDT
2
OG Pump 2A Emerg. Control Aux. Relay 99K2 Fails to Operate
OK2325
Keowee 2 Relay 99K1 Fails To Operate On Demand
OK299K1RYD
Keowee Unit 2 Relay 99K1 Spurious Operation
OK299K1RYT
Relay 99K2 Fails To Operate On Demand
OK299K2RYD
Pressure Switch 2OGPS-4 Fails to Close
OK20004PSC

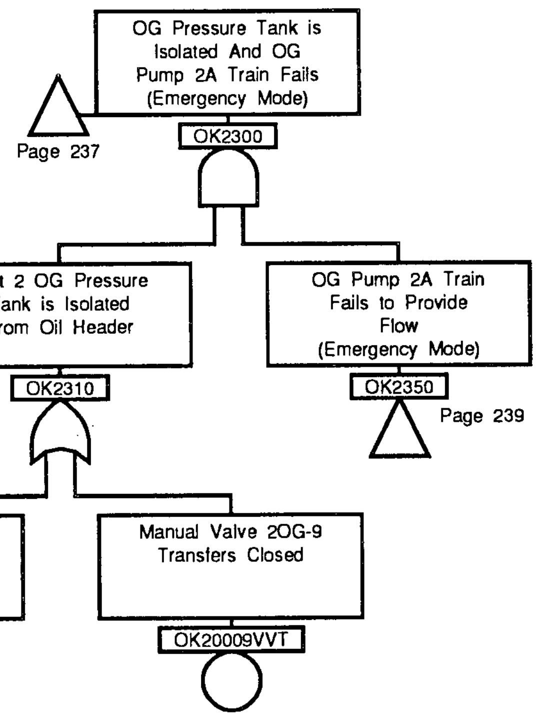
XA2XA Outputs:
Page 255, Page 244, Page 240, Page 245, Page 247, Page 273



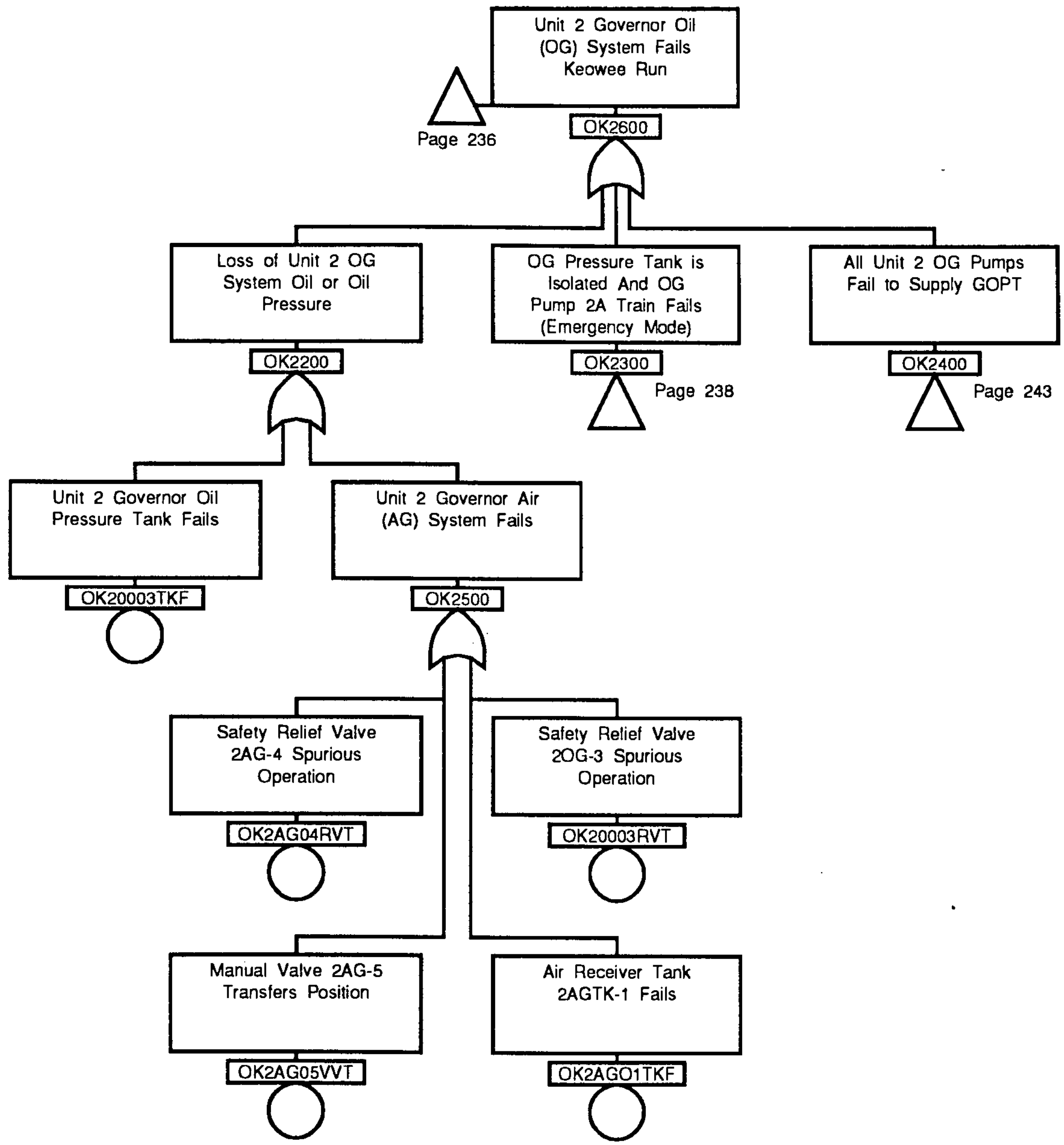


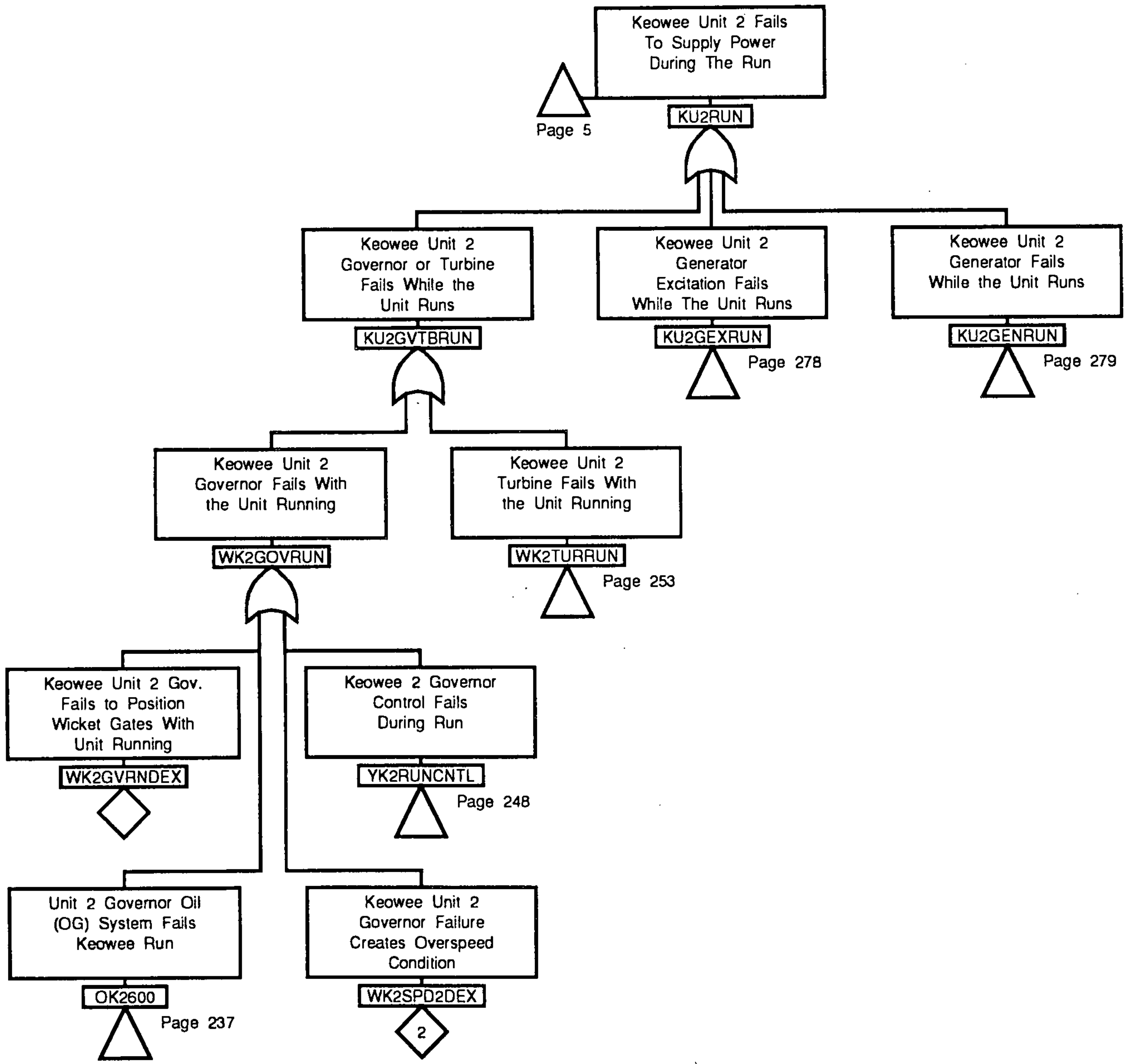
OG Pump 2A Fails (Emergency Mode)
Page 239
OK2355
OG Pump 2A Fails to Start
OK2002AGPS
2
OG Pump 2A Fails to Run
OK2002AGPR
2
Loss of Power on Keowee 600 Vac MCC-2XA
XA2XA
Page 241
Low Voltage Circuit Breaker 2XA-1D Transfers Position
OK2XA1DCLT
2
OG Pump 2A Control Circuit Fails (Emergency Mode)
OK2360
Keowee 2 Governor Oil Control Switch 188GA Spurious Operation
OK288GASWT
2
OG Pump 2A Emergency Control Relay 99K1 Fails to Operate
OK2324
Page 242


OG Pump 2A Train Fails to Provide Flow (Emergency Mode)
Page 238
OK2350
Manual Globe Valve 2OG-12 Transfers Closed
OK20012VVT
2
Relief Valve 2OG-13 Spurious Operation
OK20013RVT
2
Check Valve 2OG-11 Fails to Open
OK20011CVO
2
OG Pump 2A Fails (Emergency Mode)
OK2355
Page 240
Check Valve 2OG-11 Transfers Closed
OK20011CVT
2

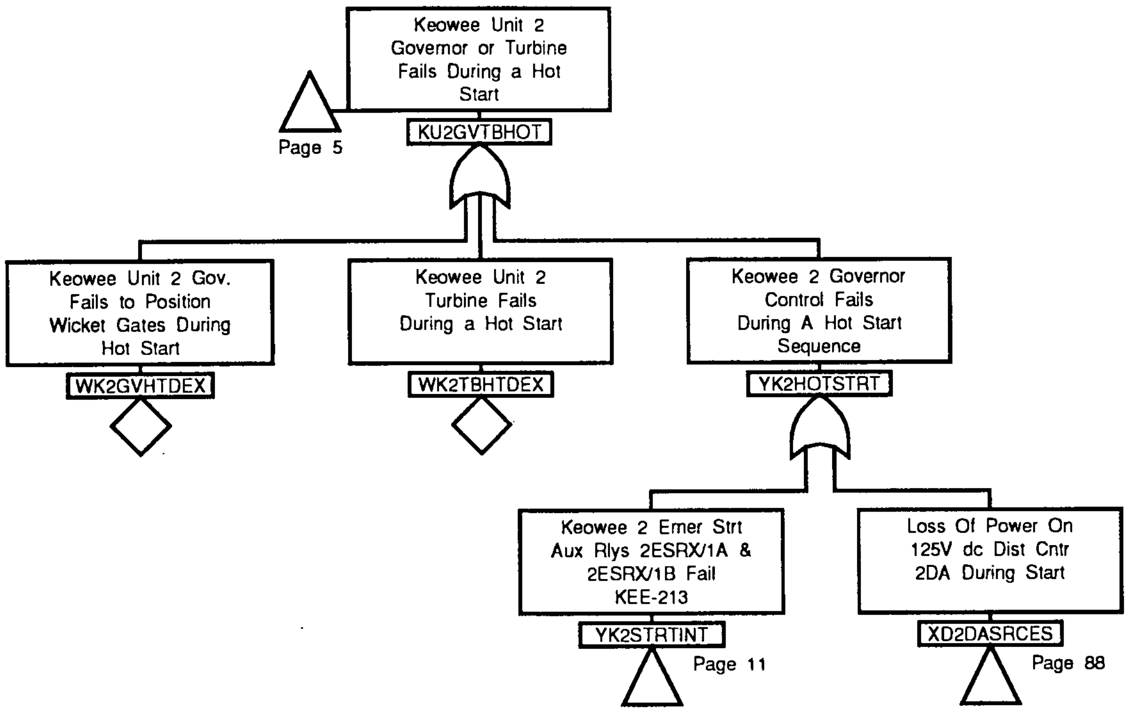


OG Pressure Tank is Isolated And OG Pump 2A Train Fails (Emergency Mode)
OK2300
Page 237
Unit 2 OG Pressure Tank is Isolated From Oil Header
OK2310
OG Pump 2A Train Fails to Provide Flow (Emergency Mode)
OK2350
Page 239
Float Valve 2OG-7 Transfers Closed
OK20007FVT
Manual Valve 2OG-9 Transfers Closed
OK20009VVT

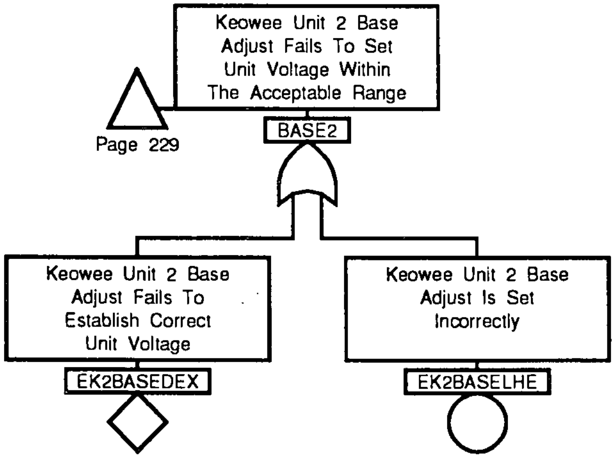

Unit 2 Governor Oil (OG) System Fails Keowee Run
OK2600
Page 236
Loss of Unit 2 OG System Oil or Oil Pressure
OK2200
OG Pressure Tank is Isolated And OG Pump 2A Train Fails (Emergency Mode)
OK2300
Page 238
All Unit 2 OG Pumps Fail to Supply GOPT
OK2400
Page 243
Unit 2 Governor Oil Pressure Tank Fails
OK20003TKF
Unit 2 Governor Air (AG) System Fails
OK2500
Safety Relief Valve 2AG-4 Spurious Operation
OK2AG04RVT
Safety Relief Valve 2OG-3 Spurious Operation
OK20003RVT
Manual Valve 2AG-5 Transfers Position
OK2AG05VVT
Air Receiver Tank 2AGTK-1 Fails
OK2AGO1TKF

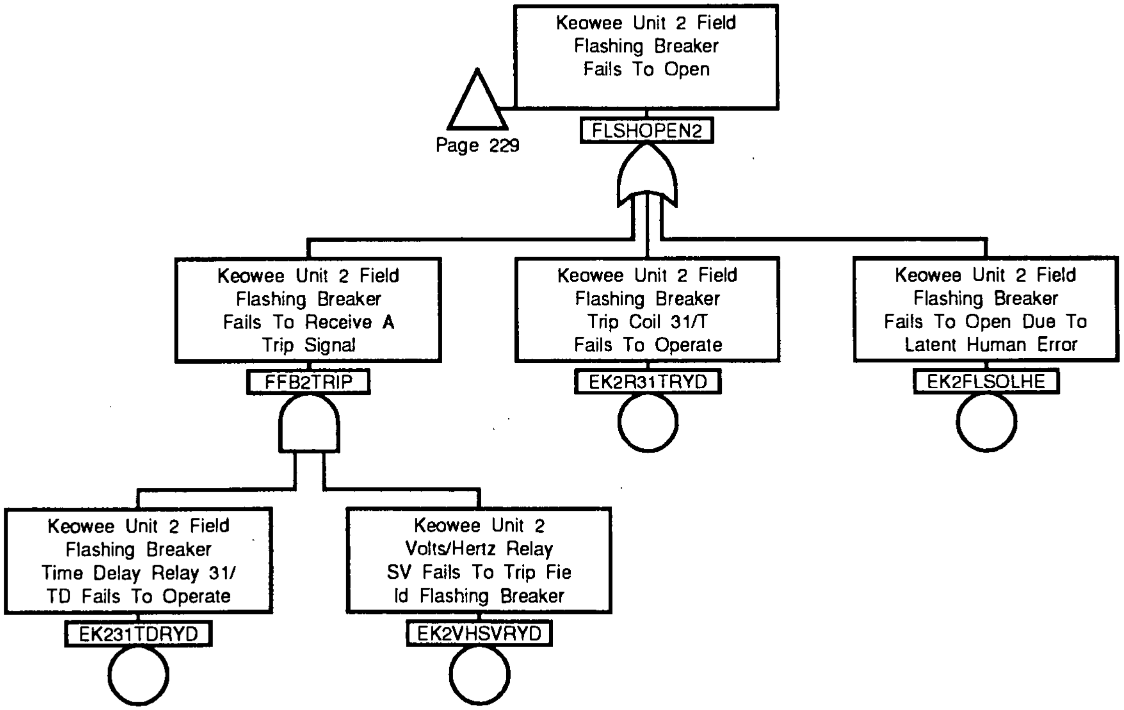


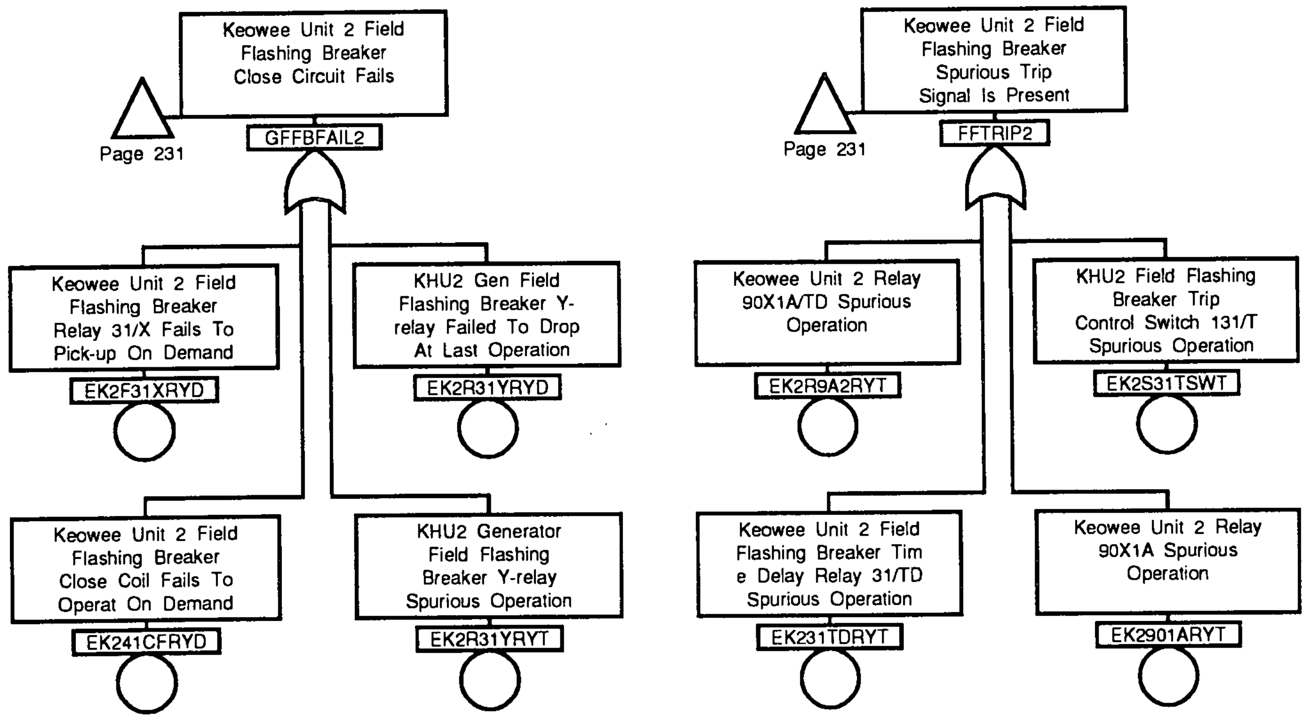
Keowee Unit 2 Fails To Supply Power During The Run
Page 5
KU2RUN
Keowee Unit 2 Governor or Turbine Fails While the Unit Runs
KU2GVTBRUN
Keowee Unit 2 Generator Excitation Fails While The Unit Runs
KU2GEXRUN
Page 278
Keowee Unit 2 Generator Fails While the Unit Runs
KU2GENRUN
Page 279
Keowee Unit 2 Governor Fails With the Unit Running
WK2GOVRUN
Keowee Unit 2 Turbine Fails With the Unit Running
WK2TURRUN
Page 253
Keowee Unit 2 Gov. Fails to Position Wicket Gates With Unit Running
WK2GVRNDEX
Keowee 2 Governor Control Fails During Run
YK2RUNCNTL
Page 248
Unit 2 Governor Oil (OG) System Fails Keowee Run
OK2600
Page 237
Keowee Unit 2 Governor Failure Creates Overspeed Condition
WK2SPD2DEX
2



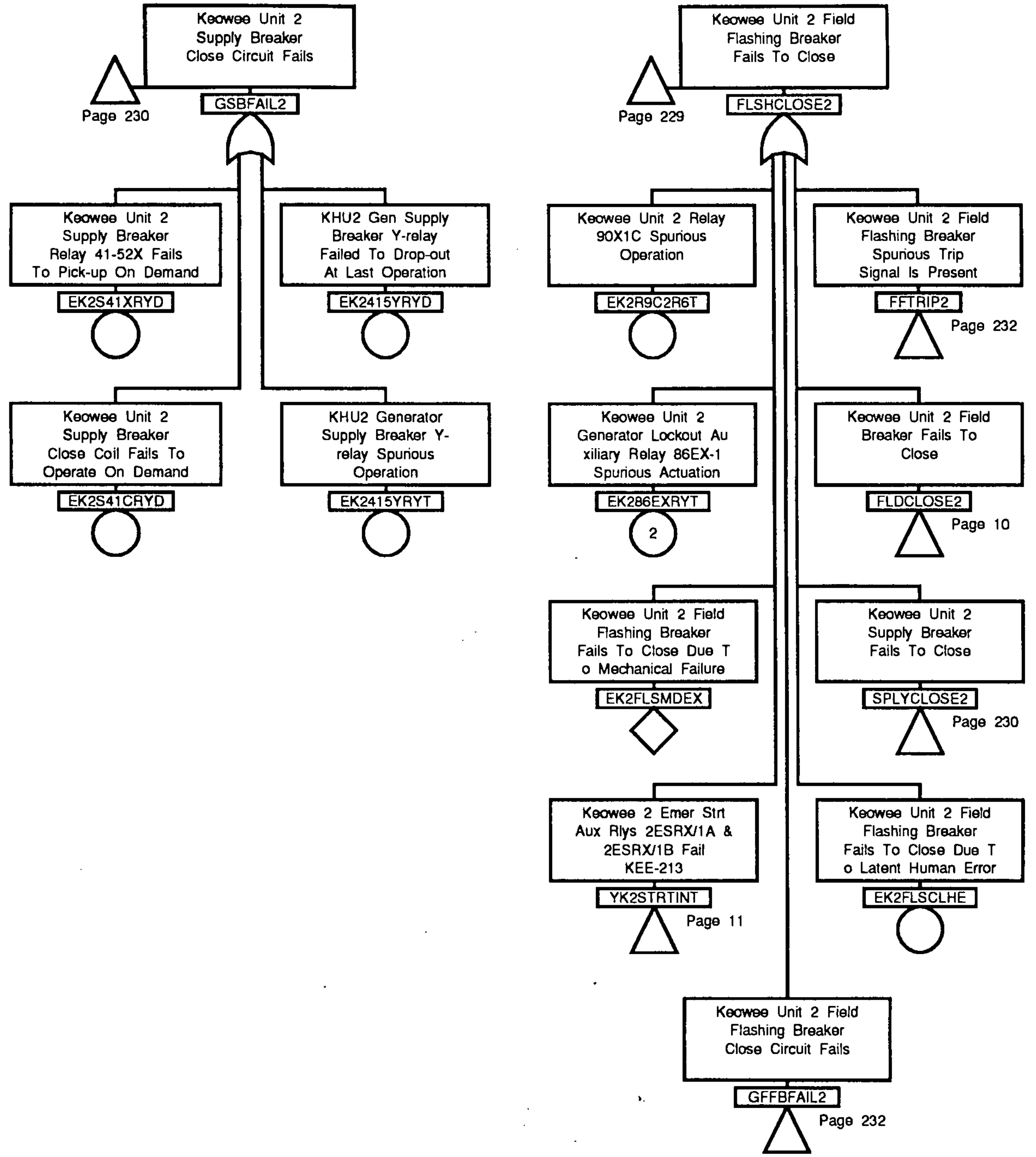
Keowee Unit 2 Governor or Turbine Fails During a Hot Start
KU2GVTBHOT
Page 5
Keowee Unit 2 Gov. Fails to Position Wicket Gates During Hot Start
WK2GVHTDEX
Keowee Unit 2 Turbine Fails During a Hot Start
WK2TBHTDEX
Keowee 2 Governor Control Fails During A Hot Start Sequence
YK2HOTSTRT
Keowee 2 Emer Strt Aux Rlys 2ESRX/1A & 2ESRX/1B Fail KEE-213
YK2STRTINT
Page 11
Loss Of Power On 125V dc Dist Cntr 2DA During Start
XD2DASRCES
Page 88


Keowee Unit 2 Base Adjust Fails To Set Unit Voltage Within The Acceptable Range
BASE2
Page 229
Keowee Unit 2 Base Adjust Fails To Establish Correct Unit Voltage
EK2BASEDEX
Keowee Unit 2 Base Adjust Is Set Incorrectly
EK2BASELHE

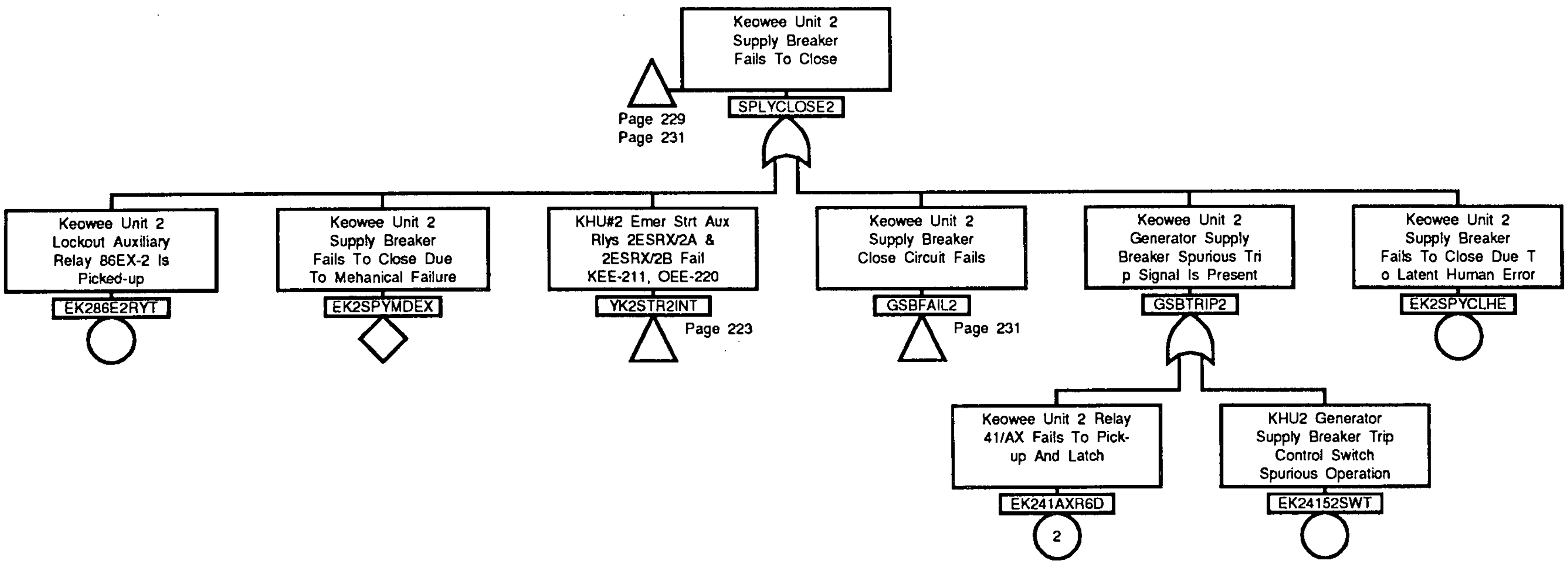

Keewee Unit 2 Field Flashing Breaker Fails To Open
FLSHOPEN2
Page 229
Keowee Unit 2 Field Flashing Breaker Fails To Receive A Trip Signal
FFB2TRIP
Keowee Unit 2 Field Flashing Breaker Trip Coil 31/T Fails To Operate
EK2R31TRYD
Keowee Unit 2 Field Flashing Breaker Fails To Open Due To Latent Human Error
EK2FLSOLHE
Keowee Unit 2 Field Flashing Breaker Time Delay Relay 31/ TD Fails To Operate
EK231TDRYD
Keowee Unit 2 Volts/Hertz Relay SV Fails To Trip Fie ld Flashing Breaker
EK2VHSVRYD

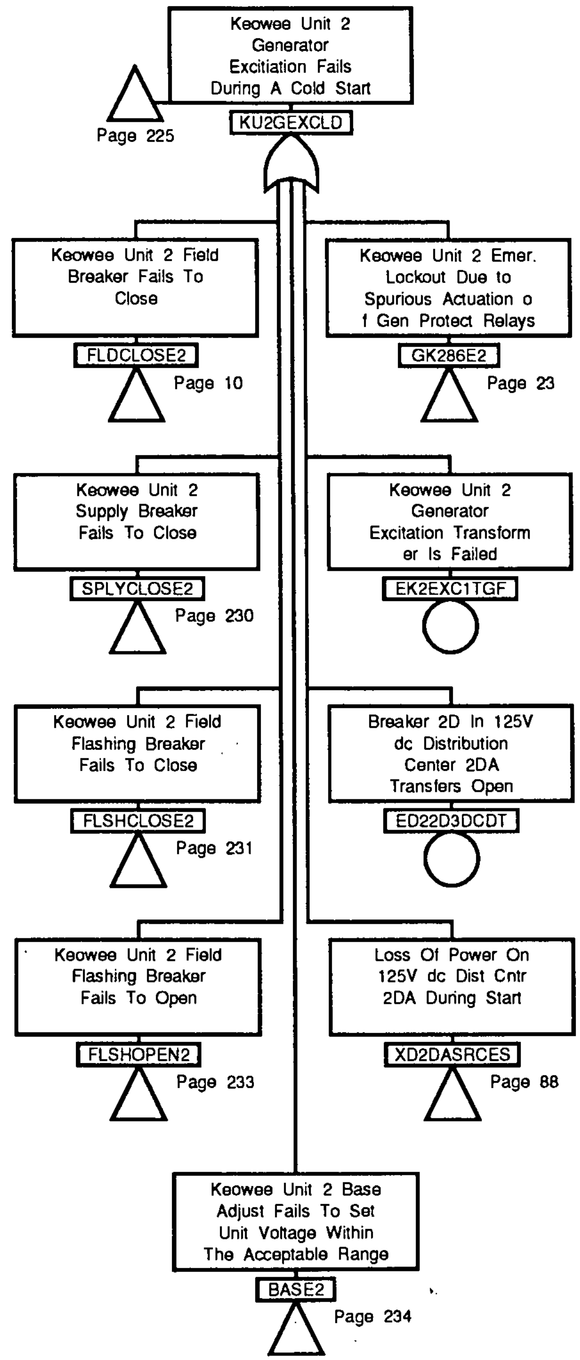


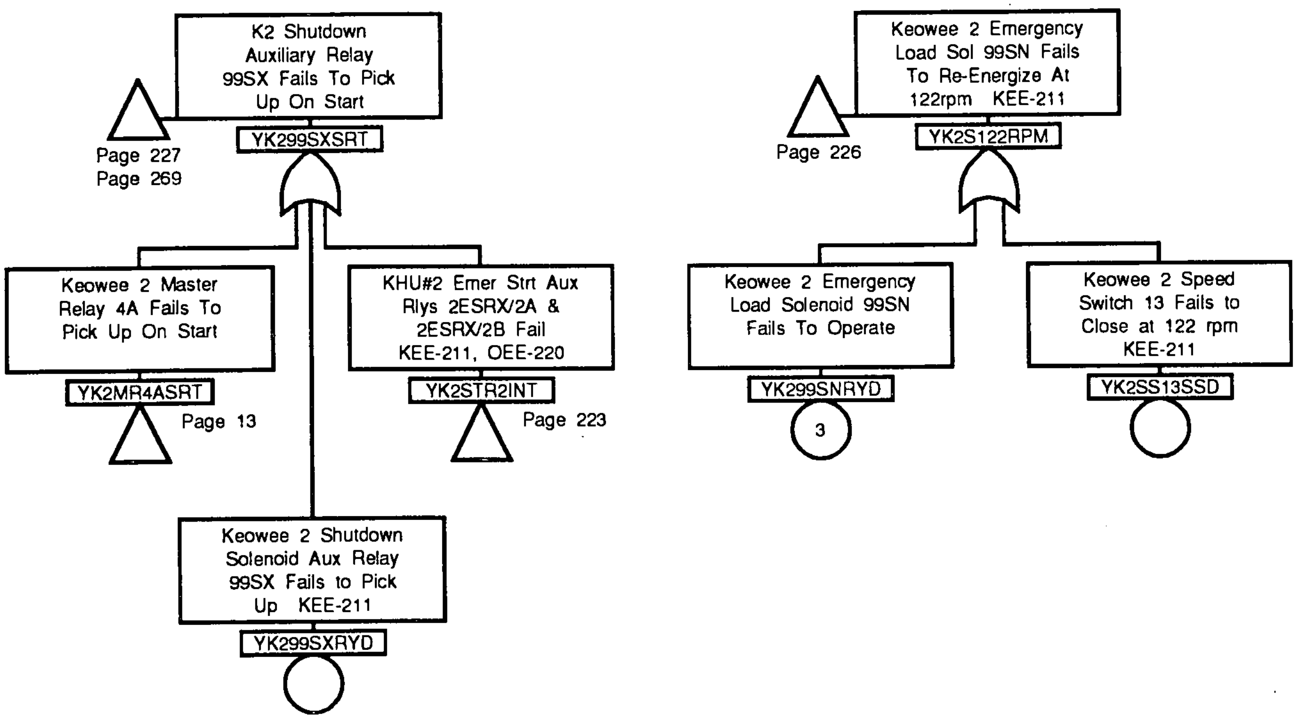
Keewee Unit 2 Field Flashing Breaker Close Circuit Fails
Page 231
GFFBFAIL2
Keowee Unit 2 Field Flashing Breaker Relay 31/X Fails To Pick-up On Demand
EK2F31XRYD
KHU2 Gen Field Flashing Breaker Y-relay Failed To Drop At Last Operation
EK2R31YRYD
Keowee Unit 2 Field Flashing Breaker Close Coil Fails To Operat On Demand
EK241CFRYD
KHU2 Generator Field Flashing Breaker Y-relay Spurious Operation
EK2R31YRYT
Keowee Unit 2 Field Flashing Breaker Spurious Trip Signal Is Present
Page 231
FFTRIP2
Keowee Unit 2 Relay 90X1A/TD Spurious Operation
EK2R9A2RYT
KHU2 Field Flashing Breaker Trip Control Switch 131/T Spurious Operation
EK2S31TSWT
Keowee Unit 2 Field Flashing Breaker Tim e Delay Relay 31/TD Spurious Operation
EK231TDRYT
Keowee Unit 2 Relay 90X1A Spurious Operation
EK2901ARYT

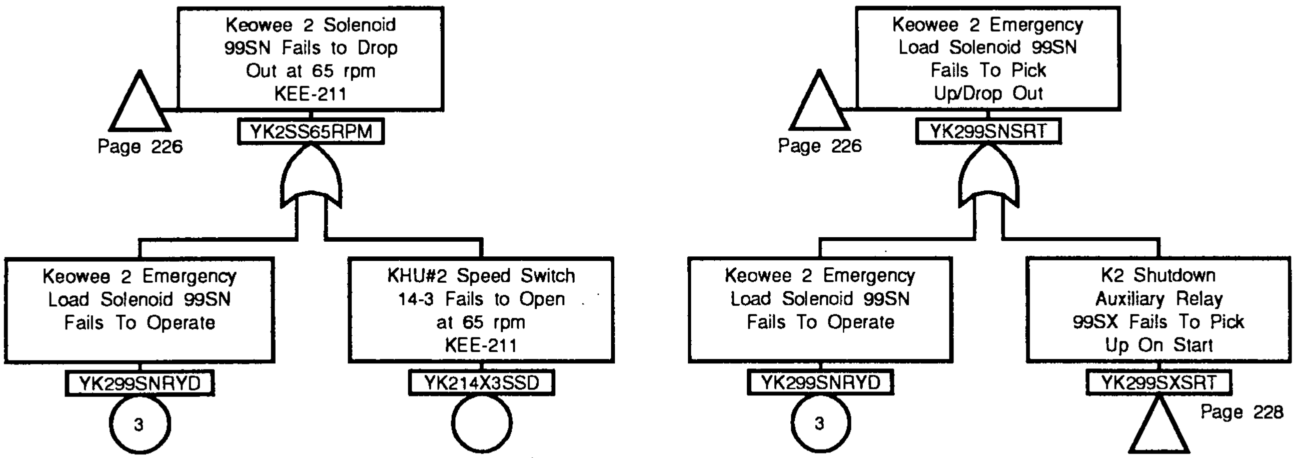


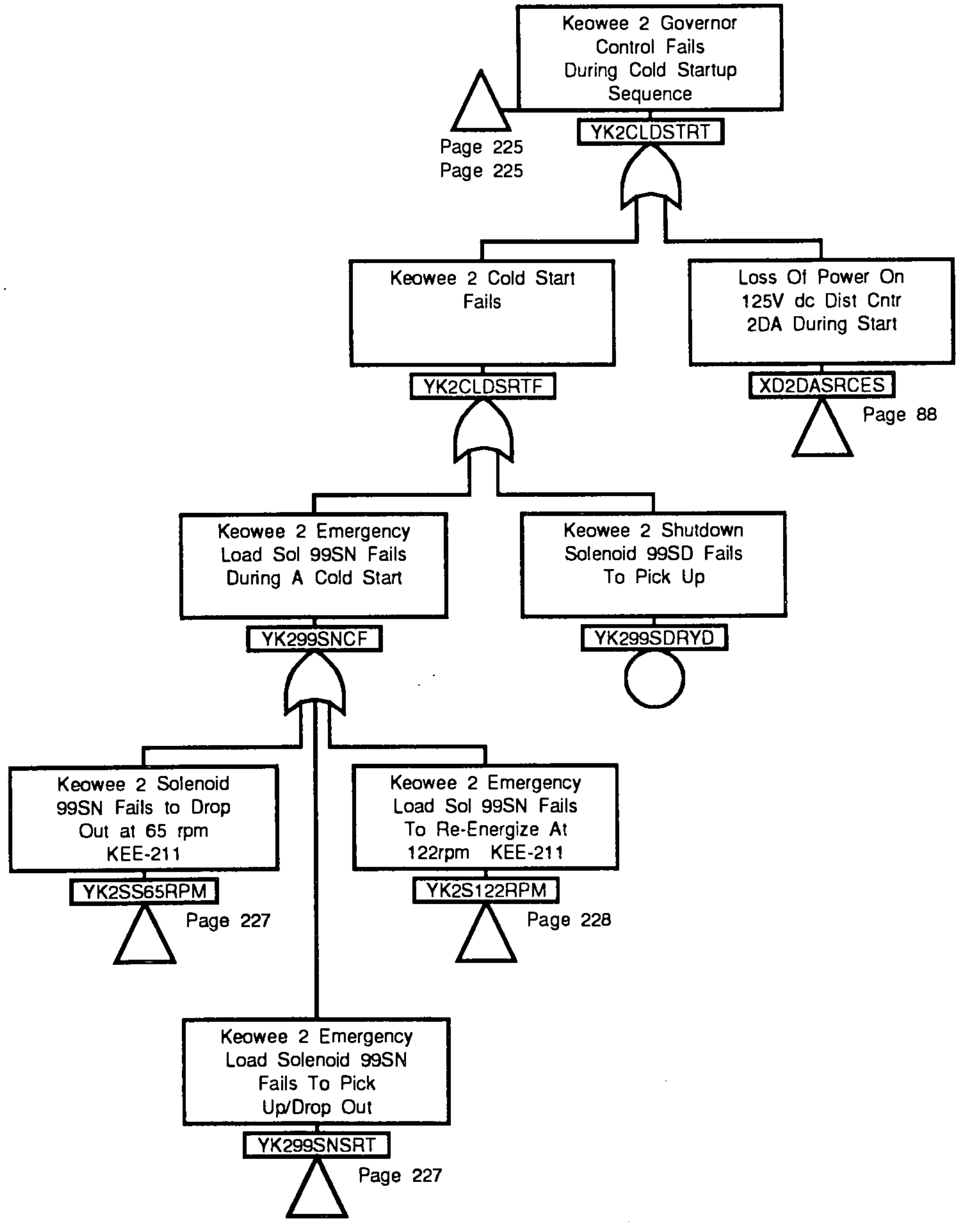
Keowee Unit 2 Supply Breaker Close Circuit Fails
GSBFAIL2
Page 230
Keowee Unit 2 Supply Breaker Relay 41-52X Fails To Pick-up On Demand
EK2S41XRYD
KHU2 Gen Supply Breaker Y-relay Failed To Drop-out At Last Operation
EK2415YRYD
Keowee Unit 2 Supply Breaker Close Coil Fails To Operate On Demand
EK2S41CRYD
KHU2 Generator Supply Breaker Y-relay Spurious Operation
EK2415YRYT
Keowee Unit 2 Field Flashing Breaker Fails To Close
FLSHCLOSE2
Page 229
Keowee Unit 2 Relay 90X1C Spurious Operation
EK2R9C2R6T
Keowee Unit 2 Field Flashing Breaker Spurious Trip Signal Is Present
FFTRIP2
Page 232
Keowee Unit 2 Generator Lockout Au xiliary Relay 86EX-1 Spurious Actuation
EK286EXRYT
2
Keowee Unit 2 Field Breaker Fails To Close
FLDCLOSE2
Page 10
Keowee Unit 2 Field Flashing Breaker Fails To Close Due T o Mechanical Failure
EK2FLSMDEX
Keowee Unit 2 Supply Breaker Fails To Close
SPLYCLOSE2
Page 230
Keowee 2 Emer Strt Aux Rlys 2ESRX/1A & 2ESRX/1B Fail KEE-213
YK2STRTINT
Page 11
Keowee Unit 2 Field Flashing Breaker Fails To Close Due T o Latent Human Error
EK2FLSCLHE
Keowee Unit 2 Field Flashing Breaker Close Circuit Fails
GFFBFAIL2
Page 232

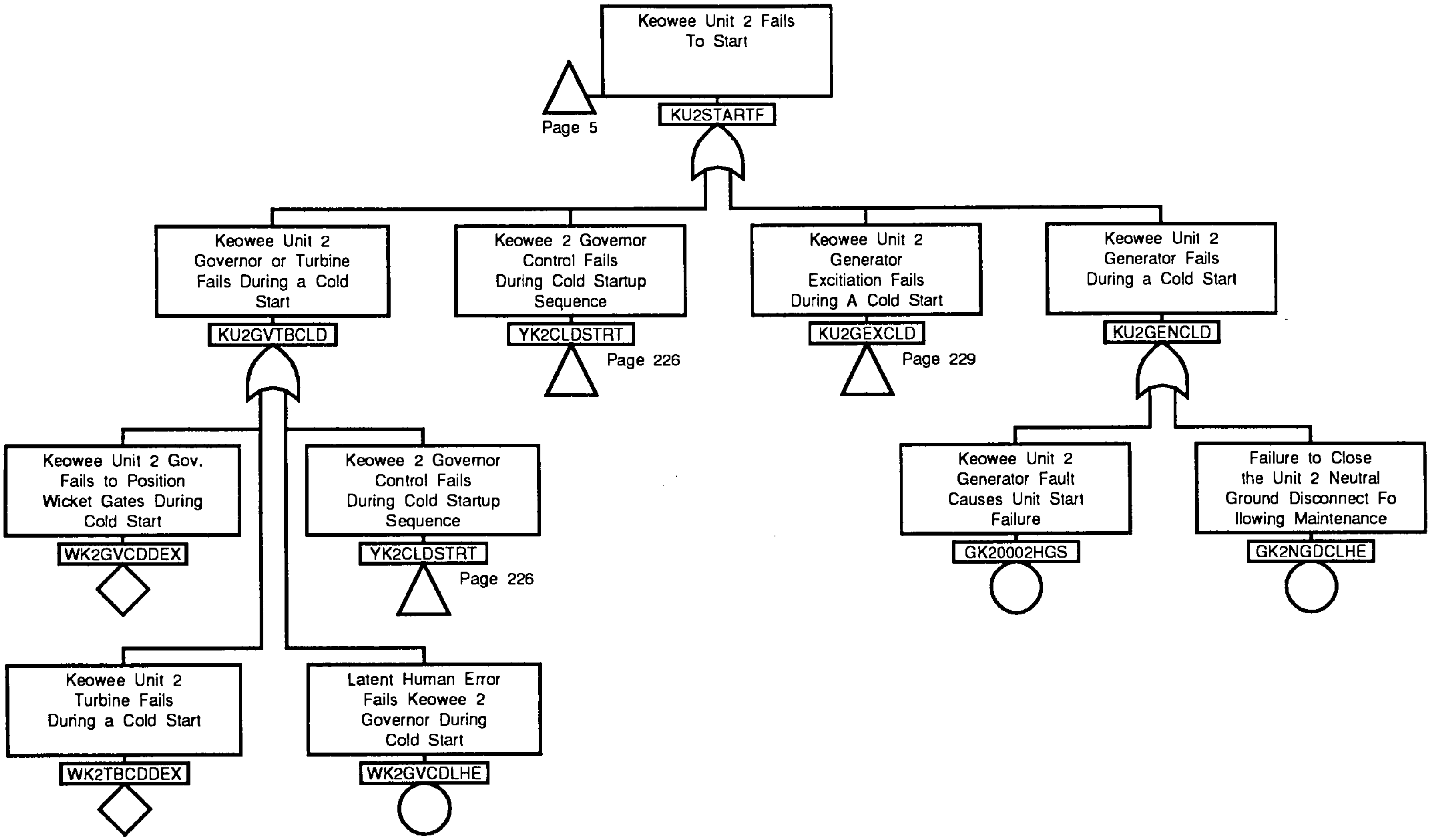

Keewee Unit 2 Supply Breaker Fails To Close
SPLYCLOSE2
Page 229
Page 231
Keowee Unit 2 Lockout Auxiliary Relay 86EX-2 Is Picked-up
EK286E2RYT
Keowee Unit 2 Supply Breaker Fails To Close Due To Mehanical Failure
EK2SPYMDEX
KHU#2 Emer Strt Aux Rlys 2ESRX/2A & 2ESRX/2B Fail KEE-211, OEE-220
YK2STR2INT
Page 223
Keowee Unit 2 Supply Breaker Close Circuit Fails
GSBFAIL2
Page 231
Keowee Unit 2 Generator Supply Breaker Spurious Tri p Signal Is Present
GSBTRIP2
Keowee Unit 2 Supply Breaker Fails To Close Due T o Latent Human Error
EK2SPYCLHE
Keowee Unit 2 Relay 41/AX Fails To Pick-up And Latch
EK241AXR6D
2
KHU2 Generator Supply Breaker Trip Control Switch Spurious Operation
EK24152SWT

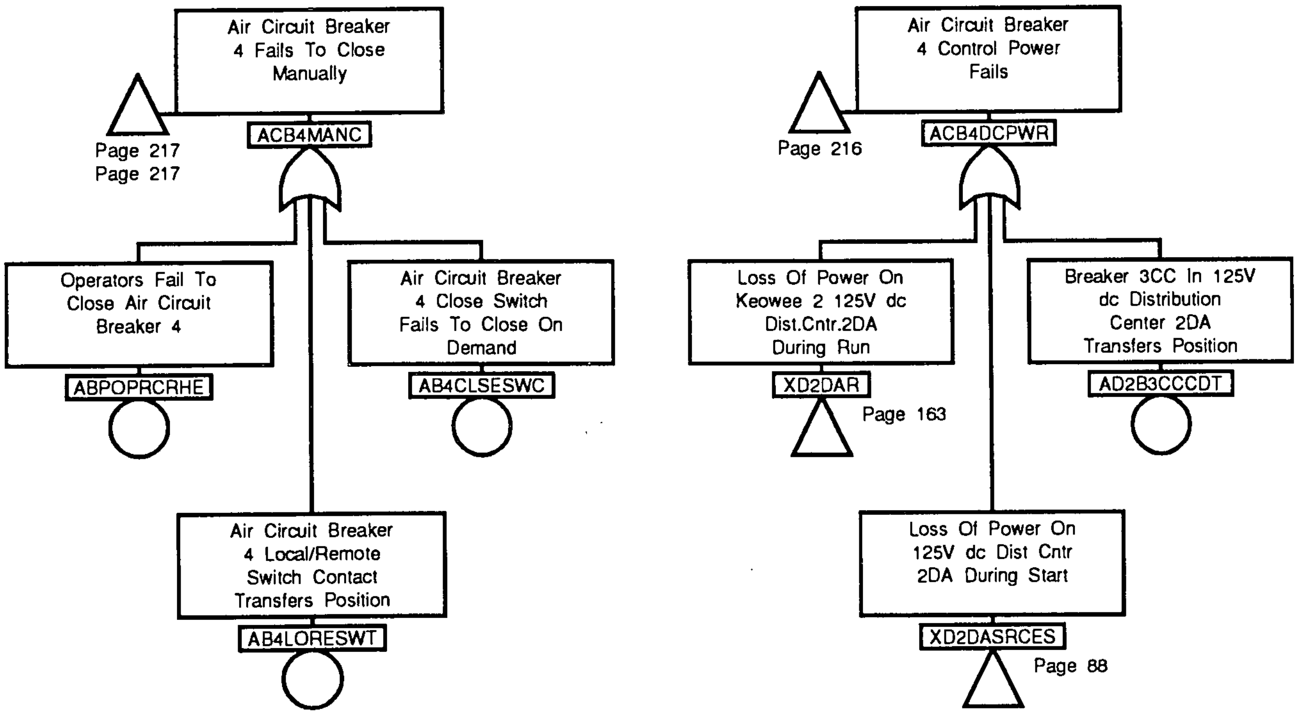

Keowee Unit 2 Generator Excitiation Fails During A Cold Start
KU2GEXCLD
Page 225
Keowee Unit 2 Field Breaker Fails To Close
FLDCLOSE2
Page 10
Keowee Unit 2 Emer. Lockout Due to Spurious Actuation o f Gen Protect Relays
GK286E2
Page 23
Keowee Unit 2 Supply Breaker Fails To Close
SPLYCLOSE2
Page 230
Keowee Unit 2 Generator Excitation Transform er Is Failed
EK2EXC1TGF
Keowee Unit 2 Field Flashing Breaker Fails To Close
FLSHCLOSE2
Page 231
Breaker 2D In 125V dc Distribution Center 2DA Transfers Open
ED22D3DCDT
Keowee Unit 2 Field Flashing Breaker Fails To Open
FLSHOPEN2
Page 233
Loss Of Power On 125V dc Dist Cntr 2DA During Start
XD2DASRCES
Page 88
Keowee Unit 2 Base Adjust Fails To Set Unit Voltage Within The Acceptable Range
BASE2
Page 234


K2 Shutdown Auxiliary Relay 99SX Fails To Pick Up On Start
YK299SXSRT
Page 227
Page 269
Keowee 2 Master Relay 4A Fails To Pick Up On Start
YK2MR4ASRT
Page 13
KHU#2 Emer Strt Aux Rlys 2ESRX/2A & 2ESRX/2B Fail KEE-211, OEE-220
YK2STR2INT
Page 223
Keowee 2 Shutdown Solenoid Aux Relay 99SX Fails to Pick Up KEE-211
YK299SXRYD
Keowee 2 Emergency Load Sol 99SN Fails To Re-Energize At 122rpm KEE-211
YK2S122RPM
Page 226
Keowee 2 Emergency Load Solenoid 99SN Fails To Operate
YK299SNRYD
3
Keowee 2 Speed Switch 13 Fails to Close at 122 rpm KEE-211
YK2SS13SSD

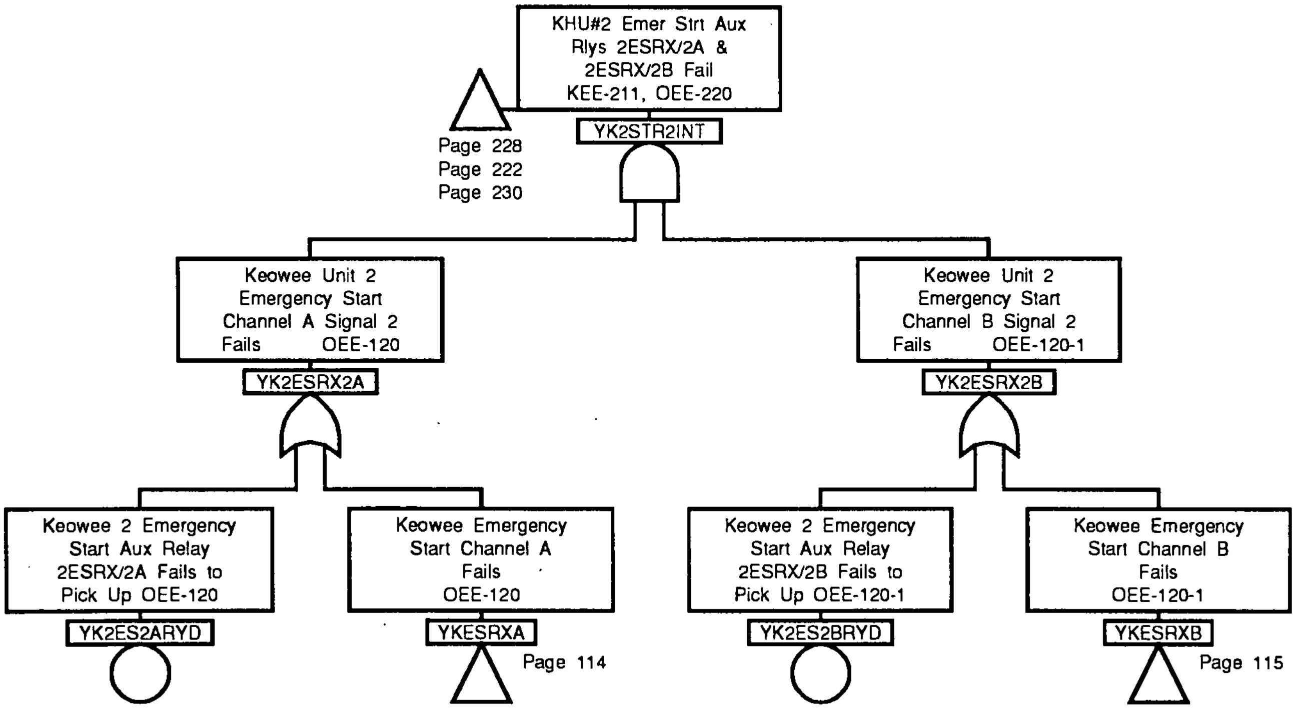

Keowee 2 Solenoid 99SN Fails to Drop Out at 65 rpm KEE-211
YK2SS65RPM
Page 226
Keowee 2 Emergency Load Solenoid 99SN Fails To Operate
YK299SNRYD
3
KHU#2 Speed Switch 14-3 Fails to Open at 65 rpm KEE-211
YK214X3SSD
Keowee 2 Emergency Load Solenoid 99SN Fails To Pick Up/Drop Out
YK299SNSRT
Page 226
Keowee 2 Emergency Load Solenoid 99SN Fails To Operate
YK299SNRYD
3
K2 Shutdown Auxiliary Relay 99SX Fails To Pick Up On Start
YK299SXSRT
Page 228

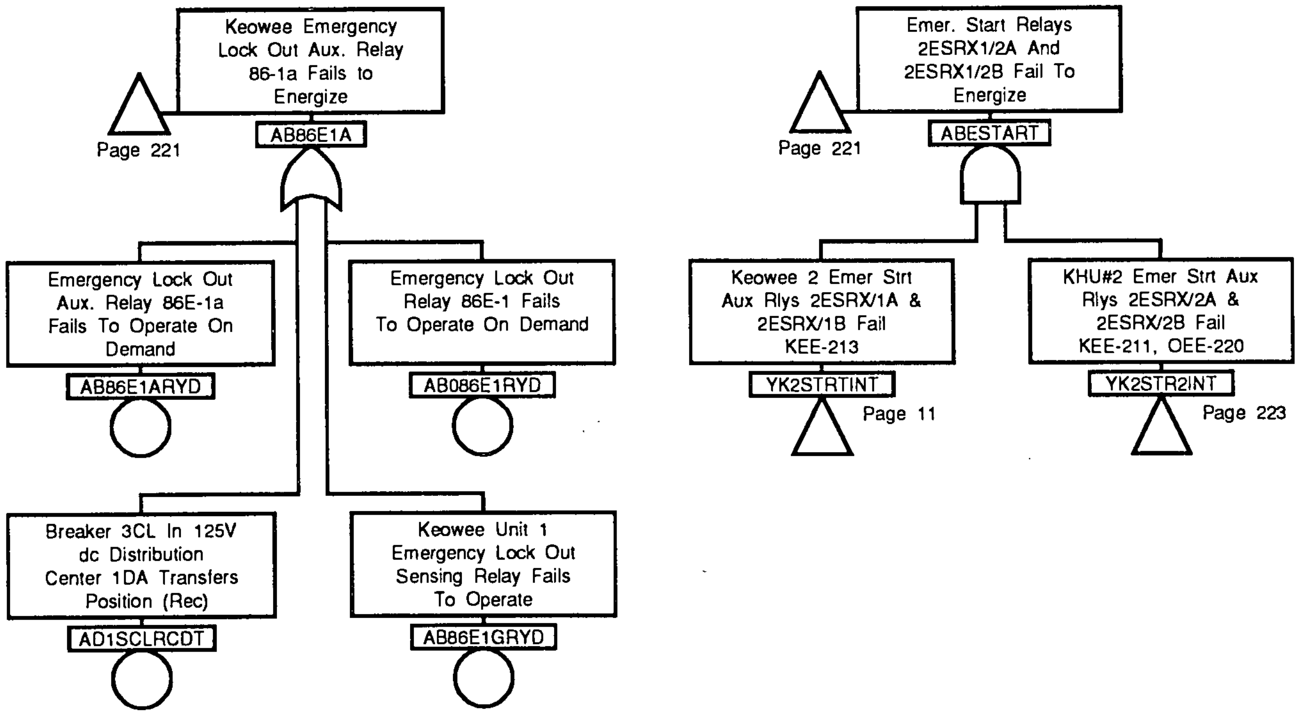

Keowee 2 Governor Control Fails During Cold Startup Sequence
YK2CLDSTRT
Page 225
Page 225
Keowee 2 Cold Start Fails
YK2CLDSRTF
Loss Of Power On 125V dc Dist Cntr 2DA During Start
XD2DASRCES
Page 88
Keowee 2 Emergency Load Sol 99SN Fails During A Cold Start
YK299SNCF
Keowee 2 Shutdown Solenoid 99SD Fails To Pick Up
YK299SDRYD
Keowee 2 Solenoid 99SN Fails to Drop Out at 65 rpm KEE-211
YK2SS65RPM
Page 227
Keowee 2 Emergency Load Sol 99SN Fails To Re-Energize At 122rpm KEE-211
YK2S122RPM
Page 228
Keowee 2 Emergency Load Solenoid 99SN Fails To Pick Up/Drop Out
YK299SNSRT
Page 227


Keewee Unit 2 Fails To Start
KU2STARTF
Page 5
Keowee Unit 2 Governor or Turbine Fails During a Cold Start
KU2GVTBCLD
Keowee 2 Governor Control Fails During Cold Startup Sequence
YK2CLDSTRT
Page 226
Keowee Unit 2 Generator Excitiation Fails During A Cold Start
KU2GEXCLD
Page 229
Keowee Unit 2 Generator Fails During a Cold Start
KU2GENCLD
Keowee Unit 2 Gov. Fails to Position Wicket Gates During Cold Start
WK2GVCDDEX
Keowee 2 Governor Control Fails During Cold Startup Sequence
YK2CLDSTRT
Page 226
Keowee Unit 2 Generator Fault Causes Unit Start Failure
GK20002HGS
Failure to Close the Unit 2 Neutral Ground Disconnect Fo llowing Maintenance
GK2NGDCLHE
Keowee Unit 2 Turbine Fails During a Cold Start
WK2TBCDDEX
Latent Human Error Fails Keowee 2 Governor During Cold Start
WK2GVCDLHE

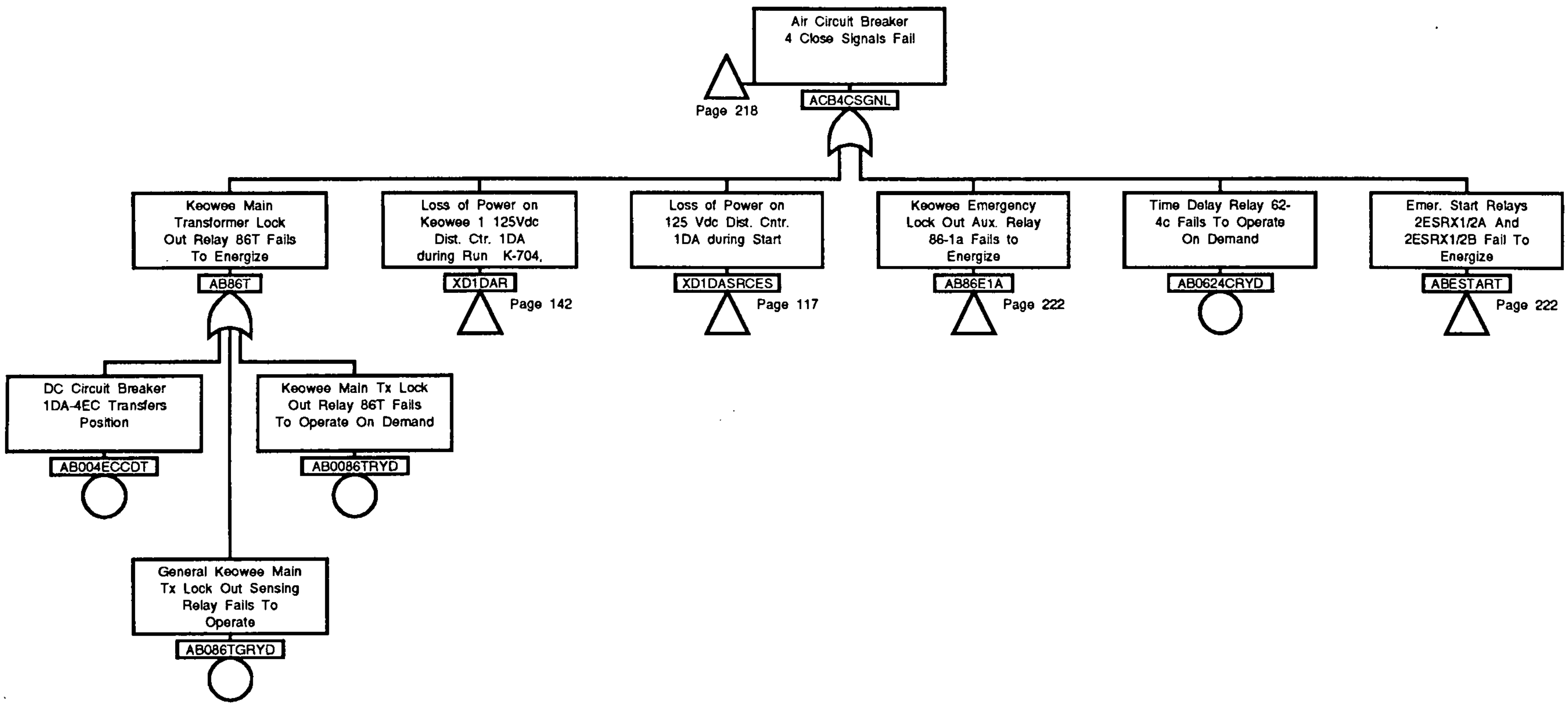


Air Circuit Breaker 4 Fails To Close Manually
ACB4MANC
Page 217
Page 217
Operators Fail To Close Air Circuit Breaker 4
ABPOPRCRHE
Air Circuit Breaker 4 Close Switch Fails To Close On Demand
AB4CLSESWC
Air Circuit Breaker 4 Local/Remote Switch Contact Transfers Position
AB4LORESWT
Air Circuit Breaker 4 Control Power Fails
ACB4DCPWR
Page 216
Loss Of Power On Keowee 2 125V dc Dist.Cntr.2DA During Run
XD2DAR
Page 163
Breaker 3CC In 125V dc Distribution Center 2DA Transfers Position
AD2B3CCCDT
Loss Of Power On 125V dc Dist Cntr 2DA During Start
XD2DASRCES
Page 88

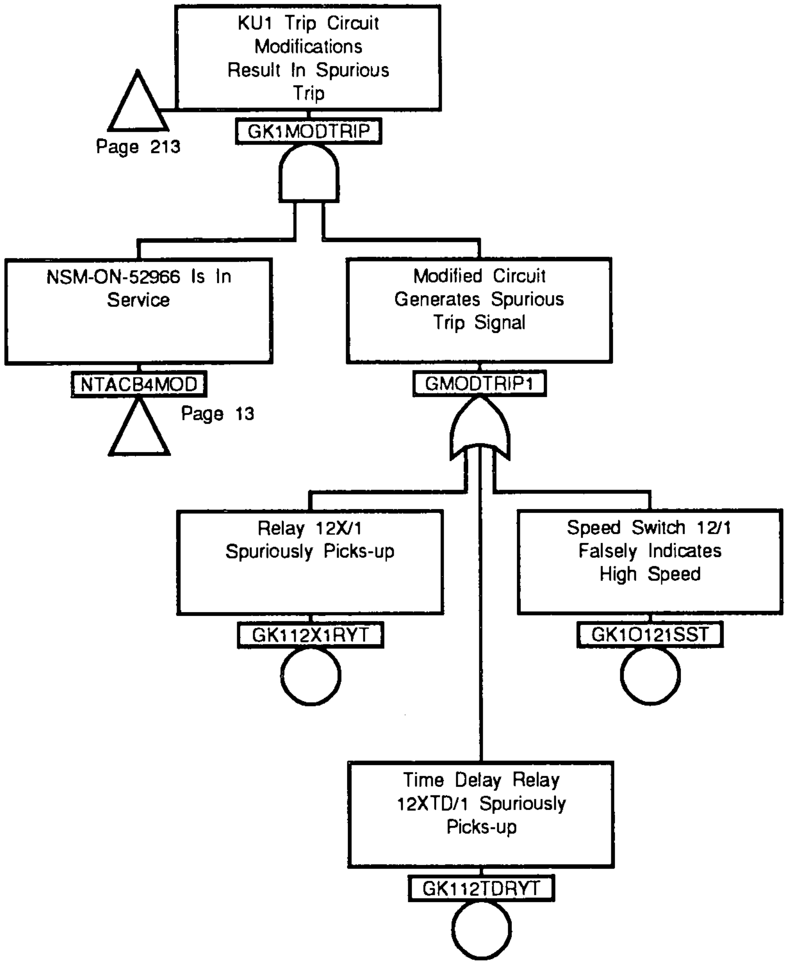

KHU#2 Emer Strt Aux Rlys 2ESRX/2A & 2ESRX/2B Fail KEE-211, OEE-220
YK2STR2INT
Page 228
Page 222
Page 230
Keowee Unit 2 Emergency Start Channel A Signal 2 Fails OEE-120
YK2ESRX2A
Keowee Unit 2 Emergency Start Channel B Signal 2 Fails OEE-120-1
YK2ESRX2B
Keowee 2 Emergency Start Aux Relay 2ESRX/2A Fails to Pick Up OEE-120
YK2ES2ARYD
Keowee Emergency Start Channel A Fails OEE-120
YKESRXA
Page 114
Keowee 2 Emergency Start Aux Relay 2ESRX/2B Fails to Pick Up OEE-120-1
YK2ES2BRYD
Keowee Emergency Start Channel B Fails OEE-120-1
YKESRXB
Page 115



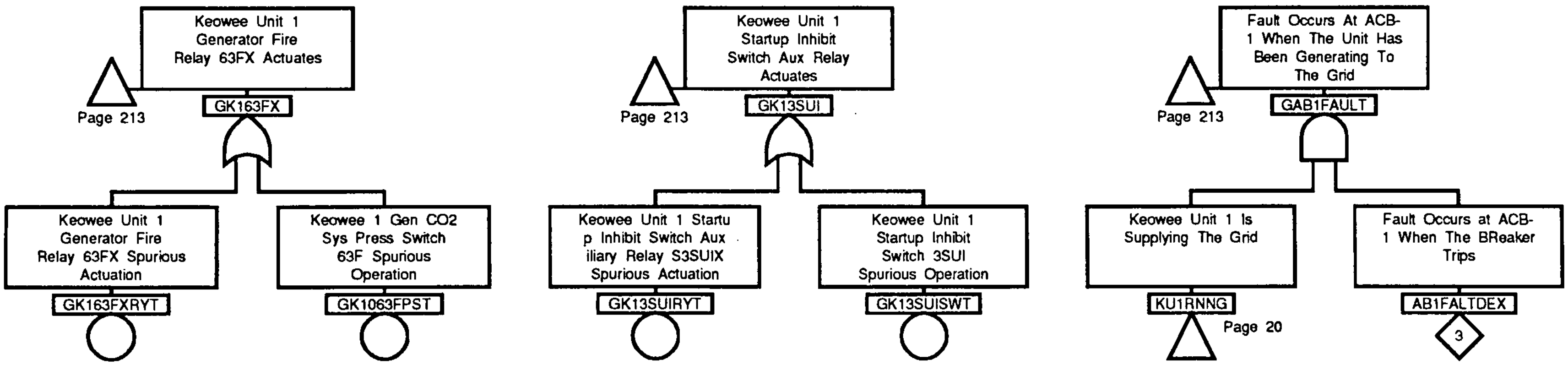
Keowee Emergency Lock Out Aux. Relay 86-1a Fails to Energize
AB86E1A
Page 221
Emergency Lock Out Aux. Relay 86E-1a Fails To Operate On Demand
AB86E1ARYD
Emergency Lock Out Relay 86E-1 Fails To Operate On Demand
AB086E1RYD
Breaker 3CL In 125V dc Distribution Center 1DA Transfers Position (Rec)
AD1SCLRCDT
Keowee Unit 1 Emergency Lock Out Sensing Relay Fails To Operate
AB86E1GRYD
Emer. Start Relays 2ESRX1/2A And 2ESRX1/2B Fail To Energize
ABESTART
Page 221
Keowee 2 Emer Strt Aux Rlys 2ESRX/1A & 2ESRX/1B Fail KEE-213
YK2STRTINT
Page 11
KHU#2 Emer Strt Aux Rlys 2ESRX/2A & 2ESRX/2B Fail KEE-211, OEE-220
YK2STR2INT
Page 223

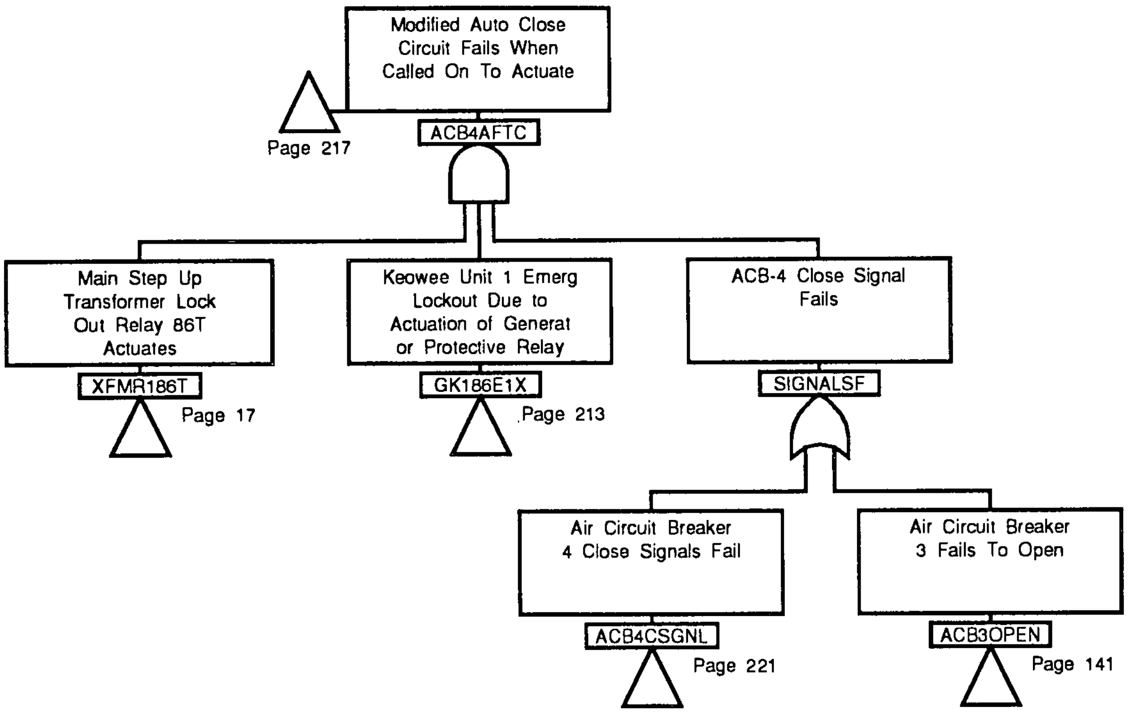


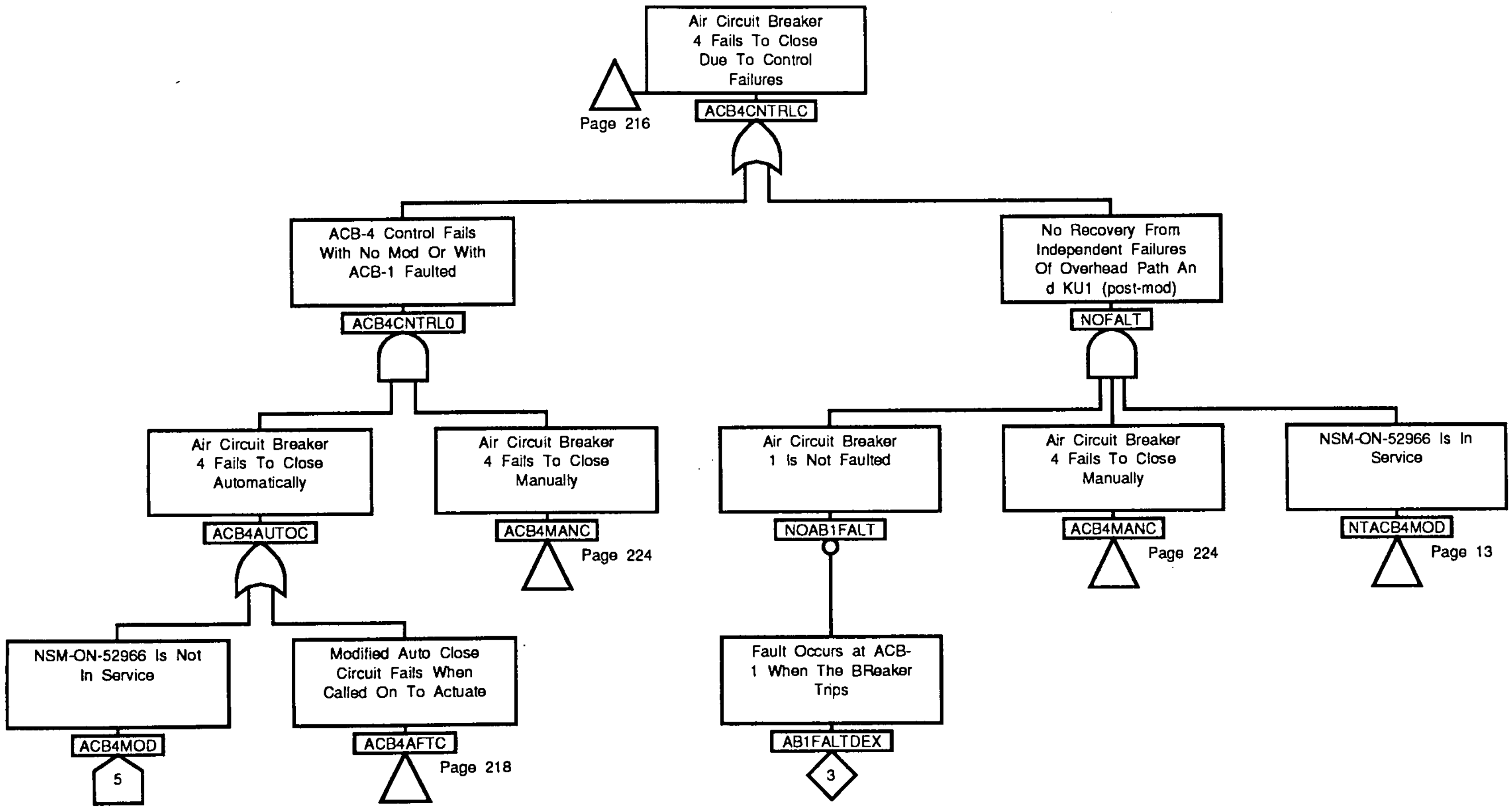
Air Circuit Breaker 4 Close Signals Fail
ACB4CSGNL
Page 218
Keowee Main Transformer Lock Out Relay 86T Fails To Energize
AB86T
Loss of Power on Keowee 1 125Vdc Dist. Ctr. 1DA during Run K-704,
XD1DAR
Page 142
Loss of Power on 125 Vdc Dist. Cntr. 1DA during Start
XD1DASRCES
Page 117
Keowee Emergency Lock Out Aux. Relay 86-1a Fails to Energize
AB86E1A
Page 222
Time Delay Relay 62-4c Fails To Operate On Demand
AB0624CRYD
Emer. Start Relays 2ESRX1/2A And 2ESRX1/2B Fail To Energize
ABESTART
Page 222
DC Circuit Breaker 1DA-4EC Transfers Position
AB004ECCDT
Keowee Main Tx Lock Out Relay 86T Fails To Operate On Demand
AB0086TRYD
General Keowee Main Tx Lock Out Sensing Relay Fails To Operate
AB086TGRYD

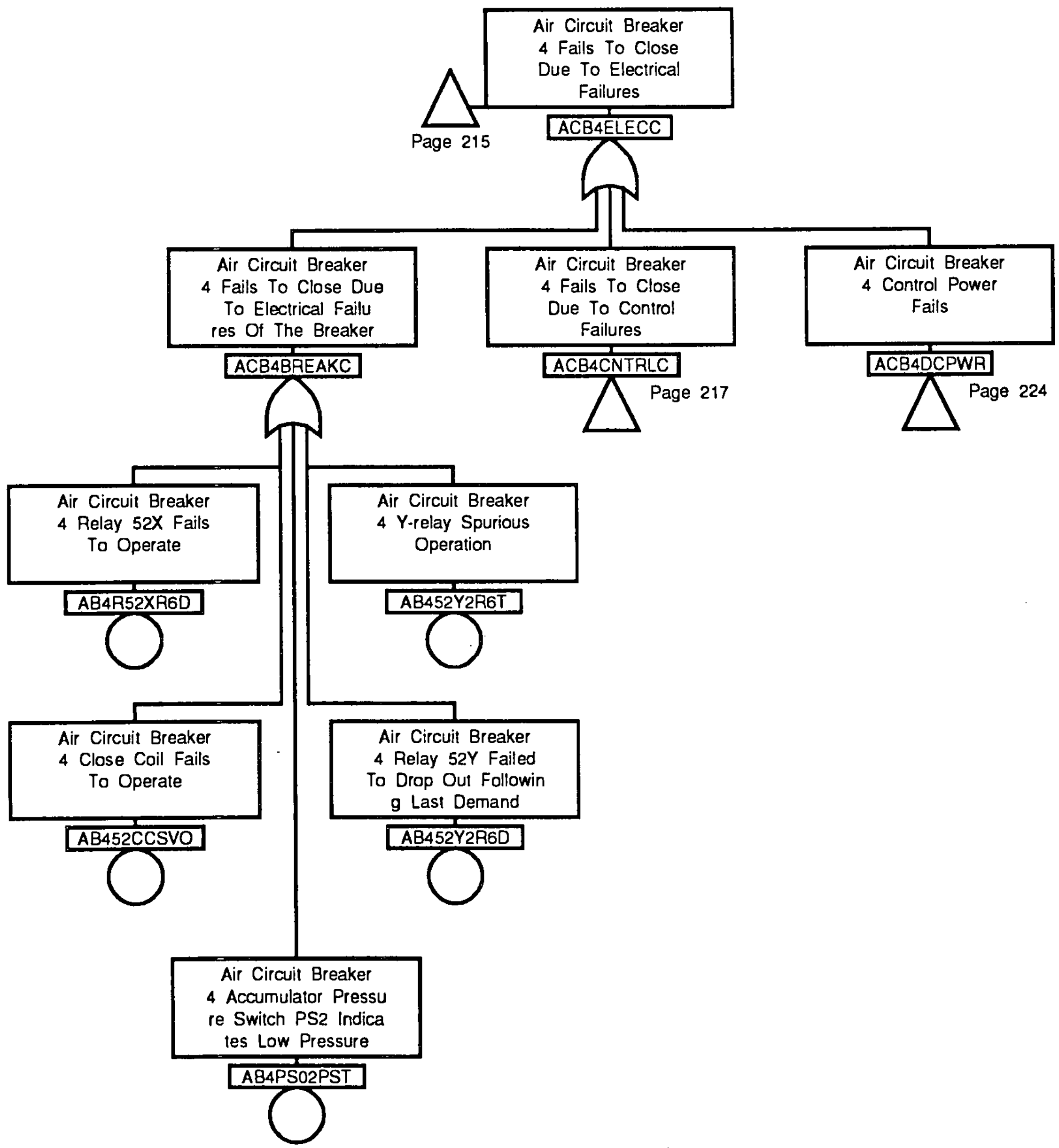


KU1 Trip Circuit Modifications Result In Spurious Trip
GK1MODTRIP
Page 213
NSM-ON-52966 Is In Service
NTACB4MOD
Page 13
Modified Circuit Generates Spurious Trip Signal
GMODTRIP1
Relay 12X/1 Spuriously Picks-up
GK112X1RYT
Speed Switch 12/1 Falsely Indicates High Speed
GK1O121SST
Time Delay Relay 12XTD/1 Spuriously Picks-up
GK112TDRYT

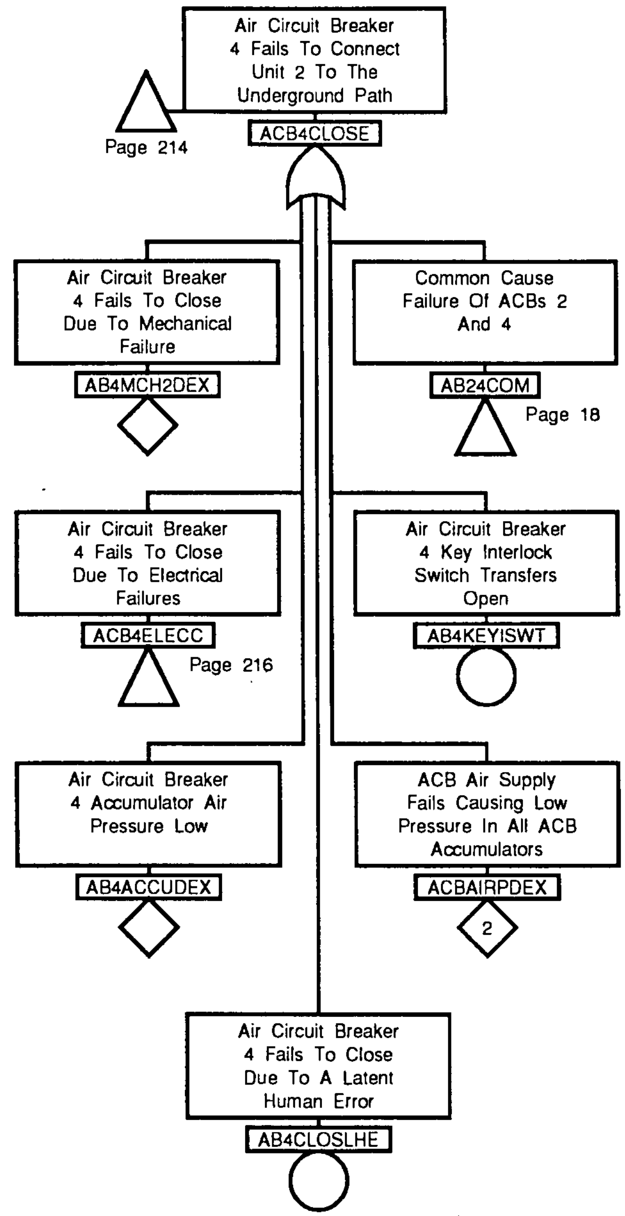

Keowee Unit 1 Generator Fire Relay 63FX Actuates
GK163FX
Page 213
Keowee Unit 1 Generator Fire Relay 63FX Spurious Actuation
GK163FXRYT
Keowee 1 Gen CO2 Sys Press Switch 63F Spurious Operation
GK1063FPST
Keowee Unit 1 Startup Inhibit Switch Aux Relay Actuates
GK13SUI
Page 213
Keowee Unit 1 Startu p Inhibit Switch Aux iliary Relay S3SUIX Spurious Actuation
GK13SUIRYT
Keowee Unit 1 Startup Inhibit Switch 3SUI Spurious Operation
GK13SUISWT
Fault Occurs At ACB-1 When The Unit Has Been Generating To The Grid
GAB1FAULT
Page 213
Keowee Unit 1 Is Supplying The Grid
KU1RNNG
Page 20
Fault Occurs at ACB-1 When The BReaker Trips
AB1FALTDEX
3


Modified Auto Close Circuit Fails When Called On To Actuate
ACB4AFTC
Page 217
Main Step Up Transformer Lock Out Relay 86T Actuates
XFMR186T
Page 17
Keowee Unit 1 Emerg Lockout Due to Actuation of Generat or Protective Relay
GK186E1X
Page 213
ACB-4 Close Signal Fails
SIGNALSF
Air Circuit Breaker 4 Close Signals Fail
ACB4CSGNL
Page 221
Air Circuit Breaker 3 Fails To Open
ACB3OPEN
Page 141

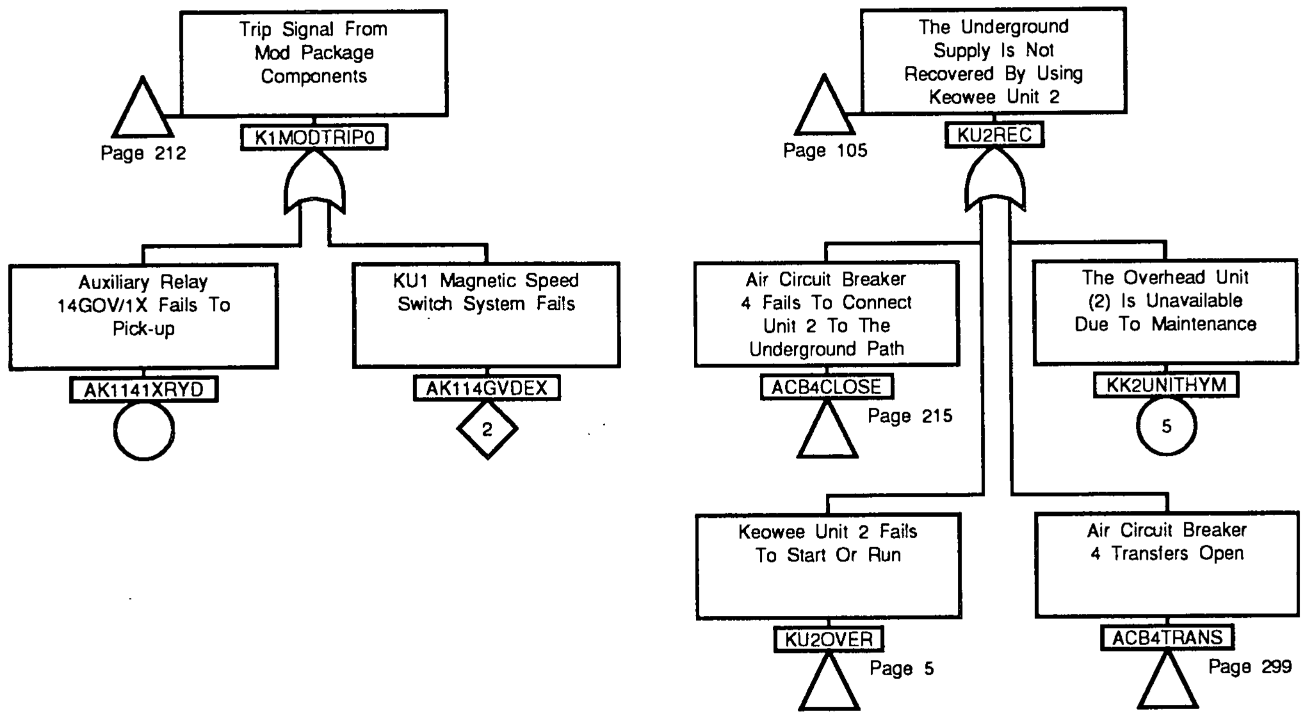

Air Circuit Breaker 4 Fails To Close Due To Control Failures
ACB4CNTRLC
Page 216
ACB-4 Control Fails With No Mod Or With ACB-1 Faulted
ACB4CNTRL0
No Recovery From Independent Failures Of Overhead Path An d KU1 (post-mod)
NOFALT
Air Circuit Breaker 4 Fails To Close Automatically
ACB4AUTOC
Air Circuit Breaker 4 Fails To Close Manually
ACB4MANC
Page 224
Air Circuit Breaker 1 Is Not Faulted
NOAB1FALT
Air Circuit Breaker 4 Fails To Close Manually
ACB4MANC
Page 224
NSM-ON-52966 Is In Service
NTACB4MOD
Page 13
NSM-ON-52966 Is Not In Service
ACB4MOD
5
Modified Auto Close Circuit Fails When Called On To Actuate
ACB4AFTC
Page 218
Fault Occurs at ACB-1 When The BReaker Trips
AB1FALTDEX
3



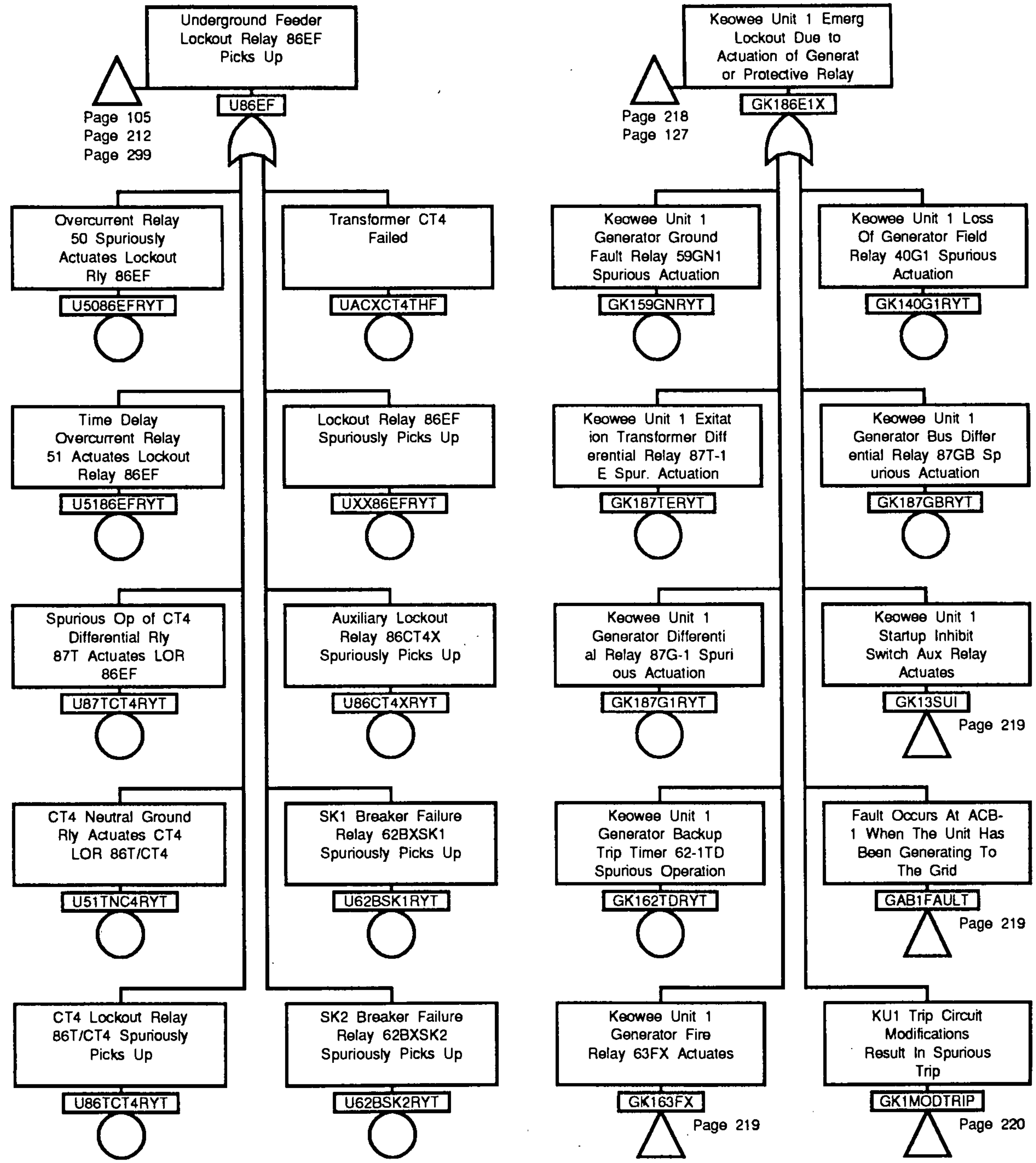
Air Circuit Breaker 4 Fails To Close Due To Electrical Failures
ACB4ELECC
Page 215
Air Circuit Breaker 4 Fails To Close Due To Electrical Failu res Of The Breaker
ACB4BREAKC
Air Circuit Breaker 4 Fails To Close Due To Control Failures
ACB4CNTRLC
Page 217
Air Circuit Breaker 4 Control Power Fails
ACB4DCPWR
Page 224
Air Circuit Breaker 4 Relay 52X Fails To Operate
AB4R52XR6D
Air Circuit Breaker 4 Y-relay Spurious Operation
AB452Y2R6T
Air Circuit Breaker 4 Close Coil Fails To Operate
AB452CCSVO
Air Circuit Breaker 4 Relay 52Y Failed To Drop Out Followin g Last Demand
AB452Y2R6D
Air Circuit Breaker 4 Accumulator Pressu re Switch PS2 Indica tes Low Pressure
AB4PS02PST

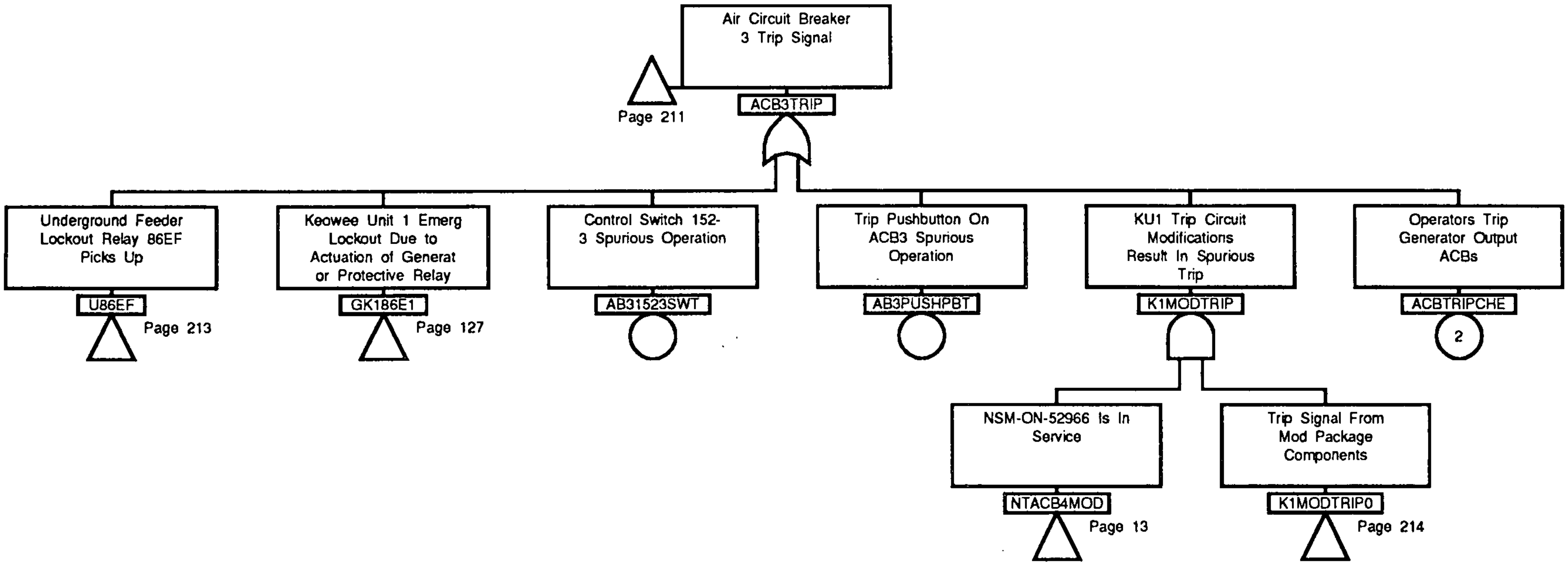


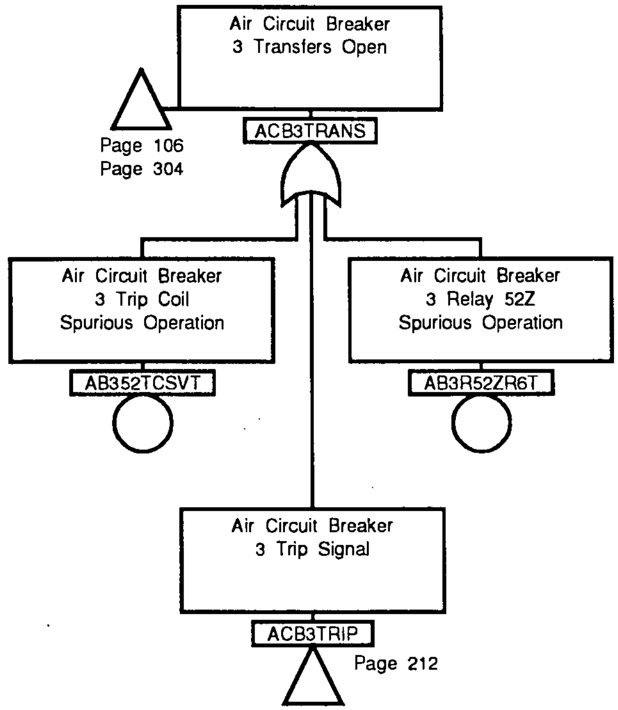
Air Circuit Breaker 4 Fails To Connect Unit 2 To The Underground Path
ACB4CLOSE
Page 214
Air Circuit Breaker 4 Fails To Close Due To Mechanical Failure
AB4MCH2DEX
Common Cause Failure Of ACBs 2 And 4
AB24COM
Page 18
Air Circuit Breaker 4 Fails To Close Due To Electrical Failures
ACB4ELECC
Page 216
Air Circuit Breaker 4 Key Interlock Switch Transfers Open
AB4KEYISWT
Air Circuit Breaker 4 Accumulator Air Pressure Low
AB4ACCUDEX
ACB Air Supply Fails Causing Low Pressure In All ACB Accumulators
ACBAIRPDEX
2
Air Circuit Breaker 4 Fails To Close Due To A Latent Human Error
AB4CLOSLHE



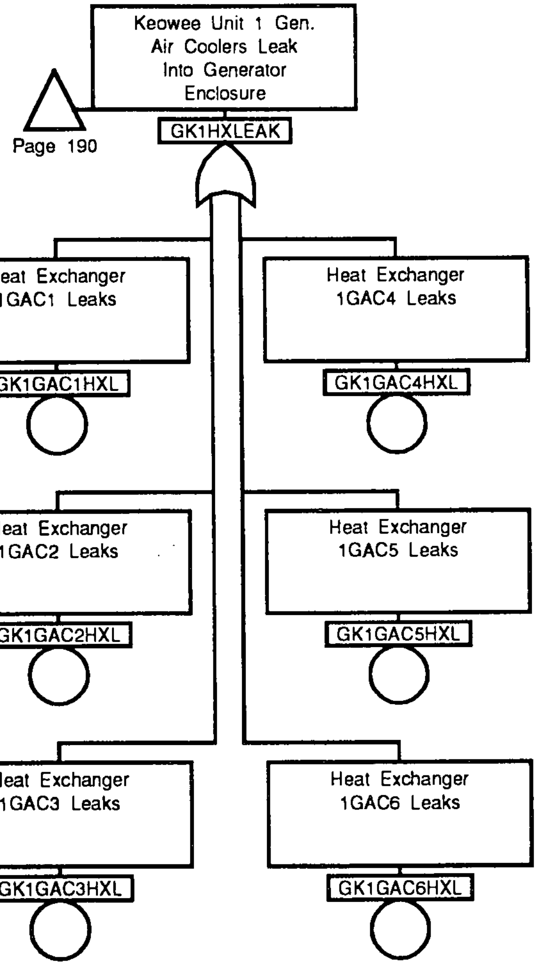
Trip Signal From Mod Package Components
K1MODTRIP0
Page 212
Auxiliary Relay 14GOV/1X Fails To Pick-up
AK1141XRYD
KU1 Magnetic Speed Switch System Fails
AK114GVDEX
2
The Underground Supply Is Not Recovered By Using Keowee Unit 2
KU2REC
Page 105
Air Circuit Breaker 4 Fails To Connect Unit 2 To The Underground Path
ACB4CLOSE
Page 215
The Overhead Unit (2) Is Unavailable Due To Maintenance
KK2UNITHYM
5
Keowee Unit 2 Fails To Start Or Run
KU2OVER
Page 5
Air Circuit Breaker 4 Transfers Open
ACB4TRANS
Page 299


Underground Feeder Lockout Relay 86EF Picks Up
U86EF
Page 105
Page 212
Page 299
Overcurrent Relay 50 Spuriously Actuates Lockout Rly 86EF
U5086EFRYT
Transformer CT4 Failed
UACXCT4THF
Time Delay Overcurrent Relay 51 Actuates Lockout Relay 86EF
U5186EFRYT
Lockout Relay 86EF Spuriously Picks Up
UXX86EFRYT
Spurious Op of CT4 Differential Rly 87T Actuates LOR 86EF
U87TCT4RYT
Auxiliary Lockout Relay 86CT4X Spuriously Picks Up
U86CT4XRYT
CT4 Neutral Ground Rly Actuates CT4 LOR 86T/CT4
U51TNC4RYT
SK1 Breaker Failure Relay 62BXSK1 Spuriously Picks Up
U62BSK1RYT
CT4 Lockout Relay 86T/CT4 Spuriously Picks Up
U86TCT4RYT
SK2 Breaker Failure Relay 62BXSK2 Spuriously Picks Up
U62BSK2RYT
Keowee Unit 1 Emerg Lockout Due to Actuation of Generat or Protective Relay
GK186E1X
Page 218
Page 127
Keowee Unit 1 Generator Ground Fault Relay 59GN1 Spurious Actuation
GK159GNRYT
Keowee Unit 1 Loss Of Generator Field Relay 40G1 Spurious Actuation
GK140G1RYT
Keowee Unit 1 Exitat ion Transformer Diff erential Relay 87T-1 E Spur. Actuation
GK187TERYT
Keowee Unit 1 Generator Bus Differ ential Relay 87GB Sp urious Actuation
GK187GBRYT
Keowee Unit 1 Generator Differenti al Relay 87G-1 Spuri ous Actuation
GK187G1RYT
Keowee Unit 1 Startup Inhibit Switch Aux Relay Actuates
GK13SUI
Page 219
Keowee Unit 1 Generator Backup Trip Timer 62-1TD Spurious Operation
GK162TDRYT
Fault Occurs At ACB-1 When The Unit Has Been Generating To The Grid
GAB1FAULT
Page 219
Keowee Unit 1 Generator Fire Relay 63FX Actuates
GK163FX
Page 219
KU1 Trip Circuit Modifications Result In Spurious Trip
GK1MODTRIP
Page 220

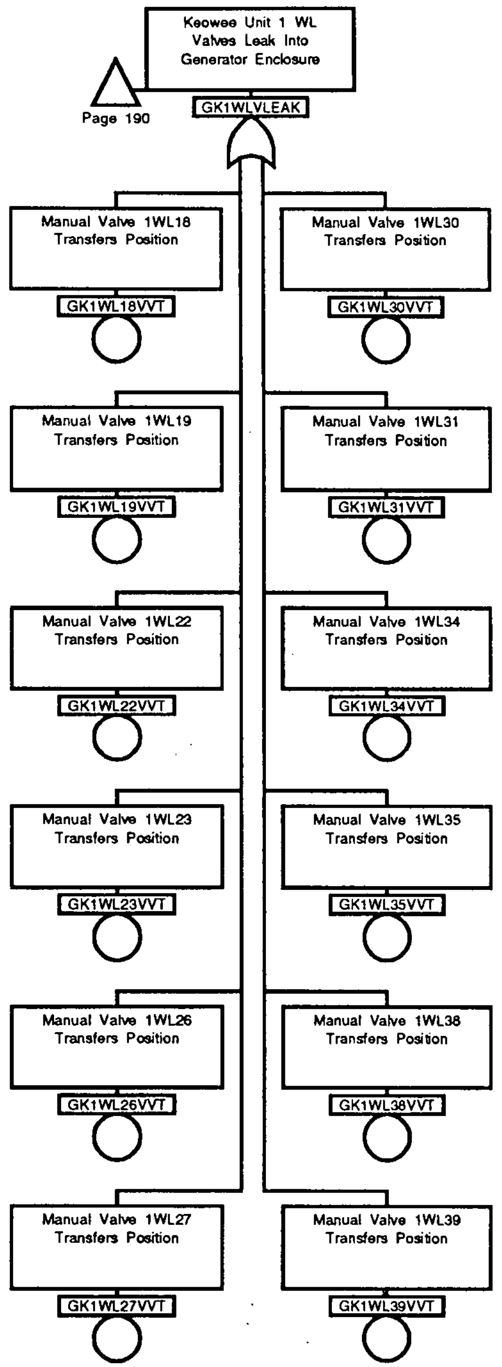

Air Circuit Breaker 3 Trip Signal
ACB3TRIP
Page 211
Underground Feeder Lockout Relay 86EF Picks Up
U86EF
Page 213
Keowee Unit 1 Emerg Lockout Due to Actuation of Generat or Protective Relay
GK186E1
Page 127
Control Switch 152-3 Spurious Operation
AB31523SWT
Trip Pushbutton On ACB3 Spurious Operation
AB3PUSHPBT
KU1 Trip Circuit Modifications Result In Spurious Trip
K1MODTRIP
Operators Trip Generator Output ACBs
ACBTRIPCHE
2
NSM-ON-52966 Is In Service
NTACB4MOD
Page 13
Trip Signal From Mod Package Components
K1MODTRIP0
Page 214



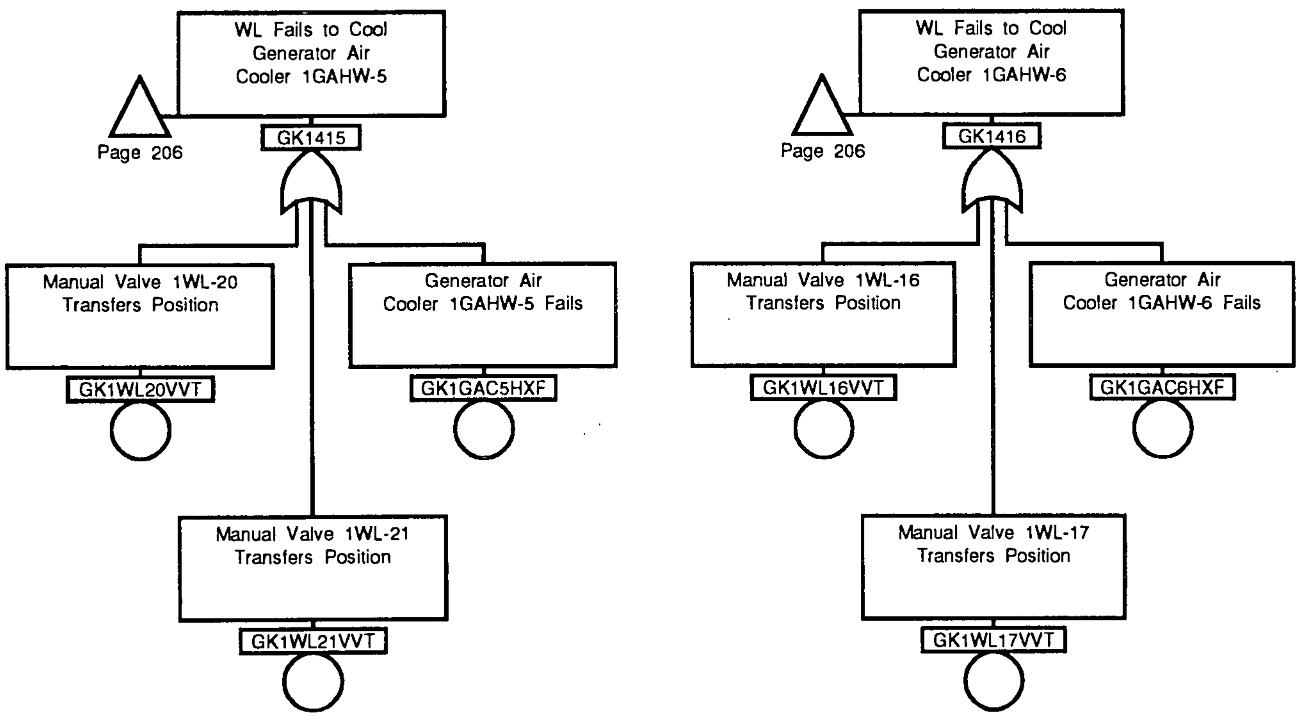
Air Circuit Breaker
3 Transfers Open
ACB3TRANS
Page 106
Page 304
Air Circuit Breaker
3 Trip Coil
Spurious Operation
AB352TCSVT
Air Circuit Breaker
3 Relay 52Z
Spurious Operation
AB3R52ZR6T
Air Circuit Breaker
3 Trip Signal
ACB3TRIP
Page 212



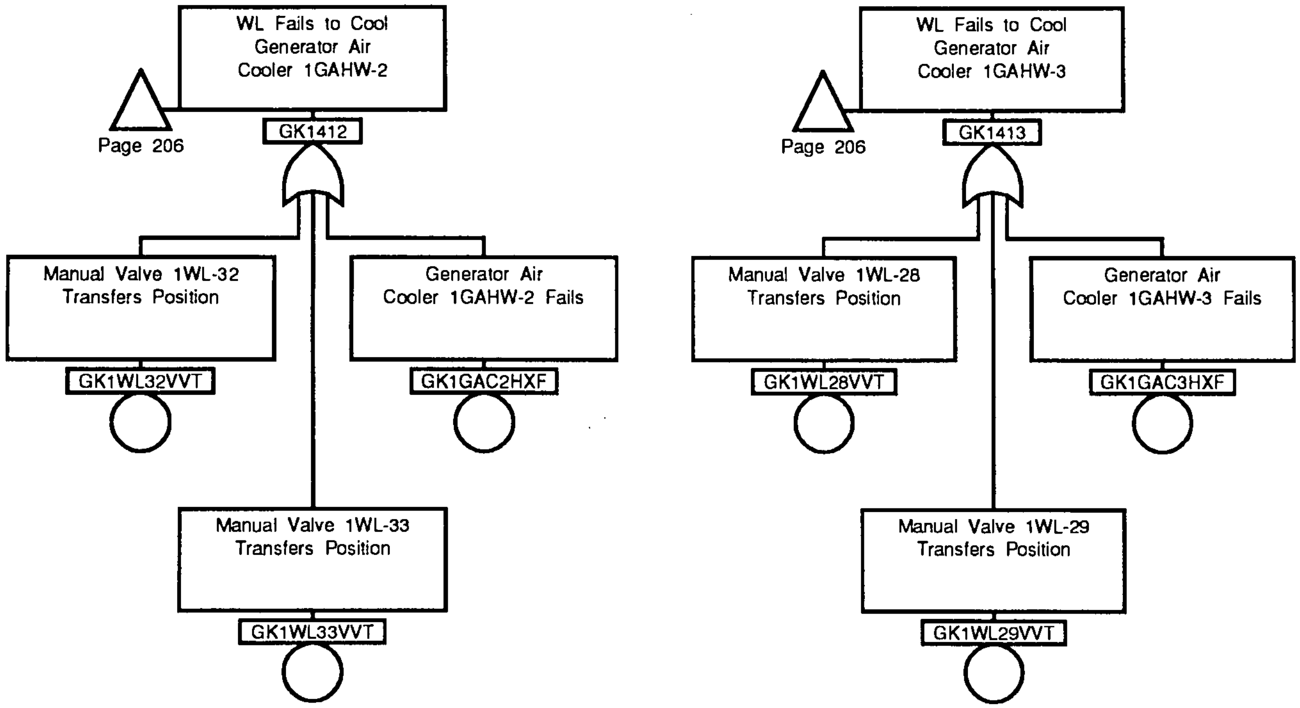
Keeowee Unit 1 Gen. Air Coolers Leak Into Generator Enclosure
GK1HXLEAK
Page 190
Heat Exchanger 1GAC1 Leaks
GK1GAC1HXL
Heat Exchanger 1GAC4 Leaks
GK1GAC4HXL
Heat Exchanger 1GAC2 Leaks
GK1GAC2HXL
Heat Exchanger 1GAC5 Leaks
GK1GAC5HXL
Heat Exchanger 1GAC3 Leaks
GK1GAC3HXL
Heat Exchanger 1GAC6 Leaks
GK1GAC6HXL

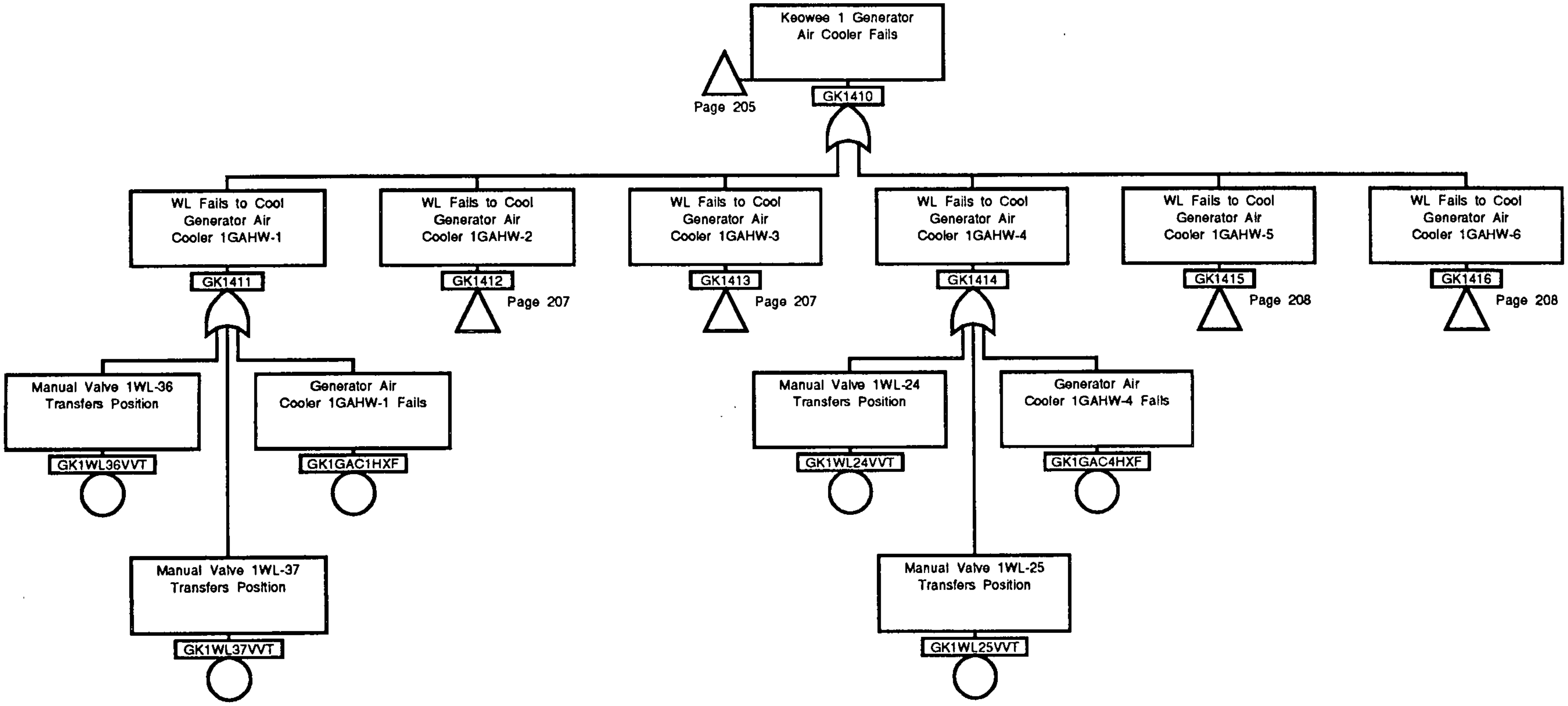


Keowee Unit 1 WL Valves Leak Into Generator Enclosure
GK1WLVLEAK
Page 190
Manual Valve 1WL18 Transfers Position
GK1WL18VVT
Manual Valve 1WL30 Transfers Position
GK1WL30VVT
Manual Valve 1WL19 Transfers Position
GK1WL19VVT
Manual Valve 1WL31 Transfers Position
GK1WL31VVT
Manual Valve 1WL22 Transfers Position
GK1WL22VVT
Manual Valve 1WL34 Transfers Position
GK1WL34VVT
Manual Valve 1WL23 Transfers Position
GK1WL23VVT
Manual Valve 1WL35 Transfers Position
GK1WL35VVT
Manual Valve 1WL26 Transfers Position
GK1WL26VVT
Manual Valve 1WL38 Transfers Position
GK1WL38VVT
Manual Valve 1WL27 Transfers Position
GK1WL27VVT
Manual Valve 1WL39 Transfers Position
GK1WL39VVT

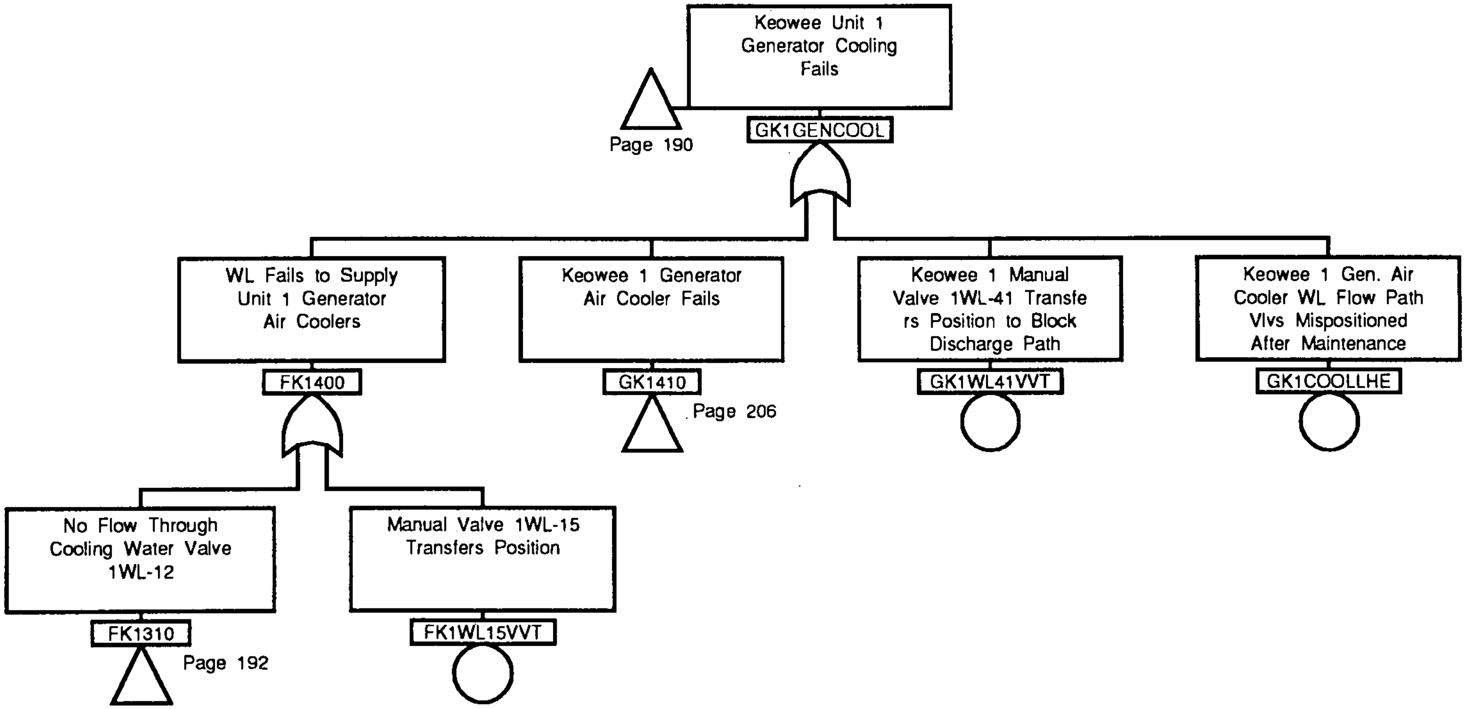


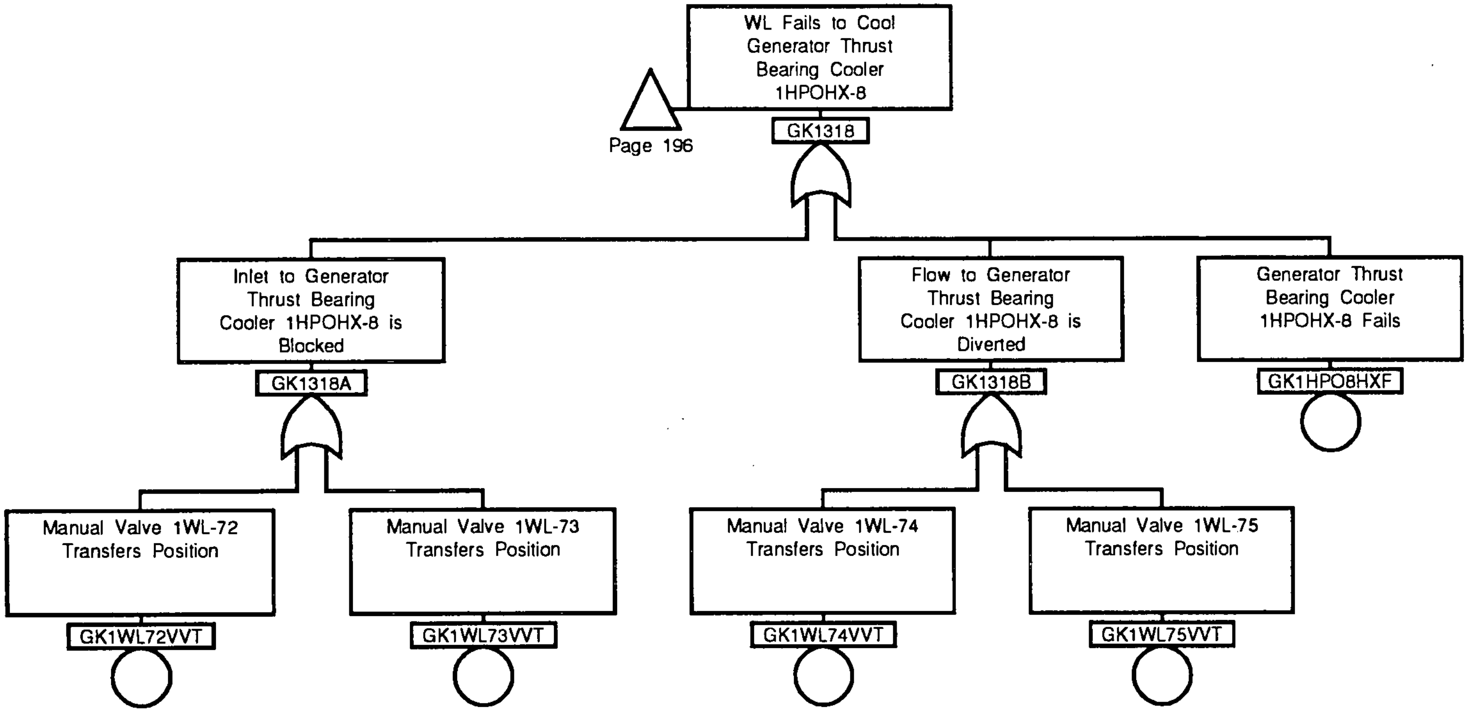
WL Fails to Cool Generator Air Cooler 1GAHW-5
GK1415
Page 206
Manual Valve 1WL-20 Transfers Position
GK1WL20VVT
Generator Air Cooler 1GAHW-5 Fails
GK1GAC5HXF
Manual Valve 1WL-21 Transfers Position
GK1WL21VVT
WL Fails to Cool Generator Air Cooler 1GAHW-6
GK1416
Page 206
Manual Valve 1WL-16 Transfers Position
GK1WL16VVT
Generator Air Cooler 1GAHW-6 Fails
GK1GAC6HXF
Manual Valve 1WL-17 Transfers Position
GK1WL17VVT

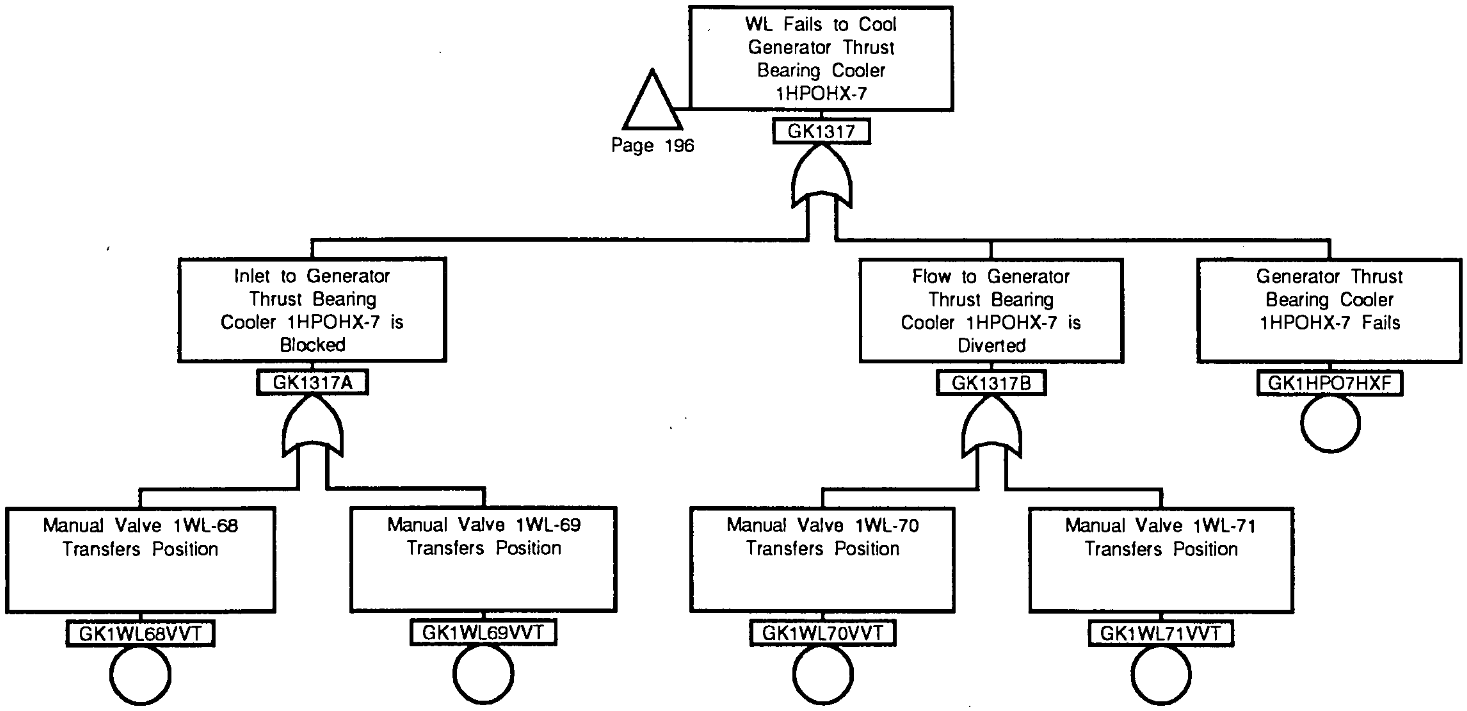

WL Fails to Cool Generator Air Cooler 1GAHW-2
Page 206
GK1412
Manual Valve 1WL-32 Transfers Position
GK1WL32VVT
Generator Air Cooler 1GAHW-2 Fails
GK1GAC2HXF
Manual Valve 1WL-33 Transfers Position
GK1WL33VVT
WL Fails to Cool Generator Air Cooler 1GAHW-3
Page 206
GK1413
Manual Valve 1WL-28 Transfers Position
GK1WL28VVT
Generator Air Cooler 1GAHW-3 Fails
GK1GAC3HXF
Manual Valve 1WL-29 Transfers Position
GK1WL29VVT

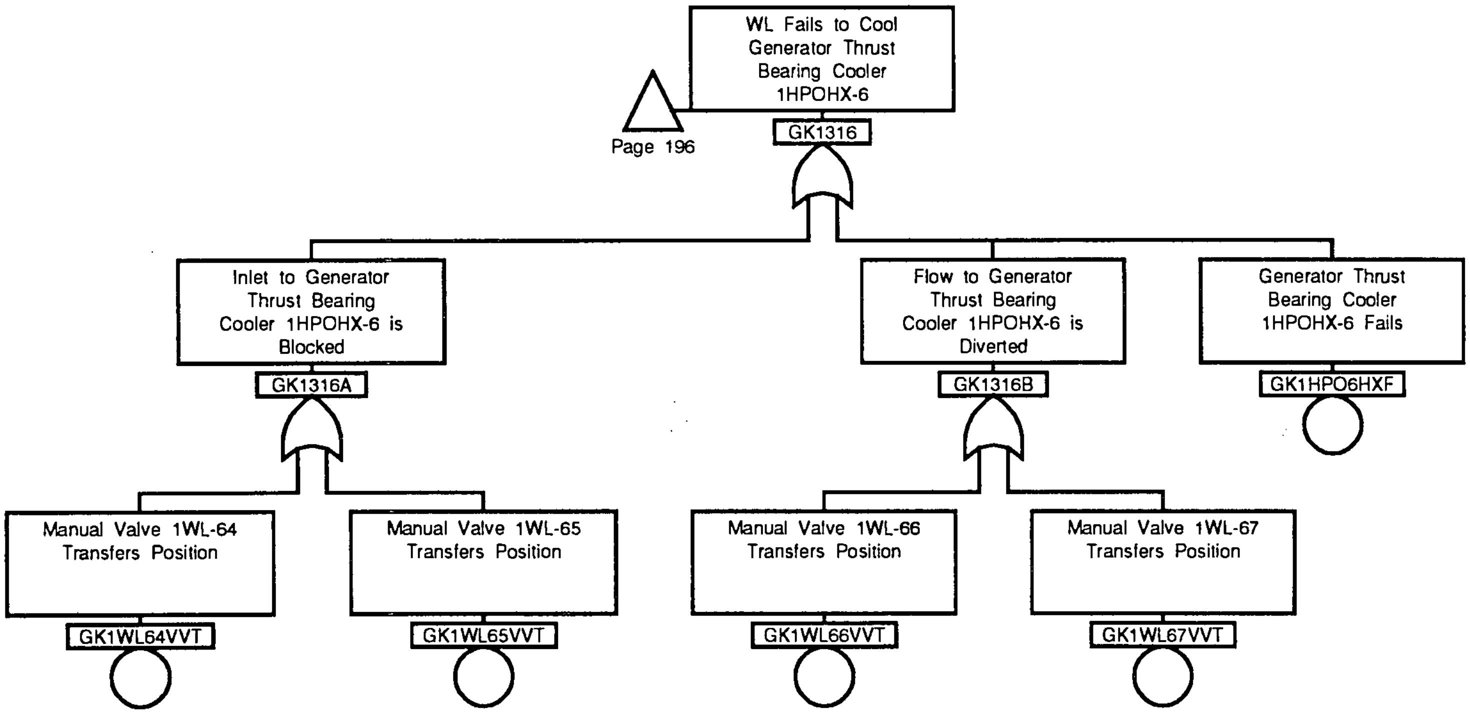


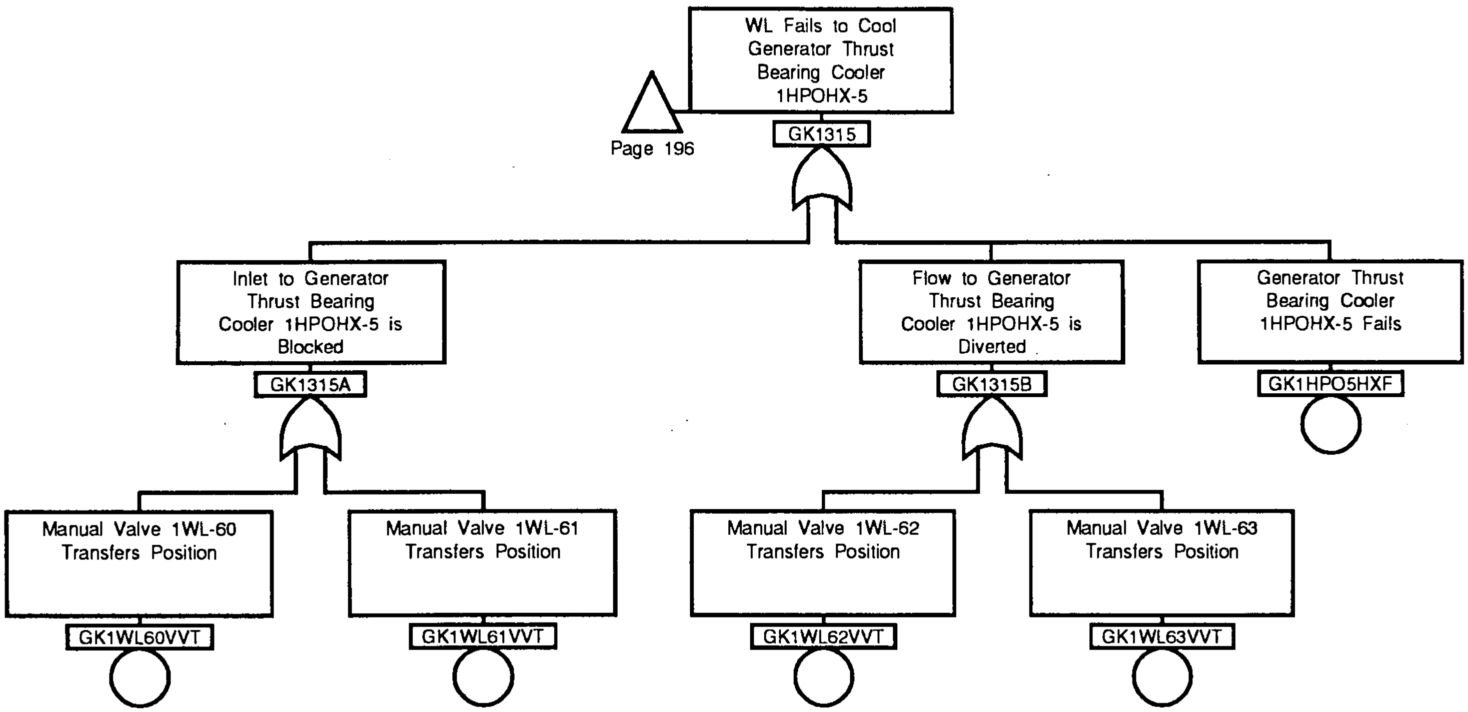
Keowee 1 Generator Air Cooler Fails
GK1410
Page 205
WL Fails to Cool Generator Air Cooler 1GAHW-1
GK1411
WL Fails to Cool Generator Air Cooler 1GAHW-2
GK1412
Page 207
WL Fails to Cool Generator Air Cooler 1GAHW-3
GK1413
Page 207
WL Fails to Cool Generator Air Cooler 1GAHW-4
GK1414
WL Fails to Cool Generator Air Cooler 1GAHW-5
GK1415
Page 208
WL Fails to Cool Generator Air Cooler 1GAHW-6
GK1416
Page 208
Manual Valve 1WL-36 Transfers Position
GK1WL36VVT
Generator Air Cooler 1GAHW-1 Fails
GK1GAC1HXF
Manual Valve 1WL-37 Transfers Position
GK1WL37VVT
Manual Valve 1WL-24 Transfers Position
GK1WL24VVT
Generator Air Cooler 1GAHW-4 Fails
GK1GAC4HXF
Manual Valve 1WL-25 Transfers Position
GK1WL25VVT


Keowee Unit 1 Generator Cooling Fails
GK1GENCOOL
Page 190
WL Fails to Supply Unit 1 Generator Air Coolers
FK1400
Keowee 1 Generator Air Cooler Fails
GK1410
Page 206
Keowee 1 Manual Valve 1WL-41 Transfe rs Position to Block Discharge Path
GK1WL41VVT
Keowee 1 Gen. Air Cooler WL Flow Path Vlvs Mispositioned After Maintenance
GK1COOLLHE
No Flow Through Cooling Water Valve 1WL-12
FK1310
Page 192
Manual Valve 1WL-15 Transfers Position
FK1WL15VVT

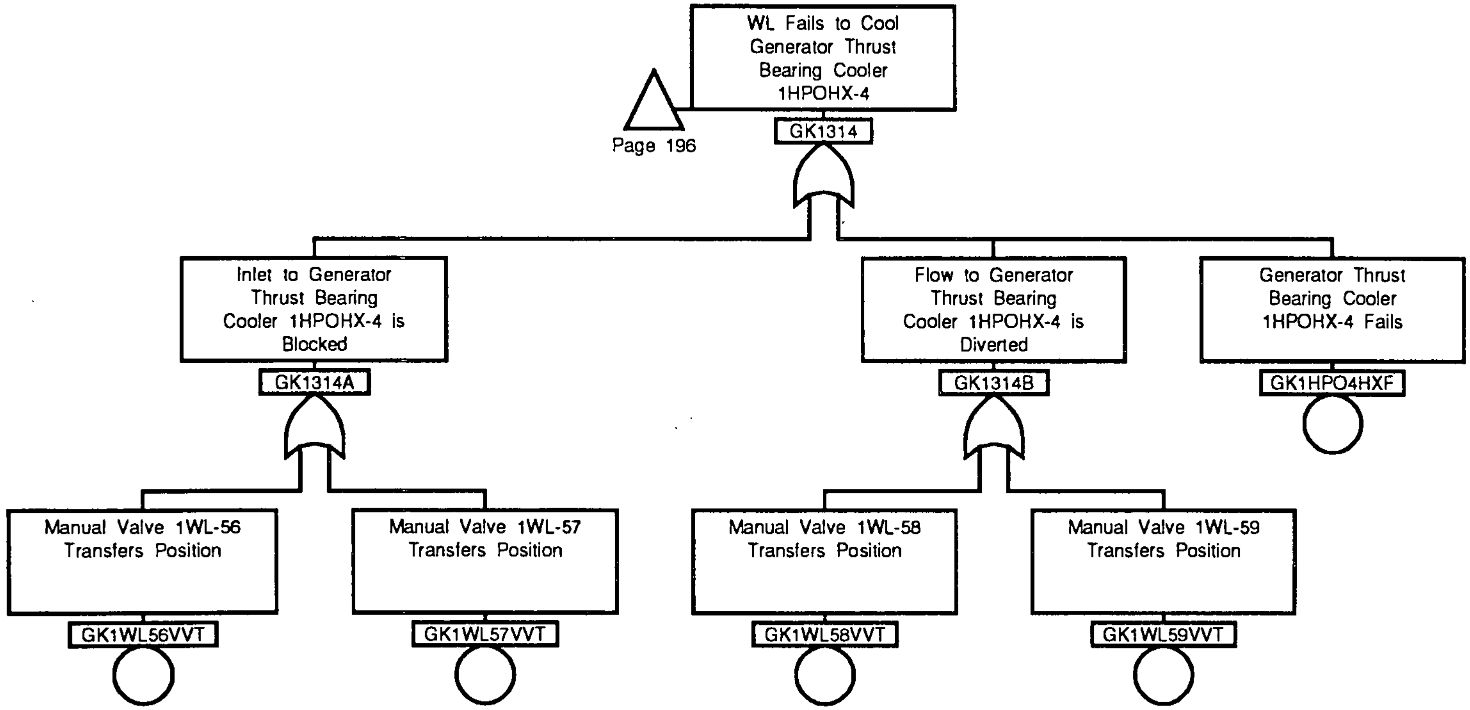

WL Fails to Cool Generator Thrust Bearing Cooler 1HPOHX-8
GK1318
Page 196
Inlet to Generator Thrust Bearing Cooler 1HPOHX-8 is Blocked
GK1318A
Flow to Generator Thrust Bearing Cooler 1HPOHX-8 is Diverted
GK1318B
Generator Thrust Bearing Cooler 1HPOHX-8 Fails
GK1HPO8HXF
Manual Valve 1WL-72 Transfers Position
GK1WL72VVT
Manual Valve 1WL-73 Transfers Position
GK1WL73VVT
Manual Valve 1WL-74 Transfers Position
GK1WL74VVT
Manual Valve 1WL-75 Transfers Position
GK1WL75VVT


WL Fails to Cool Generator Thrust Bearing Cooler 1HPOHX-7
GK1317
Page 196
Inlet to Generator Thrust Bearing Cooler 1HPOHX-7 is Blocked
GK1317A
Flow to Generator Thrust Bearing Cooler 1HPOHX-7 is Diverted
GK1317B
Generator Thrust Bearing Cooler 1HPOHX-7 Fails
GK1HPO7HXF
Manual Valve 1WL-68 Transfers Position
GK1WL68VVT
Manual Valve 1WL-69 Transfers Position
GK1WL69VVT
Manual Valve 1WL-70 Transfers Position
GK1WL70VVT
Manual Valve 1WL-71 Transfers Position
GK1WL71VVT

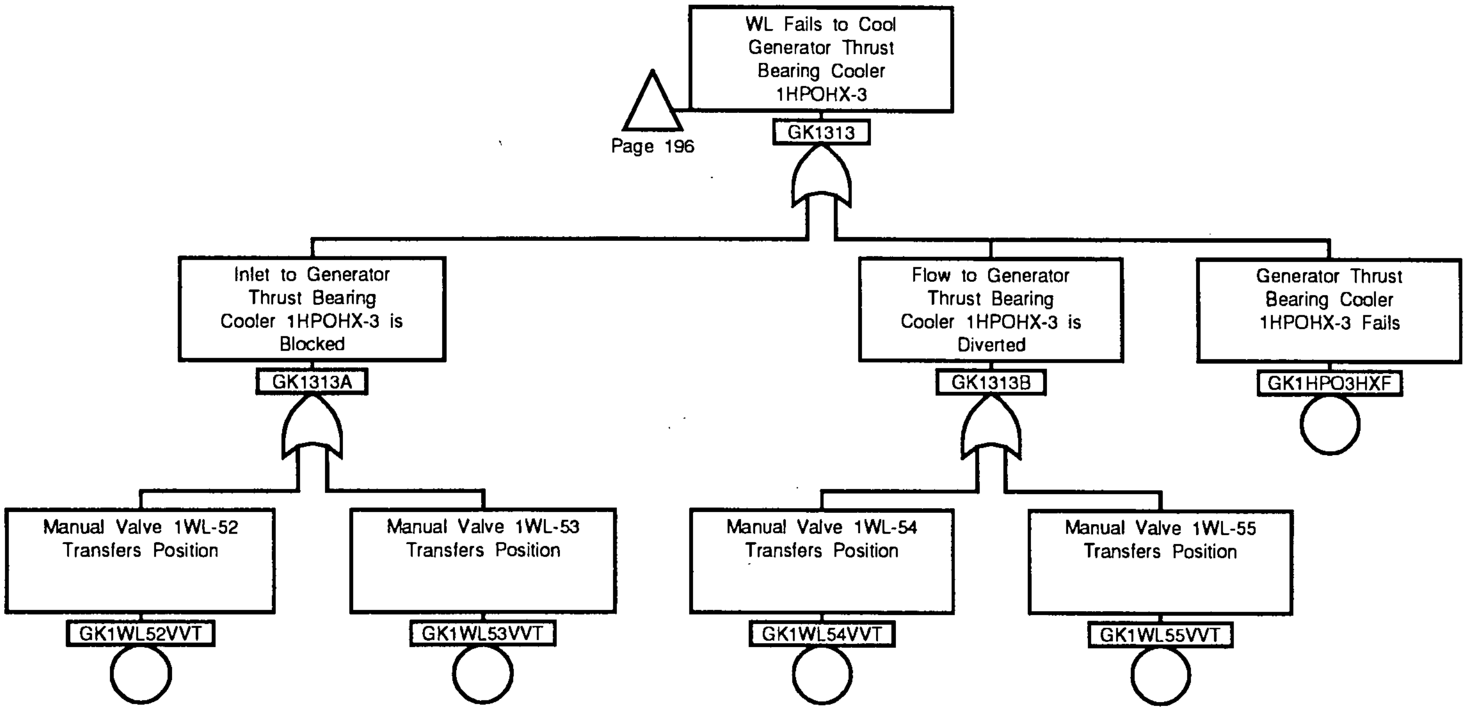

WL Fails to Cool Generator Thrust Bearing Cooler 1HPOHX-6
GK1316
Page 196
Inlet to Generator Thrust Bearing Cooler 1HPOHX-6 is Blocked
GK1316A
Flow to Generator Thrust Bearing Cooler 1HPOHX-6 is Diverted
GK1316B
Generator Thrust Bearing Cooler 1HPOHX-6 Fails
GK1HPO6HXF
Manual Valve 1WL-64 Transfers Position
GK1WL64VVT
Manual Valve 1WL-65 Transfers Position
GK1WL65VVT
Manual Valve 1WL-66 Transfers Position
GK1WL66VVT
Manual Valve 1WL-67 Transfers Position
GK1WL67VVT

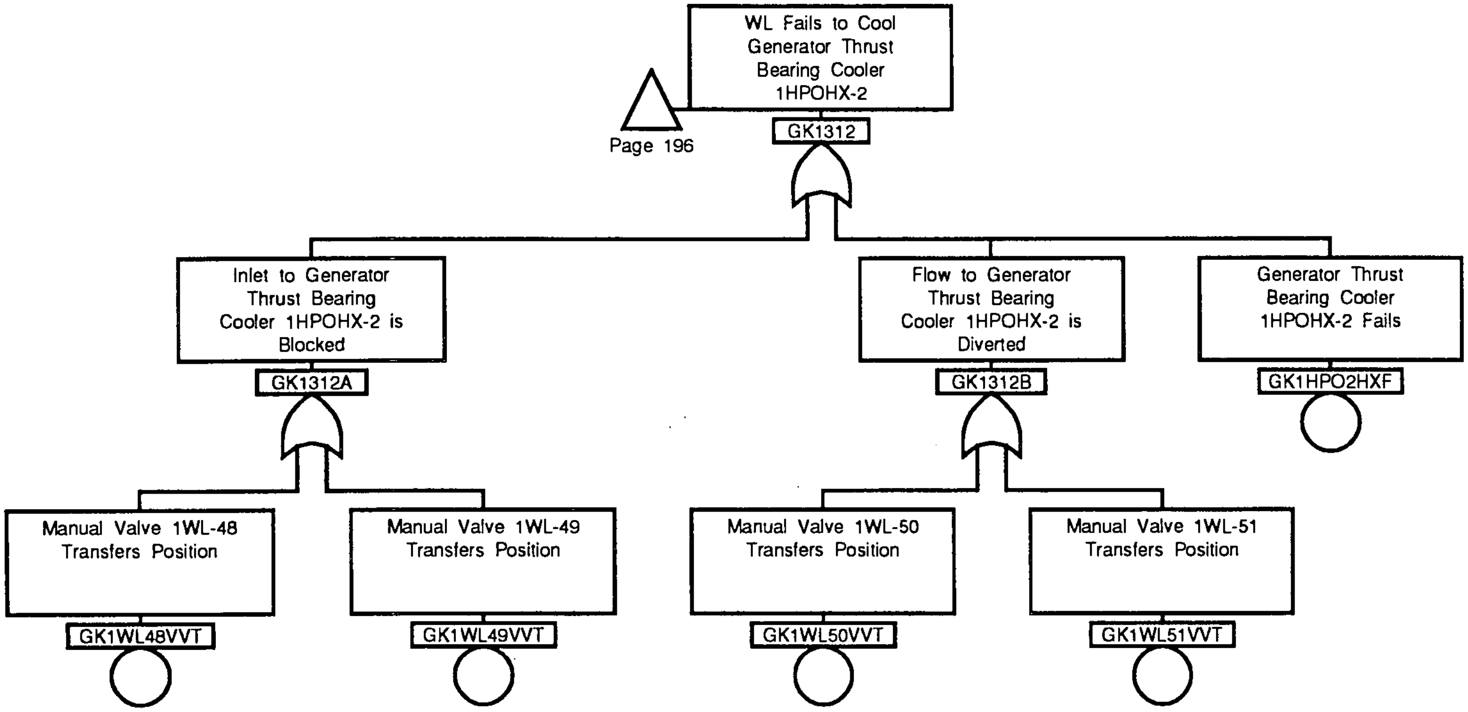


WL Fails to Cool Generator Thrust Bearing Cooler 1HPOHX-5
GK1315
Page 196
Inlet to Generator Thrust Bearing Cooler 1HPOHX-5 is Blocked
GK1315A
Flow to Generator Thrust Bearing Cooler 1HPOHX-5 is Diverted
GK1315B
Generator Thrust Bearing Cooler 1HPOHX-5 Fails
GK1HPO5HXF
Manual Valve 1WL-60 Transfers Position
GK1WL60VVT
Manual Valve 1WL-61 Transfers Position
GK1WL61VVT
Manual Valve 1WL-62 Transfers Position
GK1WL62VVT
Manual Valve 1WL-63 Transfers Position
GK1WL63VVT

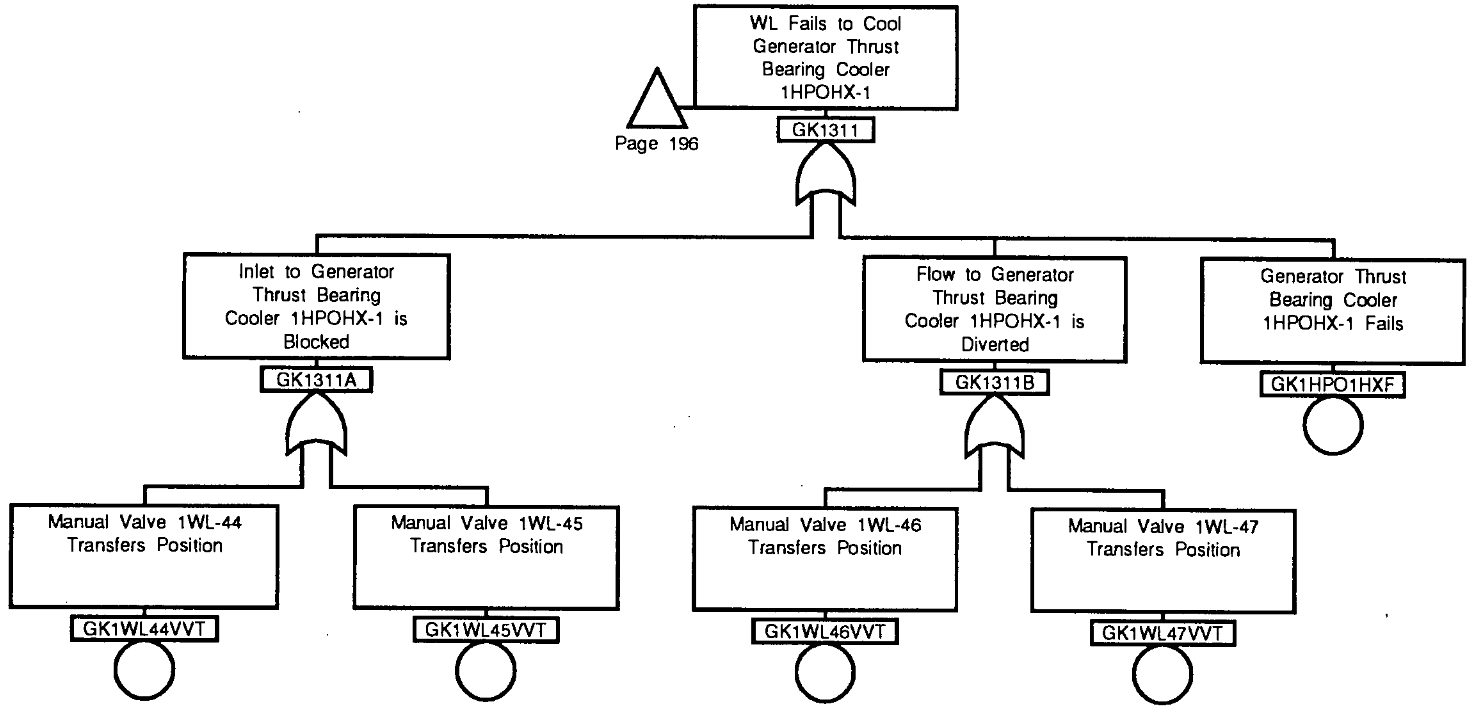


WL Fails to Cool Generator Thrust Bearing Cooler 1HPOHX-4
GK1314
Page 196
Inlet to Generator Thrust Bearing Cooler 1HPOHX-4 is Blocked
GK1314A
Flow to Generator Thrust Bearing Cooler 1HPOHX-4 is Diverted
GK1314B
Generator Thrust Bearing Cooler 1HPOHX-4 Fails
GK1HPO4HXF
Manual Valve 1WL-56 Transfers Position
GK1WL56VVT
Manual Valve 1WL-57 Transfers Position
GK1WL57VVT
Manual Valve 1WL-58 Transfers Position
GK1WL58VVT
Manual Valve 1WL-59 Transfers Position
GK1WL59VVT

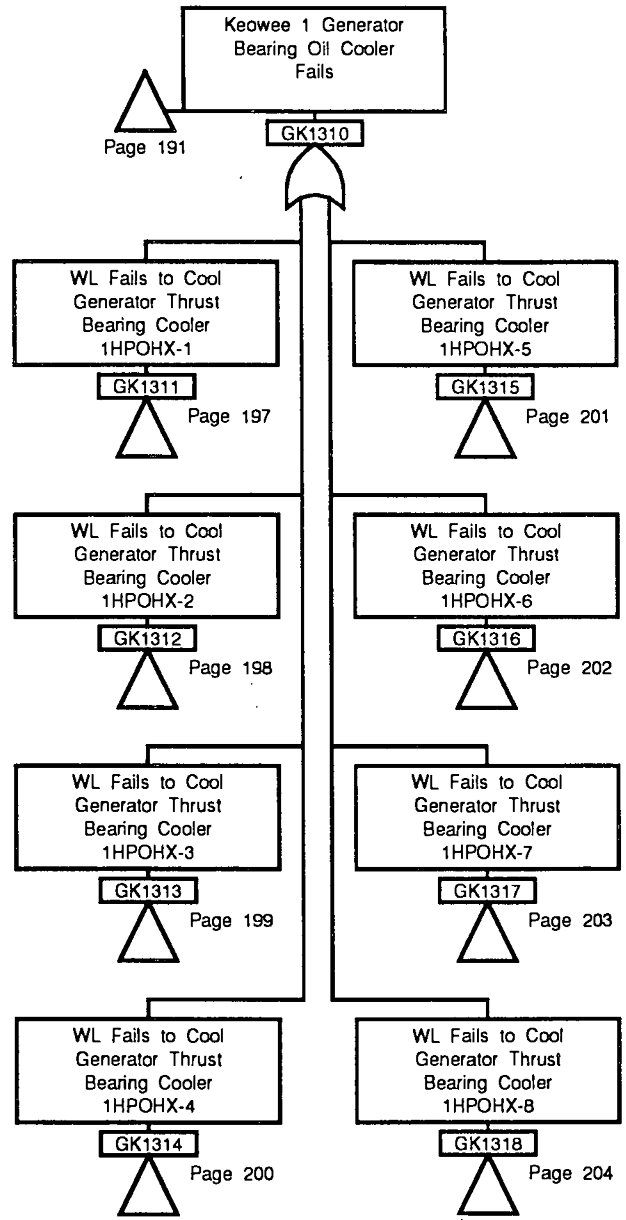

WL Fails to Cool Generator Thrust Bearing Cooler 1HPOHX-3
GK1313
Page 196
Inlet to Generator Thrust Bearing Cooler 1HPOHX-3 is Blocked
GK1313A
Flow to Generator Thrust Bearing Cooler 1HPOHX-3 is Diverted
GK1313B
Generator Thrust Bearing Cooler 1HPOHX-3 Fails
GK1HPO3HXF
Manual Valve 1WL-52 Transfers Position
GK1WL52VVT
Manual Valve 1WL-53 Transfers Position
GK1WL53VVT
Manual Valve 1WL-54 Transfers Position
GK1WL54VVT
Manual Valve 1WL-55 Transfers Position
GK1WL55VVT



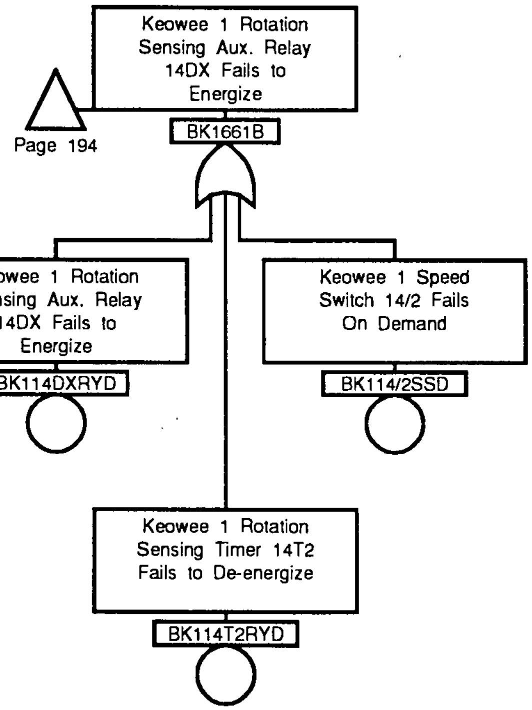
WL Fails to Cool Generator Thrust Bearing Cooler 1HPOHX-2
GK1312
Page 196
Inlet to Generator Thrust Bearing Cooler 1HPOHX-2 is Blocked
GK1312A
Flow to Generator Thrust Bearing Cooler 1HPOHX-2 is Diverted
GK1312B
Generator Thrust Bearing Cooler 1HPOHX-2 Fails
GK1HPO2HXF
Manual Valve 1WL-48 Transfers Position
GK1WL48VVT
Manual Valve 1WL-49 Transfers Position
GK1WL49VVT
Manual Valve 1WL-50 Transfers Position
GK1WL50VVT
Manual Valve 1WL-51 Transfers Position
GK1WL51VVT



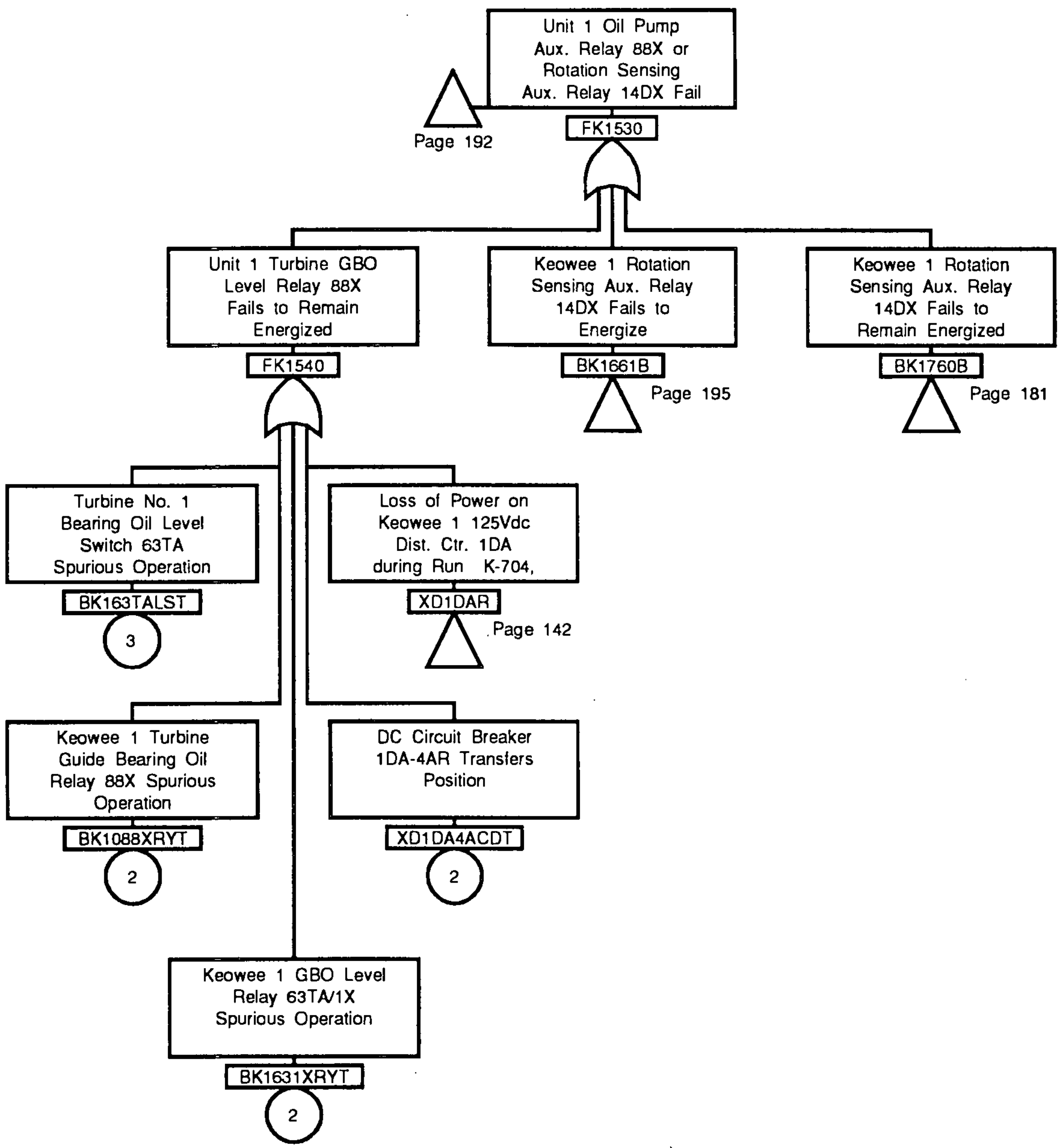
WL Fails to Cool Generator Thrust Bearing Cooler 1HPOHX-1
GK1311
Page 196
Inlet to Generator Thrust Bearing Cooler 1HPOHX-1 is Blocked
GK1311A
Flow to Generator Thrust Bearing Cooler 1HPOHX-1 is Diverted
GK1311B
Generator Thrust Bearing Cooler 1HPOHX-1 Fails
GK1HPO1HXF
Manual Valve 1WL-44 Transfers Position
GK1WL44VVT
Manual Valve 1WL-45 Transfers Position
GK1WL45VVT
Manual Valve 1WL-46 Transfers Position
GK1WL46VVT
Manual Valve 1WL-47 Transfers Position
GK1WL47VVT

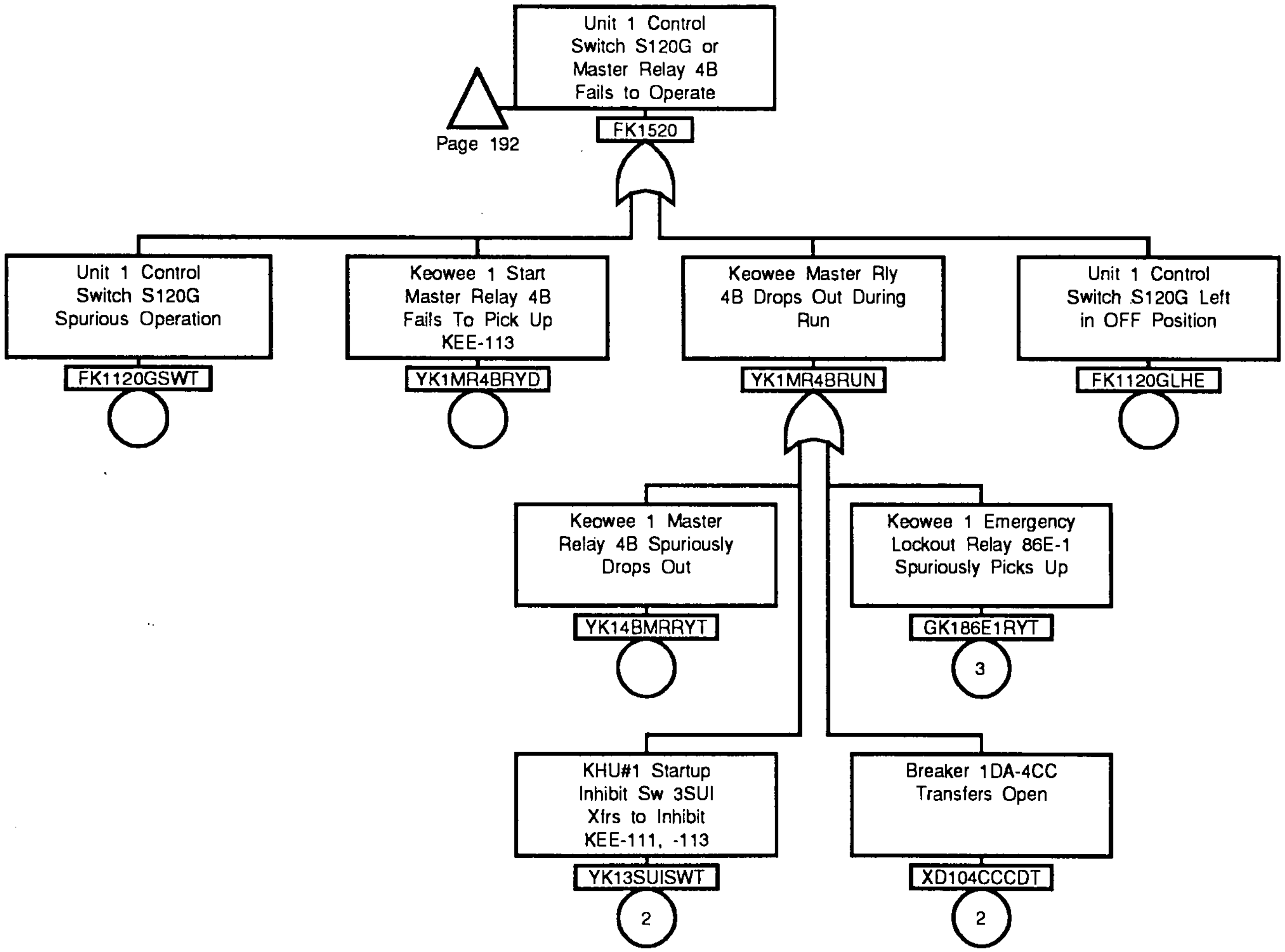


Keewee 1 Generator Bearing Oil Cooler Fails
GK1310
Page 191
WL Fails to Cool Generator Thrust Bearing Cooler 1HPOHX-1
GK1311
Page 197
WL Fails to Cool Generator Thrust Bearing Cooler 1HPOHX-5
GK1315
Page 201
WL Fails to Cool Generator Thrust Bearing Cooler 1HPOHX-2
GK1312
Page 198
WL Fails to Cool Generator Thrust Bearing Cooler 1HPOHX-6
GK1316
Page 202
WL Fails to Cool Generator Thrust Bearing Cooler 1HPOHX-3
GK1313
Page 199
WL Fails to Cool Generator Thrust Bearing Cooler 1HPOHX-7
GK1317
Page 203
WL Fails to Cool Generator Thrust Bearing Cooler 1HPOHX-4
GK1314
Page 200
WL Fails to Cool Generator Thrust Bearing Cooler 1HPOHX-8
GK1318
Page 204

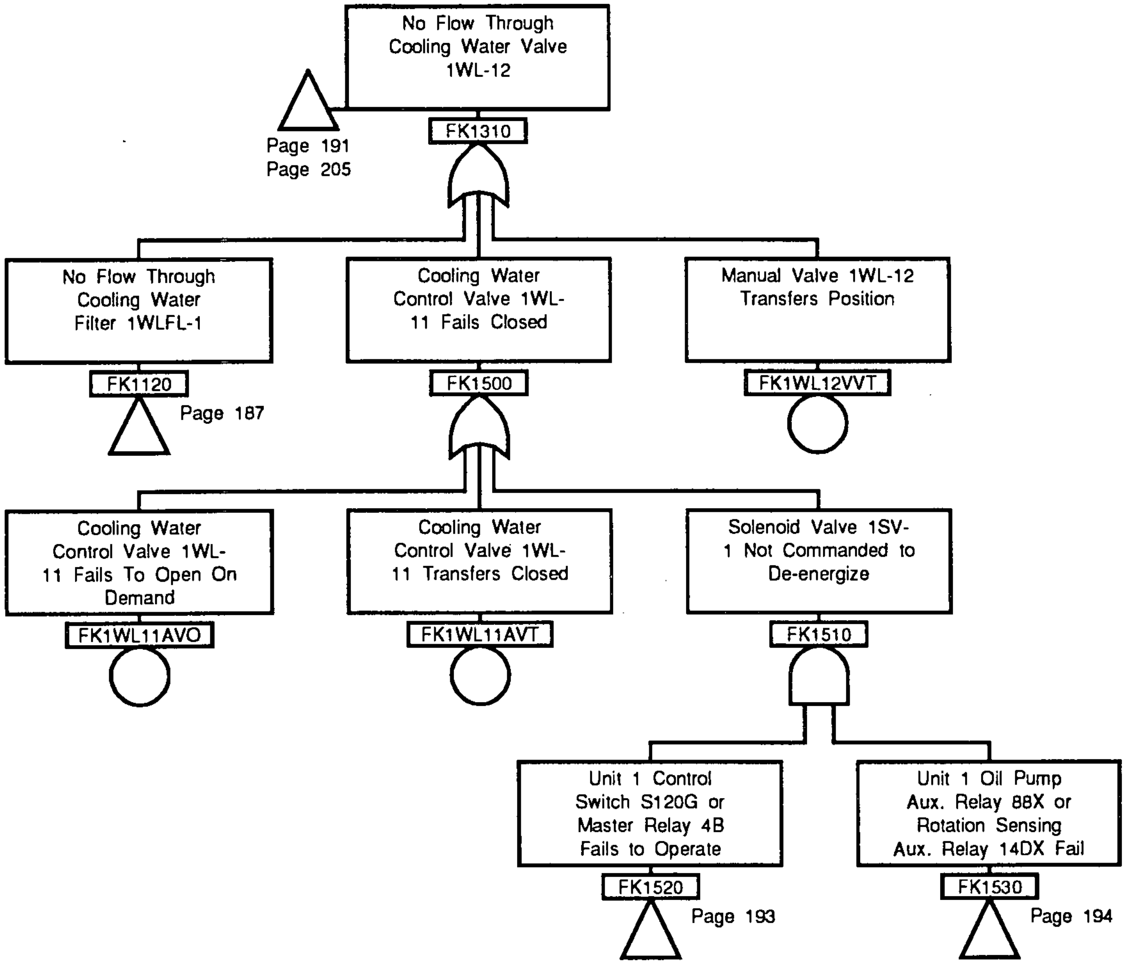


Keowee 1 Rotation Sensing Aux. Relay 14DX Fails to Energize
BK1661B
Page 194
Keowee 1 Rotation Sensing Aux. Relay 14DX Fails to Energize
BK114DXRYD
Keowee 1 Speed Switch 14/2 Fails On Demand
BK114/2SSD
Keowee 1 Rotation Sensing Timer 14T2 Fails to De-energize
BK114T2RYD


Unit 1 Oil Pump Aux. Relay 88X or Rotation Sensing Aux. Relay 14DX Fail
FK1530
Page 192
Unit 1 Turbine GBO Level Relay 88X Fails to Remain Energized
FK1540
Keowee 1 Rotation Sensing Aux. Relay 14DX Fails to Energize
BK1661B
Page 195
Keowee 1 Rotation Sensing Aux. Relay 14DX Fails to Remain Energized
BK1760B
Page 181
Turbine No. 1 Bearing Oil Level Switch 63TA Spurious Operation
BK163TALST
3
Loss of Power on Keowee 1 125Vdc Dist. Ctr. 1DA during Run K-704,
XD1DAR
Page 142
Keowee 1 Turbine Guide Bearing Oil Relay 88X Spurious Operation
BK1088XRYT
2
DC Circuit Breaker 1DA-4AR Transfers Position
XD1DA4ACDT
2
Keowee 1 GBO Level Relay 63TA/1X Spurious Operation
BK1631XRYT
2



Unit 1 Control Switch S120G or Master Relay 4B Fails to Operate
FK1520
Page 192
Unit 1 Control Switch S120G Spurious Operation
FK1120GSWT
Keowee 1 Start Master Relay 4B Fails To Pick Up KEE-113
YK1MR4BRYD
Keowee Master Rly 4B Drops Out During Run
YK1MR4BRUN
Unit 1 Control Switch S120G Left in OFF Position
FK1120GLHE
Keowee 1 Master Relay 4B Spuriously Drops Out
YK14BMRRYT
Keowee 1 Emergency Lockout Relay 86E-1 Spuriously Picks Up
GK186E1RYT
3
KHU#1 Startup Inhibit Sw 3SUI Xfrs to Inhibit KEE-111, -113
YK13SUISWT
2
Breaker 1DA-4CC Transfers Open
XD104CCCDT
2


No Flow Through Cooling Water Valve 1WL-12
FK1310
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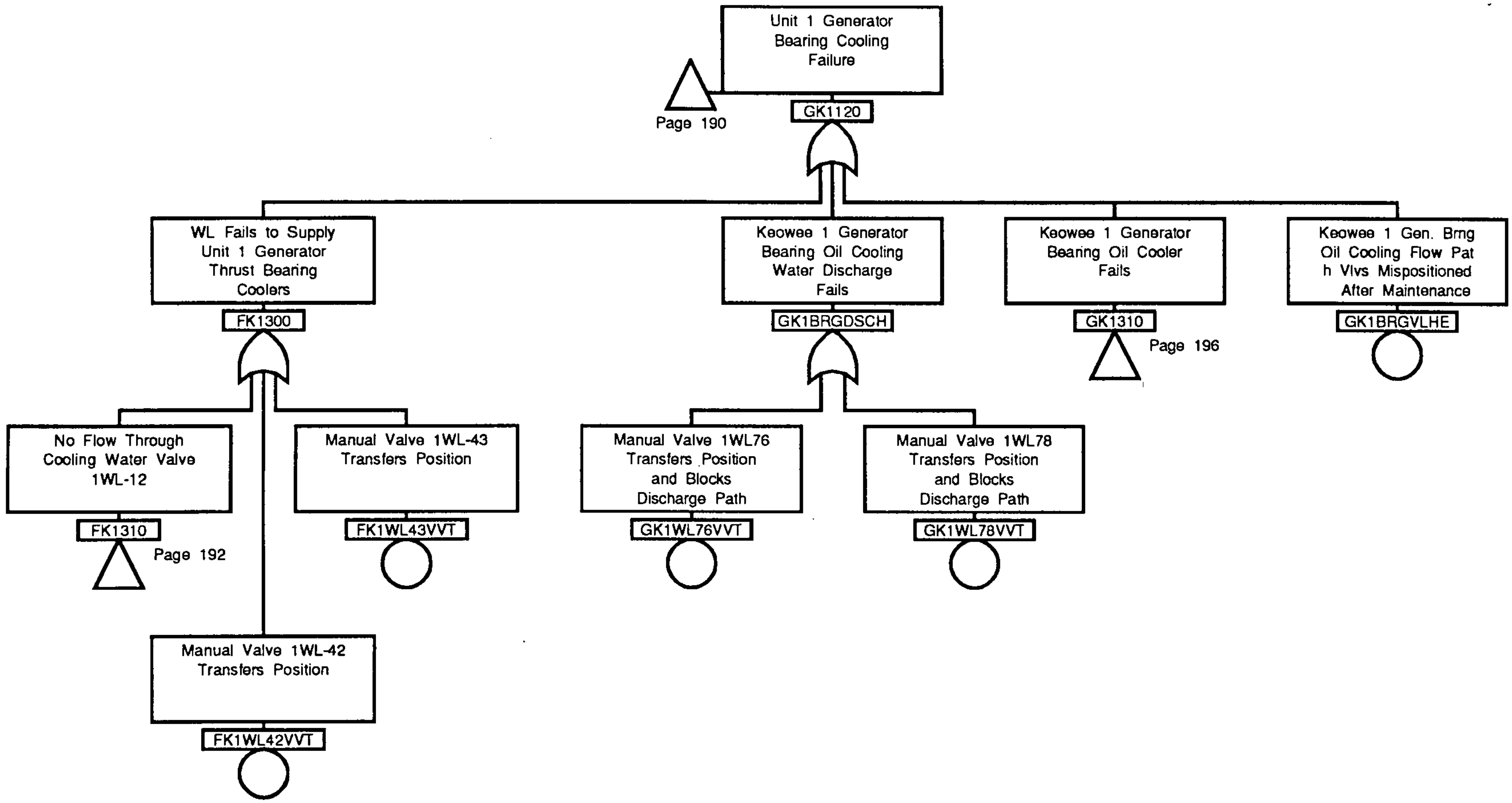
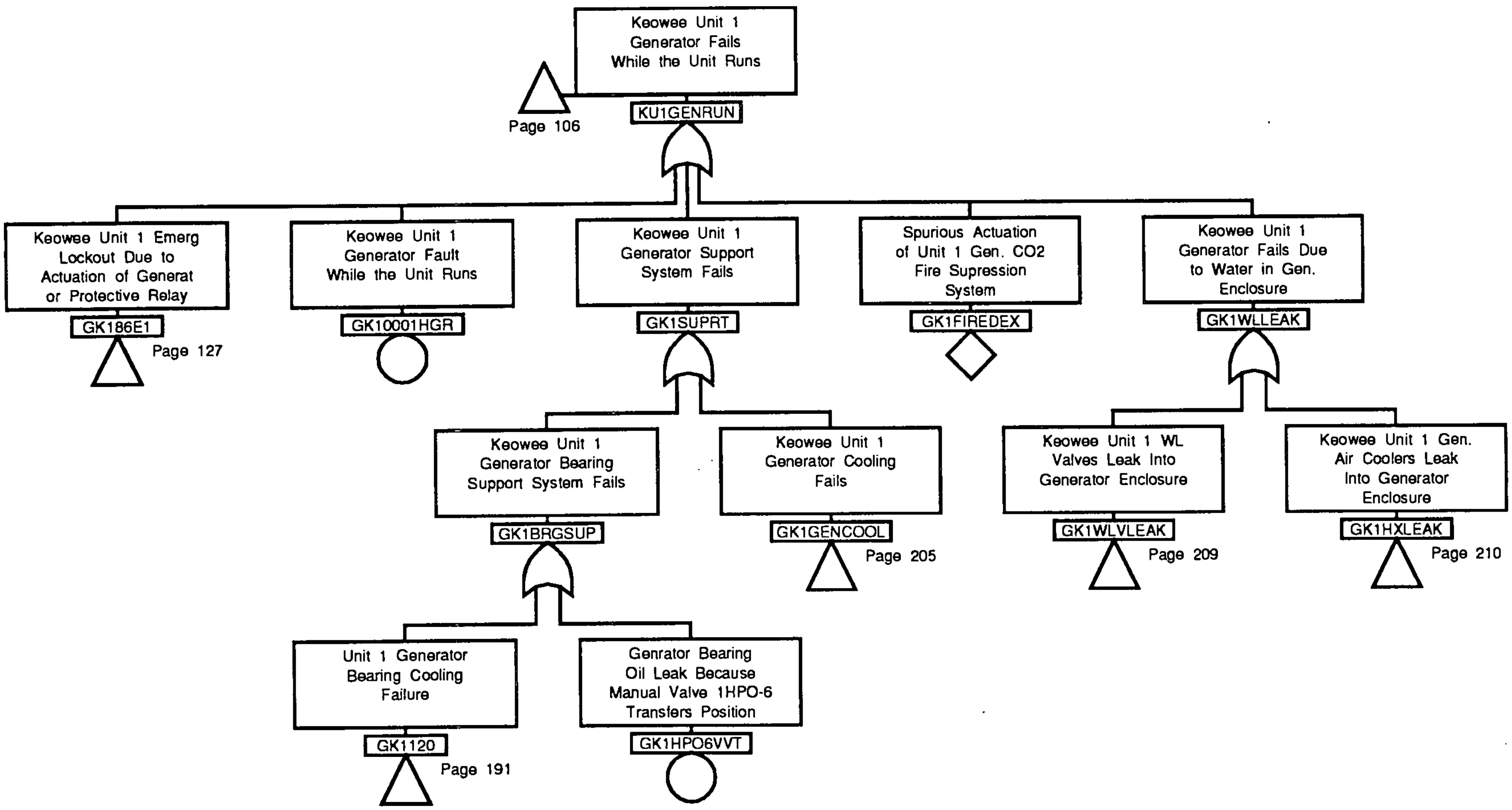
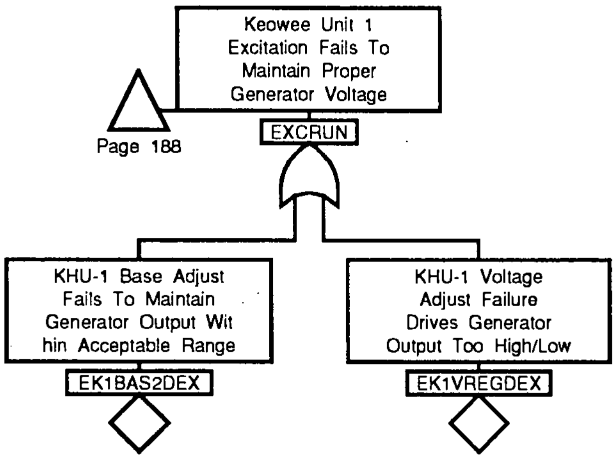
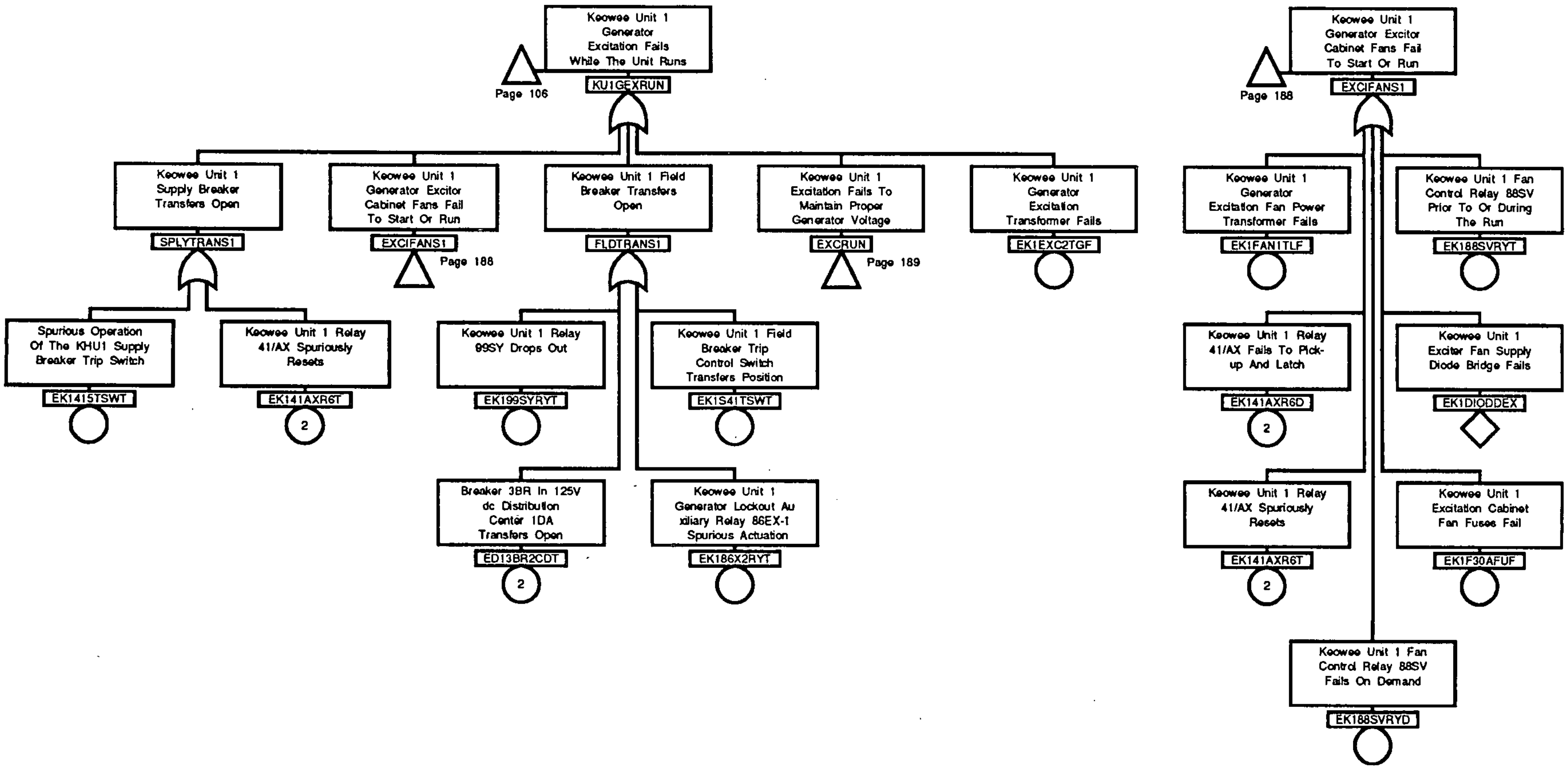
Page 205
No Flow Through Cooling Water Filter 1WLFL-1
FK1120
Page 187
Cooling Water Control Valve 1WL-11 Fails Closed
FK1500
Manual Valve 1WL-12 Transfers Position
FK1WL12VVT
Cooling Water Control Valve 1WL-11 Fails To Open On Demand
FK1WL11AVO
Cooling Water Control Valve 1WL-11 Transfers Closed
FK1WL11AVT
Solenoid Valve 1SV-1 Not Commanded to De-energize
FK1510
Unit 1 Control Switch S120G or Master Relay 4B Fails to Operate
FK1520
Page 193
Unit 1 Oil Pump Aux. Relay 88X or Rotation Sensing Aux. Relay 14DX Fail
FK1530
Page 194

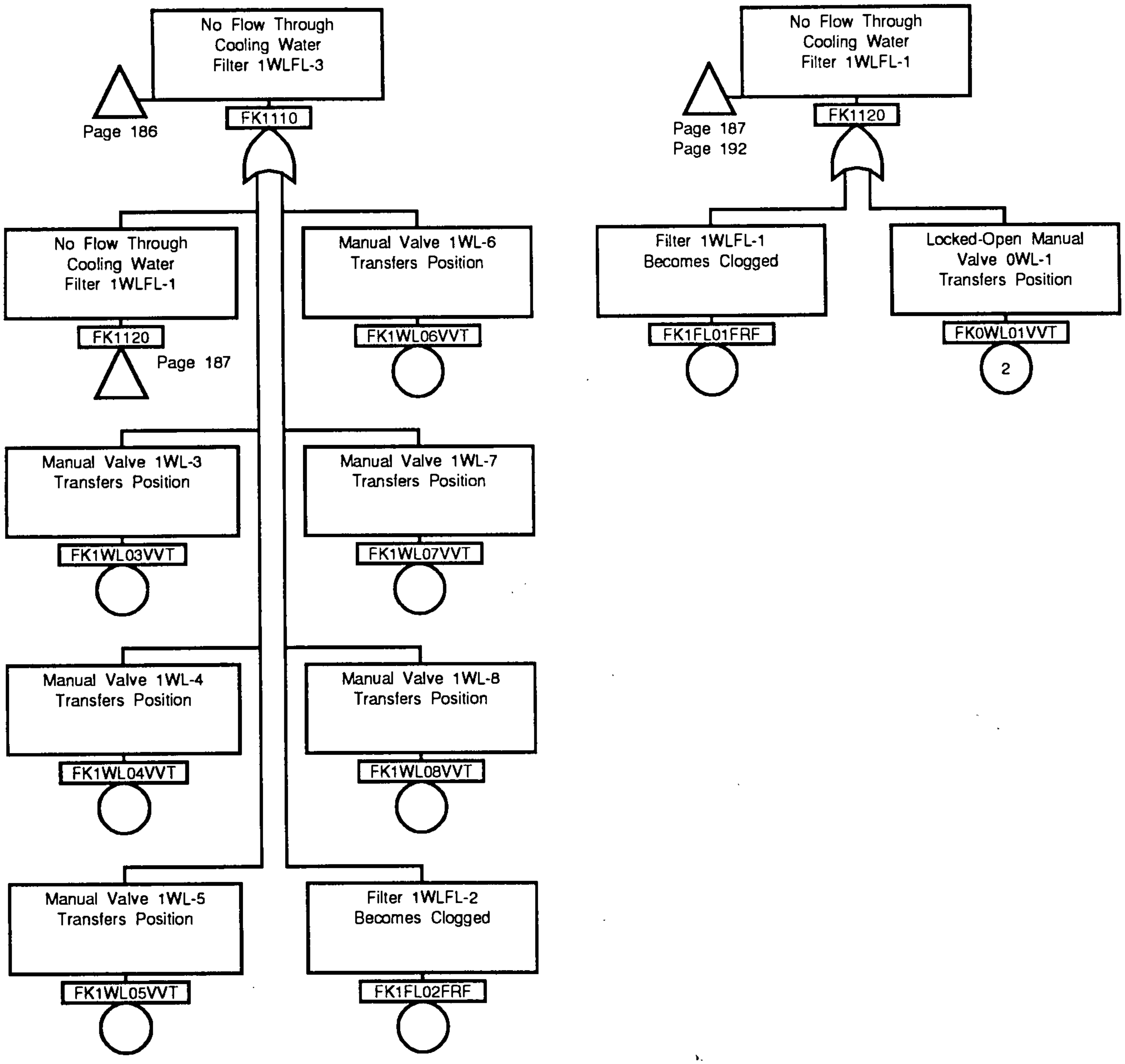

Unit 1 Generator Bearing Cooling Failure
GK1120
Page 190
WL Fails to Supply Unit 1 Generator Thrust Bearing Coolers
FK1300
Keowee 1 Generator Bearing Oil Cooling Water Discharge Fails
GK1BRGDSCH
Keowee 1 Generator Bearing Oil Cooler Fails
GK1310
Page 196
Keowee 1 Gen. Brng Oil Cooling Flow Pat h Vlvs Mispositioned After Maintenance
GK1BRGVLHE
No Flow Through Cooling Water Valve 1WL-12
FK1310
Page 192
Manual Valve 1WL-43 Transfers Position
FK1WL43VVT
Manual Valve 1WL76 Transfers Position and Blocks Discharge Path
GK1WL76VVT
Manual Valve 1WL78 Transfers Position and Blocks Discharge Path
GK1WL78VVT
Manual Valve 1WL-42 Transfers Position
FK1WL42VVT



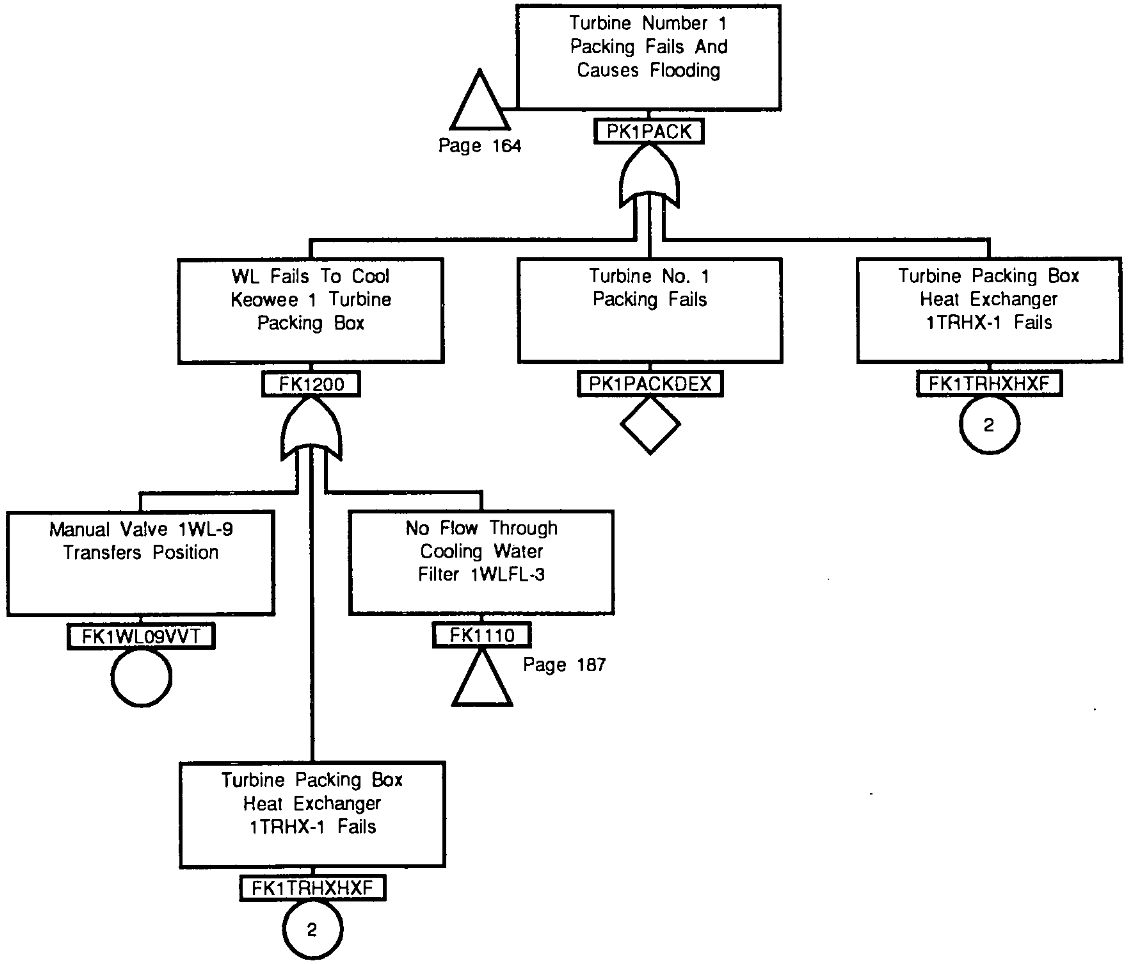
Keowee Unit 1 Generator Fails While the Unit Runs
KU1GENRUN
Page 106
Keowee Unit 1 Emerg Lockout Due to Actuation of Generat or Protective Relay
GK186E1
Page 127
Keowee Unit 1 Generator Fault While the Unit Runs
GK10001HGR
Keowee Unit 1 Generator Support System Fails
GK1SUPRT
Spurious Actuation of Unit 1 Gen. CO2 Fire Supression System
GK1FIREDEX
Keowee Unit 1 Generator Fails Due to Water in Gen. Enclosure
GK1WLLEAK
Keowee Unit 1 Generator Bearing Support System Fails
GK1BRGSUP
Keowee Unit 1 Generator Cooling Fails
GK1GENCOOL
Page 205
Keowee Unit 1 WL Valves Leak Into Generator Enclosure
GK1WLVLEAK
Page 209
Keowee Unit 1 Gen. Air Coolers Leak Into Generator Enclosure
GK1HXLEAK
Page 210
Unit 1 Generator Bearing Cooling Failure
GK1120
Page 191
Genrator Bearing Oil Leak Because Manual Valve 1HPO-6 Transfers Position
GK1HPO6VVT

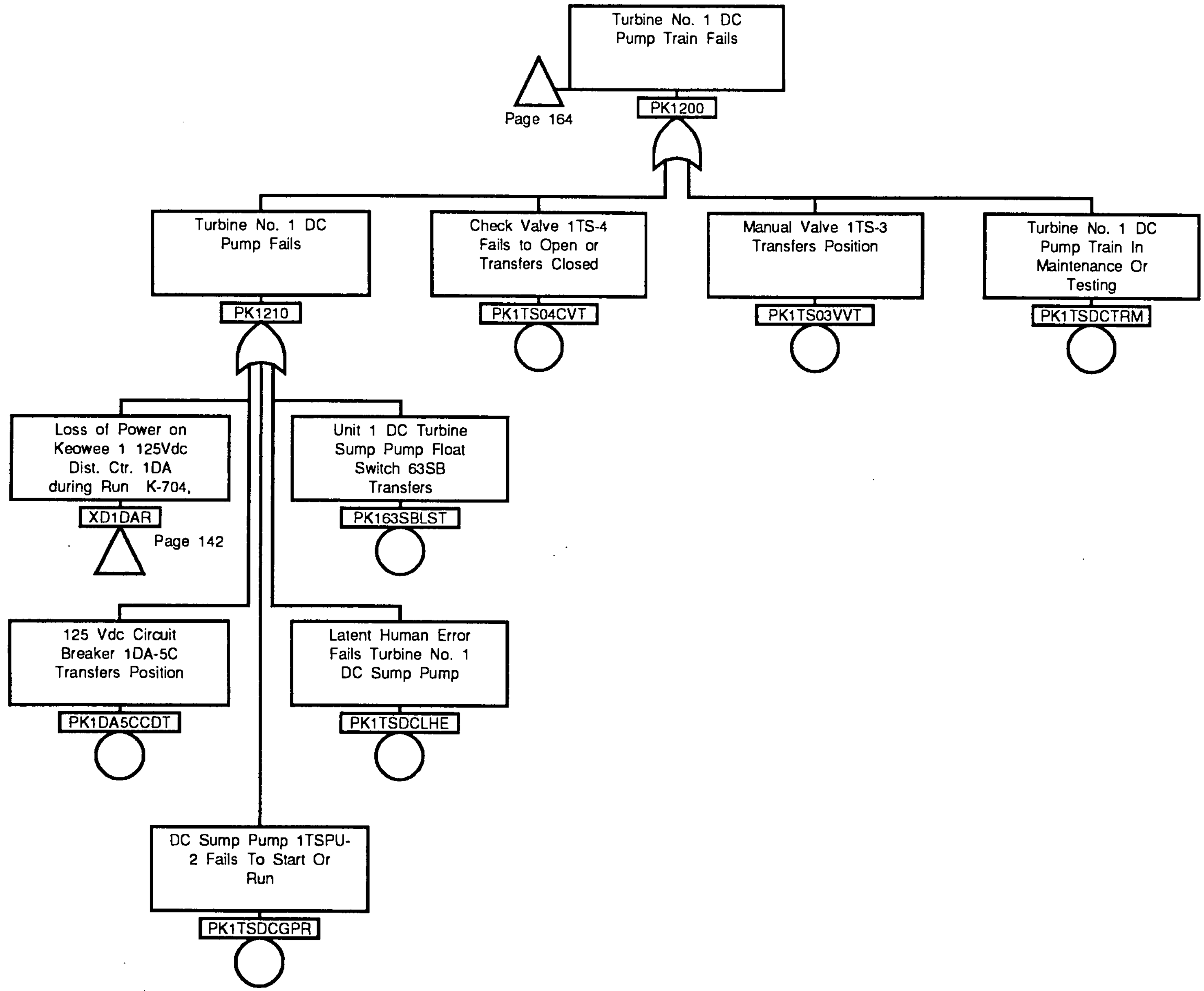

Keowee Unit 1 Excitation Fails To Maintain Proper Generator Voltage
EXCRUN
Page 188
KHU-1 Base Adjust Fails To Maintain Generator Output Wit hin Acceptable Range
EK1BAS2DEX
KHU-1 Voltage Adjust Failure Drives Generator Output Too High/Low
EK1VREGDEX


Keowee Unit 1 Generator Excitation Fails While The Unit Runs
KU1GEXRUN
Page 106
Keowee Unit 1 Supply Breaker Transfers Open
SPLYTRANS1
Keowee Unit 1 Generator Excitor Cabinet Fans Fail To Start Or Run
EXCIFANS1
Page 188
Keowee Unit 1 Field Breaker Transfers Open
FLDTRANS1
Keowee Unit 1 Excitation Fails To Maintain Proper Generator Voltage
EXCRUN
Page 189
Keowee Unit 1 Generator Excitation Transformer Fails
EK1EXC2TGF
Spurious Operation Of The KHU1 Supply Breaker Trip Switch
EK1415TSWT
Keowee Unit 1 Relay 41/AX Spuriously Resets
EK141AXR6T
2
Keowee Unit 1 Relay 99SY Drops Out
EK199SYRYT
Keowee Unit 1 Field Breaker Trip Control Switch Transfers Position
EK1S41TSWT
Breaker 3BR In 125V dc Distribution Center 1DA Transfers Open
ED13BR2CDT
2
Keowee Unit 1 Generator Lockout Au xiliary Relay 86EX-1 Spurious Actuation
EK186X2RYT
Keowee Unit 1 Generator Excitor Cabinet Fans Fail To Start Or Run
EXCIFANS1
Page 188
Keowee Unit 1 Generator Excitation Fan Power Transformer Fails
EK1FAN1TLF
Keowee Unit 1 Fan Control Relay 88SV Prior To Or During The Run
EK188SVRYT
Keowee Unit 1 Relay 41/AX Fails To Pick-up And Latch
EK141AXR6D
2
Keowee Unit 1 Exciter Fan Supply Diode Bridge Fails
EK1DIODDEX
Keowee Unit 1 Relay 41/AX Spuriously Resets
EK141AXR6T
2
Keowee Unit 1 Excitation Cabinet Fan Fuses Fail
EK1F30AFUF
Keowee Unit 1 Fan Control Relay 88SV Fails On Demand
EK188SVRYD

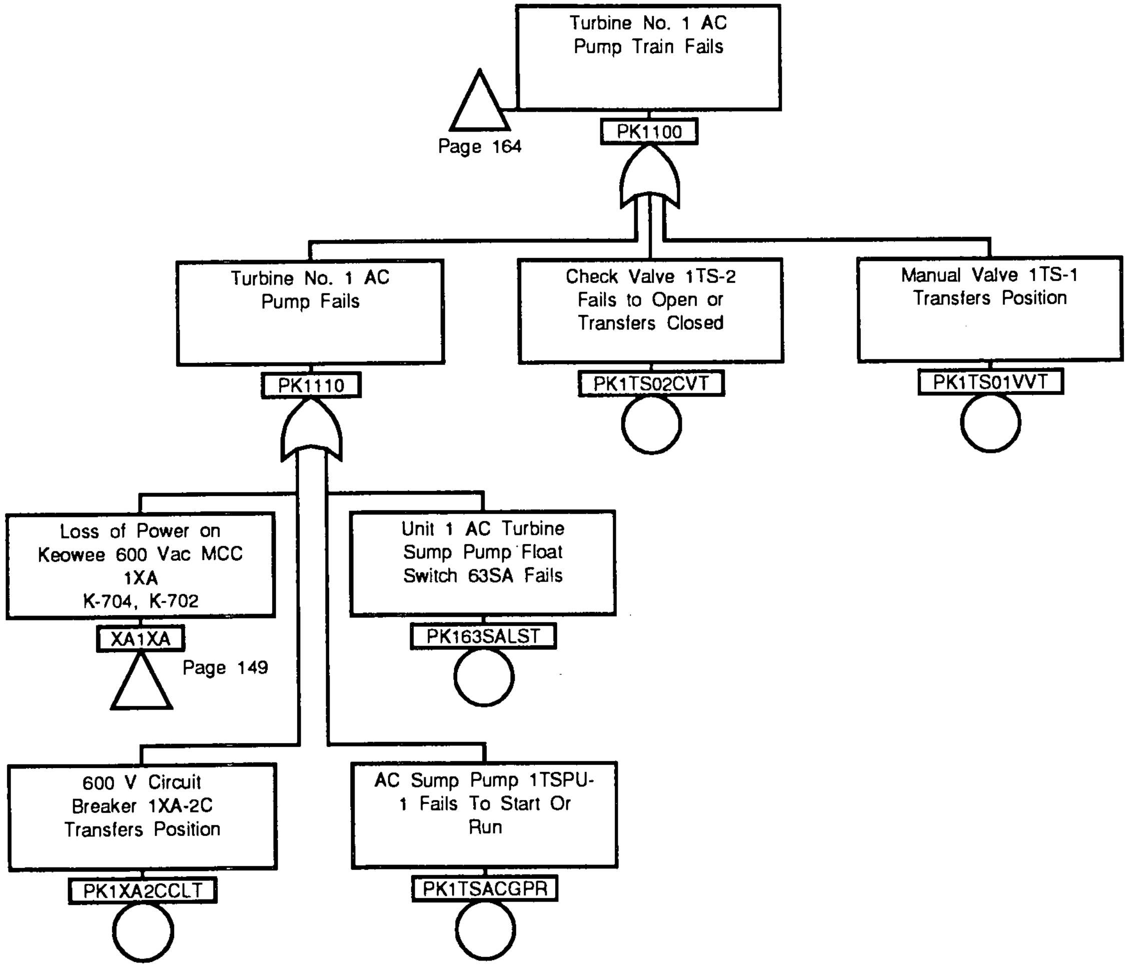


No Flow Through Cooling Water Filter 1WLFL-3
FK1110
Page 186
No Flow Through Cooling Water Filter 1WLFL-1
FK1120
Page 187
Manual Valve 1WL-6 Transfers Position
FK1WL06VVT
Manual Valve 1WL-3 Transfers Position
FK1WL03VVT
Manual Valve 1WL-7 Transfers Position
FK1WL07VVT
Manual Valve 1WL-4 Transfers Position
FK1WL04VVT
Manual Valve 1WL-8 Transfers Position
FK1WL08VVT
Manual Valve 1WL-5 Transfers Position
FK1WL05VVT
Filter 1WLFL-2 Becomes Clogged
FK1FL02FRF
No Flow Through Cooling Water Filter 1WLFL-1
FK1120
Page 187
Page 192
Filter 1WLFL-1 Becomes Clogged
FK1FL01FRF
Locked-Open Manual Valve 0WL-1 Transfers Position
FK0WL01VVT
2

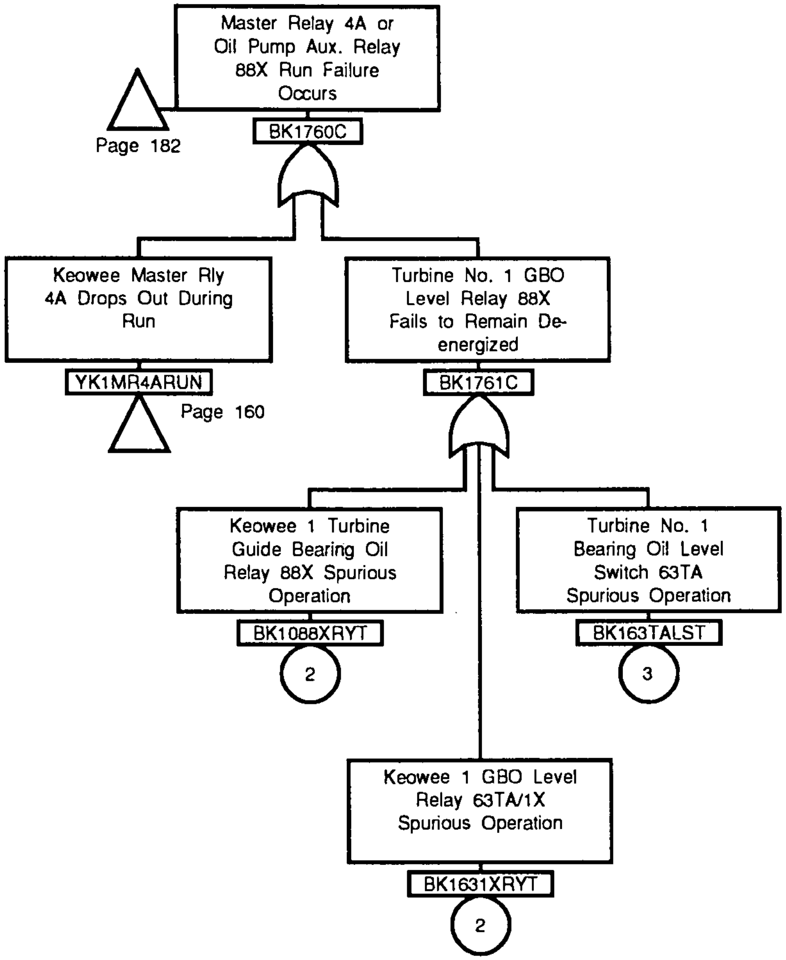

Turbine Number 1
Packing Fails And
Causes Flooding
PK1PACK
Page 164
WL Fails To Cool
Keowee 1 Turbine
Packing Box
FK1200
Turbine No. 1
Packing Fails
PK1PACKDEX
Turbine Packing Box
Heat Exchanger
1TRHX-1 Fails
FK1TRHXHXF
2
Manual Valve 1WL-9
Transfers Position
FK1WL09VVT
No Flow Through
Cooling Water
Filter 1WLFL-3
FK1110
Page 187
Turbine Packing Box
Heat Exchanger
1TRHX-1 Fails
FK1TRHXHXF
2

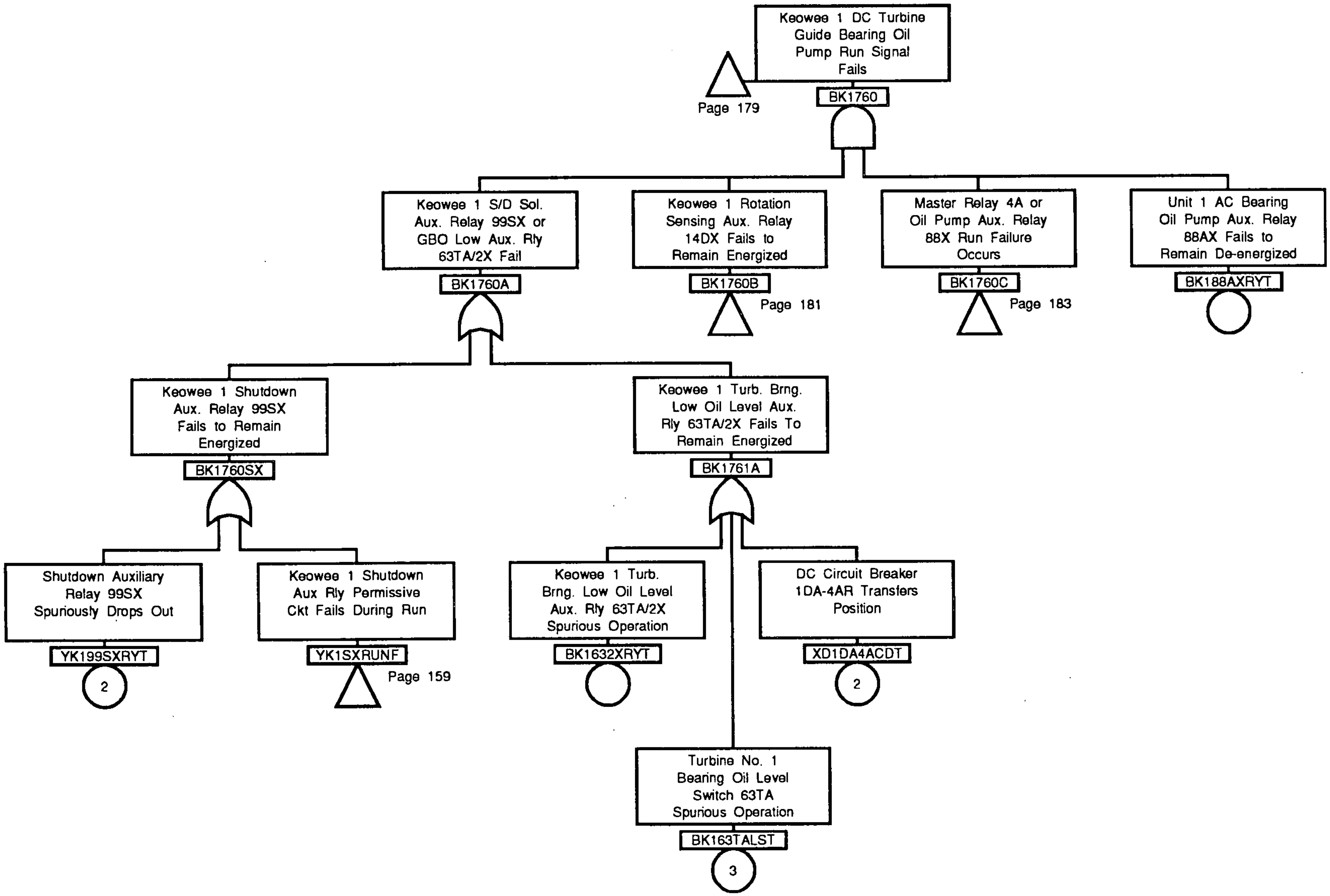


Turbine No. 1 DC Pump Train Fails
PK1200
Page 164
Turbine No. 1 DC Pump Fails
PK1210
Check Valve 1TS-4 Fails to Open or Transfers Closed
PK1TS04CVT
Manual Valve 1TS-3 Transfers Position
PK1TS03VVT
Turbine No. 1 DC Pump Train In Maintenance Or Testing
PK1TSDCTRM
Loss of Power on Keowee 1 125Vdc Dist. Ctr. 1DA during Run K-704,
XD1DAR
Page 142
Unit 1 DC Turbine Sump Pump Float Switch 63SB Transfers
PK163SBLST
125 Vdc Circuit Breaker 1DA-5C Transfers Position
PK1DA5CCDT
Latent Human Error Fails Turbine No. 1 DC Sump Pump
PK1TSDCLHE
DC Sump Pump 1TSPU-2 Fails To Start Or Run
PK1TSDCGPR

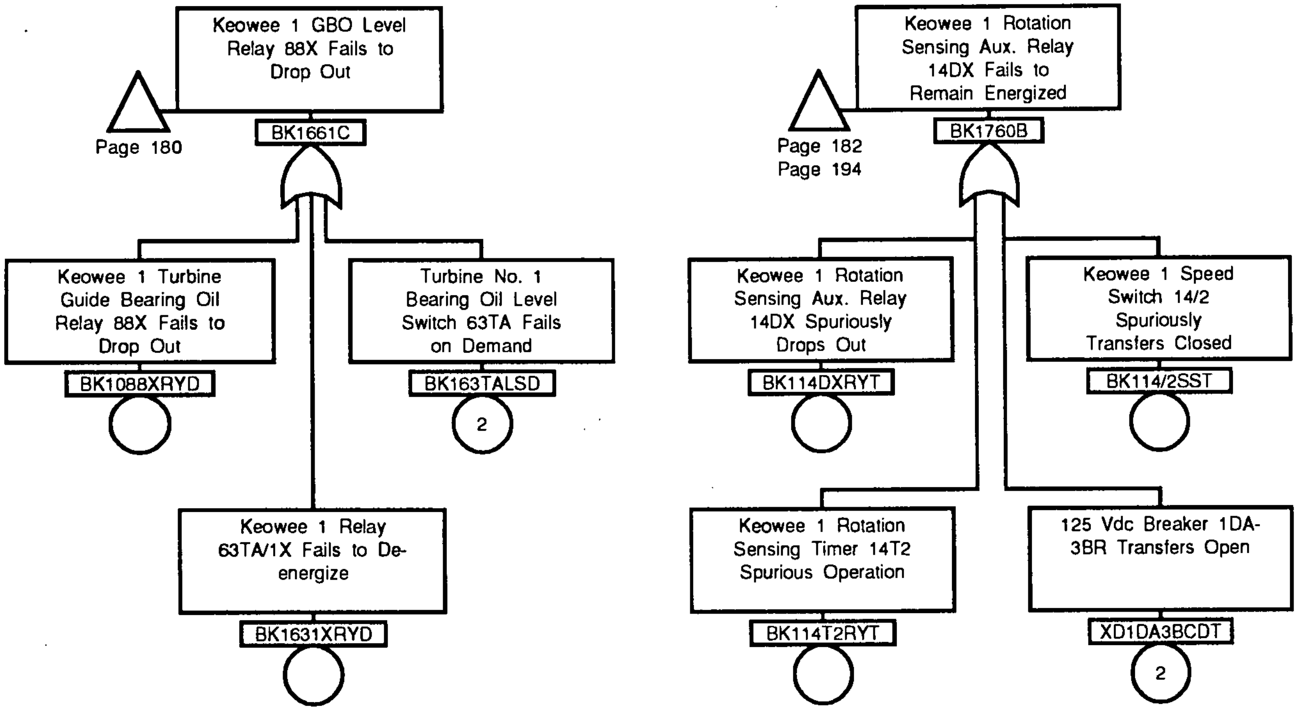


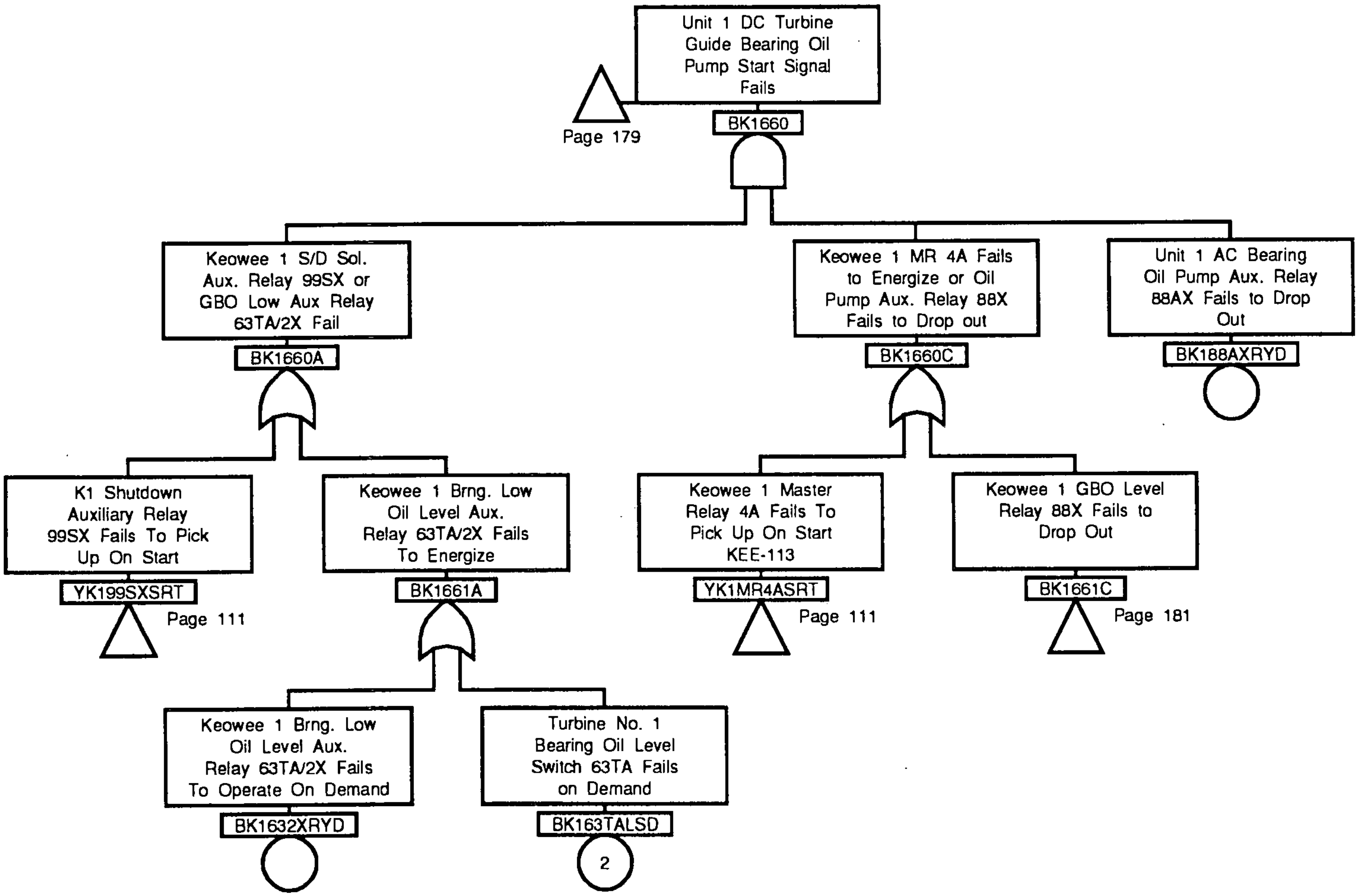
Turbine No. 1 AC Pump Train Fails
PK1100
Page 164
Turbine No. 1 AC Pump Fails
PK1110
Check Valve 1TS-2 Fails to Open or Transfers Closed
PK1TS02CVT
Manual Valve 1TS-1 Transfers Position
PK1TS01VVT
Loss of Power on Keowee 600 Vac MCC 1XA K-704, K-702
XA1XA
Page 149
Unit 1 AC Turbine Sump Pump Float Switch 63SA Fails
PK163SALST
600 V Circuit Breaker 1XA-2C Transfers Position
PK1XA2CCLT
AC Sump Pump 1TSPU-1 Fails To Start Or Run
PK1TSACGPR


Master Relay 4A or Oil Pump Aux. Relay 88X Run Failure Occurs
BK1760C
Page 182
Keowee Master Rly 4A Drops Out During Run
YK1MR4ARUN
Page 160
Turbine No. 1 GBO Level Relay 88X Fails to Remain De-energized
BK1761C
Keowee 1 Turbine Guide Bearing Oil Relay 88X Spurious Operation
BK1088XRYT
2
Turbine No. 1 Bearing Oil Level Switch 63TA Spurious Operation
BK163TALST
3
Keowee 1 GBO Level Relay 63TA/1X Spurious Operation
BK1631XRYT
2

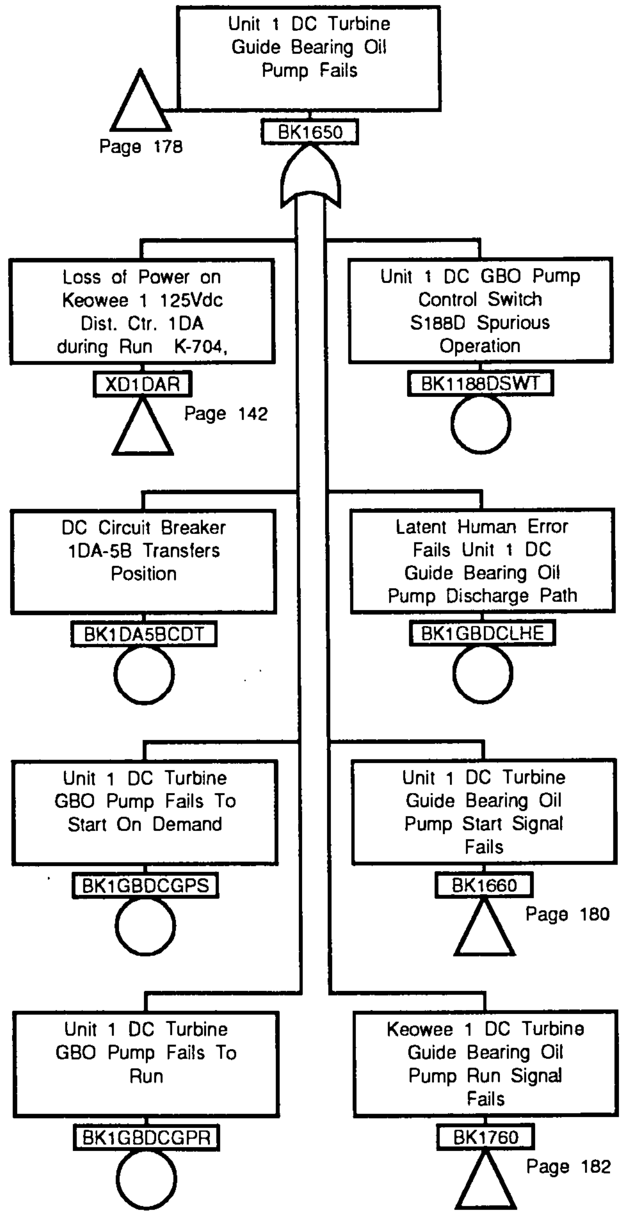


Keowee 1 DC Turbine Guide Bearing Oil Pump Run Signal Fails
BK1760
Page 179
Keowee 1 S/D Sol. Aux. Relay 99SX or GBO Low Aux. Rly 63TA/2X Fail
BK1760A
Keowee 1 Rotation Sensing Aux. Relay 14DX Fails to Remain Energized
BK1760B
Page 181
Master Relay 4A or Oil Pump Aux. Relay 88X Run Failure Occurs
BK1760C
Page 183
Unit 1 AC Bearing Oil Pump Aux. Relay 88AX Fails to Remain De-energized
BK188AXRYT
Keowee 1 Shutdown Aux. Relay 99SX Fails to Remain Energized
BK1760SX
Keowee 1 Turb. Brng. Low Oil Level Aux. Rly 63TA/2X Fails To Remain Energized
BK1761A
Shutdown Auxiliary Relay 99SX Spuriously Drops Out
YK199SXRYT
2
Keowee 1 Shutdown Aux Rly Permissive Ckt Fails During Run
YK1SXRUNF
Page 159
Keowee 1 Turb. Brng. Low Oil Level Aux. Rly 63TA/2X Spurious Operation
BK1632XRYT
DC Circuit Breaker 1DA-4AR Transfers Position
XD1DA4ACDT
2
Turbine No. 1 Bearing Oil Level Switch 63TA Spurious Operation
BK163TALST
3

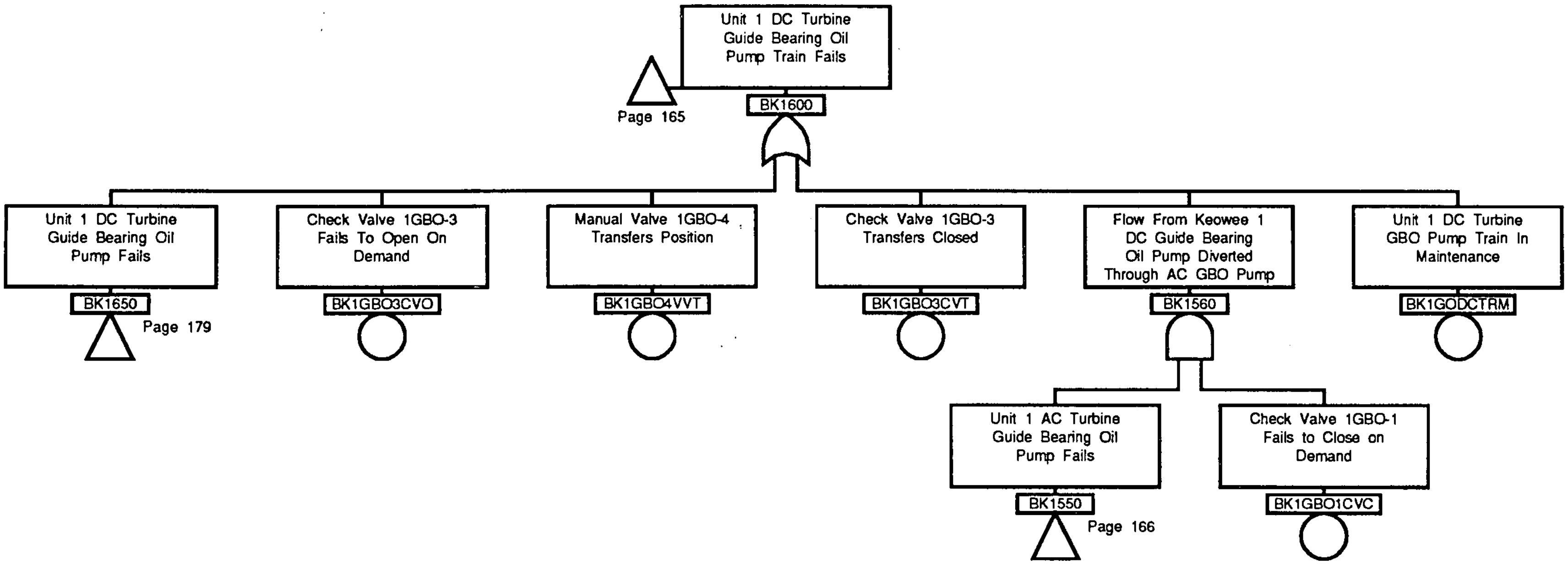

Keowee 1 GBO Level Relay 88X Fails to Drop Out
BK1661C
Page 180
Keowee 1 Turbine Guide Bearing Oil Relay 88X Fails to Drop Out
BK1088XRYD
Turbine No. 1 Bearing Oil Level Switch 63TA Fails on Demand
BK163TALSD
2
Keowee 1 Relay 63TA/1X Fails to De-energize
BK1631XRYD
Keowee 1 Rotation Sensing Aux. Relay 14DX Fails to Remain Energized
BK1760B
Page 182
Page 194
Keowee 1 Rotation Sensing Aux. Relay 14DX Spuriously Drops Out
BK114DXRYT
Keowee 1 Speed Switch 14/2 Spuriously Transfers Closed
BK114/2SST
Keowee 1 Rotation Sensing Timer 14T2 Spurious Operation
BK114T2RYT
125 Vdc Breaker 1DA-3BR Transfers Open
XD1DA3BCDT
2

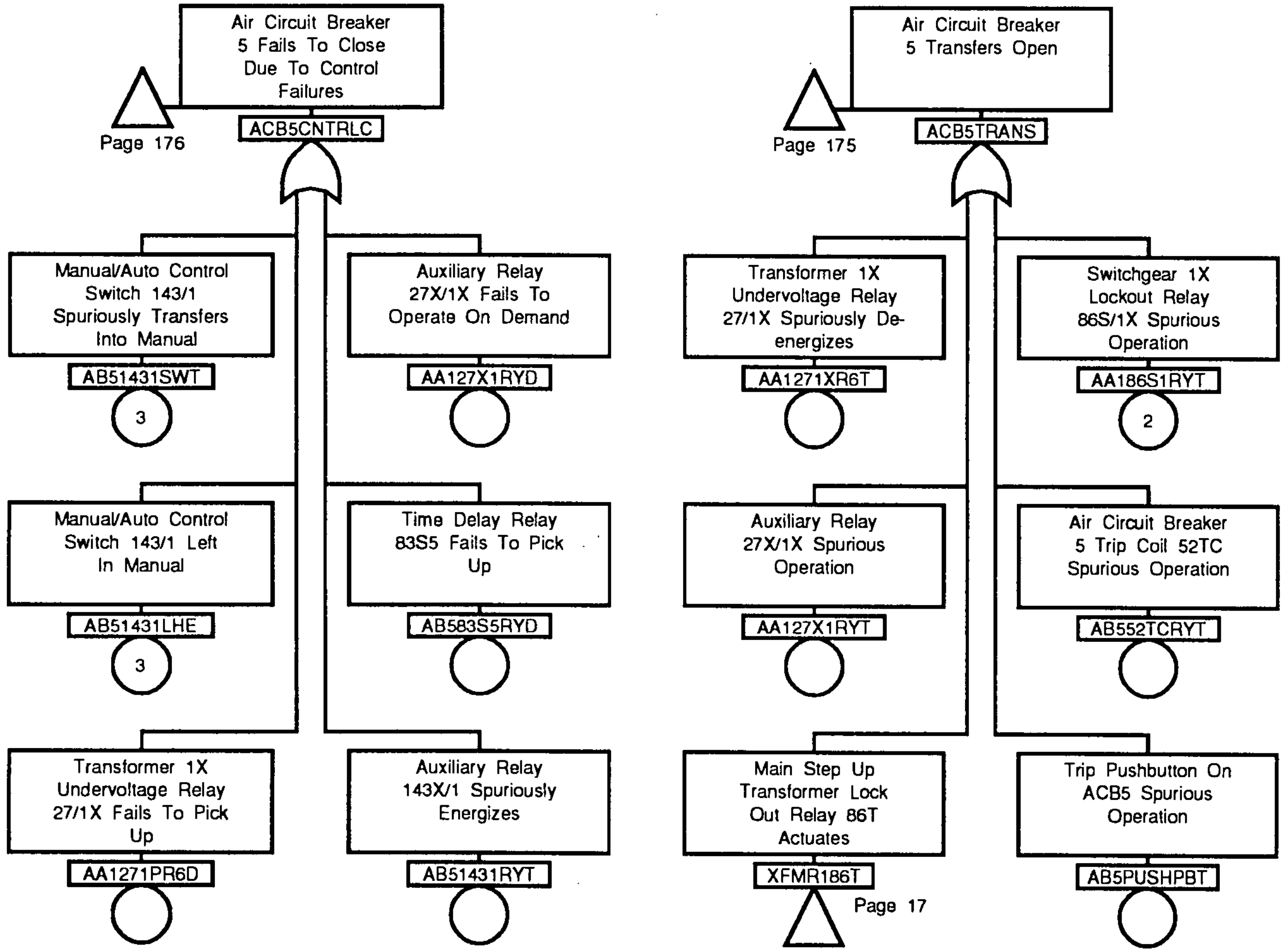


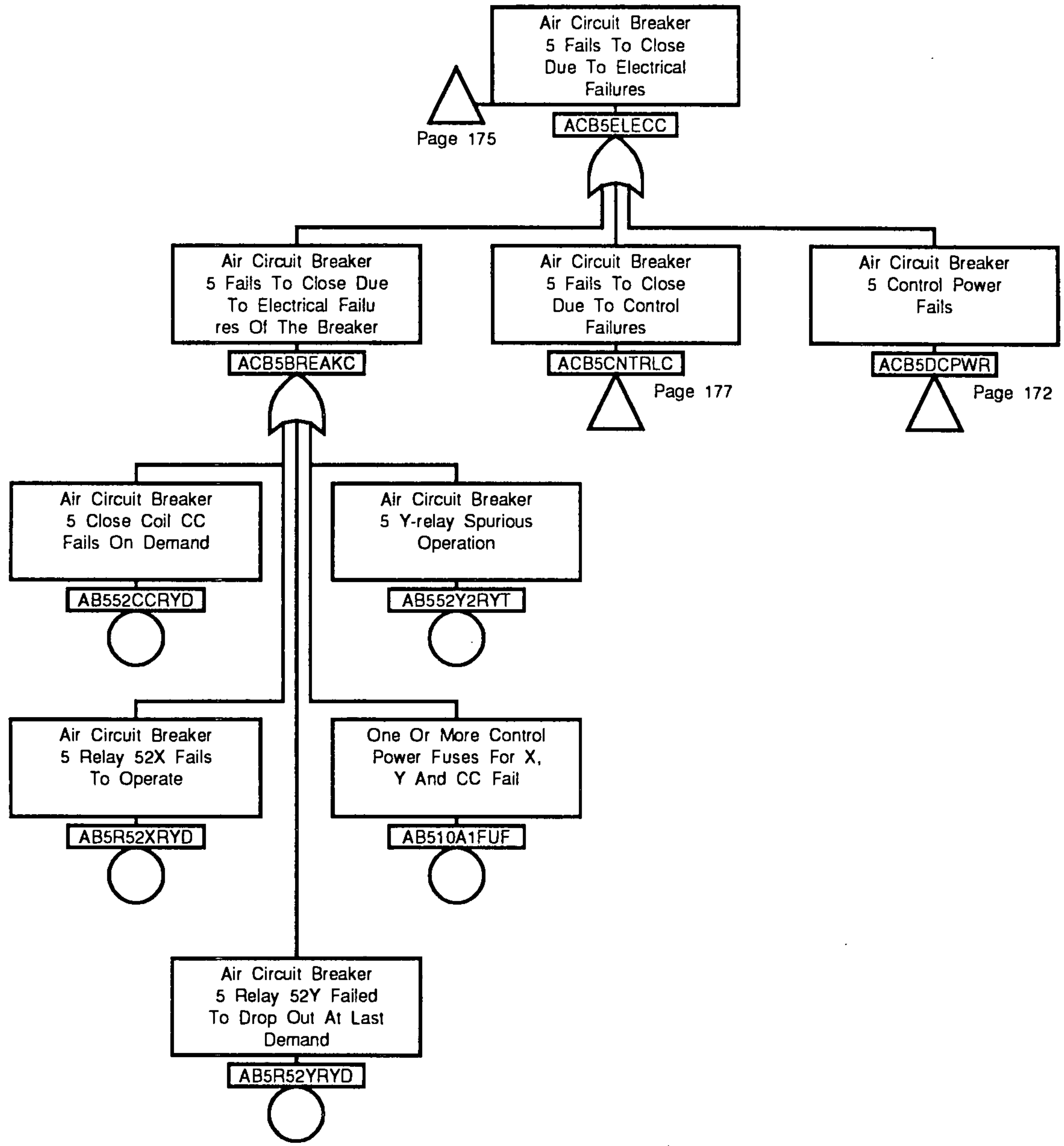
Unit 1 DC Turbine Guide Bearing Oil Pump Start Signal Fails
BK1660
Page 179
Keowee 1 S/D Sol. Aux. Relay 99SX or GBO Low Aux Relay 63TA/2X Fail
BK1660A
Keowee 1 MR 4A Fails to Energize or Oil Pump Aux. Relay 88X Fails to Drop out
BK1660C
Unit 1 AC Bearing Oil Pump Aux. Relay 88AX Fails to Drop Out
BK188AXRYD
K1 Shutdown Auxiliary Relay 99SX Fails To Pick Up On Start
YK199SXSRT
Page 111
Keowee 1 Brng. Low Oil Level Aux. Relay 63TA/2X Fails To Energize
BK1661A
Keowee 1 Master Relay 4A Fails To Pick Up On Start KEE-113
YK1MR4ASRT
Page 111
Keowee 1 GBO Level Relay 88X Fails to Drop Out
BK1661C
Page 181
Keowee 1 Brng. Low Oil Level Aux. Relay 63TA/2X Fails To Operate On Demand
BK1632XRYD
Turbine No. 1 Bearing Oil Level Switch 63TA Fails on Demand
BK163TALSD
2

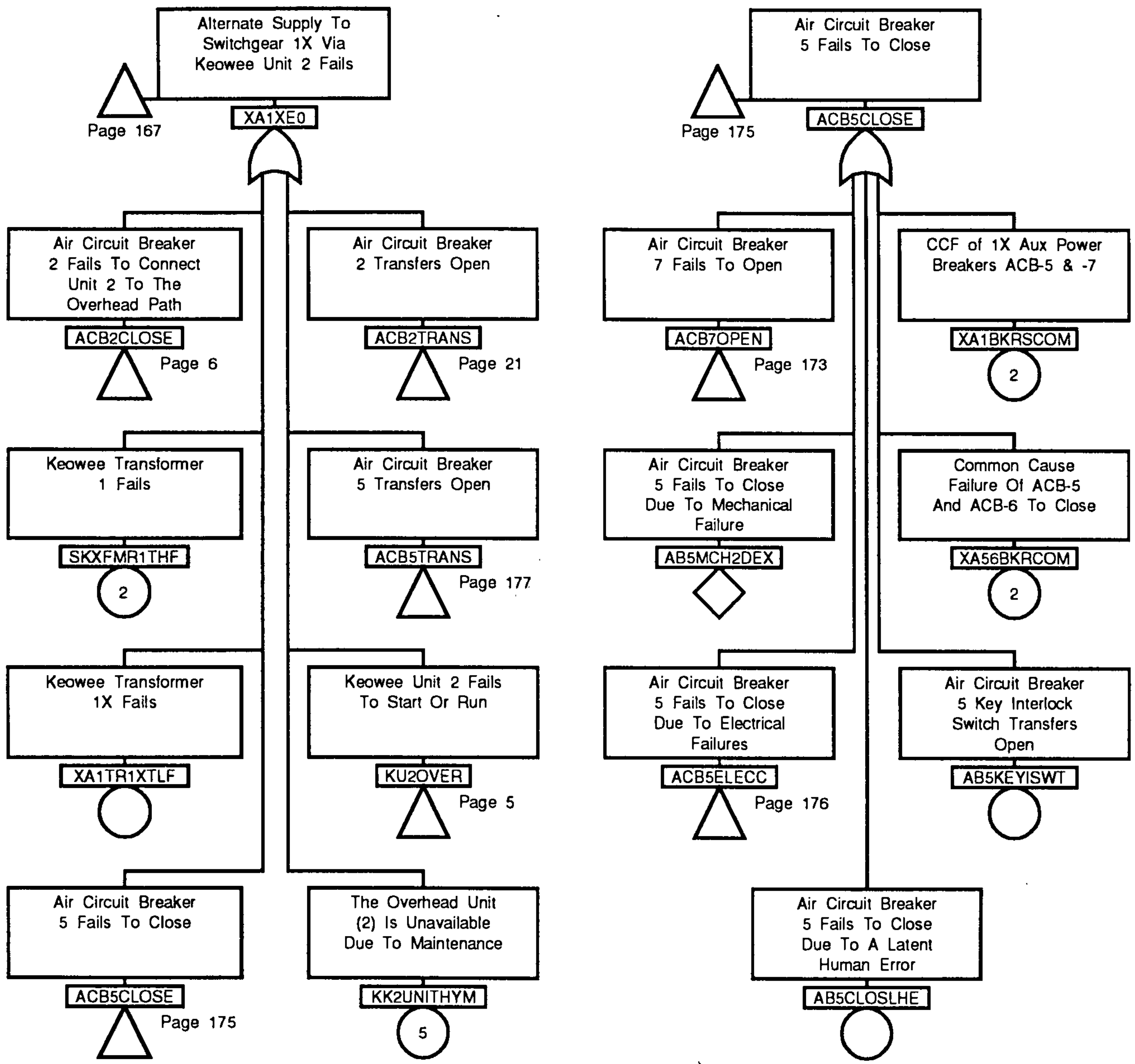


Unit 1 DC Turbine Guide Bearing Oil Pump Fails
Page 178
BK1650
Loss of Power on Keowee 1 125Vdc Dist. Ctr. 1DA during Run K-704,
XD1DAR
Page 142
Unit 1 DC GBO Pump Control Switch S188D Spurious Operation
BK1188DSWT
DC Circuit Breaker 1DA-5B Transfers Position
BK1DA5BCDT
Latent Human Error Fails Unit 1 DC Guide Bearing Oil Pump Discharge Path
BK1GBDCLHE
Unit 1 DC Turbine GBO Pump Fails To Start On Demand
BK1GBDCGPS
Unit 1 DC Turbine Guide Bearing Oil Pump Start Signal Fails
BK1660
Page 180
Unit 1 DC Turbine GBO Pump Fails To Run
BK1GBDCGPR
Keowee 1 DC Turbine Guide Bearing Oil Pump Run Signal Fails
BK1760
Page 182

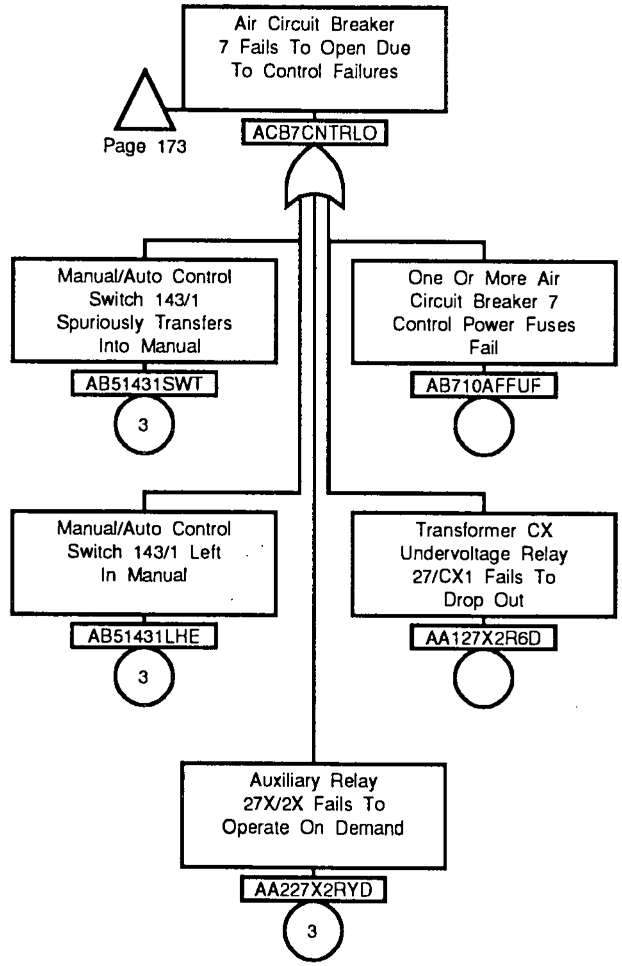

Unit 1 DC Turbine Guide Bearing Oil Pump Train Fails
BK1600
Page 165
Unit 1 DC Turbine Guide Bearing Oil Pump Fails
BK1650
Page 179
Check Valve 1GBO-3 Fails To Open On Demand
BK1GBO3CVO
Manual Valve 1GBO-4 Transfers Position
BK1GBO4VVT
Check Valve 1GBO-3 Transfers Closed
BK1GBO3CVT
Flow From Keowee 1 DC Guide Bearing Oil Pump Diverted Through AC GBO Pump
BK1560
Unit 1 DC Turbine GBO Pump Train In Maintenance
BK1GODCTRM
Unit 1 AC Turbine Guide Bearing Oil Pump Fails
BK1550
Page 166
Check Valve 1GBO-1 Fails to Close on Demand
BK1GBO1CVC

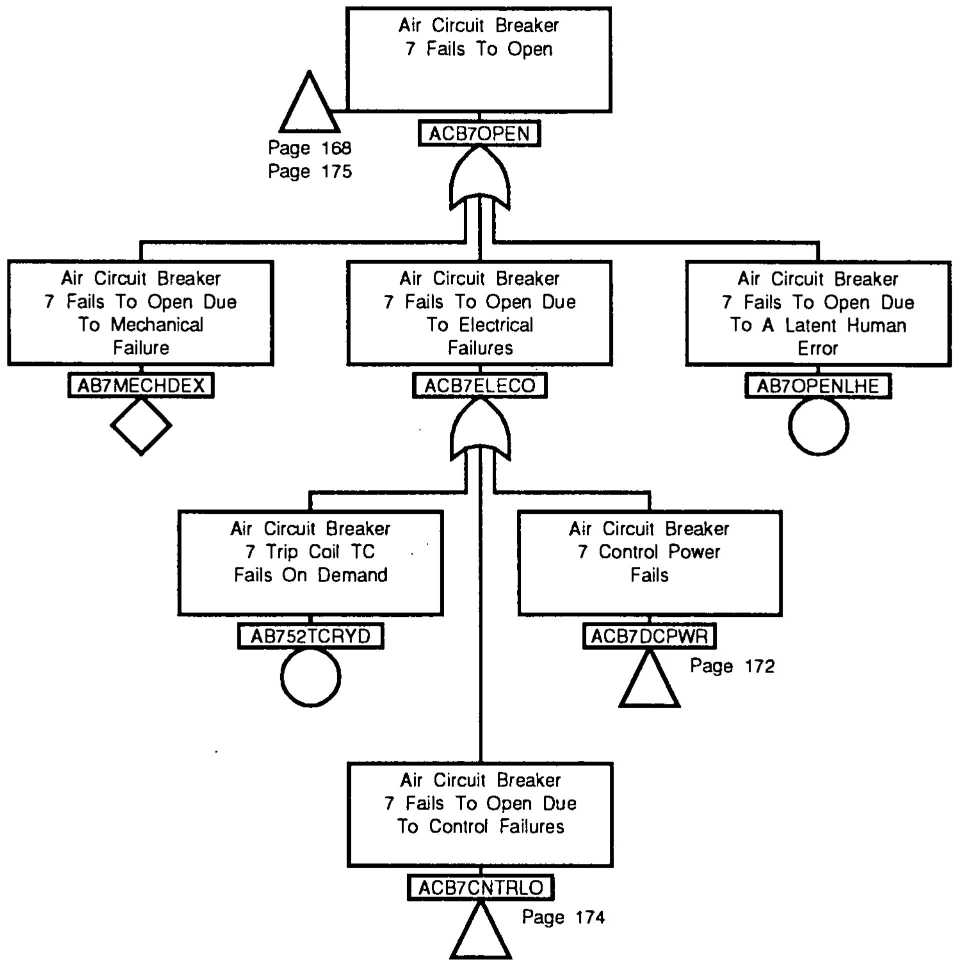

Air Circuit Breaker 5 Fails To Close Due To Control Failures
ACB5CNTRLC
Page 176
Manual/Auto Control Switch 143/1 Spuriously Transfers Into Manual
AB51431SWT
3
Auxiliary Relay 27X/1X Fails To Operate On Demand
AA127X1RYD
Manual/Auto Control Switch 143/1 Left In Manual
AB51431LHE
3
Time Delay Relay 83S5 Fails To Pick Up
AB583S5RYD
Transformer 1X Undervoltage Relay 27/1X Fails To Pick Up
AA1271PR6D
Auxiliary Relay 143X/1 Spuriously Energizes
AB51431RYT
Air Circuit Breaker 5 Transfers Open
ACB5TRANS
Page 175
Transformer 1X Undervoltage Relay 27/1X Spuriously De-energizes
AA1271XR6T
Switchgear 1X Lockout Relay 86S/1X Spurious Operation
AA186S1RYT
2
Auxiliary Relay 27X/1X Spurious Operation
AA127X1RYT
Air Circuit Breaker 5 Trip Coil 52TC Spurious Operation
AB552TCRYT
Main Step Up Transformer Lock Out Relay 86T Actuates
XFMR186T
Page 17
Trip Pushbutton On ACB5 Spurious Operation
AB5PUSHPBT

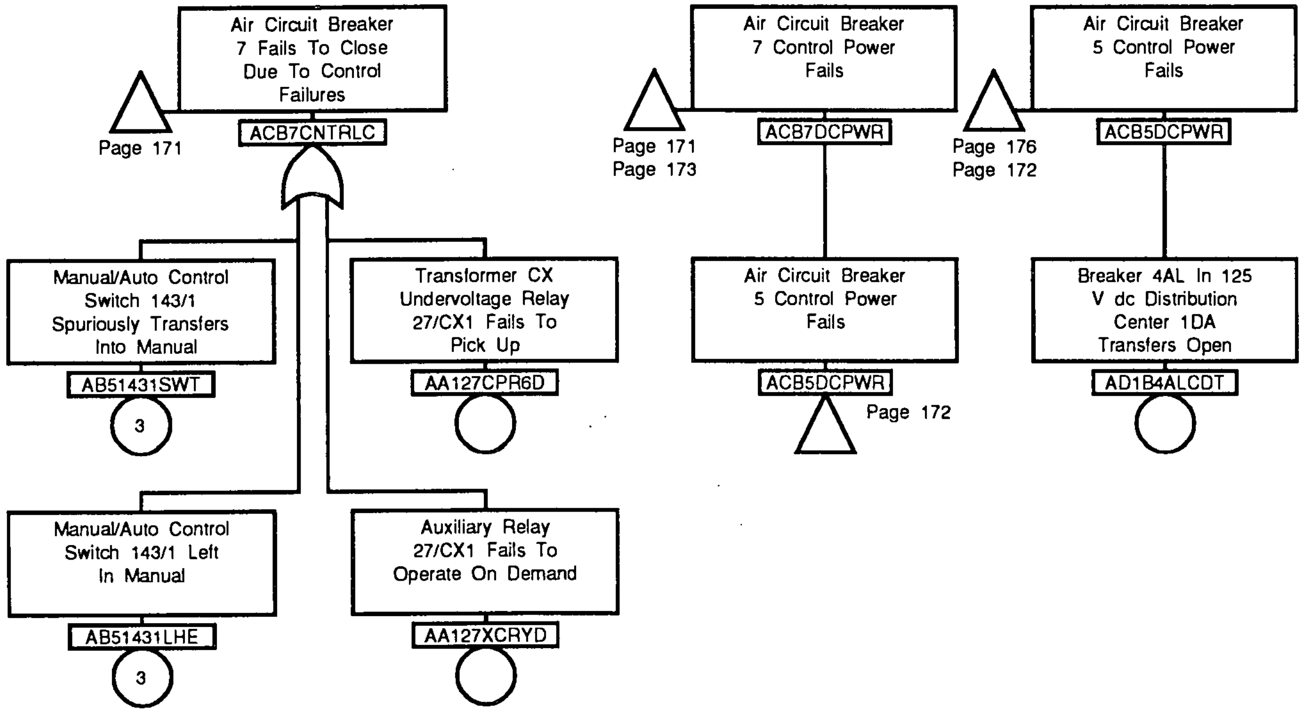

Air Circuit Breaker 5 Fails To Close Due To Electrical Failures
ACB5ELECC
Page 175
Air Circuit Breaker 5 Fails To Close Due To Electrical Failu res Of The Breaker
ACB5BREAKC
Air Circuit Breaker 5 Fails To Close Due To Control Failures
ACB5CNTRLC
Page 177
Air Circuit Breaker 5 Control Power Fails
ACB5DCPWR
Page 172
Air Circuit Breaker 5 Close Coil CC Fails On Demand
AB552CCRYD
Air Circuit Breaker 5 Y-relay Spurious Operation
AB552Y2RYT
Air Circuit Breaker 5 Relay 52X Fails To Operate
AB5R52XRYD
One Or More Control Power Fuses For X, Y And CC Fail
AB510A1FUF
Air Circuit Breaker 5 Relay 52Y Failed To Drop Out At Last Demand
AB5R52YRYD



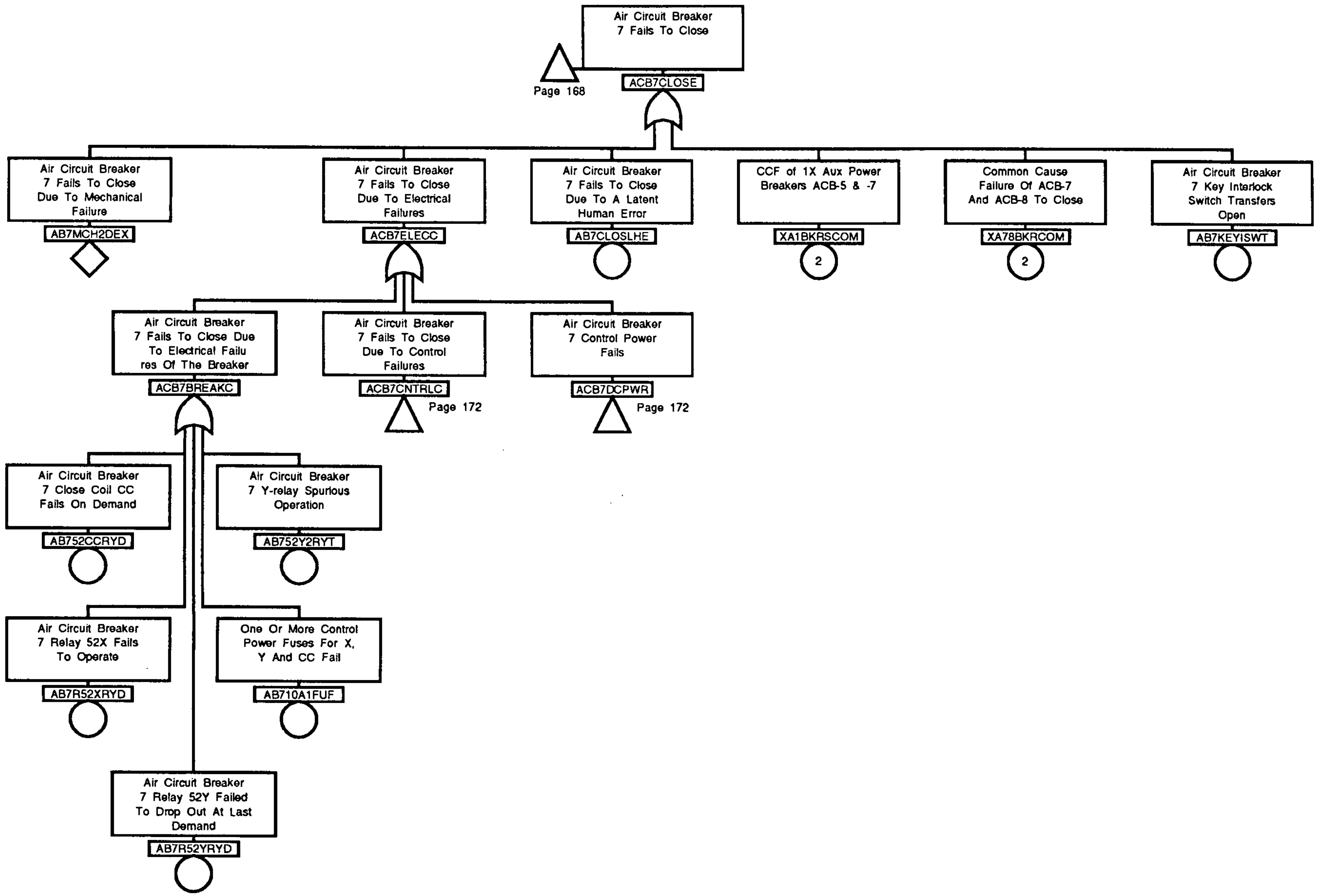
Alternate Supply To Switchgear 1X Via Keowee Unit 2 Fails
XA1XE0
Page 167
Air Circuit Breaker 2 Fails To Connect Unit 2 To The Overhead Path
ACB2CLOSE
Page 6
Air Circuit Breaker 2 Transfers Open
ACB2TRANS
Page 21
Keowee Transformer 1 Fails
SKXFMR1THF
2
Air Circuit Breaker 5 Transfers Open
ACB5TRANS
Page 177
Keowee Transformer 1X Fails
XA1TR1XTLF
Keowee Unit 2 Fails To Start Or Run
KU2OVER
Page 5
Air Circuit Breaker 5 Fails To Close
ACB5CLOSE
Page 175
The Overhead Unit (2) Is Unavailable Due To Maintenance
KK2UNITHYM
5
Air Circuit Breaker 5 Fails To Close
ACB5CLOSE
Page 175
Air Circuit Breaker 7 Fails To Open
ACB7OPEN
Page 173
CCF of 1X Aux Power Breakers ACB-5 & -7
XA1BKRSCOM
2
Air Circuit Breaker 5 Fails To Close Due To Mechanical Failure
AB5MCH2DEX
Common Cause Failure Of ACB-5 And ACB-6 To Close
XA56BKRCOM
2
Air Circuit Breaker 5 Fails To Close Due To Electrical Failures
ACB5ELECC
Page 176
Air Circuit Breaker 5 Key Interlock Switch Transfers Open
AB5KEYISWT
Air Circuit Breaker 5 Fails To Close Due To A Latent Human Error
AB5CLOSLHE

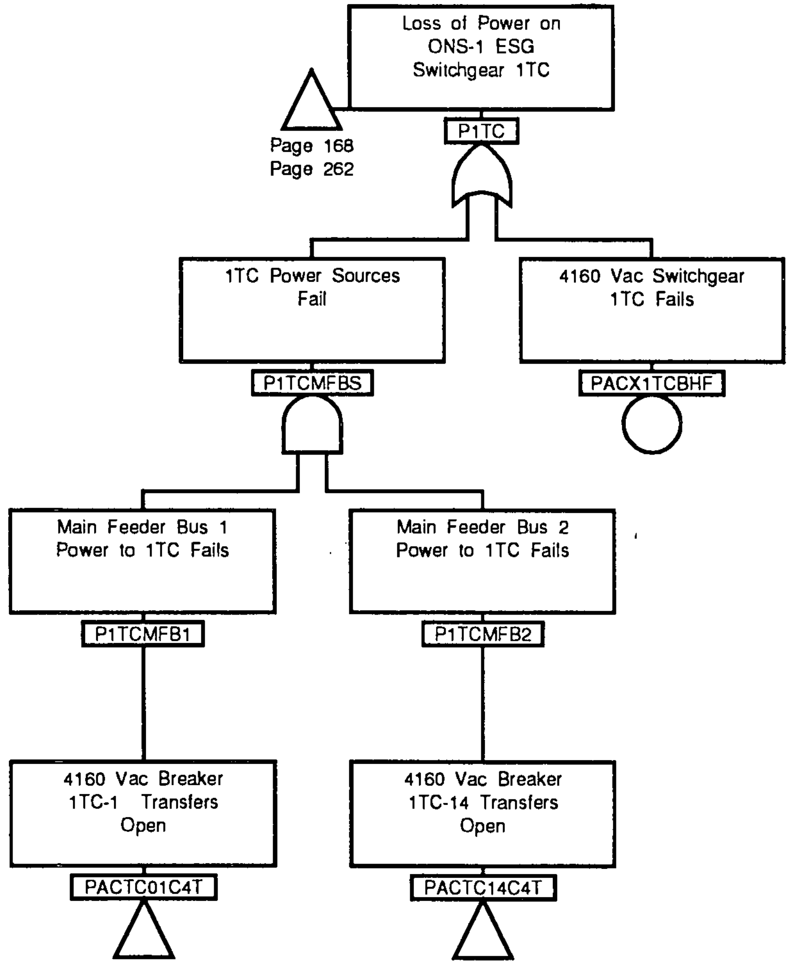

Air Circuit Breaker 7 Fails To Open Due To Control Failures
ACB7CNTRLO
Page 173
Manual/Auto Control Switch 143/1 Spuriously Transfers Into Manual
AB51431SWT
3
One Or More Air Circuit Breaker 7 Control Power Fuses Fail
AB710AFFUF
Manual/Auto Control Switch 143/1 Left In Manual
AB51431LHE
3
Transformer CX Undervoltage Relay 27/CX1 Fails To Drop Out
AA127X2R6D
Auxiliary Relay 27X/2X Fails To Operate On Demand
AA227X2RYD
3

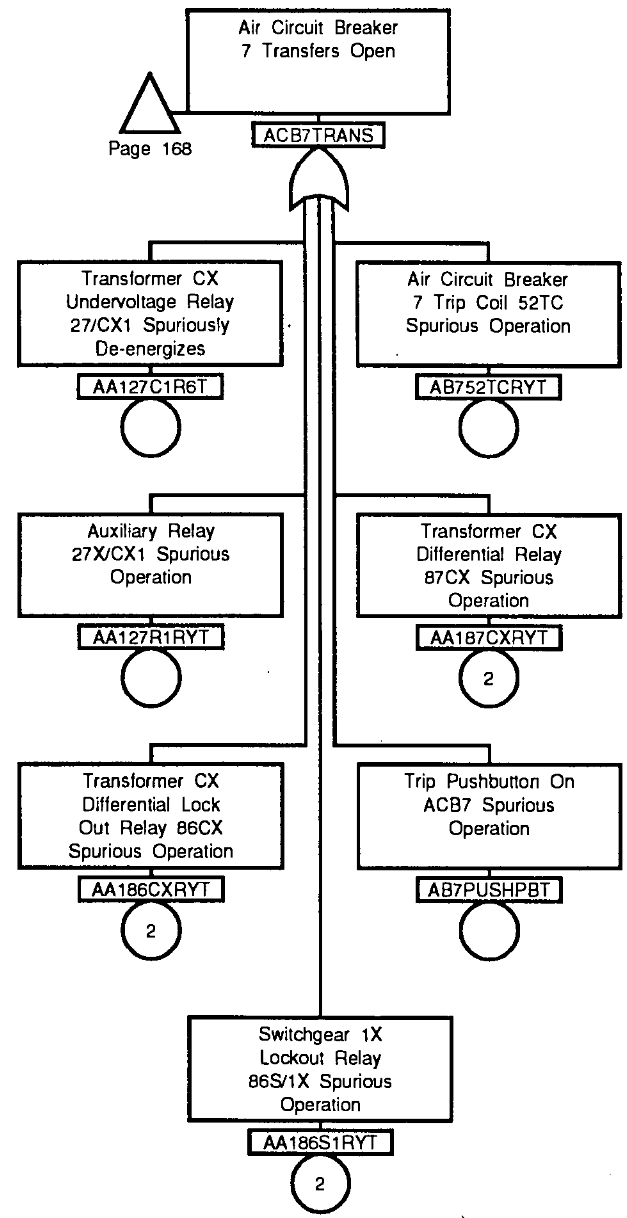

Air Circuit Breaker
7 Fails To Open
ACB7OPEN
Page 168
Page 175
Air Circuit Breaker
7 Fails To Open Due
To Mechanical
Failure
AB7MECHDEX
Air Circuit Breaker
7 Fails To Open Due
To Electrical
Failures
ACB7ELECO
Air Circuit Breaker
7 Fails To Open Due
To A Latent Human
Error
AB7OPENLHE
Air Circuit Breaker
7 Trip Coil TC
Fails On Demand
AB752TCRYD
Air Circuit Breaker
7 Control Power
Fails
ACB7DCPWR
Page 172
Air Circuit Breaker
7 Fails To Open Due
To Control Failures
ACB7CNTRLO
Page 174

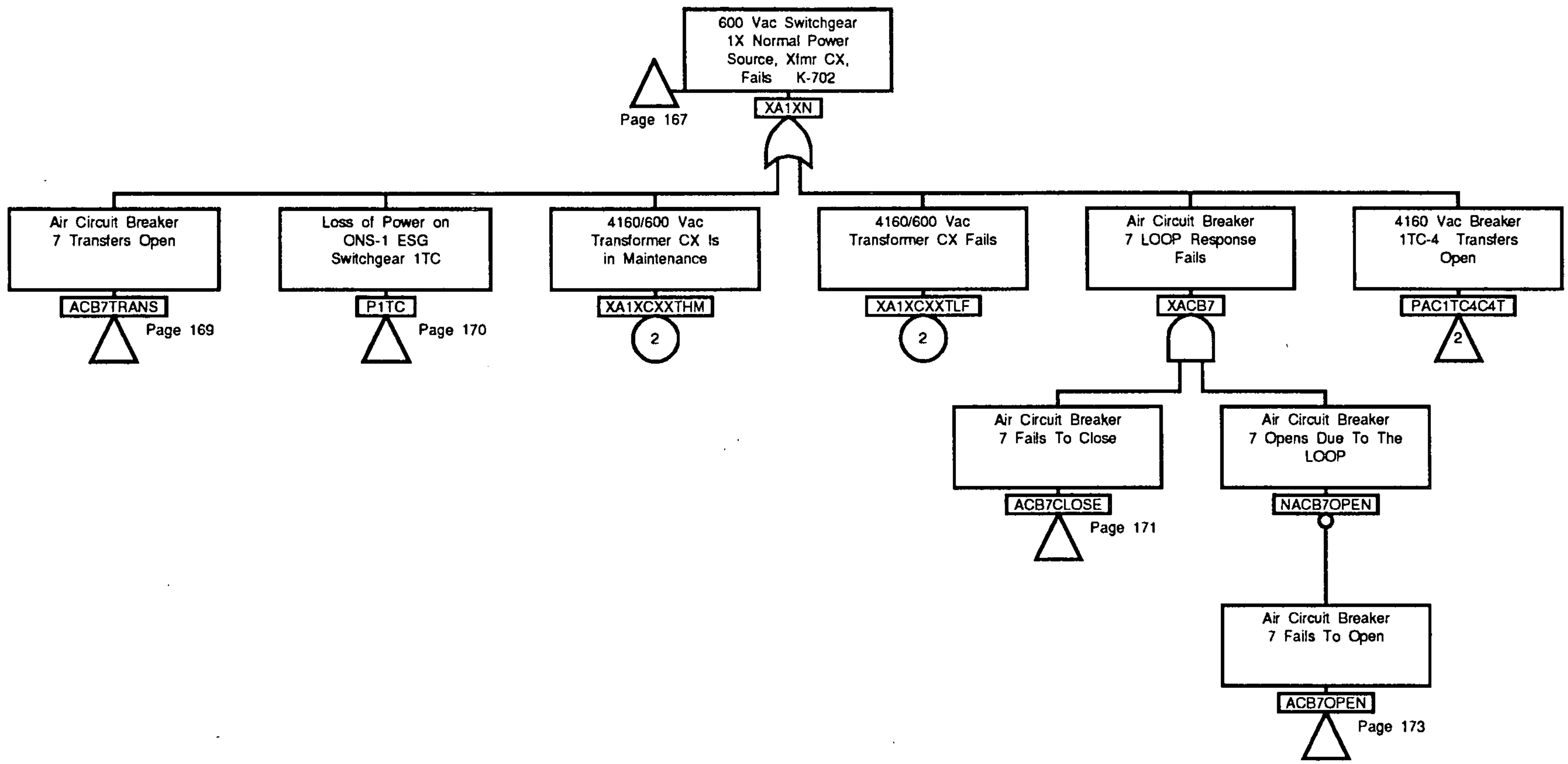


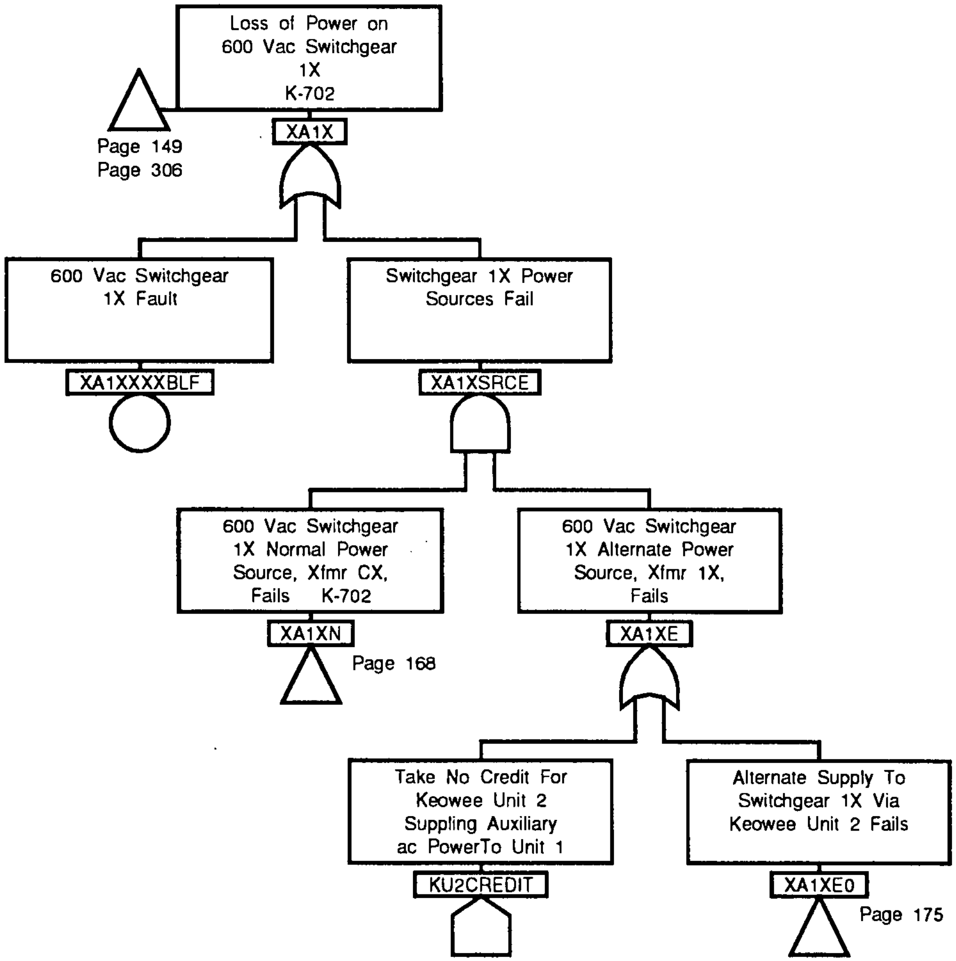
Air Circuit Breaker 7 Fails To Close Due To Control Failures
ACB7CNTRLC
Page 171
Manual/Auto Control Switch 143/1 Spuriously Transfers Into Manual
AB51431SWT
3
Transformer CX Undervoltage Relay 27/CX1 Fails To Pick Up
AA127CPR6D
Manual/Auto Control Switch 143/1 Left In Manual
AB51431LHE
3
Auxiliary Relay 27/CX1 Fails To Operate On Demand
AA127XCRYD
Air Circuit Breaker 7 Control Power Fails
ACB7DCPWR
Page 171
Page 173
Air Circuit Breaker 5 Control Power Fails
ACB5DCPWR
Page 172
Air Circuit Breaker 5 Control Power Fails
ACB5DCPWR
Page 176
Page 172
Breaker 4AL In 125 V dc Distribution Center 1DA Transfers Open
AD1B4ALCDT

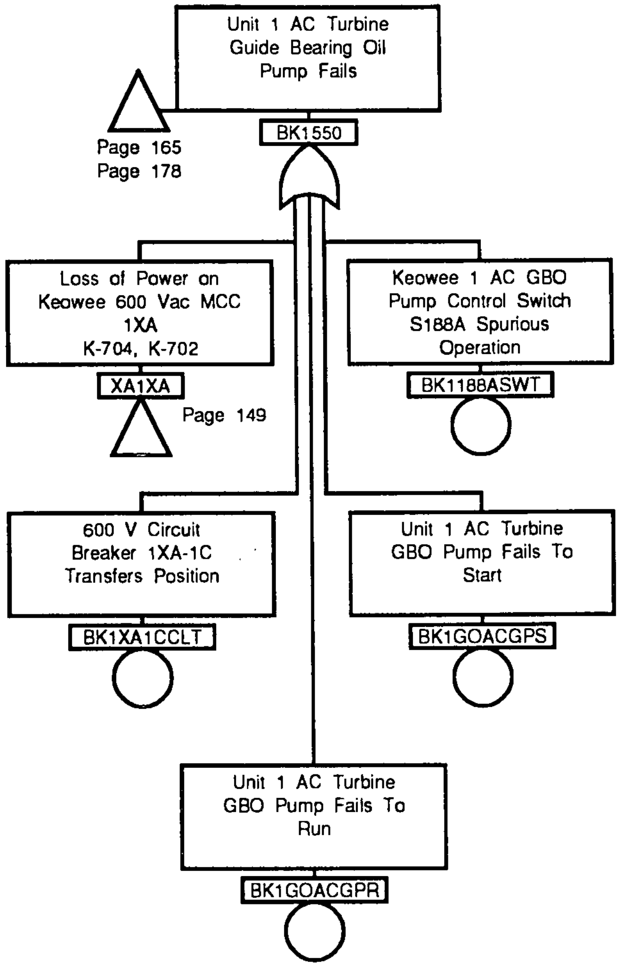

Air Circuit Breaker 7 Fails To Close
ACB7CLOSE
Page 168
Air Circuit Breaker 7 Fails To Close Due To Mechanical Failure
AB7MCH2DEX
Air Circuit Breaker 7 Fails To Close Due To Electrical Failures
ACB7ELECC
Air Circuit Breaker 7 Fails To Close Due To A Latent Human Error
AB7CLOSLHE
CCF of 1X Aux Power Breakers ACB-5 & -7
XA1BKRSCOM
2
Common Cause Failure Of ACB-7 And ACB-8 To Close
XA78BKRCOM
2
Air Circuit Breaker 7 Key Interlock Switch Transfers Open
AB7KEYISWT
Air Circuit Breaker 7 Fails To Close Due To Electrical Failu res Of The Breaker
ACB7BREAKC
Air Circuit Breaker 7 Fails To Close Due To Control Failures
ACB7CNTRLC
Page 172
Air Circuit Breaker 7 Control Power Fails
ACB7DCPWR
Page 172
Air Circuit Breaker 7 Close Coil CC Fails On Demand
AB752CCRYD
Air Circuit Breaker 7 Y-relay Spurious Operation
AB752Y2RYT
Air Circuit Breaker 7 Relay 52X Fails To Operate
AB7R52XRYD
One Or More Control Power Fuses For X, Y And CC Fail
AB710A1FUF
Air Circuit Breaker 7 Relay 52Y Failed To Drop Out At Last Demand
AB7R52YRYD

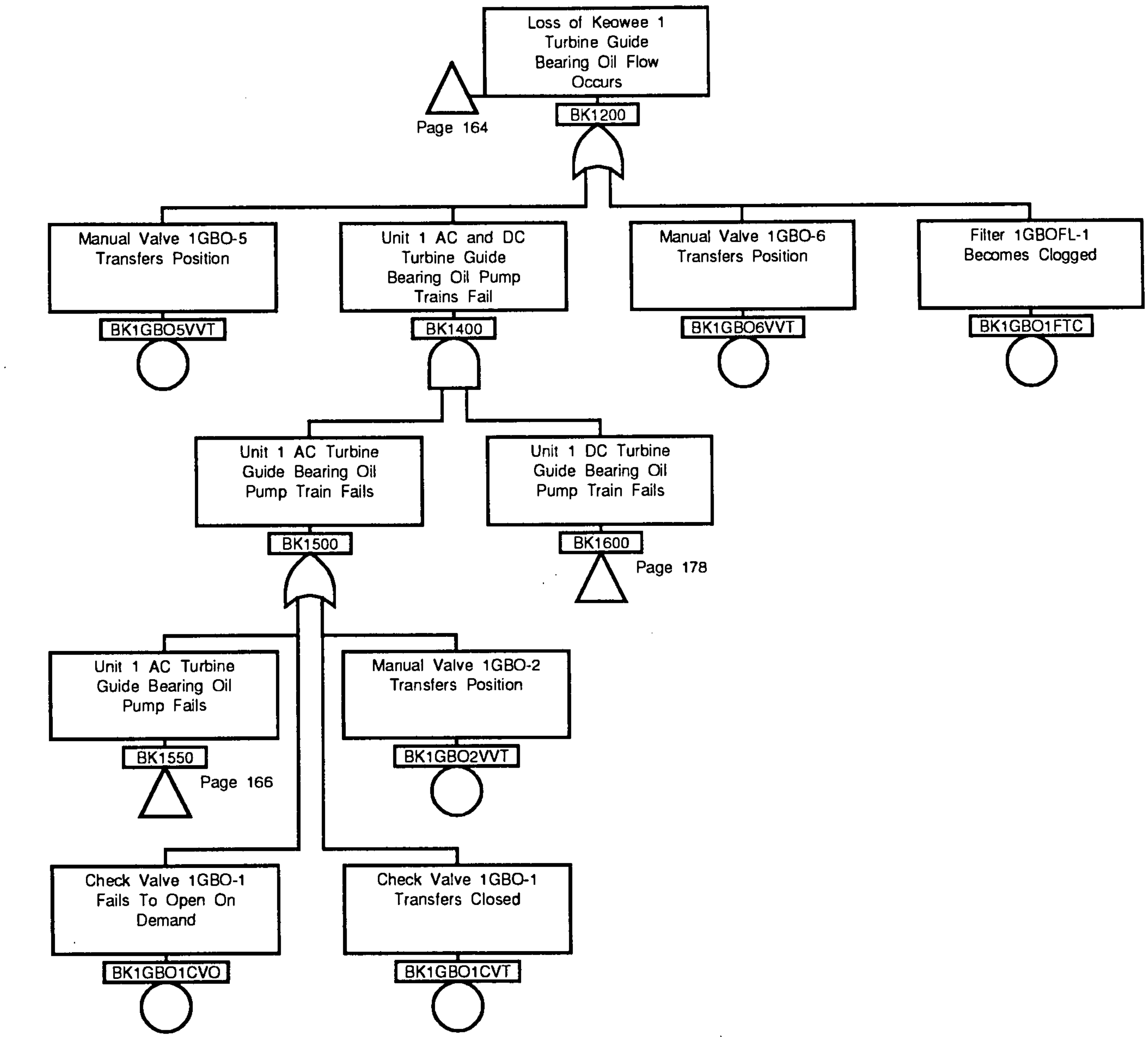

Loss of Power on
ONS-1 ESG
Switchgear 1TC
P1TC
Page 168
Page 262
1TC Power Sources
Fail
P1TCMFBS
4160 Vac Switchgear
1TC Fails
PACX1TCBHF
Main Feeder Bus 1
Power to 1TC Fails
P1TCMFB1
Main Feeder Bus 2
Power to 1TC Fails
P1TCMFB2
4160 Vac Breaker
1TC-1 Transfers
Open
PACTC01C4T
4160 Vac Breaker
1TC-14 Transfers
Open
PACTC14C4T

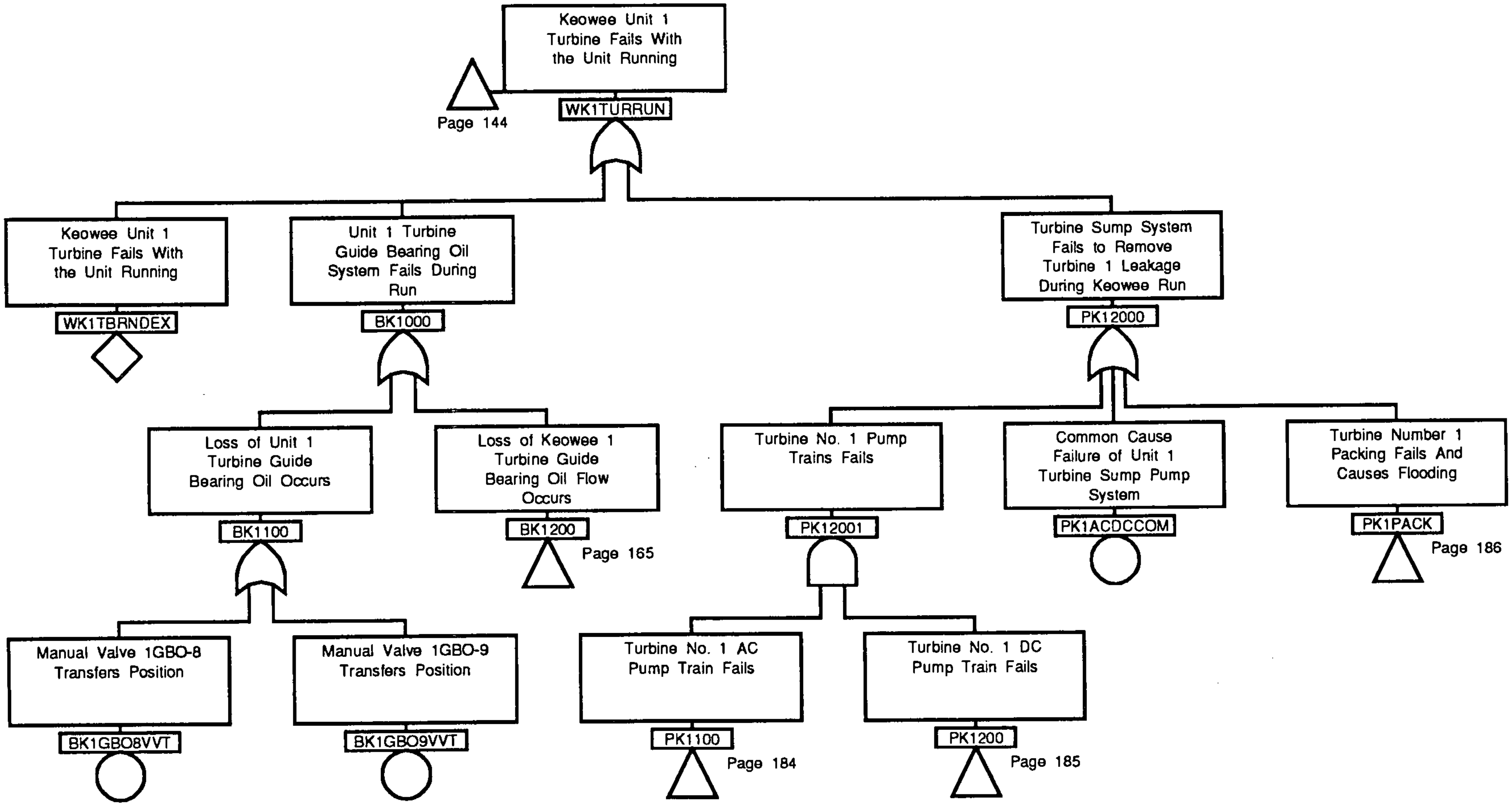

Air Circuit Breaker 7 Transfers Open
ACB7TRANS
Page 168
Transformer CX Undervoltage Relay 27/CX1 Spuriously De-energizes
AA127C1R6T
Air Circuit Breaker 7 Trip Coil 52TC Spurious Operation
AB752TCRYT
Auxiliary Relay 27X/CX1 Spurious Operation
AA127R1RYT
Transformer CX Differential Relay 87CX Spurious Operation
AA187CXRYT
2
Transformer CX Differential Lock Out Relay 86CX Spurious Operation
AA186CXRYT
2
Trip Pushbutton On ACB7 Spurious Operation
AB7PUSHPBT
Switchgear 1X Lockout Relay 86S/1X Spurious Operation
AA186S1RYT
2


600 Vac Switchgear 1X Normal Power Source, Xfmr CX, Fails K-702
XA1XN
Page 167
Air Circuit Breaker 7 Transfers Open
ACB7TRANS
Page 169
Loss of Power on ONS-1 ESG Switchgear 1TC
P1TC
Page 170
4160/600 Vac Transformer CX Is in Maintenance
XA1XCXXTHM
2
4160/600 Vac Transformer CX Fails
XA1XCXXTLF
2
Air Circuit Breaker 7 LOOP Response Fails
XACB7
4160 Vac Breaker 1TC-4 Transfers Open
PAC1TC4C4T
2
Air Circuit Breaker 7 Fails To Close
ACB7CLOSE
Page 171
Air Circuit Breaker 7 Opens Due To The LOOP
NACB7OPEN
Air Circuit Breaker 7 Fails To Open
ACB7OPEN
Page 173


Loss of Power on 600 Vac Switchgear 1X K-702
XA1X
Page 149
Page 306
600 Vac Switchgear 1X Fault
XA1XXXXBLF
Switchgear 1X Power Sources Fail
XA1XSRCE
600 Vac Switchgear 1X Normal Power Source, Xfmr CX, Fails K-702
XA1XN
Page 168
600 Vac Switchgear 1X Alternate Power Source, Xfmr 1X, Fails
XA1XE
Take No Credit For Keowee Unit 2 Suppling Auxiliary ac PowerTo Unit 1
KU2CREDIT
Alternate Supply To Switchgear 1X Via Keowee Unit 2 Fails
XA1XE0
Page 175

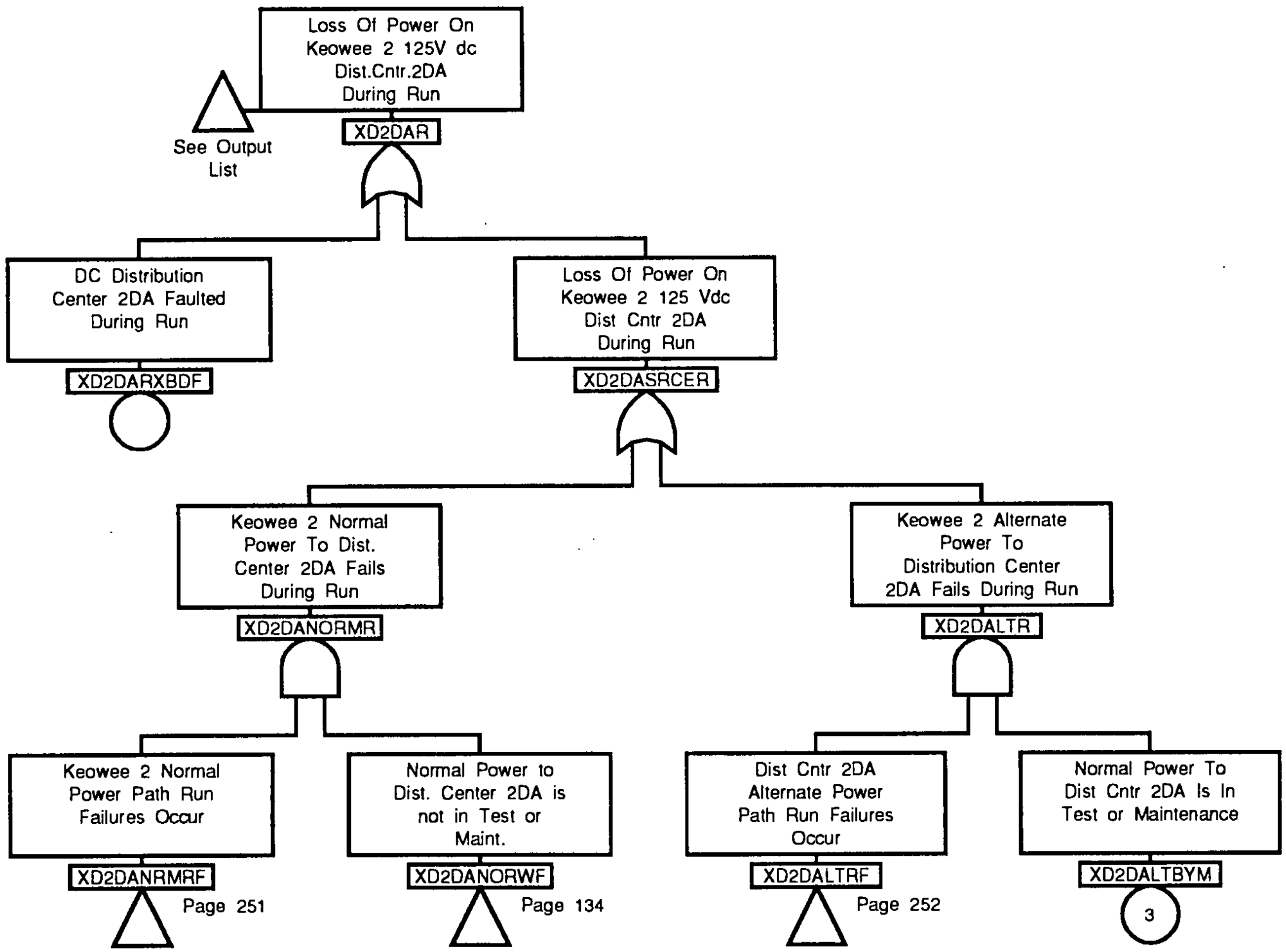

Unit 1 AC Turbine Guide Bearing Oil Pump Fails
BK1550
Page 165
Page 178
Loss of Power on Keowee 600 Vac MCC 1XA K-704, K-702
XA1XA
Page 149
Keowee 1 AC GBO Pump Control Switch S188A Spurious Operation
BK1188ASWT
600 V Circuit Breaker 1XA-1C Transfers Position
BK1XA1CCLT
Unit 1 AC Turbine GBO Pump Fails To Start
BK1GOACGPS
Unit 1 AC Turbine GBO Pump Fails To Run
BK1GOACGPR

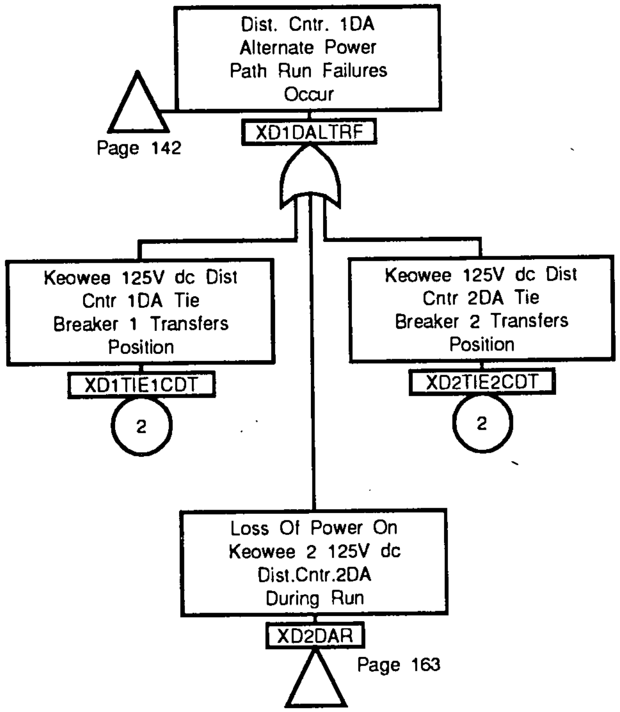

Loss of Keowee 1 Turbine Guide Bearing Oil Flow Occurs
BK1200
Page 164
Manual Valve 1GBO-5 Transfers Position
BK1GBO5VVT
Unit 1 AC and DC Turbine Guide Bearing Oil Pump Trains Fail
BK1400
Manual Valve 1GBO-6 Transfers Position
BK1GBO6VVT
Filter 1GBOFL-1 Becomes Clogged
BK1GBO1FTC
Unit 1 AC Turbine Guide Bearing Oil Pump Train Fails
BK1500
Unit 1 DC Turbine Guide Bearing Oil Pump Train Fails
BK1600
Page 178
Unit 1 AC Turbine Guide Bearing Oil Pump Fails
BK1550
Page 166
Manual Valve 1GBO-2 Transfers Position
BK1GBO2VVT
Check Valve 1GBO-1 Fails To Open On Demand
BK1GBO1CVO
Check Valve 1GBO-1 Transfers Closed
BK1GBO1CVT



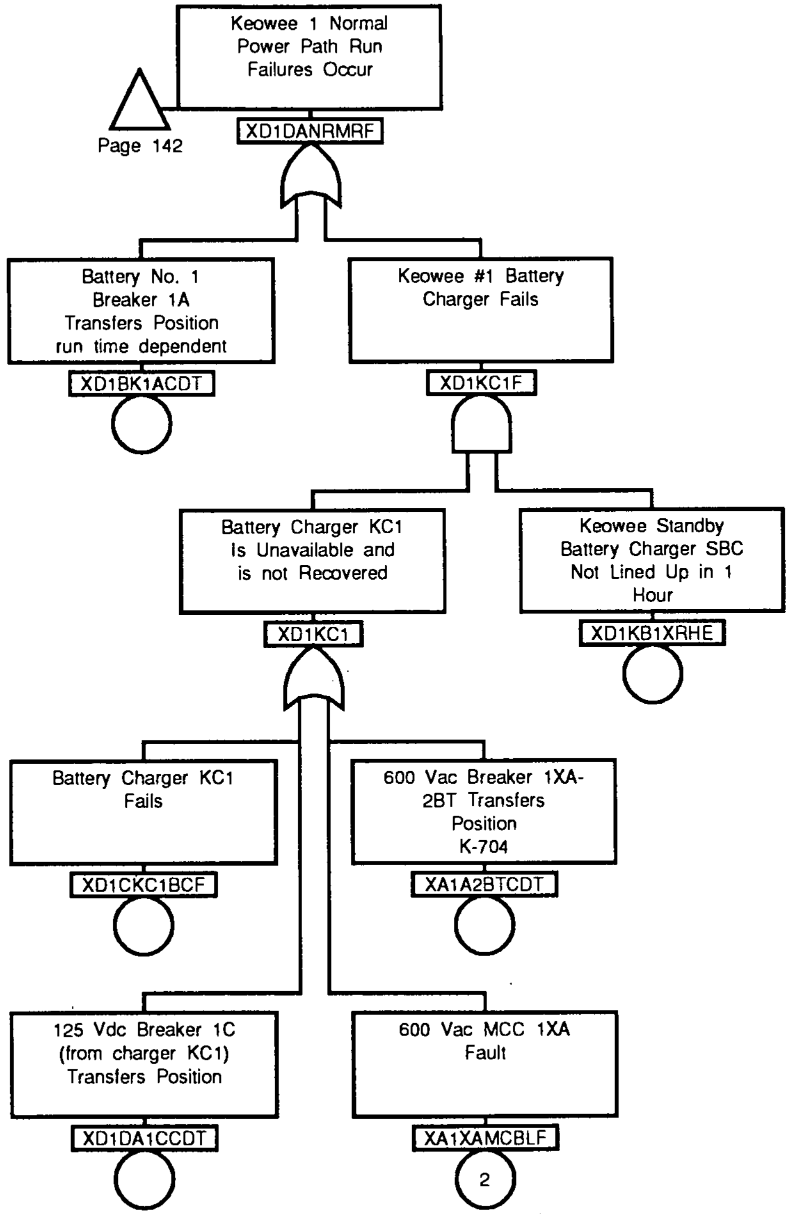
Keewee Unit 1 Turbine Fails With the Unit Running
WK1TURRUN
Page 144
Keowee Unit 1 Turbine Fails With the Unit Running
WK1TBRNDEX
Unit 1 Turbine Guide Bearing Oil System Fails During Run
BK1000
Turbine Sump System Fails to Remove Turbine 1 Leakage During Keowee Run
PK12000
Loss of Unit 1 Turbine Guide Bearing Oil Occurs
BK1100
Loss of Keowee 1 Turbine Guide Bearing Oil Flow Occurs
BK1200
Page 165
Turbine No. 1 Pump Trains Fails
PK12001
Common Cause Failure of Unit 1 Turbine Sump Pump System
PK1ACDCCOM
Turbine Number 1 Packing Fails And Causes Flooding
PK1PACK
Page 186
Manual Valve 1GBO-8 Transfers Position
BK1GBO8VVT
Manual Valve 1GBO-9 Transfers Position
BK1GBO9VVT
Turbine No. 1 AC Pump Train Fails
PK1100
Page 184
Turbine No. 1 DC Pump Train Fails
PK1200
Page 185

XD2DAR Outputs:
Page 248, Page 162, Page 224, Page 268, Page 242, Page 274, Page 283

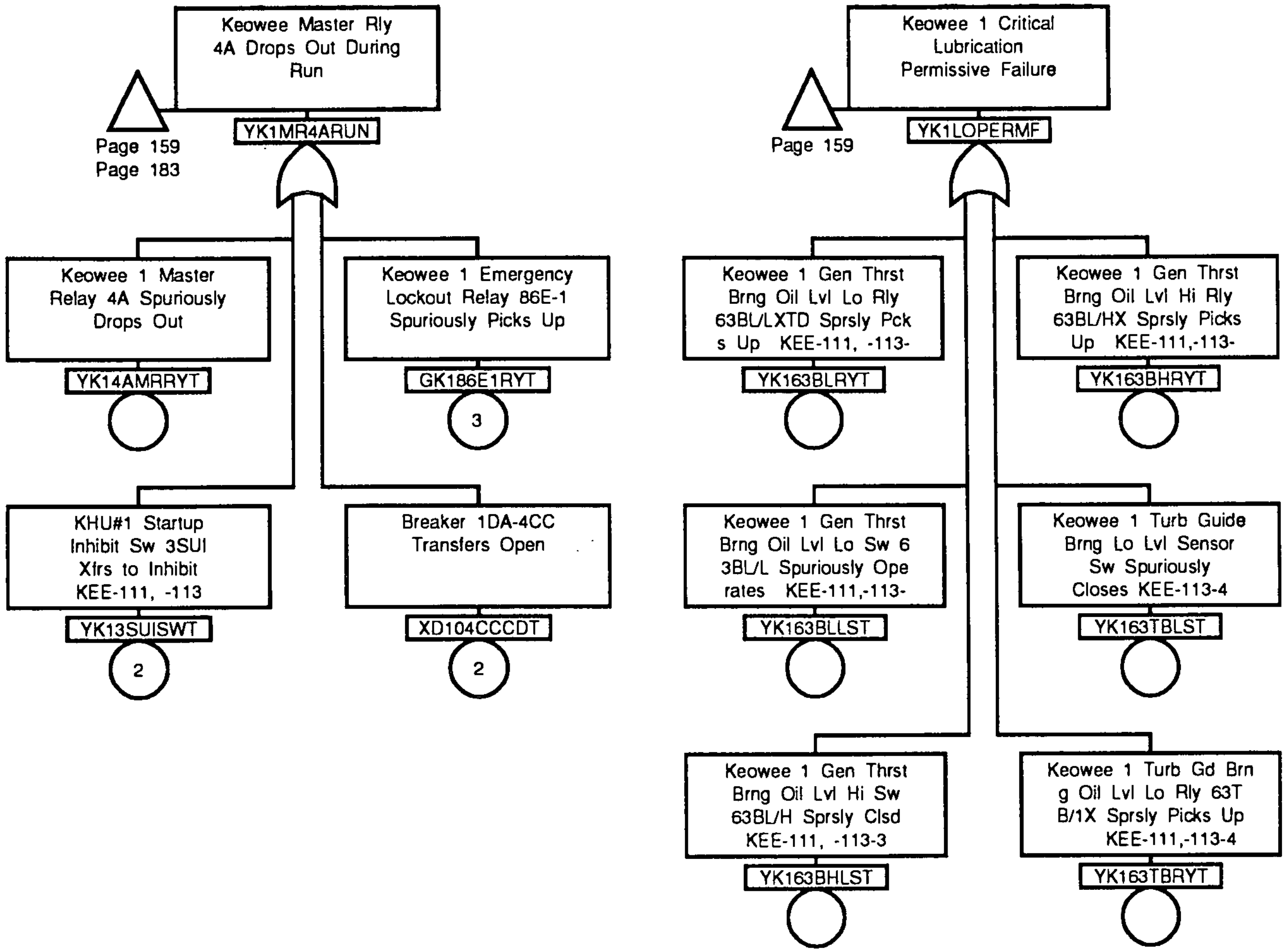


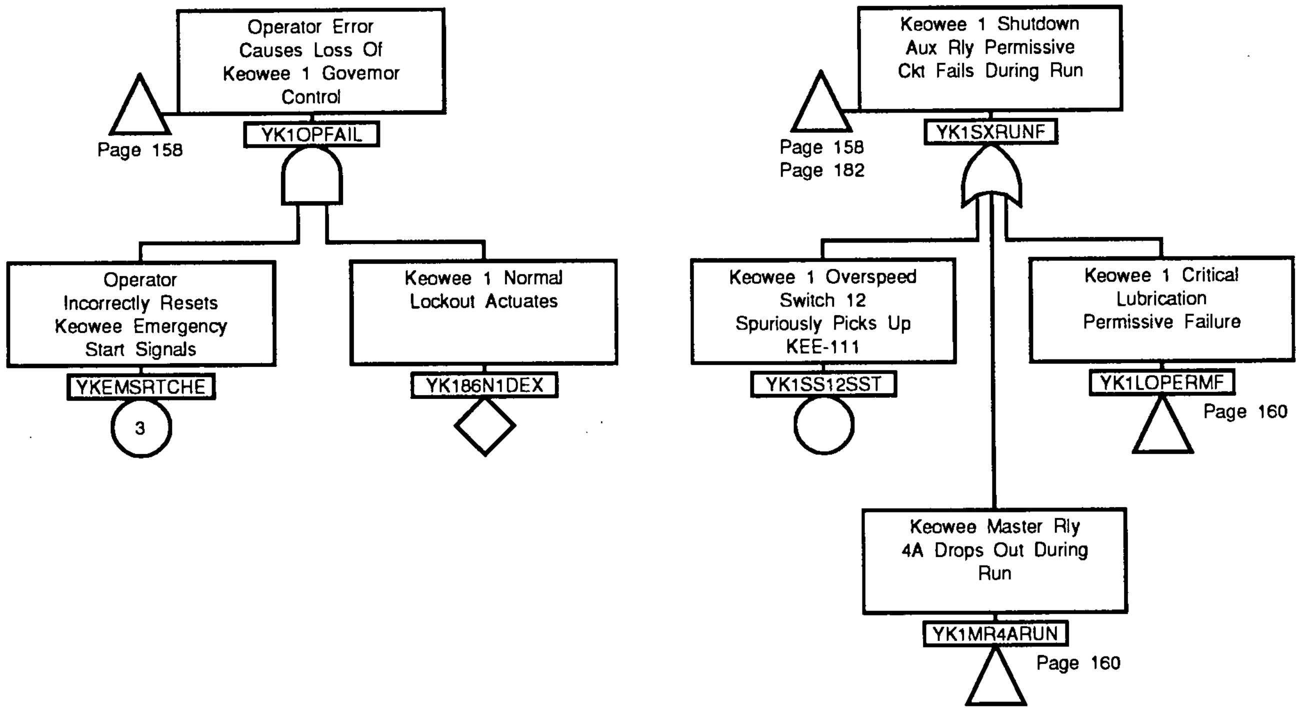


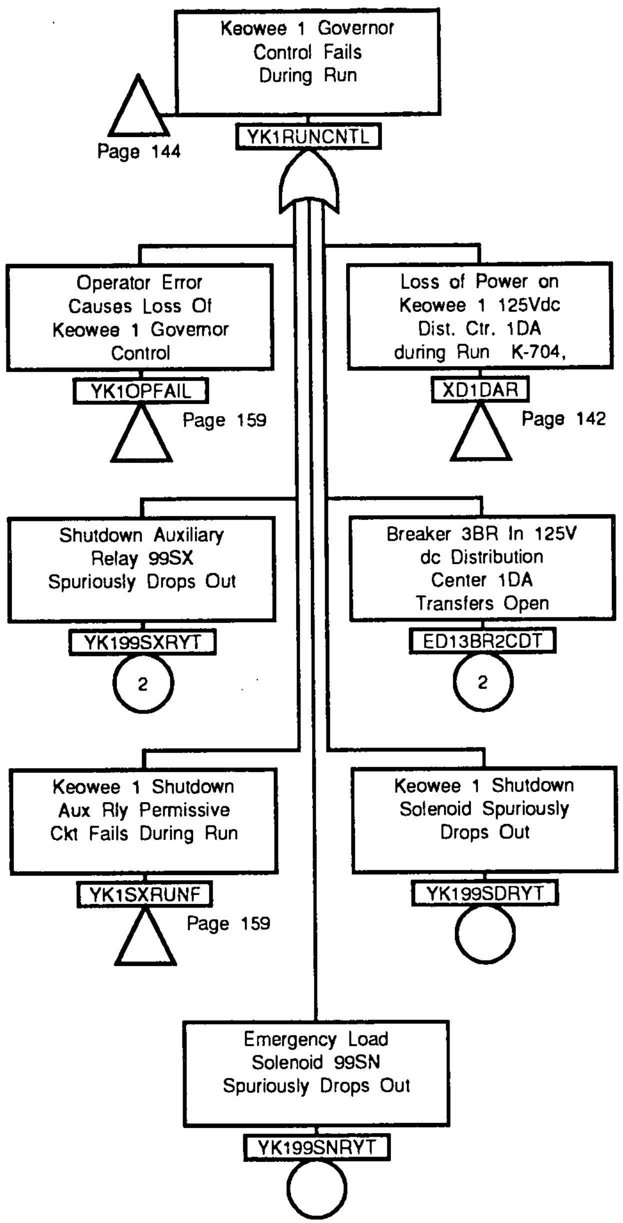
Dist. Cntr. 1DA Alternate Power Path Run Failures Occur
XD1DALTRF
Page 142
Keowee 125V dc Dist Cntr 1DA Tie Breaker 1 Transfers Position
XD1TIE1CDT
2
Keowee 125V dc Dist Cntr 2DA Tie Breaker 2 Transfers Position
XD2TIE2CDT
2
Loss Of Power On Keowee 2 125V dc Dist.Cntr.2DA During Run
XD2DAR
Page 163



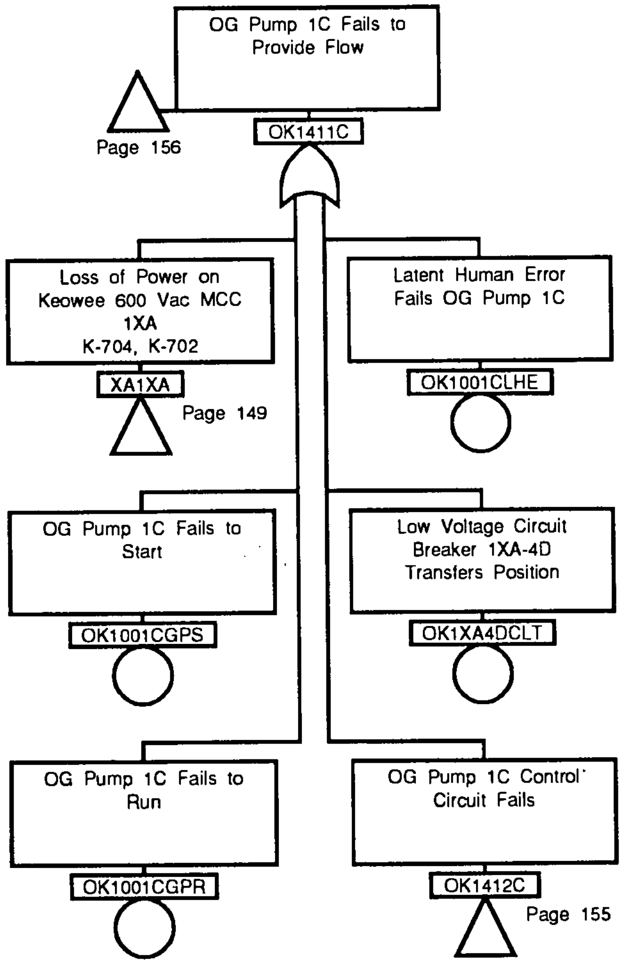
Keewee 1 Normal Power Path Run Failures Occur
Page 142
XD1DANRMRF
Battery No. 1 Breaker 1A Transfers Position run time dependent
XD1BK1ACDT
Keowee #1 Battery Charger Fails
XD1KC1F
Battery Charger KC1 Is Unavailable and is not Recovered
XD1KC1
Keowee Standby Battery Charger SBC Not Lined Up in 1 Hour
XD1KB1XRHE
Battery Charger KC1 Fails
XD1CKC1BCF
600 Vac Breaker 1XA-2BT Transfers Position K-704
XA1A2BTCDT
125 Vdc Breaker 1C (from charger KC1) Transfers Position
XD1DA1CCDT
600 Vac MCC 1XA Fault
XA1XAMCBLF
2

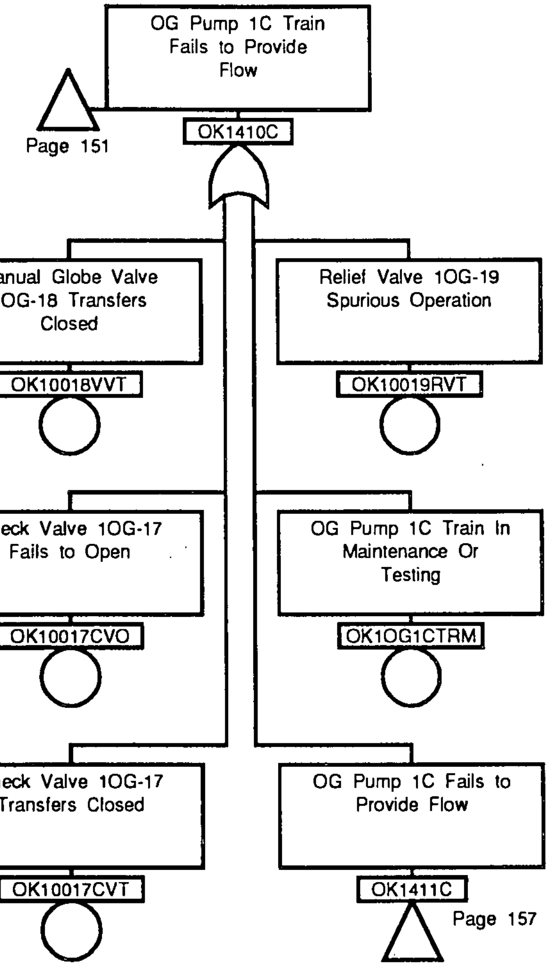

Keowee Master Rly 4A Drops Out During Run
YK1MR4ARUN
Page 159
Page 183
Keowee 1 Master Relay 4A Spuriously Drops Out
YK14AMRRYT
Keowee 1 Emergency Lockout Relay 86E-1 Spuriously Picks Up
GK186E1RYT
3
KHU#1 Startup Inhibit Sw 3SUI Xfrs to Inhibit KEE-111, -113
YK13SUISWT
2
Breaker 1DA-4CC Transfers Open
XD104CCCDT
2
Keowee 1 Critical Lubrication Permissive Failure
YK1LOPERMF
Page 159
Keowee 1 Gen Thrst Brng Oil Lvl Lo Rly 63BL/LXTD Sprsly Pcks Up KEE-111, -113-
YK163BLRYT
Keowee 1 Gen Thrst Brng Oil Lvl Hi Rly 63BL/HX Sprsly Picks Up KEE-111,-113-
YK163BHRYT
Keowee 1 Gen Thrst Brng Oil Lvl Lo Sw 63BL/L Spuriously Operates KEE-111,-113-
YK163BLLST
Keowee 1 Turb Guide Brng Lo Lvl Sensor Sw Spuriously Closes KEE-113-4
YK163TBLST
Keowee 1 Gen Thrst Brng Oil Lvl Hi Sw 63BL/H Sprsly Clsd KEE-111, -113-3
YK163BHLST
Keowee 1 Turb Gd Brng Oil Lvl Lo Rly 63TB/1X Sprsly Picks Up KEE-111,-113-4
YK163TBRYT


Operator Error Causes Loss Of Keowee 1 Governor Control
YK1OPFAIL
Page 158
Operator Incorrectly Resets Keowee Emergency Start Signals
YKEMSRTCHE
3
Keowee 1 Normal Lockout Actuates
YK186N1DEX
Keowee 1 Shutdown Aux Rly Permissive Ckt Fails During Run
YK1SXRUNF
Page 158
Page 182
Keowee 1 Overspeed Switch 12 Spuriously Picks Up KEE-111
YK1SS12SST
Keowee 1 Critical Lubrication Permissive Failure
YK1LOPERMF
Page 160
Keowee Master Rly 4A Drops Out During Run
YK1MR4ARUN
Page 160

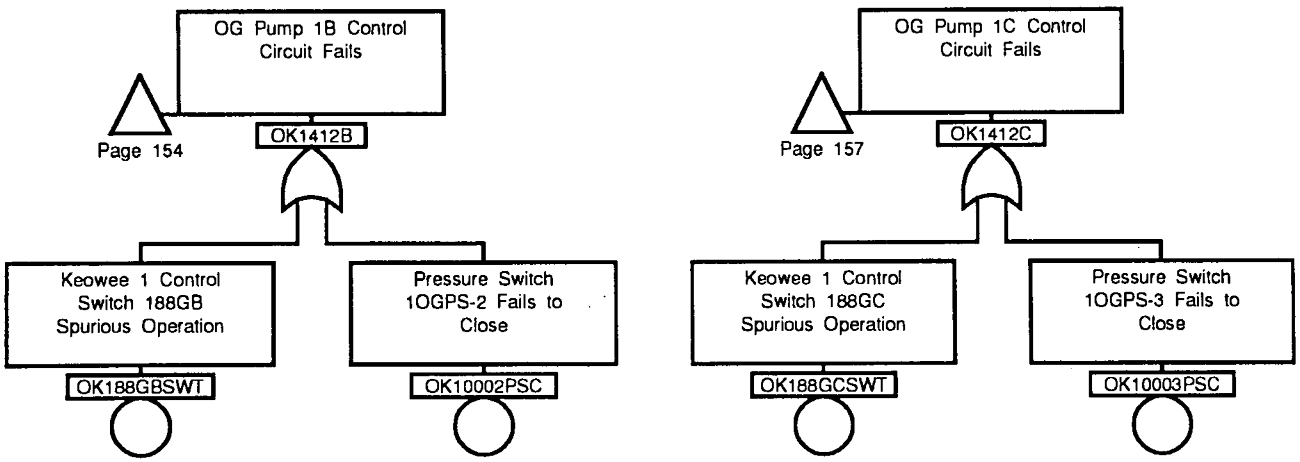


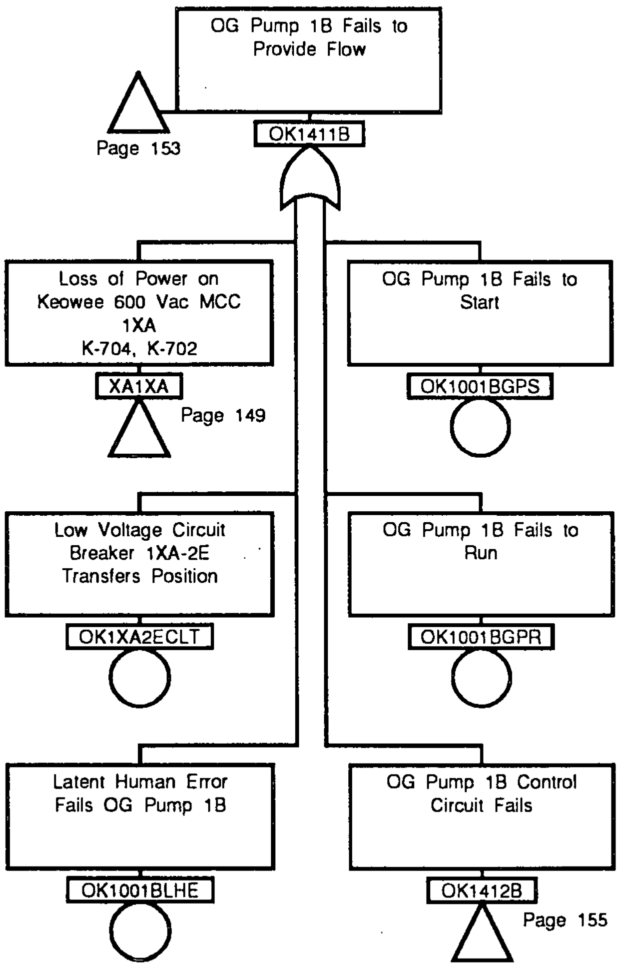
Keewee 1 Governor Control Fails During Run
YK1RUNCNTL
Page 144
Operator Error Causes Loss Of Keowee 1 Governor Control
YK1OPFAIL
Page 159
Loss of Power on Keowee 1 125Vdc Dist. Ctr. 1DA during Run K-704,
XD1DAR
Page 142
Shutdown Auxiliary Relay 99SX Spuriously Drops Out
YK199SXRYT
2
Breaker 3BR In 125V dc Distribution Center 1DA Transfers Open
ED13BR2CDT
2
Keowee 1 Shutdown Aux Rly Permissive Ckt Fails During Run
YK1SXRUNF
Page 159
Keowee 1 Shutdown Solenoid Spuriously Drops Out
YK199SDRYT
Emergency Load Solenoid 99SN Spuriously Drops Out
YK199SNRYT

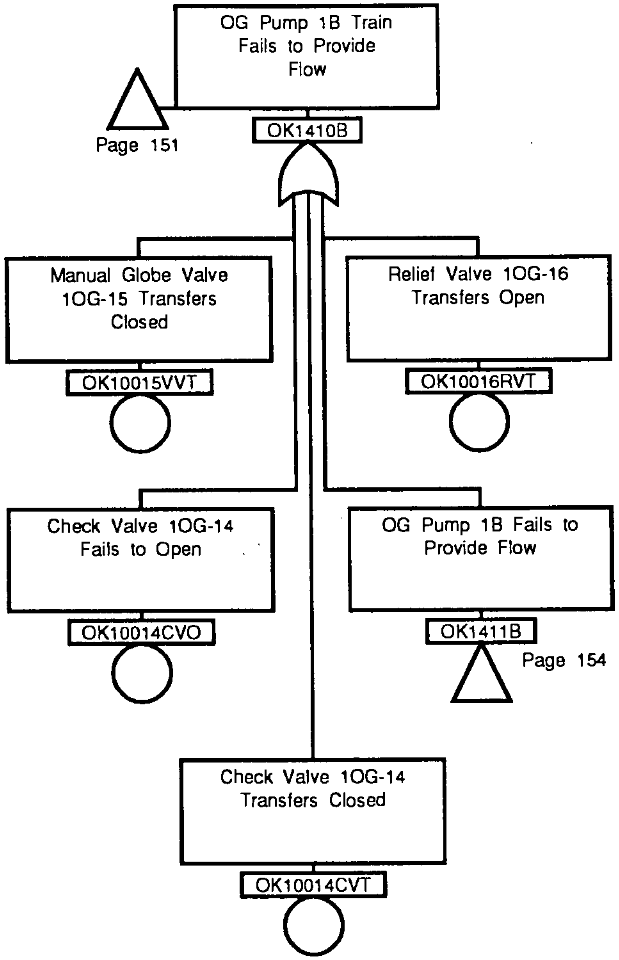

OG Pump 1C Fails to Provide Flow
OK1411C
Page 156
Loss of Power on Keowee 600 Vac MCC 1XA K-704, K-702
XA1XA
Page 149
Latent Human Error Fails OG Pump 1C
OK1001CLHE
OG Pump 1C Fails to Start
OK1001CGPS
Low Voltage Circuit Breaker 1XA-4D Transfers Position
OK1XA4DCLT
OG Pump 1C Fails to Run
OK1001CGPR
OG Pump 1C Control Circuit Fails
OK1412C
Page 155

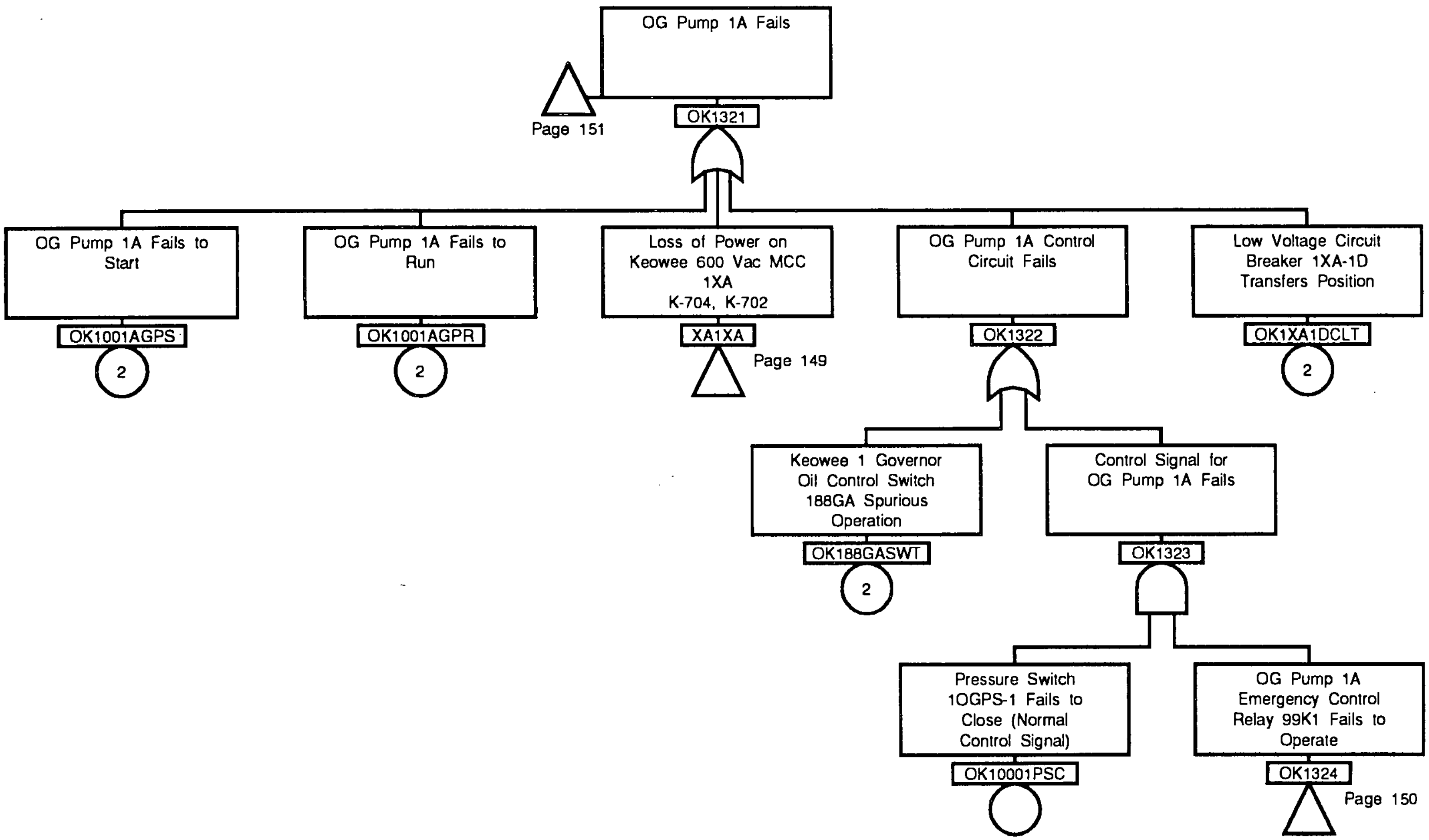


OG Pump 1C Train Fails to Provide Flow
OK1410C
Page 151
Manual Globe Valve 1OG-18 Transfers Closed
OK10018VVT
Relief Valve 1OG-19 Spurious Operation
OK10019RVT
Check Valve 1OG-17 Fails to Open
OK10017CVO
OG Pump 1C Train In Maintenance Or Testing
OK1OG1CTRM
Check Valve 1OG-17 Transfers Closed
OK10017CVT
OG Pump 1C Fails to Provide Flow
OK1411C
Page 157

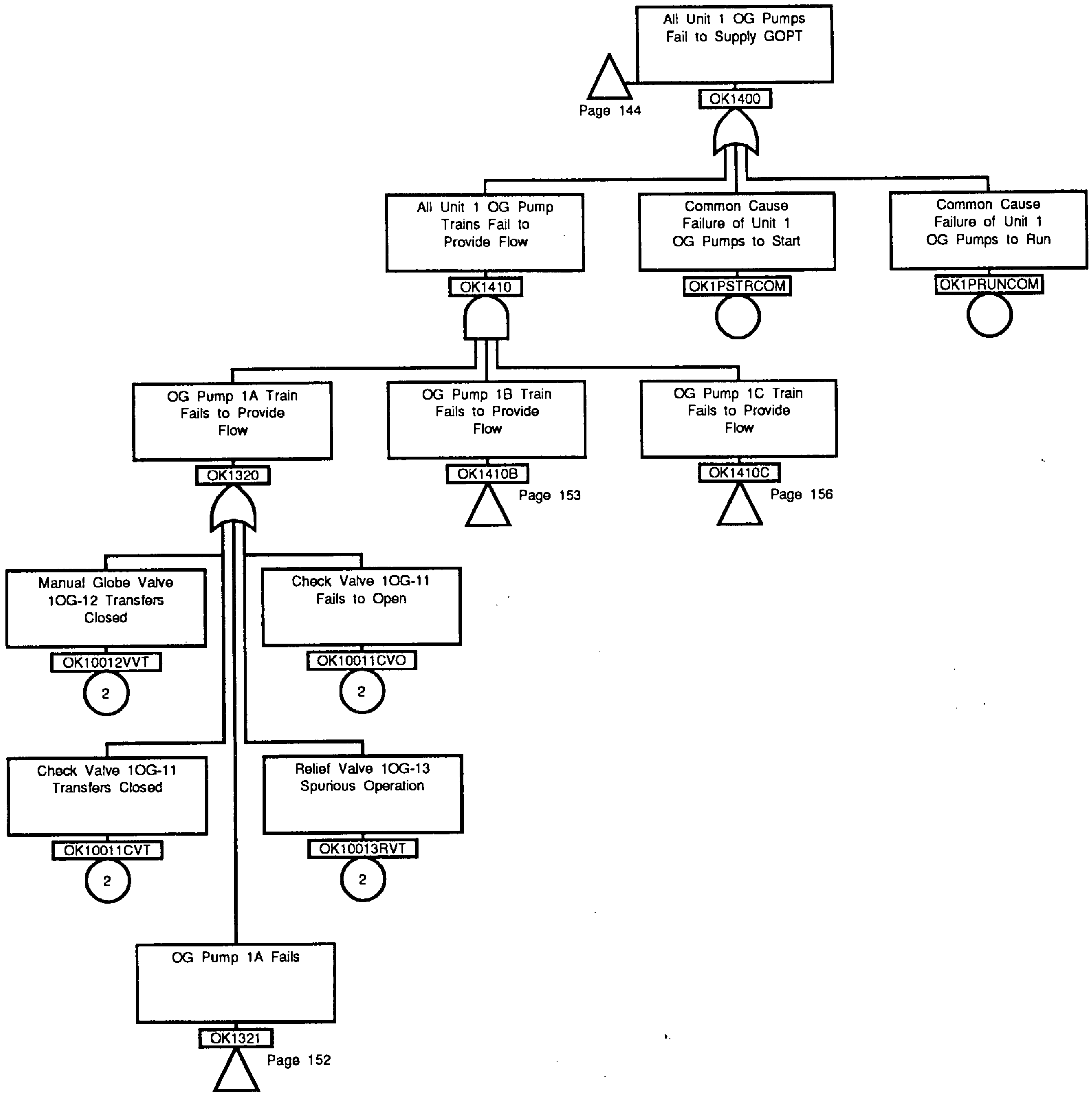

OG Pump 1B Control Circuit Fails
Page 154
OK1412B
Keowee 1 Control Switch 188GB Spurious Operation
OK188GBSWT
Pressure Switch 1OGPS-2 Fails to Close
OK10002PSC
OG Pump 1C Control Circuit Fails
Page 157
OK1412C
Keowee 1 Control Switch 188GC Spurious Operation
OK188GCSWT
Pressure Switch 1OGPS-3 Fails to Close
OK10003PSC


OG Pump 1B Fails to Provide Flow
OK1411B
Page 153
Loss of Power on Keowee 600 Vac MCC 1XA K-704, K-702
XA1XA
Page 149
OG Pump 1B Fails to Start
OK1001BGPS
Low Voltage Circuit Breaker 1XA-2E Transfers Position
OK1XA2ECLT
OG Pump 1B Fails to Run
OK1001BGPR
Latent Human Error Fails OG Pump 1B
OK1001BLHE
OG Pump 1B Control Circuit Fails
OK1412B
Page 155

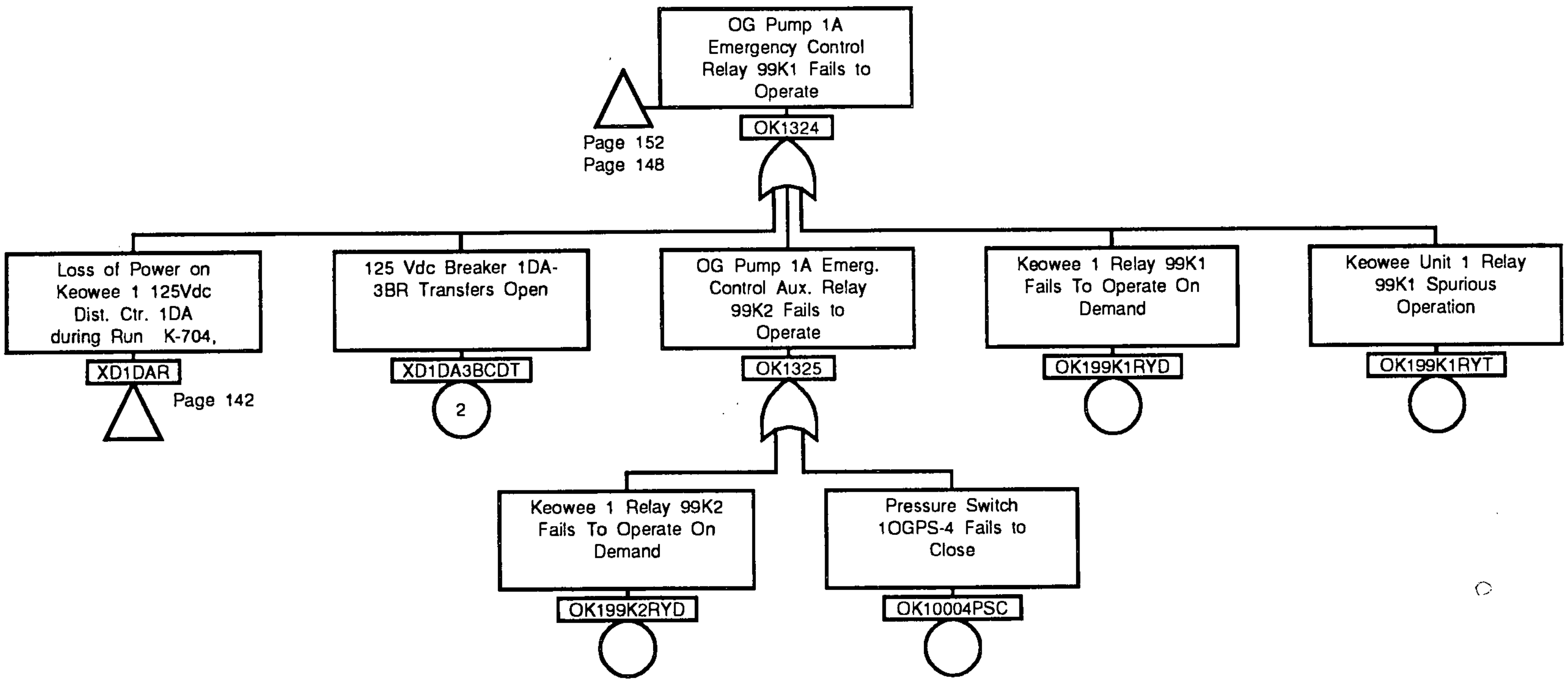

OG Pump 1B Train Fails to Provide Flow
OK1410B
Page 151
Manual Globe Valve 1OG-15 Transfers Closed
OK10015VVT
Relief Valve 1OG-16 Transfers Open
OK10016RVT
Check Valve 1OG-14 Fails to Open
OK10014CVO
OG Pump 1B Fails to Provide Flow
OK1411B
Page 154
Check Valve 1OG-14 Transfers Closed
OK10014CVT



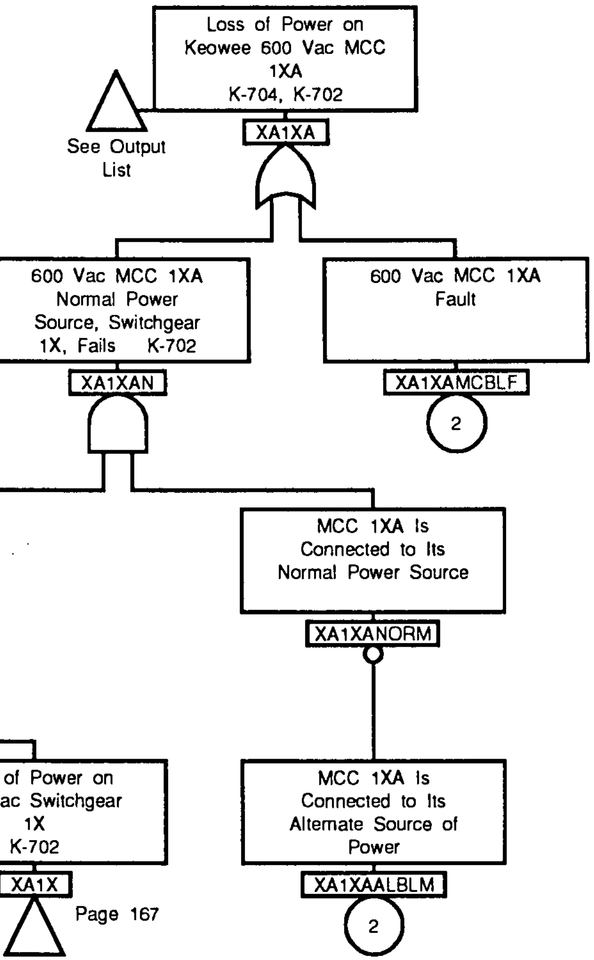
OG Pump 1A Fails
OK1321
Page 151
OG Pump 1A Fails to Start
OK1001AGPS
2
OG Pump 1A Fails to Run
OK1001AGPR
2
Loss of Power on Keowee 600 Vac MCC 1XA K-704, K-702
XA1XA
Page 149
OG Pump 1A Control Circuit Fails
OK1322
Low Voltage Circuit Breaker 1XA-1D Transfers Position
OK1XA1DCLT
2
Keowee 1 Governor Oil Control Switch 188GA Spurious Operation
OK188GASWT
2
Control Signal for OG Pump 1A Fails
OK1323
Pressure Switch 1OGPS-1 Fails to Close (Normal Control Signal)
OK10001PSC
OG Pump 1A Emergency Control Relay 99K1 Fails to Operate
OK1324
Page 150

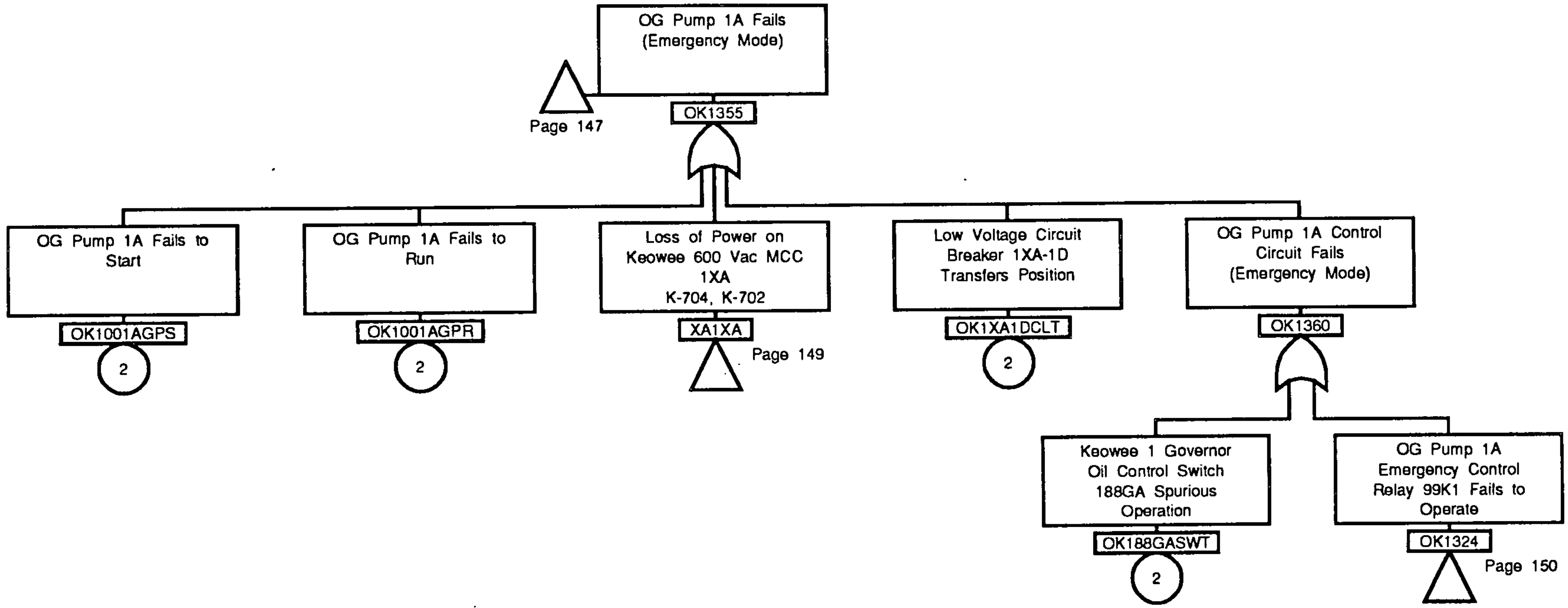


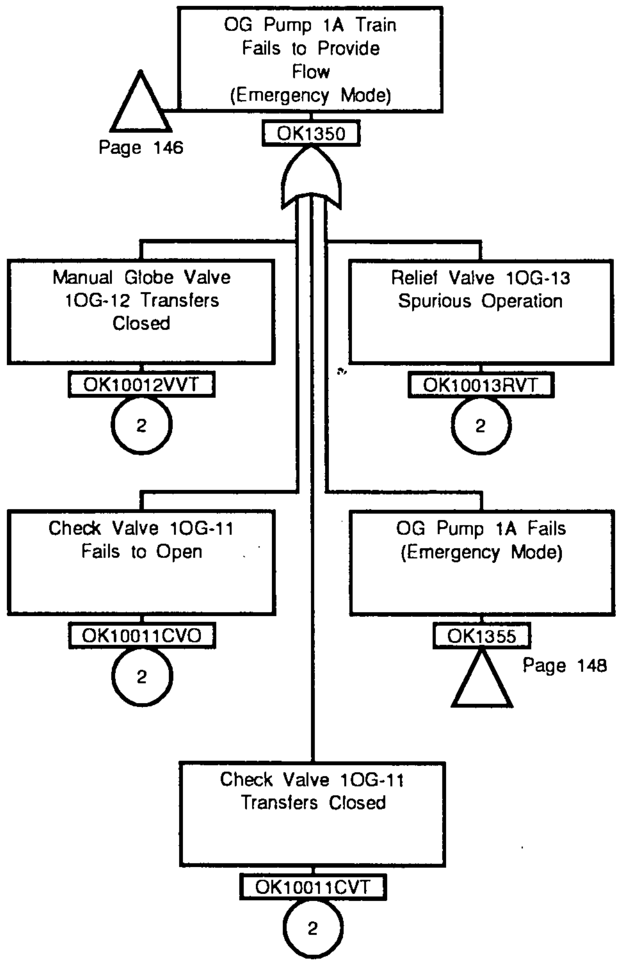
ONS-Keowee AC Power Integrated Model | FIGURE G-1 |


OG Pump 1A Emergency Control Relay 99K1 Fails to Operate
OK1324
Page 152
Page 148
Loss of Power on Keowee 1 125Vdc Dist. Ctr. 1DA during Run K-704,
XD1DAR
Page 142
125 Vdc Breaker 1DA-3BR Transfers Open
XD1DA3BCDT
2
OG Pump 1A Emerg. Control Aux. Relay 99K2 Fails to Operate
OK1325
Keowee 1 Relay 99K1 Fails To Operate On Demand
OK199K1RYD
Keowee Unit 1 Relay 99K1 Spurious Operation
OK199K1RYT
Keowee 1 Relay 99K2 Fails To Operate On Demand
OK199K2RYD
Pressure Switch 1OGPS-4 Fails to Close
OK10004PSC

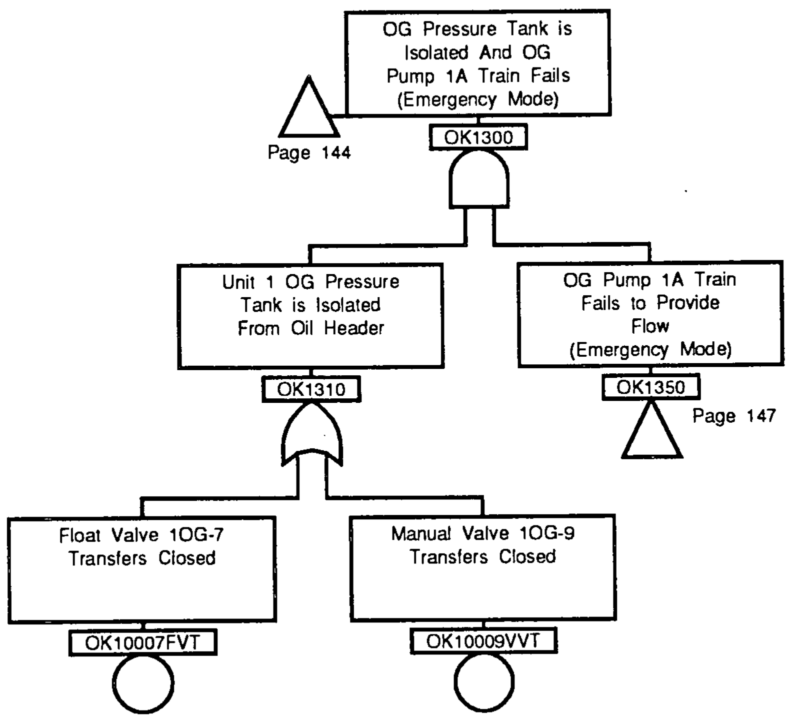
XA1XA Outputs:
Page 166, Page 152, Page 148, Page 154, Page 157, Page 184



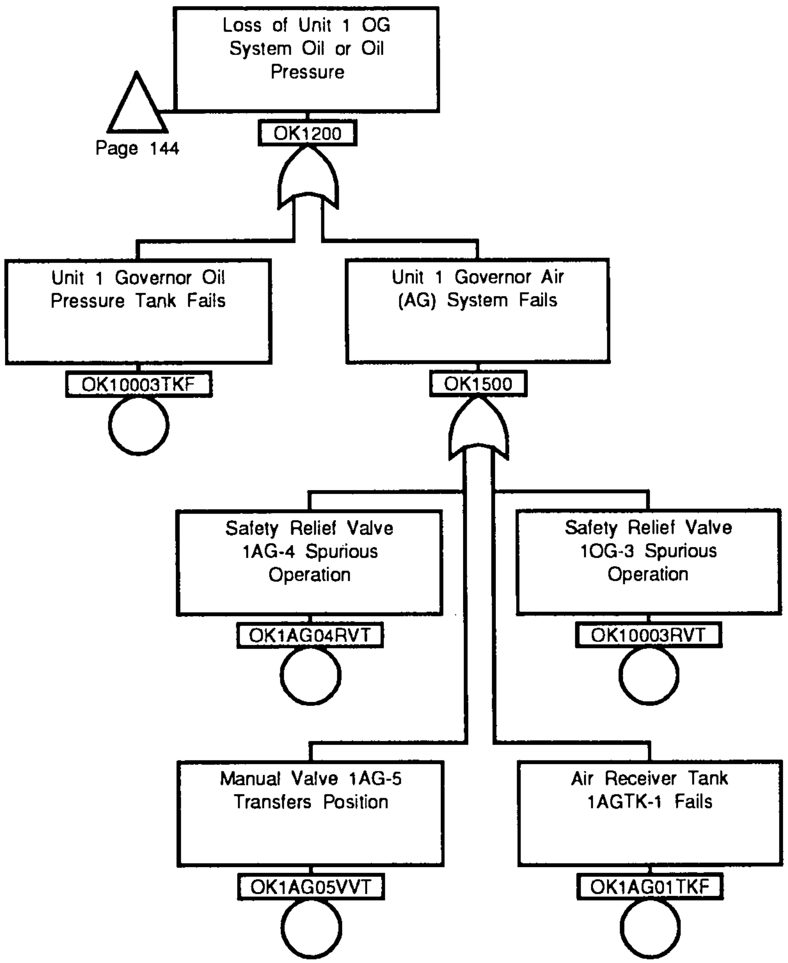

OG Pump 1A Fails (Emergency Mode)
OK1355
Page 147
OG Pump 1A Fails to Start
OK1001AGPS
2
OG Pump 1A Fails to Run
OK1001AGPR
2
Loss of Power on Keowee 600 Vac MCC 1XA K-704, K-702
XA1XA
Page 149
Low Voltage Circuit Breaker 1XA-1D Transfers Position
OK1XA1DCLT
2
OG Pump 1A Control Circuit Fails (Emergency Mode)
OK1360
Keowee 1 Governor Oil Control Switch 188GA Spurious Operation
OK188GASWT
2
OG Pump 1A Emergency Control Relay 99K1 Fails to Operate
OK1324
Page 150



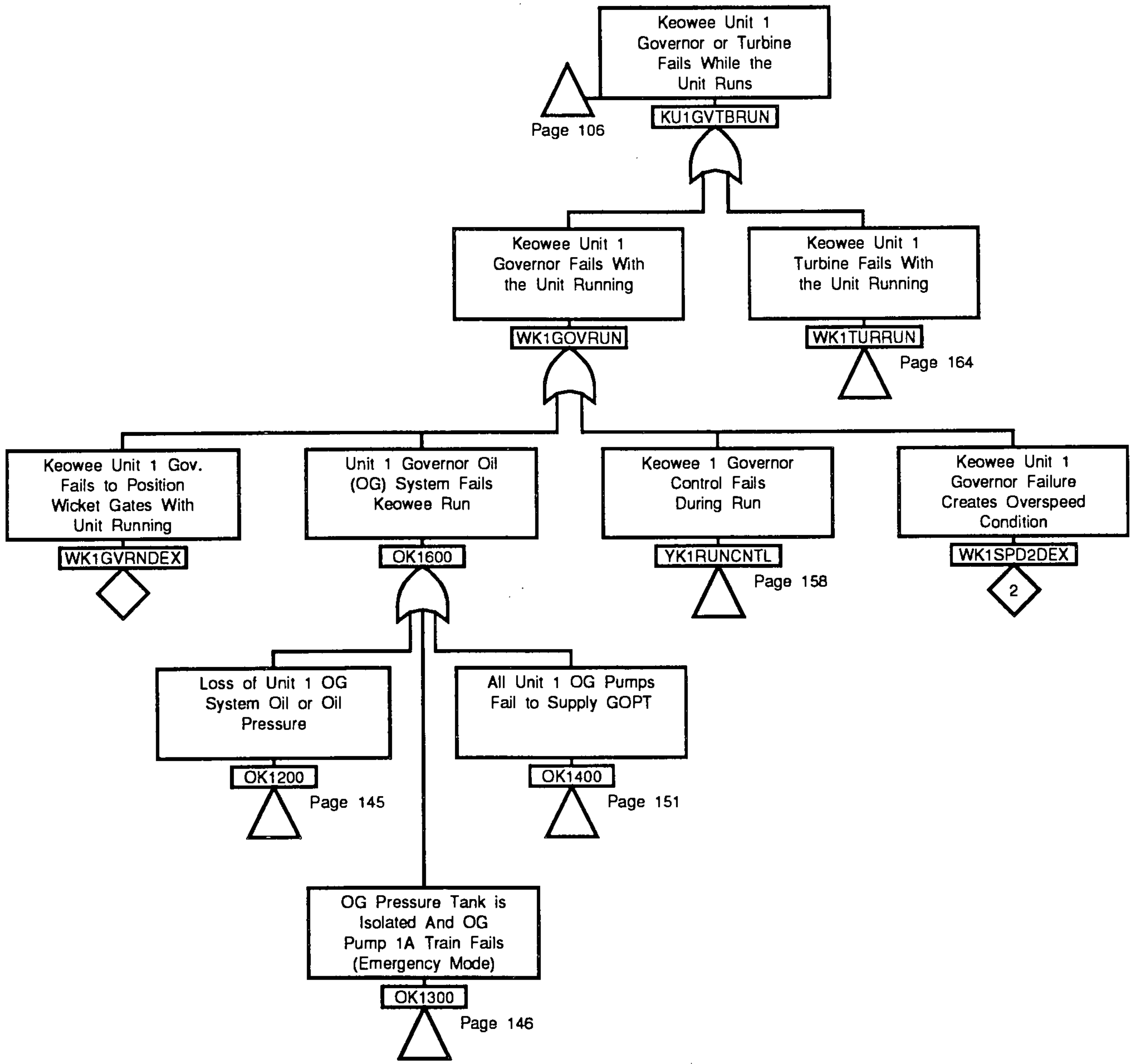
OG Pump 1A Train Fails to Provide Flow (Emergency Mode)
OK1350
Page 146
Manual Globe Valve 1OG-12 Transfers Closed
OK10012VVT
2
Relief Valve 1OG-13 Spurious Operation
OK10013RVT
2
Check Valve 1OG-11 Fails to Open
OK10011CVO
2
OG Pump 1A Fails (Emergency Mode)
OK1355
Page 148
Check Valve 1OG-11 Transfers Closed
OK10011CVT
2



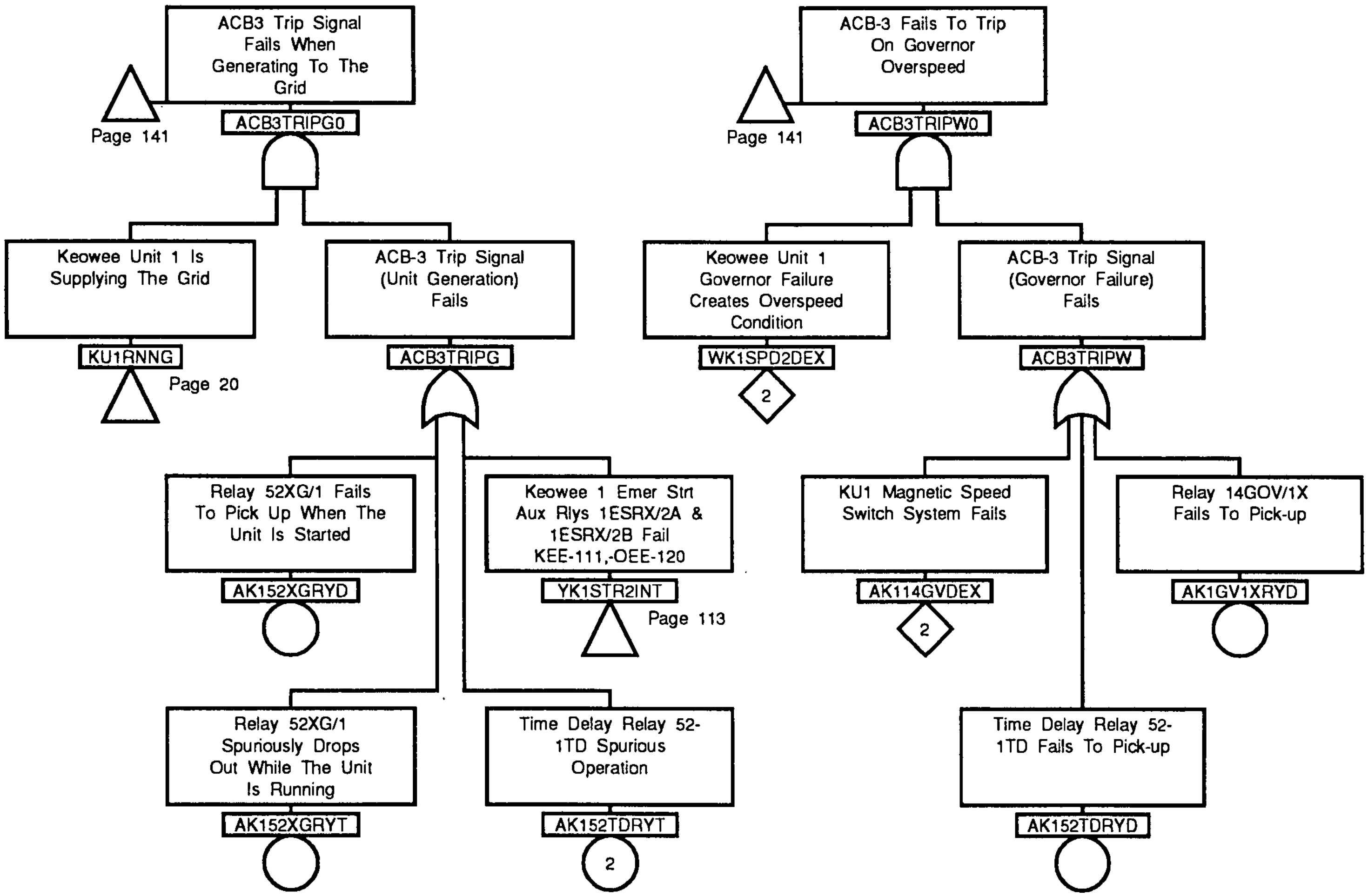
OG Pressure Tank is Isolated And OG Pump 1A Train Fails (Emergency Mode)
OK1300
Page 144
Unit 1 OG Pressure Tank is Isolated From Oil Header
OK1310
OG Pump 1A Train Fails to Provide Flow (Emergency Mode)
OK1350
Page 147
Float Valve 1OG-7 Transfers Closed
OK10007FVT
Manual Valve 1OG-9 Transfers Closed
OK10009VVT



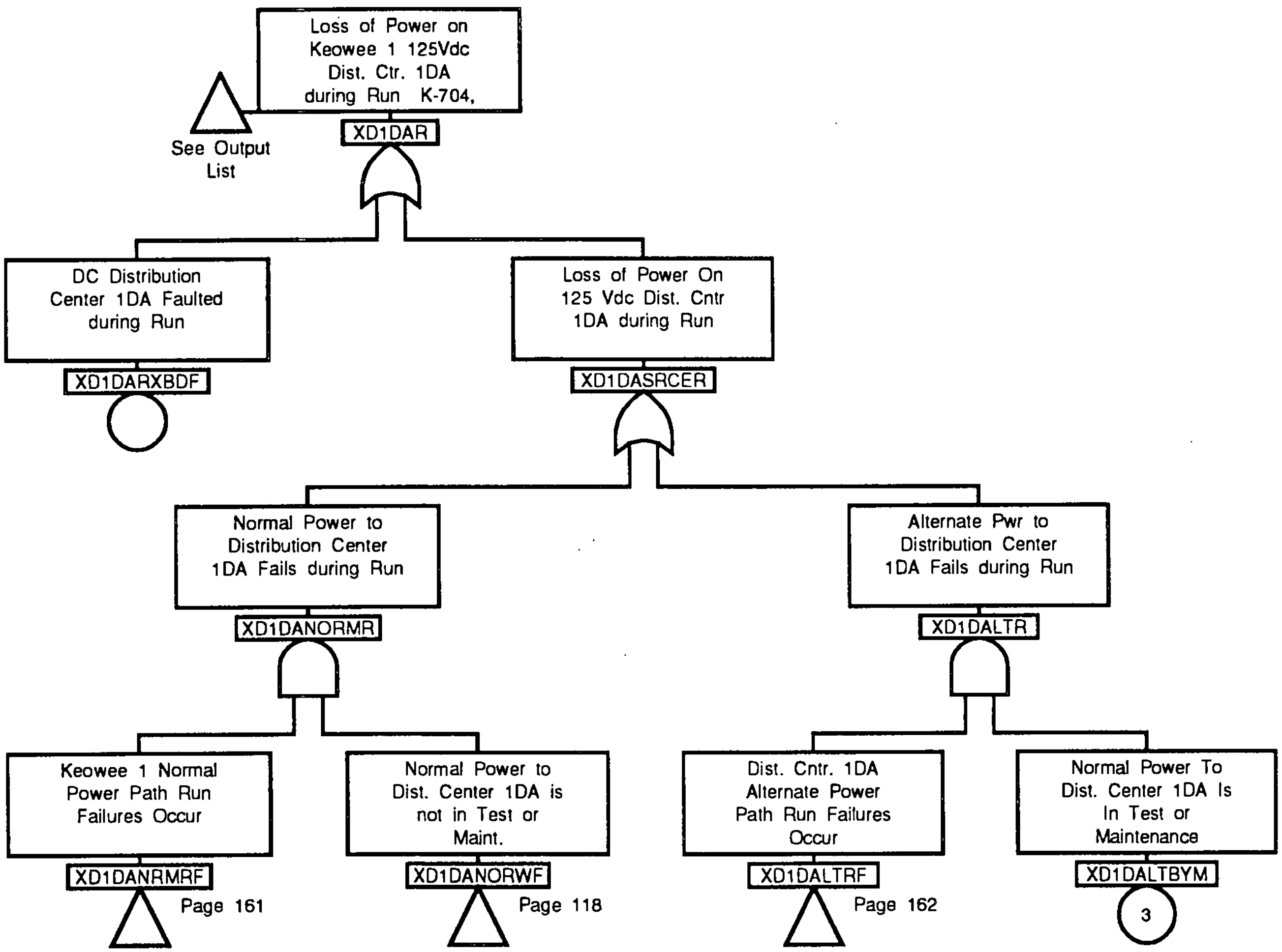
Loss of Unit 1 OG System Oil or Oil Pressure
OK1200
Page 144
Unit 1 Governor Oil Pressure Tank Fails
OK10003TKF
Unit 1 Governor Air (AG) System Fails
OK1500
Safety Relief Valve 1AG-4 Spurious Operation
OK1AG04RVT
Safety Relief Valve 1OG-3 Spurious Operation
OK10003RVT
Manual Valve 1AG-5 Transfers Position
OK1AG05VVT
Air Receiver Tank 1AGTK-1 Fails
OK1AG01TKF

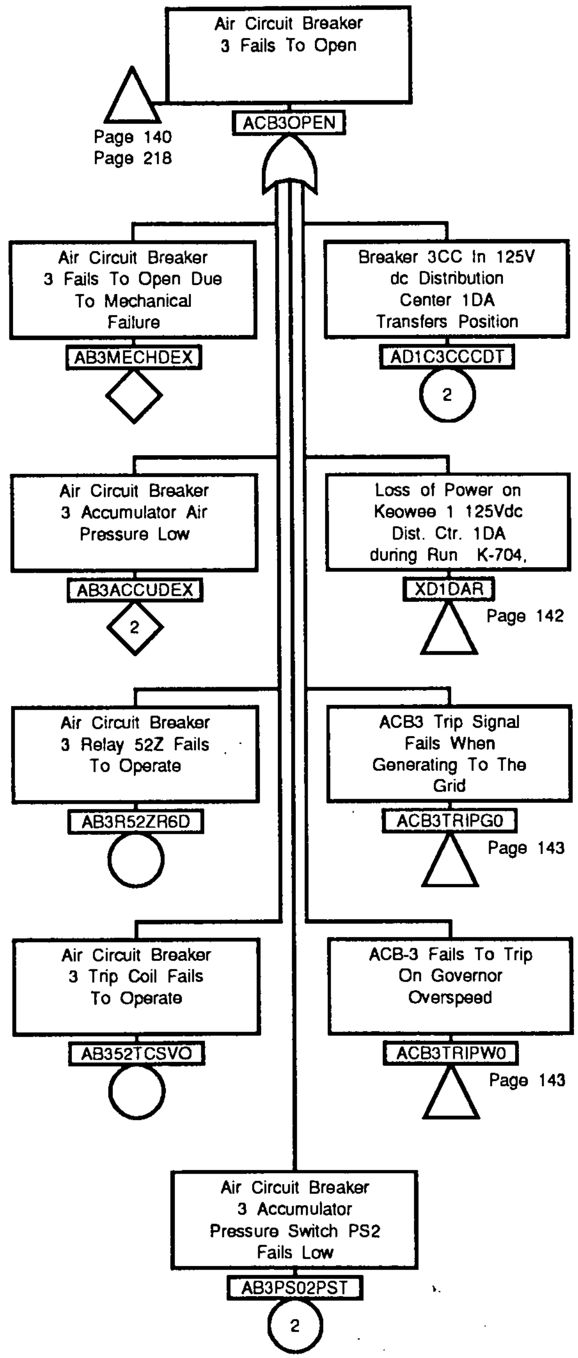


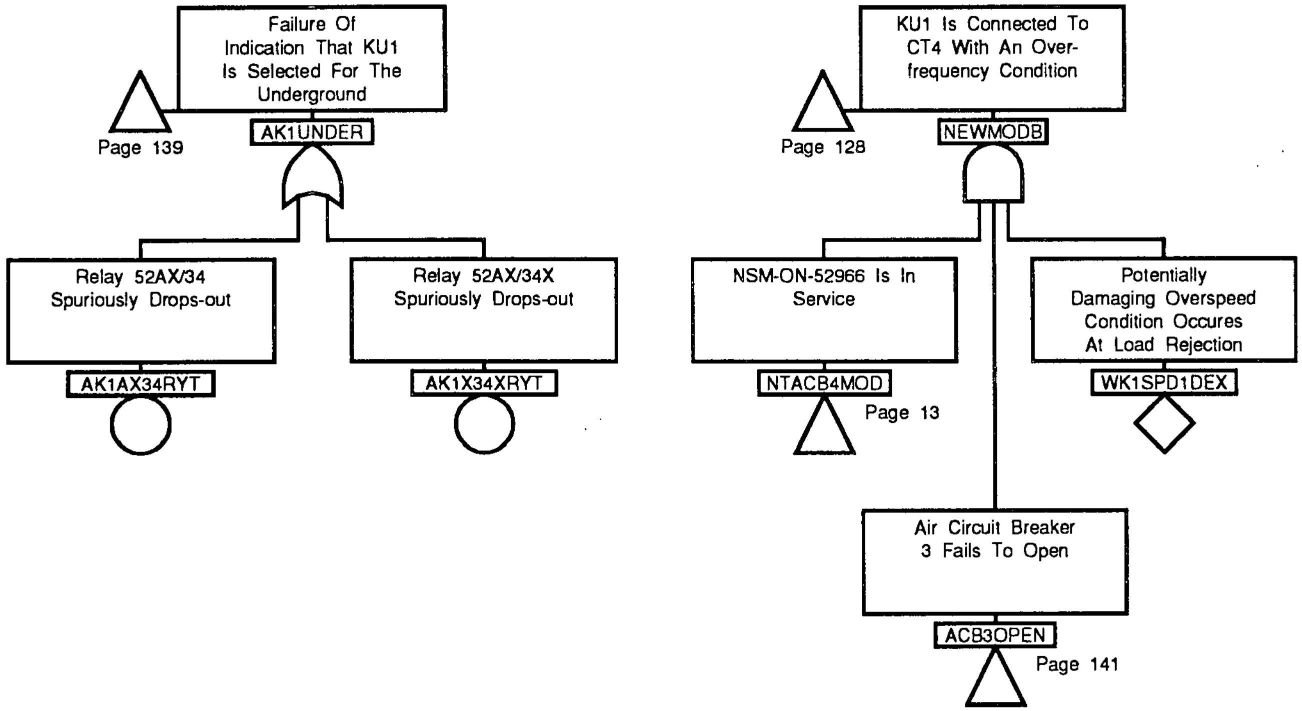
Keewee Unit 1 Governor or Turbine Fails While the Unit Runs
KU1GVTBRUN
Page 106
Keowee Unit 1 Governor Fails With the Unit Running
WK1GOVRUN
Keowee Unit 1 Turbine Fails With the Unit Running
WK1TURRUN
Page 164
Keowee Unit 1 Gov. Fails to Position Wicket Gates With Unit Running
WK1GVRNDEX
Unit 1 Governor Oil (OG) System Fails Keowee Run
OK1600
Keowee 1 Governor Control Fails During Run
YK1RUNCNTL
Page 158
Keowee Unit 1 Governor Failure Creates Overspeed Condition
WK1SPD2DEX
2
Loss of Unit 1 OG System Oil or Oil Pressure
OK1200
Page 145
All Unit 1 OG Pumps Fail to Supply GOPT
OK1400
Page 151
OG Pressure Tank is Isolated And OG Pump 1A Train Fails (Emergency Mode)
OK1300
Page 146

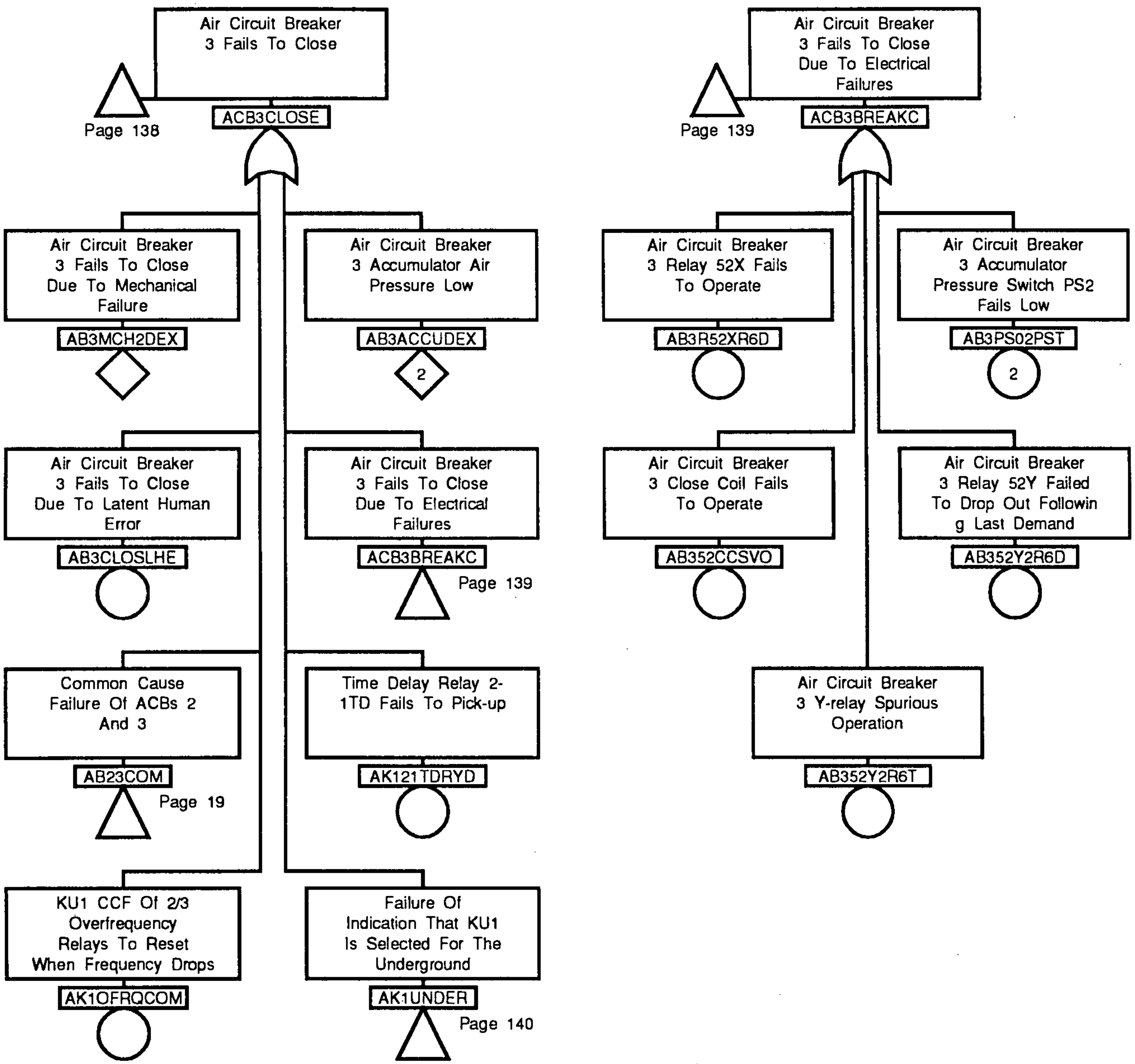

ACB3 Trip Signal Fails When Generating To The Grid
ACB3TRIPG0
Page 141
Keowee Unit 1 Is Supplying The Grid
KU1RNNG
Page 20
ACB-3 Trip Signal (Unit Generation) Fails
ACB3TRIPG
Relay 52XG/1 Fails To Pick Up When The Unit Is Started
AK152XGRYD
Keowee 1 Emer Strt Aux Rlys 1ESRX/2A & 1ESRX/2B Fail KEE-111,-OEE-120
YK1STR2INT
Page 113
Relay 52XG/1 Spuriously Drops Out While The Unit Is Running
AK152XGRYT
Time Delay Relay 52-1TD Spurious Operation
AK152TDRYT
2
ACB-3 Fails To Trip On Governor Overspeed
ACB3TRIPW0
Page 141
Keowee Unit 1 Governor Failure Creates Overspeed Condition
WK1SPD2DEX
2
ACB-3 Trip Signal (Governor Failure) Fails
ACB3TRIPW
KU1 Magnetic Speed Switch System Fails
AK114GVDEX
2
Relay 14GOV/1X Fails To Pick-up
AK1GV1XRYD
Time Delay Relay 52-1TD Fails To Pick-up
AK152TDRYD

XD1DAR Outputs:
Page 158, Page 141, Page 221, Page 179, Page 150, Page 185, Page 194

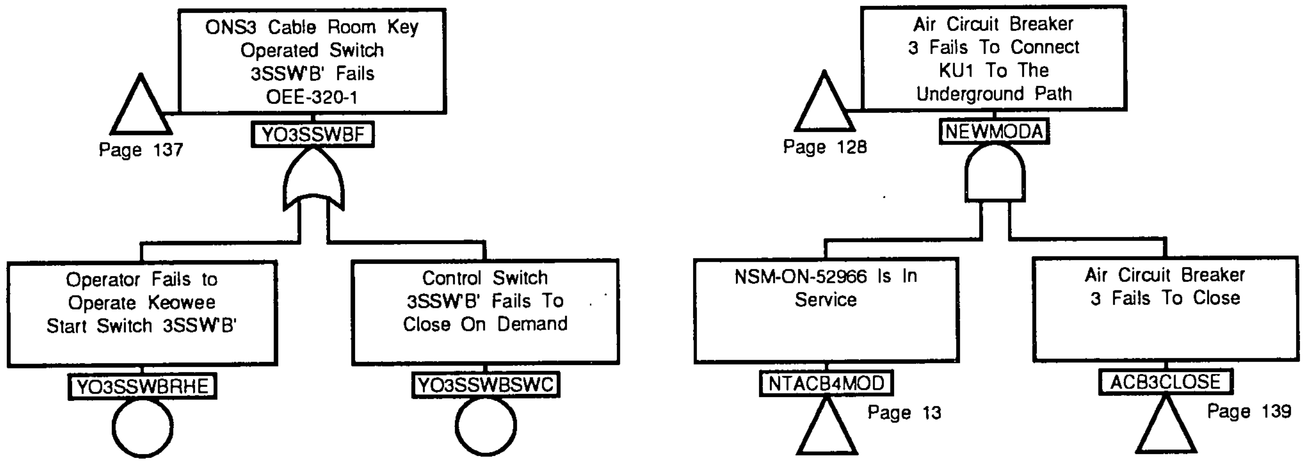


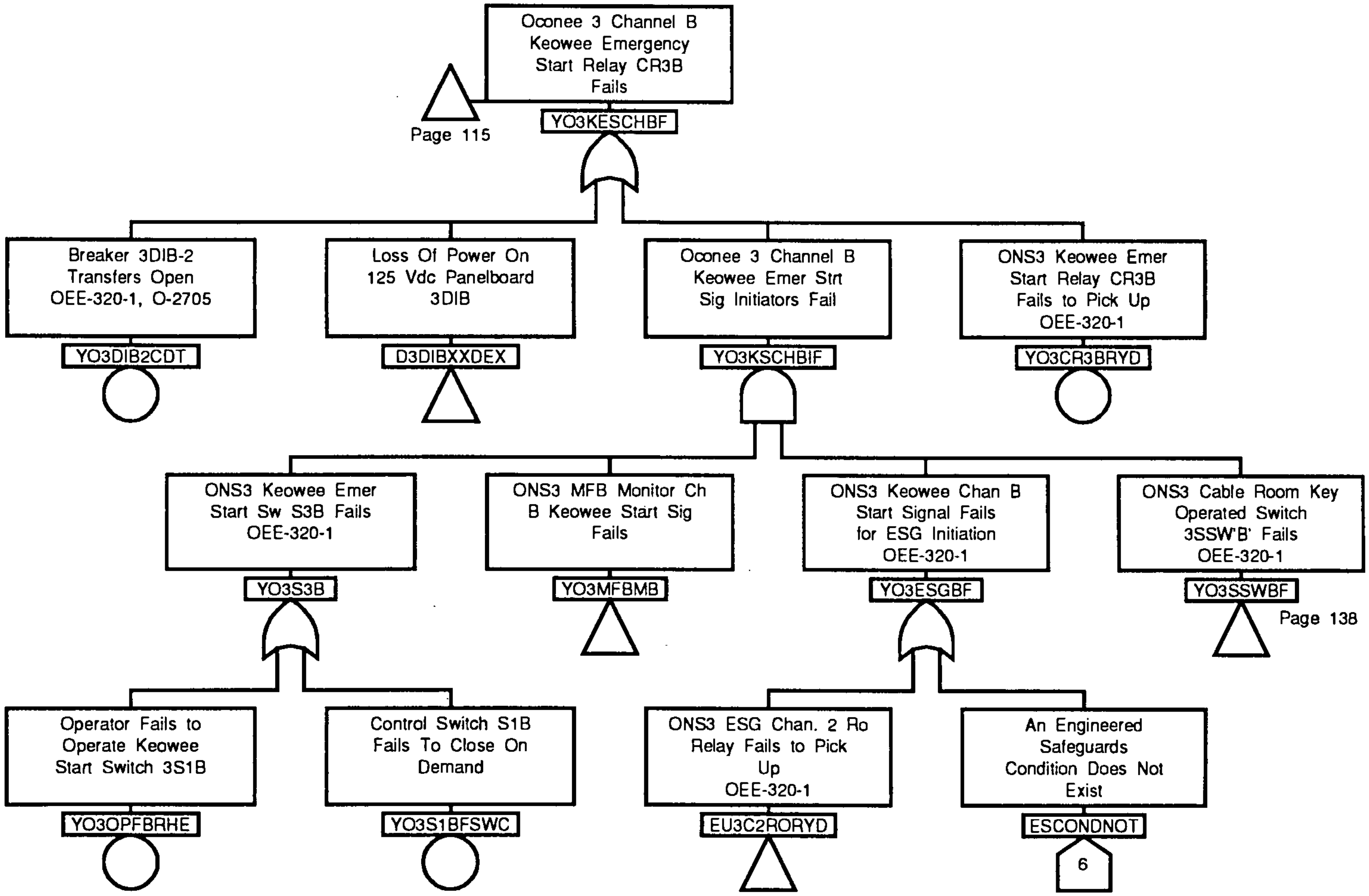

Air Circuit Breaker 3 Fails To Open
ACB3OPEN
Page 140
Page 218
Air Circuit Breaker 3 Fails To Open Due To Mechanical Failure
AB3MECHDEX
Breaker 3CC In 125V dc Distribution Center 1DA Transfers Position
AD1C3CCCDT
2
Air Circuit Breaker 3 Accumulator Air Pressure Low
AB3ACCUDEX
2
Loss of Power on Keowee 1 125Vdc Dist. Ctr. 1DA during Run K-704,
XD1DAR
Page 142
Air Circuit Breaker 3 Relay 52Z Fails To Operate
AB3R52ZR6D
ACB3 Trip Signal Fails When Generating To The Grid
ACB3TRIPG0
Page 143
Air Circuit Breaker 3 Trip Coil Fails To Operate
AB352TCSVO
ACB-3 Fails To Trip On Governor Overspeed
ACB3TRIPW0
Page 143
Air Circuit Breaker 3 Accumulator Pressure Switch PS2 Fails Low
AB3PS02PST
2


Failure Of Indication That KU1 Is Selected For The Underground
AK1UNDER
Page 139
Relay 52AX/34 Spuriously Drops-out
AK1AX34RYT
Relay 52AX/34X Spuriously Drops-out
AK1X34XRYT
KU1 Is Connected To CT4 With An Over-frequency Condition
NEWMODB
Page 128
NSM-ON-52966 Is In Service
NTACB4MOD
Page 13
Potentially Damaging Overspeed Condition Occures At Load Rejection
WK1SPD1DEX
Air Circuit Breaker 3 Fails To Open
ACB3OPEN
Page 141

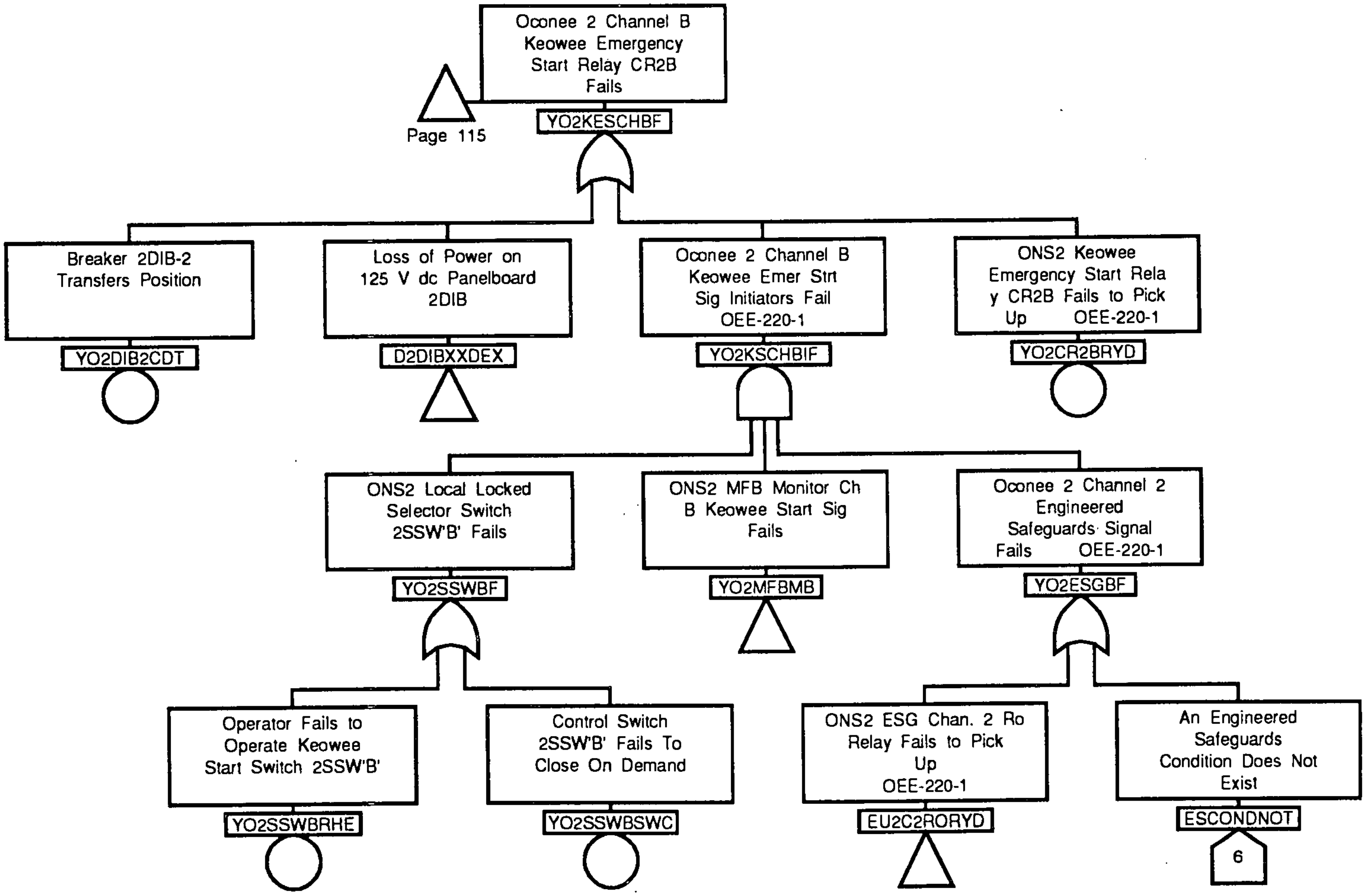


Air Circuit Breaker 3 Fails To Close
Page 138
ACB3CLOSE
Air Circuit Breaker 3 Fails To Close Due To Mechanical Failure
AB3MCH2DEX
Air Circuit Breaker 3 Accumulator Air Pressure Low
AB3ACCUDEX
2
Air Circuit Breaker 3 Fails To Close Due To Latent Human Error
AB3CLOSLHE
Air Circuit Breaker 3 Fails To Close Due To Electrical Failures
ACB3BREAKC
Page 139
Common Cause Failure Of ACBs 2 And 3
AB23COM
Page 19
Time Delay Relay 2-1TD Fails To Pick-up
AK121TDRYD
KU1 CCF Of 2/3 Overfrequency Relays To Reset When Frequency Drops
AK1OFRQCOM
Failure Of Indication That KU1 Is Selected For The Underground
AK1UNDER
Page 140
Air Circuit Breaker 3 Fails To Close Due To Electrical Failures
Page 139
ACB3BREAKC
Air Circuit Breaker 3 Relay 52X Fails To Operate
AB3R52XR6D
Air Circuit Breaker 3 Accumulator Pressure Switch PS2 Fails Low
AB3PS02PST
2
Air Circuit Breaker 3 Close Coil Fails To Operate
AB352CCSVO
Air Circuit Breaker 3 Relay 52Y Failed To Drop Out Followin g Last Demand
AB352Y2R6D
Air Circuit Breaker 3 Y-relay Spurious Operation
AB352Y2R6T

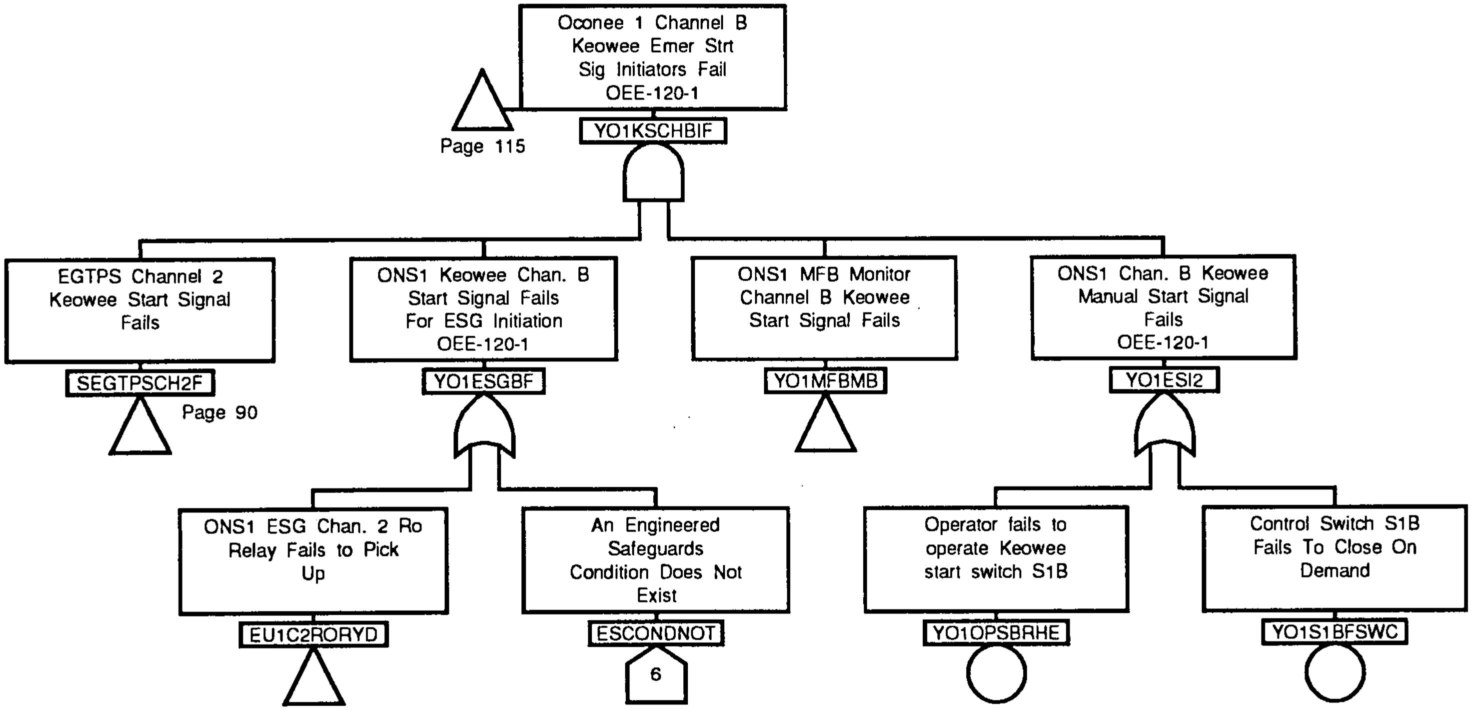

ONS3 Cable Room Key Operated Switch 3SSW'B' Fails OEE-320-1
YO3SSWBF
Page 137
Operator Fails to Operate Keowee Start Switch 3SSW'B'
YO3SSWBRHE
Control Switch 3SSW'B' Fails To Close On Demand
YO3SSWBSWC
Air Circuit Breaker 3 Fails To Connect KU1 To The Underground Path
NEWMODA
Page 128
NSM-ON-52966 Is In Service
NTACB4MOD
Page 13
Air Circuit Breaker 3 Fails To Close
ACB3CLOSE
Page 139

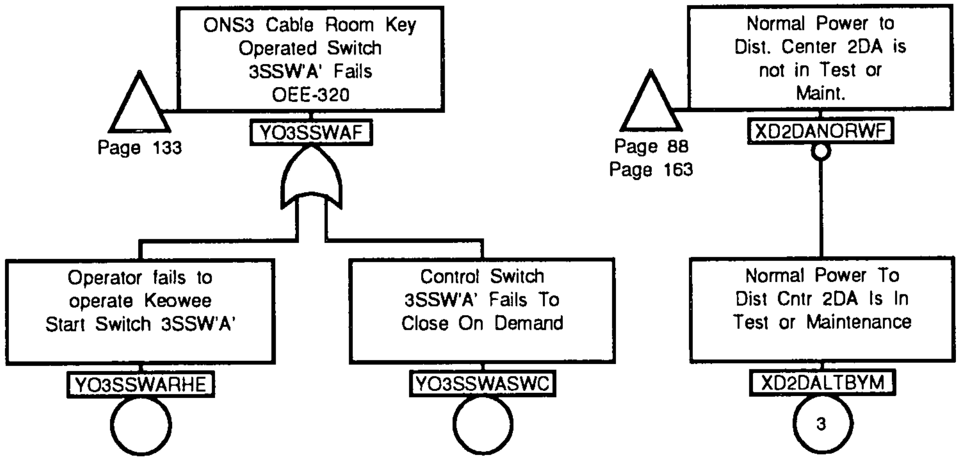


Oconee 3 Channel B Keowee Emergency Start Relay CR3B Fails
YO3KESCHBF
Page 115
Breaker 3DIB-2 Transfers Open OEE-320-1, O-2705
YO3DIB2CDT
Loss Of Power On 125 Vdc Panelboard 3DIB
D3DIBXXDEX
Oconee 3 Channel B Keowee Emer Strt Sig Initiators Fail
YO3KSCHBIF
ONS3 Keowee Emer Start Relay CR3B Fails to Pick Up OEE-320-1
YO3CR3BRYD
ONS3 Keowee Emer Start Sw S3B Fails OEE-320-1
YO3S3B
ONS3 MFB Monitor Ch B Keowee Start Sig Fails
YO3MFBMB
ONS3 Keowee Chan B Start Signal Fails for ESG Initiation OEE-320-1
YO3ESGBF
ONS3 Cable Room Key Operated Switch 3SSW'B' Fails OEE-320-1
YO3SSWBF
Page 138
Operator Fails to Operate Keowee Start Switch 3S1B
YO3OPFBRHE
Control Switch S1B Fails To Close On Demand
YO3S1BFSWC
ONS3 ESG Chan. 2 Ro Relay Fails to Pick Up OEE-320-1
EU3C2RORYD
An Engineered Safeguards Condition Does Not Exist
ESCONDNOT
6

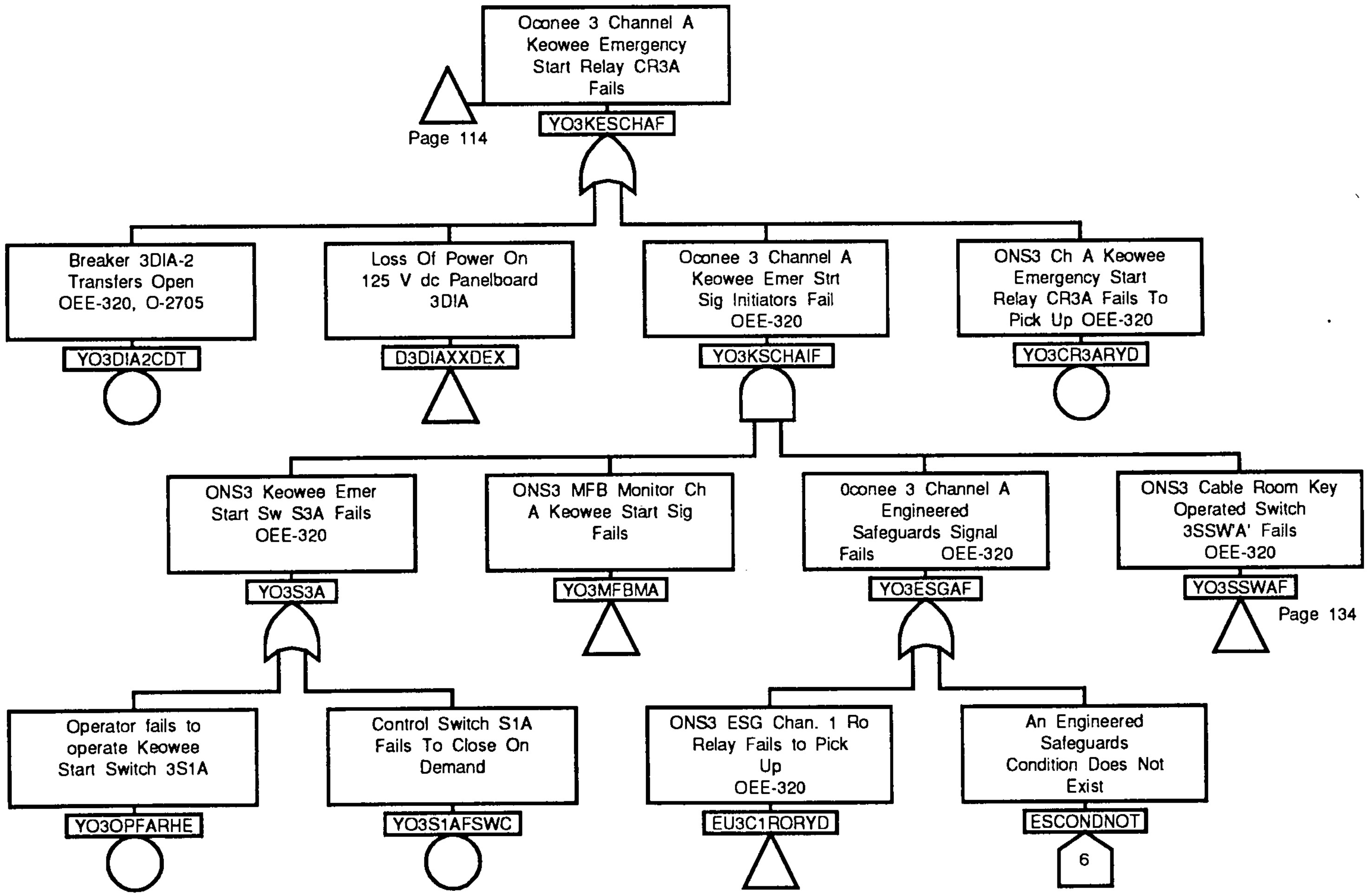


Oconee 2 Channel B Keowee Emergency Start Relay CR2B Fails
YO2KESCHBF
Page 115
Breaker 2DIB-2 Transfers Position
YO2DIB2CDT
Loss of Power on 125 V dc Panelboard 2DIB
D2DIBXXDEX
Oconee 2 Channel B Keowee Emer Strt Sig Initiators Fail OEE-220-1
YO2KSCHBIF
ONS2 Keowee Emergency Start Rela y CR2B Fails to Pick Up OEE-220-1
YO2CR2BRYD
ONS2 Local Locked Selector Switch 2SSW'B' Fails
YO2SSWBF
ONS2 MFB Monitor Ch B Keowee Start Sig Fails
YO2MFBMB
Oconee 2 Channel 2 Engineered Safeguards Signal Fails OEE-220-1
YO2ESGBF
Operator Fails to Operate Keowee Start Switch 2SSW'B'
YO2SSWBRHE
Control Switch 2SSW'B' Fails To Close On Demand
YO2SSWBSWC
ONS2 ESG Chan. 2 Ro Relay Fails to Pick Up OEE-220-1
EU2C2RORYD
An Engineered Safeguards Condition Does Not Exist
ESCONDNOT
6

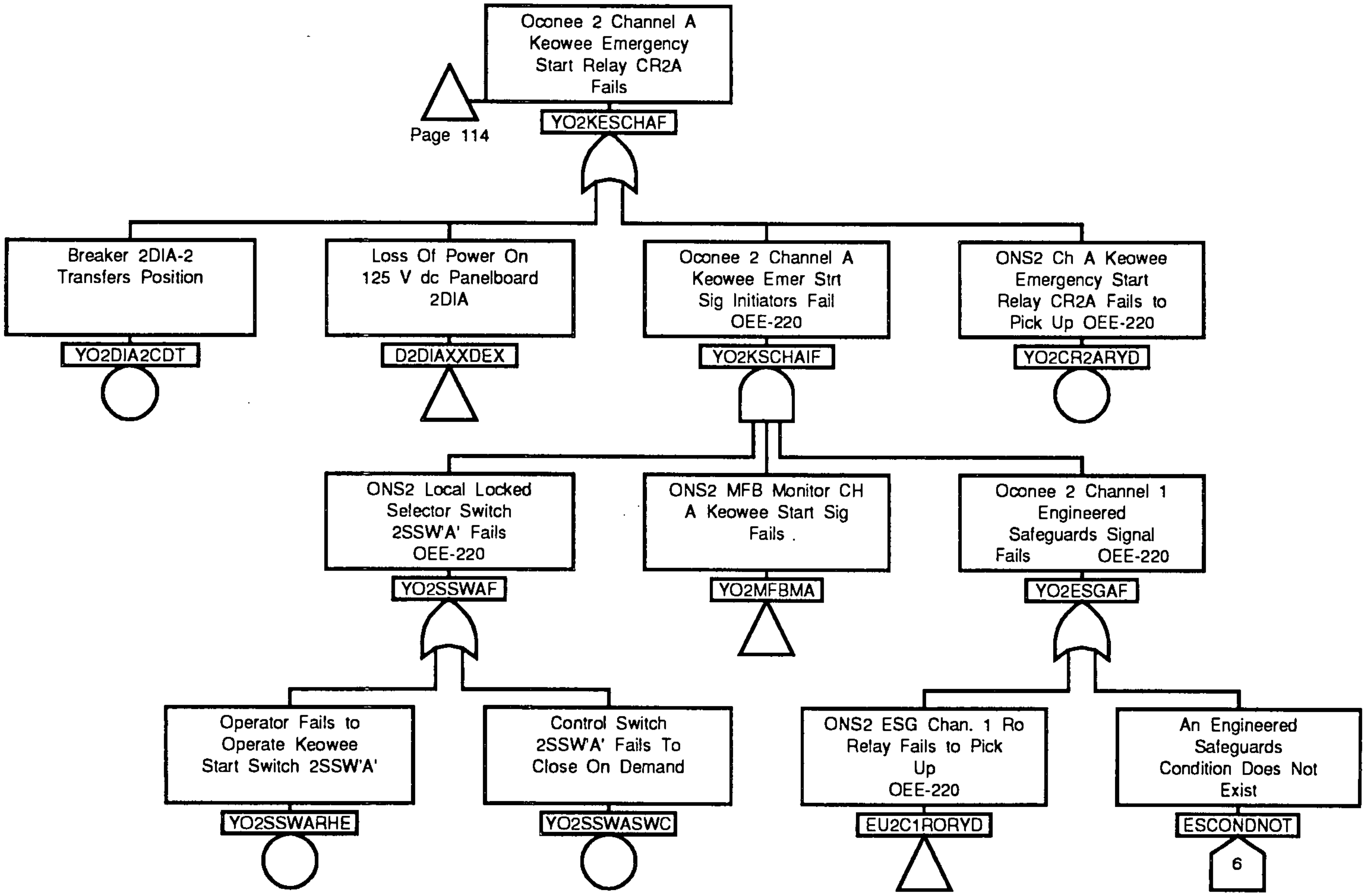

Oconee 1 Channel B Keowee Emer Strt Sig Initiators Fail OEE-120-1
YO1KSCHBIF
Page 115
EGTPS Channel 2 Keowee Start Signal Fails
SEGTPSCH2F
Page 90
ONS1 Keowee Chan. B Start Signal Fails For ESG Initiation OEE-120-1
YO1ESGBF
ONS1 MFB Monitor Channel B Keowee Start Signal Fails
YO1MFBMB
ONS1 Chan. B Keowee Manual Start Signal Fails OEE-120-1
YO1ESI2
ONS1 ESG Chan. 2 Ro Relay Fails to Pick Up
EU1C2RORYD
An Engineered Safeguards Condition Does Not Exist
ESCONDNOT
6
Operator fails to operate Keowee start switch S1B
YO1OPSBRHE
Control Switch S1B Fails To Close On Demand
YO1S1BFSWC

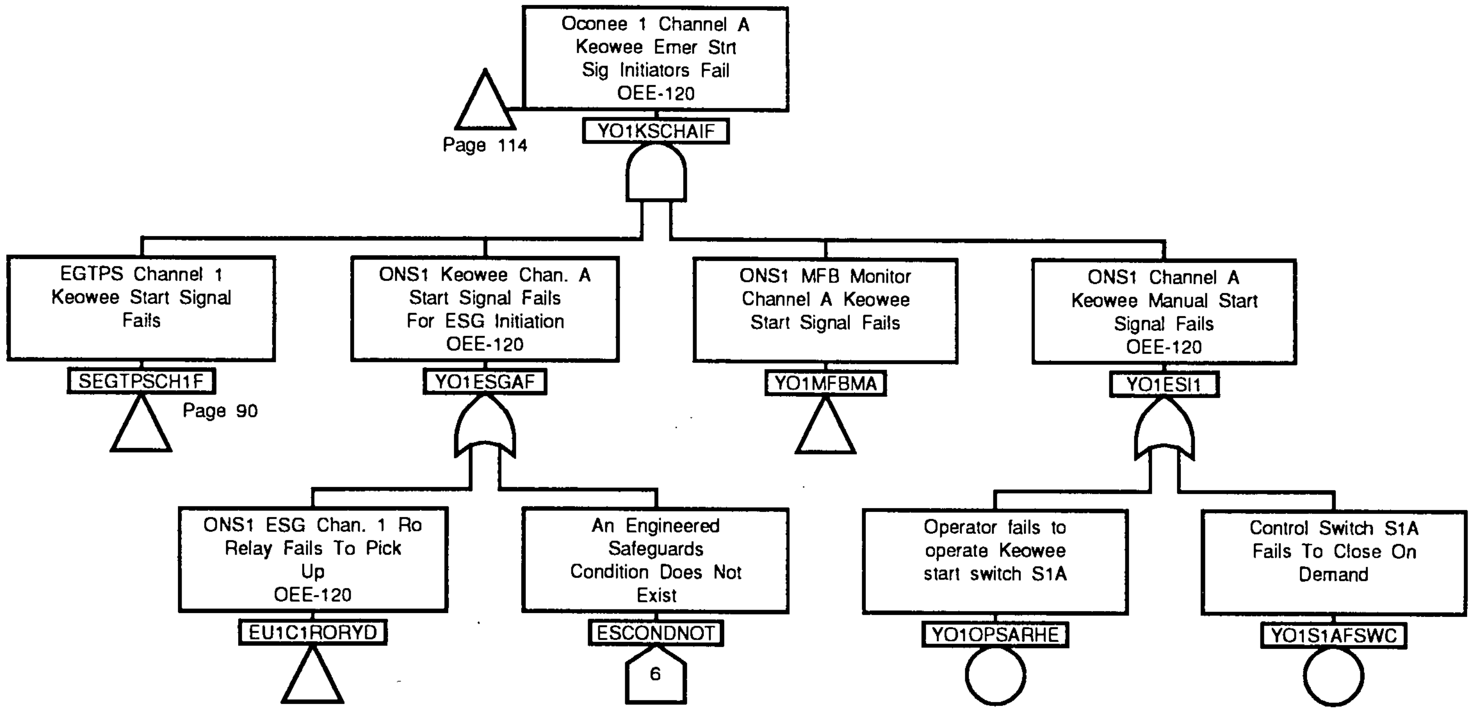


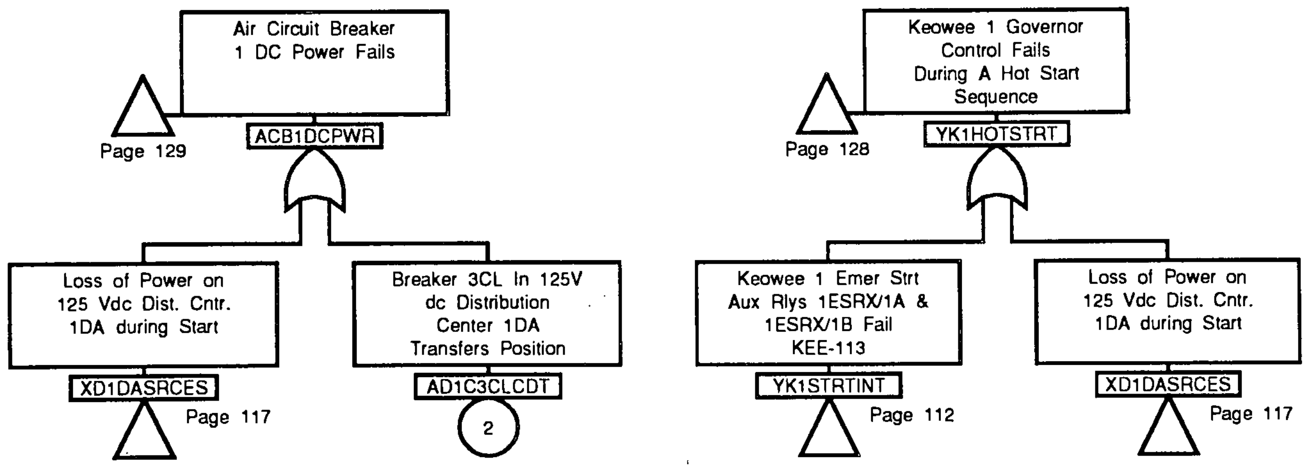
ONS3 Cable Room Key Operated Switch 3SSW'A' Fails OEE-320
YO3SSWAF
Page 133
Operator fails to operate Keowee Start Switch 3SSW'A'
YO3SSWARHE
Control Switch 3SSW'A' Fails To Close On Demand
YO3SSWASWC
Normal Power to Dist. Center 2DA is not in Test or Maint.
XD2DANORWF
Page 88
Page 163
Normal Power To Dist Cntr 2DA Is In Test or Maintenance
XD2DALTBYM
3

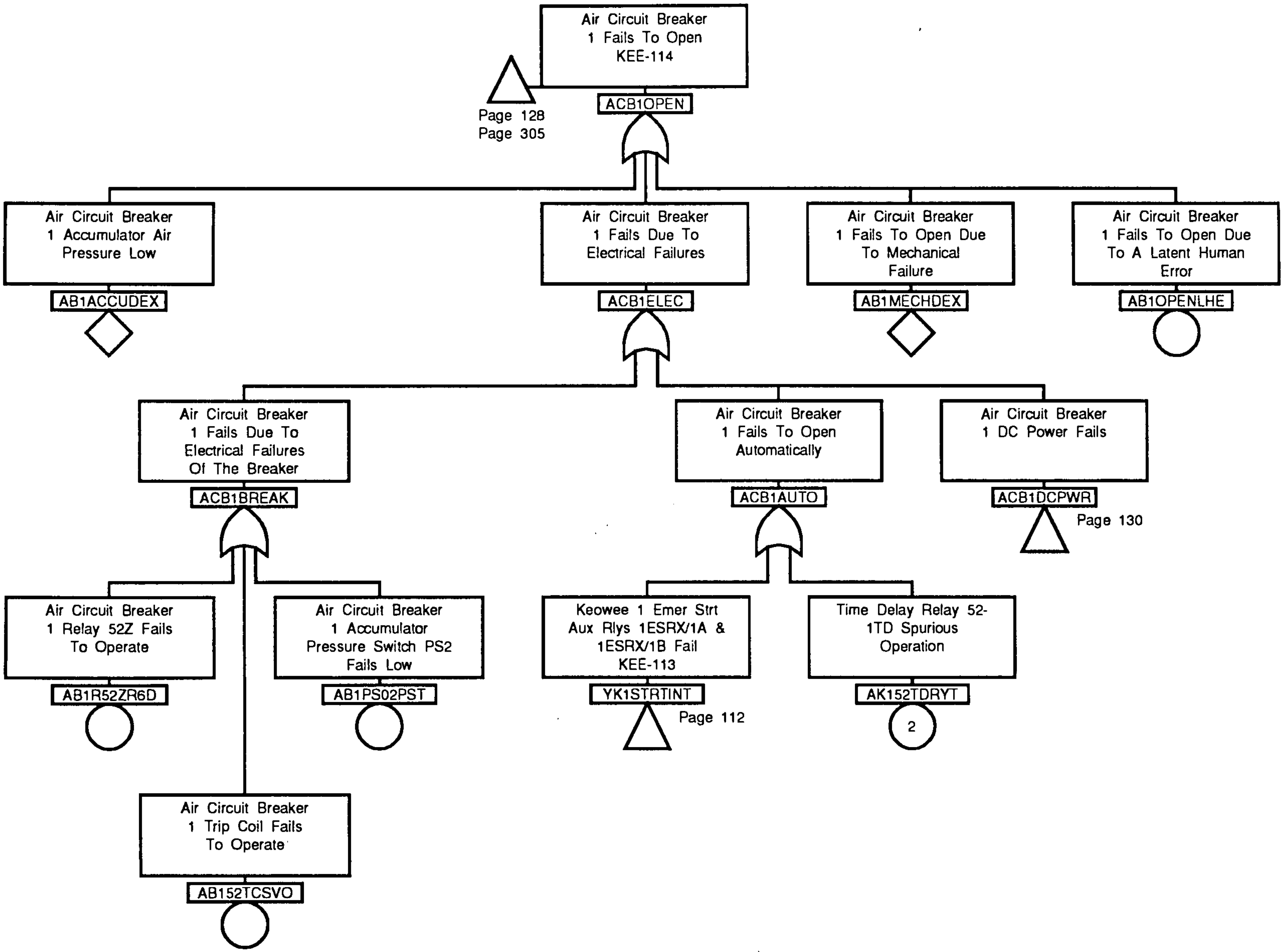


Oconee 3 Channel A Keowee Emergency Start Relay CR3A Fails
YO3KESCHAF
Page 114
Breaker 3DIA-2 Transfers Open OEE-320, O-2705
YO3DIA2CDT
Loss Of Power On 125 V dc Panelboard 3DIA
D3DIAXXDEX
Oconee 3 Channel A Keowee Emer Strt Sig Initiators Fail OEE-320
YO3KSCHAIF
ONS3 Ch A Keowee Emergency Start Relay CR3A Fails To Pick Up OEE-320
YO3CR3ARYD
ONS3 Keowee Emer Start Sw S3A Fails OEE-320
YO3S3A
ONS3 MFB Monitor Ch A Keowee Start Sig Fails
YO3MFBMA
Oconee 3 Channel A Engineered Safeguards Signal Fails OEE-320
YO3ESGAF
ONS3 Cable Room Key Operated Switch 3SSW'A' Fails OEE-320
YO3SSWAF
Page 134
Operator fails to operate Keowee Start Switch 3S1A
YO3OPFARHE
Control Switch S1A Fails To Close On Demand
YO3S1AFSWC
ONS3 ESG Chan. 1 Ro Relay Fails to Pick Up OEE-320
EU3C1RORYD
An Engineered Safeguards Condition Does Not Exist
ESCONDNOT
6

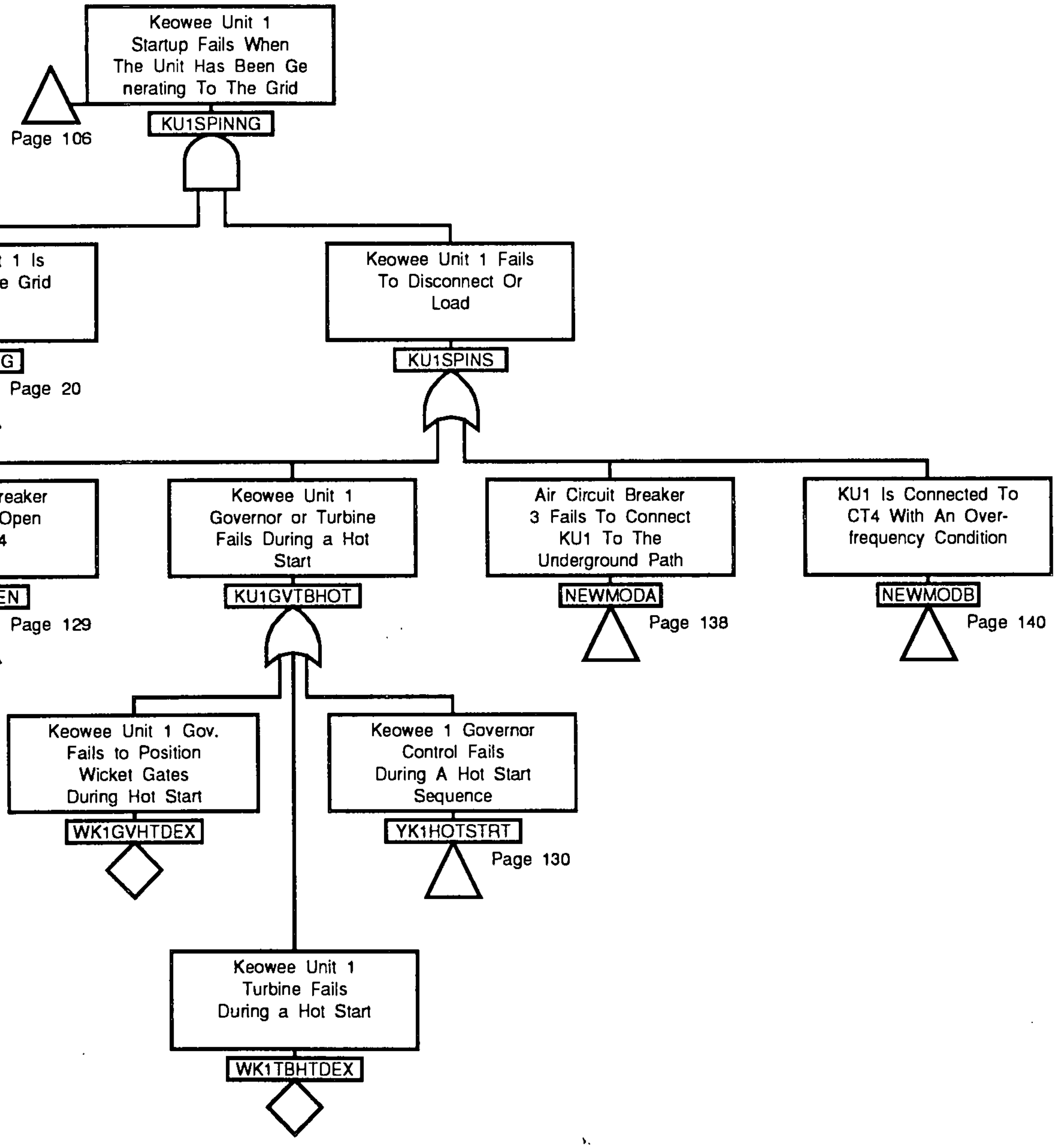

Oconee 2 Channel A Keowee Emergency Start Relay CR2A Fails
YO2KESCHAF
Page 114
Breaker 2DIA-2 Transfers Position
YO2DIA2CDT
Loss Of Power On 125 V dc Panelboard 2DIA
D2DIAXXDEX
Oconee 2 Channel A Keowee Emer Strt Sig Initiators Fail OEE-220
YO2KSCHAIF
ONS2 Ch A Keowee Emergency Start Relay CR2A Fails to Pick Up OEE-220
YO2CR2ARYD
ONS2 Local Locked Selector Switch 2SSW'A' Fails OEE-220
YO2SSWAF
ONS2 MFB Monitor CH A Keowee Start Sig Fails .
YO2MFBMA
Oconee 2 Channel 1 Engineered Safeguards Signal Fails OEE-220
YO2ESGAF
Operator Fails to Operate Keowee Start Switch 2SSW'A'
YO2SSWARHE
Control Switch 2SSW'A' Fails To Close On Demand
YO2SSWASWC
ONS2 ESG Chan. 1 Ro Relay Fails to Pick Up OEE-220
EU2C1RORYD
An Engineered Safeguards Condition Does Not Exist
ESCONDNOT
6

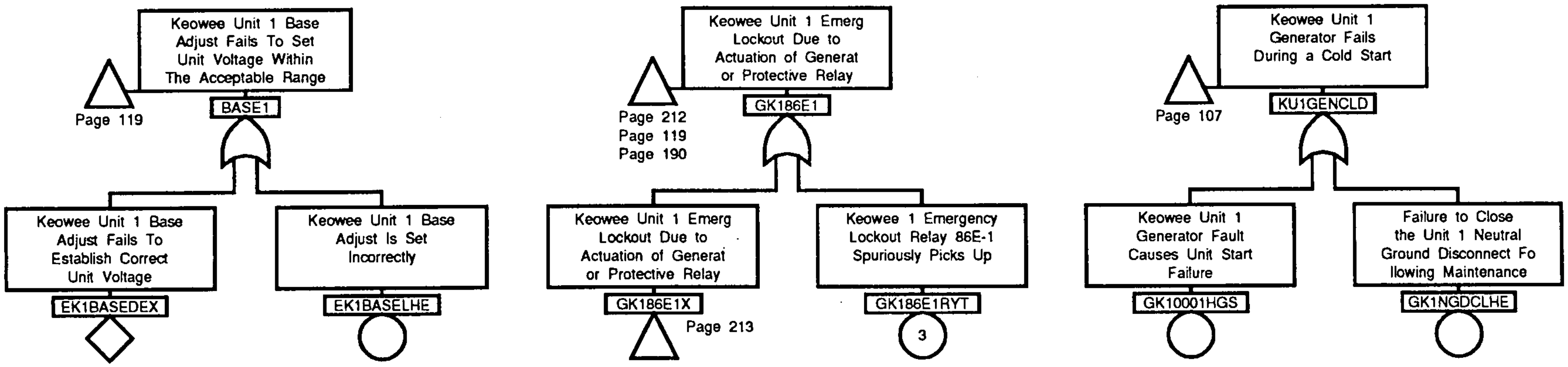

Oconee 1 Channel A Keowee Emer Strt Sig Initiators Fail OEE-120
YO1KSCHAIF
Page 114
EGTPS Channel 1 Keowee Start Signal Fails
SEGTPSCH1F
Page 90
ONS1 Keowee Chan. A Start Signal Fails For ESG Initiation OEE-120
YO1ESGAF
ONS1 MFB Monitor Channel A Keowee Start Signal Fails
YO1MFBMA
ONS1 Channel A Keowee Manual Start Signal Fails OEE-120
YO1ESI1
ONS1 ESG Chan. 1 Ro Relay Fails To Pick Up OEE-120
EU1C1RORYD
An Engineered Safeguards Condition Does Not Exist
ESCONDNOT
6
Operator fails to operate Keowee start switch S1A
YO1OPSARHE
Control Switch S1A Fails To Close On Demand
YO1S1AFSWC

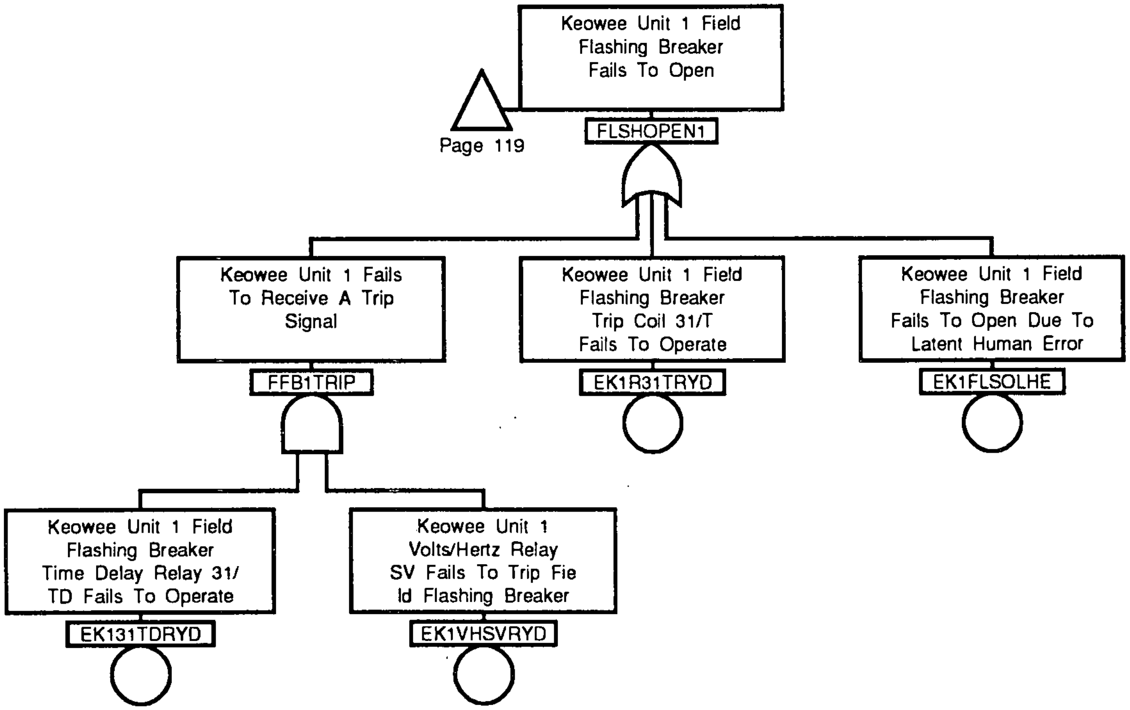

Air Circuit Breaker 1 DC Power Fails
ACB1DCPWR
Page 129
Loss of Power on 125 Vdc Dist. Cntr. 1DA during Start
XD1DASRCES
Page 117
Breaker 3CL In 125V dc Distribution Center 1DA Transfers Position
AD1C3CLCDT
2
Keowee 1 Governor Control Fails During A Hot Start Sequence
YK1HOTSTRT
Page 128
Keowee 1 Emer Strt Aux Rlys 1ESRX/1A & 1ESRX/1B Fail KEE-113
YK1STRTINT
Page 112
Loss of Power on 125 Vdc Dist. Cntr. 1DA during Start
XD1DASRCES
Page 117

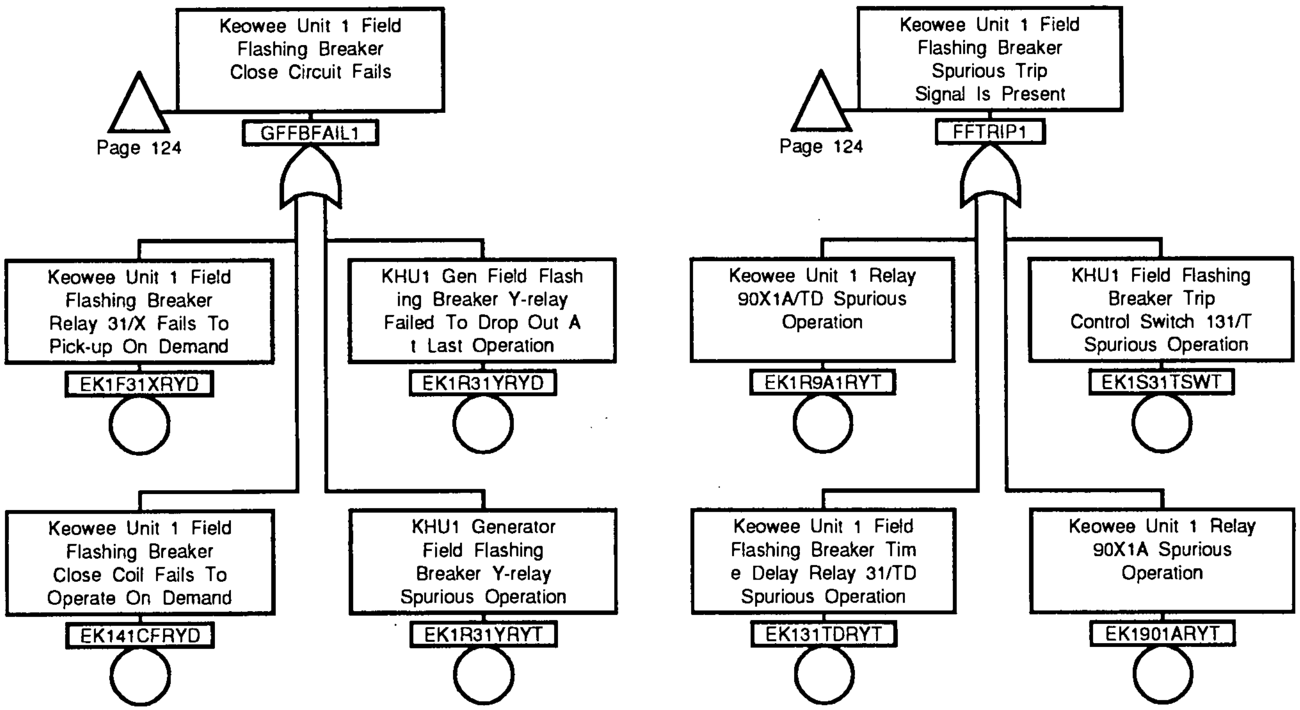


Air Circuit Breaker 1 Fails To Open KEE-114
ACB1OPEN
Page 128
Page 305
Air Circuit Breaker 1 Accumulator Air Pressure Low
AB1ACCUDEX
Air Circuit Breaker 1 Fails Due To Electrical Failures
ACB1ELEC
Air Circuit Breaker 1 Fails To Open Due To Mechanical Failure
AB1MECHDEX
Air Circuit Breaker 1 Fails To Open Due To A Latent Human Error
AB1OPENLHE
Air Circuit Breaker 1 Fails Due To Electrical Failures Of The Breaker
ACB1BREAK
Air Circuit Breaker 1 Fails To Open Automatically
ACB1AUTO
Air Circuit Breaker 1 DC Power Fails
ACB1DCPWR
Page 130
Air Circuit Breaker 1 Relay 52Z Fails To Operate
AB1R52ZR6D
Air Circuit Breaker 1 Accumulator Pressure Switch PS2 Fails Low
AB1PS02PST
Keowee 1 Emer Strt Aux Rlys 1ESRX/1A & 1ESRX/1B Fail KEE-113
YK1STRTINT
Page 112
Time Delay Relay 52-1TD Spurious Operation
AK152TDRYT
2
Air Circuit Breaker 1 Trip Coil Fails To Operate
AB152TCSVO

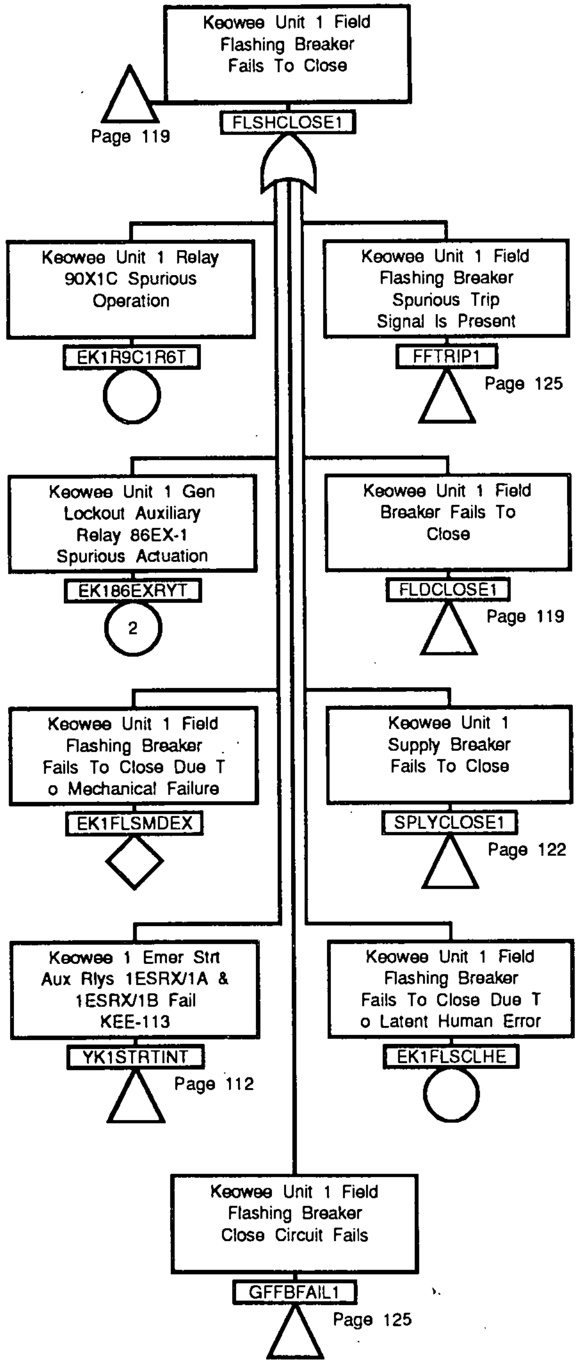

Keowee Unit 1 Startup Fails When The Unit Has Been Generating To The Grid
KU1SPINNG
Page 106
Keowee Unit 1 Is Supplying The Grid
KU1RNNG
Page 20
Keowee Unit 1 Fails To Disconnect Or Load
KU1SPINS
Air Circuit Breaker 1 Fails To Open KEE-114
ACB1OPEN
Page 129
Keowee Unit 1 Governor or Turbine Fails During a Hot Start
KU1GVTBHOT
Air Circuit Breaker 3 Fails To Connect KU1 To The Underground Path
NEWMODA
Page 138
KU1 Is Connected To CT4 With An Over-frequency Condition
NEWMODB
Page 140
Keowee Unit 1 Gov. Fails to Position Wicket Gates During Hot Start
WK1GVHTDEX
Keowee 1 Governor Control Fails During A Hot Start Sequence
YK1HOTSTRT
Page 130
Keowee Unit 1 Turbine Fails During a Hot Start
WK1TBHTDEX

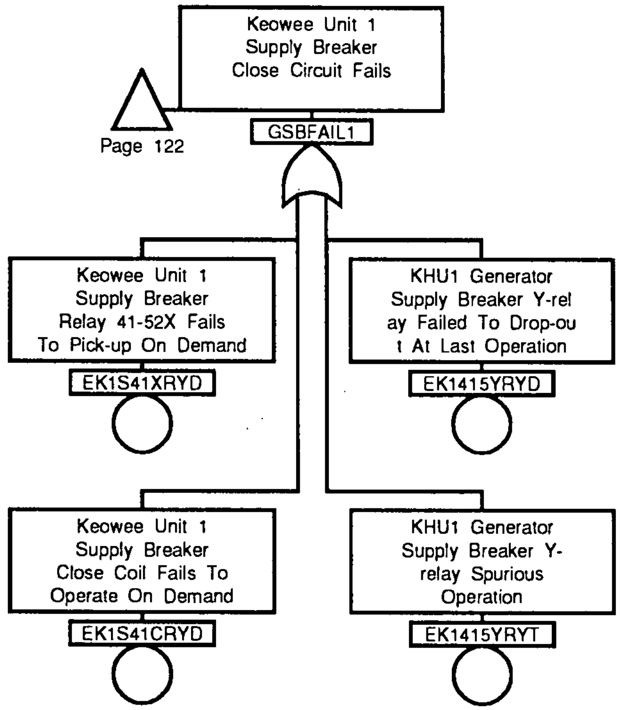

Keowee Unit 1 Base Adjust Fails To Set Unit Voltage Within The Acceptable Range
Page 119
BASE1
Keowee Unit 1 Base Adjust Fails To Establish Correct Unit Voltage
EK1BASEDEX
Keowee Unit 1 Base Adjust Is Set Incorrectly
EK1BASELHE
Keowee Unit 1 Emerg Lockout Due to Actuation of Generat or Protective Relay
Page 212
Page 119
Page 190
GK186E1
Keowee Unit 1 Emerg Lockout Due to Actuation of Generat or Protective Relay
GK186E1X
Page 213
Keowee 1 Emergency Lockout Relay 86E-1 Spuriously Picks Up
GK186E1RYT
3
Keowee Unit 1 Generator Fails During a Cold Start
Page 107
KU1GENCLD
Keowee Unit 1 Generator Fault Causes Unit Start Failure
GK10001HGS
Failure to Close the Unit 1 Neutral Ground Disconnect Fo llowing Maintenance
GK1NGDCLHE

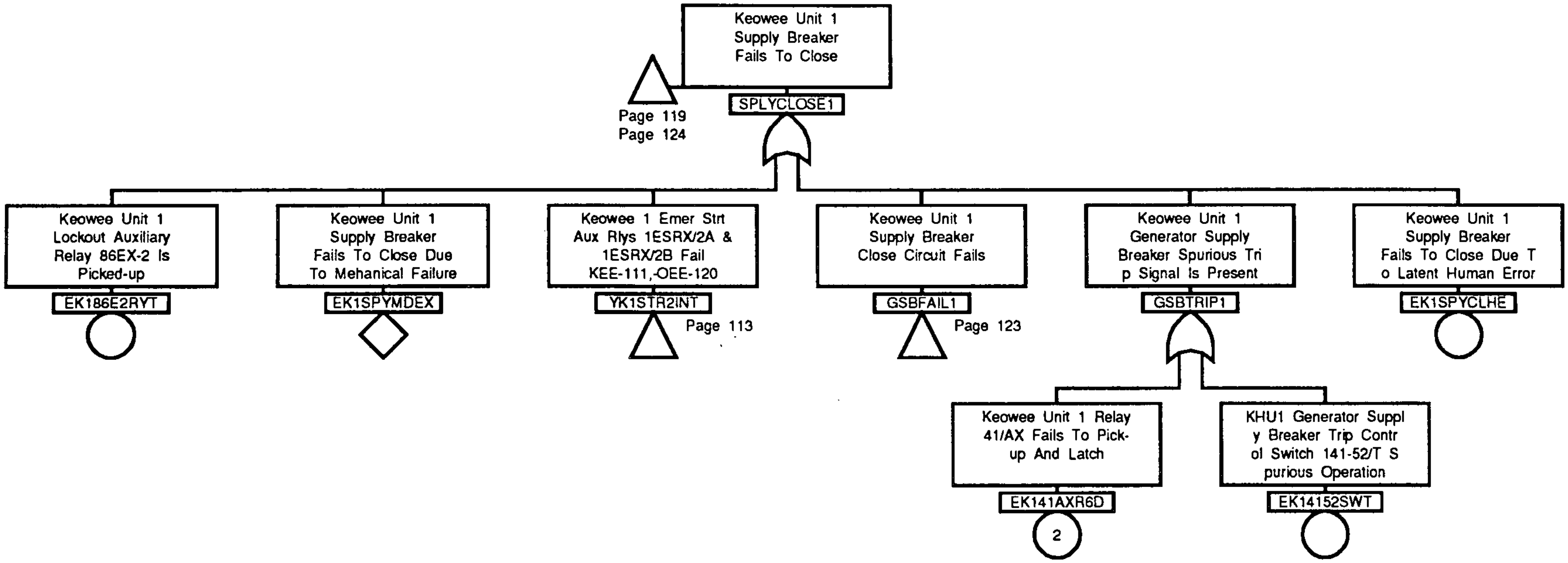

Keewee Unit 1 Field Flashing Breaker Fails To Open
Page 119
FLSHOPEN1
Keowee Unit 1 Fails To Receive A Trip Signal
FFB1TRIP
Keowee Unit 1 Field Flashing Breaker Trip Coil 31/T Fails To Operate
EK1R31TRYD
Keowee Unit 1 Field Flashing Breaker Fails To Open Due To Latent Human Error
EK1FLSOLHE
Keowee Unit 1 Field Flashing Breaker Time Delay Relay 31/ TD Fails To Operate
EK131TDRYD
Keowee Unit 1 Volts/Hertz Relay SV Fails To Trip Fie ld Flashing Breaker
EK1VHSVRYD

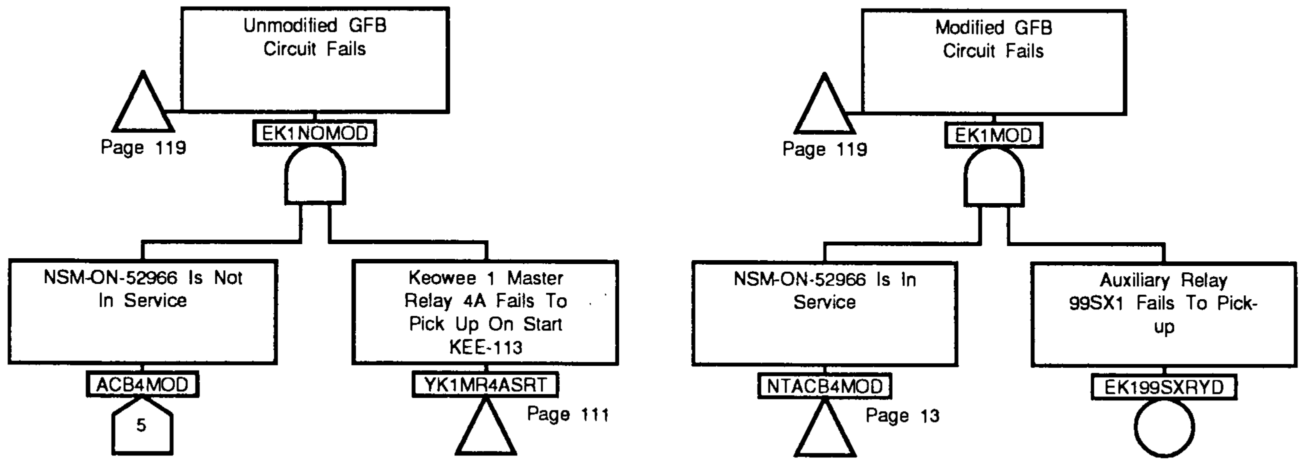


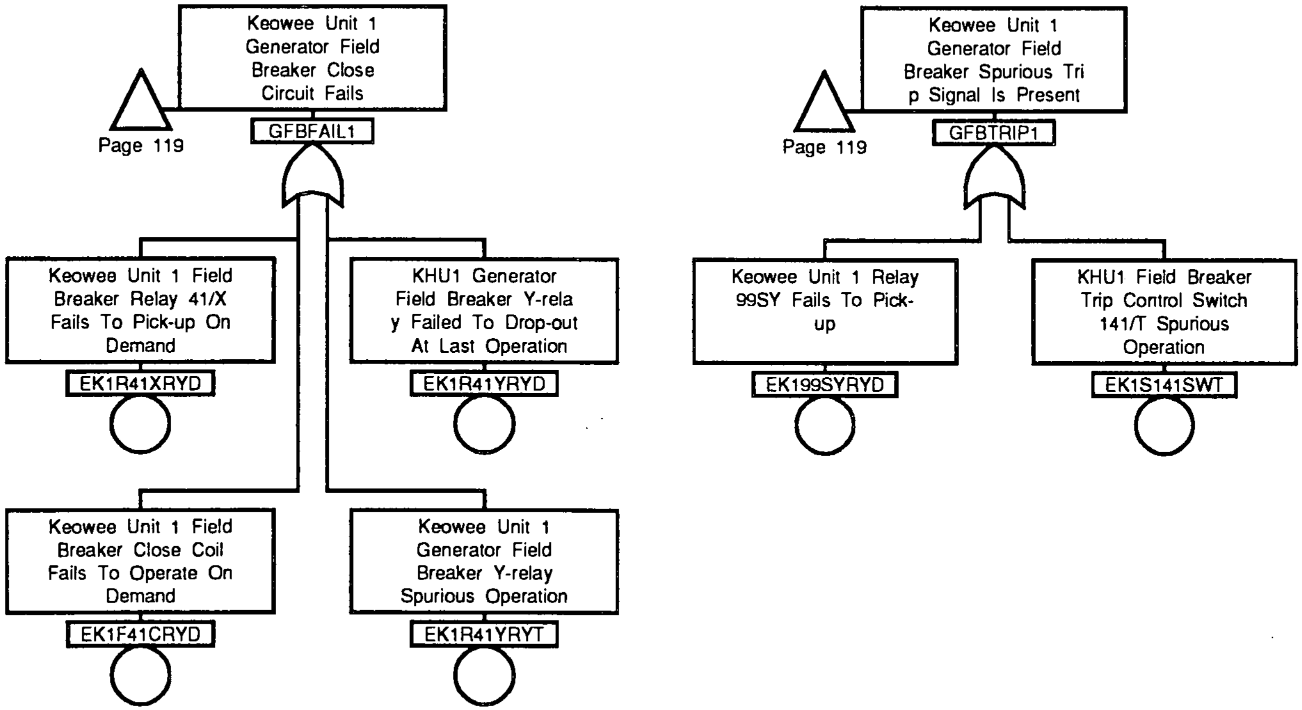
Keowee Unit 1 Field Flashing Breaker Close Circuit Fails
GFFBFAIL1
Page 124
Keowee Unit 1 Field Flashing Breaker Relay 31/X Fails To Pick-up On Demand
EK1F31XRYD
KHU1 Gen Field Flash ing Breaker Y-relay Failed To Drop Out A t Last Operation
EK1R31YRYD
Keowee Unit 1 Field Flashing Breaker Close Coil Fails To Operate On Demand
EK141CFRYD
KHU1 Generator Field Flashing Breaker Y-relay Spurious Operation
EK1R31YRYT
Keowee Unit 1 Field Flashing Breaker Spurious Trip Signal Is Present
FFTRIP1
Page 124
Keowee Unit 1 Relay 90X1A/TD Spurious Operation
EK1R9A1RYT
KHU1 Field Flashing Breaker Trip Control Switch 131/T Spurious Operation
EK1S31TSWT
Keowee Unit 1 Field Flashing Breaker Tim e Delay Relay 31/TD Spurious Operation
EK131TDRYT
Keowee Unit 1 Relay 90X1A Spurious Operation
EK1901ARYT

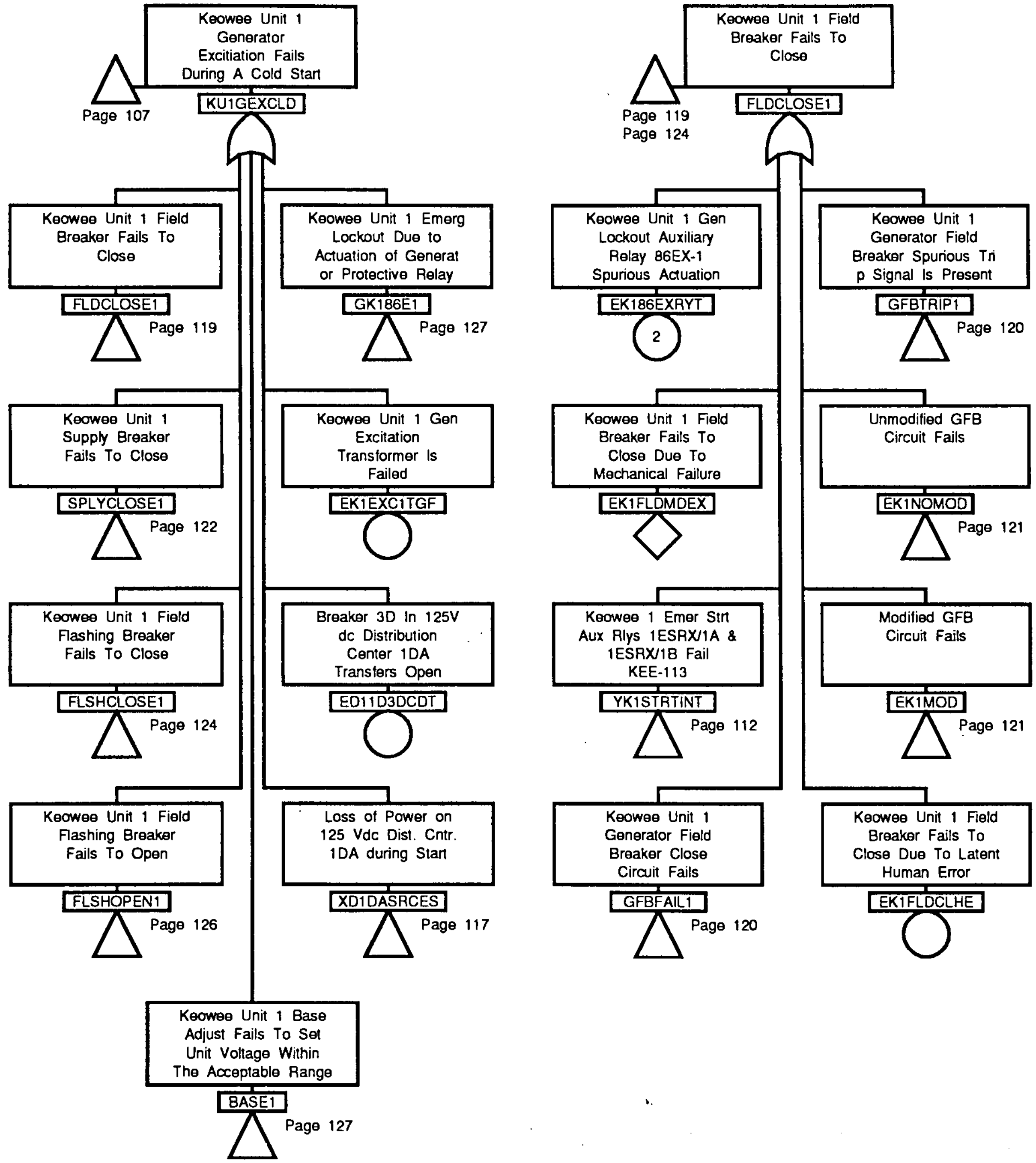

Keowee Unit 1 Field Flashing Breaker Fails To Close
FLSHCLOSE1
Page 119
Keowee Unit 1 Relay 90X1C Spurious Operation
EK1R9C1R6T
Keowee Unit 1 Field Flashing Breaker Spurious Trip Signal Is Present
FFTRIP1
Page 125
Keowee Unit 1 Gen Lockout Auxiliary Relay 86EX-1 Spurious Actuation
EK186EXRYT
2
Keowee Unit 1 Field Breaker Fails To Close
FLDCLOSE1
Page 119
Keowee Unit 1 Field Flashing Breaker Fails To Close Due T o Mechanical Failure
EK1FLSMDEX
Keowee Unit 1 Supply Breaker Fails To Close
SPLYCLOSE1
Page 122
Keowee 1 Emer Strt Aux Rlys 1ESRX/1A & 1ESRX/1B Fail KEE-113
YK1STRTINT
Page 112
Keowee Unit 1 Field Flashing Breaker Fails To Close Due T o Latent Human Error
EK1FLSCLHE
Keowee Unit 1 Field Flashing Breaker Close Circuit Fails
GFFBFAIL1
Page 125

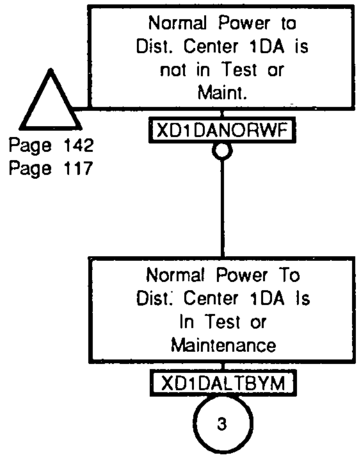

Keowee Unit 1 Supply Breaker Close Circuit Fails
GSBFAIL1
Page 122
Keowee Unit 1 Supply Breaker Relay 41-52X Fails To Pick-up On Demand
EK1S41XRYD
KHU1 Generator Supply Breaker Y-relay Failed To Drop-out At Last Operation
EK1415YRYD
Keowee Unit 1 Supply Breaker Close Coil Fails To Operate On Demand
EK1S41CRYD
KHU1 Generator Supply Breaker Y-relay Spurious Operation
EK1415YRYT


Keowee Unit 1 Supply Breaker Fails To Close
SPLYCLOSE1
Page 119
Page 124
Keowee Unit 1 Lockout Auxiliary Relay 86EX-2 Is Picked-up
EK186E2RYT
Keowee Unit 1 Supply Breaker Fails To Close Due To Mehanical Failure
EK1SPYMDEX
Keowee 1 Emer Strt Aux Rlys 1ESRX/2A & 1ESRX/2B Fail KEE-111,-OEE-120
YK1STR2INT
Page 113
Keowee Unit 1 Supply Breaker Close Circuit Fails
GSBFAIL1
Page 123
Keowee Unit 1 Generator Supply Breaker Spurious Tri p Signal Is Present
GSBTRIP1
Keowee Unit 1 Supply Breaker Fails To Close Due T o Latent Human Error
EK1SPYCLHE
Keowee Unit 1 Relay 41/AX Fails To Pick-up And Latch
EK141AXR6D
2
KHU1 Generator Suppl y Breaker Trip Contr ol Switch 141-52/T S purious Operation
EK14152SWT

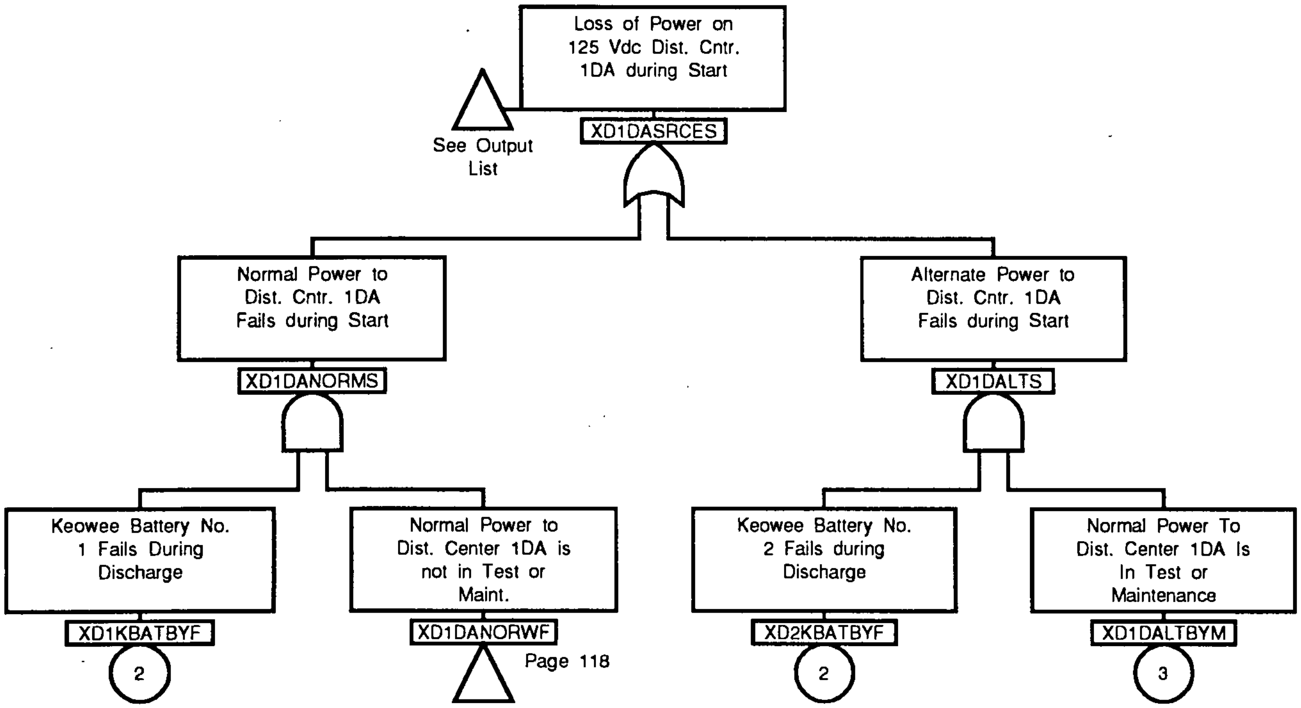

Unmodified GFB Circuit Fails
Page 119
EK1NOMOD
NSM-ON-52966 Is Not In Service
ACB4MOD
5
Keowee 1 Master Relay 4A Fails To Pick Up On Start KEE-113
YK1MR4ASRT
Page 111
Modified GFB Circuit Fails
Page 119
EK1MOD
NSM-ON-52966 Is In Service
NTACB4MOD
Page 13
Auxiliary Relay 99SX1 Fails To Pick-up
EK199SXRYD

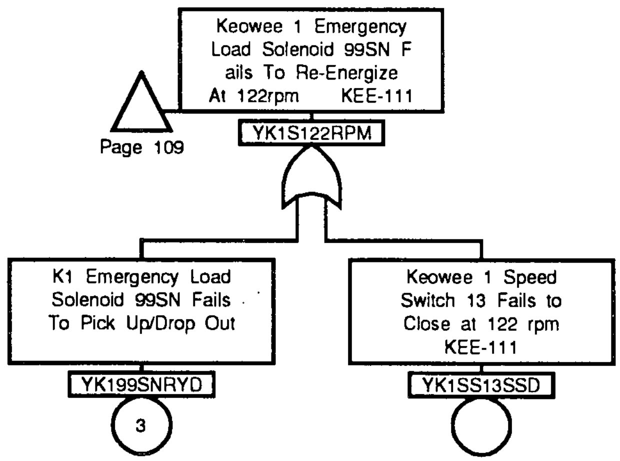

Keowee Unit 1 Generator Field Breaker Close Circuit Fails
GFBFAIL1
Page 119
Keowee Unit 1 Field Breaker Relay 41/X Fails To Pick-up On Demand
EK1R41XRYD
KHU1 Generator Field Breaker Y-rela y Failed To Drop-out At Last Operation
EK1R41YRYD
Keowee Unit 1 Field Breaker Close Coil Fails To Operate On Demand
EK1F41CRYD
Keowee Unit 1 Generator Field Breaker Y-relay Spurious Operation
EK1R41YRYT
Keowee Unit 1 Generator Field Breaker Spurious Tri p Signal Is Present
GFBTRIP1
Page 119
Keowee Unit 1 Relay 99SY Fails To Pick-up
EK199SYRYD
KHU1 Field Breaker Trip Control Switch 141/T Spurious Operation
EK1S141SWT

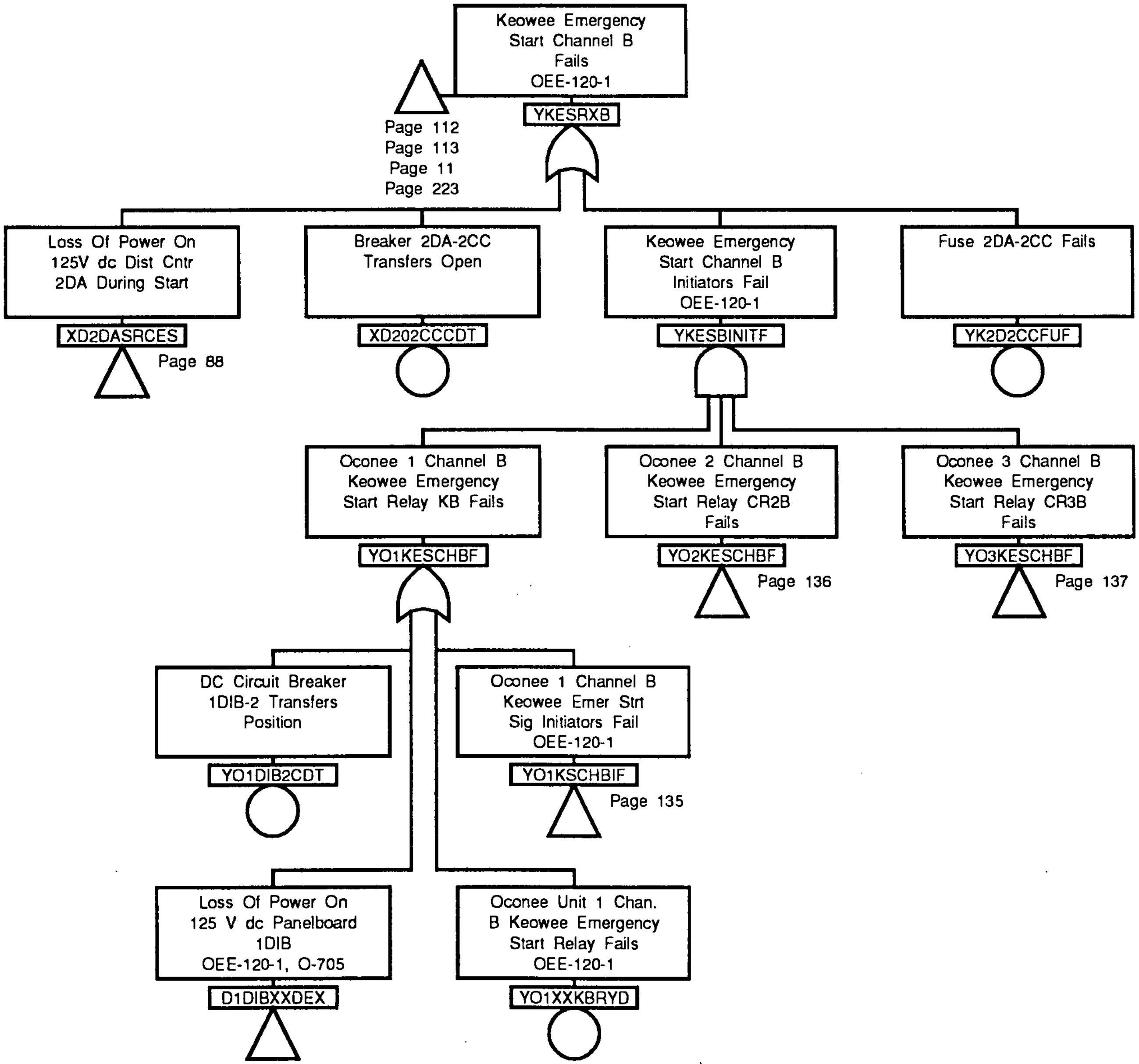

Keowee Unit 1 Generator Excitiation Fails During A Cold Start
KU1GEXCLD
Page 107
Keowee Unit 1 Field Breaker Fails To Close
FLDCLOSE1
Page 119
Keowee Unit 1 Emerg Lockout Due to Actuation of Generat or Protective Relay
GK186E1
Page 127
Keowee Unit 1 Supply Breaker Fails To Close
SPLYCLOSE1
Page 122
Keowee Unit 1 Gen Excitation Transformer Is Failed
EK1EXC1TGF
Keowee Unit 1 Field Flashing Breaker Fails To Close
FLSHCLOSE1
Page 124
Breaker 3D In 125V dc Distribution Center 1DA Transfers Open
ED11D3DCDT
Keowee Unit 1 Field Flashing Breaker Fails To Open
FLSHOPEN1
Page 126
Loss of Power on 125 Vdc Dist. Cntr. 1DA during Start
XD1DASRCES
Page 117
Keowee Unit 1 Base Adjust Fails To Set Unit Voltage Within The Acceptable Range
BASE1
Page 127
Keowee Unit 1 Field Breaker Fails To Close
FLDCLOSE1
Page 119
Page 124
Keowee Unit 1 Gen Lockout Auxiliary Relay 86EX-1 Spurious Actuation
EK186EXRYT
2
Keowee Unit 1 Generator Field Breaker Spurious Tri p Signal Is Present
GFBTRIP1
Page 120
Keowee Unit 1 Field Breaker Fails To Close Due To Mechanical Failure
EK1FLDMDEX
Unmodified GFB Circuit Fails
EK1NOMOD
Page 121
Keowee 1 Emer Strt Aux Rlys 1ESRX/1A & 1ESRX/1B Fail KEE-113
YK1STRTINT
Page 112
Modified GFB Circuit Fails
EK1MOD
Page 121
Keowee Unit 1 Generator Field Breaker Close Circuit Fails
GFBFAIL1
Page 120
Keowee Unit 1 Field Breaker Fails To Close Due To Latent Human Error
EK1FLDCLHE


Normal Power to Dist. Center 1DA is not in Test or Maint.
XD1DANORWF
Page 142
Page 117
Normal Power To Dist. Center 1DA Is In Test or Maintenance
XD1DALTBYM
3

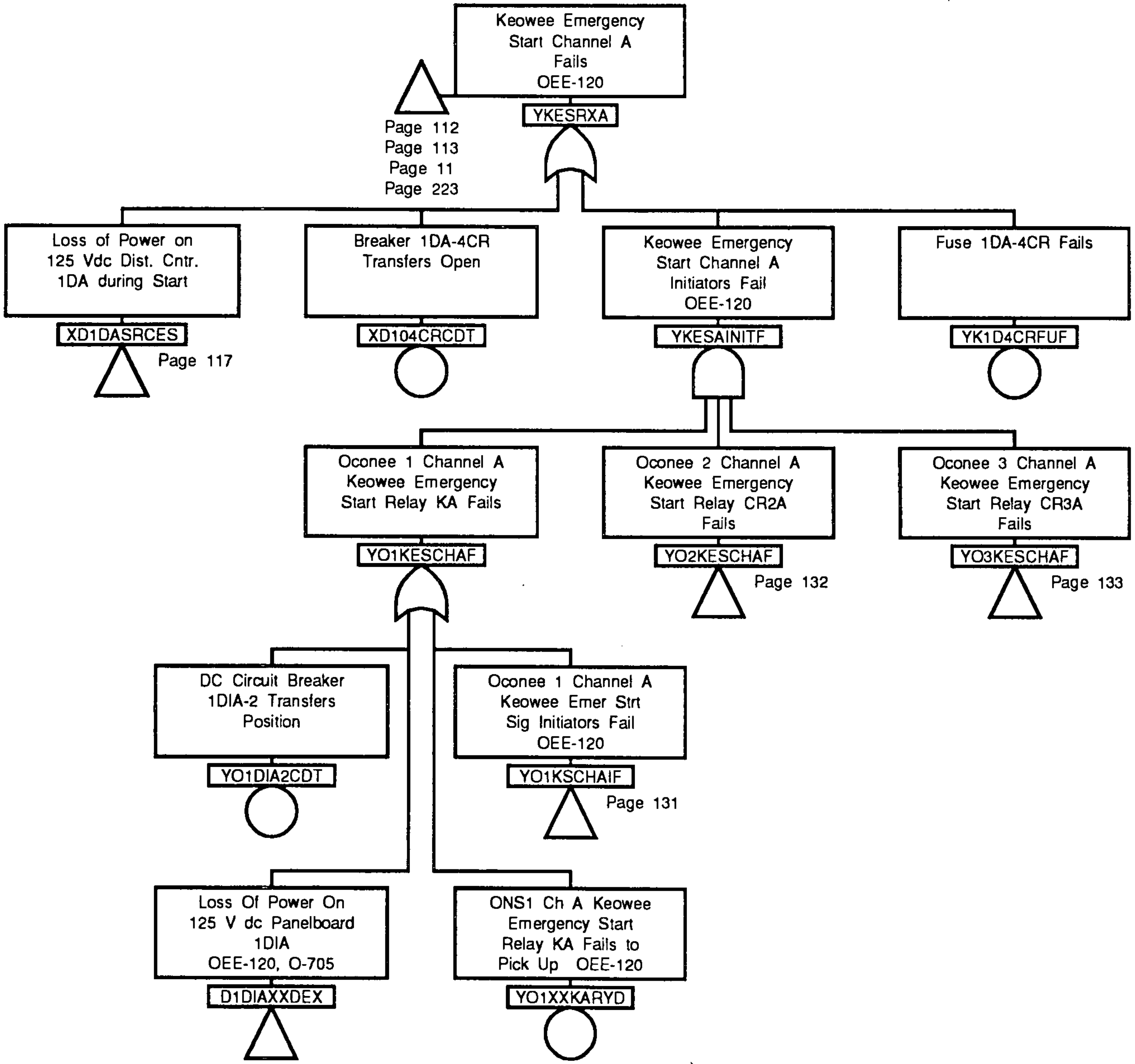
XD1DASRCES Outputs:
Page 109, Page 130, Page 114, Page 130, Page 221, Page 119



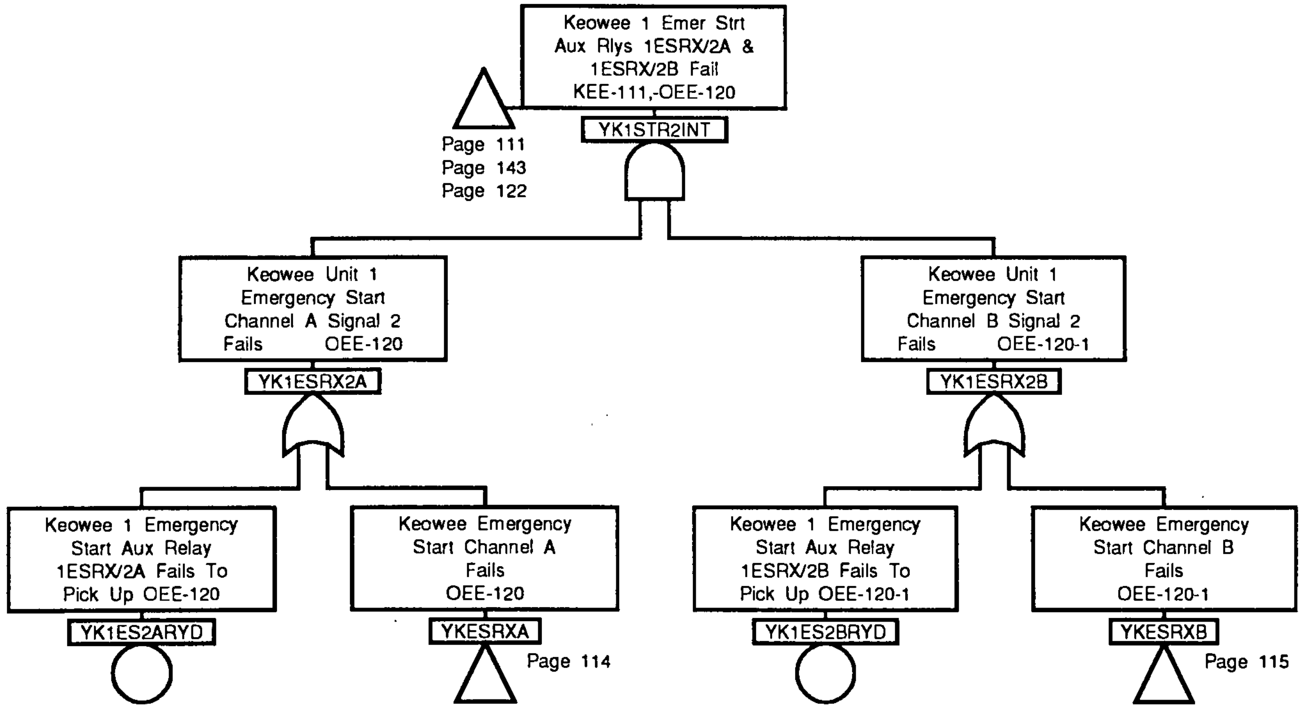

Keowee 1 Emergency Load Solenoid 99SN F ails To Re-Energize At 122rpm KEE-111
Page 109
YK1S122RPM
K1 Emergency Load Solenoid 99SN Fails To Pick Up/Drop Out
YK199SNRYD
3
Keowee 1 Speed Switch 13 Fails to Close at 122 rpm KEE-111
YK1SS13SSD



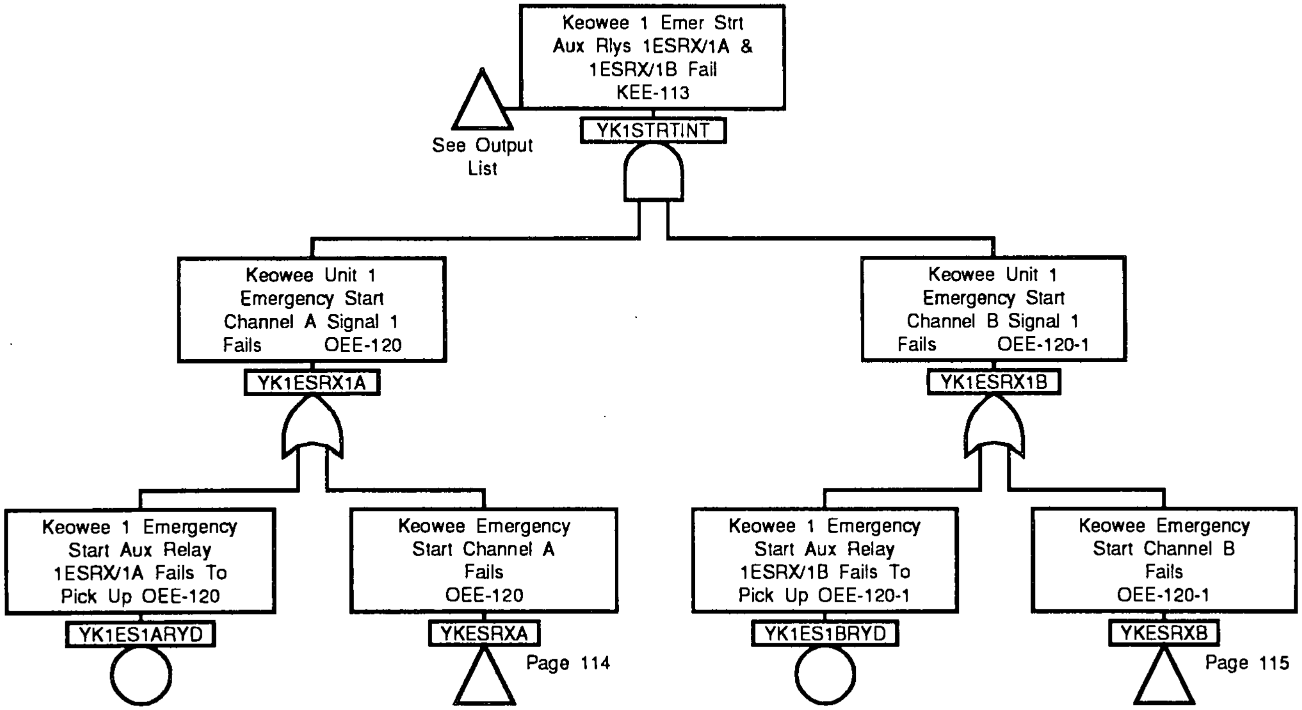
Keewee Emergency Start Channel B Fails OEE-120-1
YKESRXB
Page 112
Page 113
Page 11
Page 223
Loss Of Power On 125V dc Dist Cntr 2DA During Start
XD2DASRCES
Page 88
Breaker 2DA-2CC Transfers Open
XD202CCCDT
Keowee Emergency Start Channel B Initiators Fail OEE-120-1
YKESBINITF
Fuse 2DA-2CC Fails
YK2D2CCFUF
Oconee 1 Channel B Keowee Emergency Start Relay KB Fails
YO1KESCHBF
Oconee 2 Channel B Keowee Emergency Start Relay CR2B Fails
YO2KESCHBF
Page 136
Oconee 3 Channel B Keowee Emergency Start Relay CR3B Fails
YO3KESCHBF
Page 137
DC Circuit Breaker 1DIB-2 Transfers Position
YO1DIB2CDT
Oconee 1 Channel B Keowee Emer Strt Sig Initiators Fail OEE-120-1
YO1KSCHBIF
Page 135
Loss Of Power On 125 V dc Panelboard 1DIB OEE-120-1, O-705
D1DIBXXDEX
Oconee Unit 1 Chan. B Keowee Emergency Start Relay Fails OEE-120-1
YO1XXKBRYD

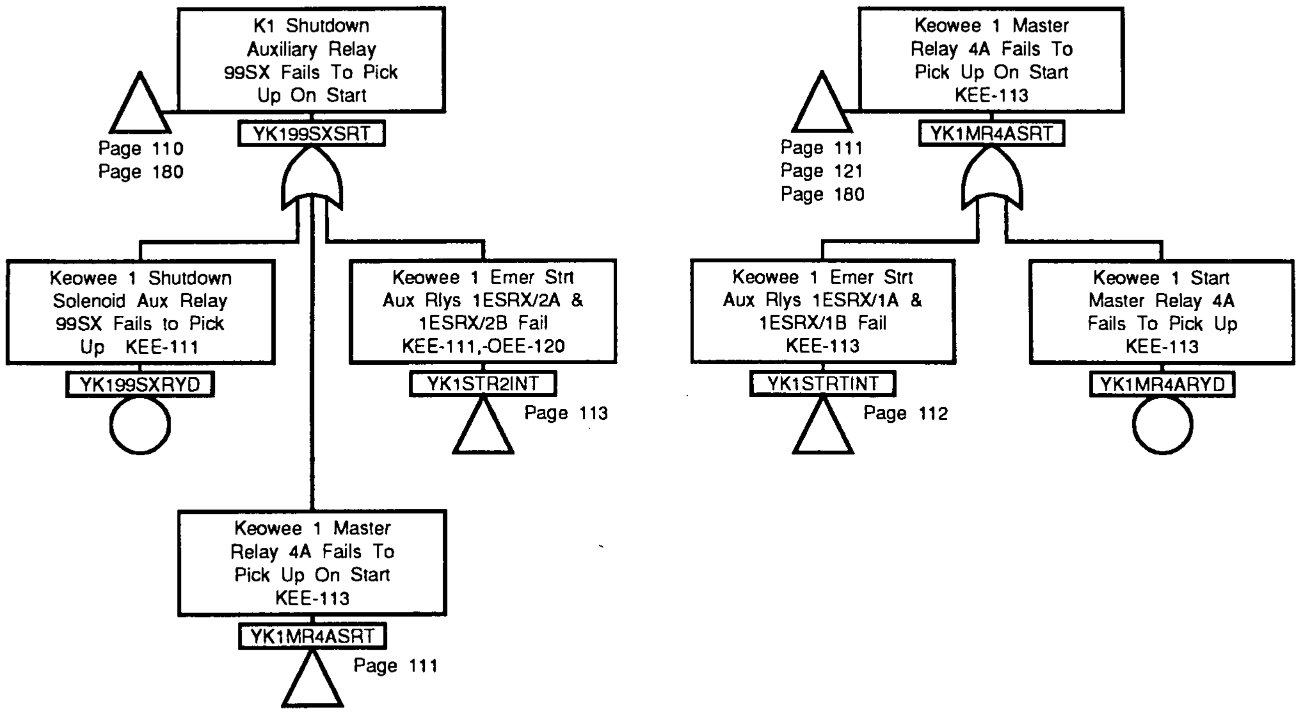


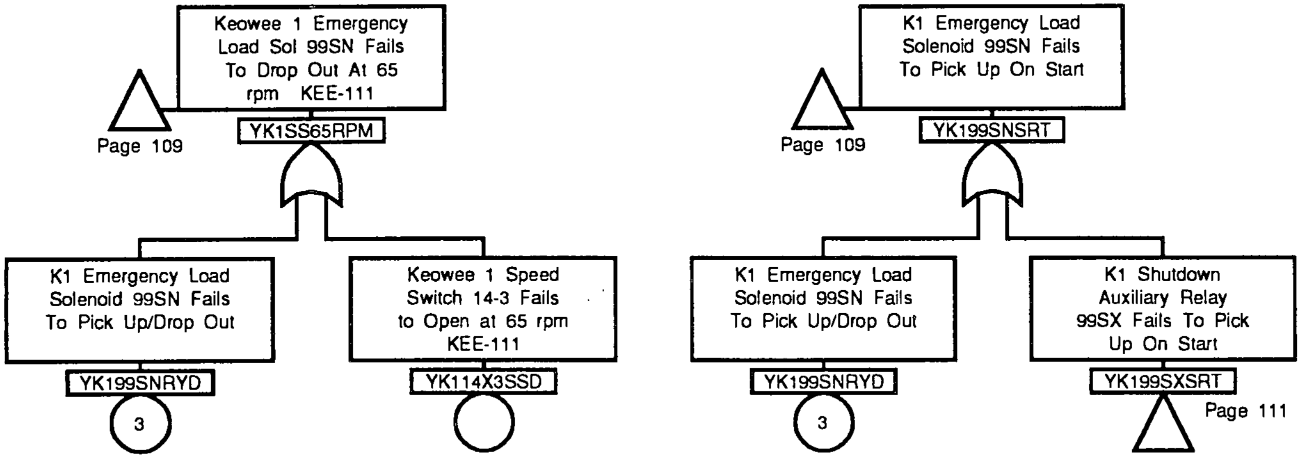
Keowee Emergency Start Channel A Fails OEE-120
YKESRXA
Page 112
Page 113
Page 11
Page 223
Loss of Power on 125 Vdc Dist. Cntr. 1DA during Start
XD1DASRCES
Page 117
Breaker 1DA-4CR Transfers Open
XD104CRCDT
Keowee Emergency Start Channel A Initiators Fail OEE-120
YKESAINITF
Fuse 1DA-4CR Fails
YK1D4CRFUF
Oconee 1 Channel A Keowee Emergency Start Relay KA Fails
YO1KESCHAF
Oconee 2 Channel A Keowee Emergency Start Relay CR2A Fails
YO2KESCHAF
Page 132
Oconee 3 Channel A Keowee Emergency Start Relay CR3A Fails
YO3KESCHAF
Page 133
DC Circuit Breaker 1DIA-2 Transfers Position
YO1DIA2CDT
Oconee 1 Channel A Keowee Emer Strt Sig Initiators Fail OEE-120
YO1KSCHAIF
Page 131
Loss Of Power On 125 V dc Panelboard 1DIA OEE-120, O-705
D1DIAXXDEX
ONS1 Ch A Keowee Emergency Start Relay KA Fails to Pick Up OEE-120
YO1XXKARYD


Keowee 1 Emer Strt Aux Rlys 1ESRX/2A & 1ESRX/2B Fail KEE-111,-OEE-120
YK1STR2INT
Page 111
Page 143
Page 122
Keowee Unit 1 Emergency Start Channel A Signal 2 Fails OEE-120
YK1ESRX2A
Keowee Unit 1 Emergency Start Channel B Signal 2 Fails OEE-120-1
YK1ESRX2B
Keowee 1 Emergency Start Aux Relay 1ESRX/2A Fails To Pick Up OEE-120
YK1ES2ARYD
Keowee Emergency Start Channel A Fails OEE-120
YKESRXA
Page 114
Keowee 1 Emergency Start Aux Relay 1ESRX/2B Fails To Pick Up OEE-120-1
YK1ES2BRYD
Keowee Emergency Start Channel B Fails OEE-120-1
YKESRXB
Page 115

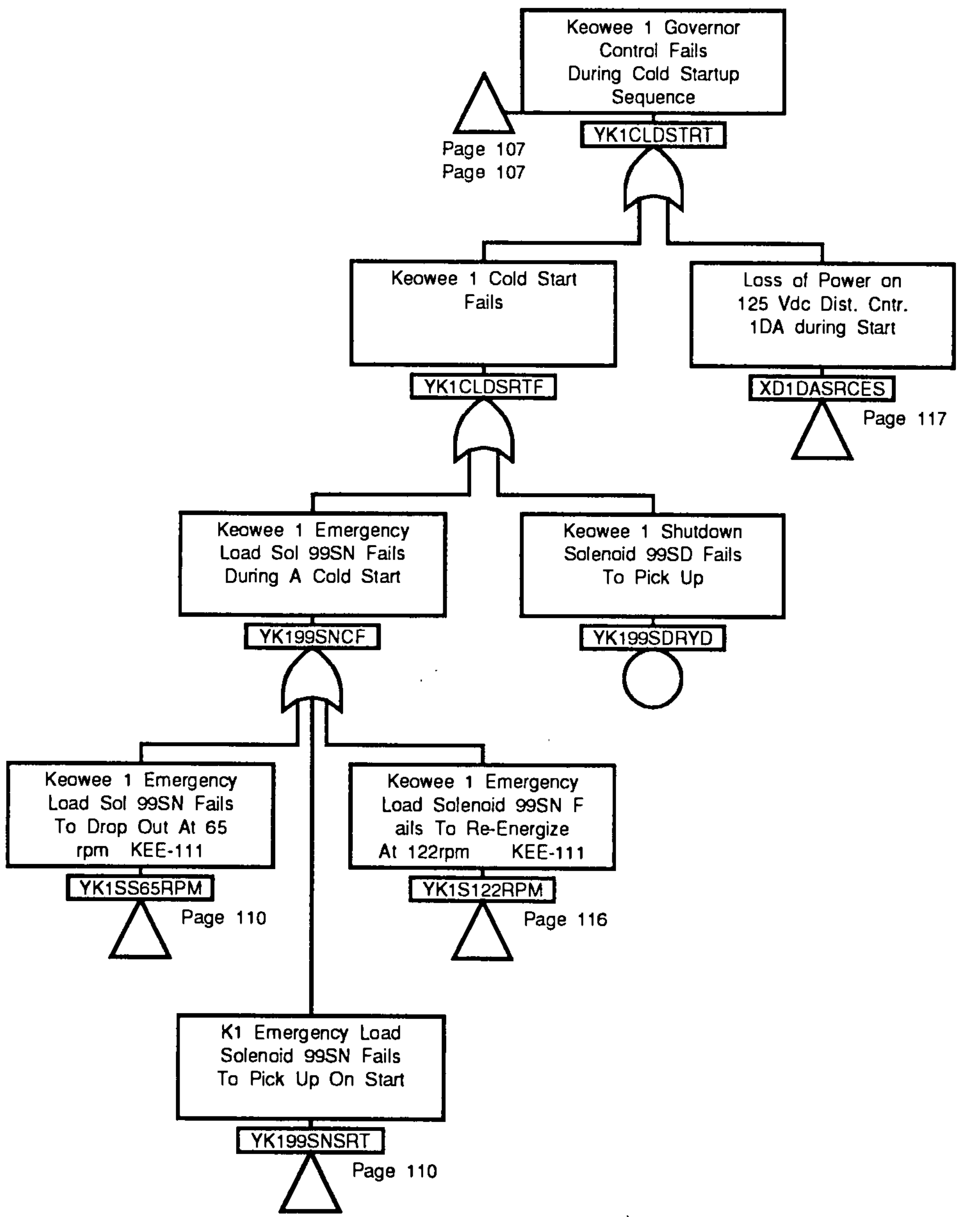
YK1STRTINT Outputs:
Page 130, Page 111, Page 129, Page 119, Page 124



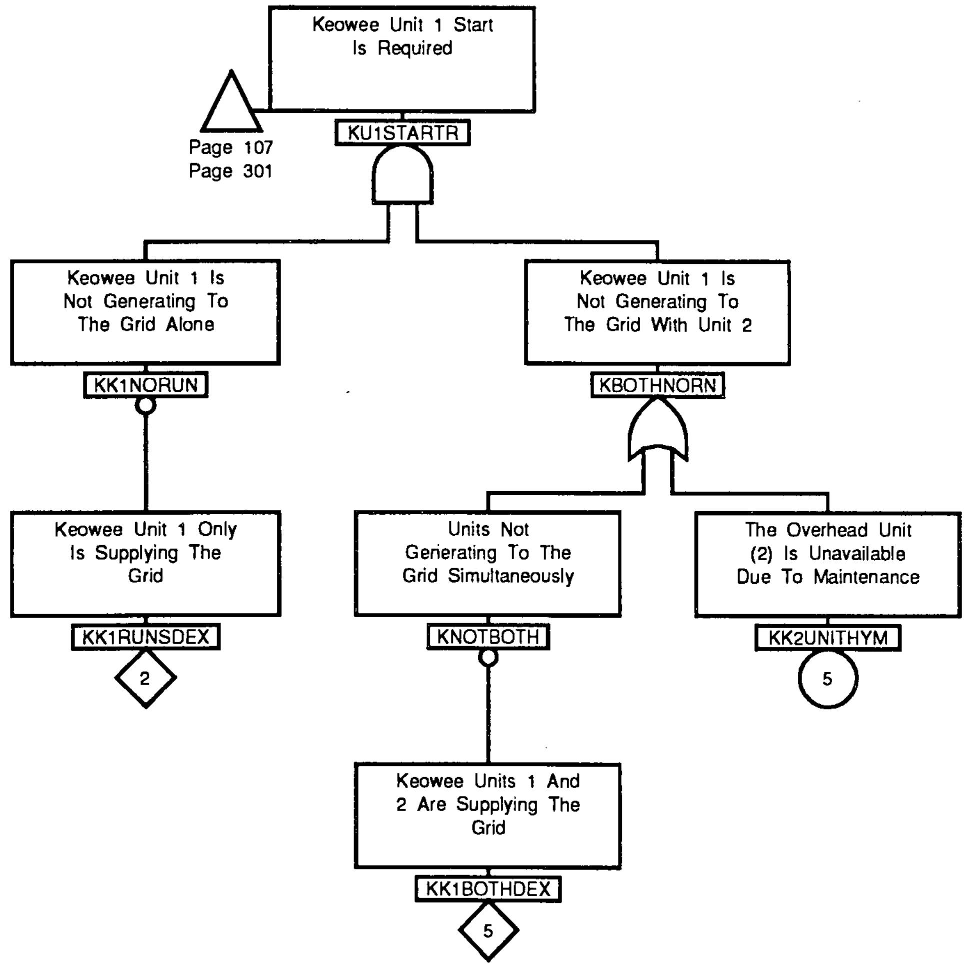

K1 Shutdown Auxiliary Relay 99SX Fails To Pick Up On Start
YK199SXSRT
Page 110
Page 180
Keowee 1 Shutdown Solenoid Aux Relay 99SX Fails to Pick Up KEE-111
YK199SXRYD
Keowee 1 Emer Strt Aux Rlys 1ESRX/2A & 1ESRX/2B Fail KEE-111,-OEE-120
YK1STR2INT
Page 113
Keowee 1 Master Relay 4A Fails To Pick Up On Start KEE-113
YK1MR4ASRT
Page 111
Keowee 1 Master Relay 4A Fails To Pick Up On Start KEE-113
YK1MR4ASRT
Page 111
Page 121
Page 180
Keowee 1 Emer Strt Aux Rlys 1ESRX/1A & 1ESRX/1B Fail KEE-113
YK1STRTINT
Page 112
Keowee 1 Start Master Relay 4A Fails To Pick Up KEE-113
YK1MR4ARYD

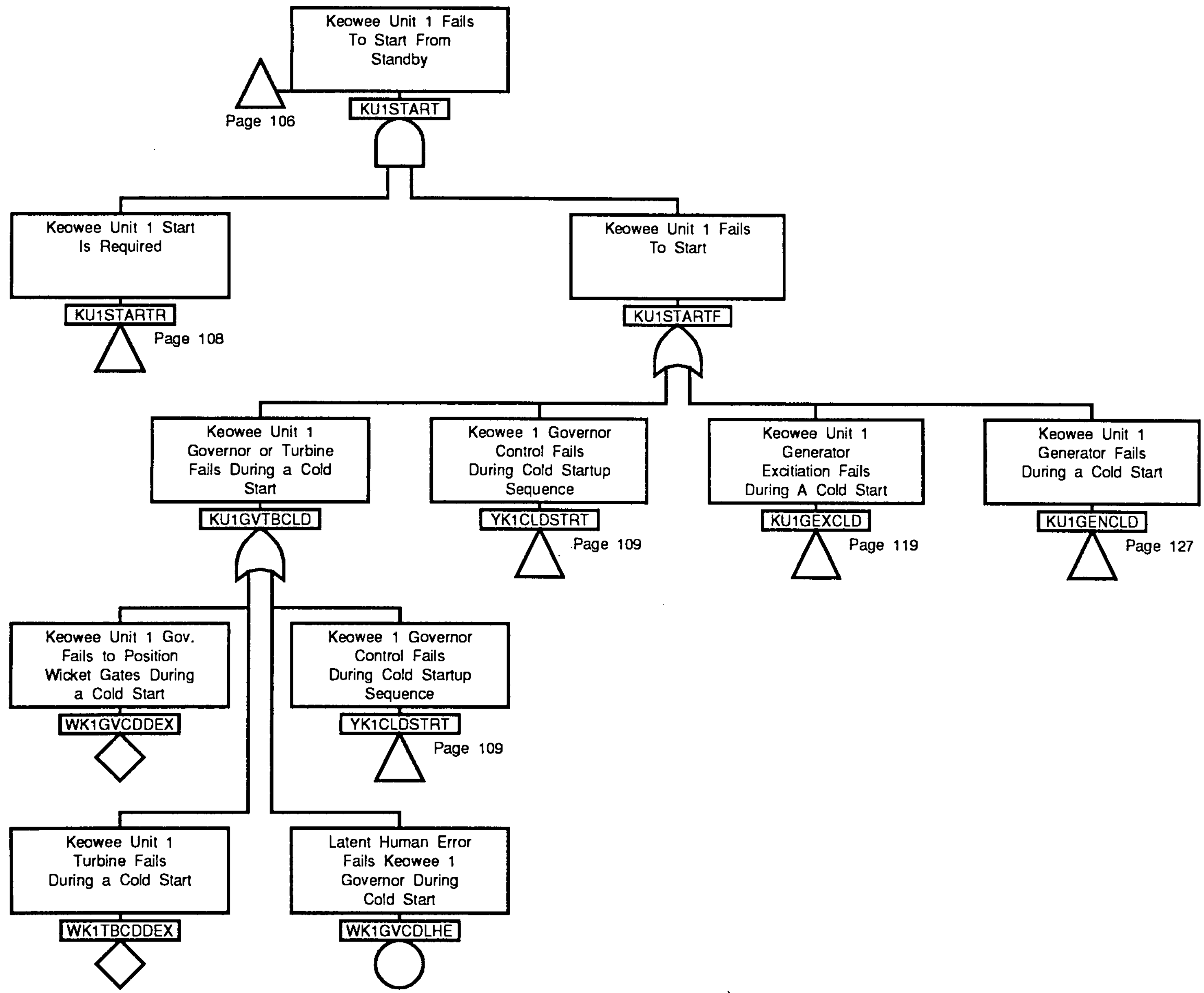


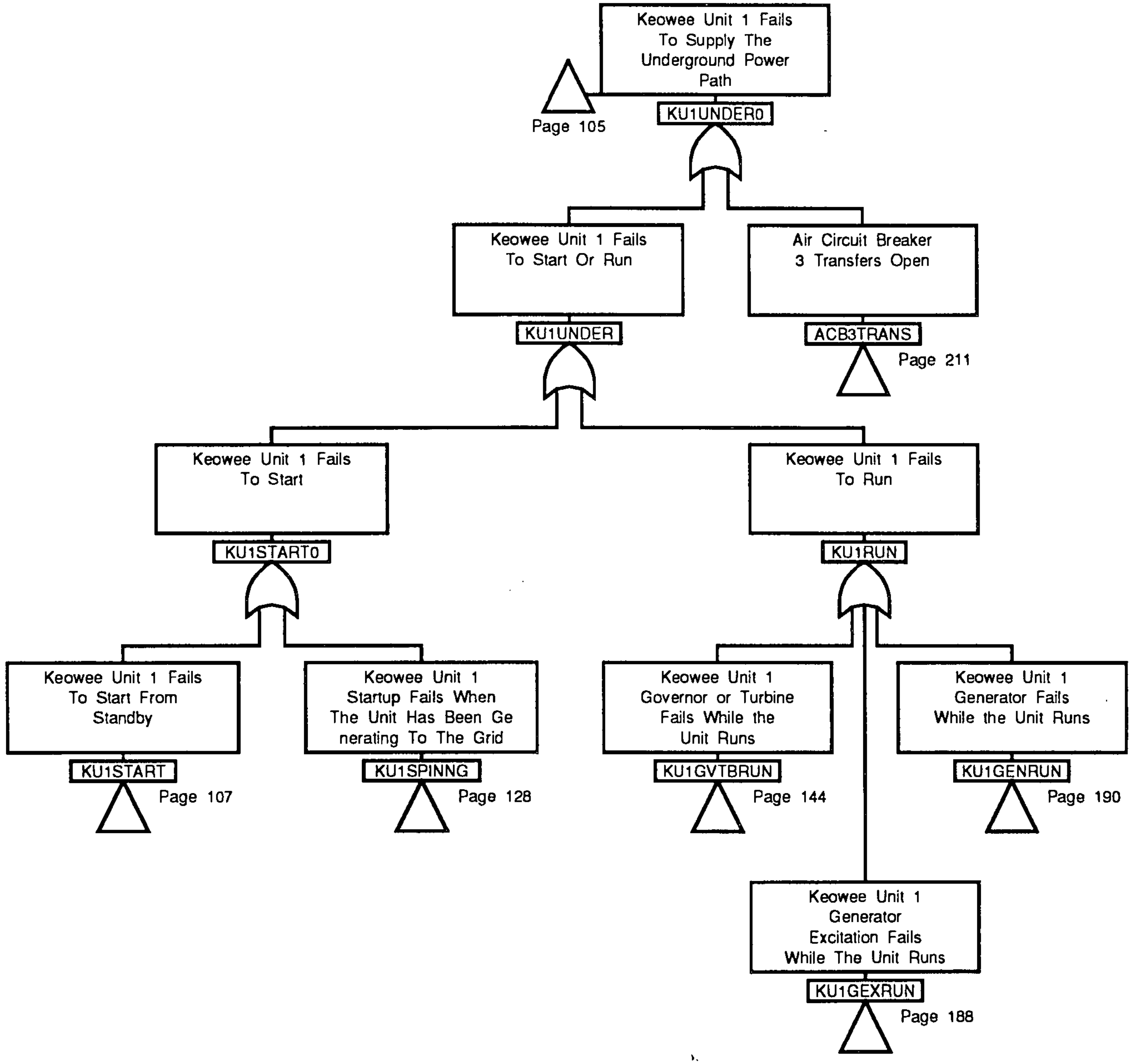
Keowee 1 Emergency Load Sol 99SN Fails To Drop Out At 65 rpm KEE-111
Page 109
YK1SS65RPM
K1 Emergency Load Solenoid 99SN Fails To Pick Up/Drop Out
YK199SNRYD
3
Keowee 1 Speed Switch 14-3 Fails to Open at 65 rpm KEE-111
YK114X3SSD
K1 Emergency Load Solenoid 99SN Fails To Pick Up On Start
Page 109
YK199SNSRT
K1 Emergency Load Solenoid 99SN Fails To Pick Up/Drop Out
YK199SNRYD
3
K1 Shutdown Auxiliary Relay 99SX Fails To Pick Up On Start
YK199SXSRT
Page 111

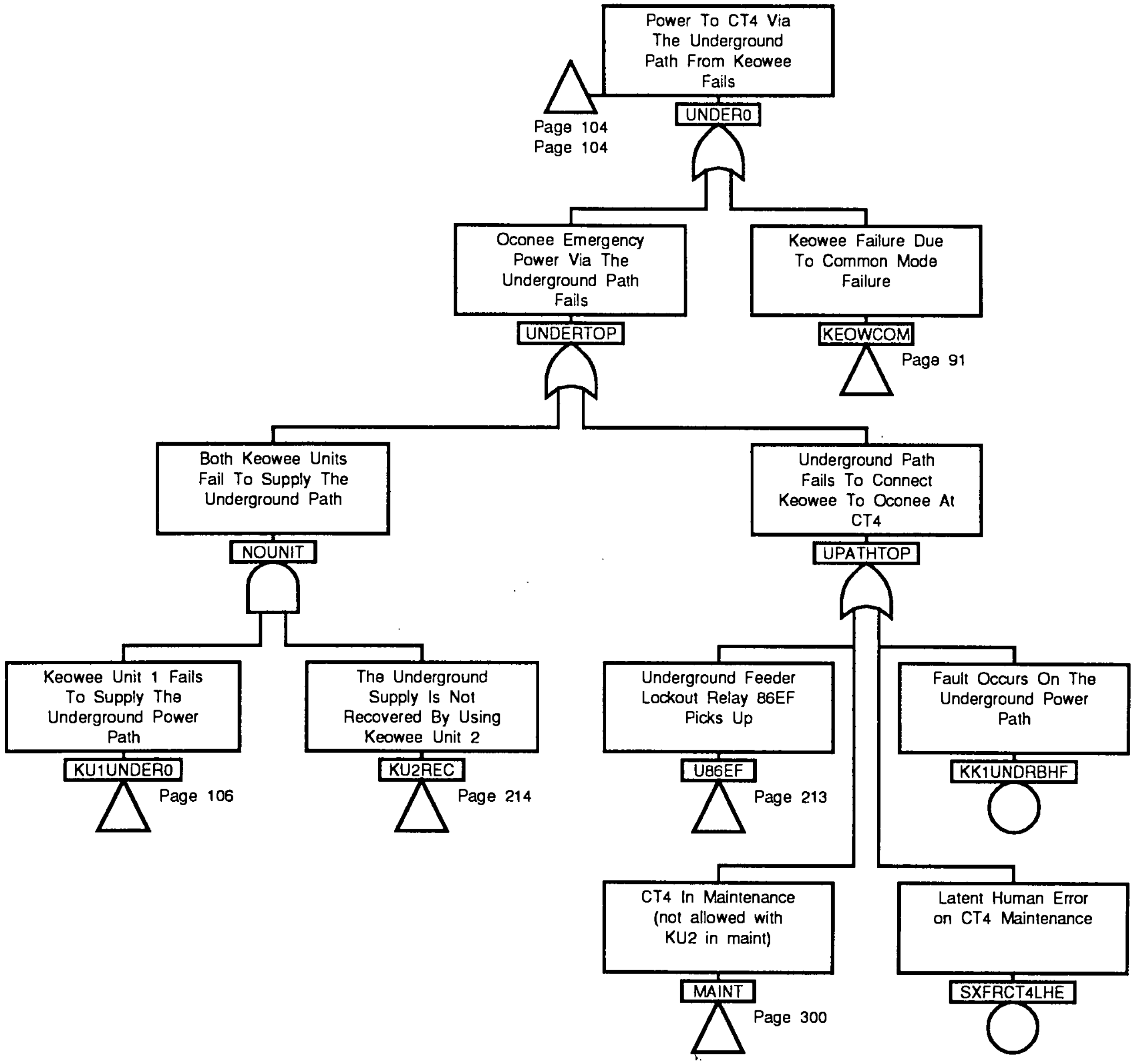


Keewee 1 Governor Control Fails During Cold Startup Sequence
YK1CLDSTRT
Page 107
Page 107
Keowee 1 Cold Start Fails
YK1CLDSRTF
Loss of Power on 125 Vdc Dist. Cntr. 1DA during Start
XD1DASRCES
Page 117
Keowee 1 Emergency Load Sol 99SN Fails During A Cold Start
YK199SNCF
Keowee 1 Shutdown Solenoid 99SD Fails To Pick Up
YK199SDRYD
Keowee 1 Emergency Load Sol 99SN Fails To Drop Out At 65 rpm KEE-111
YK1SS65RPM
Page 110
Keowee 1 Emergency Load Solenoid 99SN F ails To Re-Energize At 122rpm KEE-111
YK1S122RPM
Page 116
K1 Emergency Load Solenoid 99SN Fails To Pick Up On Start
YK199SNSRT
Page 110

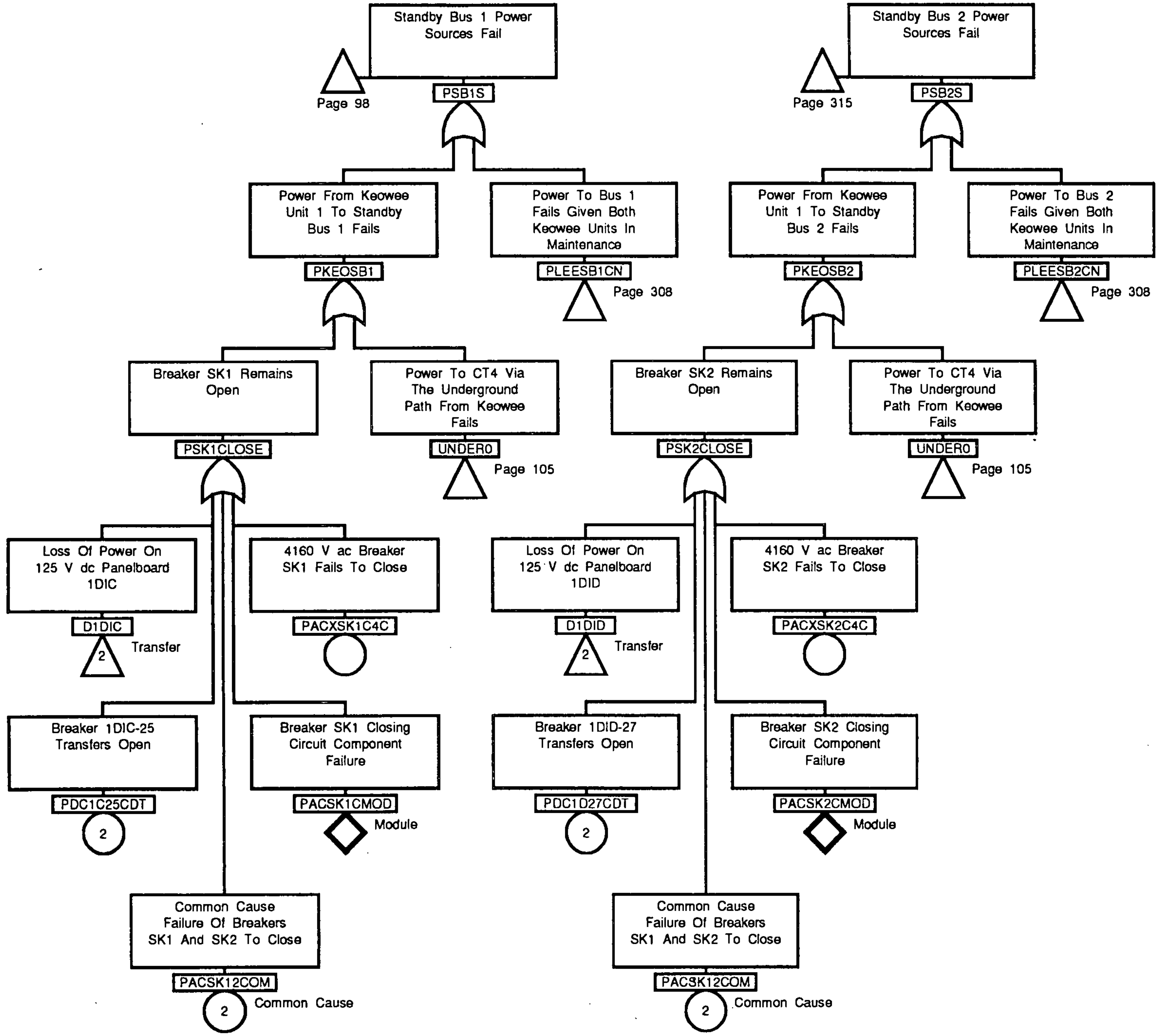

Keowee Unit 1 Start Is Required
KU1STARTR
Page 107
Page 301
Keowee Unit 1 Is Not Generating To The Grid Alone
KK1NORUN
Keowee Unit 1 Is Not Generating To The Grid With Unit 2
KBOTHNORN
Keowee Unit 1 Only Is Supplying The Grid
KK1RUNSDEX
2
Units Not Generating To The Grid Simultaneously
KNOTBOTH
The Overhead Unit (2) Is Unavailable Due To Maintenance
KK2UNITHYM
5
Keowee Units 1 And 2 Are Supplying The Grid
KK1BOTHDEX
5


Keowee Unit 1 Fails To Start From Standby
KU1START
Page 106
Keowee Unit 1 Start Is Required
KU1STARTR
Page 108
Keowee Unit 1 Fails To Start
KU1STARTF
Keowee Unit 1 Governor or Turbine Fails During a Cold Start
KU1GVTBCLD
Keowee 1 Governor Control Fails During Cold Startup Sequence
YK1CLDSTRT
Page 109
Keowee Unit 1 Generator Excitiation Fails During A Cold Start
KU1GEXCLD
Page 119
Keowee Unit 1 Generator Fails During a Cold Start
KU1GENCLD
Page 127
Keowee Unit 1 Gov. Fails to Position Wicket Gates During a Cold Start
WK1GVCDDEX
Keowee 1 Governor Control Fails During Cold Startup Sequence
YK1CLDSTRT
Page 109
Keowee Unit 1 Turbine Fails During a Cold Start
WK1TBCDDEX
Latent Human Error Fails Keowee 1 Governor During Cold Start
WK1GVCDLHE

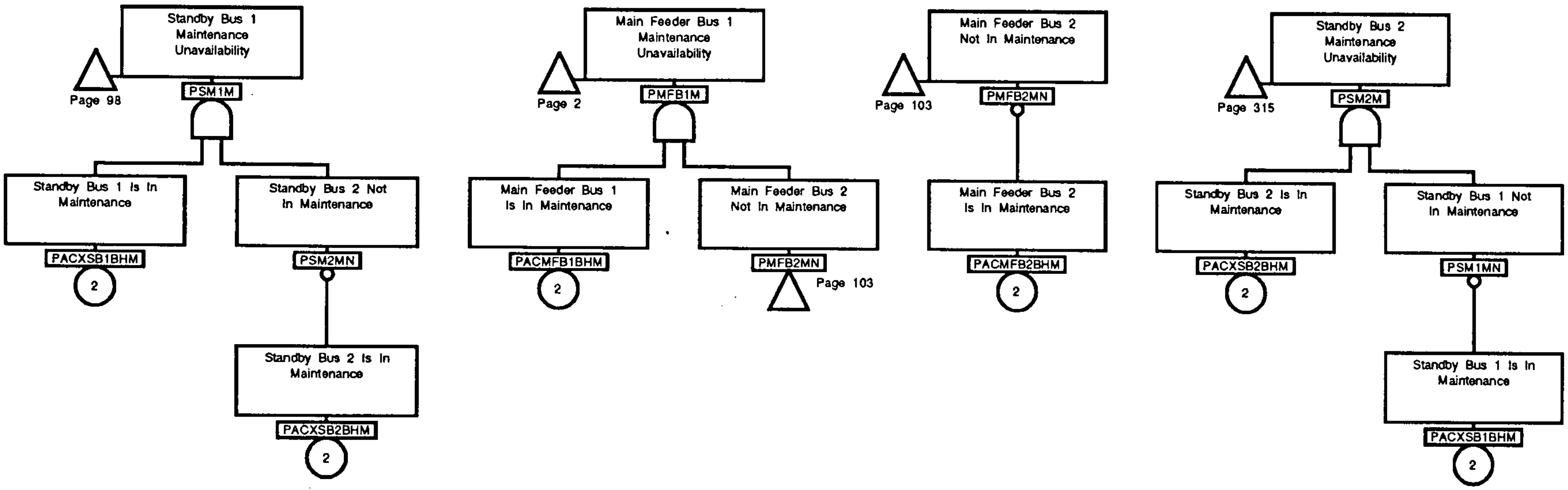

Keewee Unit 1 Fails To Supply The Underground Power Path
KU1UNDER0
Page 105
Keowee Unit 1 Fails To Start Or Run
KU1UNDER
Air Circuit Breaker 3 Transfers Open
ACB3TRANS
Page 211
Keowee Unit 1 Fails To Start
KU1START0
Keowee Unit 1 Fails To Run
KU1RUN
Keowee Unit 1 Fails To Start From Standby
KU1START
Page 107
Keowee Unit 1 Startup Fails When The Unit Has Been Ge nerating To The Grid
KU1SPINNG
Page 128
Keowee Unit 1 Governor or Turbine Fails While the Unit Runs
KU1GVTBRUN
Page 144
Keowee Unit 1 Generator Fails While the Unit Runs
KU1GENRUN
Page 190
Keowee Unit 1 Generator Excitation Fails While The Unit Runs
KU1GEXRUN
Page 188

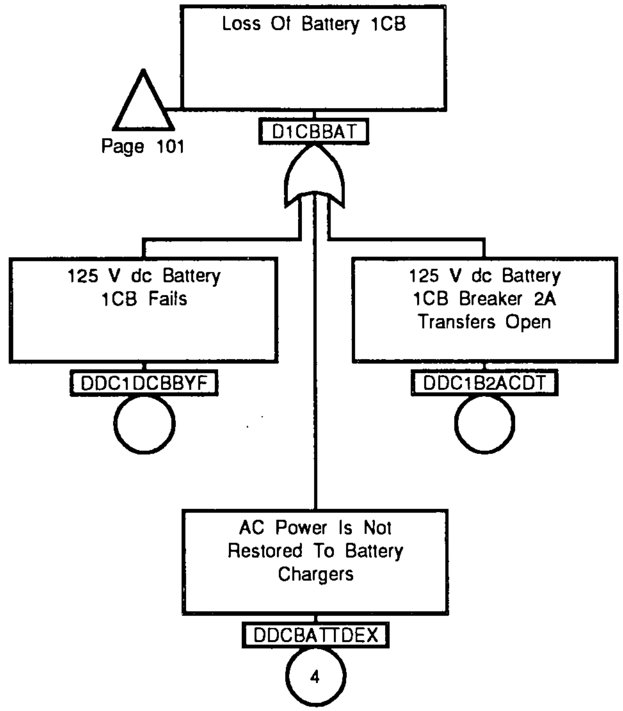


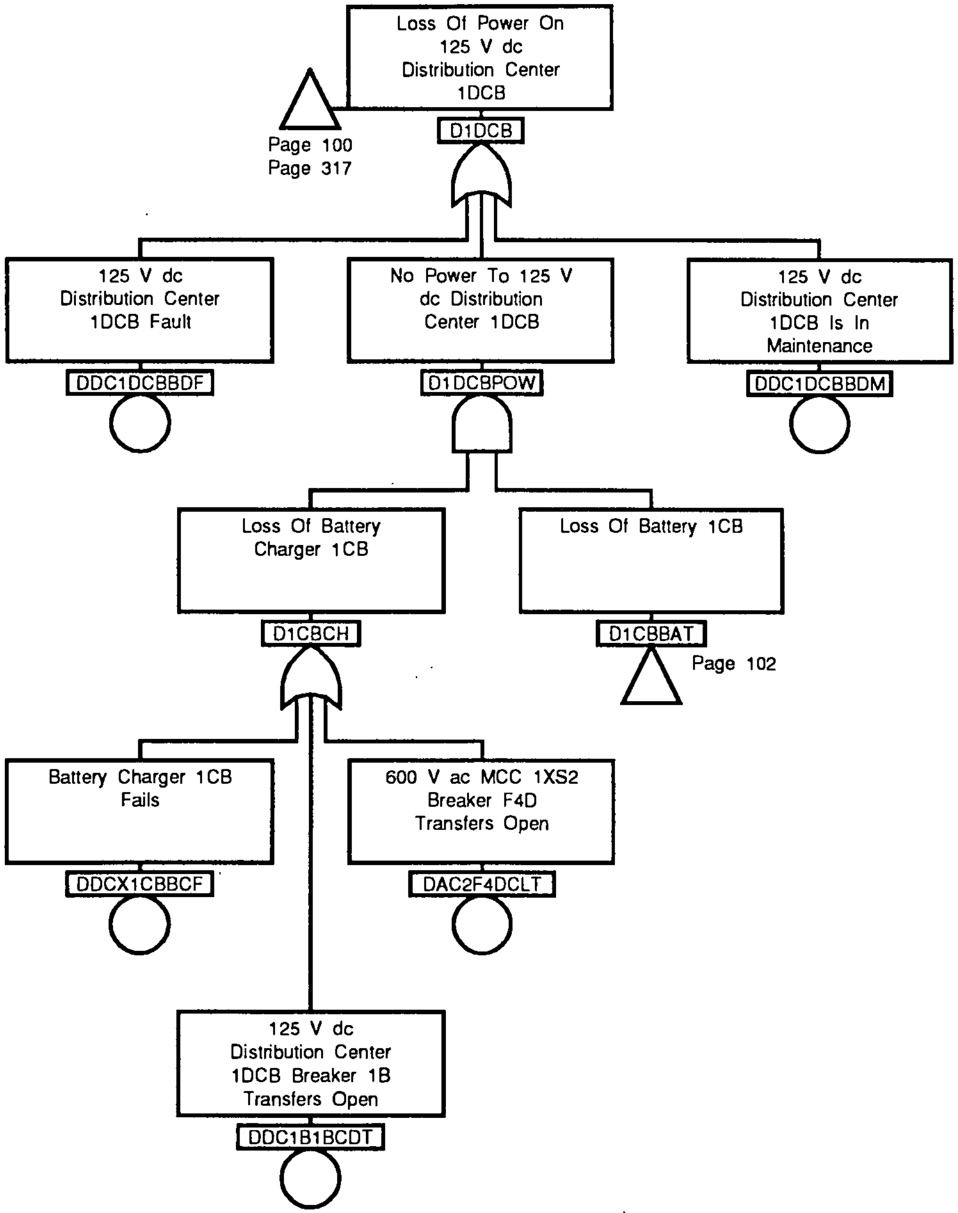
Power To CT4 Via The Underground Path From Keowee Fails
UNDER0
Page 104
Page 104
Oconee Emergency Power Via The Underground Path Fails
UNDERTOP
Keowee Failure Due To Common Mode Failure
KEOWCOM
Page 91
Both Keowee Units Fail To Supply The Underground Path
NOUNIT
Underground Path Fails To Connect Keowee To Oconee At CT4
UPATHTOP
Keowee Unit 1 Fails To Supply The Underground Power Path
KU1UNDER0
Page 106
The Underground Supply Is Not Recovered By Using Keowee Unit 2
KU2REC
Page 214
Underground Feeder Lockout Relay 86EF Picks Up
U86EF
Page 213
Fault Occurs On The Underground Power Path
KK1UNDRBHF
CT4 In Maintenance (not allowed with KU2 in maint)
MAINT
Page 300
Latent Human Error on CT4 Maintenance
SXFRCT4LHE

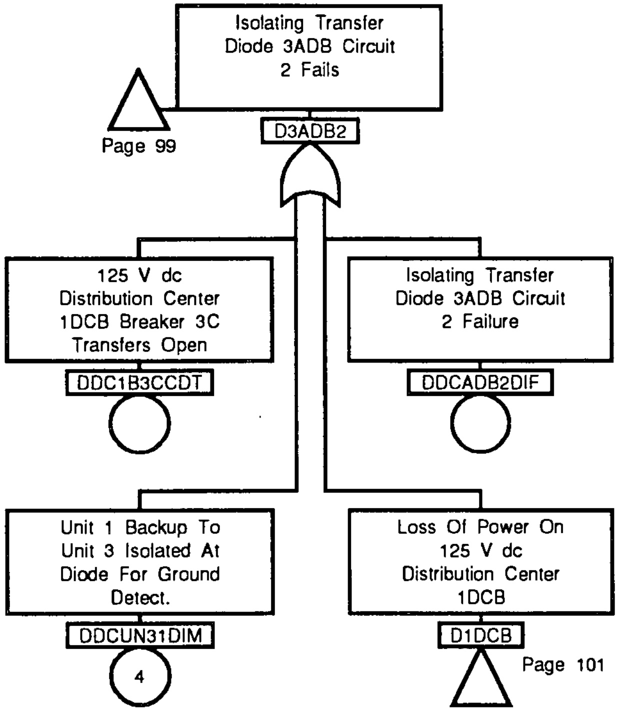


ONS-Keowee AC Power Integrated Model	FIGURE G-1	Page 104

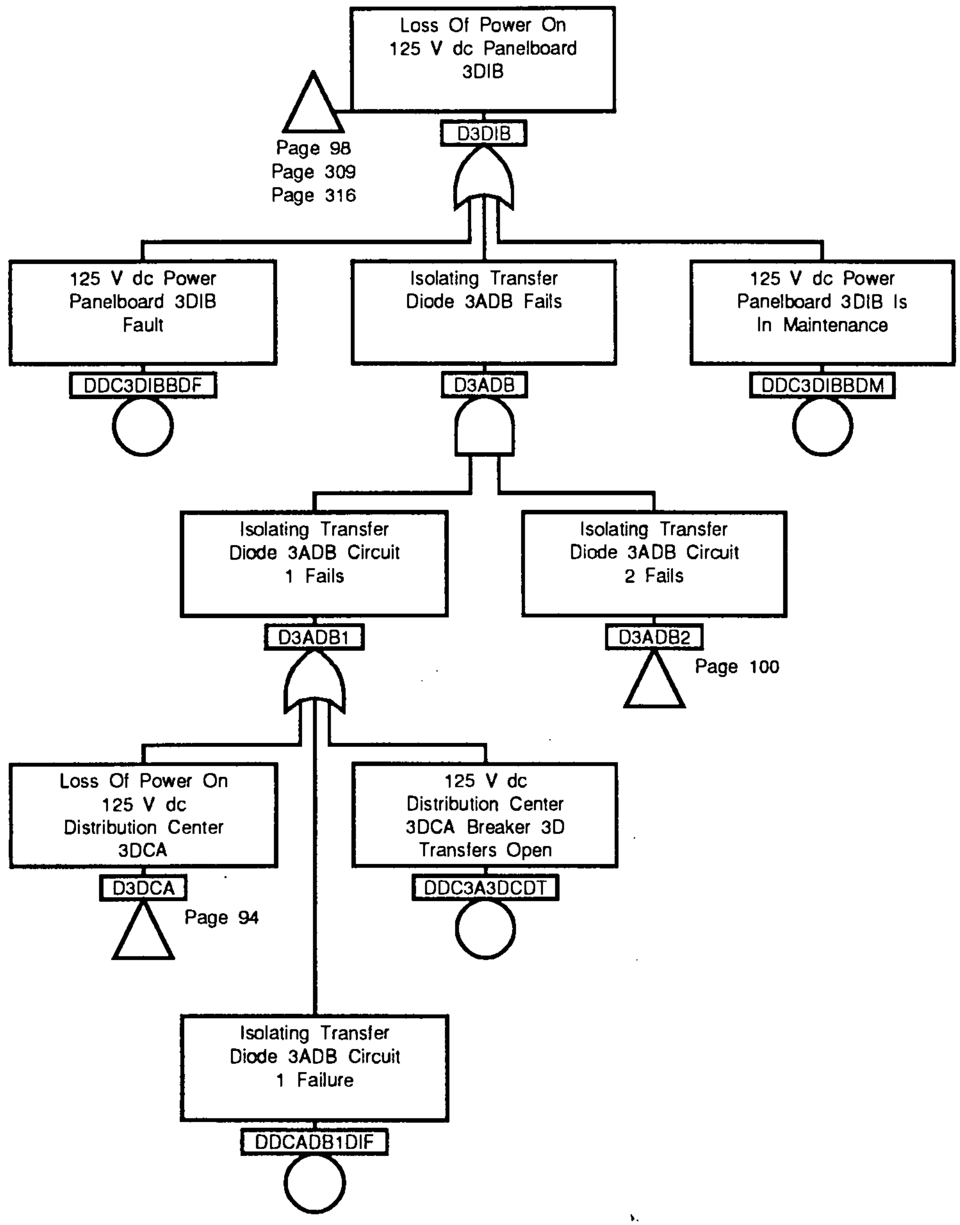

Standby Bus 1 Maintenance Unavailability
Page 98
PSM1M
Standby Bus 1 Is In Maintenance
PACXSB1BHM
2
Standby Bus 2 Not In Maintenance
PSM2MN
Standby Bus 2 Is In Maintenance
PACXSB2BHM
2
Main Feeder Bus 1 Maintenance Unavailability
Page 2
PMFB1M
Main Feeder Bus 1 Is In Maintenance
PACMFB1BHM
2
Main Feeder Bus 2 Not In Maintenance
PMFB2MN
Page 103
Main Feeder Bus 2 Not In Maintenance
Page 103
PMFB2MN
Main Feeder Bus 2 Is In Maintenance
PACMFB2BHM
2
Standby Bus 2 Maintenance Unavailability
Page 315
PSM2M
Standby Bus 2 Is In Maintenance
PACXSB2BHM
2
Standby Bus 1 Not In Maintenance
PSM1MN
Standby Bus 1 Is In Maintenance
PACXSB1BHM
2


Loss Of Battery 1CB
D1CBBAT
Page 101
125 V dc Battery 1CB Fails
DDC1DCBBYF
125 V dc Battery 1CB Breaker 2A Transfers Open
DDC1B2ACDT
AC Power Is Not Restored To Battery Chargers
DDCBATTDEX
4

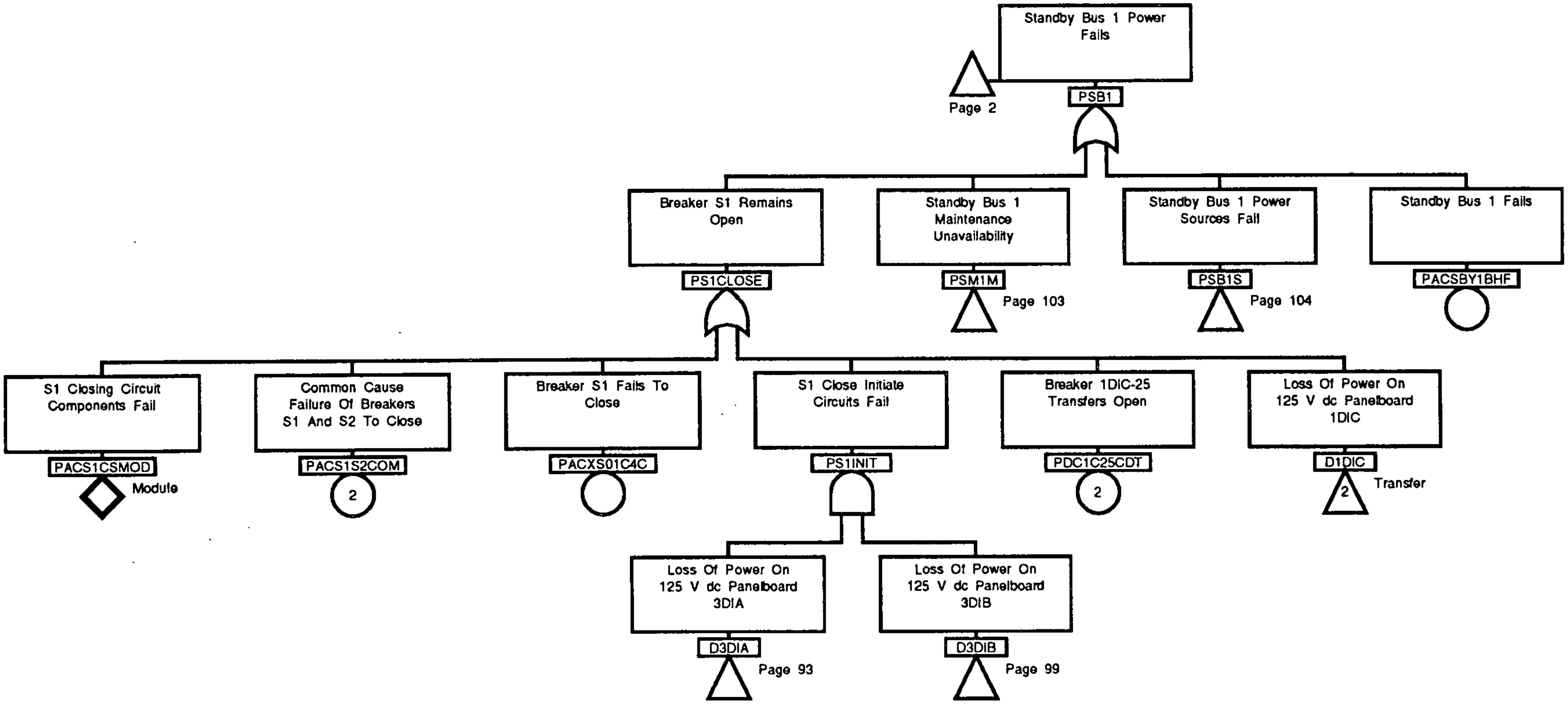

Loss Of Power On 125 V dc Distribution Center 1DCB
D1DCB
Page 100
Page 317
125 V dc Distribution Center 1DCB Fault
DDC1DCBBDF
No Power To 125 V dc Distribution Center 1DCB
D1DCBPOW
125 V dc Distribution Center 1DCB Is In Maintenance
DDC1DCBBDM
Loss Of Battery Charger 1CB
D1CBCH
Loss Of Battery 1CB
D1CBBAT
Page 102
Battery Charger 1CB Fails
DDCX1CBBCF
600 V ac MCC 1XS2 Breaker F4D Transfers Open
DAC2F4DCLT
125 V dc Distribution Center 1DCB Breaker 1B Transfers Open
DDC1B1BCDT

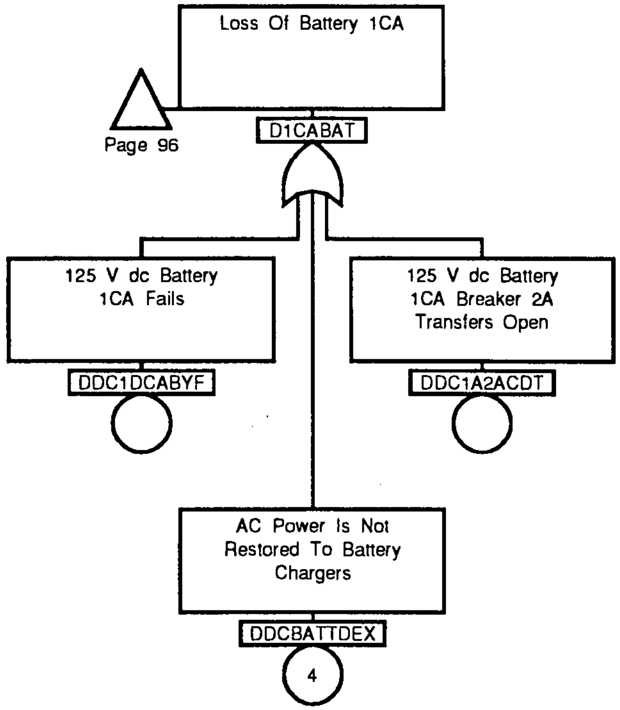


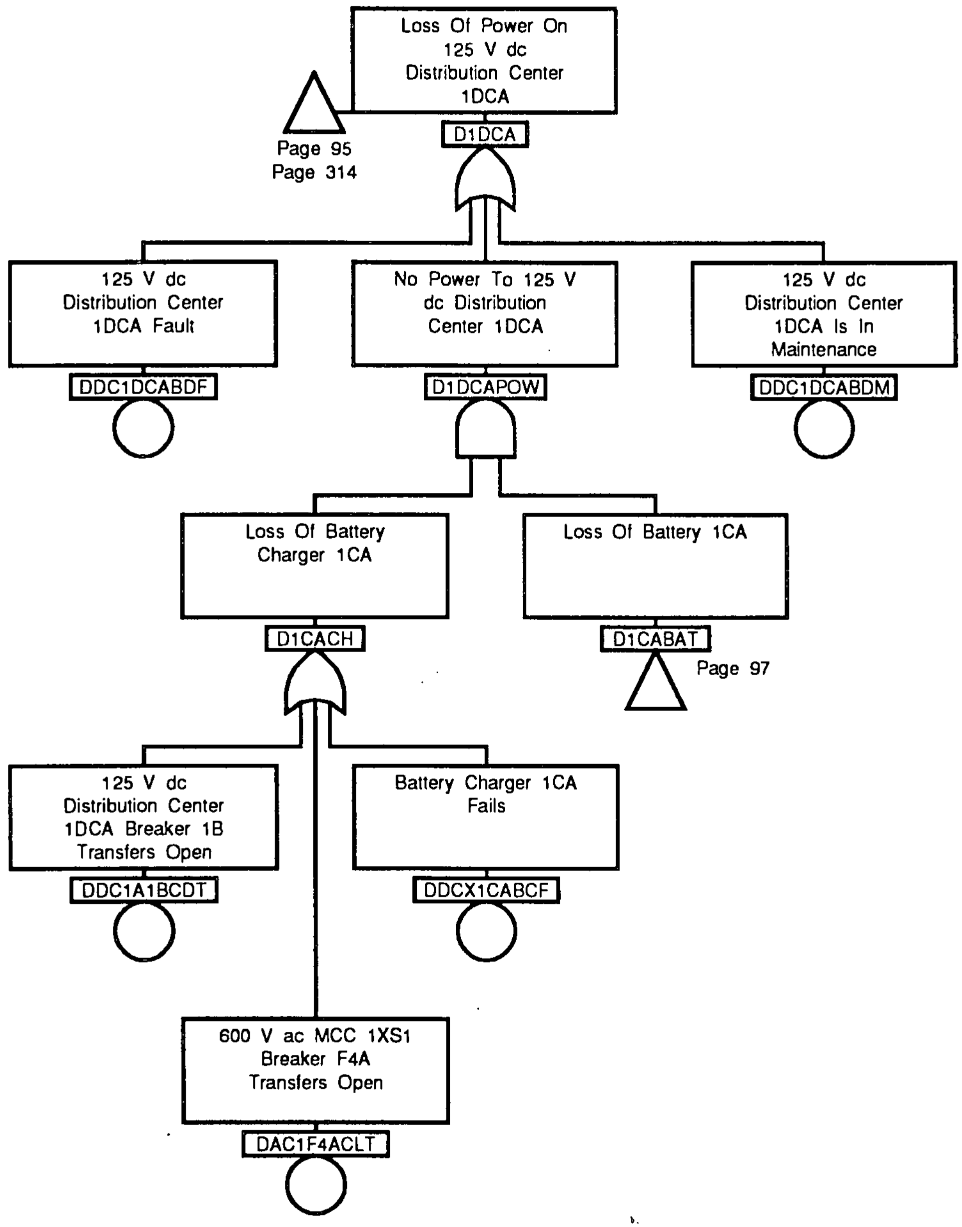
Isolating Transfer Diode 3ADB Circuit 2 Fails
D3ADB2
Page 99
125 V dc Distribution Center 1DCB Breaker 3C Transfers Open
DDC1B3CCDT
Isolating Transfer Diode 3ADB Circuit 2 Failure
DDCADB2DIF
Unit 1 Backup To Unit 3 Isolated At Diode For Ground Detect.
DDCUN31DIM
4
Loss Of Power On 125 V dc Distribution Center 1DCB
D1DCB
Page 101

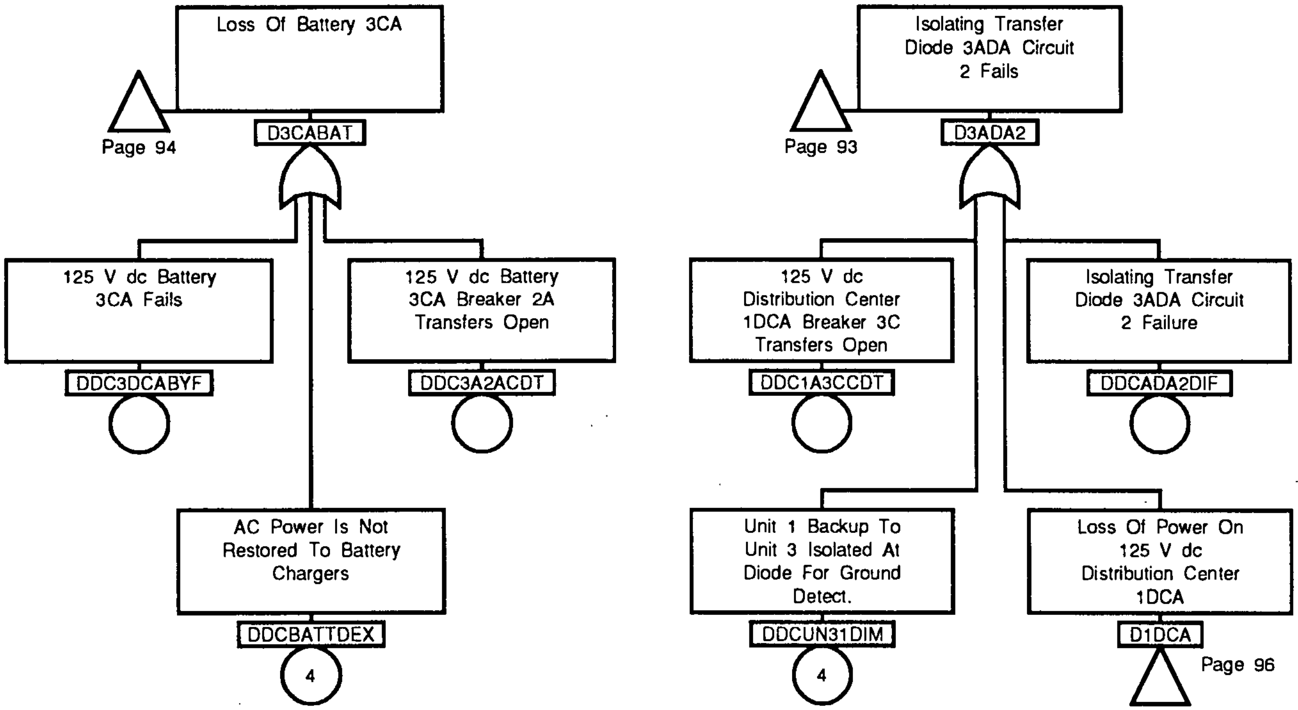


Loss Of Power On
125 V dc Panelboard
3DIB
D3DIB
Page 98
Page 309
Page 316
125 V dc Power
Panelboard 3DIB
Fault
DDC3DIBBDF
Isolating Transfer
Diode 3ADB Fails
D3ADB
125 V dc Power
Panelboard 3DIB Is
In Maintenance
DDC3DIBBDM
Isolating Transfer
Diode 3ADB Circuit
1 Fails
D3ADB1
Isolating Transfer
Diode 3ADB Circuit
2 Fails
D3ADB2
Page 100
Loss Of Power On
125 V dc
Distribution Center
3DCA
D3DCA
Page 94
125 V dc
Distribution Center
3DCA Breaker 3D
Transfers Open
DDC3A3DCDT
Isolating Transfer
Diode 3ADB Circuit
1 Failure
DDCADB1DIF

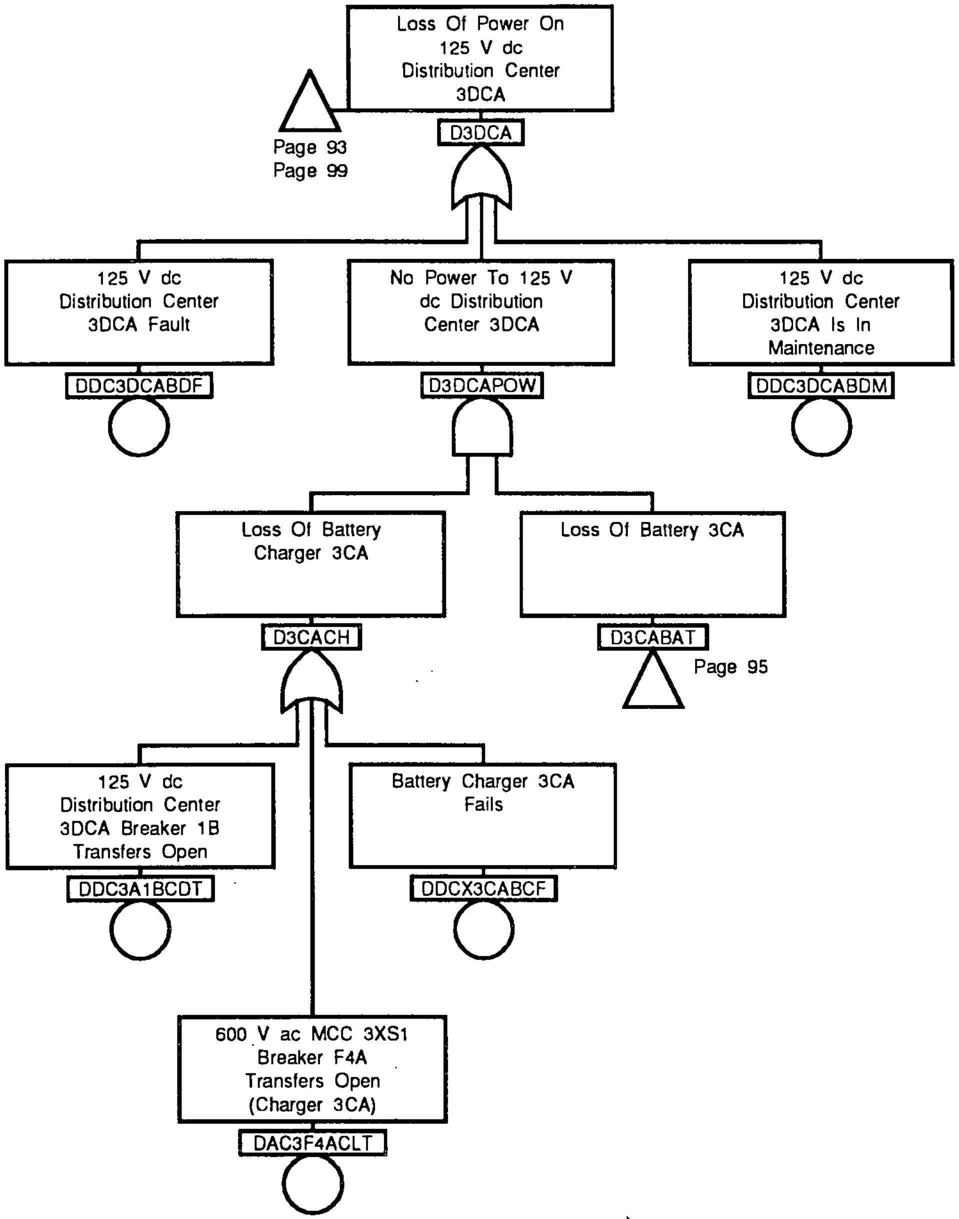

Standby Bus 1 Power Fails
PSB1
Page 2
Breaker S1 Remains Open
PS1CLOSE
Standby Bus 1 Maintenance Unavailability
PSM1M
Page 103
Standby Bus 1 Power Sources Fail
PSB1S
Page 104
Standby Bus 1 Fails
PACSBY1BHF
S1 Closing Circuit Components Fail
PACS1CSMOD
Module
Common Cause Failure Of Breakers S1 And S2 To Close
PACS1S2COM
2
Breaker S1 Fails To Close
PACXS01C4C
S1 Close Initiate Circuits Fail
PS1INIT
Breaker 1DIC-25 Transfers Open
PDC1C25CDT
2
Loss Of Power On 125 V dc Panelboard 1DIC
D1DIC
2
Transfer
Loss Of Power On 125 V dc Panelboard 3DIA
D3DIA
Page 93
Loss Of Power On 125 V dc Panelboard 3DIB
D3DIB
Page 99

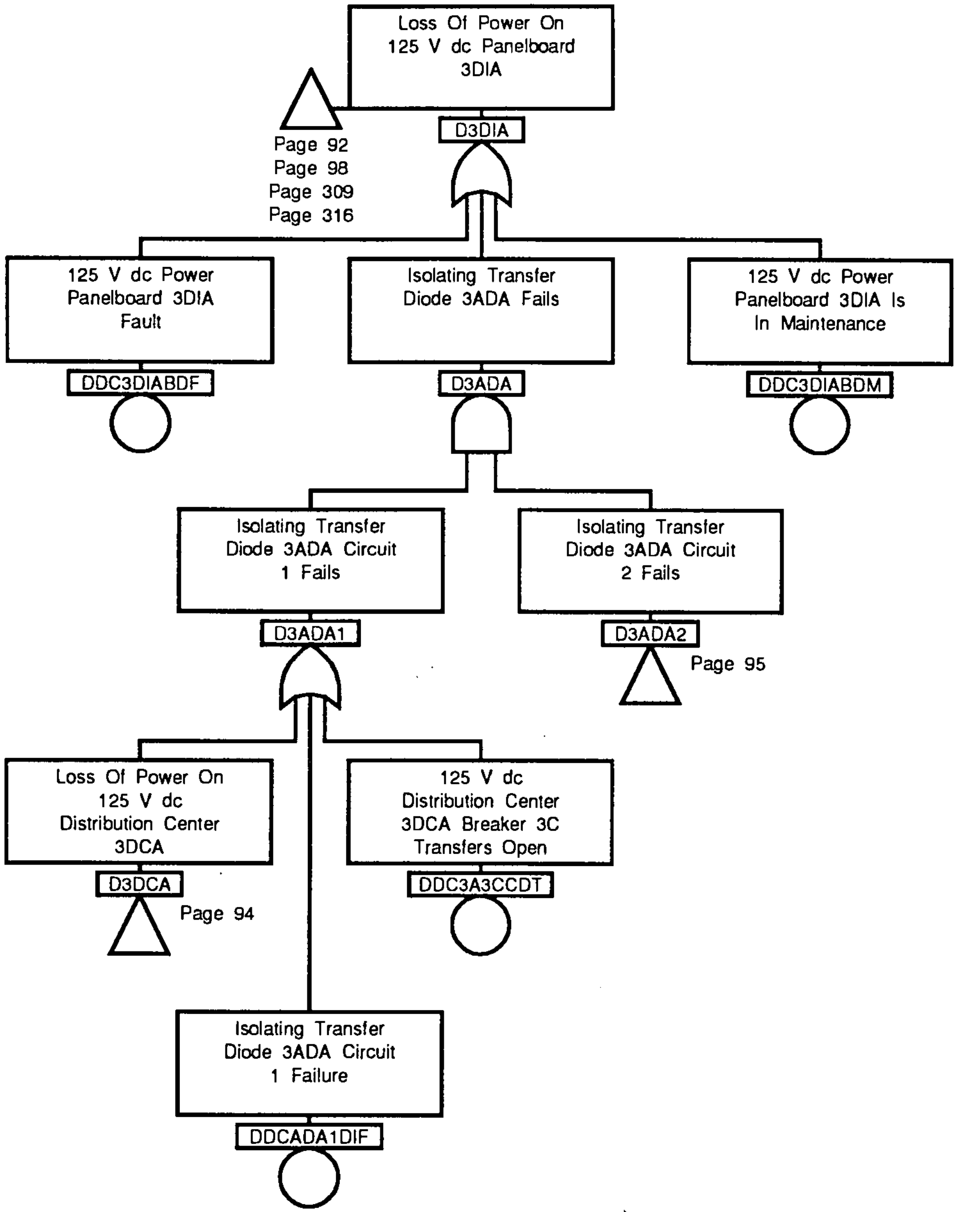

Loss Of Battery 1CA
D1CABAT
Page 96
125 V dc Battery 1CA Fails
DDC1DCABYF
125 V dc Battery 1CA Breaker 2A Transfers Open
DDC1A2ACDT
AC Power Is Not Restored To Battery Chargers
DDCBATTDEX
4

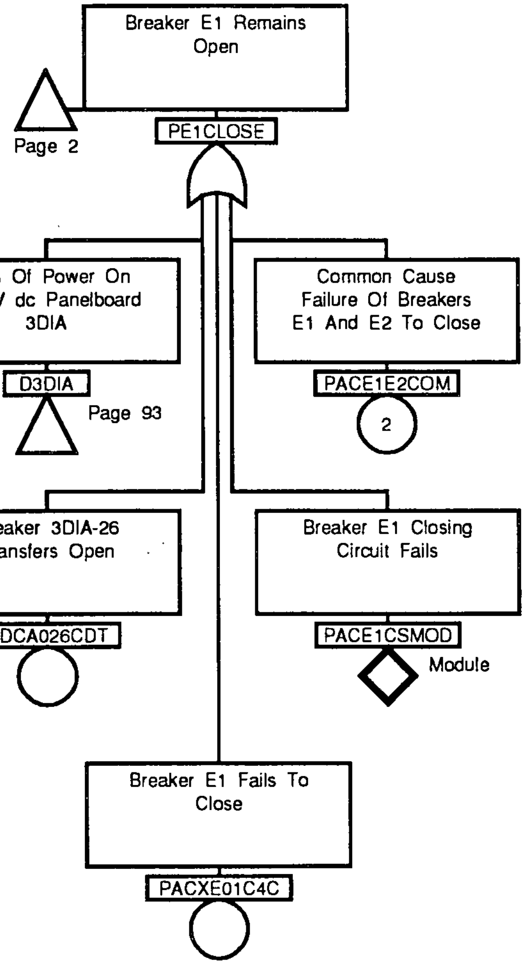

Loss Of Power On 125 V dc Distribution Center 1DCA
D1DCA
Page 95
Page 314
125 V dc Distribution Center 1DCA Fault
DDC1DCABDF
No Power To 125 V dc Distribution Center 1DCA
D1DCAPOW
125 V dc Distribution Center 1DCA Is In Maintenance
DDC1DCABDM
Loss Of Battery Charger 1CA
D1CACH
Loss Of Battery 1CA
D1CABAT
Page 97
125 V dc Distribution Center 1DCA Breaker 1B Transfers Open
DDC1A1BCDT
Battery Charger 1CA Fails
DDCX1CABCF
600 V ac MCC 1XS1 Breaker F4A Transfers Open
DAC1F4ACLT



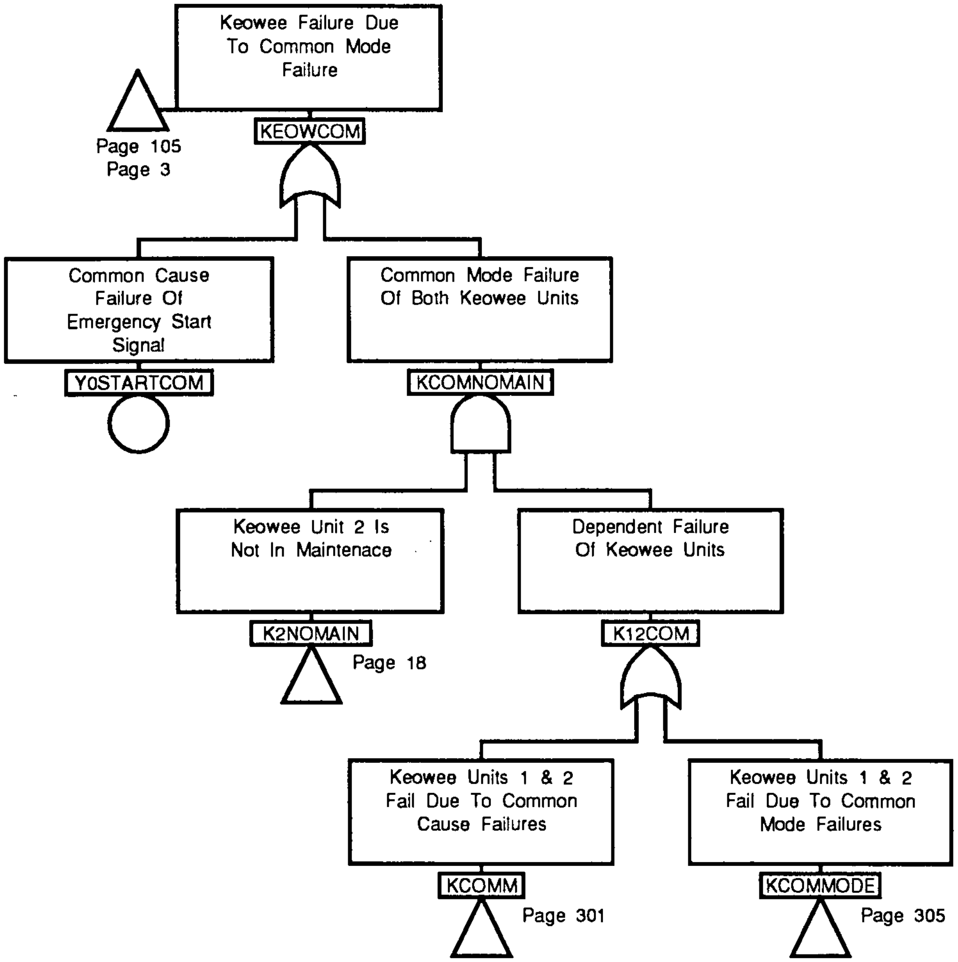
Loss Of Battery 3CA
Page 94
D3CABAT
125 V dc Battery 3CA Fails
DDC3DCABYF
125 V dc Battery 3CA Breaker 2A Transfers Open
DDC3A2ACDT
AC Power Is Not Restored To Battery Chargers
DDCBATTDEX
4
Isolating Transfer Diode 3ADA Circuit 2 Fails
Page 93
D3ADA2
125 V dc Distribution Center 1DCA Breaker 3C Transfers Open
DDC1A3CCDT
Isolating Transfer Diode 3ADA Circuit 2 Failure
DDCADA2DIF
Unit 1 Backup To Unit 3 Isolated At Diode For Ground Detect.
DDCUN31DIM
4
Loss Of Power On 125 V dc Distribution Center 1DCA
D1DCA
Page 96

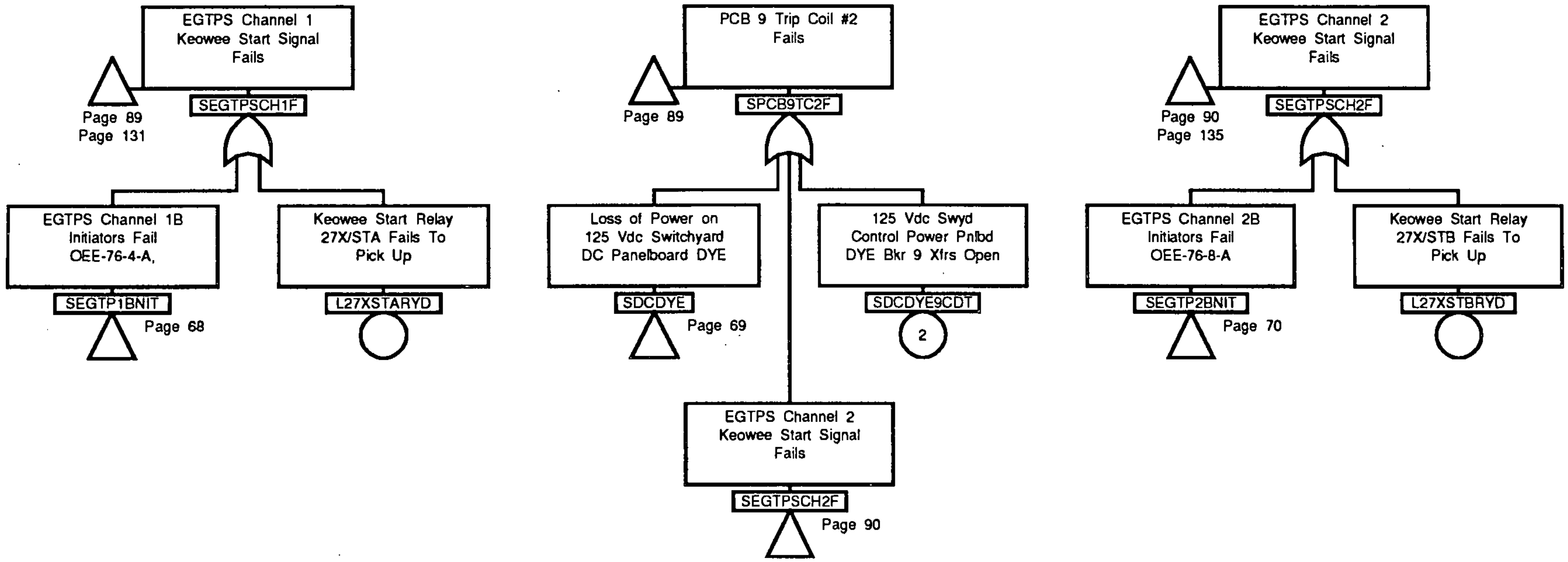

Loss Of Power On 125 V dc Distribution Center 3DCA
D3DCA
Page 93
Page 99
125 V dc Distribution Center 3DCA Fault
DDC3DCABDF
No Power To 125 V dc Distribution Center 3DCA
D3DCAPOW
125 V dc Distribution Center 3DCA Is In Maintenance
DDC3DCABDM
Loss Of Battery Charger 3CA
D3CACH
Loss Of Battery 3CA
D3CABAT
Page 95
125 V dc Distribution Center 3DCA Breaker 1B Transfers Open
DDC3A1BCDT
Battery Charger 3CA Fails
DDCX3CABCF
600 V ac MCC 3XS1 Breaker F4A Transfers Open (Charger 3CA)
DAC3F4ACLT

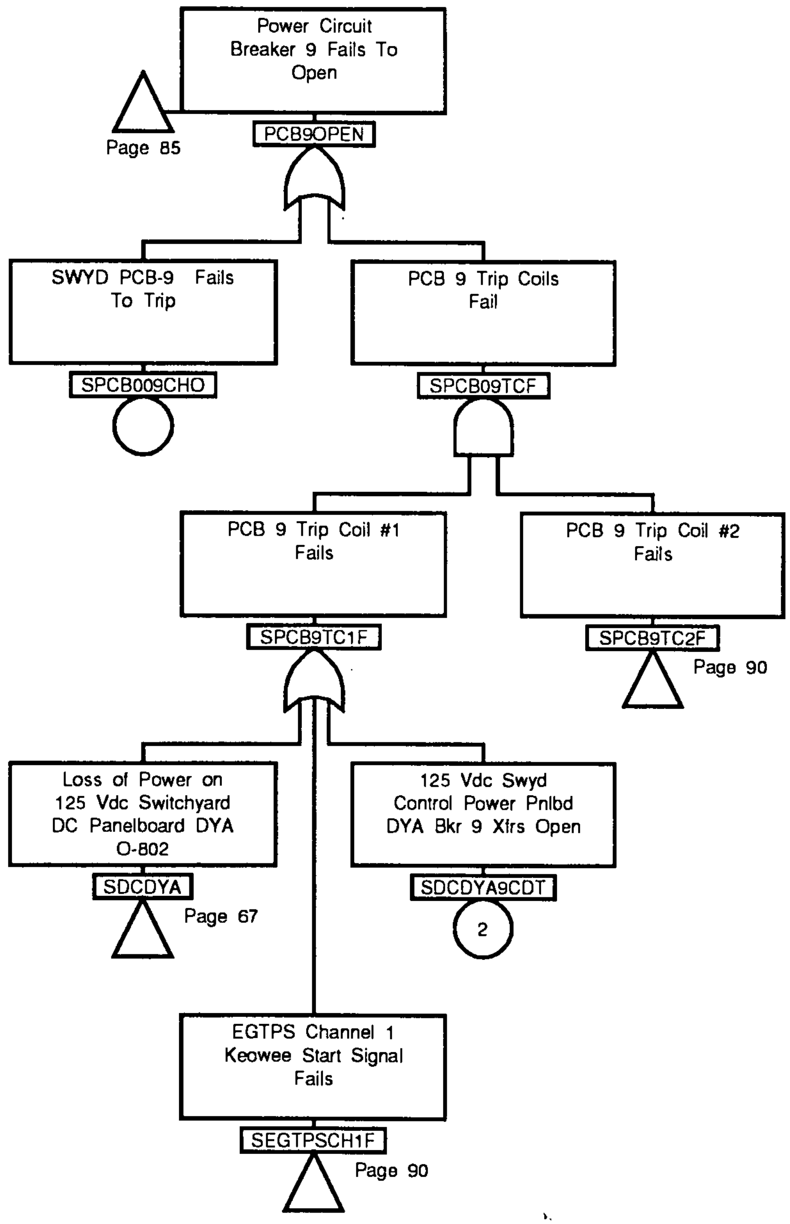

Loss Of Power On 125 V dc Panelboard 3DIA
D3DIA
Page 92
Page 98
Page 309
Page 316
125 V dc Power Panelboard 3DIA Fault
DDC3DIABDF
Isolating Transfer Diode 3ADA Fails
D3ADA
125 V dc Power Panelboard 3DIA Is In Maintenance
DDC3DIABDM
Isolating Transfer Diode 3ADA Circuit 1 Fails
D3ADA1
Isolating Transfer Diode 3ADA Circuit 2 Fails
D3ADA2
Page 95
Loss Of Power On 125 V dc Distribution Center 3DCA
D3DCA
Page 94
125 V dc Distribution Center 3DCA Breaker 3C Transfers Open
DDC3A3CCDT
Isolating Transfer Diode 3ADA Circuit 1 Failure
DDCADA1DIF



Breaker E1 Remains Open
PE1CLOSE
Page 2
Loss Of Power On 125 V dc Panelboard 3DIA
D3DIA
Page 93
Common Cause Failure Of Breakers E1 And E2 To Close
PACE1E2COM
2
Breaker 3DIA-26 Transfers Open
PDCA026CDT
Breaker E1 Closing Circuit Fails
PACE1CSMOD
Module
Breaker E1 Fails To Close
PACXE01C4C

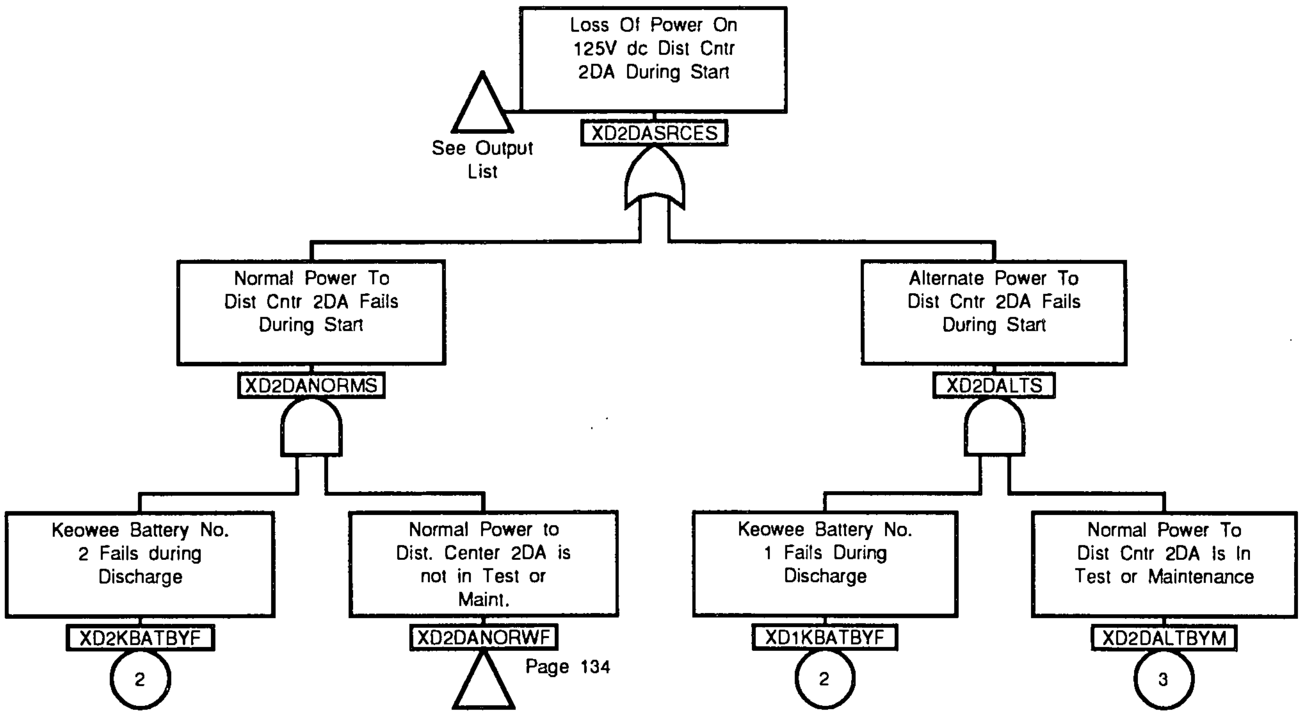

Keowee Failure Due To Common Mode Failure
KEOWCOM
Page 105
Page 3
Common Cause Failure Of Emergency Start Signal
Y0STARTCOM
Common Mode Failure Of Both Keowee Units
KCOMNOMAIN
Keowee Unit 2 Is Not In Maintenace
K2NOMAIN
Page 18
Dependent Failure Of Keowee Units
K12COM
Keowee Units 1 & 2 Fail Due To Common Cause Failures
KCOMM
Page 301
Keowee Units 1 & 2 Fail Due To Common Mode Failures
KCOMMODE
Page 305

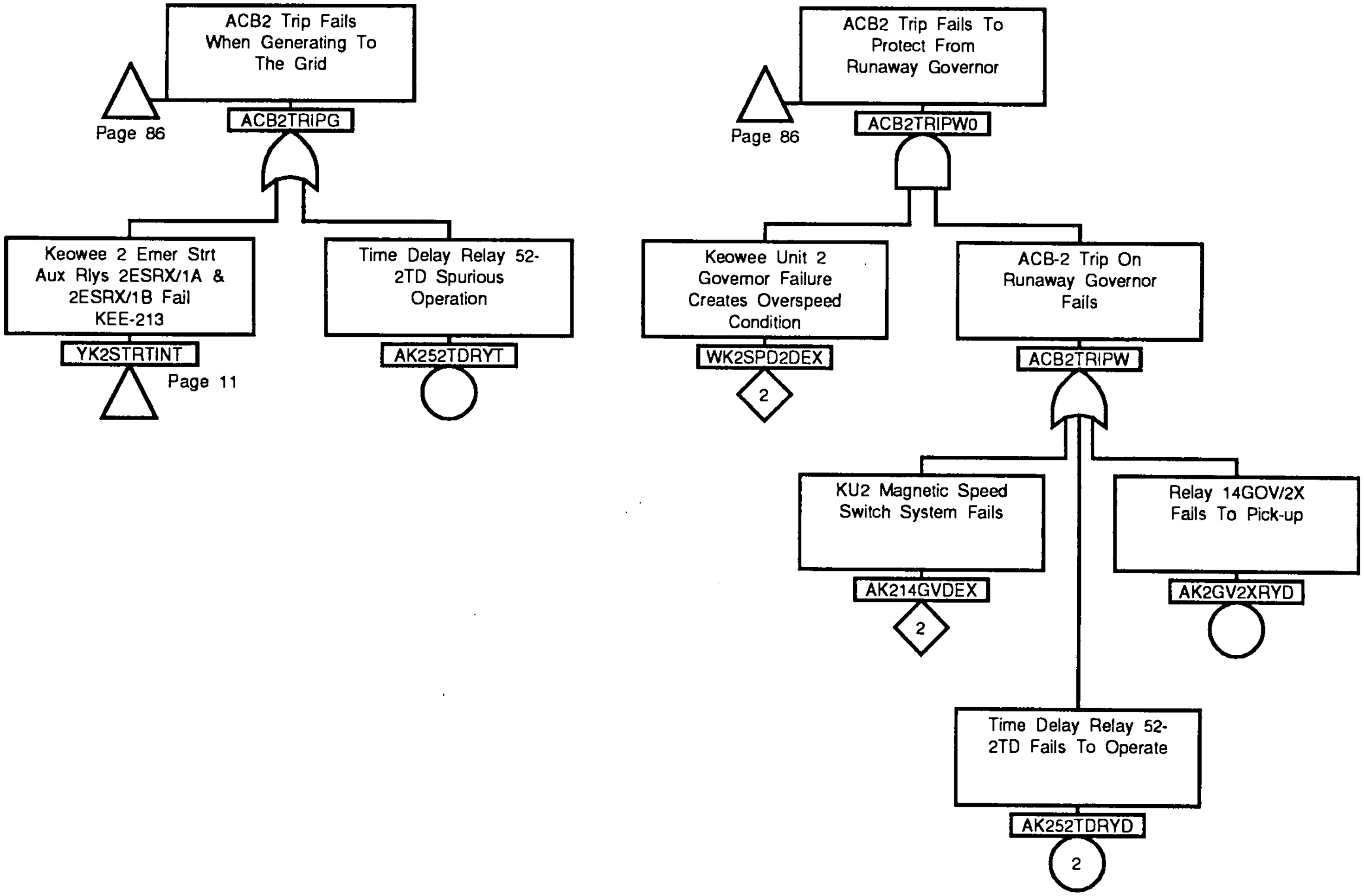

EGTPS Channel 1 Keowee Start Signal Fails
SEGTPSCH1F
Page 89
Page 131
EGTPS Channel 1B Initiators Fail OEE-76-4-A,
SEGTP1BNIT
Page 68
Keowee Start Relay 27X/STA Fails To Pick Up
L27XSTARYD
PCB 9 Trip Coil #2 Fails
SPCB9TC2F
Page 89
Loss of Power on 125 Vdc Switchyard DC Panelboard DYE
SDCDYE
Page 69
125 Vdc Swyd Control Power Pnlbd DYE Bkr 9 Xfrs Open
SDCDYE9CDT
2
EGTPS Channel 2 Keowee Start Signal Fails
SEGTPSCH2F
Page 90
EGTPS Channel 2 Keowee Start Signal Fails
SEGTPSCH2F
Page 90
Page 135
EGTPS Channel 2B Initiators Fail OEE-76-8-A
SEGTP2BNIT
Page 70
Keowee Start Relay 27X/STB Fails To Pick Up
L27XSTBRYD

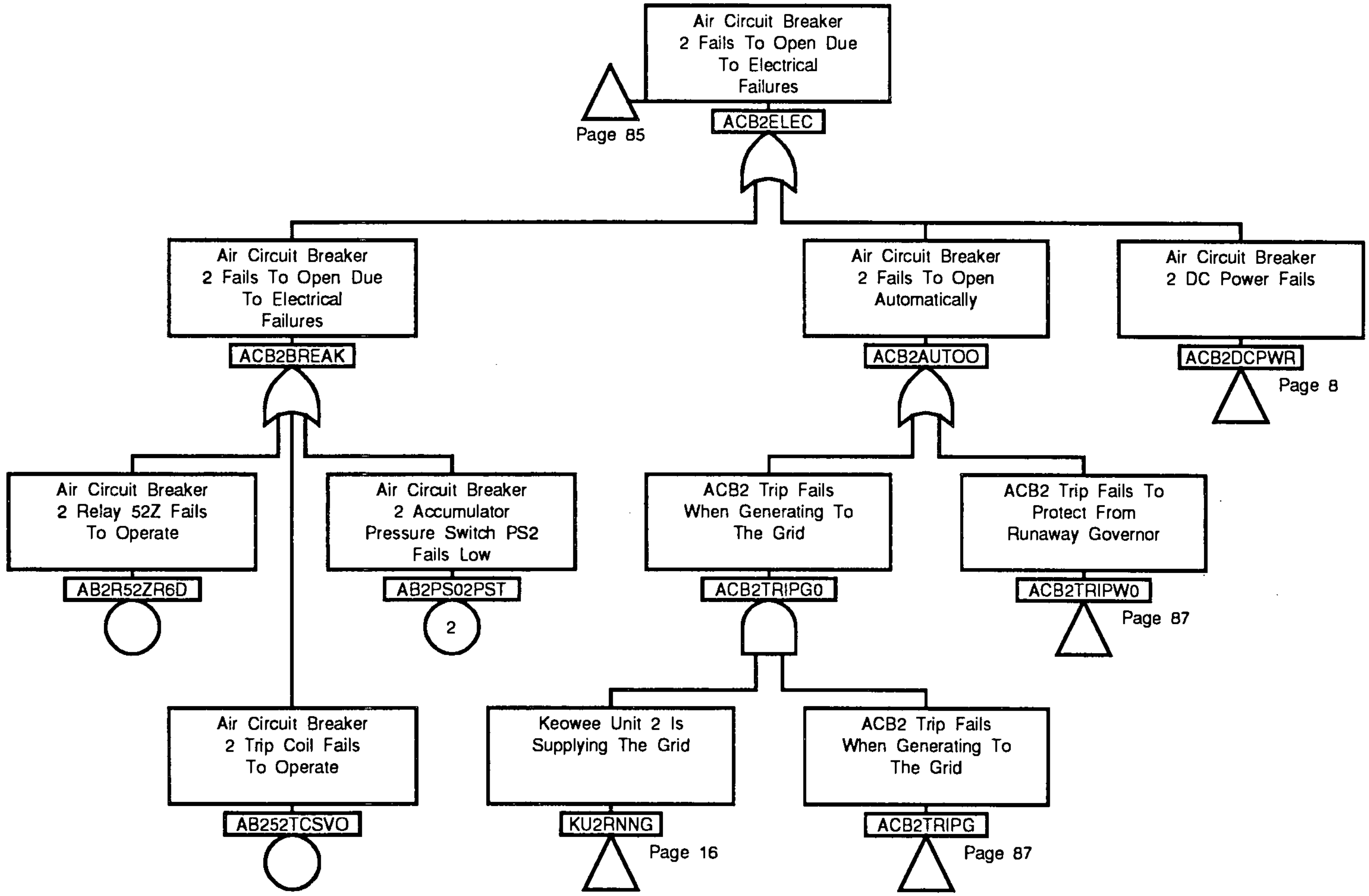


Power Circuit Breaker 9 Fails To Open
PCB9OPEN
Page 85
SWYD PCB-9 Fails To Trip
SPCB009CHO
PCB 9 Trip Coils Fail
SPCB09TCF
PCB 9 Trip Coil #1 Fails
SPCB9TC1F
PCB 9 Trip Coil #2 Fails
SPCB9TC2F
Page 90
Loss of Power on 125 Vdc Switchyard DC Panelboard DYA O-802
SDCDYA
Page 67
125 Vdc Swyd Control Power Pnlbd DYA Bkr 9 Xfrs Open
SDCDYA9CDT
2
EGTPS Channel 1 Keowee Start Signal Fails
SEGTPSCH1F
Page 90

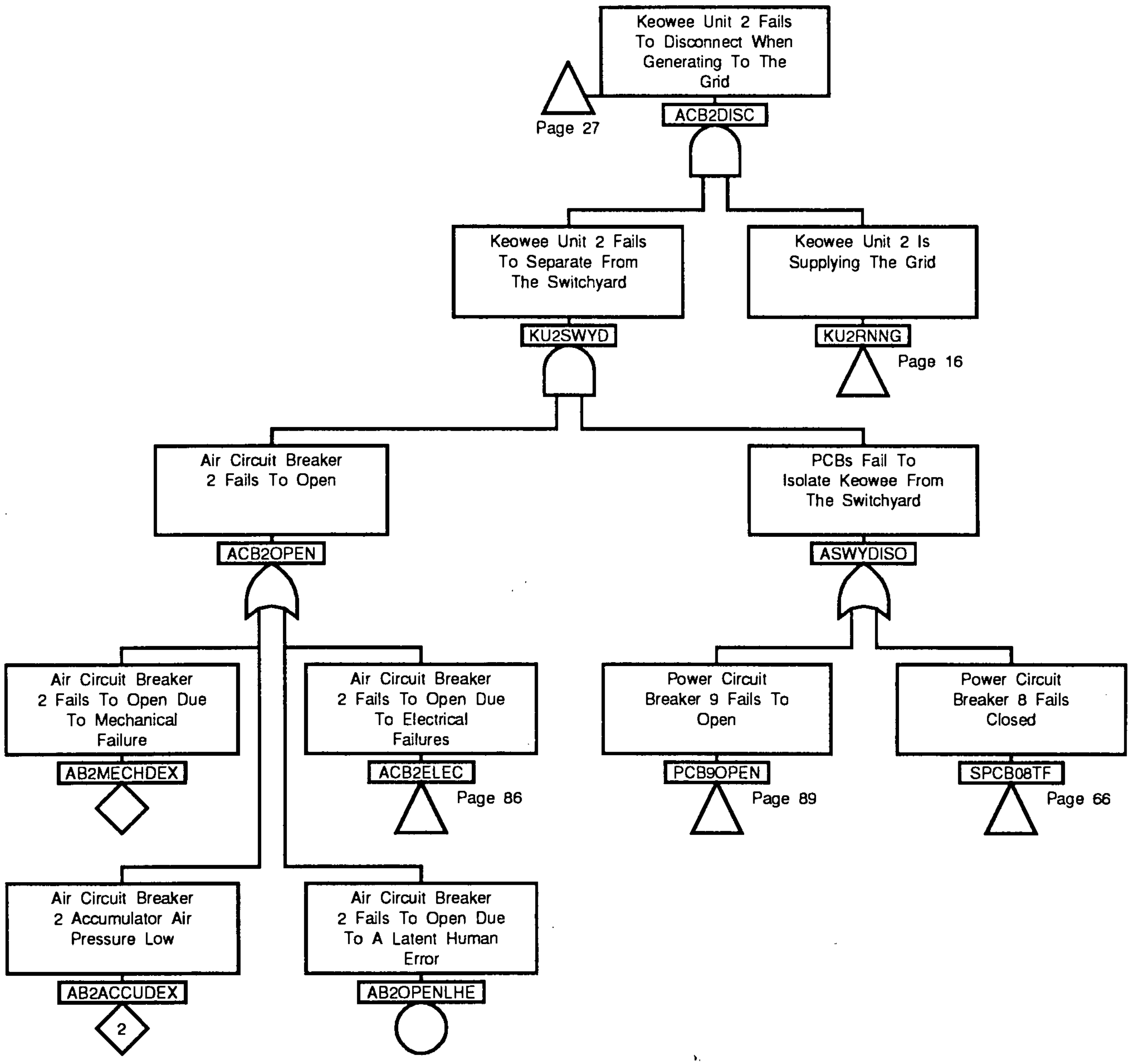
XD2DASRCES Outputs:
Page 115, Page 235, Page 226, Page 8, Page 224, Page 229



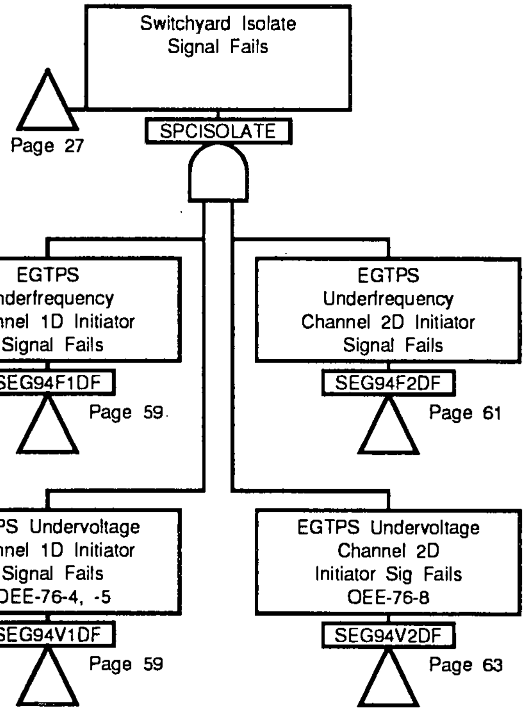

ACB2 Trip Fails When Generating To The Grid
ACB2TRIPG
Page 86
Keowee 2 Emer Strt Aux Rlys 2ESRX/1A & 2ESRX/1B Fail KEE-213
YK2STRTINT
Page 11
Time Delay Relay 52-2TD Spurious Operation
AK252TDRYT
ACB2 Trip Fails To Protect From Runaway Governor
ACB2TRIPW0
Page 86
Keowee Unit 2 Governor Failure Creates Overspeed Condition
WK2SPD2DEX
2
ACB-2 Trip On Runaway Governor Fails
ACB2TRIPW
KU2 Magnetic Speed Switch System Fails
AK214GVDEX
2
Relay 14GOV/2X Fails To Pick-up
AK2GV2XRYD
Time Delay Relay 52-2TD Fails To Operate
AK252TDRYD
2

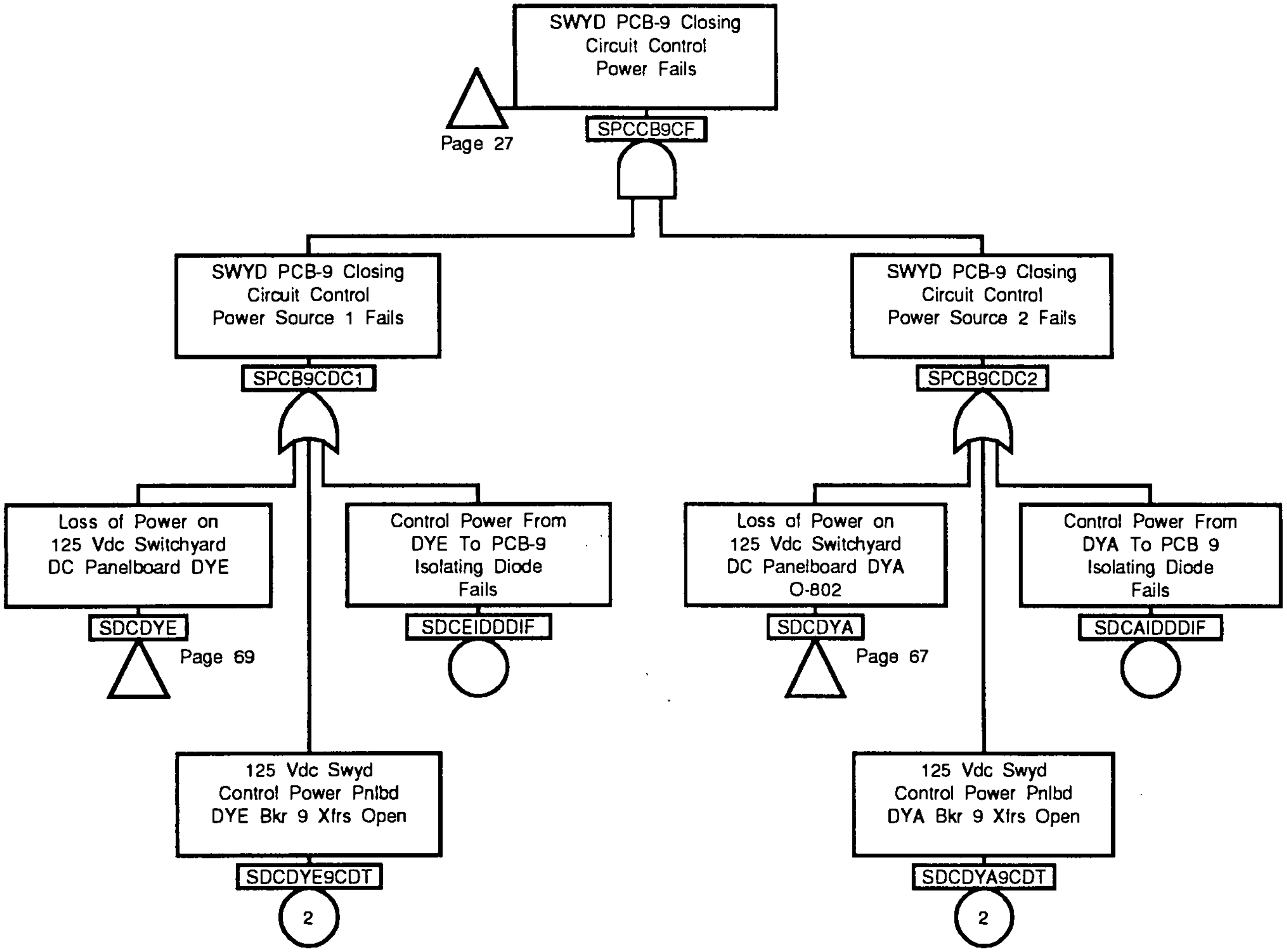


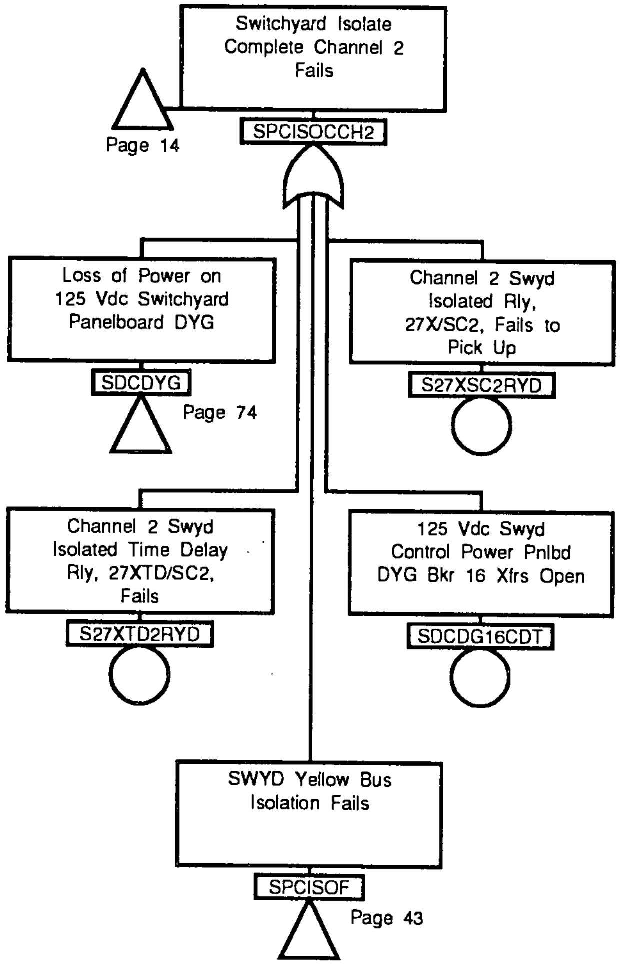
Air Circuit Breaker 2 Fails To Open Due To Electrical Failures
ACB2ELEC
Page 85
Air Circuit Breaker 2 Fails To Open Due To Electrical Failures
ACB2BREAK
Air Circuit Breaker 2 Fails To Open Automatically
ACB2AUTOO
Air Circuit Breaker 2 DC Power Fails
ACB2DCPWR
Page 8
Air Circuit Breaker 2 Relay 52Z Fails To Operate
AB2R52ZR6D
Air Circuit Breaker 2 Accumulator Pressure Switch PS2 Fails Low
AB2PS02PST
2
ACB2 Trip Fails When Generating To The Grid
ACB2TRIPG0
ACB2 Trip Fails To Protect From Runaway Governor
ACB2TRIPW0
Page 87
Air Circuit Breaker 2 Trip Coil Fails To Operate
AB252TCSVO
Keowee Unit 2 Is Supplying The Grid
KU2RNNG
Page 16
ACB2 Trip Fails When Generating To The Grid
ACB2TRIPG
Page 87

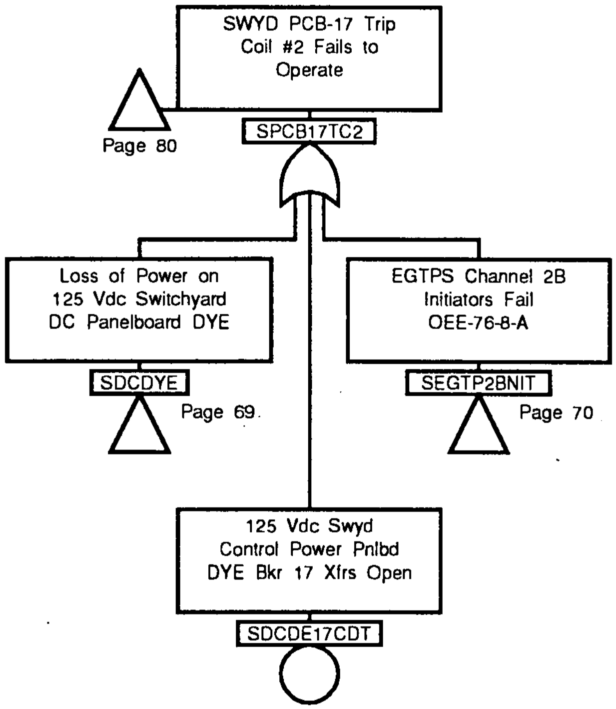


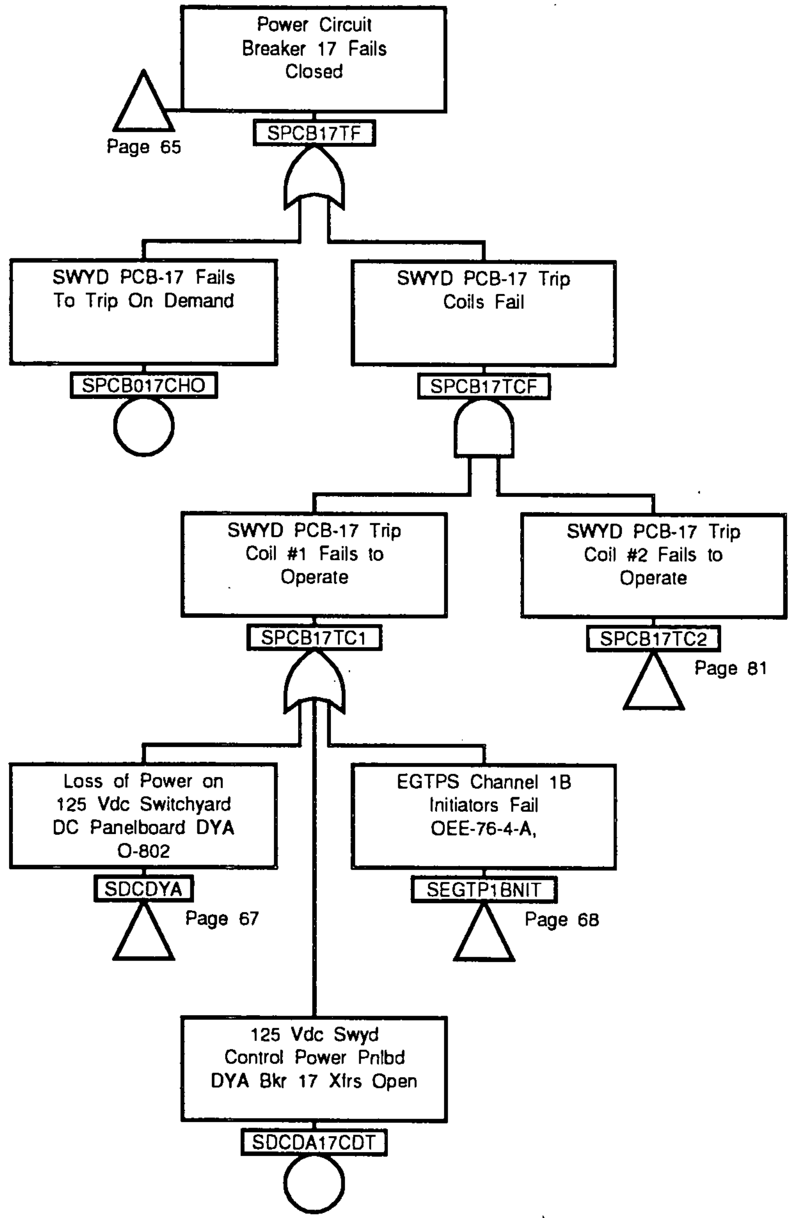
Keowee Unit 2 Fails To Disconnect When Generating To The Grid
ACB2DISC
Page 27
Keowee Unit 2 Fails To Separate From The Switchyard
KU2SWYD
Keowee Unit 2 Is Supplying The Grid
KU2RNNG
Page 16
Air Circuit Breaker 2 Fails To Open
ACB2OPEN
PCBs Fail To Isolate Keowee From The Switchyard
ASWYDISO
Air Circuit Breaker 2 Fails To Open Due To Mechanical Failure
AB2MECHDEX
Air Circuit Breaker 2 Fails To Open Due To Electrical Failures
ACB2ELEC
Page 86
Power Circuit Breaker 9 Fails To Open
PCB9OPEN
Page 89
Power Circuit Breaker 8 Fails Closed
SPCB08TF
Page 66
Air Circuit Breaker 2 Accumulator Air Pressure Low
AB2ACCUDEX
2
Air Circuit Breaker 2 Fails To Open Due To A Latent Human Error
AB2OPENLHE

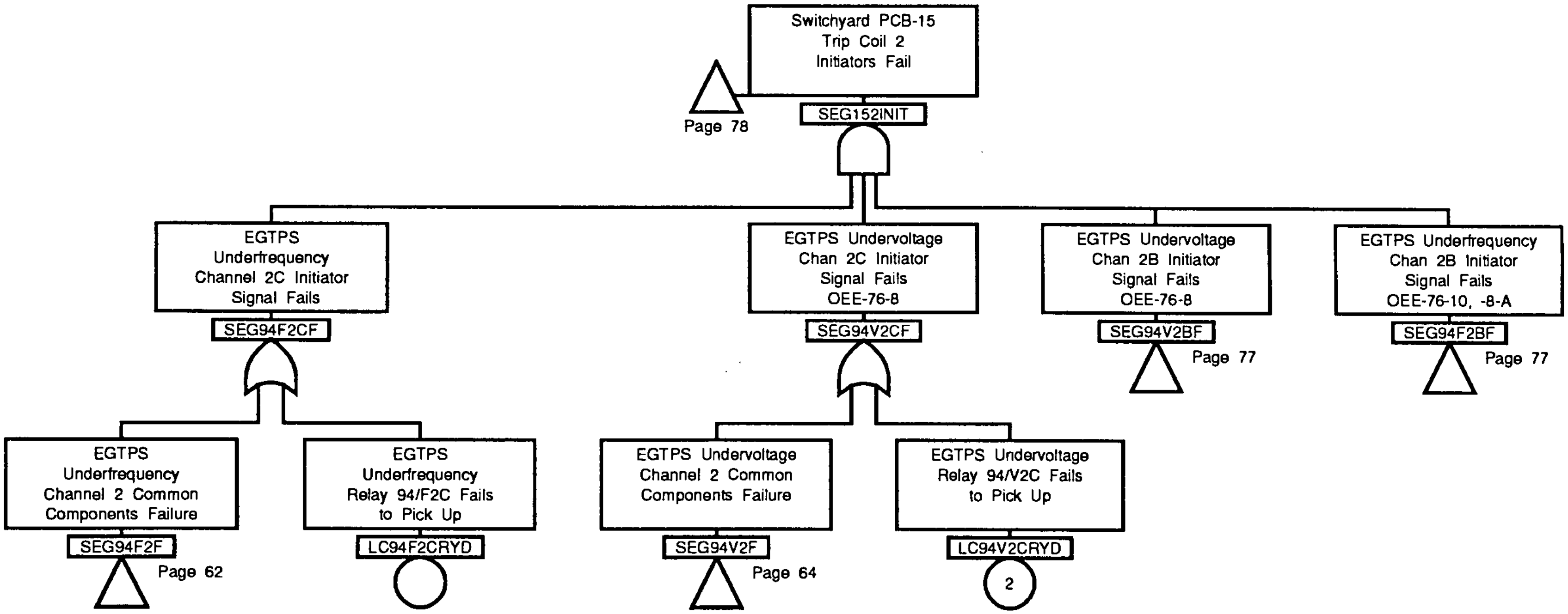

Switchyard Isolate Signal Fails
SPCISOLATE
Page 27
EGTPS Underfrequency Channel 1D Initiator Signal Fails
SEG94F1DF
Page 59
EGTPS Underfrequency Channel 2D Initiator Signal Fails
SEG94F2DF
Page 61
EGTPS Undervoltage Channel 1D Initiator Signal Fails OEE-76-4, -5
SEG94V1DF
Page 59
EGTPS Undervoltage Channel 2D Initiator Sig Fails OEE-76-8
SEG94V2DF
Page 63


SWYD PCB-9 Closing Circuit Control Power Fails
SPCCB9CF
Page 27
SWYD PCB-9 Closing Circuit Control Power Source 1 Fails
SPCB9CDC1
SWYD PCB-9 Closing Circuit Control Power Source 2 Fails
SPCB9CDC2
Loss of Power on 125 Vdc Switchyard DC Panelboard DYE
SDCDYE
Page 69
Control Power From DYE To PCB-9 Isolating Diode Fails
SDCEIDDDIF
Loss of Power on 125 Vdc Switchyard DC Panelboard DYA O-802
SDCDYA
Page 67
Control Power From DYA To PCB 9 Isolating Diode Fails
SDCAIDDDIF
125 Vdc Swyd Control Power Pnlbd DYE Bkr 9 Xfrs Open
SDCDYE9CDT
2
125 Vdc Swyd Control Power Pnlbd DYA Bkr 9 Xfrs Open
SDCDYA9CDT
2

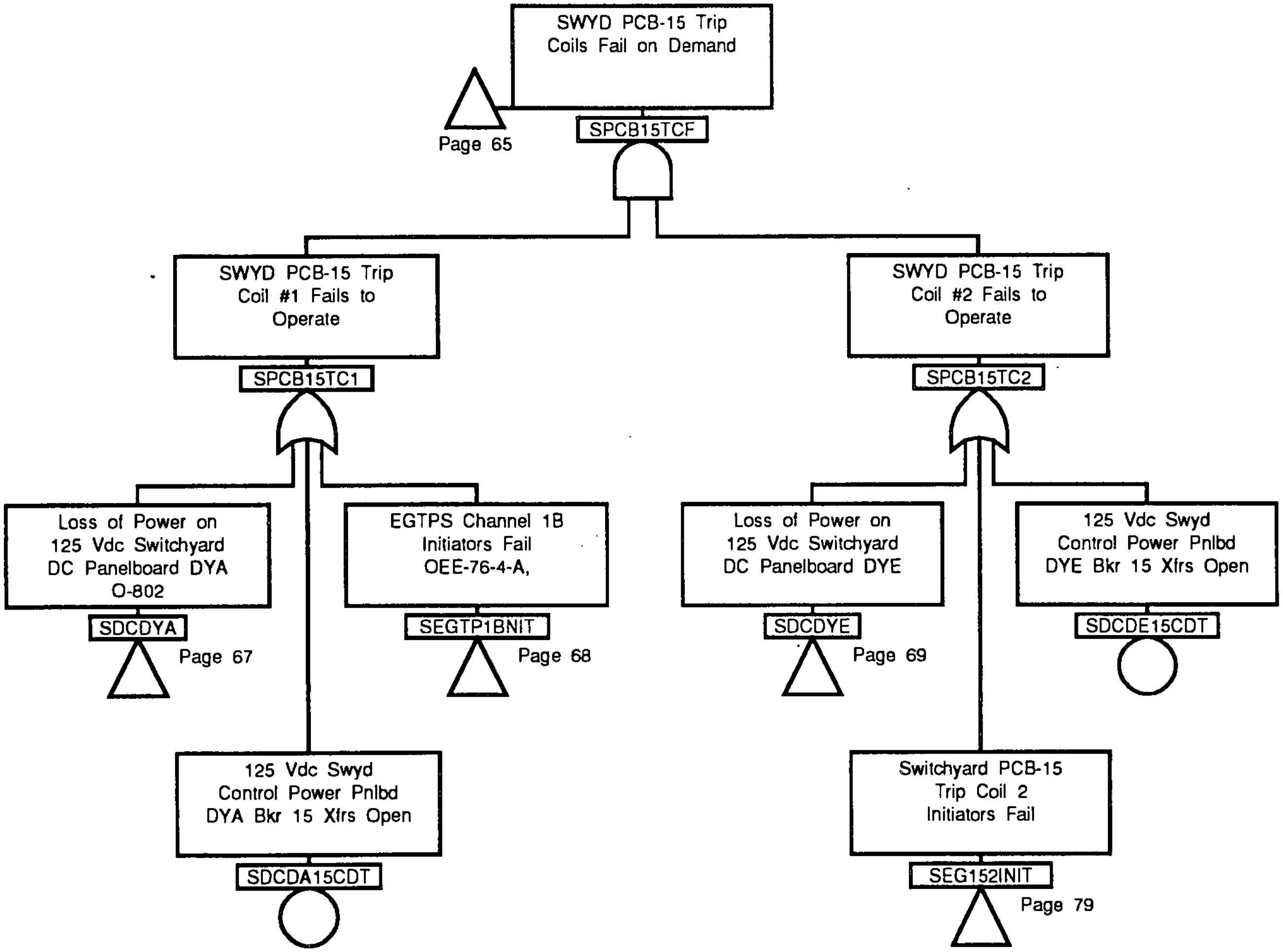

Switchyard Isolate Complete Channel 2 Fails
SPCISOCCH2
Page 14
Loss of Power on 125 Vdc Switchyard Panelboard DYG
SDCDYG
Page 74
Channel 2 Swyd Isolated Rly, 27X/SC2, Fails to Pick Up
S27XSC2RYD
Channel 2 Swyd Isolated Time Delay Rly, 27XTD/SC2, Fails
S27XTD2RYD
125 Vdc Swyd Control Power Pnlbd DYG Bkr 16 Xfrs Open
SDCDG16CDT
SWYD Yellow Bus Isolation Fails
SPCISOF
Page 43


SWYD PCB-17 Trip Coil #2 Fails to Operate
SPCB17TC2
Page 80
Loss of Power on 125 Vdc Switchyard DC Panelboard DYE
SDCDYE
Page 69
EGTPS Channel 2B Initiators Fail OEE-76-8-A
SEGTP2BNIT
Page 70
125 Vdc Swyd Control Power Pnlbd DYE Bkr 17 Xfrs Open
SDCDE17CDT

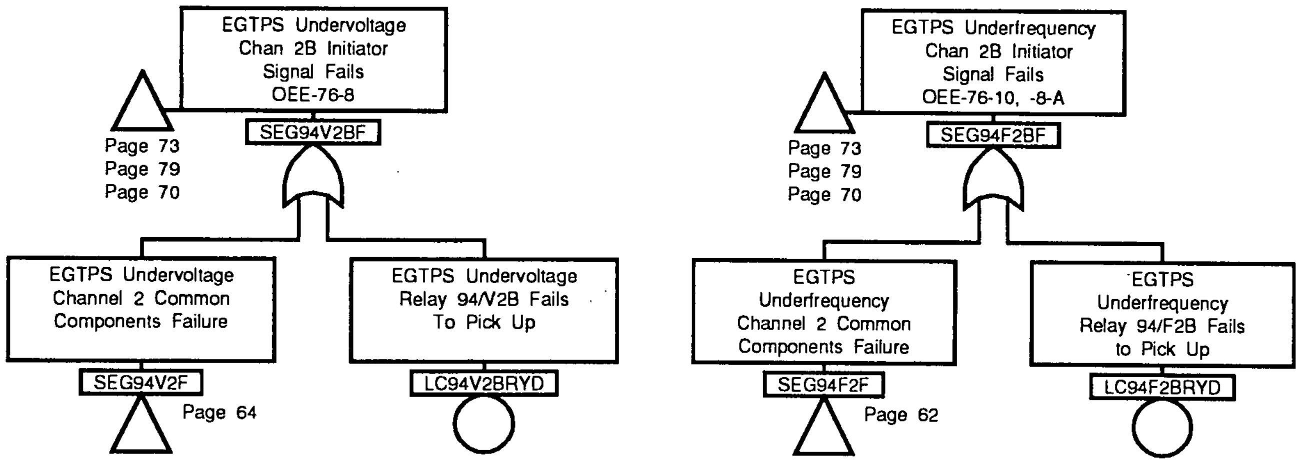

Power Circuit Breaker 17 Fails Closed
SPCB17TF
Page 65
SWYD PCB-17 Fails To Trip On Demand
SPCB017CHO
SWYD PCB-17 Trip Coils Fail
SPCB17TCF
SWYD PCB-17 Trip Coil #1 Fails to Operate
SPCB17TC1
SWYD PCB-17 Trip Coil #2 Fails to Operate
SPCB17TC2
Page 81
Loss of Power on 125 Vdc Switchyard DC Panelboard DYA O-802
SDCDYA
Page 67
EGTPS Channel 1B Initiators Fail OEE-76-4-A,
SEGTP1BNIT
Page 68
125 Vdc Swyd Control Power Pnlbd DYA Bkr 17 Xfrs Open
SDCDA17CDT



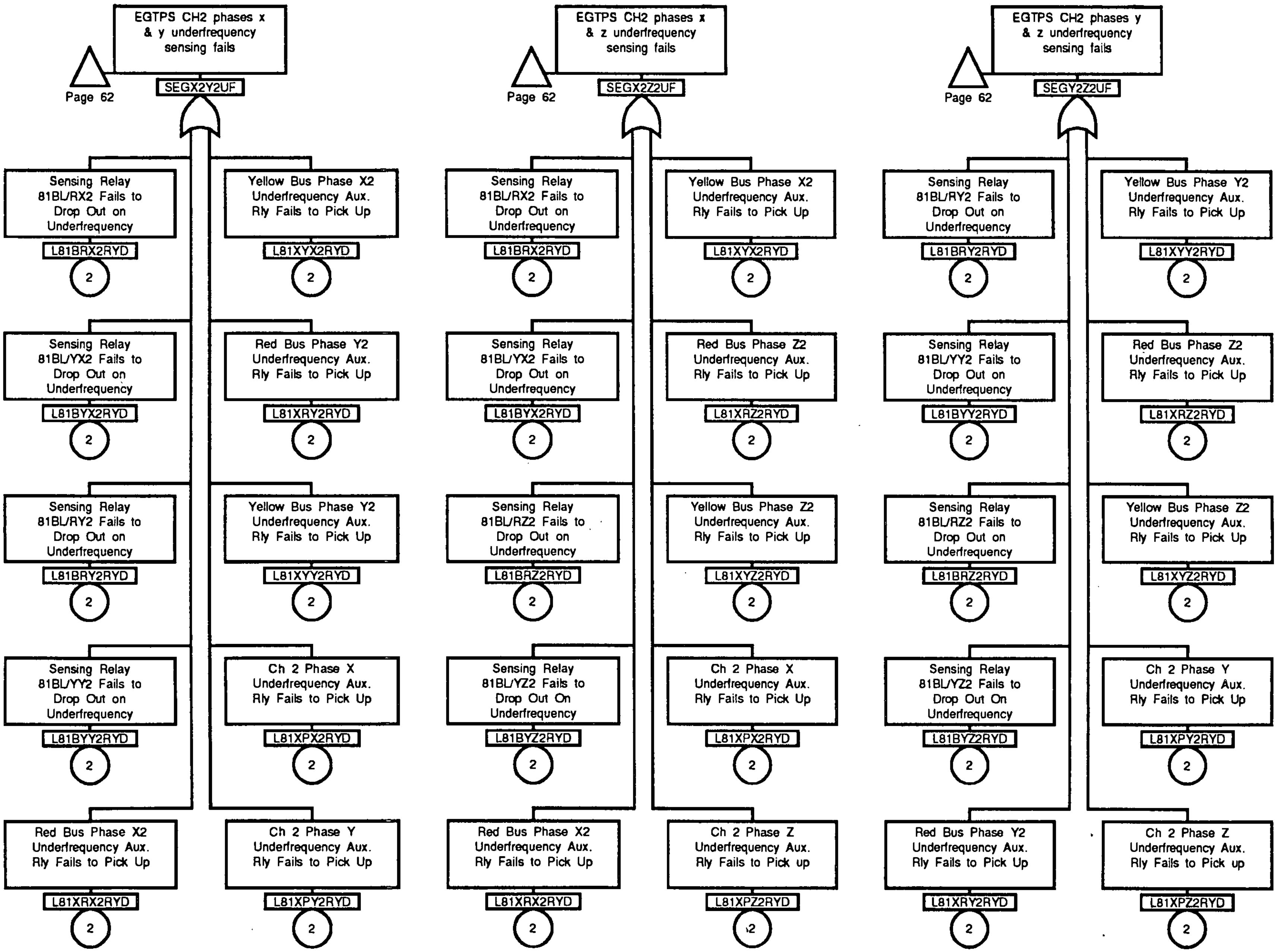
Switchyard PCB-15 Trip Coil 2 Initiators Fail
SEG152INIT
Page 78
EGTPS Underfrequency Channel 2C Initiator Signal Fails
SEG94F2CF
EGTPS Undervoltage Chan 2C Initiator Signal Fails OEE-76-8
SEG94V2CF
EGTPS Undervoltage Chan 2B Initiator Signal Fails OEE-76-8
SEG94V2BF
Page 77
EGTPS Underfrequency Chan 2B Initiator Signal Fails OEE-76-10, -8-A
SEG94F2BF
Page 77
EGTPS Underfrequency Channel 2 Common Components Failure
SEG94F2F
Page 62
EGTPS Underfrequency Relay 94/F2C Fails to Pick Up
LC94F2CRYD
EGTPS Undervoltage Channel 2 Common Components Failure
SEG94V2F
Page 64
EGTPS Undervoltage Relay 94/V2C Fails to Pick Up
LC94V2CRYD
2

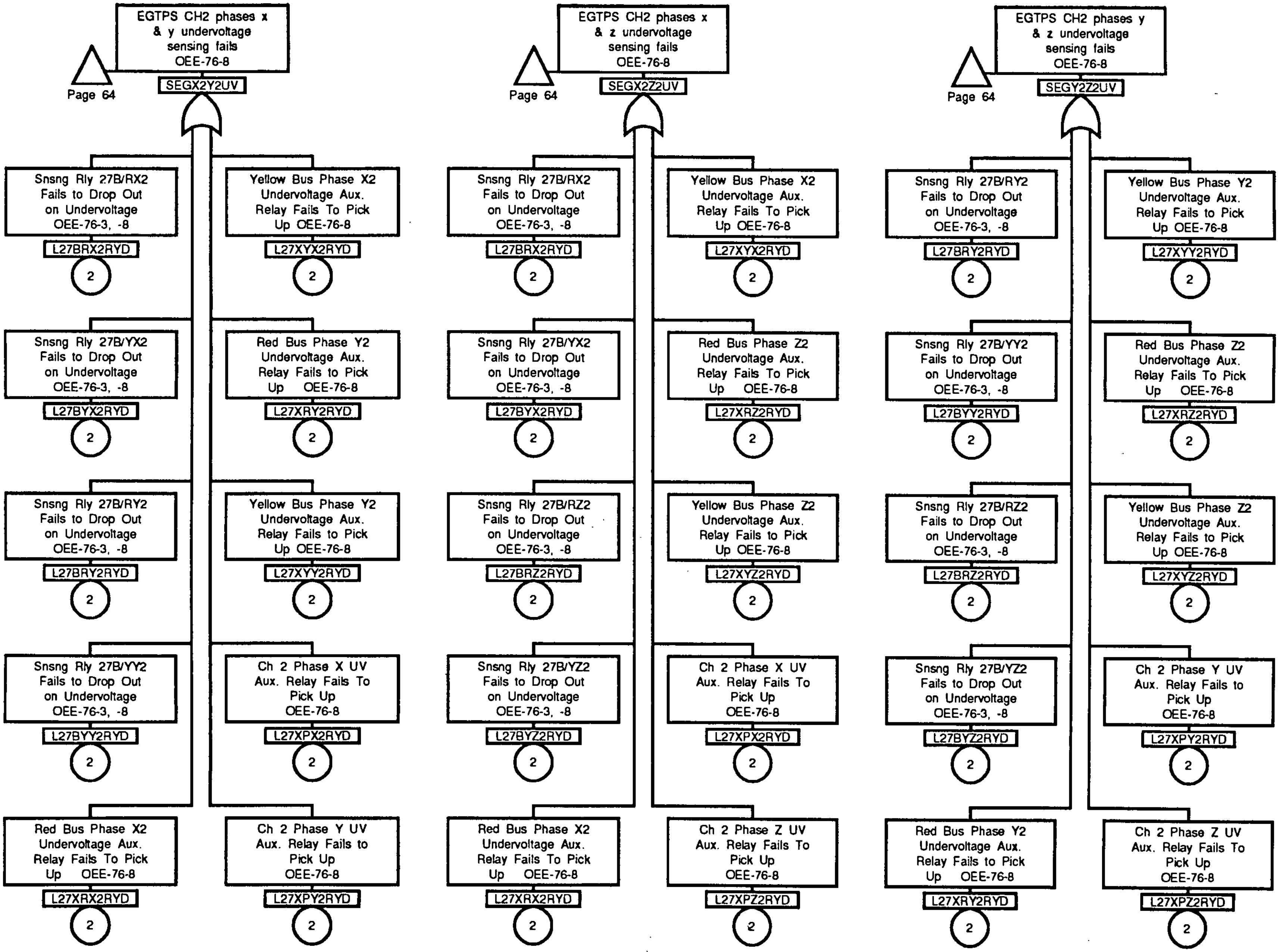


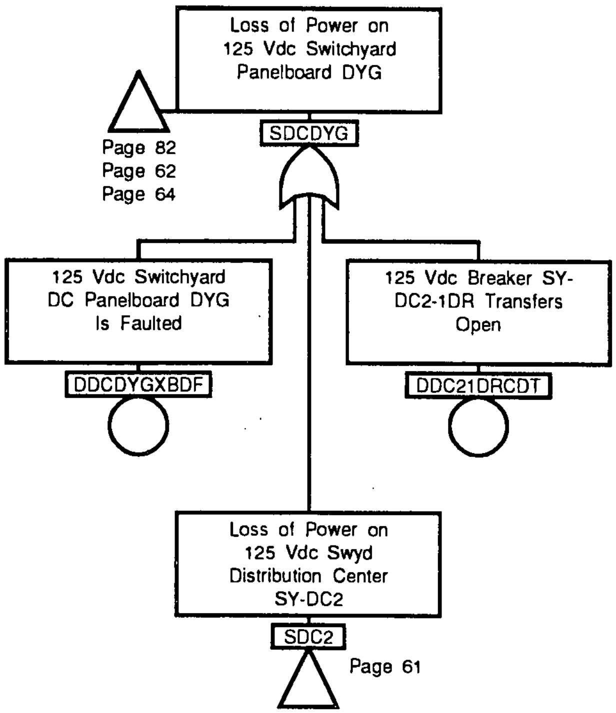
SWYD PCB-15 Trip
Coils Fail on Demand
SPCB15TCF
Page 65
SWYD PCB-15 Trip
Coil #1 Fails to
Operate
SPCB15TC1
SWYD PCB-15 Trip
Coil #2 Fails to
Operate
SPCB15TC2
Loss of Power on
125 Vdc Switchyard
DC Panelboard DYA
O-802
SDCDYA
Page 67
EGTPS Channel 1B
Initiators Fail
OEE-76-4-A,
SEGTP1BNIT
Page 68
Loss of Power on
125 Vdc Switchyard
DC Panelboard DYE
SDCDYE
Page 69
125 Vdc Swyd
Control Power Pnlbd
DYE Bkr 15 Xfrs Open
SDCDE15CDT
125 Vdc Swyd
Control Power Pnlbd
DYA Bkr 15 Xfrs Open
SDCDA15CDT
Switchyard PCB-15
Trip Coil 2
Initiators Fail
SEG152INIT
Page 79



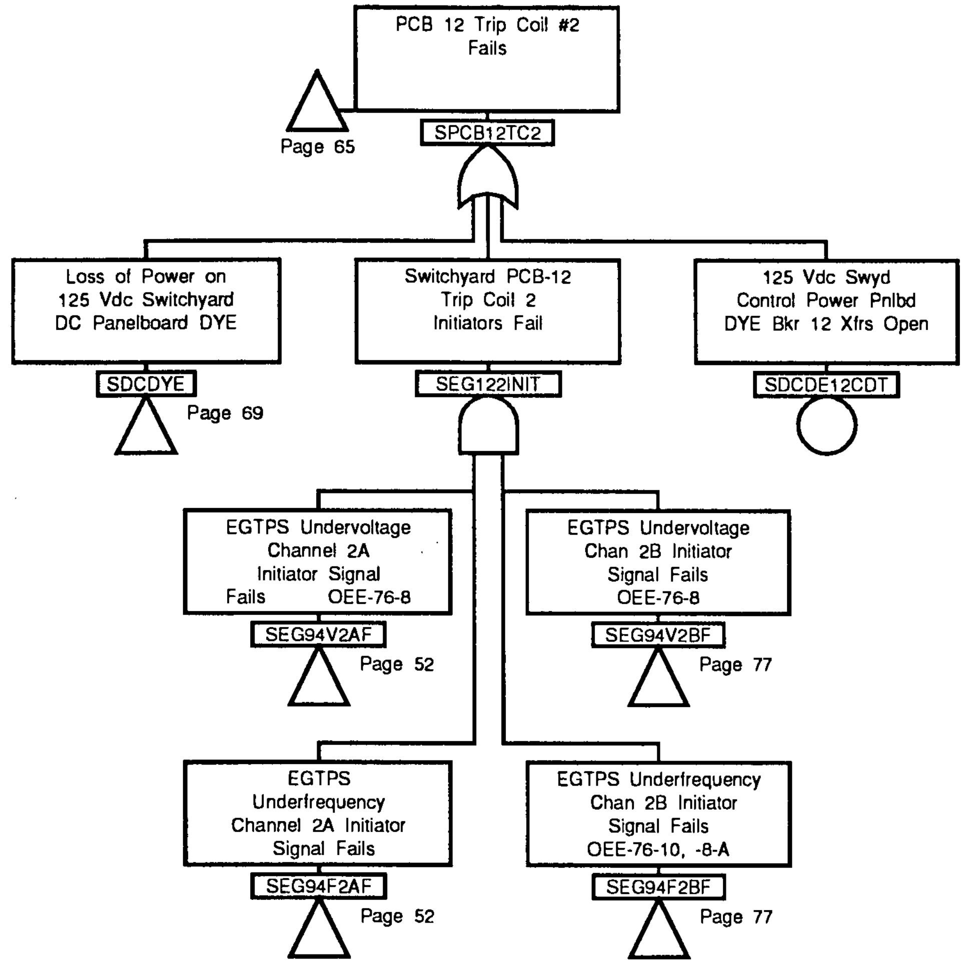
EGTPS Undervoltage Chan 2B Initiator Signal Fails OEE-76-8
SEG94V2BF
Page 73
Page 79
Page 70
EGTPS Undervoltage Channel 2 Common Components Failure
SEG94V2F
Page 64
EGTPS Undervoltage Relay 94/V2B Fails To Pick Up
LC94V2BRYD
EGTPS Underfrequency Chan 2B Initiator Signal Fails OEE-76-10, -8-A
SEG94F2BF
Page 73
Page 79
Page 70
EGTPS Underfrequency Channel 2 Common Components Failure
SEG94F2F
Page 62
EGTPS Underfrequency Relay 94/F2B Fails to Pick Up
LC94F2BRYD

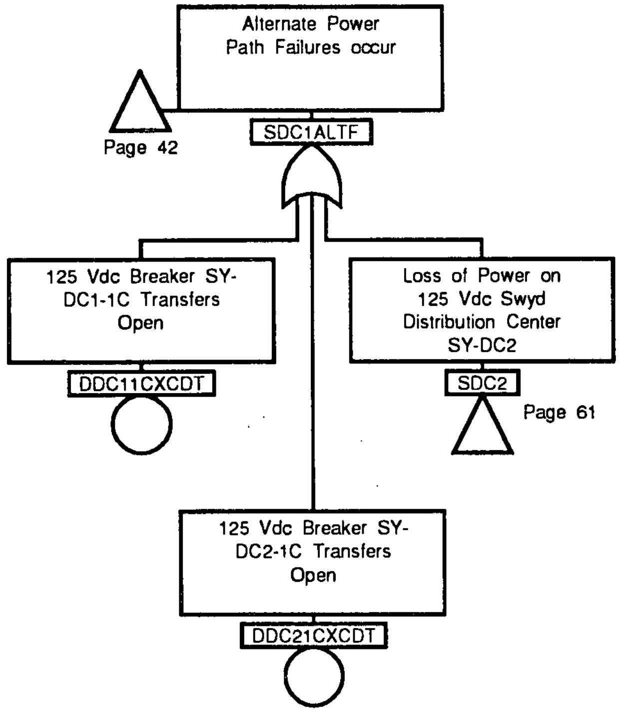

EGTPS CH2 phases x & y underfrequency sensing fails
Page 62
SEGX2Y2UF
Sensing Relay 81BL/RX2 Fails to Drop Out on Underfrequency
L81BRX2RYD
2
Yellow Bus Phase X2 Underfrequency Aux. Rly Fails to Pick Up
L81XYX2RYD
2
Sensing Relay 81BL/YX2 Fails to Drop Out on Underfrequency
L81BYX2RYD
2
Red Bus Phase Y2 Underfrequency Aux. Rly Fails to Pick Up
L81XRY2RYD
2
Sensing Relay 81BL/RY2 Fails to Drop Out on Underfrequency
L81BRY2RYD
2
Yellow Bus Phase Y2 Underfrequency Aux. Rly Fails to Pick Up
L81XYY2RYD
2
Sensing Relay 81BL/YY2 Fails to Drop Out on Underfrequency
L81BYY2RYD
2
Ch 2 Phase X Underfrequency Aux. Rly Fails to Pick Up
L81XPX2RYD
2
Red Bus Phase X2 Underfrequency Aux. Rly Fails to Pick Up
L81XRX2RYD
2
Ch 2 Phase Y Underfrequency Aux. Rly Fails to Pick Up
L81XPY2RYD
2
EGTPS CH2 phases x & z underfrequency sensing fails
Page 62
SEGX2Z2UF
Sensing Relay 81BL/RX2 Fails to Drop Out on Underfrequency
L81BRX2RYD
2
Yellow Bus Phase X2 Underfrequency Aux. Rly Fails to Pick Up
L81XYX2RYD
2
Sensing Relay 81BL/YX2 Fails to Drop Out on Underfrequency
L81BYX2RYD
2
Red Bus Phase Z2 Underfrequency Aux. Rly Fails to Pick Up
L81XRZ2RYD
2
Sensing Relay 81BL/RZ2 Fails to Drop Out on Underfrequency
L81BRZ2RYD
2
Yellow Bus Phase Z2 Underfrequency Aux. Rly Fails to Pick Up
L81XYZ2RYD
2
Sensing Relay 81BL/YZ2 Fails to Drop Out On Underfrequency
L81BYZ2RYD
2
Ch 2 Phase X Underfrequency Aux. Rly Fails to Pick Up
L81XPX2RYD
2
Red Bus Phase X2 Underfrequency Aux. Rly Fails to Pick Up
L81XRX2RYD
2
Ch 2 Phase Z Underfrequency Aux. Rly Fails to Pick up
L81XPZ2RYD
2
EGTPS CH2 phases y & z underfrequency sensing fails
Page 62
SEGY2Z2UF
Sensing Relay 81BL/RY2 Fails to Drop Out on Underfrequency
L81BRY2RYD
2
Yellow Bus Phase Y2 Underfrequency Aux. Rly Fails to Pick Up
L81XYY2RYD
2
Sensing Relay 81BL/YY2 Fails to Drop Out on Underfrequency
L81BYY2RYD
2
Red Bus Phase Z2 Underfrequency Aux. Rly Fails to Pick Up
L81XRZ2RYD
2
Sensing Relay 81BL/RZ2 Fails to Drop Out on Underfrequency
L81BRZ2RYD
2
Yellow Bus Phase Z2 Underfrequency Aux. Rly Fails to Pick Up
L81XYZ2RYD
2
Sensing Relay 81BL/YZ2 Fails to Drop Out On Underfrequency
L81BYZ2RYD
2
Ch 2 Phase Y Underfrequency Aux. Rly Fails to Pick Up
L81XPY2RYD
2
Red Bus Phase Y2 Underfrequency Aux. Rly Fails to Pick Up
L81XRY2RYD
2
Ch 2 Phase Z Underfrequency Aux. Rly Fails to Pick up
L81XPZ2RYD
2

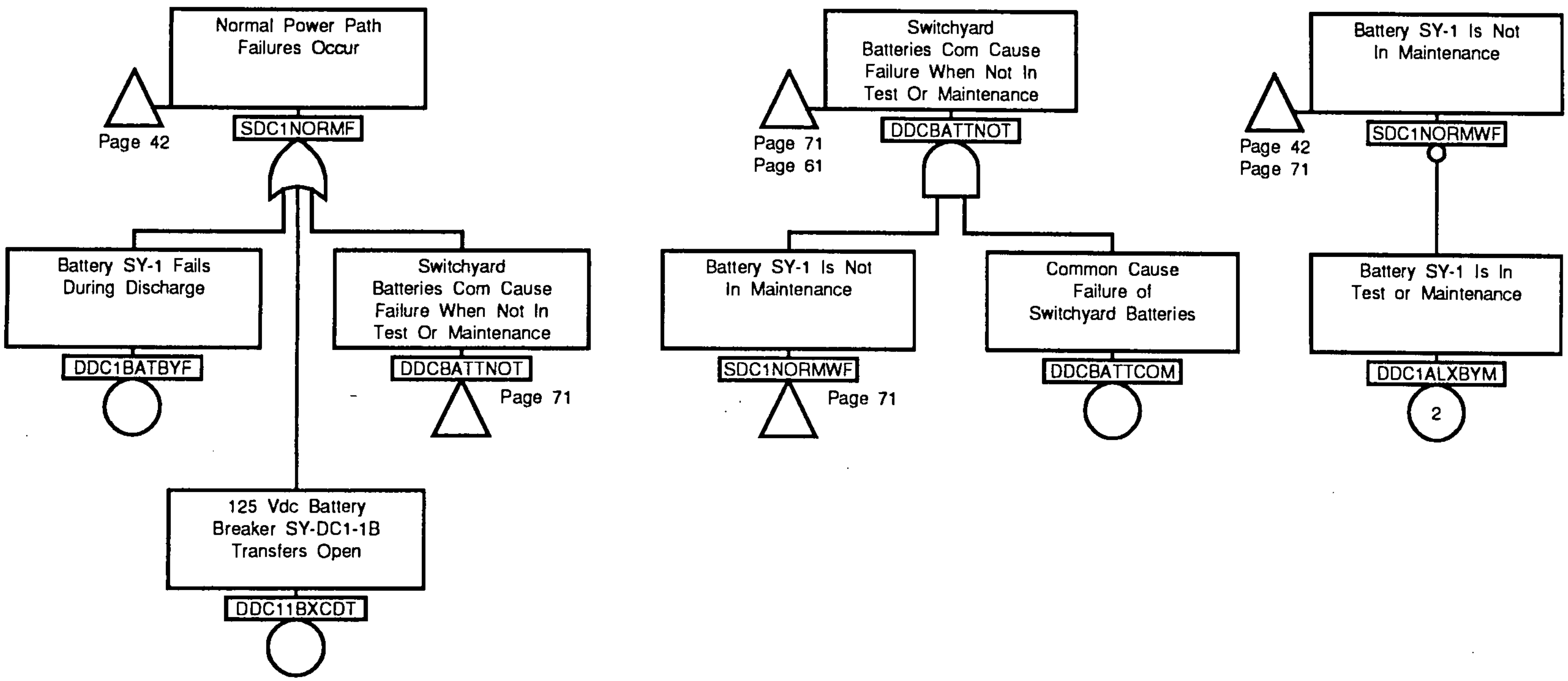

EGTPS CH2 phases x & y undervoltage sensing fails OEE-76-8
SEGX2Y2UV
Page 64
Snsng Rly 27B/RX2 Fails to Drop Out on Undervoltage OEE-76-3, -8
L27BRX2RYD
2
Yellow Bus Phase X2 Undervoltage Aux. Relay Fails To Pick Up OEE-76-8
L27XYX2RYD
2
Snsng Rly 27B/YX2 Fails to Drop Out on Undervoltage OEE-76-3, -8
L27BYX2RYD
2
Red Bus Phase Y2 Undervoltage Aux. Relay Fails to Pick Up OEE-76-8
L27XRY2RYD
2
Snsng Rly 27B/RY2 Fails to Drop Out on Undervoltage OEE-76-3, -8
L27BRY2RYD
2
Yellow Bus Phase Y2 Undervoltage Aux. Relay Fails to Pick Up OEE-76-8
L27XYY2RYD
2
Snsng Rly 27B/YY2 Fails to Drop Out on Undervoltage OEE-76-3, -8
L27BYY2RYD
2
Ch 2 Phase X UV Aux. Relay Fails To Pick Up OEE-76-8
L27XPX2RYD
2
Red Bus Phase X2 Undervoltage Aux. Relay Fails To Pick Up OEE-76-8
L27XRX2RYD
2
Ch 2 Phase Y UV Aux. Relay Fails to Pick Up OEE-76-8
L27XPY2RYD
2
EGTPS CH2 phases x & z undervoltage sensing fails OEE-76-8
SEGX2Z2UV
Page 64
Snsng Rly 27B/RX2 Fails to Drop Out on Undervoltage OEE-76-3, -8
L27BRX2RYD
2
Yellow Bus Phase X2 Undervoltage Aux. Relay Fails To Pick Up OEE-76-8
L27XYX2RYD
2
Snsng Rly 27B/YX2 Fails to Drop Out on Undervoltage OEE-76-3, -8
L27BYX2RYD
2
Red Bus Phase Z2 Undervoltage Aux. Relay Fails To Pick Up OEE-76-8
L27XRZ2RYD
2
Snsng Rly 27B/RZ2 Fails to Drop Out on Undervoltage OEE-76-3, -8
L27BRZ2RYD
2
Yellow Bus Phase Z2 Undervoltage Aux. Relay Fails to Pick Up OEE-76-8
L27XYZ2RYD
2
Snsng Rly 27B/YZ2 Fails to Drop Out on Undervoltage OEE-76-3, -8
L27BYZ2RYD
2
Ch 2 Phase X UV Aux. Relay Fails To Pick Up OEE-76-8
L27XPX2RYD
2
Red Bus Phase X2 Undervoltage Aux. Relay Fails To Pick Up OEE-76-8
L27XRX2RYD
2
Ch 2 Phase Z UV Aux. Relay Fails To Pick Up OEE-76-8
L27XPZ2RYD
2
EGTPS CH2 phases y & z undervoltage sensing fails OEE-76-8
SEGY2Z2UV
Page 64
Snsng Rly 27B/RY2 Fails to Drop Out on Undervoltage OEE-76-3, -8
L27BRY2RYD
2
Yellow Bus Phase Y2 Undervoltage Aux. Relay Fails to Pick Up OEE-76-8
L27XYY2RYD
2
Snsng Rly 27B/YY2 Fails to Drop Out on Undervoltage OEE-76-3, -8
L27BYY2RYD
2
Red Bus Phase Z2 Undervoltage Aux. Relay Fails To Pick Up OEE-76-8
L27XRZ2RYD
2
Snsng Rly 27B/RZ2 Fails to Drop Out on Undervoltage OEE-76-3, -8
L27BRZ2RYD
2
Yellow Bus Phase Z2 Undervoltage Aux. Relay Fails to Pick Up OEE-76-8
L27XYZ2RYD
2
Snsng Rly 27B/YZ2 Fails to Drop Out on Undervoltage OEE-76-3, -8
L27BYZ2RYD
2
Ch 2 Phase Y UV Aux. Relay Fails to Pick Up OEE-76-8
L27XPY2RYD
2
Red Bus Phase Y2 Undervoltage Aux. Relay Fails to Pick Up OEE-76-8
L27XRY2RYD
2
Ch 2 Phase Z UV Aux. Relay Fails To Pick Up OEE-76-8
L27XPZ2RYD
2

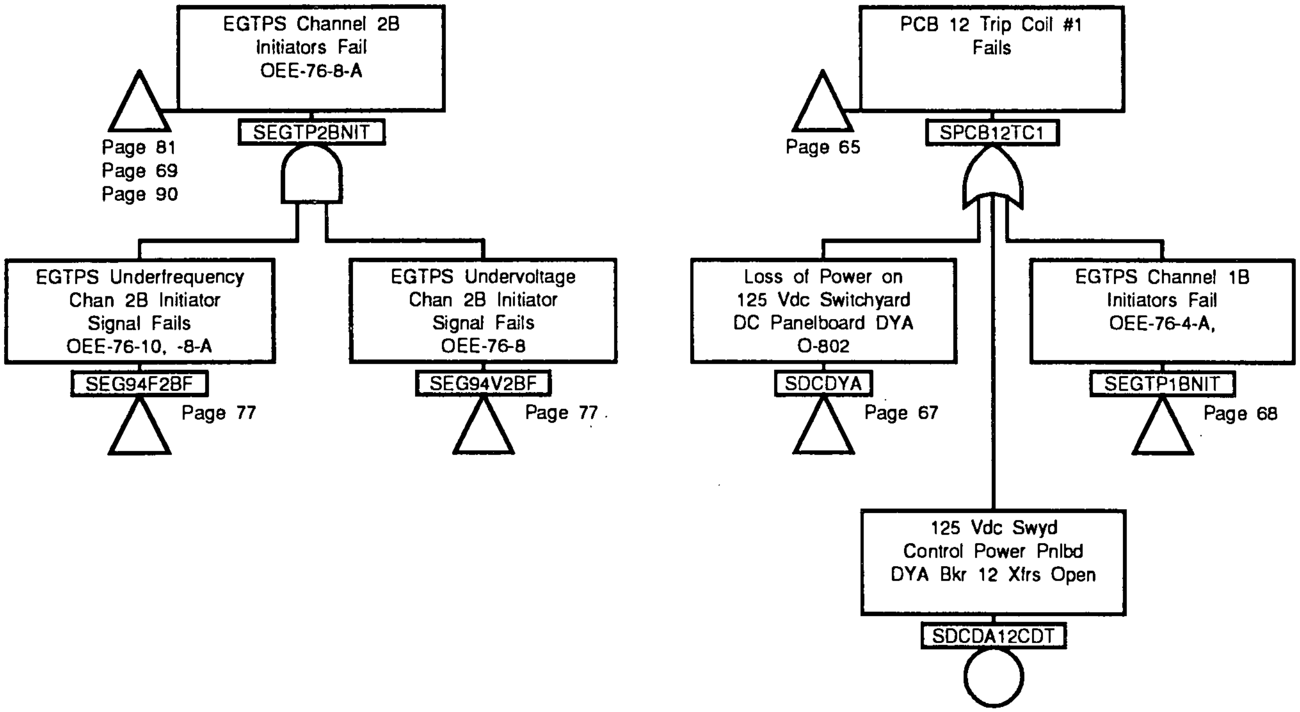


Loss of Power on
125 Vdc Switchyard
Panelboard DYG
SDCDYG
Page 82
Page 62
Page 64
125 Vdc Switchyard
DC Panelboard DYG
Is Faulted
DDCDYGXBDF
125 Vdc Breaker SY-
DC2-1DR Transfers
Open
DDC21DRCDT
Loss of Power on
125 Vdc Swyd
Distribution Center
SY-DC2
SDC2
Page 61

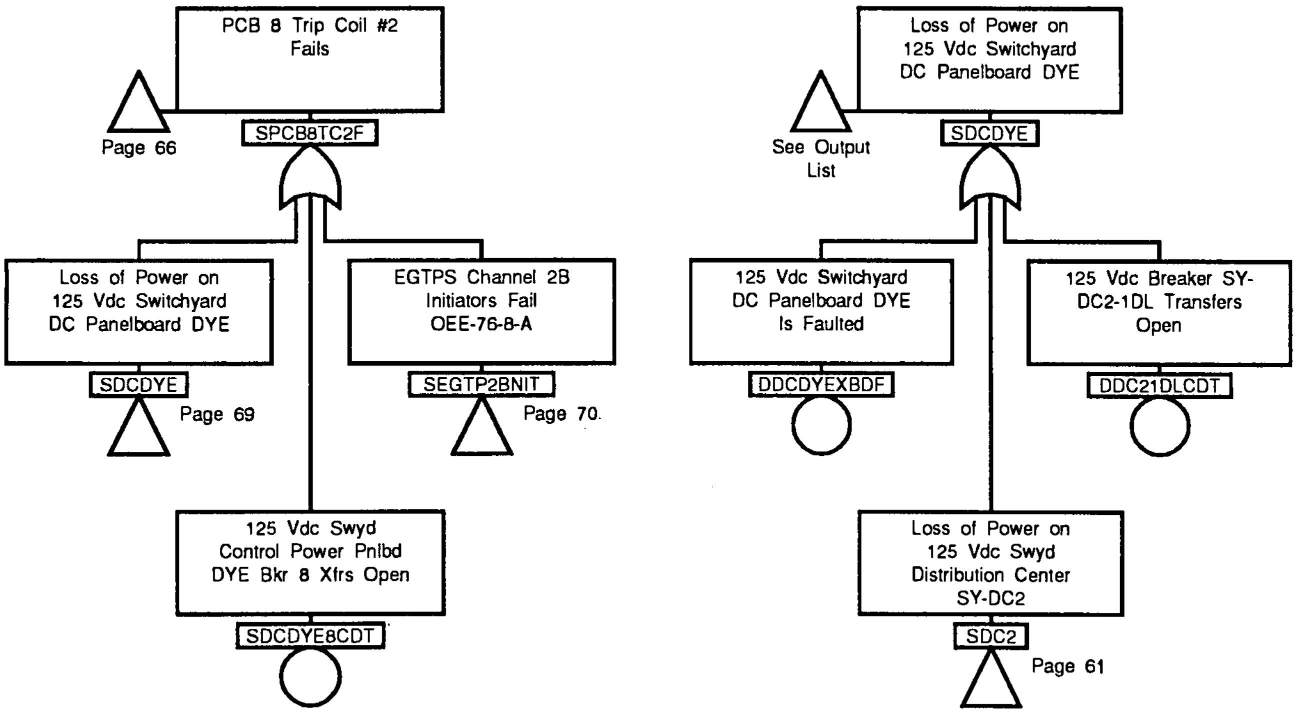

PCB 12 Trip Coil #2
Fails
Page 65
SPCB12TC2
Loss of Power on
125 Vdc Switchyard
DC Panelboard DYE
SDCDYE
Page 69
Switchyard PCB-12
Trip Coil 2
Initiators Fail
SEG122INIT
125 Vdc Swyd
Control Power Pnlbd
DYE Bkr 12 Xfrs Open
SDCDE12CDT
EGTPS Undervoltage
Channel 2A
Initiator Signal
Fails OEE-76-8
SEG94V2AF
Page 52
EGTPS Undervoltage
Chan 2B Initiator
Signal Fails
OEE-76-8
SEG94V2BF
Page 77
EGTPS
Underfrequency
Channel 2A Initiator
Signal Fails
SEG94F2AF
Page 52
EGTPS Underfrequency
Chan 2B Initiator
Signal Fails
OEE-76-10, -8-A
SEG94F2BF
Page 77

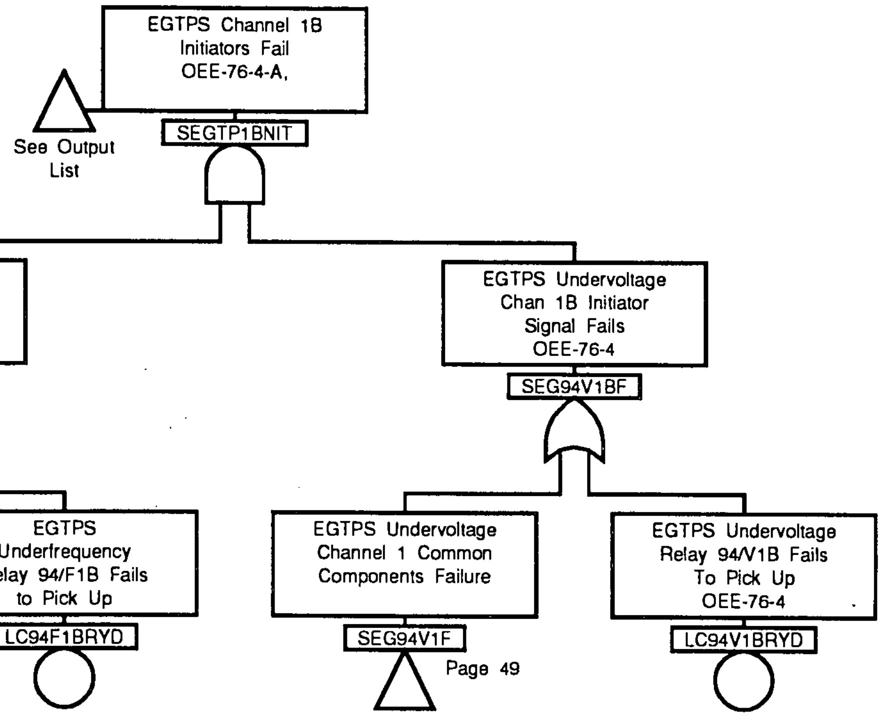

Alternate Power Path Failures occur
SDC1ALTF
Page 42
125 Vdc Breaker SY-DC1-1C Transfers Open
DDC11CXCDT
Loss of Power on 125 Vdc Swyd Distribution Center SY-DC2
SDC2
Page 61
125 Vdc Breaker SY-DC2-1C Transfers Open
DDC21CXCDT


Normal Power Path Failures Occur
SDC1NORMF
Page 42
Battery SY-1 Fails During Discharge
DDC1BATBYF
Switchyard Batteries Com Cause Failure When Not In Test Or Maintenance
DDCBATTNOT
Page 71
125 Vdc Battery Breaker SY-DC1-1B Transfers Open
DDC11BXCDT
Switchyard Batteries Com Cause Failure When Not In Test Or Maintenance
DDCBATTNOT
Page 71
Page 61
Battery SY-1 Is Not In Maintenance
SDC1NORMWF
Page 71
Common Cause Failure of Switchyard Batteries
DDCBATTCOM
Battery SY-1 Is Not In Maintenance
SDC1NORMWF
Page 42
Page 71
Battery SY-1 Is In Test or Maintenance
DDC1ALXBYM
2

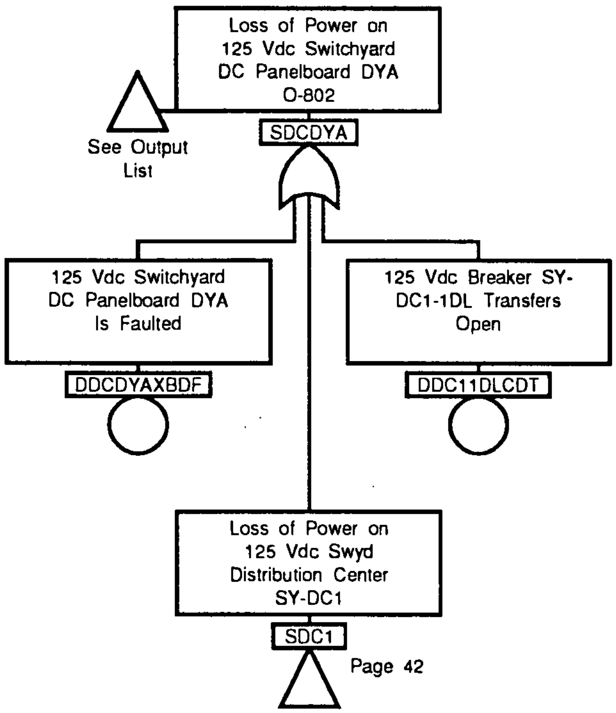

EGTPS Channel 2B Initiators Fail OEE-76-8-A
SEGTP2BNIT
Page 81
Page 69
Page 90
EGTPS Underfrequency Chan 2B Initiator Signal Fails OEE-76-10, -8-A
SEG94F2BF
Page 77
EGTPS Undervoltage Chan 2B Initiator Signal Fails OEE-76-8
SEG94V2BF
Page 77
PCB 12 Trip Coil #1 Fails
SPCB12TC1
Page 65
Loss of Power on 125 Vdc Switchyard DC Panelboard DYA O-802
SDCDYA
Page 67
EGTPS Channel 1B Initiators Fail OEE-76-4-A,
SEGTP1BNIT
Page 68
125 Vdc Swyd Control Power Pnlbd DYA Bkr 12 Xfrs Open
SDCDA12CDT

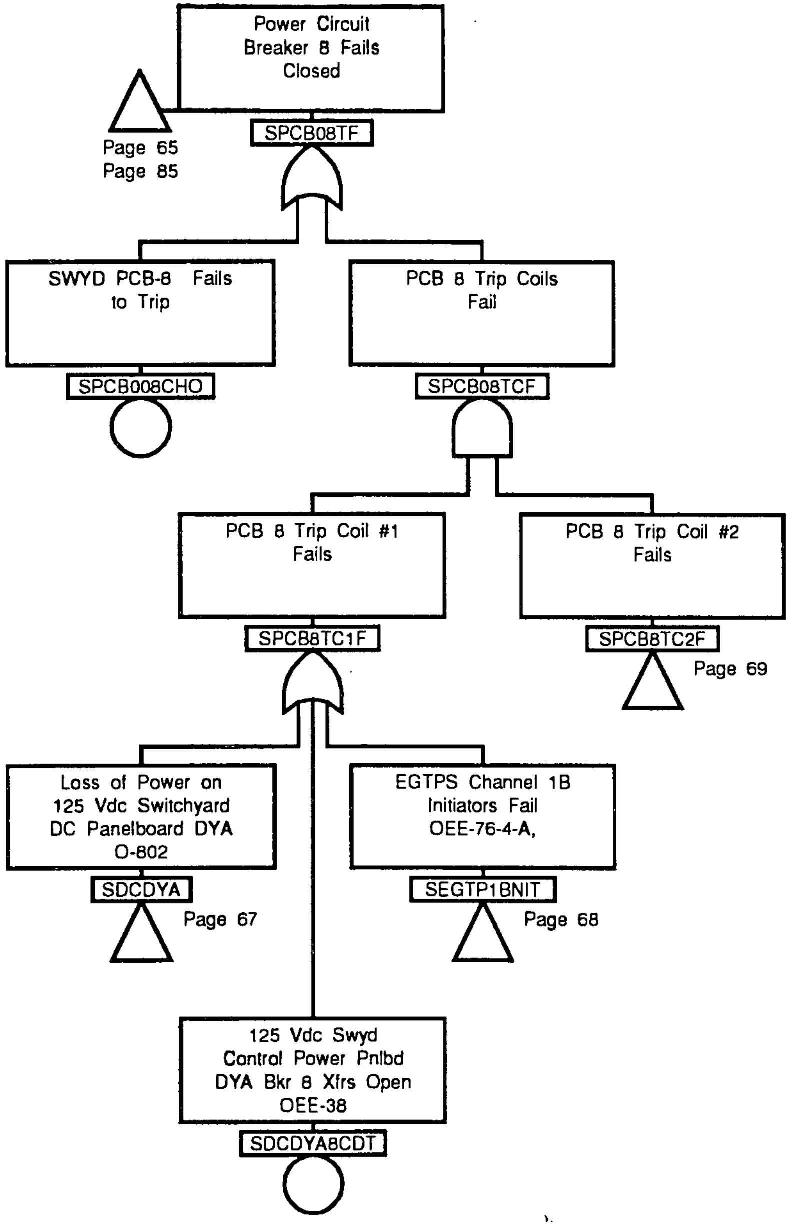
SDCDYE Outputs:
Page 73, Page 78, Page 81, Page 69, Page 90, Page 83

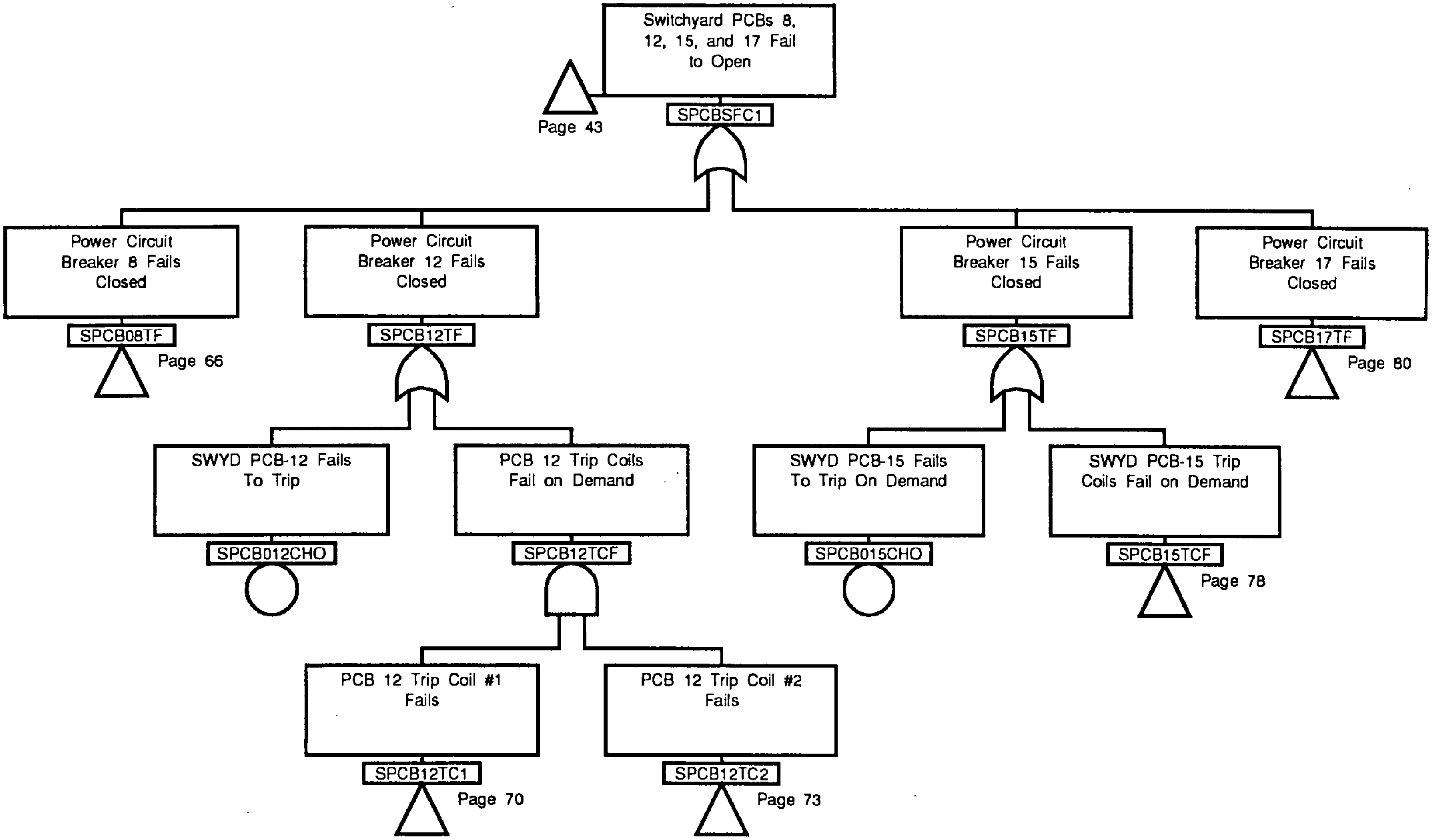


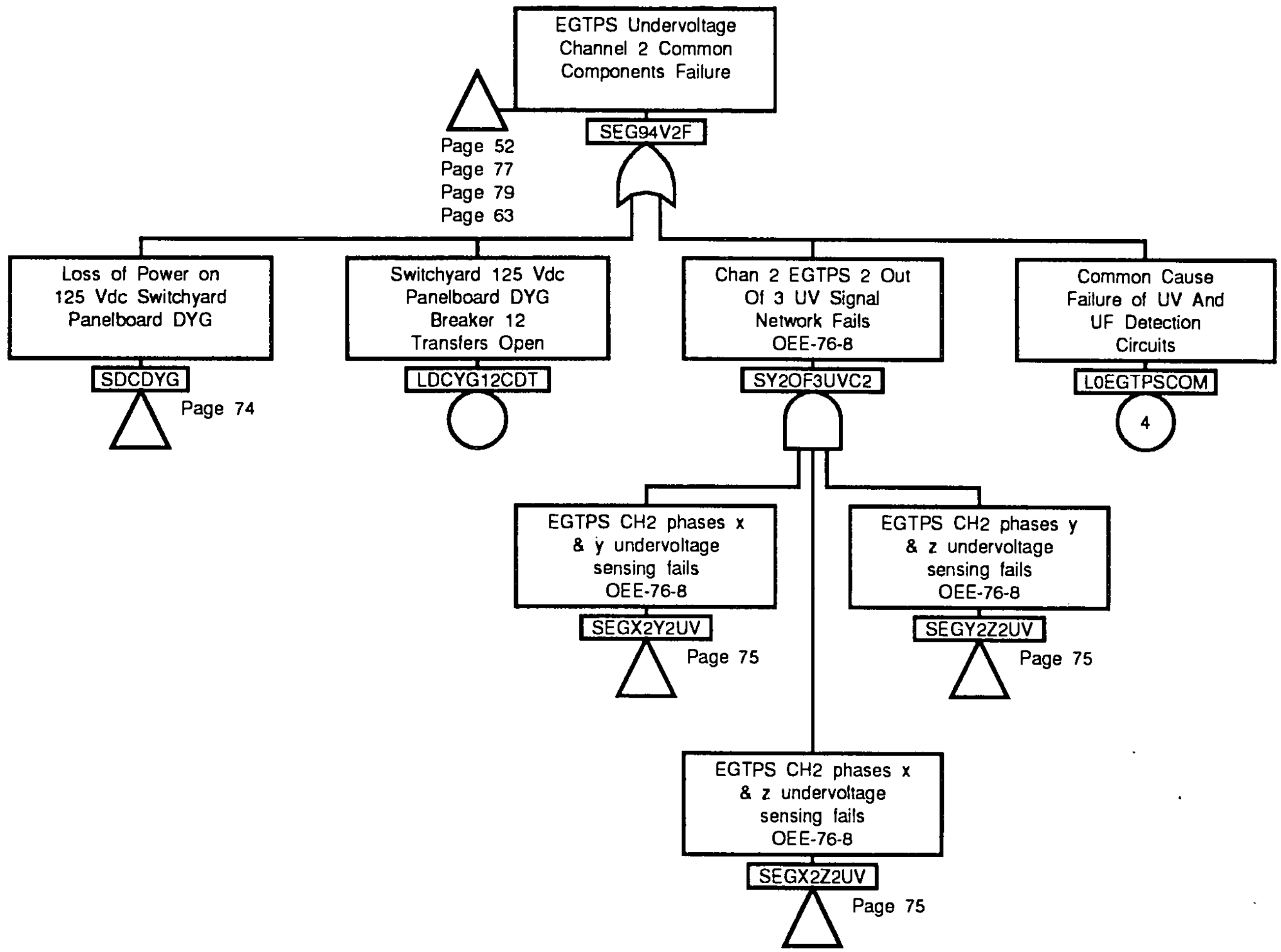

EGTPS Channel 1B Initiators Fail OEE-76-4-A,
SEGTP1BNIT
See Output List
EGTPS Underfrequency Chan 1B Initiator Signal Fails OEE-76-4-A, -6
SEG94F1BF
EGTPS Undervoltage Chan 1B Initiator Signal Fails OEE-76-4
SEG94V1BF
EGTPS Underfrequency Channel 1 Common Components Failure
SEG94F1F
Page 47
EGTPS Underfrequency Relay 94/F1B Fails to Pick Up
LC94F1BRYD
EGTPS Undervoltage Channel 1 Common Components Failure
SEG94V1F
Page 49
EGTPS Undervoltage Relay 94/V1B Fails To Pick Up OEE-76-4
LC94V1BRYD

SDCDYA Outputs:
Page 70, Page 78, Page 80, Page 66, Page 89, Page 83

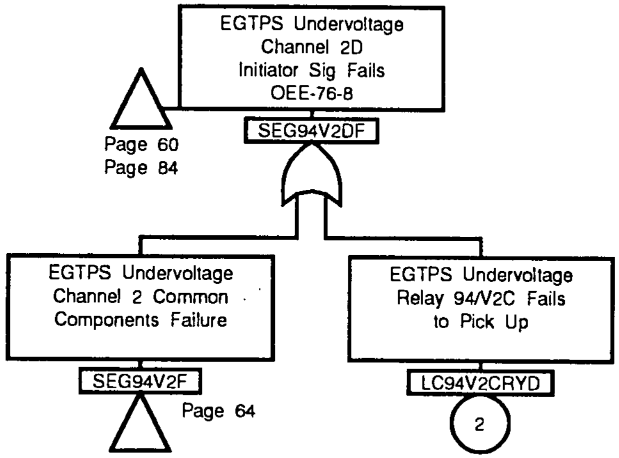


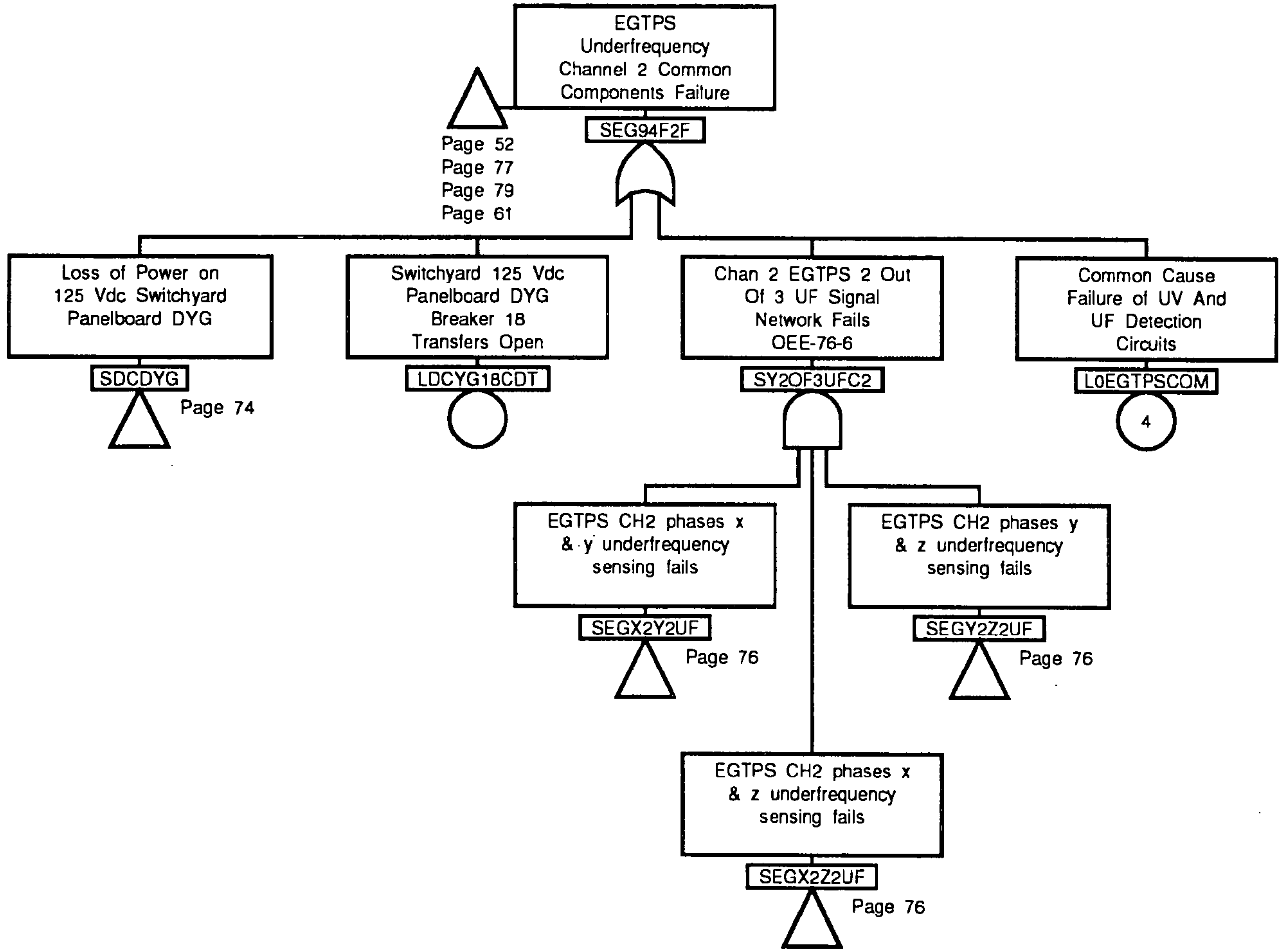

Power Circuit Breaker 8 Fails Closed
SPCB08TF
Page 65
Page 85
SWYD PCB-8 Fails to Trip
SPCB008CHO
PCB 8 Trip Coils Fail
SPCB08TCF
PCB 8 Trip Coil #1 Fails
SPCB8TC1F
PCB 8 Trip Coil #2 Fails
SPCB8TC2F
Page 69
Loss of Power on 125 Vdc Switchyard DC Panelboard DYA O-802
SDCDYA
Page 67
EGTPS Channel 1B Initiators Fail OEE-76-4-A,
SEGTP1BNIT
Page 68
125 Vdc Swyd Control Power Pnlbd DYA Bkr 8 Xfrs Open OEE-38
SDCDYA8CDT


Switchyard PCBs 8, 12, 15, and 17 Fail to Open
SPCBSFC1
Page 43
Power Circuit Breaker 8 Fails Closed
SPCB08TF
Page 66
Power Circuit Breaker 12 Fails Closed
SPCB12TF
Power Circuit Breaker 15 Fails Closed
SPCB15TF
Power Circuit Breaker 17 Fails Closed
SPCB17TF
Page 80
SWYD PCB-12 Fails To Trip
SPCB012CHO
PCB 12 Trip Coils Fail on Demand
SPCB12TCF
SWYD PCB-15 Fails To Trip On Demand
SPCB015CHO
SWYD PCB-15 Trip Coils Fail on Demand
SPCB15TCF
Page 78
PCB 12 Trip Coil #1 Fails
SPCB12TC1
Page 70
PCB 12 Trip Coil #2 Fails
SPCB12TC2
Page 73

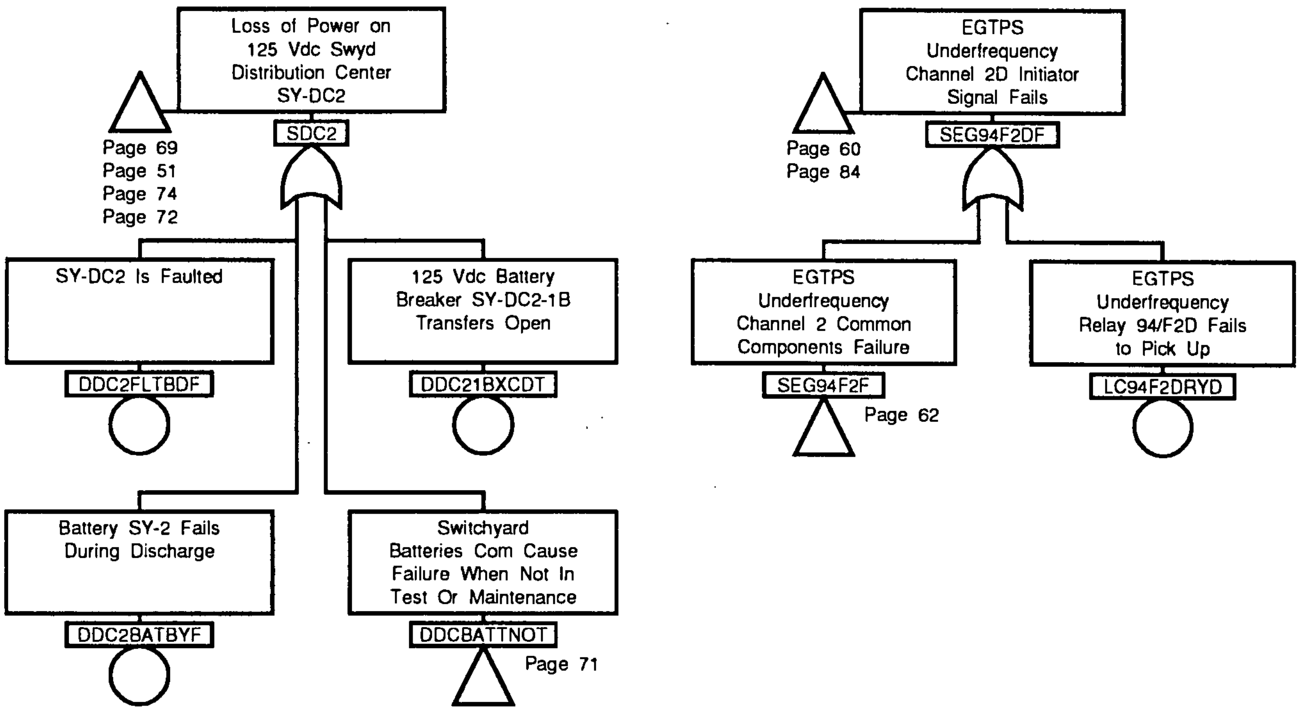


EGTPS Undervoltage Channel 2 Common Components Failure
SEG94V2F
Page 52
Page 77
Page 79
Page 63
Loss of Power on 125 Vdc Switchyard Panelboard DYG
SDCDYG
Page 74
Switchyard 125 Vdc Panelboard DYG Breaker 12 Transfers Open
LDCYG12CDT
Chan 2 EGTPS 2 Out Of 3 UV Signal Network Fails OEE-76-8
SY2OF3UVC2
Common Cause Failure of UV And UF Detection Circuits
L0EGTPSCOM
4
EGTPS CH2 phases x & y undervoltage sensing fails OEE-76-8
SEGX2Y2UV
Page 75
EGTPS CH2 phases y & z undervoltage sensing fails OEE-76-8
SEGY2Z2UV
Page 75
EGTPS CH2 phases x & z undervoltage sensing fails OEE-76-8
SEGX2Z2UV
Page 75

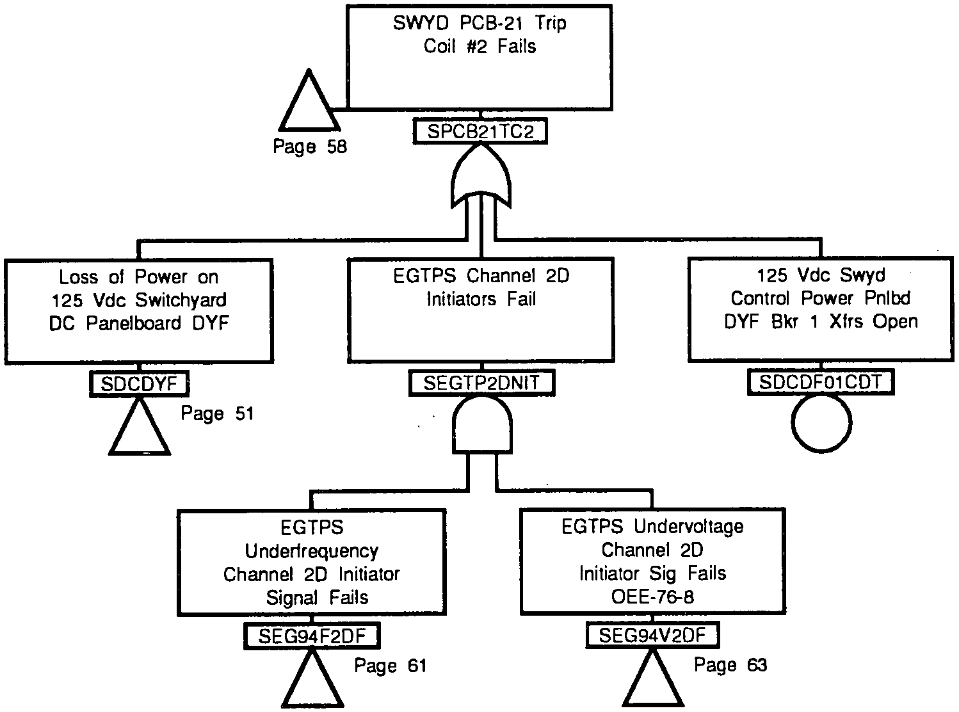

EGTPS Undervoltage
Channel 2D
Initiator Sig Fails
OEE-76-8
SEG94V2DF
Page 60
Page 84
EGTPS Undervoltage
Channel 2 Common
Components Failure
SEG94V2F
Page 64
EGTPS Undervoltage
Relay 94/V2C Fails
to Pick Up
LC94V2CRYD
2

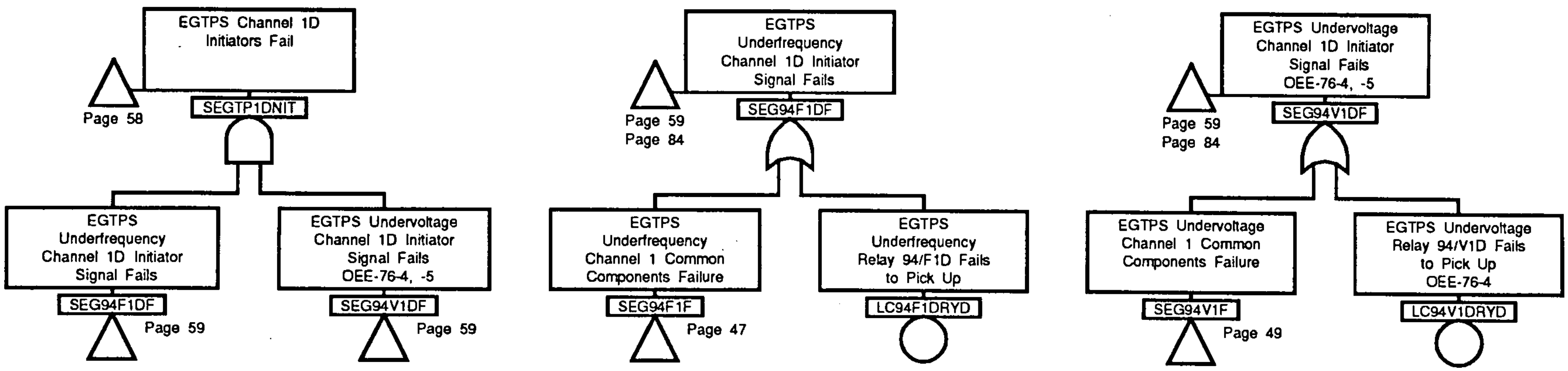


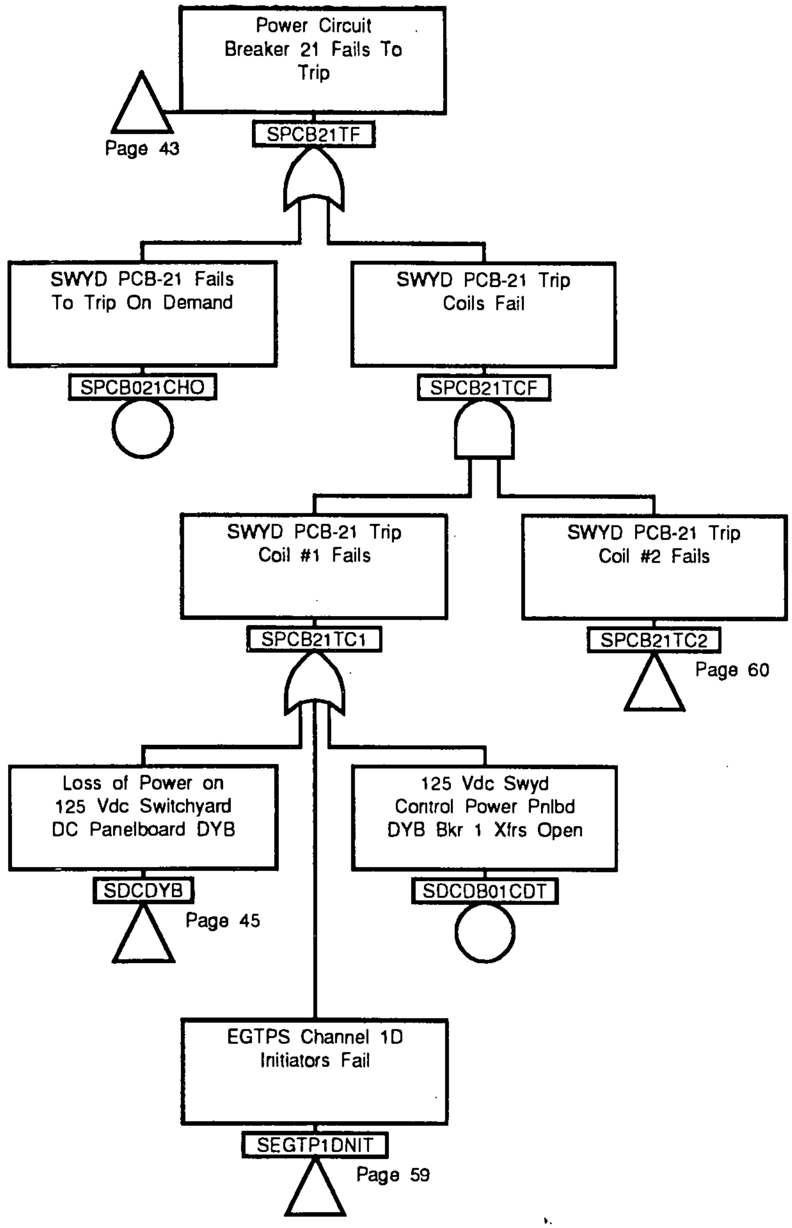
EGTPS
Underfrequency
Channel 2 Common
Components Failure
SEG94F2F
Page 52
Page 77
Page 79
Page 61
Loss of Power on
125 Vdc Switchyard
Panelboard DYG
SDCDYG
Page 74
Switchyard 125 Vdc
Panelboard DYG
Breaker 18
Transfers Open
LDCYG18CDT
Chan 2 EGTPS 2 Out
Of 3 UF Signal
Network Fails
OEE-76-6
SY2OF3UFC2
Common Cause
Failure of UV And
UF Detection
Circuits
L0EGTPSCOM
4
EGTPS CH2 phases x
& y underfrequency
sensing fails
SEGX2Y2UF
Page 76
EGTPS CH2 phases y
& z underfrequency
sensing fails
SEGY2Z2UF
Page 76
EGTPS CH2 phases x
& z underfrequency
sensing fails
SEGX2Z2UF
Page 76

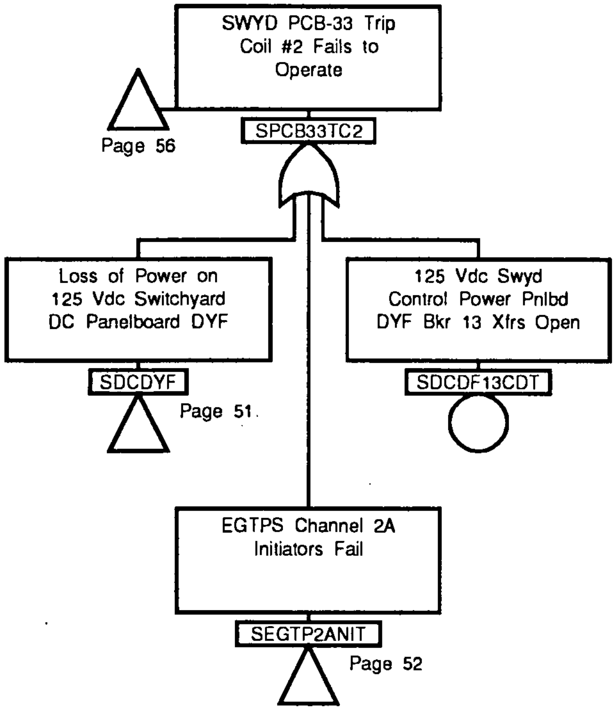


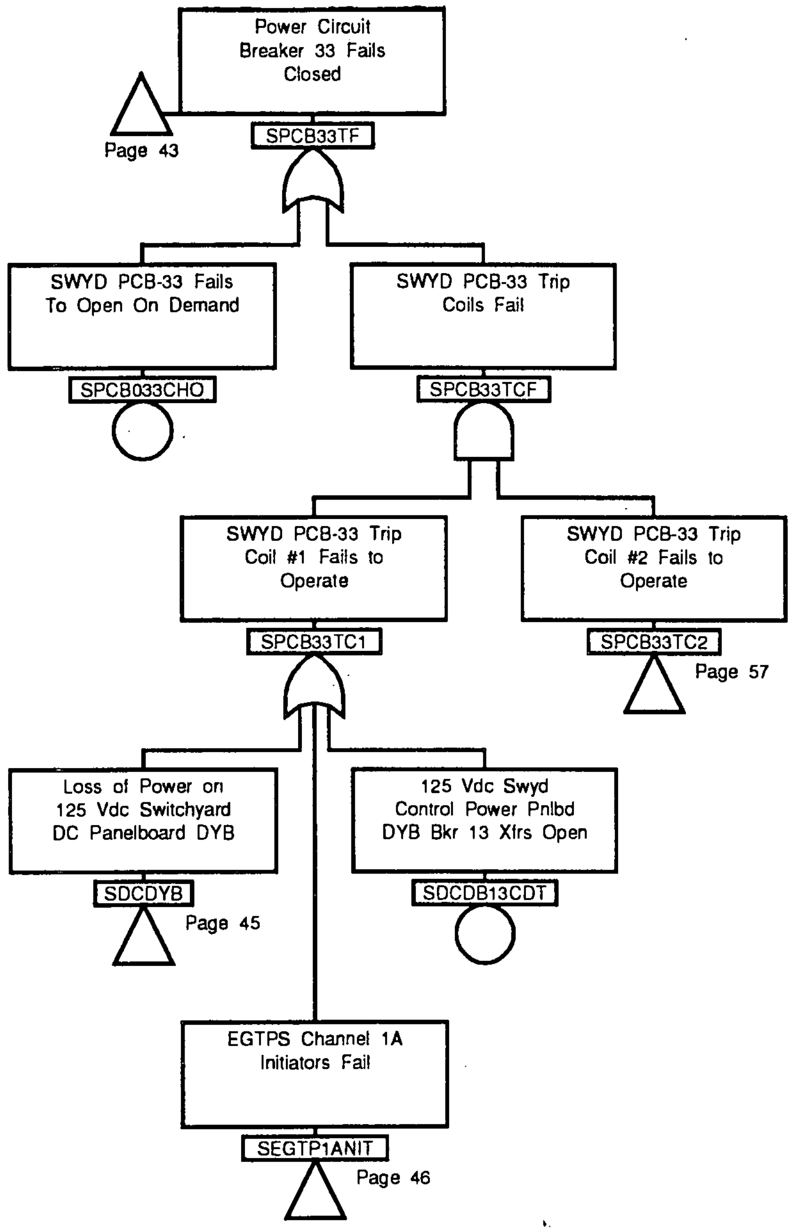
Loss of Power on 125 Vdc Swyd Distribution Center SY-DC2
SDC2
Page 69
Page 51
Page 74
Page 72
SY-DC2 Is Faulted
DDC2FLTBDF
125 Vdc Battery Breaker SY-DC2-1B Transfers Open
DDC21BXCDT
Battery SY-2 Fails During Discharge
DDC2BATBYF
Switchyard Batteries Com Cause Failure When Not In Test Or Maintenance
DDCBATTNOT
Page 71
EGTPS Underfrequency Channel 2D Initiator Signal Fails
SEG94F2DF
Page 60
Page 84
EGTPS Underfrequency Channel 2 Common Components Failure
SEG94F2F
Page 62
EGTPS Underfrequency Relay 94/F2D Fails to Pick Up
LC94F2DRYD

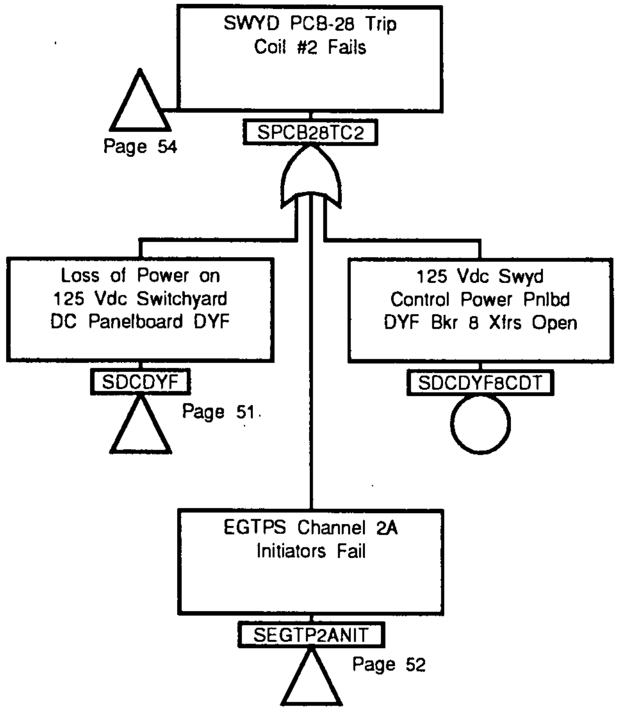

SWYD PCB-21 Trip
Coil #2 Fails
SPCB21TC2
Page 58
Loss of Power on
125 Vdc Switchyard
DC Panelboard DYF
SDCDYF
Page 51
EGTPS Channel 2D
Initiators Fail
SEGTP2DNIT
125 Vdc Swyd
Control Power Pnlbd
DYF Bkr 1 Xfrs Open
SDCDF01CDT
EGTPS
Underfrequency
Channel 2D Initiator
Signal Fails
SEG94F2DF
Page 61
EGTPS Undervoltage
Channel 2D
Initiator Sig Fails
OEE-76-8
SEG94V2DF
Page 63

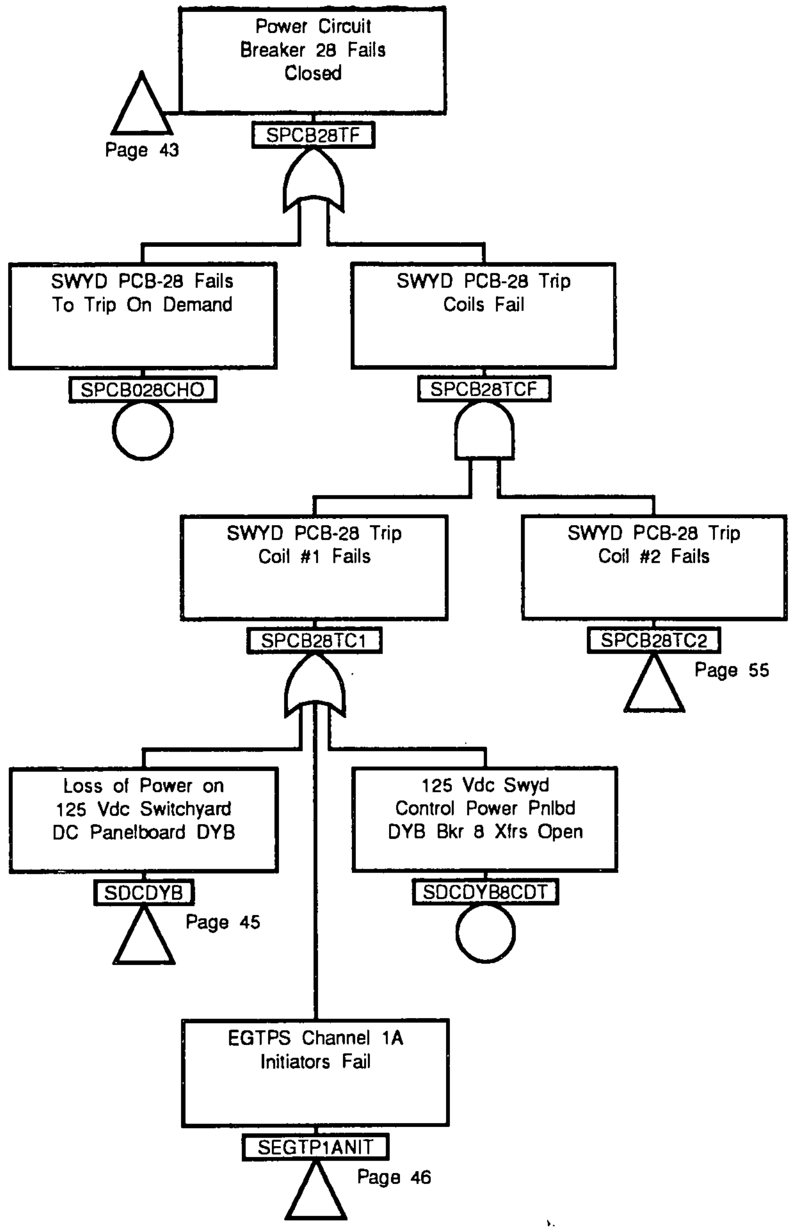

EGTPS Channel 1D Initiators Fail
SEGTP1DNIT
Page 58
EGTPS Underfrequency Channel 1D Initiator Signal Fails
SEG94F1DF
Page 59
EGTPS Undervoltage Channel 1D Initiator Signal Fails OEE-76-4, -5
SEG94V1DF
Page 59
EGTPS Underfrequency Channel 1D Initiator Signal Fails
SEG94F1DF
Page 59
Page 84
EGTPS Underfrequency Channel 1 Common Components Failure
SEG94F1F
Page 47
EGTPS Underfrequency Relay 94/F1D Fails to Pick Up
LC94F1DRYD
EGTPS Undervoltage Channel 1D Initiator Signal Fails OEE-76-4, -5
SEG94V1DF
Page 59
Page 84
EGTPS Undervoltage Channel 1 Common Components Failure
SEG94V1F
Page 49
EGTPS Undervoltage Relay 94/V1D Fails to Pick Up OEE-76-4
LC94V1DRYD


Power Circuit Breaker 21 Fails To Trip
SPCB21TF
Page 43
SWYD PCB-21 Fails To Trip On Demand
SPCB021CHO
SWYD PCB-21 Trip Coils Fail
SPCB21TCF
SWYD PCB-21 Trip Coil #1 Fails
SPCB21TC1
SWYD PCB-21 Trip Coil #2 Fails
SPCB21TC2
Page 60
Loss of Power on 125 Vdc Switchyard DC Panelboard DYB
SDCDYB
Page 45
125 Vdc Swyd Control Power Pnlbd DYB Bkr 1 Xfrs Open
SDCDB01CDT
EGTPS Channel 1D Initiators Fail
SEGTP1DNIT
Page 59

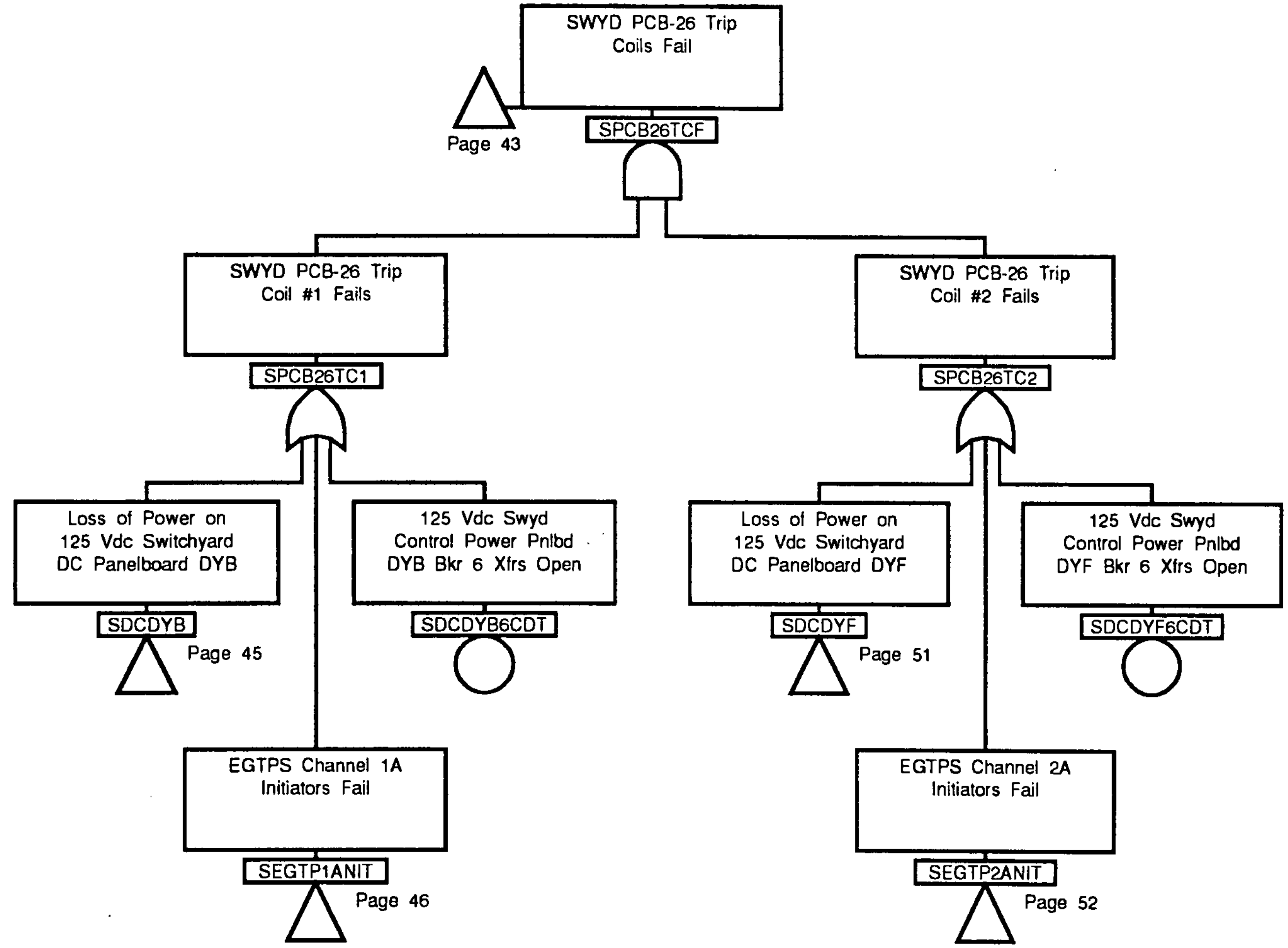

SWYD PCB-33 Trip
Coil #2 Fails to
Operate
SPCB33TC2
Page 56
Loss of Power on
125 Vdc Switchyard
DC Panelboard DYF
SDCDYF
Page 51
125 Vdc Swyd
Control Power Pnlbd
DYF Bkr 13 Xfrs Open
SDCDF13CDT
EGTPS Channel 2A
Initiators Fail
SEGTP2ANIT
Page 52

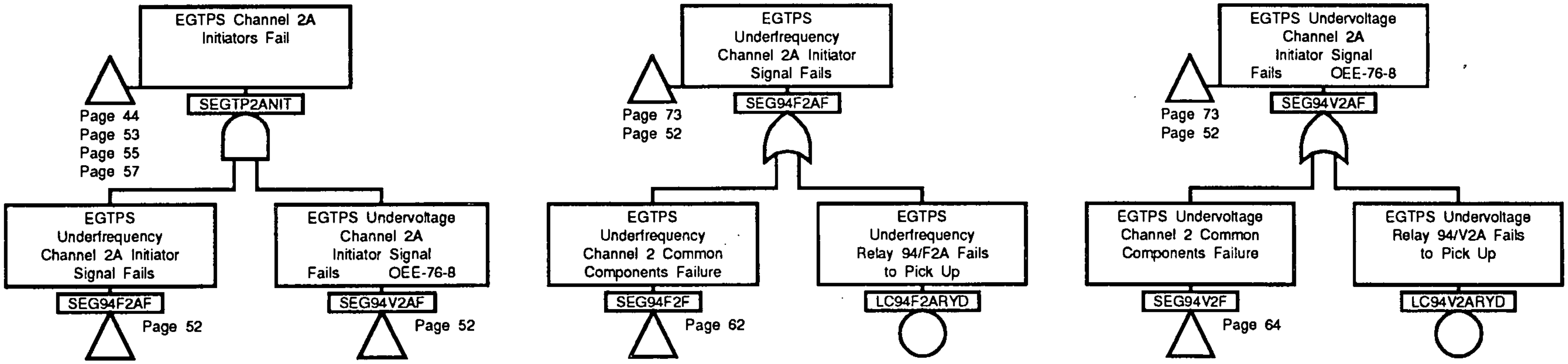

Power Circuit Breaker 33 Fails Closed
SPCB33TF
Page 43
SWYD PCB-33 Fails To Open On Demand
SPCB033CHO
SWYD PCB-33 Trip Coils Fail
SPCB33TCF
SWYD PCB-33 Trip Coil #1 Fails to Operate
SPCB33TC1
SWYD PCB-33 Trip Coil #2 Fails to Operate
SPCB33TC2
Page 57
Loss of Power on 125 Vdc Switchyard DC Panelboard DYB
SDCDYB
Page 45
125 Vdc Swyd Control Power Pnlbd DYB Bkr 13 Xfrs Open
SDCDB13CDT
EGTPS Channel 1A Initiators Fail
SEGTP1ANIT
Page 46


SWYD PCB-28 Trip Coil #2 Fails
SPCB28TC2
Page 54
Loss of Power on 125 Vdc Switchyard DC Panelboard DYF
SDCDYF
Page 51
125 Vdc Swyd Control Power Pnlbd DYF Bkr 8 Xfrs Open
SDCDYF8CDT
EGTPS Channel 2A Initiators Fail
SEGTP2ANIT
Page 52



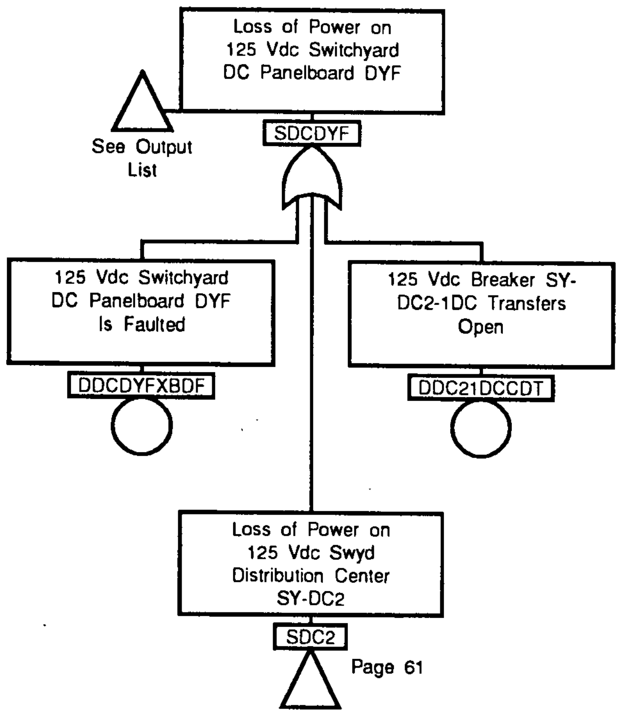
Power Circuit Breaker 28 Fails Closed
SPCB28TF
Page 43
SWYD PCB-28 Fails To Trip On Demand
SPCB028CHO
SWYD PCB-28 Trip Coils Fail
SPCB28TCF
SWYD PCB-28 Trip Coil #1 Fails
SPCB28TC1
SWYD PCB-28 Trip Coil #2 Fails
SPCB28TC2
Page 55
Loss of Power on 125 Vdc Switchyard DC Panelboard DYB
SDCDYB
Page 45
125 Vdc Swyd Control Power Pnlbd DYB Bkr 8 Xfrs Open
SDCDYB8CDT
EGTPS Channel 1A Initiators Fail
SEGTP1ANIT
Page 46

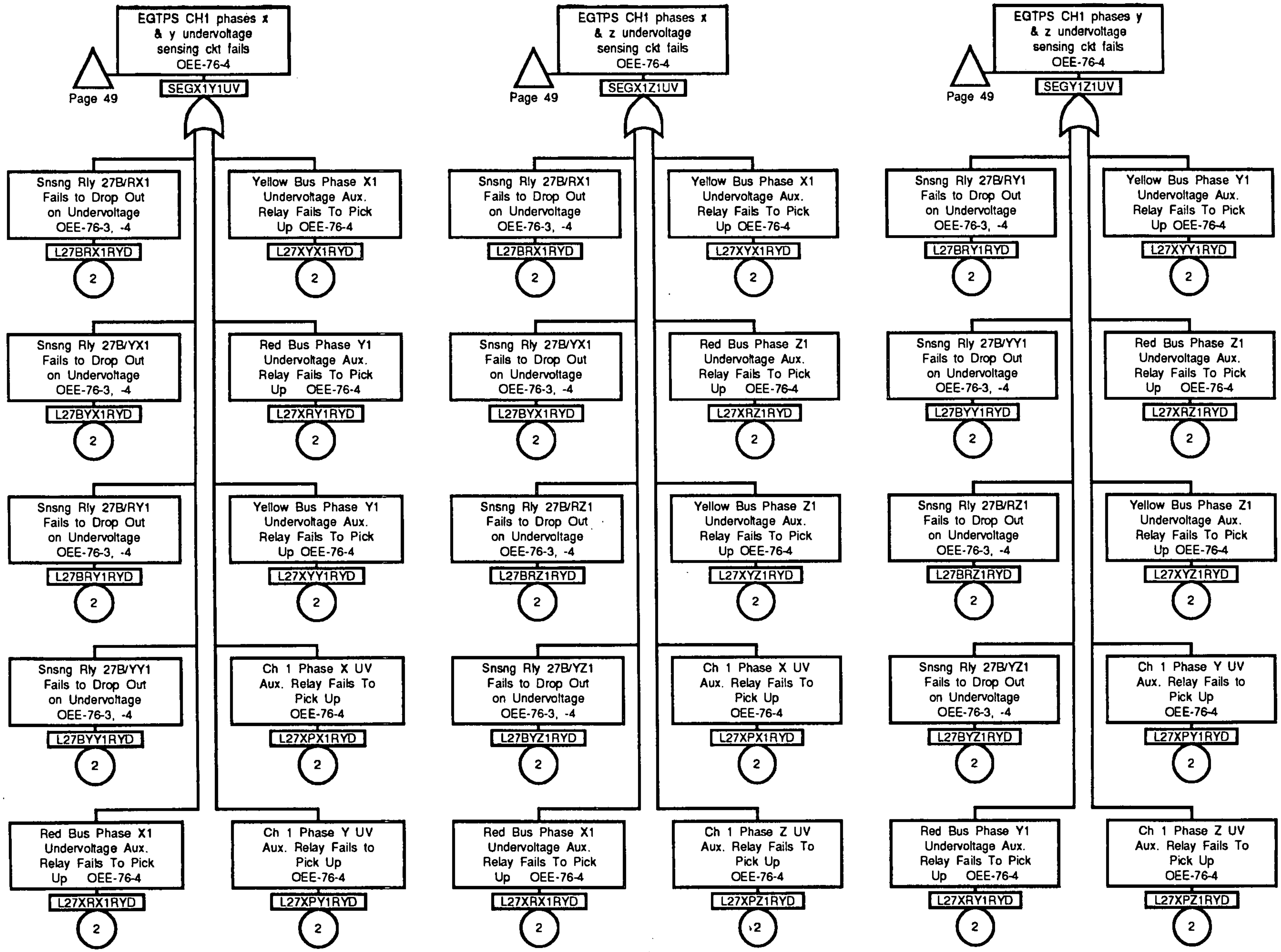

SWYD PCB-26 Trip Coils Fail
SPCB26TCF
Page 43
SWYD PCB-26 Trip Coil #1 Fails
SPCB26TC1
SWYD PCB-26 Trip Coil #2 Fails
SPCB26TC2
Loss of Power on 125 Vdc Switchyard DC Panelboard DYB
SDCDYB
Page 45
125 Vdc Swyd Control Power Pnlbd DYB Bkr 6 Xfrs Open
SDCDYB6CDT
Loss of Power on 125 Vdc Switchyard DC Panelboard DYF
SDCDYF
Page 51
125 Vdc Swyd Control Power Pnlbd DYF Bkr 6 Xfrs Open
SDCDYF6CDT
EGTPS Channel 1A Initiators Fail
SEGTP1ANIT
Page 46
EGTPS Channel 2A Initiators Fail
SEGTP2ANIT
Page 52



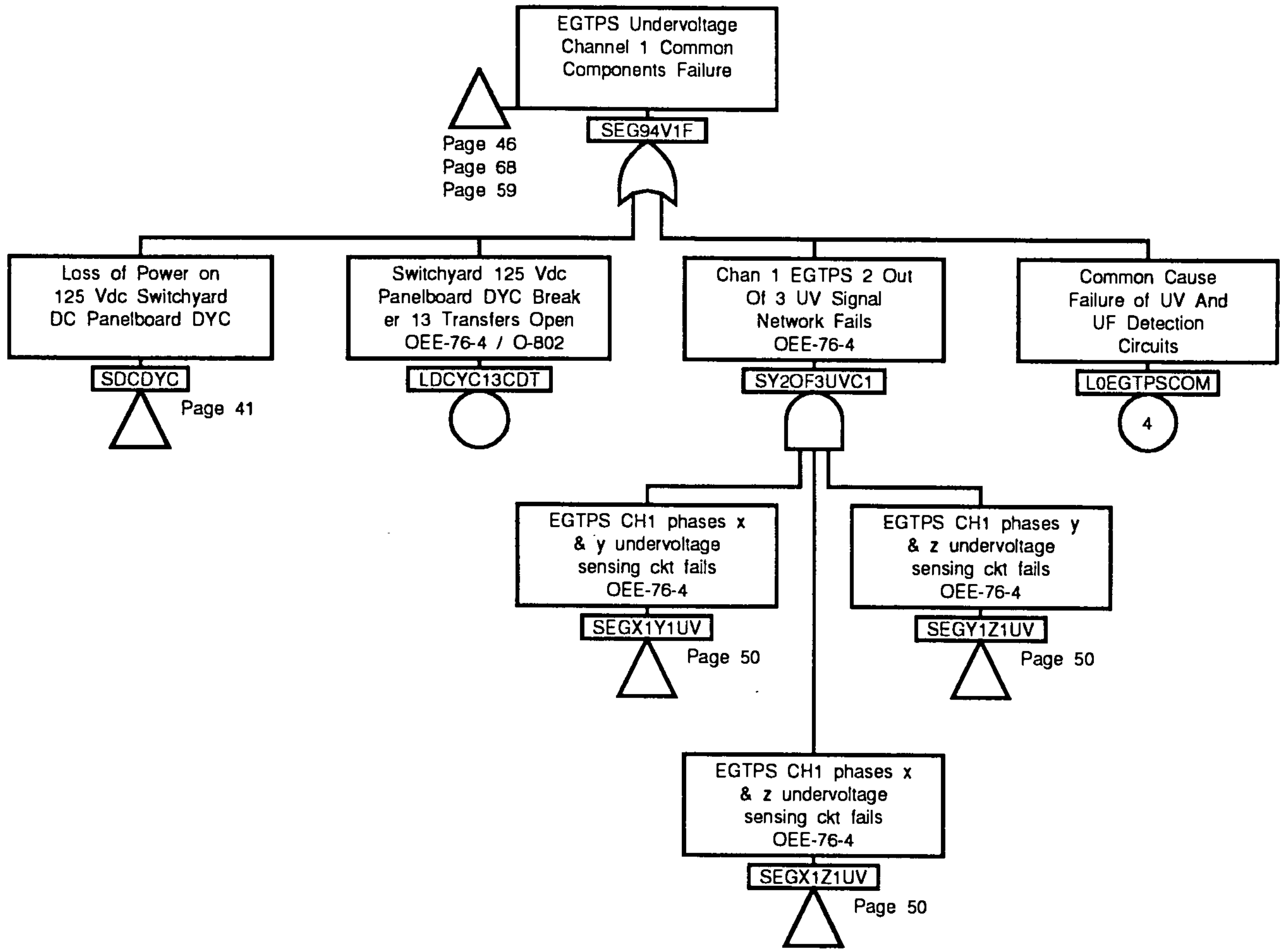
EGTPS Channel 2A Initiators Fail
Page 44
Page 53
Page 55
Page 57
SEGTP2ANIT
EGTPS Underfrequency Channel 2A Initiator Signal Fails
SEG94F2AF
Page 52
EGTPS Undervoltage Channel 2A Initiator Signal Fails OEE-76-8
SEG94V2AF
Page 52
EGTPS Underfrequency Channel 2A Initiator Signal Fails
Page 73
Page 52
SEG94F2AF
EGTPS Underfrequency Channel 2 Common Components Failure
SEG94F2F
Page 62
EGTPS Underfrequency Relay 94/F2A Fails to Pick Up
LC94F2ARYD
EGTPS Undervoltage Channel 2A Initiator Signal Fails OEE-76-8
Page 73
Page 52
SEG94V2AF
EGTPS Undervoltage Channel 2 Common Components Failure
SEG94V2F
Page 64
EGTPS Undervoltage Relay 94/V2A Fails to Pick Up
LC94V2ARYD

SDCDYF Outputs:
Page 60, Page 44, Page 53, Page 55, Page 57

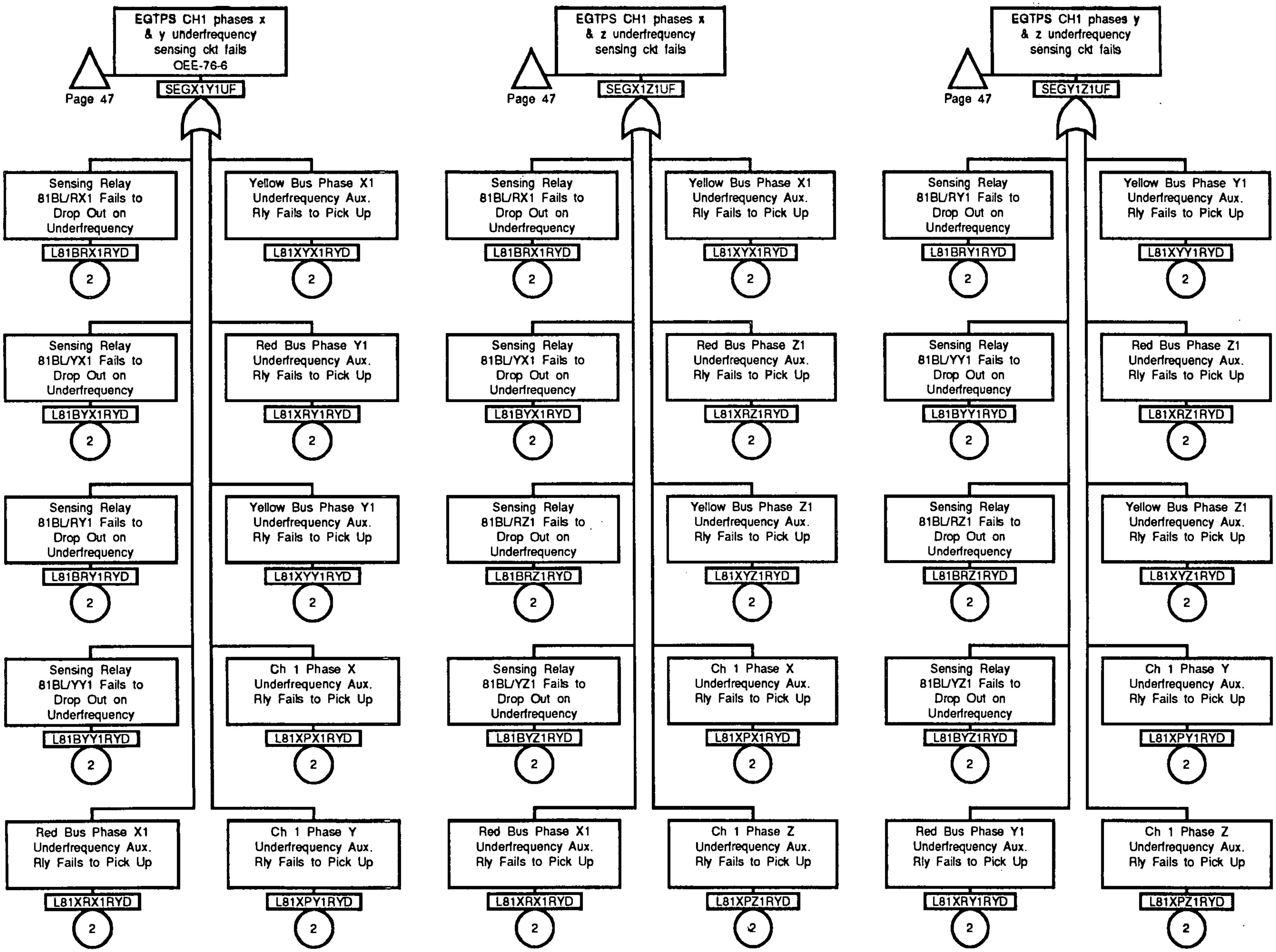




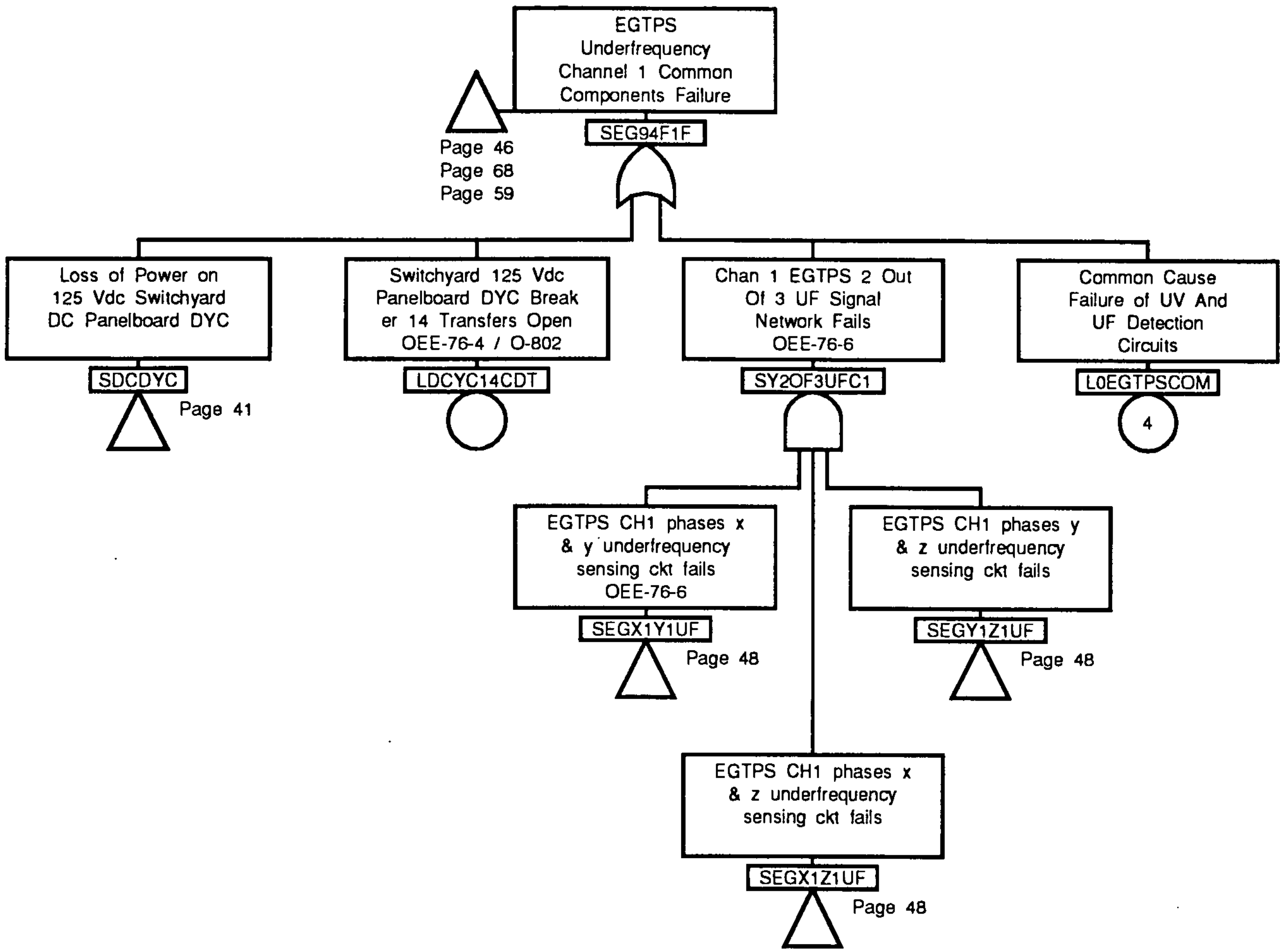
ONS-Keowee AC Power Integrated Model | FIGURE G-1

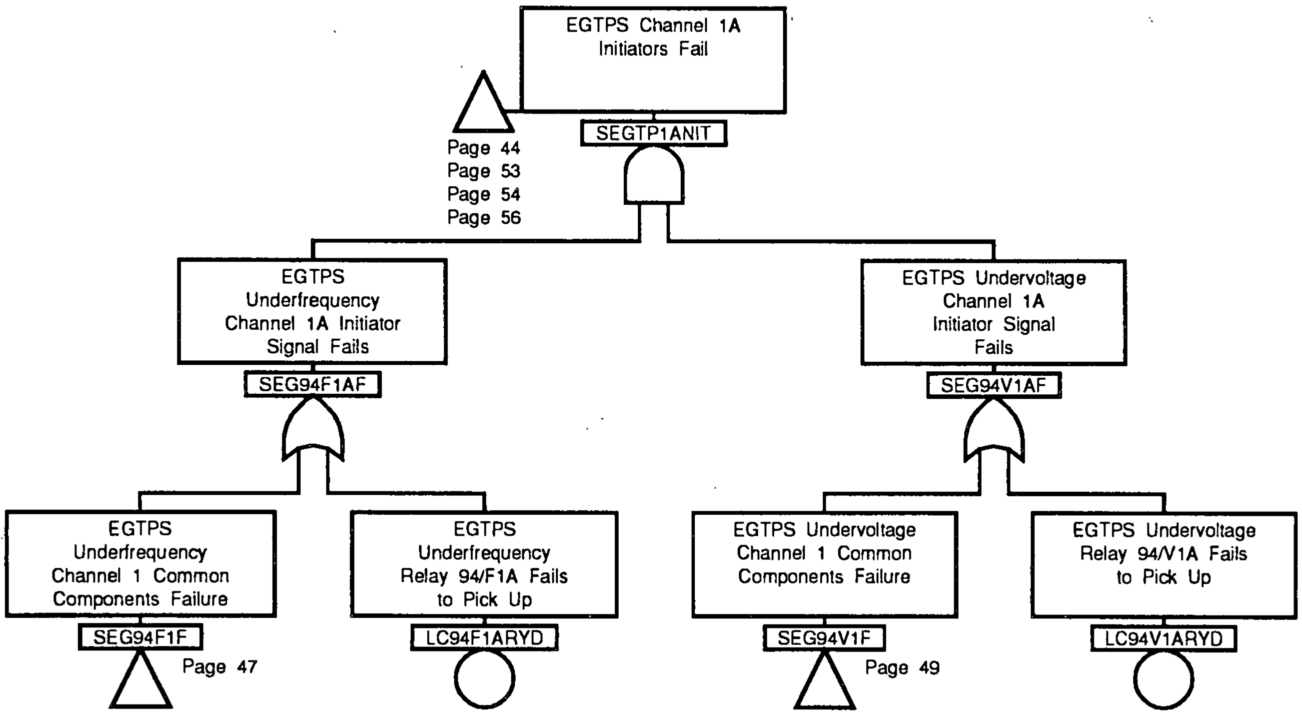


EGTPS Undervoltage Channel 1 Common Components Failure
SEG94V1F
Page 46
Page 68
Page 59
Loss of Power on 125 Vdc Switchyard DC Panelboard DYC
SDCDYC
Page 41
Switchyard 125 Vdc Panelboard DYC Breaker 13 Transfers Open OEE-76-4 / O-802
LDCYC13CDT
Chan 1 EGTPS 2 Out Of 3 UV Signal Network Fails OEE-76-4
SY2OF3UVC1
Common Cause Failure of UV And UF Detection Circuits
L0EGTPSCOM
4
EGTPS CH1 phases x & y undervoltage sensing ckt fails OEE-76-4
SEGX1Y1UV
Page 50
EGTPS CH1 phases y & z undervoltage sensing ckt fails OEE-76-4
SEGY1Z1UV
Page 50
EGTPS CH1 phases x & z undervoltage sensing ckt fails OEE-76-4
SEGX1Z1UV
Page 50



EQTPS CH1 phases x & y underfrequency sensing ckt fails OEE-76-6
Page 47
SEGX1Y1UF
Sensing Relay 81BL/RX1 Fails to Drop Out on Underfrequency
L81BRX1RYD
2
Yellow Bus Phase X1 Underfrequency Aux. Rly Fails to Pick Up
L81XYX1RYD
2
Sensing Relay 81BL/YX1 Fails to Drop Out on Underfrequency
L81BYX1RYD
2
Red Bus Phase Y1 Underfrequency Aux. Rly Fails to Pick Up
L81XRY1RYD
2
Sensing Relay 81BL/RY1 Fails to Drop Out on Underfrequency
L81BRY1RYD
2
Yellow Bus Phase Y1 Underfrequency Aux. Rly Fails to Pick Up
L81XYY1RYD
2
Sensing Relay 81BL/YY1 Fails to Drop Out on Underfrequency
L81BYY1RYD
2
Ch 1 Phase X Underfrequency Aux. Rly Fails to Pick Up
L81XPX1RYD
2
Red Bus Phase X1 Underfrequency Aux. Rly Fails to Pick Up
L81XRX1RYD
2
Ch 1 Phase Y Underfrequency Aux. Rly Fails to Pick Up
L81XPY1RYD
2
EQTPS CH1 phases x & z underfrequency sensing ckt fails
Page 47
SEGX1Z1UF
Sensing Relay 81BL/RX1 Fails to Drop Out on Underfrequency
L81BRX1RYD
2
Yellow Bus Phase X1 Underfrequency Aux. Rly Fails to Pick Up
L81XYX1RYD
2
Sensing Relay 81BL/YX1 Fails to Drop Out on Underfrequency
L81BYX1RYD
2
Red Bus Phase Z1 Underfrequency Aux. Rly Fails to Pick Up
L81XRZ1RYD
2
Sensing Relay 81BL/RZ1 Fails to Drop Out on Underfrequency
L81BRZ1RYD
2
Yellow Bus Phase Z1 Underfrequency Aux. Rly Fails to Pick Up
L81XYZ1RYD
2
Sensing Relay 81BL/YZ1 Fails to Drop Out on Underfrequency
L81BYZ1RYD
2
Ch 1 Phase X Underfrequency Aux. Rly Fails to Pick Up
L81XPX1RYD
2
Red Bus Phase X1 Underfrequency Aux. Rly Fails to Pick Up
L81XRX1RYD
2
Ch 1 Phase Z Underfrequency Aux. Rly Fails to Pick Up
L81XPZ1RYD
2
EQTPS CH1 phases y & z underfrequency sensing ckt fails
Page 47
SEGY1Z1UF
Sensing Relay 81BL/RY1 Fails to Drop Out on Underfrequency
L81BRY1RYD
2
Yellow Bus Phase Y1 Underfrequency Aux. Rly Fails to Pick Up
L81XYY1RYD
2
Sensing Relay 81BL/YY1 Fails to Drop Out on Underfrequency
L81BYY1RYD
2
Red Bus Phase Z1 Underfrequency Aux. Rly Fails to Pick Up
L81XRZ1RYD
2
Sensing Relay 81BL/RZ1 Fails to Drop Out on Underfrequency
L81BRZ1RYD
2
Yellow Bus Phase Z1 Underfrequency Aux. Rly Fails to Pick Up
L81XYZ1RYD
2
Sensing Relay 81BL/YZ1 Fails to Drop Out on Underfrequency
L81BYZ1RYD
2
Ch 1 Phase Y Underfrequency Aux. Rly Fails to Pick Up
L81XPY1RYD
2
Red Bus Phase Y1 Underfrequency Aux. Rly Fails to Pick Up
L81XRY1RYD
2
Ch 1 Phase Z Underfrequency Aux. Rly Fails to Pick Up
L81XPZ1RYD
2


EGTPS Underfrequency Channel 1 Common Components Failure
SEG94F1F
Page 46
Page 68
Page 59
Loss of Power on 125 Vdc Switchyard DC Panelboard DYC
SDCDYC
Page 41
Switchyard 125 Vdc Panelboard DYC Break er 14 Transfers Open OEE-76-4 / O-802
LDCYC14CDT
Chan 1 EGTPS 2 Out Of 3 UF Signal Network Fails OEE-76-6
SY2OF3UFC1
Common Cause Failure of UV And UF Detection Circuits
L0EGTPSCOM
4
EGTPS CH1 phases x & y underfrequency sensing ckt fails OEE-76-6
SEGX1Y1UF
Page 48
EGTPS CH1 phases y & z underfrequency sensing ckt fails
SEGY1Z1UF
Page 48
EGTPS CH1 phases x & z underfrequency sensing ckt fails
SEGX1Z1UF
Page 48


EGTPS Channel 1A Initiators Fail
SEGTP1ANIT
Page 44
Page 53
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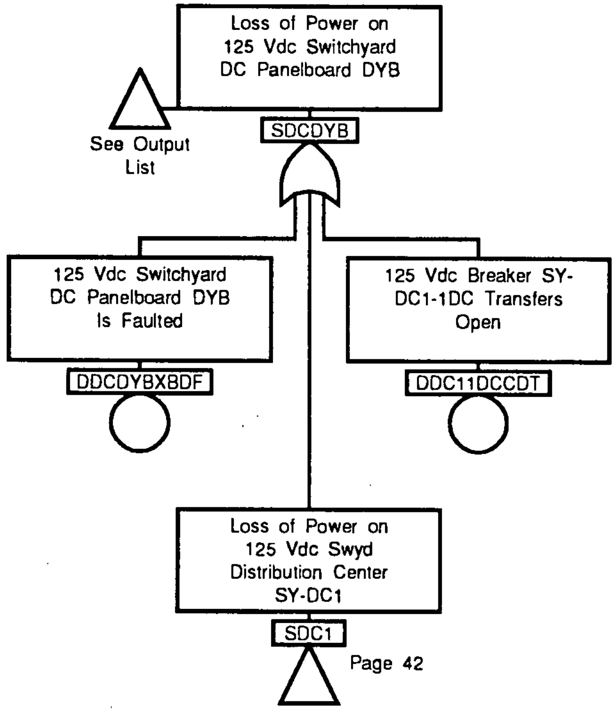
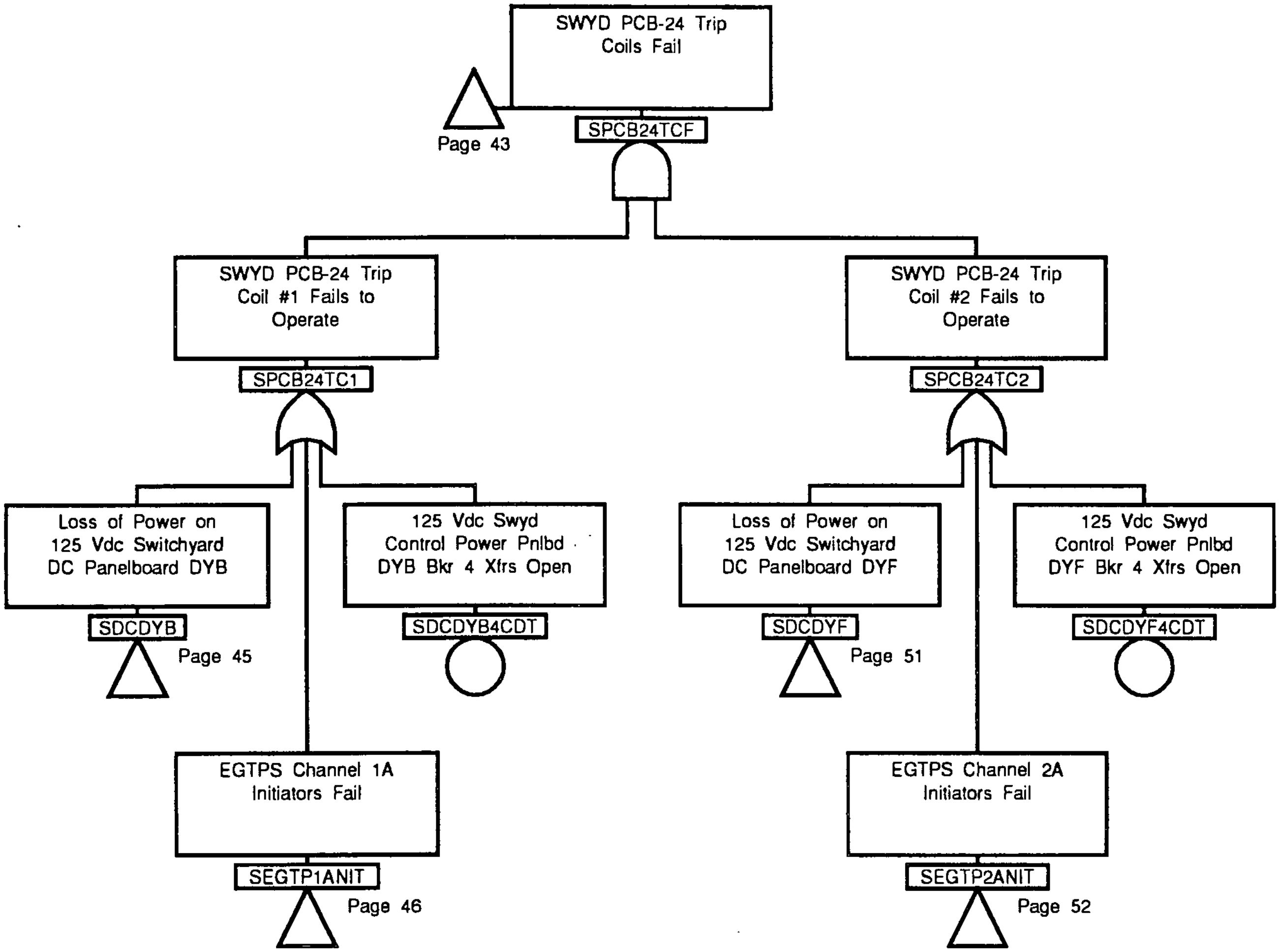
Page 56
EGTPS Underfrequency Channel 1A Initiator Signal Fails
SEG94F1AF
EGTPS Undervoltage Channel 1A Initiator Signal Fails
SEG94V1AF
EGTPS Underfrequency Channel 1 Common Components Failure
SEG94F1F
Page 47
EGTPS Underfrequency Relay 94/F1A Fails to Pick Up
LC94F1ARYD
EGTPS Undervoltage Channel 1 Common Components Failure
SEG94V1F
Page 49
EGTPS Undervoltage Relay 94/V1A Fails to Pick Up
LC94V1ARYD

SDCDYB Outputs:
Page 58, Page 44, Page 53, Page 54, Page 56





SWYD PCB-24 Trip
Coils Fail
SPCB24TCF
Page 43
SWYD PCB-24 Trip
Coil #1 Fails to
Operate
SPCB24TC1
SWYD PCB-24 Trip
Coil #2 Fails to
Operate
SPCB24TC2
Loss of Power on
125 Vdc Switchyard
DC Panelboard DYB
SDCDYB
Page 45
125 Vdc Swyd
Control Power Pnlbd
DYB Bkr 4 Xfrs Open
SDCDYB4CDT
Loss of Power on
125 Vdc Switchyard
DC Panelboard DYF
SDCDYF
Page 51
125 Vdc Swyd
Control Power Pnlbd
DYF Bkr 4 Xfrs Open
SDCDYF4CDT
EGTPS Channel 1A
Initiators Fail
SEGTP1ANIT
Page 46
EGTPS Channel 2A
Initiators Fail
SEGTP2ANIT
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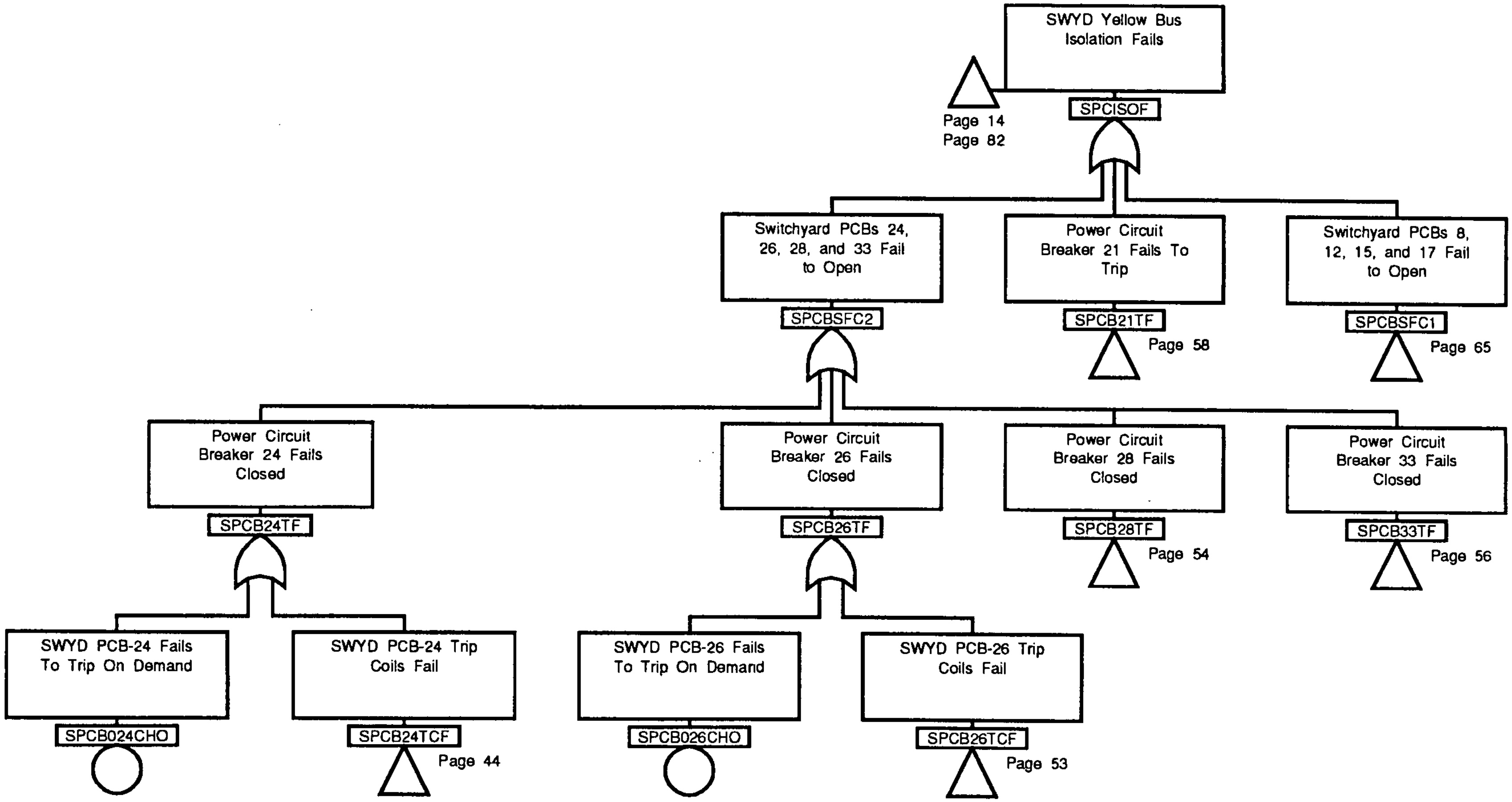
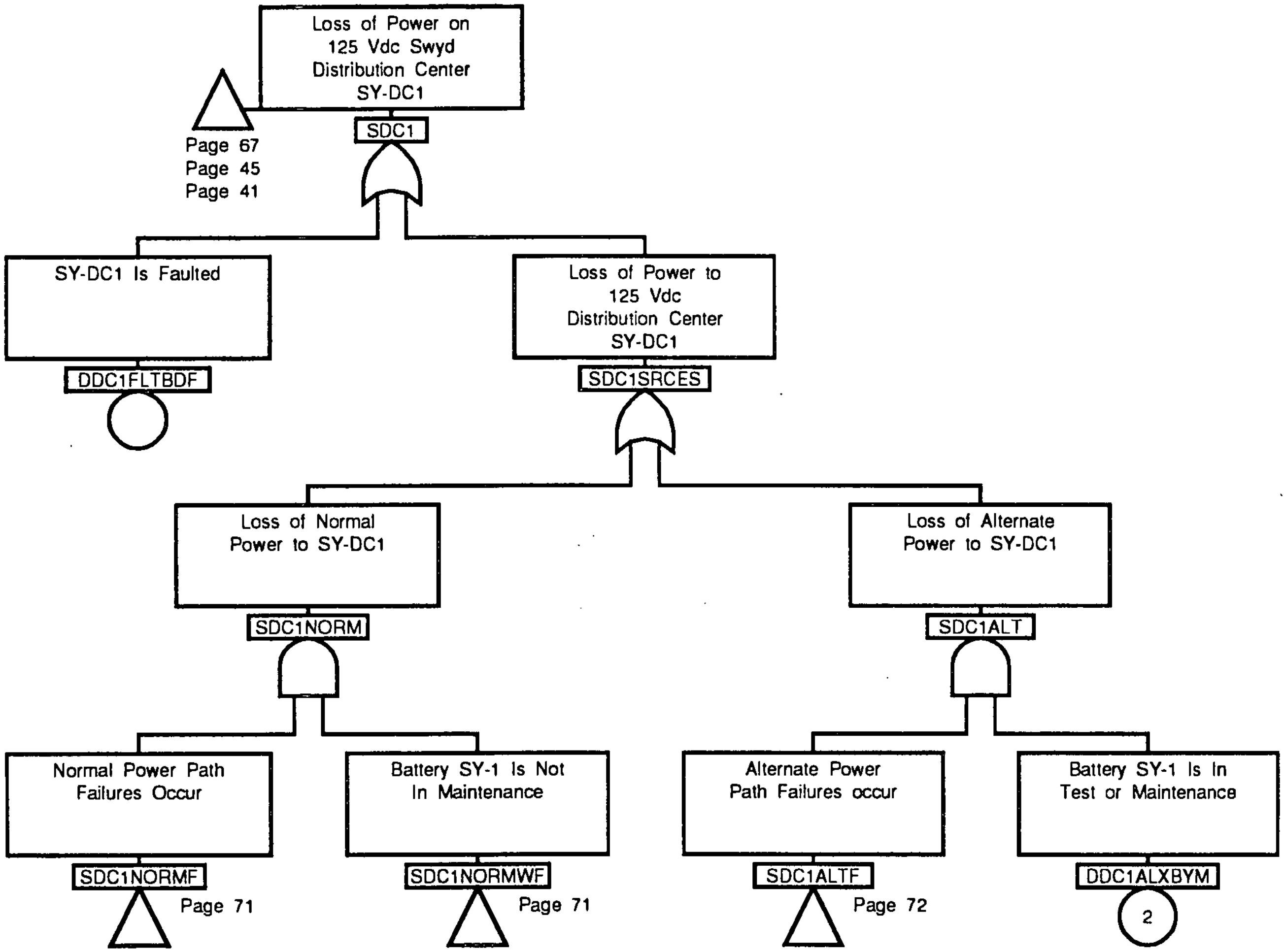
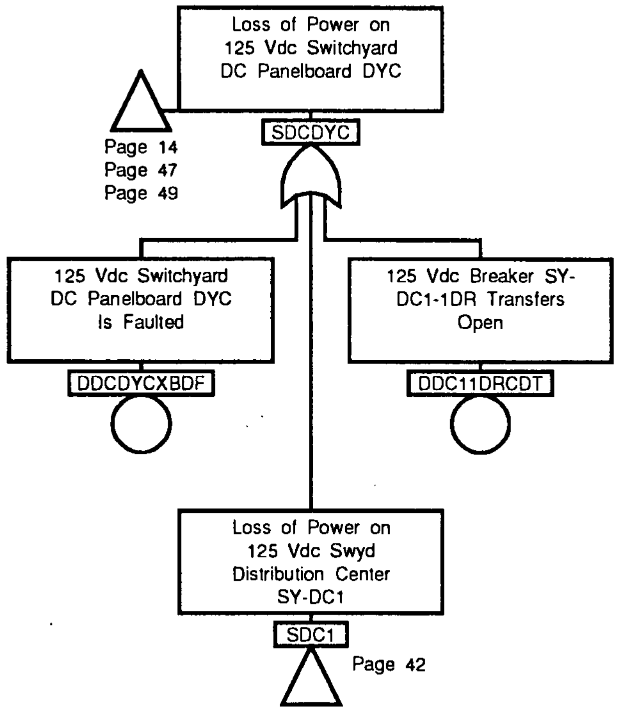


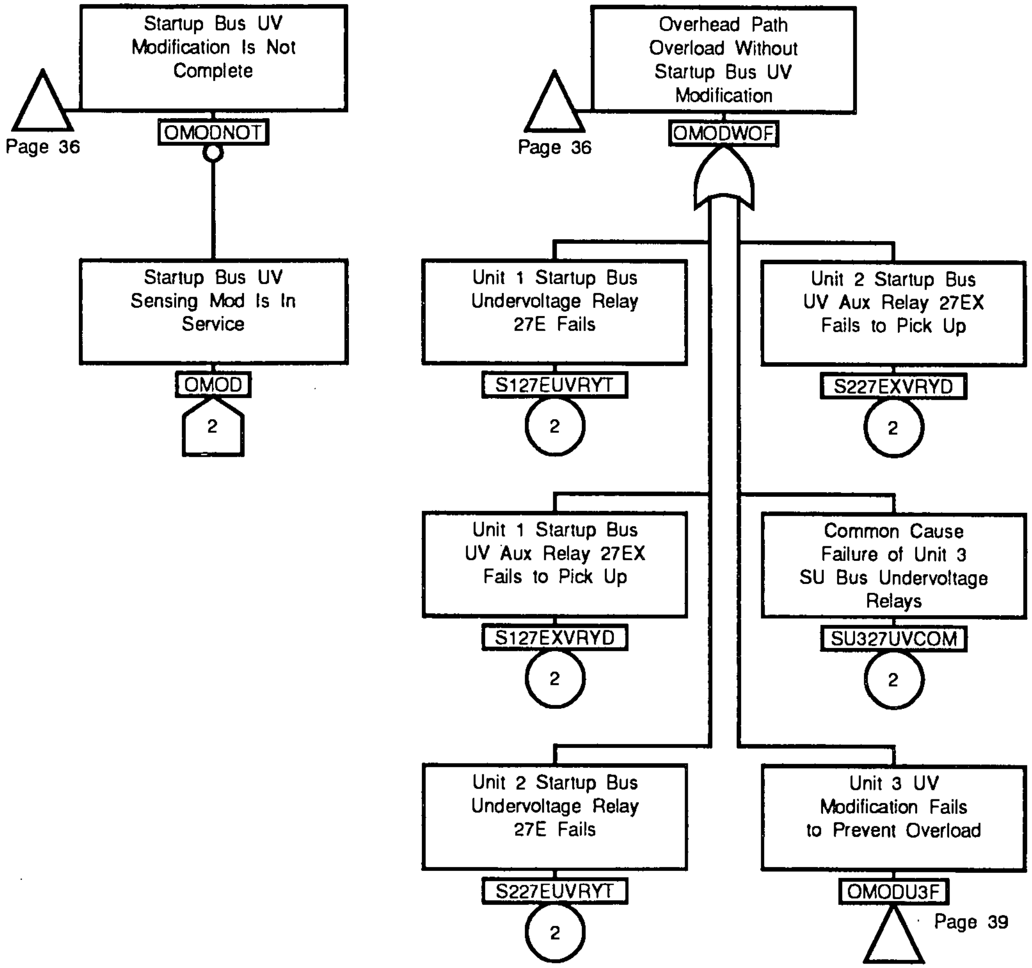
SWYD Yellow Bus Isolation Fails
SPCISOF
Page 14
Page 82
Switchyard PCBs 24, 26, 28, and 33 Fail to Open
SPCBSFC2
Power Circuit Breaker 21 Fails To Trip
SPCB21TF
Page 58
Switchyard PCBs 8, 12, 15, and 17 Fail to Open
SPCBSFC1
Page 65
Power Circuit Breaker 24 Fails Closed
SPCB24TF
Power Circuit Breaker 26 Fails Closed
SPCB26TF
Power Circuit Breaker 28 Fails Closed
SPCB28TF
Page 54
Power Circuit Breaker 33 Fails Closed
SPCB33TF
Page 56
SWYD PCB-24 Fails To Trip On Demand
SPCB024CHO
SWYD PCB-24 Trip Coils Fail
SPCB24TCF
Page 44
SWYD PCB-26 Fails To Trip On Demand
SPCB026CHO
SWYD PCB-26 Trip Coils Fail
SPCB26TCF
Page 53



Loss of Power on 125 Vdc Swyd Distribution Center SY-DC1
SDC1
Page 67
Page 45
Page 41
SY-DC1 Is Faulted
DDC1FLTBDF
Loss of Power to 125 Vdc Distribution Center SY-DC1
SDC1SRCES
Loss of Normal Power to SY-DC1
SDC1NORM
Loss of Alternate Power to SY-DC1
SDC1ALT
Normal Power Path Failures Occur
SDC1NORMF
Page 71
Battery SY-1 Is Not In Maintenance
SDC1NORMWF
Page 71
Alternate Power Path Failures occur
SDC1ALTF
Page 72
Battery SY-1 Is In Test or Maintenance
DDC1ALXBYM
2



Loss of Power on 125 Vdc Switchyard DC Panelboard DYC
SDCDYC
Page 14
Page 47
Page 49
125 Vdc Switchyard DC Panelboard DYC Is Faulted
DDCDYCXBDF
125 Vdc Breaker SY-DC1-1DR Transfers Open
DDC11DRCDT
Loss of Power on 125 Vdc Swyd Distribution Center SY-DC1
SDC1
Page 42



Startup Bus UV Modification Is Not Complete
Page 36
OMODNOT
Startup Bus UV Sensing Mod Is In Service
OMOD
2
Overhead Path Overload Without Startup Bus UV Modification
Page 36
OMODWOF
Unit 1 Startup Bus Undervoltage Relay 27E Fails
S127EUVRYT
2
Unit 2 Startup Bus UV Aux Relay 27EX Fails to Pick Up
S227EXVRYD
2
Unit 1 Startup Bus UV Aux Relay 27EX Fails to Pick Up
S127EXVRYD
2
Common Cause Failure of Unit 3 SU Bus Undervoltage Relays
SU327UVCOM
2
Unit 2 Startup Bus Undervoltage Relay 27E Fails
S227EUVRYT
2
Unit 3 UV Modification Fails to Prevent Overload
OMODU3F
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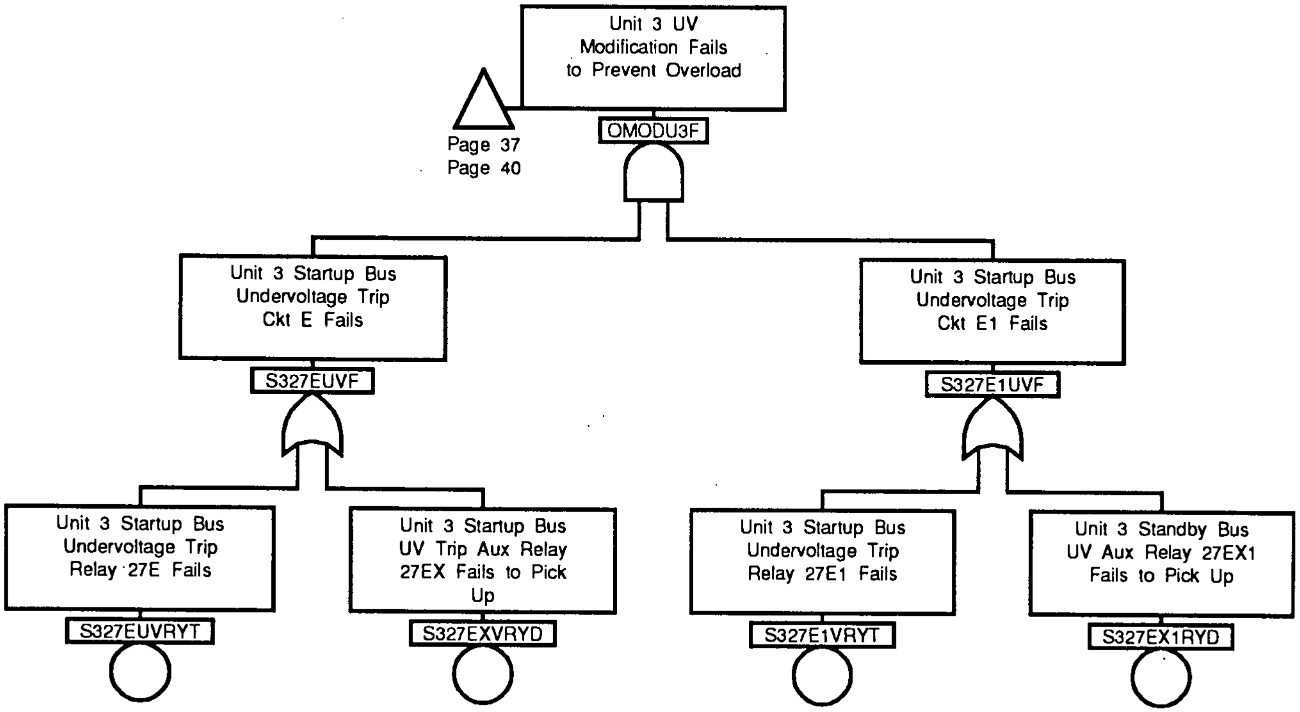
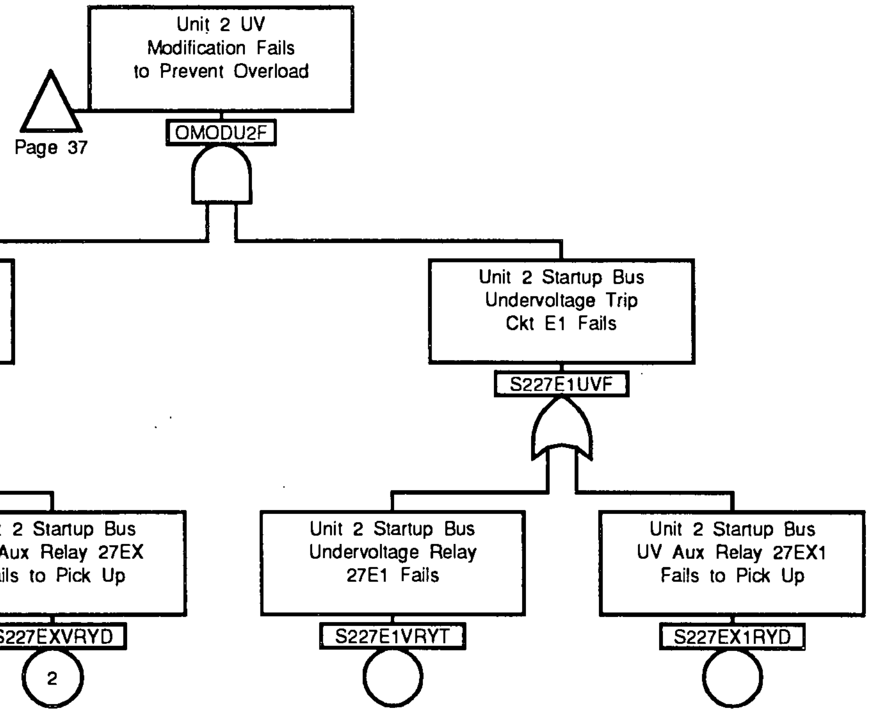
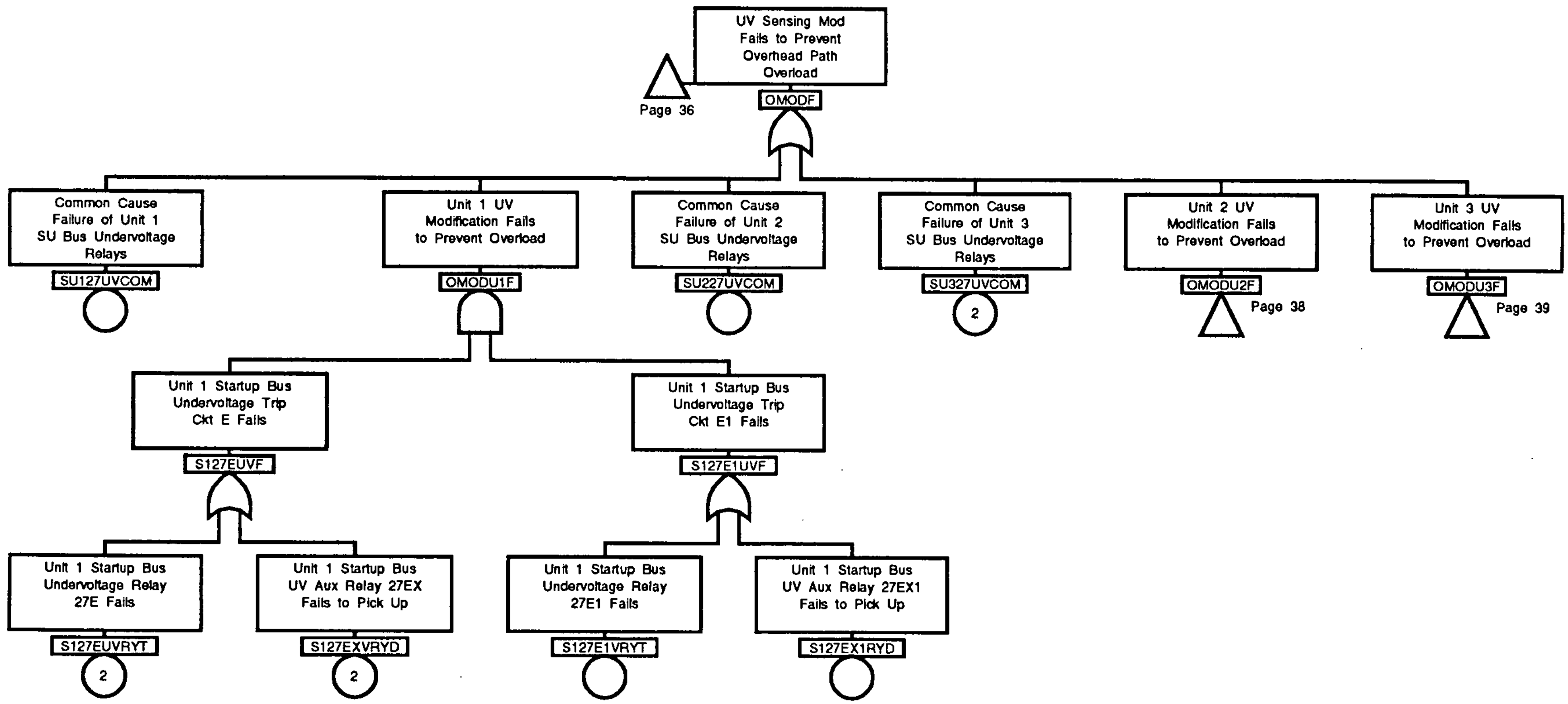
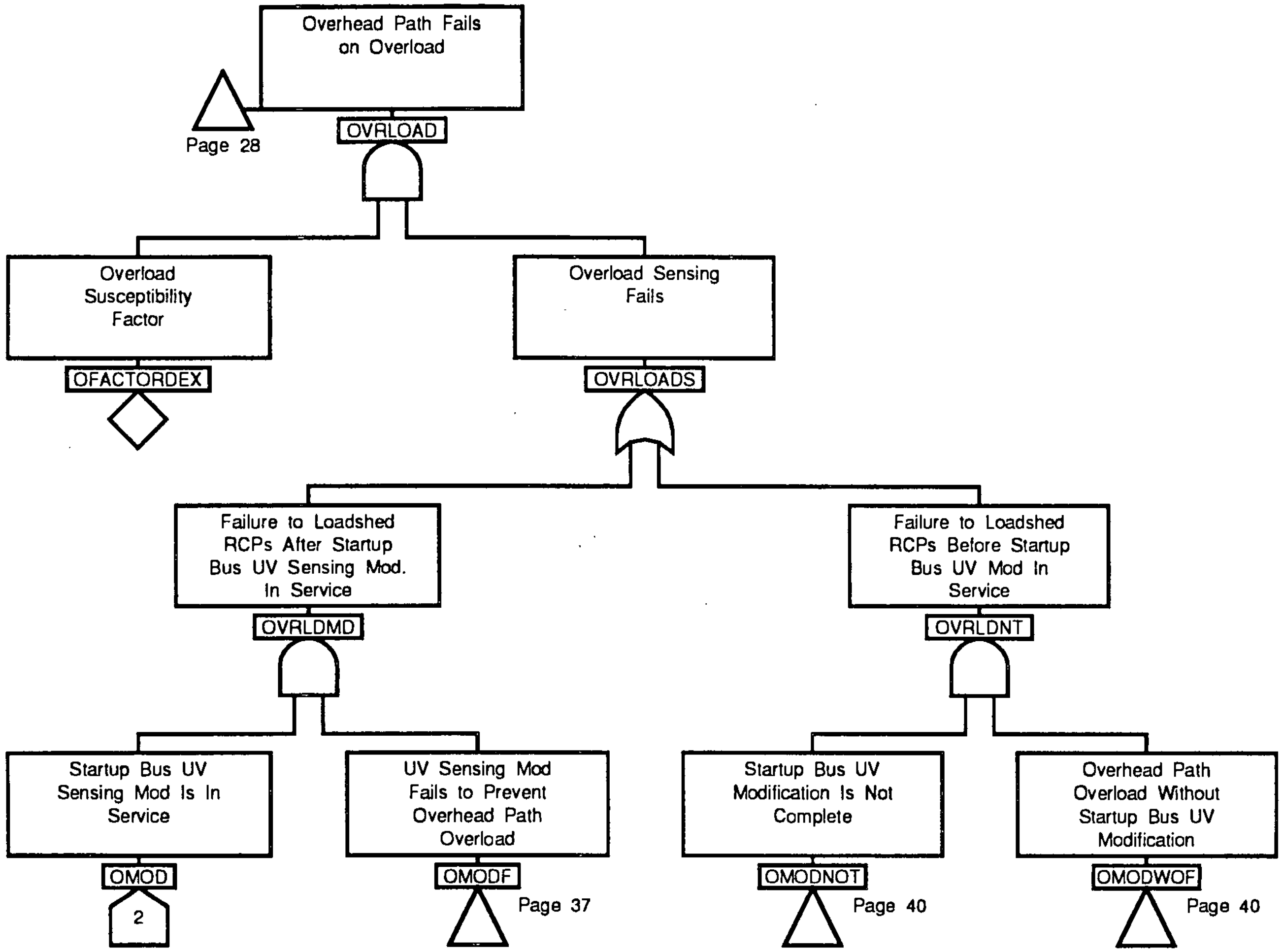


Unit 3 UV Modification Fails to Prevent Overload
OMODU3F
Page 37
Page 40
Unit 3 Startup Bus Undervoltage Trip Ckt E Fails
S327EUVF
Unit 3 Startup Bus Undervoltage Trip Ckt E1 Fails
S327E1UVF
Unit 3 Startup Bus Undervoltage Trip Relay 27E Fails
S327EUVRYT
Unit 3 Startup Bus UV Trip Aux Relay 27EX Fails to Pick Up
S327EXVRYD
Unit 3 Startup Bus Undervoltage Trip Relay 27E1 Fails
S327E1VRYT
Unit 3 Standby Bus UV Aux Relay 27EX1 Fails to Pick Up
S327EX1RYD

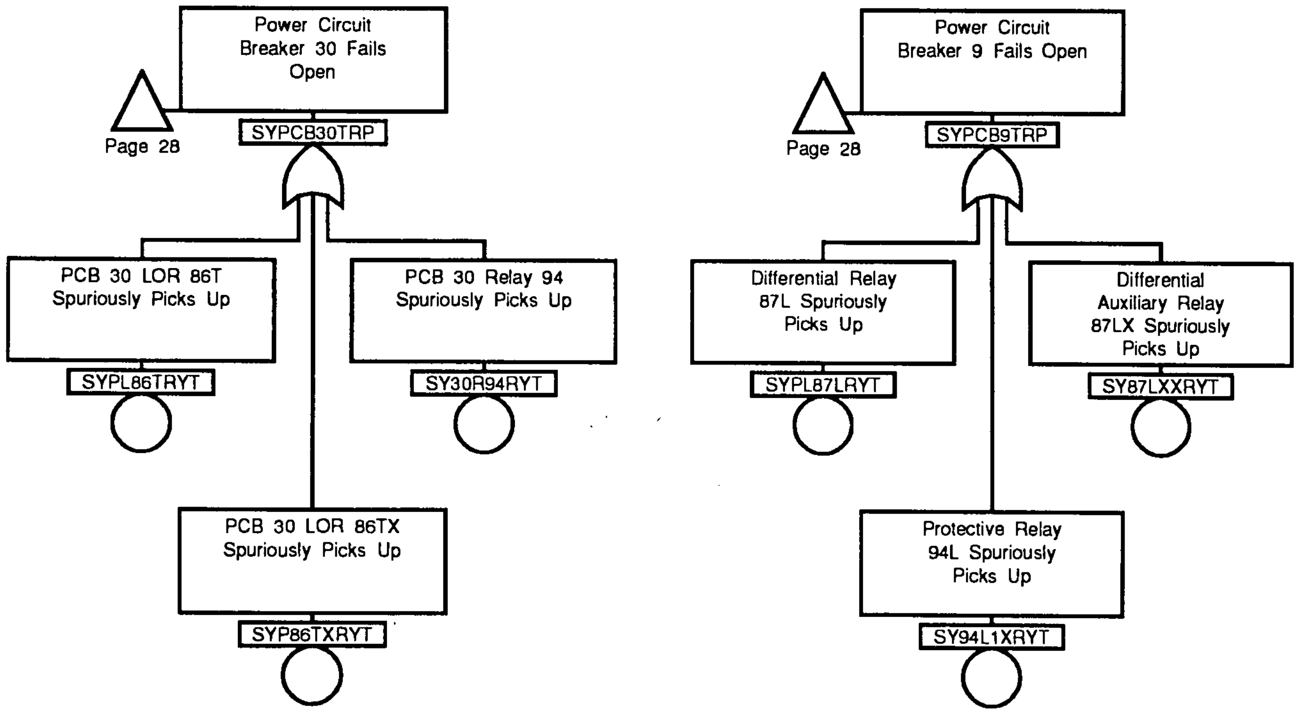

Unit 2 UV Modification Fails to Prevent Overload
Page 37
OMODU2F
Unit 2 Startup Bus Undervoltage Trip Ckt E Fails
S227EUVF
Unit 2 Startup Bus Undervoltage Trip Ckt E1 Fails
S227E1UVF
Unit 2 Startup Bus Undervoltage Relay 27E Fails
S227EUVRYT
2
Unit 2 Startup Bus UV Aux Relay 27EX Fails to Pick Up
S227EXVRYD
2
Unit 2 Startup Bus Undervoltage Relay 27E1 Fails
S227E1VRYT
Unit 2 Startup Bus UV Aux Relay 27EX1 Fails to Pick Up
S227EX1RYD



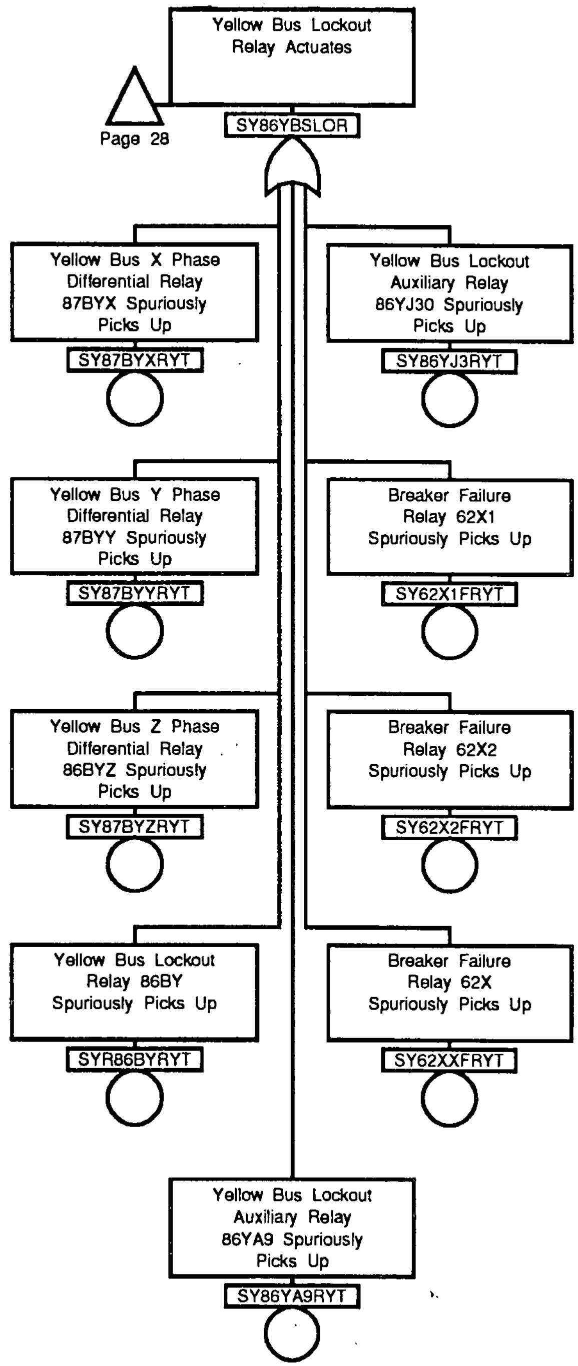
UV Sensing Mod Fails to Prevent Overhead Path Overload
OMODF
Page 36
Common Cause Failure of Unit 1 SU Bus Undervoltage Relays
SU127UVCOM
Unit 1 UV Modification Fails to Prevent Overload
OMODU1F
Common Cause Failure of Unit 2 SU Bus Undervoltage Relays
SU227UVCOM
Common Cause Failure of Unit 3 SU Bus Undervoltage Relays
SU327UVCOM
2
Unit 2 UV Modification Fails to Prevent Overload
OMODU2F
Page 38
Unit 3 UV Modification Fails to Prevent Overload
OMODU3F
Page 39
Unit 1 Startup Bus Undervoltage Trip Ckt E Fails
S127EUVF
Unit 1 Startup Bus Undervoltage Trip Ckt E1 Fails
S127E1UVF
Unit 1 Startup Bus Undervoltage Relay 27E Fails
S127EUVRYT
2
Unit 1 Startup Bus UV Aux Relay 27EX Fails to Pick Up
S127EXVRYD
2
Unit 1 Startup Bus Undervoltage Relay 27E1 Fails
S127E1VRYT
Unit 1 Startup Bus UV Aux Relay 27EX1 Fails to Pick Up
S127EX1RYD



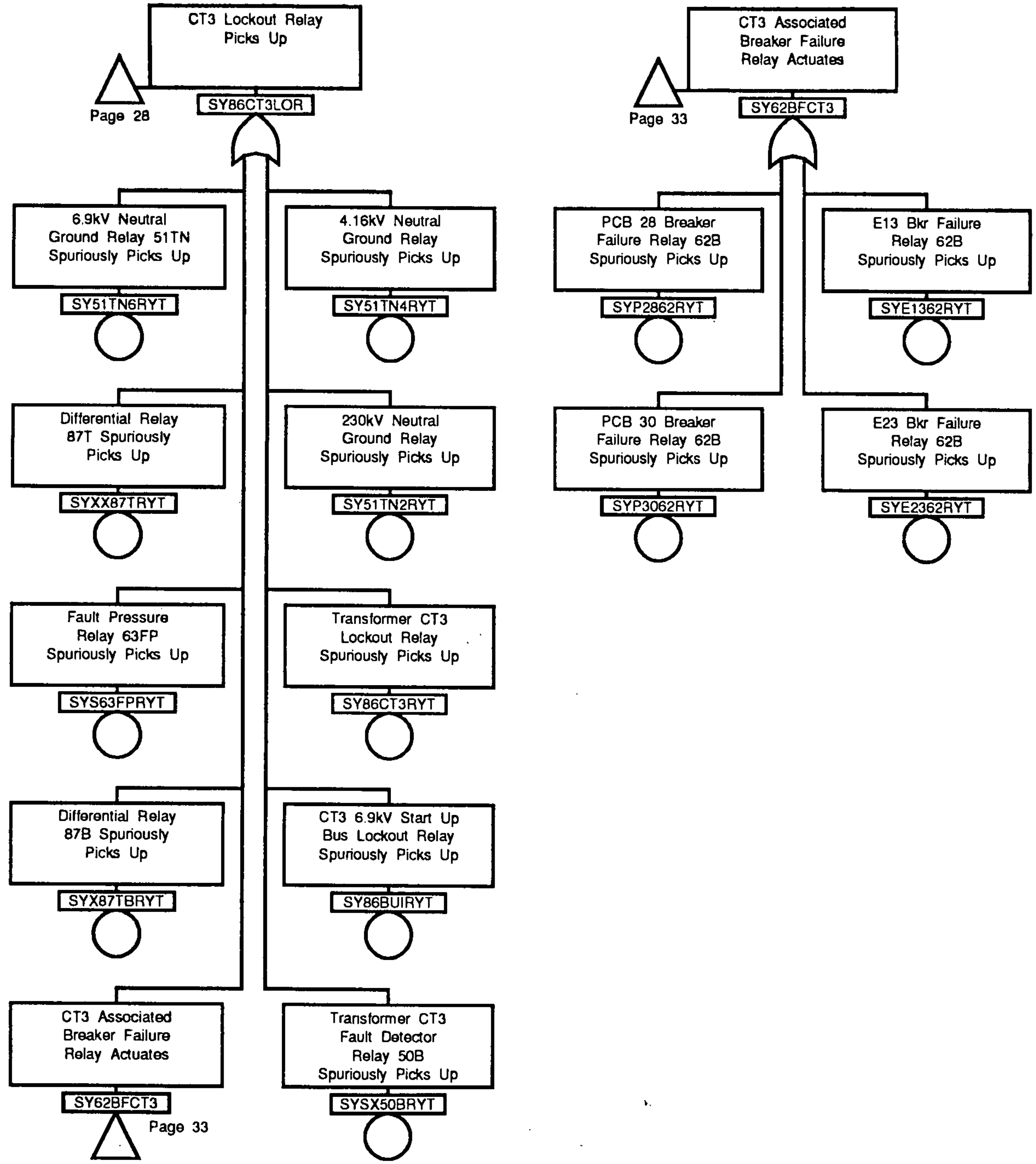
Overhead Path Fails on Overload
Page 28
OVRLOAD
Overload Susceptibility Factor
OFACTORDEX
Overload Sensing Fails
OVRLOADS
Failure to Loadshed RCPs After Startup Bus UV Sensing Mod. In Service
OVRLDMD
Failure to Loadshed RCPs Before Startup Bus UV Mod In Service
OVRLDNT
Startup Bus UV Sensing Mod Is In Service
OMOD
2
UV Sensing Mod Fails to Prevent Overhead Path Overload
OMODF
Page 37
Startup Bus UV Modification Is Not Complete
OMODNOT
Page 40
Overhead Path Overload Without Startup Bus UV Modification
OMODWOF
Page 40



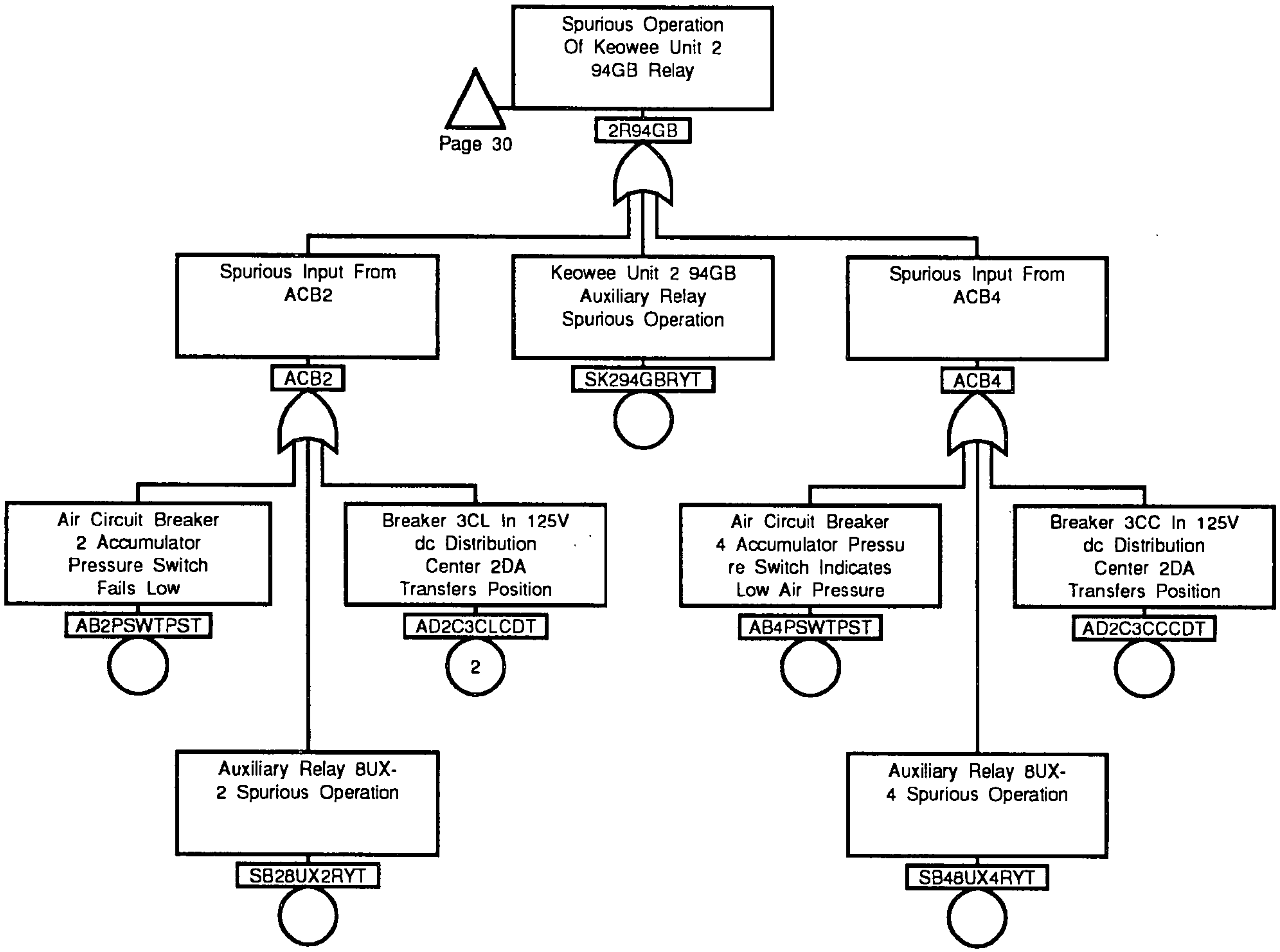
Power Circuit Breaker 30 Fails Open
SYPCB30TRP
Page 28
PCB 30 LOR 86T Spuriously Picks Up
SYPL86TRYT
PCB 30 Relay 94 Spuriously Picks Up
SY30R94RYT
PCB 30 LOR 86TX Spuriously Picks Up
SYP86TXRYT
Power Circuit Breaker 9 Fails Open
SYPCB9TRP
Page 28
Differential Relay 87L Spuriously Picks Up
SYPL87LRYT
Differential Auxiliary Relay 87LX Spuriously Picks Up
SY87LXXRYT
Protective Relay 94L Spuriously Picks Up
SY94L1XRYT

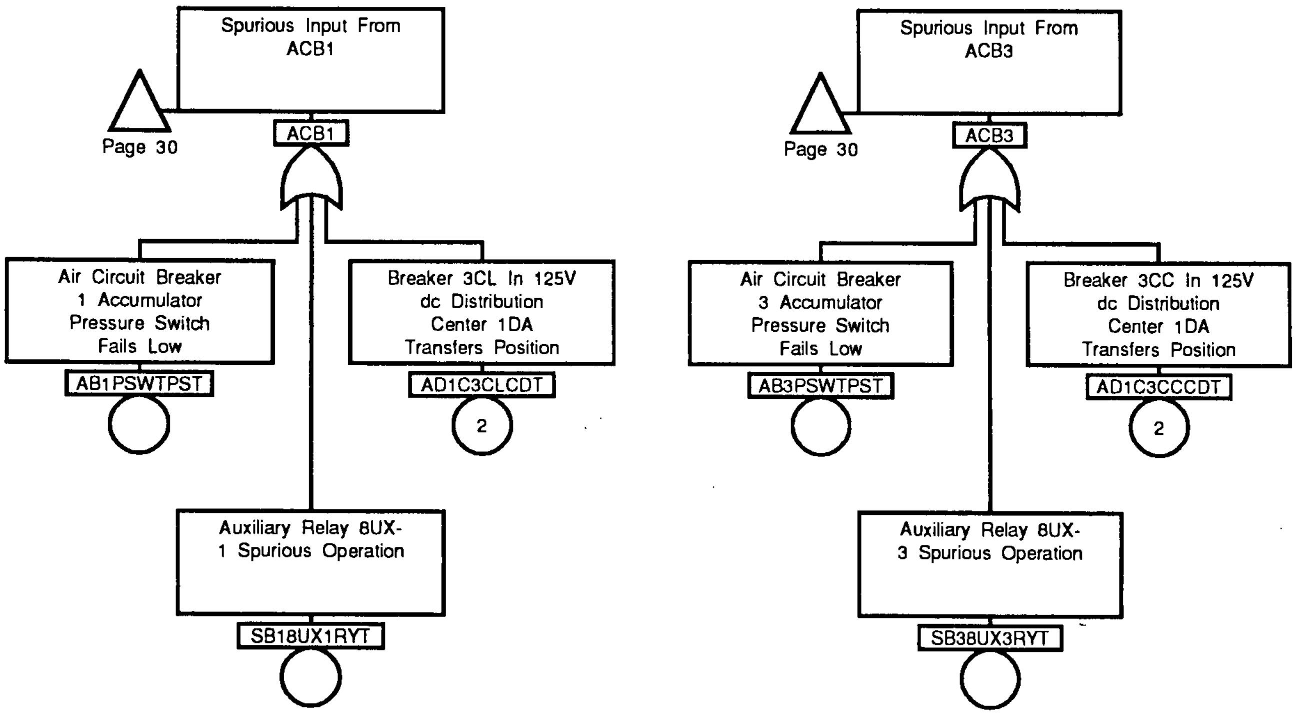


Yellow Bus Lockout Relay Actuates
SY86YBSLOR
Page 28
Yellow Bus X Phase Differential Relay 87BYX Spuriously Picks Up
SY87BYXRYT
Yellow Bus Lockout Auxiliary Relay 86YJ30 Spuriously Picks Up
SY86YJ3RYT
Yellow Bus Y Phase Differential Relay 87BYY Spuriously Picks Up
SY87BYYRYT
Breaker Failure Relay 62X1 Spuriously Picks Up
SY62X1FRYT
Yellow Bus Z Phase Differential Relay 86BYZ Spuriously Picks Up
SY87BYZRYT
Breaker Failure Relay 62X2 Spuriously Picks Up
SY62X2FRYT
Yellow Bus Lockout Relay 86BY Spuriously Picks Up
SYR86BYRYT
Breaker Failure Relay 62X Spuriously Picks Up
SY62XXFRYT
Yellow Bus Lockout Auxiliary Relay 86YA9 Spuriously Picks Up
SY86YA9RYT

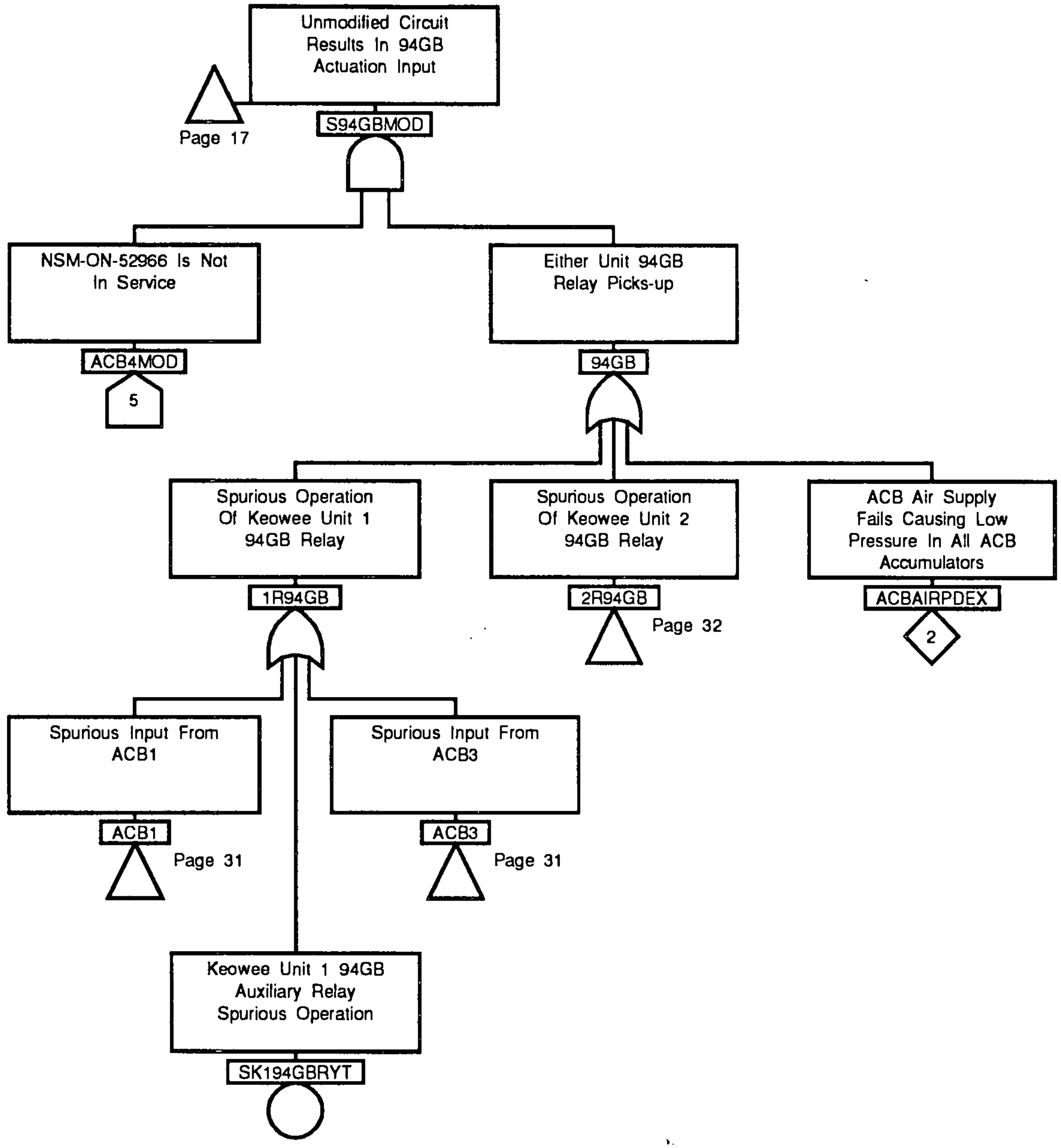


CT3 Lockout Relay Picks Up
Page 28
SY86CT3LOR
6.9kV Neutral Ground Relay 51TN Spuriously Picks Up
SY51TN6RYT
4.16kV Neutral Ground Relay Spuriously Picks Up
SY51TN4RYT
Differential Relay 87T Spuriously Picks Up
SYXX87TRYT
230kV Neutral Ground Relay Spuriously Picks Up
SY51TN2RYT
Fault Pressure Relay 63FP Spuriously Picks Up
SYS63FPRYT
Transformer CT3 Lockout Relay Spuriously Picks Up
SY86CT3RYT
Differential Relay 87B Spuriously Picks Up
SYX87TBRYT
CT3 6.9kV Start Up Bus Lockout Relay Spuriously Picks Up
SY86BUIRYT
CT3 Associated Breaker Failure Relay Actuates
SY62BFCT3
Page 33
Transformer CT3 Fault Detector Relay 50B Spuriously Picks Up
SYSX50BRYT
CT3 Associated Breaker Failure Relay Actuates
Page 33
SY62BFCT3
PCB 28 Breaker Failure Relay 62B Spuriously Picks Up
SYP2862RYT
E13 Bkr Failure Relay 62B Spuriously Picks Up
SYE1362RYT
PCB 30 Breaker Failure Relay 62B Spuriously Picks Up
SYP3062RYT
E23 Bkr Failure Relay 62B Spuriously Picks Up
SYE2362RYT

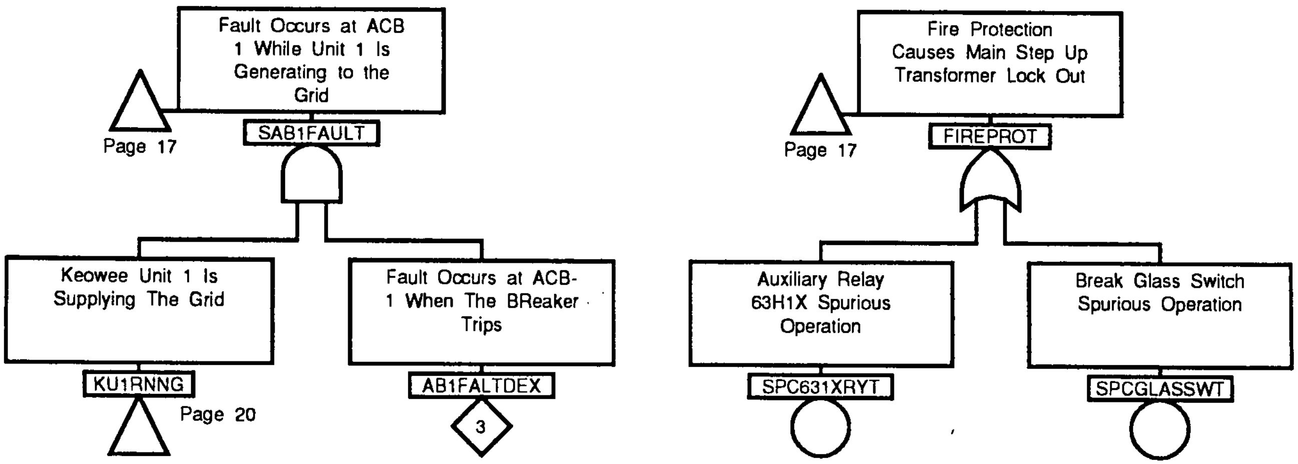

Spurious Operation Of Keowee Unit 2 94GB Relay
Page 30
2R94GB
Spurious Input From ACB2
ACB2
Keowee Unit 2 94GB Auxiliary Relay Spurious Operation
SK294GBRYT
Spurious Input From ACB4
ACB4
Air Circuit Breaker 2 Accumulator Pressure Switch Fails Low
AB2PSWTPST
Breaker 3CL In 125V dc Distribution Center 2DA Transfers Position
AD2C3CLCDT
2
Air Circuit Breaker 4 Accumulator Pressu re Switch Indicates Low Air Pressure
AB4PSWTPST
Breaker 3CC In 125V dc Distribution Center 2DA Transfers Position
AD2C3CCCDT
Auxiliary Relay 8UX-2 Spurious Operation
SB28UX2RYT
Auxiliary Relay 8UX-4 Spurious Operation
SB48UX4RYT



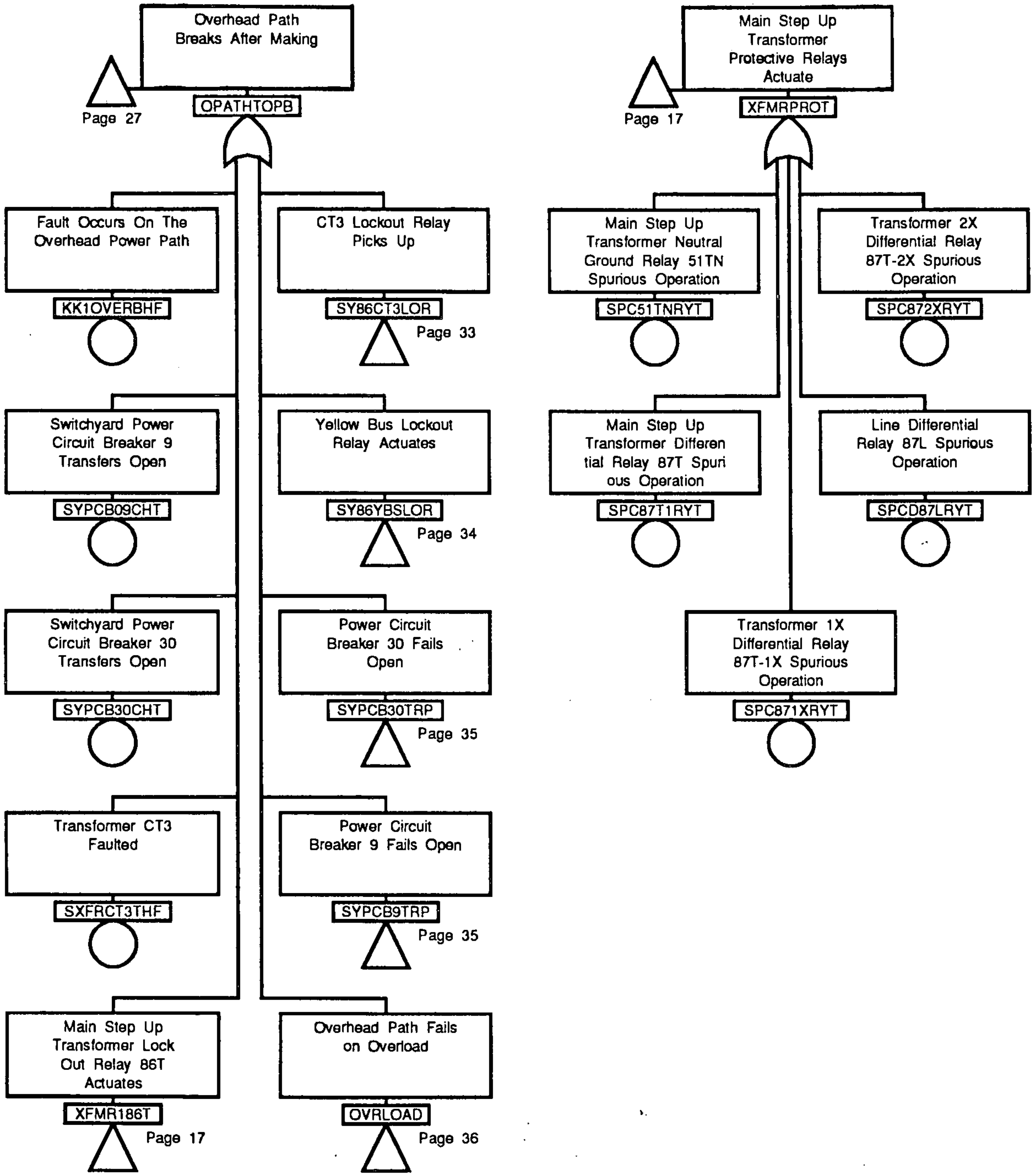
Spurious Input From ACB1
Page 30
ACB1
Air Circuit Breaker 1 Accumulator Pressure Switch Fails Low
AB1PSWTPST
Breaker 3CL In 125V dc Distribution Center 1DA Transfers Position
AD1C3CLCDT
2
Auxiliary Relay 8UX-1 Spurious Operation
SB18UX1RYT
Spurious Input From ACB3
Page 30
ACB3
Air Circuit Breaker 3 Accumulator Pressure Switch Fails Low
AB3PSWTPST
Breaker 3CC In 125V dc Distribution Center 1DA Transfers Position
AD1C3CCCDT
2
Auxiliary Relay 8UX-3 Spurious Operation
SB38UX3RYT



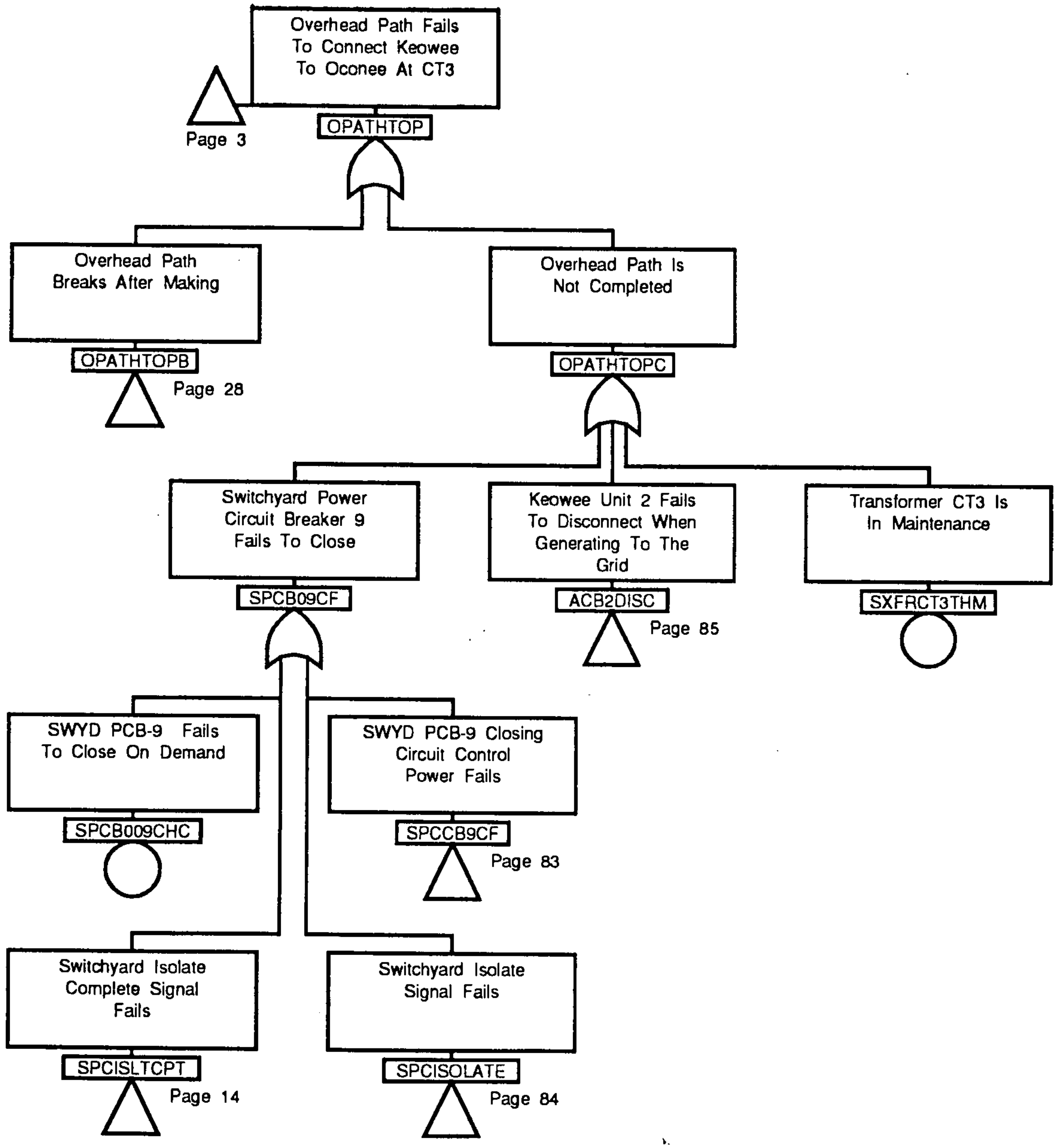
Unmodified Circuit Results In 94GB Actuation Input
Page 17
S94GBMOD
NSM-ON-52966 Is Not In Service
ACB4MOD
5
Either Unit 94GB Relay Picks-up
94GB
Spurious Operation Of Keowee Unit 1 94GB Relay
1R94GB
Spurious Operation Of Keowee Unit 2 94GB Relay
2R94GB
Page 32
ACB Air Supply Fails Causing Low Pressure In All ACB Accumulators
ACBAIRPDEX
2
Spurious Input From ACB1
ACB1
Page 31
Spurious Input From ACB3
ACB3
Page 31
Keowee Unit 1 94GB Auxiliary Relay Spurious Operation
SK194GBRYT

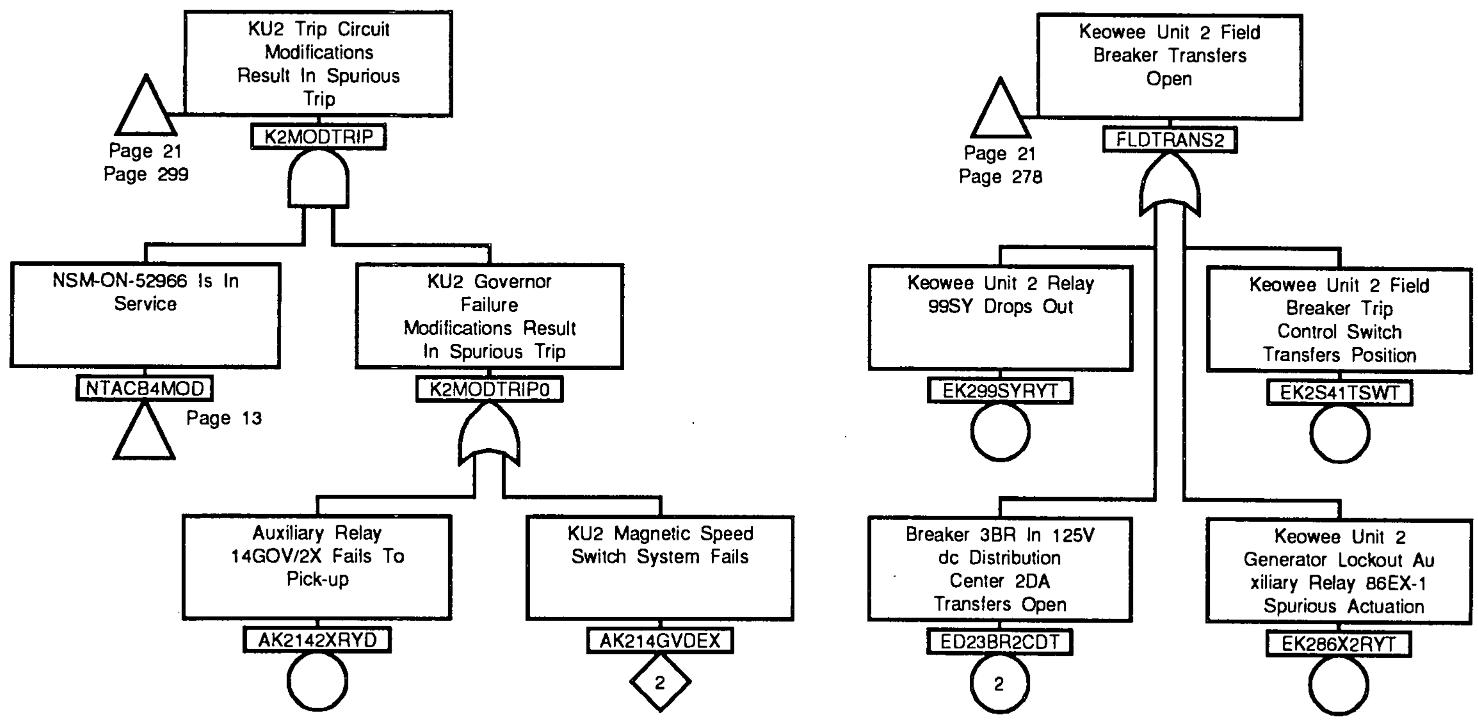


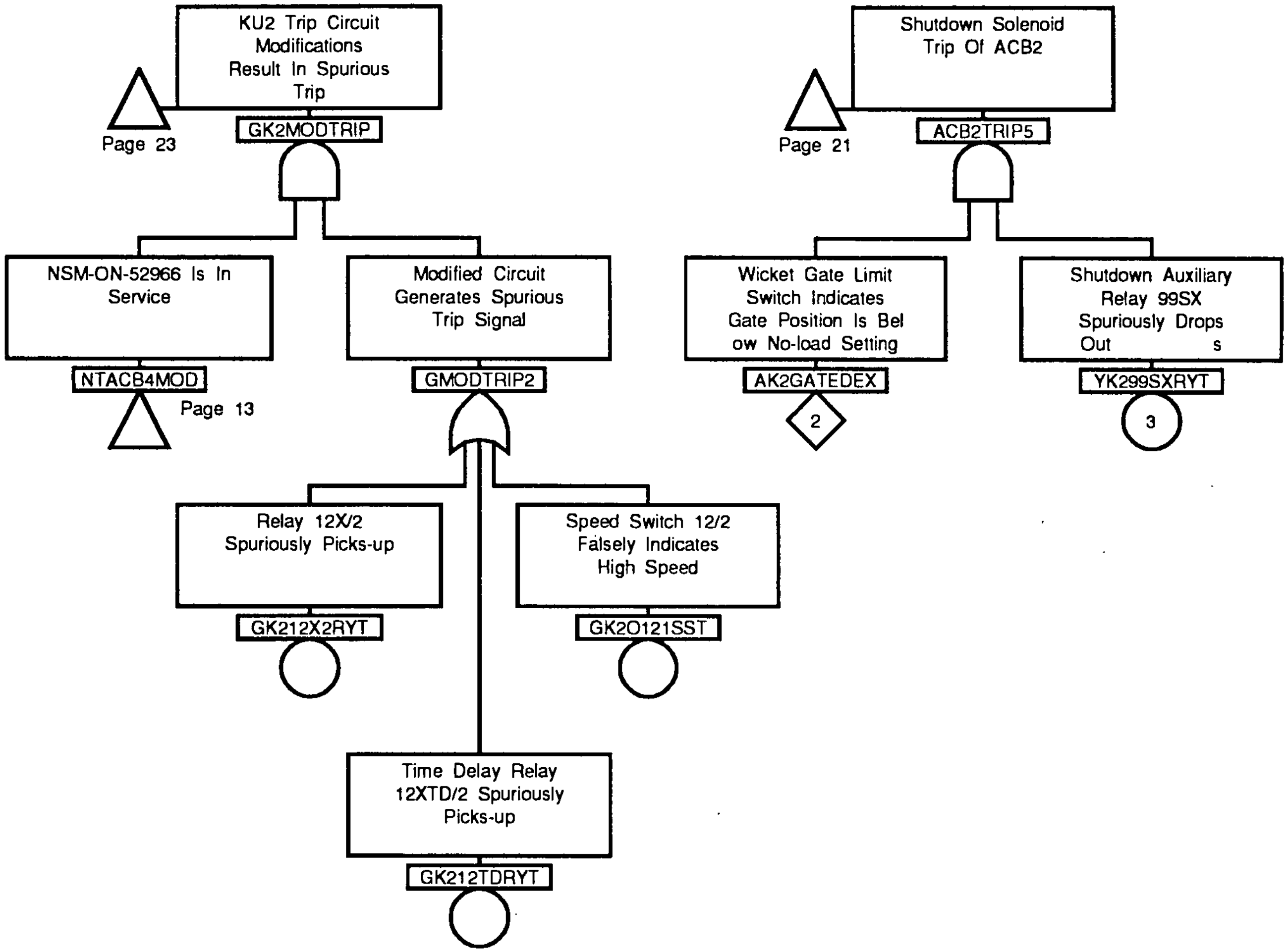
Fault Occurs at ACB 1 While Unit 1 Is Generating to the Grid
SAB1FAULT
Page 17
Keowee Unit 1 Is Supplying The Grid
KU1RNNG
Page 20
Fault Occurs at ACB-1 When The BReaker Trips
AB1FALTDEX
3
Fire Protection Causes Main Step Up Transformer Lock Out
FIREPROT
Page 17
Auxiliary Relay 63H1X Spurious Operation
SPC631XRYT
Break Glass Switch Spurious Operation
SPCGLASSWT



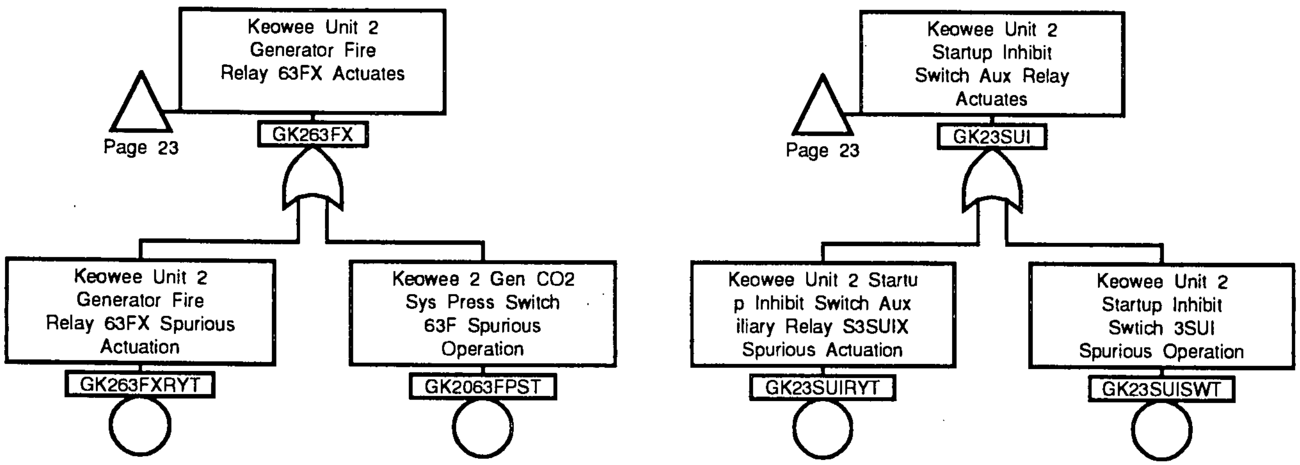
Overhead Path Breaks After Making
OPATHTOPB
Page 27
Fault Occurs On The Overhead Power Path
KK1OVERBHF
CT3 Lockout Relay Picks Up
SY86CT3LOR
Page 33
Switchyard Power Circuit Breaker 9 Transfers Open
SYPCB09CHT
Yellow Bus Lockout Relay Actuates
SY86YBSLOR
Page 34
Switchyard Power Circuit Breaker 30 Transfers Open
SYPCB30CHT
Power Circuit Breaker 30 Fails Open
SYPCB30TRP
Page 35
Transformer CT3 Faulted
SXFRCT3THF
Power Circuit Breaker 9 Fails Open
SYPCB9TRP
Page 35
Main Step Up Transformer Lock Out Relay 86T Actuates
XFMR186T
Page 17
Overhead Path Fails on Overload
OVRLOAD
Page 36
Main Step Up Transformer Protective Relays Actuate
XFMRPROT
Page 17
Main Step Up Transformer Neutral Ground Relay 51TN Spurious Operation
SPC51TNRYT
Transformer 2X Differential Relay 87T-2X Spurious Operation
SPC872XRYT
Main Step Up Transformer Differen tial Relay 87T Spuri ous Operation
SPC87T1RYT
Line Differential Relay 87L Spurious Operation
SPCD87LRYT
Transformer 1X Differential Relay 87T-1X Spurious Operation
SPC871XRYT


Overhead Path Fails To Connect Keowee To Oconee At CT3
OPATHTOP
Page 3
Overhead Path Breaks After Making
OPATHTOPB
Page 28
Overhead Path Is Not Completed
OPATHTOPC
Switchyard Power Circuit Breaker 9 Fails To Close
SPCB09CF
Keowee Unit 2 Fails To Disconnect When Generating To The Grid
ACB2DISC
Page 85
Transformer CT3 Is In Maintenance
SXFRCT3THM
SWYD PCB-9 Fails To Close On Demand
SPCB009CHC
SWYD PCB-9 Closing Circuit Control Power Fails
SPCCB9CF
Page 83
Switchyard Isolate Complete Signal Fails
SPCISLTCPT
Page 14
Switchyard Isolate Signal Fails
SPCISOLATE
Page 84

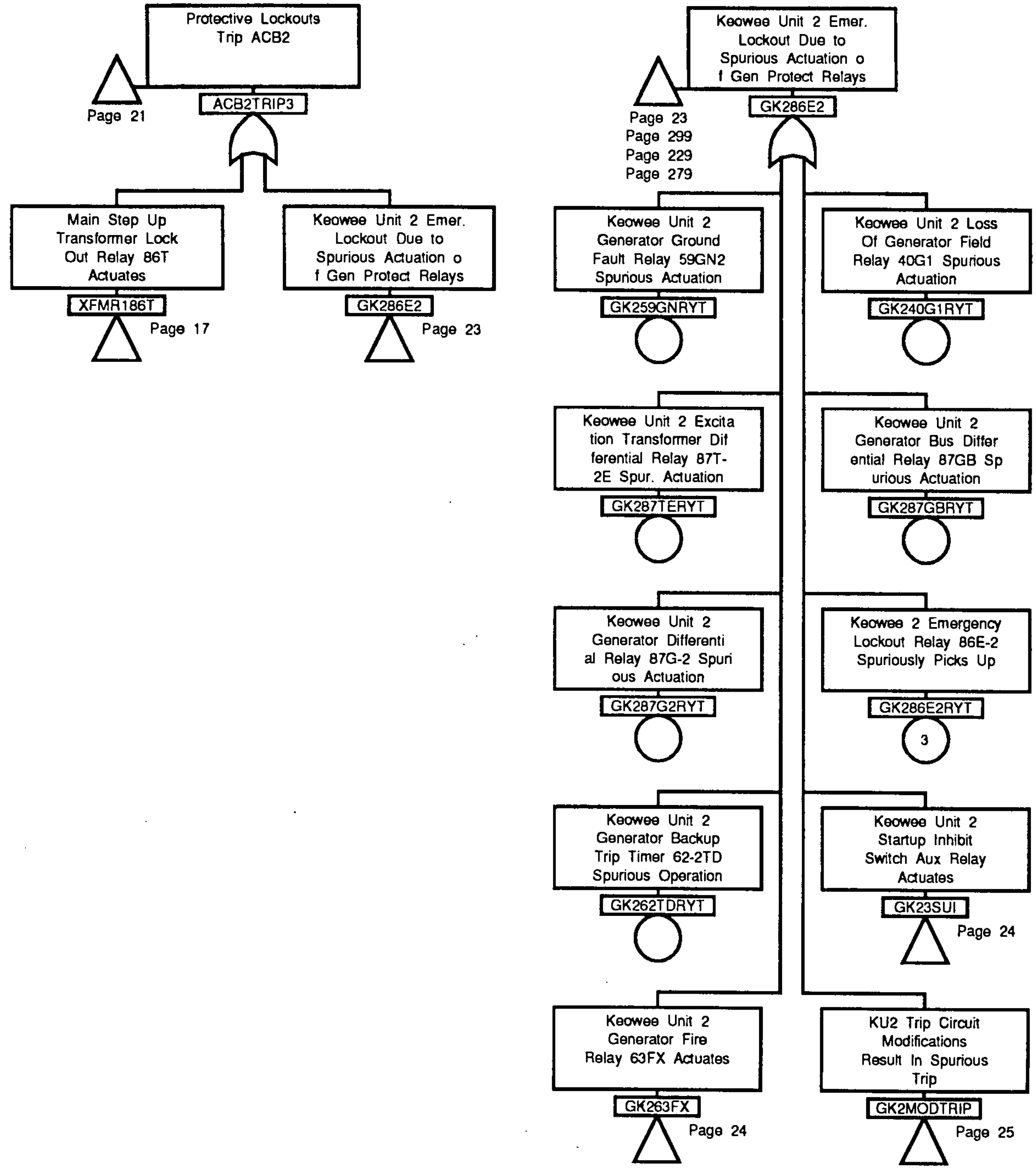

KU2 Trip Circuit Modifications Result In Spurious Trip
K2MODTRIP
Page 21
Page 299
NSM-ON-52966 Is In Service
NTACB4MOD
Page 13
KU2 Governor Failure Modifications Result In Spurious Trip
K2MODTRIP0
Auxiliary Relay 14GOV/2X Fails To Pick-up
AK2142XRYD
KU2 Magnetic Speed Switch System Fails
AK214GVDEX
2
Keowee Unit 2 Field Breaker Transfers Open
FLDTRANS2
Page 21
Page 278
Keowee Unit 2 Relay 99SY Drops Out
EK299SYRYT
Keowee Unit 2 Field Breaker Trip Control Switch Transfers Position
EK2S41TSWT
Breaker 3BR In 125V dc Distribution Center 2DA Transfers Open
ED23BR2CDT
2
Keowee Unit 2 Generator Lockout Au xiliary Relay 86EX-1 Spurious Actuation
EK286X2RYT



KU2 Trip Circuit Modifications Result In Spurious Trip
GK2MODTRIP
Page 23
NSM-ON-52966 Is In Service
NTACB4MOD
Page 13
Modified Circuit Generates Spurious Trip Signal
GMODTRIP2
Relay 12X/2 Spuriously Picks-up
GK212X2RYT
Speed Switch 12/2 Falsely Indicates High Speed
GK2O121SST
Time Delay Relay 12XTD/2 Spuriously Picks-up
GK212TDRYT
Shutdown Solenoid Trip Of ACB2
ACB2TRIP5
Page 21
Wicket Gate Limit Switch Indicates Gate Position Is Bel ow No-load Setting
AK2GATEDEX
2
Shutdown Auxiliary Relay 99SX Spuriously Drops Out s
YK299SXRYT
3



Keowee Unit 2 Generator Fire Relay 63FX Actuates
GK263FX
Page 23
Keowee Unit 2 Generator Fire Relay 63FX Spurious Actuation
GK263FXRYT
Keowee 2 Gen CO2 Sys Press Switch 63F Spurious Operation
GK2063FPST
Keowee Unit 2 Startup Inhibit Switch Aux Relay Actuates
GK23SUI
Page 23
Keowee Unit 2 Startu p Inhibit Switch Aux iliary Relay S3SUIX Spurious Actuation
GK23SUIRYT
Keowee Unit 2 Startup Inhibit Swtich 3SUI Spurious Operation
GK23SUISWT


Protective Lockouts Trip ACB2
ACB2TRIP3
Page 21
Main Step Up Transformer Lock Out Relay 86T Actuates
XFMR186T
Page 17
Keowee Unit 2 Emer. Lockout Due to Spurious Actuation o f Gen Protect Relays
GK286E2
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Keowee Unit 2 Emer. Lockout Due to Spurious Actuation o f Gen Protect Relays
GK286E2
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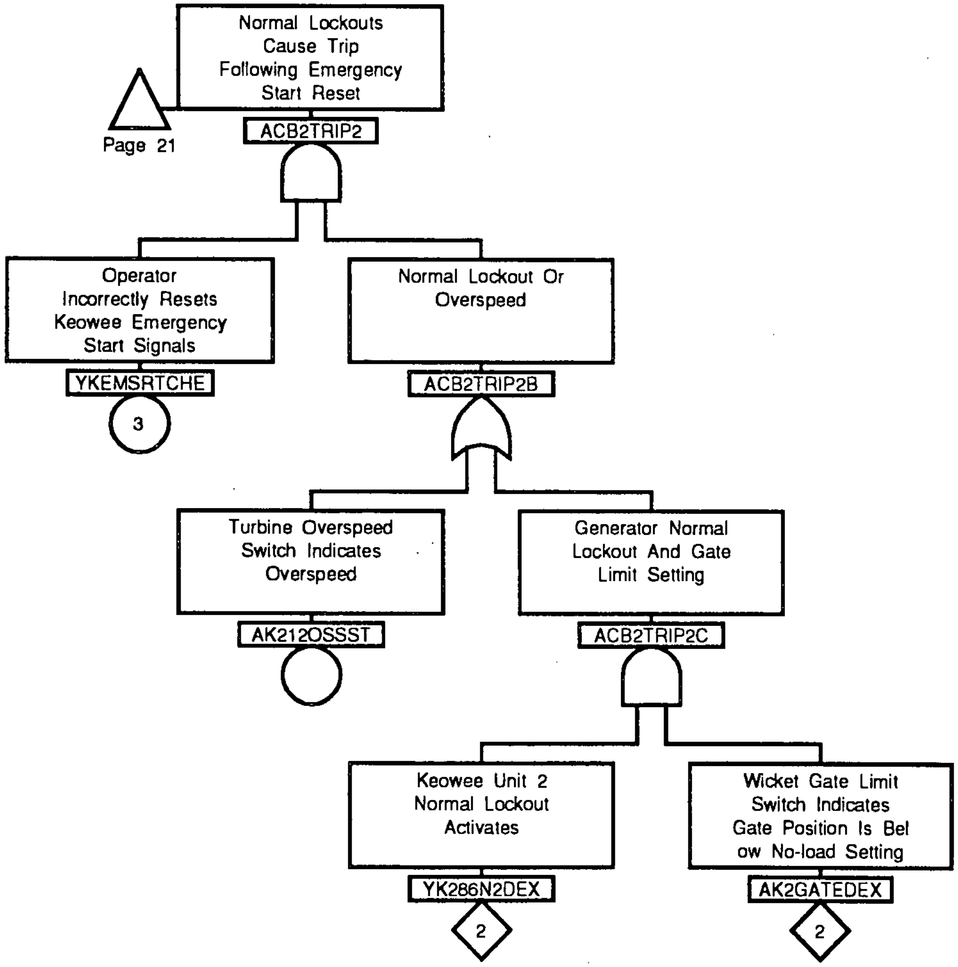
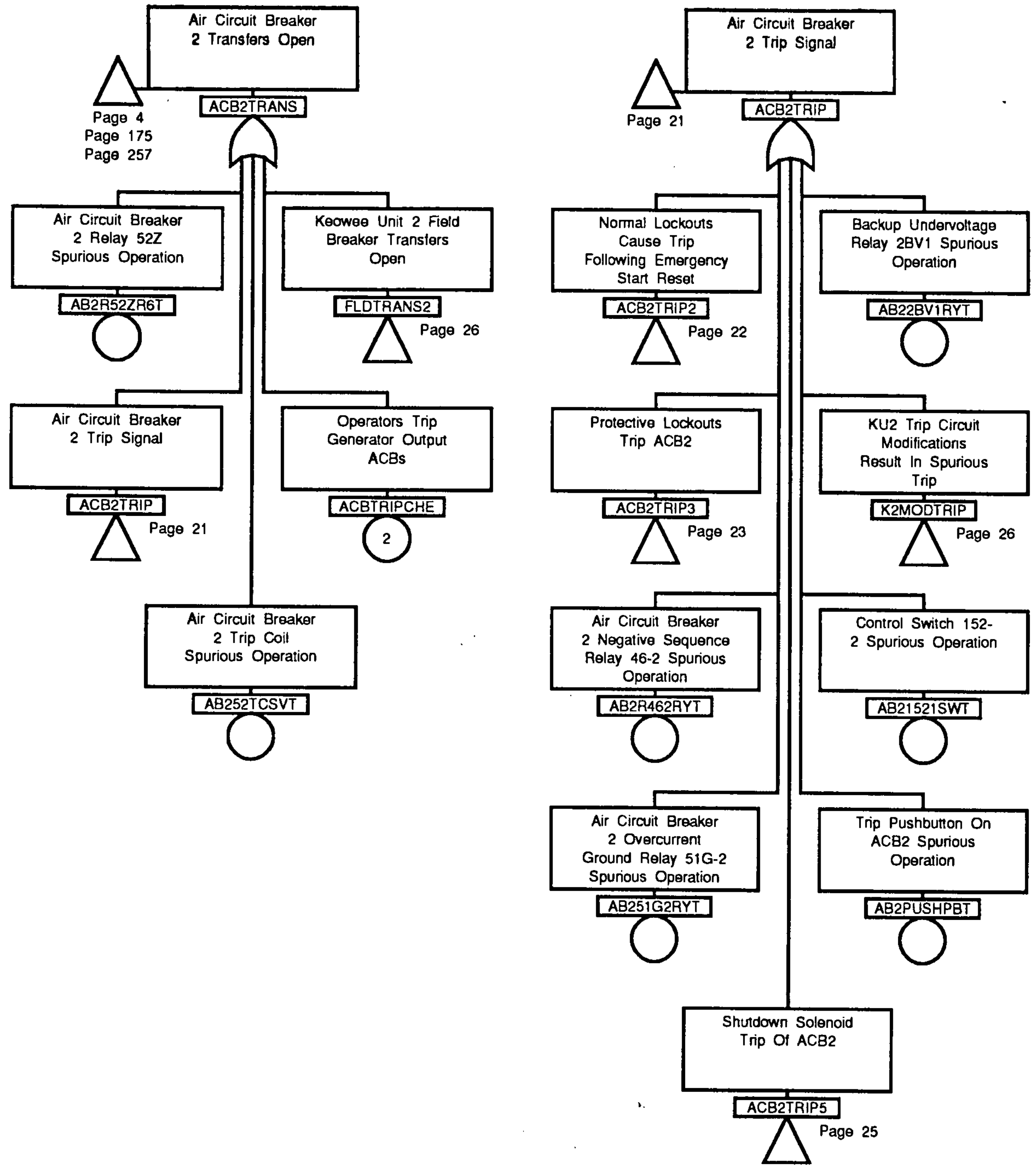
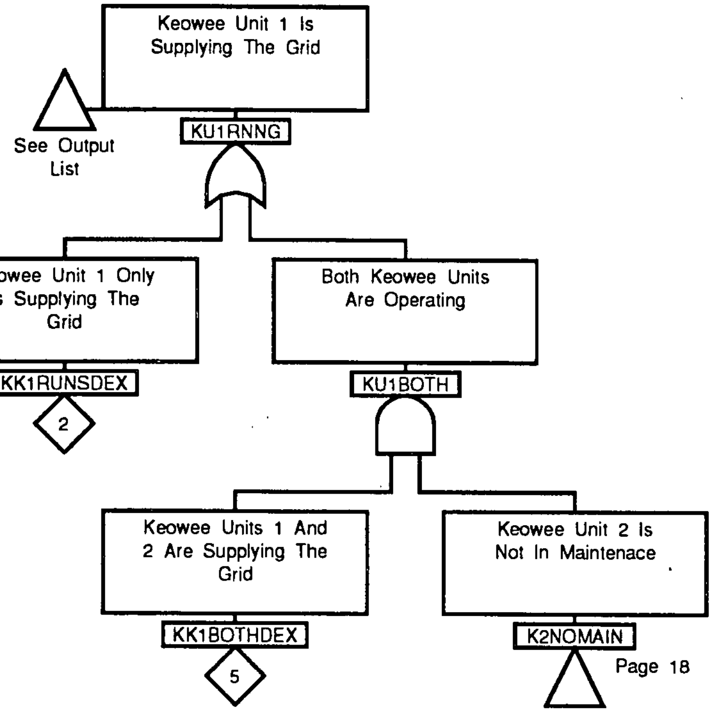
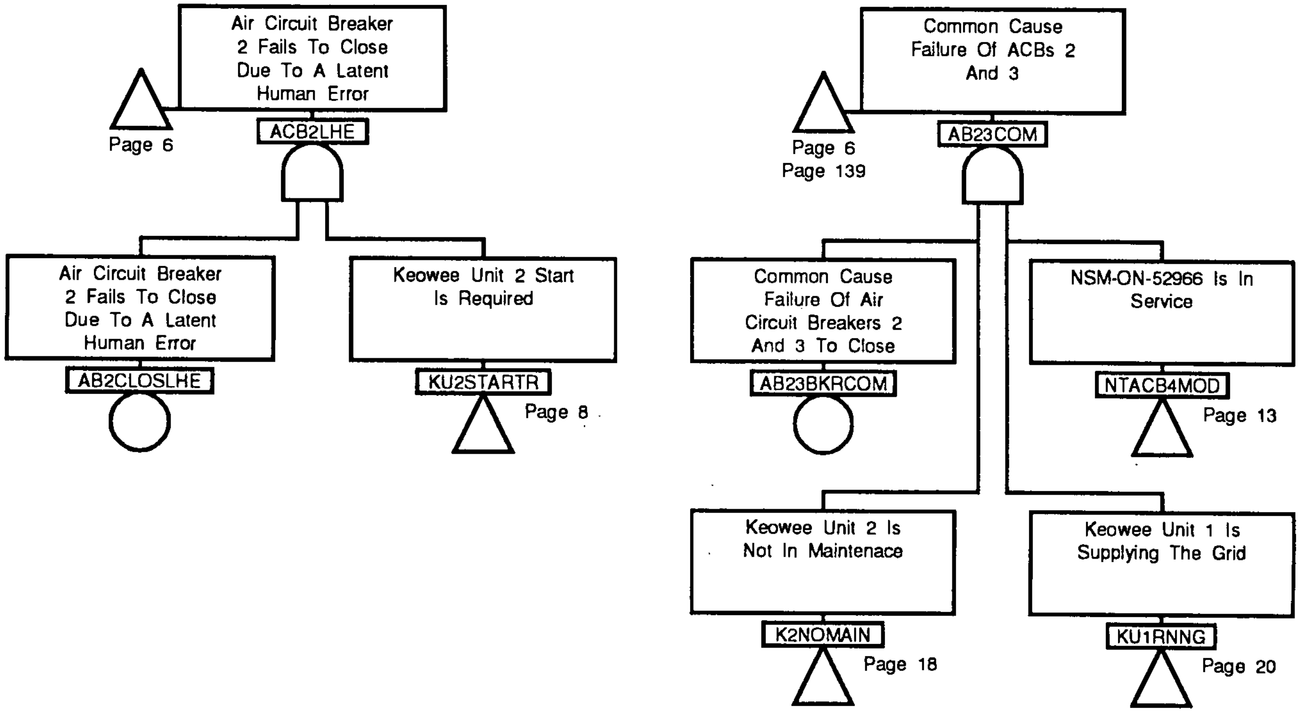
Page 279
Keowee Unit 2 Generator Ground Fault Relay 59GN2 Spurious Actuation
GK259GNRYT
Keowee Unit 2 Loss Of Generator Field Relay 40G1 Spurious Actuation
GK240G1RYT
Keowee Unit 2 Excita tion Transformer Dif ferential Relay 87T-2E Spur. Actuation
GK287TERYT
Keowee Unit 2 Generator Bus Differ ential Relay 87GB Sp urious Actuation
GK287GBRYT
Keowee Unit 2 Generator Differenti al Relay 87G-2 Spuri ous Actuation
GK287G2RYT
Keowee 2 Emergency Lockout Relay 86E-2 Spuriously Picks Up
GK286E2RYT
3
Keowee Unit 2 Generator Backup Trip Timer 62-2TD Spurious Operation
GK262TDRYT
Keowee Unit 2 Startup Inhibit Switch Aux Relay Actuates
GK23SUI
Page 24
Keowee Unit 2 Generator Fire Relay 63FX Actuates
GK263FX
Page 24
KU2 Trip Circuit Modifications Result In Spurious Trip
GK2MODTRIP
Page 25


Normal Lockouts Cause Trip Following Emergency Start Reset
ACB2TRIP2
Page 21
Operator Incorrectly Resets Keowee Emergency Start Signals
YKEMSRTCHE
3
Normal Lockout Or Overspeed
ACB2TRIP2B
Turbine Overspeed Switch Indicates Overspeed
AK212OSSST
Generator Normal Lockout And Gate Limit Setting
ACB2TRIP2C
Keowee Unit 2 Normal Lockout Activates
YK286N2DEX
2
Wicket Gate Limit Switch Indicates Gate Position Is Bel ow No-load Setting
AK2GATEDEX
2


Air Circuit Breaker 2 Transfers Open
ACB2TRANS
Page 4
Page 175
Page 257
Air Circuit Breaker 2 Relay 52Z Spurious Operation
AB2R52ZR6T
Keowee Unit 2 Field Breaker Transfers Open
FLDTRANS2
Page 26
Air Circuit Breaker 2 Trip Signal
ACB2TRIP
Page 21
Operators Trip Generator Output ACBs
ACBTRIPCHE
2
Air Circuit Breaker 2 Trip Coil Spurious Operation
AB252TCSVT
Air Circuit Breaker 2 Trip Signal
ACB2TRIP
Page 21
Normal Lockouts Cause Trip Following Emergency Start Reset
ACB2TRIP2
Page 22
Backup Undervoltage Relay 2BV1 Spurious Operation
AB22BV1RYT
Protective Lockouts Trip ACB2
ACB2TRIP3
Page 23
KU2 Trip Circuit Modifications Result In Spurious Trip
K2MODTRIP
Page 26
Air Circuit Breaker 2 Negative Sequence Relay 46-2 Spurious Operation
AB2R462RYT
Control Switch 152-2 Spurious Operation
AB21521SWT
Air Circuit Breaker 2 Overcurrent Ground Relay 51G-2 Spurious Operation
AB251G2RYT
Trip Pushbutton On ACB2 Spurious Operation
AB2PUSHPBT
Shutdown Solenoid Trip Of ACB2
ACB2TRIP5
Page 25

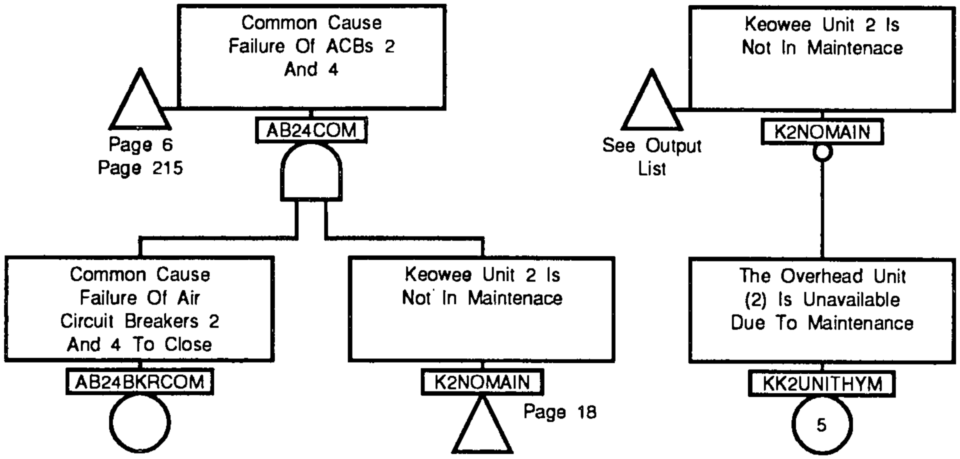
KU1RNNG Outputs:
Page 128, Page 305, Page 29, Page 19, Page 143, Page 219



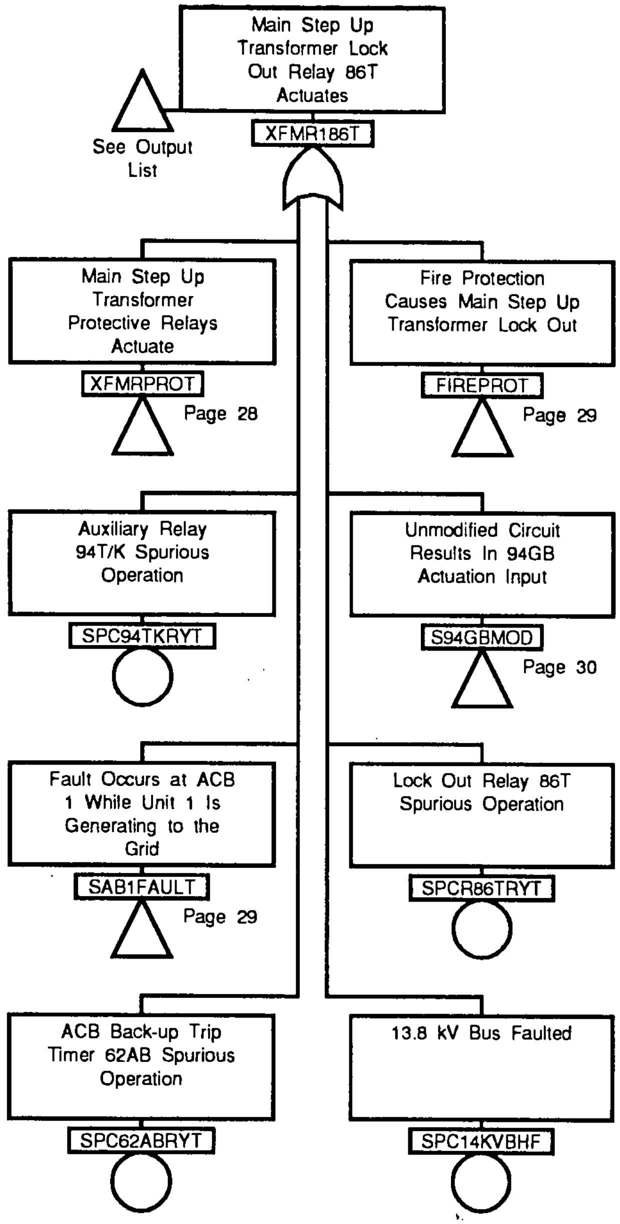


Air Circuit Breaker 2 Fails To Close Due To A Latent Human Error
ACB2LHE
Page 6
Air Circuit Breaker 2 Fails To Close Due To A Latent Human Error
AB2CLOSLHE
Keowee Unit 2 Start Is Required
KU2STARTR
Page 8
Common Cause Failure Of ACBs 2 And 3
AB23COM
Page 6
Page 139
Common Cause Failure Of Air Circuit Breakers 2 And 3 To Close
AB23BKRCOM
NSM-ON-52966 Is In Service
NTACB4MOD
Page 13
Keowee Unit 2 Is Not In Maintenace
K2NOMAIN
Page 18
Keowee Unit 1 Is Supplying The Grid
KU1RNNG
Page 20

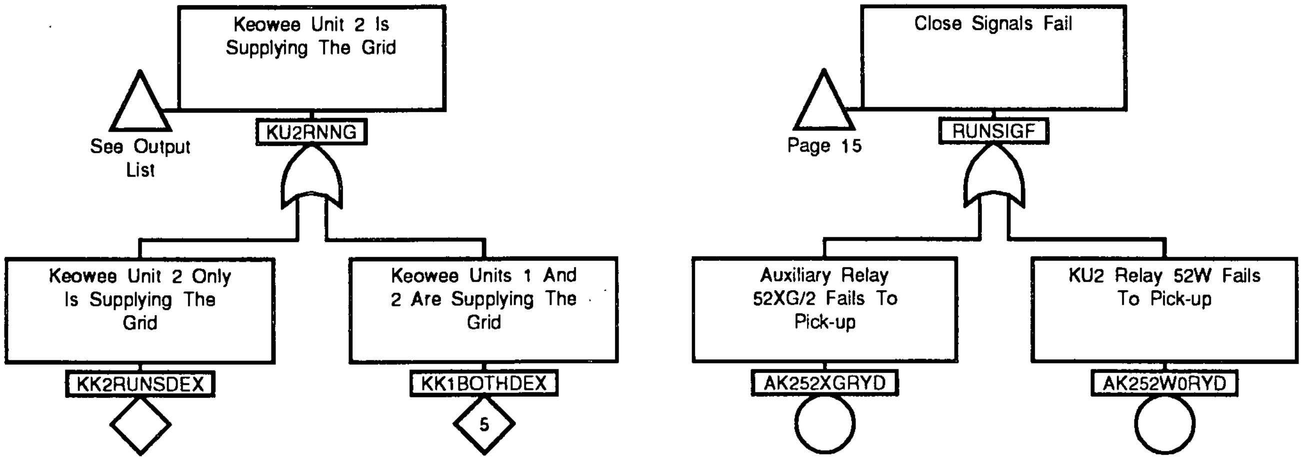
K2NOMAIN Outputs:
Page 91, Page 20, Page 302, Page 305, Page 304, Page 305, Page 300, Page 19
Page 18

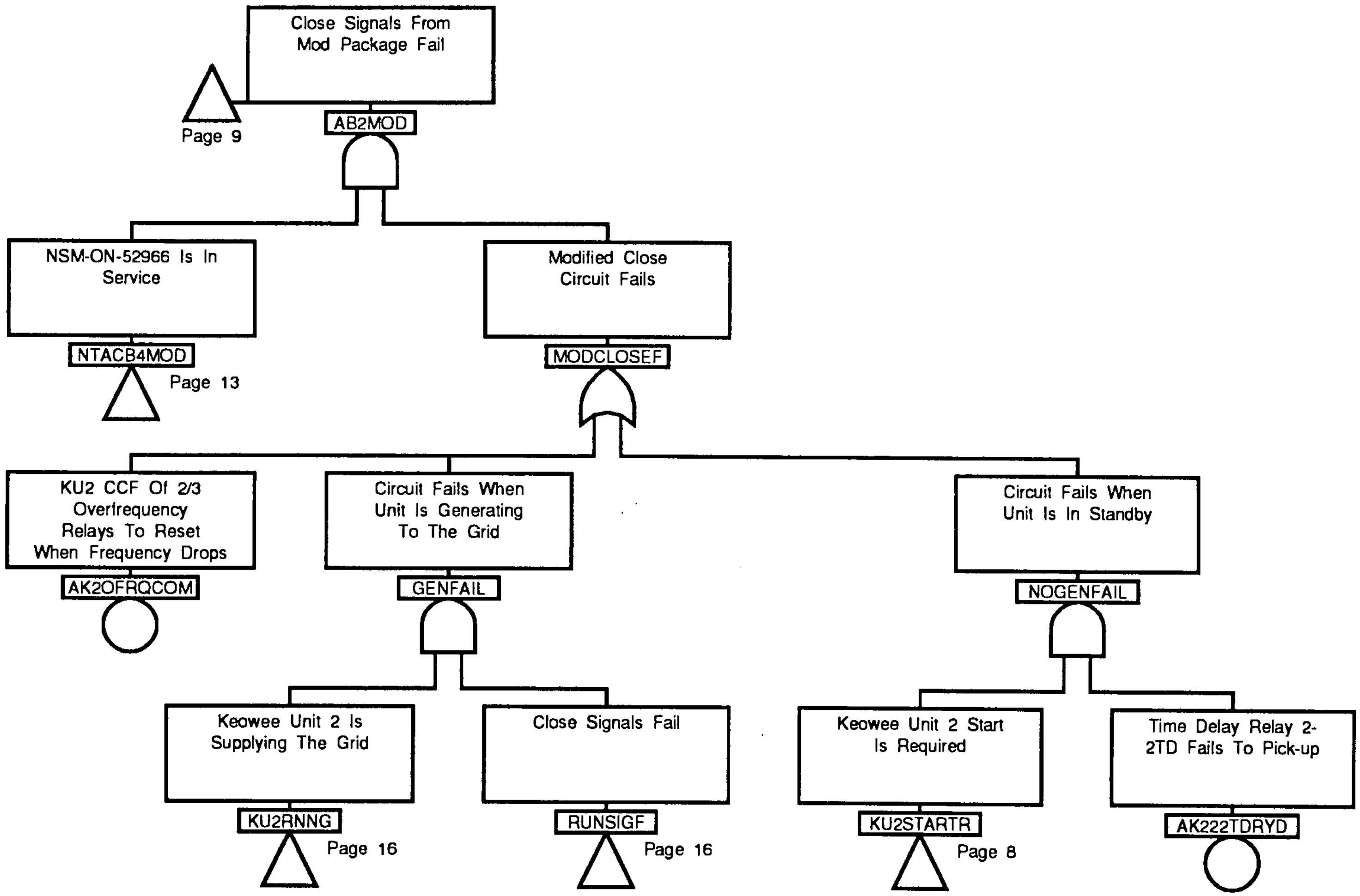


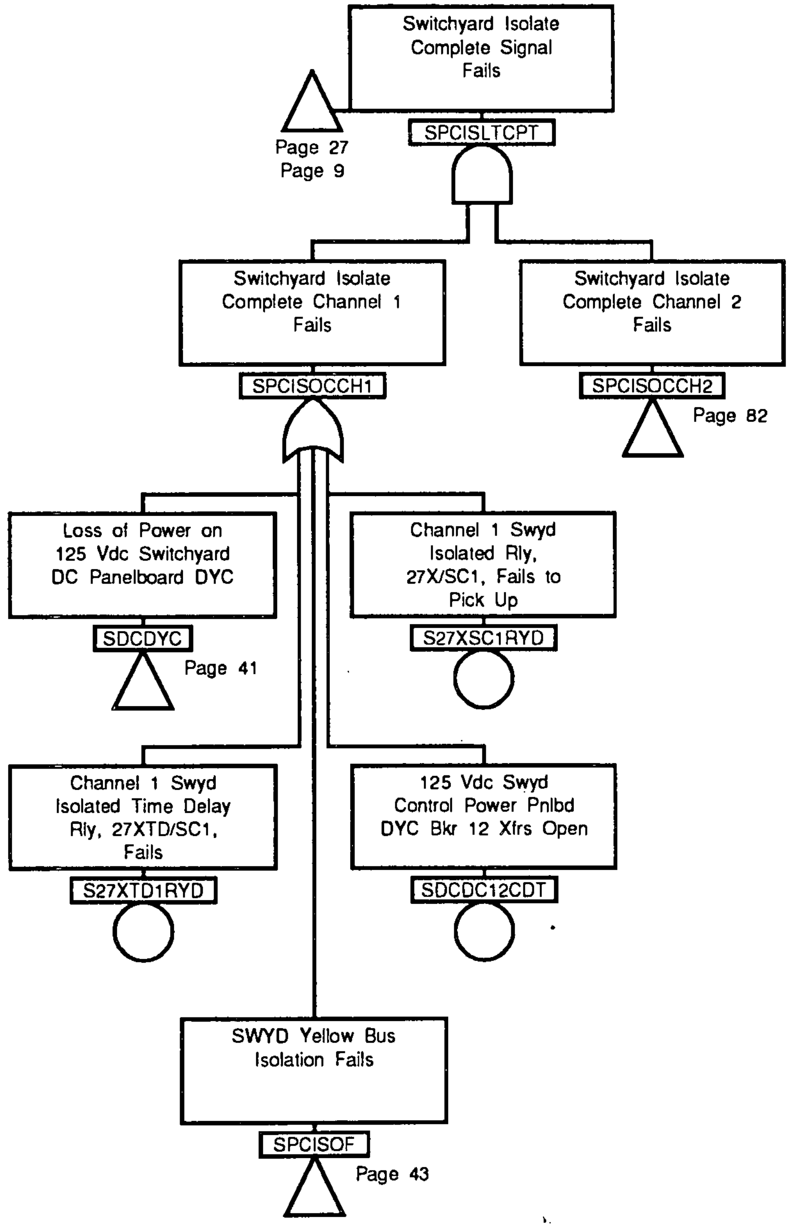
XFMR186T Outputs:
Page 28, Page 9, Page 23, Page 218, Page 177, Page 261



KU2RNNG Outputs:
Page 8, Page 5, Page 85, Page 86, Page 15




Close Signals From Mod Package Fail
AB2MOD
Page 9
NSM-ON-52966 Is In Service
NTACB4MOD
Page 13
Modified Close Circuit Fails
MODCLOSEF
KU2 CCF Of 2/3 Overfrequency Relays To Reset When Frequency Drops
AK2OFRQCOM
Circuit Fails When Unit Is Generating To The Grid
GENFAIL
Circuit Fails When Unit Is In Standby
NOGENFAIL
Keowee Unit 2 Is Supplying The Grid
KU2RNNG
Page 16
Close Signals Fail
RUNSIGF
Page 16
Keowee Unit 2 Start Is Required
KU2STARTR
Page 8
Time Delay Relay 2-2TD Fails To Pick-up
AK222TDRYD


Switchyard Isolate Complete Signal Fails
SPCISLTCPT
Page 27
Page 9
Switchyard Isolate Complete Channel 1 Fails
SPCISOCCH1
Switchyard Isolate Complete Channel 2 Fails
SPCISOCCH2
Page 82
Loss of Power on 125 Vdc Switchyard DC Panelboard DYC
SDCDYC
Page 41
Channel 1 Swyd Isolated Rly, 27X/SC1, Fails to Pick Up
S27XSC1RYD
Channel 1 Swyd Isolated Time Delay Rly, 27XTD/SC1, Fails
S27XTD1RYD
125 Vdc Swyd Control Power Pnlbd DYC Bkr 12 Xfrs Open
SDCDC12CDT
SWYD Yellow Bus Isolation Fails
SPCISOF
Page 43

NTACB4MOD Outputs:
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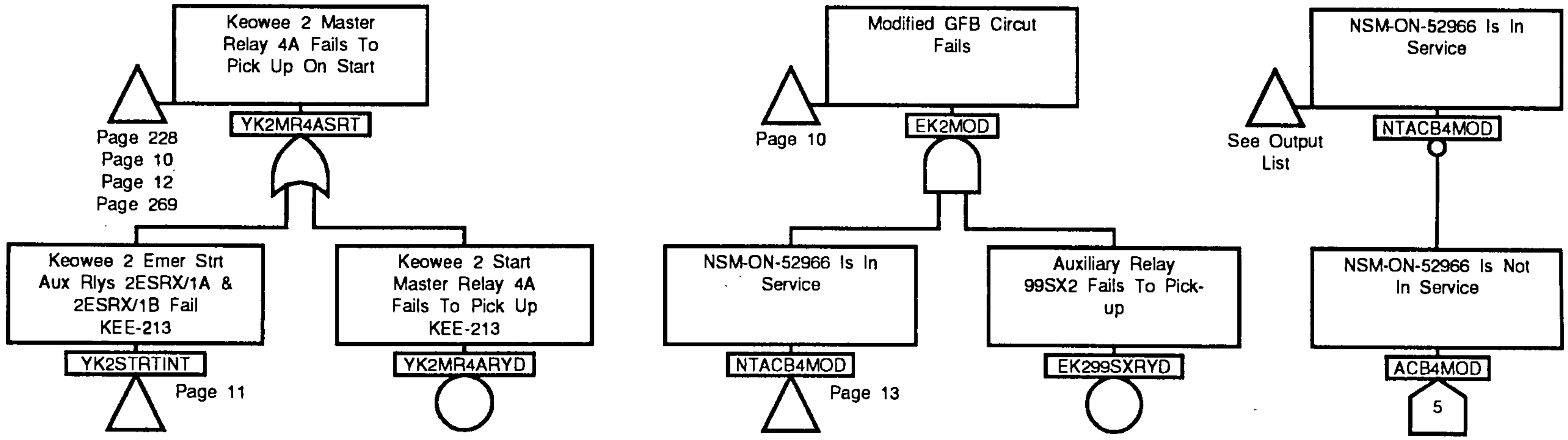
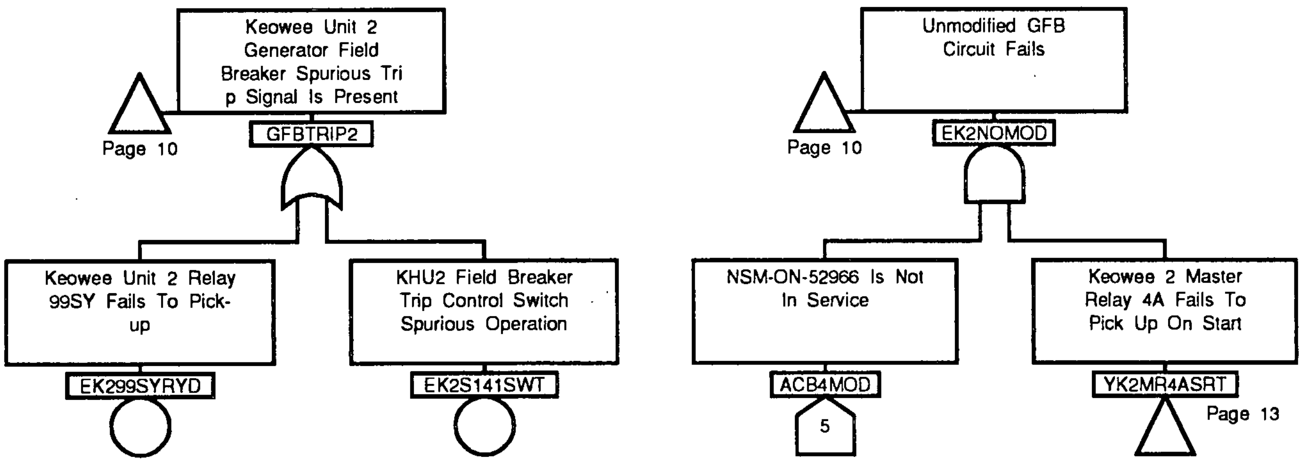
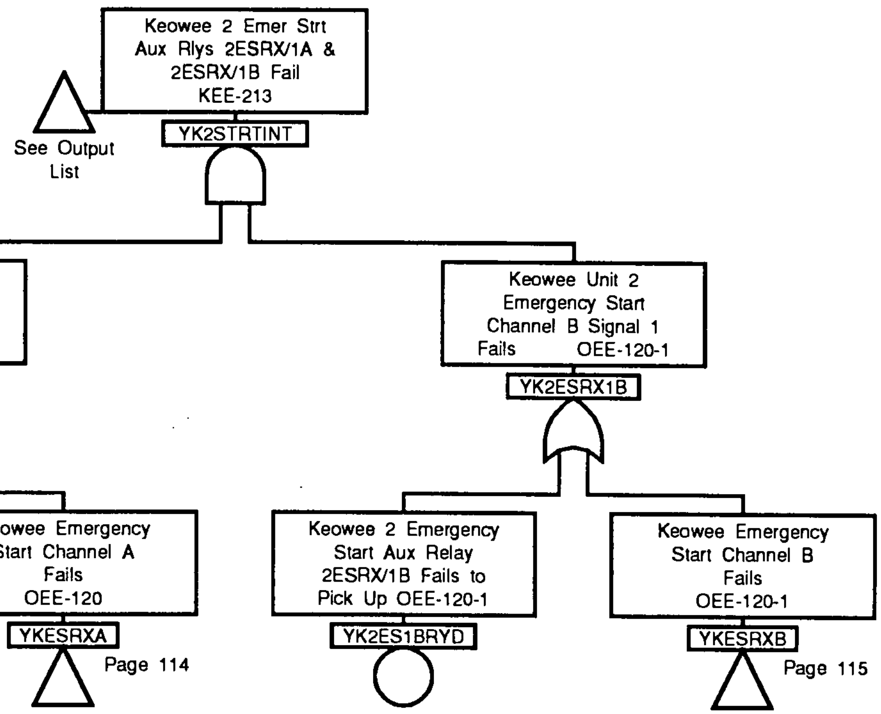
Page 13, Page 220, Page 25

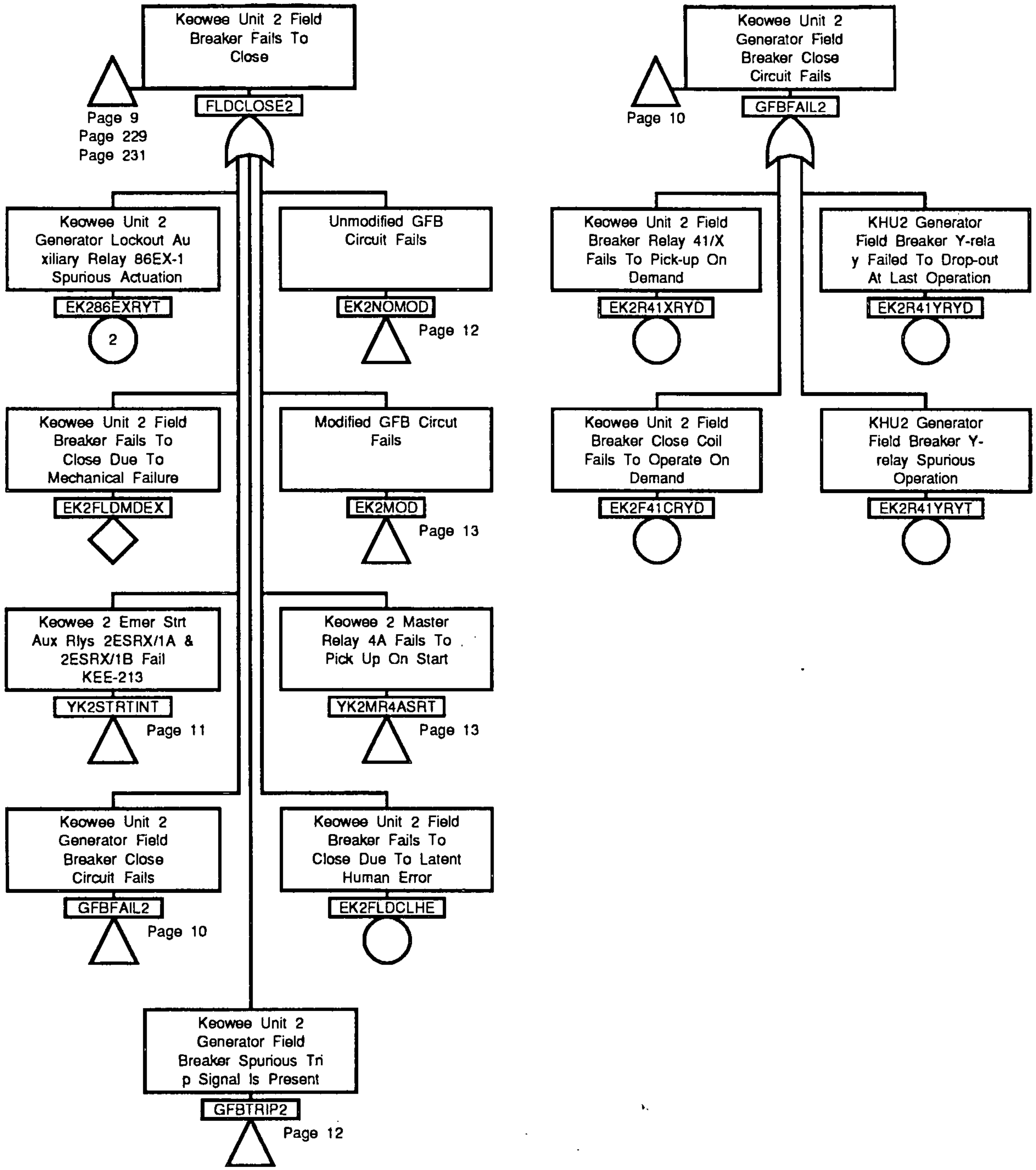




Keowee Unit 2 Generator Field Breaker Spurious Tri p Signal Is Present
GFBTRIP2
Page 10
Keowee Unit 2 Relay 99SY Fails To Pick-up
EK299SYRYD
KHU2 Field Breaker Trip Control Switch Spurious Operation
EK2S141SWT
Unmodified GFB Circuit Fails
EK2NOMOD
Page 10
NSM-ON-52966 Is Not In Service
ACB4MOD
5
Keowee 2 Master Relay 4A Fails To Pick Up On Start
YK2MR4ASRT
Page 13

YK2STRTINT Outputs:
Page 235, Page 13, Page 222, Page 87, Page 10, Page 231





Keowee Unit 2 Field Breaker Fails To Close
FLDCLOSE2
Page 9
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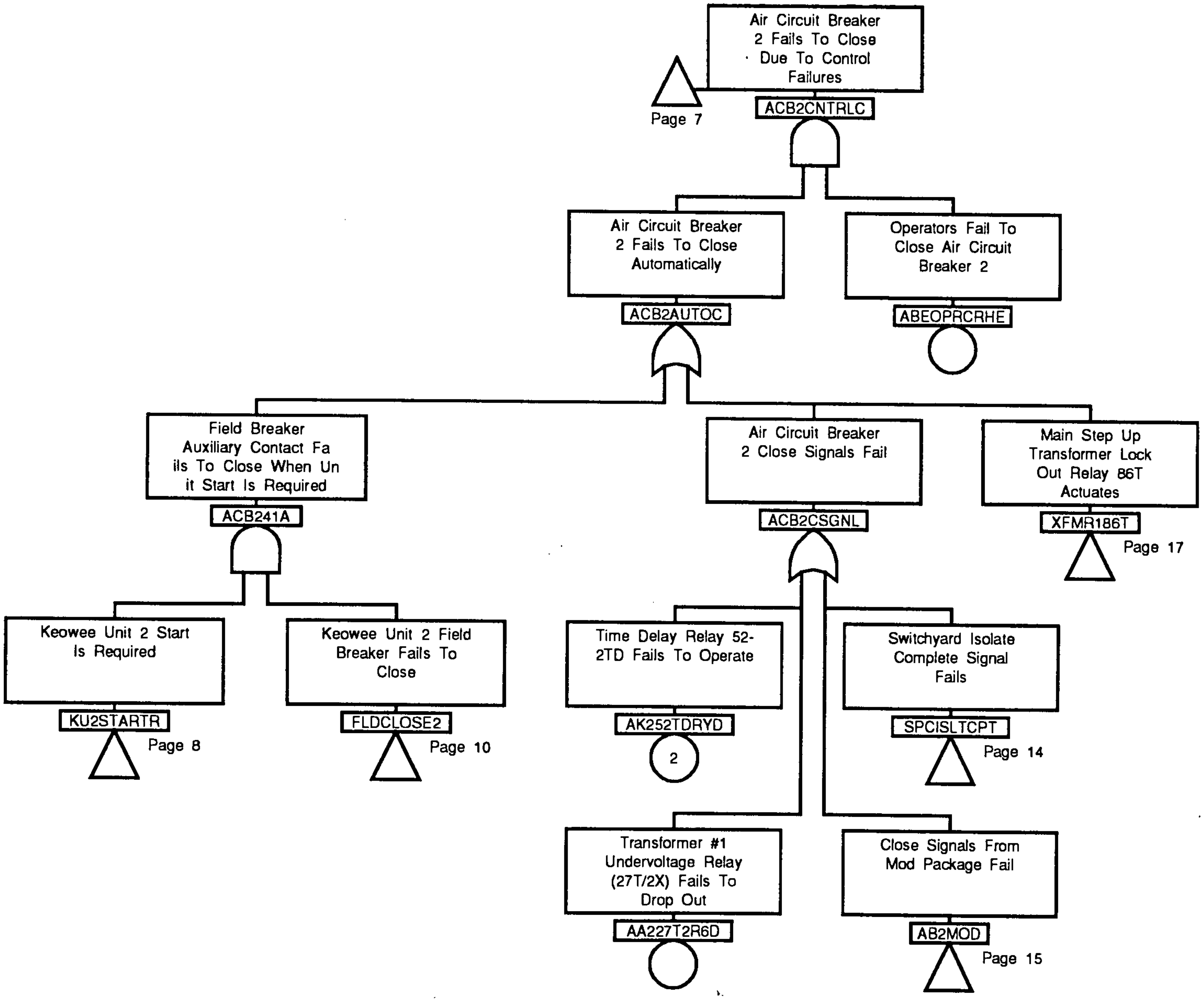
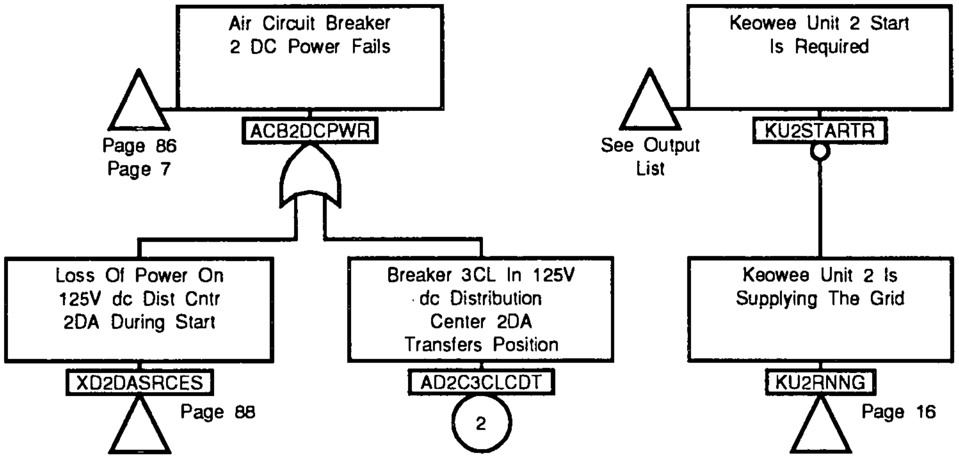
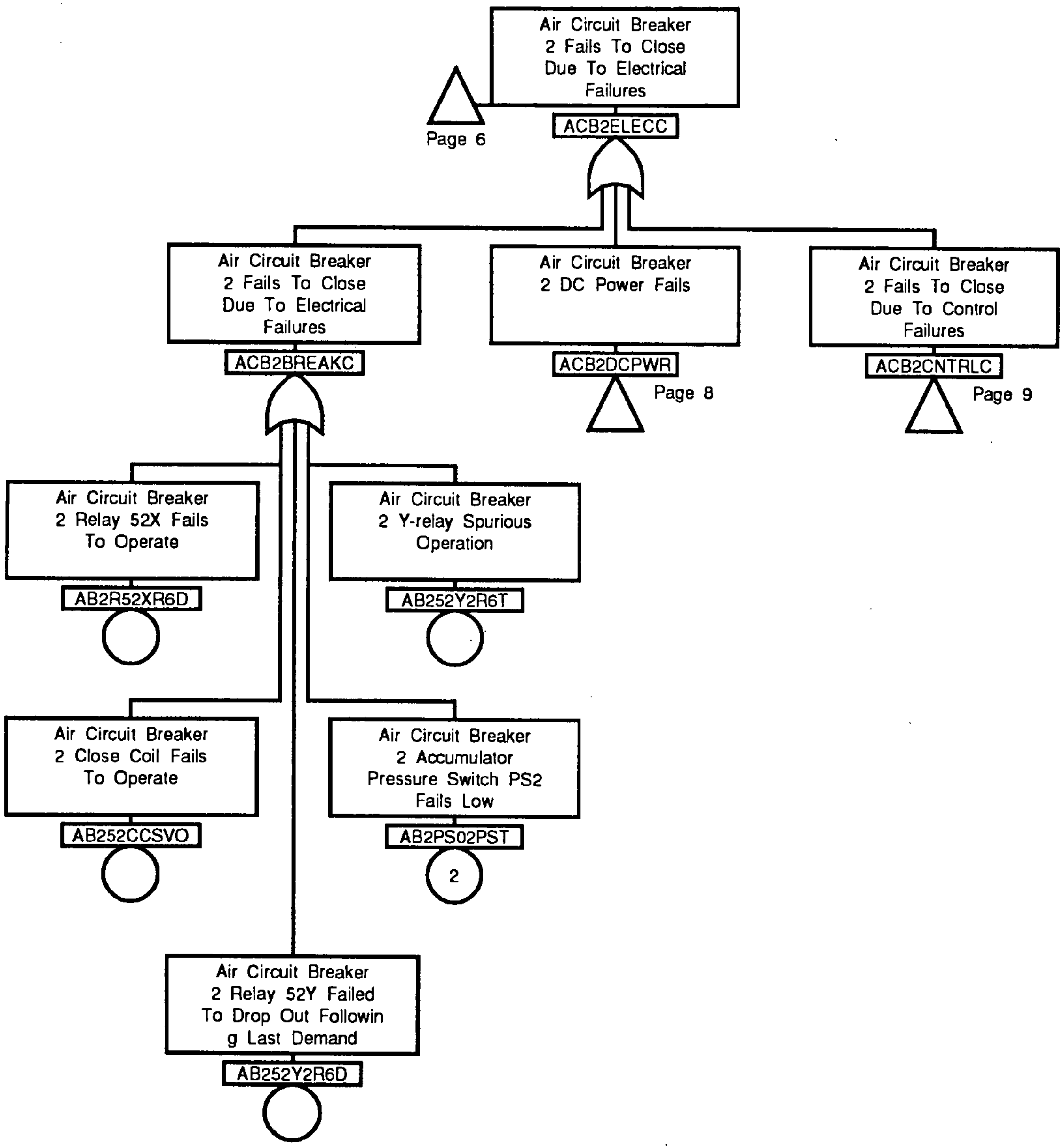
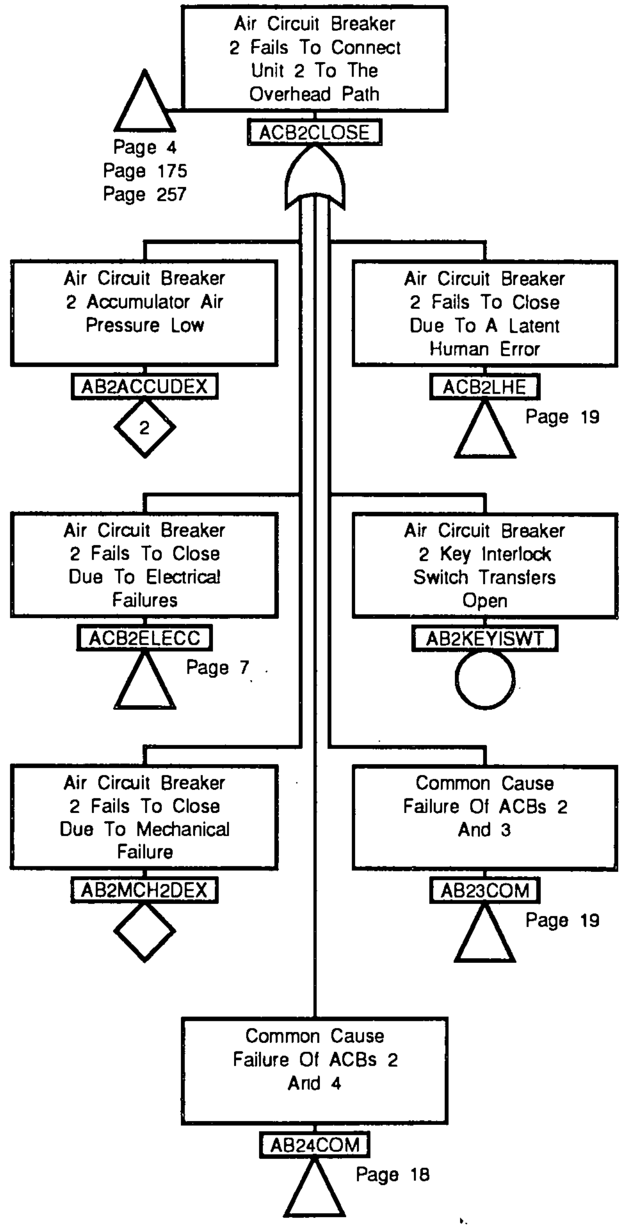
Page 231
Keowee Unit 2 Generator Field Breaker Close Circuit Fails
GFBFAIL2
Page 10
Keowee Unit 2 Generator Lockout Au xiliary Relay 86EX-1 Spurious Actuation
EK286EXRYT
2
Unmodified GFB Circuit Fails
EK2NOMOD
Page 12
Keowee Unit 2 Field Breaker Relay 41/X Fails To Pick-up On Demand
EK2R41XRYD
KHU2 Generator Field Breaker Y-rela y Failed To Drop-out At Last Operation
EK2R41YRYD
Keowee Unit 2 Field Breaker Fails To Close Due To Mechanical Failure
EK2FLDMDEX
Modified GFB Circut Fails
EK2MOD
Page 13
Keowee Unit 2 Field Breaker Close Coil Fails To Operate On Demand
EK2F41CRYD
KHU2 Generator Field Breaker Y-relay Spurious Operation
EK2R41YRYT
Keowee 2 Emer Strt Aux Rlys 2ESRX/1A & 2ESRX/1B Fail KEE-213
YK2STRTINT
Page 11
Keowee 2 Master Relay 4A Fails To Pick Up On Start
YK2MR4ASRT
Page 13
Keowee Unit 2 Generator Field Breaker Close Circuit Fails
GFBFAIL2
Page 10
Keowee Unit 2 Field Breaker Fails To Close Due To Latent Human Error
EK2FLDCLHE
Keowee Unit 2 Generator Field Breaker Spurious Tri p Signal Is Present
GFBTRIP2
Page 12

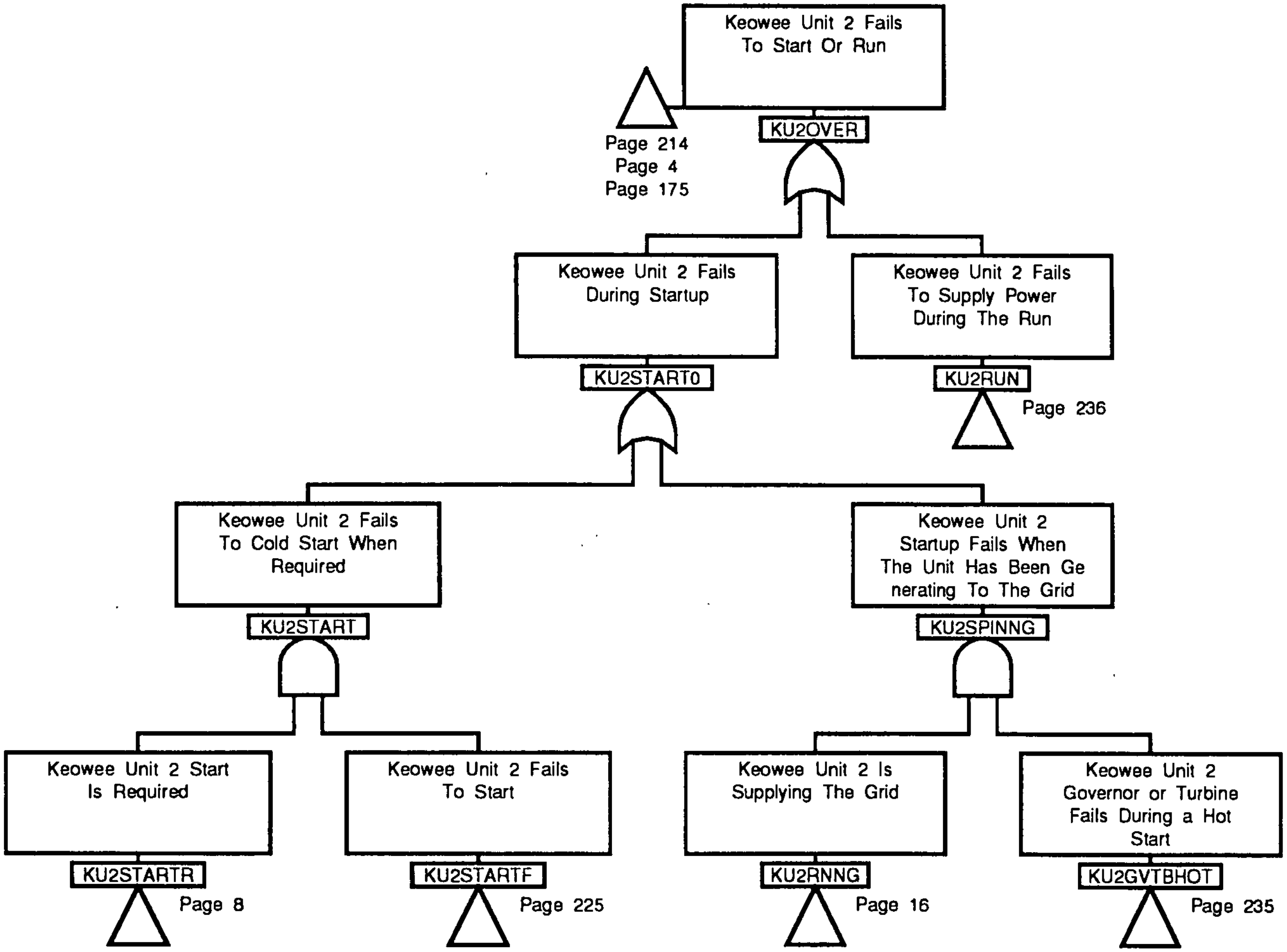


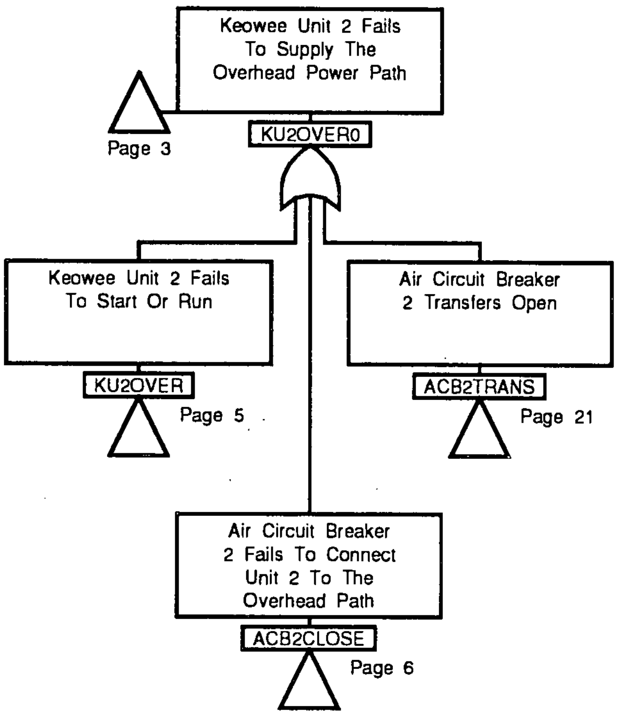
Air Circuit Breaker 2 Fails To Close Due To Control Failures
ACB2CNTRLC
Page 7
Air Circuit Breaker 2 Fails To Close Automatically
ACB2AUTOC
Operators Fail To Close Air Circuit Breaker 2
ABEOPRCRHE
Field Breaker Auxiliary Contact Fa ils To Close When Un it Start Is Required
ACB241A
Air Circuit Breaker 2 Close Signals Fail
ACB2CSGNL
Main Step Up Transformer Lock Out Relay 86T Actuates
XFMR186T
Page 17
Keowee Unit 2 Start Is Required
KU2STARTR
Page 8
Keowee Unit 2 Field Breaker Fails To Close
FLDCLOSE2
Page 10
Time Delay Relay 52-2TD Fails To Operate
AK252TDRYD
2
Switchyard Isolate Complete Signal Fails
SPCISLTCPT
Page 14
Transformer #1 Undervoltage Relay (27T/2X) Fails To Drop Out
AA227T2R6D
Close Signals From Mod Package Fail
AB2MOD
Page 15

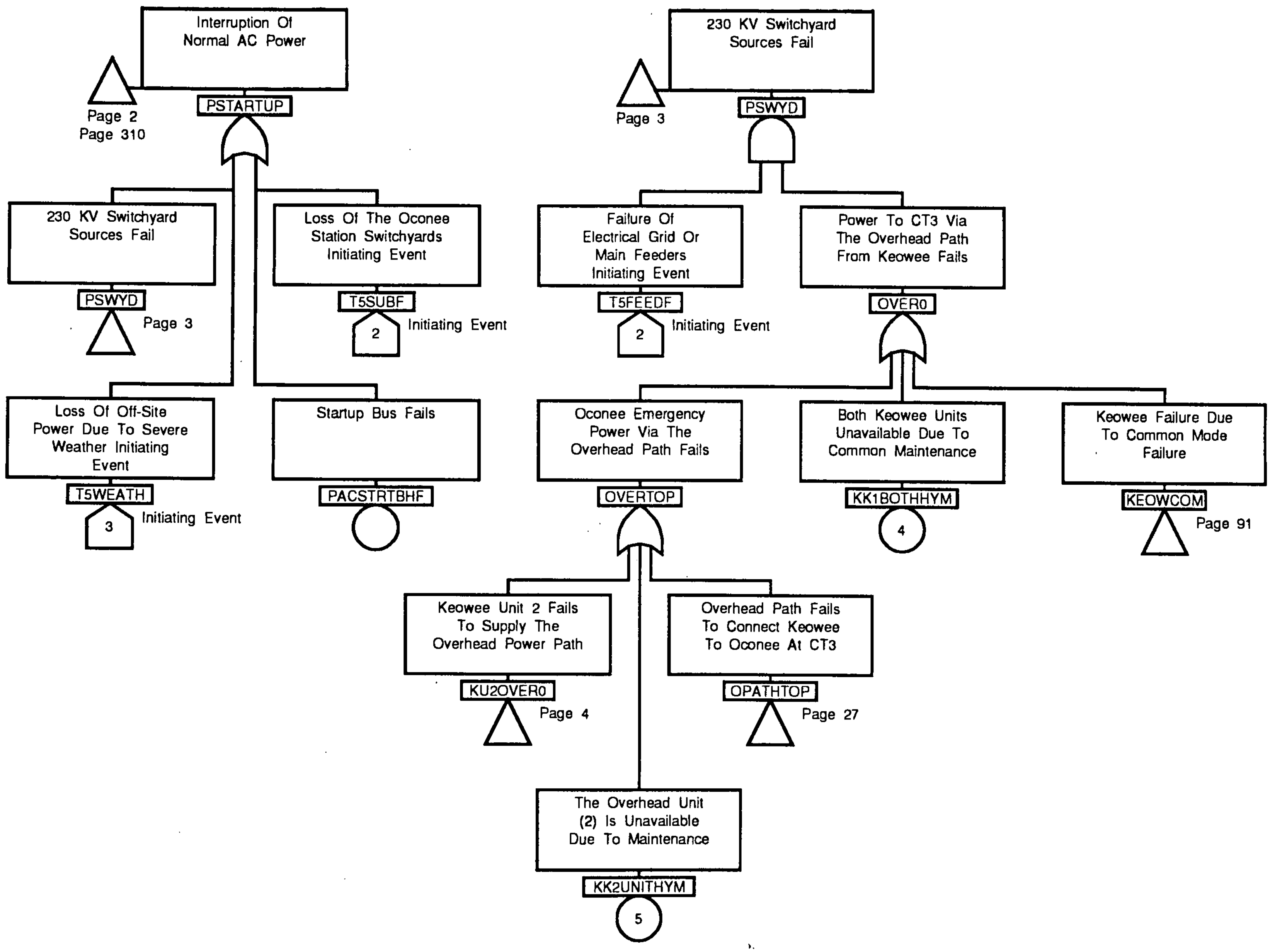

Air Circuit Breaker 2 DC Power Fails
ACB2DCPWR
Page 86
Page 7
Loss Of Power On 125V dc Dist Cntr 2DA During Start
XD2DASRCES
Page 88
Breaker 3CL In 125V dc Distribution Center 2DA Transfers Position
AD2C3CLCDT
2
Keowee Unit 2 Start Is Required
KU2STARTR
See Output List
Keowee Unit 2 Is Supplying The Grid
KU2RNNG
Page 16


Air Circuit Breaker 2 Fails To Close Due To Electrical Failures
ACB2ELECC
Page 6
Air Circuit Breaker 2 Fails To Close Due To Electrical Failures
ACB2BREAKC
Air Circuit Breaker 2 DC Power Fails
ACB2DCPWR
Page 8
Air Circuit Breaker 2 Fails To Close Due To Control Failures
ACB2CNTRLC
Page 9
Air Circuit Breaker 2 Relay 52X Fails To Operate
AB2R52XR6D
Air Circuit Breaker 2 Y-relay Spurious Operation
AB252Y2R6T
Air Circuit Breaker 2 Close Coil Fails To Operate
AB252CCSVO
Air Circuit Breaker 2 Accumulator Pressure Switch PS2 Fails Low
AB2PS02PST
2
Air Circuit Breaker 2 Relay 52Y Failed To Drop Out Followin g Last Demand
AB252Y2R6D

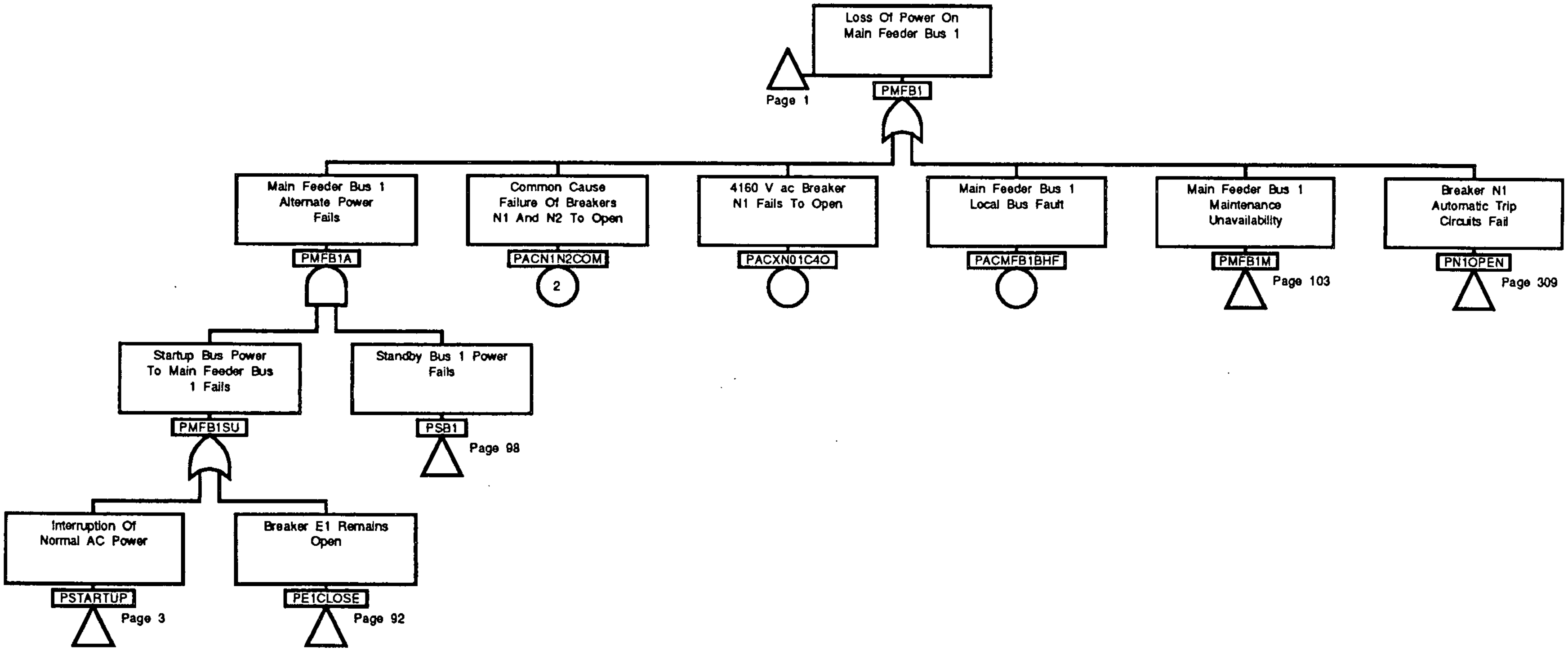

Air Circuit Breaker 2 Fails To Connect Unit 2 To The Overhead Path
ACB2CLOSE
Page 4
Page 175
Page 257
Air Circuit Breaker 2 Accumulator Air Pressure Low
AB2ACCUDEX
2
Air Circuit Breaker 2 Fails To Close Due To A Latent Human Error
ACB2LHE
Page 19
Air Circuit Breaker 2 Fails To Close Due To Electrical Failures
ACB2ELECC
Page 7
Air Circuit Breaker 2 Key Interlock Switch Transfers Open
AB2KEYISWT
Air Circuit Breaker 2 Fails To Close Due To Mechanical Failure
AB2MCH2DEX
Common Cause Failure Of ACBs 2 And 3
AB23COM
Page 19
Common Cause Failure Of ACBs 2 And 4
AB24COM
Page 18


Keowee Unit 2 Fails To Start Or Run
KU2OVER
Page 214
Page 4
Page 175
Keowee Unit 2 Fails During Startup
KU2START0
Keowee Unit 2 Fails To Supply Power During The Run
KU2RUN
Page 236
Keowee Unit 2 Fails To Cold Start When Required
KU2START
Keowee Unit 2 Startup Fails When The Unit Has Been Ge nerating To The Grid
KU2SPINNG
Keowee Unit 2 Start Is Required
KU2STARTR
Page 8
Keowee Unit 2 Fails To Start
KU2STARTF
Page 225
Keowee Unit 2 Is Supplying The Grid
KU2RNNG
Page 16
Keowee Unit 2 Governor or Turbine Fails During a Hot Start
KU2GVTBHOT
Page 235

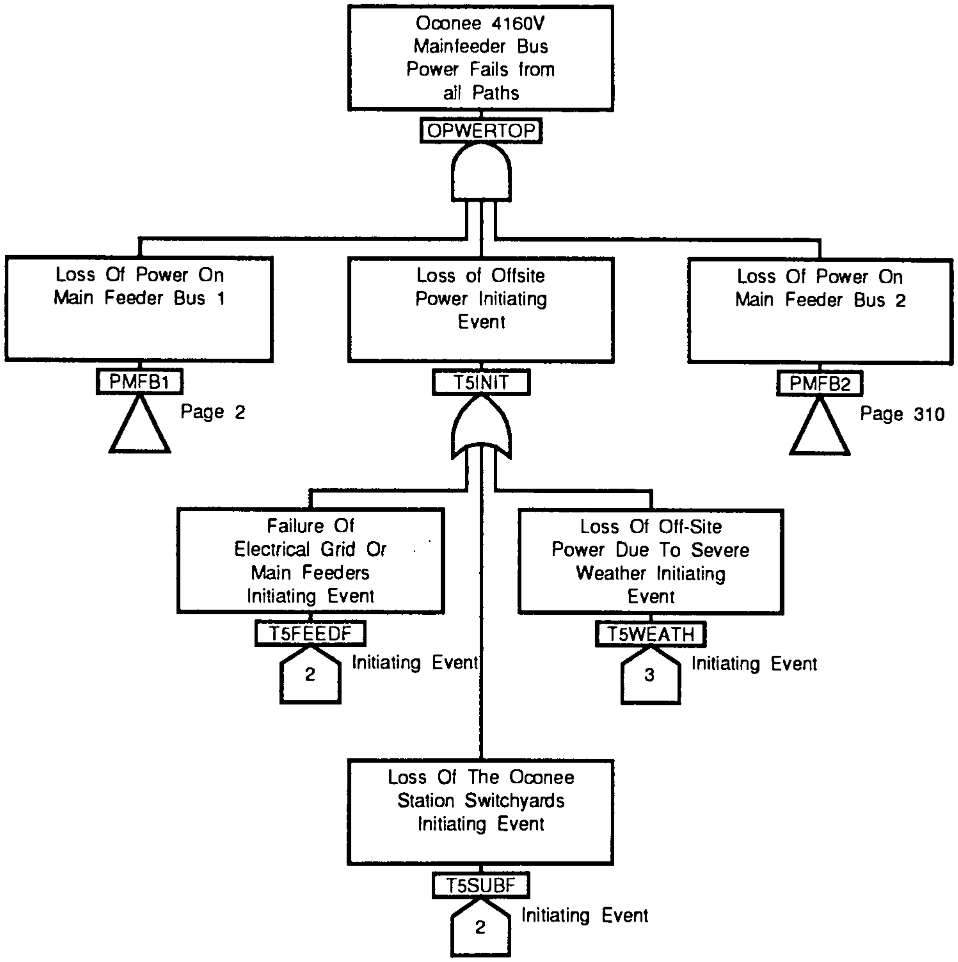

Keowee Unit 2 Fails To Supply The Overhead Power Path
Page 3
KU2OVER0
Keowee Unit 2 Fails To Start Or Run
KU2OVER
Page 5
Air Circuit Breaker 2 Transfers Open
ACB2TRANS
Page 21
Air Circuit Breaker 2 Fails To Connect Unit 2 To The Overhead Path
ACB2CLOSE
Page 6



ONS-Keowee AC Power Integrated Model | FIGURE G-1 |



Loss Of Power On Main Feeder Bus 1
Page 1
PMFB1
Main Feeder Bus 1 Alternate Power Fails
PMFB1A
Common Cause Failure Of Breakers N1 And N2 To Open
PACN1N2COM
2
4160 V ac Breaker N1 Fails To Open
PACXN01C4O
Main Feeder Bus 1 Local Bus Fault
PACMFB1BHF
Main Feeder Bus 1 Maintenance Unavailability
PMFB1M
Page 103
Breaker N1 Automatic Trip Circuits Fail
PN1OPEN
Page 309
Startup Bus Power To Main Feeder Bus 1 Fails
PMFB1SU
Standby Bus 1 Power Fails
PSB1
Page 98
Interruption Of Normal AC Power
PSTARTUP
Page 3
Breaker E1 Remains Open
PE1CLOSE
Page 92


Oconee 4160V Mainfeeder Bus Power Fails from all Paths
OPWERTOP
Loss Of Power On Main Feeder Bus 1
PMFB1
Page 2
Loss of Offsite Power Initiating Event
T5INIT
Loss Of Power On Main Feeder Bus 2
PMFB2
Page 310
Failure Of Electrical Grid Or Main Feeders Initiating Event
T5FEEDF
2
Initiating Event
Loss Of Off-Site Power Due To Severe Weather Initiating Event
T5WEATH
3
Initiating Event
Loss Of The Oconee Station Switchyards Initiating Event
T5SUBF
2
Initiating Event

LIST OF FIGURES

APPENDIX G
KEOWEE RELIABILITY ANALYSIS
OCONEE-KEOWEE AC POWER
INTEGRATED MODEL

Table 7.2-1

Keowee Emergency Power Failure Probability

Model Configuration	Failure Probability
Base Case (Failure of Keowee through both the underground path and the overhead path (Bayesian-updated data)	7.4E-03
Bayesian Updated Data Without Operator Recoveries	1.0E-02
Generic Data Without Operator Recoveries	1.3E-02

Table 7.2-2

Top 100 Cut Sets From The Keowee Emergency Power Model

Module/Event	Description	Rate	Exposure	Prob.	Cs Prob.
1) KEOWTOP					*7.35E-03
1) KK1BOTHHYM	Both Keowee Units Unavailable Due To Common Maintenance		5.23E-3	5.23E-03	5.23E-03
2)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	3.22E-04
AB0SWGRCOM	Common Cause Failure Of All Keowee Auxiliary Power Breakers		6.69E-04	6.69E-04	
AB0SWGRRHE	Recovery of Keowee Aux Power Breakers by Manual Control		5.0E-01	5.00E-01	
3)-XA1XAALBLM	MCC 1XA Is Connected to Its Alternate Source of Power		2.74E-03	2.74E-03	2.66E-04
-AD1B4ALCDT	Breaker 4AL In 125 V dc Distribution Center 1DA Transfers Open	7.5E-08	30	2.25E-06	
-AB7OPENLHE	Air Circuit Breaker 7 Fails To Open Due To A Latent Human Error		3.20E-3	3.20E-03	
-AB7MECHDEX	Air Circuit Breaker 7 Fails To Open Due To Mechanical Failure		8.01E-04	8.01E-04	
-AB752TCRYD	Air Circuit Breaker 7 Trip Coil TC Fails On Demand	3.3E-05	1	3.30E-05	
-AB710AFFUF	One Or More Air Circuit Breaker 7 Control Power Fuses Fail	3.6E-06	6	2.16E-05	
-AB51431SWT	Manual/Auto Control Switch 143/1 Spuriously Transfers Into Manual	7.0E-08	360	2.52E-05	
-AB51431LHE	Manual/Auto Control Switch 143/1 Left In Manual		3.20E-4	3.20E-04	
-AA227X2RYD	Auxiliary Relay 27X/2X Fails To Operate On Demand	3.3E-05	1	3.30E-05	
-AA127X2R6D	Transformer CX Undervoltage Relay 27/CX1 Fails To Drop Out	2.49E-04	1	2.49E-04	
AB7MCH2DEX	Air Circuit Breaker 7 Fails To Close Due To Mechanical Failure		7.04E-03	7.04E-03	
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
4)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	1.55E-04
FK0FISHCOM	Common Cause Failure Of Both Unit s WL Filters Due To Intake Debris		2.55E-3	2.55E-03	
FK0FISHDHE	Recovery of Main WL Strainer Clogging		6.3E-02	6.30E-02	
5)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	1.19E-04
EK00RUNCOM	Common Cause Failure Of Both Units Voltage Regulators To Run		1.24E-4	1.24E-04	
6) EK1VREGDEX	KHU-1 Voltage Adjust Failure Drives Generator Output Too High/Low		2.47E-3	2.47E-03	9.39E-05
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
7) GK10001HGR	Keowee Unit 1 Generator Fault While the Unit Runs	9.46E-05	24	2.27E-03	8.63E-05
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
8)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	5.58E-05
-KK2RUNSDEX	Keowee Unit 2 Only Is Supplying The Grid		0.06	6.00E-02	
-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	
-KK1BOTHDEX	Keowee Units 1 And 2 Are Supplying The Grid		0.0	0.00E+00	
EKSTARTCOM	Common Cause Failure Of Both Units Voltage Regulators To Start		6.17E-5	6.17E-05	
9)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	4.80E-05
-KK2RUNSDEX	Keowee Unit 2 Only Is Supplying The Grid		0.06	6.00E-02	
-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	
-KK1BOTHDEX	Keowee Units 1 And 2 Are Supplying The Grid		0.0	0.00E+00	
E12EXCTCOM	Units 1 & 2 Excit Fail Due To Common Cause Failure Of The Breakers		5.31E-05	5.31E-05	
10) EK1BAS2DEX	KHU-1 Base Adjust Fails To Maintain Generator Output Within Acceptable R		1.24E-3	1.24E-03	4.71E-05
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	

Table 7.2-2

Top 100 Cut Sets From The Keowee Emergency Power Model

Module/Event	Description	Rate	Exposure	Prob.	Cs Prob.
11)-XD1DALTBYM	Normal Power To Dist. Center 1DA Is In Test or Maintenance		5.48E-03	5.48E-03	3.51E-05
-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
XD1KBATBYF	Keowee Battery No. 1 Fails During Discharge	9.30E-04	1	9.30E-04	
XD0KBATRHE			1.00E+00	1.00E+00	
12)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	3.35E-05
XD0CHRGCOM	Common Cause Failure Of Keowee Battery Chargers		3.48E-05	3.48E-05	
13)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	2.60E-05
XD0BATTCOM	Common Cause Failure Of Keowee I&C Power Batteries		2.70E-05	2.70E-05	
14)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	2.37E-05
FKVALVECOM	Common Cause Failure Of Cooling Water Control Valves		2.46E-5	2.46E-05	
15)-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	2.34E-05
EK1BASEDEX	Keowee Unit 1 Base Adjust Fails To Establish Correct Unit Voltage		6.17E-4	6.17E-04	
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
16) KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	2.13E-05
WK1GVRNDEX	Keowee Unit 1 Gov. Fails to Position Wicket Gates With Unit Running		5.6E-4	5.60E-04	
17) KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	2.13E-05
WK1TBRNDEX	Keowee Unit 1 Turbine Fails With the Unit Running		5.6e-4	5.60E-04	
18)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	2.01E-05
WK00RUNCOM	Common Cause Failure of Keowee Governors to Run		2.09E-05	2.09E-05	
19)-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	1.76E-05
EK1SPYMDEX	Keowee Unit 1 Supply Breaker Fails To Close Due To Mehanical Failure		4.62E-4	4.62E-04	
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
20)-XA1XAALBLM	MCC 1XA Is Connected to Its Alternate Source of Power		2.74E-03	2.74E-03	1.73E-05
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
XA1XCXXTHM	4160/600 Vac Transformer CX Is in Maintenance		4.57E-4	4.57E-04	
21)-XA1XAALBLM	MCC 1XA Is Connected to Its Alternate Source of Power		2.74E-03	2.74E-03	1.73E-05
-AD1B4ALCDT	Breaker 4AL In 125 V dc Distribution Center 1DA Transfers Open	7.5E-08	30	2.25E-06	
-AB7OPENLHE	Air Circuit Breaker 7 Fails To Open Due To A Latent Human Error		3.20E-3	3.20E-03	
-AB7MECHDEX	Air Circuit Breaker 7 Fails To Open Due To Mechanical Failure		8.01E-04	8.01E-04	
-AB752TCRYD	Air Circuit Breaker 7 Trip Coil TC Fails On Demand	3.3E-05	1	3.30E-05	
-AB710AFFUF	One Or More Air Circuit Breaker 7 Control Power Fuses Fail	3.6E-06	6	2.16E-05	
-AB51431SWT	Manual/Auto Control Switch 143/1 Spuriously Transfers Into Manual	7.0E-08	360	2.52E-05	
-AB51431LHE	Manual/Auto Control Switch 143/1 Left In Manual		3.20E-4	3.20E-04	
-AA227X2RYD	Auxiliary Relay 27X/2X Fails To Operate On Demand	3.3E-05	1	3.30E-05	
-AA127X2R6D	Transformer CX Undervoltage Relay 27/CX1 Fails To Drop Out	2.49E-04	1	2.49E-04	
AB7MCH2DEX	Air Circuit Breaker 7 Fails To Close Due To Mechanical Failure		7.04E-03	7.04E-03	
EK2VREGDEX	KHU-2 Voltage Adjust Failure Drives Generator Output Too High/Low		2.47E-3	2.47E-03	

Table 7.2-2

Top 100 Cut Sets From The Keowee Emergency Power Model

Module/Event	Description	Rate	Exposure	Prob.	Cs Prob.
22)-XA1XAALBLM	MCC 1XA Is Connected to Its Alternate Source of Power		2.74E-03	2.74E-03	1.59E-05
-AD1B4ALCDT	Breaker 4AL In 125 V dc Distribution Center 1DA Transfers Open	7.5E-08	30	2.25E-06	
-AB7OPENLHE	Air Circuit Breaker 7 Fails To Open Due To A Latent Human Error		3.20E-3	3.20E-03	
-AB7MECHDEX	Air Circuit Breaker 7 Fails To Open Due To Mechanical Failure		8.01E-04	8.01E-04	
-AB752TCRYD	Air Circuit Breaker 7 Trip Coil TC Fails On Demand	3.3E-05	1	3.30E-05	
-AB710AFFUF	One Or More Air Circuit Breaker 7 Control Power Fuses Fail	3.6E-06	6	2.16E-05	
-AB51431SWT	Manual/Auto Control Switch 143/1 Spuriously Transfers Into Manual	7.0E-08	360	2.52E-05	
-AB51431LHE	Manual/Auto Control Switch 143/1 Left In Manual		3.20E-4	3.20E-04	
-AA227X2RYD	Auxiliary Relay 27X/2X Fails To Operate On Demand	3.3E-05	1	3.30E-05	
-AA127X2R6D	Transformer CX Undervoltage Relay 27/CX1 Fails To Drop Out	2.49E-04	1	2.49E-04	
AB7MCH2DEX	Air Circuit Breaker 7 Fails To Close Due To Mechanical Failure		7.04E-03	7.04E-03	
GK20001HGR	Keowee Unit 2 Generator Fault While the Unit Runs	9.46E-05	24	2.27E-03	
23)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	1.40E-05
OKOPRUNCOM	Common Cause Failure Of Both Governor Oil Systems To Run		1.46E-05	1.46E-05	
24)-XA1XAALBLM	MCC 1XA Is Connected to Its Alternate Source of Power		2.74E-03	2.74E-03	1.40E-05
-AD1B4ALCDT	Breaker 4AL In 125 V dc Distribution Center 1DA Transfers Open	7.5E-08	30	2.25E-06	
-AB7OPENLHE	Air Circuit Breaker 7 Fails To Open Due To A Latent Human Error		3.20E-3	3.20E-03	
-AB7MECHDEX	Air Circuit Breaker 7 Fails To Open Due To Mechanical Failure		8.01E-04	8.01E-04	
-AB752TCRYD	Air Circuit Breaker 7 Trip Coil TC Fails On Demand	3.3E-05	1	3.30E-05	
-AB710AFFUF	One Or More Air Circuit Breaker 7 Control Power Fuses Fail	3.6E-06	6	2.16E-05	
-AB51431SWT	Manual/Auto Control Switch 143/1 Spuriously Transfers Into Manual	7.0E-08	360	2.52E-05	
-AB51431LHE	Manual/Auto Control Switch 143/1 Left In Manual		3.20E-4	3.20E-04	
-AA227X2RYD	Auxiliary Relay 27X/2X Fails To Operate On Demand	3.3E-05	1	3.30E-05	
-AA127X2R6D	Transformer CX Undervoltage Relay 27/CX1 Fails To Drop Out	2.49E-04	1	2.49E-04	
AB7MCH2DEX	Air Circuit Breaker 7 Fails To Close Due To Mechanical Failure		7.04E-03	7.04E-03	
ACB4MOD	NSM-ON-52966 Is Not In Service		1	1.00E+00	
ACBAIRPDEX	ACB Air Supply Fails Causing Low Pressure In All ACB Accumulators		2.00E-03	2.00E-03	
25) EK1DIODDEX	Keowee Unit 1 Exciter Fan Supply Diode Bridge Fails		2.88E-4	2.88E-04	1.09E-05
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
26) FK1WL11AVO	Cooling Water Control Valve 1WL-11 Fails To Open On Demand	2.80E-04	1	2.80E-04	1.06E-05
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
27)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	1.01E-05
-KK2RUNSDEX	Keowee Unit 2 Only Is Supplying The Grid		0.06	6.00E-02	
-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	
-KK1BOTHDEX	Keowee Units 1 And 2 Are Supplying The Grid		0.0	0.00E+00	
WKCSTRTCOM	Common Cause Failure of Keowee Governors to Cold Start		1.12E-05	1.12E-05	
28)-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	9.88E-06
EK1SPYCLHE	Keowee Unit 1 Supply Breaker Fails To Close Due To Latent Human Error		2.60E-4	2.60E-04	
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
29)-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	9.88E-06
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
WK1GVCDLHE	Latent Human Error Fails Keowee 1 Governor During Cold Start		2.6E-4	2.60E-04	

Table 7.2-2

Top 100 Cut Sets From The Keowee Emergency Power Model

Module/Event	Description	Rate	Exposure	Prob.	Cs Prob.
30) GK1COOLLHE	Keowee 1 Gen. Air Cooler WL Flow Path Vlvs Mispositioned After Maint		2.60E-04	2.60E-04	9.88E-06
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
31)-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	9.88E-06
EK1FLDCLHE	Keowee Unit 1 Field Breaker Fails To Close Due To Latent Human Error		2.60E-4	2.60E-04	
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
32)-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	9.88E-06
EK1FLSCLHE	Keowee Unit 1 Field Flashing Breaker Fails To Close Due To Latent Human		2.60E-4	2.60E-04	
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
33)-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	9.88E-06
EK1FLSOLHE	Keowee Unit 1 Field Flashing Breaker Fails To Open Due To Latent Human E		2.60E-4	2.60E-04	
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
34)-XA1XAALBLM	MCC 1XA Is Connected to Its Alternate Source of Power		2.74E-03	2.74E-03	9.81E-06
-AD1B4ALCDT	Breaker 4AL In 125 V dc Distribution Center 1DA Transfers Open	7.5E-08	30	2.25E-06	
-AB7OPENLHE	Air Circuit Breaker 7 Fails To Open Due To A Latent Human Error		3.20E-3	3.20E-03	
-AB7MECHDEX	Air Circuit Breaker 7 Fails To Open Due To Mechanical Failure		8.01E-04	8.01E-04	
-AB752TCRYD	Air Circuit Breaker 7 Trip Coil TC Fails On Demand	3.3E-05	1	3.30E-05	
-AB710AFFUF	One Or More Air Circuit Breaker 7 Control Power Fuses Fail	3.6E-06	6	2.16E-05	
-AB51431SWT	Manual/Auto Control Switch 143/1 Spuriously Transfers Into Manual	7.0E-08	360	2.52E-05	
-AB51431LHE	Manual/Auto Control Switch 143/1 Left In Manual		3.20E-4	3.20E-04	
-AA227X2RYD	Auxiliary Relay 27X/2X Fails To Operate On Demand	3.3E-05	1	3.30E-05	
-AA127X2R6D	Transformer CX Undervoltage Relay 27/CX1 Fails To Drop Out	2.49E-04	1	2.49E-04	
AB7CLOSLHE	Air Circuit Breaker 7 Fails To Close Due To A Latent Human Error		2.60E-4	2.60E-04	
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
35) EK141AXR6D	Keowee Unit 1 Relay 41/AX Fails To Pick-up And Latch	2.49E-04	1	2.49E-04	9.46E-06
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
36)-XA1XAALBLM	MCC 1XA Is Connected to Its Alternate Source of Power		2.74E-03	2.74E-03	9.39E-06
-AD1B4ALCDT	Breaker 4AL In 125 V dc Distribution Center 1DA Transfers Open	7.5E-08	30	2.25E-06	
-AB7OPENLHE	Air Circuit Breaker 7 Fails To Open Due To A Latent Human Error		3.20E-3	3.20E-03	
-AB7MECHDEX	Air Circuit Breaker 7 Fails To Open Due To Mechanical Failure		8.01E-04	8.01E-04	
-AB752TCRYD	Air Circuit Breaker 7 Trip Coil TC Fails On Demand	3.3E-05	1	3.30E-05	
-AB710AFFUF	One Or More Air Circuit Breaker 7 Control Power Fuses Fail	3.6E-06	6	2.16E-05	
-AB51431SWT	Manual/Auto Control Switch 143/1 Spuriously Transfers Into Manual	7.0E-08	360	2.52E-05	
-AB51431LHE	Manual/Auto Control Switch 143/1 Left In Manual		3.20E-4	3.20E-04	
-AA227X2RYD	Auxiliary Relay 27X/2X Fails To Operate On Demand	3.3E-05	1	3.30E-05	
-AA127X2R6D	Transformer CX Undervoltage Relay 27/CX1 Fails To Drop Out	2.49E-04	1	2.49E-04	
AA127CPR6D	Transformer CX Undervoltage Relay 27/CX1 Fails To Pick Up	2.49E-04	1	2.49E-04	
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	

Table 7.2-2

Top 100 Cut Sets From The Keowee Emergency Power Model

Module/Event	Description	Rate	Exposure	Prob.	Cs Prob.
37)-XA1XAALBLM	MCC 1XA Is Connected to Its Alternate Source of Power		2.74E-03	2.74E-03	8.66E-06
-AD1B4ALCDT	Breaker 4AL In 125 V dc Distribution Center 1DA Transfers Open	7.5E-08	30	2.25E-06	
-AB7OPENLHE	Air Circuit Breaker 7 Fails To Open Due To A Latent Human Error		3.20E-3	3.20E-03	
-AB7MECHDEX	Air Circuit Breaker 7 Fails To Open Due To Mechanical Failure		8.01E-04	8.01E-04	
-AB752TCRYD	Air Circuit Breaker 7 Trip Coil TC Fails On Demand	3.3E-05	1	3.30E-05	
-AB710AFFUF	One Or More Air Circuit Breaker 7 Control Power Fuses Fail	3.6E-06	6	2.16E-05	
-AB51431SWT	Manual/Auto Control Switch 143/1 Spuriously Transfers Into Manual	7.0E-08	360	2.52E-05	
-AB51431LHE	Manual/Auto Control Switch 143/1 Left In Manual		3.20E-4	3.20E-04	
-AA227X2RYD	Auxiliary Relay 27X/2X Fails To Operate On Demand	3.3E-05	1	3.30E-05	
-AA127X2R6D	Transformer CX Undervoltage Relay 27/CX1 Fails To Drop Out	2.49E-04	1	2.49E-04	
AB7MCH2DEX	Air Circuit Breaker 7 Fails To Close Due To Mechanical Failure		7.04E-03	7.04E-03	
EK2BAS2DEX	KHU-2 Base Adjust Fails To Maintain Generator Output Within Acceptable R		1.24E-3	1.24E-03	
38) YOSTARTCOM	Common Cause Failure Of Emergency Start Signal		7.26E-06	7.26E-06	7.26E-06
YOSTARTRHE			1.00E+00	1.00E+00	
39)-XD2DALTBYM	Normal Power To Dist Cntr 2DA Is In Test or Maintenance		5.48E-03	5.48E-03	6.46E-06
-XA1XAALBLM	MCC 1XA Is Connected to Its Alternate Source of Power		2.74E-03	2.74E-03	
-AD1B4ALCDT	Breaker 4AL In 125 V dc Distribution Center 1DA Transfers Open	7.5E-08	30	2.25E-06	
-AB7OPENLHE	Air Circuit Breaker 7 Fails To Open Due To A Latent Human Error		3.20E-3	3.20E-03	
-AB7MECHDEX	Air Circuit Breaker 7 Fails To Open Due To Mechanical Failure		8.01E-04	8.01E-04	
-AB752TCRYD	Air Circuit Breaker 7 Trip Coil TC Fails On Demand	3.3E-05	1	3.30E-05	
-AB710AFFUF	One Or More Air Circuit Breaker 7 Control Power Fuses Fail	3.6E-06	6	2.16E-05	
-AB51431SWT	Manual/Auto Control Switch 143/1 Spuriously Transfers Into Manual	7.0E-08	360	2.52E-05	
-AB51431LHE	Manual/Auto Control Switch 143/1 Left In Manual		3.20E-4	3.20E-04	
-AA227X2RYD	Auxiliary Relay 27X/2X Fails To Operate On Demand	3.3E-05	1	3.30E-05	
-AA127X2R6D	Transformer CX Undervoltage Relay 27/CX1 Fails To Drop Out	2.49E-04	1	2.49E-04	
AB7MCH2DEX	Air Circuit Breaker 7 Fails To Close Due To Mechanical Failure		7.04E-03	7.04E-03	
XD2KBATBYF	Keowee Battery No. 2 Fails during Discharge	9.30E-04	1	9.30E-04	
40) EK1VREGDEX	KHU-1 Voltage Adjust Failure Drives Generator Output Too High/Low		2.47E-3	2.47E-03	6.10E-06
EK2VREGDEX	KHU-2 Voltage Adjust Failure Drives Generator Output Too High/Low		2.47E-3	2.47E-03	
41)-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	5.85E-06
GK10001EGS	Keowee Unit 1 Generator Fault Causes Unit Start Failure	1.54E-04	1	1.54E-04	
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	

Table 7.2-2

Top 100 Cut Sets From The Keowee Emergency Power Model

Module/Event	Description	Rate	Exposure	Prob.	Cs Prob.
42)-XA1XAALBLM	MCC 1XA Is Connected to Its Alternate Source of Power		2.74E-03	2.74E-03	5.85E-06
-AD1B4ALCDT	Breaker 4AL In 125 V dc Distribution Center 1DA Transfers Open	7.5E-08	30	2.25E-06	
-AB7OPENLHE	Air Circuit Breaker 7 Fails To Open Due To A Latent Human Error		3.20E-3	3.20E-03	
-AB7MECHDEX	Air Circuit Breaker 7 Fails To Open Due To Mechanical Failure		8.01E-04	8.01E-04	
-AB752TCRYD	Air Circuit Breaker 7 Trip Coil TC Fails On Demand	3.3E-05	1	3.30E-05	
-AB710AFFUF	One Or More Air Circuit Breaker 7 Control Power Fuses Fail	3.6E-06	6	2.16E-05	
-AB51431SWT	Manual/Auto Control Switch 143/1 Spuriously Transfers Into Manual	7.0E-08	360	2.52E-05	
-AB51431LHE	Manual/Auto Control Switch 143/1 Left In Manual		3.20E-4	3.20E-04	
-AA227X2RYD	Auxiliary Relay 27X/2X Fails To Operate On Demand	3.3E-05	1	3.30E-05	
-AA127X2R6D	Transformer CX Undervoltage Relay 27/CX1 Fails To Drop Out	2.49E-04	1	2.49E-04	
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
XA1BKRSCOM	CCF of 1X Aux Power Breakers ACB-5 & -7		3.10E-04	3.10E-04	
AB0SWGRRHE	Recovery of Keowee Aux Power Breakers by Manual Control		5.0E-01	5.00E-01	
43)-XA1XAALBLM	MCC 1XA Is Connected to Its Alternate Source of Power		2.74E-03	2.74E-03	5.85E-06
-AD1B4ALCDT	Breaker 4AL In 125 V dc Distribution Center 1DA Transfers Open	7.5E-08	30	2.25E-06	
-AB7OPENLHE	Air Circuit Breaker 7 Fails To Open Due To A Latent Human Error		3.20E-3	3.20E-03	
-AB7MECHDEX	Air Circuit Breaker 7 Fails To Open Due To Mechanical Failure		8.01E-04	8.01E-04	
-AB752TCRYD	Air Circuit Breaker 7 Trip Coil TC Fails On Demand	3.3E-05	1	3.30E-05	
-AB710AFFUF	One Or More Air Circuit Breaker 7 Control Power Fuses Fail	3.6E-06	6	2.16E-05	
-AB51431SWT	Manual/Auto Control Switch 143/1 Spuriously Transfers Into Manual	7.0E-08	360	2.52E-05	
-AB51431LHE	Manual/Auto Control Switch 143/1 Left In Manual		3.20E-4	3.20E-04	
-AA227X2RYD	Auxiliary Relay 27X/2X Fails To Operate On Demand	3.3E-05	1	3.30E-05	
-AA127X2R6D	Transformer CX Undervoltage Relay 27/CX1 Fails To Drop Out	2.49E-04	1	2.49E-04	
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
XA78BKRCOM	Common Cause Failure Of ACB-7 And ACB-8 To Close		3.10E-04	3.10E-04	
AB0SWGRRHE	Recovery of Keowee Aux Power Breakers by Manual Control		5.0E-01	5.00E-01	
44) EK1VREGDEX	KHU-1 Voltage Adjust Failure Drives Generator Output Too High/Low		2.47E-3	2.47E-03	5.61E-06
GK20001HGR	Keowee Unit 2 Generator Fault While the Unit Runs	9.46E-05	24	2.27E-03	
45) EK2VREGDEX	KHU-2 Voltage Adjust Failure Drives Generator Output Too High/Low		2.47E-3	2.47E-03	5.61E-06
GK10001HGR	Keowee Unit 1 Generator Fault While the Unit Runs	9.46E-05	24	2.27E-03	
46) GK10001HGR	Keowee Unit 1 Generator Fault While the Unit Runs	9.46E-05	24	2.27E-03	5.15E-06
GK20001HGR	Keowee Unit 2 Generator Fault While the Unit Runs	9.46E-05	24	2.27E-03	
47) KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	5.11E-06
OK1AG04RVT	Safety Relief Valve 1AG-4 Spurious Operation	5.60E-06	24	1.34E-04	
48) KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	5.11E-06
OK10003RVT	Safety Relief Valve 1OG-3 Spurious Operation	5.60E-06	24	1.34E-04	
49)-XD1DALTBYM	Normal Power To Dist. Center 1DA Is In Test or Maintenance		5.48E-03	5.48E-03	5.07E-06
-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	
-KK1BOTHDEX	Keowee Units 1 And 2 Are Supplying The Grid		0.0	0.00E+00	
XD1KBATBYF	Keowee Battery No. 1 Fails During Discharge	9.30E-04	1	9.30E-04	
XD2DALTBYM	Normal Power To Dist Cntr 2DA Is In Test or Maintenance		5.48E-03	5.48E-03	

Table 7.2-2

Top 100 Cut Sets From The Keowee Emergency Power Model

Module/Event	Description	Rate	Exposure	Prob.	Cs Prob.
50)-XD2DALTBYM	Normal Power To Dist Cntr 2DA Is In Test or Maintenance		5.48E-03	5.48E-03	5.07E-06
-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	
-KK1BOTHDEX	Keowee Units 1 And 2 Are Supplying The Grid		0.0	0.00E+00	
XD1DALTBYM	Normal Power To Dist. Center 1DA Is In Test or Maintenance		5.48E-03	5.48E-03	
XD2KBATBYF	Keowee Battery No. 2 Fails during Discharge	9.30E-04	1	9.30E-04	
51) ACB4MOD	NSM-ON-52966 Is Not In Service		1	1.00E+00	4.94E-06
ACBAIRPDEX	ACB Air Supply Fails Causing Low Pressure In All ACB Accumulators		2.00E-03	2.00E-03	
EK1VREGDEX	KHU-1 Voltage Adjust Failure Drives Generator Output Too High/Low		2.47E-3	2.47E-03	
52)-XA1XAALBLM	MCC 1XA Is Connected to Its Alternate Source of Power		2.74E-03	2.74E-03	4.89E-06
-AD1B4ALCDT	Breaker 4AL In 125 V dc Distribution Center 1DA Transfers Open	7.5E-08	30	2.25E-06	
-AB7OPENLHE	Air Circuit Breaker 7 Fails To Open Due To A Latent Human Error		3.20E-3	3.20E-03	
-AB7MECHDEX	Air Circuit Breaker 7 Fails To Open Due To Mechanical Failure		8.01E-04	8.01E-04	
-AB752TCRYD	Air Circuit Breaker 7 Trip Coil TC Fails On Demand	3.3E-05	1	3.30E-05	
-AB710AFFUF	One Or More Air Circuit Breaker 7 Control Power Fuses Fail	3.6E-06	6	2.16E-05	
-AB51431SWT	Manual/Auto Control Switch 143/1 Spuriously Transfers Into Manual	7.0E-08	360	2.52E-05	
-AB51431LHE	Manual/Auto Control Switch 143/1 Left In Manual		3.20E-4	3.20E-04	
-AA227X2RYD	Auxiliary Relay 27X/2X Fails To Operate On Demand	3.3E-05	1	3.30E-05	
-AA127X2R6D	Transformer CX Undervoltage Relay 27/CX1 Fails To Drop Out	2.49E-04	1	2.49E-04	
AB752Y2RYT	Air Circuit Breaker 7 Y-relay Spurious Operation	3.6E-07	360	1.30E-04	
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
53) ACB4MOD	NSM-ON-52966 Is Not In Service		1	1.00E+00	4.54E-06
ACBAIRPDEX	ACB Air Supply Fails Causing Low Pressure In All ACB Accumulators		2.00E-03	2.00E-03	
GK10001HGR	Keowee Unit 1 Generator Fault While the Unit Runs	9.46E-05	24	2.27E-03	
54)-XA1XAALBLM	MCC 1XA Is Connected to Its Alternate Source of Power		2.74E-03	2.74E-03	4.05E-06
-KK2RUNSDEX	Keowee Unit 2 Only Is Supplying The Grid		0.06	6.00E-02	
-KK1BOTHDEX	Keowee Units 1 And 2 Are Supplying The Grid		0.0	0.00E+00	
-AD1B4ALCDT	Breaker 4AL In 125 V dc Distribution Center 1DA Transfers Open	7.5E-08	30	2.25E-06	
-AB7OPENLHE	Air Circuit Breaker 7 Fails To Open Due To A Latent Human Error		3.20E-3	3.20E-03	
-AB7MECHDEX	Air Circuit Breaker 7 Fails To Open Due To Mechanical Failure		8.01E-04	8.01E-04	
-AB752TCRYD	Air Circuit Breaker 7 Trip Coil TC Fails On Demand	3.3E-05	1	3.30E-05	
-AB710AFFUF	One Or More Air Circuit Breaker 7 Control Power Fuses Fail	3.6E-06	6	2.16E-05	
-AB51431SWT	Manual/Auto Control Switch 143/1 Spuriously Transfers Into Manual	7.0E-08	360	2.52E-05	
-AB51431LHE	Manual/Auto Control Switch 143/1 Left In Manual		3.20E-4	3.20E-04	
-AA227X2RYD	Auxiliary Relay 27X/2X Fails To Operate On Demand	3.3E-05	1	3.30E-05	
-AA127X2R6D	Transformer CX Undervoltage Relay 27/CX1 Fails To Drop Out	2.49E-04	1	2.49E-04	
AB7MCH2DEX	Air Circuit Breaker 7 Fails To Close Due To Mechanical Failure		7.04E-03	7.04E-03	
EK2BASEDEX	Keowee Unit 2 Base Adjust Fails To Establish Correct Unit Voltage		6.17E-4	6.17E-04	

Table 7.2-2

Top 100 Cut Sets From The Keowee Emergency Power Model

Module/Event	Description	Rate	Exposure	Prob.	Cs Prob.
55)-XA1XAALBLM	MCC 1XA Is Connected to Its Alternate Source of Power		2.74E-03	2.74E-03	3.91E-06
-AD1B4ALCDT	Breaker 4AL In 125 V dc Distribution Center 1DA Transfers Open	7.5E-08	30	2.25E-06	
-AB7OPENLHE	Air Circuit Breaker 7 Fails To Open Due To A Latent Human Error		3.20E-3	3.20E-03	
-AB7MECHDEX	Air Circuit Breaker 7 Fails To Open Due To Mechanical Failure		8.01E-04	8.01E-04	
-AB752TCRYD	Air Circuit Breaker 7 Trip Coil TC Fails On Demand	3.3E-05	1	3.30E-05	
-AB710AFFUF	One Or More Air Circuit Breaker 7 Control Power Fuses Fail	3.6E-06	6	2.16E-05	
-AB51431SWT	Manual/Auto Control Switch 143/1 Spuriously Transfers Into Manual	7.0E-08	360	2.52E-05	
-AB51431LHE	Manual/Auto Control Switch 143/1 Left In Manual		3.20E-4	3.20E-04	
-AA227X2RYD	Auxiliary Relay 27X/2X Fails To Operate On Demand	3.3E-05	1	3.30E-05	
-AA127X2R6D	Transformer CX Undervoltage Relay 27/CX1 Fails To Drop Out	2.49E-04	1	2.49E-04	
AB7MCH2DEX	Air Circuit Breaker 7 Fails To Close Due To Mechanical Failure		7.04E-03	7.04E-03	
WK2GVRNDEX	Keowee Unit 2 Gov. Fails to Position Wicket Gates With Unit Running		5.6E-4	5.60E-04	
56)-XA1XAALBLM	MCC 1XA Is Connected to Its Alternate Source of Power		2.74E-03	2.74E-03	3.91E-06
-AD1B4ALCDT	Breaker 4AL In 125 V dc Distribution Center 1DA Transfers Open	7.5E-08	30	2.25E-06	
-AB7OPENLHE	Air Circuit Breaker 7 Fails To Open Due To A Latent Human Error		3.20E-3	3.20E-03	
-AB7MECHDEX	Air Circuit Breaker 7 Fails To Open Due To Mechanical Failure		8.01E-04	8.01E-04	
-AB752TCRYD	Air Circuit Breaker 7 Trip Coil TC Fails On Demand	3.3E-05	1	3.30E-05	
-AB710AFFUF	One Or More Air Circuit Breaker 7 Control Power Fuses Fail	3.6E-06	6	2.16E-05	
-AB51431SWT	Manual/Auto Control Switch 143/1 Spuriously Transfers Into Manual	7.0E-08	360	2.52E-05	
-AB51431LHE	Manual/Auto Control Switch 143/1 Left In Manual		3.20E-4	3.20E-04	
-AA227X2RYD	Auxiliary Relay 27X/2X Fails To Operate On Demand	3.3E-05	1	3.30E-05	
-AA127X2R6D	Transformer CX Undervoltage Relay 27/CX1 Fails To Drop Out	2.49E-04	1	2.49E-04	
AB7MCH2DEX	Air Circuit Breaker 7 Fails To Close Due To Mechanical Failure		7.04E-03	7.04E-03	
WK2TBRNDEX	Keowee Unit 2 Turbine Fails With the Unit Running		5.6E-4	5.60E-04	
57)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	3.91E-06
GK0LOCKCOM	Common Cause Actuation of Generator Lockouts		4.06E-06	4.06E-06	
58) KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	3.83E-06
YK1SS12SST	Keowee 1 Overspeed Switch 12 Spuriously Picks Up KEE-111	4.2E-06	24	1.01E-04	
59) EK1F30AFUF	Keowee Unit 1 Excitation Cabinet Fan Fuses Fail	3.6E-06	24	8.64E-05	3.28E-06
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	

Table 7.2-2

Top 100 Cut Sets From The Keowee Emergency Power Model

Module/Event	Description	Rate	Exposure	Prob.	Cs Prob.
60)-XA2XAALBLM	MCC 2XA Is Connected to Its Alternate Power Source		2.74E-03	2.74E-03	3.18E-06
-XA1XAALBLM	MCC 1XA Is Connected to Its Alternate Source of Power		2.74E-03	2.74E-03	
-AD2B2ALCDT	Breaker 2AL In 125V dc Distribution Center 2DA Transfers Open	7.5E-08	30	2.25E-06	
-AB6OPENLHE	Air Circuit Breaker 6 Fails To Open Due To A Latent Human Error		3.20E-3	3.20E-03	
-AB6MECHDEX	Air Circuit Breaker 6 Fails To Open Due To Mechanical Failure		8.01E-04	8.01E-04	
-AB652TCRYD	Air Circuit Breaker 6 Trip Coil 52TC Fails Fails To Operate	3.3E-05	1	3.30E-05	
-AB61432SWT	Manual/Auto Control Switch 143/2 Spuriously Transfers Into Manual	7.0E-08	360	2.52E-05	
-AB61432LHE	Manual/Auto Control Switch 143/2 Left In Manual		3.20E-4	3.20E-04	
-AB610AFFUF	One Or More Control Power Fuses For Relay 27X/2X Fail	3.6E-06	6	2.16E-05	
-AA227X2RYD	Auxiliary Relay 27X/2X Fails To Operate On Demand	3.3E-05	1	3.30E-05	
-AA2272XR6D	Transformer 2X Undervoltage Relay 27/2X Fails To Drop Out	2.49E-04	1	2.49E-04	
AB6MCH2DEX	Air Circuit Breaker 6 Fails To Close Due To Mechanical Failure		7.04E-03	7.04E-03	
XA1XCXXTHM	4160/600 Vac Transformer CX Is in Maintenance		4.57E-4	4.57E-04	
61)-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	3.13E-06
EK1EXC1TGF	Keowee Unit 1 Gen Excitation Transformer Is Failed	9.8E-07	84	8.23E-05	
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
62) EK1BAS2DEX	KHU-1 Base Adjust Fails To Maintain Generator Output Within Acceptable R		1.24E-3	1.24E-03	3.06E-06
EK2VREGDEX	KHU-2 Voltage Adjust Failure Drives Generator Output Too High/Low		2.47E-3	2.47E-03	
63) EK1VREGDEX	KHU-1 Voltage Adjust Failure Drives Generator Output Too High/Low		2.47E-3	2.47E-03	3.06E-06
EK2BAS2DEX	KHU-2 Base Adjust Fails To Maintain Generator Output Within Acceptable R		1.24E-3	1.24E-03	
64)-XA1XAALBLM	MCC 1XA Is Connected to Its Alternate Source of Power		2.74E-03	2.74E-03	3.03E-06
-KK2RUNSDEX	Keowee Unit 2 Only Is Supplying The Grid		0.06	6.00E-02	
-KK1BOTHDEX	Keowee Units 1 And 2 Are Supplying The Grid		0.0	0.00E+00	
-AD1B4ALCDT	Breaker 4AL In 125 V dc Distribution Center 1DA Transfers Open	7.5E-08	30	2.25E-06	
-AB7OPENLHE	Air Circuit Breaker 7 Fails To Open Due To A Latent Human Error		3.20E-3	3.20E-03	
-AB7MECHDEX	Air Circuit Breaker 7 Fails To Open Due To Mechanical Failure		8.01E-04	8.01E-04	
-AB752TCRYD	Air Circuit Breaker 7 Trip Coil TC Fails On Demand	3.3E-05	1	3.30E-05	
-AB710AFFUF	One Or More Air Circuit Breaker 7 Control Power Fuses Fail	3.6E-06	6	2.16E-05	
-AB51431SWT	Manual/Auto Control Switch 143/1 Spuriously Transfers Into Manual	7.0E-08	360	2.52E-05	
-AB51431LHE	Manual/Auto Control Switch 143/1 Left In Manual		3.20E-4	3.20E-04	
-AA227X2RYD	Auxiliary Relay 27X/2X Fails To Operate On Demand	3.3E-05	1	3.30E-05	
-AA127X2R6D	Transformer CX Undervoltage Relay 27/CX1 Fails To Drop Out	2.49E-04	1	2.49E-04	
AB7MCH2DEX	Air Circuit Breaker 7 Fails To Close Due To Mechanical Failure		7.04E-03	7.04E-03	
EK2SPYMDEX	Keowee Unit 2 Supply Breaker Fails To Close Due To Mehanical Failure		4.62E-4	4.62E-04	
65)-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	2.93E-06
EK1FLSMDEX	Keowee Unit 1 Field Flashing Breaker Fails To Close Due To Mechanical Fa		7.71E-5	7.71E-05	
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
66)-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	2.93E-06
EK1FLDMDEX	Keowee Unit 1 Field Breaker Fails To Close Due To Mechanical Failure		7.71E-5	7.71E-05	
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
67) KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	2.83E-06
UACXCT4THF	Transformer CT4 Failed	3.1E-06	24	7.44E-05	

Table 7.2-2

Top 100 Cut Sets From The Keowee Emergency Power Model

Module/Event	Description	Rate	Exposure	Prob.	Cs Prob.
68) EK1BAS2DEX	KHU-1 Base Adjust Fails To Maintain Generator Output Within Acceptable R		1.24E-3	1.24E-03	2.82E-06
GK20001HGR	Keowee Unit 2 Generator Fault While the Unit Runs	9.46E-05	24	2.27E-03	
69) EK2BAS2DEX	KHU-2 Base Adjust Fails To Maintain Generator Output Within Acceptable R		1.24E-3	1.24E-03	2.82E-06
GK10001HGR	Keowee Unit 1 Generator Fault While the Unit Runs	9.46E-05	24	2.27E-03	
70) ACB4MOD	NSM-ON-52966 Is Not In Service		1	1.00E+00	2.48E-06
ACBAIRPDEX	ACB Air Supply Fails Causing Low Pressure In All ACB Accumulators		2.00E-03	2.00E-03	
EK1BAS2DEX	KHU-1 Base Adjust Fails To Maintain Generator Output Within Acceptable R		1.24E-3	1.24E-03	
71)-XD1DALTBYM	Normal Power To Dist. Center 1DA Is In Test or Maintenance		5.48E-03	5.48E-03	2.45E-06
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
XD1CKC1BCF	Battery Charger KC1 Fails	2.9E-05	24	6.96E-04	
XD1KB1XRHE	Keowee Standby Battery Charger SBC Not Lined Up in 1 Hour		9.3e-02	9.30E-02	
72)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	2.35E-06
PK0SUMPCOM	Common Cause Failure Of Turbine Sump Pump System		2.44E-06	2.44E-06	
73)-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	2.31E-06
EK1BASELHE	Keowee Unit 1 Base Adjust Is Set Incorrectly		3.20E-3	3.20E-03	
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
EK0BASERHE	Recovery of Keowee Base Adjust LHE		1.9E-02	1.90E-02	
74)-XD1DALTBYM	Normal Power To Dist. Center 1DA Is In Test or Maintenance		5.48E-03	5.48E-03	2.28E-06
-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	
-KK1BOTHDEX	Keowee Units 1 And 2 Are Supplying The Grid		0.0	0.00E+00	
EK2VREGDEX	KHU-2 Voltage Adjust Failure Drives Generator Output Too High/Low		2.47E-3	2.47E-03	
XD1KBATBYF	Keowee Battery No. 1 Fails During Discharge	9.30E-04	1	9.30E-04	
XD0KBATRHE			1.00E+00	1.00E+00	
75)-XD2DALTBYM	Normal Power To Dist Cntr 2DA Is In Test or Maintenance		5.48E-03	5.48E-03	2.28E-06
EK1VREGDEX	KHU-1 Voltage Adjust Failure Drives Generator Output Too High/Low		2.47E-3	2.47E-03	
XD2KBATBYF	Keowee Battery No. 2 Fails during Discharge	9.30E-04	1	9.30E-04	
76)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	2.17E-06
EK2VREGDEX	KHU-2 Voltage Adjust Failure Drives Generator Output Too High/Low		2.47E-3	2.47E-03	
SXFRCT4THM	Transformer CT4 Is In Maintenance		9.13E-04	9.13E-04	
77) KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	2.13E-06
WK1SPD2DEX	Keowee Unit 1 Governor Failure Creates Overspeed Condition		5.6E-05	5.60E-05	
78)-XD1DALTBYM	Normal Power To Dist. Center 1DA Is In Test or Maintenance		5.48E-03	5.48E-03	2.10E-06
-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	
-KK1BOTHDEX	Keowee Units 1 And 2 Are Supplying The Grid		0.0	0.00E+00	
GK20001HGR	Keowee Unit 2 Generator Fault While the Unit Runs	9.46E-05	24	2.27E-03	
XD1KBATBYF	Keowee Battery No. 1 Fails During Discharge	9.30E-04	1	9.30E-04	
XD0KBATRHE			1.00E+00	1.00E+00	
79)-XD2DALTBYM	Normal Power To Dist Cntr 2DA Is In Test or Maintenance		5.48E-03	5.48E-03	2.10E-06
GK10001HGR	Keowee Unit 1 Generator Fault While the Unit Runs	9.46E-05	24	2.27E-03	
XD2KBATBYF	Keowee Battery No. 2 Fails during Discharge	9.30E-04	1	9.30E-04	
80) FK1WL11AVT	Cooling Water Control Valve 1WL-11 Transfers Closed	2.30E-06	24	5.52E-05	2.10E-06
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	

Table 7.2-2

Top 100 Cut Sets From The Keowee Emergency Power Model

Module/Event	Description	Rate	Exposure	Prob.	Cs Prob.
81)-OMOD	Startup Bus UV Sensing Mod Is In Service		0	0.00E+00	2.05E-06
-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
OFACTORDEX	Overload Susceptibility Factor		1.0	1.00E+00	
S227EUVRYT	Unit 2 Startup Bus Undervoltage Relay 27E Fails	3.6E-07	9	2.33E-03	
SXFRCT4THM	Transformer CT4 Is In Maintenance		9.13E-04	9.13E-04	
82)-OMOD	Startup Bus UV Sensing Mod Is In Service		0	0.00E+00	2.05E-06
-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
OFACTORDEX	Overload Susceptibility Factor		1.0	1.00E+00	
S127EUVRYT	Unit 1 Startup Bus Undervoltage Relay 27E Fails	3.6E-07	9	2.33E-03	
SXFRCT4THM	Transformer CT4 Is In Maintenance		9.13E-04	9.13E-04	
83)-XA1XAALBLM	MCC 1XA Is Connected to Its Alternate Source of Power		2.74E-03	2.74E-03	2.01E-06
-AD1B4ALCDT	Breaker 4AL In 125 V dc Distribution Center 1DA Transfers Open	7.5E-08	30	2.25E-06	
-AB7OPENLHE	Air Circuit Breaker 7 Fails To Open Due To A Latent Human Error		3.20E-3	3.20E-03	
-AB7MECHDEX	Air Circuit Breaker 7 Fails To Open Due To Mechanical Failure		8.01E-04	8.01E-04	
-AB752TCRYD	Air Circuit Breaker 7 Trip Coil TC Fails On Demand	3.3E-05	1	3.30E-05	
-AB710AFFUF	One Or More Air Circuit Breaker 7 Control Power Fuses Fail	3.6E-06	6	2.16E-05	
-AB51431SWT	Manual/Auto Control Switch 143/1 Spuriously Transfers Into Manual	7.0E-08	360	2.52E-05	
-AB51431LHE	Manual/Auto Control Switch 143/1 Left In Manual		3.20E-4	3.20E-04	
-AA227X2RYD	Auxiliary Relay 27X/2X Fails To Operate On Demand	3.3E-05	1	3.30E-05	
-AA127X2R6D	Transformer CX Undervoltage Relay 27/CX1 Fails To Drop Out	2.49E-04	1	2.49E-04	
AB7MCH2DEX	Air Circuit Breaker 7 Fails To Close Due To Mechanical Failure		7.04E-03	7.04E-03	
EK2DIODDEX	Keowee Unit 2 Exciter Fan Supply Diode Bridge Fails		2.88E-4	2.88E-04	
84)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	1.99E-06
GK20001HGR	Keowee Unit 2 Generator Fault While the Unit Runs	9.46E-05	24	2.27E-03	
SXFRCT4THM	Transformer CT4 Is In Maintenance		9.13E-04	9.13E-04	
85)-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	1.98E-06
GK1NGDCLHE	Failure to Close the Unit 1 Neutral Ground Disconnect Following Maintena		5.20E-05	5.20E-05	
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
86)-XA1XAALBLM	MCC 1XA Is Connected to Its Alternate Source of Power		2.74E-03	2.74E-03	1.96E-06
-AD1B4ALCDT	Breaker 4AL In 125 V dc Distribution Center 1DA Transfers Open	7.5E-08	30	2.25E-06	
-AB7OPENLHE	Air Circuit Breaker 7 Fails To Open Due To A Latent Human Error		3.20E-3	3.20E-03	
-AB7MECHDEX	Air Circuit Breaker 7 Fails To Open Due To Mechanical Failure		8.01E-04	8.01E-04	
-AB752TCRYD	Air Circuit Breaker 7 Trip Coil TC Fails On Demand	3.3E-05	1	3.30E-05	
-AB710AFFUF	One Or More Air Circuit Breaker 7 Control Power Fuses Fail	3.6E-06	6	2.16E-05	
-AB51431SWT	Manual/Auto Control Switch 143/1 Spuriously Transfers Into Manual	7.0E-08	360	2.52E-05	
-AB51431LHE	Manual/Auto Control Switch 143/1 Left In Manual		3.20E-4	3.20E-04	
-AA227X2RYD	Auxiliary Relay 27X/2X Fails To Operate On Demand	3.3E-05	1	3.30E-05	
-AA127X2R6D	Transformer CX Undervoltage Relay 27/CX1 Fails To Drop Out	2.49E-04	1	2.49E-04	
AB7MCH2DEX	Air Circuit Breaker 7 Fails To Close Due To Mechanical Failure		7.04E-03	7.04E-03	
FK2WL11AVO	Cooling Water Control Valve 2WL-11 Fails To Open On Demand	2.80E-04	1	2.80E-04	
87)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	1.87E-06
BKGBOILCOM	Common Cause Failure Of Turbine Guide Bearing Oil System		1.94E-06	1.94E-06	

Table 7.2-2

Top 100 Cut Sets From The Keowee Emergency Power Model

Module/Event	Description	Rate	Exposure	Prob.	Cs Prob.
88)-XD1DALTBYM	Normal Power To Dist. Center 1DA Is In Test or Maintenance		5.48E-03	5.48E-03	1.85E-06
-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	
-KK1BOTHDEX	Keowee Units 1 And 2 Are Supplying The Grid		0.0	0.00E+00	
ACB4MOD	NSM-ON-52966 Is Not In Service		1	1.00E+00	
ACBAIRPDEX	ACB Air Supply Fails Causing Low Pressure In All ACB Accumulators		2.00E-03	2.00E-03	
XD1KBATBYF	Keowee Battery No. 1 Fails During Discharge	9.30E-04	1	9.30E-04	
XD0KBATRHE			1.00E+00	1.00E+00	
89)-XA1XAALBLM	MCC 1XA Is Connected to Its Alternate Source of Power		2.74E-03	2.74E-03	1.82E-06
-AD1B4ALCDT	Breaker 4AL In 125 V dc Distribution Center 1DA Transfers Open	7.5E-08	30	2.25E-06	
-AB7OPENLHE	Air Circuit Breaker 7 Fails To Open Due To A Latent Human Error		3.20E-3	3.20E-03	
-AB7MECHDEX	Air Circuit Breaker 7 Fails To Open Due To Mechanical Failure		8.01E-04	8.01E-04	
-AB752TCRYD	Air Circuit Breaker 7 Trip Coil TC Fails On Demand	3.3E-05	1	3.30E-05	
-AB710AFFUF	One Or More Air Circuit Breaker 7 Control Power Fuses Fail	3.6E-06	6	2.16E-05	
-AB51431SWT	Manual/Auto Control Switch 143/1 Spuriously Transfers Into Manual	7.0E-08	360	2.52E-05	
-AB51431LHE	Manual/Auto Control Switch 143/1 Left In Manual		3.20E-4	3.20E-04	
-AA227X2RYD	Auxiliary Relay 27X/2X Fails To Operate On Demand	3.3E-05	1	3.30E-05	
-AA127X2R6D	Transformer CX Undervoltage Relay 27/CX1 Fails To Drop Out	2.49E-04	1	2.49E-04	
AB7MCH2DEX	Air Circuit Breaker 7 Fails To Close Due To Mechanical Failure		7.04E-03	7.04E-03	
GK2COOLLHE	Keowee 2 Gen. Air Cooler WL Flow Path Vlvs Mispositioned After Maint		2.60E-04	2.60E-04	
90)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	1.76E-06
ACB4MOD	NSM-ON-52966 Is Not In Service		1	1.00E+00	
ACBAIRPDEX	ACB Air Supply Fails Causing Low Pressure In All ACB Accumulators		2.00E-03	2.00E-03	
SXFRCT4THM	Transformer CT4 Is In Maintenance		9.13E-04	9.13E-04	
91)-XA1XAALBLM	MCC 1XA Is Connected to Its Alternate Source of Power		2.74E-03	2.74E-03	1.74E-06
-AD1B4ALCDT	Breaker 4AL In 125 V dc Distribution Center 1DA Transfers Open	7.5E-08	30	2.25E-06	
-AB7OPENLHE	Air Circuit Breaker 7 Fails To Open Due To A Latent Human Error		3.20E-3	3.20E-03	
-AB7MECHDEX	Air Circuit Breaker 7 Fails To Open Due To Mechanical Failure		8.01E-04	8.01E-04	
-AB752TCRYD	Air Circuit Breaker 7 Trip Coil TC Fails On Demand	3.3E-05	1	3.30E-05	
-AB710AFFUF	One Or More Air Circuit Breaker 7 Control Power Fuses Fail	3.6E-06	6	2.16E-05	
-AB51431SWT	Manual/Auto Control Switch 143/1 Spuriously Transfers Into Manual	7.0E-08	360	2.52E-05	
-AB51431LHE	Manual/Auto Control Switch 143/1 Left In Manual		3.20E-4	3.20E-04	
-AA227X2RYD	Auxiliary Relay 27X/2X Fails To Operate On Demand	3.3E-05	1	3.30E-05	
-AA127X2R6D	Transformer CX Undervoltage Relay 27/CX1 Fails To Drop Out	2.49E-04	1	2.49E-04	
AB7MCH2DEX	Air Circuit Breaker 7 Fails To Close Due To Mechanical Failure		7.04E-03	7.04E-03	
EK241AXR6D	Keowee Unit 2 Relay 41/AX Fails To Pick-up And Latch	2.49E-04	1	2.49E-04	

Table 7.2-2

Top 100 Cut Sets From The Keowee Emergency Power Model

Module/Event	Description	Rate	Exposure	Prob.	Cs Prob.
92)-XA1XAALBLM	MCC 1XA Is Connected to Its Alternate Source of Power		2.74E-03	2.74E-03	1.71E-06
-KK2RUNSDEX	Keowee Unit 2 Only Is Supplying The Grid		0.06	6.00E-02	
-KK1BOTHDEX	Keowee Units 1 And 2 Are Supplying The Grid		0.0	0.00E+00	
-AD1B4ALCDT	Breaker 4AL In 125 V dc Distribution Center 1DA Transfers Open	7.5E-08	30	2.25E-06	
-AB7OPENLHE	Air Circuit Breaker 7 Fails To Open Due To A Latent Human Error		3.20E-3	3.20E-03	
-AB7MECHDEX	Air Circuit Breaker 7 Fails To Open Due To Mechanical Failure		8.01E-04	8.01E-04	
-AB752TCRYD	Air Circuit Breaker 7 Trip Coil TC Fails On Demand	3.3E-05	1	3.30E-05	
-AB710AFFUF	One Or More Air Circuit Breaker 7 Control Power Fuses Fail	3.6E-06	6	2.16E-05	
-AB51431SWT	Manual/Auto Control Switch 143/1 Spuriously Transfers Into Manual	7.0E-08	360	2.52E-05	
-AB51431LHE	Manual/Auto Control Switch 143/1 Left In Manual		3.20E-4	3.20E-04	
-AA227X2RYD	Auxiliary Relay 27X/2X Fails To Operate On Demand	3.3E-05	1	3.30E-05	
-AA127X2R6D	Transformer CX Undervoltage Relay 27/CX1 Fails To Drop Out	2.49E-04	1	2.49E-04	
AB7MCH2DEX	Air Circuit Breaker 7 Fails To Close Due To Mechanical Failure		7.04E-03	7.04E-03	
EK2FLDCLHE	Keowee Unit 2 Field Breaker Fails To Close Due To Latent Human Error		2.60E-4	2.60E-04	
93)-XA1XAALBLM	MCC 1XA Is Connected to Its Alternate Source of Power		2.74E-03	2.74E-03	1.71E-06
-KK2RUNSDEX	Keowee Unit 2 Only Is Supplying The Grid		0.06	6.00E-02	
-KK1BOTHDEX	Keowee Units 1 And 2 Are Supplying The Grid		0.0	0.00E+00	
-AD1B4ALCDT	Breaker 4AL In 125 V dc Distribution Center 1DA Transfers Open	7.5E-08	30	2.25E-06	
-AB7OPENLHE	Air Circuit Breaker 7 Fails To Open Due To A Latent Human Error		3.20E-3	3.20E-03	
-AB7MECHDEX	Air Circuit Breaker 7 Fails To Open Due To Mechanical Failure		8.01E-04	8.01E-04	
-AB752TCRYD	Air Circuit Breaker 7 Trip Coil TC Fails On Demand	3.3E-05	1	3.30E-05	
-AB710AFFUF	One Or More Air Circuit Breaker 7 Control Power Fuses Fail	3.6E-06	6	2.16E-05	
-AB51431SWT	Manual/Auto Control Switch 143/1 Spuriously Transfers Into Manual	7.0E-08	360	2.52E-05	
-AB51431LHE	Manual/Auto Control Switch 143/1 Left In Manual		3.20E-4	3.20E-04	
-AA227X2RYD	Auxiliary Relay 27X/2X Fails To Operate On Demand	3.3E-05	1	3.30E-05	
-AA127X2R6D	Transformer CX Undervoltage Relay 27/CX1 Fails To Drop Out	2.49E-04	1	2.49E-04	
AB7MCH2DEX	Air Circuit Breaker 7 Fails To Close Due To Mechanical Failure		7.04E-03	7.04E-03	
EK2FLSCLHE	Keowee Unit 2 Field Flashing Breaker Fails To Close Due To Latent Human		2.60E-4	2.60E-04	
94)-XA1XAALBLM	MCC 1XA Is Connected to Its Alternate Source of Power		2.74E-03	2.74E-03	1.71E-06
-KK2RUNSDEX	Keowee Unit 2 Only Is Supplying The Grid		0.06	6.00E-02	
-KK1BOTHDEX	Keowee Units 1 And 2 Are Supplying The Grid		0.0	0.00E+00	
-AD1B4ALCDT	Breaker 4AL In 125 V dc Distribution Center 1DA Transfers Open	7.5E-08	30	2.25E-06	
-AB7OPENLHE	Air Circuit Breaker 7 Fails To Open Due To A Latent Human Error		3.20E-3	3.20E-03	
-AB7MECHDEX	Air Circuit Breaker 7 Fails To Open Due To Mechanical Failure		8.01E-04	8.01E-04	
-AB752TCRYD	Air Circuit Breaker 7 Trip Coil TC Fails On Demand	3.3E-05	1	3.30E-05	
-AB710AFFUF	One Or More Air Circuit Breaker 7 Control Power Fuses Fail	3.6E-06	6	2.16E-05	
-AB51431SWT	Manual/Auto Control Switch 143/1 Spuriously Transfers Into Manual	7.0E-08	360	2.52E-05	
-AB51431LHE	Manual/Auto Control Switch 143/1 Left In Manual		3.20E-4	3.20E-04	
-AA227X2RYD	Auxiliary Relay 27X/2X Fails To Operate On Demand	3.3E-05	1	3.30E-05	
-AA127X2R6D	Transformer CX Undervoltage Relay 27/CX1 Fails To Drop Out	2.49E-04	1	2.49E-04	
AB7MCH2DEX	Air Circuit Breaker 7 Fails To Close Due To Mechanical Failure		7.04E-03	7.04E-03	
EK2SPYCLHE	Keowee Unit 2 Supply Breaker Fails To Close Due To Latent Human Error		2.60E-4	2.60E-04	

Table 7.2-2

Top 100 Cut Sets From The Keowee Emergency Power Model

Module/Event	Description	Rate	Exposure	Prob.	Cs Prob.
95)-XA1XAALBLM	MCC 1XA Is Connected to Its Alternate Source of Power		2.74E-03	2.74E-03	1.71E-06
-KK2RUNSDEX	Keowee Unit 2 Only Is Supplying The Grid		0.06	6.00E-02	
-KK1BOTHDEX	Keowee Units 1 And 2 Are Supplying The Grid		0.0	0.00E+00	
-AD1B4ALCDT	Breaker 4AL In 125 V dc Distribution Center 1DA Transfers Open	7.5E-08	30	2.25E-06	
-AB7OPENLHE	Air Circuit Breaker 7 Fails To Open Due To A Latent Human Error		3.20E-3	3.20E-03	
-AB7MECHDEX	Air Circuit Breaker 7 Fails To Open Due To Mechanical Failure		8.01E-04	8.01E-04	
-AB752TCRYD	Air Circuit Breaker 7 Trip Coil TC Fails On Demand	3.3E-05	1	3.30E-05	
-AB710AFFUF	One Or More Air Circuit Breaker 7 Control Power Fuses Fail	3.6E-06	6	2.16E-05	
-AB51431SWT	Manual/Auto Control Switch 143/1 Spuriously Transfers Into Manual	7.0E-08	360	2.52E-05	
-AB51431LHE	Manual/Auto Control Switch 143/1 Left In Manual		3.20E-4	3.20E-04	
-AA227X2RYD	Auxiliary Relay 27X/2X Fails To Operate On Demand	3.3E-05	1	3.30E-05	
-AA127X2R6D	Transformer CX Undervoltage Relay 27/CX1 Fails To Drop Out	2.49E-04	1	2.49E-04	
AB7MCH2DEX	Air Circuit Breaker 7 Fails To Close Due To Mechanical Failure		7.04E-03	7.04E-03	
WK2GVCDLHE	Latent Human Error Fails Keowee 2 Governor During Cold Start		2.6E-4	2.60E-04	
96)-XA1XAALBLM	MCC 1XA Is Connected to Its Alternate Source of Power		2.74E-03	2.74E-03	1.71E-06
-KK2RUNSDEX	Keowee Unit 2 Only Is Supplying The Grid		0.06	6.00E-02	
-KK1BOTHDEX	Keowee Units 1 And 2 Are Supplying The Grid		0.0	0.00E+00	
-AD1B4ALCDT	Breaker 4AL In 125 V dc Distribution Center 1DA Transfers Open	7.5E-08	30	2.25E-06	
-AB7OPENLHE	Air Circuit Breaker 7 Fails To Open Due To A Latent Human Error		3.20E-3	3.20E-03	
-AB7MECHDEX	Air Circuit Breaker 7 Fails To Open Due To Mechanical Failure		8.01E-04	8.01E-04	
-AB752TCRYD	Air Circuit Breaker 7 Trip Coil TC Fails On Demand	3.3E-05	1	3.30E-05	
-AB710AFFUF	One Or More Air Circuit Breaker 7 Control Power Fuses Fail	3.6E-06	6	2.16E-05	
-AB51431SWT	Manual/Auto Control Switch 143/1 Spuriously Transfers Into Manual	7.0E-08	360	2.52E-05	
-AB51431LHE	Manual/Auto Control Switch 143/1 Left In Manual		3.20E-4	3.20E-04	
-AA227X2RYD	Auxiliary Relay 27X/2X Fails To Operate On Demand	3.3E-05	1	3.30E-05	
-AA127X2R6D	Transformer CX Undervoltage Relay 27/CX1 Fails To Drop Out	2.49E-04	1	2.49E-04	
AB7MCH2DEX	Air Circuit Breaker 7 Fails To Close Due To Mechanical Failure		7.04E-03	7.04E-03	
EK2FLSOLHE	Keowee Unit 2 Field Flashing Breaker Fails To Open Due To Latent Human E		2.60E-4	2.60E-04	
97) BK1GBO1FTC	Filter 1GBOFL-1 Becomes Clogged	1.80E-06	24	4.32E-05	1.64E-06
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
98) EK1BAS2DEX	KHU-1 Base Adjust Fails To Maintain Generator Output Within Acceptable R		1.24E-3	1.24E-03	1.54E-06
EK2BAS2DEX	KHU-2 Base Adjust Fails To Maintain Generator Output Within Acceptable R		1.24E-3	1.24E-03	
99)-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	1.52E-06
-KK1BOTHDEX	Keowee Units 1 And 2 Are Supplying The Grid		0.0	0.00E+00	
EK1BASEDEX	Keowee Unit 1 Base Adjust Fails To Establish Correct Unit Voltage		6.17E-4	6.17E-04	
EK2VREGDEX	KHU-2 Voltage Adjust Failure Drives Generator Output Too High/Low		2.47E-3	2.47E-03	
100) EK188SVRYT	Keowee Unit 1 Fan Control Relay 88SV Prior To Or During The Run	3.6E-07	108	3.89E-05	1.48E-06
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	

Table 7.2-3

Failure Probability of Keowee Power Source/Path [1]

	Underground Power	Overhead Power
Power Source [2]	2.0E-02	2.2E-02
Power Path [3]	1.1E-03	8.2E-03
Total	2.2E-02	2.8E-02
Total [4]	2.7E-02	7.0E-02

[1] These results do not include the impact of common cause failures.
[2] Power source in this case includes the Keowee unit through the generator output breaker.
[3] Power path includes components downstream of the generator output breaker through the Oconee transformer.
[4] These results include the impact of the unit maintenance unavailability.

Table 7.2-4

Top 50 Cut Sets From The Keowee Emergency Power Model
Underground Unit- Gate UNDER0

Module/Event	Description	Rate	Exposure	Prob.	Cs Prob.
1) UNDER0					*3.01E-02
1) KK1BOTHHYM	Both Keowee Units Unavailable Due To Common Maintenance		5.23E-3	5.23E-03	5.23E-03
2)-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	3.20E-03
-KK1BOTHDEX	Keowee Units 1 And 2 Are Supplying The Grid		0.0	0.00E+00	
ABPOPRCRHE	Operators Fail To Close Air Circuit Breaker 4		1.0	1.00E+00	
ACB4MOD	NSM-ON-52966 Is Not In Service		1	1.00E+00	
EK1BASELHE	Keowee Unit 1 Base Adjust Is Set Incorrectly		3.20E-3	3.20E-03	
3) ABPOPRCRHE	Operators Fail To Close Air Circuit Breaker 4		1.0	1.00E+00	2.47E-03
ACB4MOD	NSM-ON-52966 Is Not In Service		1	1.00E+00	
EK1VREGDEX	KHU-1 Voltage Adjust Failure Drives Generator Output Too High/Low		2.47E-3	2.47E-03	
4)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	2.45E-03
FK0FISHCOM	Common Cause Failure Of Both Unit s WL Filters Due To Intake Debris		2.55E-3	2.55E-03	
5) ABPOPRCRHE	Operators Fail To Close Air Circuit Breaker 4		1.0	1.00E+00	2.27E-03
ACB4MOD	NSM-ON-52966 Is Not In Service		1	1.00E+00	
GK10001HGR	Keowee Unit 1 Generator Fault While the Unit Runs	9.46E-05	24	2.27E-03	
6) ABPOPRCRHE	Operators Fail To Close Air Circuit Breaker 4		1.0	1.00E+00	1.24E-03
ACB4MOD	NSM-ON-52966 Is Not In Service		1	1.00E+00	
EK1BAS2DEX	KHU-1 Base Adjust Fails To Maintain Generator Output Within Acceptable R		1.24E-3	1.24E-03	
7)-XD1DALTBYM	Normal Power To Dist. Center 1DA Is In Test or Maintenance		5.48E-03	5.48E-03	9.25E-04
-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	
-KK1BOTHDEX	Keowee Units 1 And 2 Are Supplying The Grid		0.0	0.00E+00	
ABPOPRCRHE	Operators Fail To Close Air Circuit Breaker 4		1.0	1.00E+00	
ACB4MOD	NSM-ON-52966 Is Not In Service		1	1.00E+00	
XD1KBATBYF	Keowee Battery No. 1 Fails During Discharge	9.30E-04	1	9.30E-04	
8)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	8.78E-04
SXFRCT4THM	Transformer CT4 Is In Maintenance		9.13E-04	9.13E-04	
9)-XD1DALTBYM	Normal Power To Dist. Center 1DA Is In Test or Maintenance		5.48E-03	5.48E-03	6.92E-04
ABPOPRCRHE	Operators Fail To Close Air Circuit Breaker 4		1.0	1.00E+00	
ACB4MOD	NSM-ON-52966 Is Not In Service		1	1.00E+00	
XD1CKC1BCF	Battery Charger KC1 Fails	2.9E-05	24	6.96E-04	
XD1KB1XRHE	Keowee Standby Battery Charger SBC Not Lined Up in 1 Hour		1	1.00E+00	
10)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	6.44E-04
AB0SWGRCOM	Common Cause Failure Of All Keowee Auxiliary Power Breakers		6.69E-04	6.69E-04	
11)-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	6.17E-04
-KK1BOTHDEX	Keowee Units 1 And 2 Are Supplying The Grid		0.0	0.00E+00	
ABPOPRCRHE	Operators Fail To Close Air Circuit Breaker 4		1.0	1.00E+00	
ACB4MOD	NSM-ON-52966 Is Not In Service		1	1.00E+00	
EK1BASEDEX	Keowee Unit 1 Base Adjust Fails To Establish Correct Unit Voltage		6.17E-4	6.17E-04	

Table 7.2-4

Top 50 Cut Sets From The Keowee Emergency Power Model
Underground Unit- Gate UNDER0

Module/Event	Description	Rate	Exposure	Prob.	Cs Prob.
12) ABPOPRCRHE	Operators Fail To Close Air Circuit Breaker 4		1.0	1.00E+00	5.60E-04
ACB4MOD	NSM-ON-52966 Is Not In Service		1	1.00E+00	
WK1GVRNDEX	Keowee Unit 1 Gov. Fails to Position Wicket Gates With Unit Running		5.6E-4	5.60E-04	
13) ABPOPRCRHE	Operators Fail To Close Air Circuit Breaker 4		1.0	1.00E+00	5.60E-04
ACB4MOD	NSM-ON-52966 Is Not In Service		1	1.00E+00	
WK1TBRNDEX	Keowee Unit 1 Turbine Fails With the Unit Running		5.6e-4	5.60E-04	
14)-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	4.62E-04
-KK1BOTHDEX	Keowee Units 1 And 2 Are Supplying The Grid		0.0	0.00E+00	
ABPOPRCRHE	Operators Fail To Close Air Circuit Breaker 4		1.0	1.00E+00	
ACB4MOD	NSM-ON-52966 Is Not In Service		1	1.00E+00	
EK1SPYMDEX	Keowee Unit 1 Supply Breaker Fails To Close Due To Mehanical Failure		4.62E-4	4.62E-04	
15)-XA1XAALBLM	MCC 1XA Is Connected to Its Alternate Source of Power		2.74E-03	2.74E-03	3.08E-04
-AD1B4ALCDT	Breaker 4AL In 125 V dc Distribution Center 1DA Transfers Open	7.5E-08	30	2.25E-06	
-AB7OPENLHE	Air Circuit Breaker 7 Fails To Open Due To A Latent Human Error		3.20E-3	3.20E-03	
-AB7MECHDEX	Air Circuit Breaker 7 Fails To Open Due To Mechanical Failure		8.01E-04	8.01E-04	
-AB752TCRYD	Air Circuit Breaker 7 Trip Coil TC Fails On Demand	3.3E-05	1	3.30E-05	
-AB710AFFUF	One Or More Air Circuit Breaker 7 Control Power Fuses Fail	3.6E-06	6	2.16E-05	
-AB51431SWT	Manual/Auto Control Switch 143/1 Spuriously Transfers Into Manual	7.0E-08	360	2.52E-05	
-AB51431LHE	Manual/Auto Control Switch 143/1 Left In Manual		3.20E-4	3.20E-04	
-AA227X2RYD	Auxiliary Relay 27X/2X Fails To Operate On Demand	3.3E-05	1	3.30E-05	
-AA127X2R6D	Transformer CX Undervoltage Relay 27/CX1 Fails To Drop Out	2.49E-04	1	2.49E-04	
ABPOPRCRHE	Operators Fail To Close Air Circuit Breaker 4		1.0	1.00E+00	
ACB4MOD	NSM-ON-52966 Is Not In Service		1	1.00E+00	
XA1BKRSCOM	CCF of 1X Aux Power Breakers ACB-5 & -7		3.10E-04	3.10E-04	
16) ABPOPRCRHE	Operators Fail To Close Air Circuit Breaker 4		1.0	1.00E+00	2.88E-04
ACB4MOD	NSM-ON-52966 Is Not In Service		1	1.00E+00	
EK1DIODDEX	Keowee Unit 1 Exciter Fan Supply Diode Bridge Fails		2.88E-4	2.88E-04	
17) ABPOPRCRHE	Operators Fail To Close Air Circuit Breaker 4		1.0	1.00E+00	2.80E-04
ACB4MOD	NSM-ON-52966 Is Not In Service		1	1.00E+00	
FK1WL11AVO	Cooling Water Control Valve 1WL-11 Fails To Open On Demand	2.80E-04	1	2.80E-04	

Table 7.2-4

Top 50 Cut Sets From The Keowee Emergency Power Model
Underground Unit- Gate UNDER0

Module/Event	Description	Rate	Exposure	Prob.	Cs Prob.
18)-XA1XAALBLM	MCC 1XA Is Connected to Its Alternate Source of Power		2.74E-03	2.74E-03	2.66E-04
-AD1B4ALCDT	Breaker 4AL In 125 V dc Distribution Center 1DA Transfers Open	7.5E-08	30	2.25E-06	
-AB7OPENLHE	Air Circuit Breaker 7 Fails To Open Due To A Latent Human Error		3.20E-3	3.20E-03	
-AB7MECHDEX	Air Circuit Breaker 7 Fails To Open Due To Mechanical Failure		8.01E-04	8.01E-04	
-AB752TCRYD	Air Circuit Breaker 7 Trip Coil TC Fails On Demand	3.3E-05	1	3.30E-05	
-AB710AFFUF	One Or More Air Circuit Breaker 7 Control Power Fuses Fail	3.6E-06	6	2.16E-05	
-AB51431SWT	Manual/Auto Control Switch 143/1 Spuriously Transfers Into Manual	7.0E-08	360	2.52E-05	
-AB51431LHE	Manual/Auto Control Switch 143/1 Left In Manual		3.20E-4	3.20E-04	
-AA227X2RYD	Auxiliary Relay 27X/2X Fails To Operate On Demand	3.3E-05	1	3.30E-05	
-AA127X2R6D	Transformer CX Undervoltage Relay 27/CX1 Fails To Drop Out	2.49E-04	1	2.49E-04	
AB7MCH2DEX	Air Circuit Breaker 7 Fails To Close Due To Mechanical Failure		7.04E-03	7.04E-03	
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
19) ABPOPRCRHE	Operators Fail To Close Air Circuit Breaker 4		1.0	1.00E+00	2.60E-04
ACB4MOD	NSM-ON-52966 Is Not In Service		1	1.00E+00	
GK1COOLLHE	Keowee 1 Gen. Air Cooler WL Flow Path Vlvs Mispositioned After Maint		2.60E-04	2.60E-04	
20) ABPOPRCRHE	Operators Fail To Close Air Circuit Breaker 4		1.0	1.00E+00	2.60E-04
ACB4MOD	NSM-ON-52966 Is Not In Service		1	1.00E+00	
GK1BRGVLHE	Keowee 1 Gen. Brng Oil Cooling Flow Path Vlvs Mispositioned After Maint		2.60E-04	2.60E-04	
21)-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	2.60E-04
-KK1BOTHDEX	Keowee Units 1 And 2 Are Supplying The Grid		0.0	0.00E+00	
ABPOPRCRHE	Operators Fail To Close Air Circuit Breaker 4		1.0	1.00E+00	
ACB4MOD	NSM-ON-52966 Is Not In Service		1	1.00E+00	
WK1GVCDLHE	Latent Human Error Fails Keowee 1 Governor During Cold Start		2.6E-4	2.60E-04	
22)-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	2.60E-04
-KK1BOTHDEX	Keowee Units 1 And 2 Are Supplying The Grid		0.0	0.00E+00	
ABPOPRCRHE	Operators Fail To Close Air Circuit Breaker 4		1.0	1.00E+00	
ACB4MOD	NSM-ON-52966 Is Not In Service		1	1.00E+00	
EK1FLSOLHE	Keowee Unit 1 Field Flashing Breaker Fails To Open Due To Latent Human E		2.60E-4	2.60E-04	
23)-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	2.60E-04
-KK1BOTHDEX	Keowee Units 1 And 2 Are Supplying The Grid		0.0	0.00E+00	
ABPOPRCRHE	Operators Fail To Close Air Circuit Breaker 4		1.0	1.00E+00	
ACB4MOD	NSM-ON-52966 Is Not In Service		1	1.00E+00	
EK1SPYCLHE	Keowee Unit 1 Supply Breaker Fails To Close Due To Latent Human Error		2.60E-4	2.60E-04	
24)-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	2.60E-04
-KK1BOTHDEX	Keowee Units 1 And 2 Are Supplying The Grid		0.0	0.00E+00	
ABPOPRCRHE	Operators Fail To Close Air Circuit Breaker 4		1.0	1.00E+00	
ACB4MOD	NSM-ON-52966 Is Not In Service		1	1.00E+00	
EK1FLDCLHE	Keowee Unit 1 Field Breaker Fails To Close Due To Latent Human Error		2.60E-4	2.60E-04	

Table 7.2-4

Top 50 Cut Sets From The Keowee Emergency Power Model
Underground Unit- Gate UNDER0

Module/Event	Description	Rate	Exposure	Prob.	Cs Prob.
25)-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	2.60E-04
-KK1BOTHDEX	Keowee Units 1 And 2 Are Supplying The Grid		0.0	0.00E+00	
ABPOPRCRHE	Operators Fail To Close Air Circuit Breaker 4		1.0	1.00E+00	
ACB4MOD	NSM-ON-52966 Is Not In Service		1	1.00E+00	
EK1FLSCLHE	Keowee Unit 1 Field Flashing Breaker Fails To Close Due To Latent Human		2.60E-4	2.60E-04	
26) ABPOPRCRHE	Operators Fail To Close Air Circuit Breaker 4		1.0	1.00E+00	2.49E-04
ACB4MOD	NSM-ON-52966 Is Not In Service		1	1.00E+00	
EK141AXR6D	Keowee Unit 1 Relay 41/AX Fails To Pick-up And Latch	2.49E-04	1	2.49E-04	
27)-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	1.54E-04
-KK1BOTHDEX	Keowee Units 1 And 2 Are Supplying The Grid		0.0	0.00E+00	
ABPOPRCRHE	Operators Fail To Close Air Circuit Breaker 4		1.0	1.00E+00	
ACB4MOD	NSM-ON-52966 Is Not In Service		1	1.00E+00	
GK10001HGS	Keowee Unit 1 Generator Fault Causes Unit Start Failure	1.54E-04	1	1.54E-04	
28) ABPOPRCRHE	Operators Fail To Close Air Circuit Breaker 4		1.0	1.00E+00	1.34E-04
ACB4MOD	NSM-ON-52966 Is Not In Service		1	1.00E+00	
OK1AG04RVT	Safety Relief Valve 1AG-4 Spurious Operation	5.60E-06	24	1.34E-04	
29) ABPOPRCRHE	Operators Fail To Close Air Circuit Breaker 4		1.0	1.00E+00	1.34E-04
ACB4MOD	NSM-ON-52966 Is Not In Service		1	1.00E+00	
OK10003RVT	Safety Relief Valve 1OG-3 Spurious Operation	5.60E-06	24	1.34E-04	
30)-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	1.22E-04
EK1BASELHE	Keowee Unit 1 Base Adjust Is Set Incorrectly		3.20E-3	3.20E-03	
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
31)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	1.19E-04
EK00RUNCOM	Common Cause Failure Of Both Units Voltage Regulators To Run		1.24E-4	1.24E-04	
32) ABPOPRCRHE	Operators Fail To Close Air Circuit Breaker 4		1.0	1.00E+00	1.01E-04
ACB4MOD	NSM-ON-52966 Is Not In Service		1	1.00E+00	
YK1SS12SST	Keowee 1 Overspeed Switch 12 Spuriously Picks Up KBE-111	4.2E-06	24	1.01E-04	
33) EK1VREGDEX	KHU-1 Voltage Adjust Failure Drives Generator Output Too High/Low		2.47E-3	2.47E-03	9.39E-05
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
34) ABPOPRCRHE	Operators Fail To Close Air Circuit Breaker 4		1.0	1.00E+00	8.64E-05
ACB4MOD	NSM-ON-52966 Is Not In Service		1	1.00E+00	
EK1F30AFUF	Keowee Unit 1 Excitation Cabinet Fan Fuses Fail	3.6E-06	24	8.64E-05	
35) GK10001HGR	Keowee Unit 1 Generator Fault While the Unit Runs	9.46E-05	24	2.27E-03	8.63E-05
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
36)-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	8.23E-05
-KK1BOTHDEX	Keowee Units 1 And 2 Are Supplying The Grid		0.0	0.00E+00	
ABPOPRCRHE	Operators Fail To Close Air Circuit Breaker 4		1.0	1.00E+00	
ACB4MOD	NSM-ON-52966 Is Not In Service		1	1.00E+00	
EK1EXC1TGF	Keowee Unit 1 Gen Excitation Transformer Is Failed	9.8E-07	84	8.23E-05	

Table 7.2-4

Top 50 Cut Sets From The Keowee Emergency Power Model
Underground Unit- Gate UNDER0

Module/Event	Description	Rate	Exposure	Prob.	Cs Prob.
37)-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	7.71E-05
-KK1BOTHDEX	Keowee Units 1 And 2 Are Supplying The Grid		0.0	0.00E+00	
ABPOPRCRHE	Operators Fail To Close Air Circuit Breaker 4		1.0	1.00E+00	
ACB4MOD	NSM-ON-52966 Is Not In Service		1	1.00E+00	
EK1FLDMDEX	Keowee Unit 1 Field Breaker Fails To Close Due To Mechanical Failure		7.71E-5	7.71E-05	
38)-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	7.71E-05
-KK1BOTHDEX	Keowee Units 1 And 2 Are Supplying The Grid		0.0	0.00E+00	
ABPOPRCRHE	Operators Fail To Close Air Circuit Breaker 4		1.0	1.00E+00	
ACB4MOD	NSM-ON-52966 Is Not In Service		1	1.00E+00	
EK1FLSMDEX	Keowee Unit 1 Field Flashing Breaker Fails To Close Due To Mechanical Fa		7.71E-5	7.71E-05	
39) UACXCT4THF	Transformer CT4 Failed	3.1E-06	24	7.44E-05	7.44E-05
40) SXFRCT4LHE	Latent Human Error on CT4 Maintenance		6.40E-05	6.40E-05	6.40E-05
41) ABPOPRCRHE	Operators Fail To Close Air Circuit Breaker 4		1.0	1.00E+00	5.60E-05
ACB4MOD	NSM-ON-52966 Is Not In Service		1	1.00E+00	
WK1SPD2DEX	Keowee Unit 1 Governor Failure Creates Overspeed Condition		5.6E-05	5.60E-05	
42)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	5.58E-05
-KK2RUNSDEX	Keowee Unit 2 Only Is Supplying The Grid		0.06	6.00E-02	
-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	
-KK1BOTHDEX	Keowee Units 1 And 2 Are Supplying The Grid		0.0	0.00E+00	
EKSTARTCOM	Common Cause Failure Of Both Units Voltage Regulators To Start		6.17E-5	6.17E-05	
43) ABPOPRCRHE	Operators Fail To Close Air Circuit Breaker 4		1.0	1.00E+00	5.52E-05
ACB4MOD	NSM-ON-52966 Is Not In Service		1	1.00E+00	
FK1WL11AVT	Cooling Water Control Valve 1WL-11 Transfers Closed	2.30E-06	24	5.52E-05	
44)-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	5.20E-05
-KK1BOTHDEX	Keowee Units 1 And 2 Are Supplying The Grid		0.0	0.00E+00	
ABPOPRCRHE	Operators Fail To Close Air Circuit Breaker 4		1.0	1.00E+00	
ACB4MOD	NSM-ON-52966 Is Not In Service		1	1.00E+00	
GK1NGDCLHE	Failure to Close the Unit 1 Neutral Ground Disconnect Following Maintena		5.20E-05	5.20E-05	

Table 7.2-4

Top 50 Cut Sets From The Keowee Emergency Power Model
Underground Unit- Gate UNDER0

Module/Event	Description	Rate	Exposure	Prob.	Cs Prob.
45)-XA1XAALBLM	MCC 1XA Is Connected to Its Alternate Source of Power		2.74E-03	2.74E-03	4.92E-05
-AD1B4ALCDT	Breaker 4AL In 125 V dc Distribution Center 1DA Transfers Open	7.5E-08	30	2.25E-06	
-AB7OPENLHE	Air Circuit Breaker 7 Fails To Open Due To A Latent Human Error		3.20E-3	3.20E-03	
-AB7MECHDEX	Air Circuit Breaker 7 Fails To Open Due To Mechanical Failure		8.01E-04	8.01E-04	
-AB752TCRYD	Air Circuit Breaker 7 Trip Coil TC Fails On Demand	3.3E-05	1	3.30E-05	
-AB710AFFUF	One Or More Air Circuit Breaker 7 Control Power Fuses Fail	3.6E-06	6	2.16E-05	
-AB51431SWT	Manual/Auto Control Switch 143/1 Spuriously Transfers Into Manual	7.0E-08	360	2.52E-05	
-AB51431LHE	Manual/Auto Control Switch 143/1 Left In Manual		3.20E-4	3.20E-04	
-AA227X2RYD	Auxiliary Relay 27X/2X Fails To Operate On Demand	3.3E-05	1	3.30E-05	
-AA127X2R6D	Transformer CX Undervoltage Relay 27/CX1 Fails To Drop Out	2.49E-04	1	2.49E-04	
AB5MCH2DEX	Air Circuit Breaker 5 Fails To Close Due To Mechanical Failure		7.04E-03	7.04E-03	
AB7MCH2DEX	Air Circuit Breaker 7 Fails To Close Due To Mechanical Failure		7.04E-03	7.04E-03	
ABPOPRCRHE	Operators Fail To Close Air Circuit Breaker 4		1.0	1.00E+00	
ACB4MOD	NSM-ON-52966 Is Not In Service		1	1.00E+00	
46)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	4.80E-05
-KK2RUNSDEX	Keowee Unit 2 Only Is Supplying The Grid		0.06	6.00E-02	
-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	
-KK1BOTHDEX	Keowee Units 1 And 2 Are Supplying The Grid		0.0	0.00E+00	
E12EXCTCOM	Units 1 & 2 Excit Fail Due To Common Cause Failure Of The Breakers		5.31E-05	5.31E-05	
47) EK1BAS2DEX	KHU-1 Base Adjust Fails To Maintain Generator Output Within Acceptable R		1.24E-3	1.24E-03	4.71E-05
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
48) ABPOPRCRHE	Operators Fail To Close Air Circuit Breaker 4		1.0	1.00E+00	4.32E-05
ACB4MOD	NSM-ON-52966 Is Not In Service		1	1.00E+00	
BK1GBO1FTC	Filter 1GBOFL-1 Becomes Clogged	1.80E-06	24	4.32E-05	
49) ABPOPRCRHE	Operators Fail To Close Air Circuit Breaker 4		1.0	1.00E+00	3.89E-05
ACB4MOD	NSM-ON-52966 Is Not In Service		1	1.00E+00	
EK188SVRYT	Keowee Unit 1 Fan Control Relay 88SV Prior To Or During The Run	3.6E-07	108	3.89E-05	
50)-XD1DALTBYM	Normal Power To Dist. Center 1DA Is In Test or Maintenance		5.48E-03	5.48E-03	3.51E-05
-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
XD1KBATBYF	Keowee Battery No. 1 Fails During Discharge	9.30E-04	1	9.30E-04	

Table 7.2-5

Top 50 Cut Sets From The Keowee Emergency Power Model
Overhead Unit- Gate OVER0

Module/Event	Description	Rate	Exposure	Prob.	Cs Prob.
1) OVER0					*7.27E-02
1) KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	3.80E-02
2) KK1BOTHHYM	Both Keowee Units Unavailable Due To Common Maintenance		5.23E-3	5.23E-03	5.23E-03
3)-KK2RUNSDEX	Keowee Unit 2 Only Is Supplying The Grid		0.06	6.00E-02	3.01E-03
-KK1BOTHDEX	Keowee Units 1 And 2 Are Supplying The Grid		0.0	0.00E+00	
EK2BASELHE	Keowee Unit 2 Base Adjust Is Set Incorrectly		3.20E-3	3.20E-03	
4) EK2VREGDEX	KHU-2 Voltage Adjust Failure Drives Generator Output Too High/Low		2.47E-3	2.47E-03	2.47E-03
5)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	2.45E-03
FK0FISHCOM	Common Cause Failure Of Both Unit s WL Filters Due To Intake Debris		2.55E-3	2.55E-03	
6)-OMOD	Startup Bus UV Sensing Mod Is In Service		0.0	0.00E+00	2.33E-03
OFACTORDEX	Overload Susceptibility Factor		1.0	1.00E+00	
S227EUVRYT	Unit 2 Startup Bus Undervoltage Relay 27E Fails	3.6E-07	9	2.33E-03	
7)-OMOD	Startup Bus UV Sensing Mod Is In Service		0.0	0.00E+00	2.33E-03
OFACTORDEX	Overload Susceptibility Factor		1.0	1.00E+00	
S127EUVRYT	Unit 1 Startup Bus Undervoltage Relay 27E Fails	3.6E-07	9	2.33E-03	
8) GK20001HGR	Keowee Unit 2 Generator Fault While the Unit Runs	9.46E-05	24	2.27E-03	2.27E-03
9) ACB4MOD	NSM-ON-52966 Is Not In Service		1	1.00E+00	2.00E-03
ACBAIRPDEX	ACB Air Supply Fails Causing Low Pressure In All ACB Accumulators		2.00E-03	2.00E-03	
10) EK2BAS2DEX	KHU-2 Base Adjust Fails To Maintain Generator Output Within Acceptable R		1.24E-3	1.24E-03	1.24E-03
11)-XD2DALTBYM	Normal Power To Dist Cntr 2DA Is In Test or Maintenance		5.48E-03	5.48E-03	9.25E-04
XD2KBATBYF	Keowee Battery No. 2 Fails during Discharge	9.30E-04	1	9.30E-04	
12)-XD2DALTBYM	Normal Power To Dist Cntr 2DA Is In Test or Maintenance		5.48E-03	5.48E-03	6.92E-04
XD2CKC2BCF	Battery Charger KC2 Fails	2.9E-05	24	6.96E-04	
XD2KB2XRHE	Keowee Standby Battery Charger SBC Not Lined Up in 1 Hour		1	1.00E+00	
13)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	6.44E-04
AB0SWGRCOM	Common Cause Failure Of All Keowee Auxiliary Power Breakers		6.69E-04	6.69E-04	
14)-KK2RUNSDEX	Keowee Unit 2 Only Is Supplying The Grid		0.06	6.00E-02	5.80E-04
-KK1BOTHDEX	Keowee Units 1 And 2 Are Supplying The Grid		0.0	0.00E+00	
EK2BASEDEX	Keowee Unit 2 Base Adjust Fails To Establish Correct Unit Voltage		6.17E-4	6.17E-04	
15) WK2TBRNDEX	Keowee Unit 2 Turbine Fails With the Unit Running		5.6E-4	5.60E-04	5.60E-04
16) WK2GVRNDEX	Keowee Unit 2 Gov. Fails to Position Wicket Gates With Unit Running		5.6E-4	5.60E-04	5.60E-04
17)-KK2RUNSDEX	Keowee Unit 2 Only Is Supplying The Grid		0.06	6.00E-02	4.34E-04
-KK1BOTHDEX	Keowee Units 1 And 2 Are Supplying The Grid		0.0	0.00E+00	
EK2SPYMDEX	Keowee Unit 2 Supply Breaker Fails To Close Due To Mehanical Failure		4.62E-4	4.62E-04	

Table 7.2-5

Top 50 Cut Sets From The Keowee Emergency Power Model
Overhead Unit- Gate OVER0

Module/Event	Description	Rate	Exposure	Prob.	Cs Prob.
18)-XA2XAALBLM	MCC 2XA Is Connected to Its Alternate Power Source		2.74E-03	2.74E-03	3.08E-04
-AD2B2ALCDT	Breaker 2AL In 125V dc Distribution Center 2DA Transfers Open	7.5E-08	30	2.25E-06	
-AB6OPENLHE	Air Circuit Breaker 6 Fails To Open Due To A Latent Human Error		3.20E-3	3.20E-03	
-AB6MECHDEX	Air Circuit Breaker 6 Fails To Open Due To Mechanical Failure		8.01E-04	8.01E-04	
-AB652TCRYD	Air Circuit Breaker 6 Trip Coil 52TC Fails Fails To Operate	3.3E-05	1	3.30E-05	
-AB61432SWT	Manual/Auto Control Switch 143/2 Spuriously Transfers Into Manual	7.0E-08	360	2.52E-05	
-AB61432LHE	Manual/Auto Control Switch 143/2 Left In Manual		3.20E-4	3.20E-04	
-AB610AFFUF	One Or More Control Power Fuses For Relay 27X/2X Fail	3.6E-06	6	2.16E-05	
-AA227X2RYD	Auxiliary Relay 27X/2X Fails To Operate On Demand	3.3E-05	1	3.30E-05	
-AA2272XR6D	Transformer 2X Undervoltage Relay 27/2X Fails To Drop Out	2.49E-04	1	2.49E-04	
XA2BKRSCOM	CCF of Aux Power Breakers ACB-6 & -8		3.10E-04	3.10E-04	
19) AB2MCH2DEX	Air Circuit Breaker 2 Fails To Close Due To Mechanical Failure		3.02E-4	3.02E-04	3.02E-04
20) EK2DIODDEX	Keowee Unit 2 Exciter Fan Supply Diode Bridge Fails		2.88E-4	2.88E-04	2.88E-04
21) FK2WL11AVO	Cooling Water Control Valve 2WL-11 Fails To Open On Demand	2.80E-04	1	2.80E-04	2.80E-04
22) GK2BRGVLHE	Keowee 2 Gen. Brng Oil Cooling Flow Path Vlvs Mispositioned After Mainte		2.60E-04	2.60E-04	2.60E-04
23) GK2COOLLHE	Keowee 2 Gen. Air Cooler WL Flow Path Vlvs Mispositioned After Maint		2.60E-04	2.60E-04	2.60E-04
24) SPCB009CHC	SWYD PCB-9 Fails To Close On Demand	2.6E-04	1	2.60E-04	2.60E-04
25) AA227T2R6D	Transformer #1 Undervoltage Relay (27T/2X) Fails To Drop Out	2.49E-04	1	2.49E-04	2.49E-04
ABEOPRCRHE	Operators Fail To Close Air Circuit Breaker 2		1	1.00E+00	
26) AB252Y2R6D	Air Circuit Breaker 2 Relay 52Y Failed To Drop Out Following Last Demand	2.49E-04	1	2.49E-04	2.49E-04
27) AB2R52XR6D	Air Circuit Breaker 2 Relay 52X Fails To Operate	2.49E-04	1	2.49E-04	2.49E-04
28) EK241AXR6D	Keowee Unit 2 Relay 41/AX Fails To Pick-up And Latch	2.49E-04	1	2.49E-04	2.49E-04
29)-KK2RUNSDEX	Keowee Unit 2 Only Is Supplying The Grid		0.06	6.00E-02	2.44E-04
-KK1BOTHDEX	Keowee Units 1 And 2 Are Supplying The Grid		0.0	0.00E+00	
EK2SPYCLHE	Keowee Unit 2 Supply Breaker Fails To Close Due To Latent Human Error		2.60E-4	2.60E-04	
30)-KK2RUNSDEX	Keowee Unit 2 Only Is Supplying The Grid		0.06	6.00E-02	2.44E-04
-KK1BOTHDEX	Keowee Units 1 And 2 Are Supplying The Grid		0.0	0.00E+00	
EK2FLSCLHE	Keowee Unit 2 Field Flashing Breaker Fails To Close Due To Latent Human		2.60E-4	2.60E-04	
31)-KK2RUNSDEX	Keowee Unit 2 Only Is Supplying The Grid		0.06	6.00E-02	2.44E-04
-KK1BOTHDEX	Keowee Units 1 And 2 Are Supplying The Grid		0.0	0.00E+00	
WK2GVCDLHE	Latent Human Error Fails Keowee 2 Governor During Cold Start		2.6E-4	2.60E-04	
32)-KK2RUNSDEX	Keowee Unit 2 Only Is Supplying The Grid		0.06	6.00E-02	2.44E-04
-KK1BOTHDEX	Keowee Units 1 And 2 Are Supplying The Grid		0.0	0.00E+00	
AB2CLOSLHE	Air Circuit Breaker 2 Fails To Close Due To A Latent Human Error		2.60E-4	2.60E-04	
33)-KK2RUNSDEX	Keowee Unit 2 Only Is Supplying The Grid		0.06	6.00E-02	2.44E-04
-KK1BOTHDEX	Keowee Units 1 And 2 Are Supplying The Grid		0.0	0.00E+00	
EK2FLSOLHE	Keowee Unit 2 Field Flashing Breaker Fails To Open Due To Latent Human E		2.60E-4	2.60E-04	

Table 7.2-5

Top 50 Cut Sets From The Keowee Emergency Power Model
Overhead Unit- Gate OVER0

Module/Event	Description	Rate	Exposure	Prob.	Cs Prob.
34)-KK2RUNSDEX	Keowee Unit 2 Only Is Supplying The Grid		0.06	6.00E-02	2.44E-04
-KK1BOTHDEX	Keowee Units 1 And 2 Are Supplying The Grid		0.0	0.00E+00	
EK2FLDCLHE	Keowee Unit 2 Field Breaker Fails To Close Due To Latent Human Error		2.60E-4	2.60E-04	
35) SXFRCT3THM	Transformer CT3 Is In Maintenance		1.74E-04	1.74E-04	1.74E-04
36)-KK2RUNSDEX	Keowee Unit 2 Only Is Supplying The Grid		0.06	6.00E-02	1.45E-04
-KK1BOTHDEX	Keowee Units 1 And 2 Are Supplying The Grid		0.0	0.00E+00	
GK20002HGS	Keowee Unit 2 Generator Fault Causes Unit Start Failure	1.54E-04	1	1.54E-04	
37) OK20003RVT	Safety Relief Valve 2OG-3 Spurious Operation	5.60E-06	24	1.34E-04	1.34E-04
38) OK2AG04RVT	Safety Relief Valve 2AG-4 Spurious Operation	5.60E-06	24	1.34E-04	1.34E-04
39)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	1.19E-04
EK00RUNCOM	Common Cause Failure Of Both Units Voltage Regulators To Run		1.24E-4	1.24E-04	
40)-OMOD	Startup Bus UV Sensing Mod Is In Service		0.0	0.00E+00	1.18E-04
OFACTORDEX	Overload Susceptibility Factor		1.0	1.00E+00	
SU327UVCOM	Common Cause Failure of Unit 3 SU Bus Undervoltage Relays		1.18E-04	1.18E-04	
41)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	1.08E-04
AB24BKRCOM	Common Cause Failure Of Air Circuit Breakers 2 And 4 To Close		1.12E-04	1.12E-04	
42) YK2SS12SST	Keowee 2 Overspeed Switch 12 Spuriously Picks Up KBE-211	4.2E-06	24	1.01E-04	1.01E-04
43) EK2F30AFUF	Keowee Unit 2 Excitation Cabinet Fan Fuses Fail	3.6E-06	24	8.64E-05	8.64E-05
44) SXFRCT3THF	Transformer CT3 Faulted	3.1E-06	24	7.44E-05	7.44E-05
45)-KK2RUNSDEX	Keowee Unit 2 Only Is Supplying The Grid		0.06	6.00E-02	7.25E-05
-KK1BOTHDEX	Keowee Units 1 And 2 Are Supplying The Grid		0.0	0.00E+00	
EK2FLDMDEX	Keowee Unit 2 Field Breaker Fails To Close Due To Mechanical Failure		7.71E-5	7.71E-05	
46)-KK2RUNSDEX	Keowee Unit 2 Only Is Supplying The Grid		0.06	6.00E-02	7.25E-05
-KK1BOTHDEX	Keowee Units 1 And 2 Are Supplying The Grid		0.0	0.00E+00	
EK2FLSMDEX	Keowee Unit 2 Field Flashing Breaker Fails To Close Due To Mechanical Fa		7.71E-5	7.71E-05	
47) GK2FIREDEX	Spurious Actuation of Unit 2 Gen. CO2 Fire Supression System		7.00E-05	7.00E-05	7.00E-05
48) WK2SPD2DEX	Keowee Unit 2 Governor Failure Creates Overspeed Condition		5.6E-05	5.60E-05	5.60E-05
49)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	5.58E-05
-KK2RUNSDEX	Keowee Unit 2 Only Is Supplying The Grid		0.06	6.00E-02	
-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	
-KK1BOTHDEX	Keowee Units 1 And 2 Are Supplying The Grid		0.0	0.00E+00	
EKSTARTCOM	Common Cause Failure Of Both Units Voltage Regulators To Start		6.17E-5	6.17E-05	
50) FK2WL11AVT	Cooling Water Control Valve 2WL-11 Transfers Closed	2.30E-06	24	5.52E-05	5.52E-05

Table 7.2-6

Keowee Run Failure Probability - Base Case

	Failure Probability
Reliability Model Prediction - - Standby Unit	0.012
Reliability Model Prediction - - Grid-cycled Unit	0.011
Overall Experience (1984-1993)	0.012

Table 7.2-7

Comparison of System Level Versus Component Level
Common Cause Failure Probability

	Start Failure Prob.	Run Failure prob.	Total CCF Prob.
System Level:			
A. Generic Beta factor	4.50E-4	6.20E-4	1.07E-3
B. Keowee Beta factor	4.05E-5	3.05E-3	3.09E-3
Component Level:	1.50E-4	3.36E-3	3.51E-3

Table 7.3-1

Top 100 Cut Sets From The ONS-Keowee AC Power Integrated Model

Module/Event	Description	Rate	Exposure	Prob.	Cs Prob.
1) OPWERTOP					*6.35E-05
1)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	1.26E-05
-KK1BOTHHYM	Both Keowee Units Unavailable Due To Common Maintenance		5.23E-3	5.23E-03	
SXFRCT4THM	Transformer CT4 Is In Maintenance		9.13E-04	9.13E-04	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
2) KK1BOTHHYM	Both Keowee Units Unavailable Due To Common Maintenance		5.23E-3	5.23E-03	7.53E-06
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
PAC0T5WDEX	Modifier Since Keowee Maintenance Is Scheduled For Mild Weather Periods		1.00E-01	1.00E-01	
3)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	4.63E-06
AB0SWGRCOM	Common Cause Failure Of All Keowee Auxiliary Power Breakers		6.69E-04	6.69E-04	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
AB0SWGRRHE	Recovery of Keowee Aux Power Breakers by Manual Control		5.0E-01	5.00E-01	
4)-XA1XAALBLM	MCC 1XA Is Connected to Its Alternate Source of Power		2.74E-03	2.74E-03	3.82E-06
-AD1B4ALCDT	Breaker 4AL In 125 V dc Distribution Center 1DA Transfers Open	7.5E-08	30	2.25E-06	
-AB7OPENLHE	Air Circuit Breaker 7 Fails To Open Due To A Latent Human Error		3.20E-3	3.20E-03	
-AB7MECHDEX	Air Circuit Breaker 7 Fails To Open Due To Mechanical Failure		8.01E-04	8.01E-04	
-AB752TCRYD	Air Circuit Breaker 7 Trip Coil TC Fails On Demand	3.3E-05	1	3.30E-05	
-AB710AFFUF	One Or More Air Circuit Breaker 7 Control Power Fuses Fail	3.6E-06	6	2.16E-05	
-AB51431SWT	Manual/Auto Control Switch 143/1 Spuriously Transfers Into Manual	7.0E-08	360	2.52E-05	
-AB51431LHE	Manual/Auto Control Switch 143/1 Left In Manual		3.20E-4	3.20E-04	
-AA227X2RYD	Auxiliary Relay 27X/2X Fails To Operate On Demand	3.3E-05	1	3.30E-05	
-AA127X2R6D	Transformer CX Undervoltage Relay 27/CX1 Fails To Drop Out	2.49E-04	1	2.49E-04	
AB7MCH2DEX	Air Circuit Breaker 7 Fails To Close Due To Mechanical Failure		7.04E-03	7.04E-03	
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
5)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	2.23E-06
FK0FISHCOM	Common Cause Failure Of Both Unit s WL Filters Due To Intake Debris		2.55E-3	2.55E-03	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
FK0FISHDHE	Recovery of Main WL Strainer Clogging		6.3E-02	6.30E-02	
6) KK1BOTHHYM	Both Keowee Units Unavailable Due To Common Maintenance		5.23E-3	5.23E-03	1.98E-06
PACLINEDEX	100 kV ac Overhead Line From Lee Steam Station To CT5 Fails		7.800E-03	7.80E-03	
T5SUBF	Loss Of The Oconee Station Switchyards Initiating Event		4.86E-02	4.86E-02	
7)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	1.72E-06
EK00RUNCOM	Common Cause Failure Of Both Units Voltage Regulators To Run		1.24E-4	1.24E-04	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
8) EK1VREGDEX	KHU-1 Voltage Adjust Failure Drives Generator Output Too High/Low		2.47E-3	2.47E-03	1.35E-06
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
9) GK10001HGR	Keowee Unit 1 Generator Fault While the Unit Runs	9.46E-05	24	2.27E-03	1.24E-06
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
10) KK1BOTHHYM	Both Keowee Units Unavailable Due To Common Maintenance		5.23E-3	5.23E-03	1.11E-06
PACLINEDEX	100 kV ac Overhead Line From Lee Steam Station To CT5 Fails		7.800E-03	7.80E-03	
T5FEEDF	Failure Of Electrical Grid Or Main Feeders Initiating Event		2.730E-02	2.73E-02	
11) T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	1.07E-06
UACXCT4THF	Transformer CT4 Failed	3.1E-06	24	7.44E-05	

Table 7.3-1

Top 100 Cut Sets From The ONS-Keowee AC Power Integrated Model

Module/Event	Description	Rate	Exposure	Prob.	Cs Prob.
12) SXFRCT4LHE	Latent Human Error on CT4 Maintenance		6.40E-05	6.40E-05	9.22E-07
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
13)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	8.03E-07
-KK2RUNSDEX	Keowee Unit 2 Only Is Supplying The Grid		0.06	6.00E-02	
-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	
-KK1BOTHDEX	Keowee Units 1 And 2 Are Supplying The Grid		0.0	0.00E+00	
EKSTARTCOM	Common Cause Failure Of Both Units Voltage Regulators To Start		6.17E-5	6.17E-05	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
14)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	6.91E-07
-KK2RUNSDEX	Keowee Unit 2 Only Is Supplying The Grid		0.06	6.00E-02	
-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	
-KK1BOTHDEX	Keowee Units 1 And 2 Are Supplying The Grid		0.0	0.00E+00	
E12EXCTCOM	Units 1 & 2 Excit Fail Due To Common Cause Failure Of The Breakers		5.31E-05	5.31E-05	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
15) EK1BAS2DEX	KHU-1 Base Adjust Fails To Maintain Generator Output Within Acceptable R		1.24E-3	1.24E-03	6.79E-07
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
16) KK1BOTHHYM	Both Keowee Units Unavailable Due To Common Maintenance		5.23E-3	5.23E-03	5.67E-07
PACLEESCTR	Lee Steam Station Combustion Turbines Fail To Run For The Required Time	9.30E-05	24	2.23E-03	
T5SUBF	Loss Of The Oconee Station Switchyards Initiating Event		4.86E-02	4.86E-02	
17)-XD1DALTBYM	Normal Power To Dist. Center 1DA Is In Test or Maintenance		5.48E-03	5.48E-03	5.06E-07
-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
XD1KBATBYF	Keowee Battery No. 1 Fails During Discharge	9.30E-04	1	9.30E-04	
XD0KBATRHE	Failure To Recover DC By Cross Connecting The Distribution Centers		1.00E+00	1.00E+00	
18)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	4.82E-07
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
XD0CHRGCOM	Common Cause Failure Of Keowee Battery Chargers		3.48E-05	3.48E-05	
19)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	4.39E-07
AB0SWGRCOM	Common Cause Failure Of All Keowee Auxiliary Power Breakers		6.69E-04	6.69E-04	
T5FEEDF	Failure Of Electrical Grid Or Main Feeders Initiating Event		2.730E-02	2.73E-02	
AB0SWGRRHE	Recovery of Keowee Aux Power Breakers by Manual Control		5.0E-01	5.00E-01	
PACLEE2REC	Operators Fail To Align Power From Lee Steam Station To Standby Buses		5.0e-02	5.00E-02	
20)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	4.25E-07
-KK1BOTHHYM	Both Keowee Units Unavailable Due To Common Maintenance		5.23E-3	5.23E-03	
SXFRCT4THM	Transformer CT4 Is In Maintenance		9.13E-04	9.13E-04	
T5SUBF	Loss Of The Oconee Station Switchyards Initiating Event		4.86E-02	4.86E-02	
PACLEE1REC	Operators Fail To Align Power From Lee Steam Station To Standby Buses		1.0e-02	1.00E-02	
21)-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	4.15E-07
-KK1BOTHDEX	Keowee Units 1 And 2 Are Supplying The Grid		0.0	0.00E+00	
ABPOPRCRHE	Operators Fail To Close Air Circuit Breaker 4		9.0E-03	9.00E-03	
ACB4MOD	NSM-ON-52966 Is Not In Service		1	1.00E+00	
EK1BASELHE	Keowee Unit 1 Base Adjust Is Set Incorrectly		3.20E-3	3.20E-03	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	

Table 7.3-1

Top 100 Cut Sets From The ONS-Keowee AC Power Integrated Model

Module/Event	Description	Rate	Exposure	Prob.	Cs Prob.
22)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	3.74E-07
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
XD0BATTCOM	Common Cause Failure Of Keowee I&C Power Batteries		2.70E-05	2.70E-05	
23)-XA1XAALBLM	MCC 1XA Is Connected to Its Alternate Source of Power		2.74E-03	2.74E-03	3.62E-07
-AD1B4ALCDT	Breaker 4AL In 125 V dc Distribution Center 1DA Transfers Open	7.5E-08	30	2.25E-06	
-AB7OPENLHE	Air Circuit Breaker 7 Fails To Open Due To A Latent Human Error		3.20E-3	3.20E-03	
-AB7MECHDEX	Air Circuit Breaker 7 Fails To Open Due To Mechanical Failure		8.01E-04	8.01E-04	
-AB752TCRYD	Air Circuit Breaker 7 Trip Coil TC Fails On Demand	3.3E-05	1	3.30E-05	
-AB710AFFUF	One Or More Air Circuit Breaker 7 Control Power Fuses Fail	3.6E-06	6	2.16E-05	
-AB51431SWT	Manual/Auto Control Switch 143/1 Spuriously Transfers Into Manual	7.0E-08	360	2.52E-05	
-AB51431LHE	Manual/Auto Control Switch 143/1 Left In Manual		3.20E-4	3.20E-04	
-AA227X2RYD	Auxiliary Relay 27X/2X Fails To Operate On Demand	3.3E-05	1	3.30E-05	
-AA127X2R6D	Transformer CX Undervoltage Relay 27/CX1 Fails To Drop Out	2.49E-04	1	2.49E-04	
AB7MCH2DEX	Air Circuit Breaker 7 Fails To Close Due To Mechanical Failure		7.04E-03	7.04E-03	
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
T5FEEDF	Failure Of Electrical Grid Or Main Feeders Initiating Event		2.730E-02	2.73E-02	
PACLEE2REC	Operators Fail To Align Power From Lee Steam Station To Standby Buses		5.0e-02	5.00E-02	
24)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	3.41E-07
FKVALVECOM	Common Cause Failure Of Cooling Water Control Valves		2.46E-5	2.46E-05	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
25)-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	3.38E-07
EK1BASEDEX	Keowee Unit 1 Base Adjust Fails To Establish Correct Unit Voltage		6.17E-4	6.17E-04	
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
26) ABPOPRCRHE	Operators Fail To Close Air Circuit Breaker 4		9.0E-03	9.00E-03	3.20E-07
ACB4MOD	NSM-ON-52966 Is Not In Service		1	1.00E+00	
EK1VREGDEX	KHU-1 Voltage Adjust Failure Drives Generator Output Too High/Low		2.47E-3	2.47E-03	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
27) KK1BOTHHYM	Both Keowee Units Unavailable Due To Common Maintenance		5.23E-3	5.23E-03	3.19E-07
PACLEESCTR	Lee Steam Station Combustion Turbines Fail To Run For The Required Time	9.30E-05	24	2.23E-03	
T5FEEDF	Failure Of Electrical Grid Or Main Feeders Initiating Event		2.730E-02	2.73E-02	
28) KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	3.06E-07
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
WK1TBRNDEX	Keowee Unit 1 Turbine Fails With the Unit Running		5.6e-4	5.60E-04	
29) KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	3.06E-07
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
WK1GVRNDEX	Keowee Unit 1 Gov. Fails to Position Wicket Gates With Unit Running		5.6E-4	5.60E-04	
30) ABPOPRCRHE	Operators Fail To Close Air Circuit Breaker 4		9.0E-03	9.00E-03	2.94E-07
ACB4MOD	NSM-ON-52966 Is Not In Service		1	1.00E+00	
GK10001HGR	Keowee Unit 1 Generator Fault While the Unit Runs	9.46E-05	24	2.27E-03	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
31)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	2.90E-07
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
WK00RUNCOM	Common Cause Failure of Keowee Governors to Run		2.09E-05	2.09E-05	

Table 7.3-1

Top 100 Cut Sets From The ONS-Keowee AC Power Integrated Model

Module/Event	Description	Rate	Exposure	Prob.	Cs Prob.
32)-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	2.53E-07
EK1SPYMDEX	Keowee Unit 1 Supply Breaker Fails To Close Due To Mehanical Failure		4.62E-4	4.62E-04	
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
33)-XA1XAALBLM	MCC 1XA Is Connected to Its Alternate Source of Power		2.74E-03	2.74E-03	2.49E-07
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
XA1XCXXTHM	4160/600 Vac Transformer CX Is in Maintenance		4.57E-4	4.57E-04	
34)-XA1XAALBLM	MCC 1XA Is Connected to Its Alternate Source of Power		2.74E-03	2.74E-03	2.49E-07
-AD1B4ALCDT	Breaker 4AL In 125 V dc Distribution Center 1DA Transfers Open	7.5E-08	30	2.25E-06	
-AB7OPENLHE	Air Circuit Breaker 7 Fails To Open Due To A Latent Human Error		3.20E-3	3.20E-03	
-AB7MECHDEX	Air Circuit Breaker 7 Fails To Open Due To Mechanical Failure		8.01E-04	8.01E-04	
-AB752TCRYD	Air Circuit Breaker 7 Trip Coil TC Fails On Demand	3.3E-05	1	3.30E-05	
-AB710AFFUF	One Or More Air Circuit Breaker 7 Control Power Fuses Fail	3.6E-06	6	2.16E-05	
-AB51431SWT	Manual/Auto Control Switch 143/1 Spuriously Transfers Into Manual	7.0E-08	360	2.52E-05	
-AB51431LHE	Manual/Auto Control Switch 143/1 Left In Manual		3.20E-4	3.20E-04	
-AA227X2RYD	Auxiliary Relay 27X/2X Fails To Operate On Demand	3.3E-05	1	3.30E-05	
-AA127X2R6D	Transformer CX Undervoltage Relay 27/CX1 Fails To Drop Out	2.49E-04	1	2.49E-04	
AB7MCH2DEX	Air Circuit Breaker 7 Fails To Close Due To Mechanical Failure		7.04E-03	7.04E-03	
EK2VREGDEX	KHU-2 Voltage Adjust Failure Drives Generator Output Too High/Low		2.47E-3	2.47E-03	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
35)-XA1XAALBLM	MCC 1XA Is Connected to Its Alternate Source of Power		2.74E-03	2.74E-03	2.28E-07
-AD1B4ALCDT	Breaker 4AL In 125 V dc Distribution Center 1DA Transfers Open	7.5E-08	30	2.25E-06	
-AB7OPENLHE	Air Circuit Breaker 7 Fails To Open Due To A Latent Human Error		3.20E-3	3.20E-03	
-AB7MECHDEX	Air Circuit Breaker 7 Fails To Open Due To Mechanical Failure		8.01E-04	8.01E-04	
-AB752TCRYD	Air Circuit Breaker 7 Trip Coil TC Fails On Demand	3.3E-05	1	3.30E-05	
-AB710AFFUF	One Or More Air Circuit Breaker 7 Control Power Fuses Fail	3.6E-06	6	2.16E-05	
-AB51431SWT	Manual/Auto Control Switch 143/1 Spuriously Transfers Into Manual	7.0E-08	360	2.52E-05	
-AB51431LHE	Manual/Auto Control Switch 143/1 Left In Manual		3.20E-4	3.20E-04	
-AA227X2RYD	Auxiliary Relay 27X/2X Fails To Operate On Demand	3.3E-05	1	3.30E-05	
-AA127X2R6D	Transformer CX Undervoltage Relay 27/CX1 Fails To Drop Out	2.49E-04	1	2.49E-04	
AB7MCH2DEX	Air Circuit Breaker 7 Fails To Close Due To Mechanical Failure		7.04E-03	7.04E-03	
GK20001HGR	Keowee Unit 2 Generator Fault While the Unit Runs	9.46E-05	24	2.27E-03	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
36) PACS1S2COM	Common Cause Failure Of Breakers S1 And S2 To Close		8.900E-05	8.90E-05	2.16E-07
T5SUBF	Loss Of The Oconee Station Switchyards Initiating Event		4.86E-02	4.86E-02	
PACS1S2REC			5.0e-02	5.00E-02	
37)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	2.11E-07
FK0FISHCOM	Common Cause Failure Of Both Unit s WL Filters Due To Intake Debris		2.55E-3	2.55E-03	
T5FEEDF	Failure Of Electrical Grid Or Main Feeders Initiating Event		2.730E-02	2.73E-02	
FK0FISHDHE	Recovery of Main WL Strainer Clogging		6.3E-02	6.30E-02	
PACLEE2REC	Operators Fail To Align Power From Lee Steam Station To Standby Buses		5.0e-02	5.00E-02	
38)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	2.02E-07
OK0PRUNCOM	Common Cause Failure Of Both Governor Oil Systems To Run		1.46E-05	1.46E-05	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	

Table 7.3-1

Top 100 Cut Sets From The ONS-Keowee AC Power Integrated Model

Module/Event	Description	Rate	Exposure	Prob.	Cs Prob.
39)-XA1XAALBLM	MCC 1XA Is Connected to Its Alternate Source of Power		2.74E-03	2.74E-03	2.01E-07
-AD1B4ALCDT	Breaker 4AL In 125 V dc Distribution Center 1DA Transfers Open	7.5E-08	30	2.25E-06	
-AB7OPENLHE	Air Circuit Breaker 7 Fails To Open Due To A Latent Human Error		3.20E-3	3.20E-03	
-AB7MECHDEX	Air Circuit Breaker 7 Fails To Open Due To Mechanical Failure		8.01E-04	8.01E-04	
-AB752TCRYD	Air Circuit Breaker 7 Trip Coil TC Fails On Demand	3.3E-05	1	3.30E-05	
-AB710AFFUF	One Or More Air Circuit Breaker 7 Control Power Fuses Fail	3.6E-06	6	2.16E-05	
-AB51431SWT	Manual/Auto Control Switch 143/1 Spuriously Transfers Into Manual	7.0E-08	360	2.52E-05	
-AB51431LHE	Manual/Auto Control Switch 143/1 Left In Manual		3.20E-4	3.20E-04	
-AA227X2RYD	Auxiliary Relay 27X/2X Fails To Operate On Demand	3.3E-05	1	3.30E-05	
-AA127X2R6D	Transformer CX Undervoltage Relay 27/CX1 Fails To Drop Out	2.49E-04	1	2.49E-04	
AB7MCH2DEX	Air Circuit Breaker 7 Fails To Close Due To Mechanical Failure		7.04E-03	7.04E-03	
ACB4MOD	NSM-ON-52966 Is Not In Service		1	1.00E+00	
ACBAIRPDEX	ACB Air Supply Fails Causing Low Pressure In All ACB Accumulators		2.00E-03	2.00E-03	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
40)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	1.63E-07
EK00RUNCOM	Common Cause Failure Of Both Units Voltage Regulators To Run		1.24E-4	1.24E-04	
T5FEEDF	Failure Of Electrical Grid Or Main Feeders Initiating Event		2.730E-02	2.73E-02	
PACLEE2REC	Operators Fail To Align Power From Lee Steam Station To Standby Buses		5.0e-02	5.00E-02	
41) ABPOPRCRHE	Operators Fail To Close Air Circuit Breaker 4		9.0E-03	9.00E-03	1.61E-07
ACB4MOD	NSM-ON-52966 Is Not In Service		1	1.00E+00	
EK1BAS2DEX	KHU-1 Base Adjust Fails To Maintain Generator Output Within Acceptable R		1.24E-3	1.24E-03	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
42) EK1DIODDEX	Keowee Unit 1 Exciter Fan Supply Diode Bridge Fails		2.88E-4	2.88E-04	1.58E-07
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
43)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	1.56E-07
AB0SWGRCOM	Common Cause Failure Of All Keowee Auxiliary Power Breakers		6.69E-04	6.69E-04	
T5SUBF	Loss Of The Oconee Station Switchyards Initiating Event		4.86E-02	4.86E-02	
AB0SWGRRHE	Recovery of Keowee Aux Power Breakers by Manual Control		5.0E-01	5.00E-01	
PACLEE1REC	Operators Fail To Align Power From Lee Steam Station To Standby Buses		1.0e-02	1.00E-02	
44) FK1WL11AVO	Cooling Water Control Valve 1WL-11 Fails To Open On Demand	2.80E-04	1	2.80E-04	1.53E-07
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
45)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	1.46E-07
-KK2RUNSDEX	Keowee Unit 2 Only Is Supplying The Grid		0.06	6.00E-02	
-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	
-KK1BOTHDEX	Keowee Units 1 And 2 Are Supplying The Grid		0.0	0.00E+00	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
WKCSTRTCOM	Common Cause Failure of Keowee Governors to Cold Start		1.12E-05	1.12E-05	
46) GK1COOLLHE	Keowee 1 Gen. Air Cooler WL Flow Path Vlvs Mispositioned After Maint		2.60E-04	2.60E-04	1.42E-07
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
47)-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	1.42E-07
EK1FLDCLHE	Keowee Unit 1 Field Breaker Fails To Close Due To Latent Human Error		2.60E-4	2.60E-04	
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	

Table 7.3-1

Top 100 Cut Sets From The ONS-Keowee AC Power Integrated Model

Module/Event	Description	Rate	Exposure	Prob.	Cs Prob.
48)-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	1.42E-07
EK1SPYCLHE	Keowee Unit 1 Supply Breaker Fails To Close Due To Latent Human Error		2.60E-4	2.60E-04	
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
49)-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	1.42E-07
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
WK1GVCDLHE	Latent Human Error Fails Keowee 1 Governor During Cold Start		2.6E-4	2.60E-04	
50)-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	1.42E-07
EK1FLSCLHE	Keowee Unit 1 Field Flashing Breaker Fails To Close Due To Latent Human		2.60E-4	2.60E-04	
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
51)-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	1.42E-07
EK1FLSOLHE	Keowee Unit 1 Field Flashing Breaker Fails To Open Due To Latent Human E		2.60E-4	2.60E-04	
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
52)-XA1XAALBLM	MCC 1XA Is Connected to Its Alternate Source of Power		2.74E-03	2.74E-03	1.41E-07
-AD1B4ALCDT	Breaker 4AL In 125 V dc Distribution Center 1DA Transfers Open	7.5E-08	30	2.25E-06	
-AB7OPENLHE	Air Circuit Breaker 7 Fails To Open Due To A Latent Human Error		3.20E-3	3.20E-03	
-AB7MECHDEX	Air Circuit Breaker 7 Fails To Open Due To Mechanical Failure		8.01E-04	8.01E-04	
-AB752TCRYD	Air Circuit Breaker 7 Trip Coil TC Fails On Demand	3.3E-05	1	3.30E-05	
-AB710AFFUF	One Or More Air Circuit Breaker 7 Control Power Fuses Fail	3.6E-06	6	2.16E-05	
-AB51431SWT	Manual/Auto Control Switch 143/1 Spuriously Transfers Into Manual	7.0E-08	360	2.52E-05	
-AB51431LHE	Manual/Auto Control Switch 143/1 Left In Manual		3.20E-4	3.20E-04	
-AA227X2RYD	Auxiliary Relay 27X/2X Fails To Operate On Demand	3.3E-05	1	3.30E-05	
-AA127X2R6D	Transformer CX Undervoltage Relay 27/CX1 Fails To Drop Out	2.49E-04	1	2.49E-04	
AB7CLOSLHE	Air Circuit Breaker 7 Fails To Close Due To A Latent Human Error		2.60E-4	2.60E-04	
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
53) KK1UNDRBHF	Fault Occurs On The Underground Power Path	4.00E-07	24	9.60E-06	1.38E-07
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
54) EK141AXR6D	Keowee Unit 1 Relay 41/AX Fails To Pick-up And Latch	2.49E-04	1	2.49E-04	1.36E-07
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	

Table 7.3-1

Top 100 Cut Sets From The ONS-Keowee AC Power Integrated Model

Module/Event	Description	Rate	Exposure	Prob.	Cs Prob.
55)-XA1XAALBLM	MCC 1XA Is Connected to Its Alternate Source of Power		2.74E-03	2.74E-03	1.35E-07
-AD1B4ALCDT	Breaker 4AL In 125 V dc Distribution Center 1DA Transfers Open	7.5E-08	30	2.25E-06	
-AB7OPENLHE	Air Circuit Breaker 7 Fails To Open Due To A Latent Human Error		3.20E-3	3.20E-03	
-AB7MECHDEX	Air Circuit Breaker 7 Fails To Open Due To Mechanical Failure		8.01E-04	8.01E-04	
-AB752TCRYD	Air Circuit Breaker 7 Trip Coil TC Fails On Demand	3.3E-05	1	3.30E-05	
-AB710AFFUF	One Or More Air Circuit Breaker 7 Control Power Fuses Fail	3.6E-06	6	2.16E-05	
-AB51431SWT	Manual/Auto Control Switch 143/1 Spuriously Transfers Into Manual	7.0E-08	360	2.52E-05	
-AB51431LHE	Manual/Auto Control Switch 143/1 Left In Manual		3.20E-4	3.20E-04	
-AA227X2RYD	Auxiliary Relay 27X/2X Fails To Operate On Demand	3.3E-05	1	3.30E-05	
-AA127X2R6D	Transformer CX Undervoltage Relay 27/CX1 Fails To Drop Out	2.49E-04	1	2.49E-04	
AA127CPR6D	Transformer CX Undervoltage Relay 27/CX1 Fails To Pick Up	2.49E-04	1	2.49E-04	
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
56)-XA1XAALBLM	MCC 1XA Is Connected to Its Alternate Source of Power		2.74E-03	2.74E-03	1.29E-07
-AD1B4ALCDT	Breaker 4AL In 125 V dc Distribution Center 1DA Transfers Open	7.5E-08	30	2.25E-06	
-AB7OPENLHE	Air Circuit Breaker 7 Fails To Open Due To A Latent Human Error		3.20E-3	3.20E-03	
-AB7MECHDEX	Air Circuit Breaker 7 Fails To Open Due To Mechanical Failure		8.01E-04	8.01E-04	
-AB752TCRYD	Air Circuit Breaker 7 Trip Coil TC Fails On Demand	3.3E-05	1	3.30E-05	
-AB710AFFUF	One Or More Air Circuit Breaker 7 Control Power Fuses Fail	3.6E-06	6	2.16E-05	
-AB51431SWT	Manual/Auto Control Switch 143/1 Spuriously Transfers Into Manual	7.0E-08	360	2.52E-05	
-AB51431LHE	Manual/Auto Control Switch 143/1 Left In Manual		3.20E-4	3.20E-04	
-AA227X2RYD	Auxiliary Relay 27X/2X Fails To Operate On Demand	3.3E-05	1	3.30E-05	
-AA127X2R6D	Transformer CX Undervoltage Relay 27/CX1 Fails To Drop Out	2.49E-04	1	2.49E-04	
AB7MCH2DEX	Air Circuit Breaker 7 Fails To Close Due To Mechanical Failure		7.04E-03	7.04E-03	
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
T5SUBF	Loss Of The Oconee Station Switchyards Initiating Event		4.86E-02	4.86E-02	
PACLEE1REC	Operators Fail To Align Power From Lee Steam Station To Standby Buses		1.0e-02	1.00E-02	
57) EK1VREGDEX	KHU-1 Voltage Adjust Failure Drives Generator Output Too High/Low		2.47E-3	2.47E-03	1.28E-07
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
T5FEEDF	Failure Of Electrical Grid Or Main Feeders Initiating Event		2.730E-02	2.73E-02	
PACLEE2REC	Operators Fail To Align Power From Lee Steam Station To Standby Buses		5.0e-02	5.00E-02	
58)-XA1XAALBLM	MCC 1XA Is Connected to Its Alternate Source of Power		2.74E-03	2.74E-03	1.25E-07
-AD1B4ALCDT	Breaker 4AL In 125 V dc Distribution Center 1DA Transfers Open	7.5E-08	30	2.25E-06	
-AB7OPENLHE	Air Circuit Breaker 7 Fails To Open Due To A Latent Human Error		3.20E-3	3.20E-03	
-AB7MECHDEX	Air Circuit Breaker 7 Fails To Open Due To Mechanical Failure		8.01E-04	8.01E-04	
-AB752TCRYD	Air Circuit Breaker 7 Trip Coil TC Fails On Demand	3.3E-05	1	3.30E-05	
-AB710AFFUF	One Or More Air Circuit Breaker 7 Control Power Fuses Fail	3.6E-06	6	2.16E-05	
-AB51431SWT	Manual/Auto Control Switch 143/1 Spuriously Transfers Into Manual	7.0E-08	360	2.52E-05	
-AB51431LHE	Manual/Auto Control Switch 143/1 Left In Manual		3.20E-4	3.20E-04	
-AA227X2RYD	Auxiliary Relay 27X/2X Fails To Operate On Demand	3.3E-05	1	3.30E-05	
-AA127X2R6D	Transformer CX Undervoltage Relay 27/CX1 Fails To Drop Out	2.49E-04	1	2.49E-04	
AB7MCH2DEX	Air Circuit Breaker 7 Fails To Close Due To Mechanical Failure		7.04E-03	7.04E-03	
EK2BAS2DEX	KHU-2 Base Adjust Fails To Maintain Generator Output Within Acceptable R		1.24E-3	1.24E-03	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
59) T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	1.24E-07
U5186EFRYT	Time Delay Overcurrent Relay 51 Actuates Lockout Relay 86EF	3.6E-07	24	8.64E-06	

Table 7.3-1

Top 100 Cut Sets From The ONS-Keowee AC Power Integrated Model

Module/Event	Description	Rate	Exposure	Prob.	Cs Prob.
60) T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	1.24E-07
U62BSK1RYT	SK1 Breaker Failure Relay 62BXSK1 Spuriously Picks Up	3.6E-07	24	8.64E-06	
61) T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	1.24E-07
U87TCT4RYT	Spurious Op of CT4 Differential Rly 87T Actuates LOR 86BF	3.6E-07	24	8.64E-06	
62) T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	1.24E-07
U86TCT4RYT	CT4 Lockout Relay 86T/CT4 Spuriously Picks Up	3.6E-07	24	8.64E-06	
63) T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	1.24E-07
U51TNC4RYT	CT4 Neutral Ground Rly Actuates CT4 LOR 86T/CT4	3.6E-07	24	8.64E-06	
64) T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	1.24E-07
U5086BFRYT	Overcurrent Relay 50 Spuriously Actuates Lockout Rly 86BF	3.6E-07	24	8.64E-06	
65) T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	1.24E-07
U86CT4XRYT	Auxiliary Lockout Relay 86CT4X Spuriously Picks Up	3.6E-07	24	8.64E-06	
66) T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	1.24E-07
U62BSK2RYT	SK2 Breaker Failure Relay 62BXSK2 Spuriously Picks Up	3.6E-07	24	8.64E-06	
67) T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	1.24E-07
UXX86BFRYT	Lockout Relay 86BF Spuriously Picks Up	3.6E-07	24	8.64E-06	
68)-XD1DALTBYM	Normal Power To Dist. Center 1DA Is In Test or Maintenance		5.48E-03	5.48E-03	1.20E-07
-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	
-KK1BOTHDEX	Keowee Units 1 And 2 Are Supplying The Grid		0.0	0.00E+00	
ABPOPRCRHE	Operators Fail To Close Air Circuit Breaker 4		9.0E-03	9.00E-03	
ACB4MOD	NSM-ON-52966 Is Not In Service		1	1.00E+00	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
XD1KBATBYF	Keowee Battery No. 1 Fails During Discharge	9.30E-04	1	9.30E-04	
69) GK10001HGR	Keowee Unit 1 Generator Fault While the Unit Runs	9.46E-05	24	2.27E-03	1.18E-07
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
T5FEEDF	Failure Of Electrical Grid Or Main Feeders Initiating Event		2.730E-02	2.73E-02	
PACLEE2REC	Operators Fail To Align Power From Lee Steam Station To Standby Buses		5.0e-02	5.00E-02	
70) PACS1CSMOD	S1 Closing Circuit Components Fail		2.833E-03	2.83E-03	1.16E-07
PACS2CSMOD	S2 Closing Circuit Components Fail		2.833E-03	2.83E-03	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
71) T5FEEDF	Failure Of Electrical Grid Or Main Feeders Initiating Event		2.730E-02	2.73E-02	9.91E-08
YOSTARTCOM	Common Cause Failure Of Emergency Start Signal		7.26E-06	7.26E-06	
YOSTARTRHE	Operators Fail To Manually Start Keowee		0.5	5.00E-01	

Table 7.3-1

Top 100 Cut Sets From The ONS-Keowee AC Power Integrated Model

Module/Event	Description	Rate	Exposure	Prob.	Cs Prob.
72)-XD2DALTBYM	Normal Power To Dist Cntr 2DA Is In Test or Maintenance		5.48E-03	5.48E-03	9.31E-08
-XA1XAALBLM	MCC 1XA Is Connected to Its Alternate Source of Power		2.74E-03	2.74E-03	
-AD1B4ALCDT	Breaker 4AL In 125 V dc Distribution Center 1DA Transfers Open	7.5E-08	30	2.25E-06	
-AB7OPENLHE	Air Circuit Breaker 7 Fails To Open Due To A Latent Human Error		3.20E-3	3.20E-03	
-AB7MECHDEX	Air Circuit Breaker 7 Fails To Open Due To Mechanical Failure		8.01E-04	8.01E-04	
-AB752TCRYD	Air Circuit Breaker 7 Trip Coil TC Fails On Demand	3.3E-05	1	3.30E-05	
-AB710AFFUF	One Or More Air Circuit Breaker 7 Control Power Fuses Fail	3.6E-06	6	2.16E-05	
-AB51431SWT	Manual/Auto Control Switch 143/1 Spuriously Transfers Into Manual	7.0E-08	360	2.52E-05	
-AB51431LHE	Manual/Auto Control Switch 143/1 Left In Manual		3.20E-4	3.20E-04	
-AA227X2RYD	Auxiliary Relay 27X/2X Fails To Operate On Demand	3.3E-05	1	3.30E-05	
-AA127X2R6D	Transformer CX Undervoltage Relay 27/CX1 Fails To Drop Out	2.49E-04	1	2.49E-04	
AB7MCH2DEX	Air Circuit Breaker 7 Fails To Close Due To Mechanical Failure		7.04E-03	7.04E-03	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
XD2KBATBYF	Keowee Battery No. 2 Fails during Discharge	9.30E-04	1	9.30E-04	
73) EK1VREGDEX	KHU-1 Voltage Adjust Failure Drives Generator Output Too High/Low		2.47E-3	2.47E-03	8.79E-08
EK2VREGDEX	KHU-2 Voltage Adjust Failure Drives Generator Output Too High/Low		2.47E-3	2.47E-03	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
74)-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	8.43E-08
GK10001HGS	Keowee Unit 1 Generator Fault Causes Unit Start Failure	1.54E-04	1	1.54E-04	
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
75)-XA1XAALBLM	MCC 1XA Is Connected to Its Alternate Source of Power		2.74E-03	2.74E-03	8.42E-08
-AD1B4ALCDT	Breaker 4AL In 125 V dc Distribution Center 1DA Transfers Open	7.5E-08	30	2.25E-06	
-AB7OPENLHE	Air Circuit Breaker 7 Fails To Open Due To A Latent Human Error		3.20E-3	3.20E-03	
-AB7MECHDEX	Air Circuit Breaker 7 Fails To Open Due To Mechanical Failure		8.01E-04	8.01E-04	
-AB752TCRYD	Air Circuit Breaker 7 Trip Coil TC Fails On Demand	3.3E-05	1	3.30E-05	
-AB710AFFUF	One Or More Air Circuit Breaker 7 Control Power Fuses Fail	3.6E-06	6	2.16E-05	
-AB51431SWT	Manual/Auto Control Switch 143/1 Spuriously Transfers Into Manual	7.0E-08	360	2.52E-05	
-AB51431LHE	Manual/Auto Control Switch 143/1 Left In Manual		3.20E-4	3.20E-04	
-AA227X2RYD	Auxiliary Relay 27X/2X Fails To Operate On Demand	3.3E-05	1	3.30E-05	
-AA127X2R6D	Transformer CX Undervoltage Relay 27/CX1 Fails To Drop Out	2.49E-04	1	2.49E-04	
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
XA1BKRSCOM	CCF of 1X Aux Power Breakers ACB-5 & -7		3.10E-04	3.10E-04	
AB0SWGRRHE	Recovery of Keowee Aux Power Breakers by Manual Control		5.0E-01	5.00E-01	

Table 7.3-1

Top 100 Cut Sets From The ONS-Keowee AC Power Integrated Model

Module/Event	Description	Rate	Exposure	Prob.	Cs Prob.
76)-XA1XAALBLM	MCC 1XA Is Connected to Its Alternate Source of Power		2.74E-03	2.74E-03	8.42E-08
-AD1B4ALCDT	Breaker 4AL In 125 V dc Distribution Center 1DA Transfers Open	7.5E-08	30	2.25E-06	
-AB7OPENLHE	Air Circuit Breaker 7 Fails To Open Due To A Latent Human Error		3.20E-3	3.20E-03	
-AB7MECHDEX	Air Circuit Breaker 7 Fails To Open Due To Mechanical Failure		8.01E-04	8.01E-04	
-AB752TCRYD	Air Circuit Breaker 7 Trip Coil TC Fails On Demand	3.3E-05	1	3.30E-05	
-AB710AFFUF	One Or More Air Circuit Breaker 7 Control Power Fuses Fail	3.6E-06	6	2.16E-05	
-AB51431SWT	Manual/Auto Control Switch 143/1 Spuriously Transfers Into Manual	7.0E-08	360	2.52E-05	
-AB51431LHE	Manual/Auto Control Switch 143/1 Left In Manual		3.20E-4	3.20E-04	
-AA227X2RYD	Auxiliary Relay 27X/2X Fails To Operate On Demand	3.3E-05	1	3.30E-05	
-AA127X2R6D	Transformer CX Undervoltage Relay 27/CX1 Fails To Drop Out	2.49E-04	1	2.49E-04	
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
XA78BKRCOM	Common Cause Failure Of ACB-7 And ACB-8 To Close		3.10E-04	3.10E-04	
AB0SWGRRHE	Recovery of Keowee Aux Power Breakers by Manual Control		5.0E-01	5.00E-01	
77) EK1VREGDEX	KHU-1 Voltage Adjust Failure Drives Generator Output Too High/Low		2.47E-3	2.47E-03	8.08E-08
GK20001HGR	Keowee Unit 2 Generator Fault While the Unit Runs	9.46E-05	24	2.27E-03	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
78) EK2VREGDEX	KHU-2 Voltage Adjust Failure Drives Generator Output Too High/Low		2.47E-3	2.47E-03	8.08E-08
GK10001HGR	Keowee Unit 1 Generator Fault While the Unit Runs	9.46E-05	24	2.27E-03	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
79)-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	8.00E-08
-KK1BOTHDEX	Keowee Units 1 And 2 Are Supplying The Grid		0.0	0.00E+00	
ABPOPRCRHE	Operators Fail To Close Air Circuit Breaker 4		9.0E-03	9.00E-03	
ACB4MOD	NSM-ON-52966 Is Not In Service		1	1.00E+00	
EK1BASEDEX	Keowee Unit 1 Base Adjust Fails To Establish Correct Unit Voltage		6.17E-4	6.17E-04	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
80)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	7.62E-08
-KK2RUNSDEX	Keowee Unit 2 Only Is Supplying The Grid		0.06	6.00E-02	
-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	
-KK1BOTHDEX	Keowee Units 1 And 2 Are Supplying The Grid		0.0	0.00E+00	
EKSTARTCOM	Common Cause Failure Of Both Units Voltage Regulators To Start		6.17E-5	6.17E-05	
T5FEEDF	Failure Of Electrical Grid Or Main Feeders Initiating Event		2.730E-02	2.73E-02	
PACLEE2REC	Operators Fail To Align Power From Lee Steam Station To Standby Buses		5.0e-02	5.00E-02	
81)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	7.51E-08
FK0FISHCOM	Common Cause Failure Of Both Unit s WL Filters Due To Intake Debris		2.55E-3	2.55E-03	
T5SUBF	Loss Of The Oconee Station Switchyards Initiating Event		4.86E-02	4.86E-02	
FK0FISHDHE	Recovery of Main WL Strainer Clogging		6.3E-02	6.30E-02	
PACLEE1REC	Operators Fail To Align Power From Lee Steam Station To Standby Buses		1.0e-02	1.00E-02	
82) GK10001HGR	Keowee Unit 1 Generator Fault While the Unit Runs	9.46E-05	24	2.27E-03	7.42E-08
GK20001HGR	Keowee Unit 2 Generator Fault While the Unit Runs	9.46E-05	24	2.27E-03	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
83) KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	7.35E-08
OK1AG04RVT	Safety Relief Valve 1AG-4 Spurious Operation	5.60E-06	24	1.34E-04	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	

Table 7.3-1

Top 100 Cut Sets From The ONS-Keowee AC Power Integrated Model

Module/Event	Description	Rate	Exposure	Prob.	Cs Prob.
84) KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	7.35E-08
OK10003RVT	Safety Relief Valve 10G-3 Spurious Operation	5.60E-06	24	1.34E-04	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
85)-XD1DALTBYM	Normal Power To Dist. Center 1DA Is In Test or Maintenance		5.48E-03	5.48E-03	7.30E-08
-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	
-KK1BOTHDEX	Keowee Units 1 And 2 Are Supplying The Grid		0.0	0.00E+00	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
XD1KBATBYF	Keowee Battery No. 1 Fails During Discharge	9.30E-04	1	9.30E-04	
XD2DALTBYM	Normal Power To Dist Cntr 2DA Is In Test or Maintenance		5.48E-03	5.48E-03	
86)-XD2DALTBYM	Normal Power To Dist Cntr 2DA Is In Test or Maintenance		5.48E-03	5.48E-03	7.30E-08
-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	
-KK1BOTHDEX	Keowee Units 1 And 2 Are Supplying The Grid		0.0	0.00E+00	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
XD1DALTBYM	Normal Power To Dist. Center 1DA Is In Test or Maintenance		5.48E-03	5.48E-03	
XD2KBATBYF	Keowee Battery No. 2 Fails during Discharge	9.30E-04	1	9.30E-04	
87) PACN1N2COM	Common Cause Failure Of Breakers N1 And N2 To Open		3.000E-05	3.00E-05	7.29E-08
T5SUBF	Loss Of The Oconee Station Switchyards Initiating Event		4.86E-02	4.86E-02	
PACN1N2REC	Operators Fail To Open N1 and N2 Within 40 Minutes		5.0e-02	5.00E-02	
88) ABPOPRCRHE	Operators Fail To Close Air Circuit Breaker 4		9.0E-03	9.00E-03	7.26E-08
ACB4MOD	NSM-ON-52966 Is Not In Service		1	1.00E+00	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
WK1TBRNDEX	Keowee Unit 1 Turbine Fails With the Unit Running		5.6e-4	5.60E-04	
89) ABPOPRCRHE	Operators Fail To Close Air Circuit Breaker 4		9.0E-03	9.00E-03	7.26E-08
ACB4MOD	NSM-ON-52966 Is Not In Service		1	1.00E+00	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
WK1GVRNDEX	Keowee Unit 1 Gov. Fails to Position Wicket Gates With Unit Running		5.6E-4	5.60E-04	
90) ACBAIRPDEX	ACB Air Supply Fails Causing Low Pressure In All ACB Accumulators		2.00E-03	2.00E-03	7.11E-08
EK1VREGDEX	KHU-1 Voltage Adjust Failure Drives Generator Output Too High/Low		2.47E-3	2.47E-03	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
91)-XA1XAALBLM	MCC 1XA Is Connected to Its Alternate Source of Power		2.74E-03	2.74E-03	7.04E-08
-AD1B4ALCDT	Breaker 4AL In 125 V dc Distribution Center 1DA Transfers Open	7.5E-08	30	2.25E-06	
-AB7OPENLHE	Air Circuit Breaker 7 Fails To Open Due To A Latent Human Error		3.20E-3	3.20E-03	
-AB7MECHDEX	Air Circuit Breaker 7 Fails To Open Due To Mechanical Failure		8.01E-04	8.01E-04	
-AB752TCRYD	Air Circuit Breaker 7 Trip Coil TC Fails On Demand	3.3E-05	1	3.30E-05	
-AB710AFFUF	One Or More Air Circuit Breaker 7 Control Power Fuses Fail	3.6E-06	6	2.16E-05	
-AB51431SWT	Manual/Auto Control Switch 143/1 Spuriously Transfers Into Manual	7.0E-08	360	2.52E-05	
-AB51431LHE	Manual/Auto Control Switch 143/1 Left In Manual		3.20E-4	3.20E-04	
-AA227X2RYD	Auxiliary Relay 27X/2X Fails To Operate On Demand	3.3E-05	1	3.30E-05	
-AA127X2R6D	Transformer CX Undervoltage Relay 27/CX1 Fails To Drop Out	2.49E-04	1	2.49E-04	
AB752Y2RYT	Air Circuit Breaker 7 Y-relay Spurious Operation	3.6E-07	360	1.30E-04	
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	

Table 7.3-1

Top 100 Cut Sets From The ONS-Keowee AC Power Integrated Model

Module/Event	Description	Rate	Exposure	Prob.	Cs Prob.
92)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	6.55E-08
-KK2RUNSDEX	Keowee Unit 2 Only Is Supplying The Grid		0.06	6.00E-02	
-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	
-KK1BOTHDEX	Keowee Units 1 And 2 Are Supplying The Grid		0.0	0.00E+00	
E12EXCTCOM	Units 1 & 2 Excit Fail Due To Common Cause Failure Of The Breakers		5.31E-05	5.31E-05	
T5FEEDF	Failure Of Electrical Grid Or Main Feeders Initiating Event		2.730E-02	2.73E-02	
PACLEE2REC	Operators Fail To Align Power From Lee Steam Station To Standby Buses		5.0e-02	5.00E-02	
93) ACBAIRPDEX	ACB Air Supply Fails Causing Low Pressure In All ACB Accumulators		2.00E-03	2.00E-03	6.54E-08
GK10001HGR	Keowee Unit 1 Generator Fault While the Unit Runs	9.46E-05	24	2.27E-03	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
94) EK1BAS2DEX	KHU-1 Base Adjust Fails To Maintain Generator Output Within Acceptable R		1.24E-3	1.24E-03	6.43E-08
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
T5FEEDF	Failure Of Electrical Grid Or Main Feeders Initiating Event		2.730E-02	2.73E-02	
PACLEE2REC	Operators Fail To Align Power From Lee Steam Station To Standby Buses		5.0e-02	5.00E-02	
95) PACS1S2COM	Common Cause Failure Of Breakers S1 And S2 To Close		8.900E-05	8.90E-05	6.41E-08
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
PACS1S2REC	Failure To Manually Close Breakers S1 and S2		5.0e-02	5.00E-02	
96) PACSK12COM	Common Cause Failure Of Breakers SK1 And SK2 To Close		8.900E-05	8.90E-05	6.41E-08
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
PACSK12REC	Failure To Manually Close Breakers SK1 and SK2		5.0e-02	5.00E-02	
97)-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	5.99E-08
-KK1BOTHDEX	Keowee Units 1 And 2 Are Supplying The Grid		0.0	0.00E+00	
ABPOPRCRHE	Operators Fail To Close Air Circuit Breaker 4		9.0E-03	9.00E-03	
ACB4MOD	NSM-ON-52966 Is Not In Service		1	1.00E+00	
EK1SPYMDEX	Keowee Unit 1 Supply Breaker Fails To Close Due To Mehanical Failure		4.62E-4	4.62E-04	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
98)-XA1XAALBLM	MCC 1XA Is Connected to Its Alternate Source of Power		2.74E-03	2.74E-03	5.84E-08
-KK2RUNSDEX	Keowee Unit 2 Only Is Supplying The Grid		0.06	6.00E-02	
-KK1BOTHDEX	Keowee Units 1 And 2 Are Supplying The Grid		0.0	0.00E+00	
-AD1B4ALCDT	Breaker 4AL In 125 V dc Distribution Center 1DA Transfers Open	7.5E-08	30	2.25E-06	
-AB7OPENLHE	Air Circuit Breaker 7 Fails To Open Due To A Latent Human Error		3.20E-3	3.20E-03	
-AB7MECHDEX	Air Circuit Breaker 7 Fails To Open Due To Mechanical Failure		8.01E-04	8.01E-04	
-AB752TCRYD	Air Circuit Breaker 7 Trip Coil TC Fails On Demand	3.3E-05	1	3.30E-05	
-AB710AFFUF	One Or More Air Circuit Breaker 7 Control Power Fuses Fail	3.6E-06	6	2.16E-05	
-AB51431SWT	Manual/Auto Control Switch 143/1 Spuriously Transfers Into Manual	7.0E-08	360	2.52E-05	
-AB51431LHE	Manual/Auto Control Switch 143/1 Left In Manual		3.20E-4	3.20E-04	
-AA227X2RYD	Auxiliary Relay 27X/2X Fails To Operate On Demand	3.3E-05	1	3.30E-05	
-AA127X2R6D	Transformer CX Undervoltage Relay 27/CX1 Fails To Drop Out	2.49E-04	1	2.49E-04	
AB7MCH2DEX	Air Circuit Breaker 7 Fails To Close Due To Mechanical Failure		7.04E-03	7.04E-03	
EK2BASEDEX	Keowee Unit 2 Base Adjust Fails To Establish Correct Unit Voltage		6.17E-4	6.17E-04	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
99)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	5.80E-08
EK00RUNCOM	Common Cause Failure Of Both Units Voltage Regulators To Run		1.24E-4	1.24E-04	
T5SUBF	Loss Of The Oconee Station Switchyards Initiating Event		4.86E-02	4.86E-02	
PACLEE1REC	Operators Fail To Align Power From Lee Steam Station To Standby Buses		1.0e-02	1.00E-02	

Table 7.3-1

Top 100 Cut Sets From The ONS-Keowee AC Power Integrated Model

Module/Event	Description	Rate	Exposure	Prob.	Cs Prob.
100)-XA1XAALBLM	MCC 1XA Is Connected to Its Alternate Source of Power		2.74E-03	2.74E-03	5.64E-08
-AD1B4ALCDT	Breaker 4AL In 125 V dc Distribution Center 1DA Transfers Open	7.5E-08	30	2.25E-06	
-AB7OPENLHE	Air Circuit Breaker 7 Fails To Open Due To A Latent Human Error		3.20E-3	3.20E-03	
-AB7MECHDEX	Air Circuit Breaker 7 Fails To Open Due To Mechanical Failure		8.01E-04	8.01E-04	
-AB752TCRYD	Air Circuit Breaker 7 Trip Coil TC Fails On Demand	3.3E-05	1	3.30E-05	
-AB710AFFUF	One Or More Air Circuit Breaker 7 Control Power Fuses Fail	3.6E-06	6	2.16E-05	
-AB51431SWT	Manual/Auto Control Switch 143/1 Spuriously Transfers Into Manual	7.0E-08	360	2.52E-05	
-AB51431LHE	Manual/Auto Control Switch 143/1 Left In Manual		3.20E-4	3.20E-04	
-AA227X2RYD	Auxiliary Relay 27X/2X Fails To Operate On Demand	3.3E-05	1	3.30E-05	
-AA127X2R6D	Transformer CX Undervoltage Relay 27/CX1 Fails To Drop Out	2.49E-04	1	2.49E-04	
AB7MCH2DEX	Air Circuit Breaker 7 Fails To Close Due To Mechanical Failure		7.04E-03	7.04E-03	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
WK2GVRNDEX	Keowee Unit 2 Gov. Fails to Position Wicket Gates With Unit Running		5.6E-4	5.60E-04	

Table 7.3-2

Basic Event Importance Measures From The ONS-Keowee AC Power Integrated Model

Basic Event	Probability	Fus. Ves.	Critic	Birnbm	Red Wrth	Ach Wrth
T5WEATH	1.44E-02	8.46E-01	8.45E-01	3.79E-03	6.50E+00	5.88E+01
KK2UNITHYM	3.80E-02	2.06E-01	2.06E-01	3.50E-04	1.26E+00	6.22E+00
SXFRCT4THM	9.13E-04	2.03E-01	2.03E-01	1.43E-02	1.25E+00	2.23E+02
KK1BOTHHYM	5.23E-03	1.78E-01	1.78E-01	2.20E-03	1.22E+00	3.49E+01
PAC0T5WDEX	1.00E-01	1.17E-01	1.17E-01	7.53E-05	1.13E+00	2.05E+00
AB7MCH2DEX	7.04E-03	9.43E-02	9.42E-02	8.64E-04	1.10E+00	1.43E+01
AB0SWGRRHE	5.00E-01	9.02E-02	9.02E-02	1.16E-05	1.10E+00	1.09E+00
AB0SWGRCOM	6.69E-04	8.10E-02	8.10E-02	7.81E-03	1.09E+00	1.22E+02
T5SUBF	4.86E-02	7.92E-02	7.92E-02	1.05E-04	1.09E+00	2.55E+00
T5FEEDF	2.73E-02	7.47E-02	7.47E-02	1.76E-04	1.08E+00	3.66E+00
PACLINEDEX	7.80E-03	4.80E-02	4.80E-02	3.97E-04	1.05E+00	7.10E+00
ACB4MOD	1.00E+00	4.42E-02	4.42E-02	2.85E-06	1.05E+00	1.00E+00
PACLEE2REC	5.00E-02	4.27E-02	4.27E-02	5.51E-05	1.04E+00	1.81E+00
ABPOPRCRHE	9.00E-03	3.99E-02	3.99E-02	2.86E-04	1.04E+00	5.40E+00
FK0FISHDHE	6.30E-02	3.90E-02	3.90E-02	3.99E-05	1.04E+00	1.58E+00
FK0FISHCOM	2.55E-03	3.89E-02	3.89E-02	9.85E-04	1.04E+00	1.62E+01
EK1VREGDEX	2.47E-03	3.76E-02	3.76E-02	9.83E-04	1.04E+00	1.62E+01
GK10001HGR	2.27E-03	3.43E-02	3.43E-02	9.75E-04	1.04E+00	1.61E+01
EK00RUNCOM	1.24E-04	3.00E-02	3.00E-02	1.56E-02	1.03E+00	2.43E+02
PACLEE1REC	1.00E-02	2.61E-02	2.61E-02	1.68E-04	1.03E+00	3.58E+00
EK1BAS2DEX	1.24E-03	1.84E-02	1.84E-02	9.58E-04	1.02E+00	1.58E+01
XD1KBATBYF	9.30E-04	1.80E-02	1.80E-02	1.25E-03	1.02E+00	2.03E+01
UACXCT4THF	7.44E-05	1.74E-02	1.74E-02	1.51E-02	1.02E+00	2.35E+02
SXFRCT4LHE	6.40E-05	1.48E-02	1.48E-02	1.49E-02	1.01E+00	2.32E+02
XD0KBATRHE	1.00E+00	1.42E-02	1.42E-02	9.16E-07	1.01E+00	1.00E+00
EKSTARTCOM	6.17E-05	1.41E-02	1.40E-02	1.47E-02	1.01E+00	2.28E+02
PACLEESCTR	2.23E-03	1.37E-02	1.37E-02	3.97E-04	1.01E+00	7.14E+00
EK2VREGDEX	2.47E-03	1.27E-02	1.27E-02	3.32E-04	1.01E+00	6.13E+00
E12EXCTCOM	5.31E-05	1.21E-02	1.21E-02	1.47E-02	1.01E+00	2.28E+02
GK20001HGR	2.27E-03	1.15E-02	1.15E-02	3.27E-04	1.01E+00	6.06E+00
XD1KB1XRHE	1.00E+00	9.35E-03	9.35E-03	6.03E-07	1.01E+00	1.00E+00
XD1CKC1BCF	6.96E-04	9.34E-03	9.34E-03	8.66E-04	1.01E+00	1.44E+01
ACBAIRPDEX	2.00E-03	9.21E-03	9.20E-03	2.97E-04	1.01E+00	5.59E+00
EK1BASELHE	3.20E-03	8.92E-03	8.92E-03	1.80E-04	1.01E+00	3.78E+00
EK1BASEDEX	6.17E-04	8.52E-03	8.51E-03	8.90E-04	1.01E+00	1.48E+01
XD0CHRGCOM	3.48E-05	8.43E-03	8.42E-03	1.56E-02	1.01E+00	2.43E+02
WK1TBRNDEX	5.60E-04	7.73E-03	7.73E-03	8.90E-04	1.01E+00	1.48E+01
WK1GVRNDEX	5.60E-04	7.73E-03	7.73E-03	8.90E-04	1.01E+00	1.48E+01
XD0BATTCOM	2.70E-05	6.54E-03	6.53E-03	1.56E-02	1.01E+00	2.43E+02
EK1SPYMDEX	4.62E-04	6.25E-03	6.24E-03	8.72E-04	1.01E+00	1.45E+01
FKVALVECOM	2.46E-05	5.96E-03	5.95E-03	1.56E-02	1.01E+00	2.43E+02

Table 7.3-2

Basic Event Importance Measures From The ONS-Keowee AC Power Integrated Model

Basic Event	Probability	Fus. Ves.	Critic	Birnbm	Red Wrth	Ach Wrth
XA1XCXXTHM	4.57E-04	5.81E-03	5.81E-03	8.21E-04	1.01E+00	1.37E+01
EK2BAS2DEX	1.24E-03	5.78E-03	5.78E-03	3.01E-04	1.01E+00	5.66E+00
XD2KBATBYF	9.30E-04	5.11E-03	5.11E-03	3.54E-04	1.01E+00	6.49E+00
WK00RUNCOM	2.09E-05	5.06E-03	5.05E-03	1.56E-02	1.01E+00	2.43E+02
GK0BRGVRHE	1.00E+00	4.86E-03	4.86E-03	3.14E-07	1.00E+00	1.00E+00
Y0STARTCOM	7.26E-06	4.75E-03	4.70E-03	4.18E-02	1.00E+00	6.48E+02
Y0STARTRHE	1.00E+00	4.75E-03	4.75E-03	3.06E-07	1.00E+00	1.00E+00
PACS1S2COM	8.90E-05	4.43E-03	4.42E-03	3.21E-03	1.00E+00	5.07E+01
PACS1S2REC	5.00E-02	4.43E-03	4.43E-03	5.71E-06	1.00E+00	1.08E+00
XA1BKRSCOM	3.10E-04	4.29E-03	4.29E-03	8.94E-04	1.00E+00	1.48E+01
GK1BRGVLHE	2.60E-04	4.01E-03	4.01E-03	9.95E-04	1.00E+00	1.64E+01
EK0BASERHE	1.90E-02	3.96E-03	3.96E-03	1.35E-05	1.00E+00	1.20E+00
PACS2CSMOD	2.83E-03	3.96E-03	3.96E-03	9.01E-05	1.00E+00	2.39E+00
PACS1CSMOD	2.83E-03	3.96E-03	3.96E-03	9.01E-05	1.00E+00	2.39E+00
EK1DIODDEX	2.88E-04	3.59E-03	3.59E-03	8.04E-04	1.00E+00	1.35E+01
OK0PRUNCOM	1.46E-05	3.54E-03	3.53E-03	1.56E-02	1.00E+00	2.43E+02
XA78BKRCOM	3.10E-04	3.36E-03	3.35E-03	6.98E-04	1.00E+00	1.18E+01
FK1WL11AVO	2.80E-04	3.34E-03	3.33E-03	7.69E-04	1.00E+00	1.29E+01
WK1GVCDLHE	2.60E-04	3.10E-03	3.10E-03	7.69E-04	1.00E+00	1.29E+01
EK1FLSCLHE	2.60E-04	3.10E-03	3.10E-03	7.69E-04	1.00E+00	1.29E+01
EK1SPYCLHE	2.60E-04	3.10E-03	3.10E-03	7.69E-04	1.00E+00	1.29E+01
EK1FLDCLHE	2.60E-04	3.10E-03	3.10E-03	7.69E-04	1.00E+00	1.29E+01
EK1FLSOLHE	2.60E-04	3.10E-03	3.10E-03	7.69E-04	1.00E+00	1.29E+01
GK1COOLLHE	2.60E-04	3.10E-03	3.10E-03	7.69E-04	1.00E+00	1.29E+01
XD2CKC2BCF	6.96E-04	3.10E-03	3.10E-03	2.87E-04	1.00E+00	5.45E+00
XD2KB2XRHE	1.00E+00	3.10E-03	3.10E-03	2.00E-07	1.00E+00	1.00E+00
EK141AXR6D	2.49E-04	2.97E-03	2.97E-03	7.69E-04	1.00E+00	1.29E+01
WKCSTRTCOM	1.12E-05	2.55E-03	2.55E-03	1.47E-02	1.00E+00	2.28E+02
AB7CLOSLHE	2.60E-04	2.54E-03	2.54E-03	6.30E-04	1.00E+00	1.08E+01
AA127CPR6D	2.49E-04	2.43E-03	2.43E-03	6.30E-04	1.00E+00	1.08E+01
EK2BASEDEX	6.17E-04	2.40E-03	2.40E-03	2.51E-04	1.00E+00	4.89E+00
WK2GVRNDEX	5.60E-04	2.32E-03	2.32E-03	2.67E-04	1.00E+00	5.14E+00
WK2TBRNDEX	5.60E-04	2.32E-03	2.32E-03	2.67E-04	1.00E+00	5.14E+00
XA2BKRSCOM	3.10E-04	2.22E-03	2.22E-03	4.62E-04	1.00E+00	8.15E+00
KK1UNDRBHF	9.60E-06	2.21E-03	2.21E-03	1.49E-02	1.00E+00	2.32E+02
PACN1N2REC	5.00E-02	2.10E-03	2.10E-03	2.71E-06	1.00E+00	1.04E+00
PACN1N2COM	3.00E-05	2.10E-03	2.10E-03	4.51E-03	1.00E+00	7.09E+01
XD1DALTBYM	5.48E-03	2.09E-03	2.09E-03	2.46E-05	1.00E+00	1.38E+00
EK2BASELHE	3.20E-03	2.01E-03	2.01E-03	4.05E-05	1.00E+00	1.63E+00
U51TNC4RYT	8.64E-06	2.00E-03	2.00E-03	1.49E-02	1.00E+00	2.32E+02
U87TCT4RYT	8.64E-06	2.00E-03	2.00E-03	1.49E-02	1.00E+00	2.32E+02

Table 7.3-2

Basic Event Importance Measures From The ONS-Keowee AC Power Integrated Model

Basic Event	Probability	Fus. Ves.	Critic	Birnbm	Red Wrth	Ach Wrth
U86TCT4RYT	8.64E-06	2.00E-03	2.00E-03	1.49E-02	1.00E+00	2.32E+02
U5186EFRYT	8.64E-06	2.00E-03	2.00E-03	1.49E-02	1.00E+00	2.32E+02
UXX86EFRYT	8.64E-06	2.00E-03	2.00E-03	1.49E-02	1.00E+00	2.32E+02
U86CT4XRYT	8.64E-06	2.00E-03	2.00E-03	1.49E-02	1.00E+00	2.32E+02
U62BSK1RYT	8.64E-06	2.00E-03	2.00E-03	1.49E-02	1.00E+00	2.32E+02
U5086EFRYT	8.64E-06	2.00E-03	2.00E-03	1.49E-02	1.00E+00	2.32E+02
U62BSK2RYT	8.64E-06	2.00E-03	2.00E-03	1.49E-02	1.00E+00	2.32E+02
EK2SPYMDEX	4.62E-04	1.97E-03	1.97E-03	2.76E-04	1.00E+00	5.27E+00
GK10001HGS	1.54E-04	1.82E-03	1.82E-03	7.64E-04	1.00E+00	1.28E+01
PACSK12COM	8.90E-05	1.74E-03	1.74E-03	1.26E-03	1.00E+00	2.06E+01
OK1AG04RVT	1.34E-04	1.58E-03	1.58E-03	7.59E-04	1.00E+00	1.28E+01
OK10003RVT	1.34E-04	1.58E-03	1.58E-03	7.59E-04	1.00E+00	1.28E+01
PACSK2CMOD	1.30E-03	1.56E-03	1.56E-03	7.72E-05	1.00E+00	2.19E+00
PACSK1CMOD	1.30E-03	1.56E-03	1.56E-03	7.72E-05	1.00E+00	2.19E+00
GK2BRGVLHE	2.60E-04	1.43E-03	1.43E-03	3.56E-04	1.00E+00	6.51E+00
AB752Y2RYT	1.30E-04	1.24E-03	1.24E-03	6.20E-04	1.00E+00	1.06E+01
XD2DALTBYM	5.48E-03	1.23E-03	1.23E-03	1.45E-05	1.00E+00	1.22E+00
YK1SS12SST	1.01E-04	1.18E-03	1.18E-03	7.57E-04	1.00E+00	1.27E+01
AB6MCH2DEX	7.04E-03	1.08E-03	1.08E-03	9.86E-06	1.00E+00	1.15E+00
EK1F30AFUF	8.64E-05	1.01E-03	1.01E-03	7.51E-04	1.00E+00	1.26E+01
PACSK12REC	5.00E-02	1.00E-03	1.00E-03	1.29E-06	1.00E+00	1.02E+00
GK0LOCKCOM	4.06E-06	9.84E-04	9.82E-04	1.56E-02	1.00E+00	2.43E+02
PACXSB1BHM	1.02E-03	9.78E-04	9.78E-04	6.19E-05	1.00E+00	1.96E+00
PACXSB2BHM	1.02E-03	9.78E-04	9.78E-04	6.19E-05	1.00E+00	1.96E+00
EK1EXC1TGF	8.23E-05	9.62E-04	9.62E-04	7.54E-04	1.00E+00	1.27E+01
EK2DIODDEX	2.88E-04	9.32E-04	9.32E-04	2.09E-04	1.00E+00	4.24E+00
EK1FLSMDEX	7.71E-05	9.01E-04	9.01E-04	7.54E-04	1.00E+00	1.27E+01
EK1FLDMDEX	7.71E-05	9.01E-04	9.01E-04	7.54E-04	1.00E+00	1.27E+01
FK2WL11AVO	2.80E-04	7.52E-04	7.52E-04	1.73E-04	1.00E+00	3.69E+00
GK2COOLLHE	2.60E-04	6.99E-04	6.98E-04	1.73E-04	1.00E+00	3.69E+00
EK241AXR6D	2.49E-04	6.69E-04	6.69E-04	1.73E-04	1.00E+00	3.69E+00
WK1SPD2DEX	5.60E-05	6.57E-04	6.57E-04	7.57E-04	1.00E+00	1.27E+01
EK2SPYCLHE	2.60E-04	6.57E-04	6.57E-04	1.63E-04	1.00E+00	3.52E+00
EK2FLSOLHE	2.60E-04	6.57E-04	6.57E-04	1.63E-04	1.00E+00	3.52E+00
EK2FLSCLHE	2.60E-04	6.57E-04	6.57E-04	1.63E-04	1.00E+00	3.52E+00
EK2FLDCLHE	2.60E-04	6.57E-04	6.57E-04	1.63E-04	1.00E+00	3.52E+00
WK2GVCDLHE	2.60E-04	6.57E-04	6.57E-04	1.63E-04	1.00E+00	3.52E+00
FK1WL11AVT	5.52E-05	6.43E-04	6.43E-04	7.51E-04	1.00E+00	1.26E+01
GK1NGDCLHE	5.20E-05	6.06E-04	6.05E-04	7.51E-04	1.00E+00	1.26E+01
PK0SUMPCOM	2.44E-06	5.91E-04	5.90E-04	1.56E-02	1.00E+00	2.43E+02
XA2XAALBLM	2.74E-03	5.62E-04	5.62E-04	1.32E-05	1.00E+00	1.20E+00

Table 7.3-2

Basic Event Importance Measures From The ONS-Keowee AC Power Integrated Model

Basic Event	Probability	Fus. Ves.	Critic	Birnbm	Red Wrth	Ach Wrth
BK1GBO1FTC	4.32E-05	5.03E-04	5.03E-04	7.51E-04	1.00E+00	1.26E+01
BKGBOILCOM	1.94E-06	4.70E-04	4.69E-04	1.56E-02	1.00E+00	2.43E+02
PACXCT5THF	7.44E-05	4.58E-04	4.58E-04	3.97E-04	1.00E+00	7.15E+00
EK188SVRYT	3.89E-05	4.53E-04	4.53E-04	7.51E-04	1.00E+00	1.26E+01
AB4MCH2DEX	3.02E-04	4.08E-04	4.08E-04	8.72E-05	1.00E+00	2.35E+00
WK1GVCDDEX	3.50E-05	4.08E-04	4.08E-04	7.51E-04	1.00E+00	1.26E+01
WK1TBCDDEX	3.50E-05	4.08E-04	4.08E-04	7.51E-04	1.00E+00	1.26E+01
YK1MR4ARYD	3.30E-05	3.84E-04	3.84E-04	7.51E-04	1.00E+00	1.26E+01
YK199SXRYD	3.30E-05	3.84E-04	3.84E-04	7.51E-04	1.00E+00	1.26E+01
YK199SNRYD	3.30E-05	3.84E-04	3.84E-04	7.51E-04	1.00E+00	1.26E+01
YK199SDRYD	3.30E-05	3.84E-04	3.84E-04	7.51E-04	1.00E+00	1.26E+01
EK188SVRYD	3.30E-05	3.84E-04	3.84E-04	7.51E-04	1.00E+00	1.26E+01
EK1S41XRYD	3.30E-05	3.84E-04	3.84E-04	7.51E-04	1.00E+00	1.26E+01
EK1R31YRYD	3.30E-05	3.84E-04	3.84E-04	7.51E-04	1.00E+00	1.26E+01
EK1F31XRYD	3.30E-05	3.84E-04	3.84E-04	7.51E-04	1.00E+00	1.26E+01
EK141CFRYD	3.30E-05	3.84E-04	3.84E-04	7.51E-04	1.00E+00	1.26E+01
EK1415YRYD	3.30E-05	3.84E-04	3.84E-04	7.51E-04	1.00E+00	1.26E+01
EK199SYRYD	3.30E-05	3.84E-04	3.84E-04	7.51E-04	1.00E+00	1.26E+01
EK1S41CRYD	3.30E-05	3.84E-04	3.84E-04	7.51E-04	1.00E+00	1.26E+01
EK1R31TRYD	3.30E-05	3.84E-04	3.84E-04	7.51E-04	1.00E+00	1.26E+01
EK1R41YRYD	3.30E-05	3.84E-04	3.84E-04	7.51E-04	1.00E+00	1.26E+01
EK1F41CRYD	3.30E-05	3.84E-04	3.84E-04	7.51E-04	1.00E+00	1.26E+01
EK1R41XRYD	3.30E-05	3.84E-04	3.84E-04	7.51E-04	1.00E+00	1.26E+01
GK1FIREDEX	3.19E-05	3.71E-04	3.71E-04	7.51E-04	1.00E+00	1.26E+01
PK1PACKDEX	3.10E-05	3.61E-04	3.61E-04	7.51E-04	1.00E+00	1.26E+01
EK1R9C1R6T	3.05E-05	3.55E-04	3.55E-04	7.51E-04	1.00E+00	1.26E+01
EK1901ARYT	3.02E-05	3.52E-04	3.52E-04	7.51E-04	1.00E+00	1.26E+01
EK186EXRYT	3.02E-05	3.52E-04	3.52E-04	7.51E-04	1.00E+00	1.26E+01
EK1R9A1RYT	3.02E-05	3.52E-04	3.52E-04	7.51E-04	1.00E+00	1.26E+01
EK1415YRYT	3.02E-05	3.52E-04	3.52E-04	7.51E-04	1.00E+00	1.26E+01
EK1R41YRYT	3.02E-05	3.52E-04	3.52E-04	7.51E-04	1.00E+00	1.26E+01
EK131TDRYT	3.02E-05	3.52E-04	3.52E-04	7.51E-04	1.00E+00	1.26E+01
EK1R31YRYT	3.02E-05	3.52E-04	3.52E-04	7.51E-04	1.00E+00	1.26E+01
PK1ACDCCOM	2.77E-05	3.23E-04	3.23E-04	7.51E-04	1.00E+00	1.26E+01
AB7R52YRYD	3.30E-05	3.13E-04	3.13E-04	6.13E-04	1.00E+00	1.05E+01
AA127XCRYD	3.30E-05	3.13E-04	3.13E-04	6.13E-04	1.00E+00	1.05E+01
AB7R52XRYD	3.30E-05	3.13E-04	3.13E-04	6.13E-04	1.00E+00	1.05E+01
AB752CCRYD	3.30E-05	3.13E-04	3.13E-04	6.13E-04	1.00E+00	1.05E+01
ACBXFERCOM	1.28E-06	3.10E-04	3.10E-04	1.56E-02	1.00E+00	2.43E+02
XA0SWGRCOM	1.22E-06	2.96E-04	2.95E-04	1.56E-02	1.00E+00	2.43E+02
FK1FL02FRF	2.35E-05	2.74E-04	2.74E-04	7.51E-04	1.00E+00	1.26E+01

Table 7.3-2

Basic Event Importance Measures From The ONS-Keowee AC Power Integrated Model

Basic Event	Probability	Fus. Ves.	Critic	Birnbm	Red Wrth	Ach Wrth
EK1EXC2TGF	2.35E-05	2.74E-04	2.74E-04	7.51E-04	1.00E+00	1.26E+01
GK20002HGS	1.54E-04	2.70E-04	2.70E-04	1.13E-04	1.00E+00	2.75E+00
XA1XAALBLM	2.74E-03	2.52E-04	2.52E-04	5.94E-06	1.00E+00	1.09E+00
OK20003RVT	1.34E-04	2.51E-04	2.51E-04	1.20E-04	1.00E+00	2.87E+00
OK2AG04RVT	1.34E-04	2.51E-04	2.51E-04	1.20E-04	1.00E+00	2.87E+00
AB7KEYISWT	2.52E-05	2.39E-04	2.39E-04	6.13E-04	1.00E+00	1.05E+01
OK1PSTRCOM	2.04E-05	2.38E-04	2.38E-04	7.51E-04	1.00E+00	1.26E+01
PAC1TC4C4T	2.26E-05	2.15E-04	2.15E-04	6.16E-04	1.00E+00	1.05E+01
AB4CLOSLHE	2.60E-04	2.08E-04	2.08E-04	5.17E-05	1.00E+00	1.80E+00
PACXN02C4O	3.00E-04	2.01E-04	2.01E-04	4.33E-05	1.00E+00	1.67E+00
PACXSK2C4C	3.00E-04	2.01E-04	2.01E-04	4.33E-05	1.00E+00	1.67E+00
PACXS01C4C	3.00E-04	2.01E-04	2.01E-04	4.33E-05	1.00E+00	1.67E+00
PACXS02C4C	3.00E-04	2.01E-04	2.01E-04	4.33E-05	1.00E+00	1.67E+00
PACXN01C4O	3.00E-04	2.01E-04	2.01E-04	4.33E-05	1.00E+00	1.67E+00
PACXSK1C4C	3.00E-04	2.01E-04	2.01E-04	4.33E-05	1.00E+00	1.67E+00
AB4R52XR6D	2.49E-04	1.99E-04	1.99E-04	5.17E-05	1.00E+00	1.80E+00
AB452Y2R6D	2.49E-04	1.99E-04	1.99E-04	5.17E-05	1.00E+00	1.80E+00
AB24BKRCOM	1.12E-04	1.98E-04	1.98E-04	1.14E-04	1.00E+00	2.77E+00
YK2SS12SST	1.01E-04	1.86E-04	1.86E-04	1.19E-04	1.00E+00	2.84E+00
FK1FL01FRF	2.35E-05	1.28E-04	1.28E-04	3.50E-04	1.00E+00	6.43E+00
AB5MCH2DEX	7.04E-03	1.21E-04	1.21E-04	1.11E-06	1.00E+00	1.02E+00
WK2SPD2DEX	5.60E-05	1.05E-04	1.05E-04	1.20E-04	1.00E+00	2.87E+00
XA1X2CCCLT	2.18E-05	6.90E-05	6.90E-05	2.04E-04	1.00E+00	4.16E+00
YK114X3SSD	1.80E-05	5.70E-05	5.70E-05	2.04E-04	1.00E+00	4.17E+00
EK1FAN1TLF	1.80E-05	5.70E-05	5.70E-05	2.04E-04	1.00E+00	4.17E+00
YK1SS13SSD	1.80E-05	5.70E-05	5.70E-05	2.04E-04	1.00E+00	4.17E+00
GK1HPO3HXF	1.54E-05	4.86E-05	4.86E-05	2.04E-04	1.00E+00	4.17E+00
GK1GAC1HXF	1.54E-05	4.86E-05	4.86E-05	2.04E-04	1.00E+00	4.17E+00
GK1HPO2HXF	1.54E-05	4.86E-05	4.86E-05	2.04E-04	1.00E+00	4.17E+00
GK1GAC5HXF	1.54E-05	4.86E-05	4.86E-05	2.04E-04	1.00E+00	4.17E+00
GK1GAC4HXF	1.54E-05	4.86E-05	4.86E-05	2.04E-04	1.00E+00	4.17E+00
GK1HPO6HXF	1.54E-05	4.86E-05	4.86E-05	2.04E-04	1.00E+00	4.17E+00
GK1HPO1HXF	1.54E-05	4.86E-05	4.86E-05	2.04E-04	1.00E+00	4.17E+00
GK1HPO8HXF	1.54E-05	4.86E-05	4.86E-05	2.04E-04	1.00E+00	4.17E+00
GK1GAC3HXF	1.54E-05	4.86E-05	4.86E-05	2.04E-04	1.00E+00	4.17E+00
GK1GAC6HXF	1.54E-05	4.86E-05	4.86E-05	2.04E-04	1.00E+00	4.17E+00
GK1HPO4HXF	1.54E-05	4.86E-05	4.86E-05	2.04E-04	1.00E+00	4.17E+00
GK1HPO5HXF	1.54E-05	4.86E-05	4.86E-05	2.04E-04	1.00E+00	4.17E+00
FK1TRHXHXF	1.54E-05	4.86E-05	4.86E-05	2.04E-04	1.00E+00	4.17E+00
GK1HPO7HXF	1.54E-05	4.86E-05	4.86E-05	2.04E-04	1.00E+00	4.17E+00
GK1GAC2HXF	1.54E-05	4.86E-05	4.86E-05	2.04E-04	1.00E+00	4.17E+00

Table 7.3-2

Basic Event Importance Measures From The ONS-Keowee AC Power Integrated Model

Basic Event	Probability	Fus. Ves.	Critic	Birnbm	Red Wrth	Ach Wrth
OK10003TKF	1.10E-05	3.50E-05	3.50E-05	2.04E-04	1.00E+00	4.17E+00
OK1AG01TKF	1.10E-05	3.50E-05	3.50E-05	2.04E-04	1.00E+00	4.17E+00
GK1GAC5HXL	1.08E-05	3.42E-05	3.42E-05	2.04E-04	1.00E+00	4.17E+00
GK1GAC2HXL	1.08E-05	3.42E-05	3.42E-05	2.04E-04	1.00E+00	4.17E+00
GK1GAC3HXL	1.08E-05	3.42E-05	3.42E-05	2.04E-04	1.00E+00	4.17E+00
GK1GAC4HXL	1.08E-05	3.42E-05	3.42E-05	2.04E-04	1.00E+00	4.17E+00
GK1GAC1HXL	1.08E-05	3.42E-05	3.42E-05	2.04E-04	1.00E+00	4.17E+00
GK1GAC6HXL	1.08E-05	3.42E-05	3.42E-05	2.04E-04	1.00E+00	4.17E+00
GK1063FPST	1.03E-05	3.27E-05	3.27E-05	2.04E-04	1.00E+00	4.17E+00
EK141AXR6T	8.71E-06	2.76E-05	2.76E-05	2.04E-04	1.00E+00	4.17E+00
AB3R52ZR6T	8.71E-06	2.76E-05	2.76E-05	2.04E-04	1.00E+00	4.17E+00
YK163BLRYT	8.64E-06	2.74E-05	2.74E-05	2.04E-04	1.00E+00	4.17E+00
YK14AMRRYT	8.64E-06	2.74E-05	2.74E-05	2.04E-04	1.00E+00	4.17E+00
YK163TBRYT	8.64E-06	2.74E-05	2.74E-05	2.04E-04	1.00E+00	4.17E+00
YK163BHRYT	8.64E-06	2.74E-05	2.74E-05	2.04E-04	1.00E+00	4.17E+00
YK199SDRYT	8.64E-06	2.74E-05	2.74E-05	2.04E-04	1.00E+00	4.17E+00
YK199SXRYT	8.64E-06	2.74E-05	2.74E-05	2.04E-04	1.00E+00	4.17E+00
YK199SNRYT	8.64E-06	2.74E-05	2.74E-05	2.04E-04	1.00E+00	4.17E+00
GK187GBRYT	8.64E-06	2.74E-05	2.74E-05	2.04E-04	1.00E+00	4.17E+00
GK187TERYT	8.64E-06	2.74E-05	2.74E-05	2.04E-04	1.00E+00	4.17E+00
EK186X2RYT	8.64E-06	2.74E-05	2.74E-05	2.04E-04	1.00E+00	4.17E+00
GK186E1RYT	8.64E-06	2.74E-05	2.74E-05	2.04E-04	1.00E+00	4.17E+00
EK199SYRYT	8.64E-06	2.74E-05	2.74E-05	2.04E-04	1.00E+00	4.17E+00
GK13SUIRYT	8.64E-06	2.74E-05	2.74E-05	2.04E-04	1.00E+00	4.17E+00
GK187G1RYT	8.64E-06	2.74E-05	2.74E-05	2.04E-04	1.00E+00	4.17E+00
GK162TDRYT	8.64E-06	2.74E-05	2.74E-05	2.04E-04	1.00E+00	4.17E+00
GK159GNRYT	8.64E-06	2.74E-05	2.74E-05	2.04E-04	1.00E+00	4.17E+00
GK140G1RYT	8.64E-06	2.74E-05	2.74E-05	2.04E-04	1.00E+00	4.17E+00
GK163FXRYT	8.64E-06	2.74E-05	2.74E-05	2.04E-04	1.00E+00	4.17E+00
AA186S1RYT	8.64E-06	2.73E-05	2.73E-05	2.04E-04	1.00E+00	4.16E+00
AB710A1FUF	2.16E-05	2.34E-05	2.34E-05	6.98E-05	1.00E+00	2.08E+00
AB352TCSVT	9.36E-06	2.21E-05	2.21E-05	1.52E-04	1.00E+00	3.36E+00
XA1XCXXTLF	1.80E-05	1.96E-05	1.96E-05	7.01E-05	1.00E+00	2.09E+00
XD1DARXBDF	7.68E-06	1.81E-05	1.81E-05	1.52E-04	1.00E+00	3.36E+00
EK2FLSMDEX	7.71E-05	1.78E-05	1.78E-05	1.49E-05	1.00E+00	1.23E+00
EK2FLDMDEX	7.71E-05	1.78E-05	1.78E-05	1.49E-05	1.00E+00	1.23E+00
YK163BLLST	7.44E-06	1.76E-05	1.76E-05	1.52E-04	1.00E+00	3.36E+00
YK163TBLST	7.44E-06	1.76E-05	1.76E-05	1.52E-04	1.00E+00	3.36E+00
YK163BHLST	7.44E-06	1.76E-05	1.76E-05	1.52E-04	1.00E+00	3.36E+00
EK2F30AFUF	8.64E-05	1.73E-05	1.73E-05	1.29E-05	1.00E+00	1.20E+00
GK2FIREDEX	7.00E-05	1.72E-05	1.72E-05	1.59E-05	1.00E+00	1.25E+00

Table 7.3-2

Basic Event Importance Measures From The ONS-Keowee AC Power Integrated Model

Basic Event	Probability	Fus. Ves.	Critic	Birnbm	Red Wrth	Ach Wrth
GK1WL44VVT	6.53E-06	1.54E-05	1.54E-05	1.52E-04	1.00E+00	3.36E+00
GK1WL69VVT	6.53E-06	1.54E-05	1.54E-05	1.52E-04	1.00E+00	3.36E+00
GK1WL33VVT	6.53E-06	1.54E-05	1.54E-05	1.52E-04	1.00E+00	3.36E+00
GK1WL45VVT	6.53E-06	1.54E-05	1.54E-05	1.52E-04	1.00E+00	3.36E+00
GK1WL16VVT	6.53E-06	1.54E-05	1.54E-05	1.52E-04	1.00E+00	3.36E+00
GK1WL29VVT	6.53E-06	1.54E-05	1.54E-05	1.52E-04	1.00E+00	3.36E+00
GK1WL57VVT	6.53E-06	1.54E-05	1.54E-05	1.52E-04	1.00E+00	3.36E+00
GK1WL48VVT	6.53E-06	1.54E-05	1.54E-05	1.52E-04	1.00E+00	3.36E+00
GK1WL52VVT	6.53E-06	1.54E-05	1.54E-05	1.52E-04	1.00E+00	3.36E+00
GK1WL60VVT	6.53E-06	1.54E-05	1.54E-05	1.52E-04	1.00E+00	3.36E+00
GK1WL61VVT	6.53E-06	1.54E-05	1.54E-05	1.52E-04	1.00E+00	3.36E+00
GK1WL25VVT	6.53E-06	1.54E-05	1.54E-05	1.52E-04	1.00E+00	3.36E+00
GK1WL68VVT	6.53E-06	1.54E-05	1.54E-05	1.52E-04	1.00E+00	3.36E+00
GK1WL76VVT	6.53E-06	1.54E-05	1.54E-05	1.52E-04	1.00E+00	3.36E+00
GK1WL17VVT	6.53E-06	1.54E-05	1.54E-05	1.52E-04	1.00E+00	3.36E+00
GK1WL65VVT	6.53E-06	1.54E-05	1.54E-05	1.52E-04	1.00E+00	3.36E+00
GK1WL24VVT	6.53E-06	1.54E-05	1.54E-05	1.52E-04	1.00E+00	3.36E+00
GK1WL41VVT	6.53E-06	1.54E-05	1.54E-05	1.52E-04	1.00E+00	3.36E+00
GK1WL64VVT	6.53E-06	1.54E-05	1.54E-05	1.52E-04	1.00E+00	3.36E+00
GK1WL32VVT	6.53E-06	1.54E-05	1.54E-05	1.52E-04	1.00E+00	3.36E+00
GK1WL53VVT	6.53E-06	1.54E-05	1.54E-05	1.52E-04	1.00E+00	3.36E+00
GK1WL73VVT	6.53E-06	1.54E-05	1.54E-05	1.52E-04	1.00E+00	3.36E+00
GK1WL28VVT	6.53E-06	1.54E-05	1.54E-05	1.52E-04	1.00E+00	3.36E+00
GK1WL20VVT	6.53E-06	1.54E-05	1.54E-05	1.52E-04	1.00E+00	3.36E+00
GK1WL72VVT	6.53E-06	1.54E-05	1.54E-05	1.52E-04	1.00E+00	3.36E+00
GK1WL21VVT	6.53E-06	1.54E-05	1.54E-05	1.52E-04	1.00E+00	3.36E+00
GK1WL78VVT	6.53E-06	1.54E-05	1.54E-05	1.52E-04	1.00E+00	3.36E+00
GK1WL37VVT	6.53E-06	1.54E-05	1.54E-05	1.52E-04	1.00E+00	3.36E+00
GK1WL56VVT	6.53E-06	1.54E-05	1.54E-05	1.52E-04	1.00E+00	3.36E+00
GK1WL49VVT	6.53E-06	1.54E-05	1.54E-05	1.52E-04	1.00E+00	3.36E+00
GK1WL36VVT	6.53E-06	1.54E-05	1.54E-05	1.52E-04	1.00E+00	3.36E+00
XA1XAMCBLF	6.48E-06	1.53E-05	1.53E-05	1.52E-04	1.00E+00	3.36E+00
XA1XXXXBLF	6.48E-06	1.53E-05	1.53E-05	1.52E-04	1.00E+00	3.36E+00
ED11D3DCDT	6.30E-06	1.49E-05	1.49E-05	1.52E-04	1.00E+00	3.36E+00
AB4PS02PST	1.60E-04	1.45E-05	1.45E-05	5.86E-06	1.00E+00	1.09E+00
EK1S141SWT	5.88E-06	1.39E-05	1.39E-05	1.52E-04	1.00E+00	3.36E+00
EK14152SWT	5.88E-06	1.39E-05	1.39E-05	1.52E-04	1.00E+00	3.36E+00
EK1S31TSWT	5.88E-06	1.39E-05	1.39E-05	1.52E-04	1.00E+00	3.36E+00
AB3PUSHPBT	5.76E-06	1.36E-05	1.36E-05	1.52E-04	1.00E+00	3.36E+00
GKHPOILCOM	4.61E-07	1.27E-05	1.27E-05	1.78E-03	1.00E+00	2.86E+01
GK0COOLCOM	4.61E-07	1.27E-05	1.27E-05	1.78E-03	1.00E+00	2.86E+01

Table 7.3-2

Basic Event Importance Measures From The ONS-Keowee AC Power Integrated Model

Basic Event	Probability	Fus. Ves.	Critic	Birnbm	Red Wrth	Ach Wrth
FK0WL01VVT	4.08E-07	1.17E-05	1.17E-05	1.85E-03	1.00E+00	2.97E+01
FK2WL11AVT	5.52E-05	1.11E-05	1.11E-05	1.29E-05	1.00E+00	1.20E+00
AB452Y2R6T	1.35E-04	1.10E-05	1.10E-05	5.26E-06	1.00E+00	1.08E+00
SPCB033CHO	2.60E-05	1.01E-05	1.01E-05	2.52E-05	1.00E+00	1.39E+00
SPCB021CHO	2.60E-05	1.01E-05	1.01E-05	2.52E-05	1.00E+00	1.39E+00
SPCB028CHO	2.60E-05	1.01E-05	1.01E-05	2.52E-05	1.00E+00	1.39E+00
SPCB024CHO	2.60E-05	1.01E-05	1.01E-05	2.52E-05	1.00E+00	1.39E+00
SPCB026CHO	2.60E-05	1.01E-05	1.01E-05	2.52E-05	1.00E+00	1.39E+00
SPCB017CHO	2.60E-05	1.01E-05	1.01E-05	2.52E-05	1.00E+00	1.39E+00
SPCB015CHO	2.60E-05	1.01E-05	1.01E-05	2.52E-05	1.00E+00	1.39E+00
SPCB012CHO	2.60E-05	1.01E-05	1.01E-05	2.52E-05	1.00E+00	1.39E+00
SPCB008CHO	2.60E-05	1.01E-05	1.01E-05	2.52E-05	1.00E+00	1.39E+00
AA127C1R6T	8.71E-06	9.47E-06	9.47E-06	7.01E-05	1.00E+00	2.09E+00
AA127R1RYT	8.64E-06	9.39E-06	9.39E-06	7.01E-05	1.00E+00	2.09E+00
AA186CXRYT	8.64E-06	9.39E-06	9.39E-06	7.01E-05	1.00E+00	2.09E+00
AA187CXRYT	8.64E-06	9.39E-06	9.39E-06	7.01E-05	1.00E+00	2.09E+00
AB752TCRYT	8.64E-06	9.39E-06	9.39E-06	7.01E-05	1.00E+00	2.09E+00
ABEOPRCRHE	1.00E+00	8.60E-06	8.60E-06	5.55E-10	1.00E+00	1.00E+00
SPCB009CHC	2.60E-04	5.31E-06	5.31E-06	1.32E-06	1.00E+00	1.02E+00
AB2MCH2DEX	3.02E-04	5.11E-06	5.11E-06	1.09E-06	1.00E+00	1.02E+00
XA56BKRCOM	3.10E-04	4.50E-06	4.50E-06	9.36E-07	1.00E+00	1.01E+00
EK186E2RYT	2.16E-06	4.48E-06	4.48E-06	1.34E-04	1.00E+00	3.08E+00
AA227T2R6D	2.49E-04	4.10E-06	4.10E-06	1.06E-06	1.00E+00	1.02E+00
AB252Y2R6D	2.49E-04	4.10E-06	4.10E-06	1.06E-06	1.00E+00	1.02E+00
AB2R52XR6D	2.49E-04	4.10E-06	4.10E-06	1.06E-06	1.00E+00	1.02E+00
AB2CLOSLHE	2.60E-04	4.02E-06	4.02E-06	9.98E-07	1.00E+00	1.02E+00
GK1WL51VVT	1.84E-06	3.81E-06	3.81E-06	1.34E-04	1.00E+00	3.08E+00
GK1WL54VVT	1.84E-06	3.81E-06	3.81E-06	1.34E-04	1.00E+00	3.08E+00
FK1WL12VVT	1.84E-06	3.81E-06	3.81E-06	1.34E-04	1.00E+00	3.08E+00
GK1WL55VVT	1.84E-06	3.81E-06	3.81E-06	1.34E-04	1.00E+00	3.08E+00
GK1WL35VVT	1.84E-06	3.81E-06	3.81E-06	1.34E-04	1.00E+00	3.08E+00
GK1WL67VVT	1.84E-06	3.81E-06	3.81E-06	1.34E-04	1.00E+00	3.08E+00
GK1WL59VVT	1.84E-06	3.81E-06	3.81E-06	1.34E-04	1.00E+00	3.08E+00
FK1WL42VVT	1.84E-06	3.81E-06	3.81E-06	1.34E-04	1.00E+00	3.08E+00
GK1WL71VVT	1.84E-06	3.81E-06	3.81E-06	1.34E-04	1.00E+00	3.08E+00
FK1WL43VVT	1.84E-06	3.81E-06	3.81E-06	1.34E-04	1.00E+00	3.08E+00
GK1WL62VVT	1.84E-06	3.81E-06	3.81E-06	1.34E-04	1.00E+00	3.08E+00
GK1WL27VVT	1.84E-06	3.81E-06	3.81E-06	1.34E-04	1.00E+00	3.08E+00
FK1WL15VVT	1.84E-06	3.81E-06	3.81E-06	1.34E-04	1.00E+00	3.08E+00
GK1WL58VVT	1.84E-06	3.81E-06	3.81E-06	1.34E-04	1.00E+00	3.08E+00
GK1WL23VVT	1.84E-06	3.81E-06	3.81E-06	1.34E-04	1.00E+00	3.08E+00

Table 7.3-2

Basic Event Importance Measures From The ONS-Keowee AC Power Integrated Model

Basic Event	Probability	Fus. Ves.	Critic	Birnbm	Red Wrth	Ach Wrth
GK1WL63VVT	1.84E-06	3.81E-06	3.81E-06	1.34E-04	1.00E+00	3.08E+00
GK1WL22VVT	1.84E-06	3.81E-06	3.81E-06	1.34E-04	1.00E+00	3.08E+00
GK1WL47VVT	1.84E-06	3.81E-06	3.81E-06	1.34E-04	1.00E+00	3.08E+00
GK1WL18VVT	1.84E-06	3.81E-06	3.81E-06	1.34E-04	1.00E+00	3.08E+00
GK1WL31VVT	1.84E-06	3.81E-06	3.81E-06	1.34E-04	1.00E+00	3.08E+00
GK1WL19VVT	1.84E-06	3.81E-06	3.81E-06	1.34E-04	1.00E+00	3.08E+00
GK1WL70VVT	1.84E-06	3.81E-06	3.81E-06	1.34E-04	1.00E+00	3.08E+00
GK1WL30VVT	1.84E-06	3.81E-06	3.81E-06	1.34E-04	1.00E+00	3.08E+00
GK1WL46VVT	1.84E-06	3.81E-06	3.81E-06	1.34E-04	1.00E+00	3.08E+00
GK1WL38VVT	1.84E-06	3.81E-06	3.81E-06	1.34E-04	1.00E+00	3.08E+00
GK1WL50VVT	1.84E-06	3.81E-06	3.81E-06	1.34E-04	1.00E+00	3.08E+00
GK1WL34VVT	1.84E-06	3.81E-06	3.81E-06	1.34E-04	1.00E+00	3.08E+00
GK1WL75VVT	1.84E-06	3.81E-06	3.81E-06	1.34E-04	1.00E+00	3.08E+00
GK1WL26VVT	1.84E-06	3.81E-06	3.81E-06	1.34E-04	1.00E+00	3.08E+00
GK1WL74VVT	1.84E-06	3.81E-06	3.81E-06	1.34E-04	1.00E+00	3.08E+00
GK1WL39VVT	1.84E-06	3.81E-06	3.81E-06	1.34E-04	1.00E+00	3.08E+00
GK1WL66VVT	1.84E-06	3.81E-06	3.81E-06	1.34E-04	1.00E+00	3.08E+00
AB5CLOSLHE	2.60E-04	3.77E-06	3.77E-06	9.36E-07	1.00E+00	1.01E+00
XD104CCCDT	1.80E-06	3.74E-06	3.74E-06	1.34E-04	1.00E+00	3.08E+00
ED13BR2CDT	1.80E-06	3.74E-06	3.74E-06	1.34E-04	1.00E+00	3.08E+00
XA1A2BTCDT	1.80E-06	3.72E-06	3.72E-06	1.33E-04	1.00E+00	3.06E+00
XD1BK1ACDT	1.80E-06	3.72E-06	3.72E-06	1.33E-04	1.00E+00	3.06E+00
XD1DA1CCDT	1.80E-06	3.72E-06	3.72E-06	1.33E-04	1.00E+00	3.06E+00
DDCBATTDEX	1.00E+00	3.63E-06	3.63E-06	2.34E-10	1.00E+00	1.00E+00
DDCUN31DIM	6.93E-04	3.63E-06	3.63E-06	3.38E-07	1.00E+00	1.01E+00
DDCX3CABCF	6.96E-04	3.63E-06	3.63E-06	3.37E-07	1.00E+00	1.01E+00
AA1271PR6D	2.49E-04	3.61E-06	3.61E-06	9.36E-07	1.00E+00	1.01E+00
EK1415TSWT	1.68E-06	3.49E-06	3.49E-06	1.34E-04	1.00E+00	3.08E+00
AB31523SWT	1.68E-06	3.49E-06	3.49E-06	1.34E-04	1.00E+00	3.08E+00
GK13SUISWT	1.68E-06	3.49E-06	3.49E-06	1.34E-04	1.00E+00	3.08E+00
EK1S41TSWT	1.68E-06	3.49E-06	3.49E-06	1.34E-04	1.00E+00	3.08E+00
YK13SUISWT	1.68E-06	3.49E-06	3.49E-06	1.34E-04	1.00E+00	3.08E+00
PACX1TCBHF	9.60E-06	2.74E-06	2.74E-06	1.84E-05	1.00E+00	1.29E+00
AB8MCH2DEX	7.04E-03	2.59E-06	2.59E-06	2.37E-08	1.00E+00	1.00E+00
GK2NGDCLHE	5.20E-05	2.57E-06	2.57E-06	3.19E-06	1.00E+00	1.05E+00
BK2GBO1FTC	4.32E-05	2.27E-06	2.27E-06	3.40E-06	1.00E+00	1.05E+00
AB7PUSHPBT	7.20E-06	2.05E-06	2.05E-06	1.84E-05	1.00E+00	1.29E+00
WK2GVCDDEX	3.50E-05	1.73E-06	1.73E-06	3.19E-06	1.00E+00	1.05E+00
WK2TBCDDEX	3.50E-05	1.73E-06	1.73E-06	3.19E-06	1.00E+00	1.05E+00
PK2PACKDEX	3.10E-05	1.63E-06	1.63E-06	3.40E-06	1.00E+00	1.05E+00
PK1TSACGPR	4.20E-04	9.11E-08	9.11E-08	1.40E-08	1.00E+00	1.00E+00

Table 7.3-2

Basic Event Importance Measures From The ONS-Keowee AC Power Integrated Model

Basic Event	Probability	Fus. Ves.	Critic	Birnbm	Red Wrth	Ach Wrth
PK1TSDCLHE	3.20E-03	9.11E-08	9.11E-08	1.84E-09	1.00E+00	1.00E+00
BK1GOACGPR	3.36E-04	7.29E-08	7.29E-08	1.40E-08	1.00E+00	1.00E+00
BK1GBDCLHE	3.20E-03	7.29E-08	7.29E-08	1.47E-09	1.00E+00	1.00E+00
AA127X1RYT	1.38E-04	6.55E-08	6.55E-08	3.06E-08	1.00E+00	1.00E+00
AB552TCRYT	1.38E-04	6.55E-08	6.55E-08	3.06E-08	1.00E+00	1.00E+00
AB51431RYT	1.30E-04	6.14E-08	6.14E-08	3.06E-08	1.00E+00	1.00E+00
AB552Y2RYT	1.30E-04	6.14E-08	6.14E-08	3.06E-08	1.00E+00	1.00E+00
AB5PUSHPBT	9.22E-05	4.36E-08	4.36E-08	3.06E-08	1.00E+00	1.00E+00
SKXFMR1THF	7.44E-05	3.52E-08	3.52E-08	3.06E-08	1.00E+00	1.00E+00

Table 7.4-1

Top Cut Sets From The ONS-Keowee Core Damage Model

Module/Event	Description	Rate	Exposure	Prob.	Cs Prob.
1) CDFREQ					*1.04E-06
1)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	2.77E-07
-KK1BOTHHYM	Both Keowee Units Unavailable Due To Common Maintenance		5.23E-3	5.23E-03	
SXFRCT4THM	Transformer CT4 Is In Maintenance		9.13E-04	9.13E-04	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
NSFORCMDHE	Operators Fail To Align The SSF RCM System For Operation		1.000E-01	1.00E-01	
TACOFF2REC	Offsite power not recov. given start failures with SSHR		2.20E-01	2.20E-01	
2) KK1BOTHHYM	Both Keowee Units Unavailable Due To Common Maintenance		5.23E-3	5.23E-03	1.66E-07
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
NSFORCMDHE	Operators Fail To Align The SSF RCM System For Operation		1.000E-01	1.00E-01	
PACOT5WDEX	Modifier Since Keowee Maintenance Is Scheduled For Mild Weather Periods		1.00E-01	1.00E-01	
TACOFF2REC	Offsite power not recov. given start failures with SSHR		2.20E-01	2.20E-01	
3)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	9.69E-08
-KK1BOTHHYM	Both Keowee Units Unavailable Due To Common Maintenance		5.23E-3	5.23E-03	
SXFRCT4THM	Transformer CT4 Is In Maintenance		9.13E-04	9.13E-04	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
NACSFDGDGM	SSF Diesel Generator Is In Maintenance		3.500E-02	3.50E-02	
TACOFF2REC	Offsite power not recov. given start failures with SSHR		2.20E-01	2.20E-01	
4)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	5.89E-08
-KK1BOTHHYM	Both Keowee Units Unavailable Due To Common Maintenance		5.23E-3	5.23E-03	
SXFRCT4THM	Transformer CT4 Is In Maintenance		9.13E-04	9.13E-04	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
NACSFDGDGR	SSF Diesel Generator Fails To Run	3.00E-03	24	7.20E-02	
TACOFF3REC	Offsite power not recov. given 1 run failure with SSHR		6.50E-02	6.50E-02	
5) KK1BOTHHYM	Both Keowee Units Unavailable Due To Common Maintenance		5.23E-3	5.23E-03	5.80E-08
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
NACSFDGDGM	SSF Diesel Generator Is In Maintenance		3.500E-02	3.50E-02	
PACOT5WDEX	Modifier Since Keowee Maintenance Is Scheduled For Mild Weather Periods		1.00E-01	1.00E-01	
TACOFF2REC	Offsite power not recov. given start failures with SSHR		2.20E-01	2.20E-01	
6) KK1BOTHHYM	Both Keowee Units Unavailable Due To Common Maintenance		5.23E-3	5.23E-03	3.52E-08
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
NACSFDGDGR	SSF Diesel Generator Fails To Run	3.00E-03	24	7.20E-02	
PACOT5WDEX	Modifier Since Keowee Maintenance Is Scheduled For Mild Weather Periods		1.00E-01	1.00E-01	
TACOFF3REC	Offsite power not recov. given 1 run failure with SSHR		6.50E-02	6.50E-02	
7)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	3.32E-08
-KK1BOTHHYM	Both Keowee Units Unavailable Due To Common Maintenance		5.23E-3	5.23E-03	
SXFRCT4THM	Transformer CT4 Is In Maintenance		9.13E-04	9.13E-04	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
NACSFDGDGS	SSF Diesel Generator Fails To Start	1.20E-02	1	1.20E-02	
TACOFF2REC	Offsite power not recov. given start failures with SSHR		2.20E-01	2.20E-01	
8)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	3.01E-08
AB0SWGRCOM	Common Cause Failure Of All Keowee Auxiliary Power Breakers		6.69E-04	6.69E-04	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
NSFORCMDHE	Operators Fail To Align The SSF RCM System For Operation		1.000E-01	1.00E-01	
AB0SWGRRHE	Recovery of Keowee Aux Power Breakers by Manual Control		5.0E-01	5.00E-01	
TACOFF3REC	Offsite power not recov. given 1 run failure with SSHR		6.50E-02	6.50E-02	

Table 7.4-1

Top Cut Sets From The ONS-Keowee Core Damage Model

Module/Event	Description	Rate	Exposure	Prob.	Cs Prob.
9)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	2.77E-08
-KK1BOTHHYM	Both Keowee Units Unavailable Due To Common Maintenance		5.23E-3	5.23E-03	
SXFRCT4THM	Transformer CT4 Is In Maintenance		9.13E-04	9.13E-04	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
NSFTIMEDHE	Operators Fail To Deploy To The Standby Shutdown Facility In Time		1.00E-02	1.00E-02	
TACOFF2REC	Offsite power not recov. given start failures with SSHR		2.20E-01	2.20E-01	
10)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	2.77E-08
-KK1BOTHHYM	Both Keowee Units Unavailable Due To Common Maintenance		5.23E-3	5.23E-03	
SXFRCT4THM	Transformer CT4 Is In Maintenance		9.13E-04	9.13E-04	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
NSFCON2CMS	Train 2 Refrigerant Compressor Fails To Start	1.00E-02	1	1.00E-02	
TACOFF2REC	Offsite power not recov. given start failures with SSHR		2.20E-01	2.20E-01	
11)-XA1XAALBLM	MCC 1XA Is Connected to Its Alternate Source of Power		2.74E-03	2.74E-03	2.49E-08
-AD1B4ALCDT	Breaker 4AL In 125 V dc Distribution Center 1DA Transfers Open	7.5E-08	30	2.25E-06	
-AB7OPENLHE	Air Circuit Breaker 7 Fails To Open Due To A Latent Human Error		3.20E-3	3.20E-03	
-AB7MECHDEX	Air Circuit Breaker 7 Fails To Open Due To Mechanical Failure		8.01E-04	8.01E-04	
-AB752TCRYD	Air Circuit Breaker 7 Trip Coil TC Fails On Demand	3.3E-05	1	3.30E-05	
-AB710AFFUF	One Or More Air Circuit Breaker 7 Control Power Fuses Fail	3.6E-06	6	2.16E-05	
-AB51431SWT	Manual/Auto Control Switch 143/1 Spuriously Transfers Into Manual	7.0E-08	360	2.52E-05	
-AB51431LHE	Manual/Auto Control Switch 143/1 Left In Manual		3.20E-4	3.20E-04	
-AA227X2RYD	Auxiliary Relay 27X/2X Fails To Operate On Demand	3.3E-05	1	3.30E-05	
-AA127X2R6D	Transformer CX Undervoltage Relay 27/CX1 Fails To Drop Out	2.49E-04	1	2.49E-04	
AB7MCH2DEX	Air Circuit Breaker 7 Fails To Close Due To Mechanical Failure		7.04E-03	7.04E-03	
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
NSFORCMDHE	Operators Fail To Align The SSF RCM System For Operation		1.000E-01	1.00E-01	
TACOFF3REC	Offsite power not recov. given 1 run failure with SSHR		6.50E-02	6.50E-02	
12) KK1BOTHHYM	Both Keowee Units Unavailable Due To Common Maintenance		5.23E-3	5.23E-03	1.99E-08
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
NACSFDGDGS	SSF Diesel Generator Fails To Start	1.20E-02	1	1.20E-02	
PACOT5WDEX	Modifier Since Keowee Maintenance Is Scheduled For Mild Weather Periods		1.00E-01	1.00E-01	
TACOFF2REC	Offsite power not recov. given start failures with SSHR		2.20E-01	2.20E-01	
13)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	1.77E-08
-KK2RUNSDEX	Keowee Unit 2 Only Is Supplying The Grid		0.06	6.00E-02	
-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	
-KK1BOTHDEX	Keowee Units 1 And 2 Are Supplying The Grid		0.0	0.00E+00	
EKSTARTCOM	Common Cause Failure Of Both Units Voltage Regulators To Start		6.17E-5	6.17E-05	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
NSFORCMDHE	Operators Fail To Align The SSF RCM System For Operation		1.000E-01	1.00E-01	
TACOFF2REC	Offsite power not recov. given start failures with SSHR		2.20E-01	2.20E-01	
14)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	1.70E-08
AB0SWGRCOM	Common Cause Failure Of All Keowee Auxiliary Power Breakers		6.69E-04	6.69E-04	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
NACSFDGDGR	SSF Diesel Generator Fails To Run	3.00E-03	24	7.20E-02	
AB0SWGRRHE	Recovery of Keowee Aux Power Breakers by Manual Control		5.0E-01	5.00E-01	
TACOFF4REC	Offsite power not recov. given run failures with SSHR		5.10E-02	5.10E-02	

Table 7.4-1

Top Cut Sets From The ONS-Keowee Core Damage Model

Module/Event	Description	Rate	Exposure	Prob.	Cs Prob.
15) KK1BOTHHYM	Both Keowee Units Unavailable Due To Common Maintenance		5.23E-3	5.23E-03	1.66E-08
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
NSFCON2CMS	Train 2 Refrigerant Compressor Fails To Start	1.00E-02	1	1.00E-02	
PACOT5WDEX	Modifier Since Keowee Maintenance Is Scheduled For Mild Weather Periods		1.00E-01	1.00E-01	
TACOFF2REC	Offsite power not recov. given start failures with SSHR		2.20E-01	2.20E-01	
16) KK1BOTHHYM	Both Keowee Units Unavailable Due To Common Maintenance		5.23E-3	5.23E-03	1.66E-08
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
NSFTIMEDHE	Operators Fail To Deploy To The Standby Shutdown Facility In Time		1.00E-02	1.00E-02	
PACOT5WDEX	Modifier Since Keowee Maintenance Is Scheduled For Mild Weather Periods		1.00E-01	1.00E-01	
TACOFF2REC	Offsite power not recov. given start failures with SSHR		2.20E-01	2.20E-01	
17)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	1.52E-08
-KK2RUNSDEX	Keowee Unit 2 Only Is Supplying The Grid		0.06	6.00E-02	
-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	
-KK1BOTHDEX	Keowee Units 1 And 2 Are Supplying The Grid		0.0	0.00E+00	
E12EXCTCOM	Units 1 & 2 Excit Fail Due To Common Cause Failure Of The Breakers		5.31E-05	5.31E-05	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
NSFORCMDHE	Operators Fail To Align The SSF RCM System For Operation		1.000E-01	1.00E-01	
TACOFF2REC	Offsite power not recov. given start failures with SSHR		2.20E-01	2.20E-01	
18)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	1.45E-08
FKOFISHCOM	Common Cause Failure Of Both Unit s WL Filters Due To Intake Debris		2.55E-3	2.55E-03	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
NSFORCMDHE	Operators Fail To Align The SSF RCM System For Operation		1.000E-01	1.00E-01	
FKOFISHDHE	Recovery of Main WL Strainer Clogging		6.3E-02	6.30E-02	
TACOFF3REC	Offsite power not recov. given 1 run failure with SSHR		6.50E-02	6.50E-02	
19)-XA1XAALBLM	MCC 1XA Is Connected to Its Alternate Source of Power		2.74E-03	2.74E-03	1.40E-08
-AD1B4ALCDT	Breaker 4AL In 125 V dc Distribution Center 1DA Transfers Open	7.5E-08	30	2.25E-06	
-AB7OPENLHE	Air Circuit Breaker 7 Fails To Open Due To A Latent Human Error		3.20E-3	3.20E-03	
-AB7MECHDEX	Air Circuit Breaker 7 Fails To Open Due To Mechanical Failure		8.01E-04	8.01E-04	
-AB752TCRYD	Air Circuit Breaker 7 Trip Coil TC Fails On Demand	3.3E-05	1	3.30E-05	
-AB710AFFUF	One Or More Air Circuit Breaker 7 Control Power Fuses Fail	3.6E-06	6	2.16E-05	
-AB51431SWT	Manual/Auto Control Switch 143/1 Spuriously Transfers Into Manual	7.0E-08	360	2.52E-05	
-AB51431LHE	Manual/Auto Control Switch 143/1 Left In Manual		3.20E-4	3.20E-04	
-AA227X2RYD	Auxiliary Relay 27X/2X Fails To Operate On Demand	3.3E-05	1	3.30E-05	
-AA127X2R6D	Transformer CX Undervoltage Relay 27/CX1 Fails To Drop Out	2.49E-04	1	2.49E-04	
AB7MCH2DEX	Air Circuit Breaker 7 Fails To Close Due To Mechanical Failure		7.04E-03	7.04E-03	
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
NACSFDGDGR	SSF Diesel Generator Fails To Run	3.00E-03	24	7.20E-02	
TACOFF4REC	Offsite power not recov. given run failures with SSHR		5.10E-02	5.10E-02	
20) KK1BOTHHYM	Both Keowee Units Unavailable Due To Common Maintenance		5.23E-3	5.23E-03	1.29E-08
PACLINEDEX	100 kV ac Overhead Line From Lee Steam Station To CT5 Fails		7.800E-03	7.80E-03	
T5SUBF	Loss Of The Oconee Station Switchyards Initiating Event		4.86E-02	4.86E-02	
NSFORCMDHE	Operators Fail To Align The SSF RCM System For Operation		1.000E-01	1.00E-01	
TACOFF3REC	Offsite power not recov. given 1 run failure with SSHR		6.50E-02	6.50E-02	

Table 7.4-1

Top Cut Sets From The ONS-Keowee Core Damage Model

Module/Event	Description	Rate	Exposure	Prob.	Cs Prob.
21)-XD1DALTBYM	Normal Power To Dist. Center 1DA Is In Test or Maintenance		5.48E-03	5.48E-03	1.11E-08
-KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0.0	0.00E+00	
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
XD1KBATBYF	Keowee Battery No. 1 Fails During Discharge	9.30E-04	1	9.30E-04	
NSFORCMDHE	Operators Fail To Align The SSF RCM System For Operation		1.000E-01	1.00E-01	
XD0KBATRHE	Failure To Recover DC By Cross Connecting The Distribution Centers		1.00E+00	1.00E+00	
TACOFF2REC	Offsite power not recov. given start failures with SSHR		2.20E-01	2.20E-01	
22)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	1.05E-08
AB0SWGRCOM	Common Cause Failure Of All Keowee Auxiliary Power Breakers		6.69E-04	6.69E-04	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
NACSFDGDGM	SSF Diesel Generator Is In Maintenance		3.500E-02	3.50E-02	
AB0SWGRRHE	Recovery of Keowee Aux Power Breakers by Manual Control		5.0E-01	5.00E-01	
TACOFF3REC	Offsite power not recov. given 1 run failure with SSHR		6.50E-02	6.50E-02	
23)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	1.04E-08
-KK1BOTHHYM	Both Keowee Units Unavailable Due To Common Maintenance		5.23E-3	5.23E-03	
SXFRCT4THM	Transformer CT4 Is In Maintenance		9.13E-04	9.13E-04	
T5SUBF	Loss Of The Oconee Station Switchyards Initiating Event		4.86E-02	4.86E-02	
NACDJ01HXF	Diesel Jacket Heat Exchanger 1 Fails	6.4E-07	16	2.46E-04	
24)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	1.04E-08
-KK1BOTHHYM	Both Keowee Units Unavailable Due To Common Maintenance		5.23E-3	5.23E-03	
SXFRCT4THM	Transformer CT4 Is In Maintenance		9.13E-04	9.13E-04	
T5SUBF	Loss Of The Oconee Station Switchyards Initiating Event		4.86E-02	4.86E-02	
NACDJ02HXF	Diesel Jacket Heat Exchanger 2 Fails	6.4E-07	16	2.46E-04	
25)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	1.04E-08
FK0FISHCOM	Common Cause Failure Of Both Unit s WL Filters Due To Intake Debris		2.55E-3	2.55E-03	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
NACSFDGDGR	SSF Diesel Generator Fails To Run	3.00E-03	24	7.20E-02	
FK0FISHDHE	Recovery of Main WL Strainer Clogging		6.3E-02	6.30E-02	
TACOFF3REC	Offsite power not recov. given 1 run failure with SSHR		6.50E-02	6.50E-02	
26)-KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-2	3.80E-02	1.03E-08
EK00RUNCOM	Common Cause Failure Of Both Units Voltage Regulators To Run		1.24E-4	1.24E-04	
FEFTDFPTPR	Turbine-Driven EFW Pump Fails To Run For The Required Time	2.50E-03	24	6.00E-02	
T5WEATH	Loss Of Off-Site Power Due To Severe Weather Initiating Event		1.440E-02	1.44E-02	
NSF0ASWDHE	Operators Fail To Align The SSF ASW System For Operation		1.000E-01	1.00E-01	

Table 7.4-2

Basic Event Importance Measures From The ONS-Keowee Core Damage Model

Basic Event	Probability	Fus. Ves.	Critic	Birnbm	Red Wrth	Ach Wrth
T5WEATH	1.44E-02	9.68E-01	9.68E-01	7.01E-05	3.09E+01	6.72E+01
TACOFF2REC	2.20E-01	7.51E-01	7.51E-01	3.56E-06	4.02E+00	3.66E+00
NSF0RCMDHE	1.00E-01	5.46E-01	5.46E-01	5.69E-06	2.20E+00	5.91E+00
SXFRCT4THM	9.13E-04	5.20E-01	5.20E-01	5.94E-04	2.08E+00	5.70E+02
KK1BOTHHYM	5.23E-03	3.09E-01	3.09E-01	6.16E-05	1.45E+00	5.97E+01
PAC0T5WDEX	1.00E-01	2.99E-01	2.99E-01	3.12E-06	1.43E+00	3.69E+00
TACOFF3REC	6.50E-02	1.89E-01	1.89E-01	3.04E-06	1.23E+00	3.72E+00
NACSFDGDGM	3.50E-02	1.59E-01	1.59E-01	4.73E-06	1.19E+00	5.37E+00
NACSFDGDGR	7.20E-02	1.30E-01	1.30E-01	1.88E-06	1.15E+00	2.68E+00
AB0SWGRCOM	6.69E-04	5.53E-02	5.53E-02	8.62E-05	1.06E+00	8.36E+01
AB0SWGRRHE	5.00E-01	5.53E-02	5.53E-02	1.15E-07	1.06E+00	1.06E+00
NACSFDGDGS	1.20E-02	5.09E-02	5.09E-02	4.42E-06	1.05E+00	5.19E+00
NSFCON2CMS	1.00E-02	4.24E-02	4.24E-02	4.42E-06	1.04E+00	5.20E+00
NSFTIMEDHE	1.00E-02	4.24E-02	4.24E-02	4.42E-06	1.04E+00	5.20E+00
AB7MCH2DEX	7.04E-03	3.73E-02	3.73E-02	5.52E-06	1.04E+00	6.26E+00
T5SUBF	4.86E-02	3.24E-02	3.24E-02	6.95E-07	1.03E+00	1.63E+00
TACOFF4REC	5.10E-02	2.98E-02	2.98E-02	6.09E-07	1.03E+00	1.55E+00
FK0FISHDHE	6.30E-02	2.39E-02	2.39E-02	3.95E-07	1.02E+00	1.35E+00
FK0FISHCOM	2.55E-03	2.39E-02	2.39E-02	9.76E-06	1.02E+00	1.03E+01
KK2UNITHYM	3.80E-02	2.27E-02	2.27E-02	6.22E-07	1.02E+00	1.57E+00
EKSTARTCOM	6.17E-05	1.70E-02	1.70E-02	2.86E-04	1.02E+00	2.76E+02
E12EXCTCOM	5.31E-05	1.46E-02	1.46E-02	2.86E-04	1.01E+00	2.76E+02
PACLINEDEX	7.80E-03	1.24E-02	1.24E-02	1.65E-06	1.01E+00	2.57E+00
XD1KBATBYF	9.30E-04	1.07E-02	1.07E-02	1.20E-05	1.01E+00	1.25E+01
XD0KBATRHE	1.00E+00	1.07E-02	1.07E-02	1.11E-08	1.01E+00	1.00E+00
NACDJ02HXF	2.46E-04	1.00E-02	1.00E-02	4.25E-05	1.01E+00	4.17E+01
NACDJ01HXF	2.46E-04	1.00E-02	1.00E-02	4.25E-05	1.01E+00	4.17E+01
EK00RUNCOM	1.24E-04	9.89E-03	9.89E-03	8.31E-05	1.01E+00	8.07E+01
FEFTDFPTPR	6.00E-02	9.89E-03	9.89E-03	1.72E-07	1.01E+00	1.15E+00
NSF0ASWDHE	1.00E-01	9.89E-03	9.89E-03	1.03E-07	1.01E+00	1.09E+00

Table 7.5-1

Sensitivity Study Results
Generic Versus Bayesian Updated Data

Gate Name	Result - Bayesian Updated Data with no credit for recoveries	Result - Generic Data with no credit for recoveries	Percent Change
KEOWTOP	1.0E-02	1.3E-02	30.0%
KEOWCOM	3.5E-03	4.8E-03	37.1%
K12COM	3.6E-03	5.0E-03	38.9%
KCOMMODE	3.6E-06	4.4E-06	22.2%
KCOMRUN	3.5E-03	4.3E-03	22.9%
KU1GVTBHOT	1.6E-03	1.9E-03	18.8%
KU1RUN	1.2E-02	1.8E-02	50.0%
KU1START0	8.4E-03	1.3E-02	54.8%
KU1STARTF	8.1E-03	1.2E-02	48.1%
KU1UNDER	2.0E-02	3.0E-02	50.0%
KU1UNDER0	2.0E-02	3.0E-02	50.0%
KU2GVTBHOT	1.6E-03	1.9E-03	18.8%
KU2OVER	1.8E-02	2.6E-02	44.4%
KU2OVER0	2.2E-02	3.4E-02	54.5%
KU2RUN	1.1E-02	1.6E-02	45.5%
KU2START0	7.5E-03	1.1E-02	46.7%
KU2STARTF	7.8E-03	1.1E-02	41.0%
OPATHTOP	8.2E-03	1.8E-02	119.5%
OVER0	7.3E-02	9.4E-02	28.8%
OVERTOP	6.5E-02	9.3E-02	43.1%
UNDER0	3.0E-02	4.2E-02	40.0%
UNDERTOP	2.2E-02	3.2E-02	45.5%
UPATHTOP	1.1E-03	1.2E-03	9.1%

Table 7.5-2

Sensitivity Study Results

Grid Cycled (Overhead) Versus Standby (Underground) Generator Reliability [1]

Failure Mode	Standby Generator Failure Probability	Grid Cycled Generator Failure Probability
Cold Start Failure	8.1E-03	7.8E-03
Hot Start Failure	1.6E-03 [2]	1.6E-03
Run Failure	1.2E-02	1.1E-02

[1] These failure probabilities are for the generators exclusively and do not include the failures of the paths or output breakers.

[2] Base Case analysis does not involve hot start failures of the underground unit.

Table 7.5-3

Sensitivity Study Results
Human Error Probabilities

Data Change	Failure Probability
RHEs, DHEs & LHEs @ pre-92	7.4E-03
Base Case	7.4E-03

Table 7.5-4

Sensitivity Study Results -- Infrequently Tested/Demanded Components

Gate	Description	Base Case Value	Case 1 Value	Percent Increase	Case 2 Value	Percent Increase	Case 3 Value	Percent Increase
KU2STARTF*	Keowee Unit 2 Fails To Start	7.84E-3	7.84E-3	0	1.62E-2	107	2.44E-2	211
KU2RUN*	Keowee Unit 2 Fails To Run	1.04E-2	1.04E-2	0	1.06E-2	1.9	1.57E-2	51
KEOWTOP	Oconee Emergency Power From Keowee Fails	7.35E-3 7.28E-3**	7.39E-3	0.5	8.40E-3**	15	9.49E-3*	30

* Cutsets for gates KU2STARTF and KU2RUN have not had recovery events added.

** These values are for KEOWTOP solved at a truncation limit of 1E-7. Attempting to solve for objectives 2 and 3 at the usual limit of 1E-8 exceeded CAFTA's limit on the number of cut sets.

Table 7.5-5

Sensitivity Study Results

One Versus Two Units Generating To The Grid

	One unit generation	Two unit generation (0.034)	Two unit generation (0.3)
Recovered	7.4E-03	7.3E-03	7.3E-03
Unrecovered	1.0E-02	1.0E-02	1.0E-02

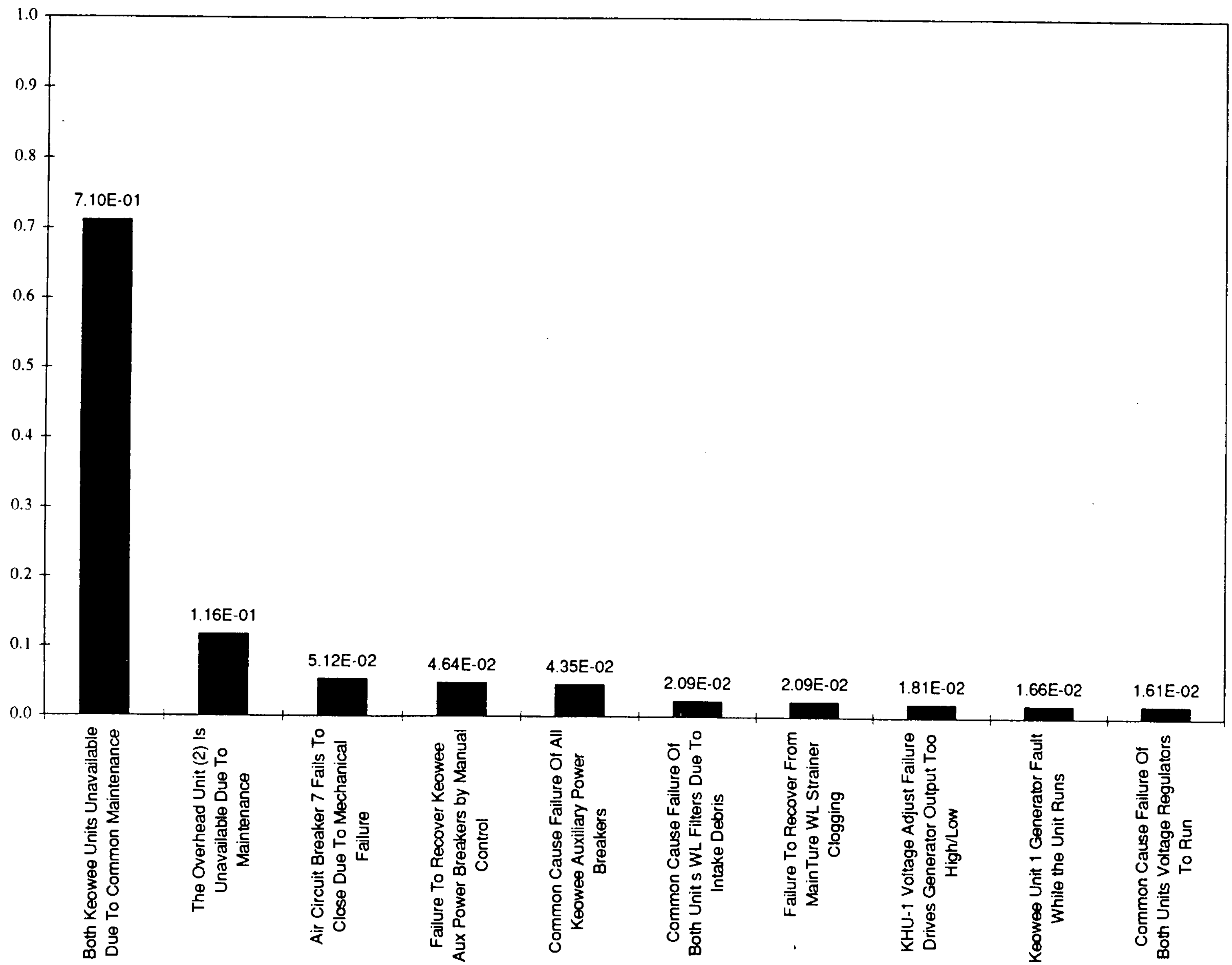
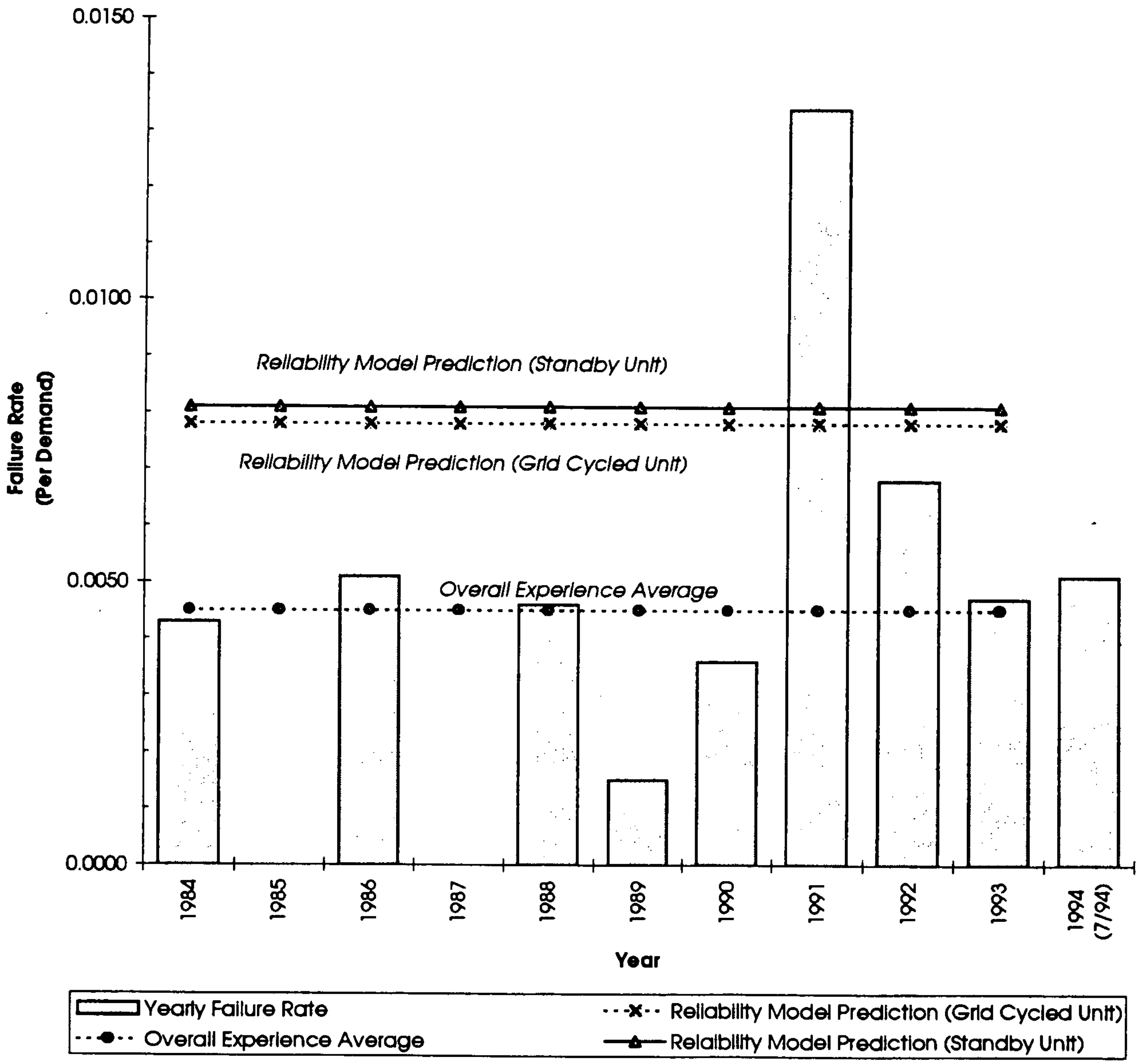


Figure 7.2-1 Dominant Contributors To Keowee Unavailability as Ranked by Importance Measure

Experience vs. Model Prediction



DATA SUMMARY

	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994•(7/94)
Yearly Failure Rate	0.0043	0.0	0.0051	0.0	0.0046	0.0015	0.0036	0.0134	0.0068	0.0047	0.0051
Reliability Model Prediction (Grid Cycled Unit)											0.0078
Reliability Model Prediction (Standby Unit)											0.0081
Overall Experience Average (1984 - 93)											0.0045

Figure 7.2-2 Keowee Start Failure Probability

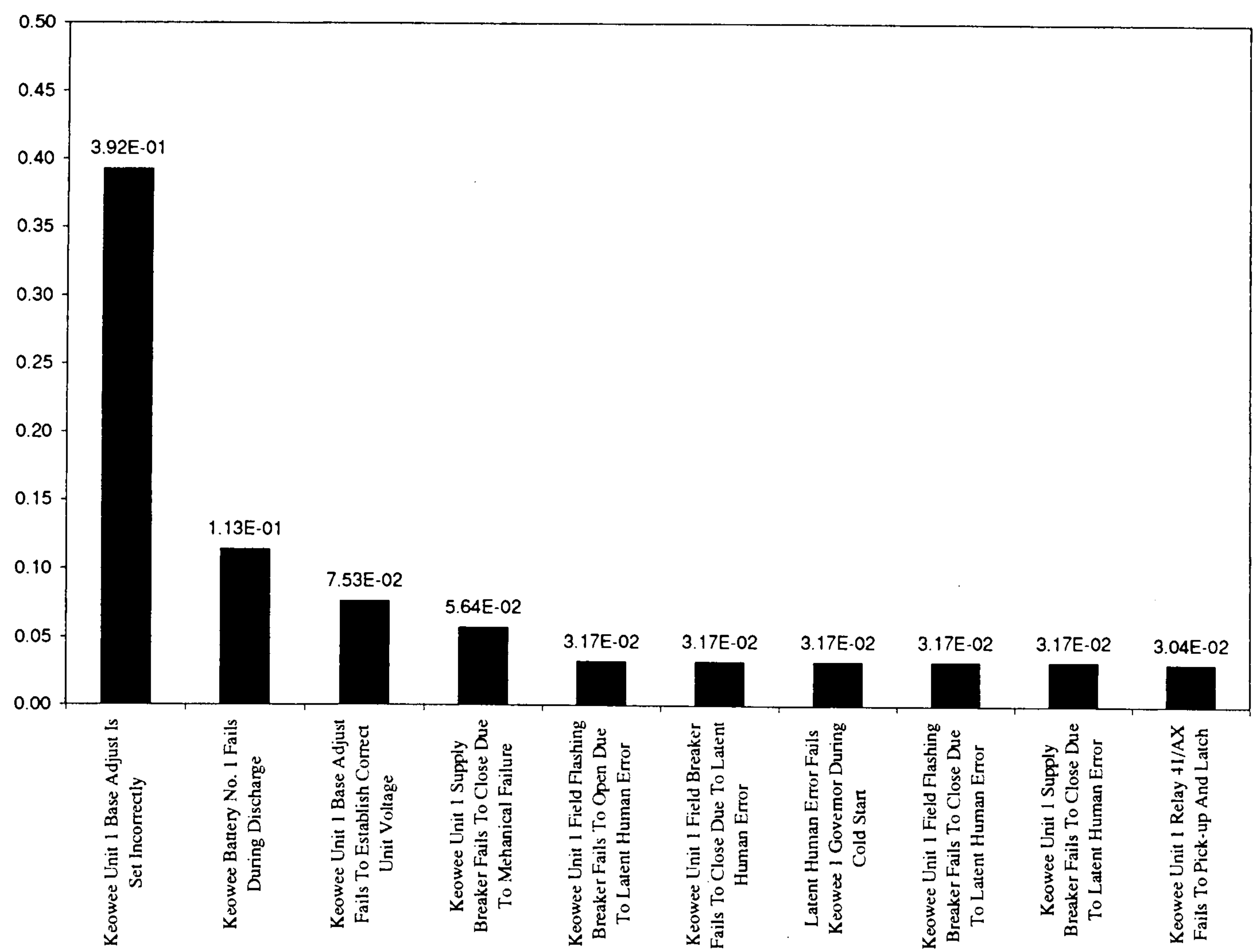


Figure 7.2-3 Dominant Contributors to Keowee Unit 1 Start Failure as Ranked by Importance Measure

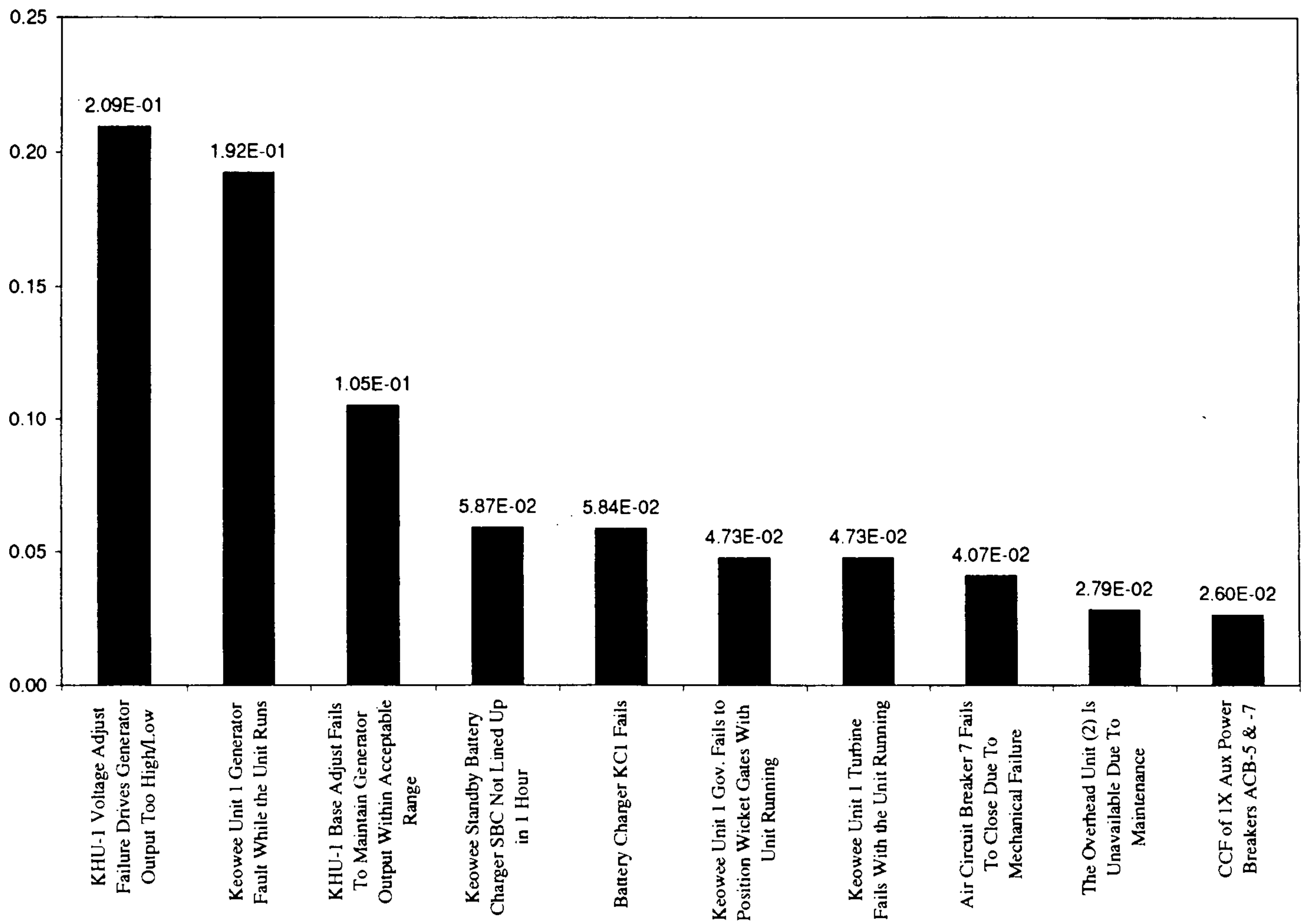


Figure 7.2-4 Dominant Contributors to Keowee Underground Unit (Unit 1) Run Failures as Ranked by Importance Measure

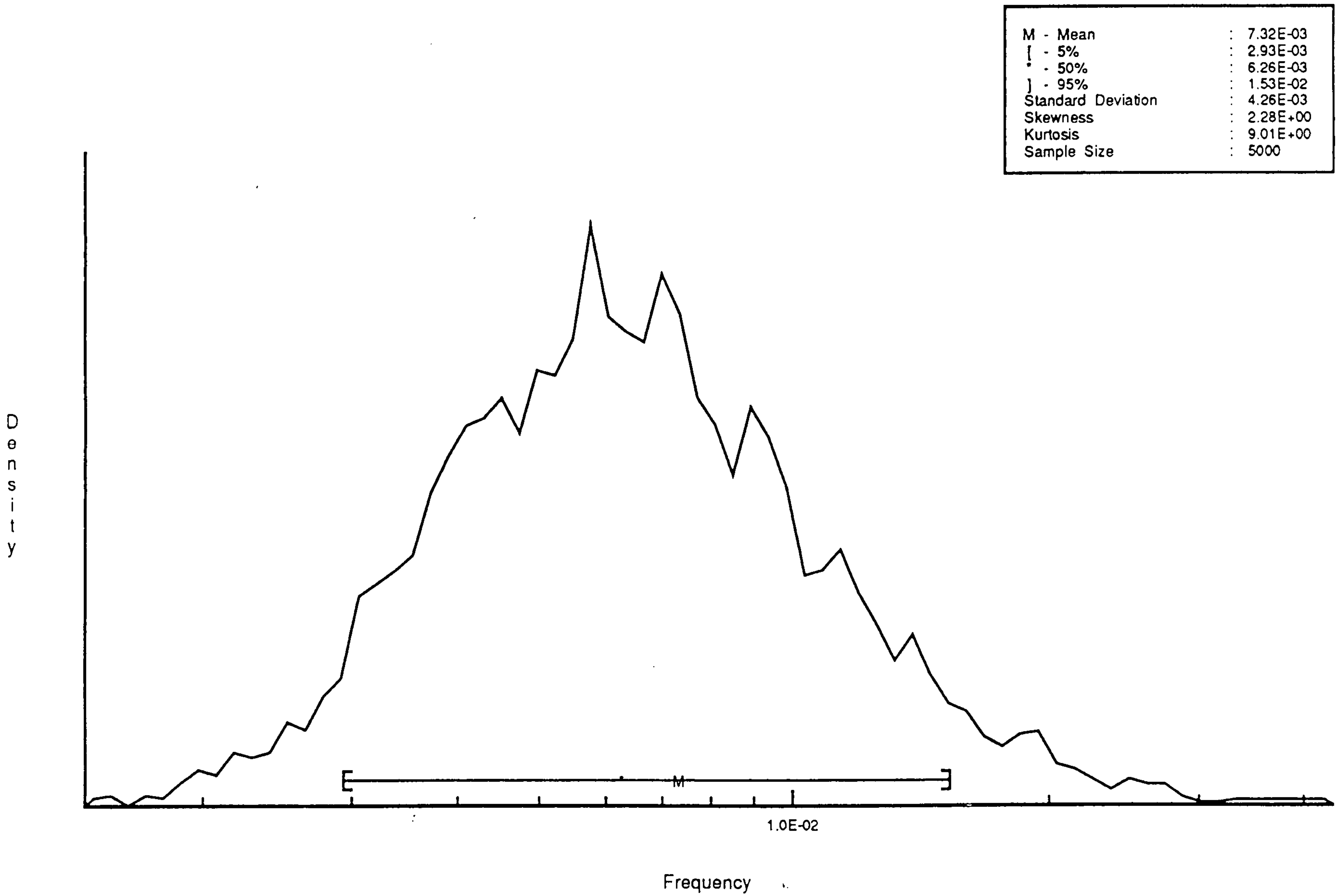


Figure 7.5-1: Probability Distribution For Model Top Gate KEOWTOP

8.0 REFERENCES

1. Oconee Nuclear Station Unit 3 Probabilistic Risk Assessment, Rev. 1, Duke Power Company, 1989.

2. Hampton, J. W., Letter to USNRC, "Detailed PRA Analysis of Keowee Concerning Its Role as an Emergency Supply," Duke Power Co., November 10, 1993.

3. Procedures for Treating Common Cause Failures in Safety and Reliability Studies, Vol. I: Procedural Framework and Examples, NUREG/CR- 4780, USNRC, 1988.

4. PRA Procedures Guide, NUREG/CR-2300, American Nuclear Society and the Institute Of Electrical And Electronic Engineers, Inc., 1983.

5. Individual Plant Examination For The Davis-Besse Nuclear Power Station, Toledo Edison Company, 1993.

6. Generic Component Failure Data Base For Light Water And Liquid Sodium Reactor PRAs, EGG-SSRE-8875, Idaho National Engineering Laboratory, 1990.

7. IEEE Guide To The Collection And Presentation Of Electrical, Electronic, Sensing Component, And Mechanical Equipment Reliability Data For Nuclear Power Generating Stations, IEEE Std 500-1984, Institute Of Electrical And Electronic Engineers, Inc., 1983.

8. EPRI, NP-6780-L, Rev. 4, Vol. 2, Ch. 1, App. A, PRA Key Assumptions And Groundrules, April, 1992.

9. Fleming, K. N., et. al., A Database of Common Cause Events for Risk and Reliability Applications, Electric Power Research Institute, EPRI-TR-100382, 1992.

10. Molesh, A., et. al., Procedures For Treating Common Cause Failures in Safety and Reliability Studies, Vol. II: Analytical Background and Techniques, NUREG/CR-4780 (EPRI NP-5613), USNRC, 1989.

11. Molesh, A., Procedures For Treating Common Cause Failures in Safety and Reliability Studies, NUREG/CR-5801, USNRC, 1993.

12. Wakefield, D. J., et. al., SHARP 1 -- A Revised Systematic Human Action Reliability Procedure, EPRI TR-101711, Electric Power Research Institute, 1992.

13. Swain, A. D., H. E. Guttmann, Handbook of Human Reliability Analysis with Emphasis on Nuclear Plant Applications Final Report, NUREG/CR-1278, USNRC, 1983.

14. Parry, G. W.,. Lydell, B, An Approach to the Analysis of Operator Actions in Probabilistic Risk Assessment, EPRI-TR-100259, Electric Power Research Institute, 1992.

15. Gertman, David I., et. al., INTENT: A Method For Estimating Human Error Probabilities for Errors of Intention, EGG-SRE-9178, Idaho National Engineering Laboratory, 1990.

16. Licensee Event Report (LER) 270/92-04, Loss of Offsite Power at Oconee Unit 2

APPENDIX A.1

HIGH LEVEL LOGIC MODEL

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A.1 HIGH LEVEL LOGIC MODEL

A.1.1 OBJECTIVES

The objectives of the high level logic model are to:

- provide a top gate representing the overall failure probability of Keowee to supply power,
- provide a means for integration of the system models,
- provide a means for introducing the various operating modes of the station into the analysis, including generation to the grid and maintenance,
- provide a convenient location for development of dependent failures,
- provide a pictorial "story" of how the major systems/components influence the Keowee supply
- provide intermediate gates at appropriate places for analysis of reliability at the unit and power path levels,
- provide intermediate gates at appropriate places for analysis of unit start and run reliability,
- eliminate to the extent practical all invalid cut sets in the top gate solution as well as the intermediate gate solutions.

A.1.2 DESCRIPTION OF HIGH LEVEL LOGIC MODEL TREE

A.1.2.1 TOP GATE

In order to satisfy the stated objectives the model has been developed with the following attributes.

The top gate for the high level logic model "KEOWTOP: Oconee Transformers CT3 And CT4 Fail To Receive Power From Keowee" represents the failure probability of interest in this analysis.

The high level logic model tree separates the solution into the overhead and underground supplies. Additionally, the unit related failures are on a different branch of the tree than the path related failures. Also, start and run failures of the two units are evaluated on different branches of the tree. These features allow the evaluation of the reliability at these lower levels. Events representing the probability of various operating conditions are included in the

model such as, Unit 1 generating to the grid alone or with Unit 2, Unit 2 in maintenance, and both Keowee units in maintenance.

The effort is made to eliminate invalid cut sets from occurring in the solutions. This often requires the use of NOT gates in the high level logic model. It is recognized that this often complicates the tree and the cut sets, but the benefit is in the overall reproducibility by not relying on the analyst's judgment on deleting invalid results.

The high level logic model tree has relatively few basic events. Many of the termination points for this tree are transfers to the individual system models. Refer to Table A.1-1 for a list of the fault tree transfers and to Table A.1-2 for the basic events.

The high level logic model is included as Figure A.1-1. Refer to section 4.0 for discussion of the systems analysis assumptions and the process.

A.1.2.2 UNDERGROUND POWER SUPPLY

The highest level gate for the evaluation of the underground supply reliability "UNDER0: Power To CT4 Via The Underground Path From Keowee Fails" includes all failure modes for the underground supply. The gate includes the common cause failures, double maintenance failure, as well as the unit and path failures. Progressively finer levels of detail about the underground supply are available at the lower gates in the tree. The following discussion provides a summary of the kind of information available at some of the lower gates of the underground branch of the tree.

UNDERTOP: Oconee Emergency Power Via The Underground Path Fails

The inputs to this gate consider the availability of a Keowee unit to supply the underground path and the proper function of the path itself. The availability of a Keowee unit to supply the underground path further considers that either unit may be available to supply the underground path. Keowee Unit 1 is the unit assumed to be normally aligned to the underground path. However, for combinations of overhead path failures and underground unit (Unit 1) failures it is possible to recover the emergency power supply by aligning the overhead unit (Unit 2) to the underground path. Refer to Section 4.0 for more information regarding the assumed alignment of the units.

KU1UNDER0: Keowee Unit 1 Fails To Supply The Underground Path

At this level of the tree, failures on the Unit 1 side of Keowee contribute to the failure probability. The inputs to this gate consider failures of the unit to function and the successful maintenance of the connection to the underground path via Air Circuit Breaker 3 (ACB-3). The unit failure further considers the failure of the unit to start or to run for the required mission time. Start failures are also further subdivided.

A Keowee unit that is available for its emergency power supply function may either be in standby or generating to the grid. Either of these conditions may exist at the time an emergency start signal is received. These two conditions place different demands on the Keowee units when the start signal is received. Both situations are included in the model as "start" failures event though in one case the unit is operating at the time the start signal is received. The unit start from standby is referred to as a "cold start" while the unit start from generating to the grid is referred to as a "hot start". Component failures contributing to these start failures are conditioned in the tree by the probability that the unit is in the applicable mode.

For the base case analysis, the unit aligned to the underground path (Unit 1) is assumed to not be generating to the grid. This is consistent with the current operating restrictions applied to the Keowee units. However, the ability to analyze the condition where both units may be allowed to generate to the grid has been built into the high level tree. Refer to section 4.0 for discussion of the systems analysis assumptions.

A.1.2.3 OVERHEAD POWER SUPPLY

The highest level gate for the evaluation of the overhead supply reliability "OVER0: Power To CT3 Via The Overhead Path From Keowee Fails" includes all failure modes for the overhead supply. The gate includes the common cause failures, double maintenance failure, as well as the unit and path failures. Progressively finer levels of detail about the overhead supply are available at the lower gates in the tree. The following discussion provides a summary of the kind of information available at some of the lower gates of the overhead branch of the tree.

OVERTOP: Oconee Emergency Power Via The Overhead Path Fails

The inputs to this gate consider the availability of Keowee Unit 2 to supply the overhead path, including maintenance unavailability, and the proper function of the path itself.

KU2OVER0: Keowee Unit 2 Fails To Supply The Overhead Power Path

At this level of the tree, failures on the Unit 2 side of Keowee contribute to the failure probability. The inputs to this gate consider failures of the unit to function and the successful maintenance of the connection to the overhead path via Air Circuit Breaker 2 (ACB-2). The unit failure further considers the failure of the unit to start or to run for the required mission time. Start failures are also further subdivided into the "hot start" and "cold start" failures described above. No restrictions on generating to the grid are in place on the unit aligned to the overhead path.

A.1.2.4 DOUBLE MAINTENANCE

Both Keowee units can be in maintenance simultaneously. This event automatically leads to failure of Keowee as an emergency power supply for Oconee. This basic event is included on both the underground and overhead branches of the tree.

Refer to Section 5.3 and Appendix C.1 for information on the quantification of this event.

A.1.2.5 DEPENDENT FAILURES

Common cause and other dependent failures affecting both Keowee units have been grouped under the gate "KEOWCOM: Keowee Failure Due To Common Mode Failures". Component common cause events and special situations that lead to failure of both units are included here. Special situations include the opportunity for both units to be connected to the same path inadvertently. Since no attempt is made to synchronize units with each other on an emergency start, both units are assumed to fail if they inadvertently close on the same path. Failures which would lead to this occurrence are included in the analysis.

Refer to Section 5.4 and Appendix C.2 for information on the quantification of common cause events.

A.1.3 DATA

The high level logic model uses basic events to condition the failures according to the various possible operating configurations of the Keowee units. These events identify the probability that a unit is generating to the grid and are based on the Keowee operating history. Other specific component failure probabilities are also required. These events are included in the model as undeveloped (DEX) events and the calculation of their values is presented here.

Unit Run Information

The unit run information is based on the data for the most recent years where both units were allowed to generate to the grid, 1989 through 1991. This data is presented in the following table.

	STATION RUN HOURS	TOTAL UNIT HOURS	UNIT 1	UNIT 2
1989	513.40	740.70	312.10	428.60
1990	865.60	1190.40	636.10	554.30
1991	773.70	1109.70	562.00	547.70
TOTALS	2152.70	3040.80	1510.20	1530.60
	UNITS 1 & 2 RUN TOGETHER	UNIT 1 ALONE	UNIT 2 ALONE	
HOURS	888.10	622.10	642.50	
YEARLY FRACTION	0.034	0.024	0.024	

In the above data the unit run hours are available, however, no information is available on whether the unit was aligned to the overhead or the underground path. It is assumed in the calculations that each unit's generation hours are equally divided between the overhead and underground alignment.

KK1RUNSDEX: Keowee Unit 1 Supplying The Grid

This event represents the probability that the unit aligned to the underground (Keowee Unit 1 in the model) is generating to the grid by itself.

In the current operating configuration, the underground unit is not used for generation to the grid. For the base case calculation, this DEX has the value 0.0.

The base case value of KK1RUNSDEX = 0.0

In sensitivity studies where both units can generate to the grid this DEX takes on the value based on the operating history given above. With the assumption that 50% of a unit's hours of generation come while aligned to the underground path, the DEX is calculated as shown below.

The sensitivity study value of KK1RUNSDEX = (622.1+642.5)/2/(3*8760) = 2.4E-2

KK2RUNSDEX: Keowee Unit 2 Supplying The Grid

This event represents the probability that the unit aligned to the overhead (Keowee Unit 2 in the model) is generating to the grid by itself. No restrictions are placed on generation to the grid by the unit aligned to the overhead path.

Historically, a unit generates approximately 6% of the time.

The value of KK2RUNSDEX = 6.0E-02

KK1BOTHDEX: Keowee Units 1 & 2 Supplying The Grid

In the current operating configuration, the underground unit is not used for generation to the grid. For the base case calculation, this DEX has the value 0.0.

The base case value of KK1BOTHDEX = 0.0

In sensitivity studies where both units can generate to the grid this DEX takes on the value based on the operating history given above.

The value of KK1BOTHDEX = 888.1/(3*8760) = 3.4E-2

KB4CONNDEX: Air Circuit Breaker 4 Connects Unit 2 To The Underground Path

This DEX represents the potential for ACB-4 to spuriously close and parallel the two units. No single failure exists that would cause the spurious closure of ACB-4. When ACB-3 is closed both the positive and negative sides of the ACB-4 close coil are separated from the power supply by open contacts. Spurious operation of the close coil should be far less likely for this design than might otherwise be the case. The value for this event is estimated as 1% of the RYT type code value of 4.7E-7/hour with a 24 hour mission time.

The value of KB4CONNDEX= 1.1E-7

K12COM1DEX: Grid Degradation Occurs And Causes Failure Of Both Keowee Units

No record of such an event occurring on the Duke system has been identified. A review of the industry events in NSAC-204 comprising more than 1000 reactor years of experience, leads to the conclusion that generator failure from an unisolated fault is a rare event. The Keowee generators, main step-up transformer, and the switchyard all have protective relaying. Calculation OSC-5096 specifically considers Keowee stability for various fault conditions. Therefore, a screening value of 1.00E-06 is selected for this event.

The value of K12COM1DEX is 1.00E-06

WK1SPD1DEX &WK2SPD1DEX: Potentially Damaging Overfrequency Occurs At Load Rejection

When Keowee is generating to the grid, an emergency start signal causes a load rejection to occur. The loss of load on the generator will result in a turbine speed transient. Until the governor closes the wicket gates to the no load setting an overspeed/overfrequency condition exists. Depending on unit load and the lake levels at the time of the emergency start, the overfrequency is potentially damaging to the Oconee loads. A damaging overfrequency condition is conservatively assumed to always occur.

The value of WK1SPD1DEX = WK2SPD1DEX = 1.0

A.1.4 RESULTS

The High Level Logic Model is not a system as such and, therefore, no system level results are determined. The results of the Keowee model solution are presented in Section 7.2.

A.1.5 REFERENCES

OSS-0254.00-00-2005, Keowee Emergency Power Design Basis Document

Table A.1-1

High Level Logic Model Fault Tree Transfers

Transfer Gate Name	Description
UPATHTOP	Underground Path Fails To Connect Keowee To Oconee
ACB3TRANS	Air Circuit Breaker 3 Transfers Open
KU1GVTBCLD	Keowee Unit 1 Governor Or Turbine Fails During A Cold Start
KU1GEXCLD	Keowee Unit 1 Generator Excitation Fails During A Cold Start
YK1CLDSTRT	Keowee Unit 1 Governor Control Fails During A Cold Start
KU1GENCLD	Keowee Unit 1 Generator Fails During A Cold Start
ACB1OPEN	Air Circuit Breaker 1 Fails To Open
ACB3CLOSE	Air Circuit Breaker 3 Fails To Close
ACB3OPEN	Air Circuit Breaker 3 Fails To Open
KU1GVTBRUN	Keowee Unit 1 Governor Or Turbine Fails While The Unit Runs

Table A.1-1

High Level Logic Model Fault Tree Transfers

Transfer Gate Name	Description
KU1GEXRUN	Keowee Unit 1 Generator Excitation Fails While The Unit Runs
KU1GENRUN	Keowee Unit 1 Generator Fails While The Unit Runs
ACB4CLOSE	Air Circuit Breaker 4 Fails To Connect Unit 2 To The Underground Path
ACB4TRANS	Air Circuit Breaker 4 Transfers Open
KU2GVTBCLD	Keowee Unit 2 Governor Or Turbine Fails During A Cold Start
KU2GEXCLD	Keowee Unit 2 Generator Excitation Fails During A Cold Start
YK2CLDSTRT	Keowee Unit 2 Governor Control Fails During A Cold Start
KU2GENCLD	Keowee Unit 2 Generator Fails During A Cold Start

Table A.1-1

High Level Logic Model Fault Tree Transfers

Transfer Gate Name	Description
KU2GVTBHOT	Keowee Unit 2 Governor Or Turbine Fails During A Hot Start
KU2GVTBRUN	Keowee Unit 2 Governor Or Turbine Fails While The Unit Runs
KU2GEXRUN	Keowee Unit 2 Generator Excitation Fails While The Unit Runs
KU2GENRUN	Keowee Unit 2 Generator Fails While The Unit Runs
ACB2CLOSE	Air Circuit Breaker 2 Fails Close
ACB2TRANS	Air Circuit Breaker 2 Transfers Open
OPATHTOP	Overhead Path Fails To Connect Keowee To Oconee

Table A.1-2

High Level Logic Model Reliability Data

Event Name	Description	Failure Rate[1]	Factor	Rational For Factor[2]	Failure Probability
AB0SWGRCOM	Common Cause Failure Of All Keowee Auxiliary Power Breakers		6.69E-04		6.69E-04
ACB4MOD	NSM-ON-52966 Is Not In Service		1		1.00E+00
ACBXFERCOM	Common Cause Failure That Results In ACBs 2 & 3 Transfering Open		1.28E-06		1.28E-06
BKGBOILCOM	Common Cause Failure Of Turbine Guide Bearing Oil System		1.94E-06		1.94E-06
E12EXCTCOM	Units 1 & 2 Excit Fail Due To Common Cause Failure Of The Breakers		5.31E-05		5.31E-05
EK00RUNCOM	Common Cause Failure Of Both Units Voltage Regulators To Run		1.24E-04		1.24E-04
EKSTARTCOM	Common Cause Failure Of Both Units Voltage Regulators To Start		6.17E-05		6.17E-05
FK0FISHCOM	Common Cause Failure Of Both Unit s WL Filters Due To Intake Debris		2.55E-03		2.55E-03
FKVALVECOM	Common Cause Failure Of Cooling Water Control Valves		2.46E-05		2.46E-05
GK0COOLCOM	Common Cause Failure of Generator Air Cooling		4.61E-07		4.61E-07
GK0LOCKCOM	Common Cause Actuation of Generator Lockouts		4.06E-06		4.06E-06
GKHPOILCOM	Common Cause Failure of Generator Thrust Bearings		4.61E-07		4.61E-07
K12COM1DEX	Grid Degradation Occurs And Causes Failure Of Both Keowee Units		1.00E-06		1.00E-06

[1] [illegible]Demand, H=Hour
[2] [illegible]s for assigning basic event factors are discussed in Table C.

Table A.1-2

High Level Logic Model Reliability Data

Event Name	Description	Failure Rate[1]	Factor	Rational For Factor[2]	Failure Probability
KA127T1R6D	Xfrmr 1X UV Relay 27T/1X Fails To Pick-up	2.49E-04 /D	1 D	1 demand per emergency start	2.49E-04
KA127T1R6T	Xfrmr 1X UV Relay 27T/1X Spuriously De-energizes	3.63E-07 /H	360 H	Rule 4:Indicated by computer point.	1.31E-04
KA227T2R6T	Xfmr 2X UV Relay 27T/2x Spuriously De-energizes	3.63E-07 /H	360 H	Rule 4:Indicated by computer point.	1.31E-04
KB4CONNDEX	Air Circuit Breaker 4 Connects Unit 2 To The Underground Path		1.10E-07		1.10E-07
KK1BOTHDEX	Keowee Units 1 And 2 Are Supplying The Grid		0		0.00E+00
KK1BOTHHYM	Both Keowee Units Unavailable Due To Common Maintenance		5.23E-03		5.23E-03
KK1RUNSDEX	Keowee Unit 1 Only Is Supplying The Grid		0		0.00E+00
KK2RUNSDEX	Keowee Unit 2 Only Is Supplying The Grid		0.06		6.00E-02
KK2UNITHYM	The Overhead Unit (2) Is Unavailable Due To Maintenance		3.80E-02		3.80E-02
OK0PRUNCOM	Common Cause Failure Of Both Governor Oil Systems To Run		1.46E-05		1.46E-05
PK0SUMPCOM	Common Cause Failure Of Turbine Sump Pump System		2.44E-06		2.44E-06
WK00RUNCOM	Common Cause Failure of Keowee Governors to Run		2.09E-05		2.09E-05
WK1SPD1DEX	Potentially Damaging Overspeed Condition Occures At Load Rejection		1		1.00E+00
WKCSTRTCOM	Common Cause Failure of Keowee Governors to Cold Start		1.12E-05		1.12E-05
WKHSTRTCOM	Common Cause Failure of Keowee Governors to Hot Start		3.50E-06		3.50E-06

[1] D=Demand, H=Hour

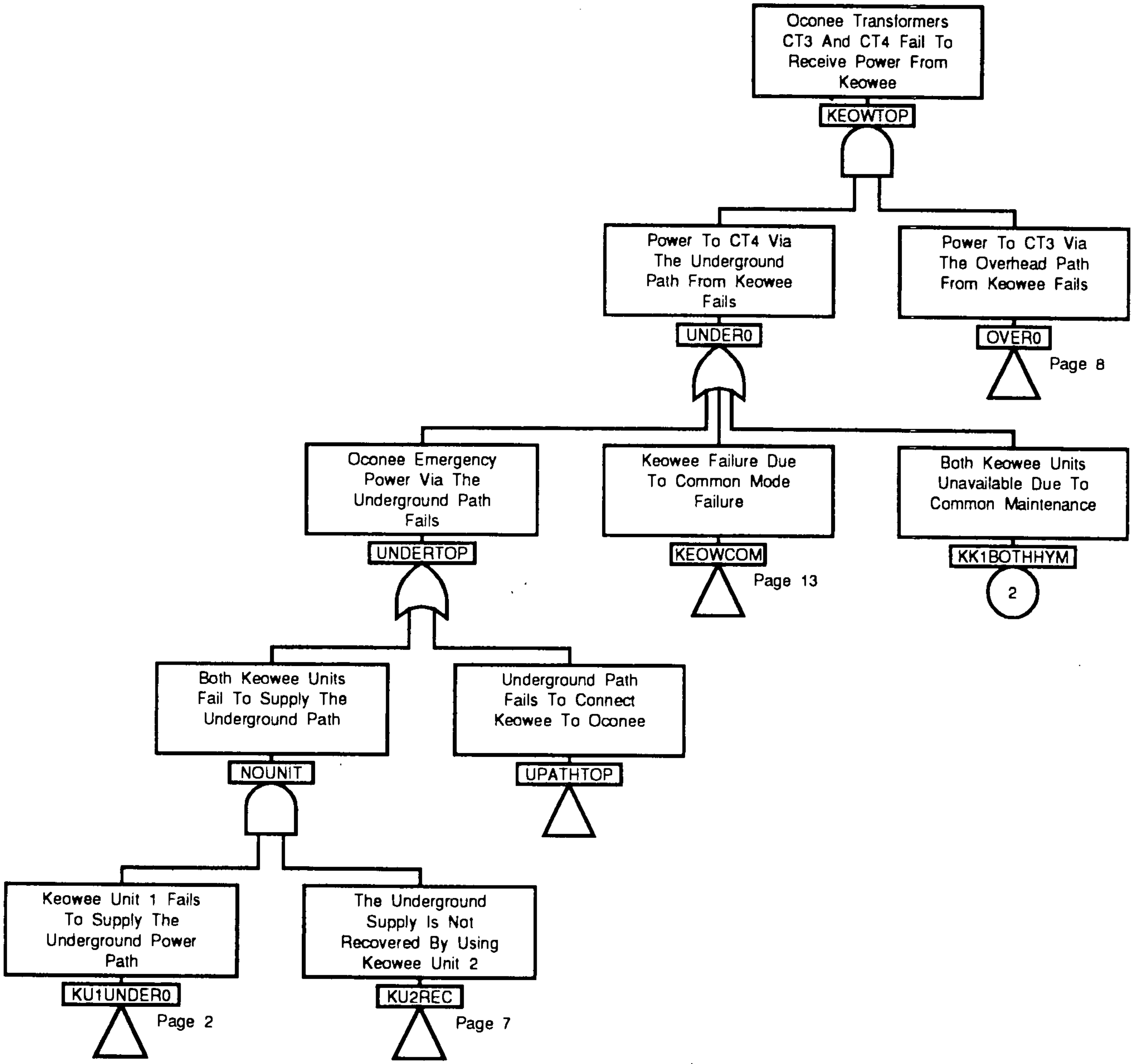
[2] Rules for assigning basic event factors are discussed in Table C.1-4

Table A.1-2

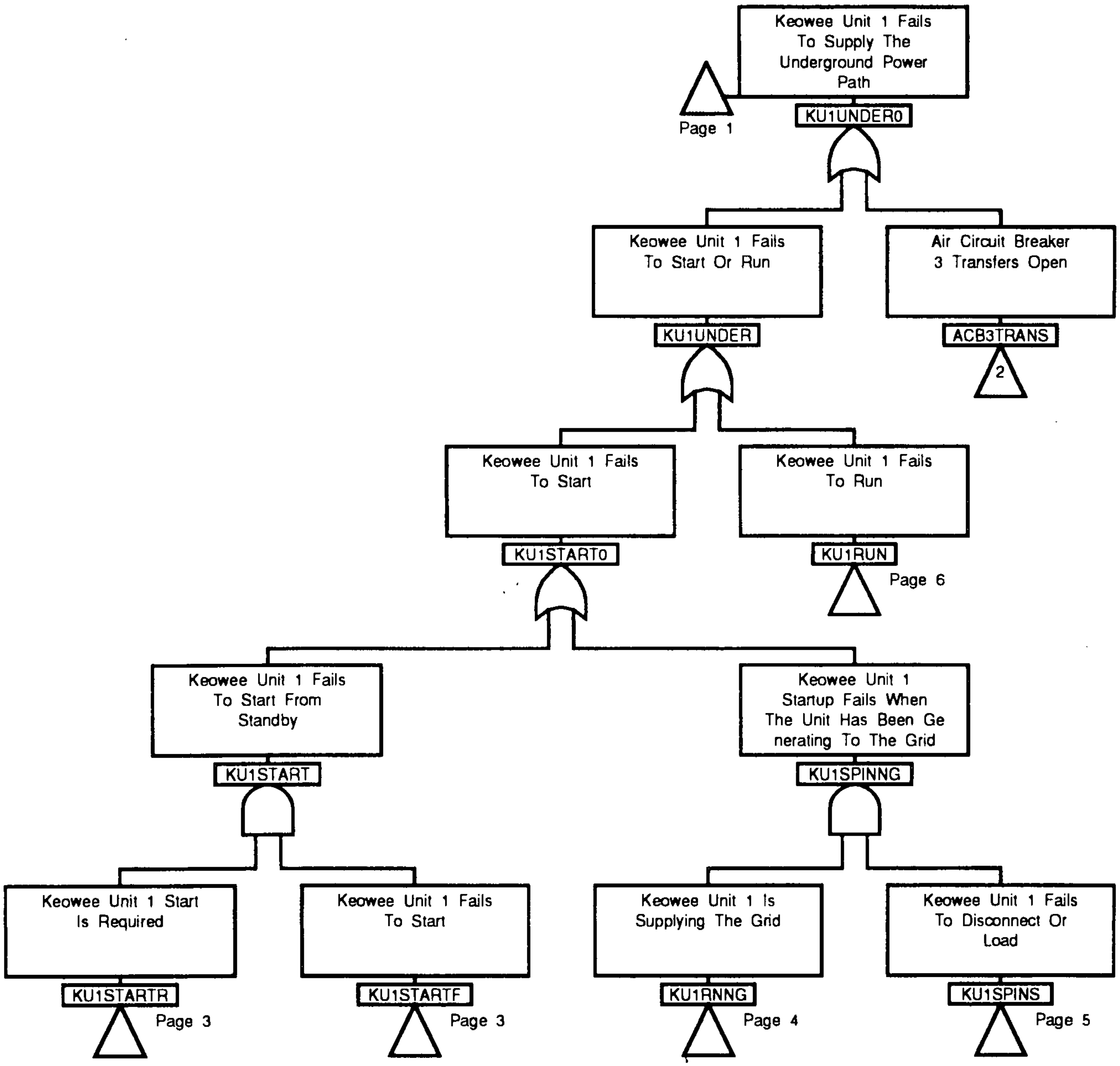
<u>High Level Logic Model Reliability Data</u>

Event Name	Description	Failure Rate[1]	Factor	Rational For Factor[2]	Failure Probability
XA0SWGRCOM	Common Cause Failure Of Transformers 1X, 2X, And CX		1.22E-06		1.22E-06
XA1XAALBLM	MCC 1XA Is Connected to Its Alternate Source of Power		2.74E-03		2.74E-03
XA2XAALBLM	MCC 2XA Is Connected to Its Alternate Power Source		2.74E-03		2.74E-03
XD0BATTCOM	Common Cause Failure Of Keowee I&C Power Batteries		2.70E-05		2.70E-05
XD0CHRGCOM	Common Cause Failure Of Keowee Battery Chargers		3.48E-05		3.48E-05
Y0STARTCOM	Common Cause Failure Of Emergency Start Signal		7.26E-06		7.26E-06

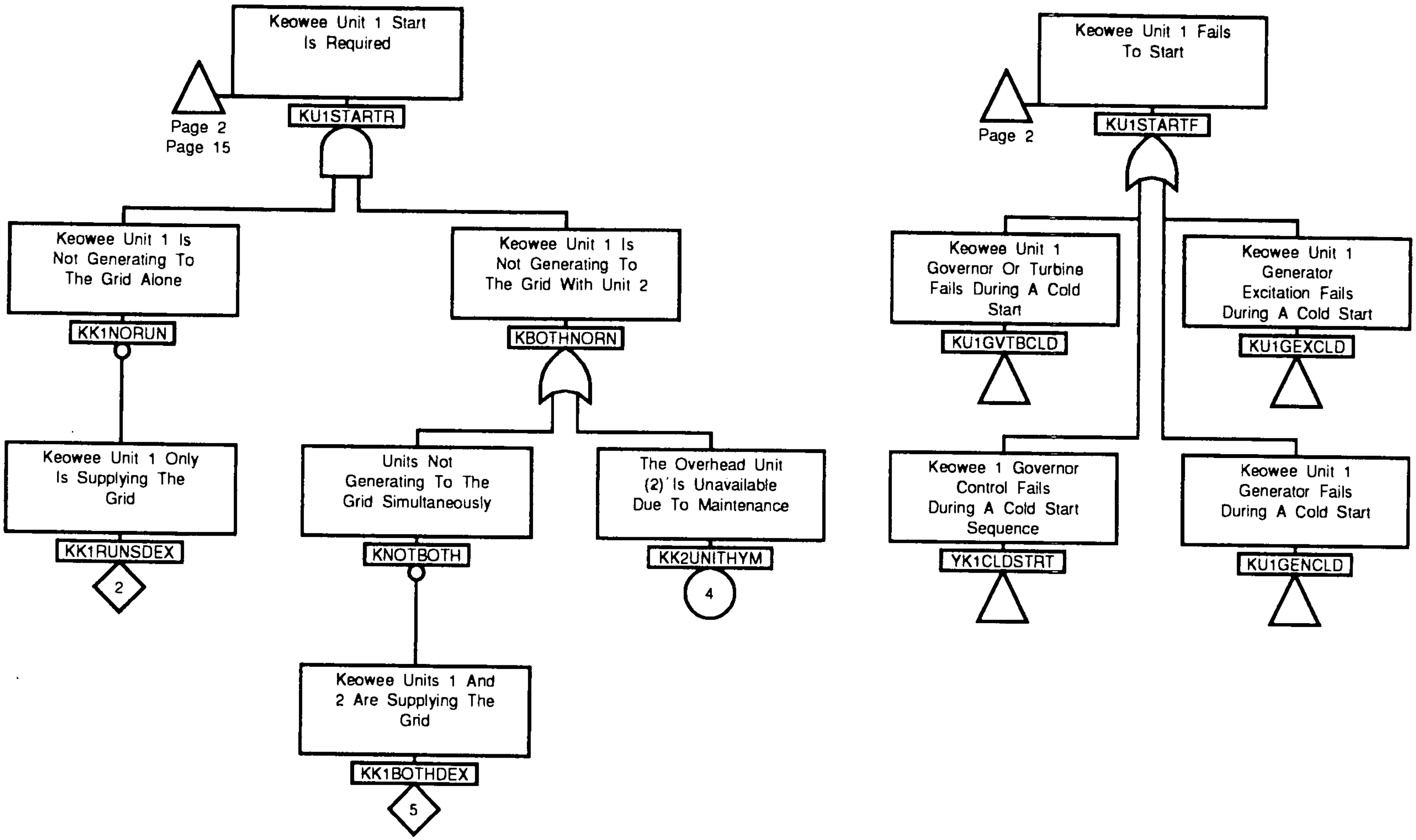
[1] D=Demand, H=Hour
[2] [illegible]s for assigning basic event factors are discussed in Table C.[illegible]



High Level Logic Model Tree | FIGURE A.1-1 |

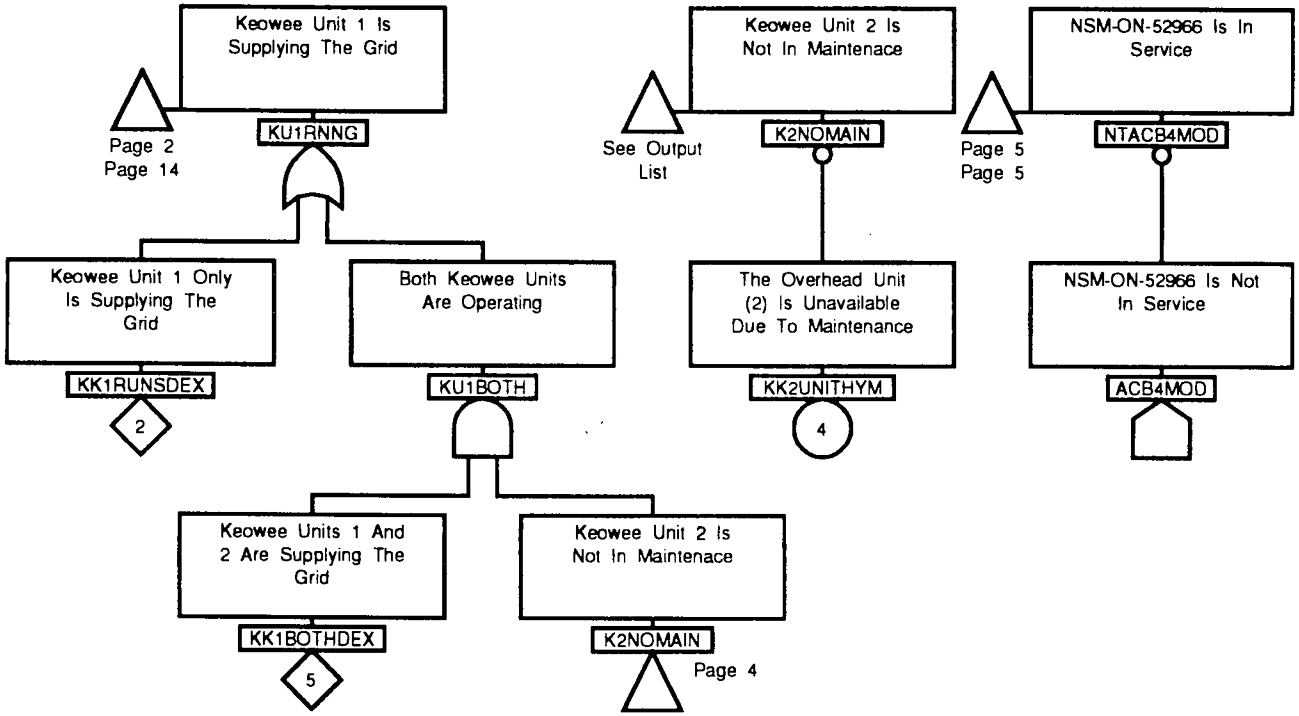


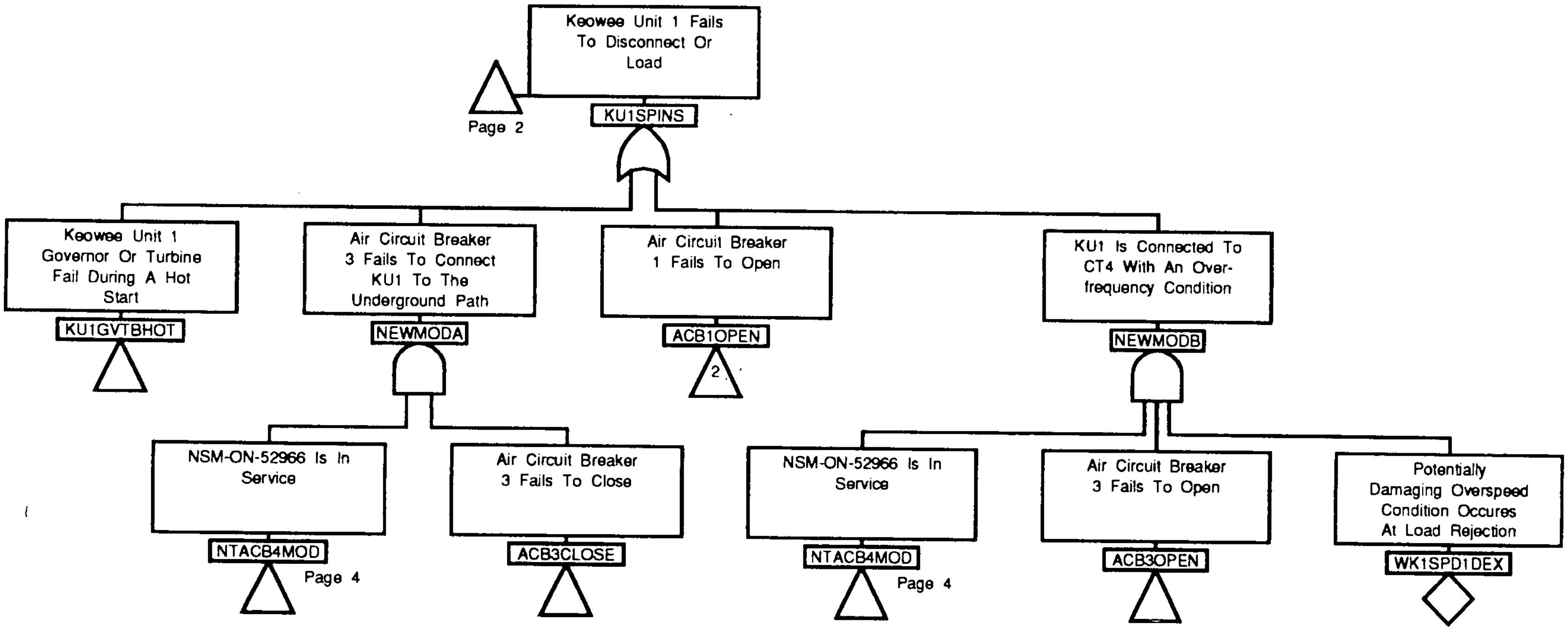
High Level Logic Model Tree	FIGURE A.1-1	Page 2



High Level Logic Model Tree	FIGURE A.1-1	Page 3

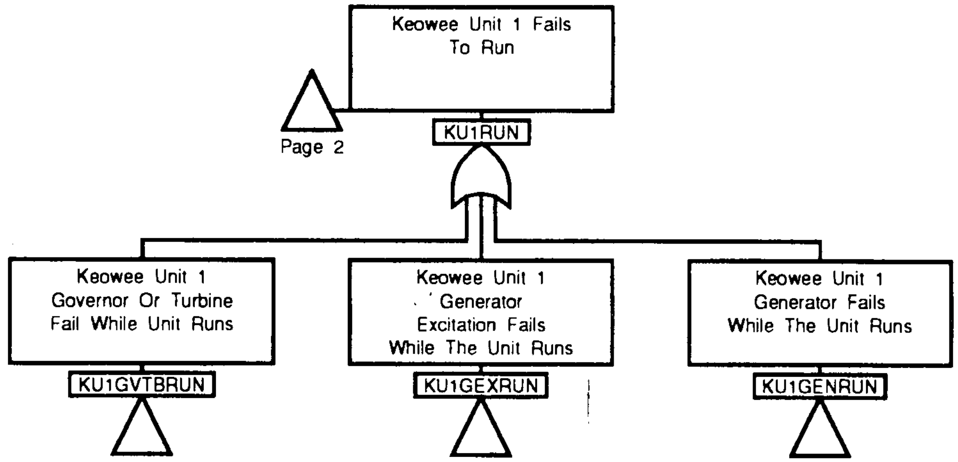
K2NOMAIN Outputs:
Page 13, Page 4, Page 16, Page 14, Page 19, Page 19

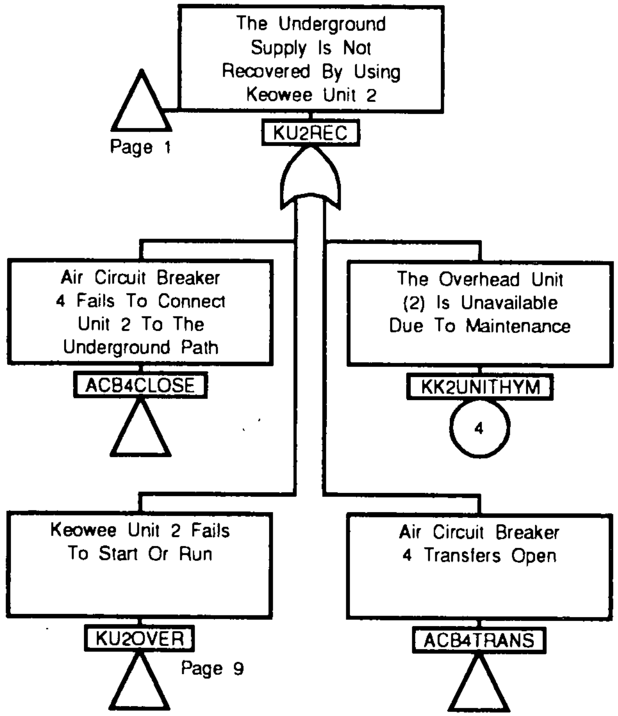




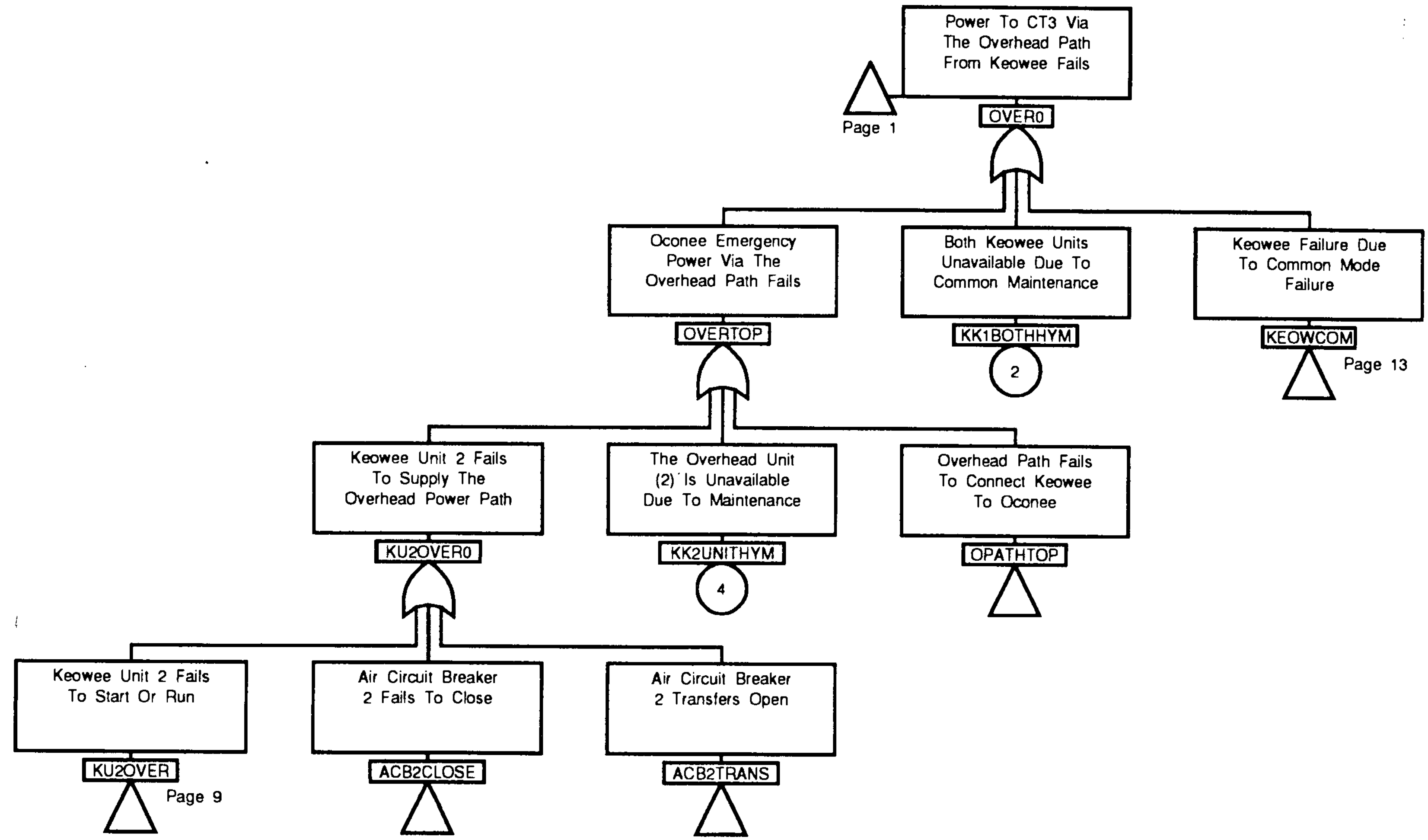
High Level Logic Model Tree

FIGURE A.1-1

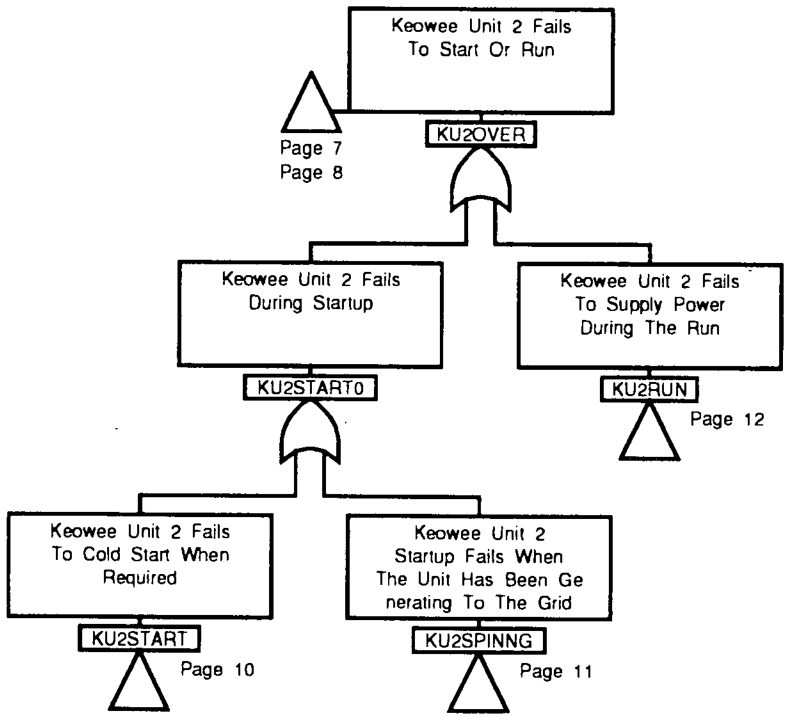

Keewee Unit 1 Fails
To Run
Page 2
KU1RUN
Keowee Unit 1
Governor Or Turbine
Fail While Unit Runs
KU1GVTBRUN
Keowee Unit 1
Generator
Excitation Fails
While The Unit Runs
KU1GEXRUN
Keowee Unit 1
Generator Fails
While The Unit Runs
KU1GENRUN



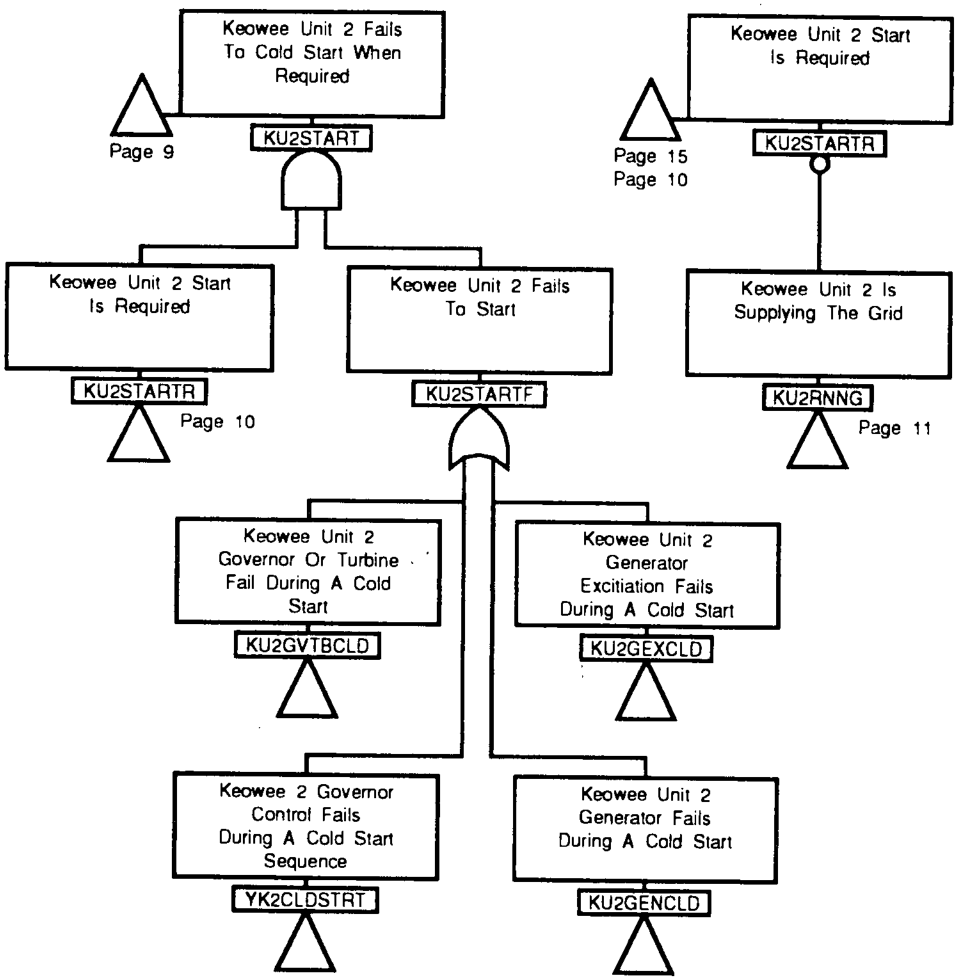
The Underground Supply Is Not Recovered By Using Keowee Unit 2
KU2REC
Page 1
Air Circuit Breaker 4 Fails To Connect Unit 2 To The Underground Path
ACB4CLOSE
The Overhead Unit (2) Is Unavailable Due To Maintenance
KK2UNITHYM
4
Keowee Unit 2 Fails To Start Or Run
KU2OVER
Page 9
Air Circuit Breaker 4 Transfers Open
ACB4TRANS

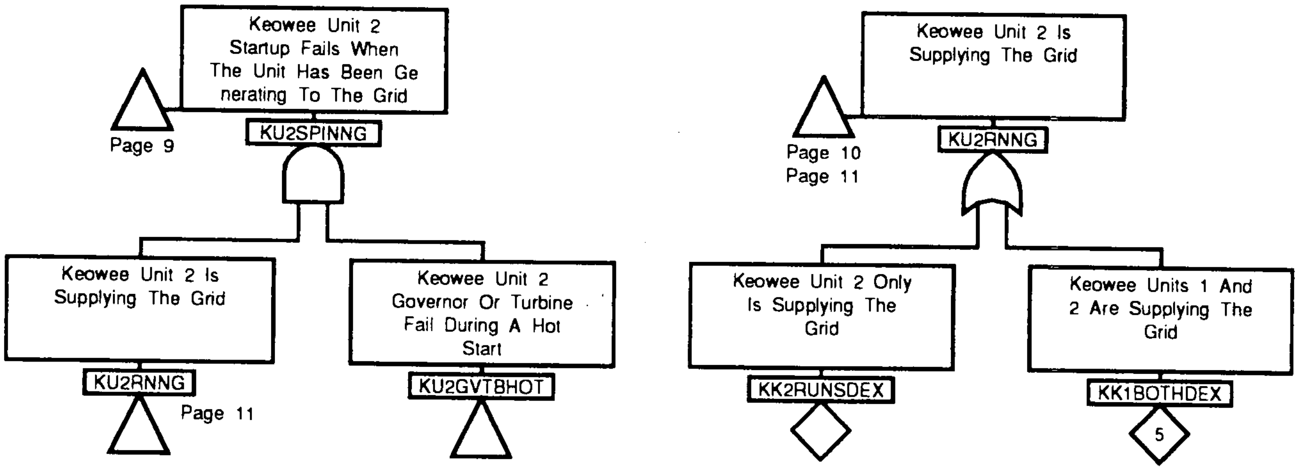


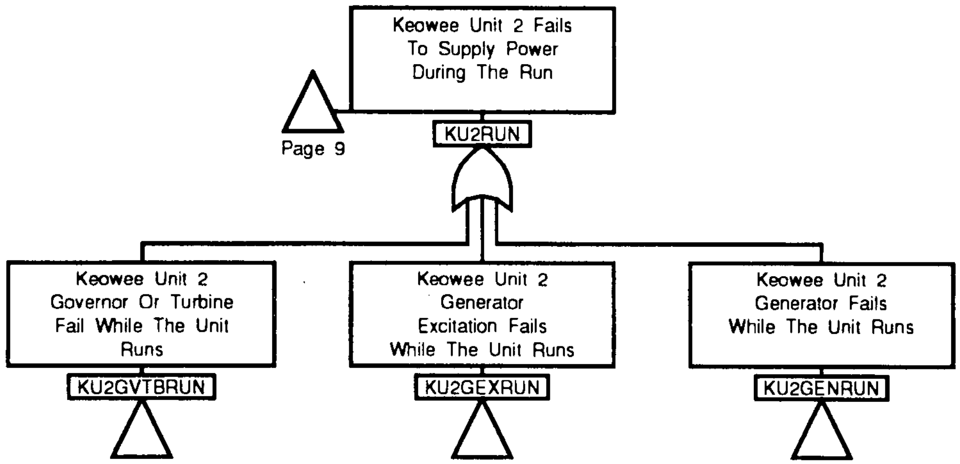
High Level Logic Model Tree | FIGURE A.1-1 |



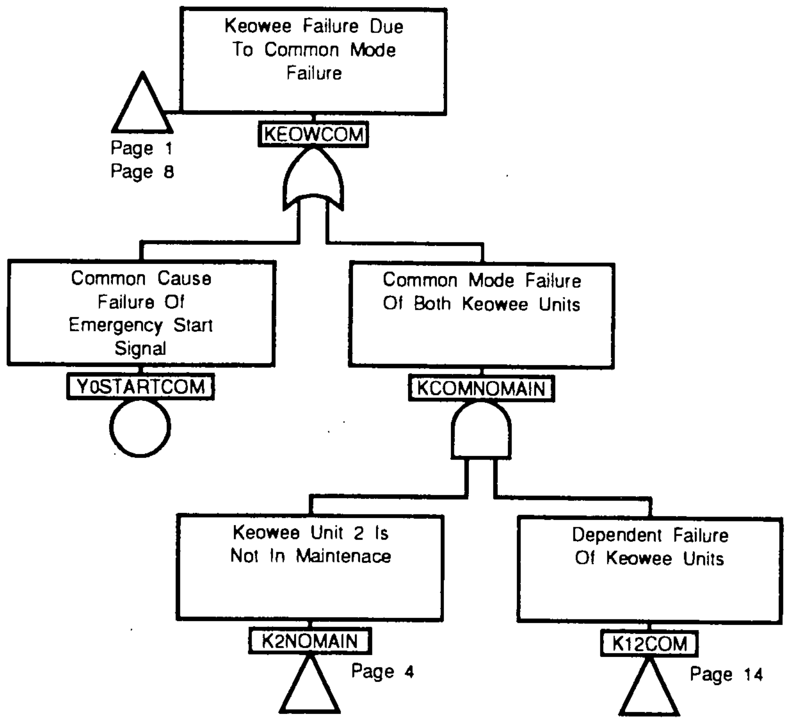
High Level Logic Model Tree | FIGURE A.1-1 |


Keowee Unit 2 Fails To Cold Start When Required
KU2START
Page 9
Keowee Unit 2 Start Is Required
KU2STARTR
Page 15
Page 10
Keowee Unit 2 Start Is Required
KU2STARTR
Page 10
Keowee Unit 2 Fails To Start
KU2STARTF
Keowee Unit 2 Is Supplying The Grid
KU2RNNG
Page 11
Keowee Unit 2 Governor Or Turbine Fail During A Cold Start
KU2GVTBCLD
Keowee Unit 2 Generator Excitiation Fails During A Cold Start
KU2GEXCLD
Keowee 2 Governor Control Fails During A Cold Start Sequence
YK2CLDSTRT
Keowee Unit 2 Generator Fails During A Cold Start
KU2GENCLD

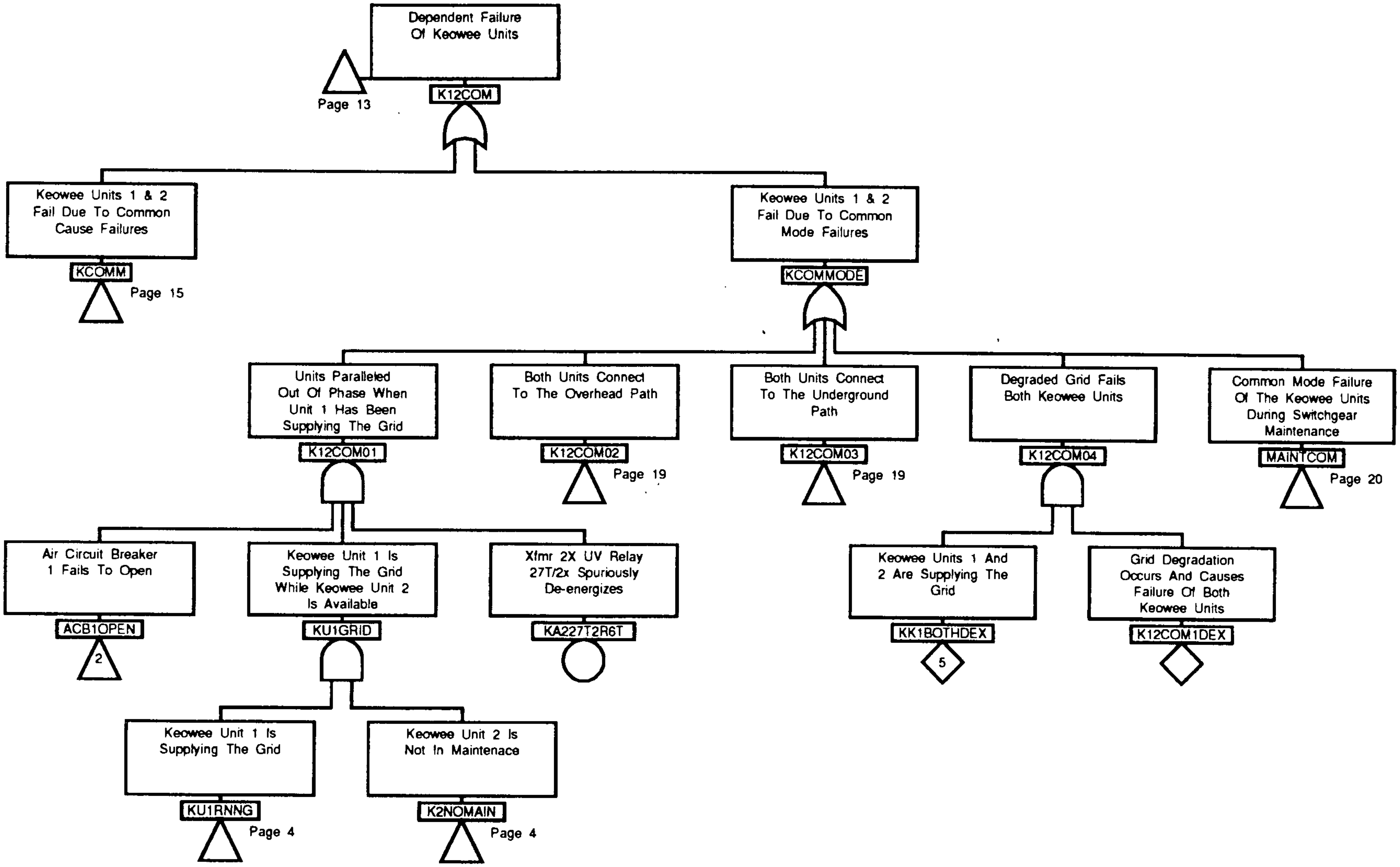

Keowee Unit 2 Startup Fails When The Unit Has Been Ge nerating To The Grid
KU2SPINNG
Page 9
Keowee Unit 2 Is Supplying The Grid
KU2RNNG
Page 11
Keowee Unit 2 Governor Or Turbine Fail During A Hot Start
KU2GVTBHOT
Keowee Unit 2 Is Supplying The Grid
KU2RNNG
Page 10
Page 11
Keowee Unit 2 Only Is Supplying The Grid
KK2RUNSDEX
Keowee Units 1 And 2 Are Supplying The Grid
KK1BOTHDEX
5



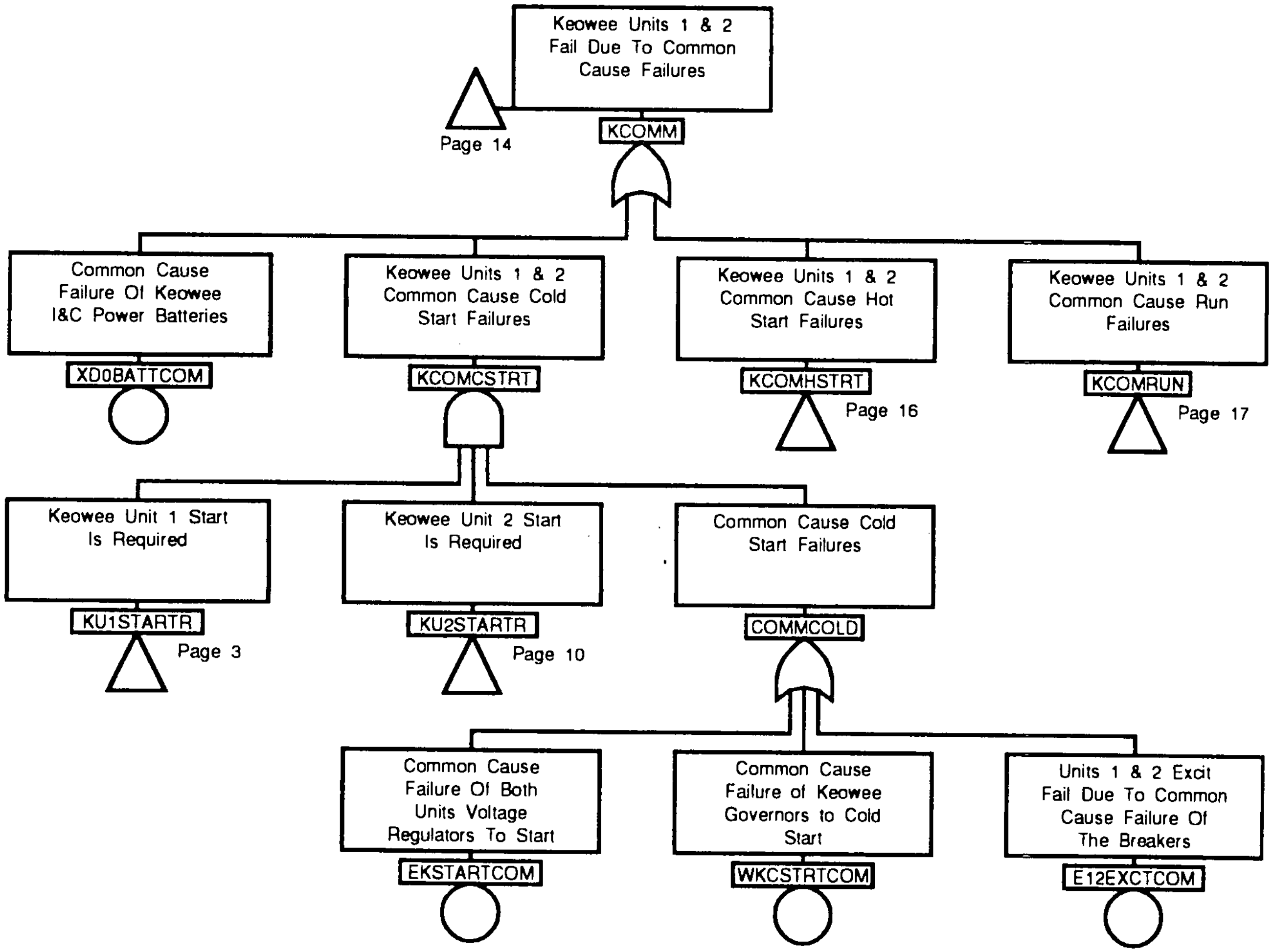
High Level Logic Model Tree | FIGURE A.1-1 |



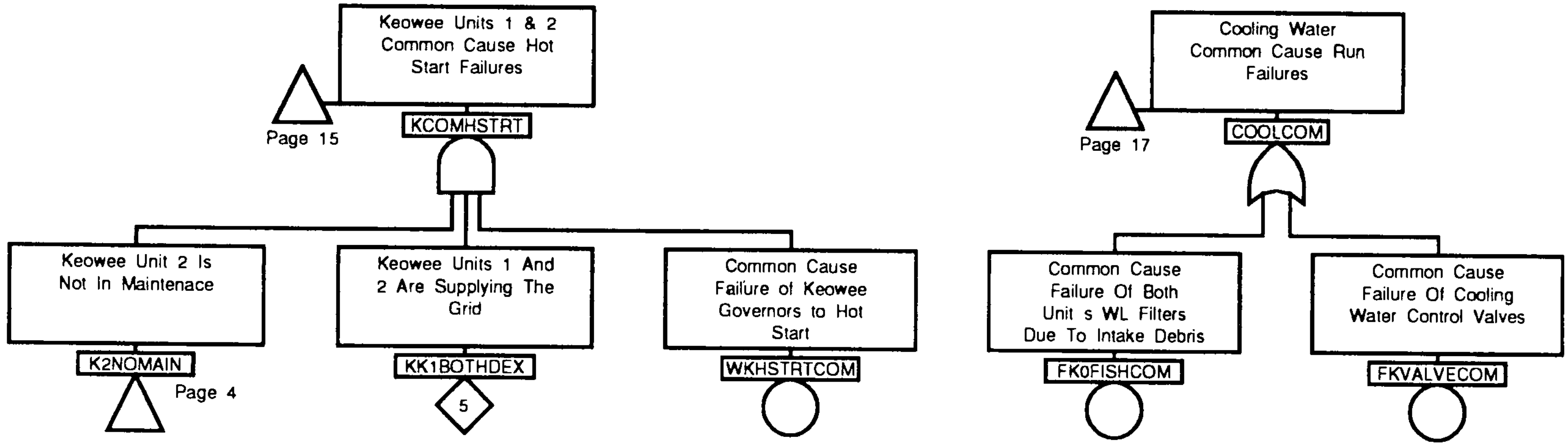
High Level Logic Model Tree | FIGURE A.1-1 |



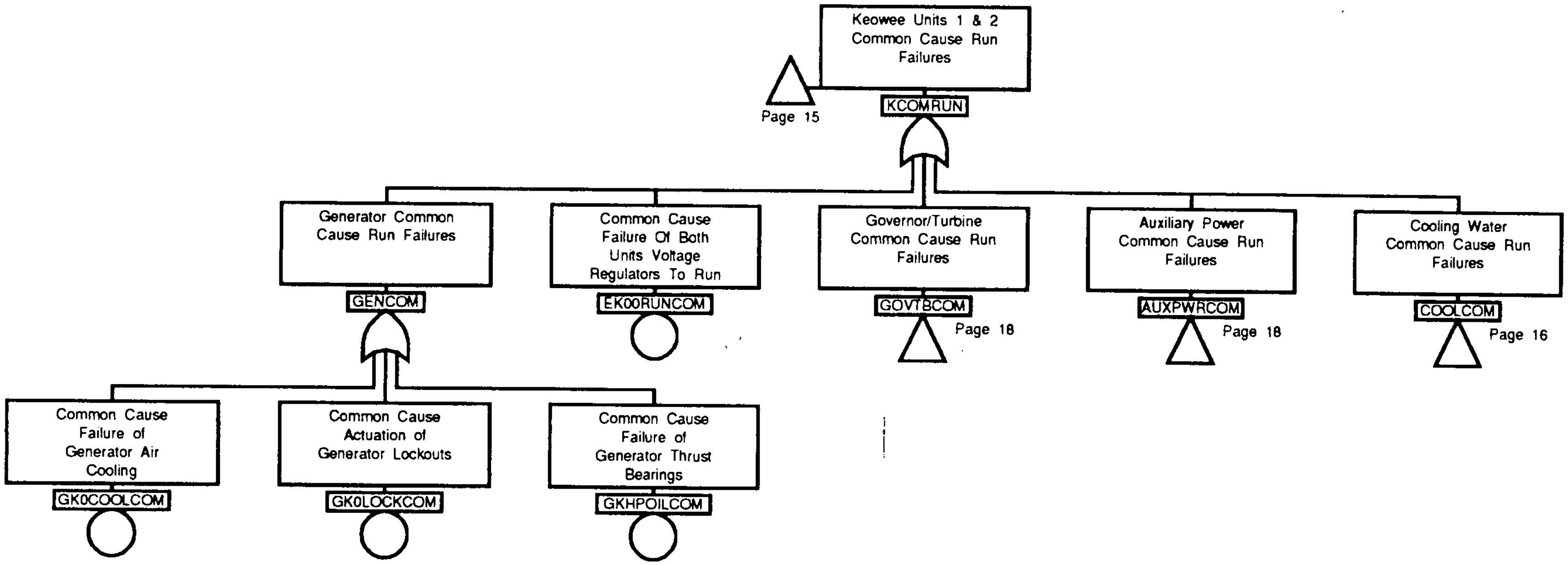
High Level Logic Model Tree | FIGURE A.1-1 |



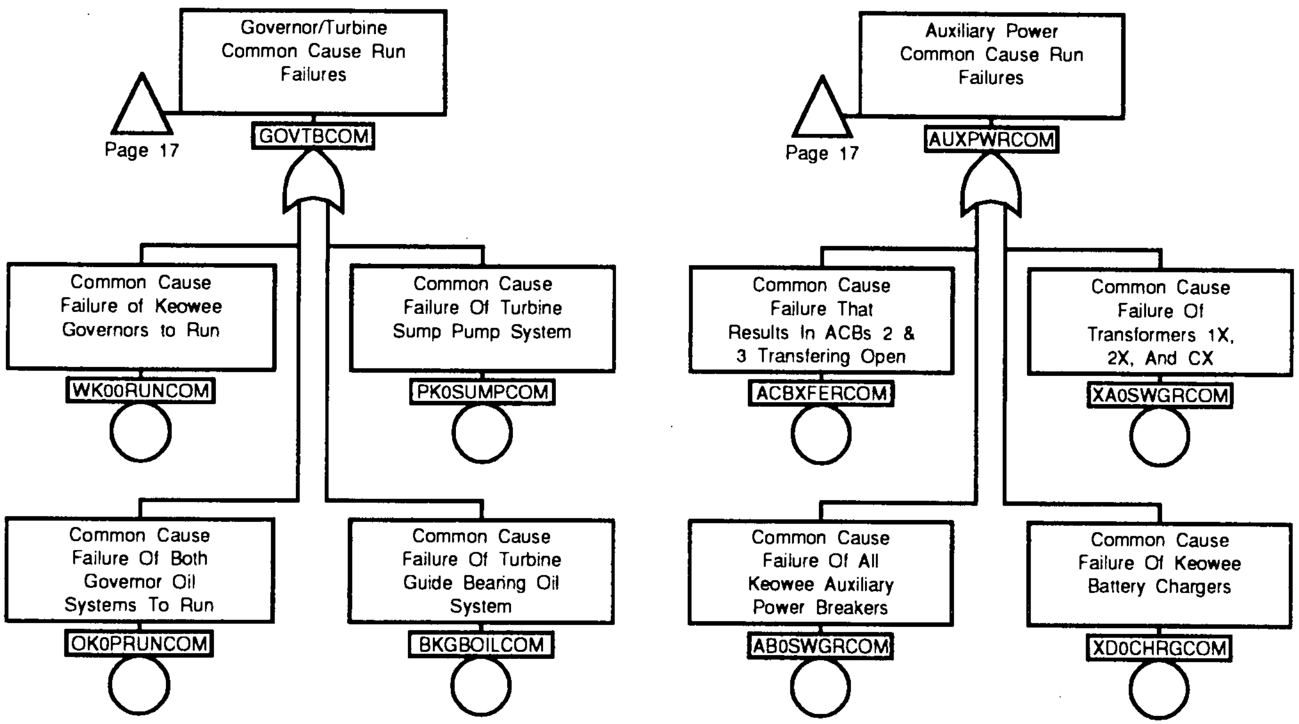
High Level Logic Model Tree | FIGURE A.1-1



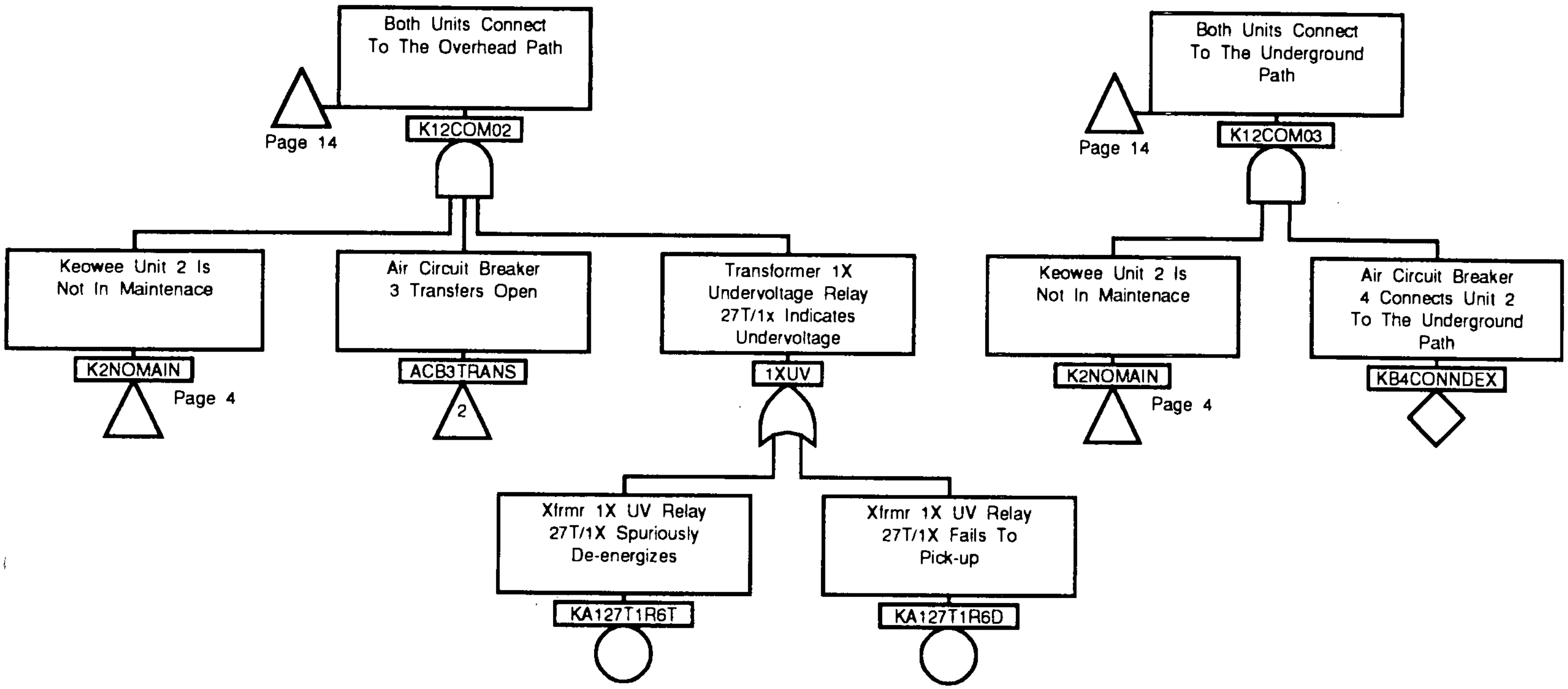
Keowee Units 1 & 2 Common Cause Hot Start Failures
KCOMHSTRT
Page 15
Keowee Unit 2 Is Not In Maintenace
K2NOMAIN
Page 4
Keowee Units 1 And 2 Are Supplying The Grid
KK1BOTHDEX
5
Common Cause Failure of Keowee Governors to Hot Start
WKHSTRTCOM
Cooling Water Common Cause Run Failures
COOLCOM
Page 17
Common Cause Failure Of Both Unit s WL Filters Due To Intake Debris
FK0FISHCOM
Common Cause Failure Of Cooling Water Control Valves
FKVALVECOM



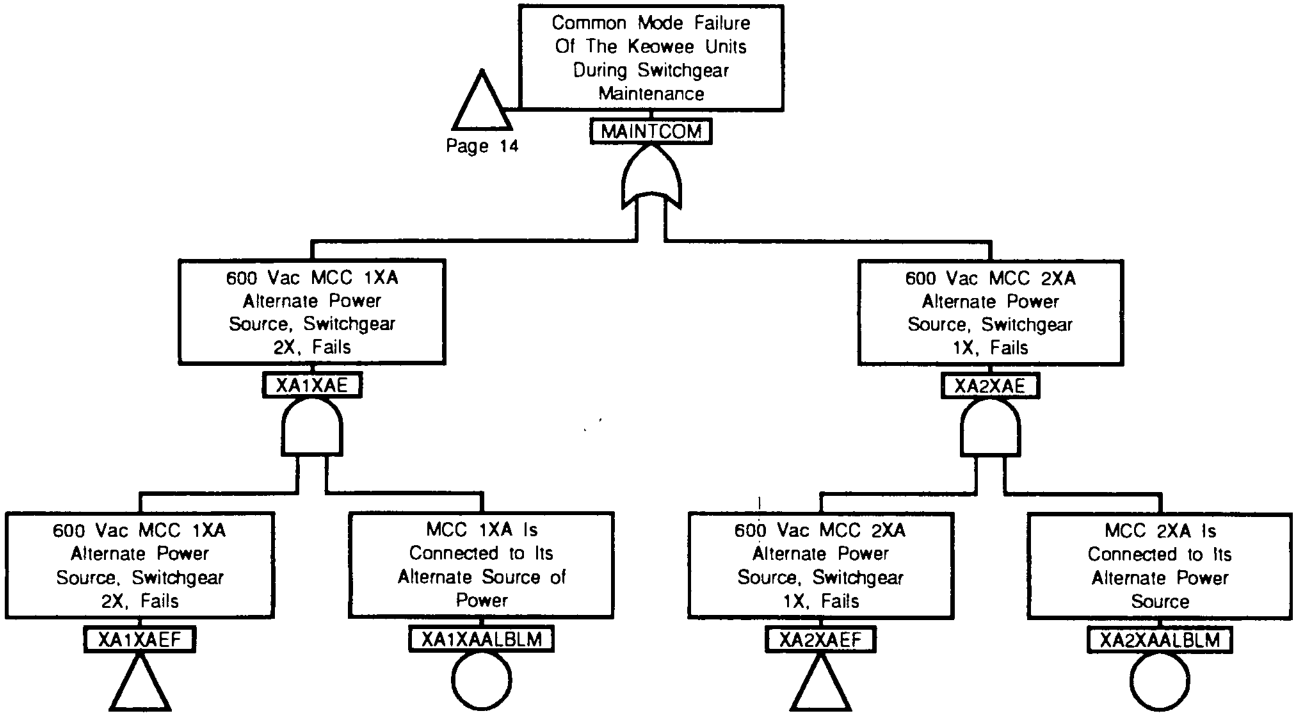
High Level Logic Model Tree | FIGURE A.1-1 |



Governor/Turbine Common Cause Run Failures
GOVTBCOM
Page 17
Common Cause Failure of Keowee Governors to Run
WK00RUNCOM
Common Cause Failure Of Turbine Sump Pump System
PK0SUMPCOM
Common Cause Failure Of Both Governor Oil Systems To Run
OK0PRUNCOM
Common Cause Failure Of Turbine Guide Bearing Oil System
BKGBOILCOM
Auxiliary Power Common Cause Run Failures
AUXPWRCOM
Page 17
Common Cause Failure That Results In ACBs 2 & 3 Transfering Open
ACBXFERCOM
Common Cause Failure Of Transformers 1X, 2X, And CX
XA0SWGRCOM
Common Cause Failure Of All Keowee Auxiliary Power Breakers
AB0SWGRCOM
Common Cause Failure Of Keowee Battery Chargers
XD0CHRGCOM



High Level Logic Model Tree | FIGURE A.1-1 |



High Level Logic Model Tree | FIGURE A.1-1

Gate/Event Name	Page	Zone
1XUV	19	
AB0SWGRCOM	18	
ACB1OPEN	5	
ACB1OPEN	14	
ACB2CLOSE	8	
ACB2TRANS	8	
ACB3CLOSE	5	
ACB3OPEN	5	
ACB3TRANS	2	
ACB3TRANS	19	
ACB4CLOSE	7	
ACB4MOD	4	
ACB4TRANS	7	
ACBXFERCOM	18	
AUXPWRCOM	17	
AUXPWRCOM	18	
BKGBOILCOM	18	
COMMCOLD	15	
COOLCOM	16	
COOLCOM	17	
E12EXCTCOM	15	
EK00RUNCOM	17	
EKSTARTCOM	15	
FK0FISHCOM	16	
FKVALVECOM	16	
GENCOM	17	
GK0COOLCOM	17	
GK0LOCKCOM	17	
GKHPOILCOM	17	
GOVTBCOM	17	
GOVTBCOM	18	
K12COM	13	
K12COM	14	
K12COM01	14	
K12COM02	14	
K12COM02	19	
K12COM03	14	
K12COM03	19	
K12COM04	14	
K12COM1DEX	14	
K2NOMAIN	4	
K2NOMAIN	4	
K2NOMAIN	13	
K2NOMAIN	14	
K2NOMAIN	16	
K2NOMAIN	19	
K2NOMAIN	19	
KA127T1R6D	19	
KA127T1R6T	19	
KA227T2R6T	14	
KB4CONNDEX	19	
KBOTHNORN	3	
KCOMCSTRT	15	
KCOMHSTRT	15	
KCOMHSTRT	16	
KCOMM	14	
KCOMM	15	
KCOMMODE	14	
KCOMNOMAIN	13	
KCOMRUN	15	
KCOMRUN	17	
KEOWCOM	1	
KEOWCOM	8	
KEOWCOM	13	
KEOWTOP	1	
KK1BOTHDEX	3	
KK1BOTHDEX	4	
KK1BOTHDEX	11	
KK1BOTHDEX	14	
KK1BOTHDEX	16	
KK1BOTHHYM	1	
KK1BOTHHYM	8	
KK1NORUN	3	
KK1RUNSDEX	3	
KK1RUNSDEX	4	
KK2RUNSDEX	11	
KK2UNITHYM	3	
KK2UNITHYM	4	
KK2UNITHYM	7	
KK2UNITHYM	8	
KNOTBOTH	3	
KU1BOTH	4	
KU1GENCLD	3	
KU1GENRUN	6	
KU1GEXCLD	3	
KU1GEXRUN	6	
KU1GRID	14	
KU1GVTBCLD	3	
KU1GVTBHOT	5	
KU1GVTBRUN	6	
KU1RNNG	2	
KU1RNNG	4	
KU1RNNG	14	
KU1RUN	2	
KU1RUN	6	
KU1SPINNG	2	
KU1SPINS	2	
KU1SPINS	5	
KU1START	2	
KU1START0	2	
KU1STARTF	2	
KU1STARTF	3	
KU1STARTR	2	
KU1STARTR	3	
KU1STARTR	15	
KU1UNDER	2	
KU1UNDER0	1	
KU1UNDER0	2	
KU2GENCLD	10	
KU2GENRUN	12	
KU2GEXCLD	10	
KU2GEXRUN	12	
KU2GVTBCLD	10	
KU2GVTBHOT	11	
KU2GVTBRUN	12	
KU2OVER	7	
KU2OVER	8	
KU2OVER	9	
KU2OVER0	8	
KU2REC	1	
KU2REC	7	
KU2RNNG	10	
KU2RNNG	11	
KU2RNNG	11	
KU2RUN	9	
KU2RUN	12	
KU2SPINNG	9	
KU2SPINNG	11	
KU2START	9	
KU2START	10	
KU2START0	9	
KU2STARTF	10	
KU2STARTR	10	
KU2STARTR	10	
KU2STARTR	10	
KU2STARTR	15	
MAINTCOM	14	
MAINTCOM	20	
NEWMODA	5	
NEWMODB	5	
NOUNIT	1	
NTACB4MOD	4	
NTACB4MOD	5	
NTACB4MOD	5	
OK0PRUNCOM	18	
OPATHTOP	8	
OVER0	1	
OVER0	8	
OVERTOP	8	
PK0SUMPCOM	18	
UNDER0	1	
UNDERTOP	1	
UPATHTOP	1	

Gate/Event Name	Page	Zone	Gate/Event Name	Page	Zone	Gate/Event Name	Page	Zone	Gate/Event Name	Page	Zone
WK00RUNCOM	18										
WK1SPD1DEX	5										
WKCSTRTCOM	15										
WKHSTRTCOM	16										
XA0SWGRCOM	18										
XA1XAALBLM	20										
XA1XAE	20										
XA1XAEF	20										
XA2XAALBLM	20										
XA2XAE	20										
XA2XAEF	20										
XD0BATTCOM	15										
XD0CHRGCOM	18										
Y0STARTCOM	13										
YK1CLDSTRT	3										
YK2CLDSTRT	10										

APPENDIX A.2

KEOWEE EMERGENCY POWER PATHS

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

A.2 KEOWEE EMERGENCY POWER PATHS

A.2.1 OBJECTIVES

The main objective of this analysis is to develop logic models of the emergency power paths and the Switchyard Isolation function. This model is combined with the high level logic model and remaining system models to form an integrated model for assessing the reliability of Keowee. Other objectives are to identify major contributors to system unreliability, significant potential human errors and common-cause failure modes.

The scope of this analysis is limited to equipment required to support a Keowee emergency start and run under load following a loss of offsite power condition.

A.2.2 SYSTEM DESIGN

The Keowee underground power path connects a designated Keowee unit to the Oconee standby buses via transformer CT4. This path is dedicated for emergency power purposes and energizes whenever the designated Keowee unit is started. The overhead power path connects the remaining Keowee unit to the Oconee startup transformers through the 230 kV switchyard in loss of off-site power (LOOP) events. When a LOOP is detected by the External Grid Trouble Protection System (EGTPS), the EGTPS initiates a switchyard yellow bus isolation from the grid, and aligns emergency power from Keowee to the startup transformer of each Oconee unit.

Figure A.2-1 shows the overhead power path. Given an EGTPS actuation, the Keowee units are signaled to emergency start and a switchyard yellow bus isolation is initiated. The yellow bus isolation signal includes components which command power circuit breakers (PCBs) 8, 9, 12, 15, 17, 21, 24, 26, 28, and 33 to trip open and PCBs 9, 18, 27, and 30 to close. The PCB 9 close signal is not completed until the following is accomplished:

(1) a redundant switchyard isolated confirmed relay [27X/SC1 (27X/SC2)] signal is generated after the successful opening of PCBs 8, 12, 15, 17, 21, 24, 26, 28, and 33, and

(2) relay 27X/SC1 (27X/SC2) operates a time delay relay 27XTD/SC1 (27XTD/SC2), which [4 seconds after the operation of 27X/SC1 (27X/SC2)] disables the PCB 9 trip coil and enables the close coil.

The switchyard isolated confirmed relay [27X/SC1 (27X/SC2)] signal also actuates a switchyard isolation auxiliary relay SIA (SIB), which in turn actuates the Keowee Unit 1 and Unit 2 Switchyard Isolated Interposing Relays [1SIXA and 2SIXA (1SIXB and 2SIXB)]. The switchyard isolated interposing relays provide close permissive interlocks for the automatic closing circuits of ACB-1 and ACB-2.

A.2.3 SYSTEM BOUNDARIES

Overhead Path

The overhead path begins with the Keowee Main Step-Up Transformer and extends through the 230 kV Switchyard to the Oconee 3 startup breakers side of Transformer CT3. In the 230 kV Switchyard PCB 9 must be closed to complete the connection. Red Bus/Yellow Bus tie breakers PCBs 8, 17, and 26 as well as yellow bus isolation breakers PCBs 12, 15, 21, 24, and 33 must be open to isolate the emergency power path from switchyard connections.

Underground Path

The underground path begins at the 13.8 kV underground cable side of air circuit breaker (ACB)-3 and ACB-4 and continues to the standby bus feeder breakers side of CT4.

Electrical Power Supplies

The 230 kV Switchyard DC Power System provides the control power for the switchyard PCBs. Trip coils #1 for PCBs 8 through 17 are powered by Switchyard DC Panelboard DYA. Trip coils #1 for PCBs 21 through 33 are powered by Switchyard DC Panelboard DYB. Trip coils #2 for PCBs 8 through 17 are powered from Switchyard DC Panelboard DYE and trip coils #2 for PCBs 21 through 33 are powered by Switchyard DC Panelboard DYF. Closing coil power for each PCB is auctioneered between two

switchyard dc panelboards. For PCB 9, DYA and DYE are used, and for PCB 30, DYB and DYF are used. The Switchyard Isolate Complete Channel 1 logic uses control power from DYC and Channel 2 uses DYG.

External Control Systems

The automatic control signals that manipulate the 230 kV Switchyard PCBs are initiated by the EGTPS Channel 1 and Channel 2 (see Appendix A.3).

A.2.4 INSTRUMENTATION AND CONTROLS

The controls for the 230 kV Switchyard breakers are located in the Oconee 1 and 2 Control Room. All switchyard disconnects, both manual and motor-operated, have position indication in the control room. Synchronizing circuits and potential transformer inputs are selected by sync-scope selector switches. White indicating lights show which incoming lines or transformers are energized. Transducers as well as directly connected instrument transformers provide electrical measurements for the 230 kV Switchyard in the control room.

A.2.5 LOCATION WITHIN THE PLANT

The 230 kV Switchyard is located on the east side of the Turbine Building. It is the interface for Oconee Generator Units 1 and 2, Oconee Startup Transformers CT1, CT2, and CT3, the Oconee 525 kV Switchyard, the Keowee overhead line, and the 230 kV transmission lines (Dacus Black and White lines, Central Black and White lines, Calhoun Black and White lines, and Jocassee Black and White lines).

The CT4 Transformer is located in the Unit 1/2 Blockhouse adjacent to the east side of the Turbine Building.

A.2.6 NORMAL OPERATION

During the startup and shutdown of an Oconee unit, the 230 kV Switchyard provides power to the unit auxiliary loads through the respective unit startup transformer. When the unit generators are operating, the 230 kV Switchyard is the point where generated power from Oconee 1 and Oconee 2 is distributed to the 230 kV transmission system. The Keowee overhead path is normally energized by the switchyard through PCB 9 to provide auxiliary power to the Keowee unit assigned to the overhead power path.

The Keowee underground power path is normally not energized (unless the assigned Keowee unit is operating).

A.2.7 PERFORMANCE DURING KEOWEE EMERGENCY OPERATION

During Oconee emergency operation involving a loss of off-site power, the overhead power path through the isolated Yellow Bus of the 230 kV Switchyard provides emergency power from Keowee to the startup transformers of the Oconee units. The underground power path provides power through the CT4 Transformer to the Oconee 4160 V Standby Buses.

A.2.8 TEST AND MAINTENANCE

Testing

The Degraded Grid and Switchyard Isolation Functional Test is performed one channel at a time on a refueling frequency. The test includes the following:

(1) functional verification of the Keowee overhead ACB and PCB-9 operation during switchyard isolation,

(2) demonstration of the operability of the Degraded Grid Protection System (DGPS),

(3) demonstration of the ability of the overhead Keowee unit to energize the 230 kV Yellow Bus for all three Oconee units' Startup Transformers and carry the shutdown loads of Oconee Unit 1, and

(4) demonstration of the capability to realign the 230 kV Yellow Bus back to the system grid, while Oconee loads are being fed from the overhead Keowee unit.

A.2.9 OPERATING EXPERIENCE

A summary of significant operating events is provided in Table A.2-4.

A.2.10 ASSUMPTIONS

A.2.10.1 SYSTEM DESIGN ASSUMPTIONS

1. The switchyard PCBs are assumed to have adequate operating gas pressure prior to the actuating event.

2. The switchyard and emergency power paths are not operating in any kind of extreme environmental conditions prior to the actuating event.

A.2.10.2 OPERATIONAL ASSUMPTIONS

1. The switchyard is operating in a normal operational alignment with all switchyard breakers closed.

A.2.10.3 MODELING ASSUMPTIONS

1. The failure of any breaker to open or close in accordance with the switchyard isolation logic and overhead path alignment logic is a failure to establish the power path.

2. Operator action is not modeled.

3. The Unit 3 Startup Bus undervoltage detection function is provided by redundant circuits to ensure reactor coolant pumps are loadshed before the overhead path to the Unit 3 Startup Bus is completed. When reactor coolant pumps trip logic is not satisfied by a Startup Bus undervoltage signal, it is assumed that the reactor coolant pumps will overload the Startup Transformer when the pumps attempt to re-start. The modification which provides redundant Startup Bus undervoltage relays has been completed on Unit 3 and installation is planned for completion on Units 1 and 2.

A.2.11 FAULT TREE ANALYSIS

A.2.11.1 TOP EVENT SUCCESS CRITERIA

Success for either the underground power path or the overhead power path is that the path is established and maintained for 24 hours after the initiating event.

A.2.11.2 DETAILED FAILURE CRITERIA

1. Switchyard Yellow Bus isolation and closing of breakers necessary to establish the overhead power path to the startup transformers are the desired final actions and the top events in this section of the analysis. Lower levels of the fault tree involve breaker trip relays and closing coil operations that must occur to accomplish the top events.

A.2.11.3 DESCRIPTION OF FAULT TREE

The System fault tree is shown in Figure A.2-2. The Fault Tree Modeling Guidelines (Appendix B) were followed in developing the fault tree. A list of all fault tree transfers is presented in Table A.2-4.

A.2.11.4 HUMAN INTERACTIONS

Human reliability analysis was performed as described in Appendix C.3. One possible human action has been determined that could impact success of the underground power path.

SXFRCT4LHE

This basic event accounts for technician errors during CT4 maintenance that may not be detected during post maintenance testing.

A.2.11.5 RELIABILITY DATA

Appendix C.1 discusses development of the reliability data. System reliability data is listed in Table A.2-5.

A.2.11.6 COMMON CAUSE ASSESSMENT

Common cause analysis was performed as described in Appendix C.2.

SU327UVCOM This basic event accounts for the possibility that both Unit 3 Startup Bus undervoltage relays experience a common cause failure. The relays are of the same make and model, and common cause failures are assumed to exist.

A.2.12 RESULTS

Reliability of the system is defined as the probability that the system will succeed in supporting Keowee emergency operation (black start plus a 24 hour run). The system model yields a probability of approximately 1.14E-03 for failure to maintain the underground path for the mission time of the event. The failure of the overhead path is 8.08E-03. Thus the reliability of the underground path is 99.89% and the reliability of the overhead path is computed to be 99.19%. The relative importance of the various component failures is shown in Tables A.2-6 and -7.

A.2.13 REFERENCES

A.2.13.1 DOCUMENTS

1. OSS-0254-00-00-2004, 230 kV Switchyard Design Basis Document

A.2.13.2 DRAWINGS

1. OEE-38, Rev. 12, 230 kV Switchyard Control PCB No. 8 Trip Coil No. 1

2. OEE-38A, Rev. 7, 230 kV Switchyard Control PCB No. 8 Trip Coil No. 2

3. OEE-39, Rev. 11, 230 kV Switchyard Control PCB No. 9 Trip Coil No. 1

4. OEE-39A, Rev. 9, 230 kV Switchyard Control PCB No. 9 Trip Coil No. 2

5. OEE-39B, Rev. 1, 230 kV Switchyard Control PCB No. 9 Close Coil

6. OEE-42, Rev. 6, 230 kV Switchyard Control PCB No. 12 Trip Coil No. 1

7. OEE-42A, Rev. 6, 230 kV Switchyard Control PCB No. 12 Trip Coil No. 2

8. OEE-45, Rev. 6, 230 kV Switchyard Control PCB No. 15 Trip Coil No. 1

9. OEE-45A, Rev. 7, 230 kV Switchyard Control PCB No. 15 Trip Coil No. 2

10. OEE-47, Rev. 10, 230 kV Switchyard Control PCB No. 17 Trip Coil No. 1

11. OEE-47A, Rev. 7, 230 kV Switchyard Control PCB No. 17 Trip Coil No. 2

12. OEE-51, Rev. 11, 230 kV Switchyard Control PCB No. 21 Trip Coil No. 1

13. OEE-51A, Rev. 15, 230 kV Switchyard Control PCB No. 21 Trip Coil No. 2

14. OEE-54, Rev. 11, 230 kV Switchyard Control PCB No. 24 Trip Coil No. 1

15. OEE-54A, Rev. 14, 230 kV Switchyard Control PCB No. 24 Trip Coil No. 2

16. OEE-56, Rev. 12, 230 kV Switchyard Control PCB No. 26 Trip Coil No. 1

17. OEE-56A, Rev. 9, 230 kV Switchyard Control PCB No. 26 Trip Coil No. 2

18. OEE-58, Rev. 3, 230 kV Switchyard Control PCB No. 28 Trip Coil No. 1

19. OEE-58A, Rev. 2, 230 kV Switchyard Control PCB No. 28 Trip Coil No. 2

20. OEE-60B, Rev. 0, 230 kV Switchyard Control PCB No. 30 Close Coil

21. OEE-63, Rev. 5, 230 kV Switchyard Control PCB No. 33 Trip Coil No. 1

22. OEE-63A, Rev. 5, 230 kV Switchyard Control PCB No. 33 Trip Coil No. 2

23. OEE-71-2, & -3 series, Startup Transformer CT3 Diff. Lock Out

24. OEE-76 series, External Grid Trouble Protective System

25. OEE-78, Rev. 4, Transf. CT4 Diff. Lockout

26. OEE-317-56, Rev. 6, 6900V. Switchgear #3TA Breaker Throwover Circuit

27. KEE-17 series, Keowee Hydro Station Transformer Differential

Table A.2-1

Keowee Emergency Power Paths Power Supplies

Component	Power Supply[1]	Compartment Number
PCB-9 Trip Coil #1	SDC Pnlbd DYA	Bkr 9
PCB-9 Trip Coil #2	SDC Pnlbd DYE	Bkr 9
PCB-9 Closing Coil	SDC Pnlbd DYE	Bkr 9
PCB-9 Closing Coil	SDC Pnlbd DYA	Bkr 9
PCB-30 Closing Coil	SDC Pnlbd DYB	Bkr 10
PCB-30 Closing Coil	SDC Pnlbd DYF	Bkr 10
PCB-8 Trip Coil #1	SDC Pnlbd DYA	Bkr 8
PCB-8 Trip Coil #2	SDC Pnlbd DYE	Bkr 8
PCB-12 Trip Coil #1	SDC Pnlbd DYA	Bkr 12
PCB-12 Trip Coil #2	SDC Pnlbd DYE	Bkr 12
PCB-15 Trip Coil #1	SDC Pnlbd DYA	Bkr 15
PCB-15 Trip Coil #2	SDC Pnlbd DYE	Bkr 15
PCB-17 Trip Coil #1	SDC Pnlbd DYA	Bkr 17
PCB-17 Trip Coil #2	SDC Pnlbd DYE	Bkr 17
PCB-21 Trip Coil #1	SDC Pnlbd DYB	Bkr 1
PCB-21 Trip Coil #2	SDC Pnlbd DYF	Bkr 1

[1] MCC = Motor Control Center
DC = Distribution Center

Table A.2-1

Keowee Emergency Power Paths Power Supplies

Component	Power Supply[1]	Compartment Number
PCB-24 Trip Coil #1	SDC Pnlbd DYB	Bkr 4
PCB-24 Trip Coil #2	SDC Pnlbd DYF	Bkr 4
PCB-26 Trip Coil #1	SDC Pnlbd DYB	Bkr 6
PCB-26 Trip Coil #2	SDC Pnlbd DYF	Bkr 6
PCB-28 Trip Coil #1	SDC Pnlbd DYB	Bkr 8
PCB-28 Trip Coil #2	SDC Pnlbd DYF	Bkr 8
PCB-33 Trip Coil #1	SDC Pnlbd DYB	Bkr 13
PCB-33 Trip Coil #2	SDC Pnlbd DYF	Bkr 13
Swyd Isolate Complete Ch 1	SDC Pnlbd DYC	Bkr 12
Swyd Isolate Complete Ch 2	SDC Pnlbd DYG	Bkr 16

[1] MCC = Motor Control Center
DC = Distribution Center

Table A.2-2

Keowee Emergency Power Paths Test Procedures

Procedure	Test Frequency	Description
PT/0/A/0610/22, Degraded Grid and Switchyard Isolation Functional Test	Unit 1 Refueling	Functional verification of overhead ACB and PCB-9 operation during Switchyard Isolation. Demonstration of Degraded Grid Protection System operability. Demonstration of Keowee units' "Black Start" capability. Demonstration of Overhead unit ability to energize the Startup Transformers and carry the shutdown loads of Unit 1. Demonstration of capability to realign Yellow Bus back to the grid while feeding the Oconee loads from the overhead unit.

Table A.2-3

Keeowee Emergency Power Paths Significant Operating Events

Date	Unit	Component	Event Summary
11/20/86	1/2	94T/K Relay	Keowee main step-up transformer locked out and PCBs 8 and 9 tripped open, which isolated Oconee's overhead emergency power path as a result of relay 94T/K actuation caused by vibration due to drilling and grinding on a panel at Keowee. The 94T/K relay is known to be mechanically sensitive.
1/31/86	0	PCB-20	While troubleshooting PCBs in the 230 kV Swyd PCB-24 was manually closed without reseting the Generator Lockout relays. A yellow bus lockout occurred. When all the tie breakers opened, all of Generator #1 current passed through PCB-20 to the grid. The breaker exploded apparently due to degraded breaker contacts. A Unit 1 Reactor trip ensued.
3/27/86	2	Lightning Arrestors	While changing lightning arrestors a capacitor was not re-installed on the X-phase due to a stripped bolt. When Keowee 2 was started for an operational test an emergency lockout was received due to a Generator Ground fault Overvoltage (59GN2 Relay). The Y and Z-phase capacitors were removed and the the unit tested satisfactorily.

Table A.2-3

Keeowee Emergency Power Paths Significant Operating Events

Date	Unit	Component	Event Summary
8/28/85	0	CT-3	Oconee 3 was in a refueling outage with auxiliary power being supplied through CT-3 when the transformer's Fault Pressure Relay actuated. A lockout occurred which cleared and de-energized CT-3 and the Unit 3 Main Feeder Buses resulting in a Unit 3 LOOP. The cause of the fault pressure could not be determined.
9/28/84	1/2	PCB-22	PCB-22 short circuited when being returned to service following maintenance. This caused a Red Bus differential lockout which opened PCB-8 and-9. The reason PCB-9 opened is unknown.
1/26/84	2	ACB-2	While Keowee 2 was out of service for annual ACB maintenance, the maintenance crew failed to lift the trip wires before servicing ACB-2. This caused PCB-8 and -9 to open.

Table A.2-4

Keowee Emergency Power Paths Fault Tree Transfers

Transfer Gate Name	Description	Components Supplied
SDCDYA	Loss of Power on 125 Vdc Swyd DC Pnlbd DYA	PCB-9 Trip Coil #1 PCB-9 Clsng Ckt Source #1 PCB-8 Trip Coil #1 PCB-12 Trip Coil #1 PCB-15 Trip Coil #1 PCB-17 Trip Coil #1
SDCDYB	Loss of Power on 125 Vdc Swyd DC Pnlbd DYB	PCB-30 Clsng Ckt Source #1 PCB-21 Trip Coil #1 PCB-24 Trip Coil #1 PCB-26 Trip Coil #1 PCB-28 Trip Coil #1 PCB-33 Trip Coil #1
SDCDYC	Loss of Power on 125 Vdc Swyd DC Pnlbd DYC	Swyd Isolate Complete Ch 1
SDCDYE	Loss of Power on 125 Vdc Swyd DC Pnlbd DYE	PCB-9 Trip Coil #2 PCB-9 Clsng Ckt Source #2 PCB-8 Trip Coil #2 PCB-12 Trip Coil #2 PCB-15 Trip Coil #2 PCB-17 Trip Coil #2

Table A.2-4

Keowee Emergency Power Paths Fault Tree Transfers

Transfer Gate Name	Description	Components Supplied
SDCDYF	Loss of Power on 125 Vdc Swyd DC Pnlbd DYF	PCB-30 Clsng Ckt Source #2 PCB-21 Trip Coil #2 PCB-24 Trip Coil #2 PCB-26 Trip Coil #2 PCB-28 Trip Coil #2 PCB-33 Trip Coil #2
SDCDYG	Loss of Power on 125 Vdc Swyd DC Pnlbd DYG	Swyd Isolate Complete Ch 2 PCB-9 Clsng Ckt Source #1
SDCDYC	Loss of Power on 125 Vdc Swyd DC Pnlbd DYC	Swyd Isolate Complete Ch 1
SEGTP1ANIT	EGTPS Ch 1A Initiators Fail	PCB-24 Trip Coil #1 PCB-26 Trip Coil #1 PCB-28 Trip Coil #1 PCB-33 Trip Coil #1
SEGTP2ANIT	EGTPS Ch 2A Initiators Fail	PCB-24 Trip Coil #2 PCB-26 Trip Coil #2 PCB-28 Trip Coil #2 PCB-33 Trip Coil #2

Table A.2-4

Keowee Emergency Power Paths Fault Tree Transfers

Transfer Gate Name	Description	Components Supplied
SEGTP1BNIT	EGTPS Ch 1B Initiators Fail	Keowee Start Relay 27X/STA PCB-8 Trip Coil #1 PCB-12 Trip Coil #1 PCB-15 Trip Coil #1 PCB-17 Trip Coil #1
SEGTP2BNIT	EGTPS Ch 2B Initiators Fail	Keowee Start Relay 27X/STB PCB-8 Trip Coil #2 PCB-17 Trip Coil #2
SEG94V1AF	EGTPS UV Ch 1 Relay 94V1A Fails	EGTPS Ch 1A
SEG94V2AF	EGTPS UV Ch 2 Relay 94V2A Fails	PCB-12 Trip Coil #2 EGTPS Ch 2A
SEG94F1AF	EGTPS UF Ch 1 Relay 94F1A Fails	EGTPS Ch 1A
SEG94F2AF	EGTPS UF Ch 2 Relay 94 F2A Fails	PCB-12 Trip Coil #2 EGTPS Ch 2A

Table A.2-4

Keowee Emergency Power Paths Fault Tree Transfers

Transfer Gate Name	Description	Components Supplied
SEG94V1DF	EGTPS UV Ch 1 Relay 94 V1D Fails	Swyd Isolate Signal EGTPS Ch 1D
SEG94F1DF	EGTPS UF Ch1 Relay 94 F1D Fails	Swyd Isolate Signal EGTPS Ch 1D
SEG94V2BF	EGTPS UV Ch 2 Relay 94 V2B Fails	PCB-12 Trip Coil #2 PCB-15 Trip Coil #2
SEG94F2BF	EGTPS UF Ch 2 Relay 94 F2B Fails	PCB-12 Trip Coil #2 PCB-15 Trip Coil #2
SEG94V2CF	EGTPS UV Ch 2 Relay 94V2C Fails	PCB-15 Trip Coil #2
SEG94F2CF	EGTPS UF Ch 2 Relay 94F2C Fails	PCB-15 Trip Coil #2
SEG94V2DF	EGTPS UV Ch 2 Relay 94V2D Fails	Swyd Isolate Signal PCB-21 Trip Coil #2
SEG94F2DF	EGTPS UF Ch 2 Relay 94F2D Fails	Swyd Isolate Signal PCB-21 Trip Coil #2

Table A.2-5

Keowee Emergency Power Paths Reliability Data

Event Name	Description	Failure Rate[1]	Factor	Rationale For Factor[2]	Failure Probability
AB1FALTDEX	Fault Occurs at ACB 1				0.00E+00
AB1PSWTPST	Air Circuit Breaker 1 Accumulator Pressure Switch Fails Low	4.30E-07 /H	24 H	Rule 5: Last demanded at unit start	1.03E-05
AB2PSWTPST	Air Circuit Breaker 2 Accumulator Pressure Switch Fails Low	4.30E-07 /H	24 H	Rule 5: Last demanded at unit start	1.03E-05
AB3PSWTPST	Air Circuit Breaker 3 Accumulator Pressure Switch Fails Low	4.30E-07 /H	24 H	Assumed ACB-3 would have to open half way through the mission to allow recovery by closing ACB-4.	1.03E-05
AB4PSWTPST	Air Circuit Breaker 4 Accumulator Pressure Switch Indicates Low Air Pressure	4.30E-07 /H	12 H	Half the time since the last operation and assume ACB-4 is needed half way through the mission (360+12)	5.16E-06
ACBAIRPDEX	ACB Air Supply Fails Causing Low Pressure In All ACB Accumulators	2.00E-03			2.00E-03
AD1C3CCCDT	Breaker 3CC In 125V dc Distribution Center 1DA Transfers Position	7.50E-08 /H	24 H	Rule 1: Loss of power is alarmed	1.80E-06
AD1C3CLCDT	Breaker 3CL In 125V dc Distribution Center 1DA Transfers Position	7.50E-08 /H	24 H	Rule 1: Loss of power is alarmed	1.80E-06
AD2C3CCCDT	Breaker 3CC In 125V dc Distribution Center 2DA Transfers Position	7.50E-08 /H	24 H	Rule 1: Loss of power is alarmed	1.80E-06
AD2C3CLCDT	Breaker 3CL In 125V dc Distribution Center 2DA Transfers Position	7.50E-08 /H	24 H	Rule 1: Loss of power is alarmed	1.80E-06
KK1OVERBHF	Fault Occurs On The Overhead Power Path	4.00E-07 /H	24 H		9.60E-06
KK1UNDRBHF	Fault Occurs On The Underground Power Path	4.00E-07 /H	24 H		9.60E-06

Table A.2-5

Keowee Emergency Power Paths Reliability Data

Event Name	Description	Failure Rate[1]	Factor	Rationale For Factor[2]	Failure Probability
S27XSC1RYD	Channel 1 Swyd Isolated Rly, 27X/SC1, Fails to Pick Up	3.30E-05 /D	1 D	1 demand per swyd isolation event	3.30E-05
S27XSC2RYD	Channel 2 Swyd Isolated Rly, 27X/SC2, Fails to Pick Up	3.30E-05 /D	1 D	1 demand per swyd isolation event	3.30E-05
S27XTD1RYD	Channel 1 Swyd Isolated Time Delay Rly, 27XTD/SC1, Fails	3.30E-05 /D	1 D	1 demand per swyd isolation event	3.30E-05
S27XTD2RYD	Channel 2 Swyd Isolated Time Delay Rly, 27XTD/SC2, Fails	3.30E-05 /D	1 D	1 demand per swyd isolation event	3.30E-05
SB18UX1RYT	Auxiliary Relay 8UX-1 Spurious Operation	3.60E-06 /H	24 H		8.64E-06
SB28UX2RYT	Auxiliary Relay 8UX-2 Spurious Operation	3.60E-06 /H	24 H		8.64E-06
SB38UX3RYT	Auxiliary Relay 8UX-3 Spurious Operation	3.60E-06 /H	24 H		8.64E-06
SB48UX4RYT	Auxiliary Relay 8UX-4 Spurious Operation	3.60E-06 /H	24 H		8.64E-06
SDCAIDDDIF	Control Power From DYA To PCB 9 Isolating Diode Fails	3.80E-06 /H	24 H		9.12E-05
SDCBIDXDIF	Control Power From DYB To PCB-30 Isolating Diode Fails (2 Diodes)	3.80E-06 /H	24 H		9.12E-05
SDCDA12CDT	125 Vdc Swyd Control Power Pnlbd DYA Bkr 12 Xfrs Open	7.50E-08 /H	24 H	Rule 1: Loss of power is alarmed	1.80E-06
SDCDA15CDT	125 Vdc Swyd Control Power Pnlbd DYA Bkr 15 Xfrs Open	7.50E-08 /H	24 H	Rule 1: Loss of power is alarmed	1.80E-06
SDCDA17CDT	125 Vdc Swyd Control Power Pnlbd DYA Bkr 17 Xfrs Open	7.50E-08 /H	24 H	Rule 1: Loss of power is alarmed	1.80E-06

Table A.2-5

Keowee Emergency Power Paths Reliability Data

Event Name	Description	Failure Rate[1]	Factor	Rationale For Factor[2]	Failure Probability
SDCDB01CDT	125 Vdc Swyd Control Power Pnlbd DYB Bkr 1 Xfrs Open	7.50E-08 /H	24 H	Rule 1: Loss of power is alarmed	1.80E-06
SDCDB13CDT	125 Vdc Swyd Control Power Pnlbd DYB Bkr 13 Xfrs Open	7.50E-08 /H	24 H	Rule 1: Loss of power is alarmed	1.80E-06
SDCDC12CDT	125 Vdc Swyd Control Power Pnlbd DYC Bkr 12 Xfrs Open	7.50E-08 /H	24 H	Rule 1: Loss of power is alarmed	1.80E-06
SDCDE12CDT	125 Vdc Swyd Control Power Pnlbd DYE Bkr 12 Xfrs Open	7.50E-08 /H	24 H	Rule 1: Loss of power is alarmed	1.80E-06
SDCDE15CDT	125 Vdc Swyd Control Power Pnlbd DYE Bkr 15 Xfrs Open	7.50E-08 /H	24 H	Rule 1: Loss of power is alarmed	1.80E-06
SDCDE17CDT	125 Vdc Swyd Control Power Pnlbd DYE Bkr 17 Xfrs Open	7.50E-08 /H	24 H	Rule 1: Loss of power is alarmed	1.80E-06
SDCDF01CDT	125 Vdc Swyd Control Power Pnlbd DYF Bkr 1 Xfrs Open	7.50E-08 /H	24 H	Rule 1: Loss of power is alarmed	1.80E-06
SDCDF13CDT	125 Vdc Swyd Control Power Pnlbd DYF Bkr 13 Xfrs Open	7.50E-08 /H	24 H	Rule 1: Loss of power is alarmed	1.80E-06
SDCDG16CDT	125 Vdc Swyd Control Power Pnlbd DYG Bkr 16 Xfrs Open	7.50E-08 /H	24 H	Rule 1: Loss of power is alarmed	1.80E-06
SDCDY10CDT	125 Vdc Swyd Control Power Pnlbd DYB Bkr 10 Xfrs Open	7.50E-08 /H	24 H	Rule 1: Loss of power is alarmed	1.80E-06
SDCDYA8CDT	125 Vdc Swyd Control Power Pnlbd DYA Bkr 8 Xfrs Open	7.50E-08 /H	24 H	Rule 1: Loss of power is alarmed	1.80E-06
SDCDYA9CDT	125 Vdc Swyd Control Power Pnlbd DYA Bkr 9 Xfrs Open	7.50E-08 /H	24 H	Rule 1: Loss of power is alarmed	1.80E-06
SDCDYB4CDT	125 Vdc Swyd Control Power Pnlbd DYB Bkr 4 Xfrs Open	7.50E-08 /H	24 H	Rule 1: Loss of power is alarmed	1.80E-06

Table A.2-5

Keowee Emergency Power Paths Reliability Data

Event Name	Description	Failure Rate[1]	Factor	Rationale For Factor[2]	Failure Probability
SDCDYB6CDT	125 Vdc Swyd Control Power Pnlbd DYB Bkr 6 Xfrs Open	7.50E-08 /H	24 H	Rule 1: Loss of power is alarmed	1.80E-06
SDCDYB8CDT	125 Vdc Swyd Control Power Pnlbd DYB Bkr 8 Xfrs Open	7.50E-08 /H	24 H	Rule 1: Loss of power is alarmed	1.80E-06
SDCDYE8CDT	125 Vdc Swyd Control Power Pnlbd DYE Bkr 8 Xfrs Open	7.50E-08 /H	24 H	Rule 1: Loss of power is alarmed	1.80E-06
SDCDYE9CDT	125 Vdc Swyd Control Power Pnlbd DYE Bkr 9 Xfrs Open	7.50E-08 /H	24 H	Rule 1: Loss of power is alarmed	1.80E-06
SDCDYF4CDT	125 Vdc Swyd Control Power Pnlbd DYF Bkr 4 Xfrs Open	7.50E-08 /H	24 H	Rule 1: Loss of power is alarmed	1.80E-06
SDCDYF6CDT	125 Vdc Swyd Control Power Pnlbd DYF Bkr 6 Xfrs Open	7.50E-08 /H	24 H	Rule 1: Loss of power is alarmed	1.80E-06
SDCDYF8CDT	125 Vdc Swyd Control Power Pnlbd DYF Bkr 8 Xfrs Open	7.50E-08 /H	24 H	Rule 1: Loss of power is alarmed	1.80E-06
SDCDYY0CDT	125 Vdc Swyd Control Power Pnlbd DYF Bkr 10 Xfrs Open	7.50E-08 /H	24 H	Rule 1: Loss of power is alarmed	1.80E-06
SDCEIDDDIF	Control Power From DYE To PCB-9 Isolating Diode Fails	3.80E-06 /H	24 H	Rule 1: Loss of power is alarmed	9.12E-05
SDCFIDXDIF	Control Power From DYF To PCB-30 Isolating Diode Fails (2 diodes)	3.80E-06 /H	24 H	Rule 1: Loss of power is alarmed	9.12E-05
SK194GBRYT	Keowee Unit 1 94GB Auxiliary Relay Spurious Operation	3.60E-06 /H	24 H		8.64E-06
SK294GBRYT	Keowee Unit 2 94GB Auxiliary Relay Spurious Operation	3.60E-06 /H	24 H		8.64E-06
SPC14KVBHF	13.8 kV Bus Faulted	4.00E-07 /H	24 H		9.60E-06

Table A.2-5

Keowee Emergency Power Paths Reliability Data

Event Name	Description	Failure Rate[1]	Factor	Rationale For Factor[2]	Failure Probability
SPC51TNRYT	Main Step Up Transformer Neutral Ground Relay 51TN Spurious Operation	3.60E-06 /H	24 H		8.64E-06
SPC62ABRYT	ACB Back-up Trip Timer 62AB Spurious Operation	3.60E-06 /H	24 H		8.64E-06
SPC631XRYT	Auxiliary Relay 63H1X Spurious Operation	3.60E-06 /H	24 H		8.64E-06
SPC871XRYT	Transformer 1X Differential Relay 87T-1X Spurious Operation	3.60E-06 /H	72 H		2.59E-05
SPC872XRYT	Transformer 2X Differential Relay 87T-2X Spurious Operation	3.60E-06 /H	72 H		2.59E-05
SPC87T1RYT	Main Step Up Transformer Differential Relay 87T Spurious Operation	3.60E-06 /H	72 H		2.59E-05
SPC94TKRYT	Auxiliary Relay 94T/K Spurious Operation	3.60E-06 /H	24 H		8.64E-06
SPCB008CHO	SWYD PCB-8 Fails to Trip	2.60E-05 /D	1 D	1 demand per swyd isolation event	2.60E-05
SPCB009CHC	SWYD PCB-9 Fails To Close On Demand	2.60E-04 /D	1 D	1 demand per swyd isolation event	9.40E-04
SPCB009CHO	SWYD PCB-9 Fails To Trip	2.60E-05 /D	1 D	1 demand per swyd isolation event	2.60E-04
SPCB012CHO	SWYD PCB-12 Fails To Trip	2.60E-05 /D	1 D	1 demand per swyd isolation event	2.60E-05
SPCB015CHO	SWYD PCB-15 Fails To Trip On Demand	2.60E-05 /D	1 D	1 demand per swyd isolation event	2.60E-05
SPCB017CHO	SWYD PCB-17 Fails To Trip On Demand	2.60E-05 /D	1 D	1 demand per swyd isolation event	2.60E-05
SPCB021CHO	SWYD PCB-21 Fails To Trip On Demand	2.60E-05 /D	1 D	1 demand per swyd isolation event	2.60E-05
SPCB024CHO	SWYD PCB-24 Fails To Trip On Demand	2.60E-05 /D	1 D	1 demand per swyd isolation event	2.60E-05
SPCB026CHO	SWYD PCB-26 Fails To Trip On Demand	2.60E-05 /D	1 D	1 demand per swyd isolation event	2.60E-05

Table A.2-5

Keowee Emergency Power Paths Reliability Data

Event Name	Description	Failure Rate[1]	Factor	Rationale For Factor[2]	Failure Probability
SPCB028CHO	SWYD PCB-28 Fails To Trip On Demand	2.60E-05 /D	1 D	1 demand per swyd isolation event	2.60E-05
SPCB030CHC	SWYD PCB-30 Fails To Close On Demand	2.60E-04 /D	1 D	1 demand per swyd isolation event	2.60E-04
SPCB033CHO	SWYD PCB-33 Fails To Open On Demand	2.60E-05 /D	1 D	1 demand per swyd isolation event	2.60E-05
SPCD87LRYT	Line Differential Relay 87L Spurious Operation	3.60E-06 /H	24 H		8.64E-06
SPCGLASSWT	Break Glass Switch Spurious Operation	7.00E-08 /H	24 H		1.75E-06
SPCR86TRYT	Lock Out Relay 86T Spurious Operation	3.60E-06 /H	24 H		8.64E-06
SXFRCT3THF	Transformer CT3 Faulted	3.10E-06 /H	24 H		7.44E-05
SXFRCT3THM	Transformer CT3 Is In Maintenance				1.74E-04
SXFRCT4LHE	Latent Human Error On CT4 Maintenance				6.40E-05
SXFRCT4THM	Transformer CT4 Is In Maintenance				9.13E-04
SY30R94RYT	PCB 30 Relay 94 Spuriously Picks Up	3.60E-06 /H	24 H		8.64E-06
SY51TN2RYT	230kV Neutral Ground Relay Spuriously Picks Up	3.60E-06 /H	24 H		8.64E-06
SY51TN4RYT	4.16kV Neutral Ground Relay Spuriously Picks Up	3.60E-06 /H	24 H		8.64E-06
SY51TN6RYT	6.9kV Neutral Ground Relay 51TN Spuriously Picks Up	3.60E-06 /H	24 H		8.64E-06
SY62X1FRYT	Breaker Failure Relay 62X1 Spuriously Picks Up	3.60E-06 /H	24 H		8.64E-06
SY62X2FRYT	Breaker Failure Relay 62X2 Spuriously Picks Up	3.60E-06 /H	24 H		8.64E-06

Table A.2-5

Keeowee Emergency Power Paths Reliability Data

Event Name	Description	Failure Rate[1]	Factor	Rationale For Factor[2]	Failure Probability
SY62XXFRYT	Breaker Failure Relay 62X Spuriously Picks Up	3.60E-06 /H	24 H		8.64E-06
SY86BUIRYT	CT3 6.9kV Start Up Bus Lockout Relay Spuriously Picks Up	3.60E-06 /H	24 H		8.64E-06
SY86CT3RYT	Transformer CT3 Lockout Relay Spuriously Picks Up	3.60E-06 /H	24 H		8.64E-06
SY86YA9RYT	Yellow Bus Lockout Auxiliary Relay 86YA9 Spuriously Picks Up	3.60E-06 /H	24 H		8.64E-06
SY86YJ3RYT	Yellow Bus Lockout Auxiliary Relay 86YJ30 Spuriously Picks Up	3.60E-06 /H	24 H		8.64E-06
SY87BYXRYT	Yellow Bus X Phase Differential Relay 87BYX Spuriously Picks Up	3.60E-06 /H	24 H		8.64E-06
SY87BYYRYT	Yellow Bus Y Phase Differential Relay 87BYY Spuriously Picks Up	3.60E-06 /H	24 H		8.64E-06
SY87BYZRYT	Yellow Bus Z Phase Differential Relay 86BYZ Spuriously Picks Up	3.60E-06 /H	24 H		8.64E-06
SY87LXXRYT	Differential Auxiliary Relay 87LX Spuriously Picks Up	3.60E-06 /H	24 H		8.64E-06
SY94L1XRYT	Protective Relay 94L Spuriously Picks Up	3.60E-06 /H	24 H		8.64E-06
SYE1362RYT	E13 Bkr Failure Relay 62B Spuriously Picks Up	3.60E-06 /H	24 H		8.64E-06
SYE2362RYT	E23 Bkr Failure Relay 62B Spuriously Picks Up	3.60E-06 /H	24 H		8.64E-06
SYP2862RYT	PCB 28 Breaker Failure Relay 62B Spuriously Picks Up	3.60E-06 /H	24 H		8.64E-06

Table A.2-5

Keowee Emergency Power Paths Reliability Data

Event Name	Description	Failure Rate[1]	Factor	Rationale For Factor[2]	Failure Probability
SYP3062RYT	PCB 30 Breaker Failure Relay 62B Spuriously Picks Up	3.60E-06 /H	24 H		8.64E-06
SYP86TXRYT	PCB 30 LOR 86TX Spuriously Picks Up	3.60E-06 /H	24 H		8.64E-06
SYPCB09CHT	Switchyard Power Circuit Breaker 9 Transfers Open	1.90E-06 /H	24 H		4.56E-05
SYPCB30CHT	Switchyard Power Circuit Breaker 30 Transfers Open	1.90E-06 /H	24 H		4.56E-05
SYPL86TRYT	PCB 30 LOR 86T Spuriously Picks Up	3.60E-06 /H	24 H		8.64E-06
SYPL87LRYT	Differential Relay 87L Spuriously Picks Up	3.60E-06 /H	24 H		8.64E-06
SYR86BYRYT	Yellow Bus Lockout Relay 86BY Spuriously Picks Up	3.60E-06 /H	24 H		8.64E-06
SYS63FPRYT	Fault Pressure Relay 63FP Spuriously Picks Up	3.60E-06 /H	24 H		8.64E-06
SYSX50BRYT	Transformer CT3 Fault Detector Relay 50B Spuriously Picks Up	3.60E-06 /H	24 H		8.64E-06
SYX87TBRYT	Differential Relay 87B Spuriously Picks Up	3.60E-06 /H	24 H		8.64E-06
SYXX87TRYT	Differential Relay 87T Spuriously Picks Up	3.60E-06 /H	24 H		8.64E-06
U5086EFRYT	Overcurrent Relay 50 Spuriously Actuates Lockout Rly 86EF	3.60E-06 /H	24 H		8.64E-06
U5186EFRYT	Time Delay Overcurrent Relay 51 Actuates Lockout Relay 86EF	3.60E-06 /H	24 H		8.64E-06
U51TNC4RYT	CT4 Neutral Ground Rly Actuates CT4 LOR 86T/CT4	3.60E-06 /H	24 H		8.64E-06

Table A.2-5

Keowee Emergency Power Paths Reliability Data

Event Name	Description	Failure Rate[1]	Factor	Rationale For Factor[2]	Failure Probability
U62BSK1RYT	SK1 Breaker Failure Relay 62BXSK1 Spuriously Picks Up	3.60E-06 /H	24 H		8.64E-06
U62BSK2RYT	SK2 Breaker Failure Relay 62BXSK2 Spuriously Picks Up	3.60E-06 /H	24 H		8.64E-06
U86CT4XRYT	Auxiliary Lockout Relay 86CT4X Spuriously Picks Up	3.60E-06 /H	24 H		8.64E-06
U86TCT4RYT	CT4 Lockout Relay 86T/CT4 Spuriously Picks Up	3.60E-06 /H	24 H		8.64E-06
U87TCT4RYT	Spurious Op of CT4 Differential Rly 87T Actuates LOR 86EF	3.60E-06 /H	24 H		8.64E-06
UACXCT4THF	Transformer CT4 Failed	3.10E-06 /H	24 H		7.44E-05
UXX86EFRYT	Lockout Relay 86EF Spuriously Picks Up	3.60E-06 /H	24 H		8.64E-06

[1] D = Demand, H = Hour

[2] Rules for assigning basic event factors are discussed in Table C.1-4.

Table A.2-6

Keeowee Emergency Power Paths Dominant Minimal Cut Sets

Cut Sets For Gate UPATHTOP: Underground Path Fails To Connect Keowee To Oconee

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
1)	9.13E-04	80.1	SXFRCT4THM	9.13E-04	Transformer CT4 Is In Maintenance
			K2NOMAIN	1.00E+00	Keowee Unit 2 Is Not In Maintenance
2)	7.44E-05	6.5	UACXCT4THF	7.44E-05	Transformer CT4 Failed
3)	6.40E-05	5.6	SXFRCT4LHE	6.40E-05	Latent Human Error On CT4 Maintenance
4)	9.60E-06	0.8	KK1UNDRBHF	9.60E-06	Fault Occurs On The Underground Power Path
5)	8.64E-06	0.8	U62BSK2RYT	8.64E-06	SK2 Breaker Failure Relay 62BXSK2 Spuriously Picks Up
6)	8.64E-06	0.8	U87TCT4RYT	8.64E-06	Spurious Op of CT4 Differential Rly 87T Actuates LOR 86EF
7)	8.64E-06	0.8	U62BSK1RYT	8.64E-06	SK1 Breaker Failure Relay 62BXSK1 Spuriously Picks Up
8)	8.64E-06	0.8	U86TCT4RYT	8.64E-06	CT4 Lockout Relay 86T/CT4 Spuriously Picks Up
9)	8.64E-06	0.8	U5086EFRYT	8.64E-06	Overcurrent Relay 50 Spuriously Actuates Lockout Rly 86EF
10)	8.64E-06	0.8	UXX86EFRYT	8.64E-06	Lockout Relay 86EF Spuriously Picks Up

Table A.2-6

Keeowee Emergency Power Paths Dominant Minimal Cut Sets

Cut Sets For Gate UPATHTOP: Underground Path Fails To Connect Keowee To Oconee

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
11)	8.64E-06	0.8	U5186EFRYT	8.64E-06	Time Delay Overcurrent Relay 51 Actuates Lockout Relay 86EF
12)	8.64E-06	0.8	U51TNC4RYT	8.64E-06	CT4 Neutral Ground Rly Actuates CT4 LOR 86T/CT4
13)	8.64E-06	0.8	U86CT4XRYT	8.64E-06	Auxiliary Lockout Relay 86CT4X Spuriously Picks Up
Total:	1.14E-03				

Table A.2-7

Keowee Emergency Power Paths Dominant Minimal Cut Sets

Cut Sets For Gate OPATHTOP: Overhead Path Fails To Connect Keowee To Oconee

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
1)	2.33E-03		-OMOD	1.00E+00	Startup Bus UV Sensing Mod Is In Service
			FACTORDEX	1.00E+00	Overload Susceptibility Factor
		28.8	S227EUVRYT	2.33E-03	Unit 2 Startup Bus Undervoltage Relay 27E Fails
2)	2.33E-03		-OMOD	1.00E+00	Startup Bus UV Sensing Mod Is In Service
			FACTORDEX	1.00E+00	Overload Susceptibility Factor
		28.8	S127EUVRYT	2.33E-03	Unit 1 Startup Bus Undervoltage Relay 27E Fails
3)	2.00E-03	24.8	ACBAIRPDEX	2.00E-03	ACB Air Supply Fails Causing Low Pressure In All ACB Accumulators
			ACB4MOD	1.00E+00	NSM-ON-52966 Is Not In Service
4)	2.60E-04	3.2	SPCB009CHC	2.60E-04	SWYD PCB-9 Fails To Close On Demand
5)	1.74E-04	2.2	SXFRCT3THM	1.74E-04	Transformer CT4 Is In Maintenance
6)	1.18E-04		OMOD	1.00E+00	Startup Bus UV Sensing Mod Is In Service
			FACTORDEX	1.00E+00	Overload Susceptibility Factor
		1.5	SU327UVCOM	1.18E-04	Common Cause Failure Of Startup Bus Undervoltage Relay
7)	7.44E-05	0.9	SXFRCT3THF	7.44E-05	Transformer CT3 Faulted

Table A.2-7

Keewee Emergency Power Paths Dominant Minimal Cut Sets

Cut Sets For Gate OPATHTOP: Overhead Path Fails To Connect Keowee To Oconee

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
8)	4.56E-05	0.6	SYPCB09CHT	4.56E-5	Switchyard Power Circuit Breaker 9 Transfers Open
9)	4.56E-05	0.6	SYPCB30CHT	4.56E-5	Switchyard Power Circuit Breaker 30 Transfers Open
10)	2.60E-05	0.3	SPCB008CHO	2.60E-05	SWYD PCB-8 Fails to Trip On Demand
11)	2.60E-05	0.3	SPCB012CHO	2.60E-05	SWYD PCB-12 Fails To Trip On Demand
12)	2.60E-05	0.3	SPCB015CHO	2.60E-05	SWYD PCB-15 Fails To Trip On Demand
13)	2.60E-05	0.3	SPCB017CHO	2.60E-05	SWYD PCB-17 Fails To Trip On Demand
14)	2.60E-05	0.3	SPCB021CHO	2.60E-05	SWYD PCB-21 Fails To Trip On Demand
15)	2.60E-05	0.3	SPCB024CHO	2.60E-05	SWYD PCB-24 Fails To Trip On Demand
16)	2.60E-05	0.3	SPCB026CHO	2.60E-05	SWYD PCB-26 Fails To Trip On Demand
17)	2.60E-05	0.3	SPCB028CHO	2.60E-05	SWYD PCB-28 Fails To Trip On Demand

Table A.2-7

Keeowee Emergency Power Paths Dominant Minimal Cut Sets

Cut Sets For Gate OPATHTOP: Overhead Path Fails To Connect Keowee To Oconee

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
18)	2.60E-05	0.3	SPCB033CHO	2.60E-05	SWYD PCB-33 Fails To Trip On Demand
19)	2.59E-05	0.3	SPC87T1RYT	2.59E-05	Main Step Up Transformer Differential Relay 87T Spurious Open
20)	2.59E-05	0.3	SPC871XRYT	2.59E-05	Transformer 1X Differential Relay 87T-1X Spurious Operation
21)	2.59E-05	0.3	SPC872XRYT	2.59E-05	Transformer 2X Differential Relay 87T-2X Spurious Operation
22)	1.03E-05	0.1	AB1PSWTPST	1.03E-05	Air Circuit Breaker 1 Accumulator Pressure Switch Fails Low
			ACB4MOD	1.00E+00	NSM-ON-52966 Is Not In Service
23)	1.03E-05	0.1	AB2PSWTPST	1.03E-05	Air Circuit Breaker 2 Accumulator Pressure Switch Fails Low
			ACB4MOD	1.00E+00	NSM-ON-52966 Is Not In Service
24)	1.03E-05	0.1	AB3PSWTPST	1.03E-05	Air Circuit Breaker 3 Accumulator Pressure Switch Fails Low
			ACB4MOD	1.00E+00	NSM-ON-52966 Is Not In Service
25)	9.60E-06	0.1	SPC14KVBHF	9.60E-06	13.8 kV Bus Faulted
26)	9.60E-06	0.1	KK1OVERBHF	9.60E-06	Fault Occurs On The Overhead Power Path

Table A.2-7

Keowee Emergency Power Paths Dominant Minimal Cut Sets

Cut Sets For Gate OPATHTOP: Overhead Path Fails To Connect Keowee To Oconee

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
27)	8.64E-06		ACB4MOD	1.00E+00	NSM-ON-52966 Is Not In Service
		0.1	SB48UX4RYT	8.64E-06	Auxiliary Relay 8UX-4 Spurious Operation
28)	8.64E-06		ACB4MOD	1.00E+00	NSM-ON-52966 Is Not In Service
		0.1	SB28UX2RYT	8.64E-06	Auxiliary Relay 8UX-2 Spurious Operation
29)	8.64E-06		ACB4MOD	1.00E+00	NSM-ON-52966 Is Not In Service
		0.1	SB38UX3RYT	8.64E-06	Auxiliary Relay 8UX-3 Spurious Operation
30)	8.64E-06		ACB4MOD	1.00E+00	NSM-ON-52966 Is Not In Service
		0.1	SK294GBRYT	8.64E-06	Keowee Unit 2 94GB Auxiliary Relay Spurious Operation
31)	8.64E-06		ACB4MOD	1.00E+00	NSM-ON-52966 Is Not In Service
		0.1	SK194GBRYT	8.64E-06	Keowee Unit 1 94GB Auxiliary Relay Spurious Operation
32)	8.64E-06		ACB4MOD	1.00E+00	NSM-ON-52966 Is Not In Service
		0.1	SB18UX1RYT	8.64E-06	Auxiliary Relay 8UX-1 Spurious Operation
33)	8.64E-06	0.1	SPCD87LRYT	8.64E-06	Line Differential Relay 87L Spurious Operation

Table A.2-7

Keeowee Emergency Power Paths Dominant Minimal Cut Sets

Cut Sets For Gate OPATHTOP: Overhead Path Fails To Connect Keowee To Oconee

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
34)	8.64E-06	0.1	SY86YA9RYT	8.64E-06	Yellow Bus Lockout Auxiliary Relay 86YA9 Spuriously Picks Up
35)	8.64E-06	0.1	SYR86BYRYT	8.64E-06	Yellow Bus Lockout Relay 86BY Spuriously Picks Up
36)	8.64E-06	0.1	SY62XXFRYT	8.64E-06	Breaker Failure Relay 62X Spuriously Picks Up
37)	8.64E-06	0.1	SY62X1FRYT	8.64E-06	Breaker Failure Relay 62X1 Spuriously Picks Up
38)	8.64E-06	0.1	SYPL86TRYT	8.64E-06	PCB 30 LOR 86T Spuriously Picks Up
39)	8.64E-06	0.1	SY87LXXRYT	8.64E-06	Differential Auxiliary Relay 87LX Spuriously Picks Up
40)	8.64E-06	0.1	SYPL87LRYT	8.64E-06	Differential Relay 87L Spuriously Picks Up
41)	8.64E-06	0.1	SYXX87TRYT	8.64E-06	Differential Relay 87T Spuriously Picks Up
42)	8.64E-06	0.1	SPC62ABRYT	8.64E-06	ACB Back-up Trip Timer 62AB Spurious Operation
43)	8.64E-06	0.1	SPC631XRYT	8.64E-06	Auxiliary Relay 63H1X Spurious Operation

Table A.2-7

Keowee Emergency Power Paths Dominant Minimal Cut Sets

Cut Sets For Gate OPATHTOP: Overhead Path Fails To Connect Keowee To Oconee

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
44)	8.64E-06	0.1	SY51TN2RYT	8.64E-06	230kV Neutral Ground Relay Spuriously Picks Up
45)	8.64E-06	0.1	SPC94TKRYT	8.64E-06	Auxiliary Relay 94T/K Spurious Operation
46)	8.64E-06	0.1	SYS63FPRYT	8.64E-06	Fault Pressure Relay 63FP Spuriously Picks Up
47)	8.64E-06	0.1	SYSX50BRYT	8.64E-06	Transformer CT3 Fault Detector Relay 50B Spuriously Picks Up
48)	8.64E-06	0.1	SY30R94RYT	8.64E-06	PCB 30 Relay 94 Spuriously Picks Up
49)	8.64E-06	0.1	SY51TN4RYT	8.64E-06	4.16kV Neutral Ground Relay Spuriously Picks Up
50)	8.64E-06	0.1	SYE2362RYT	8.64E-06	E23 Bkr Failure Relay 62B Spuriously Picks Up
51)	8.64E-06	0.1	SPC51TNRYT	8.64E-06	Main Step Up Transformer Neutral Ground Relay 51TN Spurious
52)	8.64E-06	0.1	SPCR86TRYT	8.64E-06	Lock Out Relay 86T Spurious Operation
53)	8.64E-06	0.1	SY51TN6RYT	8.64E-06	6.9kV Neutral Ground Relay 51TN Spuriously Picks Up

Table A.2-7

Keowee Emergency Power Paths Dominant Minimal Cut Sets

Cut Sets For Gate OPATHTOP: Overhead Path Fails To Connect Keowee To Oconee

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
54)	8.64E-06	0.1	SY94L1XRYT	8.64E-06	Protective Relay 94L Spuriously Picks Up
55)	8.64E-06	0.1	SYP86TXRYT	8.64E-06	PCB 30 LOR 86TX Spuriously Picks Up
56)	8.64E-06	0.1	SY86YJ3RYT	8.64E-06	Yellow Bus Lockout Aux Relay 86YJ30 Spuriously Picks UP
57)	8.64E-06	0.1	SY86BUIRYT	8.64E-06	CT3 6.9kV Start Up Bus Lockout Relay Spuriously Picks Up
58)	8.64E-06	0.1	SY86CT3RYT	8.64E-06	Transformer CT3 Lockout Relay Spuriously Picks Up
59)	8.64E-06	0.1	SYE1362RYT	8.64E-06	E13 Bkr Failure Relay 62B Spuriously Picks Up
60)	8.64E-06	0.1	SY87BYXRYT	8.64E-06	Yellow Bus X Phase Differential Relay 87BYX Spuriously Picks
61)	8.64E-06	0.1	SYP3062RYT	8.64E-06	PCB 30 Breaker Failure Relay 62B Spuriously Picks Up
62)	8.64E-06	0.1	SY62X2FRYT	8.64E-06	Breaker Failure Relay 62X2 Spuriously Picks Up
63)	8.64E-06	0.1	SYX87TBRYT	8.64E-06	Differential Relay 87B Spuriously Picks Up

Table A.2-7

Keeowee Emergency Power Paths Dominant Minimal Cut Sets

Cut Sets For Gate OPATHTOP: Overhead Path Fails To Connect Keowee To Oconee

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
64)	8.64E-06	0.1	SY87BYYRYT	8.64E-06	Yellow Bus Y Phase Differential Relay 87BYY Spuriously Picks
65)	8.64E-06	0.1	SY87BYZRYT	8.64E-06	Yellow Bus Z Phase Differential Relay 86BYZ Spuriously Picks
66)	8.64E-06	0.1	SYP2862RYT	8.64E-06	PCB 28 Breaker Failure Relay 62B Spuriously Picks Up
67)	5.44E-06		-OMOD	1.00E+00	Startup Bus UV Sensing Mod Is In Service
			OFACTORDEX	1.00E+00	Overload Susceptibility Factor
		<0.1	S327E1VRYT	2.33E-03	Unit 3 Startup Bus Undervoltage Trip Relay 27E1 Fails
		<0.1	S327EUVRYT	2.33E-03	Unit 3 Startup Bus Undervoltage Trip Relay 27E Fails
68)	5.16E-06	0.1	AB4PSWTPST	5.16E-06	Air Circuit Breaker 4 Accumulator Pressure Switch Indicates
			ACB4MOD	1.00E+00	NSM-ON-52966 Is Not In Service
69)	1.80E-06		ACB4MOD	1.00E+00	NSM-ON-52966 Is Not In Service
		<0.1	AD1C3CCCDT	1.80E-06	Bkr 3CC In 125V dc Distribution Center 1DA Transfers Position
70)	1.80E-06		ACB4MOD	1.00E+00	NSM-ON-52966 Is Not In Service
		<0.1	AD1C3CLCDT	1.80E-06	Bkr 3CL In 125V dc Distribution Center 1DA Transfers Position

Table A.2-7

Keeowee Emergency Power Paths Dominant Minimal Cut Sets

Cut Sets For Gate OPATHTOP: Overhead Path Fails To Connect Keowee To Oconee

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
71)	1.80E-06		ACB4MOD	1.00E+00	NSM-ON-52966 Is Not In Service
		<0.1	AD2C3CCCDT	1.80E-06	Bkr 3CC In 125V dc Distribution Center 2DA Transfers Position
72)	1.80E-06		ACB4MOD	1.00E+00	NSM-ON-52966 Is Not In Service
		<0.1	AD2C3CLCDT	1.80E-06	Bkr 3CL In 125V dc Distribution Center 2DA Transfers Position
73)	1.68E-06	<0.1	SPCGLASSWT	1.86E-06	Break Glass Switch Spurious Operation
Total:	8.08E-03				

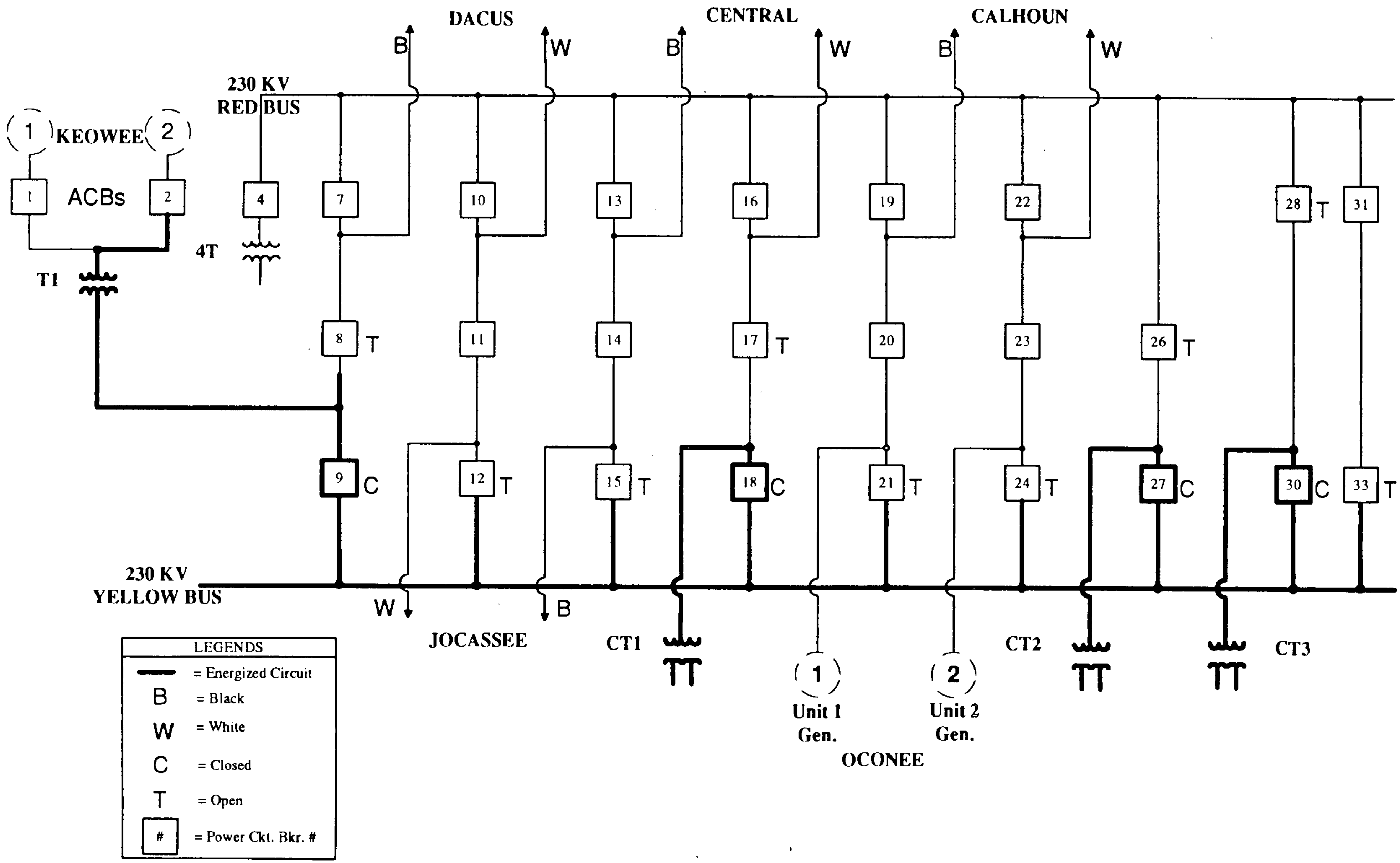
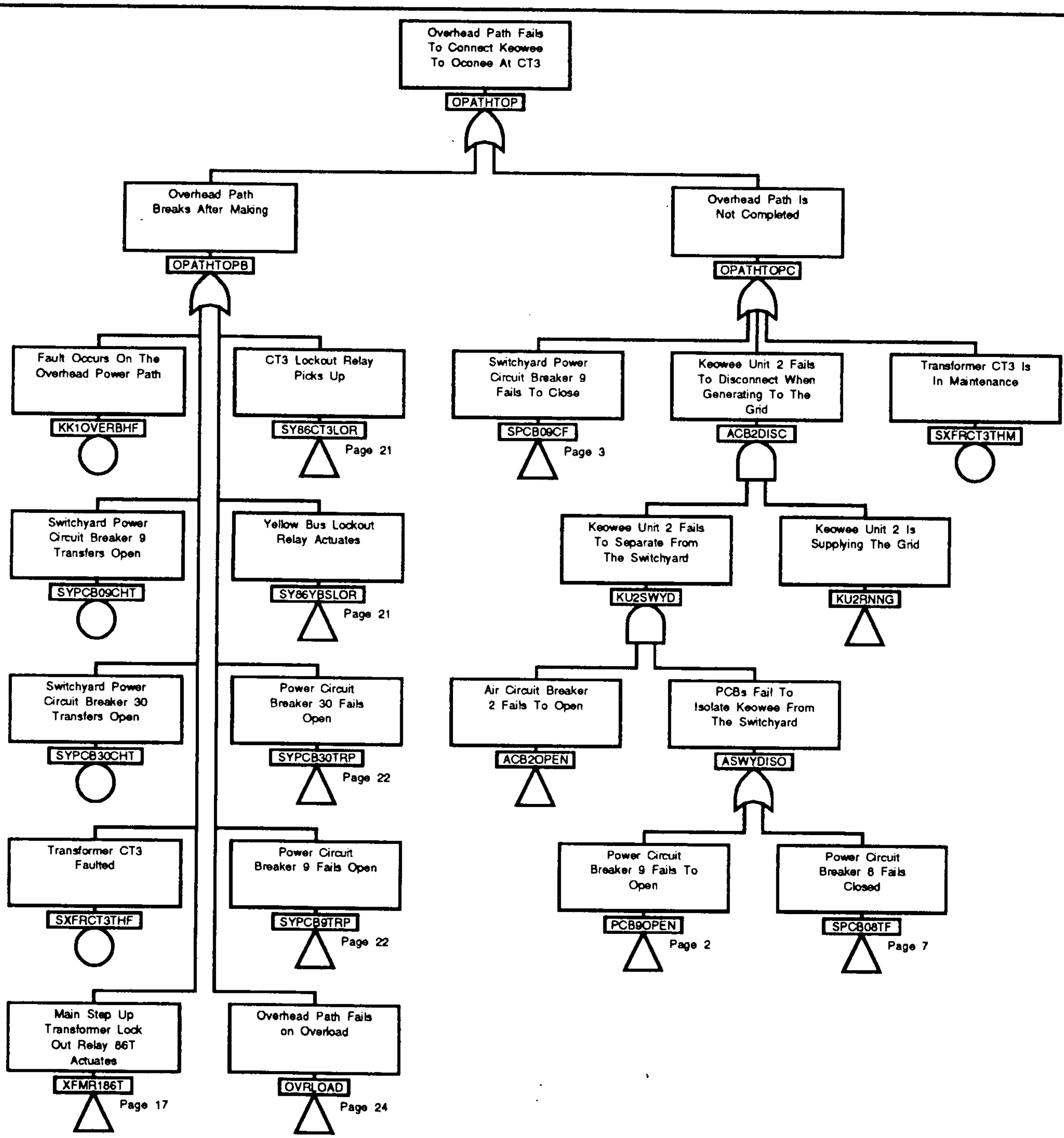
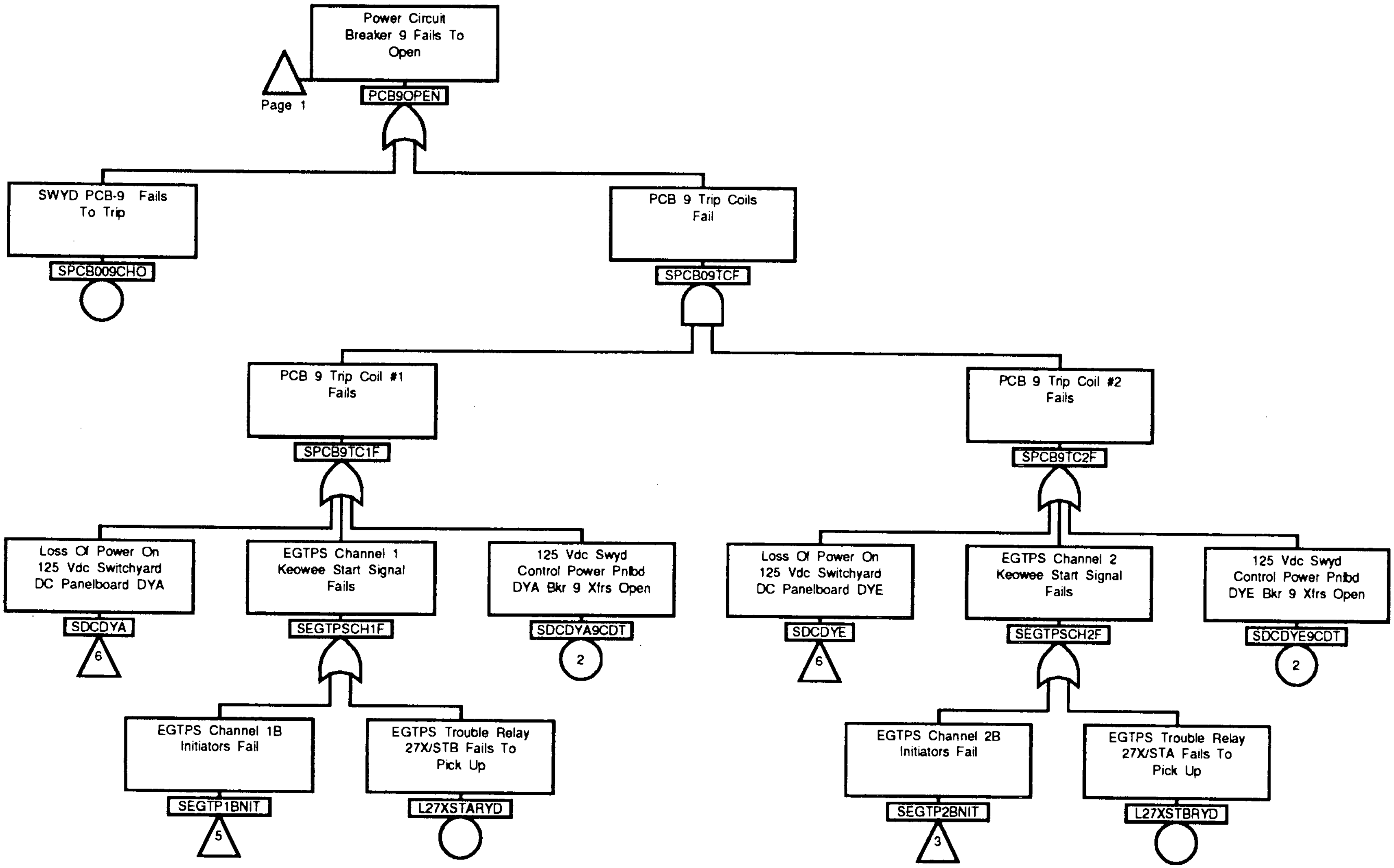


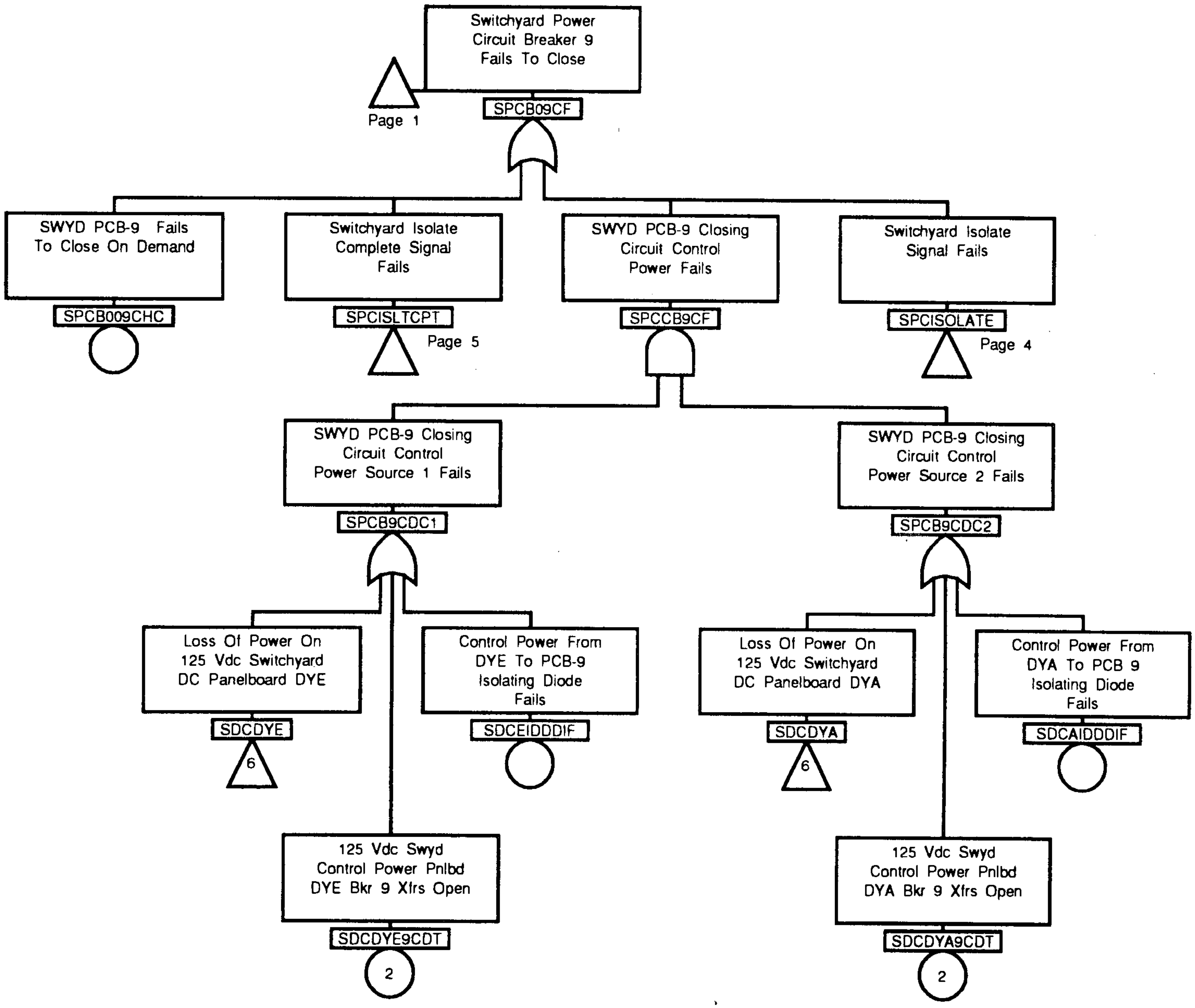
Figure A.2-1 Overhead Power Path



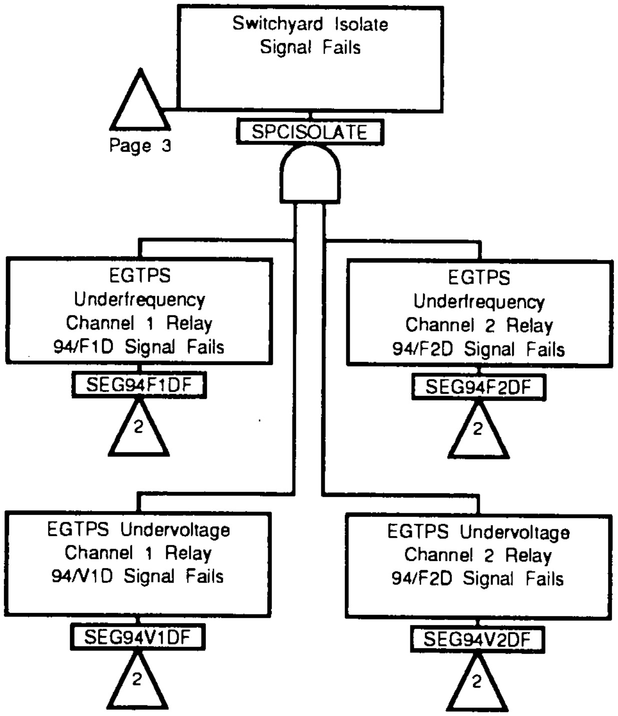
Keowee Emergency Power Paths Fau Tree | FIGURE A.2-2 | Pa 1



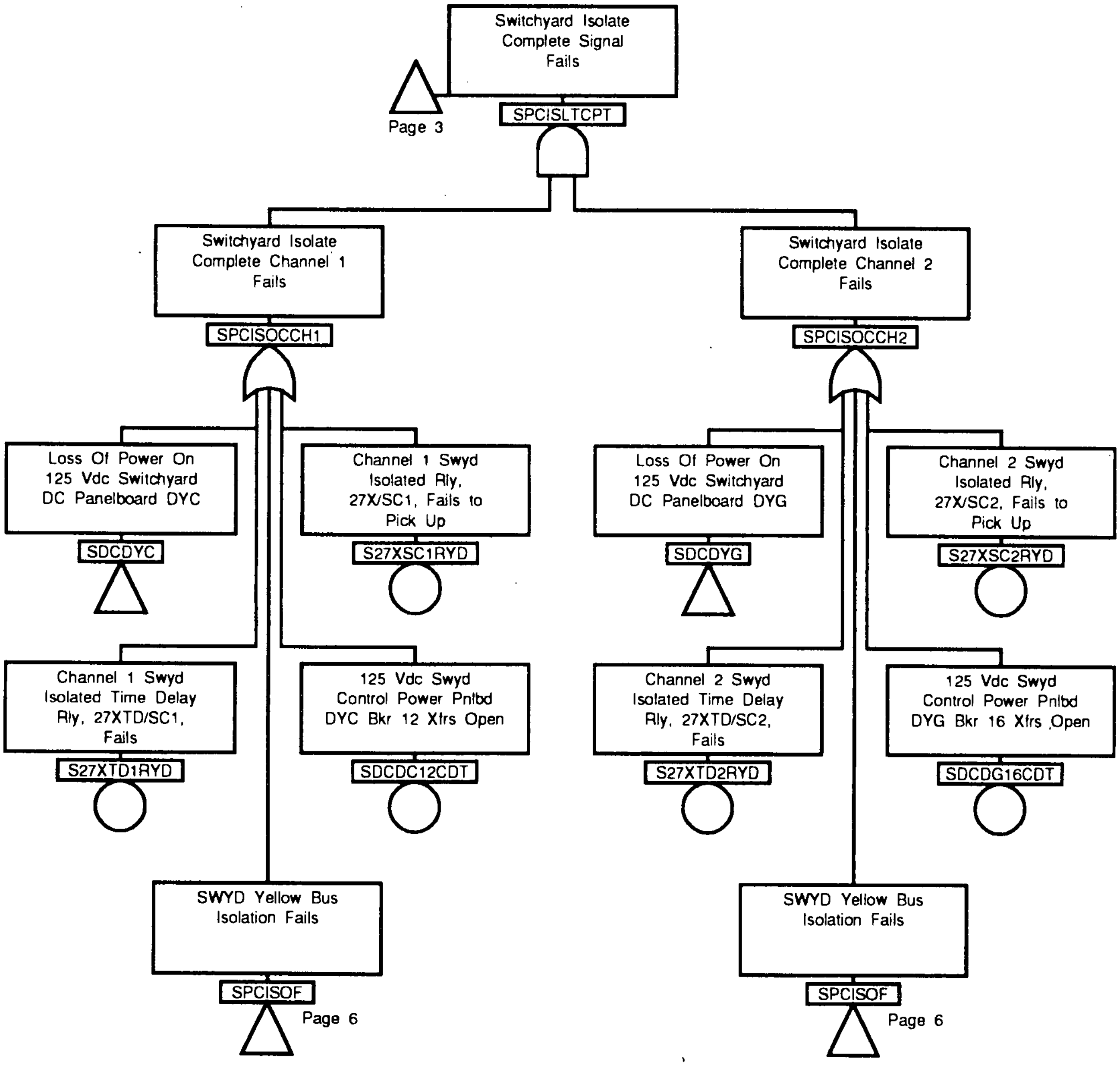
Keowee Emergency Power Paths Fault Tree | FIGURE A.2-2 | Page 2



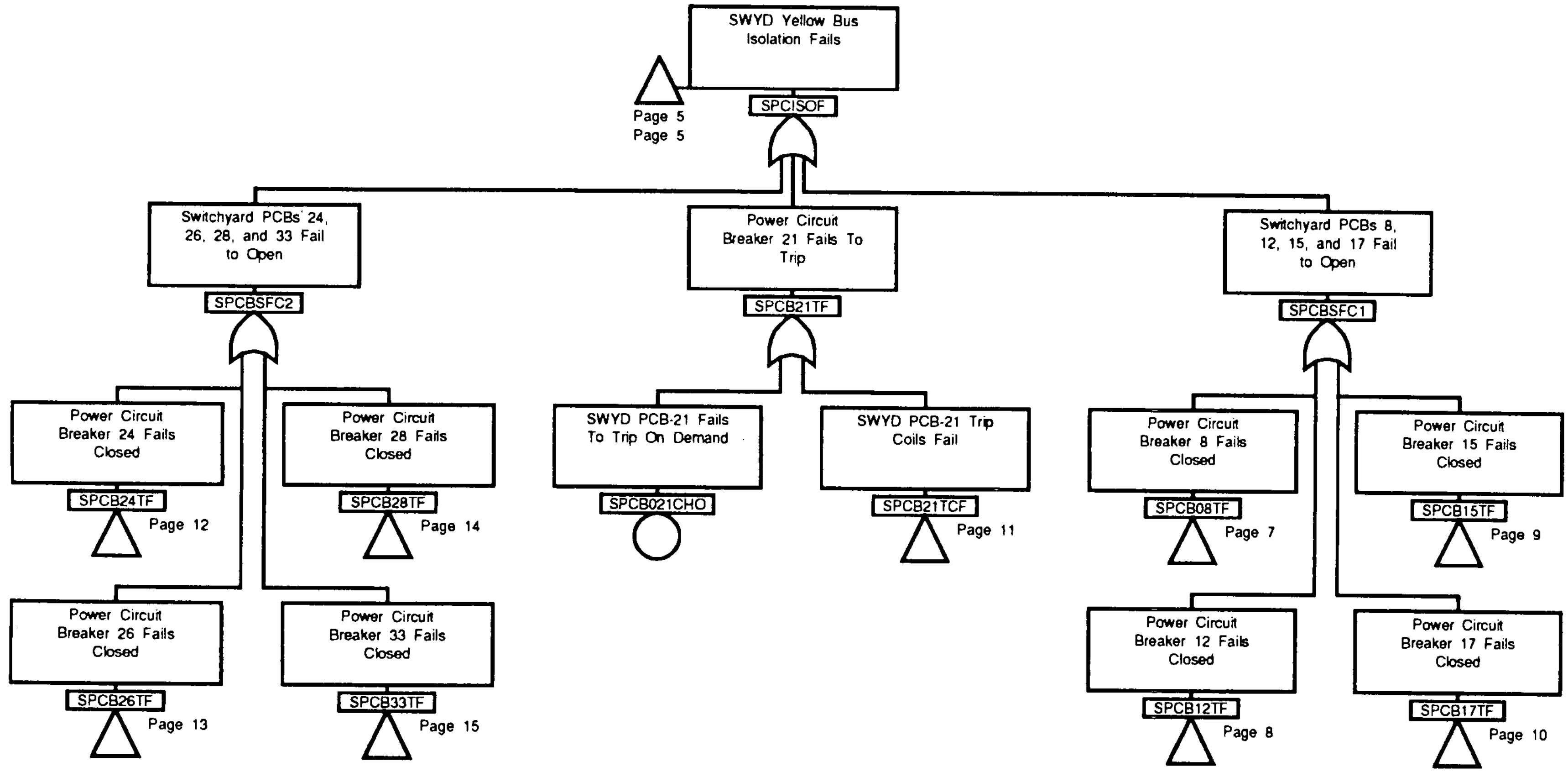
Switchyard Power Circuit Breaker 9 Fails To Close
SPCB09CF
Page 1
SWYD PCB-9 Fails To Close On Demand
SPCB009CHC
Switchyard Isolate Complete Signal Fails
SPCISLTCPT
Page 5
SWYD PCB-9 Closing Circuit Control Power Fails
SPCCB9CF
Switchyard Isolate Signal Fails
SPCISOLATE
Page 4
SWYD PCB-9 Closing Circuit Control Power Source 1 Fails
SPCB9CDC1
SWYD PCB-9 Closing Circuit Control Power Source 2 Fails
SPCB9CDC2
Loss Of Power On 125 Vdc Switchyard DC Panelboard DYE
SDCDYE
6
Control Power From DYE To PCB-9 Isolating Diode Fails
SDCEIDDDIF
Loss Of Power On 125 Vdc Switchyard DC Panelboard DYA
SDCDYA
6
Control Power From DYA To PCB 9 Isolating Diode Fails
SDCAIDDDIF
125 Vdc Swyd Control Power Pnlbd DYE Bkr 9 Xfrs Open
SDCDYE9CDT
2
125 Vdc Swyd Control Power Pnlbd DYA Bkr 9 Xfrs Open
SDCDYA9CDT
2



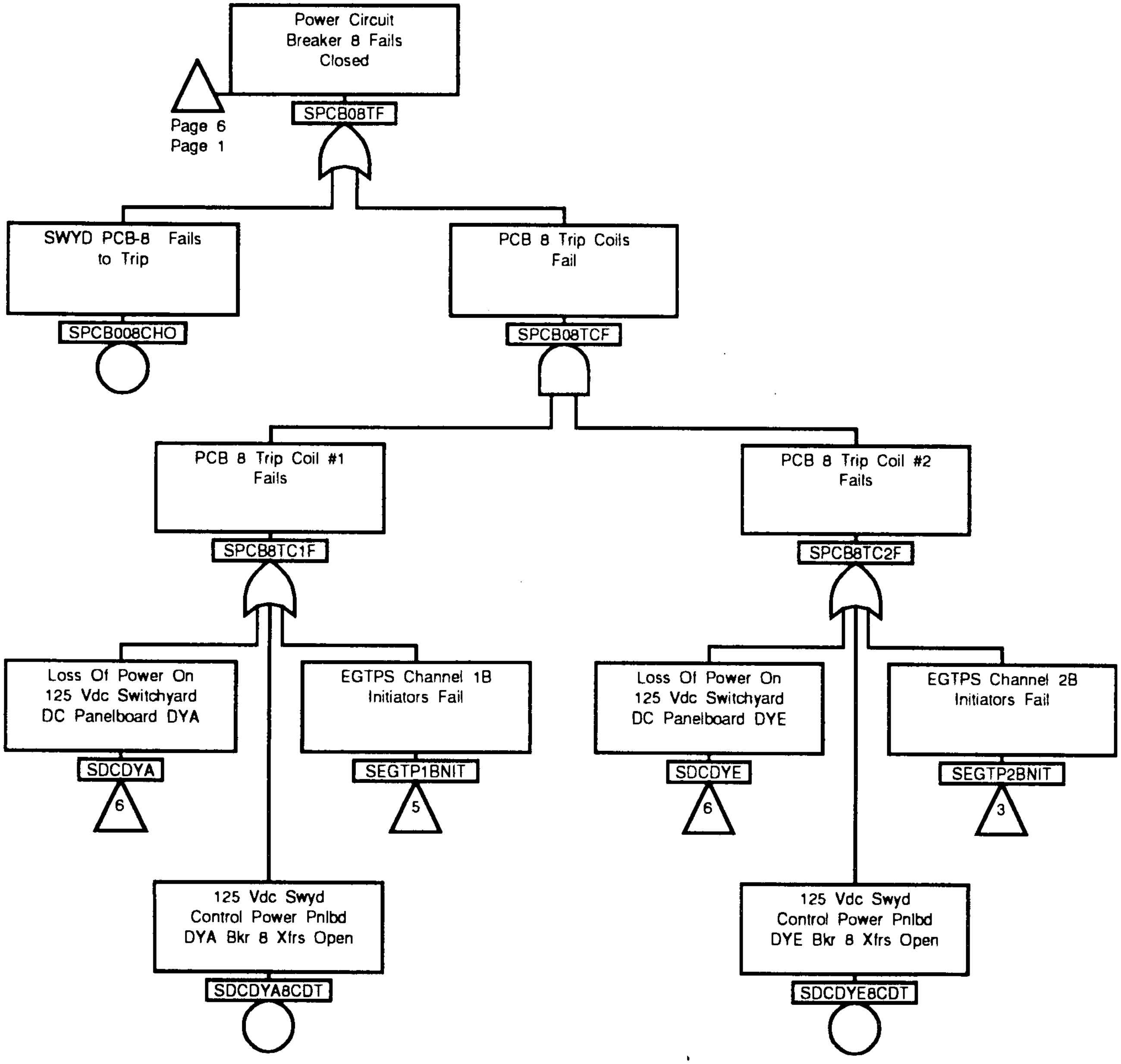
Keowee Emergency Power Paths Fault Tree	FIGURE A.2-2	Page 4



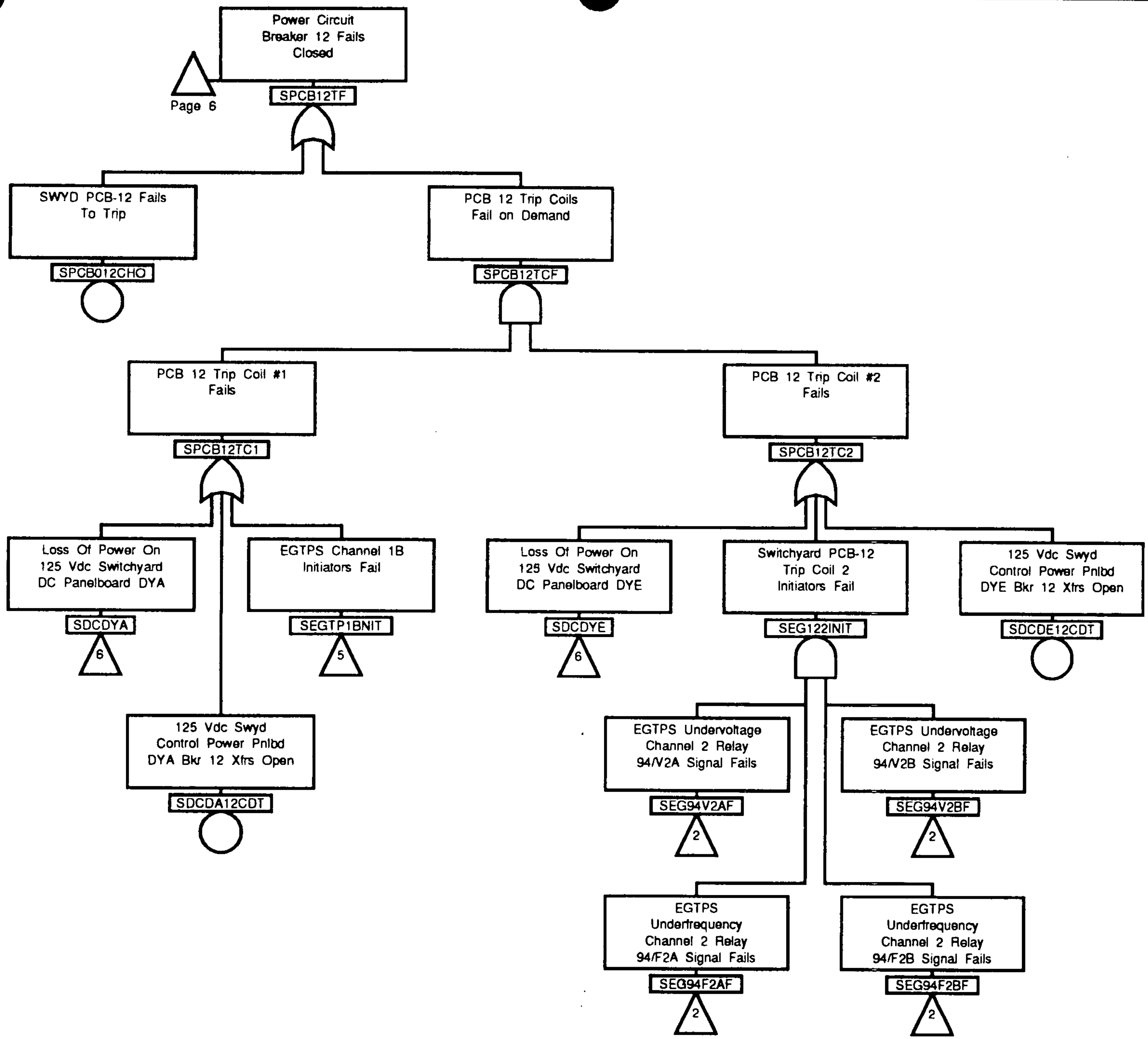
Keowee Emergency Power Paths Fault Tree | FIGURE A.2-2 |



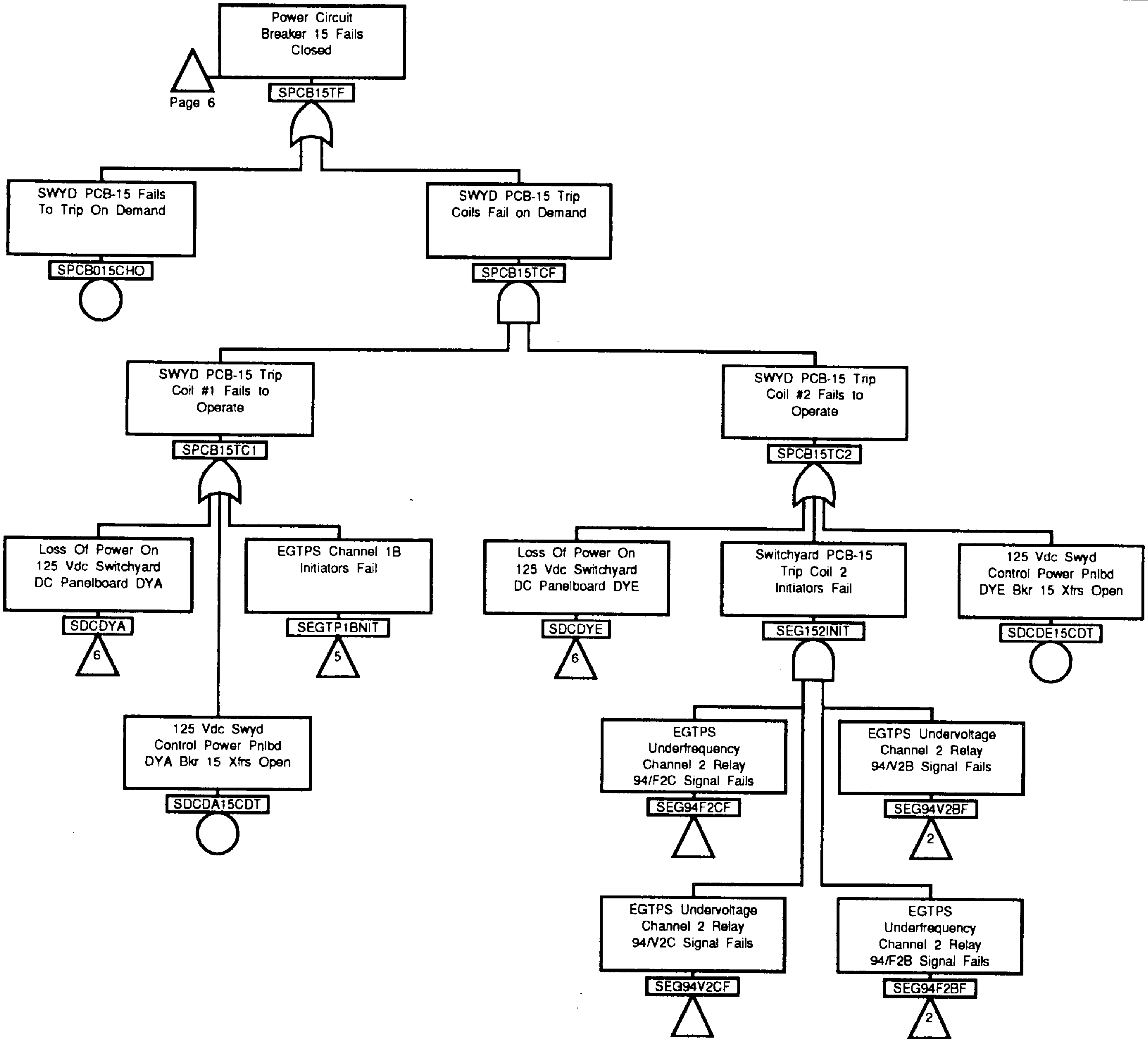
Keowee Emergency Power Paths Fault Tree | FIGURE A.2-2 |



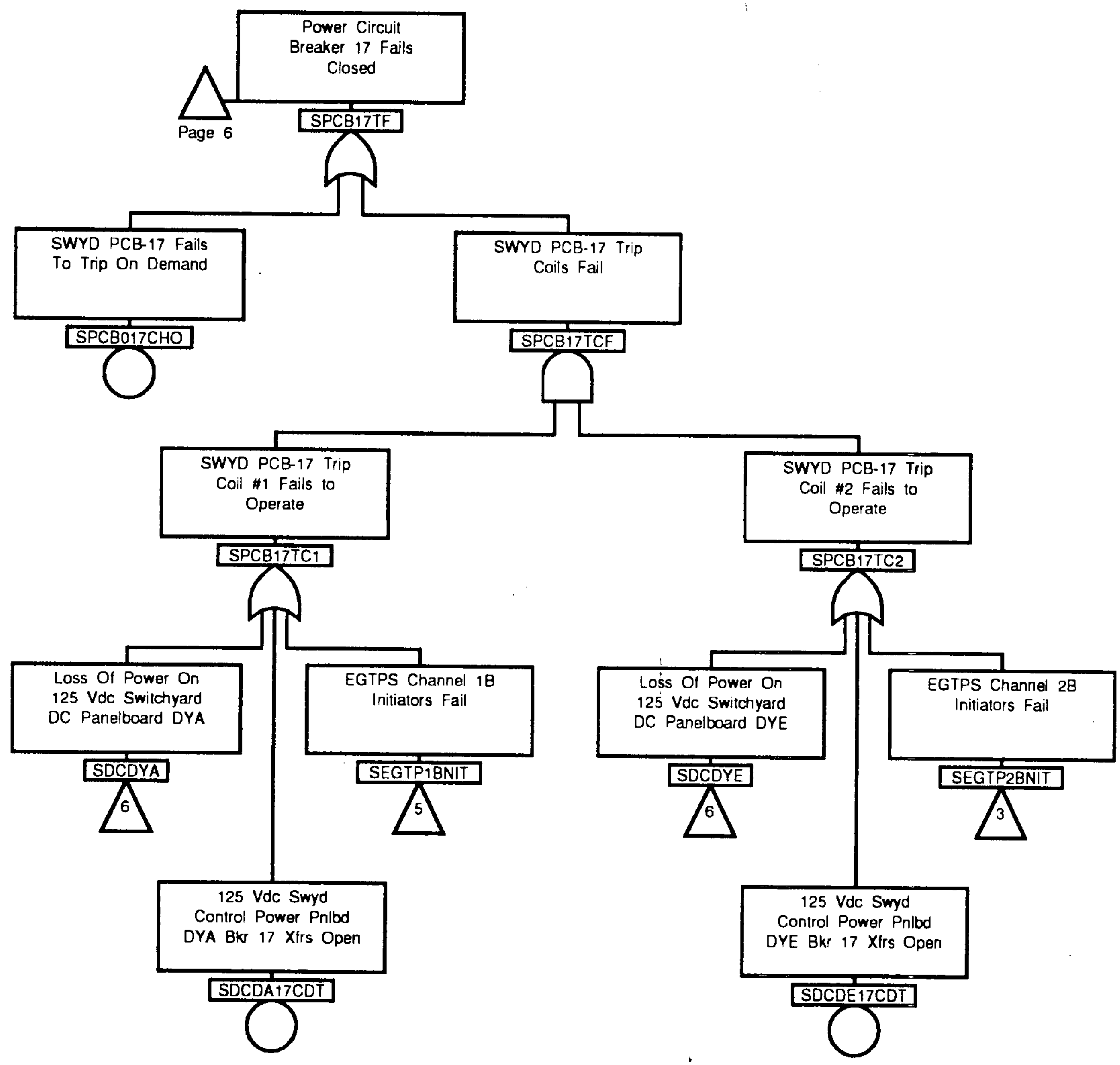
Power Circuit Breaker 8 Fails Closed
SPCB08TF
Page 6
Page 1
SWYD PCB-8 Fails to Trip
SPCB008CHO
PCB 8 Trip Coils Fail
SPCB08TCF
PCB 8 Trip Coil #1 Fails
SPCB8TC1F
PCB 8 Trip Coil #2 Fails
SPCB8TC2F
Loss Of Power On 125 Vdc Switchyard DC Panelboard DYA
SDCDYA
6
EGTPS Channel 1B Initiators Fail
SEGTP1BNIT
5
Loss Of Power On 125 Vdc Switchyard DC Panelboard DYE
SDCDYE
6
EGTPS Channel 2B Initiators Fail
SEGTP2BNIT
3
125 Vdc Swyd Control Power Pnlbd DYA Bkr 8 Xfrs Open
SDCDYA8CDT
125 Vdc Swyd Control Power Pnlbd DYE Bkr 8 Xfrs Open
SDCDYE8CDT



Power Circuit Breaker 12 Fails Closed
Page 6
SPCB12TF
SWYD PCB-12 Fails To Trip
SPCB012CHO
PCB 12 Trip Coils Fail on Demand
SPCB12TCF
PCB 12 Trip Coil #1 Fails
SPCB12TC1
PCB 12 Trip Coil #2 Fails
SPCB12TC2
Loss Of Power On 125 Vdc Switchyard DC Panelboard DYA
SDCDYA
6
EGTPS Channel 1B Initiators Fail
SEGTP1BNIT
5
125 Vdc Swyd Control Power Pnlbd DYA Bkr 12 Xfrs Open
SDCDA12CDT
Loss Of Power On 125 Vdc Switchyard DC Panelboard DYE
SDCDYE
6
Switchyard PCB-12 Trip Coil 2 Initiators Fail
SEG122INIT
125 Vdc Swyd Control Power Pnlbd DYE Bkr 12 Xfrs Open
SDCDE12CDT
EGTPS Undervoltage Channel 2 Relay 94/V2A Signal Fails
SEG94V2AF
2
EGTPS Undervoltage Channel 2 Relay 94/V2B Signal Fails
SEG94V2BF
2
EGTPS Underfrequency Channel 2 Relay 94/F2A Signal Fails
SEG94F2AF
2
EGTPS Underfrequency Channel 2 Relay 94/F2B Signal Fails
SEG94F2BF
2

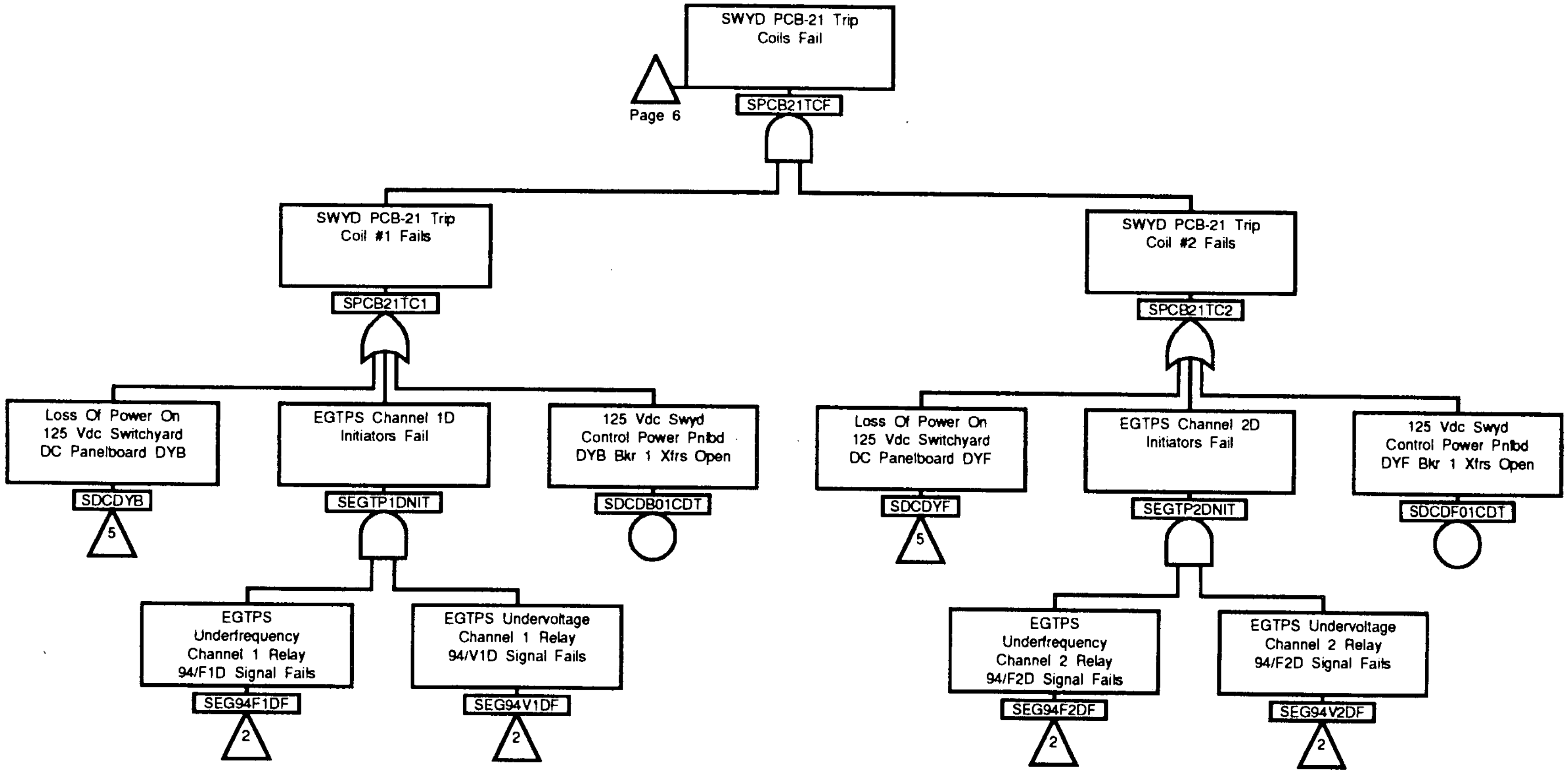


Power Circuit Breaker 15 Fails Closed
SPCB15TF
Page 6
SWYD PCB-15 Fails To Trip On Demand
SPCB015CHO
SWYD PCB-15 Trip Coils Fail on Demand
SPCB15TCF
SWYD PCB-15 Trip Coil #1 Fails to Operate
SPCB15TC1
SWYD PCB-15 Trip Coil #2 Fails to Operate
SPCB15TC2
Loss Of Power On 125 Vdc Switchyard DC Panelboard DYA
SDCDYA
6
EGTPS Channel 1B Initiators Fail
SEGTP1BNIT
5
125 Vdc Swyd Control Power Pnlbd DYA Bkr 15 Xfrs Open
SDCDA15CDT
Loss Of Power On 125 Vdc Switchyard DC Panelboard DYE
SDCDYE
6
Switchyard PCB-15 Trip Coil 2 Initiators Fail
SEG152INIT
125 Vdc Swyd Control Power Pnlbd DYE Bkr 15 Xfrs Open
SDCDE15CDT
EGTPS Underfrequency Channel 2 Relay 94/F2C Signal Fails
SEG94F2CF
EGTPS Undervoltage Channel 2 Relay 94/V2B Signal Fails
SEG94V2BF
2
EGTPS Undervoltage Channel 2 Relay 94/V2C Signal Fails
SEG94V2CF
EGTPS Underfrequency Channel 2 Relay 94/F2B Signal Fails
SEG94F2BF
2

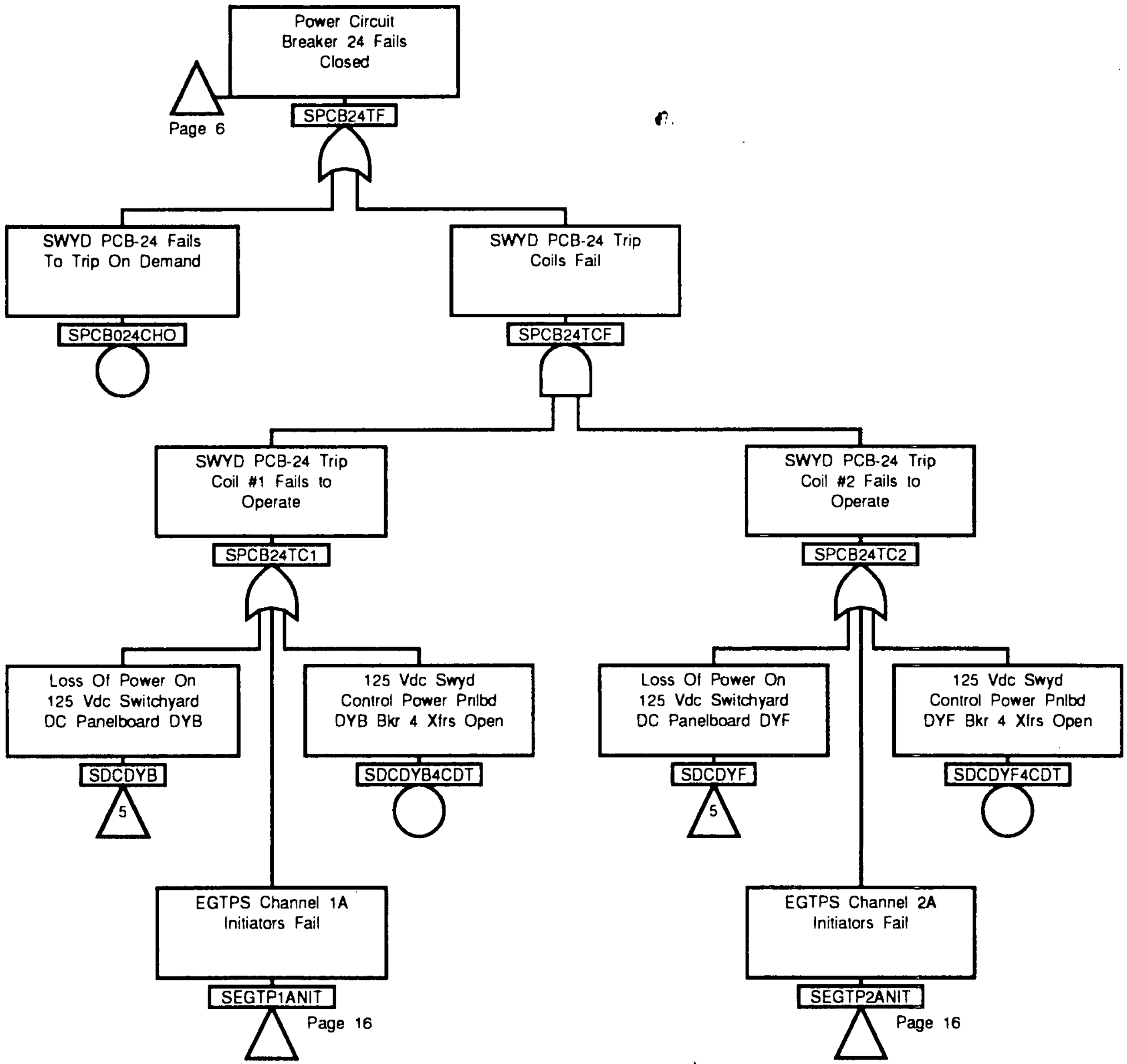


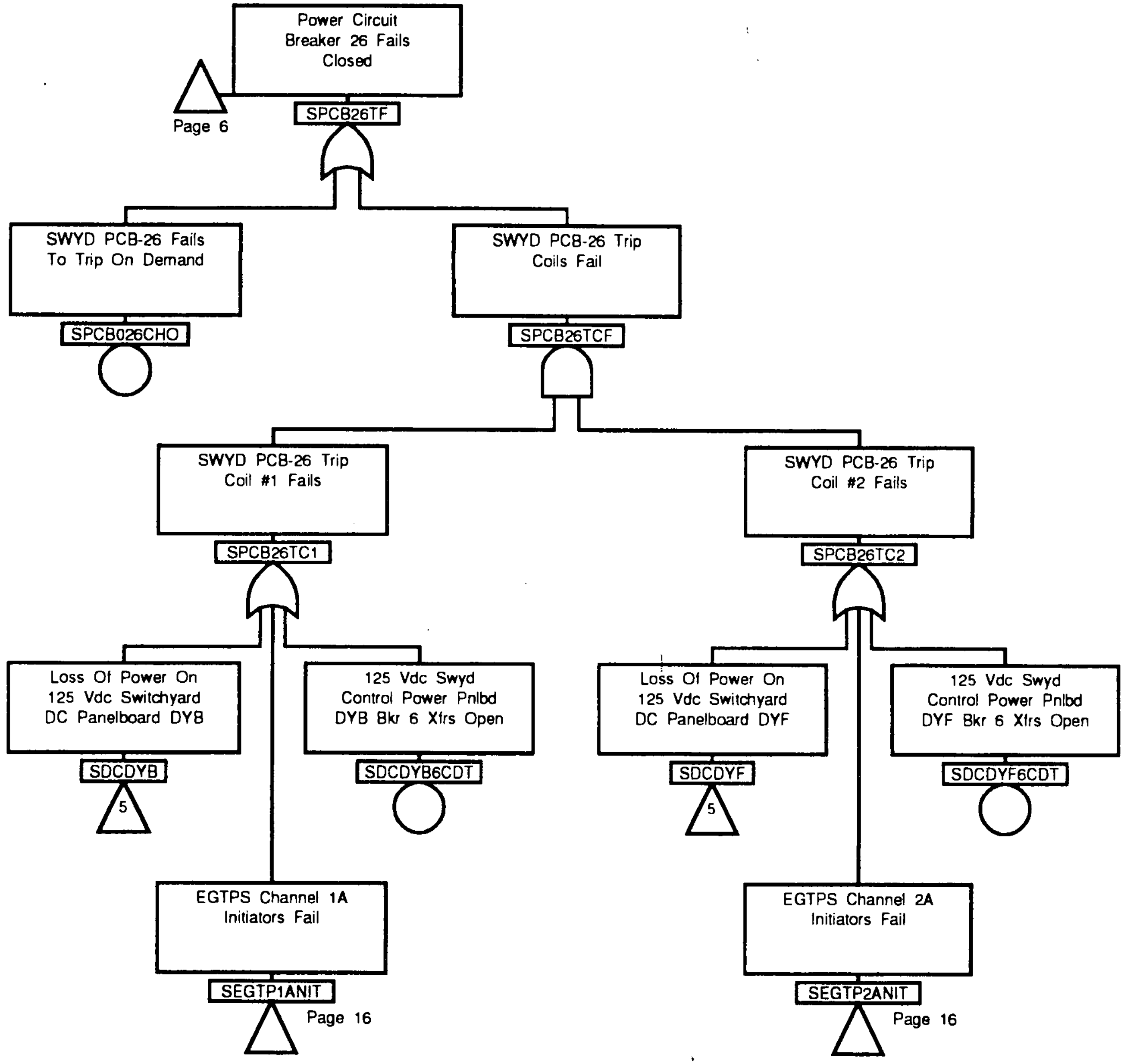
Keowee Emergency Power Paths Fault Tree

FIGURE A.2-2

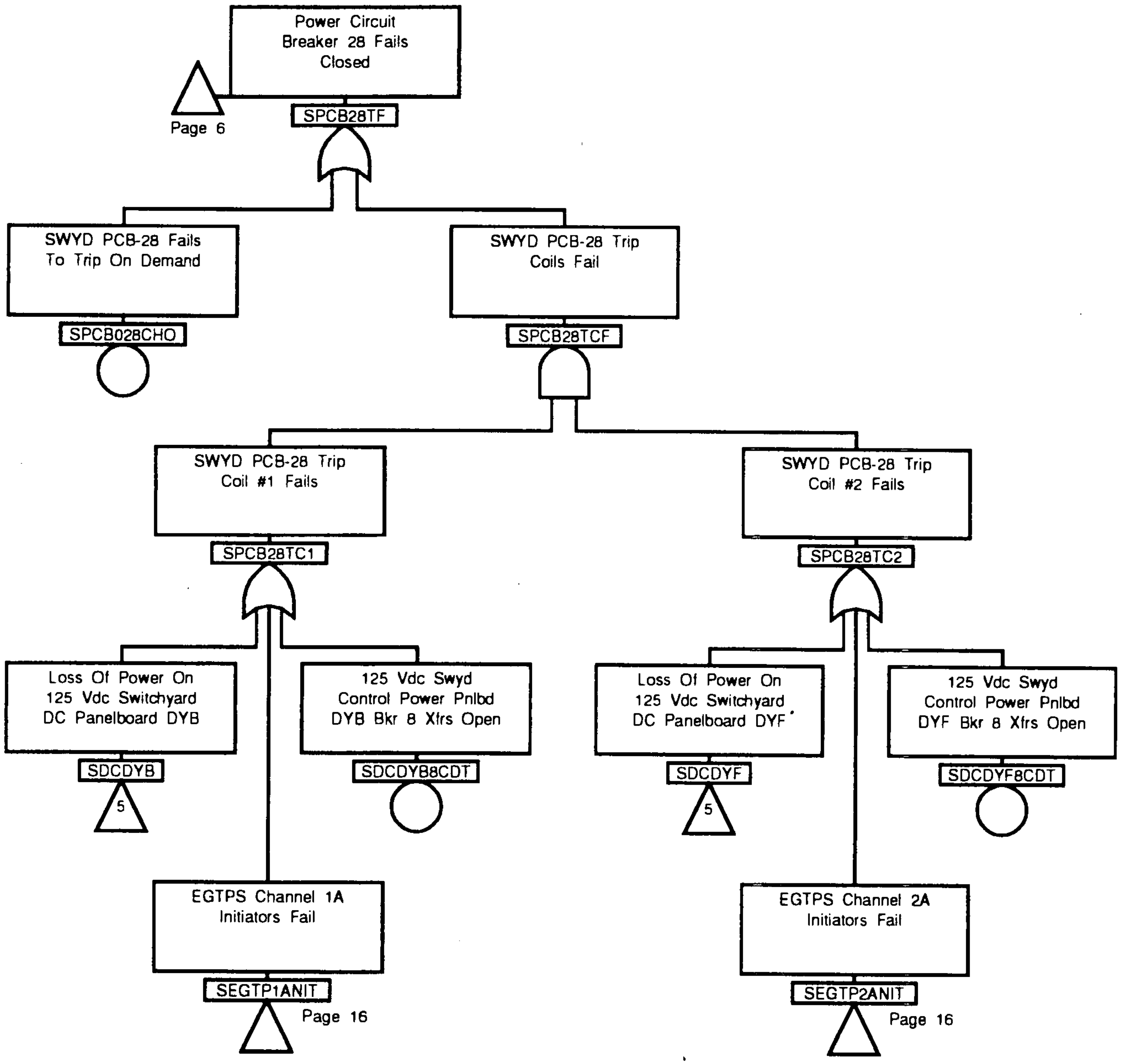


Keowee Emergency Power Paths Fault Tree | FIGURE A.2-2 |

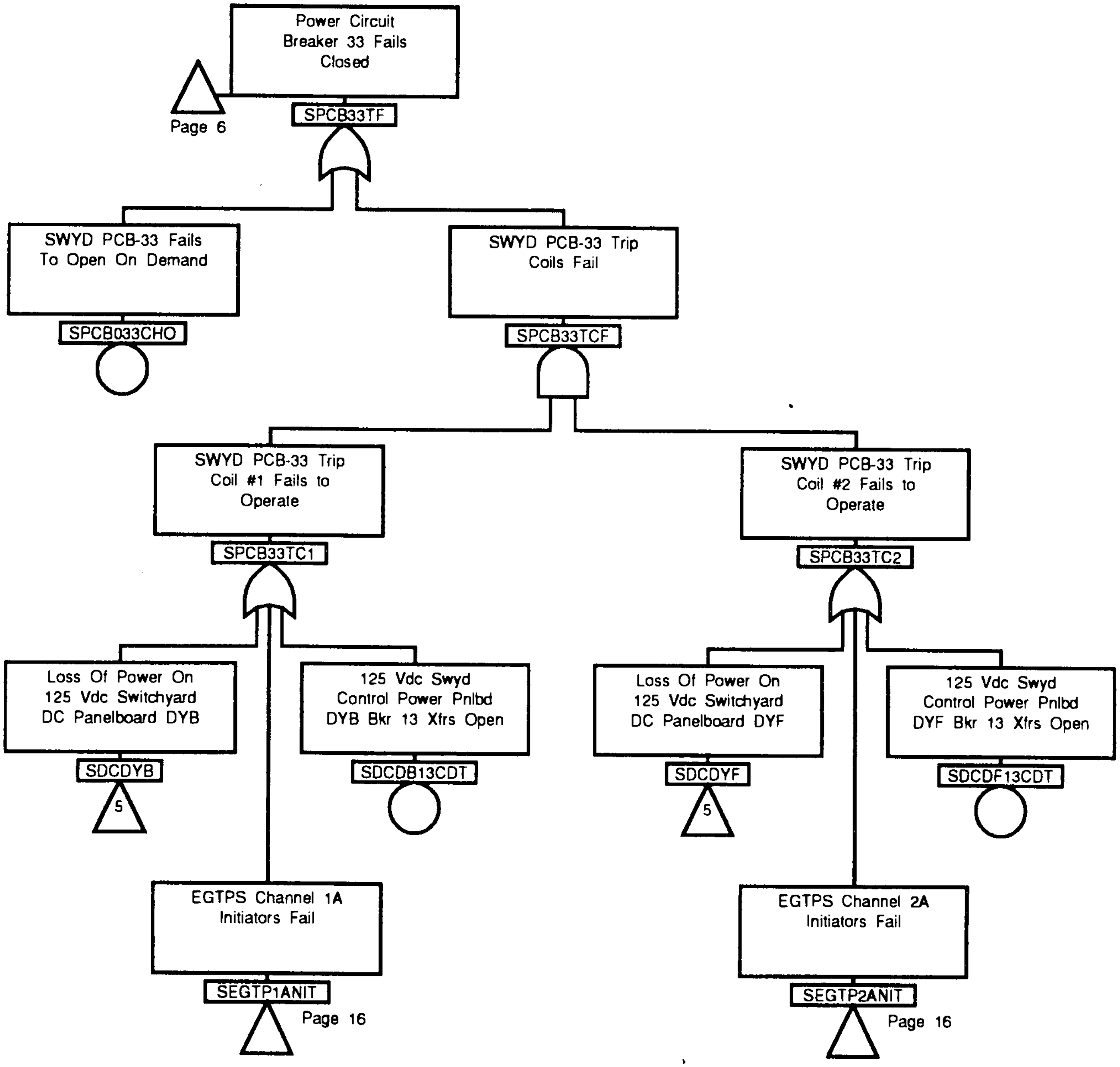

Power Circuit Breaker 24 Fails Closed
Page 6
SPCB24TF
SWYD PCB-24 Fails To Trip On Demand
SPCB024CHO
SWYD PCB-24 Trip Coils Fail
SPCB24TCF
SWYD PCB-24 Trip Coil #1 Fails to Operate
SPCB24TC1
SWYD PCB-24 Trip Coil #2 Fails to Operate
SPCB24TC2
Loss Of Power On 125 Vdc Switchyard DC Panelboard DYB
SDCDYB
5
125 Vdc Swyd Control Power Pnlbd DYB Bkr 4 Xfrs Open
SDCDYB4CDT
Loss Of Power On 125 Vdc Switchyard DC Panelboard DYF
SDCDYF
5
125 Vdc Swyd Control Power Pnlbd DYF Bkr 4 Xfrs Open
SDCDYF4CDT
EGTPS Channel 1A Initiators Fail
SEGTP1ANIT
Page 16
EGTPS Channel 2A Initiators Fail
SEGTP2ANIT
Page 16



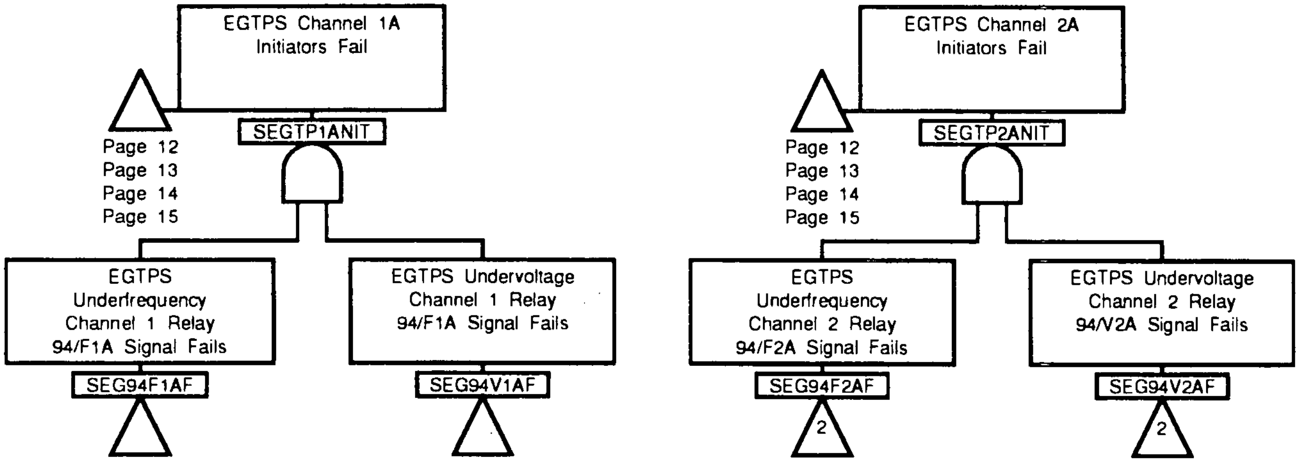
Keeowee Emergency Power Paths Fault Tree | FIGURE A.2-2 |



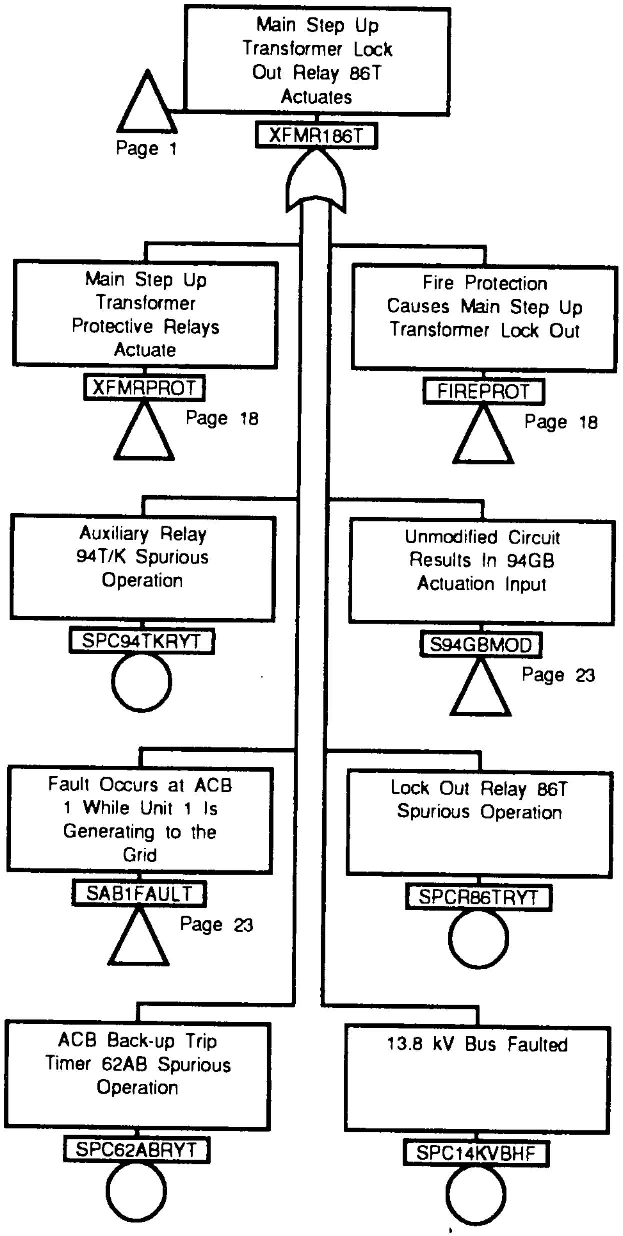
Keowee Emergency Power Paths Fault Tree | FIGURE A.2-2 |

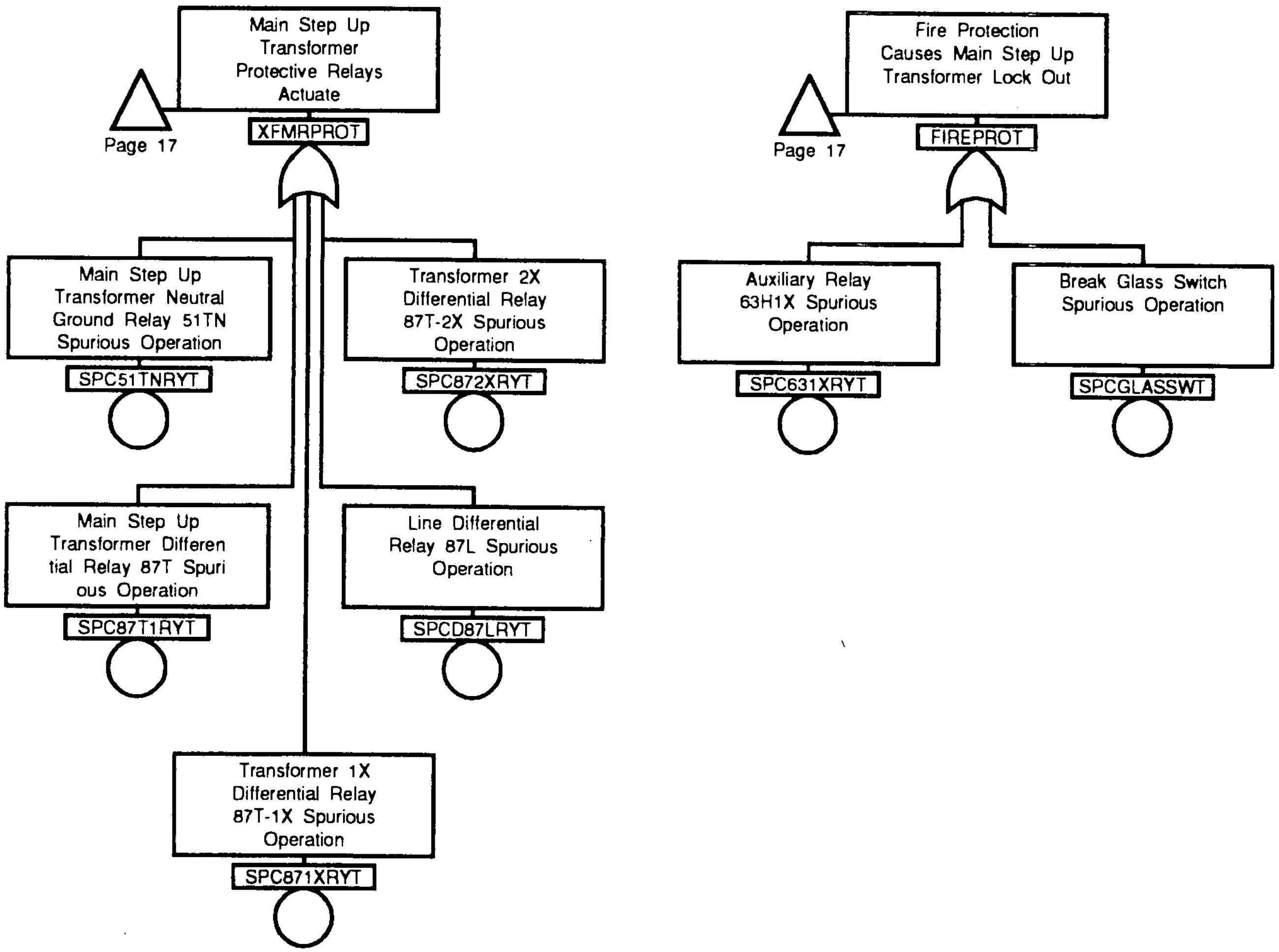


Keowee Emergency Power Paths Fault Tree	FIGURE A.2-2	Page 15

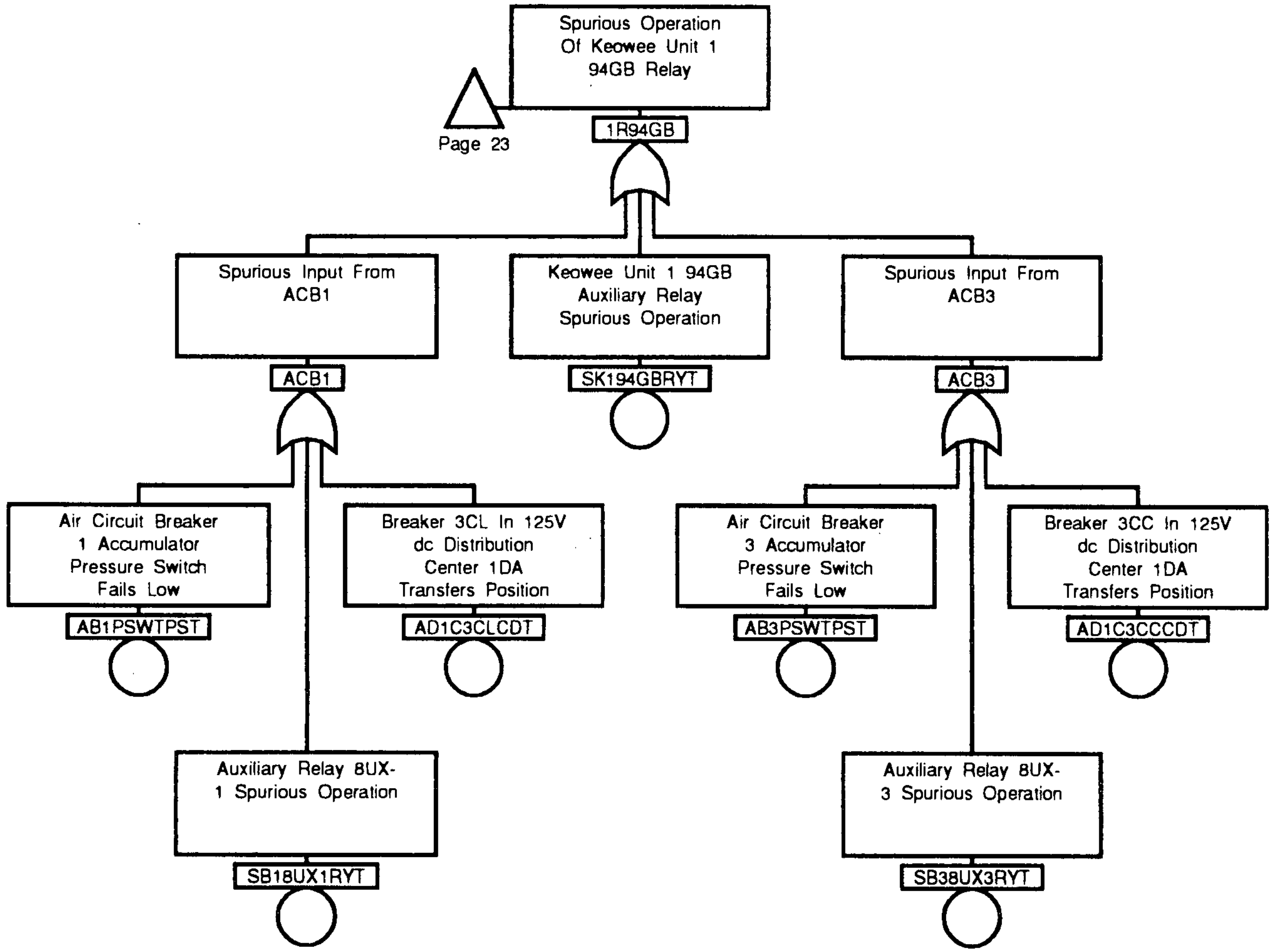


Keowee Emergency Power Paths Fault Tree	FIGURE A.2-2	Page 16

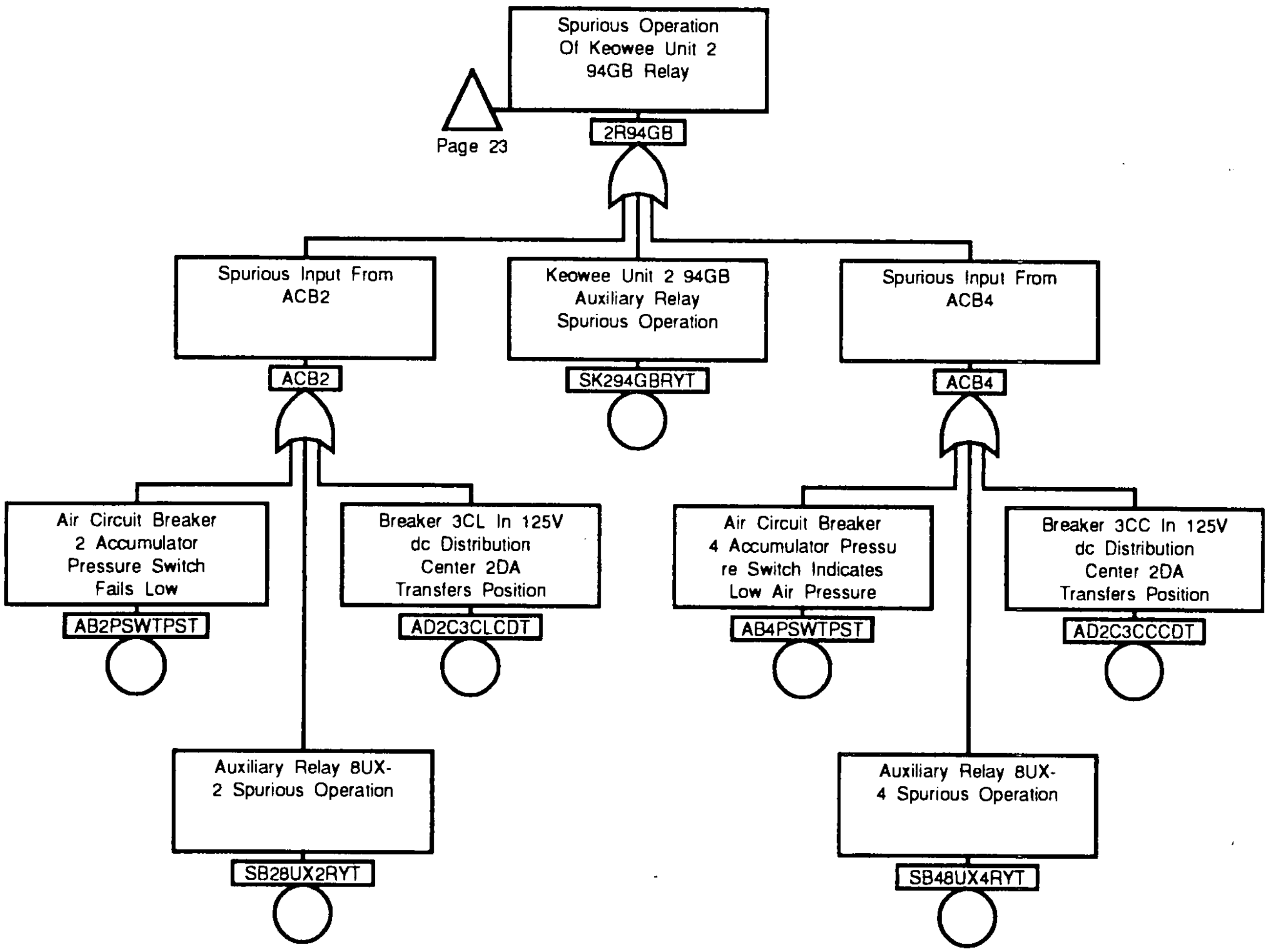

Main Step Up Transformer Lock Out Relay 86T Actuates
XFMR186T
Page 1
Main Step Up Transformer Protective Relays Actuate
XFMRPROT
Page 18
Fire Protection Causes Main Step Up Transformer Lock Out
FIREPROT
Page 18
Auxiliary Relay 94T/K Spurious Operation
SPC94TKRYT
Unmodified Circuit Results In 94GB Actuation Input
S94GBMOD
Page 23
Fault Occurs at ACB 1 While Unit 1 Is Generating to the Grid
SAB1FAULT
Page 23
Lock Out Relay 86T Spurious Operation
SPCR86TRYT
ACB Back-up Trip Timer 62AB Spurious Operation
SPC62ABRYT
13.8 kV Bus Faulted
SPC14KVBHF



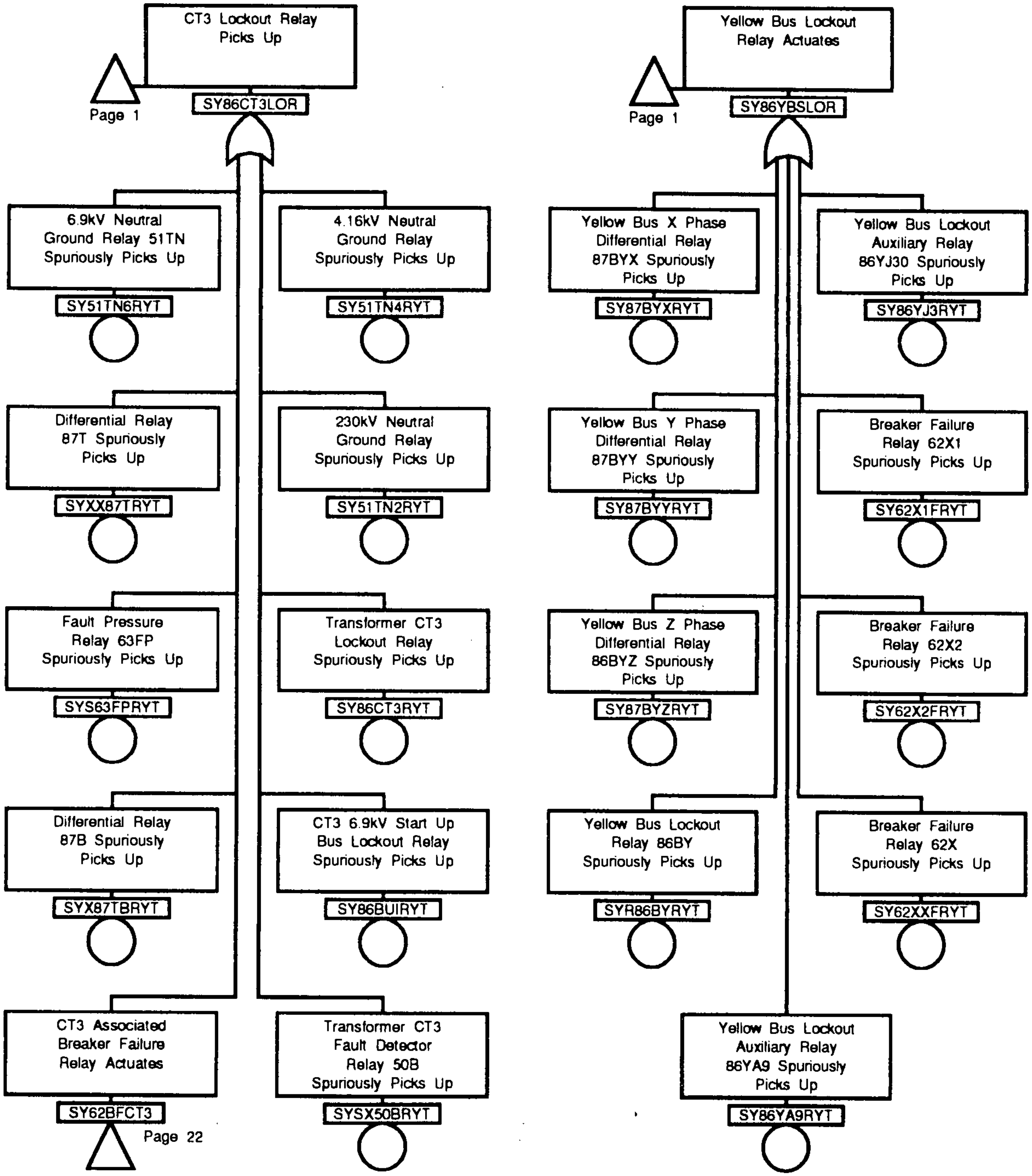
Keowee Emergency Power Paths Fault Tree | FIGURE A.2-2 |



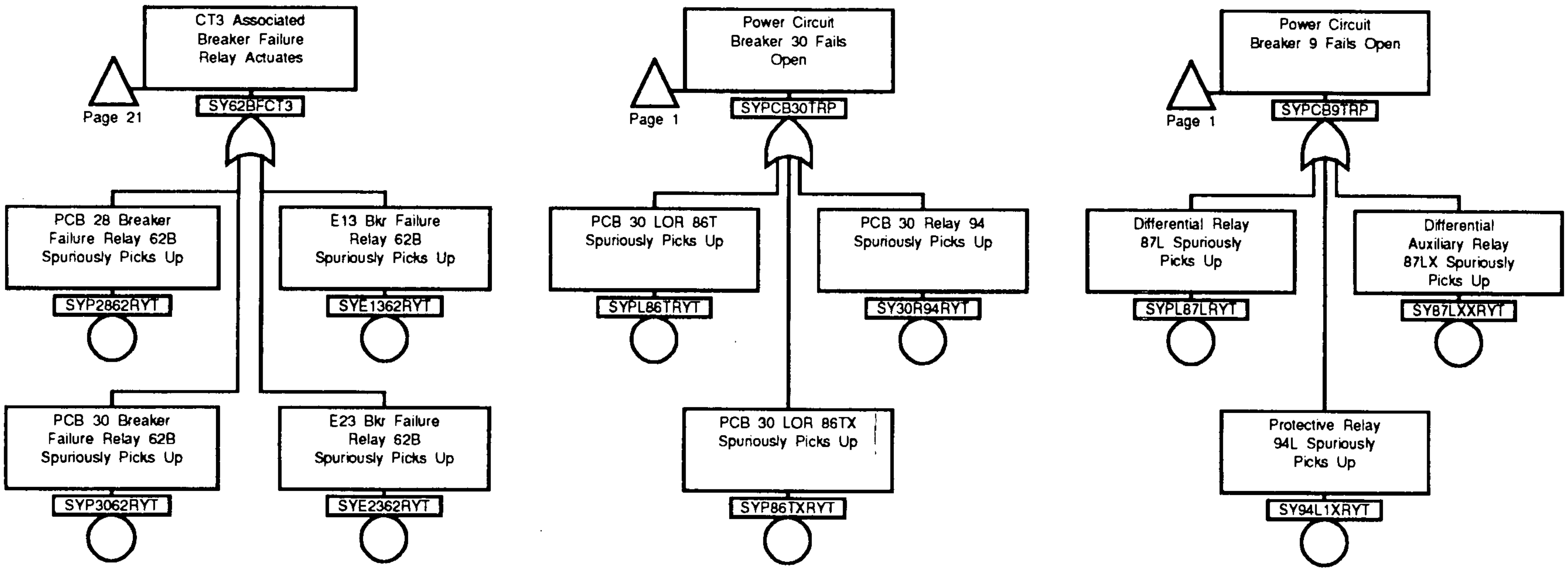
Keowee Emergency Power Paths Fault Tree	FIGURE A.2-2	Page 19



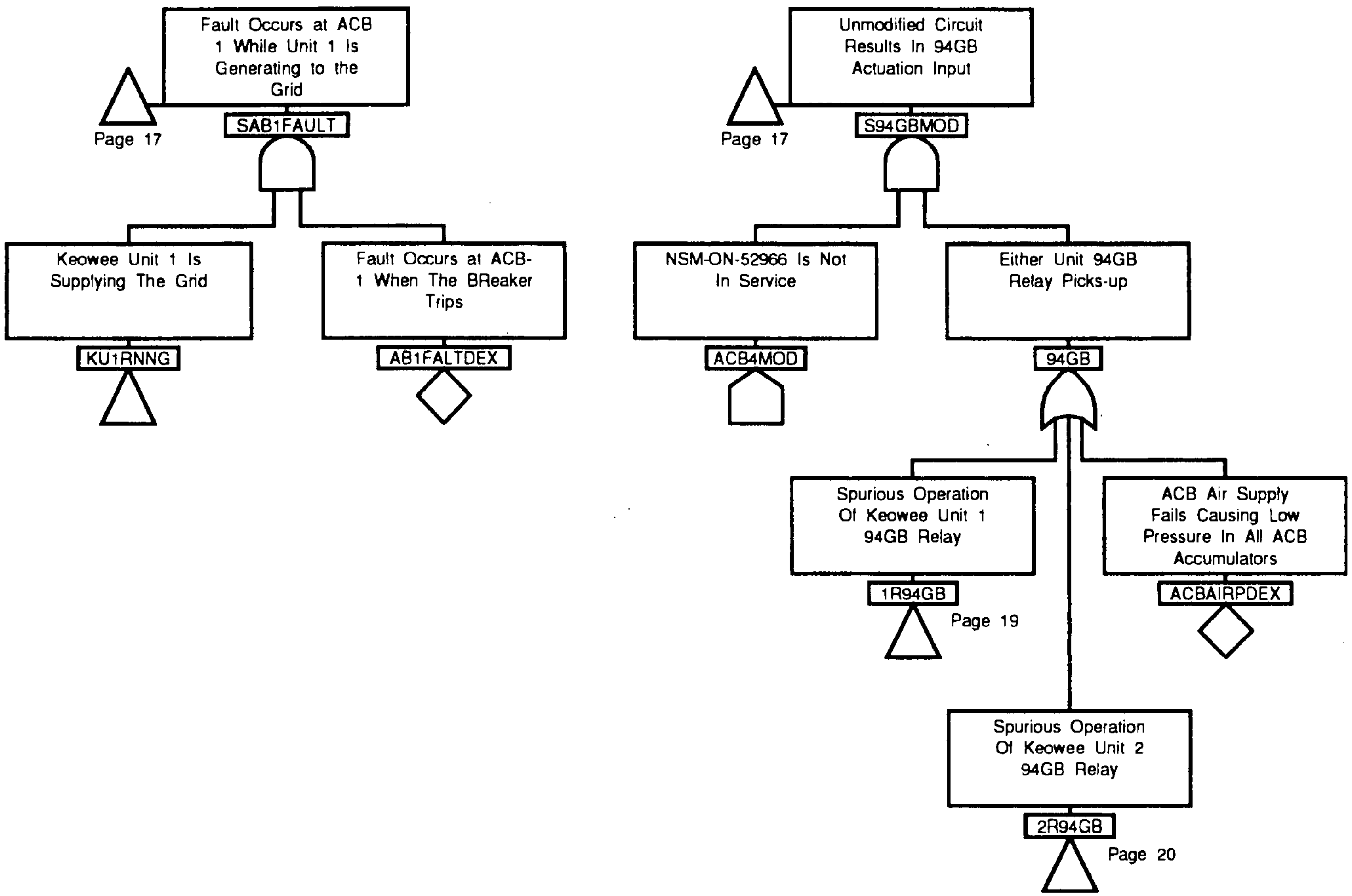
Keowee Emergency Power Paths Fault Tree	FIGURE A.2-2	Page 20



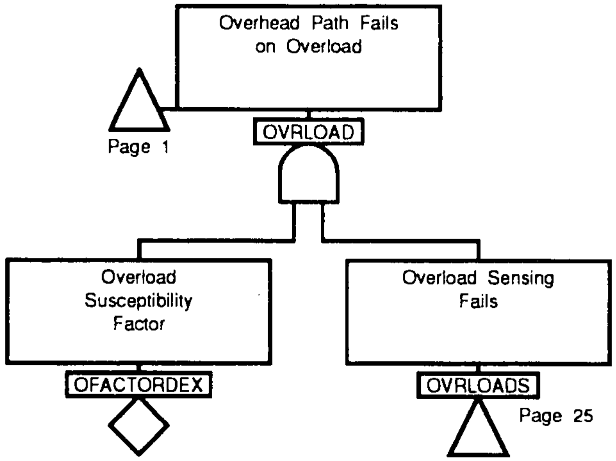
Keowee Emergency Power Paths Fault Tree | FIGURE A.2-2 |



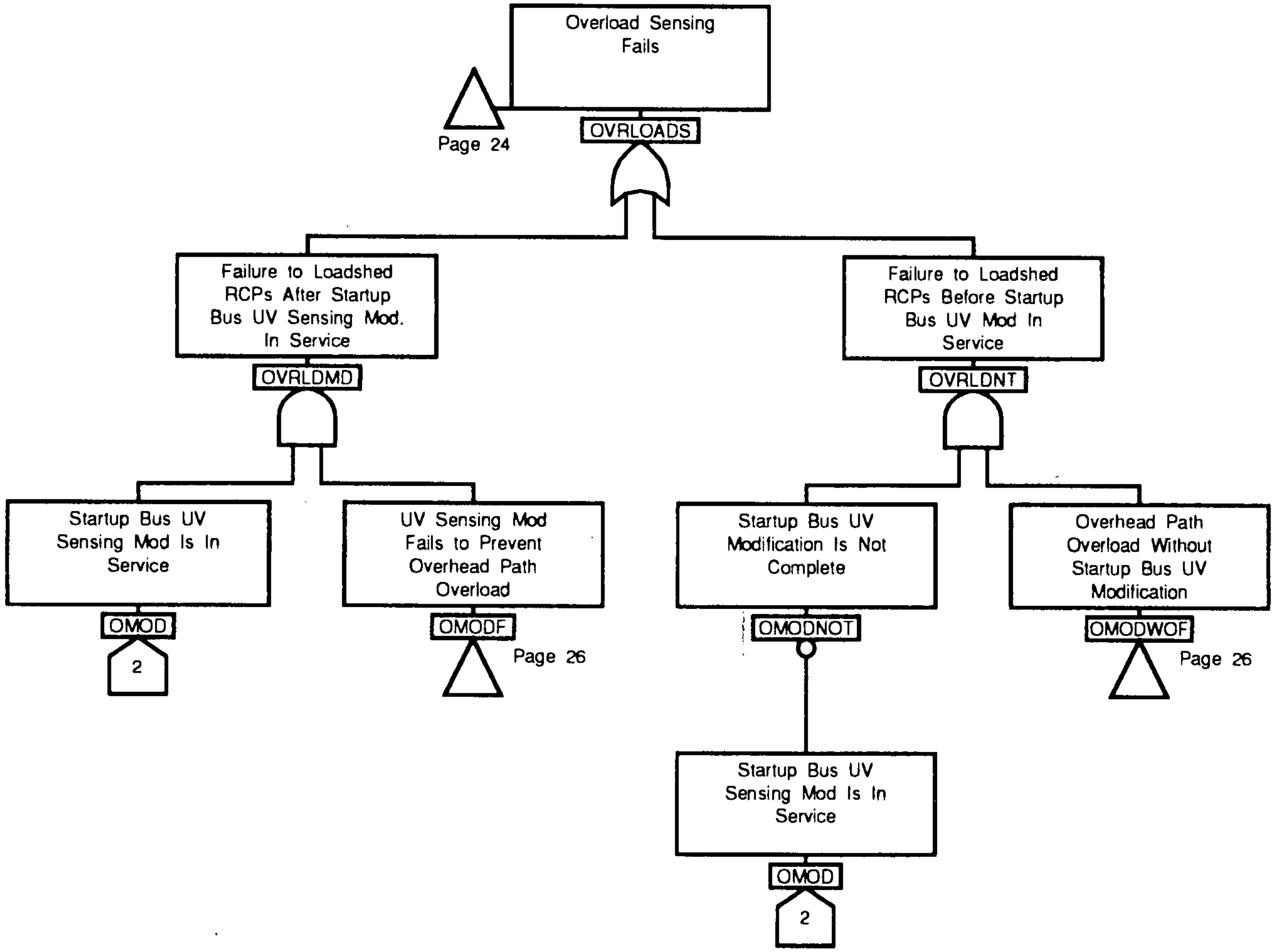
CT3 Associated Breaker Failure Relay Actuates
SY62BFCT3
Page 21
PCB 28 Breaker Failure Relay 62B Spuriously Picks Up
SYP2862RYT
E13 Bkr Failure Relay 62B Spuriously Picks Up
SYE1362RYT
PCB 30 Breaker Failure Relay 62B Spuriously Picks Up
SYP3062RYT
E23 Bkr Failure Relay 62B Spuriously Picks Up
SYE2362RYT
Power Circuit Breaker 30 Fails Open
SYPCB30TRP
Page 1
PCB 30 LOR 86T Spuriously Picks Up
SYPL86TRYT
PCB 30 Relay 94 Spuriously Picks Up
SY30R94RYT
PCB 30 LOR 86TX Spuriously Picks Up
SYP86TXRYT
Power Circuit Breaker 9 Fails Open
SYPCB9TRP
Page 1
Differential Relay 87L Spuriously Picks Up
SYPL87LRYT
Differential Auxiliary Relay 87LX Spuriously Picks Up
SY87LXXRYT
Protective Relay 94L Spuriously Picks Up
SY94L1XRYT



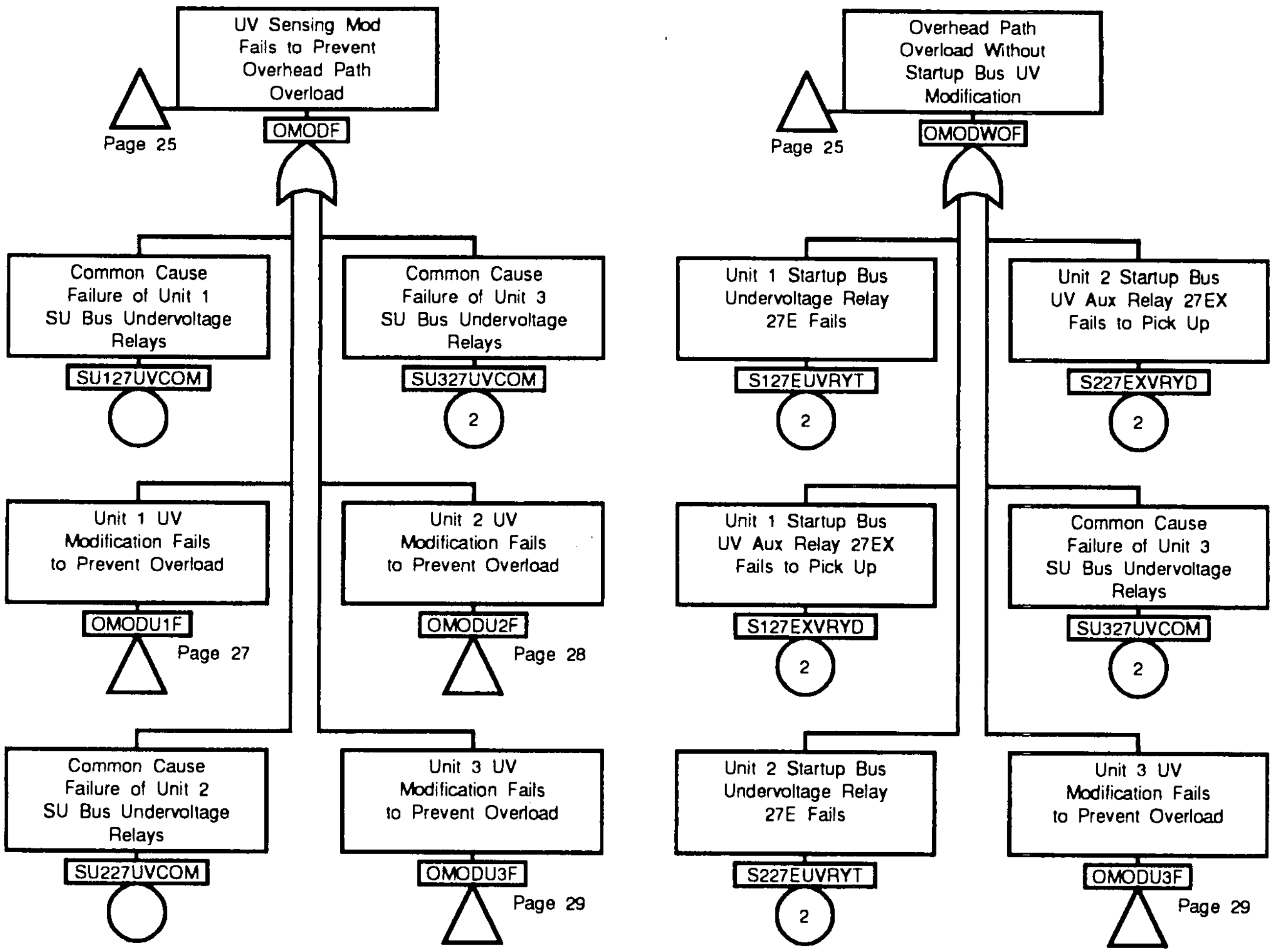
Fault Occurs at ACB 1 While Unit 1 Is Generating to the Grid
Page 17
SAB1FAULT
Keowee Unit 1 Is Supplying The Grid
KU1RNNG
Fault Occurs at ACB-1 When The BReaker Trips
AB1FALTDEX
Unmodified Circuit Results In 94GB Actuation Input
Page 17
S94GBMOD
NSM-ON-52966 Is Not In Service
ACB4MOD
Either Unit 94GB Relay Picks-up
94GB
Spurious Operation Of Keowee Unit 1 94GB Relay
1R94GB
Page 19
ACB Air Supply Fails Causing Low Pressure In All ACB Accumulators
ACBAIRPDEX
Spurious Operation Of Keowee Unit 2 94GB Relay
2R94GB
Page 20



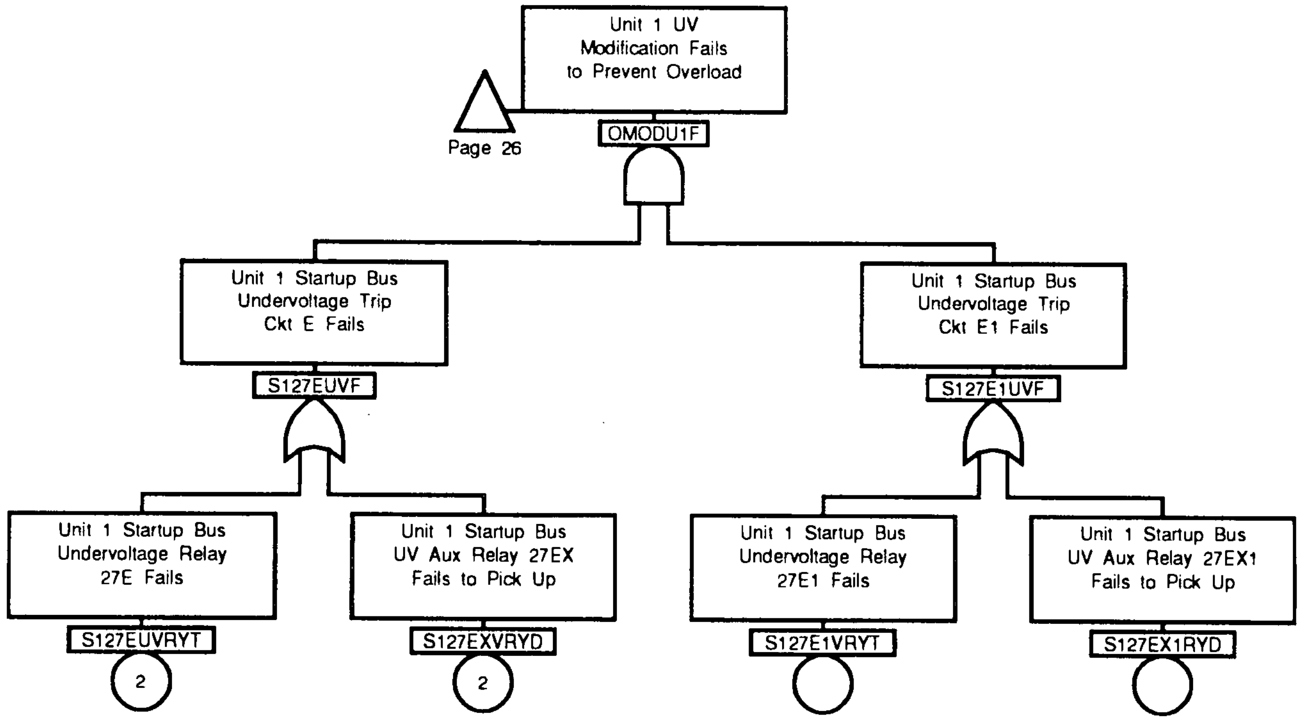
Keeowee Emergency Power Paths Fault Tree | FIGURE A.2-2 |

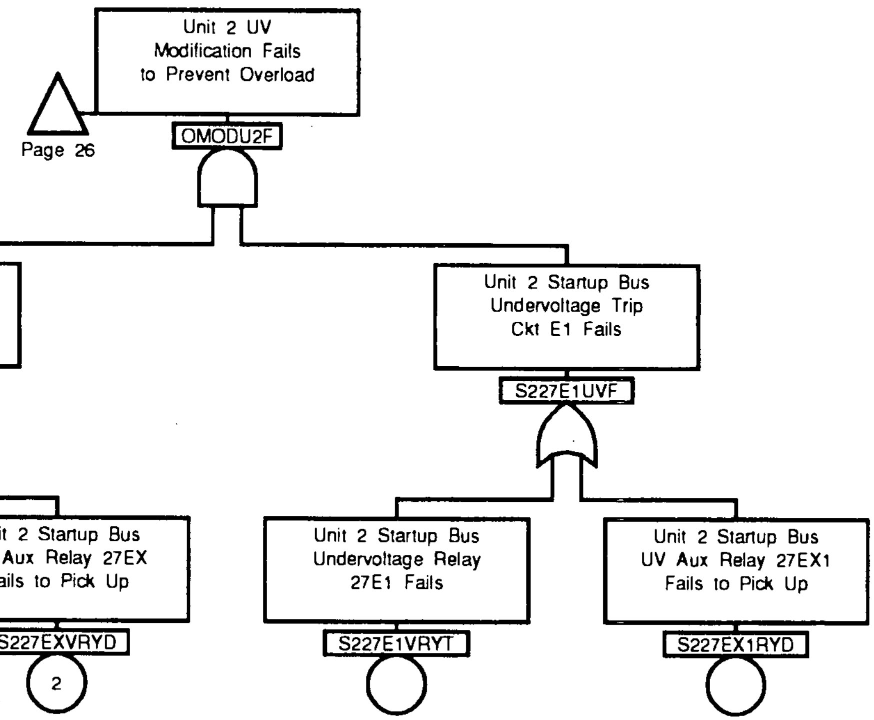


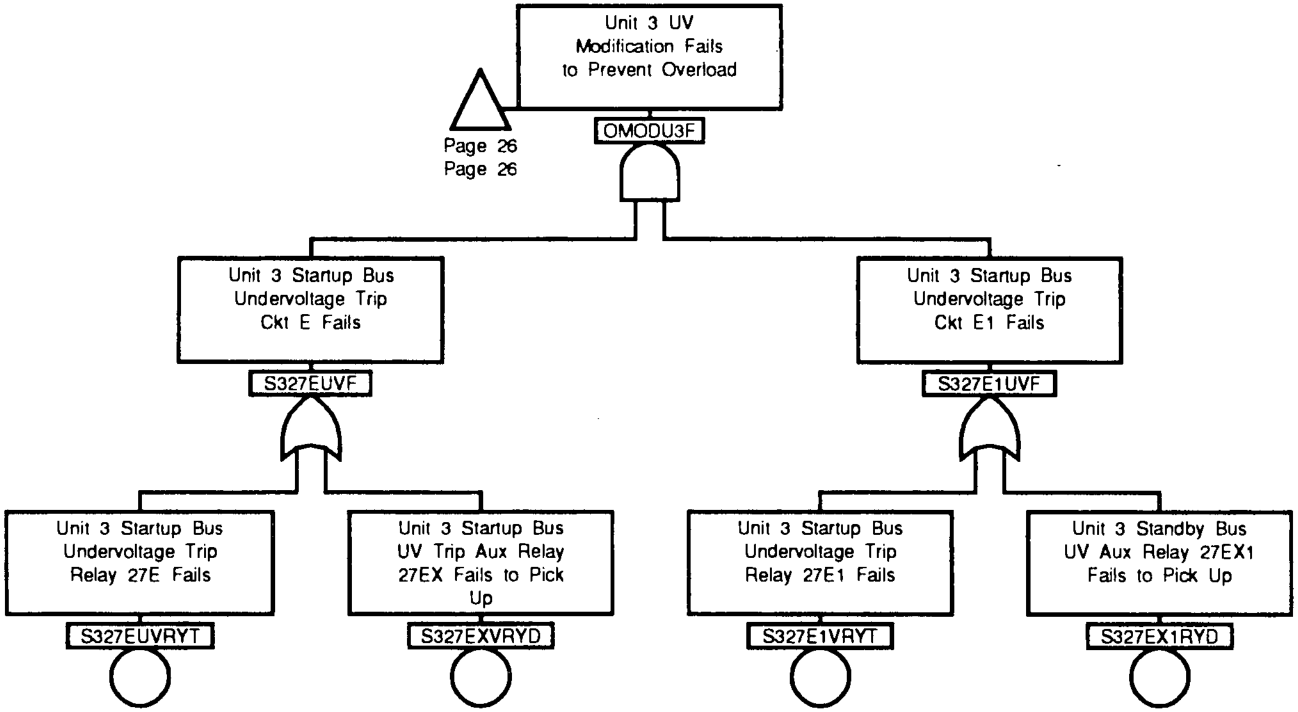
Overload Sensing Fails
Page 24
OVRLOADS
Failure to Loadshed RCPs After Startup Bus UV Sensing Mod. In Service
OVRLDMD
Failure to Loadshed RCPs Before Startup Bus UV Mod In Service
OVRLDNT
Startup Bus UV Sensing Mod Is In Service
OMOD
2
UV Sensing Mod Fails to Prevent Overhead Path Overload
OMODF
Page 26
Startup Bus UV Modification Is Not Complete
OMODNOT
Overhead Path Overload Without Startup Bus UV Modification
OMODWOF
Page 26
Startup Bus UV Sensing Mod Is In Service
OMOD
2

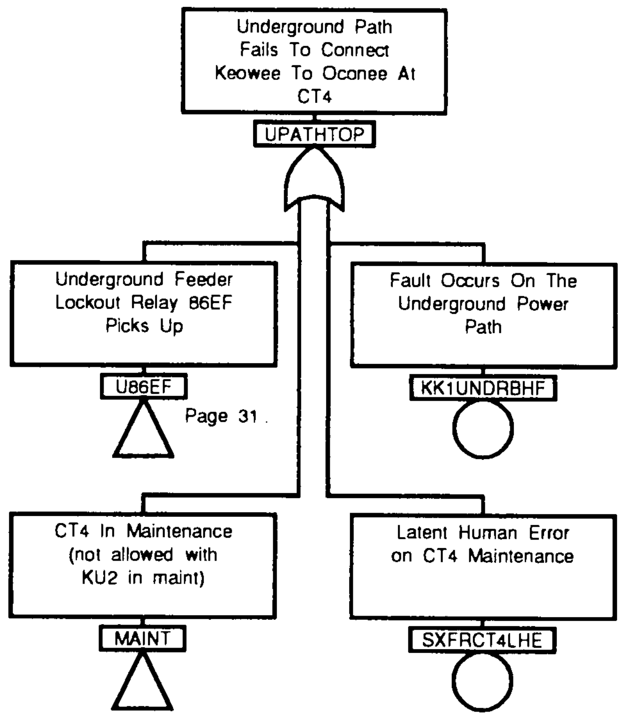


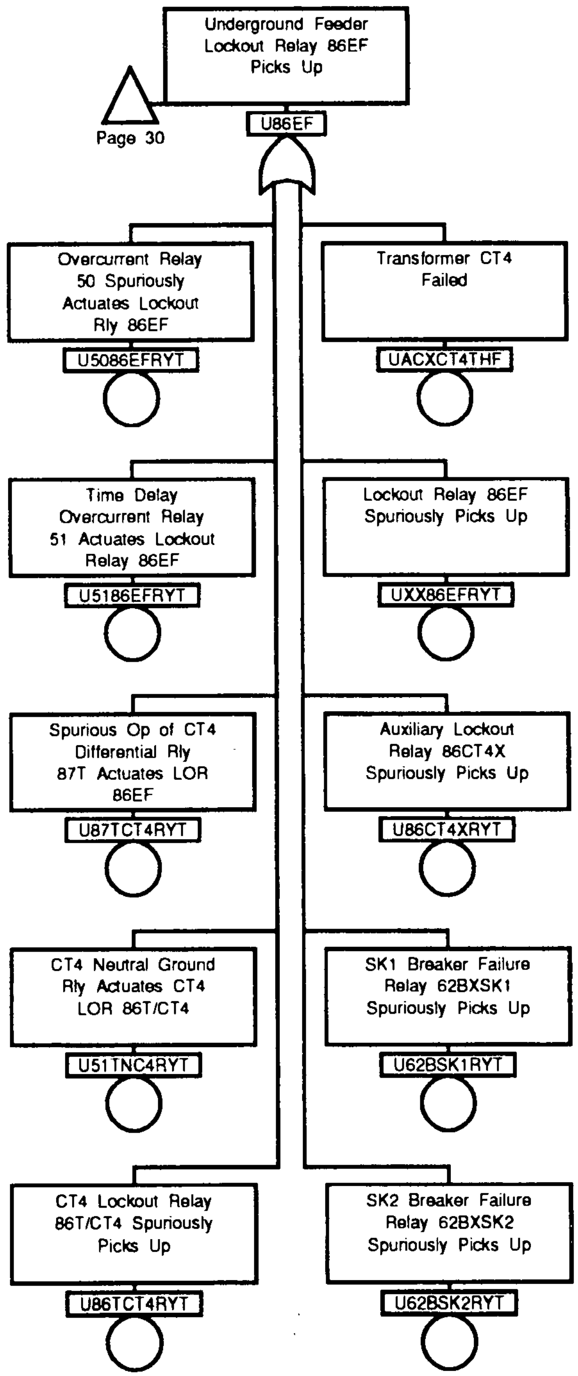
Keowee Emergency Power Paths Fault Tree | FIGURE A.2-2 |


Unit 1 UV
Modification Fails
to Prevent Overload
OMODU1F
Page 26
Unit 1 Startup Bus
Undervoltage Trip
Ckt E Fails
S127EUVF
Unit 1 Startup Bus
Undervoltage Trip
Ckt E1 Fails
S127E1UVF
Unit 1 Startup Bus
Undervoltage Relay
27E Fails
S127EUVRYT
2
Unit 1 Startup Bus
UV Aux Relay 27EX
Fails to Pick Up
S127EXVRYD
2
Unit 1 Startup Bus
Undervoltage Relay
27E1 Fails
S127E1VRYT
Unit 1 Startup Bus
UV Aux Relay 27EX1
Fails to Pick Up
S127EX1RYD


Unit 2 UV
Modification Fails
to Prevent Overload
OMODU2F
Page 26
Unit 2 Startup Bus
Undervoltage Trip
Ckt E Fails
S227EUVF
Unit 2 Startup Bus
Undervoltage Trip
Ckt E1 Fails
S227E1UVF
Unit 2 Startup Bus
Undervoltage Relay
27E Fails
S227EUVRYT
2
Unit 2 Startup Bus
UV Aux Relay 27EX
Fails to Pick Up
S227EXVRYD
2
Unit 2 Startup Bus
Undervoltage Relay
27E1 Fails
S227E1VRYT
Unit 2 Startup Bus
UV Aux Relay 27EX1
Fails to Pick Up
S227EX1RYD


Unit 3 UV Modification Fails to Prevent Overload
OMODU3F
Page 26
Page 26
Unit 3 Startup Bus Undervoltage Trip Ckt E Fails
S327EUVF
Unit 3 Startup Bus Undervoltage Trip Ckt E1 Fails
S327E1UVF
Unit 3 Startup Bus Undervoltage Trip Relay 27E Fails
S327EUVRYT
Unit 3 Startup Bus UV Trip Aux Relay 27EX Fails to Pick Up
S327EXVRYD
Unit 3 Startup Bus Undervoltage Trip Relay 27E1 Fails
S327E1VRYT
Unit 3 Standby Bus UV Aux Relay 27EX1 Fails to Pick Up
S327EX1RYD


Underground Path Fails To Connect Keowee To Oconee At CT4
UPATHTOP
Underground Feeder Lockout Relay 86EF Picks Up
U86EF
Page 31
Fault Occurs On The Underground Power Path
KK1UNDRBHF
CT4 In Maintenance (not allowed with KU2 in maint)
MAINT
Latent Human Error on CT4 Maintenance
SXFRCT4LHE



Underground Feeder Lockout Relay 86EF Picks Up
U86EF
Page 30
Overcurrent Relay 50 Spuriously Actuates Lockout Rly 86EF
U5086EFRYT
Transformer CT4 Failed
UACXCT4THF
Time Delay Overcurrent Relay 51 Actuates Lockout Relay 86EF
U5186EFRYT
Lockout Relay 86EF Spuriously Picks Up
UXX86EFRYT
Spurious Op of CT4 Differential Rly 87T Actuates LOR 86EF
U87TCT4RYT
Auxiliary Lockout Relay 86CT4X Spuriously Picks Up
U86CT4XRYT
CT4 Neutral Ground Rly Actuates CT4 LOR 86T/CT4
U51TNC4RYT
SK1 Breaker Failure Relay 62BXSK1 Spuriously Picks Up
U62BSK1RYT
CT4 Lockout Relay 86T/CT4 Spuriously Picks Up
U86TCT4RYT
SK2 Breaker Failure Relay 62BXSK2 Spuriously Picks Up
U62BSK2RYT

Gate/Event Name	Page	Zone	Gate/Event Name	Page	Zone	Gate/Event Name	Page	Zone	Gate/Event Name	Page	Zone
1R94GB	19		OMODNOT	25		S27XSC2RYD	5		SDCDYA9CDT	3	
1R94GB	23		OMODU1F	26		S27XTD1RYD	5		SDCDYB	11	
2R94GB	20		OMODU1F	27		S27XTD2RYD	5		SDCDYB	12	
2R94GB	23		OMODU2F	26		S327E1UVF	29		SDCDYB	13	
94GB	23		OMODU2F	28		S327E1VRYT	29		SDCDYB	14	
AB1FALTDEX	23		OMODU3F	26		S327EUVF	29		SDCDYB	15	
AB1PSWTPST	19		OMODU3F	26		S327EUVRYT	29		SDCDYB4CDT	12	
AB2PSWTPST	20		OMODU3F	29		S327EX1RYD	29		SDCDYB6CDT	13	
AB3PSWTPST	19		OMODWOF	25		S327EXVRYD	29		SDCDYB8CDT	14	
AB4PSWTPST	20		OMODWOF	26		S94GBMOD	17		SDCDYC	5	
ACB1	19		OPATHTOP	1		S94GBMOD	23		SDCDYE	2	
ACB2	20		OPATHTOPB	1		SAB1FAULT	17		SDCDYE	3	
ACB2DISC	1		OPATHTOPC	1		SAB1FAULT	23		SDCDYE	7	
ACB2OPEN	1		OVRLDMD	25		SB18UX1RYT	19		SDCDYE	8	
ACB3	19		OVRLDNT	25		SB28UX2RYT	20		SDCDYE	9	
ACB4	20		OVRLOAD	1		SB38UX3RYT	19		SDCDYE	10	
ACB4MOD	23		OVRLOAD	24		SB48UX4RYT	20		SDCDYE8CDT	7	
ACBAIRPDEX	23		OVRLOADS	24		SDCAIDDDIF	3		SDCDYE9CDT	2	
AD1C3CCCDT	19		OVRLOADS	25		SDCDA12CDT	8		SDCDYE9CDT	3	
AD1C3CLCDT	19		PCB9OPEN	1		SDCDA15CDT	9		SDCDYF	11	
AD2C3CCCDT	20		PCB9OPEN	2		SDCDA17CDT	10		SDCDYF	12	
AD2C3CLCDT	20		S127E1UVF	27		SDCDB01CDT	11		SDCDYF	13	
ASWYDISO	1		S127E1VRYT	27		SDCDB13CDT	15		SDCDYF	14	
FIREPROT	17		S127EUVF	27		SDCDC12CDT	5		SDCDYF	15	
FIREPROT	18		S127EUVRYT	26		SDCDE12CDT	8		SDCDYF4CDT	12	
KK1OVERBHF	1		S127EUVRYT	27		SDCDE15CDT	9		SDCDYF6CDT	13	
KK1UNDRBHF	30		S127EX1RYD	27		SDCDE17CDT	10		SDCDYF8CDT	14	
KU1RNNG	23		S127EXVRYD	26		SDCDF01CDT	11		SDCDYG	5	
KU2RNNG	1		S127EXVRYD	27		SDCDF13CDT	15		SDCEIDDDIF	3	
KU2SWYD	1		S227E1UVF	28		SDCDG16CDT	5		SEG122INIT	8	
L27XSTARYD	2		S227E1VRYT	28		SDCDYA	2		SEG152INIT	9	
L27XSTBRYD	2		S227EUVF	28		SDCDYA	3		SEG94F1AF	16	
MAINT	30		S227EUVRYT	26		SDCDYA	7		SEG94F1DF	4	
OFACTORDEX	24		S227EUVRYT	28		SDCDYA	8		SEG94F1DF	11	
OMOD	25		S227EX1RYD	28		SDCDYA	9		SEG94F2AF	8	
OMOD	25		S227EXVRYD	26		SDCDYA	10		SEG94F2AF	16	
OMODF	25		S227EXVRYD	28		SDCDYA8CDT	7		SEG94F2BF	8	
OMODF	26		S27XSC1RYD	5		SDCDYA9CDT	2		SEG94F2BF	9	

Gate/Event Name	Page	Zone	Gate/Event Name	Page	Zone	Gate/Event Name	Page	Zone	Gate/Event Name	Page	Zone
SEG94F2CF	9		SPC51TNRYT	18		SPCB17TF	6		SPCISLTCPT	3	
SEG94F2DF	4		SPC62ABRYT	17		SPCB17TF	10		SPCISLTCPT	5	
SEG94F2DF	11		SPC631XRYT	18		SPCB21TC1	11		SPCISOCCH1	5	
SEG94V1AF	16		SPC871XRYT	18		SPCB21TC2	11		SPCISOCCH2	5	
SEG94V1DF	4		SPC872XRYT	18		SPCB21TCF	6		SPCISOF	5	
SEG94V1DF	11		SPC87T1RYT	18		SPCB21TCF	11		SPCISOF	5	
SEG94V2AF	8		SPC94TKRYT	17		SPCB21TF	6		SPCISOF	6	
SEG94V2AF	16		SPCB008CHO	7		SPCB24TC1	12		SPCISOLATE	3	
SEG94V2BF	8		SPCB009CHC	3		SPCB24TC2	12		SPCISOLATE	4	
SEG94V2BF	9		SPCB009CHO	2		SPCB24TCF	12		SPCR86TRYT	17	
SEG94V2CF	9		SPCB012CHO	8		SPCB24TF	6		SU127UVCOM	26	
SEG94V2DF	4		SPCB015CHO	9		SPCB24TF	12		SU227UVCOM	26	
SEG94V2DF	11		SPCB017CHO	10		SPCB26TC1	13		SU327UVCOM	26	
SEGTP1ANIT	12		SPCB021CHO	6		SPCB26TC2	13		SU327UVCOM	26	
SEGTP1ANIT	13		SPCB024CHO	12		SPCB26TCF	13		SXFRCT3THF	1	
SEGTP1ANIT	14		SPCB026CHO	13		SPCB26TF	6		SXFRCT3THM	1	
SEGTP1ANIT	15		SPCB028CHO	14		SPCB26TF	13		SY30R94RYT	22	
SEGTP1ANIT	16		SPCB033CHO	15		SPCB28TC1	14		SY51TN2RYT	21	
SEGTP1BNIT	2		SPCB08TCF	7		SPCB28TC2	14		SY51TN4RYT	21	
SEGTP1BNIT	7		SPCB08TF	1		SPCB28TCF	14		SY51TN6RYT	21	
SEGTP1BNIT	8		SPCB08TF	6		SPCB28TF	6		SY62BFCT3	21	
SEGTP1BNIT	9		SPCB08TF	7		SPCB28TF	14		SY62BFCT3	22	
SEGTP1BNIT	10		SPCB09CF	1		SPCB33TC1	15		SY62X1FRYT	21	
SEGTP1DNIT	11		SPCB09CF	3		SPCB33TC2	15		SY62X2FRYT	21	
SEGTP2ANIT	12		SPCB09TCF	2		SPCB33TCF	15		SY62XXFRYT	21	
SEGTP2ANIT	13		SPCB12TC1	8		SPCB33TF	6		SY86BUIRYT	21	
SEGTP2ANIT	14		SPCB12TC2	8		SPCB33TF	15		SY86CT3LOR	1	
SEGTP2ANIT	15		SPCB12TCF	8		SPCB8TC1F	7		SY86CT3LOR	21	
SEGTP2ANIT	16		SPCB12TF	6		SPCB8TC2F	7		SY86CT3RYT	21	
SEGTP2BNIT	2		SPCB12TF	8		SPCB9CDC1	3		SY86YA9RYT	21	
SEGTP2BNIT	7		SPCB15TC1	9		SPCB9CDC2	3		SY86YBSLOR	1	
SEGTP2BNIT	10		SPCB15TC2	9		SPCB9TC1F	2		SY86YBSLOR	21	
SEGTP2DNIT	11		SPCB15TCF	9		SPCB9TC2F	2		SY86YJ3RYT	21	
SEGTPSCH1F	2		SPCB15TF	6		SPCBSFC1	6		SY87BYXRYT	21	
SEGTPSCH2F	2		SPCB15TF	9		SPCBSFC2	6		SY87BYYRYT	21	
SK194GBRYT	19		SPCB17TC1	10		SPCCB9CF	3		SY87BYZRYT	21	
SK294GBRYT	20		SPCB17TC2	10		SPCD87LRYT	18		SY87LXXRYT	22	
SPC14KVBHF	17		SPCB17TCF	10		SPCGLASSWT	18		SY94L1XRYT	22	

Gate/Event Name	Page	Zone	Gate/Event Name	Page	Zone	Gate/Event Name	Page	Zone	Gate/Event Name	Page	Zone
SYE1362RYT	22										
SYE2362RYT	22										
SYP2862RYT	22										
SYP3062RYT	22										
SYP86TXRYT	22										
SYPCB09CHT	1										
SYPCB30CHT	1										
SYPCB30TRP	1										
SYPCB30TRP	22										
SYPCB9TRP	1										
SYPCB9TRP	22										
SYPL86TRYT	22										
SYPL87LRYT	22										
SYR86BYRYT	21										
SYS63FPRYT	21										
SYSX50BRYT	21										
SYX87TBRYT	21										
SYXX87TRYT	21										
U5086EFRYT	31										
U5186EFRYT	31										
U51TNC4RYT	31										
U62BSK1RYT	31										
U62BSK2RYT	31										
U86CT4XRYT	31										
U86EF	30										
U86EF	31										
U86TCT4RYT	31										
U87TCT4RYT	31										
UACXCT4THF	31										
UPATHTOP	30										
UXX86EFRYT	31										
XFMR186T	1										
XFMR186T	17										
XFMRPROT	17										
XFMRPROT	18										

APPENDIX A.3
EXTERNAL GRID TROUBLE PROTECTION SYSTEM

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LIST OF FIGURES

A.3 EXTERNAL GRID TROUBLE PROTECTION SYSTEM

A.3.1 OBJECTIVES

The main objective of this analysis is to develop a logic model of the External Grid Trouble Protection System (EGTPS). This model is combined with the high-level model and remaining system models to form an integrated model for assessing the reliability of Keowee. Other objectives are to identify major contributors to system unreliability, significant potential human errors and common-cause failure modes.

The scope of this analysis is limited to EGTPS equipment required to support a Keowee emergency start and run under load following a loss of off-site power condition.

A.3.2 SYSTEM DESIGN

The EGTPS provides detection of impending collapse or degraded voltage on the 230 kV grid or the 230 kV Switchyard when voltage and/or frequency on the 230 kV red and yellow buses deteriorates to system actuation set points. When the system actuates, it provides Emergency Start (ES) signals to the Keowee hydro units. The system then provides the breaker manipulation logic to isolate the 230 kV switchyard yellow bus and establish the overhead power path from the Keowee unit aligned to the overhead power path through the isolated switchyard yellow bus to the startup transformers of all three Oconee units.

The EGTPS contains two undervoltage and two underfrequency initiation channels consisting of networks of undervoltage relays and underfrequency relays. A channel is actuated when two out of three phases of both switchyard yellow bus and switchyard red bus sensing relays detect undervoltage or underfrequency conditions. When a channel is actuated, four tripping relays ("94" relays) carry out the EGTPS function.

Figure A.3-1 is a logic diagram of the EGTPS Channel 1. When channel 1 is actuated:

1. Relays 94/V1A or 94/F1A actuate trip coil #1 of Power Circuit Breakers (PCBs) 24, 26, 28, and 33.

2. Relays 94/V1B or 94/F1B actuate trip coil #1 of PCBs 8, 12, 15, and 17; they also actuate EGTPS Trouble Relay 27X/STA which in turn provides the Channel 1 Keowee Emergency Start signal and actuates PCB 9 trip coil #1.

3. Relays 94/V1C or 94/F1C actuate statalarms and event recorders.

4. Relays 94/V1D or 94/F1D actuate trip coil #1 of PCB 21 and the close coils of PCBs 9, 18, 27, and 30.

For channel 2:

1. Relays 94/V2A or 94/F2A actuate the trip coil #2 of PCBs 12, 24, 26, 28, and 33.

2. Relays 94/V2B or 94/F2B actuate the trip coil #2 of PCBs 8, 12, 15, and 17; they actuate EGTPS Trouble Relay 27X/STB which provides the Channel 2 Keowee Emergency Start signal and actuates PCB 9 trip coil #2.

3. Relays 94/V2C or 94/F2C actuate the trip coil #2 of PCB 15 and statalarms and event recorders.

4. Relays 94/V2D or 94/F2D actuate trip coil #2 of PCB 21 and the close coils of PCBs 9, 18, 27 and 30.

Other system outputs are switchyard isolation confirmed signals which are generated when all of the following PCBs are opened to isolate the switchyard:

1.	PCB 8	4.	PCB 17	7.	PCB 26
2.	PCB 12	5.	PCB 21	8.	PCB 28
3.	PCB 15	6.	PCB 24	9.	PCB 33

The switchyard isolation confirmed relay 27X/SC1(2) operates the switchyard isolation auxiliary relay SIA(B), which in turn operates the Keowee Unit 1 and Keowee Unit 2 Switchyard Isolated Interposing Relays [1SIXA(B) and 2SIXA(B)]. The switchyard isolated interposing relays provide the close permissive in the automatic close circuits of ACB-1 and ACB-2. Also, the PCB 9 automatic close circuit requires operation of a

switchyard isolation complete time delay relay, 27XTD/SC1 or 27XTD/SC2. The time delay provides adequate time (about 4 seconds) for Reactor Coolant Pump Switchgear breakers to open before PCB 9 closes re-energizing the switchyard and the main feeder buses through the yellow bus and the startup transformers. This portion of the EGTPS is modeled in the switchyard isolation model (Appendix A.2).

Undervoltage Channel 1 is composed of six undervoltage relays (27B), each connected to a phase of the yellow and red buses. When a 27B ac relay detects undervoltage and drops out, an associated auxiliary dc relay (27X) is picked up. When two auxiliary relays of the same phase (one on the yellow bus and one on the red bus) are picked up concurrently, a phase undervoltage auxiliary relay (27X/RY) picks up. When two out of three 27X/RY relays (X,Y,and Z phases) are picked up, the Channel 1 tripping relays (the 94 relays) are picked up.

Underfrequency Channel 1 is composed of six underfrequency relays (81B), connected to the phases of the yellow and red buses in a configuration similar to that of the undervoltage relays. When an 81B ac relay detects underfrequency and drops out, an associated auxiliary dc relay (81X) picks up. A phase underfrequency auxiliary relay picks up when yellow bus and red bus same phase relays pick up. When two out of three 81X/RY relays (X,Y, and Z phases) pick up, the Channel 1 tripping relays again pick up.

The Channel 2 undervoltage and underfrequency components of the EGTPS are configured similarly, but different manufacturer components are used to minimize common mode failures.

A.3.3 SYSTEM BOUNDARIES

Electrical Power Supplies

The 230 kV Switchyard DC Power System (Appendix A.9) provides control power to both channels of the EGTPS.

External Control Systems

The EGTPS interfaces with the Oconee Unit 1 Keowee Emergency Start System. It does not require any external controls for its operation.

A.3.4 INSTRUMENTATION AND CONTROLS

The EGTPS panels are located in the 230 kV switchyard relay house. There are six green lights on the EGTPS undervoltage Channel 1 panel. Each light indicates the trip status of the red and yellow bus phase undervoltage relays. The lights turn on for an undervoltage condition. Three red indicating lights per channel indicate when both red and yellow buses are experiencing undervoltage on one particular phase. Six green lights on the EGTPS underfrequency Channel 1 panel similarly indicate the trip status of the red and yellow bus phase underfrequency relays. Three red lamps indicate simultaneous underfrequency conditions on like phases of the red and yellow bus. A pair of blue lamps for each channel are connected in two out of three logic to indicate whenever one of the three logic inputs are satisfied. A single, normally on, lamp on each channel related panel of undervoltage and underfrequency indicates the presence of 125 Vdc control power. The EGTPS panels and their associated channels are identified as follows:

Panel	SBR-17	Undervoltage Channel 1
Panel	SRF-17	Underfrequency Channel 1
Panel	RF-17	Undervoltage Channel 2
Panel	RB-17	Underfrequency Channel 2

A Switchyard Isolation Confirmed signal is generated when the switchyard PCB auxiliary contacts show that the switchyard yellow bus has been isolated from the grid and the switchyard PCBs are aligned to supply power to the unit startup transformers via the overhead power path. The "SWYD ISOLATED SIGNAL" indicating lights are located on the Switchyard Isolated Signal test panels. Both channels' test panels are in the switchyard relay house.

Statalarms pertaining to the EGTPS are located in the Oconee Unit 1/2 Control Room on Annunciator Alarm Panels SA15 and SA16. These alarms are listed in Table A.3-4.

A.3.5 LOCATION WITHIN THE PLANT

The External Grid Trouble Protection System is physically located in the Switchyard Relay House. The undervoltage and underfrequency sensor relays are on each phase of the switchyard red and yellow buses in the 230 kV switchyard.

A.3.6 NORMAL OPERATION

The system is normally operating, monitoring the voltage and frequency of the grid at the 230 kV Switchyard. Routine testing of both voltage and frequency channels assures their operability.

A.3.7 PERFORMANCE DURING KEOWEE EMERGENCY OPERATION

The EGTPS is designed to initiate the emergency response necessary to recover from a LOOP event. The system is battery powered in order to be capable of performing its function if ac power is lost. The system (1) provides signals to start the Keowee emergency generators; (2) provides signals to isolate the switchyard from the grid; and (3) establish a power path from the Keowee unit (connected to the overhead) to the startup transformers after a time delay (4-5 seconds) to assure necessary load shed is accomplished.

A Keowee emergency start and energizing of Transformer CT4 can also be accomplished by the Main Feeder Bus Monitors and the Engineered Safeguards Actuation System associated with each Oconee unit. For the overhead power path, however, operation of the EGTPS is necessary to isolate the switchyard and establish the connection between Keowee and the startup transformers of the Oconee units.

A.3.8 TEST AND MAINTENANCE

Testing

The EGTPS Logic And Switchyard Isolation Logic Test is performed quarterly to verify operation of system logic associated with the EGTPS and Switchyard Isolation, and to verify the actuation set-point of time delay relays for PCB-9 close permissive. Since system actuation requires 2 out of 3 logic, the individual voltage and frequency channels can be tested without disabling the system or disabling a single channel.

Installed test circuitry is used to verify that each channel's red and yellow bus, X, Y, and Z phases undervoltage and underfrequency conditions can be detected. Logic operation is verified by observing statalarms, switchyard event recorder printouts, and indicating lights.

Nine pushbuttons (one per breaker) are provided in the switchyard relay house to simulate the response of each PCB affected by a switchyard isolation signal.

The Degraded Grid and Switchyard Isolation Functional Test is performed one channel at a time on a refueling frequency. The test includes (1) functional verification of overhead ACB and PCB-9 operation during switchyard isolation, (2) demonstration of the operability of the Degraded Grid Protection System (DGPS), (3) demonstration of the ability of the overhead Keowee unit to energize the 230 kV Yellow Bus for all three Oconee units' Startup Transformers and carry the shutdown loads of Oconee Unit 1, and (4) demonstration of the capability to realign the 230 kV Yellow Bus back to the system grid while Oconee loads are being fed from the Overhead Keowee unit. The test is directly associated with the switchyard isolation model (Appendix A.2) and the Keowee emergency start model (Appendix A.5), but is mentioned here since it requires de-energizing the EGTPS while the DGPS logic is verified. The verification of DGPS operability is estimated to require about three hours to complete. Following the DGPS verification, the EGTPS is enabled. Prior to the test, a Lee Gas Turbine is aligned to energize CT-5.

The EGTPS testing requirements are listed in Table A.3-2.

A.3.9 OPERATING EXPERIENCE

There have been no reported instances of EGTPS failures.

A.3.10 ASSUMPTIONS

A.3.10.1 SYSTEM DESIGN ASSUMPTIONS

1. Undervoltage Channel 2 is similar in operation and redundant to undervoltage Channel 1. (The major difference between the two channels is that each channel uses different manufacturer components to minimize common mode failures.)

2. Underfrequency Channel 2 is similar in operation and redundant to underfrequency Channel 1. (The major difference between the two channels is that each channel uses different manufacturer components to minimize common mode failure.)

A.3.10.2 OPERATIONAL ASSUMPTIONS

1. Both Channels of undervoltage detection and underfrequency detection are assumed operational.

A.3.10.3 MODELING ASSUMPTIONS

1. Only the undervoltage and underfrequency detection functions of the EGTPS are modeled in this section of the analysis. The Switchyard Isolation Complete function is covered in Appendix A.2.

A.3.11 FAULT TREE ANALYSIS

A.3.11.1 TOP EVENT SUCCESS CRITERIA

Success of the EGTPS System requires that the initiating event (LOOP) is detected, the output tripping relays provide signals to their output functions and at least one channelized EGTPS Trouble Relay (27X/STA or 27X/STB) actuates.

A.3.11.2 DETAILED FAILURE CRITERIA

1. Start relay operations are the desired final actions of the EGTPS channels in this section of the analysis and their failures are top events of the fault tree. Progressively lower levels of the fault tree involve the circuit components necessary to generate the final actions in reverse order. Thus, the circuit components which sense the initiator for which they are designed are at the bottom of the fault trees.

A.3.11.3 DESCRIPTION OF FAULT TREE

The EGTPS System fault tree is shown in Figure A.3-2. The Fault Tree Modeling Guidelines (Appendix B) were followed in developing the fault tree. A list of all fault tree transfers is presented in Table A.3-3.

A.3.11.4 HUMAN INTERACTIONS

There are no human reliability events in the EGTPS fault tree, since the human interactions are very few in this system and immediate feedback of inappropriate action is expected.

A.3.11.5 RELIABILITY DATA

Section 5.3 discusses development of the reliability data. For the base case solution, the plant-specific failure rate data and generic failure rate data were combined using a Bayesian update.

As discussed in Section 5.3, consideration of relevant statalarms is part of the process of determining each basic event factor. EGTPS statalarms are listed in Table A.3-4.

System reliability data is listed in Table A.3-5.

A.3.11.6 COMMON CAUSE ASSESSMENT

Common cause failure of electromagnetic relays may result in the failure of the Channel 1 detection circuits. This may include both undervoltage detection and underfrequency detection. Similarly for the Channel 2 detectors common cause failure of solid state relays may involve the solid state undervoltage devices and the solid state frequency devices. Thus, a common cause failure probability is included for the same channel undervoltage and underfrequency components. The common-cause events are quantified in Appendix C.2.

A.3.12 RESULTS

Reliability of the EGTPS is defined as the probability that the system will succeed in providing Keowee Emergency Start signals when a LOOP occurs. The system model yields a probability of approximately 3E-05 for a channel [up to and including the EGTPS Trouble Relay 27X/STA(B)] to fail to provide a Keowee Emergency Start signal.

Table A.3-6 lists the dominant minimal cut sets for the External Grid Trouble Protection System. The dominant contributor to failure is "EGTPS Trouble Relay 27X/STA(B) Fails To Pick Up". "Common Cause Failure Of The UV and UF Detection Circuits" are the next highest contributors to channel unreliability.

A.3.13 REFERENCES

A.3.13.1 DOCUMENTS

1. OSS-0254.00-00-2005, Rev. 2, Keowee Emergency Power Design Basis Document.

2. OSS-0254.00-00-2004, Rev. 1, 230 kV Switchyard Design Basis Document.

A.3.13.2 PROCEDURES

1. PT/0/A/0610/02, Change 14, External Grid Trouble Protective System Logic And Switchyard Isolation Logic Test.

Table A.3-1

EGTPS Power Supplies

Component	Power Supply[1]	Panelboard Number
EGTPS		
Undervoltage Ch. 1	230 kV Switchyard 125 Vdc Control Power System	
	DC 1DA	DYC-13
Underfrequency Ch. 1	DC 1DA	DYC-14
Undervoltage Ch. 2	DC 2DA	DYG-12
Underfrequency Ch. 2	DC 2DA	DYG-18
External Grid Trouble Switchyard Isolated System		
SWYD Isolate Complete Ch. 1	DC 1DA	DYC-12
SWYD Isolate Complete Ch. 2	DC 2DA	DYG-16

[1] MCC = Motor Control Center
DC = Distribution Center

Table A.3-2

EGTPS Test Procedures

Procedure	Test Frequency	Description
PT/0/A/0610/02, EGTPS Logic And Switchyard Isolation Logic Test.	Quarterly	Verify operation of system logic associated with EGTPS and switchyard isolation circuits.

Table A.3-3

EGTPS Fault Tree Transfers

Transfer Gate Name	Description	Components Supplied
SDCDYC	Loss of Power on 125 V dc SWYD DC Panelboard DYC	EGTPS Channel 1
SDCDYG	Loss of Power on 125 V dc SWYD DC Panelboard DYG	EGTPS Channel 2

Table A.3-4

EGTPS Statalarms

Point No.	Alarm	Actuator
SA15-1	CHANNEL #1 TEST	Test Pushbuttons
SA15-2	CHANNEL #1 UNDERFREQUENCY	94/F1C
SA15-3	CHANNEL #2 TEST	Test Pushbuttons
SA15-4	CHANNEL #2 UNDERFREQUENCY	94/F2C
SA15-5	CHANNEL #1 DC SUPPLY FAILURE	74B/V1 & 74B/F1
SA15-6	CHAN. #1 UNDERVOLTAGE INITIATED	27X
SA15-7	CHAN #2 UNDERVOLTAGE INITIATED	27X
SA15-9	CHANNEL #1 UNDERVOLTAGE	94/V1C
SA15-10	CHAN. #1 UNDERFREQUENCY INITIATED	81X
SA15-11	CHANNEL #2 UNDERVOLTAGE	94/V2C
SA15-12	CHAN #2 UNDERFREQUENCY INITIATED	81X
SA16-1	EGTPS CHAN. #1 VOLTAGE RELAY COIL TROUBLE	74M
SA16-2	EGTPS CHAN.#1 FREQ. RELAY COIL TROUBLE	74M
SA16-3	EGTPS CHAN.#2 VOLTAGE RELAY COIL TROUBLE	74M
SA16-4	EGTPS CHAN.#2 FREQ. RELAY COIL TROUBLE	74M
SA16-5	CHAN. #1 SWYD ISOLATED TEST	Test Pushbuttons
SA16-6	CHAN. #2 SWYD ISOLATED TEST	Test Pushbuttons

Table A.3-5

EGTPS Reliability Data

Event Name	Description	Failure Rate[1]	Factor	Failure Probability
L0EGTPSCOM	Common Cause Failure of UV And UF Detection Circuits			1.78E-06
L27BRX1RYD	Snsng Rly 27B/RX1 Fails to Drop Out on Undervoltage	3.30E-05	1 D	3.30E-05
L27BRX2RYD	Snsng Rly 27B/RX2 Fails to Drop Out on Undervoltage	3.30E-05	1 D	3.30E-05
L27BRY1RYD	Snsng Rly 27B/RY1 Fails to Drop Out on Undervoltage	3.30E-05	1 D	3.30E-05
L27BRY2RYD	Snsng Rly 27B/RY2 Fails to Drop Out on Undervoltage	3.30E-05	1 D	3.30E-05
L27BRZ1RYD	Snsng Rly 27B/RZ1 Fails to Drop Out on Undervoltage	3.30E-05	1 D	3.30E-05
L27BRZ2RYD	Snsng Rly 27B/RZ2 Fails to Drop Out on Undervoltage	3.30E-05	1 D	3.30E-05
L27BYX1RYD	Snsng Rly 27B/YX1 Fails to Drop Out on Undervoltage	3.30E-05	1 D	3.30E-05
L27BYX2RYD	Snsng Rly 27B/YX2 Fails to Drop Out on Undervoltage	3.30E-05	1 D	3.30E-05
L27BYY1RYD	Snsng Rly 27B/YY1 Fails to Drop Out on Undervoltage	3.30E-05	1 D	3.30E-05
L27BYY2RYD	Snsng Rly 27B/YY2 Fails to Drop Out on Undervoltage	3.30E-05	1 D	3.30E-05
L27BYZ1RYD	Snsng Rly 27B/YZ1 Fails to Drop Out on Undervoltage	3.30E-05	1 D	3.30E-05
L27BYZ2RYD	Snsng Rly 27B/YZ2 Fails to Drop Out on Undervoltage	3.30E-05	1 D	3.30E-05
L27XPX1RYD	Ch 1 Phase X UV Aux. Relay Fails To Pick Up	3.30E-05	1 D	3.30E-05
L27XPX2RYD	Ch 2 Phase X UV Aux. Relay Fails To Pick Up	3.30E-05	1 D	3.30E-05
L27XPY1RYD	Ch 1 Phase Y UV Aux. Relay Fails to Pick Up	3.30E-05	1 D	3.30E-05
L27XPY2RYD	Ch 2 Phase Y UV Aux. Relay Fails to Pick Up	3.30E-05	1 D	3.30E-05
L27XPZ1RYD	Ch 1 Phase Z UV Aux. Relay Fails To Pick Up	3.30E-05	1 D	3.30E-05
L27XPZ2RYD	Ch 2 Phase Z UV Aux. Relay Fails To Pick Up	3.30E-05	1 D	3.30E-05
L27XRX1RYD	Red Bus Phase X1 UV Aux. Relay Fails To Pick Up	3.30E-05	1 D	3.30E-05
L27XRX2RYD	Red Bus Phase X2 UV Aux. Relay Fails To Pick Up	3.30E-05	1 D	3.30E-05
L27XRY1RYD	Red Bus Phase Y1 UV Aux. Relay Fails To Pick Up	3.30E-05	1 D	3.30E-05
L27XRY2RYD	Red Bus Phase Y2 UV Aux. Relay Fails To Pick Up	3.30E-05	1 D	3.30E-05
L27XRZ1RYD	Red Bus Phase Z1 UV Aux. Relay Fails To Pick Up	3.30E-05	1 D	3.30E-05
L27XRZ2RYD	Red Bus Phase Z2 UV Aux. Relay Fails To Pick Up	3.30E-05	1 D	3.30E-05
L27XSTARYD	Ch 1 EGTPS Trouble Relay 27X/STA Fails To Pick Up	3.30E-05	1 D	3.30E-05
L27XSTBRYD	Ch 2 EGTPS Trouble Relay 27X/STB Fails To Pick Up	3.30E-05	1 D	3.30E-05
L27XYX1RYD	Yellow Bus Phase X1 UV Aux. Relay Fails To Pick Up	3.30E-05	1 D	3.30E-05
L27XYX2RYD	Yellow Bus Phase X2 UV Aux. Relay Fails To Pick Up	3.30E-05	1 D	3.30E-05
L27XYY1RYD	Yellow Bus Phase Y1 UV Aux. Relay Fails To Pick Up	3.30E-05	1 D	3.30E-05
L27XYY2RYD	Yellow Bus Phase Y2 UV Aux. Relay Fails To Pick Up	3.30E-05	1 D	3.30E-05
L27XYZ1RYD	Yellow Bus Phase Z1 UV Aux. Relay Fails To Pick Up	3.30E-05	1 D	3.30E-05
L27XYZ2RYD	Yellow Bus Phase Z2 UV Aux. Relay Fails To Pick Up	3.30E-05	1 D	3.30E-05

Table A.3-5

EGTPS Reliability Data

Event Name	Description	Failure Rate[1]	Factor	Failure Probability
L81BRX1RYD	Sensing Rly 81BL/RX1 Fails To Drop Out On Underfreq.	3.30E-05	1 D	3.30E-05
L81BRX2RYD	Sensing Rly 81BL/RX2 Fails To Drop Out On Underfreq.	3.30E-05	1 D	3.30E-05
L81BRY1RYD	Sensing Rly 81BL/RY1 Fails To Drop Out On Underfreq.	3.30E-05	1 D	3.30E-05
L81BRY2RYD	Sensing Rly 81BL/RY2 Fails To Drop Out On Underfreq.	3.30E-05	1 D	3.30E-05
L81BRZ1RYD	Sensing Rly 81BL/RZ1 Fails To Drop Out On Underfreq.	3.30E-05	1 D	3.30E-05
L81BRZ2RYD	Sensing Rly 81BL/RZ2 Fails To Drop Out On Underfreq.	3.30E-05	1 D	3.30E-05
L81BYX1RYD	Sensing Rly 81BL/YX1 Fails To Drop Out On Underfreq.	3.30E-05	1 D	3.30E-05
L81BYX2RYD	Sensing Rly 81BL/YX2 Fails To Drop Out On Underfreq.	3.30E-05	1 D	3.30E-05
L81BYY1RYD	Sensing Rly 81BL/YY1 Fails To Drop Out On Underfreq.	3.30E-05	1 D	3.30E-05
L81BYY2RYD	Sensing Rly 81BL/YY2 Fails To Drop Out On Underfreq.	3.30E-05	1 D	3.30E-05
L81BYZ1RYD	Sensing Rly 81BL/YZ1 Fails To Drop Out On Underfreq.	3.30E-05	1 D	3.30E-05
L81BYZ2RYD	Sensing Rly 81BL/YZ2 Fails To Drop Out On Underfreq.	3.30E-05	1 D	3.30E-05
L81XPX1RYD	Ch 1 Phase X Underfreq. Aux. Relay Fails To Pick Up	3.30E-05	1 D	3.30E-05
L81XPX2RYD	Ch 2 Phase X Underfreq. Aux. Relay Fails To Pick Up	3.30E-05	1 D	3.30E-05
L81XPY1RYD	Ch 1 Phase Y Underfreq. Aux. Relay Fails To Pick Up	3.30E-05	1 D	3.30E-05
L81XPY2RYD	Ch 2 Phase Y Underfreq. Aux. Relay Fails To Pick Up	3.30E-05	1 D	3.30E-05
L81XPZ1RYD	Ch 1 Phase Z Underfreq. Aux. Relay Fails To Pick Up	3.30E-05	1 D	3.30E-05
L81XPZ2RYD	Ch 2 Phase Z Underfreq. Aux. Relay Fails To Pick Up	3.30E-05	1 D	3.30E-05
L81XRX1RYD	Red Bus Phase X1 Underfreq. Aux. Rly Fails To Pick Up	3.30E-05	1 D	3.30E-05
L81XRX2RYD	Red Bus Phase X2 Underfreq. Aux. Rly Fails To Pick Up	3.30E-05	1 D	3.30E-05
L81XRY1RYD	Red Bus Phase Y1 Underfreq. Aux. Rly Fails To Pick Up	3.30E-05	1 D	3.30E-05
L81XRY2RYD	Red Bus Phase Y2 Underfreq. Aux. Rly Fails To Pick Up	3.30E-05	1 D	3.30E-05
L81XRZ1RYD	Red Bus Phase Z1 Underfreq. Aux. Rly Fails To Pick Up	3.30E-05	1 D	3.30E-05
L81XRZ2RYD	Red Bus Phase Z2 Underfreq. Aux. Rly Fails To Pick Up	3.30E-05	1 D	3.30E-05
L81XYX1RYD	Yellow Bus Phase X1 UF Aux. Rly Fails To Pick Up	3.30E-05	1 D	3.30E-05
L81XYX2RYD	Yellow Bus Phase X2 UF Aux. Rly Fails To Pick Up	3.30E-05	1 D	3.30E-05
L81XYY1RYD	Yellow Bus Phase Y1 UF Aux. Rly Fails To Pick Up	3.30E-05	1 D	3.30E-05
L81XYY2RYD	Yellow Bus Phase Y2 UF Aux. Rly Fails To Pick Up	3.30E-05	1 D	3.30E-05
L81XYZ1RYD	Yellow Bus Phase Z1 UF Aux. Rly Fails To Pick Up	3.30E-05	1 D	3.30E-05
L81XYZ2RYD	Yellow Bus Phase Z2 UF Aux. Rly Fails To Pick Up	3.30E-05	1 D	3.30E-05
LC94F1ARYD	EGTPS Underfrequency Relay 94/F1A Fails To Pick Up	3.30E-05	1 D	3.30E-05
LC94F1BRYD	EGTPS Underfrequency Relay 94/F1B Fails To Pick Up	3.30E-05	1 D	3.30E-05

Table A.3-5

EGTPS Reliability Data

Event Name	Description	Failure Rate[1]	Factor	Failure Probability
LC94F1DRYD	EGTPS Underfrequency Relay 94/F1D Fails To Pick Up	3.30E-05	1 D	3.30E-05
LC94F2ARYD	EGTPS Underfrequency Relay 94/F2A Fails To Pick Up	3.30E-05	1 D	3.30E-05
LC94F2BRYD	EGTPS Underfrequency Relay 94/F2B Fails To Pick Up	3.30E-05	1 D	3.30E-05
LC94F2CRYD	EGTPS Underfrequency Relay 94/F2C Fails To Pick Up	3.30E-05	1 D	3.30E-05
LC94F2DRYD	EGTPS Underfrequency Relay 94/F2D Fails To Pick Up	3.30E-05	1 D	3.30E-05
LC94V1ARYD	EGTPS Undervoltage Relay 94/V1A Fails To Pick Up	3.30E-05	1 D	3.30E-05
LC94V1BRYD	EGTPS Undervoltage Relay 94/V1B Fails To Pick Up	3.30E-05	1 D	3.30E-05
LC94V1DRYD	EGTPS Undervoltage Relay 94/V1D Fails To Pick Up	3.30E-05	1 D	3.30E-05
LC94V2ARYD	EGTPS Undervoltage Relay 94/V2A Fails To Pick Up	3.30E-05	1 D	3.30E-05
LC94V2BRYD	EGTPS Undervoltage Relay 94/V2B Fails To Pick Up	3.30E-05	1 D	3.30E-05
LC94V2CRYD	EGTPS Undervoltage Relay 94/V2C Fails To Pick Up	3.30E-05	1 D	3.30E-05
LDCYC13CDT	Switchyard 125 Vdc Panelboard DYC Bkr 13 Xfrs Open	7.50E-08	24 H	1.80E-06
LDCYC14CDT	Switchyard 125 Vdc Panelboard DYC Bkr 14 Xfrs Open	7.50E-08	24 H	1.80E-06
LDCYG12CDT	Switchyard 125 Vdc Panelboard DYG Bkr 12 Xfrs Open	7.50E-08	24 H	1.80E-06
LDCYG18CDT	Switchyard 125 Vdc Panelboard DYG Bkr 18 Xfrs Open	7.50E-08	24 H	1.80E-06

[1] D = Demand, H=Hour

[2] Rules for assigning basic event factors are discussed in Table C.1-4.

Table A.3-6

EGTPS Dominant Minimal Cutsets

Cutsets For Gate SEG94F1AF: EGTPS Channel 1 Relay 94/F1A Signal Fails

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
1)	3.30E-05	90.0	LC94F1ARYD	3.30E-05	EGTPS Relay 94/F1A Fails to Pick Up
2)	1.80E-06	4.9	LDCYC14CDT	1.80E-06	Switchyard 125 Vdc Panelboard DYC Breaker 14 Transfers Open
3)	1.78E-06	4.9	L0EGTPSCOM	1.78E-06	Common Cause Failure of UV and UF Detection Circuits
Total:	3.66E-05				

Table A.3-6

EGTPS Dominant Minimal Cutsets

Cutsets For Gate SEG94F1DF: EGTPS Channel 1 Relay 94/F1D Signal Fails

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
1)	3.30E-05	90.0	LC94F1DRYD	3.30E-05	EGTPS Relay 94/F1D Fails to Pick Up
2)	1.80E-06	4.9	LDCYC14CDT	1.80E-06	Switchyard 125 Vdc Panelboard DYC Breaker 14 Transfers Open
3)	1.78E-06	4.9	L0EGTPSCOM	1.78E-06	Common Cause Failure of UV and UF Detection Circuits
Total:	3.66E-05				

Table A.3-6

EGTPS Dominant Minimal Cutsets

Cutsets For Gate SEG94F2AF: EGTPS Channel 2 Relay 94/F2A Signal Fails

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
1)	3.30E-05	90.0	LC94F2ARYD	3.30E-05	EGTPS Relay 94/F2A Fails to Pick Up
2)	1.80E-06	4.9	LDCYG18CDT	1.80E-06	Switchyard 125 Vdc Panelboard DYG Breaker 18 Transfers Open
3)	1.78E-06	4.9	L0EGTPSCOM	1.78E-06	Common Cause Failure of UV and UF Detection Circuits
Total:	3.66E-05				

Table A.3-6

EGTPS Dominant Minimal Cutsets

Cutsets For Gate SEG94F2CF: EGTPS Channel 2 Relay 94/F2C Signal Fails

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
1)	3.30E-05	90.0	LC94F2CRYD	3.30E-05	EGTPS Relay 94/F2C Fails to Pick Up
2)	1.80E-06	4.9	LDCYG18CDT	1.80E-06	Switchyard 125 Vdc Panelboard DYG Breaker 18 Transfers Open
3)	1.78E-06	4.9	L0EGTPSCOM	1.78E-06	Common Cause Failure of UV and UF Detection Circuits
Total:	3.66E-05				

Table A.3-6

EGTPS Dominant Minimal Cutsets

Cutsets For Gate SEG94F2DF: EGTPS Channel 2 Relay 94/F2D Signal Fails

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
1)	3.30E-05	90.0	LC94F2DRYD	3.30E-05	EGTPS Relay 94/F2D Fails to Pick Up
2)	1.80E-06	4.9	LDCYG18CDT	1.80E-06	Switchyard 125 Vdc Panelboard DYG Breaker 18 Transfers Open
3)	1.78E-06	4.9	L0EGTPSCOM	1.78E-06	Common Cause Failure of UV and UF Detection Circuits
Total:	3.66E-05				

Table A.3-6

EGTPS Dominant Minimal Cutsets

Cutsets For Gate SEG94V1AF: EGTPS Channel 1 Relay 94/V1A Signal Fails

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
1)	3.30E-05	90.0	LC94V1ARYD	3.30E-05	EGTPS Relay 94/V1A Fails to Pick Up
2)	1.80E-06	4.9	LDCYC13CDT	1.80E-06	Switchyard 125 Vdc Panelboard DYC Breaker 13 Transfers Open
3)	1.78E-06	4.9	L0EGTPSCOM	1.78E-06	Common Cause Failure of UV and UF Detection Circuits
Total:	3.66E-05				

Table A.3-6

EGTPS Dominant Minimal Cutsets

Cutsets For Gate SEG94V1DF: EGTPS Channel 1 Relay 94/V1D Signal Fails

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
1)	3.30E-05	90.0	LC94V1DRYD	3.30E-05	EGTPS Relay 94/V1D Fails to Pick Up
2)	1.80E-06	4.9	LDCYC13CDT	1.80E-06	Switchyard 125 Vdc Panelboard DYC Breaker 13 Transfers Open
3)	1.78E-06	4.9	L0EGTPSCOM	1.78E-06	Common Cause Failure of UV and UF Detection Circuits
Total:	3.66E-05				

Table A.3-6

EGTPS Dominant Minimal Cutsets

Cutsets For Gate SEG94V2AF: EGTPS Channel 2 Relay 94/V2A Signal Fails

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
1)	3.30E-05	90.0	LC94V2ARYD	3.30E-05	EGTPS Relay 94/V2A Fails to Pick Up
2)	1.80E-06	4.9	LDCYG12CDT	1.80E-06	Switchyard 125 Vdc Panelboard DYG Breaker 12 Transfers Open
3)	1.78E-06	4.9	L0EGTPSCOM	1.78E-06	Common Cause Failure of UV and UF Detection Circuits
Total:	3.66E-05				

Table A.3-6

EGTPS Dominant Minimal Cutsets

Cutsets For Gate SEG94V2CF: EGTPS Channel 2 Relay 94/V2C Signal Fails

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
1)	3.30E-05	90.0	LC94V2CRYD	3.30E-05	EGTPS Relay 94/V2C Fails to Pick Up
2)	1.80E-06	4.9	LDCYG12CDT	1.80E-06	Switchyard 125 Vdc Panelboard DYG Breaker 12 Transfers Open
3)	1.78E-06	4.9	L0EGTPSCOM	1.78E-06	Common Cause Failure of UV and UF Detection Circuits
Total:	3.66E-05				

Table A.3-6

EGTPS Dominant Minimal Cutsets

Cutsets For Gate SEG94V2DF: EGTPS Channel 2 Relay 94/V2D Signal Fails

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
1)	3.30E-05	90.0	LC94V2DRYD	3.30E-05	EGTPS Relay 94/V2D Fails to Pick Up
2)	1.80E-06	4.9	LDCYG12CDT	1.80E-06	Switchyard 125 Vdc Panelboard DYG Breaker 12 Transfers Open
3)	1.78E-06	4.9	L0EGTPSCOM	1.78E-06	Common Cause Failure of UV and UF Detection Circuits
Total:	3.66E-05				

Table A.3-6

EGTPS Dominant Minimal Cutsets

Cutsets For Gate SEGTPSCH1F: EGTPS Channel 1 Keowee Start Signal Fails

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
1)	3.30E-05	94.8	L27XSTARYD	3.30E-05	Ch 1 EGTPS Trouble Relay 27X/STA Fails to Pick Up
2)	1.78E-06	5.1	L0EGTPSCOM	1.78E-06	Common Cause Failure of UV and UF Detection Circuits
Total:	3.48E-05				

Table A.3-6

EGTPS Dominant Minimal Cutsets

Cutsets For Gate SEGTPSCH2F: EGTPS Channel 2 Keowee Start Signal Fails

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
1)	3.30E-05	94.8	L27XSTBRYD	3.30E-05	Ch 2 EGTPS Trouble Relay 27X/STB Fails to Pick Up
2)	1.78E-06	5.1	L0EGTPSCOM	1.78E-06	Common Cause Failure of UV and UF Detection Circuits
Total:	3.48E-05				

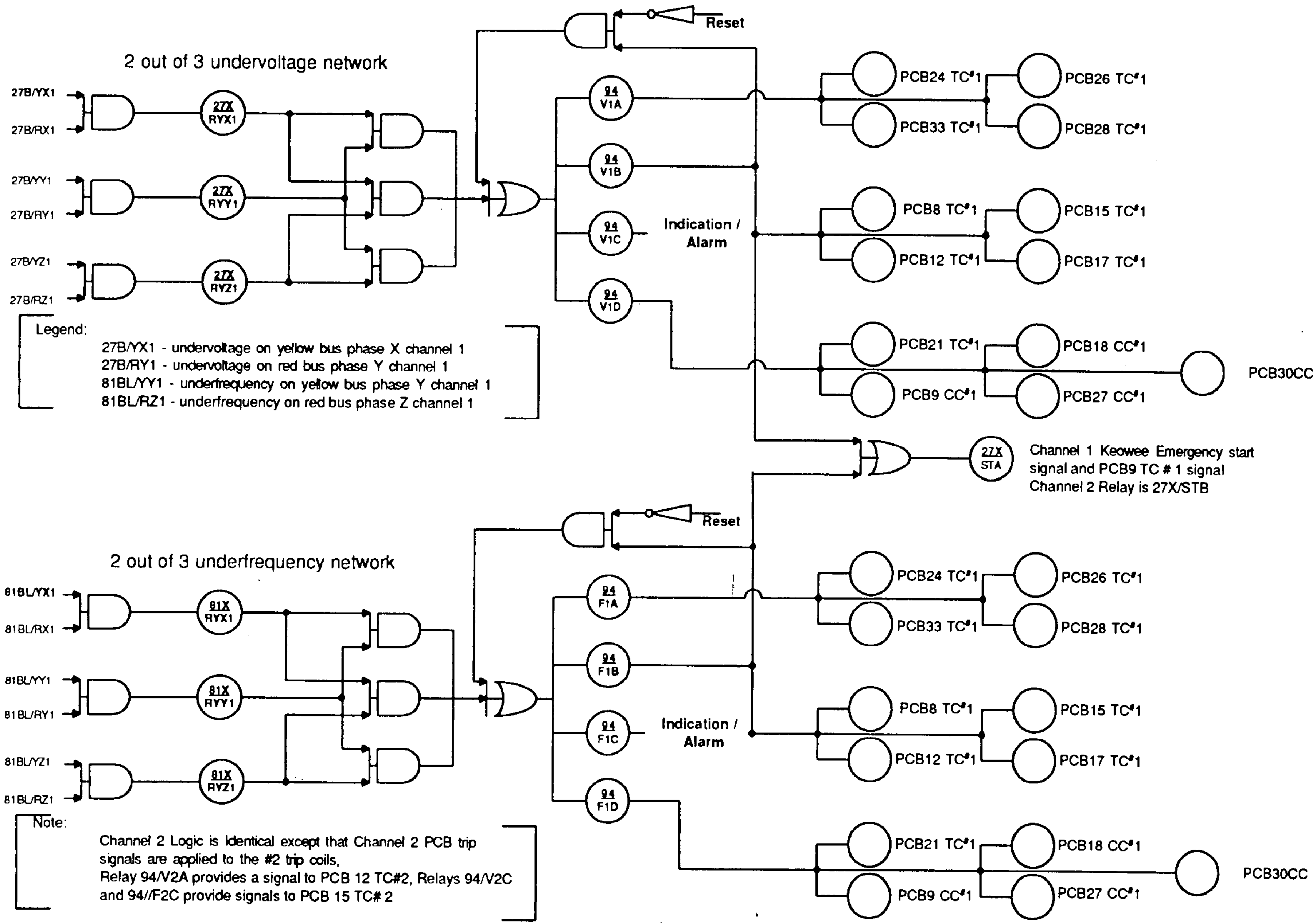
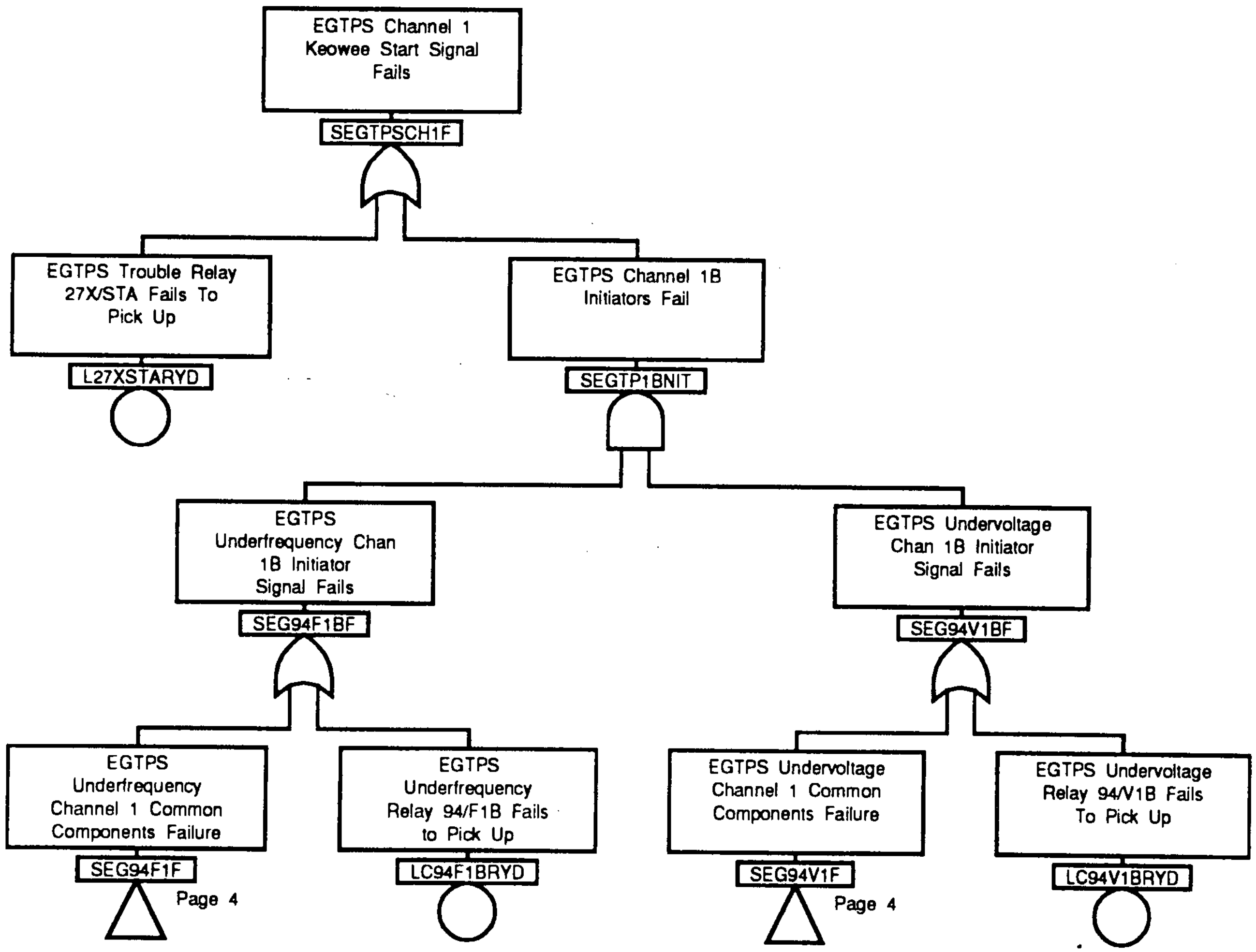
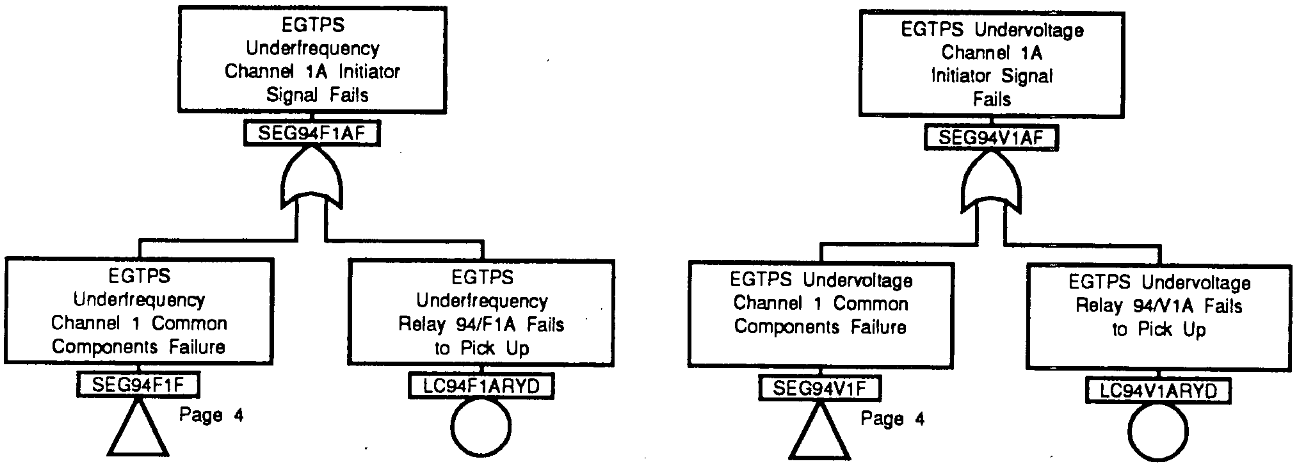


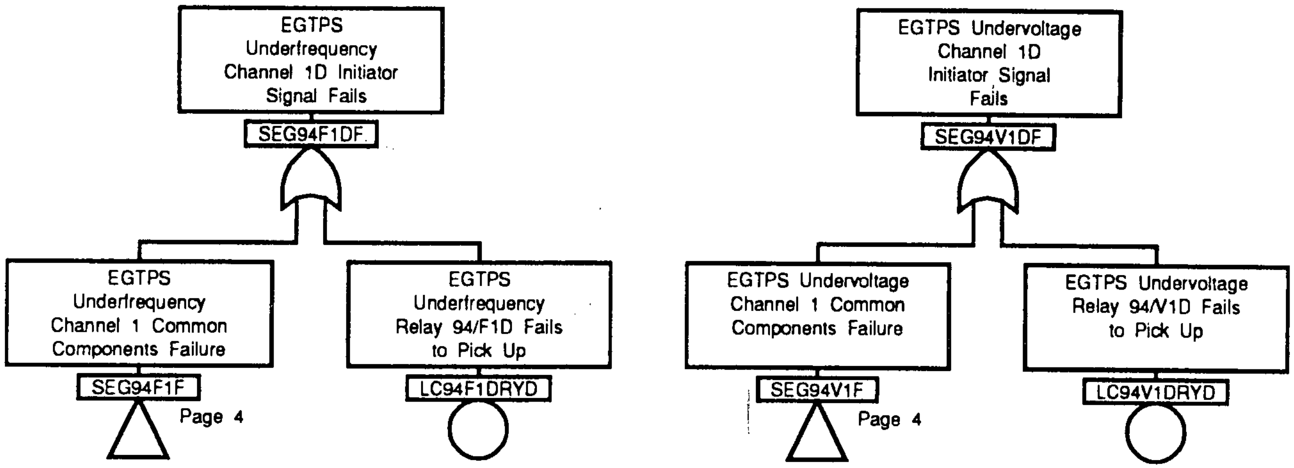
Figure A.3-1 Logic Diagram External Grid Trouble Protection System Channel 1



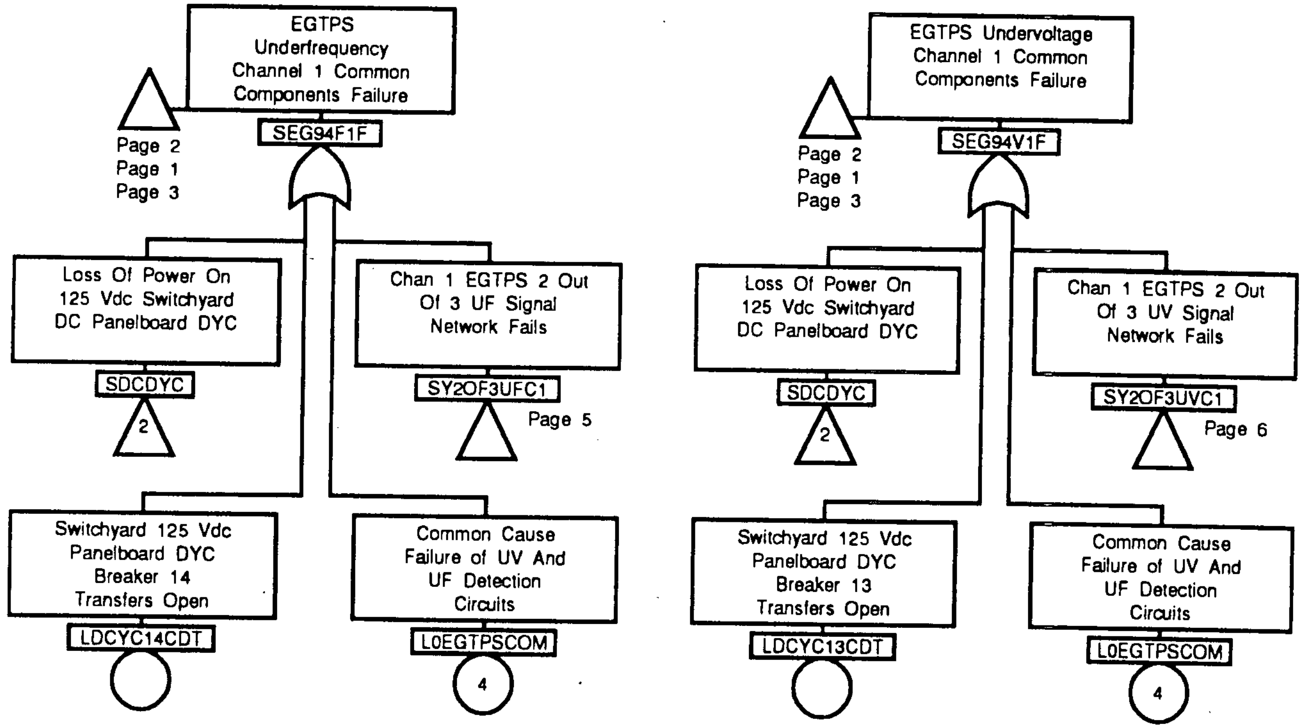
External Grid Trouble Protection System | FIGURE A.3-2 | Page 1



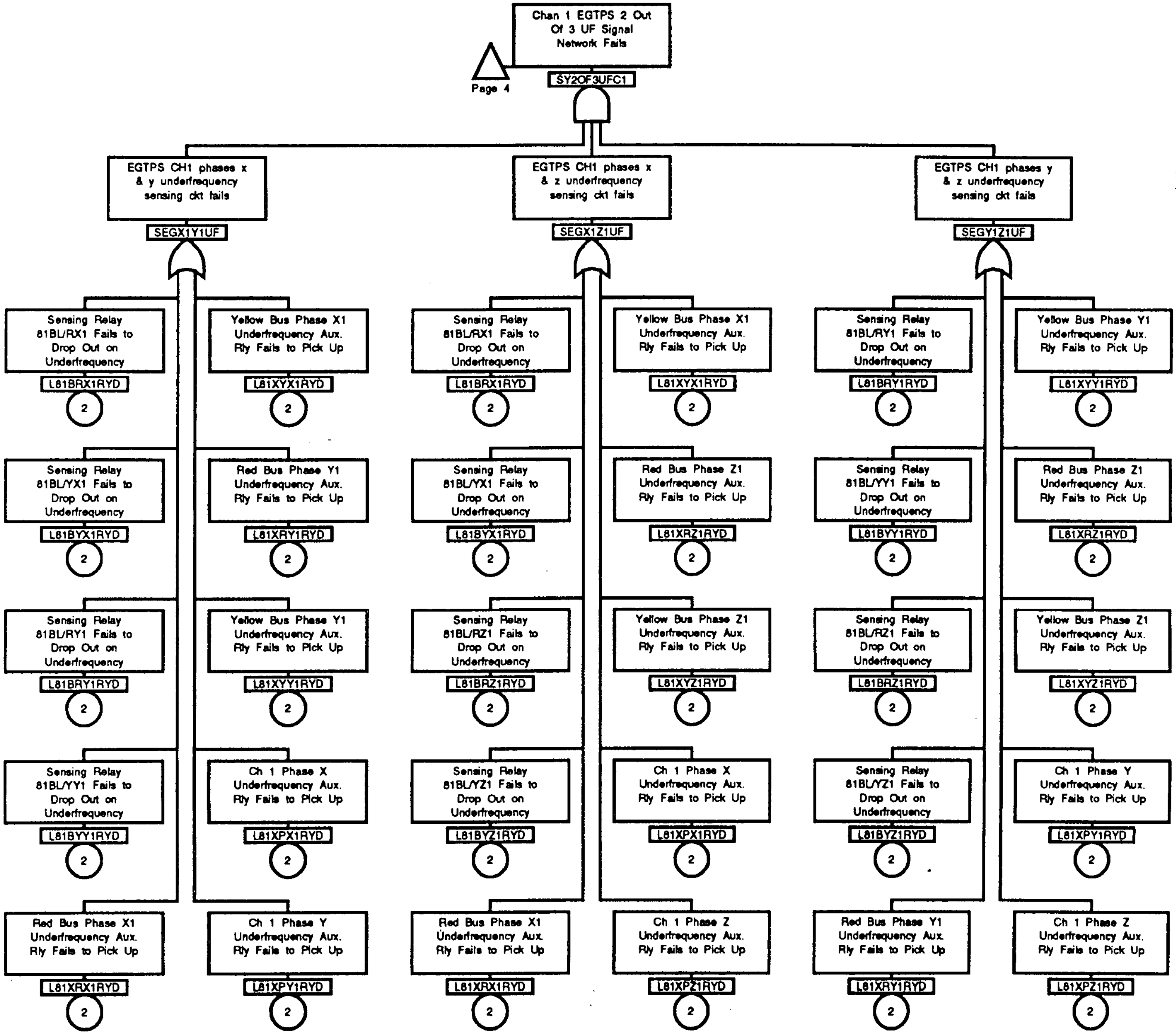
External Grid Trouble Protection System | FIGURE A.3-2 |



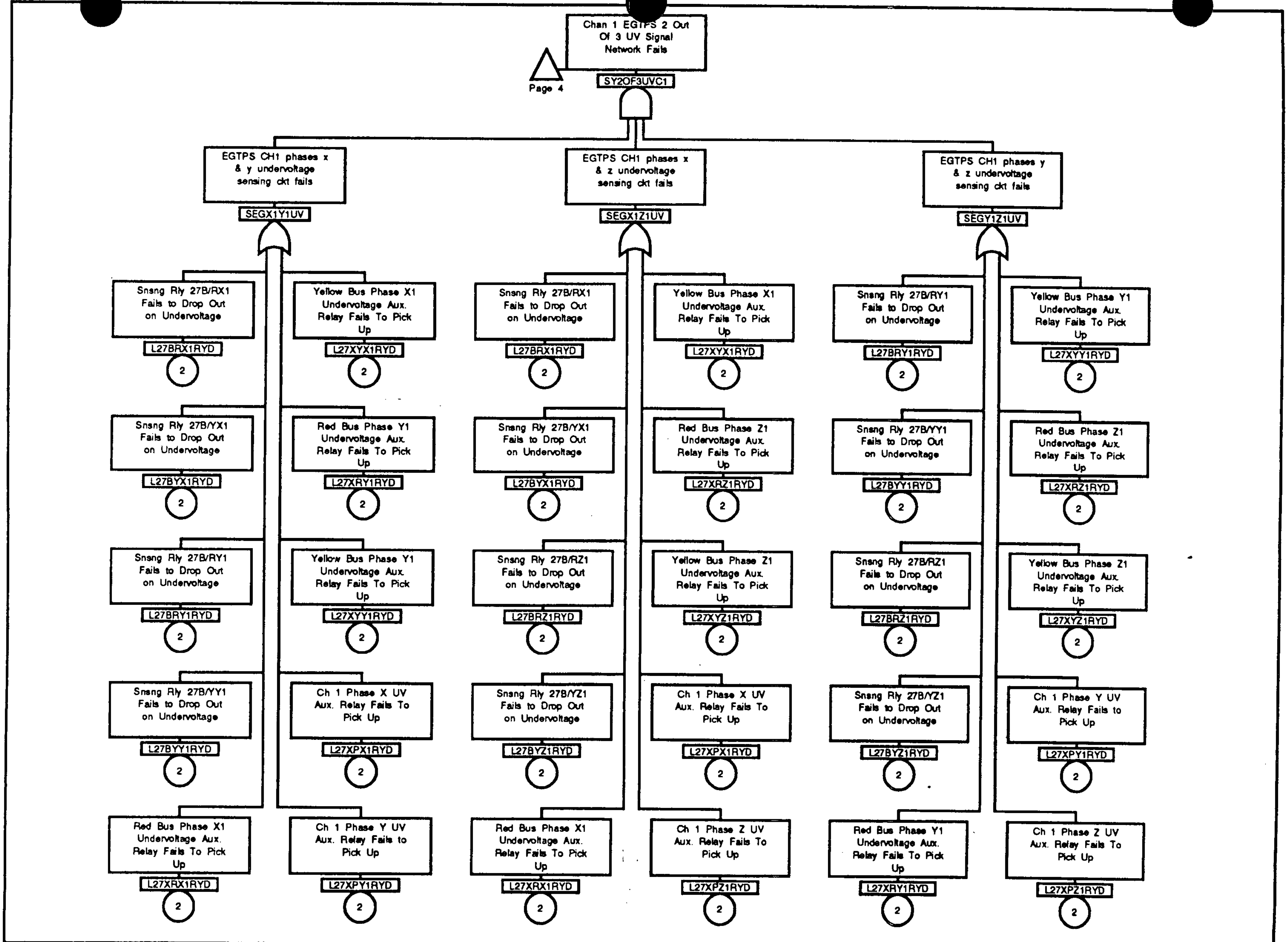
External Grid Trouble Protection System | FIGURE A.3-2 |



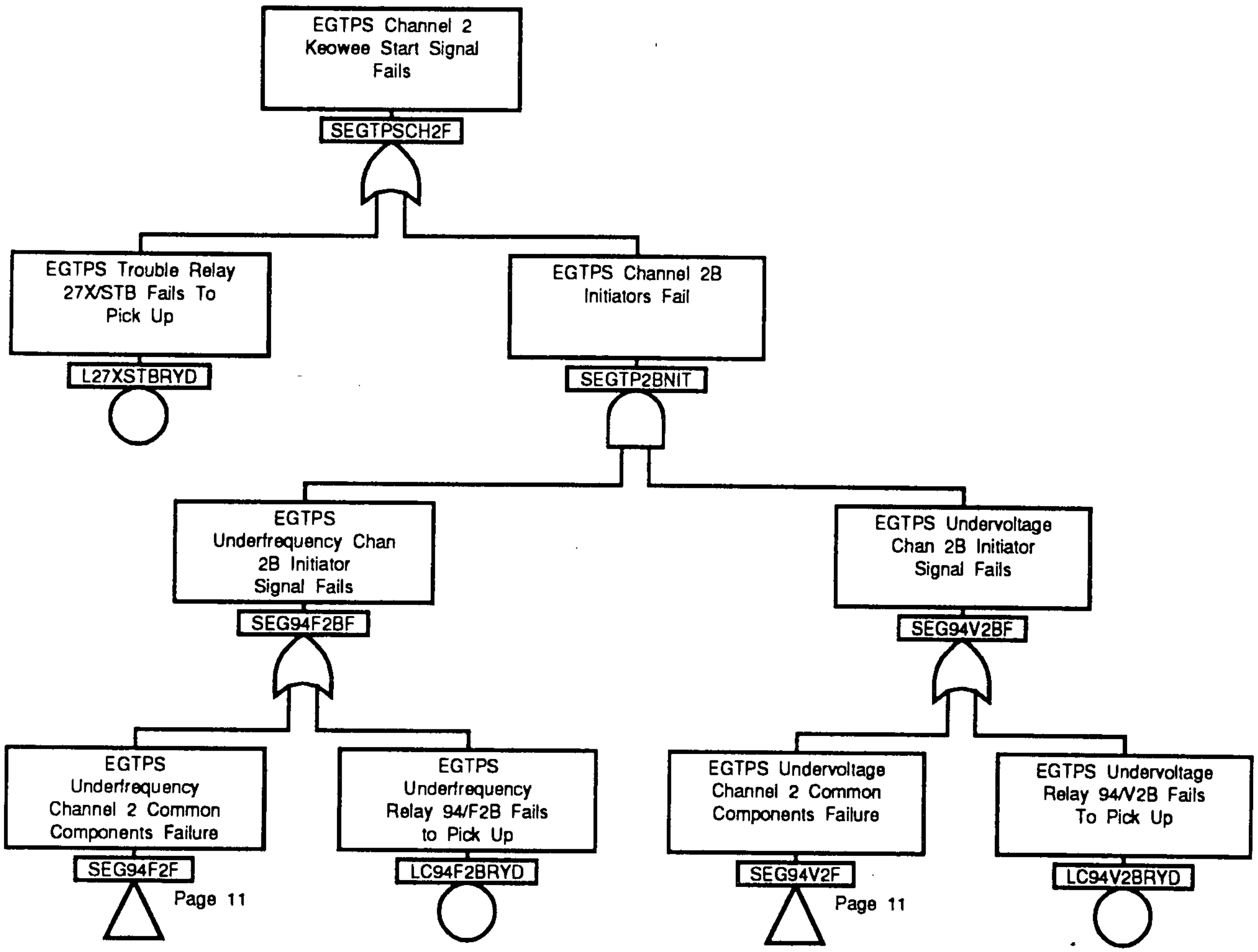
External Grid Trouble Protection System | FIGURE A.3-2 |



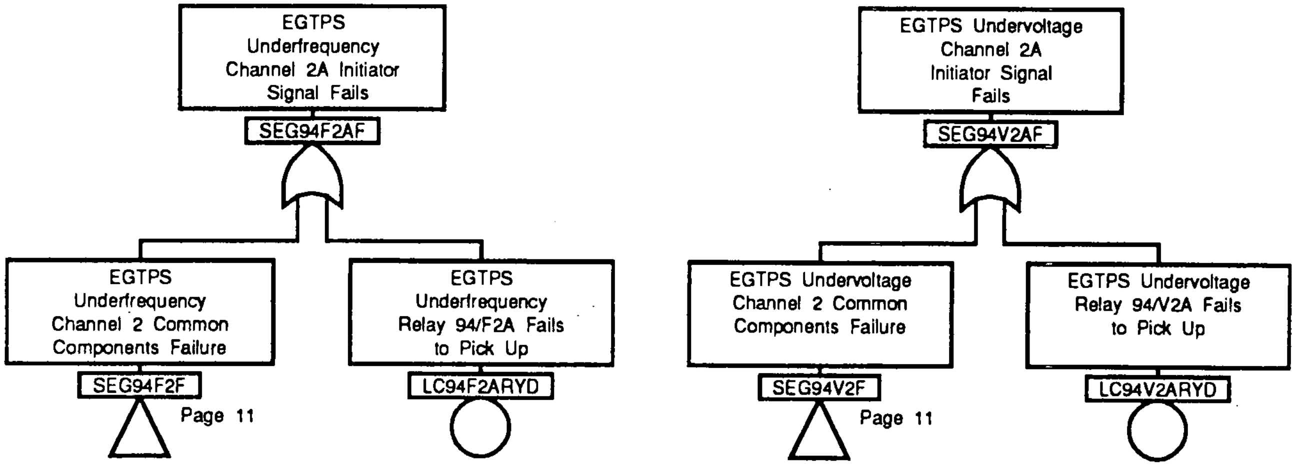
External Grid Trouble Protection System | FIGURE A.3-2 | Page 5

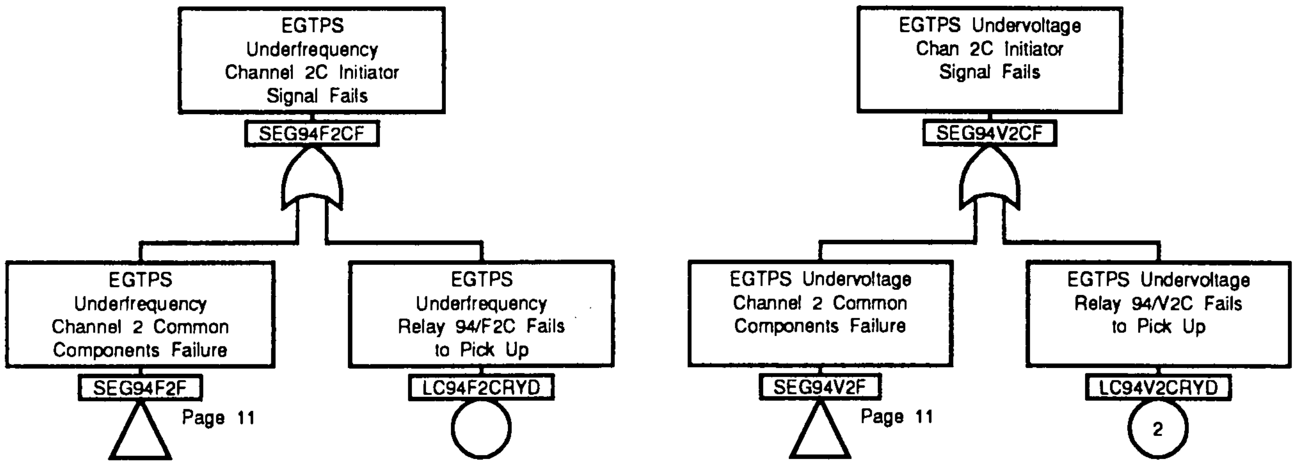


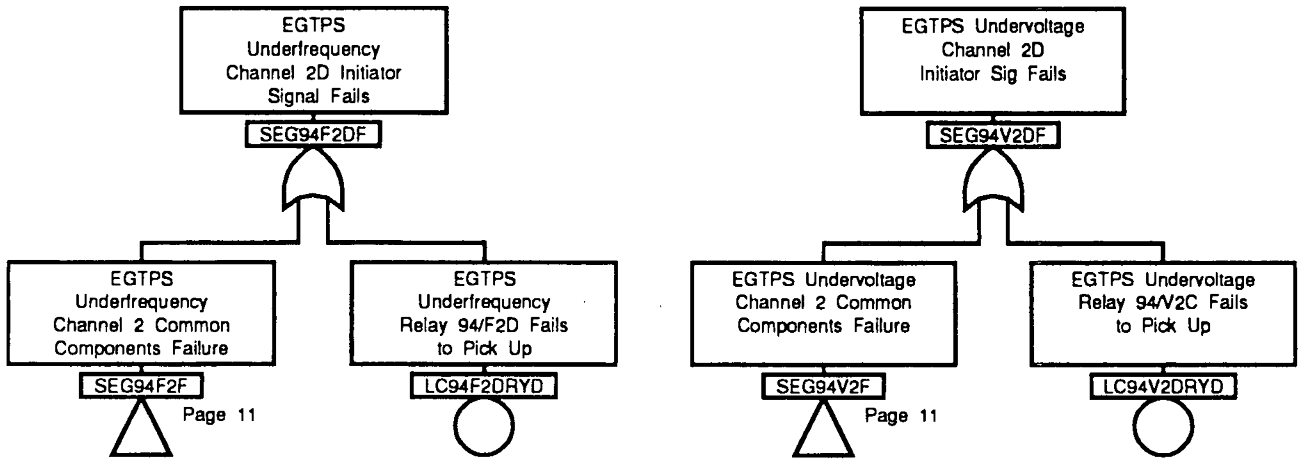
External Grid Trouble Protection System | FIGURE A.3-2 | Page 6

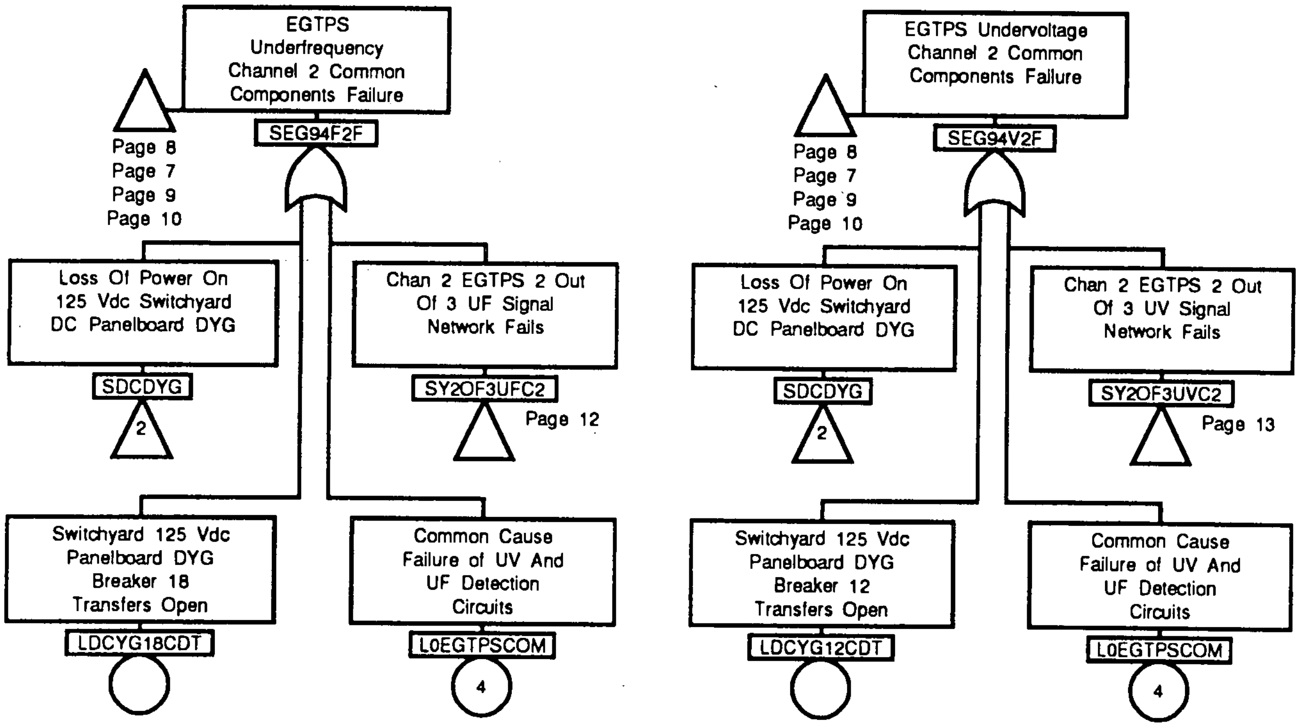


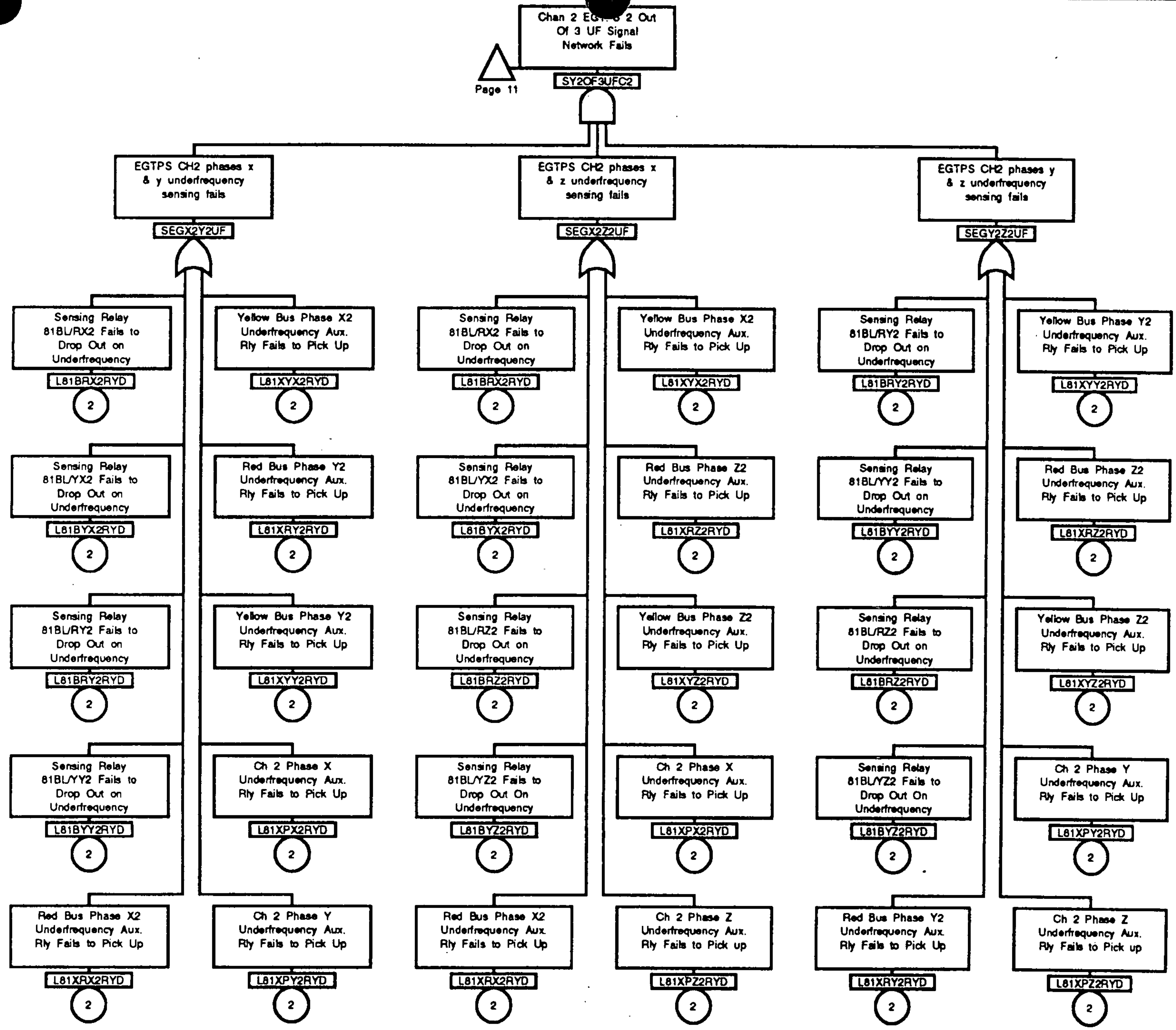
EGTPS Channel 2 Keowee Start Signal Fails
SEGTPSCH2F
EGTPS Trouble Relay 27X/STB Fails To Pick Up
L27XSTBRYD
EGTPS Channel 2B Initiators Fail
SEGTP2BNIT
EGTPS Underfrequency Chan 2B Initiator Signal Fails
SEG94F2BF
EGTPS Undervoltage Chan 2B Initiator Signal Fails
SEG94V2BF
EGTPS Underfrequency Channel 2 Common Components Failure
SEG94F2F
Page 11
EGTPS Underfrequency Relay 94/F2B Fails to Pick Up
LC94F2BRYD
EGTPS Undervoltage Channel 2 Common Components Failure
SEG94V2F
Page 11
EGTPS Undervoltage Relay 94/V2B Fails To Pick Up
LC94V2BRYD


EGTPS Underfrequency Channel 2A Initiator Signal Fails
SEG94F2AF
EGTPS Underfrequency Channel 2 Common Components Failure
SEG94F2F
Page 11
EGTPS Underfrequency Relay 94/F2A Fails to Pick Up
LC94F2ARYD
EGTPS Undervoltage Channel 2A Initiator Signal Fails
SEG94V2AF
EGTPS Undervoltage Channel 2 Common Components Failure
SEG94V2F
Page 11
EGTPS Undervoltage Relay 94/V2A Fails to Pick Up
LC94V2ARYD

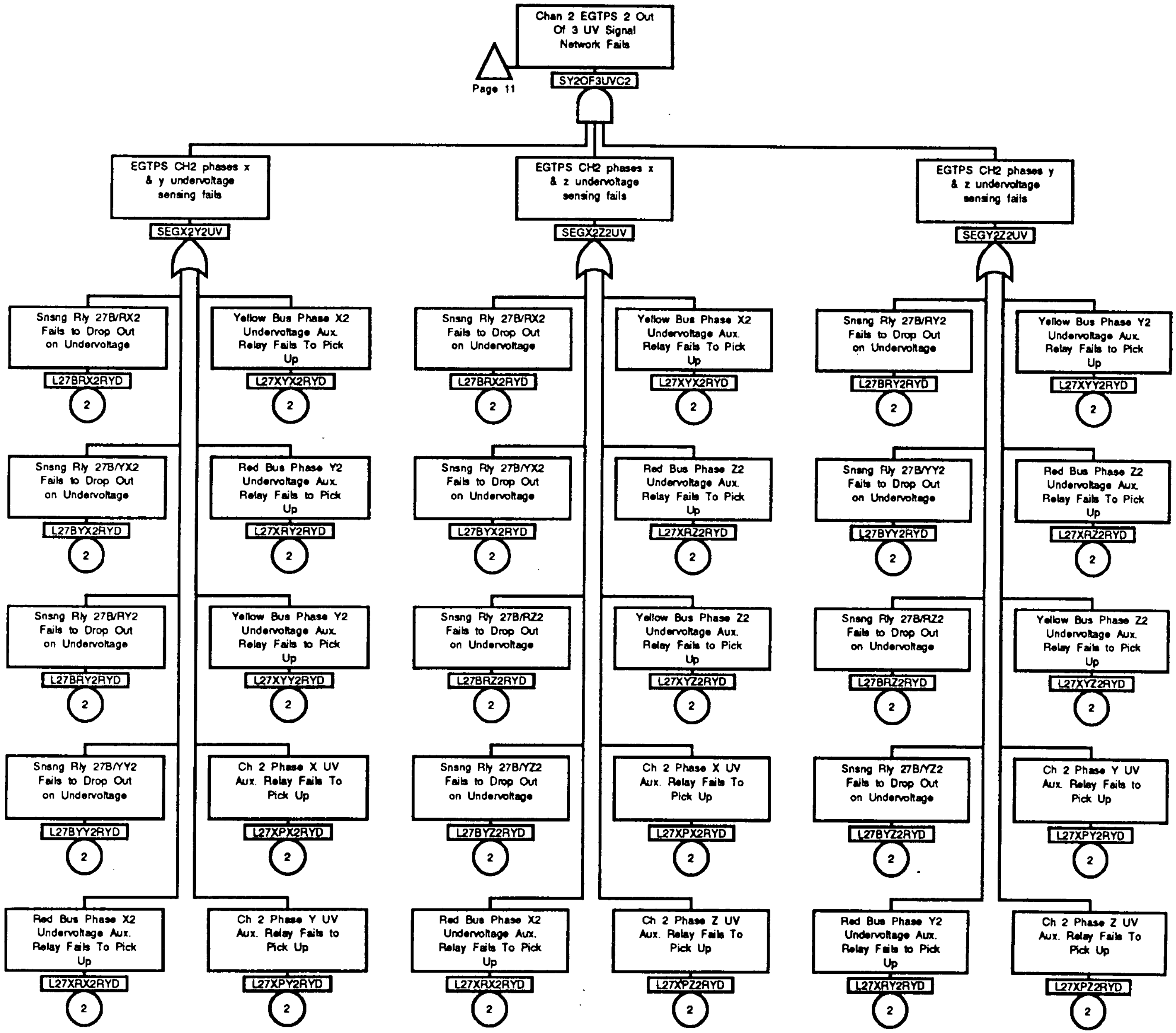

EGTPS Underfrequency Channel 2C Initiator Signal Fails
SEG94F2CF
EGTPS Underfrequency Channel 2 Common Components Failure
SEG94F2F
Page 11
EGTPS Underfrequency Relay 94/F2C Fails to Pick Up
LC94F2CRYD
EGTPS Undervoltage Chan 2C Initiator Signal Fails
SEG94V2CF
EGTPS Undervoltage Channel 2 Common Components Failure
SEG94V2F
Page 11
EGTPS Undervoltage Relay 94/V2C Fails to Pick Up
LC94V2CRYD
2


EGTPS
Underfrequency
Channel 2D Initiator
Signal Fails
SEG94F2DF
EGTPS
Underfrequency
Channel 2 Common
Components Failure
SEG94F2F
Page 11
EGTPS
Underfrequency
Relay 94/F2D Fails
to Pick Up
LC94F2DRYD
EGTPS Undervoltage
Channel 2D
Initiator Sig Fails
SEG94V2DF
EGTPS Undervoltage
Channel 2 Common
Components Failure
SEG94V2F
Page 11
EGTPS Undervoltage
Relay 94/V2C Fails
to Pick Up
LC94V2DRYD


EGTPS
Underfrequency
Channel 2 Common
Components Failure
SEG94F2F
Page 8
Page 7
Page 9
Page 10
Loss Of Power On
125 Vdc Switchyard
DC Panelboard DYG
SDCDYG
2
Chan 2 EGTPS 2 Out
Of 3 UF Signal
Network Fails
SY2OF3UFC2
Page 12
Switchyard 125 Vdc
Panelboard DYG
Breaker 18
Transfers Open
LDCYG18CDT
Common Cause
Failure of UV And
UF Detection
Circuits
L0EGTPSCOM
4
EGTPS Undervoltage
Channel 2 Common
Components Failure
SEG94V2F
Page 8
Page 7
Page 9
Page 10
Loss Of Power On
125 Vdc Switchyard
DC Panelboard DYG
SDCDYG
2
Chan 2 EGTPS 2 Out
Of 3 UV Signal
Network Fails
SY2OF3UVC2
Page 13
Switchyard 125 Vdc
Panelboard DYG
Breaker 12
Transfers Open
LDCYG12CDT
Common Cause
Failure of UV And
UF Detection
Circuits
L0EGTPSCOM
4



External Grid Trouble Protection System | FIGURE A.3-2 | Page 12



External Grid Trouble Protection System | FIGURE A.3-2 |

Gate/Event Name	Page	Zone	Gate/Event Name	Page	Zone	Gate/Event Name	Page	Zone	Gate/Event Name	Page	Zone
L0EGTPSCOM	4		L27XPZ2RYD	13		L81BRZ2RYD	12		L81XYX1RYD	5	
L0EGTPSCOM	4		L27XPZ2RYD	13		L81BRZ2RYD	12		L81XYX1RYD	5	
L0EGTPSCOM	11		L27XRX1RYD	6		L81BYX1RYD	5		L81XYX2RYD	12	
L0EGTPSCOM	11		L27XRX1RYD	6		L81BYX1RYD	5		L81XYX2RYD	12	
L27BRX1RYD	6		L27XRX2RYD	13		L81BYX2RYD	12		L81XYY1RYD	5	
L27BRX1RYD	6		L27XRX2RYD	13		L81BYX2RYD	12		L81XYY1RYD	5	
L27BRX2RYD	13		L27XRY1RYD	6		L81BYY1RYD	5		L81XYY2RYD	12	
L27BRX2RYD	13		L27XRY1RYD	6		L81BYY1RYD	5		L81XYY2RYD	12	
L27BRY1RYD	6		L27XRY2RYD	13		L81BYY2RYD	12		L81XYZ1RYD	5	
L27BRY1RYD	6		L27XRY2RYD	13		L81BYY2RYD	12		L81XYZ1RYD	5	
L27BRY2RYD	13		L27XRZ1RYD	6		L81BYZ1RYD	5		L81XYZ2RYD	12	
L27BRY2RYD	13		L27XRZ1RYD	6		L81BYZ1RYD	5		L81XYZ2RYD	12	
L27BRZ1RYD	6		L27XRZ2RYD	13		L81BYZ2RYD	12		LC94F1ARYD	2	
L27BRZ1RYD	6		L27XRZ2RYD	13		L81BYZ2RYD	12		LC94F1BRYD	1	
L27BRZ2RYD	13		L27XSTARYD	1		L81XPX1RYD	5		LC94F1DRYD	3	
L27BRZ2RYD	13		L27XSTBRYD	7		L81XPX1RYD	5		LC94F2ARYD	8	
L27BYX1RYD	6		L27XYX1RYD	6		L81XPX2RYD	12		LC94F2BRYD	7	
L27BYX1RYD	6		L27XYX1RYD	6		L81XPX2RYD	12		LC94F2CRYD	9	
L27BYX2RYD	13		L27XYX2RYD	13		L81XPY1RYD	5		LC94F2DRYD	10	
L27BYX2RYD	13		L27XYX2RYD	13		L81XPY1RYD	5		LC94V1ARYD	2	
L27BYY1RYD	6		L27XYY1RYD	6		L81XPY2RYD	12		LC94V1BRYD	1	
L27BYY1RYD	6		L27XYY1RYD	6		L81XPY2RYD	12		LC94V1DRYD	3	
L27BYY2RYD	13		L27XYY2RYD	13		L81XPZ1RYD	5		LC94V2ARYD	8	
L27BYY2RYD	13		L27XYY2RYD	13		L81XPZ1RYD	5		LC94V2BRYD	7	
L27BYZ1RYD	6		L27XYZ1RYD	6		L81XPZ2RYD	12		LC94V2CRYD	9	
L27BYZ1RYD	6		L27XYZ1RYD	6		L81XPZ2RYD	12		LC94V2CRYD	10	
L27BYZ2RYD	13		L27XYZ2RYD	13		L81XRX1RYD	5		LDCYC13CDT	4	
L27BYZ2RYD	13		L27XYZ2RYD	13		L81XRX1RYD	5		LDCYC14CDT	4	
L27XPX1RYD	6		L81BRX1RYD	5		L81XRX2RYD	12		LDCYG12CDT	11	
L27XPX1RYD	6		L81BRX1RYD	5		L81XRX2RYD	12		LDCYG18CDT	11	
L27XPX2RYD	13		L81BRX2RYD	12		L81XRY1RYD	5		SDCDYC	4	
L27XPX2RYD	13		L81BRX2RYD	12		L81XRY1RYD	5		SDCDYC	4	
L27XPY1RYD	6		L81BRY1RYD	5		L81XRY2RYD	12		SDCDYG	11	
L27XPY1RYD	6		L81BRY1RYD	5		L81XRY2RYD	12		SDCDYG	11	
L27XPY2RYD	13		L81BRY2RYD	12		L81XRZ1RYD	5		SEG94F1AF	2	
L27XPY2RYD	13		L81BRY2RYD	12		L81XRZ1RYD	5		SEG94F1BF	1	
L27XPZ1RYD	6		L81BRZ1RYD	5		L81XRZ2RYD	12		SEG94F1DF	3	
L27XPZ1RYD	6		L81BRZ1RYD	5		L81XRZ2RYD	12		SEG94F1F	1	

Gate/Event Name	Page	Zone
SEG94F1F	2	
SEG94F1F	3	
SEG94F1F	4	
SEG94F2AF	8	
SEG94F2BF	7	
SEG94F2CF	9	
SEG94F2DF	10	
SEG94F2F	7	
SEG94F2F	8	
SEG94F2F	9	
SEG94F2F	10	
SEG94F2F	11	
SEG94V1AF	2	
SEG94V1BF	1	
SEG94V1DF	3	
SEG94V1F	1	
SEG94V1F	2	
SEG94V1F	3	
SEG94V1F	4	
SEG94V2AF	8	
SEG94V2BF	7	
SEG94V2CF	9	
SEG94V2DF	10	
SEG94V2F	7	
SEG94V2F	8	
SEG94V2F	9	
SEG94V2F	10	
SEG94V2F	11	
SEGTP1BNIT	1	
SEGTP2BNIT	7	
SEGTPSCH1F	1	
SEGTPSCH2F	7	
SEGX1Y1UF	5	
SEGX1Y1UV	6	
SEGX1Z1UF	5	
SEGX1Z1UV	6	
SEGX2Y2UF	12	
SEGX2Y2UV	13	
SEGX2Z2UF	12	
SEGX2Z2UV	13	
SEGY1Z1UF	5	
SEGY1Z1UV	6	
SEGY2Z2UF	12	
SEGY2Z2UV	13	
SY2OF3UFC1	4	
SY2OF3UFC1	5	
SY2OF3UFC2	11	
SY2OF3UFC2	12	
SY2OF3UVC1	4	
SY2OF3UVC1	6	
SY2OF3UVC2	11	
SY2OF3UVC2	13	

APPENDIX A.4
AIR CIRCUIT BREAKERS

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A.4 AIR CIRCUIT BREAKERS

A.4.1 OBJECTIVES

The main objective of this analysis is to develop a logic model of the Air Circuit Breakers (ACBs). This model is combined with the high-level model and remaining system models to form an integrated model for assessing the reliability of Keowee. Other objectives are to identify major contributors to component unreliability, significant potential human errors and common-cause failure modes.

The scope of this analysis is limited to ACB equipment required to support a Keowee emergency start and run under load following a loss of offsite power.

A.4.2 SYSTEM DESIGN

A.4.2.1 AIR CIRCUIT BREAKER 1

ACB-1 provides the electrical connection for Keowee Unit 1 to the Keowee main step-up transformer. This breaker must be closed for Keowee Unit 1 to provide power to the grid or to supply Oconee emergency power through the overhead path. Air is used both to provide motive force for opening and closing the breaker as well as the insulating medium for extinguishing the arc when opening the breaker. This breaker is rated for 15 kV and 4000 A.

ACB-1 contains an air accumulator normally charged to 150 psig. This accumulator stores enough air at the nominal operating pressure for three to four operations of the breaker. Typical pressure drops during operation are 25 psig during the opening operation and 2 psig during the closing operation.

ACB-1 is provided with disconnect switches on either side of the breaker that can be used to isolate the breaker at both ends from the 13.8 kV electrical bus.

A simplified elementary diagram for ACB-1 is included as Figure A.4-1.

A.4.2.2 AIR CIRCUIT BREAKER 2

ACB-2 provides the electrical connection for Keowee Unit 2 to the main step-up transformer. This breaker must be closed for Keowee Unit 2 to provide power to the grid or to supply Oconee emergency power through the overhead path. Air is used both to provide motive force for opening and closing the breaker as well as the insulating medium for extinguishing the arc when opening the breaker. This breaker is rated for 15 kV and 4000 A.

ACB-2 contains an air accumulator normally charged to 150 psig. This accumulator stores enough air at the nominal operating pressure for three to four operations of the breaker. Typical pressure drops during operation are 25 psig during the opening operation and 2 psig during the closing operation.

ACB-2 is provided with disconnect switches on either side of the breaker that can be used to isolate the breaker at both ends from the 13.8 kV electrical bus.

A simplified elementary diagram for ACB-2 is included as Figure A.4-2.

A.4.2.3 AIR CIRCUIT BREAKER 3

ACB-3 provides the electrical connection for Keowee Unit 1 to transformer CT4 at Oconee through the underground path. This breaker must be closed for Keowee Unit 1 to provide emergency power through the underground path. Air is used both to provide motive force for opening and closing the breaker as well as the insulating medium for extinguishing the arc when opening the breaker. This breaker is rated for 15 kV and 2000 A.

ACB-3 contains an air accumulator normally charged to 150 psig. This accumulator stores enough air at the nominal operating pressure for three to four operations of the breaker. Typical pressure drops during operation are 25 psig during the opening operation and 2 psig during the closing operation.

ACB-3 is provided with disconnect switches on either side of the breaker that can be used to isolate the breaker at both ends from the 13.8 kV electrical bus. A motor operated

disconnect switch is provided between ACB-3 and the Keowee Unit 1 generator for isolation purposes (this disconnect has been disabled).

A simplified elementary diagram for ACB-3 is included as Figure A.4-3.

A.4.2.4 AIR CIRCUIT BREAKER 4

ACB-4 provides the electrical connection for Keowee Unit 2 to transformer CT4 at Oconee through the underground path. This breaker must be closed for Keowee Unit 2 to provide emergency power through the underground path. Air is used both to provide motive force for opening and closing the breaker as well as the insulating medium for extinguishing the arc when opening the breaker. This breaker is rated for 15 kV and 2000 A.

ACB-4 contains an air accumulator normally charged to 150 psig. This accumulator stores enough air at the nominal operating pressure for three to four operations of the breaker. Typical pressure drops during operation are 25 psig during the opening operation and 2 psig during the closing operation.

ACB-4 is provided with disconnect switches on either side of the breaker that can be used to isolate the breaker at both ends from the 13.8 kV electrical bus. A motor operated disconnect switch is provided between ACB-4 and the Keowee Unit 2 generator for isolation purposes (this disconnect has been disabled).

A simplified elementary diagram for ACB-4 is included as Figure A.4-4.

A.4.2.5 AIR CIRCUIT BREAKER 5

ACB-5 provides the electrical connection for transformer 1X at Keowee to 600 V ac load center 1X. This breaker must be closed for load center 1X to receive power from the 13.8 kV bus through transformer 1X. Air is used as the insulating medium for extinguishing the arc when opening the breaker. Operation of the breaker is electromechanical, air pressure is not required for breaker operation.

A simplified elementary diagram for ACB-5 is included as Figure A.4-5.

A.4.2.6 AIR CIRCUIT BREAKER 6

ACB-6 provides the electrical connection for transformer 2X at Keowee to 600 V ac load center 2X. This breaker must be closed for load center 2X to receive power from the 13.8 kV bus through transformer 2X. Air is used as the insulating medium for extinguishing the arc when opening the breaker. Operation of the breaker is electromechanical, air pressure is not required for breaker operation.

A simplified elementary diagram for ACB-6 is included as Figure A.4-6.

A.4.2.7 AIR CIRCUIT BREAKER 7

ACB-7 provides the electrical connection for transformer CX at Keowee to 600 V ac load center 1X. This breaker must be closed for load center 1X to receive power from the 4160 V ac underground supply from Oconee Unit 1, switchgear 1TC-4, through transformer CX. Air is used as the insulating medium for extinguishing the arc when opening the breaker. Operation of the breaker is electromechanical, air pressure is not required for breaker operation.

A simplified elementary diagram for ACB-7 is included as Figure A.4-7.

A.4.2.8 AIR CIRCUIT BREAKER 8

ACB-8 provides the electrical connection for transformer CX at Keowee to 600 V ac load center 2X. This breaker must be closed for load center 2X to receive power from the 4160 V ac underground supply from Oconee Unit 1, switchgear 1TC-4, through transformer CX. Air is used as the insulating medium for extinguishing the arc when opening the breaker. Operation of the breaker is electromechanical, air pressure is not required for breaker operation.

A simplified elementary diagram for ACB-8 is included as Figure A.4-8.

A.4.3 SYSTEM BOUNDARIES

Air Systems

ACBs 1, 2, 3, and 4 receive air from the Generator ACB Air System. A check valve located at the ACB provides isolation on loss of the air supply. Leakage of air on loss of the supply is limited to 5 psi/hr, however, the nominal rate is 2 to 3 psi/hr. The Generator ACB Air System is required for long term operability of ACBs 1 through 4.

Electrical Power Supplies

Control power is furnished from 125 V dc distribution centers 1DA (ACBs 1, 3, 5, and 7) and 2DA (ACBs 2, 4, 6, and 8). The power supplies for the modeled components are listed in Table A.4-1.

External Control Systems

Various ACBs receive Keowee emergency start signals, under-voltage relay inputs, generator lockout relay signals, or transformer lockout signals. The effect of these signals on breaker function is further described in Section A.4.4, Instrumentation and Controls.

Other System Boundaries

N/A

A.4.4 INSTRUMENTATION AND CONTROLS

A.4.4.1 EMERGENCY START RELAYS

ACBs 1 and 2 receive emergency start signals to trip. This isolates the Keowee units from the switchyard while the Oconee loads are load shed. The emergency start signal also begins a timing sequence for both breakers. After 6.5 seconds, ACB-1 receives a permissive to close if required. ACB-2 receives a similar permissive in 4 seconds. The stagger on the timing assures that both breakers would not attempt to close simultaneously, possibly tying the two units together when not synchronized.

A.4.4.2 UNDER-VOLTAGE RELAYS

<u>27T/1X and 27T/2X</u>

UV relays 27T/1X and 27T/2X (which are model MG-6 relays) monitor voltage on the 13.8 kV bus. They provide a permissive to close to ACB-1 (27T/1X) and ACB-2 (27T/2X). These permissives prevent automatic closure of the ACB if the 13.8 kV bus happens to be energized from some other source, e.g. the other unit or from the grid, when the unit may not be synchronized with the other source.

<u>27/1X , 27/2X, 27/CX1, and 27CX2</u>

UV relays 27/1X, 27/2X, and 27/CX1 and 27/CX2 (which are model MG-6 relays) monitor voltage on the 600 V ac side of transformers 1X, 2X, and CX respectively. These relays incorporate a 4 second time delay so that a momentary loss of voltage does not result in a control action. Through auxiliary relays, these UV relays provide control functions for ACBs 5, 6, 7, and 8.

- ACB-5 receives a signal from 27/1X to trip if voltage is lost at transformer 1X and a permissive to close if voltage is available from transformer 1X.

- ACB-6 receives a signal from 27/2X to trip if voltage is lost at transformer 2X and a permissive to close if voltage is available from transformer 2X.

- ACB-7 receives a signal from 27/CX1 to trip if voltage is lost at transformer CX and a permissive to close if voltage is available from transformer CX.

- ACB-8 receives a signal from 27/CX2 to trip if voltage is lost at transformer CX and a permissive to close if voltage is available from transformer CX.

A.4.4.3 LOCKOUT RELAYS

Generator lockout relays 86E-1 (Unit 1) and 86E-2 (Unit 2) provide trip signals to their respective output breakers, ACBs 1 and 3, and ACBs 2 and 4.

Main step-up transformer lockout relay 86T provides control to prevent closure of, or to trip, those ACBs which are required to isolate the overhead transformer, ACBs 1, 2, 5, and 7.

CT4 lockout relay 86EF provides a trip signal to those breakers which are required to isolate the underground feeder bus, ACBs 3 and 4.

Transformer CX lockout relay provides a trip signal to those breakers which are required to isolate the transformer, ACBs 6 and 8.

Load center lockout relays 86S/1X, load center 1X, and 86S/2X, load center 2X, provide a trip signal to those breakers which are required to isolate their respective load centers, ACBs 5 and 7, and ACBs 6 and 8.

A.4.4.4 INTERLOCKS BETWEEN ACBS

On each Keowee unit the underground and overhead breakers are interlocked such that the overhead breaker (ACB-1 or ACB-2) can not close automatically if its respective underground breaker (ACB-3 or ACB-4) is aligned to the underground path. Alignment to the underground path is indicated when both the breaker and its associated disconnect are closed.

The underground supply breakers (ACB-3 and ACB-4) are interlocked with each other such that ACB-3(4) can not be closed from the control room if ACB-4(3) is aligned to the underground path. Alignment to the underground path is indicated when both the breaker and its associated disconnect are closed.

The auxiliary power breakers are interlocked with each other so that a 600 V ac load center can be fed from only one source at a time. ACB-5 and ACB-7 are interlocked such that ACB-5(7) can not close automatically or manually from the control room if ACB-7(5) is closed.

A.4.4.5 INTERLOCKS WITH OTHER KEOWEE SYSTEMS/COMPONENTS

The overhead supply breakers (ACB-1 and ACB-2) are interlocked with the generator field breaker of its respective unit such that the ACB can not close unless the generator field breaker is closed.

ACBs 5, 6, 7, and 8 have automatic or manual control as selected on switchgear 1X and 2X. This feature is further described in Section A.4.7.3.

A.4.5 LOCATION WITHIN THE PLANT

The ACBs are located within the Keowee powerhouse on the operating floor, elevation 702'. Additionally, ACBs 3 and 4 are located within a missile protected vault.

A.4.6 NORMAL OPERATION

ACB-1 or ACB-2 is closed when its respective Keowee unit is being used to generate to the grid. When the unit is not generating to the grid, the breaker is open.

The underground supply breaker (ACB-3 or ACB-4) on the Keowee unit dedicated to the underground path is closed at all times. If that unit is generating to the grid, the underground path is energized all the way through transformer CT4 at Oconee.

Current operating restrictions do not allow the Keowee unit dedicated to the underground to generate to the grid.

The Keowee unit dedicated to the underground path receives auxiliary ac power from transformer CX by closing its respective load center feeder breaker from transformer CX, ACB-7 (Unit 1) or ACB-8 (Unit 2). For the underground unit, the supply from transformer CX becomes the preferred source of ac power in an emergency start situation. This is further described in Section A.4.7.3.

The Keowee unit dedicated to the overhead path receives auxiliary ac power through its respective transformer on the 13.8 kV bus (1X or 2X) This is accomplished by closing the appropriate load center feeder breaker, ACB-5 (Unit 1) or ACB-6 (Unit 2). For the overhead unit, the 13.8 kV bus transformer becomes the preferred source of auxiliary ac power in an emergency start situation. This is further described in Section A.4.7.3.

At least every 30 days the unit assigned to the underground supply is swapped to the overhead and vice versa.

A.4.7 PERFORMANCE DURING KEOWEE EMERGENCY OPERATION

A.4.7.1 ACB-1 AND ACB-2

If ACB-1 or ACB-2 is closed when an emergency start signal is received, the breaker is tripped. After a time delay of 6.5 seconds on Unit 1 and 4 seconds on Unit 2, the trip signal is removed and a permissive is present to allow the breaker to close as required. For the unit not aligned to the underground path, the overhead ACB will close if the following conditions are met:

- there is no main step-up transformer lockout
- the 13.8 kV bus is de-energized
- the unit's generator field breaker is racked in and closed
- the ACB's disconnect is closed
- the main step-up transformer disconnect is closed
- the unit's underground supply ACB is open or the disconnect is open
- a train A or B switchyard isolate complete signal is present
- air pressure in the ACB accumulator is above the block setpoint

A.4.7.2 ACB-3 AND ACB-4

Normally, either ACB-3 or ACB-4 is closed. No breaker operation is required if the unit designated to the underground path starts successfully.

When NSM-ON-52966 is placed in service, the operation of ACBs 3 and 4 will be altered. If the unit aligned to the underground path is generating to the grid when an emergency start signal is received, the corresponding underground supply breaker will open and then close in order to connect the unit to the underground path. The opening operation is intended to protect the Oconee loads from the potential over-frequency condition.

A.4.7.3 ACBS 5, 6, 7, AND 8

As noted in Section A.4.6, each unit's auxiliary ac power system has a preferred source of power depending on whether the unit is designated for the underground or the overhead path. ACBs 5 and 7 are controlled and interlocked to provide power to Unit 1 from any available source. ACBs 6 and 8 are similarly controlled for Unit 2. The following description of breaker operation is applicable to these pairs of breakers.

If voltage is lost to the preferred source of auxiliary ac power, a 4 second time delay begins. If voltage is not restored within this interval, the ACB closed on the preferred source is tripped. At this time, a 30 second timing sequence begins. During this interval, the ACB to the preferred source will re-close if voltage is available from this source even if voltage is available at the alternate source as well. If voltage is available only on the alternate source, then the ACB to the alternate supply will close. This ACB will remain closed as long as voltage is available on this supply even if the preferred source is re-energized. Under-voltage relays at the transformers provide the voltage sensing for control of the ACBs.

A.4.8 TEST AND MAINTENANCE

Testing

The test procedures applicable to the ACBs are detailed in Table A.4-3.

Maintenance

The maintenance procedures applicable to the ACBs are detailed in Table A.4-4.

A.4.9 OPERATING EXPERIENCE

A summary of significant operating events is provided in Table A.4-5.

A.4.10 ASSUMPTIONS

A.4.10.1 SYSTEM DESIGN ASSUMPTIONS

Adequate air pressure is available for ACB operations as long as the pressure is above the alarm setpoint.

A.4.10.2 OPERATIONAL ASSUMPTIONS

1. The underground and overhead unit assignments are swapped at least every 30 days.

2. One channel of the under-voltage relays 27T/1X and 27T/2X are tested every refueling outage.

3. Under-voltage relays 27/1X, 27/2X, 27/CX1, and 27/CX2 are tested on an annual basis.

4. The time delay relays 52-1TD and 52-2TD are tested annually.

A.4.10.3 MODELING ASSUMPTIONS

The following assumptions have been made in the development of the fault trees for the Air Circuit Breakers.

1. The breaker failure type codes (CHO, CHT, CHC) are not included as they would be redundant to modeling the failures of the breaker component parts.

2. ACB-1, 2, 3, 4 trip and closing coils are adequately modeled as solenoid valves.

3. Passive failures of air piping and check valve failures which could go undetected by the low pressure alarm and result in breaker failure are not probabilistically significant.

4. Mis-positioning of valves on the breaker air plumbing is considered in the quantification of the latent human error.

5. Breaker, disconnect, and relay contacts are not modeled as moving independently of the primary device. That is, the contacts fail only when the primary device fails.

6. ACBs 1 and 2 control power fuses blown or control power disconnects left open would be alarmed. These failures are not modeled due to the low probability of going undetected.

7. The presence of a main step-up transformer lock-out (86T) or a switchgear lockout (86S/1X or 86S/2X) prior to a LOOP would be indicated on the statalarm panel and therefore these failures are not included in the ACB-5, 6, 7, 8 fail to

close gates. Failures of these relays are included as run failures in the breaker transfers open logic.

8. Relays 83S1X and 83S2X identify the primary and alternate supplies for switchgear centers 1X and 2X respectively. Transfer of the relay out of the correct position does not contribute to failure since the auto-throwover logic always causes the switchgear to connect to which ever source is available regardless of whether it is the primary or alternate.

9. Leaving the control power disconnects in the open position is considered in the quantification of the open and close latent human errors for ACBs 5, 6, 7, 8.

Failure (transfers position) of under-voltage relay (27/1X, 27/2X, 27CX1, or 27CX2) prior to the LOOP could result in a plant configuration different than that assumed for the analysis. Since this transfer of ACBs 5, 6, 7, or 8 would be expected to be detected early, the exposure to this failure is small and would not contribute to the breaker failure probability. Failure of these relays prior to the mission is not included in the tree.

A.4.11 FAULT TREE ANALYSIS

A.4.11.1 TOP EVENT SUCCESS CRITERIA

Air circuit breaker operation is successful if the breaker moves to the required position and remains in that position for the required 24 hour mission .

A.4.11.2 DETAILED FAILURE CRITERIA

N/A

A.4.11.3 DESCRIPTION OF FAULT TREE

The ACBs fault tree is shown in Figure A.4-9. The Fault Tree Modeling Guidelines (Appendix B) were followed in developing the fault tree. A list of all fault tree top events (19 events in all) is presented in Table A.4-8. A list of all fault tree transfers is presented in Table A.4-6.

The specific failure of a breaker (failure to open or failure to close) that is required for the Keowee analysis is explicitly included as a top event (e.g., Air Circuit Breaker 2 Fails To Close, and Air Circuit Breaker 7 Fails To Open). In some cases the operation of one of the ACBs is dependent on operation of one of the other ACBs and these intra-model transfers are included.

Failure events considered in the trees include breaker failures due to either mechanical or electrical problems. In general, adequate generic data bases are available for electrical components, relays, switches, fuses, and solenoids. These failures are modeled explicitly through the basic events involving failures of these components. The mechanical failures have been developed from the plant specific data collected on the Keowee breakers. These generally are modeled as undeveloped events in the fault trees.

The tree structure allows the analysis of the Keowee reliability with the features of NSM-ON-52966, described in Appendix E. The branches of the tree that incorporate this NSM have an impact on the solution only when the event defining the inclusion of this modification is set appropriately.

Human events impacting the model are described in Section A.4.11.4.

Common-cause events impacting the model are described in Section A.4.11.6.

A.4.11.4 HUMAN INTERACTIONS

The success or failure of the Air Circuit Breakers to perform their function is impacted by several human actions. Those events explicitly included in the system fault tree are discussed below. Refer to Section 5.5 and Appendix C.3 for information on the quantification of human error events.

<u>ACBxOPENLHE, ACBxCLOSLHE</u>
(x = 1 through 8 as appropriate)

These basic events account for the potential of the plant personnel to fail to properly restore the ACBs. Post-maintenance testing is expected to detect the majority of errors. However, some errors may escape detection and fail the breaker at some future time.

ABEOPRCREC, ABPOPRCREC

These events consider the opportunity for the operators to close ACBs 2 and 4 respectively in order to complete the power path alignment. The fault tree includes these possible operator actions to recover from potential failures, mostly control system failures.

A.4.11.5 RELIABILITY DATA

Reliability data used in the Air Circuit Breaker analysis are listed in Table A.4-9.

Section 5.3 discusses development of the reliability data. For the base case solution, the plant-specific failure rate data and generic failure rate data were combined using a Bayesian update.

A.4.11.5.1 Exposure Times

Time dependent failures require an exposure time for determination of the failure probability. Failure times have been established based on the consideration of the time since the last test or operation of the component. Table A.4-9 contains a brief explanation of the rational used in determining the exposure time for each time dependent failure.

A.4.11.5.2 Undeveloped Events

The following undeveloped events (DEX) are included in the ACB fault tree. Refer to Table A.4-9 for descriptions of these events. In quantifying these events, Air Circuit Breakers 1,2,3 and 4 are considered in the same component population. Even though the current carrying capacity of ACBs 3 and 4 is different than that of ACBs 1 and 2, they are identical in the construction of the openning and closing mechanisms. Including all four breakers in the same component population is appropriate. ACBs 5, 6, 7, and 8 are considered together as a component population.

AB1MECHDEX (AB[2,3]MECHDEX): Air Circuit Breaker 1(2,3) Fails To Open Due To Mechanical Failure.

The 2/28/90 event, from Table A.4-5, involving a bad blast valve is considered a failure of ACB-2 to open since the blast valve functions to extinguish the arc when the breaker opens.

AB1MECHDEX, AB2MECHDEX, and AB3MECHDEX are quantified by considering the one component failure to open in the population over the total demands to open for the population.

1/(Unit 1 starts + Unit 2 starts +(2 x (61+10)) = 1.51E-04/demand

With one breaker demand for the emergency operation of Keowee, AB1MECHDEX = AB2MECHDEX = AB3MECHDEX = 1.51E-04

AB2MCH2DEX AB[3,4]MCH2DEX: Air Circuit Breaker 2 (3,4) Fails To Close Due To Mechanical Failure.

The 8/21/87 and 11/28/92 events, from Table A.4-5, are failures of ACB-2 and ACB-3 to close

AB2MCH2DEX, AB3MCH2DEX and AB4MCH2DEX are quantified by considering the two component failures to close over the total demands of the four breakers to close.

2/(Unit 1 starts + Unit 2 starts +(2 x (61+10)) = 3.02E-04/demand

With one breaker demand for the emergency operation of Keowee, AB2MCH2DEX = AB3MCH2DEX = AB4MCH2DEX = 3.02E-04

ACBAIRPDEX: ACB Air Supply Fails Causing Low Pressure In All ACB Accumulators

Failure of the ACB Air System may lead to loss of air pressure. All of the ACBs leak to varying degrees, therefore, loss of the compressors eventually leads to loss of air pressure in all of the ACB accumulators.

This event is developed on the assumption that the loss of air supply is dominated by a common cause failure of the air compressors to start during a black start of the Keowee

units. From the Catawba PRA data, the air compressor fails to start value is 1.00E-02. Using a generic Beta factor of 0.1 the common cause failure to start is calculated to be 1.00E-03. This value is then doubled to provide some allowance for failure modes not explicitly considered.

The value of ACBAIRPDEX = 2.00E-03

This failure is included in the ACB4CLOSE gate logic. The demand for ACB-4 to close is a recovery action and may come late enough in the mission for the air pressure to decay to a low value due to leakage.

AB6MECHDEX (AB7MECHDEX): Air Circuit Breaker 6(7) Fails To Open Due To Mechanical Failure.

There are no failure to open events for ACBs 5, 6, 7, or 8 in the event data base.

These breakers are manipulated during the monthly swap of the unit alignments. Additionally, they are tested annually.

AB5MECHDEX, AB6MECHDEX, AB7MECHDEX, and AB8MECHDEX are quantified by using the chi-squared distribution as discussed in Section 5.3.

0.455/(2x4x(61+10)) = 8.01E-04/demand

With one breaker demand for the emergency operation of Keowee, AB5MECHDEX = AB6MECHDEX = AB7MECHDEX = AB8MECHDEX = 8.01E-04

AB5MCH2DEX (AB[6, 7, 8]MCH2DEX): Air Circuit Breaker 5([6, 7, 8]) Fails To Close Due To Mechanical Failure.

The failure to close events on 10/19/92 for ACBs 5 and 7 resulted from impact spring failures. Other failure to close events for ACBs 5, 6, 7, and 8 contained in Table A.4-5 are all due to the X-relay failures or to the slow relay pick-up experienced when the X-relays were first replaced. The X-relays have all been replaced and timers installed to correct the pick-up problem, therefore, these events are not included in the failure computation for these basic events.

Since the breaker controls are modeled explicitly, failures of these components, if they were still part of the breaker construction, would have been modeled in the control component failures and not included in the DEX calculation. The DEX calculation includes those failures that are mechanical in nature and not explicitly modeled elsewhere. Two failure to close events, applicable to the current breaker construction, are found in Table A.4-5.

AB5MCH2DEX, AB6MCH2DEX, AB7MCH2DEX, and AB8MCH2DEX are quantified by using the chi-squared distribution as discussed in Section 5.3.

$$2/(4x(61+10)) = 7.04E\text{-}03/\text{demand}$$

With one breaker demand for the emergency operation of Keowee, AB5MCH2DEX = AB6MCH2DEX = AB7MCH2DEX = AB8MCH2DEX = 7.04E-03

<u>AB1ACCUDEX (AB[3, 4, 5] ACCUDEX): Air Circuit Breaker 1([2, 3, 4]) Accumulator Air Pressure Low.</u>

The different current carrying capacities of ACBs 1 and 2, and 3 and 4 are not believed to affect the availability of adequate air pressure in the accumulators. They are considered a single population for the calculation of these basic events. The accumulator pressure DEX for a breaker is applied to both the failure to open and failure to close gates for the respective breaker.

No ACB failures due to low air pressure are identified in Table A.4-5.

AB1ACCUDEX, AB2ACCUDEX, AB3ACCUDEX, and AB4ACCUDEX are quantified by using the chi-squared distribution as discussed in Section 5.3. The number of unit starts is much larger than the ACB 3 and 4 operations and is assumed to dominate the total demands.

$$0.455/(2x(\text{Unit 1 starts} + \text{Unit 2 starts})) = 3.51E\text{-}05/\text{demand}$$

With one breaker demand for the emergency operation of Keowee, AB1ACCUDEX = AB2ACCUDEX = AB3ACCUDEX = AB4ACCUDEX = 3.51E-05.

AK2GATEDEX: Wicket Gate Limit Switch Indicates Gate Position Is Below No-load Setting

This event is having the gate position limit switch falsely indicate that the gate position is below no load. There are no reported failures of this device in the Keowee operational data.

This failure is quantified as a spurious operation of a limit switch over the 24 hour mission. From the McGuire PRA, the spurious operation of a limit switch occurs with the failure rate of 8.80E-07/hour.

For the 24 hour mission, AK2GATEDEX = 2.11E-05.

YK1(2)86N2DEX: Keowee Unit 1(2) Normal Lock-out Actuates

The events on 8/1/88, 8/18/88, and 5/10/84, from Table C.1-1 of Appendix C, are actuations of the normal lockout relay.

YK186N2DEX and YK286N2DEX are quantified by considering the 3 failures over the total run hours of the Keowee units.

3/(Unit 1 run hours+Unit 2 run hours) = 3.09E-4/hour

For the 24 hour mission, YK186N2DEX = YK286N2DEX = 7.41E-03.

A.4.11.6 COMMON-CAUSE ASSESSMENT

AB23BKRCOM, AB24BKRCOM

These events consider the potential for the breakers that are required to close (either 2 &3 or 2 & 4) failing to do so due to a common cause. These ACBs share many common elements in their design and construction. The potential for common cause failures of the breakers is assumed to exist.

Quantification of these events is discussed in the common cause failure analysis, described in Section 5.4 and Appendix C.2.

A.4.12 RESULTS

Tables A.4-10 through A.4 -28 lists the dominant minimal cut sets (failure sequences) for the Air Circuit Breaker top events. A list of dominant contributors to unavailability is given in Tables A.4-29 through A.4-47.

The dominant contributors to the unavailability of the Air Circuit Breakers tend to be the control relay failures, latent human errors and breaker mechanical failures.

A.4.13 REFERENCES

A.4.13.1 DOCUMENTS

1. OSS-0254.00-00-2005, Keowee Emergency Power Design Basis Document

A.4.13.2 PROCEDURES

1. MP/0/A/2000/053, Monthly Surveillance Test of ACB No. 3 and No. 4 Interlock
2. PT/0/A/0620/016, Keowee Hydro Emergency Start Test
3. MP/0/A/2000/068, Monthly Surveillance Test Of Overhead Emergency Feed Path "B" Finger
4. OP/1/A/2000/50, Unit No. 1 Electromechanical Relay ACB Trip Test
5. OP/0/A/2000/044, Keowee Emergency Power Path And Auxiliary Alignment
6. OP/0/A/2000/045, Auxiliary Power Transfer Test
7. MP/0/A/2001/02, ACB Inspection and Maintenance
8. OP/0/A/2000/005, ACB No. 1
9. OP/0/A/2000/007, ACB No. 3

10. OP/0/A/2000/009, ACB No. 5

11. AP/0/A/2000/002, Keowee Hydro Station Emergency Start

12. OP/0/A/2000/049, Auxiliary Power Transfer Test

A.4.13.3 DRAWINGS

1. K-700, Rev. 9, One Line Diagram, Relays and Meters 13.8-230kV.

2. KEE-27-1, Rev. 4, Keowee Hydro Station Units No. 1 & 2, Elementary Diagram, 600V Switchgear No. 1X ACB-5 and ACB-7.

3. KEE-27-2, Rev. 4, Keowee Hydro Station Units No. 1 & 2, Elementary Diagram, 600V Switchgear No. 2X ACB-6 and ACB-8.

4. KEE-27-3, Rev. 4, Keowee Hydro Station Units No. 1 & 2, Elementary Diagram, 600V Switchgear No. 1X Auto Thrower Relaying.

5. KEE-27-3-1, Rev. 1, Keowee Hydro Station Units No. 1 & 2, Elementary Diagram, 600V Switchgear No. 2X Auto Thrower Relaying.

6. KEE-112-2, Rev. 9, Keowee Hydro Station Unit No. 1, Elementary Diagram, Excitation System Generator Field Breaker.

7. KEE-212-2, Rev. 9, Keowee Hydro Station Unit No. 2, Elementary Diagram, Excitation System Generator Field Breaker.

8. KEE-113, Rev. 8, Keowee Hydro Station Unit No. 1, Elementary Diagram, Master Control System Start-up Controls.

9. KEE-213, Rev. 8, Keowee Hydro Station Unit No. 2, Elementary Diagram, Master Control System Start-up Controls.

10. KEE-113-5, Rev. 8, Keowee Hydro Station Unit No. 1, Elementary Diagram, Master Control System Turbine Miscellaneous Relaying.

11. KEE-213-5, Rev. 5, Keowee Hydro Station Unit No. 2, Elementary Diagram, Master Control System Turbine Miscellaneous Relaying.

12. KEE-114, Rev. 12, Keowee Hydro Station Unit No. 1, Elementary Diagram, Generator Control ACB-1 Control Circuit.

13. KEE-214, Rev. 9, Keowee Hydro Station Unit No. 2, Elementary Diagram, Generator Control ACB-2 Control Circuit.

14. KEE-114-1, Rev. 13, Keowee Hydro Station Unit No. 1, Elementary Diagram, Generator Control ACB-3 Control Circuit.

15. KEE-214-1, Rev. 10, Keowee Hydro Station Unit No. 2, Elementary Diagram, Generator Control ACB-4 Control Circuit.

16. KEE-114-3, Rev. 11, Keowee Hydro Station Unit No. 1, Elementary Diagram, Generator Control Normal and Emergency Lockout.

17. KEE-214-3, Rev. 8, Keowee Hydro Station Unit No. 2, Elementary Diagram, Generator Control Normal and Emergency Lockout.

Table A.4-1

Air Circuit Breaker Power Supplies

Component	Power Supply[1]	Compartment Number
ACB-1	125 V dc DC 1DA	3CL
ACB-2	125 V dc DC 2DA	3CL
ACB-3	125 V dc DC 1DA	3CC
ACB-4	125 V dc DC 2DA	3CC
ACB-5	125 V dc DC 1DA	4AL
ACB-6	125 V dc DC 2DA	2AL
ACB-7	125 V dc DC 1DA	4AL
ACB-8	125 V dc DC 2DA	2AL

[1] DC = Distribution Center

Table A.4-2

Air Circuit Breaker External Controls

Component	Signal
ACB-1	Emergency Start Relays 1ESRX/1A and 1ESRX/1B to Open
ACB-2	Emergency Start Relays 2ESRX/1A and 2ESRX/1B to Open
	Switchyard Isolate Complete Signal to Close
	Generator Field Breaker Is Closed Permissive to Close
	Overhead Transformer Lock-out Permissive (no lock-out)
ACB-3	None (pre-modification)
	1ESRX/1A and 1ESRX/1B to Open (post-modification)
	Overfrequency Relays Signal to Close (post-modification)

Table A.4-2

Air Circuit Breaker External Controls

Component	Signal
ACB-4	Close on Indication of Main Transformer Lock-out and Unit 1 Generator Emergency Lock-out (post-modification)
ACB-5	None
ACB-6	None
ACB-7	None
ACB-8	None

Table A.4-3

Air Circuit Breaker Test Procedures

Procedure	Test Frequency	Description
MP/0/A/2000/053 Monthly Surveillance Test of ACB No. 3 and No. 4 Interlock	Monthly	Functional test of interlock circuitry between ACB No. 3 and ACB No. 4.
PT/0/A/0620/016 Keowee Hydro Emergency Start Test	Periodic	Demonstrate the operability of each Keowee unit's emergency start circuitry from each control room.
MP/0/A/2000/068 Monthly Surveillance Test Of Overhead Emergency Feed Path "B" Finger Circuitry.	Monthly	Test of interlock circuitry between ACB No. 1 and ACB No. 3, and between ACB No. 2 and ACB No. 4.
OP/0/A/2000/049 Auxiliary Power Transfer Test	Annually	Verifies proper operation of the auto throwover circuits on ACBs 5 through 8.

Table A.4-3

Air Circuit Breaker Test Procedures

Procedure	Test Frequency	Description
OP/1/A/2000/50 Unit No. 1 Electro-Mechanical Relay ACB Trip Test	Quarterly	Verify tripping of ACB No. 1 and ACB No. 3 on actuation of the GENERATOR GROUND FAULT OVERVOLTAGE relay 59GN-1
OP/0/A/2000/044 Keowee Emergency Power Path And Auxiliary Alignment	Monthly	Change the alignment of the Keowee units and the auxiliary power source.
OP/0/A/2000/044 Auxiliary Power Transfer Test	Periodic	Demonstrate the ability of the 600 V ac load center to close its auxiliary and normal feeder breakers with the appropriate time delays.

Table A.4-4

Air Circuit Breaker Maintenance Procedures

Procedure	Maintenance Frequency	Description
MP/0/A/2001/02 ACB Inspection and Maintenance	Annual	Establishes the requirements for the inspection and maintenance of the ACBs.
OP/0/A/2000/005 ACB No. 1	As needed	Removal from service and restoration to service of ACB No. 1
OP/0/A/2000/007 ACB No. 3	As needed	Removal from service and restoration to service of ACB No. 3
OP/0/A/2000/009 ACB No. 5	As needed	Removal from service and restoration to service of ACB No. 5

Table A.4-5

Air Circuit Breaker Significant Operating Events

Date	Unit	Component	Event Summary
1-31-87	1	ACB-5	Oconee was performing a test on PCB 8 and 9 when ACB-5 tripped. Would not re-close.
8-21-87	1	ACB-3	Oconee attempted to line unit 1 up to the underground but they could not get ACB-3 to close due to a loose terminal.
2-28-90	2	ACB-2	ACB-2 out of service to replace a bad Blast Valve Pin in ACB-2.
3-1-92	1	ACB-5	After Oconee had completed the performance of a Switchyard test and had closed PCB's 8 & 9, ACB-5 failed to close automatically.
7-17-92	2	ACB-8	Keowee Operator found blown fuse in ACB-8 closing circuit during a time when Unit 1 was out of service and Unit 2 was lined up to feed CT4 and the standby busses with Unit 2 auxiliaries being fed through ACB-6. This made Unit 2 technically inoperable.
9-29-92	2	ACB-2	During the performance of post-mod. testing, it was discovered that ACB-2 did not close immediately after opening ACB-1 as the procedure required.
10-19-92	1	ACB-5, ACB-7	Oconee LOOP Event - Initially Unit 1 was generating to the grid and Unit 2 was lined up to the underground path. When the Swyd Isolation and the 1st ES actuation occurred, ACB-1 tripped and then re-closed. Unit 2 started and was supplying CT4. The K Operator tripped ACB-1 which de-energized all of Keowee's auxiliaries. ACB-5 and ACB-7 failed to transfer as designed to re-energize the 1X Swgr.

Table A.4-5

Air Circuit Breaker Significant Operating Events

Date	Unit	Component	Event Summary
10-19-92	2	ACB-8	Oconee LOOP Event - Following the Keowee Operator tripping ACB-1 and relay operation in the Oconee 230 KV switchyard causing a Main Transformer lockout, ACB-8 failed to close to re-energize 2X.
10-20-92	1	ACB-5	While testing the ACB5/ACB7 swap-over function, ACB 5 failed to close when ACB 7 was tripped.
10-22-92	1	ACB-1	Unit 1 had just been shut down and a cabinet inspection team was performing a cabinet inspection in Cabinet 1LC1 at Keowee when they discovered a broken lug on Emergency Start Timer 52-1TD (contact 4A) which trips ACB-1 on receipt of an ES signal.
11-24-92	2	ACB-6, ACB-8	While attempting to tie Keowee Unit 2 to the overhead after a successful Emergency Start Test of both units, feeder breakers for load center 2X, ACB-6 and ACB-8, would not close manually, which left Keowee Unit-2 without power.
11-28-92	2	ACB-2	Keowee Unit 2 was started for system generation but ACB-2 would not close either automatically or manually. The operator found a smoking relay in the ACB-2 cabinet.

Table A.4-6

Air Circuit Breaker Fault Tree Transfers

Transfer Gate Name	Description	Components Supplied
YK1STRTINT	Keowee 1 Emergency Start Aux Relays 1ESRX/1A & 1ESRX/1B Fail	ACB-1
YK2STRTINT	Keowee 2 Emergency Start Aux Relays 2ESRX/1A & 2ESRX/1B Fail	ACB-2, ACB-4
XD1DASRCES	Loss of Power to 125 V dc Distribution Center 1DA During Start	ACB-1, ACB-4
XD2DASRCES	Loss of Power to 125 V dc Distribution Center 2DA During Start	ACB-2
XFMR186T	Main Step-up Transformer Lock Out Relay 86T Actuates	ACB-2, ACB-5, ACB-6
KU2STARTR	Keowee Unit 2 Start Is Required	ACB-2
SPCISLTCPT	Switchyard Isolate Complete Signal Fails	ACB-2
KU2RNNG	Keowee Unit 2 Is Supplying The Grid	ACB-2
K2NOMAIN	Keowee Unit 2 Is Not In Maintenance	ACB-2

Table A.4-6

Air Circuit Breaker Fault Tree Transfers

Transfer Gate Name	Description	Components Supplied
KU1RNNG	Keowee Unit 1 Is Supplying The Grid	ACB-2, ACB-3
NTACB4MOD	NSM-ON-52966 Is In Service	ACB-2, ACB-3, ACB-4
FLDTRANS2	Keowee Unit 2 Field Breaker Transfers Open	ACB-2
GK286E2	Keowee Unit 2 Emergency Lock Out Due To Spurious Actuation Of Generator Protective Relay	ACB-2, ACB-4
U86EF	Underground Feeder Lock Out Relay 86EF Picks UP	ACB-3, ACB-4
GK186E1	Keowee Unit 1 Emergency Lock Out Due To Spurious Actuation Of Generator Protective Relay	ACB-3
GK186E1X	Keowee Unit 1 Emergency Lock Out Due To Spurious Actuation Of Generator Protective Relay	ACB-3

Table A.4-6

Air Circuit Breaker Fault Tree Transfers

Transfer Gate Name	Description	Components Supplied
XD1DAR	Loss Of Power On Keowee 1 125 V dc Distribution Center 1DA During Run	ACB-3, ACB-4
XD2DAR	Loss Of Power On Keowee 2 125 V dc Distribution Center 2DA During Run	ACB-4
YK2STR2INT	Keowee 2 Emergency Start Aux Relays 2ESRX/2A & 2ESRX/2B Fail	ACB-4

Table A.4-7

Air Circuit Breaker Statalarms

Point No.	Alarm	Actuator
1SA1-21	ACB-1 AIR PRESS LOW	63TX1
1SA1-22	ACB-3 AIR PRESS LOW	63TX3
1SA2-41	EMERG. START ACB 1 CLOSED	52-1/b
1SA2-42	EMERG. START ACB 3 CLOSED	52-3/b
1SA1-50	UNIT 1 DC SUPPLY FAILURE	"8" series relay
2SA1-21	ACB-2 AIR PRESS LOW	63TX2
2SA1-22	ACB-4 AIR PRESS LOW	63TX4
2SA2-41	EMERG. START ACB 2 CLOSED	52-2/b
2SA2-42	EMERG. START ACB 4 CLOSED	52-4/b
2SA1-50	UNIT 2 DC SUPPLY FAILURE	"8" series relay

Table A.4-8

Air Circuit Breaker Fault Tree Top Events

Gate Name	Description
ACB1OPEN	Air Circuit Breaker 1 Fails To Open
ACB2CLOSE	Air Circuit Breaker 2 Fails To Close
ACB2OPEN	Air Circuit Breaker 2 Fails To Open
ACB2TRANS	Air Circuit Breaker 2 Transfers Open
ACB3CLOSE	Air Circuit Breaker 3 Fails To Close
ACB3OPEN	Air Circuit Breaker 3 Fails To Open
ACB3TRANS	Air Circuit Breaker 3 Transfers Open
ACB4CLOSE	Air Circuit Breaker 4 Fails To Close
ACB4TRANS	Air Circuit Breaker 4 Transfers Open
ACB5CLOSE	Air Circuit Breaker 5 Fails To Close
ACB5TRANS	Air Circuit Breaker 5 Transfers Open
ACB6CLOSE	Air Circuit Breaker 6 Fails To Close
ACB6OPEN	Air Circuit Breaker 6 Fails To Open
ACB6TRANS	Air Circuit Breaker 6 Transfers Open
ACB7CLOSE	Air Circuit Breaker 7 Fails To Close
ACB7OPEN	Air Circuit Breaker 7 Fails To Open
ACB7TRANS	Air Circuit Breaker 7 Transfers Open
ACB8CLOSE	Air Circuit Breaker 8 Fails To Close
ACB8TRANS	Air Circuit Breaker 8 Transfers Open

Table A.4-9

Air Circuit Breaker Reliability Data

Event Name	Description	Failure Rate[1]	Factor	Rational For Factor[2]	Failure Probability
AA1271PR6D	Transformer 1X Undervoltage Relay 27/1X Fails To Pick Up	2.49E-04 /D	1 D	1 demand per emergency start required.	2.49E-04
AA1271XR6T	Transformer 1X Undervoltage Relay 27/1X Spuriously De-energizes	3.63E-07 /H	30 H	Rule 4: Indicated by computer point.	1.09E-05
AA127C1R6T	Transformer CX Undervoltage Relay 27/CX1 Spuriously De-energizes	3.63E-07 /H	24 H	Rule 3: Would align the unit 1 auxiliaries to transformer 1X. This is not the assumed initial condition for the KPRA. Indicated by computer point.	8.71E-06
AA127CPR6D	Transformer CX Undervoltage Relay 27/CX1 Fails To Pick Up	2.49E-04 /D	1 D	1 demand per emergency start required.	2.49E-04
AA127R1RYT	Auxiliary Relay 27X/CX1 Spurious Operation	3.60E-07 /H	24 H	Rule 3: Would align the unit 1 auxiliaries to transformer 1X. This is not the assumed initial condition for the KPRA. Indicated by computer point.	8.64E-06
AA127X1RYD	Auxiliary Relay 27X/1X Fails To Operate On Demand	3.30E-05 /D	1 D	1 demand per emergency start required.	3.30E-05
AA127X1RYT	Auxiliary Relay 27X/1X Spurious Operation	3.60E-07 /H	384 H	Rule 6:Spurious operation of the relay would be detected during the monthly swap by the trip of ACB-5.	1.38E-04
AA127X2R6D	Transformer CX Undervoltage Relay 27/CX1 Fails To Drop Out	2.49E-04 /D	1 D	1 demand per emergency start required.	2.49E-04
AA127XCRYD	Auxiliary Relay 27/CX1 Fails To Operate On Demand	3.30E-05 /D	1 D	1 demand per emergency start required.	3.30E-05
AA186CXRYT	Transformer CX Differential Lock Out Relay 86CX Spurious Operation	3.60E-07 /H	24 H	Rule 3: Indicated, and would place Keowee in a different condition than assumed for the analysis.	8.64E-06
AA186S1RYT	Switchgear 1X Lockout Relay 86S/1X Spurious Operation	3.60E-07 /H	24 H	Rule 3: Would put switchgear 1X in maintenance.	8.64E-06

[1]D=Demand, H=Hour

[2]Rules for assigning basic event factors are discussed in Table C.1-4

Table A.4-9

Air Circuit Breaker Reliability Data

Event Name	Description	Failure Rate[1]	Factor	Rational For Factor[2]	Failure Probability
AA187CXRYT	Transformer CX Differential Relay 87CX Spurious Operation	3.60E-07 /H	24 H	Rule 3: Would align the unit 1 auxiliaries to transformer 1X. This is not the assumed initial condition for the KPRA. Indicated by computer point.	8.64E-06
AA2272PR6D	Transformer 2X Undervoltage Relay 27/2X Fails To Pick Up	2.49E-04 /D	1 D	1 demand per emergency start required.	2.49E-04
AA2272XR6D	Transformer 2X Undervoltage Relay 27/2X Fails To Drop Out	2.49E-04 /D	1 D	1 demand per emergency start required.	2.49E-04
AA2272XR6T	Transformer 2X Undervoltage Relay 27/2X Spuriously De-energizes	3.63E-07 /H	24 H	Rule 3: Would align the unit 2 auxiliaries to transformer CX. This is not the assumed condition for the KPRA. Indicated by computer point.	8.71E-06
AA227C2R6T	Transformer CX Undervoltage Relay 27/CX2 Spuriously De-energizes	3.63E-07 /H	30 H	Rule 4: Indicated by computer point.	1.09E-05
AA227C2RYD	Auxiliary Relay 27X/CX2 Fails To Operate On Demand	3.30E-05 /D	1 D	1 demand per emergency start required.	3.30E-05
AA227CPR6D	Transformer CX Undervoltage Relay 27/CX2 Fails To Pick Up	2.49E-04 /D	1 D	1 demand per emergency start required.	2.49E-04
AA227R2RYT	Auxiliary Relay 27X/CX2 Spurious Operation	3.60E-07 /H	384 H	Rule 6:Spurious operation of the relay would be detected during the monthly swap by the trip of ACB-8.	1.38E-04
AA227T2R6D	Transformer #1 Undervoltage Relay (27T/2X) Fails To Drop Out	2.49E-04 /D	1 D	1 demand per emergency start required.	2.49E-04
AA227X2RYD	Auxiliary Relay 27X/2X Fails To Operate On Demand	3.30E-05 /D	1 D	1 demand per emergency start required.	3.30E-05
AA227X2RYT	Auxiliary Relay 27X/2X Spurious Operation	3.60E-07 /H	24 H	Rule 3: Would align the unit 2 auxiliaries to transformer CX. This is not the assumed	8.64E-06

[1]D=Demand, H=Hour

[2]Rules for assigning basic event factors are discussed in Table C.1-4

Table A.4-9

Air Circuit Breaker Reliability Data

Event Name	Description	Failure Rate[1]	Factor	Rational For Factor[2]	Failure Probability
				condition for the KPRA.	
AA286S2RYT	Switchgear 2X Lockout Relay 86S/2X Spurious Operation	3.60E-07 /H	24 H	Indicated by computer point. Rule 3: Would put switchgear 2X in maintenance.	8.64E-06
AB004ECCDT	DC Circuit Breaker 1DA-4EC Transfers Position	7.50E-08 /H	30 H	Rule 4: Indicated by rounds.	2.25E-06
AB0086TRYD	Keowee Main Tx Lock Out Relay 86T Fails To Operate On Demand	3.30E-05 /D	1 D	1 demand per emergency start required.	3.30E-05
AB0624CRYD	Time Delay Relay 62-4c Fails To Operate On Demand	3.30E-05 /D	1 D	1 demand per emergency start required.	3.30E-05
AB086E1RYD	Emergency Lock Out Relay 86E-1 Fails To Operate On Demand	3.30E-05 /D	1 D	1 demand per emergency start required.	3.30E-05
AB086TGRYD	General Keowee Main Tx Lock Out Sensing Relay Fails To Operate	3.30E-05 /D	1 D	1 demand per emergency start required.	3.30E-05
AB152TCSVO	Air Circuit Breaker 1 Trip Coil Fails To Operate	2.90E-05 /D	1 D	1 demand per emergency start required.	2.90E-05
AB1ACCUDEX	Air Circuit Breaker 1 Accumulator Air Pressure Low		3.51E-05		3.51E-05
AB1FALTDEX	Fault Occurs at ACB-1 When The BReaker Trips		0		0.00E+00
AB1MECHDEX	Air Circuit Breaker 1 Fails To Open Due To Mechanical Failure		1.51E-04		1.51E-04
AB1OPENLHE	Air Circuit Breaker 1 Fails To Open Due To A Latent Human Error		2.60E-04		2.60E-04
AB1PS02PST	Air Circuit Breaker 1 Accumulator Pressure Switch PS2 Fails Low	4.30E-07 /H	12 H	Rule 5: Last demanded at unit start.	5.16E-06

[1]D=Demand, H=Hour

[2]Rules for assigning basic event factors are discussed in Table C.1-4

Table A.4-9

Air Circuit Breaker Reliability Data

Event Name	Description	Failure Rate[1]	Factor	Rational For Factor[2]	Failure Probability
AB1R52ZR6D	Air Circuit Breaker 1 Relay 52Z Fails To Operate	2.49E-04 /D	1 D	1 demand per emergency start required.	2.49E-04
AB21521SWT	Control Switch 152-2 Spurious Operation	7.00E-08 /H	30 H	Causes trip of ACB-2. Half time between rounds plus the mission.	2.10E-06
AB22BV1RYT	Backup Undervoltage Relay 2BV1 Spurious Operation	3.60E-07 /H	24 H	Rule 3: Results in emergency lock-out.	8.64E-06
AB23BKRCOM	Common Cause Failure Of Air Circuit Breakers 2 And 3 To Close		1.12E-04		1.12E-04
AB24BKRCOM	Common Cause Failure Of Air Circuit Breakers 2 And 4 To Close		1.12E-04		1.12E-04
AB251G2RYT	Air Circuit Breaker 2 Overcurrent Ground Relay 51G-2 Spurious Operation	3.60E-07 /H	24 H	Rule 3: Indicated by event recorder.	8.64E-06
AB252CCSVO	Air Circuit Breaker 2 Close Coil Fails To Operate	2.90E-05 /D	1 D	1 demand per emergency start required.	2.90E-05
AB252TCSVO	Air Circuit Breaker 2 Trip Coil Fails To Operate	2.90E-05 /D	1 D	1 demand per emergency start required.	2.90E-05
AB252TCSVT	Air Circuit Breaker 2 Trip Coil Spurious Operation	3.90E-07 /H	36 H	Rule 6 method. Causes trip of ACB-2.	1.40E-05
AB252Y2R6D	Air Circuit Breaker 2 Relay 52Y Failed To Drop Out Following Last Demand	2.49E-04 /D	1 D	1 demand per emergency start required.	2.49E-04
AB252Y2R6T	Air Circuit Breaker 2 Y-relay Spurious Operation	3.63E-07 /H	12 H	Rule 6 method. Causes trip of ACB-2.	4.36E-06
AB2ACCUDEX	Air Circuit Breaker 2 Accumulator Air Pressure Low		3.51E-05		3.51E-05
AB2CLOSLHE	Air Circuit Breaker 2 Fails To Close Due To A Latent Human Error		2.60E-04		2.60E-04

[1]D=Demand, H=Hour

[2]Rules for assigning basic event factors are discussed in Table C.1-4

Table A.4-9

Air Circuit Breaker Reliability Data

Event Name	Description	Failure Rate[1]	Factor	Rational For Factor[2]	Failure Probability
AB2KEYISWT	Air Circuit Breaker 2 Key Interlock Switch Transfers Open	7.00E-08 /H	12 H	Rule 6 method. Causes trip of ACB-2.	8.40E-07
AB2MCH2DEX	Air Circuit Breaker 2 Fails To Close Due To Mechanical Failure		3.02E-04		3.02E-04
AB2MECHDEX	Air Circuit Breaker 2 Fails To Open Due To Mechanical Failure		1.51E-04		1.51E-04
AB2OPENLHE	Air Circuit Breaker 2 Fails To Open Due To A Latent Human Error		2.60E-04		2.60E-04
AB2PS02PST	Air Circuit Breaker 2 Accumulator Pressure Switch PS2 Fails Low	4.30E-07 /H	12 H	Half of the time since the last start. Causes failure of ACB-2 to close.	5.16E-06
AB2PUSHPBT	Trip Pushbutton On ACB2 Spurious Operation	2.40E-07 /H	36 H	Rule 6 method. Causes trip of ACB-2.	8.64E-06
AB2R462RYT	Air Circuit Breaker 2 Negative Sequence Relay 46-2 Spurious Operation	3.60E-07 /H	24 H	Rule 3: Indicated by event recorder.	8.64E-06
AB2R52XR6D	Air Circuit Breaker 2 Relay 52X Fails To Operate	2.49E-04 /D	1 D	1 demand per emergency start required.	2.49E-04
AB2R52ZR6D	Air Circuit Breaker 2 Relay 52Z Fails To Operate	2.49E-04 /D	1 D	1 demand per emergency start required.	2.49E-04
AB2R52ZR6T	Air Circuit Breaker 2 Relay 52Z Spurious Operation	3.63E-07 /H	36 H	Rule 6 method. Causes trip of ACB-2.	1.31E-05
AB31523SWT	Control Switch 152-3 Spurious Operation	7.00E-08 /H	24 H	Trips ACB-3.	1.68E-06
AB352CCSVO	Air Circuit Breaker 3 Close Coil Fails To Operate	2.90E-05 /D	1 D	1 demand per emergency start required.	2.90E-05
AB352TCSVO	Air Circuit Breaker 3 Trip Coil Fails To Operate	2.90E-05 /D	1 D	1 demand per emergency start required.	2.90E-05
AB352TCSVT	Air Circuit Breaker 3 Trip Coil Spurious Operation	3.90E-07 /H	24 H	Trips ACB-3.	9.36E-06

[1]D=Demand, H=Hour

[2]Rules for assigning basic event factors are discussed in Table C.1-4

Table A.4-9

Air Circuit Breaker Reliability Data

Event Name	Description	Failure Rate[1]	Factor	Rational For Factor[2]	Failure Probability
AB352Y2R6D	Air Circuit Breaker 3 Relay 52Y Failed To Drop Out Following Last Demand	2.49E-04 /D	1 D	1 demand per emergency start required.	2.49E-04
AB352Y2R6T	Air Circuit Breaker 3 Y-relay Spurious Operation	3.63E-07 /H	360 H	Rule 5.ACB-3 would not close.	1.31E-04
AB3ACCUDEX	Air Circuit Breaker 3 Accumulator Air Pressure Low		3.51E-05		3.51E-05
AB3CLOSLHE	Air Circuit Breaker 3 Fails To Close Due To Latent Human Error		2.60E-04		2.60E-04
AB3MCH2DEX	Air Circuit Breaker 3 Fails To Close Due To Mechanical Failure		3.02E-04		3.02E-04
AB3MECHDEX	Air Circuit Breaker 3 Fails To Open Due To Mechanical Failure		1.51E-04		1.51E-04
AB3PS02PST	Air Circuit Breaker 3 Accumulator Pressure Switch PS2 Fails Low	4.30E-07 /H	372 H	Assumed ACB-3 would have to open half way through the mission to allow recovery by closing ACB-4.	1.60E-04
AB3PUSHPBT	Trip Pushbutton On ACB3 Spurious Operation	2.40E-07 /H	24 H	Trips ACB-3.	5.76E-06
AB3R52XR6D	Air Circuit Breaker 3 Relay 52X Fails To Operate	2.49E-04 /D	1 D	1 demand per emergency start required.	2.49E-04
AB3R52ZR6D	Air Circuit Breaker 3 Relay 52Z Fails To Operate	2.49E-04 /D	1 D	1 demand per emergency start required.	2.49E-04
AB3R52ZR6T	Air Circuit Breaker 3 Relay 52Z Spurious Operation	3.63E-07 /H	24 H	Trips ACB-3.	8.71E-06
AB41523SWT	Control Switch 152-4 Spurious Operation	7.00E-08 /H	24 H	Assumed that recovery via ACB-4 was needed at the beginning of the mission.	1.68E-06
AB452CCSVO	Air Circuit Breaker 4 Close Coil Fails To Operate	2.90E-05 /D	1 D	1 demand per emergency start required.	2.90E-05

[1] D=Demand, H=Hour

[2] Rules for assigning basic event factors are discussed in Table C.1-4

Table A.4-9

Air Circuit Breaker Reliability Data

Event Name	Description	Failure Rate[1]	Factor	Rational For Factor[2]	Failure Probability
AB452TCSVT	Air Circuit Breaker 4 Trip Coil Spurious Operation	3.90E-07 /H	24 H	Assumed that recovery via ACB-4 was needed at the beginning of the mission.	9.36E-06
AB452Y2R6D	Air Circuit Breaker 4 Relay 52Y Failed To Drop Out Following Last Demand	2.49E-04 /D	1 D	1 demand per emergency start required.	2.49E-04
AB452Y2R6T	Air Circuit Breaker 4 Y-relay Spurious Operation	3.63E-07 /H	372 H	Half the time since the last operation and assume ACB-4 is needed half way through the mission (360+12)	1.35E-04
AB4ACCUDEX	Air Circuit Breaker 4 Accumulator Air Pressure Low		3.51E-05		3.51E-05
AB4CLOSLHE	Air Circuit Breaker 4 Fails To Close Due To A Latent Human Error		2.60E-04		2.60E-04
AB4CLSESWC	Air Circuit Breaker 4 Close Switch Fails To Close On Demand	1.00E-05 /D	1 D	1 demand per emergency start required.	1.00E-05
AB4KEYISWT	Air Circuit Breaker 4 Key Interlock Switch Transfers Open	7.00E-08 /H	372 H	Half the time since the last operation and assume ACB-4 is needed half way through the mission (360+12)	2.60E-05
AB4LORESWT	Air Circuit Breaker 4 Local/Remote Switch Contact Transfers Position	7.00E-08 /H	372 H	Half the time since the last operation and assume ACB-4 is needed half way through the mission (360+12)	2.60E-05
AB4MCH2DEX	Air Circuit Breaker 4 Fails To Close Due To Mechanical Failure		3.02E-04		3.02E-04
AB4PS02PST	Air Circuit Breaker 4 Accumulator Pressure Switch PS2 Indicates Low Pressure	4.30E-07 /H	372 H	Half the time since the last operation and assume ACB-4 is needed half way through the mission (360+12)	1.60E-04
AB4PUSHPBT	Trip Pushbutton On ACB-4 Spurious Operation	2.40E-07 /H	24 H	Assumed that recovery via ACB-4 was needed at the beginning of the mission.	5.76E-06

[1]D=Demand, H=Hour

[2]Rules for assigning basic event factors are discussed in Table C.1-4

Table A.4-9

Air Circuit Breaker Reliability Data

Event Name	Description	Failure Rate[1]	Factor	Rational For Factor[2]	Failure Probability
AB4R52XR6D	Air Circuit Breaker 4 Relay 52X Fails To Operate	2.49E-04 /D	1 D	1 demand per emergency start required.	2.49E-04
AB4R52ZR6T	Air Circuit Breaker 4 Relay 52Z Spurious Operation	3.63E-07 /H	24 H	Assumed that recovery via ACB-4 was needed at the beginning of the mission.	8.71E-06
AB510A1FUF	One Or More Control Power Fuses For X, Y And CC Fail	3.60E-06 /H	6 H	Rule 2: Indicated by loss of position indication.	2.16E-05
AB51431LHE	Manual/Auto Control Switch 143/1 Left In Manual		3.20E-04		3.20E-04
AB51431RYT	Auxiliary Relay 143X/1 Spuriously Energizes	3.60E-07 /H	360 H	Half the time since the unit alignment was swapped. ACB 5 would fail to close.	1.30E-04
AB51431SWT	Manual/Auto Control Switch 143/1 Spuriously Transfers Into Manual	7.00E-08 /H	360 H	Half the time since the unit alignment was swapped. ACB 5 would fail to close.	2.52E-05
AB552CCRYD	Air Circuit Breaker 5 Close Coil CC Fails On Demand	3.30E-05 /D	1 D	1 demand per emergency start required.	3.30E-05
AB552TCRYT	Air Circuit Breaker 5 Trip Coil 52TC Spurious Operation	3.60E-07 /H	384 H	Rule 6:Half the time since the unit alignment was swapped plus the mission. ACB 5 would fail to close or remain closed.	1.38E-04
AB552Y2RYT	Air Circuit Breaker 5 Y-relay Spurious Operation	3.60E-07 /H	360 H	Half the time since the unit alignment was swapped. ACB 5 would fail to close.	1.30E-04
AB583S5RYD	Time Delay Relay 83S5 Fails To Pick Up	3.30E-05 /D	1 D	1 demand per emergency start required.	3.30E-05
AB5CLOSLHE	Air Circuit Breaker 5 Fails To Close Due To A Latent Human Error		2.60E-04		2.60E-04
AB5KEYISWT	Air Circuit Breaker 5 Key Interlock Switch Transfers Open	7.00E-08 /H	360 H	Half the time since the unit alignment was swapped. ACB 5 would fail to close.	2.52E-05

[1]D=Demand, H=Hour

[2]Rules for assigning basic event factors are discussed in Table C.1-4

Table A.4-9

Air Circuit Breaker Reliability Data

Event Name	Description	Failure Rate[1]	Factor	Rational For Factor[2]	Failure Probability
AB5MCH2DEX	Air Circuit Breaker 5 Fails To Close Due To Mechanical Failure		7.04E-03		7.04E-03
AB5PUSHPBT	Trip Pushbutton On ACB5 Spurious Operation	2.40E-07 /H	384 H	Rule 6: Contributes to unit run failure by preventing closure of ACB 5.	9.22E-05
AB5R52XRYD	Air Circuit Breaker 5 Relay 52X Fails To Operate	3.30E-05 /D	1 D	1 demand per emergency start required.	3.30E-05
AB5R52YRYD	Air Circuit Breaker 5 Relay 52Y Failed To Drop Out At Last Demand	3.30E-05 /D	1 D	1 demand per emergency start required.	3.30E-05
AB610A1FUF	One Or More Control Power Fuses For X, Y And CC Fail	3.60E-06 /H	6 H	Rule 2: Indicated by loss of position indication.	2.16E-05
AB610AFFUF	One Or More Control Power Fuses For Relay 27X/2X Fail	3.60E-06 /H	6 H	Rule 2: Indicated by loss of position indication.	2.16E-05
AB61432LHE	Manual/Auto Control Switch 143/2 Left In Manual		3.20E-04		3.20E-04
AB61432SWT	Manual/Auto Control Switch 143/2 Spuriously Transfers Into Manual	7.00E-08 /H	360 H	Half the time since the unit alignment was swapped. ACB 6 would fail to close.	2.52E-05
AB652CCRYD	Air Circuit Breaker 6 Close Coil CC Fails On Demand	3.30E-05 /D	1 D	1 demand per emergency start required.	3.30E-05
AB652TCRYD	Air Circuit Breaker 6 Trip Coil 52TC Fails Fails To Operate	3.30E-05 /D	1 D	1 demand per emergency start required.	3.30E-05
AB652TCRYT	Air Circuit Breaker 6 Trip Coil 52TC Spurious Operation	3.60E-07 /H	24 H	Rule 1: Actuation prior to the emergency start would place the units in a configuration that is abnormal and not consistent with the modeling assumptions.	8.64E-06
AB652Y2RYT	Air Circuit Breaker 6 Y-relay Spurious Operation	3.60E-07 /H	360 H	Half the time since the unit alignment was swapped. Would prevent ACB 6 from closing.	1.30E-04

[1]D=Demand, H=Hour

[2]Rules for assigning basic event factors are discussed in Table C.1-4

Table A.4-9

Air Circuit Breaker Reliability Data

Event Name	Description	Failure Rate[1]	Factor	Rational For Factor[2]	Failure Probability
AB6CLOSLHE	Air Circuit Breaker 6 Fails To Close Due To A Latent Human Error		2.60E-04		2.60E-04
AB6KEYISWT	Air Circuit Breaker 6 Key Interlock Switch Transfers Open	7.00E-08 /H	360 H	Half the time since the unit alignment was swapped. Would prevent ACB 6 from closing.	2.52E-05
AB6MCH2DEX	Air Circuit Breaker 6 Fails To Close Due To Mechanical Failure		7.04E-03		7.04E-03
AB6MECHDEX	Air Circuit Breaker 6 Fails To Open Due To Mechanical Failure		8.01E-04		8.01E-04
AB6OPENLHE	Air Circuit Breaker 6 Fails To Open Due To A Latent Human Error		3.20E-03		3.20E-03
AB6PUSHPBT	Trip Pushbutton On ACB6 Spurious Operation	2.40E-07 /H	24 H	Rule 1: Actuation prior to the emergency start would place the units in a configuration that is abnormal and not consistent with the modeling assumptions.	5.76E-06
AB6R52XRYD	Air Circuit Breaker 6 Relay 52X Fails To Operate	3.30E-05 /D	1 D	1 demand per emergency start required.	3.30E-05
AB6R52YRYD	Air Circuit Breaker 6 Relay 52Y Failed To Drop Out At Last Demand	3.30E-05 /D	1 D	1 demand per emergency start required.	3.30E-05
AB710A1FUF	One Or More Control Power Fuses For X, Y And CC Fail	3.60E-06 /H	6 H	Rule 2: Indicated by loss of position indication.	2.16E-05
AB710AFFUF	One Or More Air Circuit Breaker 7 Control Power Fuses Fail	3.60E-06 /H	6 H	Rule 2: Indicated by loss of monitoring lights.	2.16E-05
AB752CCRYD	Air Circuit Breaker 7 Close Coil CC Fails On Demand	3.30E-05 /D	1 D	1 demand per emergency start required.	3.30E-05
AB752TCRYD	Air Circuit Breaker 7 Trip Coil TC Fails On Demand	3.30E-05 /D	1 D	1 demand per emergency start required.	3.30E-05

[1]D=Demand, H=Hour

[2]Rules for assigning basic event factors are discussed in Table C.1-4

Table A.4-9

Air Circuit Breaker Reliability Data

Event Name	Description	Failure Rate[1]	Factor	Rational For Factor[2]	Failure Probability
AB752TCRYT	Air Circuit Breaker 7 Trip Coil 52TC Spurious Operation	3.60E-07 /H	24 H	Rule 1: Actuation prior to the emergency start would place the units in a configuration that is abnormal and not consistent with the modeling assumptions.	8.64E-06
AB752Y2RYT	Air Circuit Breaker 7 Y-relay Spurious Operation	3.60E-07 /H	360 H	Half the time since the unit alignment was swapped. Would prevent ACB 7 from closing.	1.30E-04
AB7CLOSLHE	Air Circuit Breaker 7 Fails To Close Due To A Latent Human Error		2.60E-04		2.60E-04
AB7KEYISWT	Air Circuit Breaker 7 Key Interlock Switch Transfers Open	7.00E-08 /H	360 H	Half the time since the unit alignment was swapped. Would prevent ACB 7 from closing.	2.52E-05
AB7MCH2DEX	Air Circuit Breaker 7 Fails To Close Due To Mechanical Failure		7.04E-03		7.04E-03
AB7MECHDEX	Air Circuit Breaker 7 Fails To Open Due To Mechanical Failure		8.01E-04		8.01E-04
AB7OPENLHE	Air Circuit Breaker 7 Fails To Open Due To A Latent Human Error		3.20E-03		3.20E-03
AB7PUSHPBT	Trip Pushbutton On ACB7 Spurious Operation	2.40E-07 /H	30 H	Rule 1: Actuation prior to the emergency start would place the units in a configuration that is abnormal and not consistent with the modeling assumptions.	7.20E-06
AB7R52XRYD	Air Circuit Breaker 7 Relay 52X Fails To Operate	3.30E-05 /D	1 D	1 demand per emergency start required.	3.30E-05
AB7R52YRYD	Air Circuit Breaker 7 Relay 52Y Failed To Drop Out At Last Demand	3.30E-05 /D	1 D	1 demand per emergency start required.	3.30E-05
AB810A1FUF	One Or More Control Power Fuses For X, Y And CC Fail	3.60E-06 /H	6 H	Rule 2: Indicated by loss of position indication.	2.16E-05

[1] D=Demand, H=Hour

[2] Rules for assigning basic event factors are discussed in Table C.1-4

Table A.4-9

Air Circuit Breaker Reliability Data

Event Name	Description	Failure Rate[1]	Factor	Rational For Factor[2]	Failure Probability
AB81432RYT	Auxiliary Relay 143X/2 Spuriously Energizes	3.60E-07 /H	360 H	Half the time since the unit alignment was swapped. ACB 8 would fail to close.	1.30E-04
AB852CCRYD	Air Circuit Breaker 8 Close Coil CC Fails On Demand	3.30E-05 /D	1 D	1 demand per emergency start required.	3.30E-05
AB852TCRYT	Air Circuit Breaker 8 Trip Coil 52TC Spurious Operation	3.60E-07 /H	384 H	Rule 6: Would prevent ACB 8 from closing or remaining closed.	1.38E-04
AB852Y2RYT	Air Circuit Breaker 8 Y-relay Spurious Operation	3.60E-07 /H	360 H	Half the time since the unit alignment was swapped. ACB 8 would fail to close.	1.30E-04
AB86E1ARYD	Emergency Lock Out Aux. Relay 86E-1a Fails To Operate On Demand	3.30E-05 /D	1 D	1 demand per emergency start required.	3.30E-05
AB86E1GRYD	Keowee Unit 1 Emergency Lock Out Sensing Relay Fails To Operate	3.30E-05 /D	1 D	1 demand per emergency start required.	3.30E-05
AB883S8RYD	Time Delay Relay 83S8 Fails To Pick Up	3.30E-05 /D	1 D	1 demand per emergency start required.	3.30E-05
AB8KEYISWT	Air Circuit Breaker 8 Key Interlock Switch Transfers Open	7.00E-08 /H	360 H	Half the time since the unit alignment was swapped. ACB 8 would fail to close.	2.52E-05
AB8MCH2DEX	Air Circuit Breaker 8 Fails To Close Due To Mechanical Failure		7.04E-03		7.04E-03
AB8PUSHPBT	Trip Pushbutton On ACB8 Spurious Operation	2.40E-07 /H	384 H	Rule 6: Would prevent ACB 8 from closing or remaining closed.	9.22E-05
AB8R52XRYD	Air Circuit Breaker 8 Relay 52X Fails To Operate	3.30E-05 /D	1 D	1 demand per emergency start required.	3.30E-05
AB8R52YRYD	Air Circuit Breaker 8 Relay 52Y Failed To Drop Out At Last Demand	3.30E-05 /D	1 D	1 demand per emergency start required.	3.30E-05
ABEOPRCRHE	Operators Fail To Close Air Circuit Breaker 2		1		1.00E+00

[1]D=Demand, H=Hour

[2]Rules for assigning basic event factors are discussed in Table C.1-4

Table A.4-9

Air Circuit Breaker Reliability Data

Event Name	Description	Failure Rate[1]	Factor	Rational For Factor[2]	Failure Probability
ABPOPRCRHE	Operators Fail To Close Air Circuit Breaker 4		9.00E-03		9.00E-03
ACB4MOD	NSM-ON-52966 Is Not In Service		1		1.00E+00
ACBAIRPDEX	ACB Air Supply Fails Causing Low Pressure In All ACB Accumulators		2.00E-03		2.00E-03
ACBTRIPCHE	Operators Trip Gènèrator Output ACBs		0		0.00E+00
AD1B4ALCDT	Breaker 4AL In 125 V dc Distribution Center 1DA Transfers Open	7.50E-08 /H	30 H	Breaker position change would be discovered by loss of lights during rounds. It is assumed that the demand for ACB 5 could come at any time during the mission.	2.25E-06
AD1C3CCCDT	Breaker 3CC In 125V dc Distribution Center 1DA Transfers Position	7.50E-08 /H	24 H	Rule 1: Loss of power is alarmed.	1.80E-06
AD1C3CLCDT	Breaker 3CL In 125V dc Distribution Center 1DA Transfers Position	7.50E-08 /H	24 H	Rule 1: Loss of power is alarmed.	1.80E-06
AD1SCLRCDT	Breaker 3CL In 125V dc Distribution Center 1DA Transfers Position (Rec)	7.50E-08 /H	12 H	The need for the recovery is assumed to occur half way through the mission.	9.00E-07
AD2B2ALCDT	Breaker 2AL In 125V dc Distribution Center 2DA Transfers Open	7.50E-08 /H	30 H	Breaker position change would be discovered by loss of lights during rounds. It is assumed that the demand for ACB 6 could come at any time during the mission.	2.25E-06
AD2B3CCCDT	Breaker 3CC In 125V dc Distribution Center 2DA Transfers Position	7.50E-08 /H	12 H	The need for ACB 4 is assumed to occur half way through the mission.	9.00E-07
AD2C3CLCDT	Breaker 3CL In 125V dc Distribution Center 2DA Transfers Position	7.50E-08 /H	24 H	Rule 1: Breaker transferring open would result in overhead transformer lock-out.	1.80E-06

[1]D=Demand, H=Hour

[2]Rules for assigning basic event factors are discussed in Table C.1-4

Table A.4-9

Air Circuit Breaker Reliability Data

Event Name	Description	Failure Rate[1]	Factor	Rational For Factor[2]	Failure Probability
AK1141XRYD	Auxiliary Relay 14GOV/1X Fails To Pick-up	3.30E-05 /D	1 D	1 demand per emergency start required.	3.30E-05
AK114GVDEX	KU1 Magnetic Speed Switch System Fails		1.00E-04		1.00E-04
AK121TDRYD	Time Delay Relay 2-1TD Fails To Pick-up	3.30E-05 /D	1 D	1 demand per emergency start required.	3.30E-05
AK152TDRYD	Time Delay Relay 52-1TD Fails To Pick-up	3.30E-05 /D	1 D	1 demand per emergency start required.	3.30E-05
AK152TDRYT	Time Delay Relay 52-1TD Spurious Operation	3.60E-07 /H	4380 H	Tested annually.	1.58E-03
AK152XGRYD	Relay 52XG/1 Fails To Pick Up When The Unit Is Started	3.30E-05 /D	1 D	1 demand per emergency start required.	3.30E-05
AK152XGRYT	Relay 52XG/1 Spuriously Drops Out While The Unit Is Running	3.60E-07 /H	2 H	Relay used to indicate that unit 1 is generating to the grid. Assumed that the unit generates 4 hours per day and used half of that time as the exposure time.	7.20E-07
AK1AX34RYT	Relay 52AX/34 Spuriously Drops-out	3.60E-07 /H	6 H	Rule 2: Failure would be indicated during the rounds by loss of indicating light.	2.16E-06
AK1GV1XRYD	Relay 14GOV/1X Fails To Pick-up	3.30E-05 /D	1 D	1 demand per emergency start required.	3.30E-05
AK1OFRQCOM	KU1 CCF Of 2/3 Overfrequency Relays To Reset When Frequency Drops		3.30E-06		3.30E-06
AK1X34XRYT	Relay 52AX/34X Spuriously Drops-out	3.60E-07 /H	6 H	Rule 2: Failure would be indicated during the rounds by loss of indicating light.	2.16E-06
AK212OSSST	Turbine Overspeed Switch Indicates Overspeed	4.20E-06 /H	36 H	Rule 6: With other events could result in trip of ACB 2.	1.51E-04
AK2142XRYD	Auxiliary Relay 14GOV/2X Fails To Pick-up	3.30E-05 /D	1 D	1 demand per emergency start required.	3.30E-05
AK214GVDEX	KU2 Magnetic Speed Switch System Fails		1.00E-04		1.00E-04

[1]D=Demand, H=Hour

[2]Rules for assigning basic event factors are discussed in Table C.1-4

Table A.4-9

Air Circuit Breaker Reliability Data

Event Name	Description	Failure Rate[1]	Factor	Rational For Factor[2]	Failure Probability
AK222TDRYD	Time Delay Relay 2-2TD Fails To Pick-up	3.30E-05 /D	1 D	1 demand per emergency start required.	3.30E-05
AK252TDRYD	Time Delay Relay 52-2TD Fails To Operate	3.30E-05 /D	1 D	1 demand per emergency start required.	3.30E-05
AK252TDRYT	Time Delay Relay 52-2TD Spurious Operation	3.60E-07 /H	4380 H	Tested annually.	1.58E-03
AK252W0RYD	KU2 Relay 52W Fails To Pick-up	3.30E-05 /D	1 D	1 demand per emergency start required.	3.30E-05
AK252XGRYD	Auxiliary Relay 52XG/2 Fails To Pick-up	3.30E-05 /D	1 D	1 demand per emergency start required.	3.30E-05
AK2GATEDEX	Wicket Gate Limit Switch Indicates Gate Position Is Below No-load Setting		2.11E-05		2.11E-05
AK2GV2XRYD	Relay 14GOV/2X Fails To Pick-up	3.30E-05 /D	1 D	1 demand per emergency start required.	3.30E-05
AK2OFRQCOM	KU2 CCF Of 2/3 Overfrequency Relays To Reset When Frequency Drops		3.30E-06		3.30E-06
KU2RNNG	Keowee Unit 2 Is Generating To The Grid		1.00E+00		1.00E+00
WK1SPD2DEX	Keowee Unit 1 Governor Failure Creates Overspeed Condition		1.20E-04		1.20E-04
WK2SPD2DEX	Keowee Unit 2 Governor Failure Creates Overspeed Condition		1.20E-04		1.20E-04
XA1BKRSCOM	CCF of 1X Aux Power Breakers ACB-5 & -7		3.10E-04		3.10E-04
XA2BKRSCOM	CCF of Aux Power Breakers ACB-6 & -8		3.10E-04		3.10E-04
XA56BKRCOM	Common Cause Failure Of ACB-5 And ACB-6 To Close		3.10E-04		3.10E-04
XA78BKRCOM	Common Cause Failure Of ACB-7 And ACB-8 To Close		3.10E-04		3.10E-04
YK286N2DEX	Keowee Unit 2 Normal Lockout Activates		7.41E-03		7.41E-03

[1]D=Demand, H=Hour

[2]Rules for assigning basic event factors are discussed in Table C.1-4

Table A.4-9

Air Circuit Breaker Reliability Data

Event Name	Description	Failure Rate[1]	Factor	Rational For Factor[2]	Failure Probability
YK299SXRYT	Shutdown Auxiliary Relay 99SX Spuriously Drops Out	3.60E-07 /H	24 H	Rule 1	8.64E-06
YKEMSRTCHE	Operator Incorrectly Resets Keowee Emergency Start Signals		0		0.00E+00

[1]D=Demand, H=Hour

[2]Rules for assigning basic event factors are discussed in Table C.1-4

Table A.4-10

Air Circuit Breaker Dominant Minimal Cut Sets

Cut Sets for Gate ACB1OPEN: ACB-1 Fails To Open

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
1)	1.58E-03	68.4%	AK152TDRYT	1.58E-03	Time Delay Relay 52-1TD Spurious Operation
2)	2.60E-04	11.3%	AB1OPENLHE	2.60E-04	Air Circuit Breaker 1 Fails To Open Due To A Latent Human Error
3)	2.49E-04	10.8%	AB1R52ZR6D	2.49E-04	Air Circuit Breaker 1 Relay 52Z Fails To Operate
4)	1.51E-04	6.5%	AB1MECHDEX	1.51E-04	Air Circuit Breaker 1 Fails To Open Due To Mechanical Failure
5)	3.51E-05	1.5%	AB1ACCUDEX	3.51E-05	Air Circuit Breaker 1 Accumulator Air Pressure Low
6)	2.90E-05	1.3%	AB152TCSVO	2.90E-05	Air Circuit Breaker 1 Trip Coil Fails To Operate
7)	5.16E-06	0.2%	AB1PS02PST	5.16E-06	Air Circuit Breaker 1 Accumulator Pressure Switch PS2 Fails Low
8)	1.80E-06	0.1%	AD1C3CLCDT	1.80E-06	Breaker 3CL In 125V dc Distribution Center 1DA Transfers Position

Total Event Probability = 2.31E-03

Table A.4-11

Air Circuit Breaker Dominant Minimal Cut Sets

Cut Sets for Gate ACB2CLOSE: ACB-2 Fails To Close

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
1)	3.02E-04	26.0%	AB2MCH2DEX	3.02E-04	Air Circuit Breaker 2 Fails To Close Due To Mechanical Failure
2)	2.49E-04	21.5%	AA227T2R6D	2.49E-04	Transformer #1 Undervoltage Relay (27T/2X) Fails To Drop Out
			ABEOPRCRHE	1.00E+00	Operators Fail To Close Air Circuit Breaker 2
3)	2.49E-04	21.5%	AB2R52XR6D	2.49E-04	Air Circuit Breaker 2 Relay 52X Fails To Operate
4)	2.49E-04	21.5%	AB252Y2R6D	2.49E-04	Air Circuit Breaker 2 Relay 52Y Failed To Drop Out Following Last Demand
5)	3.51E-05	3.0%	AB2ACCUDEX	3.51E-05	Air Circuit Breaker 2 Accumulator Air Pressure Low
6)	3.30E-05	2.8%	ABEOPRCRHE	1.00E+00	Operators Fail To Close Air Circuit Breaker 2
			AK252TDRYD	3.30E-05	Time Delay Relay 52-2TD Fails To Operate
7)	2.90E-05	2.5%	AB252CCSVO	2.90E-05	Air Circuit Breaker 2 Close Coil Fails To Operate

Total Event Probability = 1.16E-03

Table A.4-12

Air Circuit Breaker Dominant Minimal Cut Sets

Cut Sets for Gate ACB2OPEN: ACB-2 Fails To Open

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
1)	1.58E-03	68.4%	AK252TDRYT	1.58E-03	Time Delay Relay 52-2TD Spurious Operation
			KU2RNNG	1.00E+00	Keowee Unit 2 Is Supplying The Grid
2)	2.60E-04	11.3%	AB2OPENLHE	2.60E-04	Air Circuit Breaker 2 Fails To Open Due To A Latent Human Error
3)	2.49E-04	10.8%	AB2R52ZR6D	2.49E-04	Air Circuit Breaker 2 Relay 52Z Fails To Operate
4)	1.51E-04	6.5%	AB2MECHDEX	1.51E-04	Air Circuit Breaker 2 Fails To Open Due To Mechanical Failure
5)	3.51E-05	1.5%	AB2ACCUDEX	3.51E-05	Air Circuit Breaker 2 Accumulator Air Pressure Low
6)	2.90E-05	1.3%	AB252TCSVO	2.90E-05	Air Circuit Breaker 2 Trip Coil Fails To Operate
7)	5.16E-06	0.2%	AB2PS02PST	5.16E-06	Air Circuit Breaker 2 Accumulator Pressure Switch PS2 Fails Low
8)	1.80E-06	0.1%	AD2C3CLCDT	1.80E-06	Breaker 3CL In 125V dc Distribution Center 2DA Transfers Position
9)	1.20E-08	0.0%	AK214GVDEX	1.00E-04	KU2 Magnetic Speed Switch System Fails
			WK2SPD2DEX	1.20E-04	Keowee Unit 2 Governor Failure Creates Overspeed Condition
10)	3.96E-09	0.0%	AK252TDRYD	3.30E-05	Time Delay Relay 52-2TD Fails To Operate
			WK2SPD2DEX	1.20E-04	Keowee Unit 2 Governor Failure Creates Overspeed Condition
11)	3.96E-09	0.0%	AK2GV2XRYD	3.30E-05	Relay 14GOV/2X Fails To Pick-up
			WK2SPD2DEX	1.20E-04	Keowee Unit 2 Governor Failure Creates Overspeed Condition

Total Event Probability = 2.31E-03

Table A.4-13

Air Circuit Breaker Dominant Minimal Cut Sets

Cut Sets for Gate ACB2TRANS: ACB-2 Transfers Open

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
1)	1.40E-05	21.9%	AB252TCSVT	1.40E-05	Air Circuit Breaker 2 Trip Coil Spurious Operation
2)	1.31E-05	20.5%	AB2R52ZR6T	1.31E-05	Air Circuit Breaker 2 Relay 52Z Spurious Operation
3)	8.64E-06	13.5%	AB2R462RYT	8.64E-06	Air Circuit Breaker 2 Negative Sequence Relay 46-2 Spurious Operation
4)	8.64E-06	13.5%	AB2PUSHPBT	8.64E-06	Trip Pushbutton On ACB2 Spurious Operation
5)	8.64E-06	13.5%	AB251G2RYT	8.64E-06	Air Circuit Breaker 2 Overcurrent Ground Relay 51G-2 Spurious Operation
6)	8.64E-06	13.5%	AB22BV1RYT	8.64E-06	Backup Undervoltage Relay 2BV1 Spurious Operation
7)	2.10E-06	3.3%	AB21521SWT	2.10E-06	Control Switch 152-2 Spurious Operation

Total Event Probability = 6.38E-05

Table A.4-14

Air Circuit Breaker Dominant Minimal Cut Sets

Cut Sets for Gate ACB3CLOSE: ACB-3 Fails To Close

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
1)	3.02E-04	20.8%	AB3MCH2DEX	3.02E-04	Air Circuit Breaker 3 Fails To Close Due To Mechanical Failure
2)	2.60E-04	17.9%	AB3CLOSLHE	2.60E-04	Air Circuit Breaker 3 Fails To Close Due To Latent Human Error
3)	2.49E-04	17.2%	AB3R52XR6D	2.49E-04	Air Circuit Breaker 3 Relay 52X Fails To Operate
4)	2.49E-04	17.2%	AB352Y2R6D	2.49E-04	Air Circuit Breaker 3 Relay 52Y Failed To Drop Out Following Last Demand
5)	1.60E-04	11.0%	AB3PS02PST	1.60E-04	Air Circuit Breaker 3 Accumulator Pressure Switch PS2 Fails Low
6)	1.31E-04	9.0%	AB352Y2R6T	1.31E-04	Air Circuit Breaker 3 Y-relay Spurious Operation
7)	3.51E-05	2.4%	AB3ACCUDEX	3.51E-05	Air Circuit Breaker 3 Accumulator Air Pressure Low
8)	3.30E-05	2.3%	AK121TDRYD	3.30E-05	Time Delay Relay 2-1TD Fails To Pick-up
9)	2.90E-05	2.0%	AB352CCSVO	2.90E-05	Air Circuit Breaker 3 Close Coil Fails To Operate

Total Event Probability = 1.45E-03

Table A.4-15

Air Circuit Breaker Dominant Minimal Cut Sets

Cut Sets for Gate ACB3OPEN: ACB-3 Fails To Open

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
1)	2.49E-04	39.8%	AB3R52ZR6D	2.49E-04	Air Circuit Breaker 3 Relay 52Z Fails To Operate
2)	1.60E-04	25.6%	AB3PS02PST	1.60E-04	Air Circuit Breaker 3 Accumulator Pressure Switch PS2 Fails Low
3)	1.51E-04	24.1%	AB3MECHDEX	1.51E-04	Air Circuit Breaker 3 Fails To Open Due To Mechanical Failure
4)	3.51E-05	5.6%	AB3ACCUDEX	3.51E-05	Air Circuit Breaker 3 Accumulator Air Pressure Low
5)	2.90E-05	4.6%	AB352TCSVO	2.90E-05	Air Circuit Breaker 3 Trip Coil Fails To Operate

Total Event Probability = 6.26E-04

Table A.4-16

Air Circuit Breaker Dominant Minimal Cut Sets

Cut Sets for Gate ACB3TRANS: ACB-3 Transfers Open

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
1)	9.36E-06	36.7%	AB352TCSVT	9.36E-06	Air Circuit Breaker 3 Trip Coil Spurious Operation
2)	8.71E-06	34.2%	AB3R52ZR6T	8.71E-06	Air Circuit Breaker 3 Relay 52Z Spurious Operation
3)	5.76E-06	22.6%	AB3PUSHPBT	5.76E-06	Trip Pushbutton On ACB3 Spurious Operation
4)	1.68E-06	6.6%	AB31523SWT	1.68E-06	Control Switch 152-3 Spurious Operation

Total Event Probability = 2.55E-05

Table A.4-17

Air Circuit Breaker Dominant Minimal Cut Sets

Cut Sets for Gate ACB4CLOSE: ACB-4 Fails To Close

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
1)	9.00E-03	72.6%	ABPOPRCRHE	9.00E-03	Operators Fail To Close Air Circuit Breaker 4
			ACB4MOD	1.00E+00	NSM-ON-52966 Is Not In Service
2)	2.00E-03	16.1%	ACBAIRPDEX	2.00E-03	ACB Air Supply Fails Causing Low Pressure In All ACB Accumulators
3)	3.02E-04	2.4%	AB4MCH2DEX	3.02E-04	Air Circuit Breaker 4 Fails To Close Due To Mechanical Failure
4)	2.60E-04	2.1%	AB4CLOSLHE	2.60E-04	Air Circuit Breaker 4 Fails To Close Due To A Latent Human Error
5)	2.49E-04	2.0%	AB452Y2R6D	2.49E-04	Air Circuit Breaker 4 Relay 52Y Failed To Drop Out Following Last Demand
6)	2.49E-04	2.0%	AB4R52XR6D	2.49E-04	Air Circuit Breaker 4 Relay 52X Fails To Operate
7)	1.60E-04	1.3%	AB4PS02PST	1.60E-04	Air Circuit Breaker 4 Accumulator Pressure Switch PS2 Indicates Low Pres
8)	1.35E-04	1.1%	AB452Y2R6T	1.35E-04	Air Circuit Breaker 4 Y-relay Spurious Operation

Total Event Probability = 1.24E-02

Table A.4-18

Air Circuit Breaker Dominant Minimal Cut Sets

Cut Sets for Gate ACB4TRANS: ACB-4 Transfers Open

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
1)	9.36E-06	36.7%	AB452TCSVT	9.36E-06	Air Circuit Breaker 4 Trip Coil Spurious Operation
2)	8.71E-06	34.2%	AB4R52ZR6T	8.71E-06	Air Circuit Breaker 4 Relay 52Z Spurious Operation
3)	5.76E-06	22.6%	AB4PUSHPBT	5.76E-06	Trip Pushbutton On ACB-4 Spurious Operation
4)	1.68E-06	6.6%	AB41523SWT	1.68E-06	Control Switch 152-4 Spurious Operation

Total Event Probability = 2.55E-05

Table A.4-19

Air Circuit Breaker Dominant Minimal Cut Sets

Cut Sets for Gate ACB5CLOSE: ACB-5 Fails To Close

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
1)	7.04E-03	52.9%	AB5MCH2DEX	7.04E-03	Air Circuit Breaker 5 Fails To Close Due To Mechanical Failure
2)	3.20E-03	24.1%	AB7OPENLHE	3.20E-03	Air Circuit Breaker 7 Fails To Open Due To A Latent Human Error
3)	8.01E-04	6.0%	AB7MECHDEX	8.01E-04	Air Circuit Breaker 7 Fails To Open Due To Mechanical Failure
4)	3.20E-04	2.4%	AB51431LHE	3.20E-04	Manual/Auto Control Switch 143/1 Left In Manual
5)	3.10E-04	2.3%	XA1BKRSCOM	3.10E-04	CCF of 1X Aux Power Breakers ACB-5 & -7
6)	3.10E-04	2.3%	XA56BKRCOM	3.10E-04	Common Cause Failure Of ACB-5 And ACB-6 To Close
7)	2.60E-04	2.0%	AB5CLOSLHE	2.60E-04	Air Circuit Breaker 5 Fails To Close Due To A Latent Human Error
8)	2.49E-04	1.9%	AA1271PR6D	2.49E-04	Transformer 1X Undervoltage Relay 27/1X Fails To Pick Up
9)	2.49E-04	1.9%	AA127X2R6D	2.49E-04	Transformer CX Undervoltage Relay 27/CX1 Fails To Drop Out
10)	1.30E-04	1.0%	AB51431RYT	1.30E-04	Auxiliary Relay 143X/1 Spuriously Energizes
11)	1.30E-04	1.0%	AB552Y2RYT	1.30E-04	Air Circuit Breaker 5 Y-relay Spurious Operation

Total Event Probability = 1.33E-02

Table A.4-20

Air Circuit Breaker Dominant Minimal Cut Sets

Cut Sets for Gate ACB5TRANS: ACB-5 Transfers Open

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
1)	1.38E-04	35.6%	AA127X1RYT	1.38E-04	Auxiliary Relay 27X/1X Spurious Operation
2)	1.38E-04	35.6%	AB552TCRYT	1.38E-04	Air Circuit Breaker 5 Trip Coil 52TC Spurious Operation
3)	9.22E-05	23.8%	AB5PUSHPBT	9.22E-05	Trip Pushbutton On ACB5 Spurious Operation
4)	1.09E-05	2.8%	AA1271XR6T	1.09E-05	Transformer 1X Undervoltage Relay 27/1X Spuriously De-energizes
5)	8.64E-06	2.2%	AA186S1RYT	8.64E-06	Switchgear 1X Lockout Relay 86S/1X Spurious Operation

Total Event Probability = 3.88E-04

Table A.4-21

Air Circuit Breaker Dominant Minimal Cut Sets

Cut Sets for Gate ACB6CLOSE: ACB-6 Fails To Close

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
1)	7.04E-03	79.9%	AB6MCH2DEX	7.04E-03	Air Circuit Breaker 6 Fails To Close Due To Mechanical Failure
2)	3.20E-04	3.6%	AB61432LHE	3.20E-04	Manual/Auto Control Switch 143/2 Left In Manual
3)	3.10E-04	3.5%	XA56BKRCOM	3.10E-04	Common Cause Failure Of ACB-5 And ACB-6 To Close
4)	3.10E-04	3.5%	XA2BKRSCOM	3.10E-04	CCF of Aux Power Breakers ACB-6 & -8
5)	2.60E-04	3.0%	AB6CLOSLHE	2.60E-04	Air Circuit Breaker 6 Fails To Close Due To A Latent Human Error
6)	2.49E-04	2.8%	AA2272PR6D	2.49E-04	Transformer 2X Undervoltage Relay 27/2X Fails To Pick Up
7)	1.30E-04	1.5%	AB652Y2RYT	1.30E-04	Air Circuit Breaker 6 Y-relay Spurious Operation

Total Event Probability = 8.81E-03

Table A.4-22

Air Circuit Breaker Dominant Minimal Cut Sets

Cut Sets for Gate ACB6OPEN: ACB-6 Fails To Open

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
1)	3.20E-03	68.4%	AB6OPENLHE	3.20E-03	Air Circuit Breaker 6 Fails To Open Due To A Latent Human Error
2)	8.01E-04	17.1%	AB6MECHDEX	8.01E-04	Air Circuit Breaker 6 Fails To Open Due To Mechanical Failure
3)	3.20E-04	6.8%	AB61432LHE	3.20E-04	Manual/Auto Control Switch 143/2 Left In Manual
4)	2.49E-04	5.3%	AA2272XR6D	2.49E-04	Transformer 2X Undervoltage Relay 27/2X Fails To Drop Out

Total Event Probability = 4.68E-03

Table A.4-23

Air Circuit Breaker Dominant Minimal Cut Sets

Cut Sets for Gate ACB6TRANS: ACB-6 Transfers Open

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
1)	8.71E-06	21.6%	AA2272XR6T	8.71E-06	Transformer 2X Undervoltage Relay 27/2X Spuriously De-energizes
2)	8.64E-06	21.4%	AA227X2RYT	8.64E-06	Auxiliary Relay 27X/2X Spurious Operation
3)	8.64E-06	21.4%	AB652TCRYT	8.64E-06	Air Circuit Breaker 6 Trip Coil 52TC Spurious Operation
4)	8.64E-06	21.4%	AA286S2RYT	8.64E-06	Switchgear 2X Lockout Relay 86S/2X Spurious Operation
5)	5.76E-06	14.3%	AB6PUSHPBT	5.76E-06	Trip Pushbutton On ACB6 Spurious Operation

Total Event Probability = 4.04E-05

Table A.4-24

Air Circuit Breaker Dominant Minimal Cut Sets

Cut Sets for Gate ACB7CLOSE: ACB-7 Fails To Close

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
1)	7.04E-03	79.9%	AB7MCH2DEX	7.04E-03	Air Circuit Breaker 7 Fails To Close Due To Mechanical Failure
2)	3.20E-04	3.6%	AB51431LHE	3.20E-04	Manual/Auto Control Switch 143/1 Left In Manual
3)	3.10E-04	3.5%	XA78BKRCOM	3.10E-04	Common Cause Failure Of ACB-7 And ACB-8 To Close
4)	3.10E-04	3.5%	XA1BKRSCOM	3.10E-04	CCF of 1X Aux Power Breakers ACB-5 & -7
5)	2.60E-04	3.0%	AB7CLOSLHE	2.60E-04	Air Circuit Breaker 7 Fails To Close Due To A Latent Human Error
6)	2.49E-04	2.8%	AA127CPR6D	2.49E-04	Transformer CX Undervoltage Relay 27/CX1 Fails To Pick Up
7)	1.30E-04	1.5%	AB752Y2RYT	1.30E-04	Air Circuit Breaker 7 Y-relay Spurious Operation

Total Event Probability = 8.81E-03

Table A.4-25

Air Circuit Breaker Dominant Minimal Cut Sets

Cut Sets for Gate ACB7OPEN: ACB-7 Fails To Open

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
1)	3.20E-03	68.4%	AB7OPENLHE	3.20E-03	Air Circuit Breaker 7 Fails To Open Due To A Latent Human Error
2)	8.01E-04	17.1%	AB7MECHDEX	8.01E-04	Air Circuit Breaker 7 Fails To Open Due To Mechanical Failure
3)	3.20E-04	6.8%	AB51431LHE	3.20E-04	Manual/Auto Control Switch 143/1 Left In Manual
4)	2.49E-04	5.3%	AA127X2R6D	2.49E-04	Transformer CX Undervoltage Relay 27/CX1 Fails To Drop Out

Total Event Probability = 4.68E-03

Table A.4-26

Air Circuit Breaker Dominant Minimal Cut Sets

Cut Sets for Gate ACB7TRANS: ACB-7 Transfers Open

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
1)	8.71E-06	14.7%	AA127C1R6T	8.71E-06	Transformer CX Undervoltage Relay 27/CX1 Spuriously De-energizes
2)	8.64E-06	14.6%	AA127R1RYT	8.64E-06	Auxiliary Relay 27X/CX1 Spurious Operation
3)	8.64E-06	14.6%	AB752TCRYT	8.64E-06	Air Circuit Breaker 7 Trip Coil 52TC Spurious Operation
4)	8.64E-06	14.6%	AA187CXRYT	8.64E-06	Transformer CX Differential Relay 87CX Spurious Operation
5)	8.64E-06	14.6%	AA186S1RYT	8.64E-06	Switchgear 1X Lockout Relay 86S/1X Spurious Operation
6)	8.64E-06	14.6%	AA186CXRYT	8.64E-06	Transformer CX Differential Lock Out Relay 86CX Spurious Operation
7)	7.20E-06	12.2%	AB7PUSHPBT	7.20E-06	Trip Pushbutton On ACB7 Spurious Operation

Total Event Probability = 5.91E-05

Table A.4-27

Air Circuit Breaker Dominant Minimal Cut Sets

Cut Sets for Gate ACB8CLOSE: ACB-8 Fails To Close

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
1)	7.04E-03	54.2%	AB8MCH2DEX	7.04E-03	Air Circuit Breaker 8 Fails To Close Due To Mechanical Failure
2)	3.20E-03	24.6%	AB6OPENLHE	3.20E-03	Air Circuit Breaker 6 Fails To Open Due To A Latent Human Error
3)	8.01E-04	6.2%	AB6MECHDEX	8.01E-04	Air Circuit Breaker 6 Fails To Open Due To Mechanical Failure
4)	3.20E-04	2.5%	AB61432LHE	3.20E-04	Manual/Auto Control Switch 143/2 Left In Manual
5)	3.10E-04	2.4%	XA2BKRSCOM	3.10E-04	CCF of Aux Power Breakers ACB-6 & -8
6)	3.10E-04	2.4%	XA78BKRCOM	3.10E-04	Common Cause Failure Of ACB-7 And ACB-8 To Close
7)	2.49E-04	1.9%	AA227CPR6D	2.49E-04	Transformer CX Undervoltage Relay 27/CX2 Fails To Pick Up
8)	2.49E-04	1.9%	AA2272XR6D	2.49E-04	Transformer 2X Undervoltage Relay 27/2X Fails To Drop Out
9)	1.30E-04	1.0%	AB81432RYT	1.30E-04	Auxiliary Relay 143X/2 Spuriously Energizes
10)	1.30E-04	1.0%	AB852Y2RYT	1.30E-04	Air Circuit Breaker 8 Y-relay Spurious Operation

Total Event Probability = 1.30E-02

Table A.4-28

Air Circuit Breaker Dominant Minimal Cut Sets

Cut Sets for Gate ACB8TRANS: ACB-8 Transfers Open

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
1)	1.38E-04	34.1%	AA227R2RYT	1.38E-04	Auxiliary Relay 27X/CX2 Spurious Operation
2)	1.38E-04	34.1%	AB852TCRYT	1.38E-04	Air Circuit Breaker 8 Trip Coil 52TC Spurious Operation
3)	9.22E-05	22.8%	AB8PUSHPBT	9.22E-05	Trip Pushbutton On ACB8 Spurious Operation
4)	1.09E-05	2.7%	AA227C2R6T	1.09E-05	Transformer CX Undervoltage Relay 27/CX2 Spuriously De-energizes
5)	8.64E-06	2.1%	AA286S2RYT	8.64E-06	Switchgear 2X Lockout Relay 86S/2X Spurious Operation
6)	8.64E-06	2.1%	AA187CXRYT	8.64E-06	Transformer CX Differential Relay 87CX Spurious Operation
7)	8.64E-06	2.1%	AA186CXRYT	8.64E-06	Transformer CX Differential Lock Out Relay 86CX Spurious Operation

Total Event Probability=4.05E-04

Table A.4-29

Air Circuit Breaker Dominant Contributors To Unavailability

Rank	Event Description	Mean Unavailability[1]	Approximate Unavailability Contribution[2]
	Air Circuit Breaker 1 Fails To Open		
1	AK152TDRYT Time Delay Relay 52-1TD Spurious Operation	1.58E-03	68.3%
2	AB1OPENLHE Air Circuit Breaker 1 Fails To Open Due To A Latent Human Error	2.59E-04	11.2%
3	AB1R52ZR6D Air Circuit Breaker 1 Relay 52Z Fails To Operate	2.49E-04	10.8%
4	AB1MECHDEX Air Circuit Breaker 1 Fails To Open Due To Mechanical Failure	1.51E-04	6.5%
5	AB1ACCUDEX Air Circuit Breaker 1 Accumulator Air Pressure Low	3.51E-05	1.5%
6	AB152TCSVO Air Circuit Breaker 1 Trip Coil Fails To Operate	2.89E-05	1.3%

[1] The mean unavailability is the summation of the values of all cut sets in which the event appears

[2] The contribution to unavailability is calculated by dividing the mean unavailability by the overall system unavailability and then multiplying by 100 percent

Table A.4-30

Air Circuit Breaker Dominant Contributors To Unavailability

Rank	Event Description	Mean Unavailability[1]	Approximate Unavailability Contribution[2]
Air Circuit Breaker 2 Fails To Close			
1	AB2MCH2DEX Air Circuit Breaker 2 Fails To Close Due To Mechanical Failure	2.82E-04	26.1%
2	ABEOPRCRHE Operators Fail To Close Air Circuit Breaker 2	2.49E-04	24.3%
3	AB252Y2R6D Air Circuit Breaker 2 Relay 52Y Failed To Drop Out Following Last Demand	2.49E-04	21.5%
4	AB2R52XR6D Air Circuit Breaker 2 Relay 52X Fails To Operate	2.49E-04	21.5%
5	AA227T2R6D Transformer #1 Undervoltage Relay (27T/2X) Fails To Drop Out	3.51E-05	21.5%
6	AB2ACCUDEX Air Circuit Breaker 2 Accumulator Air Pressure Low	3.31E-05	3.0%
7	AK252TDRYD Time Delay Relay 52-2TD Fails To Operate	2.90E-05	2.9%

[1] The mean unavailability is the summation of the values of all cut sets in which the event appears

[2] The contribution to unavailability is calculated by dividing the mean unavailability by the overall system unavailability and then multiplying by 100 percent

Table A.4-31

Air Circuit Breaker Dominant Contributors To Unavailability

Rank	Event Description	Mean Unavailability[1]	Approximate Unavailability Contribution[2]
Air Circuit Breaker 2 Fails To Open			
1	AK252TDRYT Time Delay Relay 52-2TD Spurious Operation	1.58E-03	68.3%
2	AB2OPENLHE Air Circuit Breaker 2 Fails To Open Due To A Latent Human Error	2.59E-04	11.2%
3	AB2R52ZR6D Air Circuit Breaker 2 Relay 52Z Fails To Operate	2.49E-04	10.8%
4	AB2MECHDEX Air Circuit Breaker 2 Fails To Open Due To Mechanical Failure	1.51E-04	6.5%
5	AB2ACCUDEX Air Circuit Breaker 2 Accumulator Air Pressure Low	3.51E-05	1.5%
6	AB252TCSVO Air Circuit Breaker 2 Trip Coil Fails To Operate	2.89E-05	1.3%

[1] The mean unavailability is the summation of the values of all cut sets in which the event appears

[2] The contribution to unavailability is calculated by dividing the mean unavailability by the overall system unavailability and then multiplying by 100 percent

Table A.4-32

Air Circuit Breaker Dominant Contributors To Unavailability

Rank	Event Description	Mean Unavailability[1]	Approximate Unavailability Contribution[2]
	Air Circuit Breaker 2 Transfers Open		
1	AB252TCSVT Air Circuit Breaker 2 Trip Coil Spurious Operation	1.40E-05	22.0%
2	AB2R52ZR6T Air Circuit Breaker 2 Relay 52Z Spurious Operation	1.31E-05	20.5%
3	AB2PUSHPBT Trip Pushbutton On ACB2 Spurious Operation	8.61E-06	13.5%
4	AB22BV1RYT Backup Undervoltage Relay 2BV1 Spurious Operation	8.61E-06	13.5%
5	AB2R462RYT Air Circuit Breaker 2 Negative Sequence Relay 46-2 Spurious Operation	8.61E-06	13.5%
6	AB251G2RYT Air Circuit Breaker 2 Overcurrent Ground Relay 51G-2 Spurious Operation	8.61E-06	13.5%
7	AB21521SWT Control Switch 152-2 Spurious Operation	2.10E-06	3.3%

[1] The mean unavailability is the summation of the values of all cut sets in which the event appears

[2] The contribution to unavailability is calculated by dividing the mean unavailability by the overall system unavailability and then multiplying by 100 percent

Table A.4-33

Air Circuit Breaker Dominant Contributors To Unavailability

Rank	Event Description	Mean Unavailability[1]	Approximate Unavailability Contribution[2]
Air Circuit Breaker 3 Fails To Close			
1	AB3MCH2DEX Air Circuit Breaker 3 Fails To Close Due To Mechanical Failure	3.00E-04	21%
2	AB3CLOSLHE Air Circuit Breaker 3 Fails To Close Due To Latent Human Error	2.60E-04	18%
3	AB352Y2R6D Air Circuit Breaker 3 Relay 52Y Failed To Drop Out Following Last Demand	2.48E-04	17%
4	AB3R52XR6D Air Circuit Breaker 3 Relay 52X Fails To Operate	2.48E-04	17%
5	AB3PS02PST Air Circuit Breaker 3 Accumulator Pressure Switch PS2 Fails Low	1.60E-04	11%
6	AB352Y2R6T Air Circuit Breaker 3 Y-relay Spurious Operation	1.30E-04	9%
7	AB3ACCUDEX Air Circuit Breaker 3 Accumulator Air Pressure Low	3.49E-05	2%
8	AK121TDRYD Time Delay Relay 2-1TD Fails To Pick-up	3.29E-05	2%
9	AB352CCSVO Air Circuit Breaker 3 Close Coil Fails To Operate	2.89E-05	2%

[1] The mean unavailability is the summation of the values of all cut sets in which the event appears

[2] The contribution to unavailability is calculated by dividing the mean unavailability by the overall system unavailability and then multiplying by 100 percent

Table A.4-34

Air Circuit Breaker Dominant Contributors To Unavailability

Rank	Event Description	Mean Unavailability[1]	Approximate Unavailability Contribution[2]
Air Circuit Breaker 3 Fails To Open			
1	AB3R52ZR6D Air Circuit Breaker 3 Relay 52Z Fails To Operate	2.49E-04	39.8%
2	AB3PS02PST Air Circuit Breaker 3 Accumulator Pressure Switch PS2 Fails Low	1.60E-04	25.6%
3	AB3MECHDEX Air Circuit Breaker 3 Fails To Open Due To Mechanical Failure	1.51E-04	24.1%
4	AB3ACCUDEX Air Circuit Breaker 3 Accumulator Air Pressure Low	3.51E-05	5.6%
5	AB352TCSVO Air Circuit Breaker 3 Trip Coil Fails To Operate	2.90E-05	4.6%

[1] The mean unavailability is the summation of the values of all cut sets in which the event appears

[2] The contribution to unavailability is calculated by dividing the mean unavailability by the overall system unavailability and then multiplying by 100 percent

Table A.4-35

Air Circuit Breaker Dominant Contributors To Unavailability

Rank	Event Description	Mean Unavailability[1]	Approximate Unavailability Contribution[2]
	Air Circuit Breaker 3 Transfers Open		
1	AB352TCSVT Air Circuit Breaker 3 Trip Coil Spurious Operation	9.36E-06	36.7%
2	AB3R52ZR6T Air Circuit Breaker 3 Relay 52Z Spurious Operation	8.7E-06	34.1%
3	AB3PUSHPBT Trip Pushbutton On ACB3 Spurious Operation	5.76E-06	22.6%
4	AB31523SWT Control Switch 152-3 Spurious Operation	1.68E-06	6.6%

[1] The mean unavailability is the summation of the values of all cut sets in which the event appears

[2] The contribution to unavailability is calculated by dividing the mean unavailability by the overall system unavailability and then multiplying by 100 percent

Table A.4-36

Air Circuit Breaker Dominant Contributors To Unavailability

Rank	Event Description	Mean Unavailability[1]	Approximate Unavailability Contribution[2]
	Air Circuit Breaker 4 Fails To Close		
1	ACB4MOD NSM-ON-52966 Is Not In Service	8.97E-03	72.3%
2	ABPOPRCRHE Operators Fail To Close Air Circuit Breaker 4	8.94E-03	72.1%
3	ACBAIRPDEX ACB Air Supply Fails Causing Low Pressure In All ACB Accumulators	1.97E-03	15.9%
4	AB4MCH2DEX Air Circuit Breaker 4 Fails To Close Due To Mechanical Failure	2.98E-04	2.4%
5	AB4CLOSLHE Air Circuit Breaker 4 Fails To Close Due To A Latent Human Error	2.55E-04	2.1%
6	AB452Y2R6D Air Circuit Breaker 4 Relay 52Y Failed To Drop Out Following Last Demand	2.46E-04	2.0%
7	AB4R52XR6D Air Circuit Breaker 4 Relay 52X Fails To Operate	2.46E-04	2.0%
8	AB4PS02PST Air Circuit Breaker 4 Accumulator Pressure Switch PS2 Indicates Low Pres	1.57E-04	1.3%
9	AB452Y2R6T Air Circuit Breaker 4 Y-relay Spurious Operation	1.33E-04	1.1%

[1] The mean unavailability is the summation of the values of all cut sets in which the event appears

[2] The contribution to unavailability is calculated by dividing the mean unavailability by the overall system unavailability and then multiplying by 100 percent

Table A.4-37

Air Circuit Breaker Dominant Contributors To Unavailability

Rank	Event Description	Mean Unavailability[1]	Approximate Unavailability Contribution[2]
Air Circuit Breaker 4 Transfers Open			
1	AB452TCSVT Air Circuit Breaker 4 Trip Coil Spurious Operation	9.36E-06	36.7%
2	AB4R52ZR6T Air Circuit Breaker 4 Relay 52Z Spurious Operation	8.7E-06	34.1%
3	AB4PUSHPBT Trip Pushbutton On ACB-4 Spurious Operation	5.76E-06	22.6%
4	AB41523SWT Control Switch 152-4 Spurious Operation	1.68E-06	6.6%

[1] The mean unavailability is the summation of the values of all cut sets in which the event appears

[2] The contribution to unavailability is calculated by dividing the mean unavailability by the overall system unavailability and then multiplying by 100 percent

Table A.4-38

Air Circuit Breaker Dominant Contributors To Unavailability

Rank	Event Description	Mean Unavailability[1]	Approximate Unavailability Contribution[2]
Air Circuit Breaker 5 Fails To Close			
1	AB5MCH2DEX Air Circuit Breaker 5 Fails To Close Due To Mechanical Failure	7.01E-03	52.7%
2	AB7OPENLHE Air Circuit Breaker 7 Fails To Open Due To A Latent Human Error	3.18E-03	23.9%
3	AB7MECHDEX Air Circuit Breaker 7 Fails To Open Due To Mechanical Failure	7.93E-04	6.0%
4	AB51431LHE Manual/Auto Control Switch 143/1 Left In Manual	3.17E-04	2.4%
5	XA1BKRSCOM CCF of 1X Aux Power Breakers ACB-5 & -7	3.07E-04	2.3%
6	XA56BKRCOM Common Cause Failure Of ACB-5 And ACB-6 To Close	3.07E-04	2.3%
7	AB5CLOSLHE Air Circuit Breaker 5 Fails To Close Due To A Latent Human Error	2.57E-04	1.9%
8	AA127X2R6D Transformer CX Undervoltage Relay 27/CX1 Fails To Drop Out	2.46E-04	1.9%
9	AA1271PR6D Transformer 1X Undervoltage Relay 27/1X Fails To Pick Up	2.46E-04	1.9%

[1] The mean unavailability is the summation of the values of all cut sets in which the event appears

[2] The contribution to unavailability is calculated by dividing the mean unavailability by the overall system unavailability and then multiplying by 100 percent

Table A.4-39

Air Circuit Breaker Dominant Contributors To Unavailability

Rank	Event Description	Mean Unavailability[1]	Approximate Unavailability Contribution[2]
Air Circuit Breaker 5 Transfers Open			
1	AB552TCRYT Air Circuit Breaker 5 Trip Coil 52TC Spurious Operation	1.38E-04	35.6%
2	AA127X1RYT Auxiliary Relay 27X/1X Spurious Operation	1.38E-04	35.6%
3	AB5PUSHPBT Trip Pushbutton On ACB5 Spurious Operation	9.20E-05	23.7%
4	AA1271XR6T Transformer 1X Undervoltage Relay 27/1X Spuriously De-energizes	1.09E-05	2.8%
5	AA186S1RYT Switchgear 1X Lockout Relay 86S/1X Spurious Operation	8.65E-06	2.2%

1 The mean unavailability is the summation of the values of all cut sets in which the event appears

2 The contribution to unavailability is calculated by dividing the mean unavailability by the overall system unavailability and then multiplying by 100 percent

Table A.4-40

Air Circuit Breaker Dominant Contributors To Unavailability

Rank	Event Description	Mean Unavailability[1]	Approximate Unavailability Contribution[2]
Air Circuit Breaker 6 Fails To Close			
1	AB6MCH2DEX Air Circuit Breaker 6 Fails To Close Due To Mechanical Failure	7.03E-03	79.8%
2	AB61432LHE Manual/Auto Control Switch 143/2 Left In Manual	3.17E-04	3.6%
3	XA2BKRSCOM CCF of Aux Power Breakers ACB-6 & -8	3.07E-04	3.5%
4	XA56BKRCOM Common Cause Failure Of ACB-5 And ACB-6 To Close	3.07E-04	3.5%
5	AB6CLOSLHE Air Circuit Breaker 6 Fails To Close Due To A Latent Human Error	2.58E-04	2.9%
6	AA2272PR6D Transformer 2X Undervoltage Relay 27/2X Fails To Pick Up	2.47E-04	2.8%
7	AB652Y2RYT Air Circuit Breaker 6 Y-relay Spurious Operation	1.29E-04	1.5%

[1] The mean unavailability is the summation of the values of all cut sets in which the event appears

[2] The contribution to unavailability is calculated by dividing the mean unavailability by the overall system unavailability and then multiplying by 100 percent

Table A.4-41

Air Circuit Breaker Dominant Contributors To Unavailability

Rank	Event Description	Mean Unavailability[1]	Approximate Unavailability Contribution[2]
Air Circuit Breaker 6 Fails To Open			
1	AB6OPENLHE Air Circuit Breaker 6 Fails To Open Due To A Latent Human Error	3.20E-03	68.3%
2	AB6MECHDEX Air Circuit Breaker 6 Fails To Open Due To Mechanical Failure	8.00E-04	17.1%
3	AB61432LHE Manual/Auto Control Switch 143/2 Left In Manual	3.19E-04	6.8%
4	AA2272XR6D Transformer 2X Undervoltage Relay 27/2X Fails To Drop Out	2.48E-04	5.3%

1 The mean unavailability is the summation of the values of all cut sets in which the event appears

2 The contribution to unavailability is calculated by dividing the mean unavailability by the overall system unavailability and then multiplying by 100 percent

Table A.4-42

Air Circuit Breaker Dominant Contributors To Unavailability

Rank	Event Description	Mean Unavailability[1]	Approximate Unavailability Contribution[2]
Air Circuit Breaker 6 Transfers Open			
1	AA2272XR6T Transformer 2X Undervoltage Relay 27/2X Spuriously De-energizes	8.73E-06	21.6%
2	AB652TCRYT Air Circuit Breaker 6 Trip Coil 52TC Spurious Operation	8.65E-06	21.4%
3	AA227X2RYT Auxiliary Relay 27X/2X Spurious Operation	8.65E-06	21.4%
4	AA286S2RYT Switchgear 2X Lockout Relay 86S/2X Spurious Operation	8.65E-06	21.4%
5	AB6PUSHPBT Trip Pushbutton On ACB6 Spurious Operation	5.78E-06	14.3%

1 The mean unavailability is the summation of the values of all cut sets in which the event appears

2 The contribution to unavailability is calculated by dividing the mean unavailability by the overall system unavailability and then multiplying by 100 percent

Table A.4-43

Air Circuit Breaker Dominant Contributors To Unavailability

Rank	Event Description	Mean Unavailability[1]	Approximate Unavailability Contribution[2]
	Air Circuit Breaker 7 Fails To Close		
1	AB7MCH2DEX Air Circuit Breaker 7 Fails To Close Due To Mechanical Failure	7.03E-03	79.8%
2	AB51431LHE Manual/Auto Control Switch 143/1 Left In Manual	3.17E-04	3.6%
3	XA1BKRSCOM CCF of 1X Aux Power Breakers ACB-5 & -7	3.07E-04	3.5%
4	XA78BKRCOM Common Cause Failure Of ACB-7 And ACB-8 To Close	3.07E-04	3.5%
5	AB7CLOSLHE Air Circuit Breaker 7 Fails To Close Due To A Latent Human Error	2.58E-04	2.9%
6	AA127CPR6D Transformer CX Undervoltage Relay 27/CX1 Fails To Pick Up	2.47E-04	2.8%
7	AB752Y2RYT Air Circuit Breaker 7 Y-relay Spurious Operation	1.29E-04	1.5%

[1] The mean unavailability is the summation of the values of all cut sets in which the event appears

[2] The contribution to unavailability is calculated by dividing the mean unavailability by the overall system unavailability and then multiplying by 100 percent

Table A.4-44

Air Circuit Breaker Dominant Contributors To Unavailability

Rank	Event Description	Mean Unavailability[1]	Approximate Unavailability Contribution[2]
	Air Circuit Breaker 7 Fails To Open		
1	AB7OPENLHE Air Circuit Breaker 7 Fails To Open Due To A Latent Human Error	3.20E-03	68.3%
2	AB7MECHDEX Air Circuit Breaker 7 Fails To Open Due To Mechanical Failure	8.00E-04	17.1%
3	AB51431LHE Manual/Auto Control Switch 143/1 Left In Manual	3.19E-04	6.8%
4	AA127X2R6D Transformer CX Undervoltage Relay 27/CX1 Fails To Drop Out	2.48E-04	5.3%

[1] The mean unavailability is the summation of the values of all cut sets in which the event appears

[2] The contribution to unavailability is calculated by dividing the mean unavailability by the overall system unavailability and then multiplying by 100 percent

Table A.4-45

Air Circuit Breaker Dominant Contributors To Unavailability

Rank	Event Description	Mean Unavailability[1]	Approximate Unavailability Contribution[2]
Air Circuit Breaker 7 Transfers Open			
1	AA127C1R6T Transformer CX Undervoltage Relay 27/CX1 Spuriously De-energizes	8.69E-06	14.7%
2	AB752TCRYT Air Circuit Breaker 7 Trip Coil 52TC Spurious Operation	8.63E-06	14.6%
3	AA127R1RYT Auxiliary Relay 27X/CX1 Spurious Operation	8.63E-06	14.6%
4	AA186S1RYT Switchgear 1X Lockout Relay 86S/1X Spurious Operation	8.63E-06	14.6%
5	AA186CXRYT Transformer CX Differential Lock Out Relay 86CX Spurious Operation	8.63E-06	14.6%
6	AA187CXRYT Transformer CX Differential Relay 87CX Spurious Operation	8.63E-06	14.6%
7	AB7PUSHPBT Trip Pushbutton On ACB7 Spurious Operation	7.21E-06	12.2%

[1] The mean unavailability is the summation of the values of all cut sets in which the event appears

[2] The contribution to unavailability is calculated by dividing the mean unavailability by the overall system unavailability and then multiplying by 100 percent

Table A.4-46

Air Circuit Breaker Dominant Contributors To Unavailability

Rank	Event Description	Mean Unavailability[1]	Approximate Unavailability Contribution[2]
	Air Circuit Breaker 8 Fails To Close		
1	AB8MCH2DEX Air Circuit Breaker 8 Fails To Close Due To Mechanical Failure	6.99E-03	53.8%
2	AB6OPENLHE Air Circuit Breaker 6 Fails To Open Due To A Latent Human Error	3.17E-03	24.4%
3	AB6MECHDEX Air Circuit Breaker 6 Fails To Open Due To Mechanical Failure	7.90E-04	6.1%
4	AB61432LHE Manual/Auto Control Switch 143/2 Left In Manual	3.16E-04	2.4%
5	XA2BKRSCOM CCF of Aux Power Breakers ACB-6 & -8	3.06E-04	2.4%
6	XA78BKRCOM Common Cause Failure Of ACB-7 And ACB-8 To Close	3.06E-04	2.4%
7	AA227CPR6D Transformer CX Undervoltage Relay 27/CX2 Fails To Pick Up	2.46E-04	1.9%
8	AA2272XR6D Transformer 2X Undervoltage Relay 27/2X Fails To Drop Out	2.46E-04	1.9%

[1] The mean unavailability is the summation of the values of all cut sets in which the event appears

[2] The contribution to unavailability is calculated by dividing the mean unavailability by the overall system unavailability and then multiplying by 100 percent

Table A.4-47

Air Circuit Breaker Dominant Contributors To Unavailability

Rank	Event Description	Mean Unavailability[1]	Approximate Unavailability Contribution[2]
Air Circuit Breaker 8 Transfers Open			
1	AA227R2RYT Auxiliary Relay 27X/CX2 Spurious Operation	1.38E-04	34.1%
2	AB852TCRYT Air Circuit Breaker 8 Trip Coil 52TC Spurious Operation	1.38E-04	34.1%
3	AB8PUSHPBT Trip Pushbutton On ACB8 Spurious Operation	9.19E-05	22.7%
4	AA227C2R6T Transformer CX Undervoltage Relay 27/CX2 Spuriously De-energizes	1.09E-05	2.7%
5	AA286S2RYT Switchgear 2X Lockout Relay 86S/2X Spurious Operation	8.63E-06	2.1%
6	AA187CXRYT Transformer CX Differential Relay 87CX Spurious Operation	8.63E-06	2.1%
7	AA186CXRYT Transformer CX Differential Lock Out Relay 86CX Spurious Operation	8.63E-06	2.1%

[1] The mean unavailability is the summation of the values of all cut sets in which the event appears

[2] The contribution to unavailability is calculated by dividing the mean unavailability by the overall system unavailability and then multiplying by 100 percent

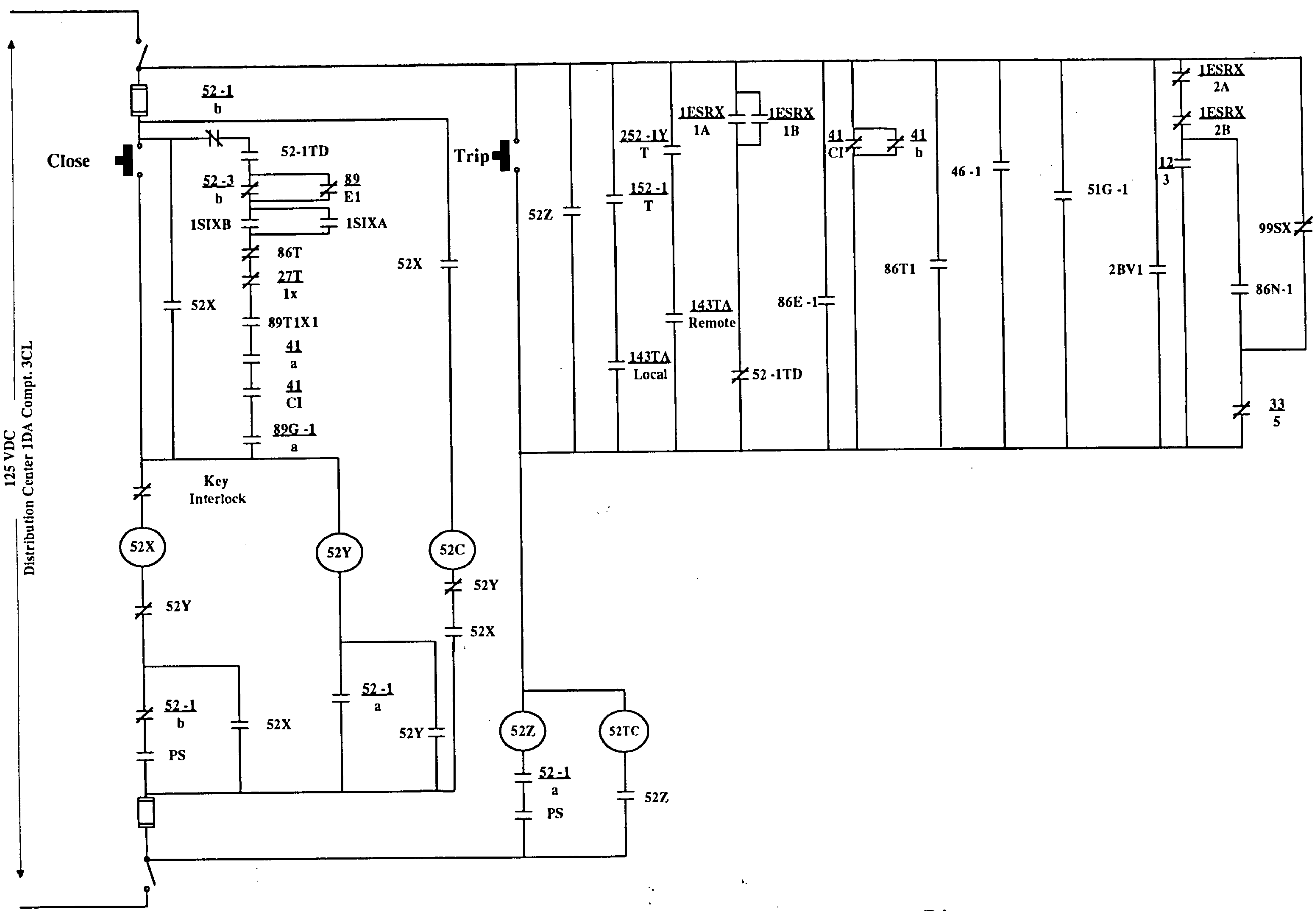


Figure A.4-1 Simplified Air Circuit Breaker #1 Elementary Diagram

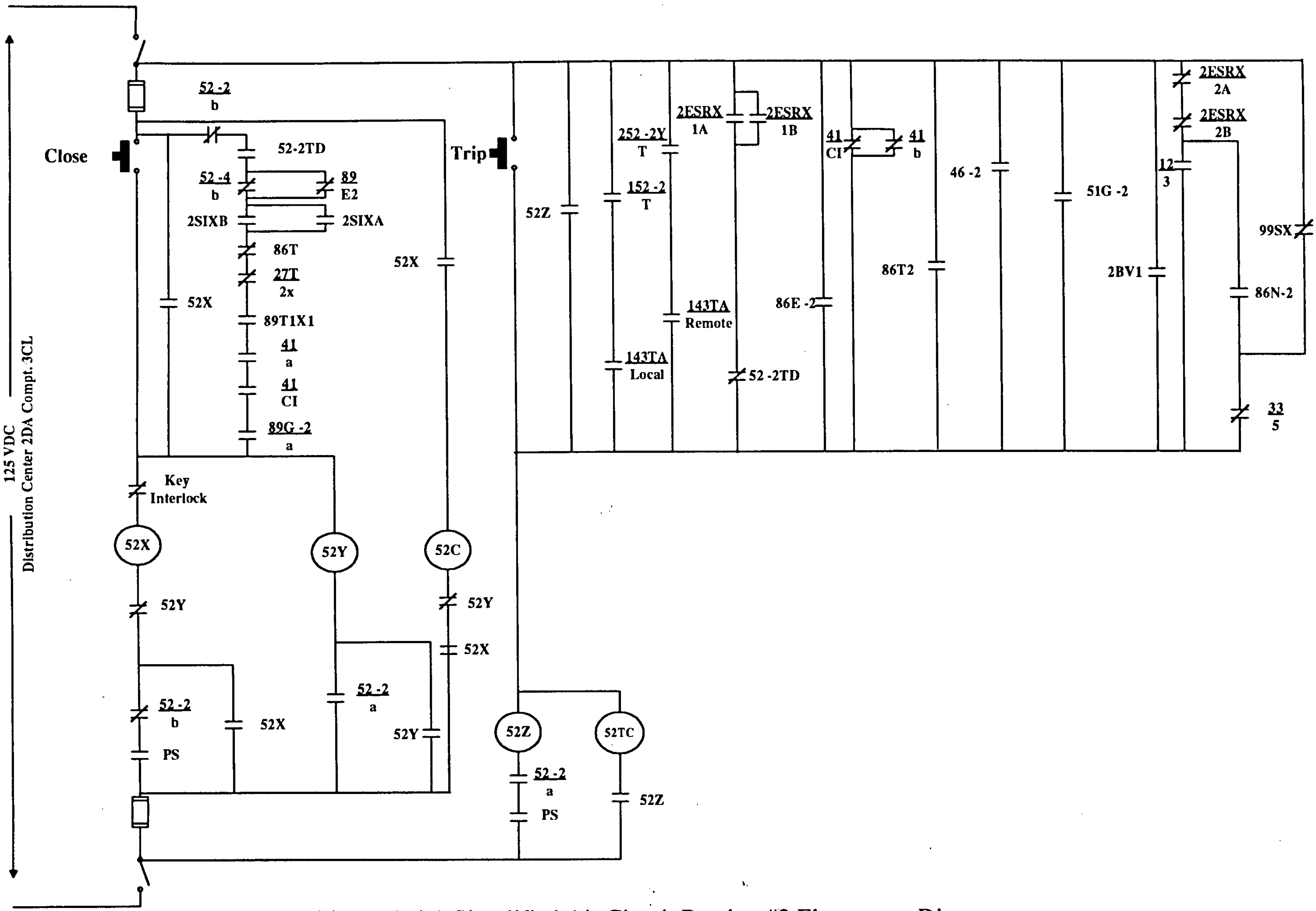


Figure A.4-2 Simplified Air Circuit Breaker #2 Elementary Diagram

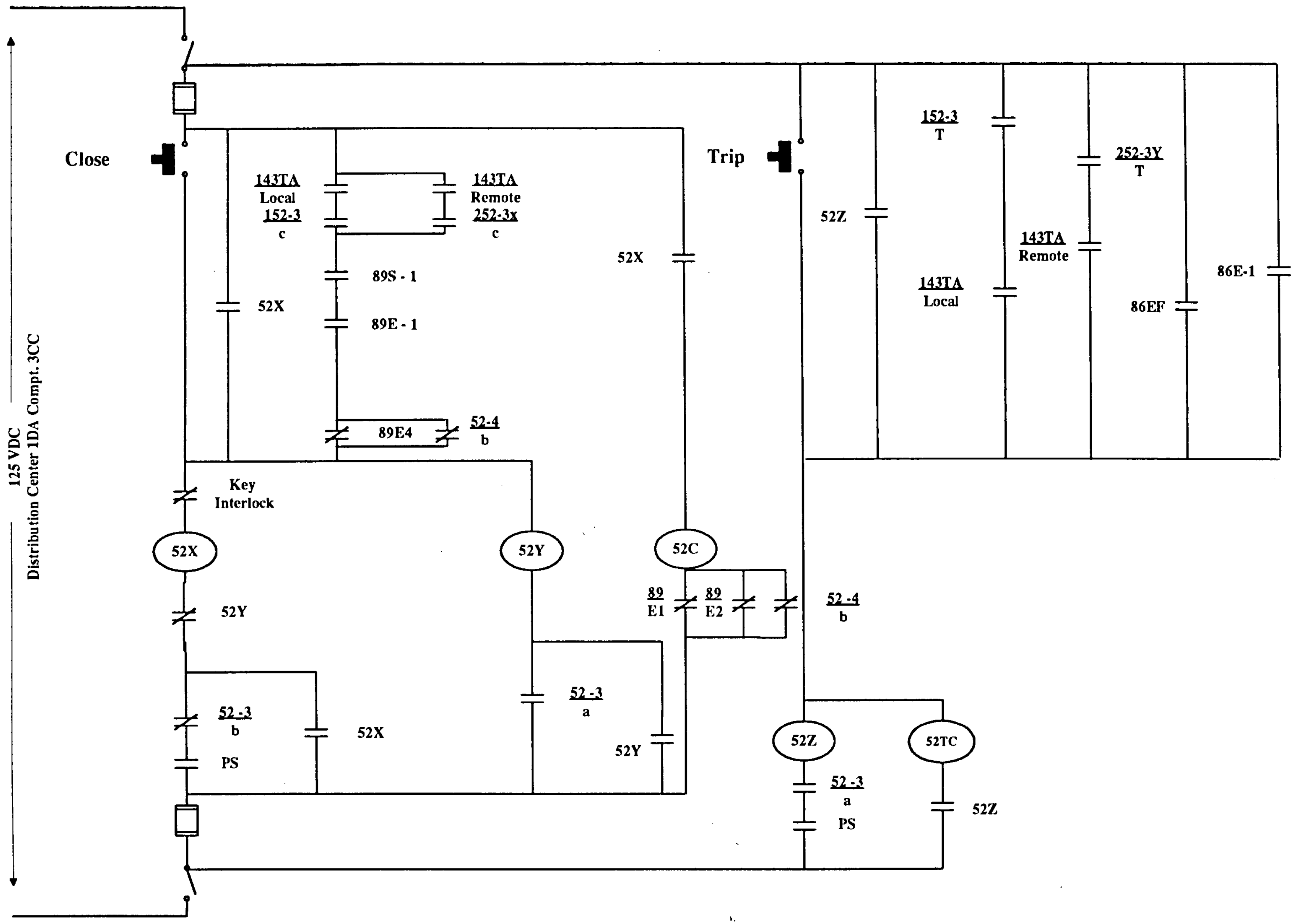


Figure A.4-3 Simplified Air Circuit Breaker #3 Elementary Diagram

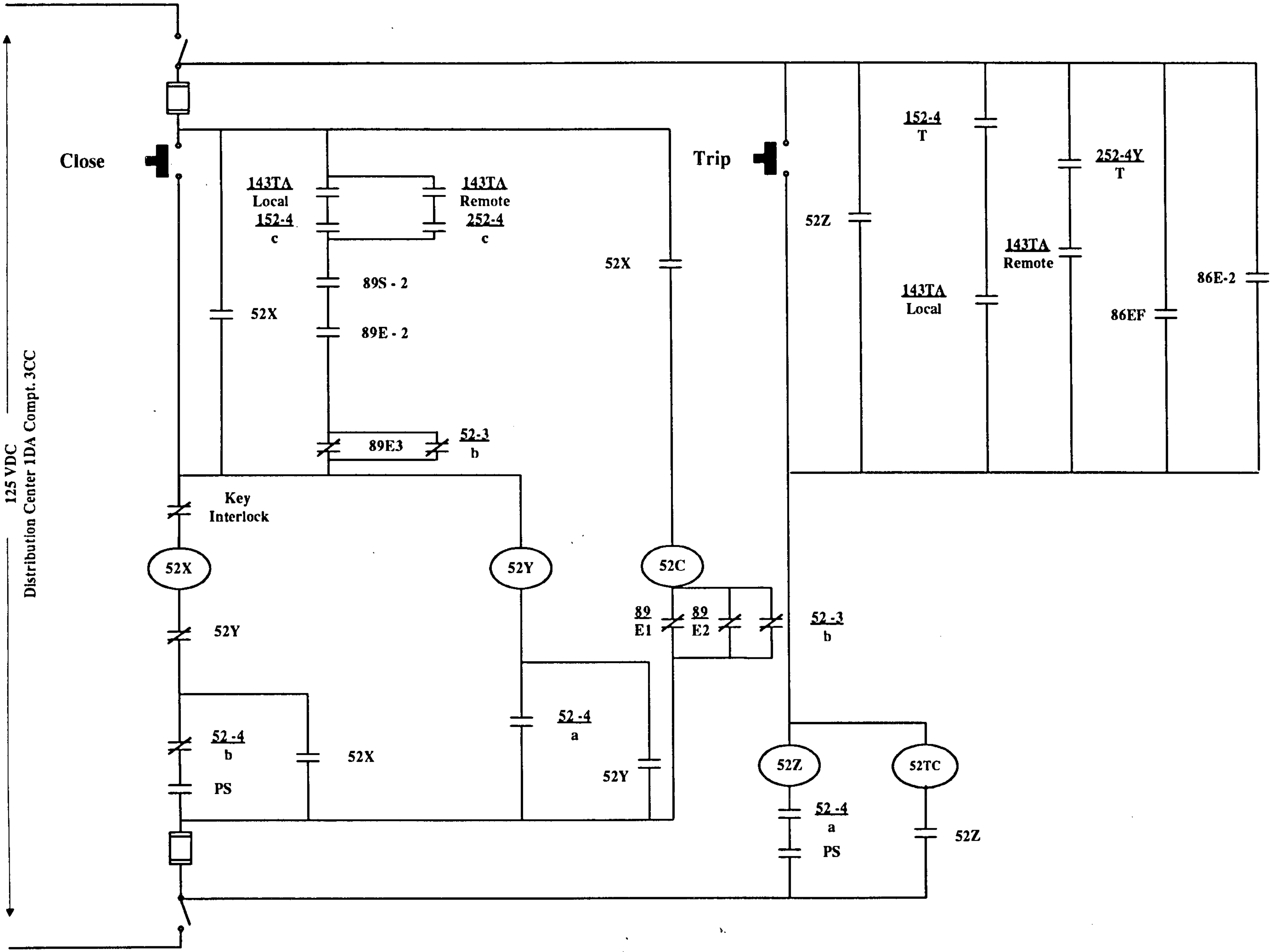


Figure A.4-4 Simplified Air Circuit Breaker #4 Elementary Diagram

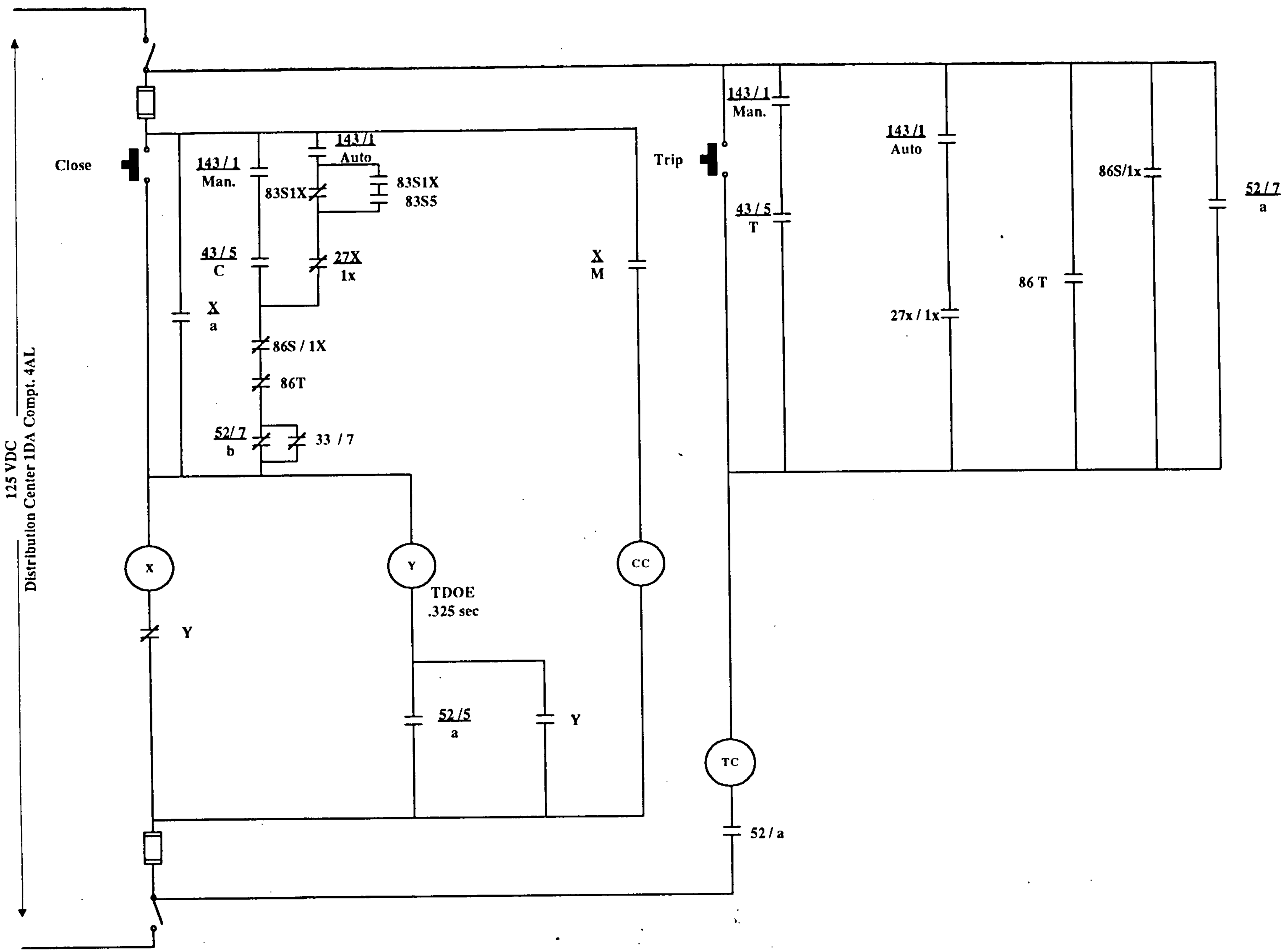


Figure A.4-5 Simplified Air Circuit Breaker #5 Elementary Diagram

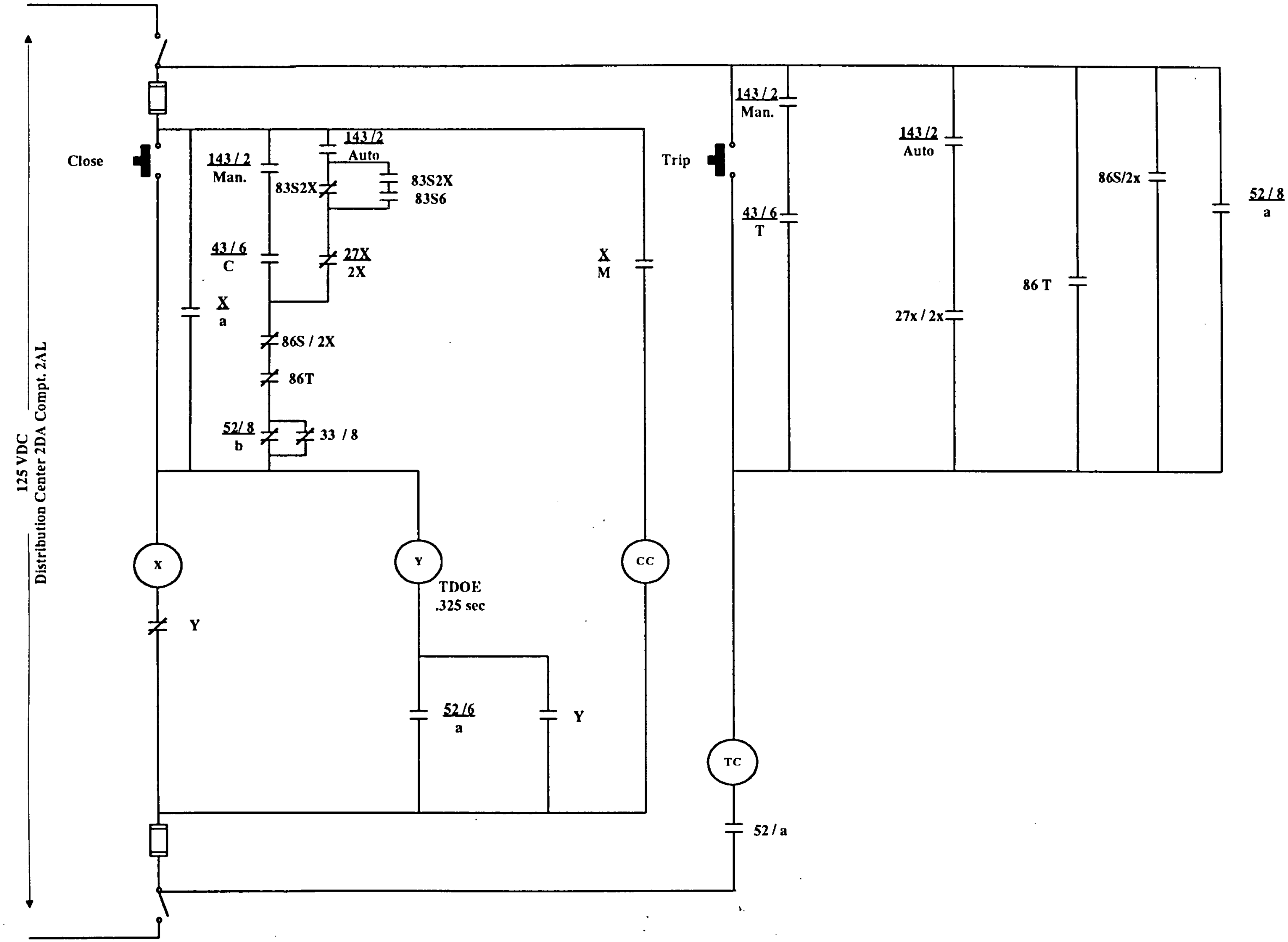


Figure A.4-6 Simplified Air Circuit Breaker #6 Elementary Diagram

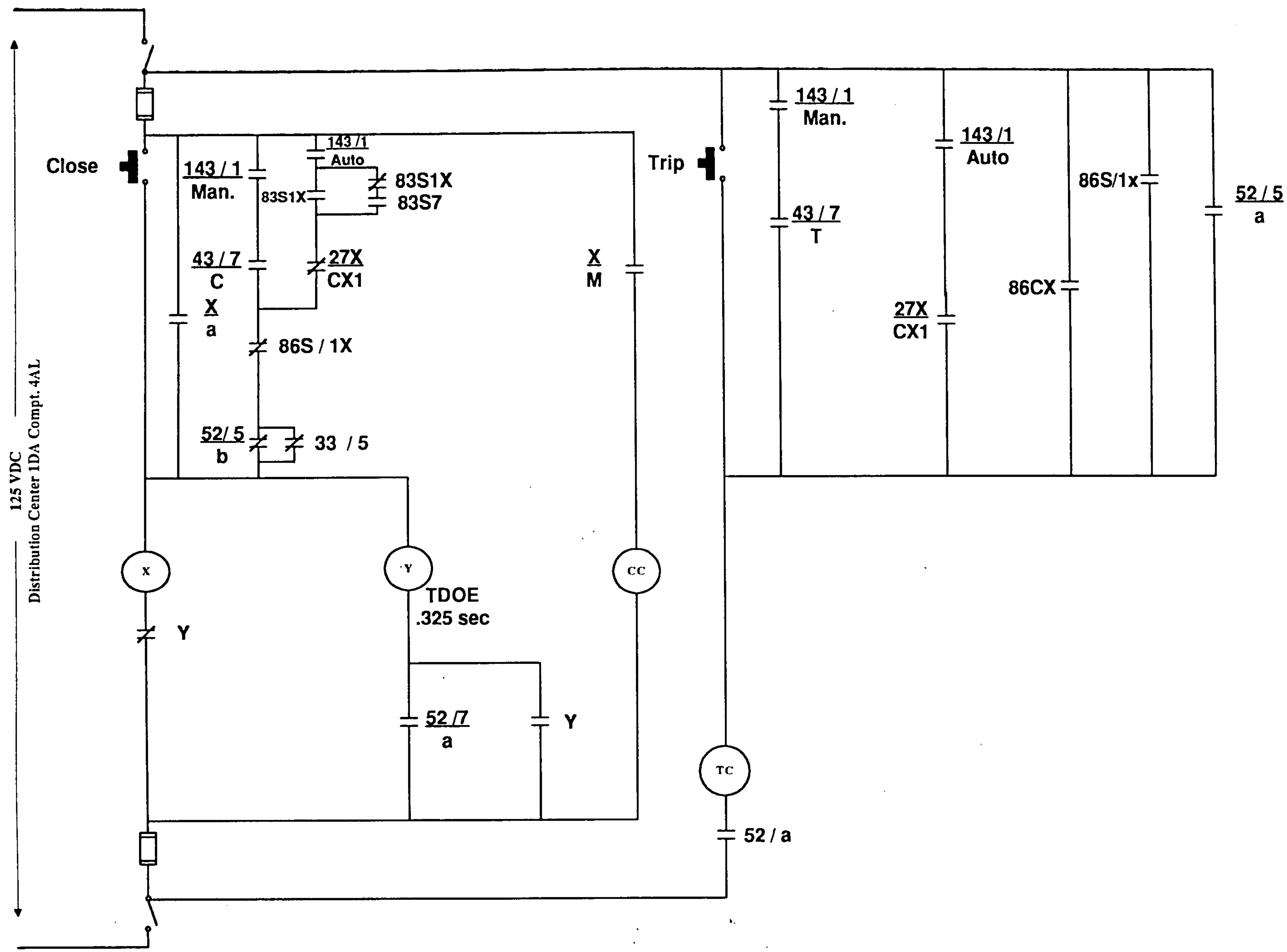


Figure A.4-7 Simplified Air Circuit Breaker #7 Elementary Diagram

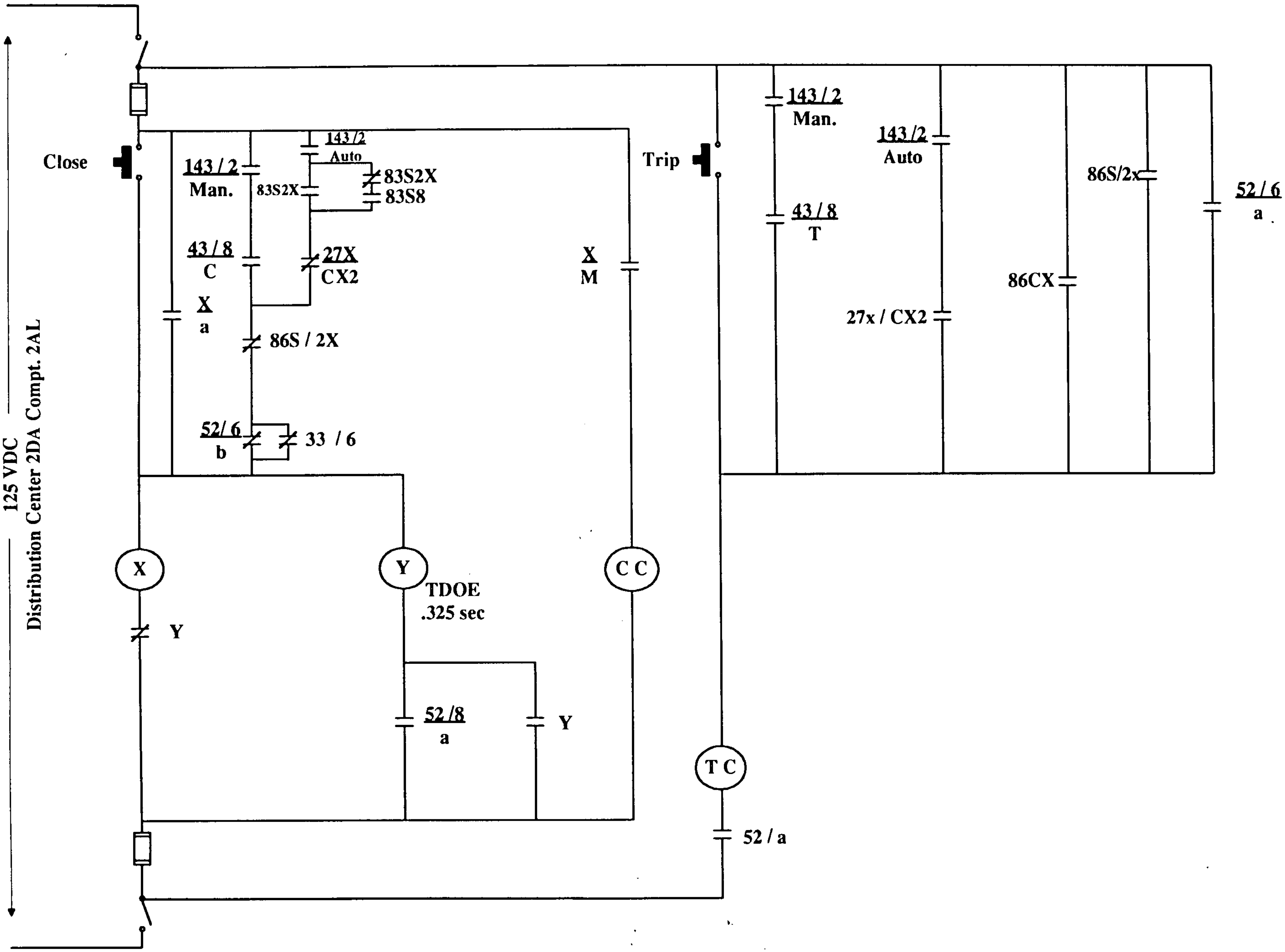
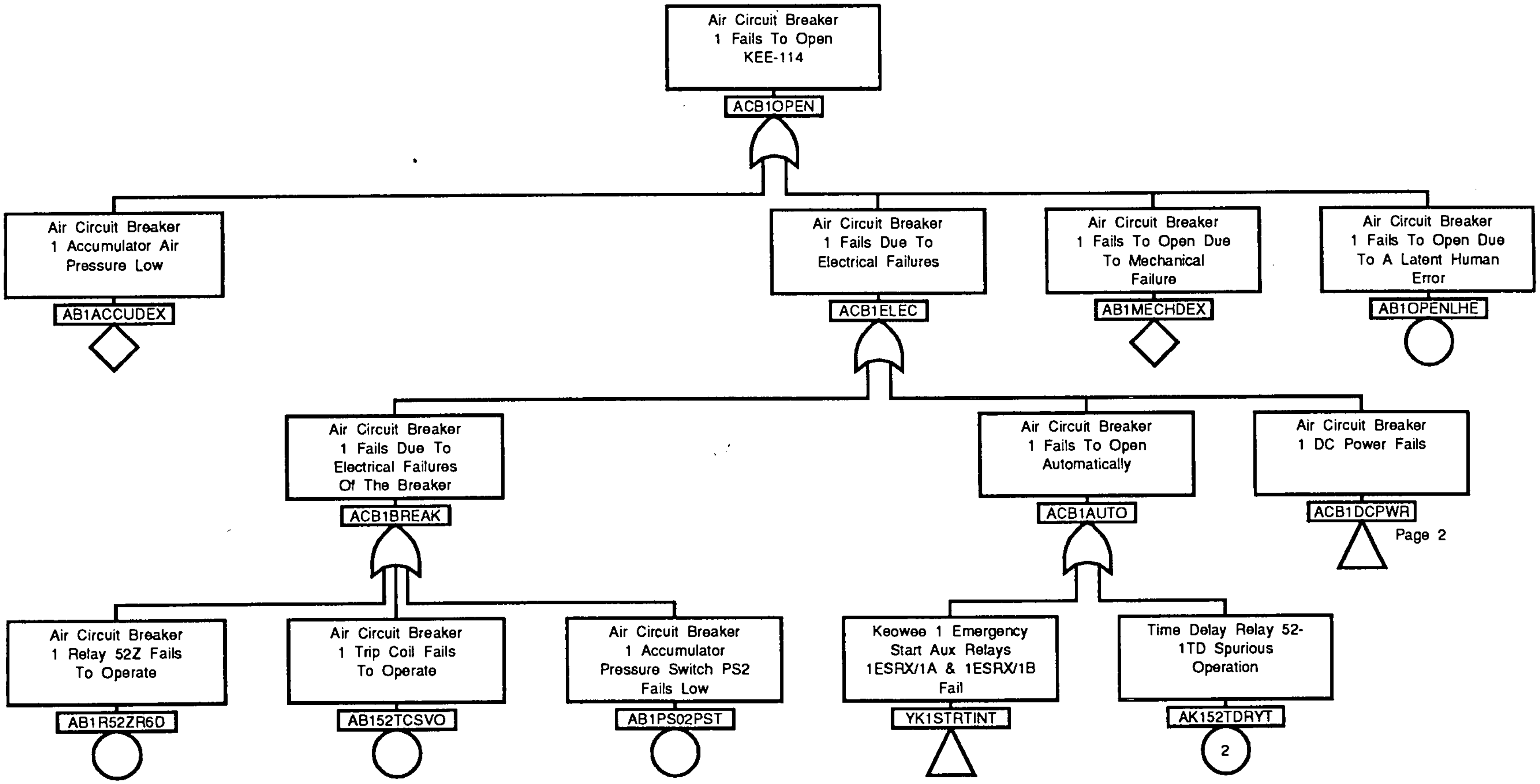
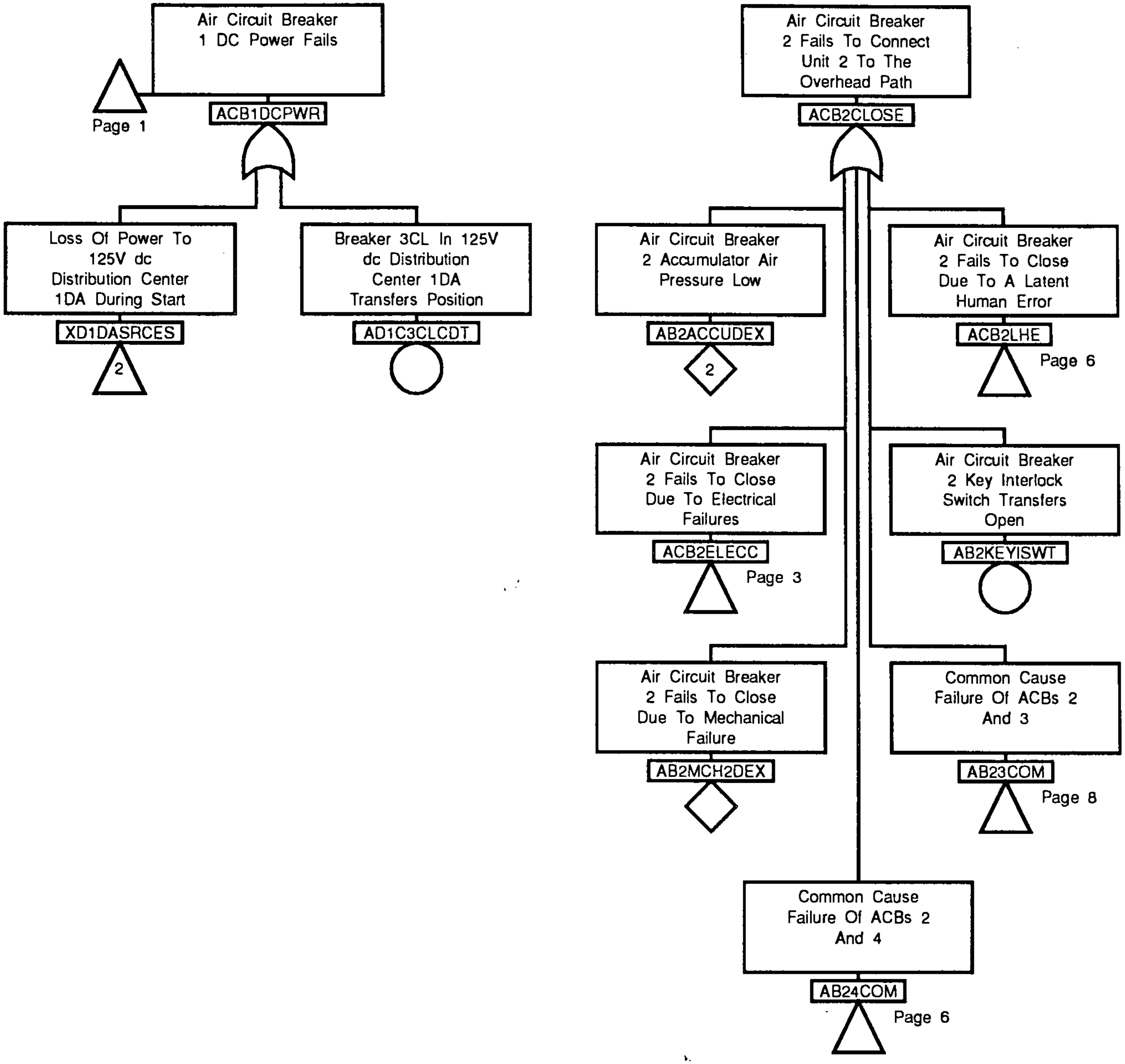


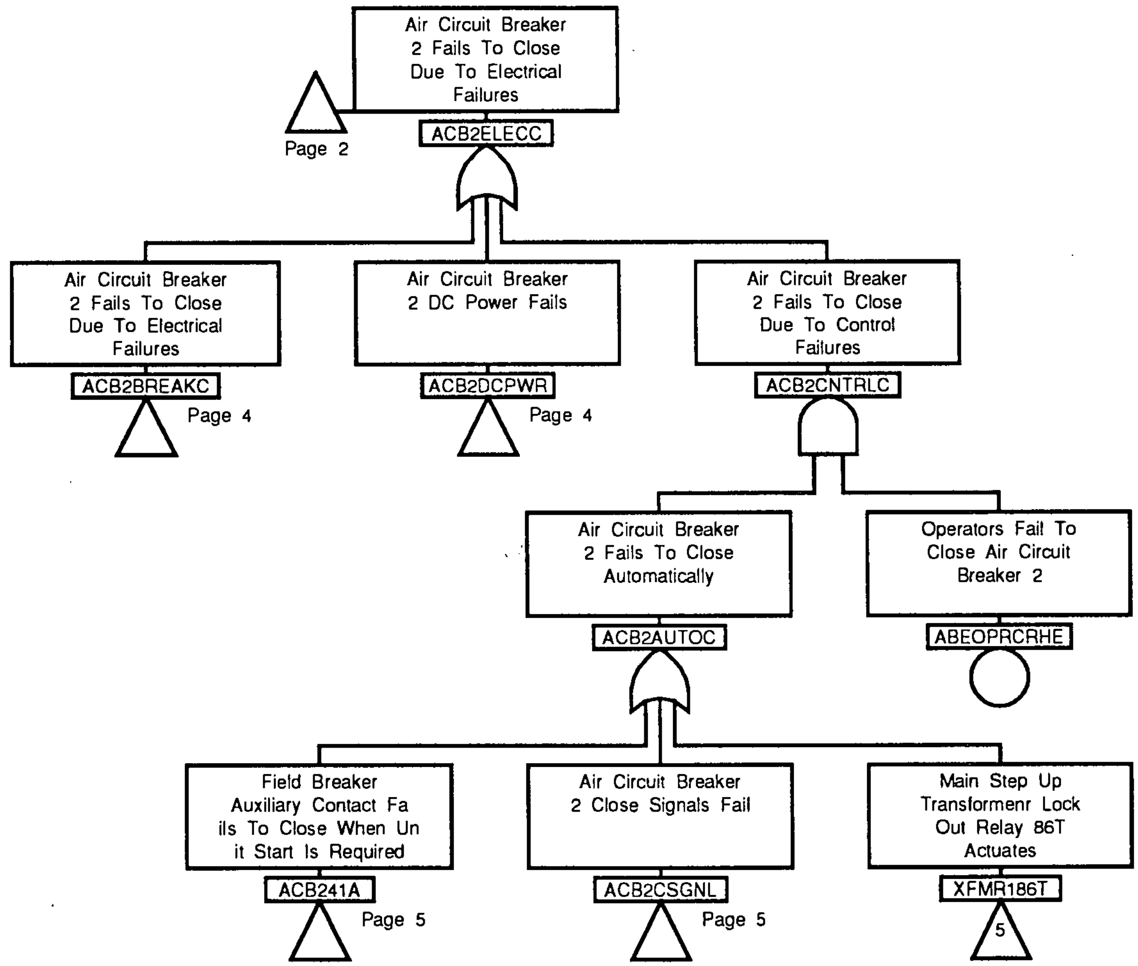
Figure A.4-8 Simplified Air Circuit Breaker #8 Elementary Diagram



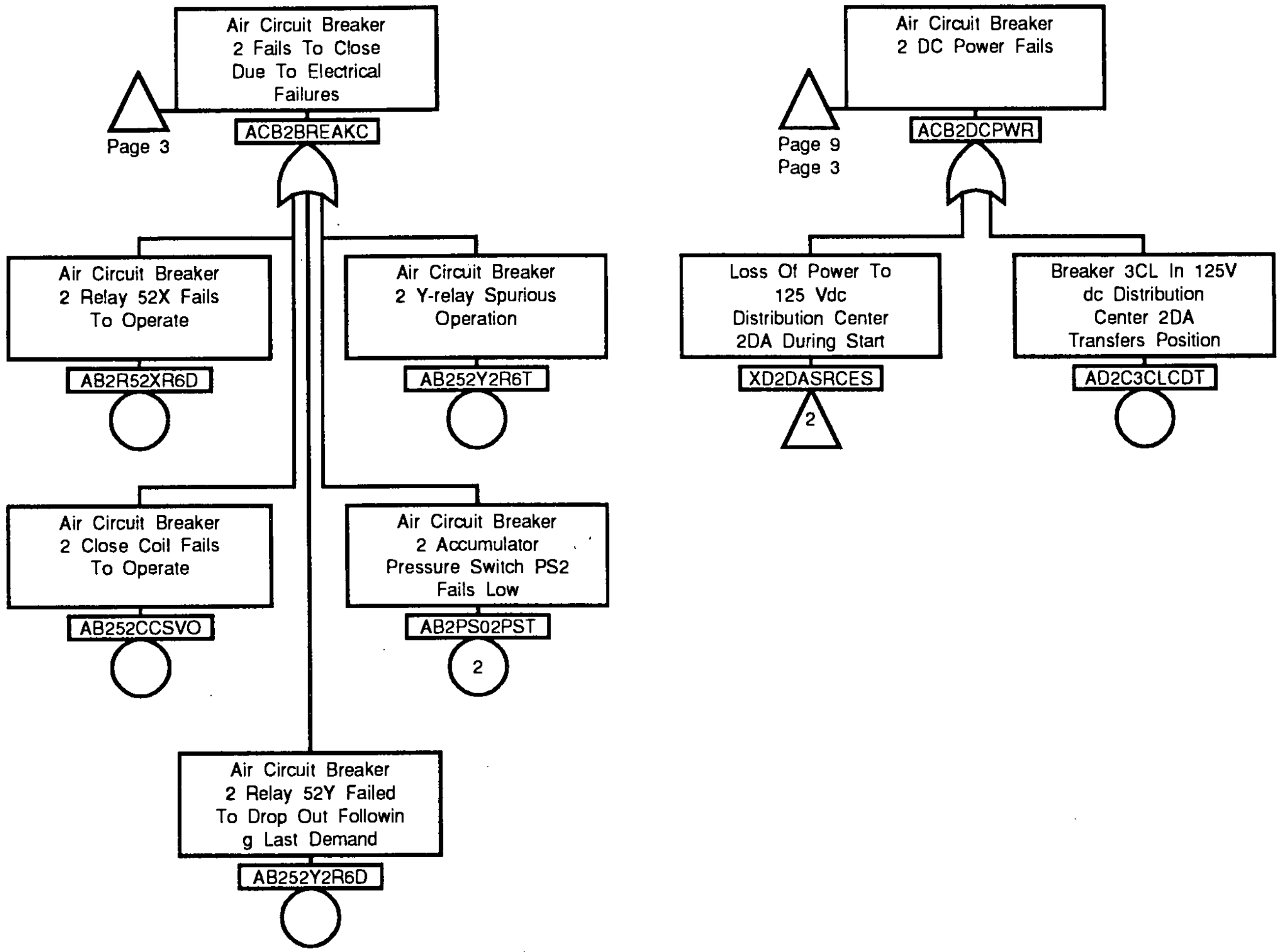
Air Circuit Breaker Fault Trees | FIGURE A.4-9 | Page 1



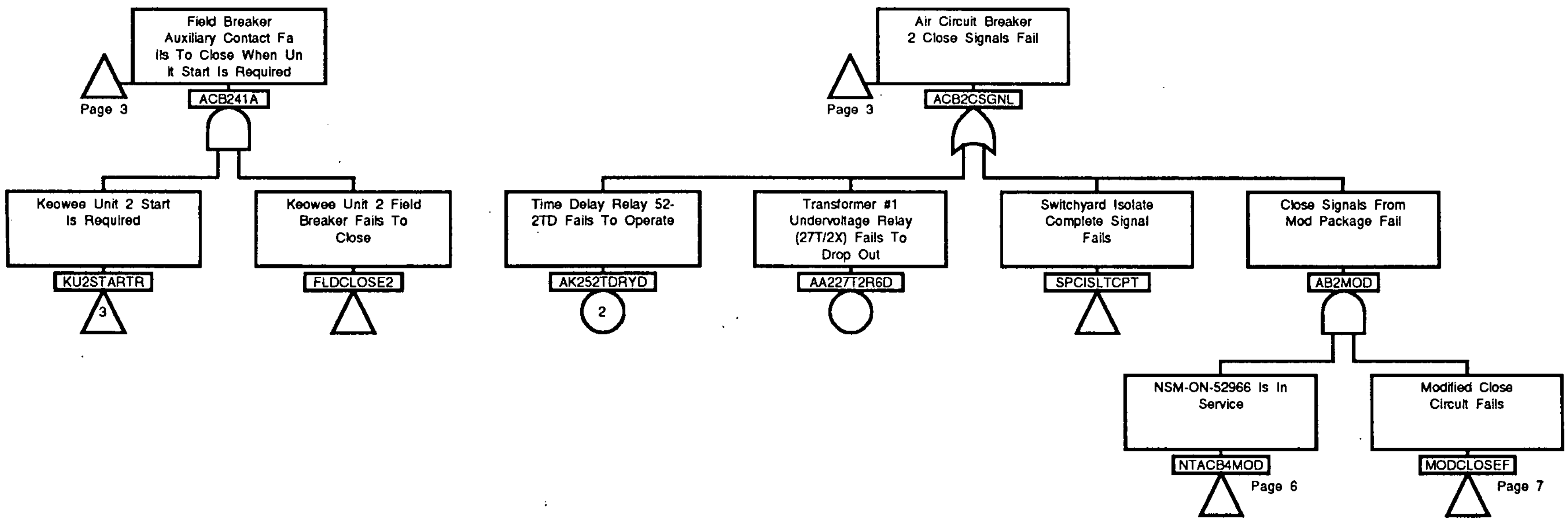
Air Circuit Breaker Fault Trees | FIGURE A.4-9 | Page 2



Air Circuit Breaker Fault Trees	FIGURE A.4-9	Page 3

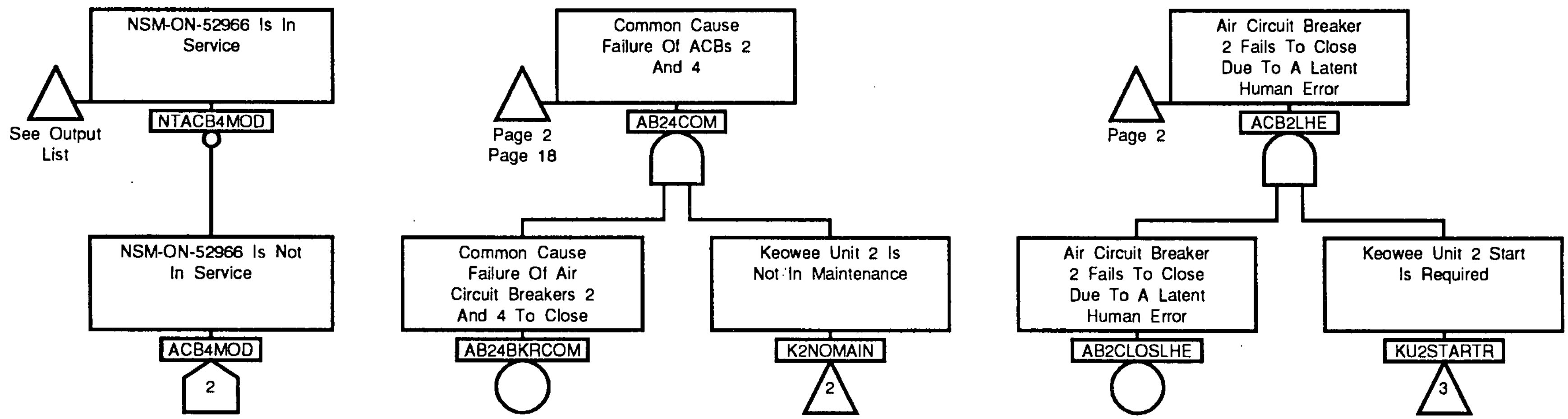


Air Circuit Breaker 2 Fails To Close Due To Electrical Failures
ACB2BREAKC
Page 3
Air Circuit Breaker 2 Relay 52X Fails To Operate
AB2R52XR6D
Air Circuit Breaker 2 Y-relay Spurious Operation
AB252Y2R6T
Air Circuit Breaker 2 Close Coil Fails To Operate
AB252CCSVO
Air Circuit Breaker 2 Accumulator Pressure Switch PS2 Fails Low
AB2PS02PST
2
Air Circuit Breaker 2 Relay 52Y Failed To Drop Out Followin g Last Demand
AB252Y2R6D
Air Circuit Breaker 2 DC Power Fails
ACB2DCPWR
Page 9
Page 3
Loss Of Power To 125 Vdc Distribution Center 2DA During Start
XD2DASRCES
2
Breaker 3CL In 125V dc Distribution Center 2DA Transfers Position
AD2C3CLCDT

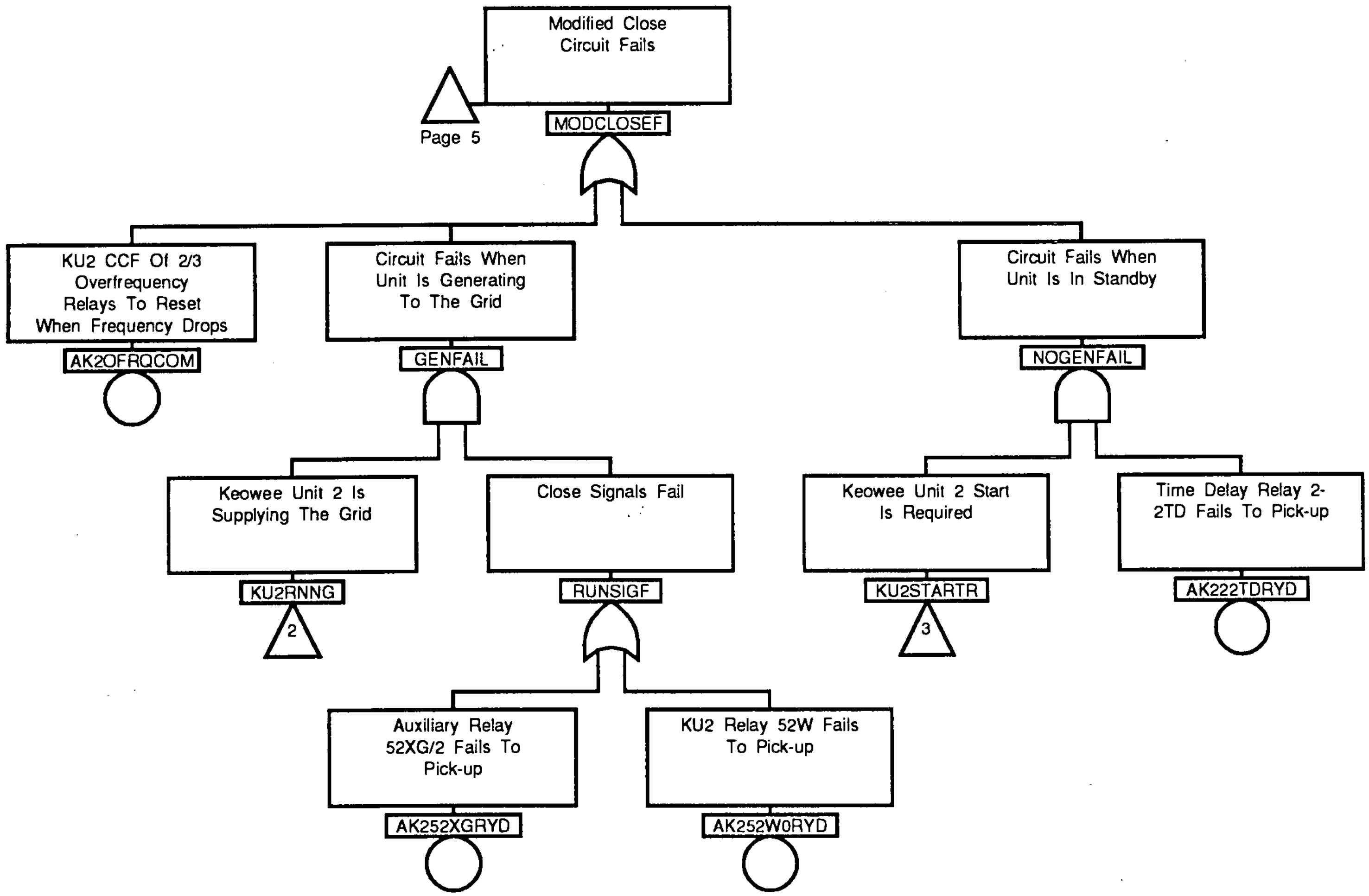


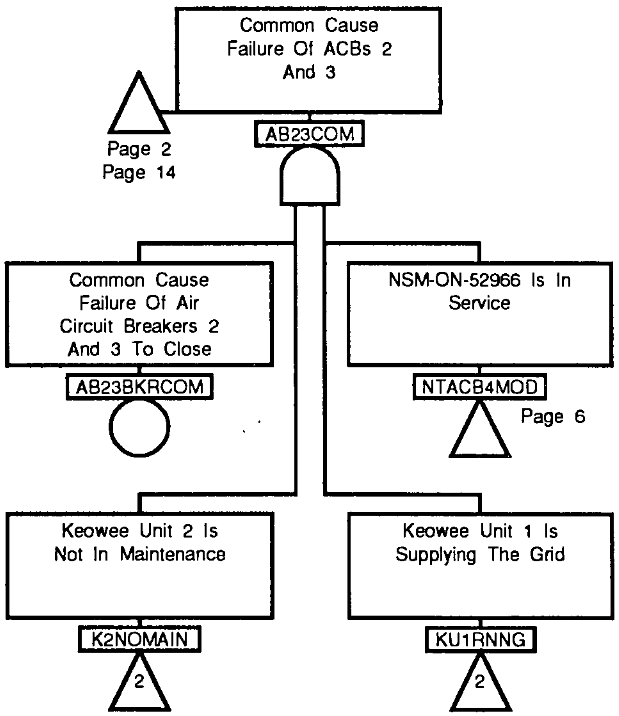
Air Circuit Breaker Fault Trees | FIGURE A.4-9 | Page 5

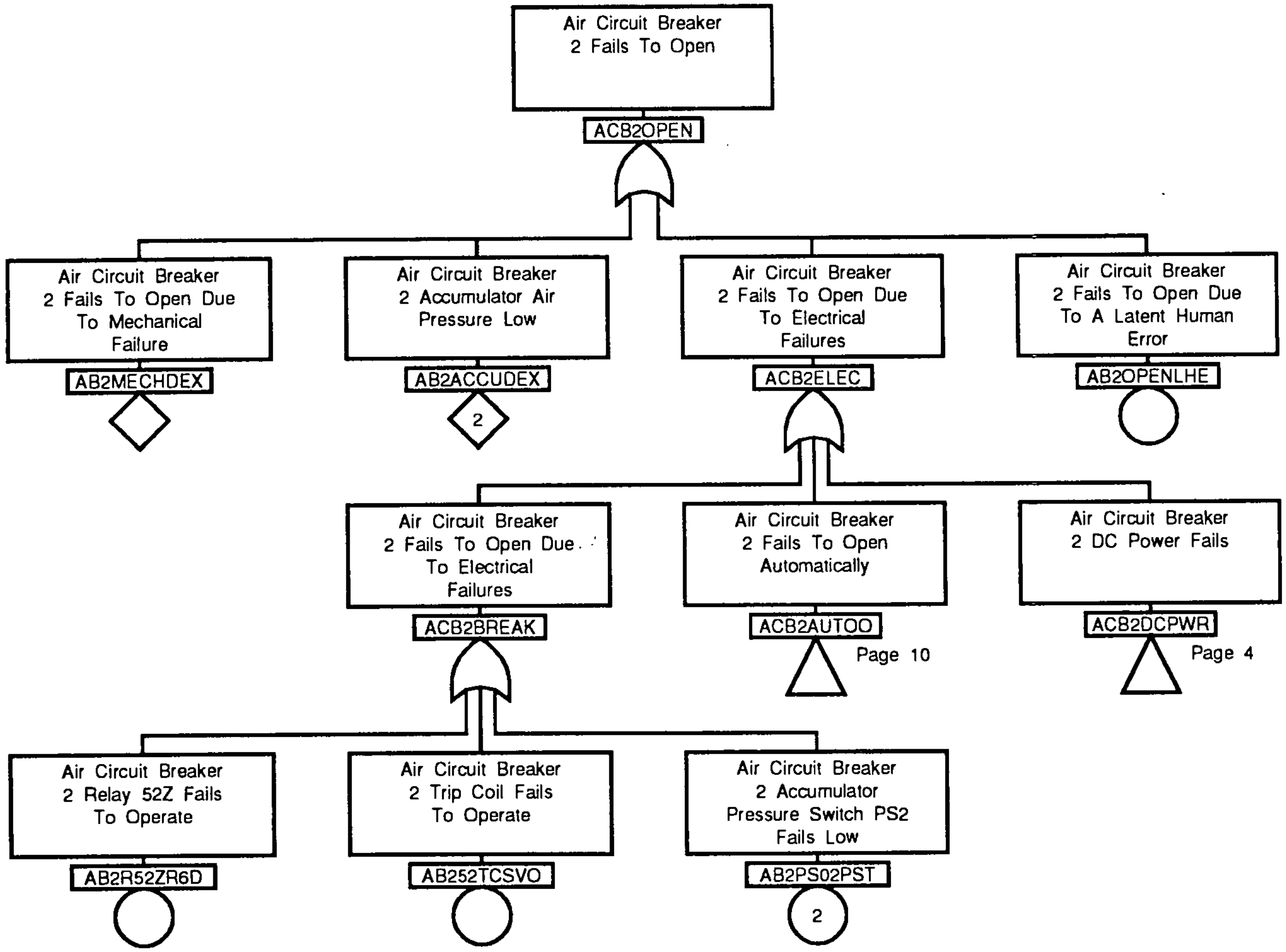
NTACB4MOD Outputs:
Page 8, Page 5, Page 16, Page 13, Page 28



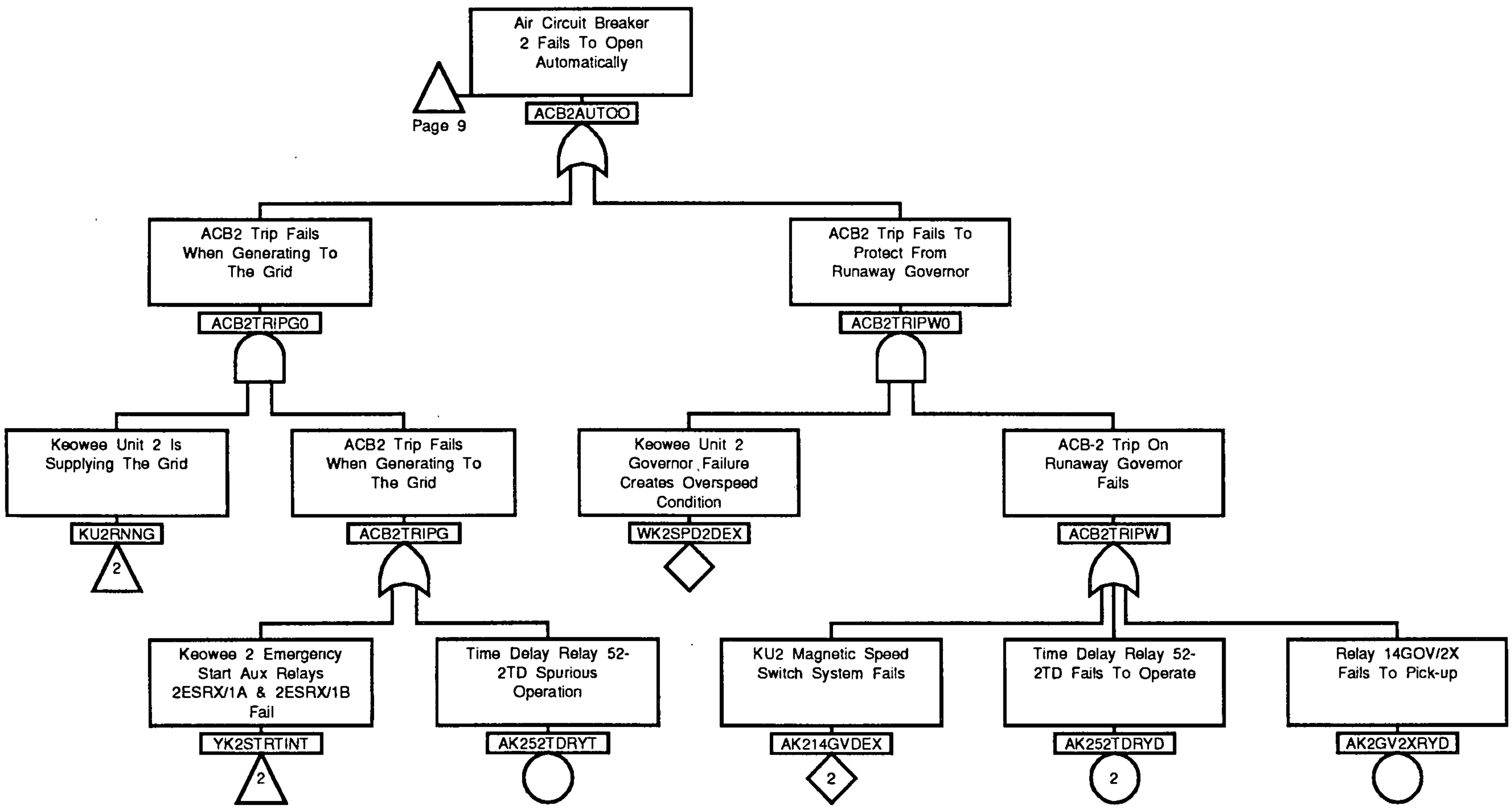
Air Circuit Breaker Fault Trees | FIGURE A.4-9 | Page 6

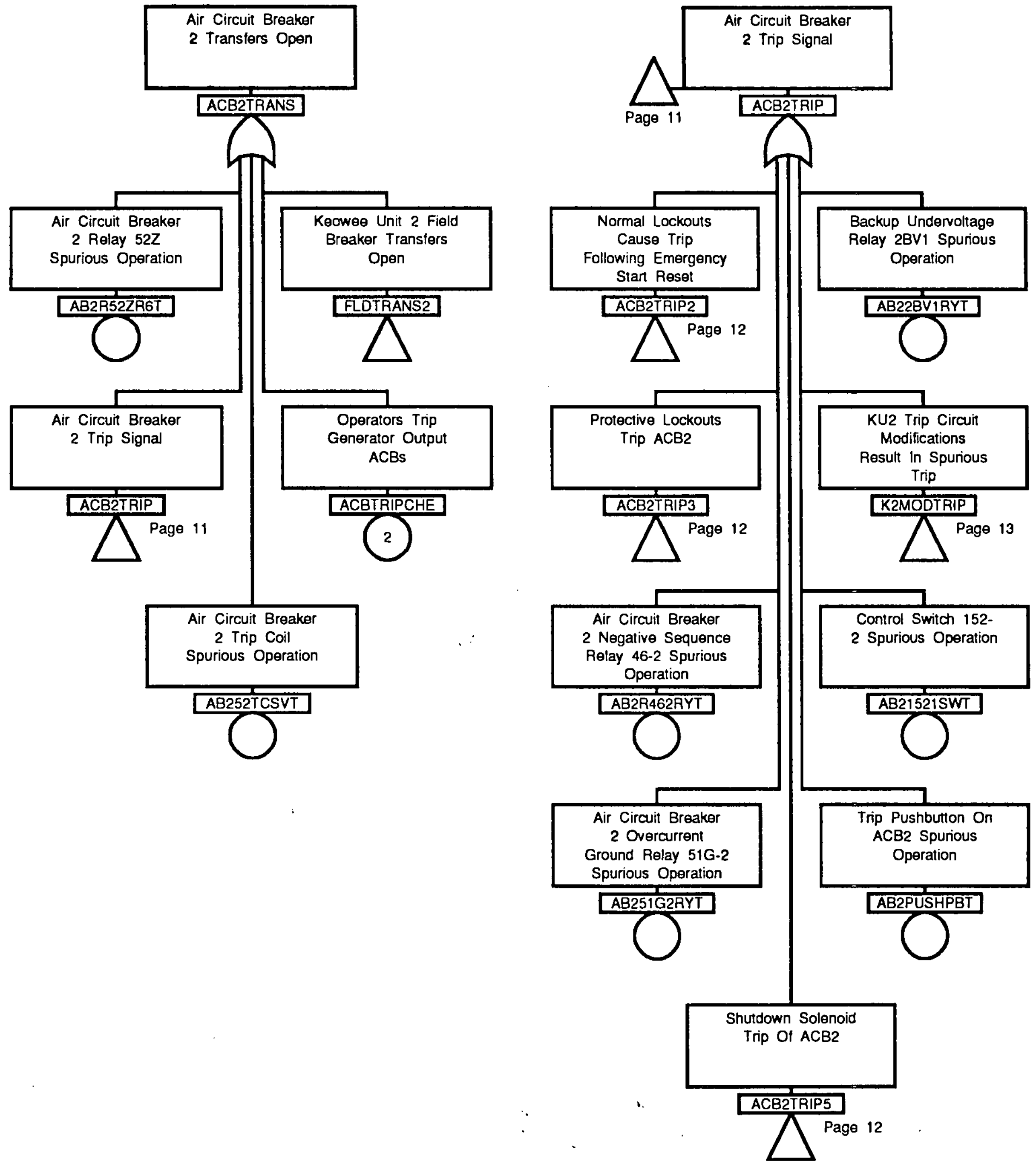

Modified Close Circuit Fails
MODCLOSEF
Page 5
KU2 CCF Of 2/3 Overfrequency Relays To Reset When Frequency Drops
AK2OFRQCOM
Circuit Fails When Unit Is Generating To The Grid
GENFAIL
Circuit Fails When Unit Is In Standby
NOGENFAIL
Keowee Unit 2 Is Supplying The Grid
KU2RNNG
2
Close Signals Fail
RUNSIGF
Keowee Unit 2 Start Is Required
KU2STARTR
3
Time Delay Relay 2-2TD Fails To Pick-up
AK222TDRYD
Auxiliary Relay 52XG/2 Fails To Pick-up
AK252XGRYD
KU2 Relay 52W Fails To Pick-up
AK252W0RYD

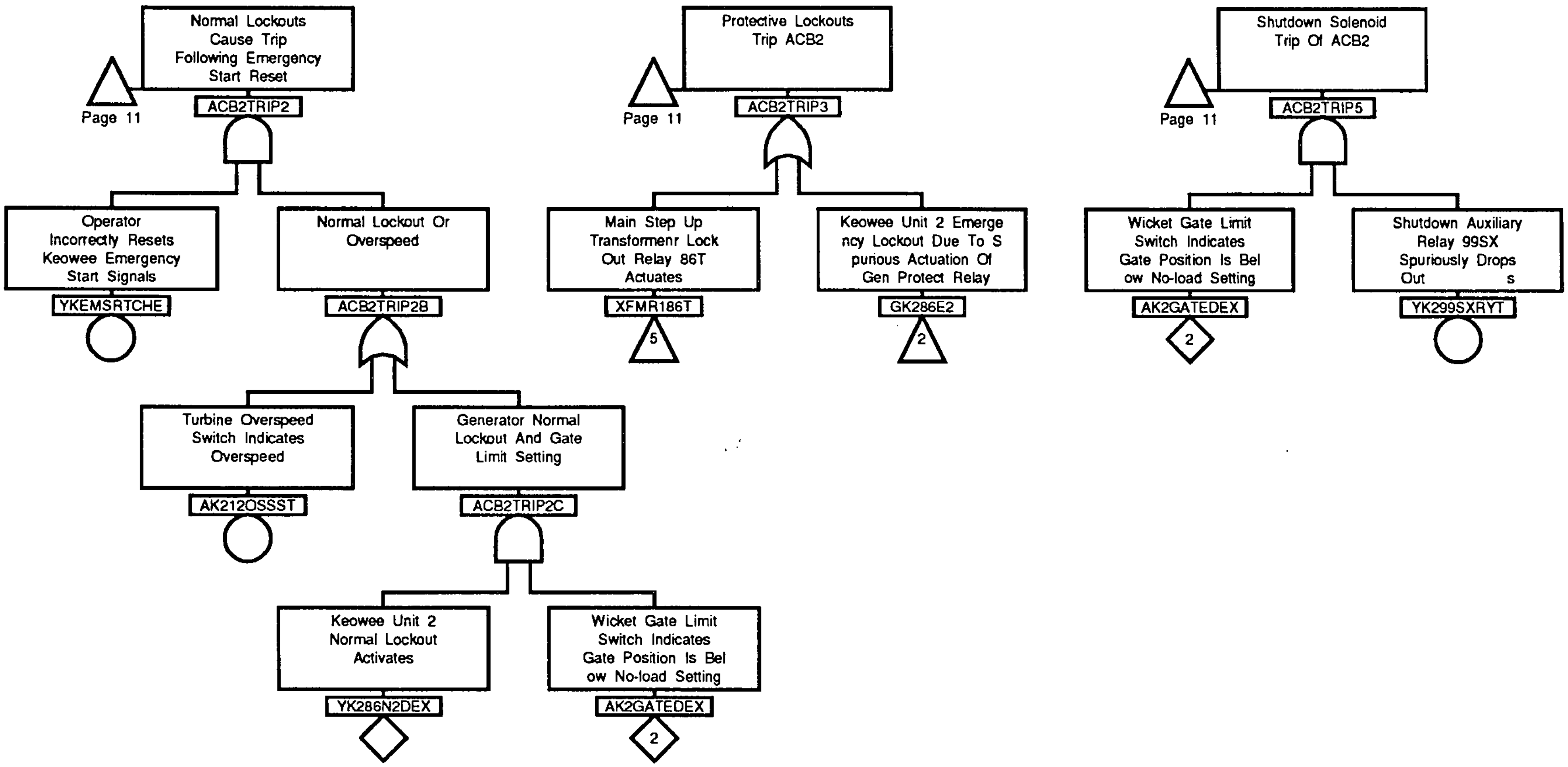

Common Cause Failure Of ACBs 2 And 3
Page 2
Page 14
AB23COM
Common Cause Failure Of Air Circuit Breakers 2 And 3 To Close
AB23BKRCOM
NSM-ON-52966 Is In Service
NTACB4MOD
Page 6
Keowee Unit 2 Is Not In Maintenance
K2NOMAIN
2
Keowee Unit 1 Is Supplying The Grid
KU1RNNG
2



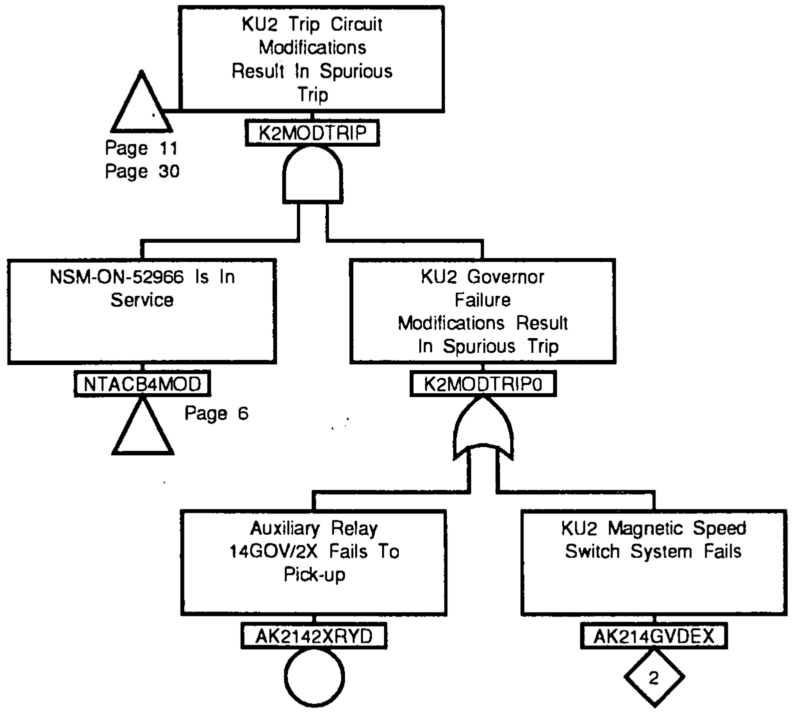
Air Circuit Breaker Fault Trees | FIGURE A.4-9 |

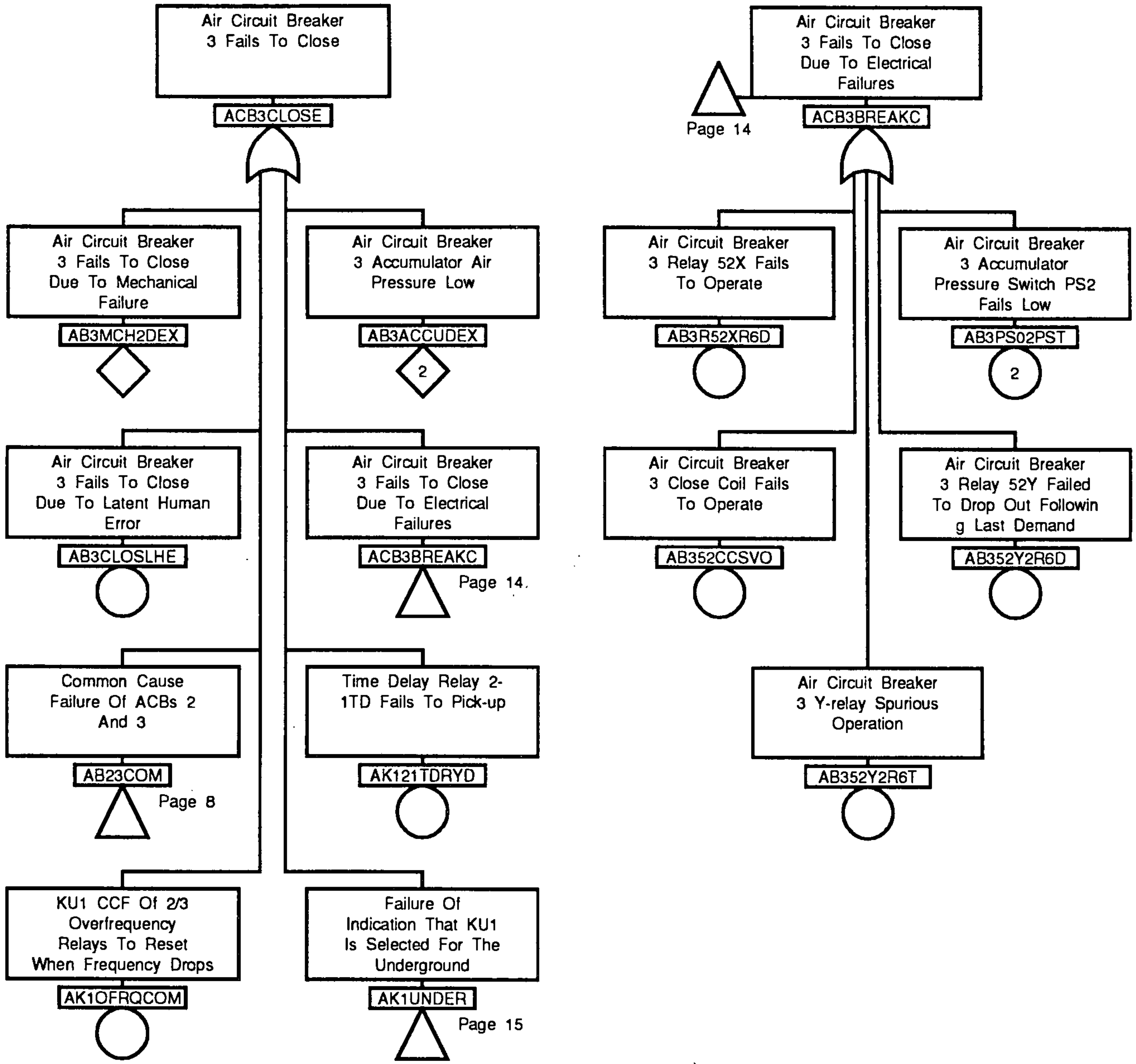

Air Circuit Breaker 2 Fails To Open Automatically
ACB2AUTOO
Page 9
ACB2 Trip Fails When Generating To The Grid
ACB2TRIPG0
ACB2 Trip Fails To Protect From Runaway Governor
ACB2TRIPW0
Keowee Unit 2 Is Supplying The Grid
KU2RNNG
2
ACB2 Trip Fails When Generating To The Grid
ACB2TRIPG
Keowee Unit 2 Governor Failure Creates Overspeed Condition
WK2SPD2DEX
ACB-2 Trip On Runaway Governor Fails
ACB2TRIPW
Keowee 2 Emergency Start Aux Relays 2ESRX/1A & 2ESRX/1B Fail
YK2STRTINT
2
Time Delay Relay 52-2TD Spurious Operation
AK252TDRYT
KU2 Magnetic Speed Switch System Fails
AK214GVDEX
2
Time Delay Relay 52-2TD Fails To Operate
AK252TDRYD
2
Relay 14GOV/2X Fails To Pick-up
AK2GV2XRYD


Air Circuit Breaker 2 Transfers Open
ACB2TRANS
Air Circuit Breaker 2 Relay 52Z Spurious Operation
AB2R52ZR6T
Keowee Unit 2 Field Breaker Transfers Open
FLDTRANS2
Air Circuit Breaker 2 Trip Signal
ACB2TRIP
Page 11
Operators Trip Generator Output ACBs
ACBTRIPCHE
2
Air Circuit Breaker 2 Trip Coil Spurious Operation
AB252TCSVT
Air Circuit Breaker 2 Trip Signal
Page 11
ACB2TRIP
Normal Lockouts Cause Trip Following Emergency Start Reset
ACB2TRIP2
Page 12
Backup Undervoltage Relay 2BV1 Spurious Operation
AB22BV1RYT
Protective Lockouts Trip ACB2
ACB2TRIP3
Page 12
KU2 Trip Circuit Modifications Result In Spurious Trip
K2MODTRIP
Page 13
Air Circuit Breaker 2 Negative Sequence Relay 46-2 Spurious Operation
AB2R462RYT
Control Switch 152-2 Spurious Operation
AB21521SWT
Air Circuit Breaker 2 Overcurrent Ground Relay 51G-2 Spurious Operation
AB251G2RYT
Trip Pushbutton On ACB2 Spurious Operation
AB2PUSHPBT
Shutdown Solenoid Trip Of ACB2
ACB2TRIP5
Page 12

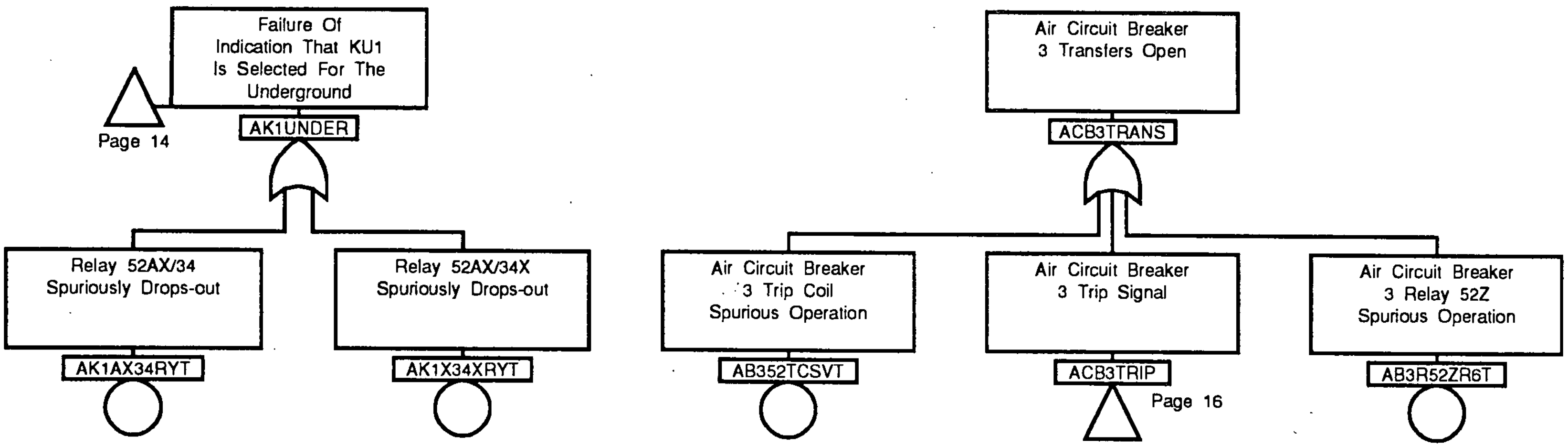


Normal Lockouts Cause Trip Following Emergency Start Reset
Page 11
ACB2TRIP2
Operator Incorrectly Resets Keowee Emergency Start Signals
YKEMSRTCHE
Normal Lockout Or Overspeed
ACB2TRIP2B
Turbine Overspeed Switch Indicates Overspeed
AK212OSSST
Generator Normal Lockout And Gate Limit Setting
ACB2TRIP2C
Keowee Unit 2 Normal Lockout Activates
YK286N2DEX
Wicket Gate Limit Switch Indicates Gate Position Is Bel ow No-load Setting
AK2GATEDEX
2
Protective Lockouts Trip ACB2
Page 11
ACB2TRIP3
Main Step Up Transformenr Lock Out Relay 86T Actuates
XFMR186T
5
Keowee Unit 2 Emerge ncy Lockout Due To S purious Actuation Of Gen Protect Relay
GK286E2
2
Shutdown Solenoid Trip Of ACB2
Page 11
ACB2TRIP5
Wicket Gate Limit Switch Indicates Gate Position Is Bel ow No-load Setting
AK2GATEDEX
2
Shutdown Auxiliary Relay 99SX Spuriously Drops Out s
YK299SXRYT

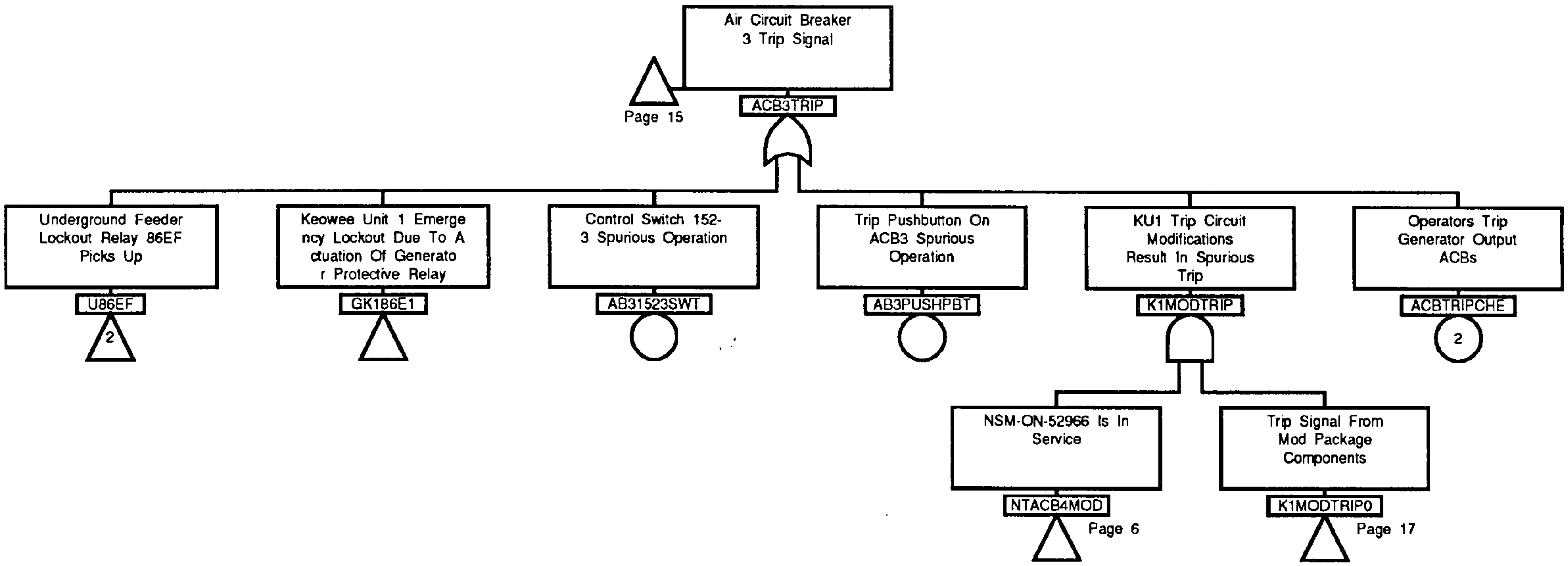

KU2 Trip Circuit Modifications Result In Spurious Trip
K2MODTRIP
Page 11
Page 30
NSM-ON-52966 Is In Service
NTACB4MOD
Page 6
KU2 Governor Failure Modifications Result In Spurious Trip
K2MODTRIP0
Auxiliary Relay 14GOV/2X Fails To Pick-up
AK2142XRYD
KU2 Magnetic Speed Switch System Fails
AK214GVDEX
2



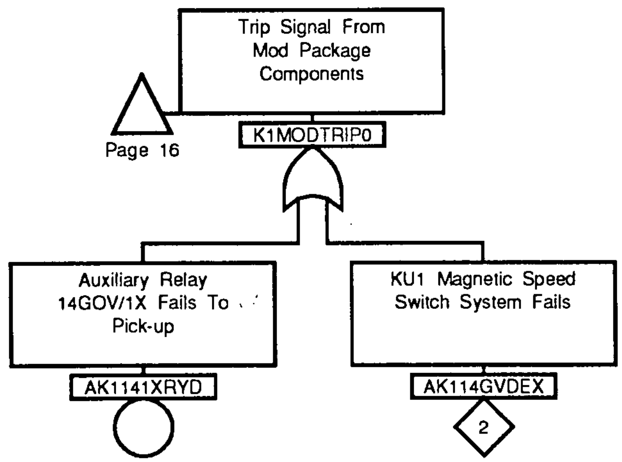
Air Circuit Breaker Fault Trees | FIGURE A.4-9 |



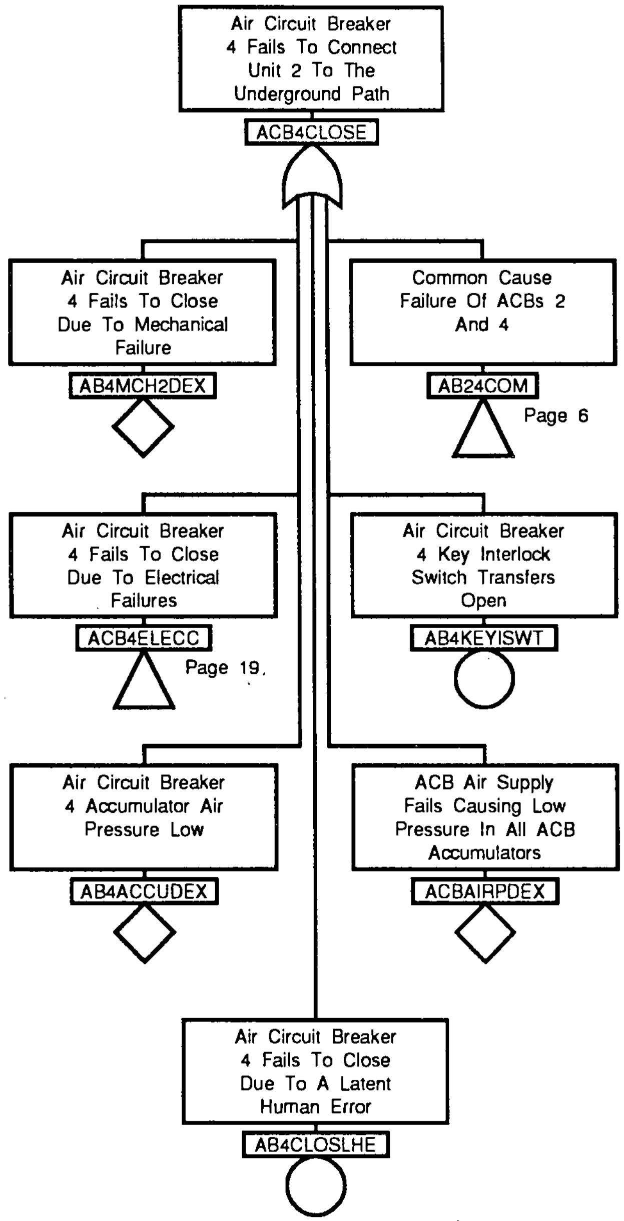
Failure Of Indication That KU1 Is Selected For The Underground
AK1UNDER
Page 14
Relay 52AX/34 Spuriously Drops-out
AK1AX34RYT
Relay 52AX/34X Spuriously Drops-out
AK1X34XRYT
Air Circuit Breaker 3 Transfers Open
ACB3TRANS
Air Circuit Breaker 3 Trip Coil Spurious Operation
AB352TCSVT
Air Circuit Breaker 3 Trip Signal
ACB3TRIP
Page 16
Air Circuit Breaker 3 Relay 52Z Spurious Operation
AB3R52ZR6T

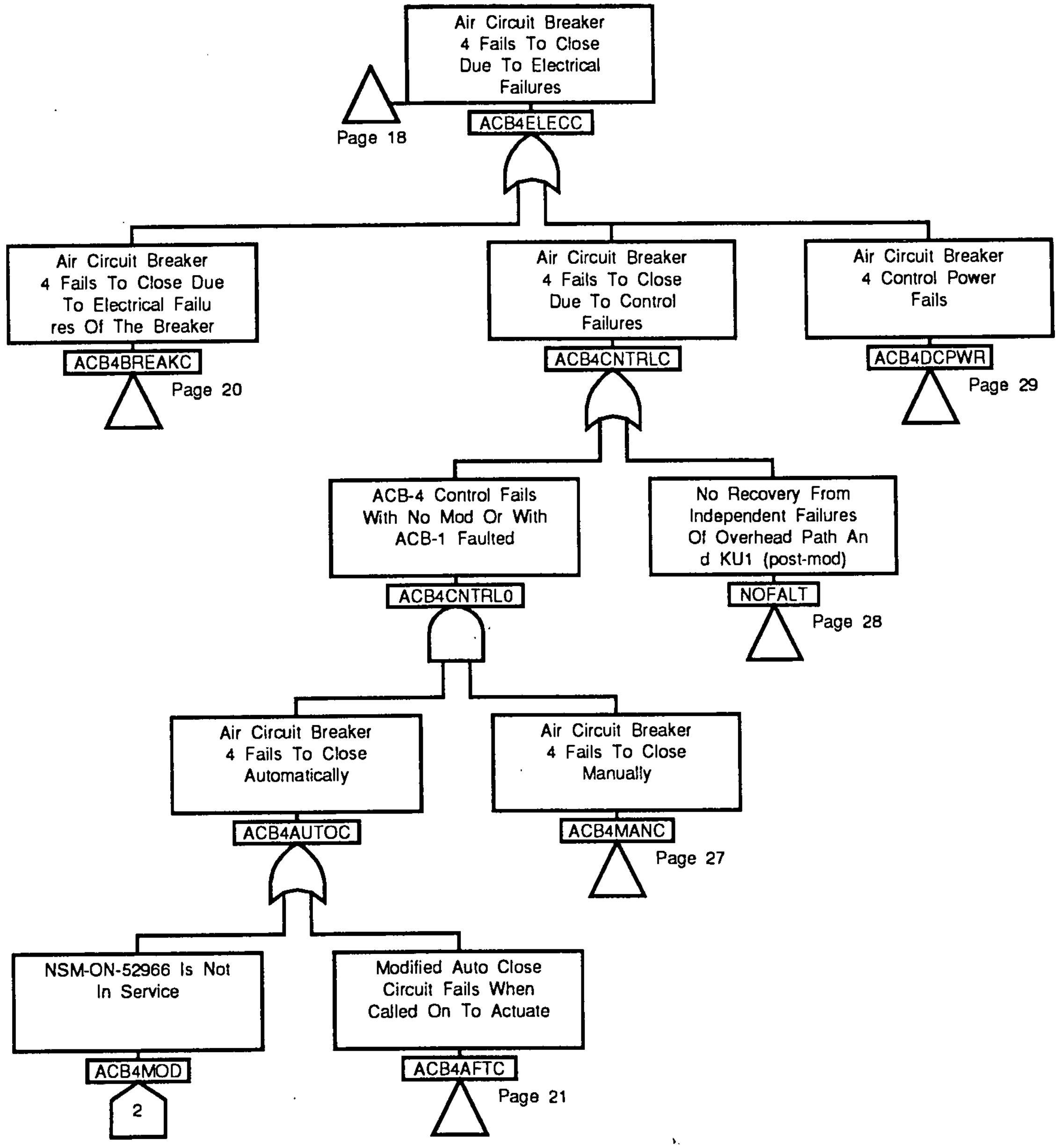


Air Circuit Breaker 3 Trip Signal
ACB3TRIP
Page 15
Underground Feeder Lockout Relay 86EF Picks Up
U86EF
2
Keowee Unit 1 Emergency Lockout Due To Actuation Of Generator Protective Relay
GK186E1
Control Switch 152-3 Spurious Operation
AB31523SWT
Trip Pushbutton On ACB3 Spurious Operation
AB3PUSHPBT
KU1 Trip Circuit Modifications Result In Spurious Trip
K1MODTRIP
Operators Trip Generator Output ACBs
ACBTRIPCHE
2
NSM-ON-52966 Is In Service
NTACB4MOD
Page 6
Trip Signal From Mod Package Components
K1MODTRIP0
Page 17

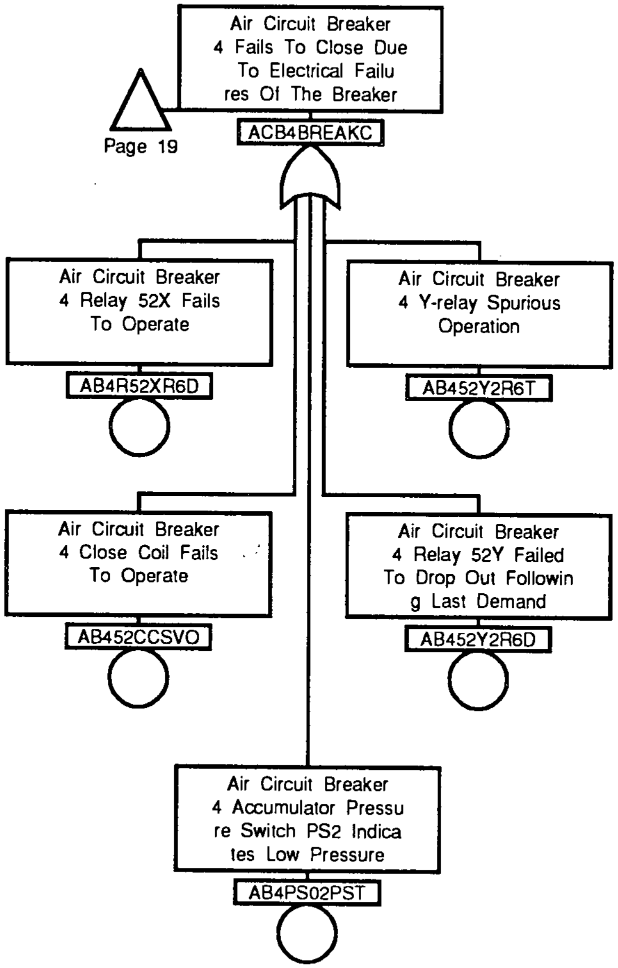


Trip Signal From Mod Package Components
K1MODTRIP0
Page 16
Auxiliary Relay 14GOV/1X Fails To Pick-up
AK1141XRYD
KU1 Magnetic Speed Switch System Fails
AK114GVDEX
2

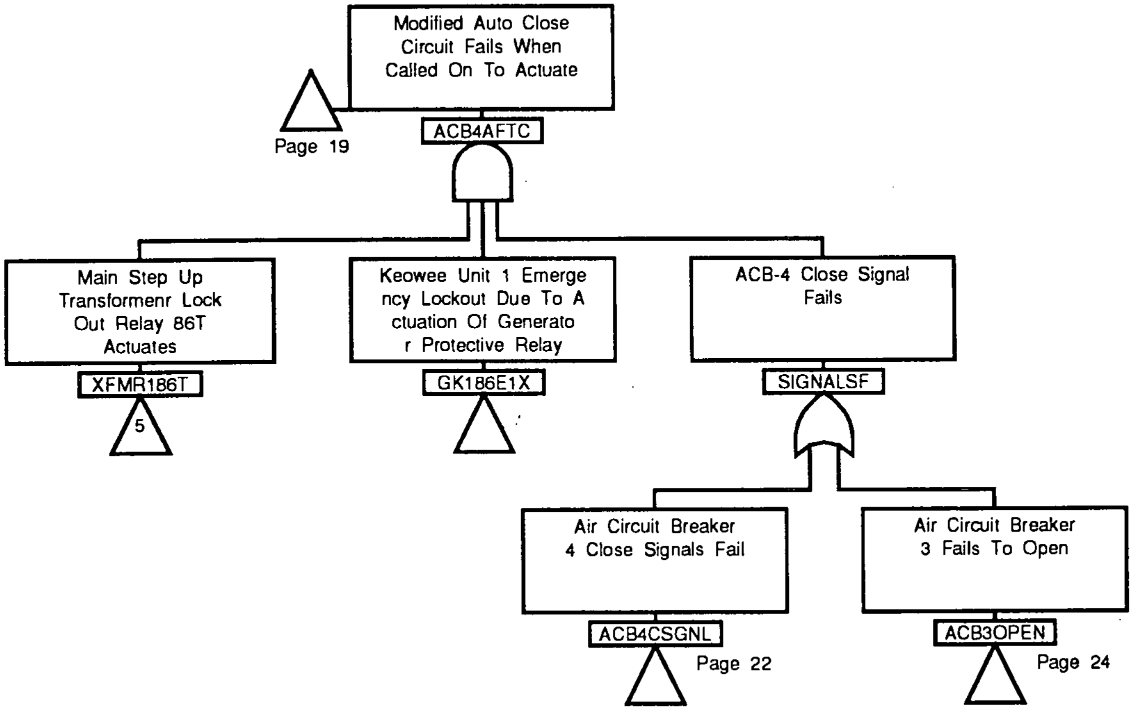

Air Circuit Breaker 4 Fails To Connect Unit 2 To The Underground Path
ACB4CLOSE
Air Circuit Breaker 4 Fails To Close Due To Mechanical Failure
AB4MCH2DEX
Common Cause Failure Of ACBs 2 And 4
AB24COM
Page 6
Air Circuit Breaker 4 Fails To Close Due To Electrical Failures
ACB4ELECC
Page 19
Air Circuit Breaker 4 Key Interlock Switch Transfers Open
AB4KEYISWT
Air Circuit Breaker 4 Accumulator Air Pressure Low
AB4ACCUDEX
ACB Air Supply Fails Causing Low Pressure In All ACB Accumulators
ACBAIRPDEX
Air Circuit Breaker 4 Fails To Close Due To A Latent Human Error
AB4CLOSLHE



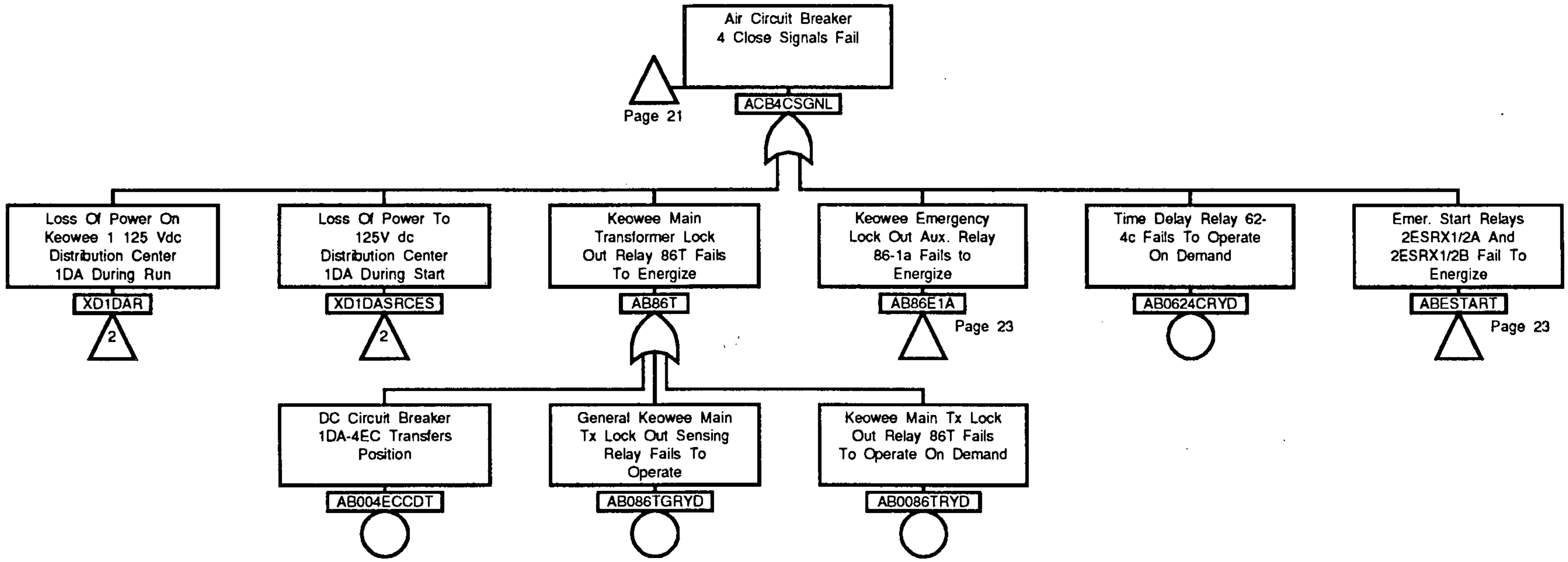
Air Circuit Breaker Fault Trees | FIGURE A.4-9 |



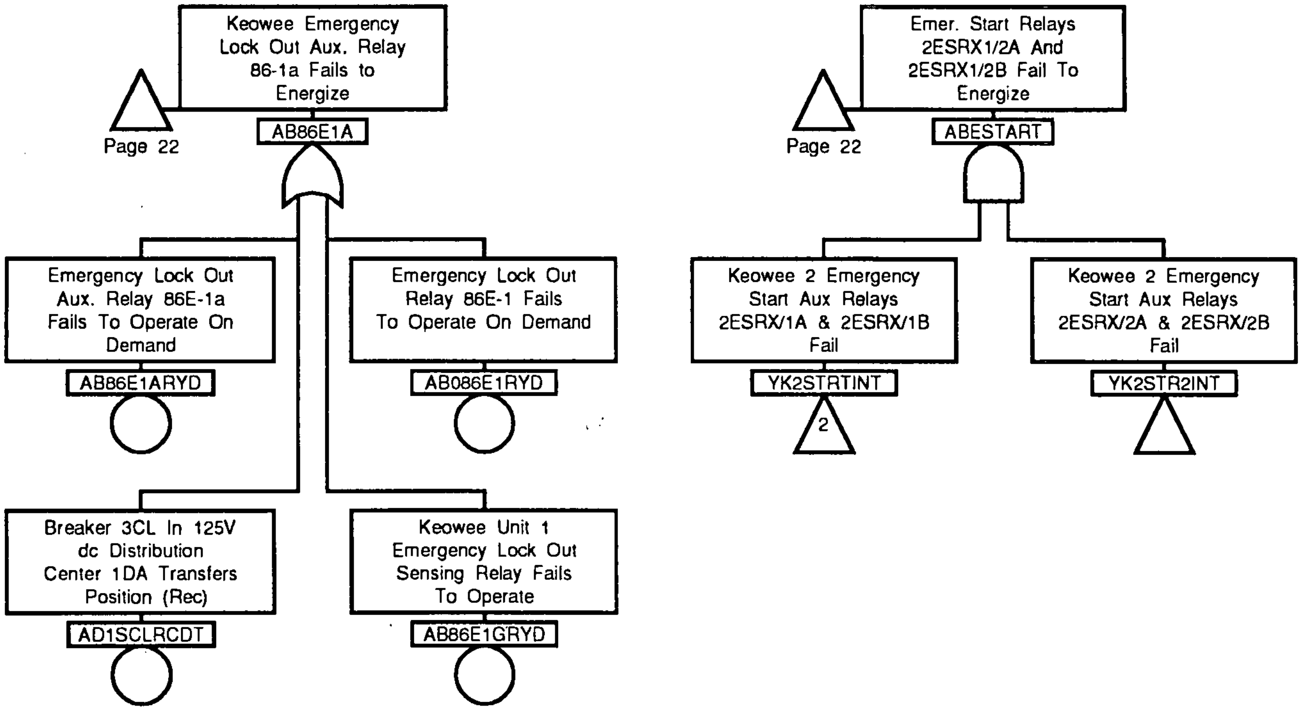
Air Circuit Breaker 4 Fails To Close Due To Electrical Failu res Of The Breaker
ACB4BREAKC
Page 19
Air Circuit Breaker 4 Relay 52X Fails To Operate
AB4R52XR6D
Air Circuit Breaker 4 Y-relay Spurious Operation
AB452Y2R6T
Air Circuit Breaker 4 Close Coil Fails To Operate
AB452CCSVO
Air Circuit Breaker 4 Relay 52Y Failed To Drop Out Followin g Last Demand
AB452Y2R6D
Air Circuit Breaker 4 Accumulator Pressu re Switch PS2 Indica tes Low Pressure
AB4PS02PST



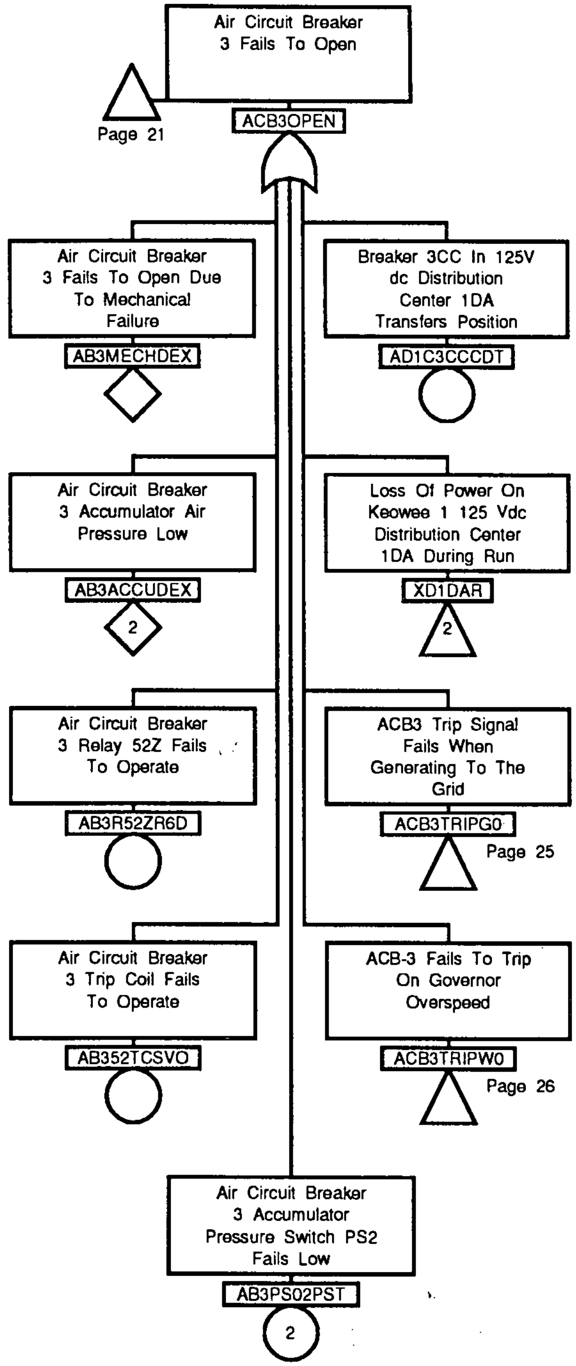
Modified Auto Close Circuit Fails When Called On To Actuate
ACB4AFTC
Page 19
Main Step Up Transformenr Lock Out Relay 86T Actuates
XFMR186T
5
Keowee Unit 1 Emerge ncy Lockout Due To A ctuation Of Generato r Protective Relay
GK186E1X
ACB-4 Close Signal Fails
SIGNALSF
Air Circuit Breaker 4 Close Signals Fail
ACB4CSGNL
Page 22
Air Circuit Breaker 3 Fails To Open
ACB3OPEN
Page 24

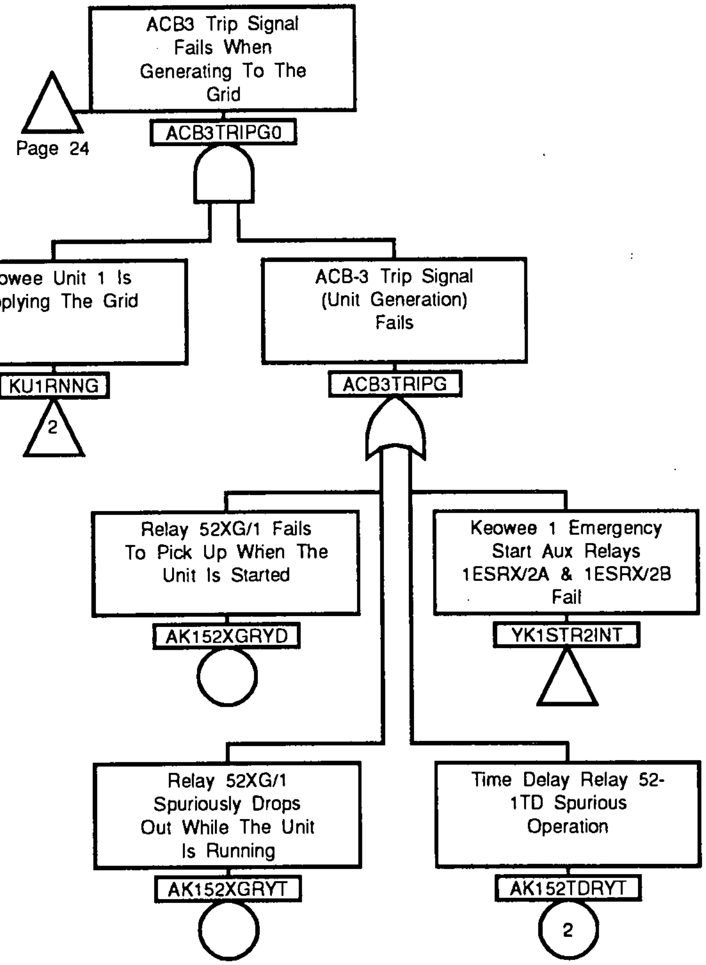


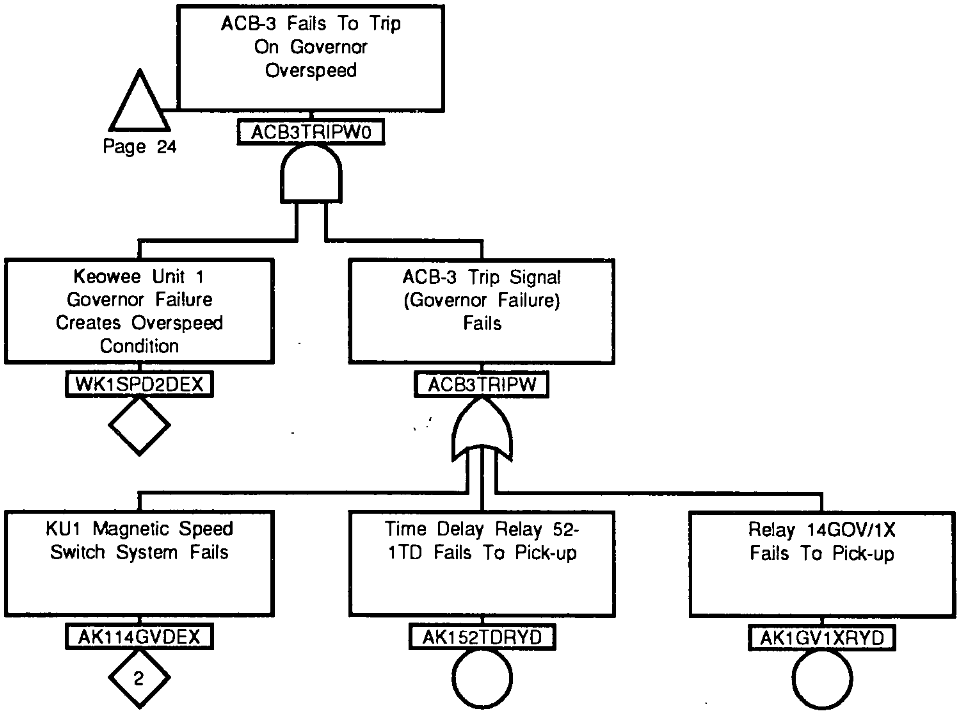
Air Circuit Breaker 4 Close Signals Fail
ACB4CSGNL
Page 21
Loss Of Power On Keowee 1 125 Vdc Distribution Center 1DA During Run
XD1DAR
2
Loss Of Power To 125V dc Distribution Center 1DA During Start
XD1DASRCES
2
Keowee Main Transformer Lock Out Relay 86T Fails To Energize
AB86T
Keowee Emergency Lock Out Aux. Relay 86-1a Fails to Energize
AB86E1A
Page 23
Time Delay Relay 62-4c Fails To Operate On Demand
AB0624CRYD
Emer. Start Relays 2ESRX1/2A And 2ESRX1/2B Fail To Energize
ABESTART
Page 23
DC Circuit Breaker 1DA-4EC Transfers Position
AB004ECCDT
General Keowee Main Tx Lock Out Sensing Relay Fails To Operate
AB086TGRYD
Keowee Main Tx Lock Out Relay 86T Fails To Operate On Demand
AB0086TRYD

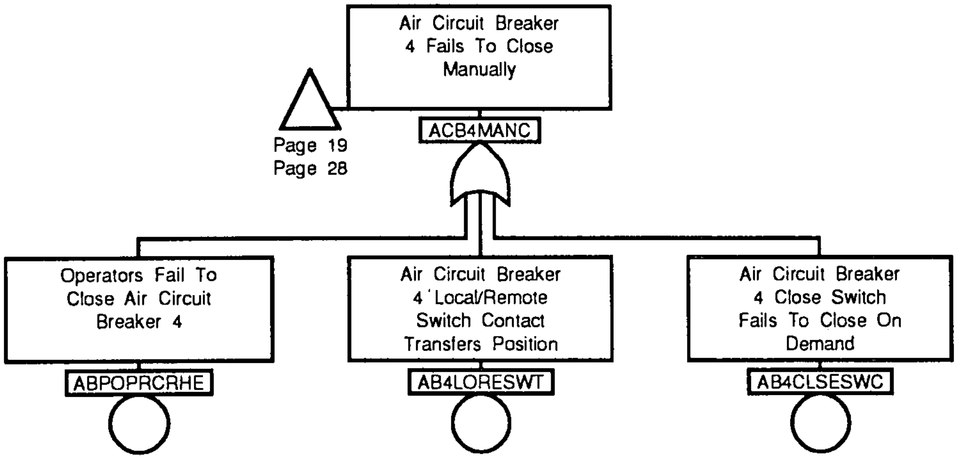


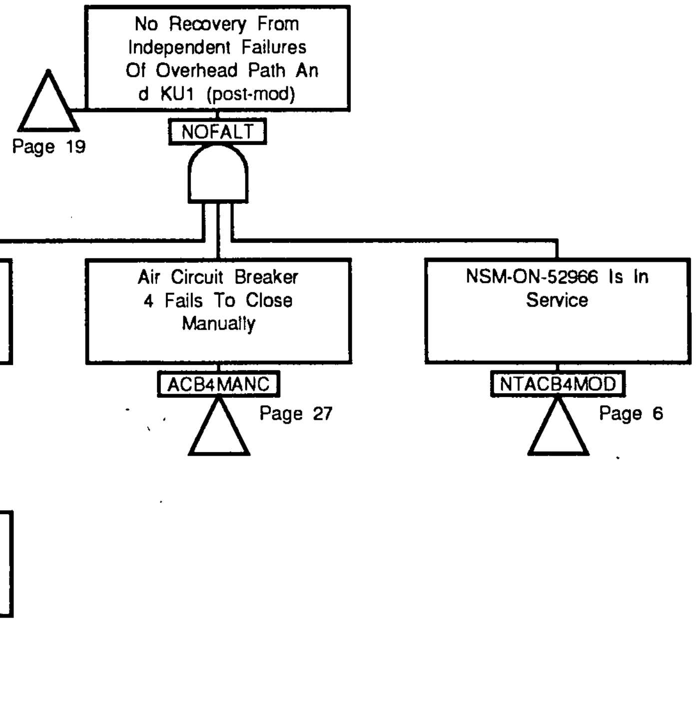
Keowee Emergency Lock Out Aux. Relay 86-1a Fails to Energize
AB86E1A
Page 22
Emergency Lock Out Aux. Relay 86E-1a Fails To Operate On Demand
AB86E1ARYD
Emergency Lock Out Relay 86E-1 Fails To Operate On Demand
AB086E1RYD
Breaker 3CL In 125V dc Distribution Center 1DA Transfers Position (Rec)
AD1SCLRCDT
Keowee Unit 1 Emergency Lock Out Sensing Relay Fails To Operate
AB86E1GRYD
Emer. Start Relays 2ESRX1/2A And 2ESRX1/2B Fail To Energize
ABESTART
Page 22
Keowee 2 Emergency Start Aux Relays 2ESRX/1A & 2ESRX/1B Fail
YK2STRTINT
2
Keowee 2 Emergency Start Aux Relays 2ESRX/2A & 2ESRX/2B Fail
YK2STR2INT


Air Circuit Breaker 3 Fails To Open
ACB3OPEN
Page 21
Air Circuit Breaker 3 Fails To Open Due To Mechanical Failure
AB3MECHDEX
Breaker 3CC In 125V dc Distribution Center 1DA Transfers Position
AD1C3CCCDT
Air Circuit Breaker 3 Accumulator Air Pressure Low
AB3ACCUDEX
2
Loss Of Power On Keowee 1 125 Vdc Distribution Center 1DA During Run
XD1DAR
2
Air Circuit Breaker 3 Relay 52Z Fails To Operate
AB3R52ZR6D
ACB3 Trip Signal Fails When Generating To The Grid
ACB3TRIPG0
Page 25
Air Circuit Breaker 3 Trip Coil Fails To Operate
AB352TCSVO
ACB-3 Fails To Trip On Governor Overspeed
ACB3TRIPW0
Page 26
Air Circuit Breaker 3 Accumulator Pressure Switch PS2 Fails Low
AB3PS02PST
2

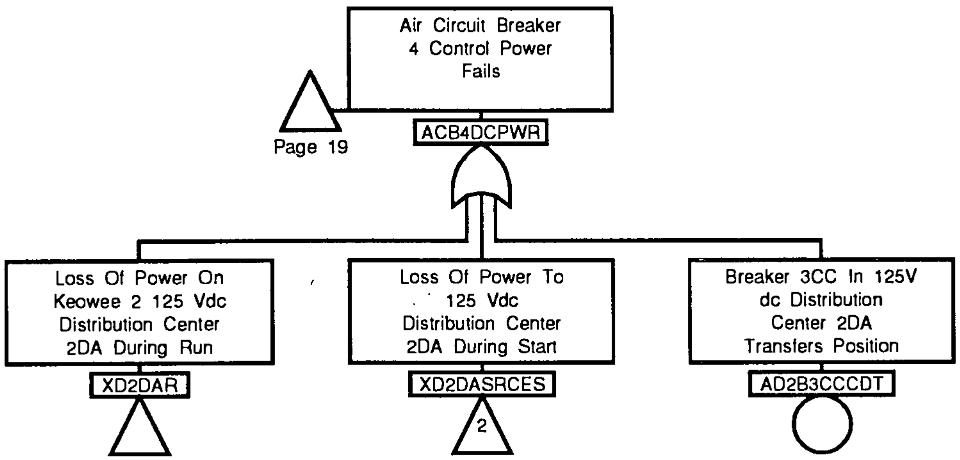

ACB3 Trip Signal Fails When Generating To The Grid
ACB3TRIPG0
Page 24
Keowee Unit 1 Is Supplying The Grid
KU1RNNG
2
ACB-3 Trip Signal (Unit Generation) Fails
ACB3TRIPG
Relay 52XG/1 Fails To Pick Up When The Unit Is Started
AK152XGRYD
Keowee 1 Emergency Start Aux Relays 1ESRX/2A & 1ESRX/2B Fail
YK1STR2INT
Relay 52XG/1 Spuriously Drops Out While The Unit Is Running
AK152XGRYT
Time Delay Relay 52-1TD Spurious Operation
AK152TDRYT
2


ACB-3 Fails To Trip On Governor Overspeed
ACB3TRIPW0
Page 24
Keowee Unit 1 Governor Failure Creates Overspeed Condition
WK1SPD2DEX
ACB-3 Trip Signal (Governor Failure) Fails
ACB3TRIPW
KU1 Magnetic Speed Switch System Fails
AK114GVDEX
2
Time Delay Relay 52-1TD Fails To Pick-up
AK152TDRYD
Relay 14GOV/1X Fails To Pick-up
AK1GV1XRYD

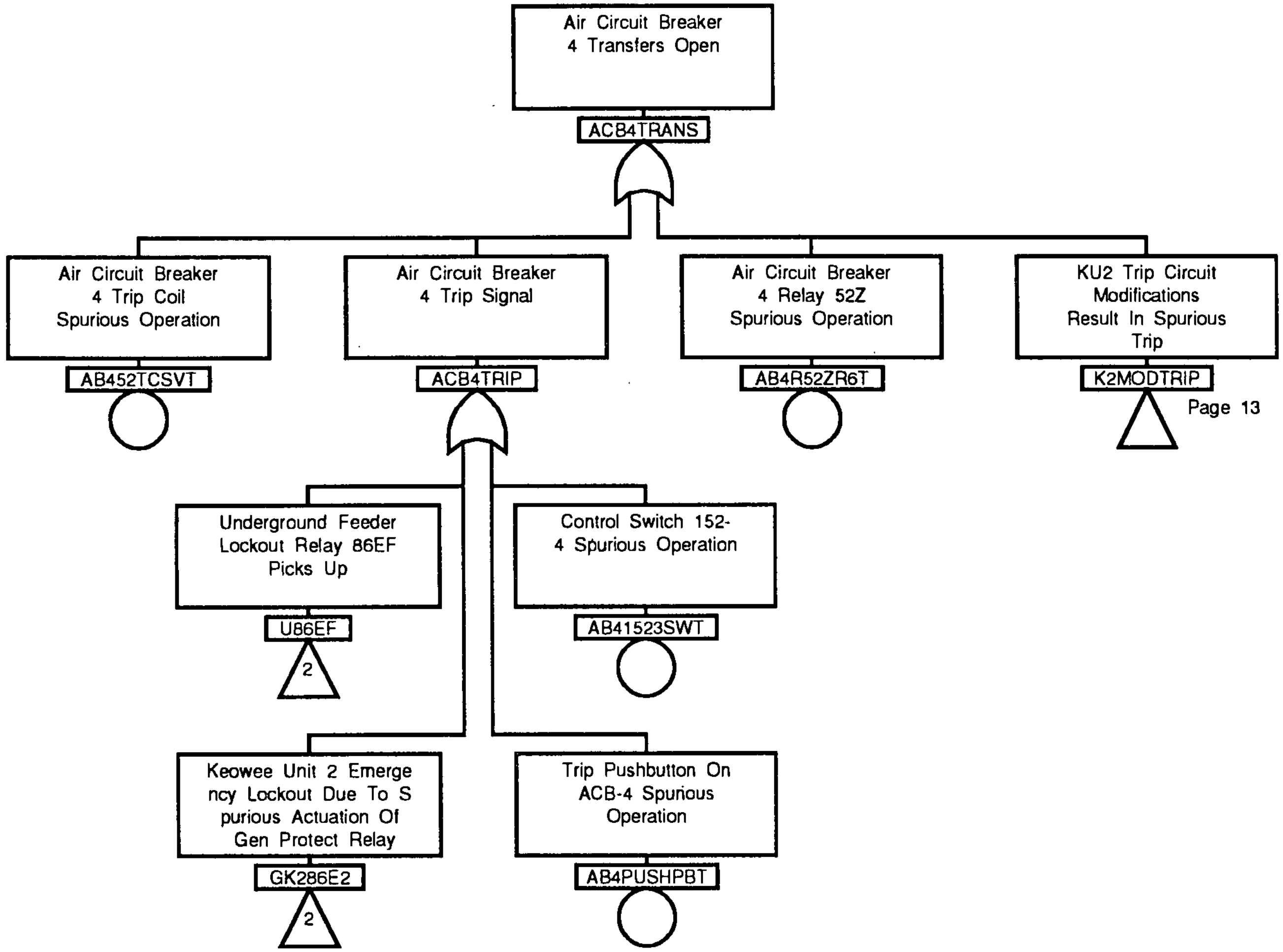

Air Circuit Breaker 4 Fails To Close Manually
ACB4MANC
Page 19
Page 28
Operators Fail To Close Air Circuit Breaker 4
ABPOPRCRHE
Air Circuit Breaker 4 Local/Remote Switch Contact Transfers Position
AB4LORESWT
Air Circuit Breaker 4 Close Switch Fails To Close On Demand
AB4CLSESWC



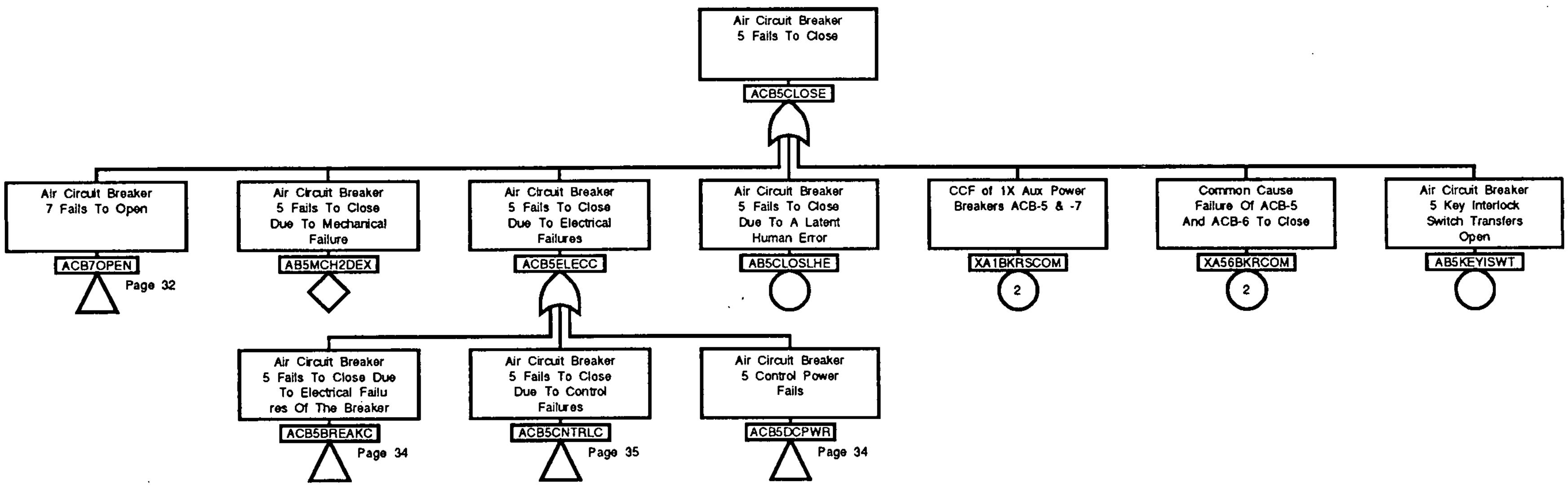
No Recovery From Independent Failures Of Overhead Path An d KU1 (post-mod)
NOFALT
Page 19
Air Circuit Breaker 1 Is Not Faulted
NOAB1FALT
Air Circuit Breaker 4 Fails To Close Manually
ACB4MANC
Page 27
NSM-ON-52966 Is In Service
NTACB4MOD
Page 6
Fault Occurs at ACB-1 When The BReaker Trips
AB1FALTDEX



Air Circuit Breaker 4 Control Power Fails
ACB4DCPWR
Page 19
Loss Of Power On Keowee 2 125 Vdc Distribution Center 2DA During Run
XD2DAR
Loss Of Power To 125 Vdc Distribution Center 2DA During Start
XD2DASRCES
2
Breaker 3CC In 125V dc Distribution Center 2DA Transfers Position
AD2B3CCCDT

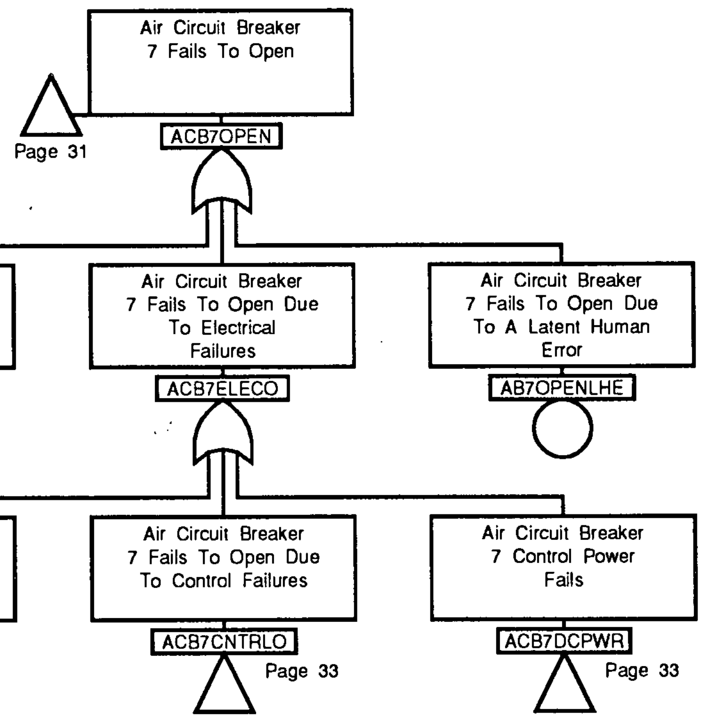


Air Circuit Breaker 4 Transfers Open
ACB4TRANS
Air Circuit Breaker 4 Trip Coil Spurious Operation
AB452TCSVT
Air Circuit Breaker 4 Trip Signal
ACB4TRIP
Air Circuit Breaker 4 Relay 52Z Spurious Operation
AB4R52ZR6T
KU2 Trip Circuit Modifications Result In Spurious Trip
K2MODTRIP
Page 13
Underground Feeder Lockout Relay 86EF Picks Up
U86EF
2
Control Switch 152-4 Spurious Operation
AB41523SWT
Keowee Unit 2 Emergency Lockout Due To Spurious Actuation Of Gen Protect Relay
GK286E2
2
Trip Pushbutton On ACB-4 Spurious Operation
AB4PUSHPBT

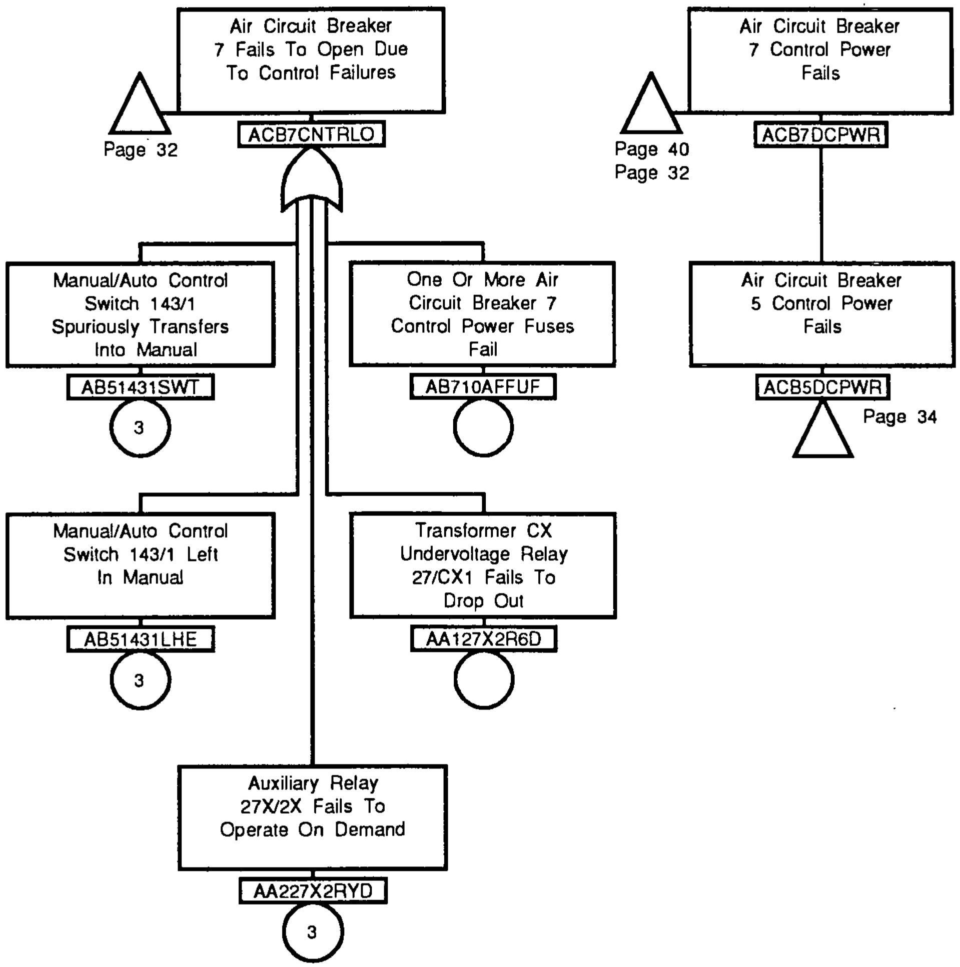


Air Circuit Breaker Fault Trees

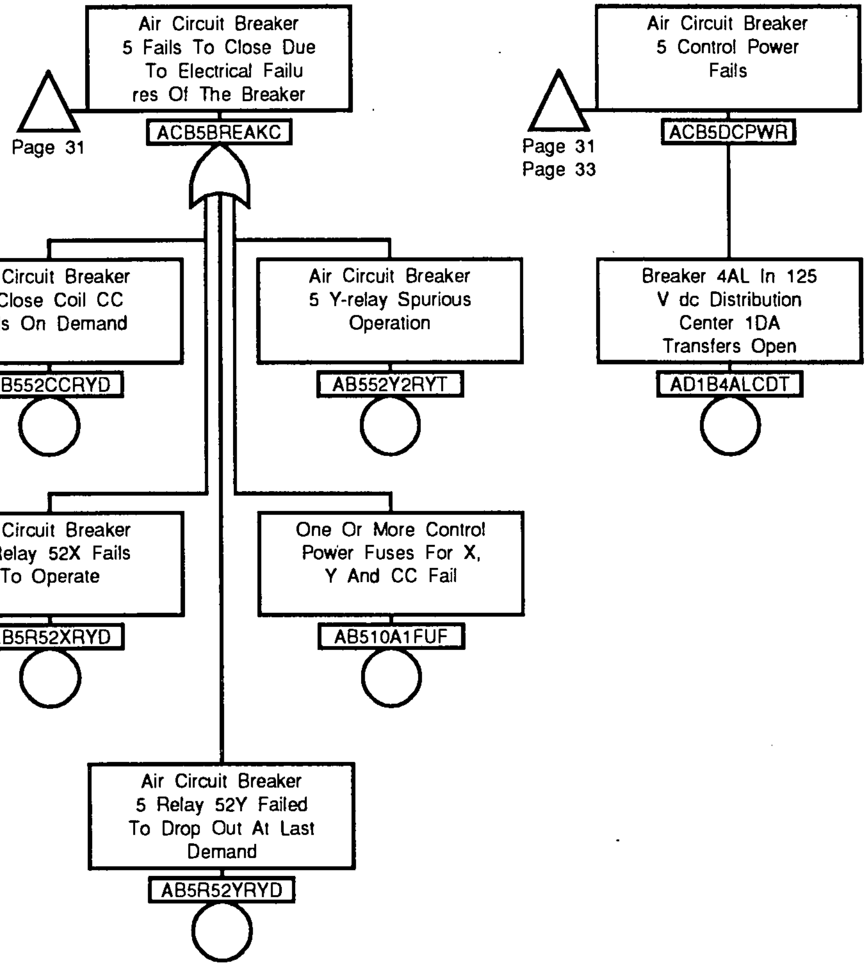
FIGURE A.4-9



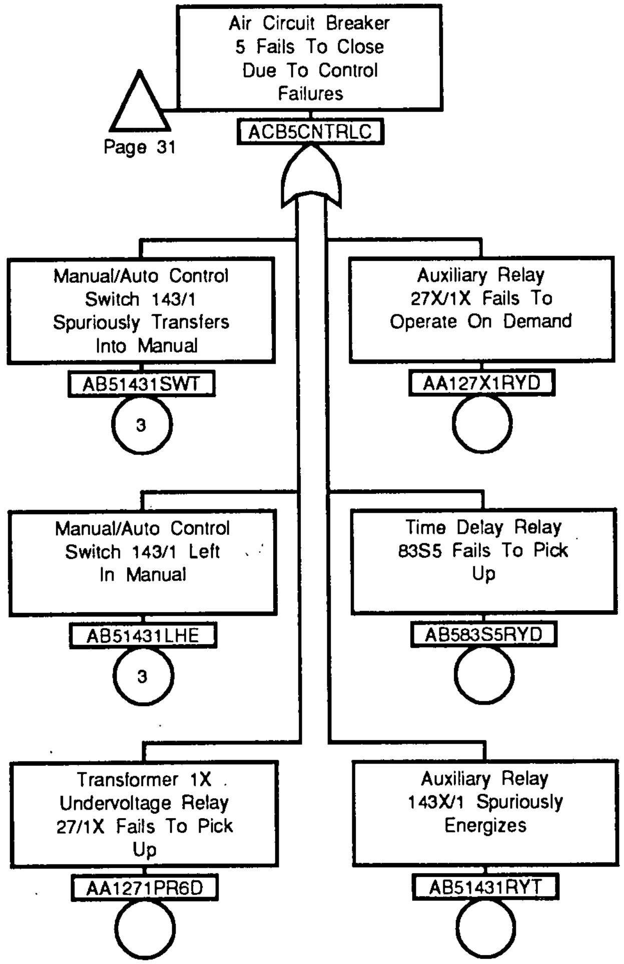
Air Circuit Breaker Fault Trees | FIGURE A.4-9 |



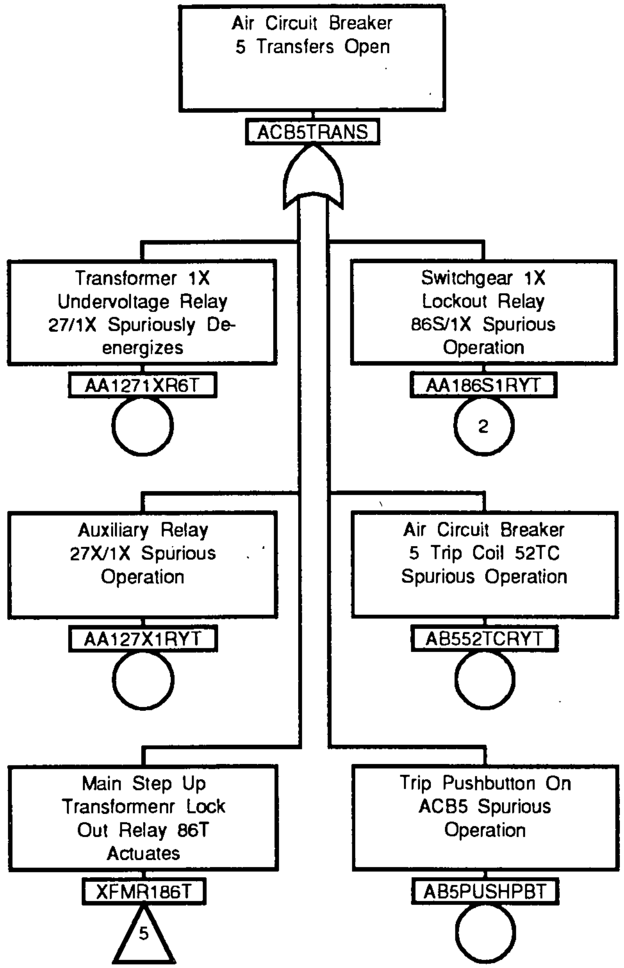
Air Circuit Breaker 7 Fails To Open Due To Control Failures
ACB7CNTRLO
Page 32
Manual/Auto Control Switch 143/1 Spuriously Transfers Into Manual
AB51431SWT
3
One Or More Air Circuit Breaker 7 Control Power Fuses Fail
AB710AFFUF
Manual/Auto Control Switch 143/1 Left In Manual
AB51431LHE
3
Transformer CX Undervoltage Relay 27/CX1 Fails To Drop Out
AA127X2R6D
Auxiliary Relay 27X/2X Fails To Operate On Demand
AA227X2RYD
3
Air Circuit Breaker 7 Control Power Fails
ACB7DCPWR
Page 40
Page 32
Air Circuit Breaker 5 Control Power Fails
ACB5DCPWR
Page 34



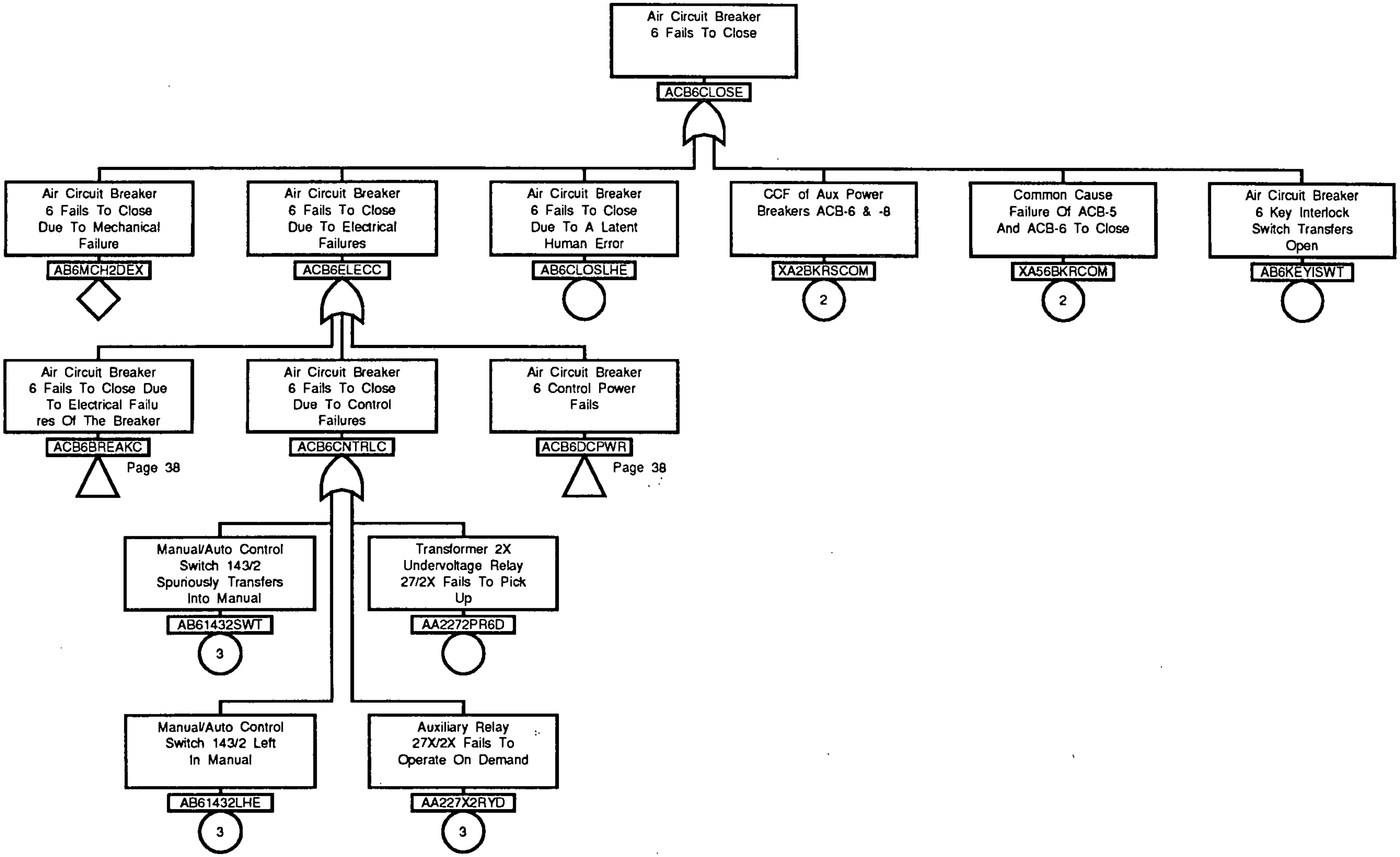
Air Circuit Breaker Fault Trees | FIGURE A.4-9 |



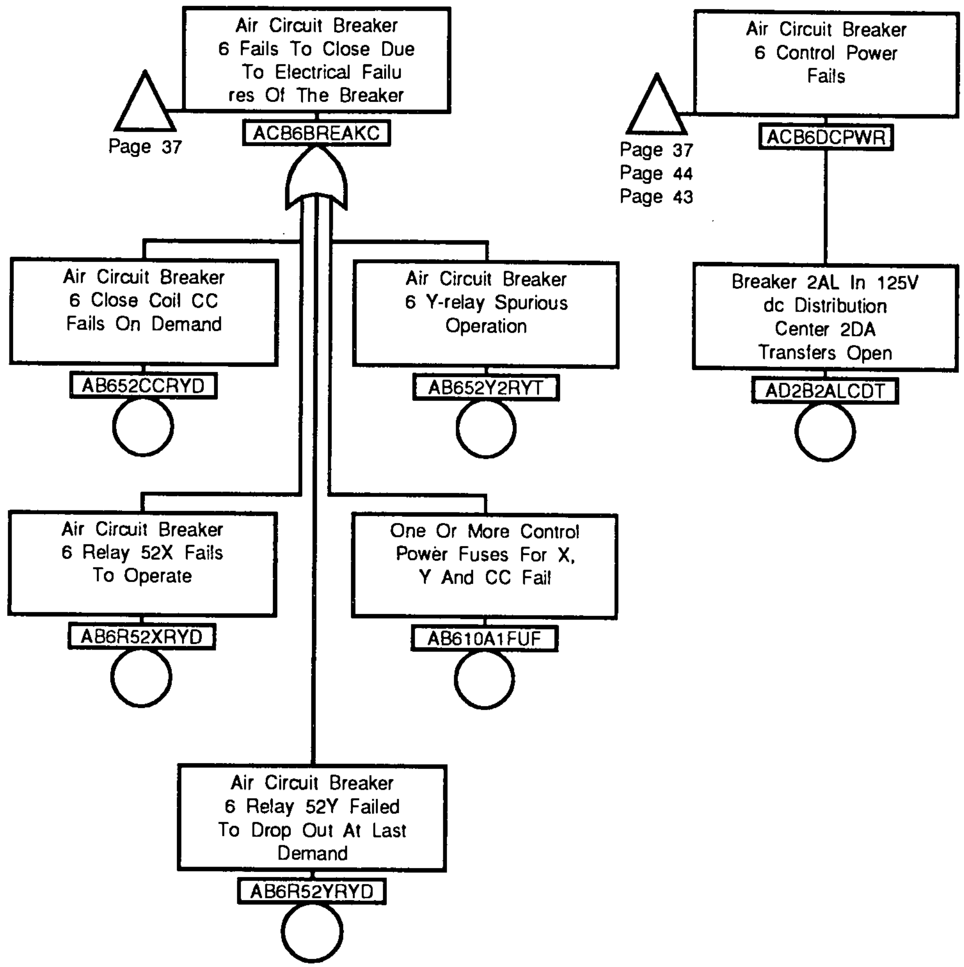
Air Circuit Breaker 5 Fails To Close Due To Control Failures
ACB5CNTRLC
Page 31
Manual/Auto Control Switch 143/1 Spuriously Transfers Into Manual
AB51431SWT
3
Auxiliary Relay 27X/1X Fails To Operate On Demand
AA127X1RYD
Manual/Auto Control Switch 143/1 Left In Manual
AB51431LHE
3
Time Delay Relay 83S5 Fails To Pick Up
AB583S5RYD
Transformer 1X Undervoltage Relay 27/1X Fails To Pick Up
AA1271PR6D
Auxiliary Relay 143X/1 Spuriously Energizes
AB51431RYT

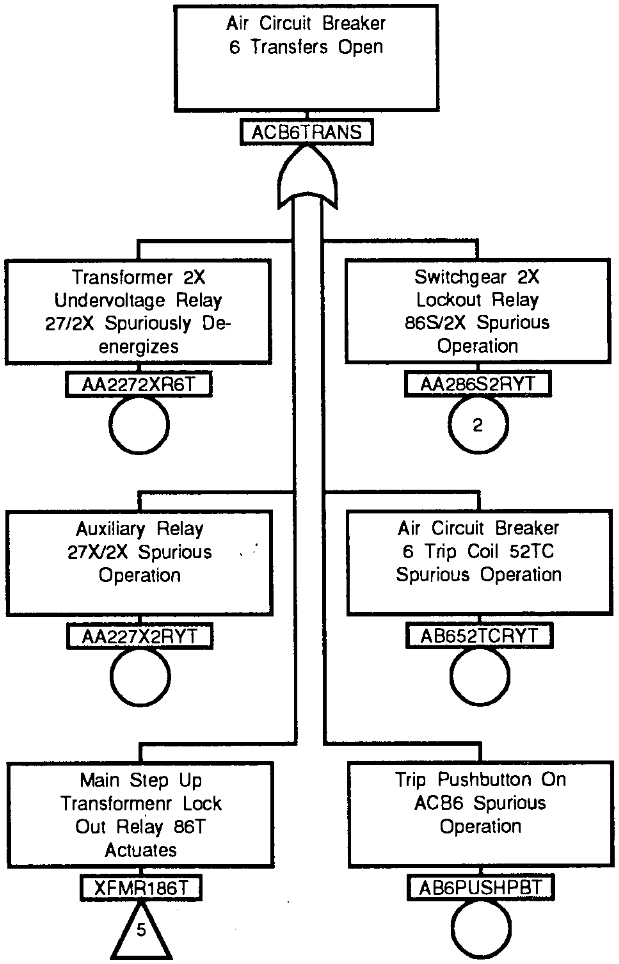


Air Circuit Breaker 5 Transfers Open
ACB5TRANS
Transformer 1X Undervoltage Relay 27/1X Spuriously De-energizes
AA1271XR6T
Switchgear 1X Lockout Relay 86S/1X Spurious Operation
AA186S1RYT
2
Auxiliary Relay 27X/1X Spurious Operation
AA127X1RYT
Air Circuit Breaker 5 Trip Coil 52TC Spurious Operation
AB552TCRYT
Main Step Up Transformenr Lock Out Relay 86T Actuates
XFMR186T
5
Trip Pushbutton On ACB5 Spurious Operation
AB5PUSHPBT

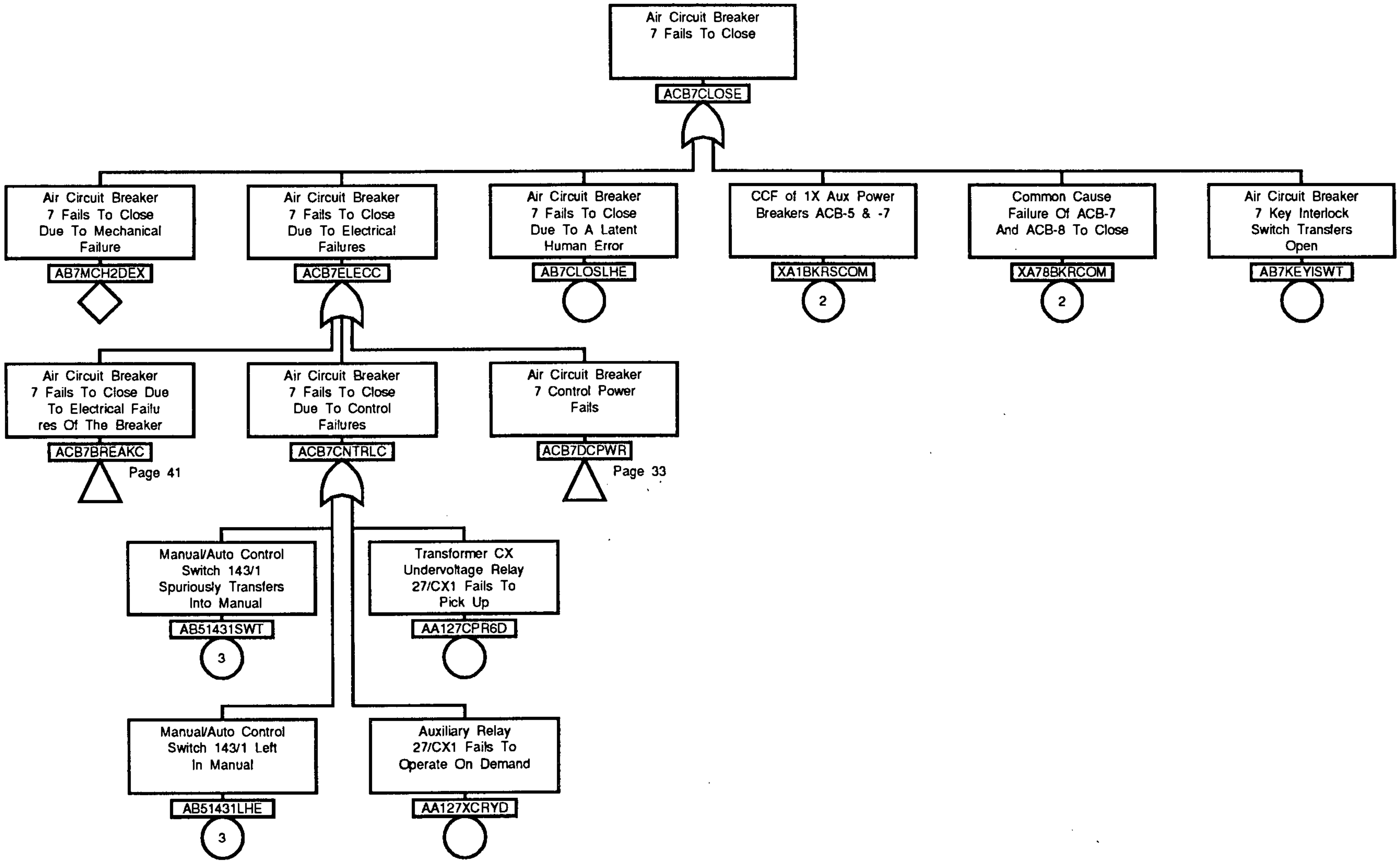


Air Circuit Breaker 6 Fails To Close
ACB6CLOSE
Air Circuit Breaker 6 Fails To Close Due To Mechanical Failure
AB6MCH2DEX
Air Circuit Breaker 6 Fails To Close Due To Electrical Failures
ACB6ELECC
Air Circuit Breaker 6 Fails To Close Due To A Latent Human Error
AB6CLOSLHE
CCF of Aux Power Breakers ACB-6 & -8
XA2BKRSCOM
2
Common Cause Failure Of ACB-5 And ACB-6 To Close
XA56BKRCOM
2
Air Circuit Breaker 6 Key Interlock Switch Transfers Open
AB6KEYISWT
Air Circuit Breaker 6 Fails To Close Due To Electrical Failu res Of The Breaker
ACB6BREAKC
Page 38
Air Circuit Breaker 6 Fails To Close Due To Control Failures
ACB6CNTRLC
Air Circuit Breaker 6 Control Power Fails
ACB6DCPWR
Page 38
Manual/Auto Control Switch 143/2 Spuriously Transfers Into Manual
AB61432SWT
3
Transformer 2X Undervoltage Relay 27/2X Fails To Pick Up
AA2272PR6D
Manual/Auto Control Switch 143/2 Left In Manual
AB61432LHE
3
Auxiliary Relay 27X/2X Fails To Operate On Demand
AA227X2RYD
3

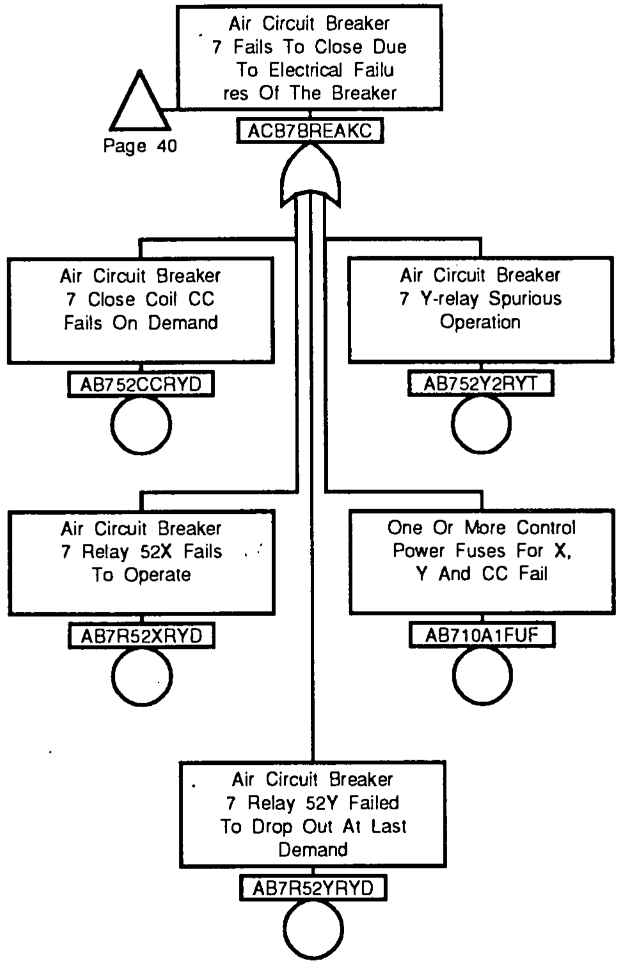

Air Circuit Breaker 6 Fails To Close Due To Electrical Failu res Of The Breaker
ACB6BREAKC
Page 37
Air Circuit Breaker 6 Close Coil CC Fails On Demand
AB652CCRYD
Air Circuit Breaker 6 Y-relay Spurious Operation
AB652Y2RYT
Air Circuit Breaker 6 Relay 52X Fails To Operate
AB6R52XRYD
One Or More Control Power Fuses For X, Y And CC Fail
AB610A1FUF
Air Circuit Breaker 6 Relay 52Y Failed To Drop Out At Last Demand
AB6R52YRYD
Air Circuit Breaker 6 Control Power Fails
ACB6DCPWR
Page 37
Page 44
Page 43
Breaker 2AL In 125V dc Distribution Center 2DA Transfers Open
AD2B2ALCDT

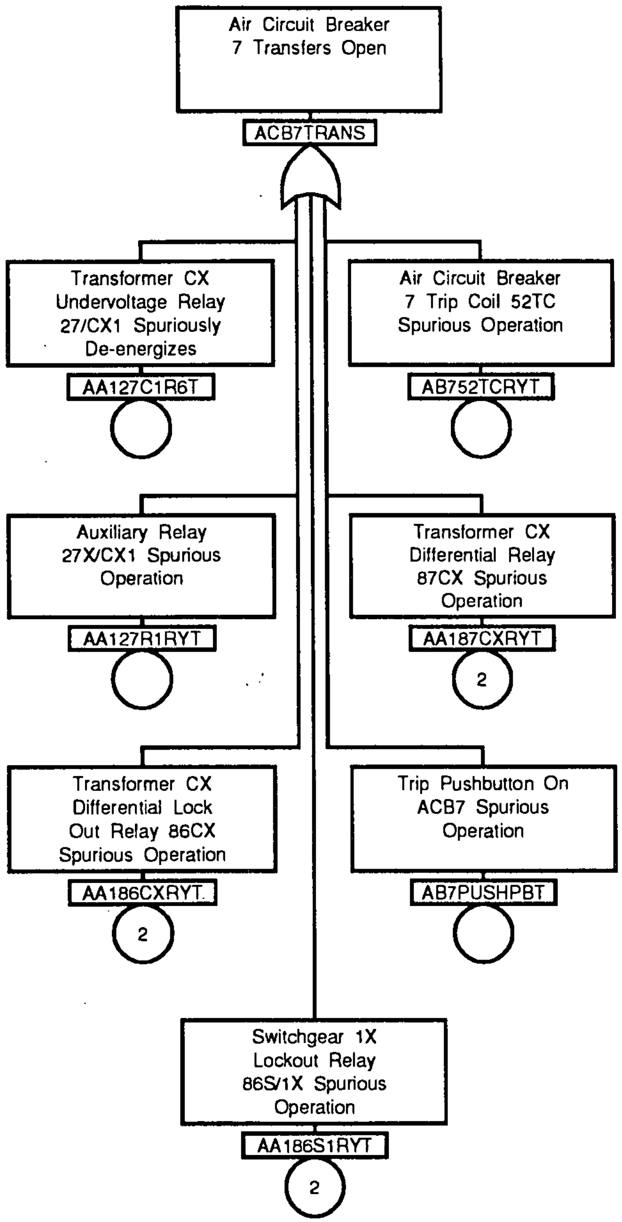


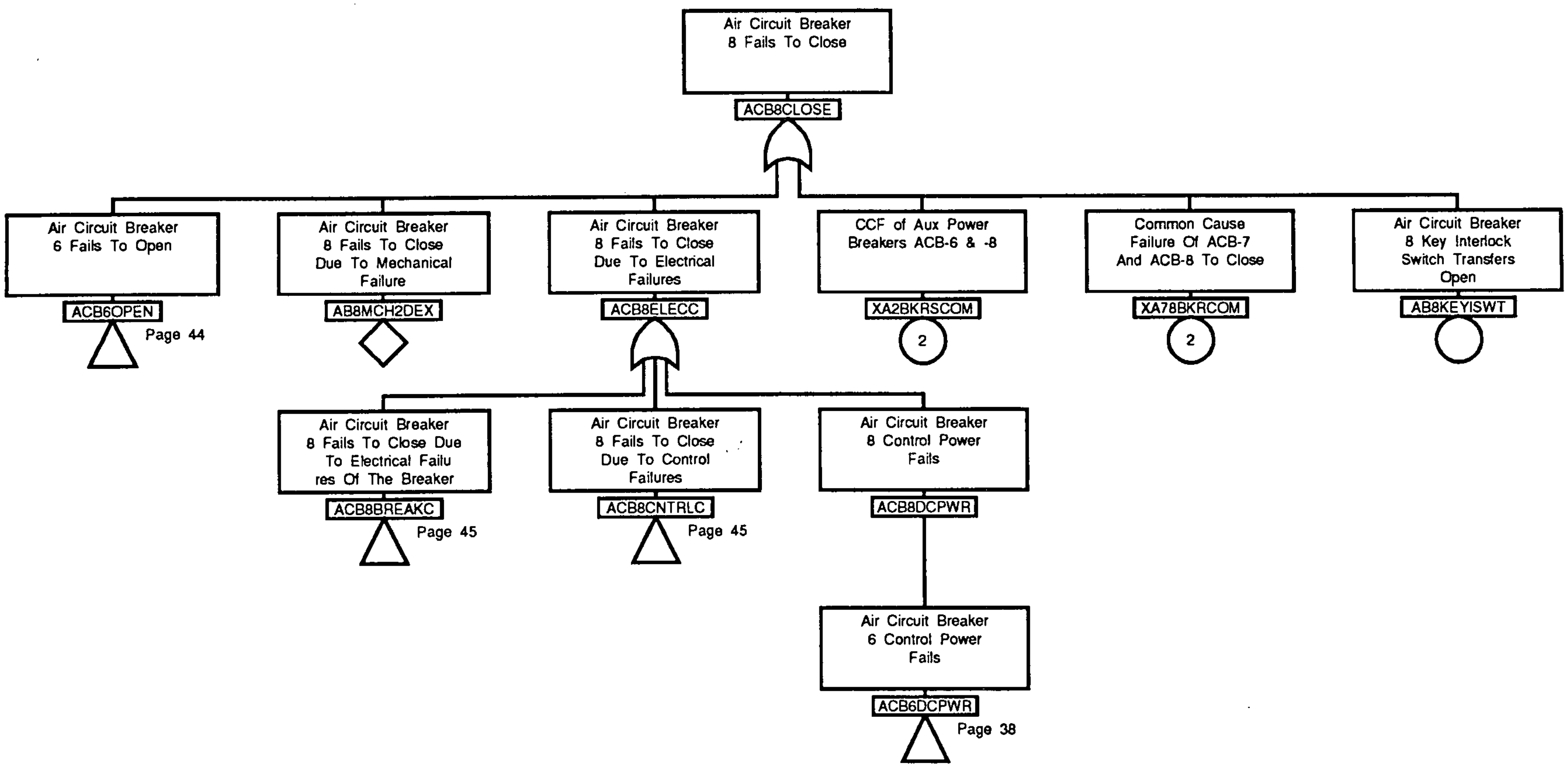
Air Circuit Breaker 6 Transfers Open
ACB6TRANS
Transformer 2X Undervoltage Relay 27/2X Spuriously De-energizes
AA2272XR6T
Switchgear 2X Lockout Relay 86S/2X Spurious Operation
AA286S2RYT
2
Auxiliary Relay 27X/2X Spurious Operation
AA227X2RYT
Air Circuit Breaker 6 Trip Coil 52TC Spurious Operation
AB652TCRYT
Main Step Up Transformenr Lock Out Relay 86T Actuates
XFMR186T
5
Trip Pushbutton On ACB6 Spurious Operation
AB6PUSHPBT



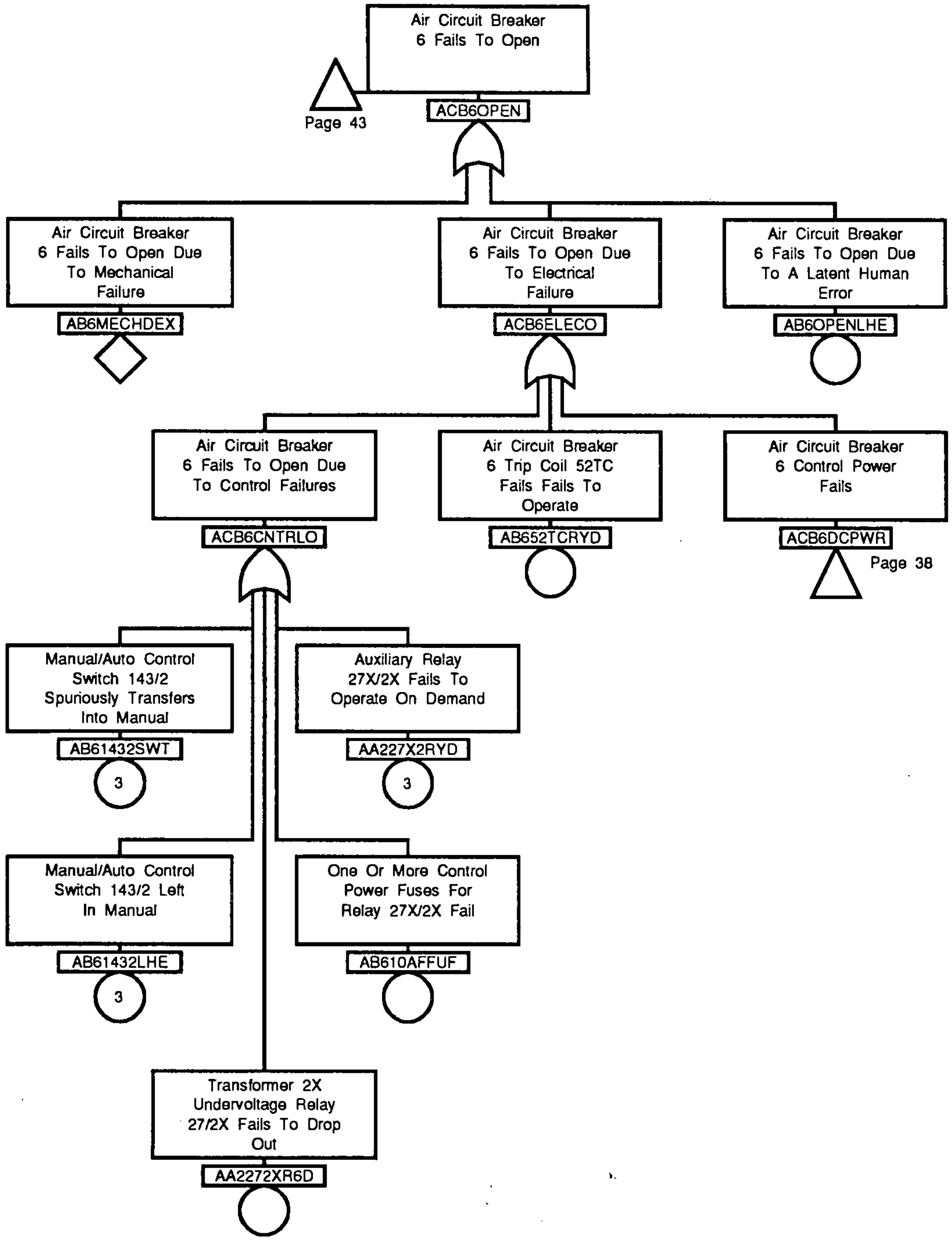
Air Circuit Breaker Fault Trees	FIGURE A.4-9	Page 40


Air Circuit Breaker 7 Fails To Close Due To Electrical Failu res Of The Breaker
ACB7BREAKC
Page 40
Air Circuit Breaker 7 Close Coil CC Fails On Demand
AB752CCRYD
Air Circuit Breaker 7 Y-relay Spurious Operation
AB752Y2RYT
Air Circuit Breaker 7 Relay 52X Fails To Operate
AB7R52XRYD
One Or More Control Power Fuses For X, Y And CC Fail
AB710A1FUF
Air Circuit Breaker 7 Relay 52Y Failed To Drop Out At Last Demand
AB7R52YRYD

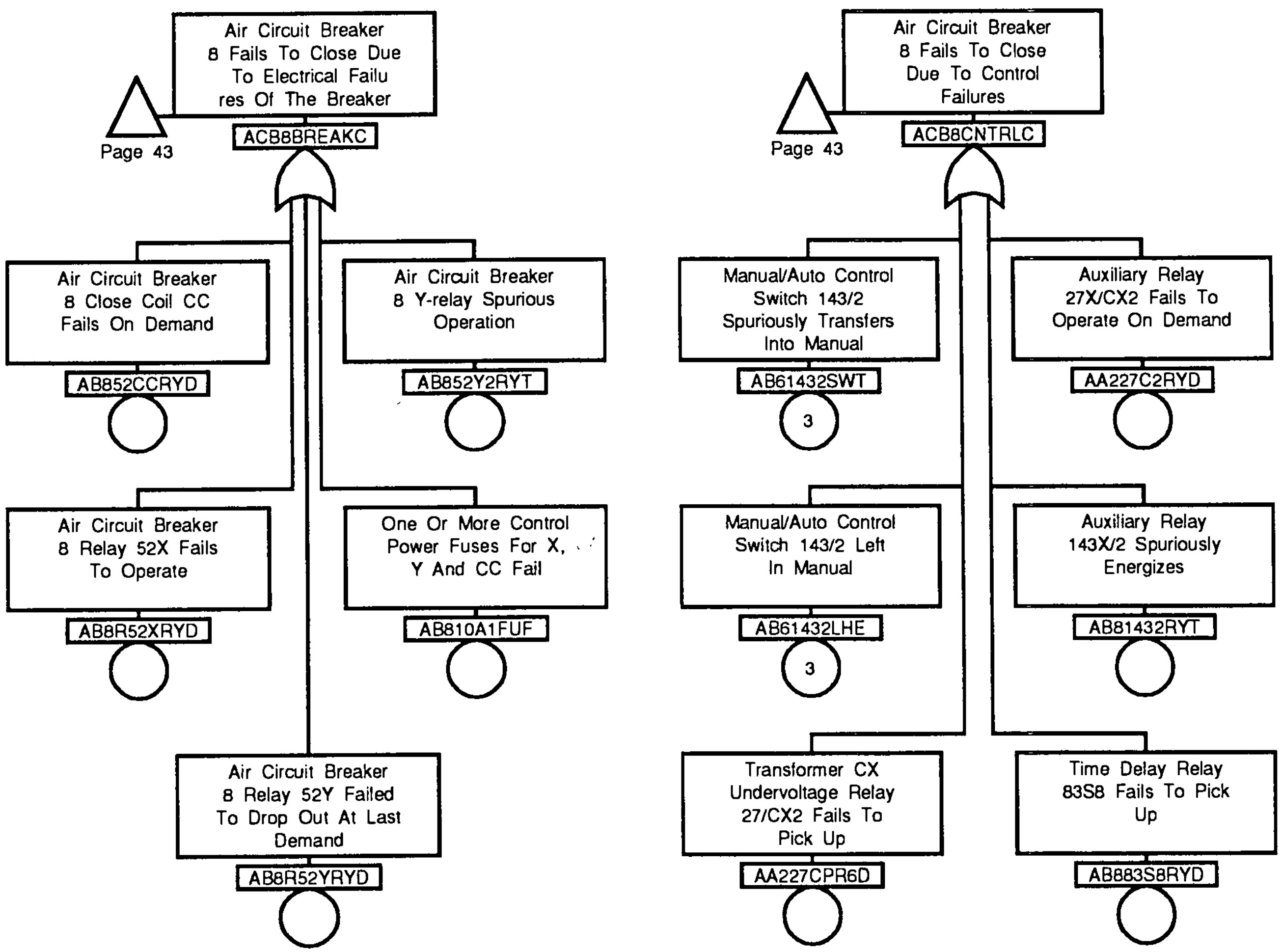

Air Circuit Breaker 7 Transfers Open
ACB7TRANS
Transformer CX Undervoltage Relay 27/CX1 Spuriously De-energizes
AA127C1R6T
Air Circuit Breaker 7 Trip Coil 52TC Spurious Operation
AB752TCRYT
Auxiliary Relay 27X/CX1 Spurious Operation
AA127R1RYT
Transformer CX Differential Relay 87CX Spurious Operation
AA187CXRYT
2
Transformer CX Differential Lock Out Relay 86CX Spurious Operation
AA186CXRYT
2
Trip Pushbutton On ACB7 Spurious Operation
AB7PUSHPBT
Switchgear 1X Lockout Relay 86S/1X Spurious Operation
AA186S1RYT
2



Air Circuit Breaker 8 Fails To Close
ACB8CLOSE
Air Circuit Breaker 6 Fails To Open
ACB6OPEN
Page 44
Air Circuit Breaker 8 Fails To Close Due To Mechanical Failure
AB8MCH2DEX
Air Circuit Breaker 8 Fails To Close Due To Electrical Failures
ACB8ELECC
CCF of Aux Power Breakers ACB-6 & -8
XA2BKRSCOM
2
Common Cause Failure Of ACB-7 And ACB-8 To Close
XA78BKRCOM
2
Air Circuit Breaker 8 Key Interlock Switch Transfers Open
AB8KEYISWT
Air Circuit Breaker 8 Fails To Close Due To Electrical Failu res Of The Breaker
ACB8BREAKC
Page 45
Air Circuit Breaker 8 Fails To Close Due To Control Failures
ACB8CNTRLC
Page 45
Air Circuit Breaker 8 Control Power Fails
ACB8DCPWR
Air Circuit Breaker 6 Control Power Fails
ACB6DCPWR
Page 38

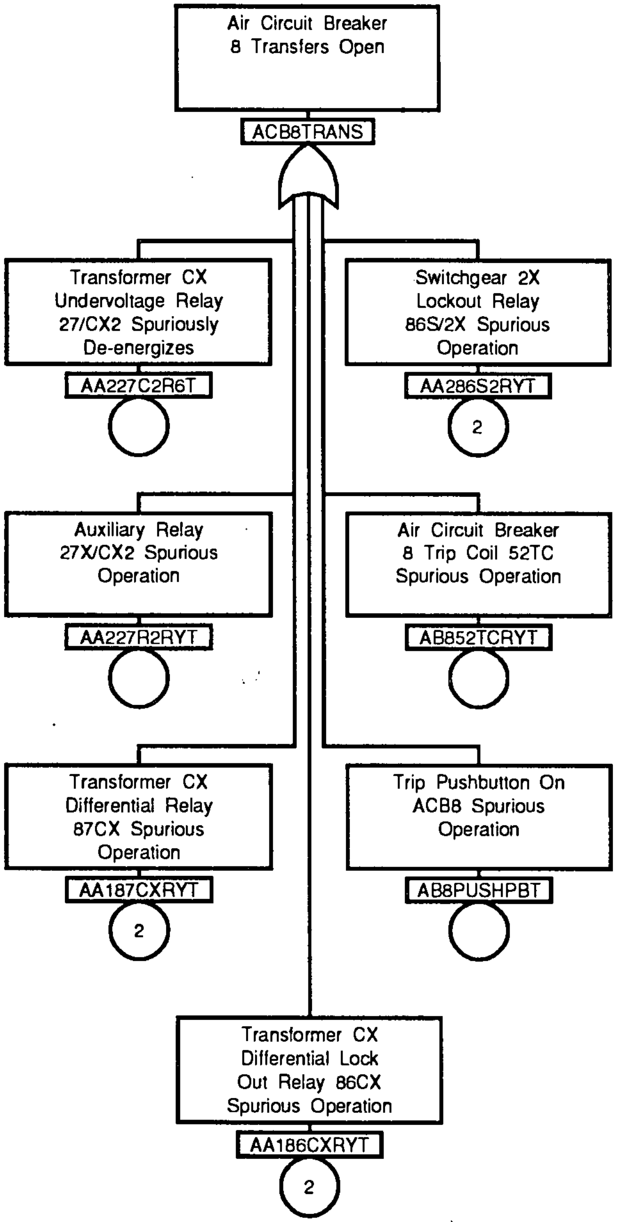


Air Circuit Breaker Fault Trees | FIGURE A.4-9 |



Air Circuit Breaker Fault Trees

FIGURE A.4-9


Air Circuit Breaker 8 Transfers Open
ACB8TRANS
Transformer CX Undervoltage Relay 27/CX2 Spuriously De-energizes
AA227C2R6T
Switchgear 2X Lockout Relay 86S/2X Spurious Operation
AA286S2RYT
2
Auxiliary Relay 27X/CX2 Spurious Operation
AA227R2RYT
Air Circuit Breaker 8 Trip Coil 52TC Spurious Operation
AB852TCRYT
Transformer CX Differential Relay 87CX Spurious Operation
AA187CXRYT
2
Trip Pushbutton On ACB8 Spurious Operation
AB8PUSHPBT
Transformer CX Differential Lock Out Relay 86CX Spurious Operation
AA186CXRYT
2

Gate/Event Name	Page	Zone	Gate/Event Name	Page	Zone	Gate/Event Name	Page	Zone	Gate/Event Name	Page	Zone
AA1271PR6D	35		AB1OPENLHE	1		AB352Y2R6D	14		AB552Y2RYT	34	
AA1271XR6T	36		AB1PS02PST	1		AB352Y2R6T	14		AB583S5RYD	35	
AA127C1R6T	42		AB1R52ZR6D	1		AB3ACCUDEX	14		AB5CLOSLHE	31	
AA127CPR6D	40		AB21521SWT	11		AB3ACCUDEX	24		AB5KEYISWT	31	
AA127R1RYT	42		AB22BV1RYT	11		AB3CLOSLHE	14		AB5MCH2DEX	31	
AA127X1RYD	35		AB23BKRCOM	8		AB3MCH2DEX	14		AB5PUSHPBT	36	
AA127X1RYT	36		AB23COM	2		AB3MECHDEX	24		AB5R52XRYD	34	
AA127X2R6D	33		AB23COM	8		AB3PS02PST	14		AB5R52YRYD	34	
AA127XCRYD	40		AB23COM	14		AB3PS02PST	24		AB610A1FUF	38	
AA186CXRYT	42		AB24BKRCOM	6		AB3PUSHPBT	16		AB610AFFUF	44	
AA186CXRYT	46		AB24COM	2		AB3R52XR6D	14		AB61432LHE	37	
AA186S1RYT	36		AB24COM	6		AB3R52ZR6D	24		AB61432LHE	44	
AA186S1RYT	42		AB24COM	18		AB3R52ZR6T	15		AB61432LHE	45	
AA187CXRYT	42		AB251G2RYT	11		AB41523SWT	30		AB61432SWT	37	
AA187CXRYT	46		AB252CCSVO	4		AB452CCSVO	20		AB61432SWT	44	
AA2272PR6D	37		AB252TCSVO	9		AB452TCSVT	30		AB61432SWT	45	
AA2272XR6D	44		AB252TCSVT	11		AB452Y2R6D	20		AB652CCRYD	38	
AA2272XR6T	39		AB252Y2R6D	4		AB452Y2R6T	20		AB652TCRYD	44	
AA227C2R6T	46		AB252Y2R6T	4		AB4ACCUDEX	18		AB652TCRYT	39	
AA227C2RYD	45		AB2ACCUDEX	2		AB4CLOSLHE	18		AB652Y2RYT	38	
AA227CPR6D	45		AB2ACCUDEX	9		AB4CLSESWC	27		AB6CLOSLHE	37	
AA227R2RYT	46		AB2CLOSLHE	6		AB4KEYISWT	18		AB6KEYISWT	37	
AA227T2R6D	5		AB2KEYISWT	2		AB4LORESWT	27		AB6MCH2DEX	37	
AA227X2RYD	33		AB2MCH2DEX	2		AB4MCH2DEX	18		AB6MECHDEX	44	
AA227X2RYD	37		AB2MECHDEX	9		AB4PS02PST	20		AB6OPENLHE	44	
AA227X2RYD	44		AB2MOD	5		AB4PUSHPBT	30		AB6PUSHPBT	39	
AA227X2RYT	39		AB2OPENLHE	9		AB4R52XR6D	20		AB6R52XRYD	38	
AA286S2RYT	39		AB2PS02PST	4		AB4R52ZR6T	30		AB6R52YRYD	38	
AA286S2RYT	46		AB2PS02PST	9		AB510A1FUF	34		AB710A1FUF	41	
AB004ECCDT	22		AB2PUSHPBT	11		AB51431LHE	33		AB710AFFUF	33	
AB0086TRYD	22		AB2R462RYT	11		AB51431LHE	35		AB752CCRYD	41	
AB0624CRYD	22		AB2R52XR6D	4		AB51431LHE	40		AB752TCRYD	32	
AB086E1RYD	23		AB2R52ZR6D	9		AB51431RYT	35		AB752TCRYT	42	
AB086TGRYD	22		AB2R52ZR6T	11		AB51431SWT	33		AB752Y2RYT	41	
AB152TCSVO	1		AB31523SWT	16		AB51431SWT	35		AB7CLOSLHE	40	
AB1ACCUDEX	1		AB352CCSVO	14		AB51431SWT	40		AB7KEYISWT	40	
AB1FALTDEX	28		AB352TCSVO	24		AB552CCRYD	34		AB7MCH2DEX	40	
AB1MECHDEX	1		AB352TCSVT	15		AB552TCRYT	36		AB7MECHDEX	32	

APPENDIX A.5
KEOWEE START AND RUN CONTROL

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A.5 KEOWEE EMERGENCY START

A.5.1 OBJECTIVES

The objective of this analysis is to develop a logic model of the Keowee Emergency Starting Sequences from the point that the individual Oconee units recognize the need for Keowee emergency start, to the positioning of electrical relays and solenoids that cause the Keowee turbine wicket gates to come under the control of their hydraulic governor units. This model is combined with the high-level model and remaining system models to form an integrated model for assessing the reliability of Keowee. Other objectives are to identify major contributors to system unreliability, significant potential human errors and common-cause failure modes.

The scope of this analysis is limited to instrumentation and control equipment required to support a Keowee emergency start and run under load following a loss of off-site power event for an Oconee unit.

A.5.2 EMERGENCY START DESIGN

Each Keowee unit has its own automatic startup equipment contained in separate cubicles within the Keowee control room. The initiation of emergency startup is accomplished by control signals from either Oconee control area. Normal startup is by operator action while emergency startup is automatic. On emergency automatic startup, both units are started simultaneously; the unit tied to the underground feeder supplies that feeder to Transformer CT4, and the other unit is available to supply the Oconee Startup Transformers through a 230 kV overhead transmission line and the Oconee 230 kV switchyard. Each unit is capable of accepting full emergency power load as it accelerates from zero to rated speed and voltage within 23 seconds of the receipt of the emergency start signal. If the units are operating when the emergency start signal occurs, they are separated from the network, the switchyard yellow bus is isolated, and the unit not tied to the underground power path will reconnect to the 230 kV overhead transmission line in about 6.5 seconds (Unit 1) or 4.0 seconds (Unit 2) after the switchyard isolate complete signal is received.

A diagram of the Keowee emergency start logic is provided as Figure A.5-1. The diagram shows the kinds of events or initiators that will actuate the Oconee 1, Channel A Keowee Emergency Start Relay KA. Not shown is the completely redundant Channel B that actuates Oconee 1, Keowee Emergency Start Relay KB. Each channel is sensitive to Engineered Safeguards (ESG) System initiators, Main Feeder Bus Monitor initiators, and External Grid Trouble Protection System (EGTPS) initiators, as well as a manual Emergency Start Pushbutton Switch in the Oconee 1 & 2 Control Room, and a manual Emergency Start Key-Switch in the Oconee 1 & 2 Cable Room. After a Keowee Emergency Start Relay has been picked up, it seals itself in until the signal is intentionally cleared by manual reset. The ESG System contact is also sealed in when the ESG System is actuated; therefore, when a Keowee Emergency Start Signal is initiated by an ESG signal, the ESG signal must be cleared before the Keowee Emergency Start signal can be cleared.

The Oconee 2 Keowee Emergency Start Relays, CR2A and CR2B, are similarly actuated by automatic signals from the Unit 2 ESG System, and the Unit 2 Main Feeder Bus Monitor System. The relays can be manually actuated by Unit 2 local locked selector switches, 2SSW'A' for Channel A, and 2SSW'B' for Channel B. The Channel A, Keowee Emergency Start Relay CR2A is shown in Figure A.5-1. It should be noted that there is no EGTPS input to the Oconee 2 Keowee Emergency Start Relays.

The Oconee 3, Keowee Emergency Start Relays, CR3A and CR3B, are actuated by automatic signals from the Unit 3 ESG System, and the Unit 3 Main Feeder Bus Monitoring System. The relays can be manually actuated by individual manual Emergency Start Pushbutton Switches in the Oconee 3 Control Room and manual Emergency Start Key-Switches in the Oconee 3 Cable Room. There is no EGTPS input to the Oconee 3 Keowee Emergency Start Relays.

The Keowee emergency start signal can be provided by any one of the Oconee units, but the EGTPS Keowee Emergency Start signal is applied to Oconee Unit 1 only. The EGTPS through relay STA provides a Keowee Start signal to Oconee Unit 1, Channel A Emergency Start Relay KA in the Oconee Unit 1 Control Room. The Channel B EGTPS, Keowee Emergency Start signal is applied through relay STB and actuates Emergency Start Relay KB in the Oconee 1 Control Room. The KA relay actuates four Emergency Start auxiliary relays at Keowee. Two of these are used in the Keowee Unit 1 Start Logic,

and the other two are used in the Unit 2 Start Logic. The four relays are described as follows:

1. Channel A Emergency Start Auxiliary Relay 1ESRX/2A or Channel B counterpart 1ESRX/2B must be picked up to complete one of several permissives that must be satisfied before the Keowee 1 Shutdown Auxiliary Relay (99SX) can be picked up, and 99SX must be picked up to start Keowee Unit 1.

2. Channel A Emergency Start Auxiliary Relay 1ESRX/1A or Channel B counterpart 1ESRX/1B must be picked up, or all of the Keowee 1 normal start permissives must be satisfied to satisfy one of three conditions needed to actuate the Keowee 1 Master Relays 4A and 4B. The other two necessary conditions are Emergency Lockout Relay 86E-1 "not tripped" and the Unit 1 Startup Inhibit Key Switch 3SUI "Uninhibited". 'Master Relay 4A picked up' is also one of the several permissives that must be satisfied to pick up 99SX in logic description 1 above.

3. Channel A Emergency Start Auxiliary Relay 2ESRX/2A or Channel B counterpart 2ESRX/2B must be picked up to complete one of the permissives necessary to pickup the Keowee 2 Shutdown Auxiliary Relay (99SX). The Keowee Unit 2 logic is similar to the Keowee Unit 1 logic.

4. Channel A Emergency Start Auxiliary Relay 2ESRX/1A or Channel B counterpart 2ESRX/1B must be picked up, or all of the Keowee 2 normal start permissives must be satisfied to satisfy one of three conditions needed to actuate the Keowee 2 Master Relays 4A and 4B. The other two necessary are Emergency Lockout Relay 86E-2 "not tripped" and the Unit 2 Startup Inhibit Key Switch 3SUI "Uninhibited".

In addition to energizing the Master Relays and the Shutdown Auxiliary Relays, the Emergency Start Auxiliary Relays have the following functions:

1. Energize the closing circuits of the Generator Field Breaker 41.

2. Energize the closing circuits of the Generator Excitation Supply Breaker 41-52.

3. Energize the closing circuits of the Field Flashing Breaker 31.

4. Energize the trip circuits of overhead breakers ACB-1 and ACB-2 to ensure the separation of Keowee Units from the 230kV Switchyard.

5. Energize the Partial Shutdown (Emergency Load) Solenoids 99SN.

6. Block the Dashpot Bypass Solenoid 99BP.

7. Block operation of the governor speed changer motor by the autosynchronizer.

8. Block operation of the Motor Generator Relay 83.

9. Block operation of the Lockout Auxiliary Relays 86EX-1 and 86EX-2 from any normal lockout relay actuation.

10. Inhibit load frequency control.

11. Block operation of the synchronizing relay.

12. Bypass the normal lockout relay functions.

After the Shutdown Auxiliary Relay 99SX is energized as part of the emergency start sequence, the following actions take place:

1. The Shutdown Solenoid 99SD and the Partial Shutdown (Emergency Load) Solenoid 99SN are energized, and then the wicket gates open toward the preset 50% position.

2. At 37 RPM the Emergency Load Solenoid 99SN automatically de-energizes and the wicket gates move to the no load setting.

3. At 122 RPM the Emergency Load Solenoid again energizes and the unit comes under governor control accelerating to 128.6 RPM.

The Keowee unit tied to the underground power path is now available to supply power to the Standby Bus via CT-4 and the SK breakers. The Keowee unit tied to the overhead

power path will automatically energize the 230kV Switchyard by closing the overhead path ACB (ACB-1 or ACB-2) if switchyard isolation has occurred (ACB-1 closes 6.5 seconds after switchyard isolation or ACB-2 closes 4 seconds after switchyard isolation).

When a Keowee Unit is operating in the Emergency Mode, actuation of any of the following devices will trip the unit:

1. The Startup Inhibited Key operated switch 3SUI in the "inhibit" position

2. Emergency Lockout Relay 86E

3. Turbine Guide Bearing Low Oil Level Relay 63TB/1X

4. Generator Bearing High Oil Level Relay 63BL/HX

5. Generator Bearing Low Oil Level Relay 63BL/LXTD

6. Generator Overspeed Switch (12) open, indicating the unit speed is greater than the trip setpoint.

A.5.3 SYSTEM BOUNDARIES

Electrical Power Supplies

Control power for Channel A Emergency Start Auxiliary Relays (for Keowee 1 and 2) is supplied by 125 Vdc Distribution Center 1DA, and control power for Channel B Emergency Start Auxiliary Relays (for Keowee 1 and 2) comes from 125 Vdc Distribution Center 2DA. The Keowee Unit 1 turbine and governor startup control power is from Distribution Center 1DA, and the Keowee Unit 2 turbine and governor startup control power is from Distribution Center 2DA.

Control power for Oconee Units 1, 2, and 3, Channel A Keowee Emergency Start logic and Relays KA, CR2A, and CR3A comes from 125 Vdc Panelboards 1DIA, 2DIA, and 3DIA respectively. Similarly, control power for the Channel B Keowee Emergency Start

logic and Relays KB, CR2B, and CR3B is from 125 Vdc Panelboards 1DIB, 2DIB, and 3DIB respectively.

External Control Systems

The EGTPS (Appendix A. 3) provides the Keowee emergency start signals when it senses a loss of power in the 230 kV switchyard. Automatic emergency start signals are also provided to Keowee by the Engineered Safeguards Actuation System in each unit and by the Main Feeder Bus Monitor System in each unit.

A.5.4 INSTRUMENTATION AND CONTROLS

Oconee 1

The Oconee 1&2 Control Room has all the alarms and controls for normal operation of the Keowee Units. All controls of importance located on the Keowee control boards are duplicated in the Oconee 1&2 Control Room.

When Oconee 1, Channel A(B) Keowee Emergency Start Relay KA (KB) is actuated the following indication is available:

> A red light on Emergency Power Switching Logic Panel 3, EPSLP3.
>
> A statalarm in the Control Room, 1SA15-28 (1SA14-28) Keowee Emergency Start Channel A (B) Logic Initiate.
>
> The status of the emergency start relay KA (KB) is also monitored by computer.

An amber light is provided on EPSLP3 to indicate the availability of DC control power to the Channel A (B) Keowee emergency start logic.

A statalarm in the Control Room, 1SA15-29 (1SA14-29) Keowee Emergency Start Channel A (B) Logic DC Power Lost, indicates the loss of DC control power to the Channel A (B) emergency start logic.

A red coil monitor light is provided on EPSLP3 to monitor the circuit continuity through the Emergency Start Relay KA (KB). The light is lit when relay KA (KB) is de-energized. The status of the coil monitor relays is monitored by computer.

On 1EPSLP3 Channel A (B) one red coil monitoring light monitors the continuity through the four Keowee emergency start auxiliary relays. The light is lit when the relays are de-energized. The status of the coil monitor relay is monitored by the plant computer.
A red light on EPSLP3 and a statalarm, 1SA15-30 (1SA14-30) on 1VB2 Switchyard Isolation Confirmed Channel A (B) Logic, indicates when the switchyard isolation auxiliary relay SIA (SIB) is energized. The status of the switchyard isolation relays are also monitored by the plant computer.

Oconee 2

When Oconee 2 Channel A (B) Keowee Emergency Start Relay CR2A (CR2B) is actuated the following indication is available:

A red light on EPSLP3.

A statalarm in the Control Room, 2SA15-28 (2SA14-28) Keowee Emergency Start Channel A (B) Logic Initiate.

The status of the emergency start relay CR2A (CR2B) is also monitored by computer.

An amber light is provided on EPSLP3 to indicate the availability of DC control power to the Channel A (B) Keowee emergency start logic.

A statalarm in the Control Room, 2SA15-29 (2SA14-29) Keowee Emergency Start Channel A (B) Logic DC Power Lost, indicates the loss of DC control power to the Channel A (B) Keowee emergency start logic.

A red coil monitor light is provided on EPSLP3 to monitor the circuit continuity through the Emergency Start Relay CR2A (CR2B). The light is lit when relay CR2A (CR2B) is de-energized. The status of the coil monitor relays is monitored by computer.

Oconee 3

When Oconee 3 Channel A (B) Keowee Emergency Start Relay CR3A (CR3B) is actuated the following indication is available:

A red light on EPSLP3.

A statalarm in the Control Room, 3SA15-28 (3SA14-28) Keowee Emergency Start Channel A (B) Logic Initiate.

The status of the emergency start relay CR3A (CR3B) is monitored by computer.

An amber light is provided on EPSLP3 to indicate the availability of DC control power to the Channel A (B) Keowee emergency start logic.

A statalarm in the Control Room, 3SA15-29 (3SA14-29) Keowee Emergency Start Channel A (B) Logic DC Power Lost, indicates the loss of DC control power to the Channel A (B) Keowee emergency start logic.

A red coil monitor light is provided on EPSLP3 to monitor the circuit continuity through the Emergency Start Relay CR3A (CR3B). The light is lit when relay CR3A (CR3B) is de-energized. The status of the coil monitor relays is monitored by computer.

Keowee

The Keowee Control Room has sufficient controls, alarms, and indications to start, control, and run both units in manual or automatic control.

A.5.5 LOCATION WITHIN THE PLANT

The automatic startup circuitry for the Keowee units is in separate cubicles of the Keowee control room. The Oconee emergency power start signal circuitry is located in each Oconee control room and the cable rooms.

A.5.6 NORMAL OPERATION

This analysis concerns emergency startup of the Keowee hydro-electric generators. The generator and the governor itself work the same for normal starts as they do for emergency starts. The difference between a normal start and run operation and an emergency start and run operation is the much greater number of permissive interlocks that must be satisfied to keep the master relays picked up during the normal start and run operation.

A.5.7 PERFORMANCE DURING KEOWEE EMERGENCY OPERATION

The initiating event analyzed in this study is the LOOP. The LOOP initiates a dual channel EGTPS response and a dual channel Main Feeder Bus Monitor response in the affected Oconee unit(s). EGTPS Train A Output Relay STA or the Train B Output Relay STB actuates the Oconee 1 Keowee Emergency Start Relay KA or KB respectively. The unit 1 KA relay, the unit 2 CR2A relay, or the unit 3 CR3A relay will actuate the Keowee Channel A Emergency Start Auxiliary Relays, 1ESRX/1A, 1ESRX/2A, 2ESRX/1A, and 2ESRX/2A. The unit 1 KB relay, the unit 2 CR2B relay, or the unit 3 CR3B relay will actuate the Keowee Channel B Emergency Start Auxiliary Relays, 1ESRX/1B, 1ESRX/2B, 2ESRX/1B, and 2ESRX/2B. Keowee Unit 1(2) emergency start initiation is complete when any of the following emergency start auxiliary relay pairs are actuated:

1. 1ESRX/1A and 1ESRX/2A (2ESRX/1A and 2ESRX/2A)

2. 1ESRX/1A and 1ESRX/2B (2ESRX/1A and 2ESRX/2B)

3. 1ESRX/1B and 1ESRX/2A (2ESRX/1B and 2ESRX/2A)

4. 1ESRX/1B and 1ESRX/2B (2ESRX/1B and 2ESRX/2B)

A.5.8 TEST AND MAINTENANCE

Testing

The Degraded Grid and Switchyard Isolation Functional Test is performed during Oconee Unit 1 refueling. The test includes (1) functional verification of overhead ACB and PCB-9 operation during switchyard isolation, (2) demonstration of the operability of the Degraded Grid Protection System (DGPS), (3) demonstration of the ability of the overhead Keowee unit to energize the 230 kV Yellow Bus for all three Oconee Units' Startup Transformers, and (4) demonstration of the capability to realign the 230 kV Yellow Bus back to the system grid while Oconee loads are being fed from the overhead Keowee unit.

A.5.9 OPERATING EXPERIENCE

There have been no reported instances of Keowee Emergency Start signal failures.

A.5.10 ASSUMPTIONS

A.5.10.1 SYSTEM DESIGN ASSUMPTIONS

1. The Keowee Start/Run Model is comprised of the control circuitry that must be actuated to emergency start the Keowee turbine units through actuation of the governor control system. Keowee controls are assumed to be in their normal operating positions.

2. The EGTPS and Keowee support systems are assumed to be in their normal operating configurations.

A.5.10.2 OPERATIONAL ASSUMPTIONS

1. The hot start sequence is challenged when the Keowee unit is running on the grid at the time the emergency start signal occurs.

2. The cold start sequence is challenged when the unit is idle, standing by for emergency operation at the time the emergency start occurs.

A.5.10.3 MODELING ASSUMPTIONS

1. The Keowee Start/Run model is a support system for the Keowee Hydro Unit Governor and Turbine System. The top events provide the sequence control logic component failures to the Keowee Hydro Unit Governor and Turbine System as follows:

   a. The Keowee Start/Run model top gate YK1CLDSTRT (Keowee 1 Governor Control Fails During A Cold Start Sequence) is one of three OR gate inputs to the Keowee Hydro Unit Governor and Turbine top event, (Keowee Unit 1 Governor or Turbine Fails During a Cold Start).

   b. The Keowee Start/Run model top gate YK1HOTSTRT (Keowee 1 Governor Control Fails During A Hot Start Sequence) is one of three OR gate inputs to the Keowee Hydro Unit Governor and Turbine top event, (Keowee 1 Governor Control Fails During a Cold Start).

   c. YK1RUNCNTL (Keowee 1 Governor Control Fails During Run) is one of three OR gate inputs to Keowee Hydro Unit Governor and Turbine System gate Keowee Unit 1 Governor Fails With the Unit Running.

2. The Keowee Unit 2 model is symmetric to the Unit 1 model.

3. Conditioning logic is applied in the high level logic model.

A.5.11 <u>FAULT TREE ANALYSIS</u>

A.5.11.1 TOP EVENT SUCCESS CRITERIA

Success of the Keowee Start/Run function requires that the governor control successfully starts the Keowee Unit and governor control continues without failure for 24 hours.

A.5.11.2 DETAILED FAILURE CRITERIA

1. Failure of Keowee governor control during a cold start is the result of demand failures of the relays, solenoids, and a battery that must function during the Keowee emergency start sequence when the Keowee unit is initially in a standby state. This includes the transmittal of the start signal and proper operation of the turbine speed switches as the unit starts and approaches operating speed.

2. Failure of Keowee governor control during a hot start involves the same potential failures that are involved in cold start except for the speed switches. There is no noticeable difference between the history of hot start and the history of cold start failure rates.

3. Failure of Keowee governor control during run is influenced by time related failures of breakers, relays, solenoids, and switches over the 24 hr mission time of the emergency generator.

A.5.11.3 DESCRIPTION OF FAULT TREE

The Keowee Start/Run fault tree is shown in Figure A.5-2. The Fault Tree Modeling Guidelines (Appendix B) were followed in developing the fault tree. A list of all fault tree transfers is presented in Table A.5-4. Modules were not developed for the Keowee fault trees.

Human reliability analysis was performed as described in Appendix C.3. Human events impacting the model are described in Section A.5.11.4.

Common-cause analysis was performed as described in Appendix C.2. Common-cause events impacting the model are described in Section A.5.11.6.

A.5.11.4 HUMAN INTERACTIONS

Human actions by the operators or maintenance technicians can adversely affect Start/Run function circuit reliability. The normal Start/Run functions are initiated nearly every day and much more frequently than the emergency start functions. Any latent human error is expected to be discovered in the daily exercise of the function.

YKEMSRTCHE

This commission error event accounts for the potential of an operator to reset an emergency start signal.

A.5.11.5 RELIABILITY DATA

Section 5.3 discusses development of the reliability data. For the base case solution, the plant-specific failure rate data and generic failure rate data were combined using a Bayesian update.

As discussed in Section 5.3, consideration of relevant statalarms is part of the process of determining each basic event factor. Keowee Start/Run statalarms are listed in Table A.5-6.

System reliability data is listed in Table A.5-6.

A.5.11.6 COMMON-CAUSE ASSESSMENT

The common cause failures of the Keowee Start/Run control circuitry are included in the Keowee PRA high level logic tree.

A.5.12 RESULTS

Reliability of the Keowee Start/Run function is defined as the probability that the system will succeed in supporting Keowee emergency operation (black start plus a 24 hour run). The system model yields a governor control failure probability of approximately 1.7E-04 for a cold start, and 2.0E-04 for a 24-hr run. The model solution for failure of a hot start (unit running at the time the LOOP occurs) results in cut sets below the solve truncation limit of 1.0E-08. Thus, the reliability of each unit's governor control cold start is 99.98%, and the 24 hr run reliability is 99.98%.

Table A.5-7 and -8 lists the dominant minimal cut sets (failure sequences) for the Keowee Start/Run functions. The relative contribution to the total for each failure is shown in these tables.

A.5.13 REFERENCES

A.5.13.1 DOCUMENTS

1. OSS-0254.00-00-2005, Rev. 2, Keowee Emergency Power Design Basis Document.

2. Duke Power Company Oconee Nuclear Station Emergency Power Switching Logic Description Of Operation

A.5.13.2 DRAWINGS

1. OEE-120, Rev. 10, (Oconee Unit 1) Channel 'A' Keowee Emergency Start.

2. OEE-120-1, Rev. 12, (Oconee Unit 1) Channel 'B' Keowee Emergency Start.

3. OEE-220, Rev. 4, (Oconee Unit 2) Channel 'A' Keowee Emergency Start.

4. OEE-220-1, Rev. 4 (Oconee Unit 2) Channel 'B' Keowee Emergency Start.

5. KEE-111, Rev. 11, (Keowee Unit 1) Turbine and Governor Systems Startup Control.

6. KEE-113, Rev. 8, (Keowee Unit 1) Master Control System Startup Controls.

7. KEE-113-03, Rev. 9, (Keowee Unit 1) Master Control System Generator Miscellaneous Relaying.

8. KEE-113-04, Rev. 8, (Keowee Unit 1) Master Control System Turbine Miscellaneous Relaying.

9. KEE-113-05, Rev. 8, (Keowee Unit 1) Master Control System Turbine Miscellaneous Relaying.

10. KEE-114-3, Rev. 11, (Keowee Unit 1) Generator Control Normal and Emergency Lockout.

Table A.5-1

Keowee Start And Run Control Power Supplies

Component	Power Supply	Compartment Number
Keowee Emergency Start Channel A	Keowee #1, 125 Vdc Power Supply Distribution Center 1DA	1DA-4CR
Keowee Emergency Start Channel B	Keowee #2, 125 Vdc Power Supply Distribution Center 2DA	2DA-2CC
ONS1 Channel A, Keowee Emergency Start Relay, KA	ONS1 125 Vdc Vital I&C Power Distribution Center 1DIA	1DIA-2
ONS1 Channel B, Keowee Emergency Start Relay, KB	ONS1 125 Vdc Vital I&C Power Distribution Center 1DIB	1DIB-2
ONS2 Channel A, Keowee Emergency Start Relay CR2A	ONS2 125 Vdc Vital I&C Power Distribution Center 2DIA	2DIA-2
ONS2 Channel B, Keowee Emergency Start Relay CR2B	ONS2 125 Vdc Vital I&C Power Distribution Center 2DIB	2DIB-2
ONS3 Channel A, Keowee Emergency Start Relay CR3A	ONS3 125 Vdc Vital I&C Power Distribution Center 3DIA	3DIA-2
ONS3 Channel B, Keowee Emergency Start Relay CR3B	ONS3 125 Vdc Vital I&C Power Distribution Center 3DIB	3DIB-2

Table A.5-2

Keowee Start And Run Control Test Procedures

Procedure	Test Frequency	Description
PT/0/A0610/22	ONS1 Refueling	Degraded Grid and Switchyard Isolation Functional Test. ("Black Start" of both Keowee units is demonstrated in this test.)

Table A.5-3

Keowee Start And Run Control Significant Operating Events

Date	Unit	Component	Event Summary
5/30/85	1/2	Emergency Start Switch	Unit 1 was Emergency Started for test. The unit operated as designed, but the Emergency Start Switch would not reset. Further Emergency Start testing was postponed until the problem was resolved. Two broken wires and a loose connection were found in the circuitry.
4/23/86	1	Key Interlock Switch	At time 1520 an attempt to start Unit 1 for an operability check after maintenance failed. The problem was an out of adjustment Key Interlock Switch. At time 1824 Unit 1 was started successfully.

Table A.5-4

Keowee Start And Run Control Fault Tree Transfers

Transfer Gate Name	Description	Components Supplied
XD1DASRCES	Loss Of Power On Keowee 1 125 Vdc Distribution Center 1DA During Start	Keowee 1 Shtdwn Sol. 99SD, Keowee 1 Emer. Load Sol. 99SN
XD2DASRCES	Loss Of Power On Keowee 2 125 Vdc Distribution Center 2DA During Start	Keowee 2 Shtdwn Sol. 99SD, Keowee 2 Emer. Load Sol. 99SN
XD1DAR	Loss Of Power To Keowee 1 125 Vdc Dist. Cntr. 1DA During Run	Shutdown Aux. Rly. 99SX Keowee 1 Shtdwn. Solenoid Keowee 1 Emer. Load Sol.
XD2DAR	Loss Of Power To Keowee 2 125 Vdc Dist. Cntr. 2DA During Run	Shutdown Aux. Rly. 99SX Keowee 2 Shtdwn. Solenoid Keowee 2 Emer. Load Sol.
XD1DA	Loss Of Power On Keowee 1 125 Vdc Dist. Cntr. 1DA	Keowee 1 Emergency Start Aux. Rly 1ESRX/1A
XD2DA	Loss Of Power On Keowee 2 125 Vdc Dist. Cntr. 2DA	Keowee 2 Emergency Start Aux. Rly 1ESRX/1B
D1DIADEX	Loss Of Power On 125 Vdc Panelboard 1DIA	Oconee 1 Channel A Keowee Emergency Start Relay KA

Table A.5-4

Keowee Start And Run Control Fault Tree Transfers

Transfer Gate Name	Description	Components Supplied
D1DIBDEX	Loss Of Power On 125 Vdc Panelboard 1DIB	Oconee 1 Channel B Keowee Emergency Start Relay KB
D2DIA	Loss Of Power On 125 Vdc Panelboard 2DIA	Oconee 2 Channel A Keowee Emergency Start Relay CR2A
D2DIB	Loss Of Power On 125 Vdc Panelboard 2DIB	Oconee 2 Channel B Keowee Emergency Start Relay CR2B
D3DIA	Loss Of Power On 125 Vdc Panelboard 3DIA	Oconee 3 Channel A Keowee Emergency Start Relay CR3A
D3DIB	Loss Of Power On 125 Vdc Panelboard 3DIB	Oconee 3 Channel B Keowee Emergency Start Relay CR3B
SEGTPSCH1F	EGTPS Channel 1 Keowee Start Signal	Oconee 1 Channel A Keowee Emergency Start Relay KA
SEGTPSCH2F	EGTPS Channel 2 Keowee Start Signal	Oconee 1 Channel B Keowee Emergency Start Relay KB
YO1MFBMA	Oconee 1 MFB Monitor Chan. A Keowee Start Signal	Oconee 1 Channel A Keowee Emergency Start Relay KA

Table A.5-4

Keowee Start And Run Control Fault Tree Transfers

Transfer Gate Nane	Description	Components Supplied
YO1MFBMB	Oconee 1 MFB Monitor Chan. B Keowee Start Signal	Oconee 1 Channel B Keowee Emergency Start Relay KB
YO2MFBMA	Oconee 2 MFB Monitor Chan. A Keowee Start Signal	Oconee 2 Channel A Keowee Emergency Start Relay CR2A
YO2MFBMB	Oconee 2 MFB Monitor Chan. B Keowee Start Signal	Oconee 2 Channel B Keowee Emergency Start Relay CR2B
YO3MFBMA	Oconee 3 MFB Monitor Chan A Keowee Start Signal	Oconee 3 Channel A Keowee Emergency Start Relay CR3A
YO3MFBMB	Oconee 3 MFB Monitor Chan B Keowee Start Signal	Oconee 3 Channel B Keowee Emergency Start Relay CR3B

Table A.5-5

Keowee Start And Run Control Statalarms

Point No.	Alarm	Actuator
	ALARM PANELS ON 1VB2	
1SA14-28	KEO. EMERG. START CHNL. B LOGIC INITIATE	KB
1SA14-29	KEO. EMERG. START CHNL. B LOGIC DC PWR LOST	8ESB
1SA14-30	SWYD ISOLATION CONFIRMED CHNL. B LOGIC	SIB
1SA15-28	KEO. EMERG. START CHNL. A LOGIC INITIATE	KA
1SA15-29	KEO. EMERG. START CHNL. A LOGIC DC PWR LOST	8ESA
1SA15-30	SWYD ISOLATION CONFIRMED CHNL. A LOGIC	SIA
1SA16-19	13.8KV FEEDER DE-ENERGIZED	TDUVX

Table A.5-5

Keowee Start And Run Control Statalarms

Point No.	Alarm	Actuator
	ALARM PANELS ON 2VB2	
2SA14-28	KEO. EMERG. START CHNL. B LOGIC INITIATE	CR2B
2SA14-29	KEO. EMERG. START CHNL. B LOGIC DC PWR LOST	8ESB
2SA15-28	KEO. EMERG. START CHNL. A LOGIC INITIATE	CR2A
2SA15-29	KEO. EMERG. START CHNL. A LOGIC DC PWR LOST	8ESA

Table A.5-5

Keowee Start And Run Control Statalarms

Point No.	Alarm	Actuator
	ALARM PANELS ON 3VB2	
3SA14-28	KEO. EMERG. START CHNL B LOGIC INITIATE	CR3B
3SA14-29	KEO. EMERG. START CHNL B LOGIC DC PWR LOST	8ESB
3SA15-28	KEO. EMERG. START CHNL A LOGIC INITIATE	CR3A
3SA15-29	KEO. EMERG. START CHNL. A LOGIC DC PWR LOST	8ESA

Table A.5-6

Keowee Start and Run Control Reliability Data

Event Name	Description	Failure Rate[1]	Factor	Rationale For Factor[2]	Failure Probability
D1DIAXXDEX	Loss Of Power On 125 V dc Panelboard 1DIA				6.50E-06
D1DIBXXDEX	Loss Of Power On 125 V dc Panelboard 1DIB				6.50E-06
D2DIAXXDEX	Loss Of Power On 125 V dc Panelboard 2DIA				6.50E-06
D2DIBXXDEX	Loss of Power on 125 V dc Panelboard 2DIB				6.50E-06
D3DIAXXDEX	Loss Of Power On 125 V dc Panelboard 3DIA				6.50E-06
D3DIBXXDEX	Loss Of Power On 125 Vdc Panelboard 3DIB				6.50E-06
ED13BR2CDT	Breaker 3BR In 125V dc Distribution Center 1DA Transfers Open	7.50E-08 /H	24 H		1.80E-06
ED23BR2CDT	Breaker 3BR In 125V dc Distribution Center 2DA Transfers Open	7.50E-08 /H	24 H		1.80E-06
EU1C1RORYD	ONS1 ESG Chan. 1 Ro Relay Fails To Pick Up	3.30E-05 /D	1 D	(No credit taken for a start signal from Oconee Engineered Safeguards System.)	1.00E+00
EU1C2RORYD	ONS1 ESG Chan. 2 Ro Relay Fails to Pick Up	3.30E-05 /D	1 D	(No credit taken for a start signal from Oconee Engineered Safeguards System.)	1.00E+00
EU2C1RORYD	ONS2 ESG Chan. 1 Ro Relay Fails to Pick Up	3.30E-05 /D	1 D	(No credit taken for a start signal from Oconee Engineered Safeguards System.)	1.00E+00

Table A.5-6

Keowee Start and Run Control Reliability Data

Event Name	Description	Failure Rate[1]	Factor	Rationale For Factor[2]	Failure Probability
EU2C2RORYD	ONS2 ESG Chan. 2 Ro Relay Fails to Pick Up	3.30E-05 /D	1 D	(No credit taken for a start signal from Oconee Engineered Safeguards System.)	1.00E+00
EU3C1RORYD	ONS3 ESG Chan. 1 Ro Relay Fails to Pick Up	3.30E-05 /D	1 D	(No credit taken for a start signal from Oconee Engineered Safeguards System.)	1.00E+00
EU3C2RORYD	ONS3 ESG Chan. 2 Ro Relay Fails to Pick Up	3.30E-05 /D	1 D	(No credit taken for a start signal from Oconee Engineered Safeguards System.)	1.00E+00
GK186E1RYT	Keowee 1 Emergency Lockout Relay 86E-1 Spuriously Picks Up	3.60E-07 /H	24 H		8.64E-06
GK286E2RYT	Keowee 2 Emergency Lockout Relay 86E-2 Spuriously Picks Up	3.60E-07 /H	24 H		8.64E-06
XD104CCCDT	Breaker 1DA-4CC Transfers Open	7.50E-08 /H	24 H		1.80E-06
XD104CRCDT	Breaker 1DA-4CR Transfers Open	7.50E-08 /H	6 H		3.96E-07
XD202CCCDT	Breaker 2DA-2CC Transfers Open	7.50E-08 /H	24 H		1.80E-06
XD204CCCDT	Breaker 2DA-4CC Transfers Open	7.50E-08 /H	24 H		1.80E-06
YK114X3SSD	Keowee 1 Speed Switch 14-3 Fails to Open at 65 rpm	1.80E-05 /D	1 D		1.80E-05
YK13SUISWT	KHU#1 Startup Inhibit Sw 3SUI Xfrs to Inhibit	7.00E-08 /H	24 H		1.68E-06
YK14AMRRYT	Keowee 1 Master Relay 4A Spuriously Drops Out	3.60E-07 /H	24 H		8.64E-06
YK14BMRRYT	Keowee 1 Master Relay 4B Spuriously Drops Out	3.60E-07 /H	24 H		8.64E-06

Table A.5-6

Keowee Start and Run Control Reliability Data

Event Name	Description	Failure Rate[1]	Factor	Rationale For Factor[2]	Failure Probability
YK163BHLST	Keowee 1 Gen Thrst Brng Oil Lvl Hi Sw 63BL/H Sprsly Clsd	3.10E-07 /H	24 H		7.44E-06
YK163BHRYT	Keowee 1 Gen Thrst Brng Oil Lvl Hi Rly 63BL/HX Sprsly Picks Up	3.60E-07 /H	24 H		8.64E-06
YK163BLLST	Keowee 1 Gen Thrst Brng Oil Lvl Lo Sw 63BL/L Spuriously Operates	3.10E-07 /H	24 H		7.44E-06
YK163BLRYT	Keowee 1 Gen Thrst Brng Oil Lvl Lo Rly 63BL/LXTD Sprsly PIcks Up	3.60E-07 /H	24 H		8.64E-06
YK163TBLST	Keowee 1 Turb Guide Brng Lo Lvl Sensor Sw Spuriously Closes	3.10E-07 /H	24 H		7.44E-06
YK163TBRYT	Keowee 1 Turb Gd Brng Oil Lvl Lo Rly 63TB/1X Sprsly Picks Up	3.60E-07 /H	24 H		8.64E-06
YK186N1DEX	Keowee 1 Normal Lockout Actuates				9.89E-03
YK199SDRYD	Keowee 1 Shutdown Solenoid 99SD Fails To Pick Up	3.30E-05 /D	1 D		3.30E-05
YK199SDRYT	Keowee 1 Shutdown Solenoid Spuriously Drops Out	3.60E-07 /H	24 H		8.64E-06
YK199SNRYD	K1 Emergency Load Solenoid 99SN Fails To Pick Up/Drop Out	3.30E-05 /D	1 D		3.30E-05
YK199SNRYT	Emergency Load Solenoid 99SN Spuriously Drops Out	3.60E-07 /H	24 H		8.64E-06
YK199SXRYD	Keowee 1 Shutdown Solenoid Aux Relay 99SX Fails to Pick Up	3.30E-05 /D	1 D		3.30E-05
YK199SXRYT	Shutdown Auxiliary Relay 99SX Spuriously Drops Out	3.60E-07 /H	24 H		8.64E-06
YK1D4CRFUF	Fuse 1DA-4CR Fails	3.60E-06 /H	6 H		2.16E-05

Table A.5-6

Keowee Start and Run Control Reliability Data

Event Name	Description	Failure Rate[1]	Factor	Rationale For Factor[2]	Failure Probability
YK1ES1ARYD	Keowee 1 Emergency Start Aux Relay 1ESRX/1A Fails To Pick Up	3.30E-05 /D	1 D		3.30E-05
YK1ES1BRYD	Keowee 1 Emergency Start Aux Relay 1ESRX/1B Fails To Pick Up	3.30E-05 /D	1 D		3.30E-05
YK1ES2ARYD	Keowee 1 Emergency Start Aux Relay 1ESRX/2A Fails To Pick Up	3.30E-05 /D	1 D		3.30E-05
YK1ES2BRYD	Keowee 1 Emergency Start Aux Relay 1ESRX/2B Fails To Pick Up	3.30E-05 /D	1 D		3.30E-05
YK1MR4ARYD	Keowee 1 Start Master Relay 4A Fails To Pick Up	3.30E-05 /D	1 D		3.30E-05
YK1MR4BRYD	Keowee 1 Start Master Relay 4B Fails To Pick Up	3.30E-05 /D	1 D		3.30E-05
YK1SS12SST	Keowee 1 Overspeed Switch 12 Spuriously Picks Up	4.21E-06 /H	24 H		1.01E-04
YK1SS13SSD	Keowee 1 Speed Switch 13 Fails to Close at 122 rpm	1.80E-05 /D	1 D		1.80E-05
YK214X3SSD	KHU#2 Speed Switch 14-3 Fails to Open at 65 rpm	1.80E-05 /D	1 D		1.80E-05
YK23SUISWT	KHU#2 Startup Inhbt Sw 3SUI Sprsly Xfrs to Inhibit	7.00E-08 /H	24 H		1.68E-06
YK24AMRRYT	Keowee 2 Master Relay 4A Spuriously Drops Out	3.60E-07 /H	24 H		8.64E-06
YK24BMRRYT	Keowee 2 Master Relay 4B Spuriously Drops Out	3.60E-07 /H	24 H		8.64E-06
YK263BHLST	Keowee 2 Gen Thrst Brng Oil Lvl Hi Sw 63BL/H Sprsly Clsd	3.10E-07 /H	24 H		7.44E-06

Table A.5-6

Keowee Start and Run Control Reliability Data

Event Name	Description	Failure Rate[1]	Factor	Rationale For Factor[2]	Failure Probability
YK263BHRYT	Keowee 2 Gen Thrst Brng Oil Lvl Hi Rly 63BL/HX Sprsly Picks Up	3.60E-07 /H	24 H		8.64E-06
YK263BLLST	Keowee 2 Gen Thrst Brng Oil Lvl Lo Sw 63BL/L Sprsly Opens	3.10E-07 /H	24 H		7.44E-06
YK263BLRYT	Keowee 2 Gen Thrst Brng Oil Lvl Lo Rly 63BL/LXTD Sprsly Picks Up	3.60E-07 /H	24 H		8.64E-06
YK263TBLST	Keowee 2 Turb Guide Brng Lo Lvl Sensor Sw Sprsly Closes	3.10E-07 /H	24 H		7.44E-06
YK263TBRYT	Keowee 2 Turb Gd Brng Oil Lvl Lo Rly 63TB/1X Sprsly Picks Up	3.60E-07 /H	24 H		8.64E-06
YK286N2DEX	Keowee Unit 2 Normal Lockout Activates				7.41E-03
YK299SDRYD	Keowee 2 Shutdown Solenoid 99SD Fails To Pick Up	3.30E-05 /D	1 D		3.30E-05
YK299SDRYT	Keowee 2 Shutdown Solenoid Spuriously Drops Out	3.60E-07 /H	24 H		8.64E-06
YK299SNRYD	Keowee 2 Emergency Load Solenoid 99SN Fails To Operate	3.30E-05 /D	1 D		3.30E-05
YK299SNRYT	Emergency Load Solenoid 99SN Spuriously Drops Out	3.60E-07 /H	24 H		8.64E-06
YK299SXRYD	Keowee 2 Shutdown Solenoid Aux Relay 99SX Fails to Pick Up	3.30E-05 /D	1 D		3.30E-05
YK299SXRYT	Shutdown Auxiliary Relay 99SX Spuriously Drops Out	3.60E-07 /H	24 H		8.64E-06
YK2D2CCFUF	Fuse 2DA-2CC Fails	3.60E-06 /H	6 H		2.16E-05

Table A.5-6

Keowee Start and Run Control Reliability Data

Event Name	Description	Failure Rate[1]	Factor	Rationale For Factor[2]	Failure Probability
YK2ES1ARYD	Keowee 2 Emergency Start Aux Relay 2ESRX/1A Fails To Pick Up	3.30E-05 /D	1 D		3.30E-05
YK2ES1BRYD	Keowee 2 Emergency Start Aux Relay 2ESRX/1B Fails to Pick Up	3.30E-05 /D	1 D		3.30E-05
YK2ES2ARYD	Keowee 2 Emergency Start Aux Relay 2ESRX/2A Fails to Pick Up	3.30E-05 /D	1 D		3.30E-05
YK2ES2BRYD	Keowee 2 Emergency Start Aux Relay 2ESRX/2B Fails to Pick Up	3.30E-05 /D	1 D		3.30E-05
YK2MR4ARYD	Keowee 2 Start Master Relay 4A Fails To Pick Up	3.30E-05 /D	1 D		3.30E-05
YK2MR4BRYD	Keowee 2 Start Master Relay 4B Fails to Pick Up	3.30E-05 /D	1 D		3.30E-05
YK2SS12SST	Keowee 2 Overspeed Switch 12 Spuriously Picks Up	4.21E-06 /H	24 H		1.01E-04
YK2SS13SSD	Keowee 2 Speed Switch 13 Fails to Close at 122 rpm	1.80E-05	1 D		1.80E-05
YKEMSRTCHE	Operator Incorrectly Resets Keowee Emergency Start Signals			(Event included for sensitivity study only.)	0.00E+00
YO1DIA2CDT	DC Circuit Breaker 1DIA-2 Transfers Position	7.50E-08 /H	30 H		2.25E-06
YO1DIB2CDT	DC Circuit Breaker 1DIB-2 Transfers Position	7.50E-08 /H	30 H		2.25E-06
YO1OPSARHE	Operator fails to operate Keowee start switch S1A		1 D	(No credit taken for Oconee Operator action.)	1.00E+00
YO1OPSBRHE	Operator fails to operate Keowee start switch S1B		1 D	(No credit taken for Oconee Operator action.)	1.00E+00

Table A.5-6

Keowee Start and Run Control Reliability Data

Event Name	Description	Failure Rate[1]	Factor	Rationale For Factor[2]	Failure Probability
YO1S1AFSWC	Control Switch S1A Fails To Close On Demand	1.00E-05 /D	1 D		1.00E-05
YO1S1BFSWC	Control Switch S1B Fails To Close On Demand	1.00E-05 /D	1 D		1.00E-05
YO1XXKARYD	ONS1 Ch A Keowee Emergency Start Relay KA Fails to Pick Up	3.30E-05 /D	1 D		3.30E-05
YO1XXKBRYD	Oconee Unit 1 Chan. B Keowee Emergency Start Relay Fails	3.30E-05 /D	1 D		3.30E-05
YO2CR2ARYD	ONS2 Ch A Keowee Emergency Start Relay CR2A Fails to Pick Up	3.30E-05 /D	1 D		3.30E-05
YO2CR2BRYD	ONS2 Keowee Emergency Start Relay CR2B Fails to Pick Up	3.30E-05 /D	1 D		3.30E-05
YO2DIA2CDT	Breaker 2DIA-2 Transfers Position	7.50E-08 /H	30 H		2.25E-06
YO2DIB2CDT	Breaker 2DIB-2 Transfers Position	7.50E-08 /H	30 H		2.25E-06
YO2SSWARHE	Operator Fails to Operate Keowee Start Switch 2SSW'A'		1 D	(No credit taken for Oconee Operator action.)	1.00E+00
YO2SSWASWC	Control Switch 2SSW'A' Fails To Close On Demand	1.00E-05 /D	1 D		1.00E-05
YO2SSWBRHE	Operator Fails to Operate Keowee Start Switch 2SSW'B'		1 D	(No credit taken for Oconee Operator action.)	1.00E+00
YO2SSWBSWC	Control Switch 2SSW'B' Fails To Close On Demand	1.00E-05 /D	1 D		1.00E-05
YO3CR3ARYD	ONS3 Ch A Keowee Emergency Start Relay CR3A Fails To Pick Up	3.30E-05 /D	1 D		3.30E-05
YO3CR3BRYD	ONS3 Keowee Emer Start Relay CR3B Fails to Pick Up	3.30E-05 /D	1 D		3.30E-05

Table A.5-6

Keowee Start and Run Control Reliability Data

Event Name	Description	Failure Rate[1]	Factor	Rationale For Factor[2]	Failure Probability
YO3DIA2CDT	Breaker 3DIA-2 Transfers Open	7.50E-08 /H	30 H		2.25E-06
YO3DIB2CDT	Breaker 3DIB-2 Transfers Open	7.50E-08 /H	30 H		2.25E-06
YO3OPFARHE	Operator fails to operate Keowee Start Switch 3S1A		1 D	(No credit taken for Oconee Operator action.)	1.00E+00
YO3OPFBRHE	Operator Fails to Operate Keowee Start Switch 3S1B		1 D	(No credit taken for Oconee Operator action.)	1.00E+00
YO3S1AFSWC	Control Switch S1A Fails To Close On Demand	1.00E-05 /D	1 D		1.00E-05
YO3S1BFSWC	Control Switch S1B Fails To Close On Demand	1.00E-05 /D	1 D		1.00E-05
YO3SSWARHE	Operator fails to operate Keowee Start Switch 3SSW'A'		1 D	(No credit taken for Oconee Operator action.)	1.00E+00
YO3SSWASWC	Control Switch 3SSW'A' Fails To Close On Demand	1.00E-05 /D	1 D		1.00E-05
YO3SSWBRHE	Operator Fails to Operate Keowee Start Switch 3SSW'B'		1 D	(No credit taken for Oconee Operator action.)	1.00E+00
YO3SSWBSWC	Control Switch 3SSW'B' Fails To Close On Demand	1.00E-05 /D	1 D		1.00E-05

[1] D = Demand, H = Hour

[2] Rules for assigning basic event factors are discussed in Table C.1-4.

Table A.5-7

Keeowee Start and Run Control Dominant Minimal Cut Sets

Cut Sets For Gate YK1CLDSTRT: Keowee 1 Governor Control Fails During A Cold Start Sequence

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
1)	3.30E-05	19.6	YK199SDRYD	3.30E-05	Keowee 1 Shutdown Solenoid 99SD Fails To Pick Up
2)	3.30E-05	19.6	YK199SNRYD	3.30E-05	K1 Emergency Load Solenoid 99SN Fails To Pick Up/Drop Out
3)	3.30E-05	19.6	YK199SXRYD	3.30E-05	Keowee 1 Shutdown Solenoid Aux Relay 99SX Fails to Pick Up
4)	3.30E-05	19.6	YK1MR4ARYD	3.30E-05	Keowee 1 Start Master Relay 4A Fails To Pick Up
5)	1.80E-05	10.7	YK1SS13SSD	1.80E-05	Keowee 1 Speed Switch 13 Fails to Close at 122 rpm
6)	1.80E-05	10.7	YK114X3SSD	1.80E-05	Keowee 1 Speed Switch 14-3 Fails to Open at 65 rpm
Total:	1.68E-04				

Table A.5-8

Keowee Start and Run Control Dominant Minimal Cut Sets

Cut Sets For Gate YK1RUNCNTL: Keowee 1 Governor Control Fails During Run

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
1)	1.01E-04	51.0	YK1SS12SST	1.01E-04	Keowee 1 Overspeed Switch 12 Spuriously Picks Up
2)	8.64E-06	4.4	YK163BHRYT	8.64E-06	Keowee 1 Gen Thrst Brng Oil Lvl Hi Rly 63BL/HX Sprsly Picks
3)	8.64E-06	4.4	YK163BLRYT	8.64E-06	Keowee 1 Gen Thrst Brng Oil Lvl Lo Rly 63BL/LXTD Sprsly Pcks
4)	8.64E-06	4.4	YK163TBRYT	8.64E-06	Keowee 1 Turb Gd Brng Oil Lvl Lo Rly 63TB/1X Sprsly Picks Up
5)	8.64E-06	4.4	YK14AMRRYT	8.64E-06	Keowee 1 Master Relay 4A Spuriously Drops Out
6)	8.64E-06	4.4	GK186E1RYT	8.64E-06	Keowee 1 Emergency Lockout Relay 86E-1 Spuriously Picks Up
7)	8.64E-06	4.4	YK199SDRYT	8.64E-06	Keowee 1 Shutdown Solenoid Spuriously Drops Out
8)	8.64E-06	4.4	YK199SXRYT	8.64E-06	Shutdown Auxiliary Relay 99SX Spuriously Drops Out
9)	8.64E-06	4.4	YK199SNRYT	8.64E-06	Emergency Load Solenoid 99SN Spuriously Drops Out
10)	7.44E-06	3.8	YK163TBLST	7.44E-06	Keowee 1 Turb Guide Brng Lo Lvl Sensor Sw Spuriously Closes

Table A.5-8

Keeowee Start and Run Control Dominant Minimal Cut Sets

Cut Sets For Gate YK1RUNCNTL: Keowee 1 Governor Control Fails During Run

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
11)	7.44E-06	3.8	YK163BLLST	7.44E-06	Keowee 1 Gen Thrst Brng Oil Lvl Lo Sw 63BL/L Spuriously Oper
12)	7.44E-06	3.8	YK163BHLST	7.44E-06	Keowee 1 Gen Thrst Brng Oil Lvl Hi Sw 63BL/H Sprsly Clsd
13)	1.80E-06	0.9	ED13BR2CDT	1.80E-06	Breaker 3BR In 125V dc Distribution Center 1DA Transfers Ope
14)	1.80E-06	0.9	XD104CCCDT	1.80E-06	Breaker 1DA-4CC Transfers Open
15)	1.68E-06	0.8	YK13SUISWT	1.68E-06	KHU#1 Startup Inhibit Sw 3SUI Xfrs to Inhibit
Total:	1.98E-04				

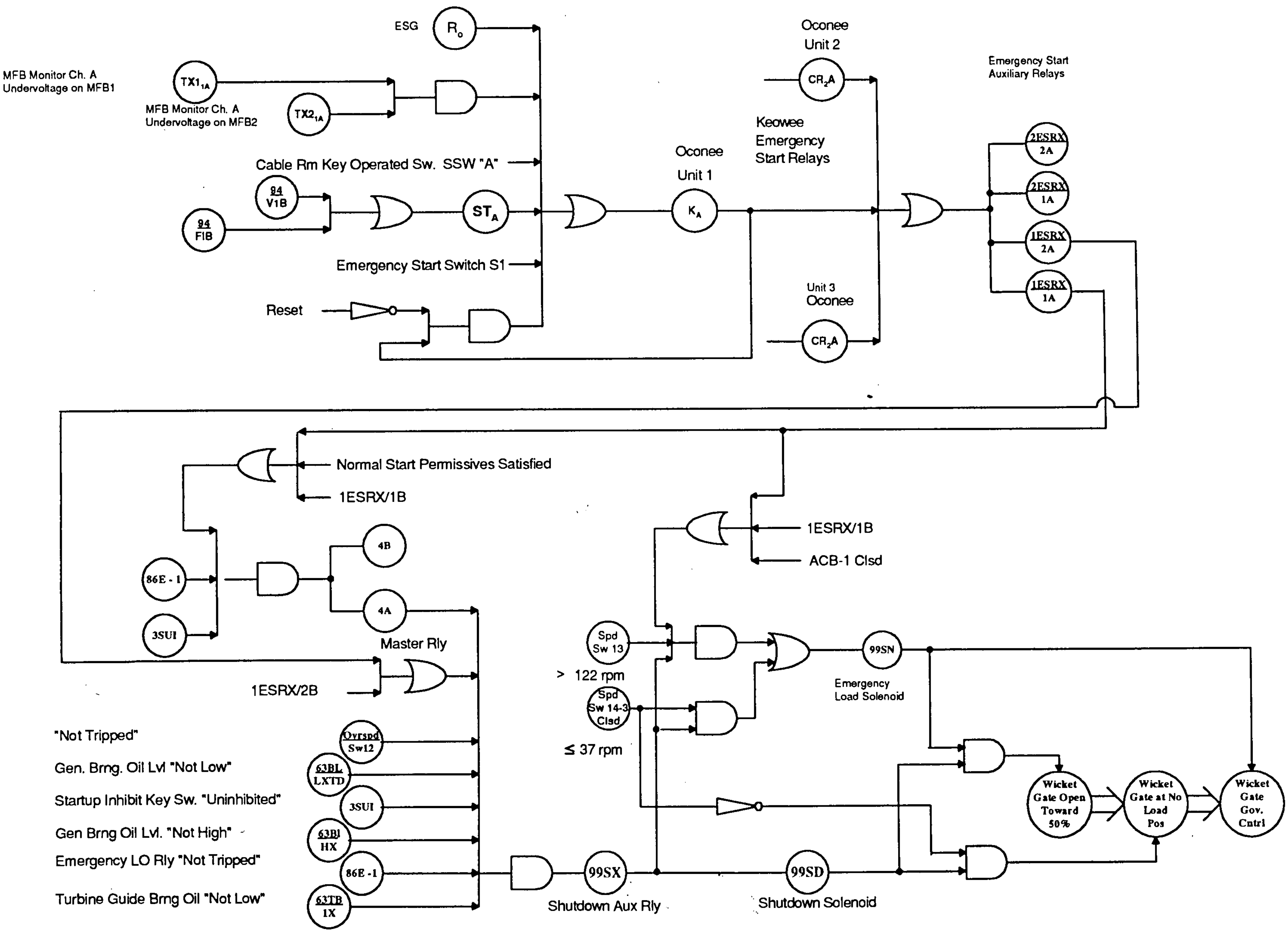
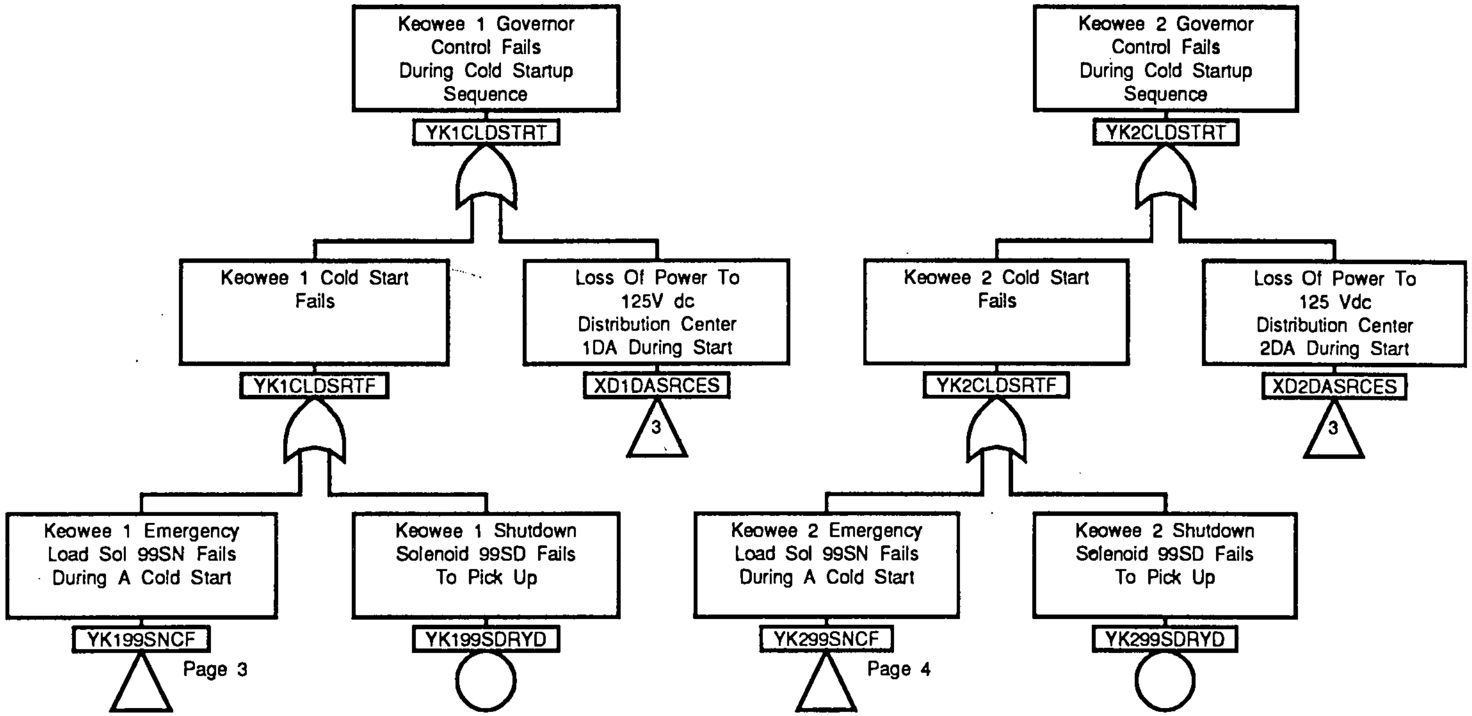
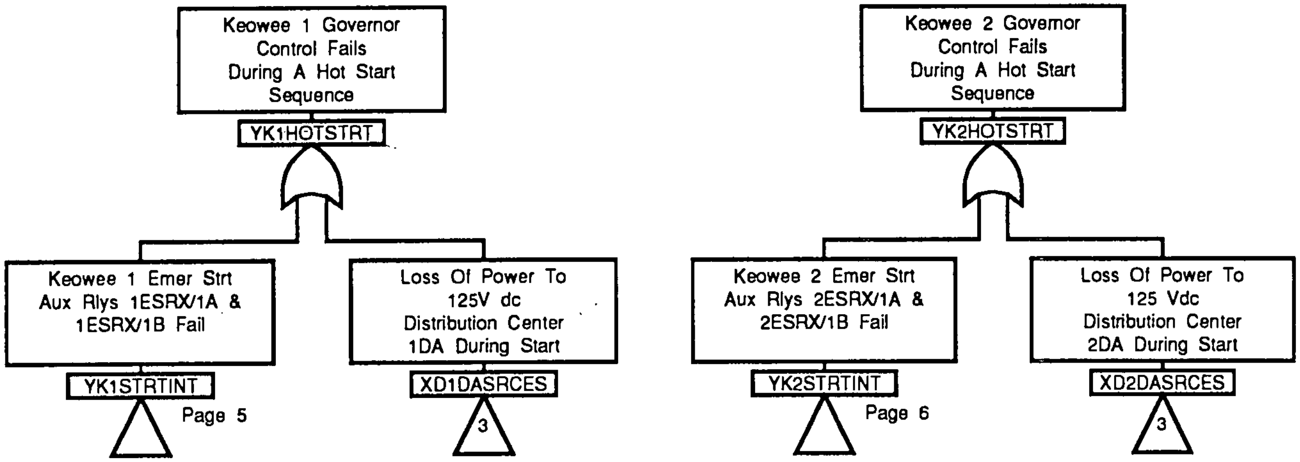
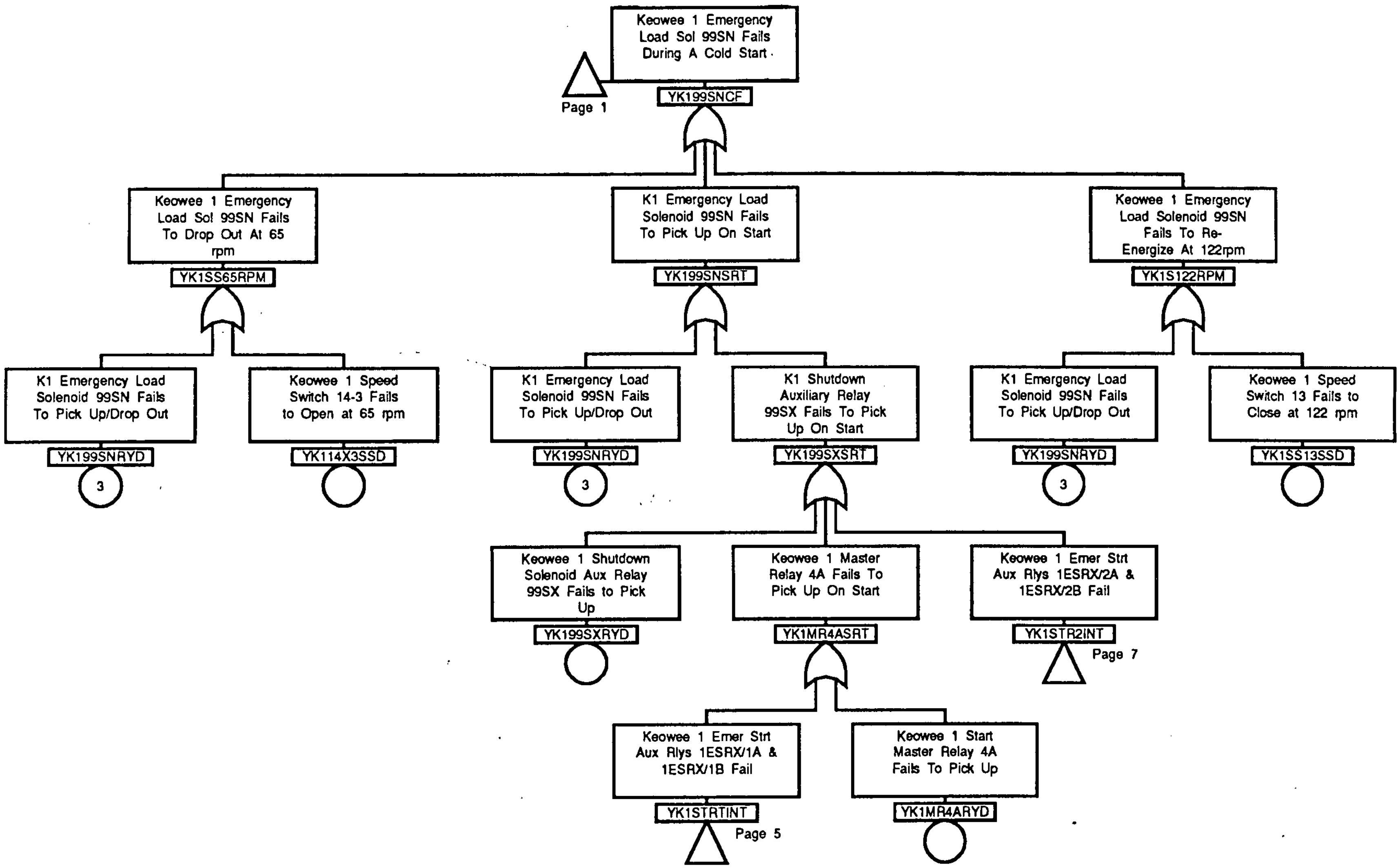


Figure A.5-1 Keowee Unit 1 Emergency Start Logic

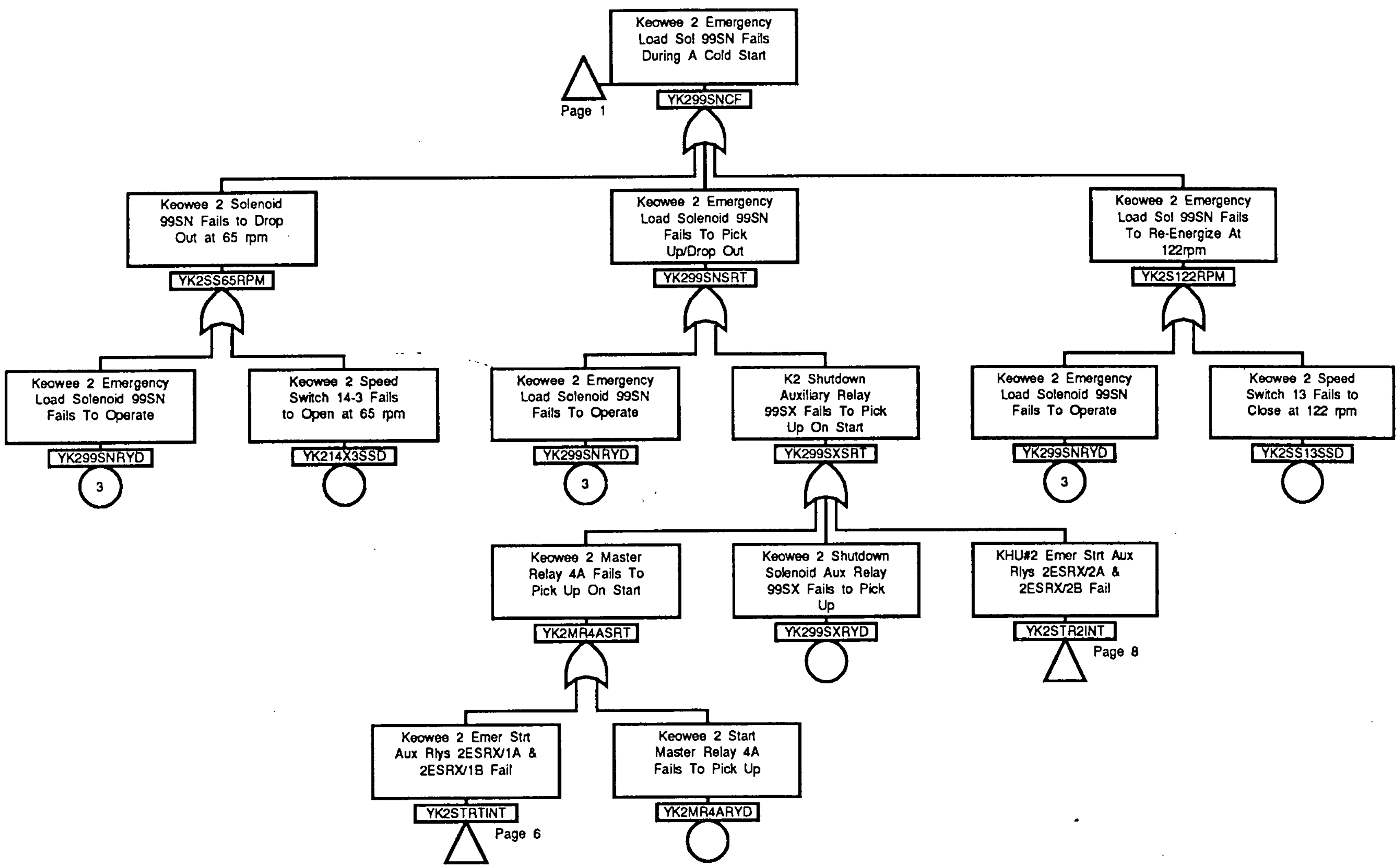


Keowee (Emergency) Start/Run Fault Tree	FIGURE A.5-2	Page 1

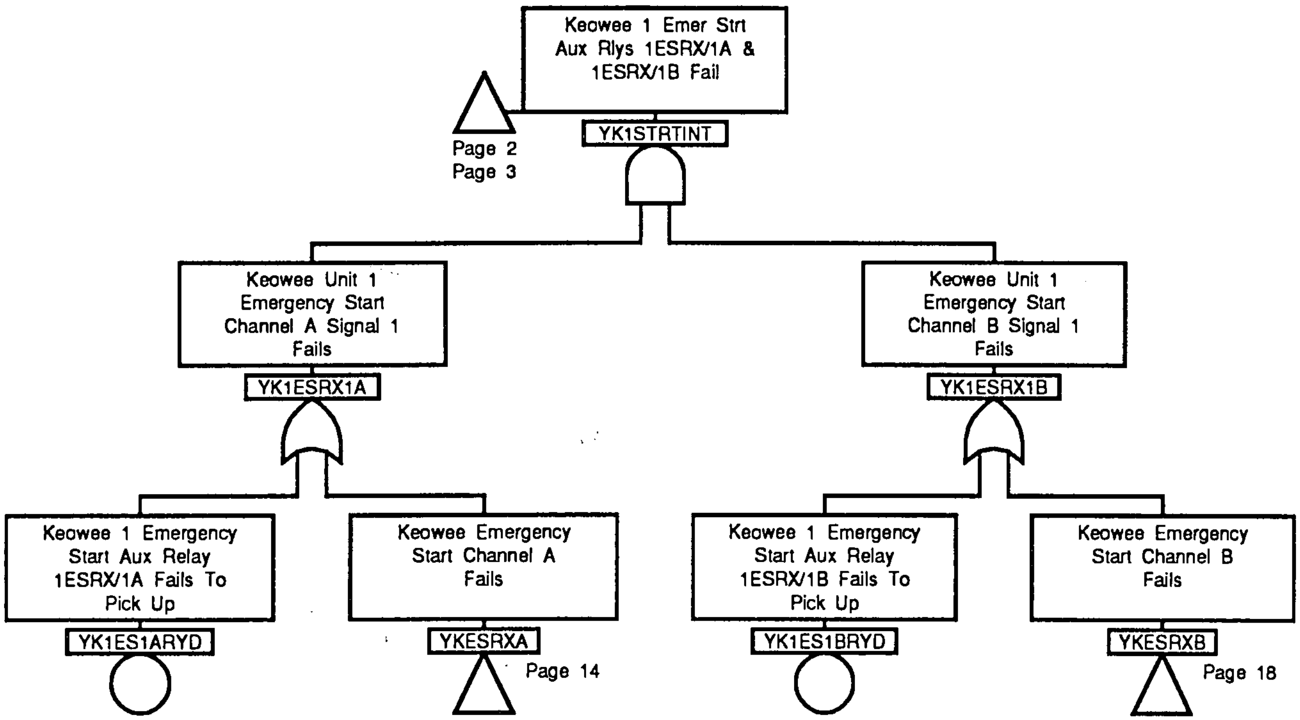

Keewee 1 Governor Control Fails During A Hot Start Sequence
YK1HOTSTRT
Keowee 1 Emer Strt Aux Rlys 1ESRX/1A & 1ESRX/1B Fail
YK1STRTINT
Page 5
Loss Of Power To 125V dc Distribution Center 1DA During Start
XD1DASRCES
3
Keowee 2 Governor Control Fails During A Hot Start Sequence
YK2HOTSTRT
Keowee 2 Emer Strt Aux Rlys 2ESRX/1A & 2ESRX/1B Fail
YK2STRTINT
Page 6
Loss Of Power To 125 Vdc Distribution Center 2DA During Start
XD2DASRCES
3



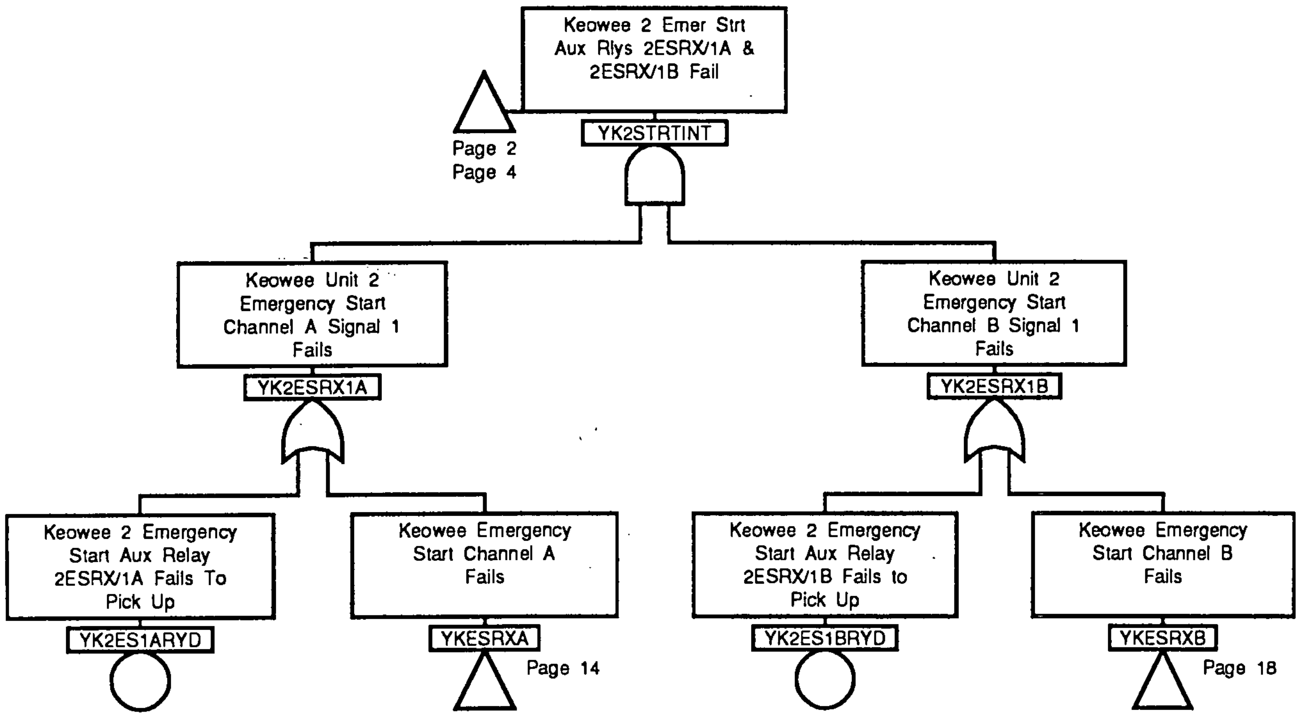
Keowee (Emergency) Start/Run Fault Tree | FIGURE A.5-2 | Page 3



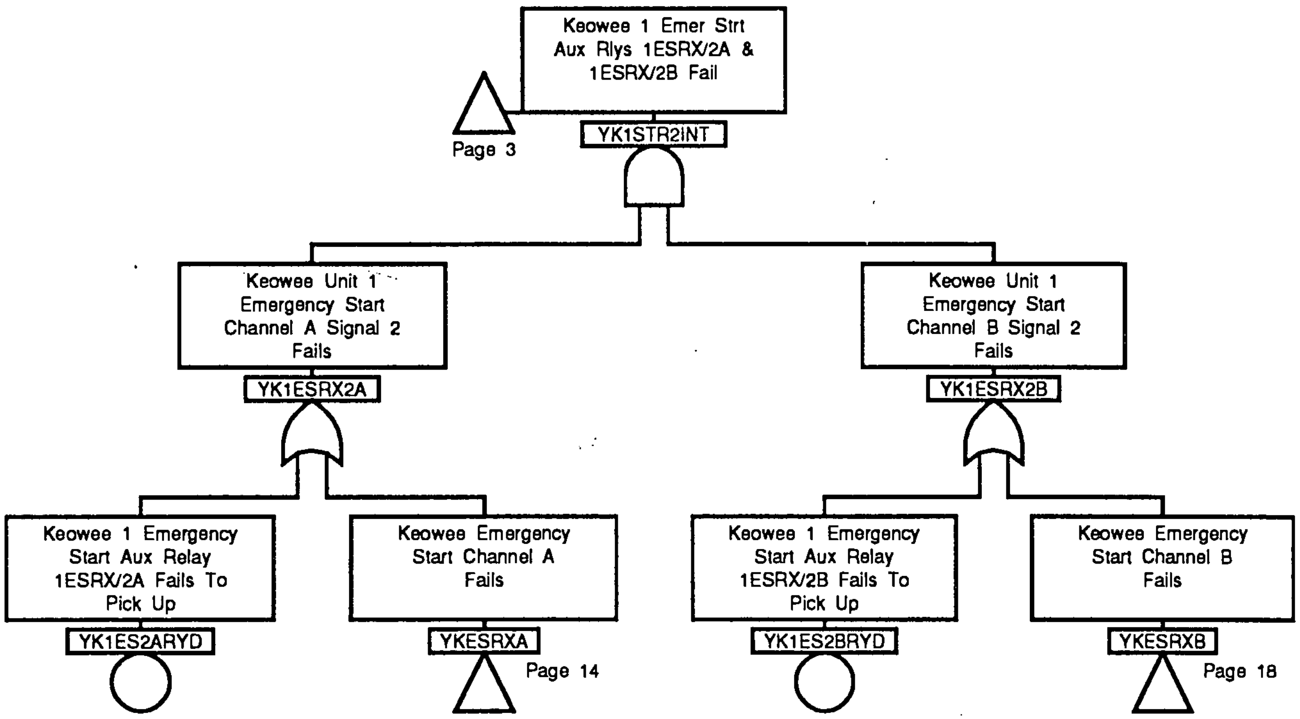
Keowee (Emergency) Start/Run Fault Tree | FIGURE A.5-2 |

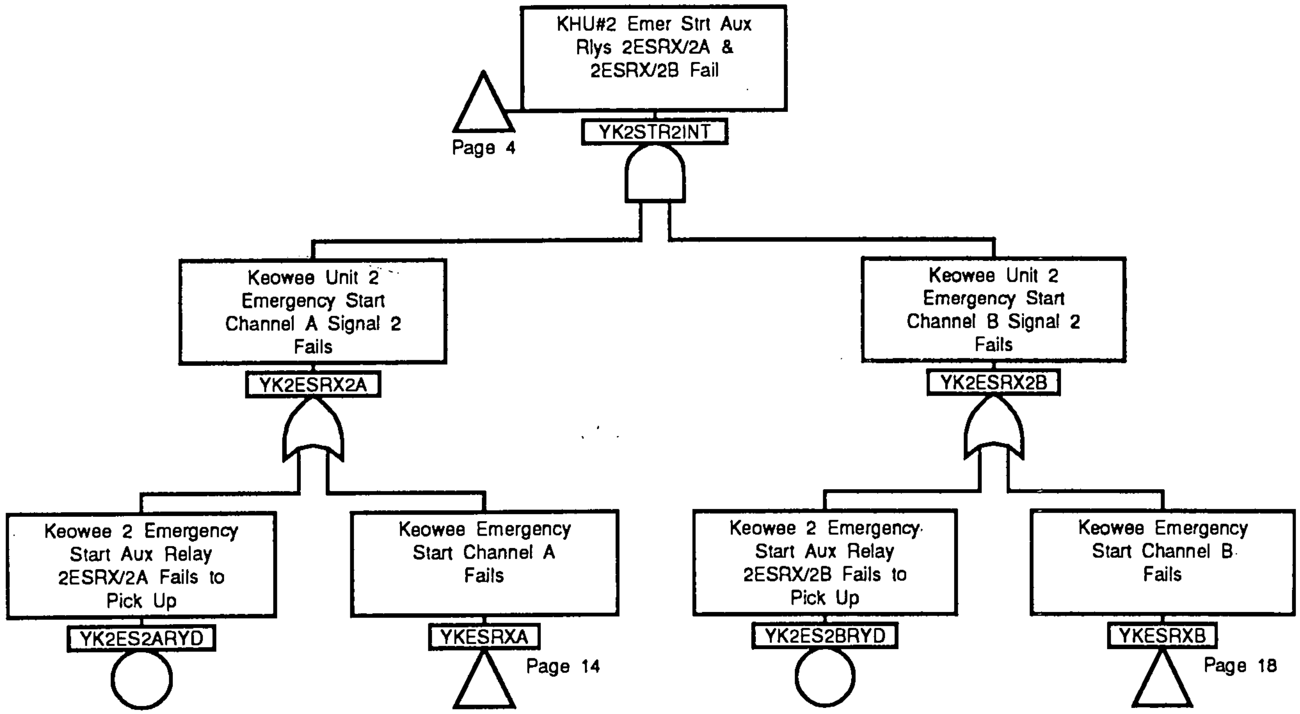


Keowee (Emergency) Start/Run Fault Tree | FIGURE A.5-2 |

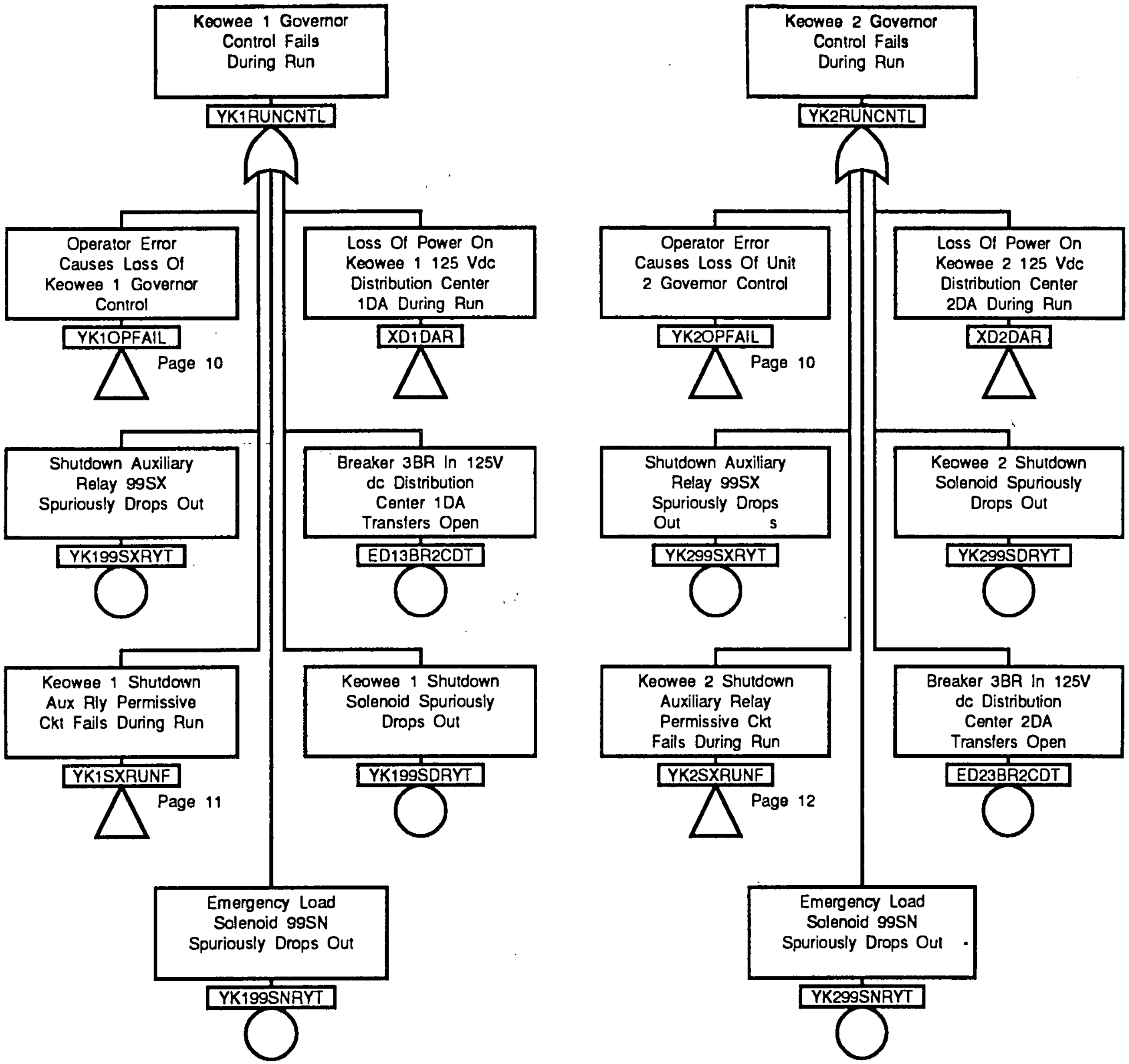


Keowee 2 Emer Strt Aux Rlys 2ESRX/1A & 2ESRX/1B Fail
YK2STRTINT
Page 2
Page 4
Keowee Unit 2 Emergency Start Channel A Signal 1 Fails
YK2ESRX1A
Keowee Unit 2 Emergency Start Channel B Signal 1 Fails
YK2ESRX1B
Keowee 2 Emergency Start Aux Relay 2ESRX/1A Fails To Pick Up
YK2ES1ARYD
Keowee Emergency Start Channel A Fails
YKESRXA
Page 14
Keowee 2 Emergency Start Aux Relay 2ESRX/1B Fails to Pick Up
YK2ES1BRYD
Keowee Emergency Start Channel B Fails
YKESRXB
Page 18

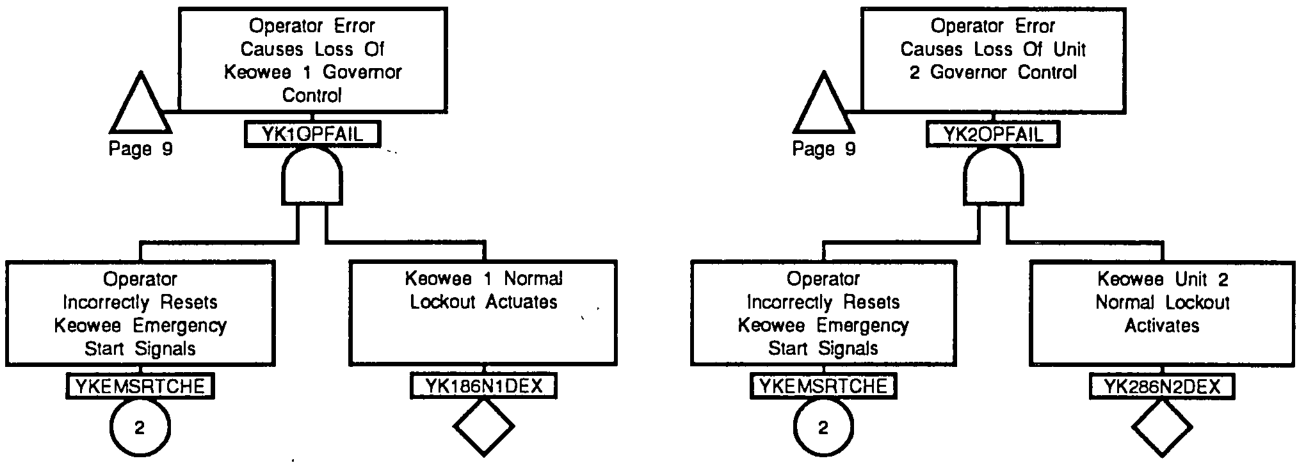

Keowee 1 Emer Strt Aux Rlys 1ESRX/2A & 1ESRX/2B Fail
YK1STR2INT
Page 3
Keowee Unit 1 Emergency Start Channel A Signal 2 Fails
YK1ESRX2A
Keowee Unit 1 Emergency Start Channel B Signal 2 Fails
YK1ESRX2B
Keowee 1 Emergency Start Aux Relay 1ESRX/2A Fails To Pick Up
YK1ES2ARYD
Keowee Emergency Start Channel A Fails
YKESRXA
Page 14
Keowee 1 Emergency Start Aux Relay 1ESRX/2B Fails To Pick Up
YK1ES2BRYD
Keowee Emergency Start Channel B Fails
YKESRXB
Page 18



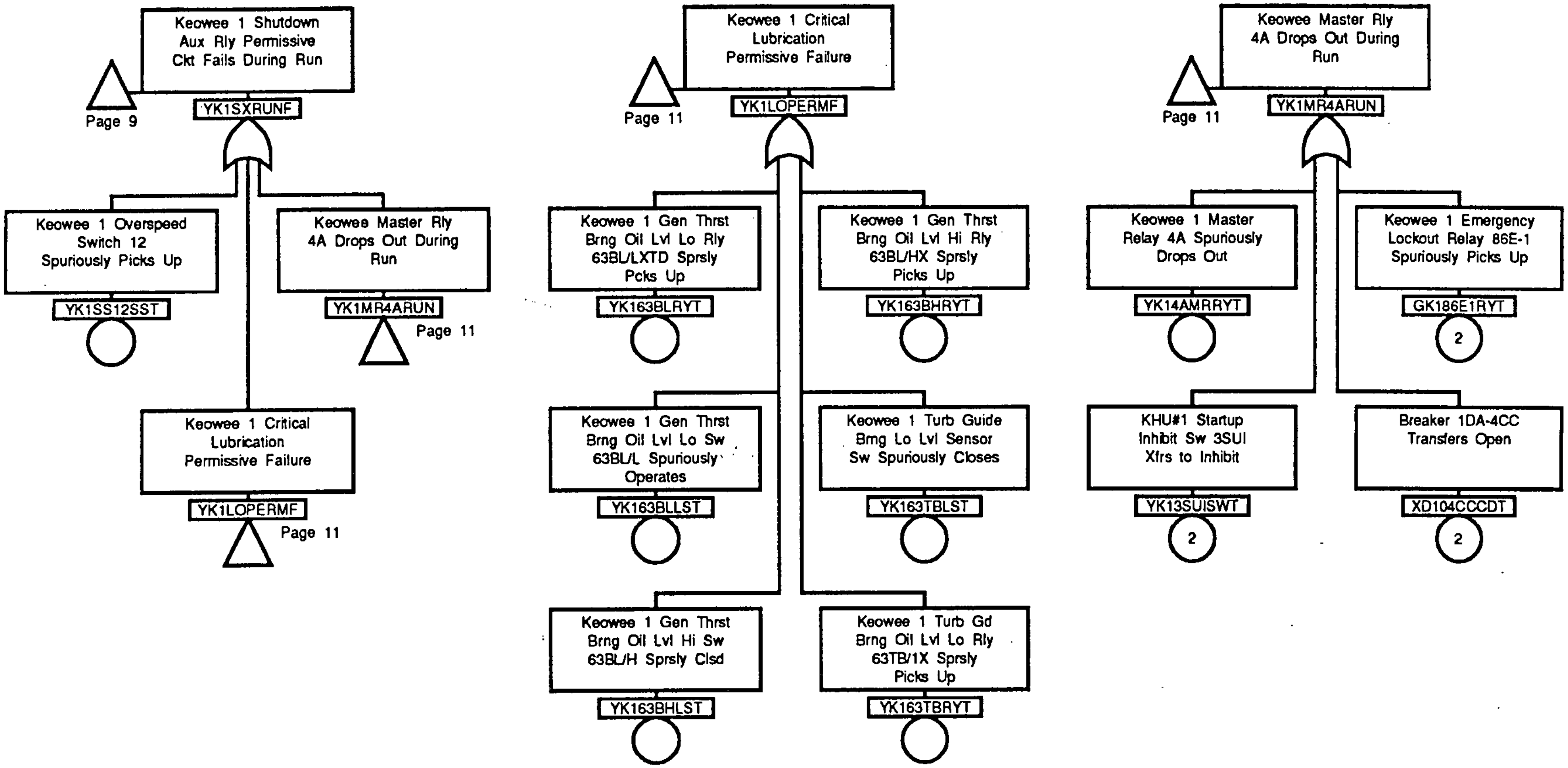
Keowee (Emergency) Start/Run Fault Tree | FIGURE A.5-2 |



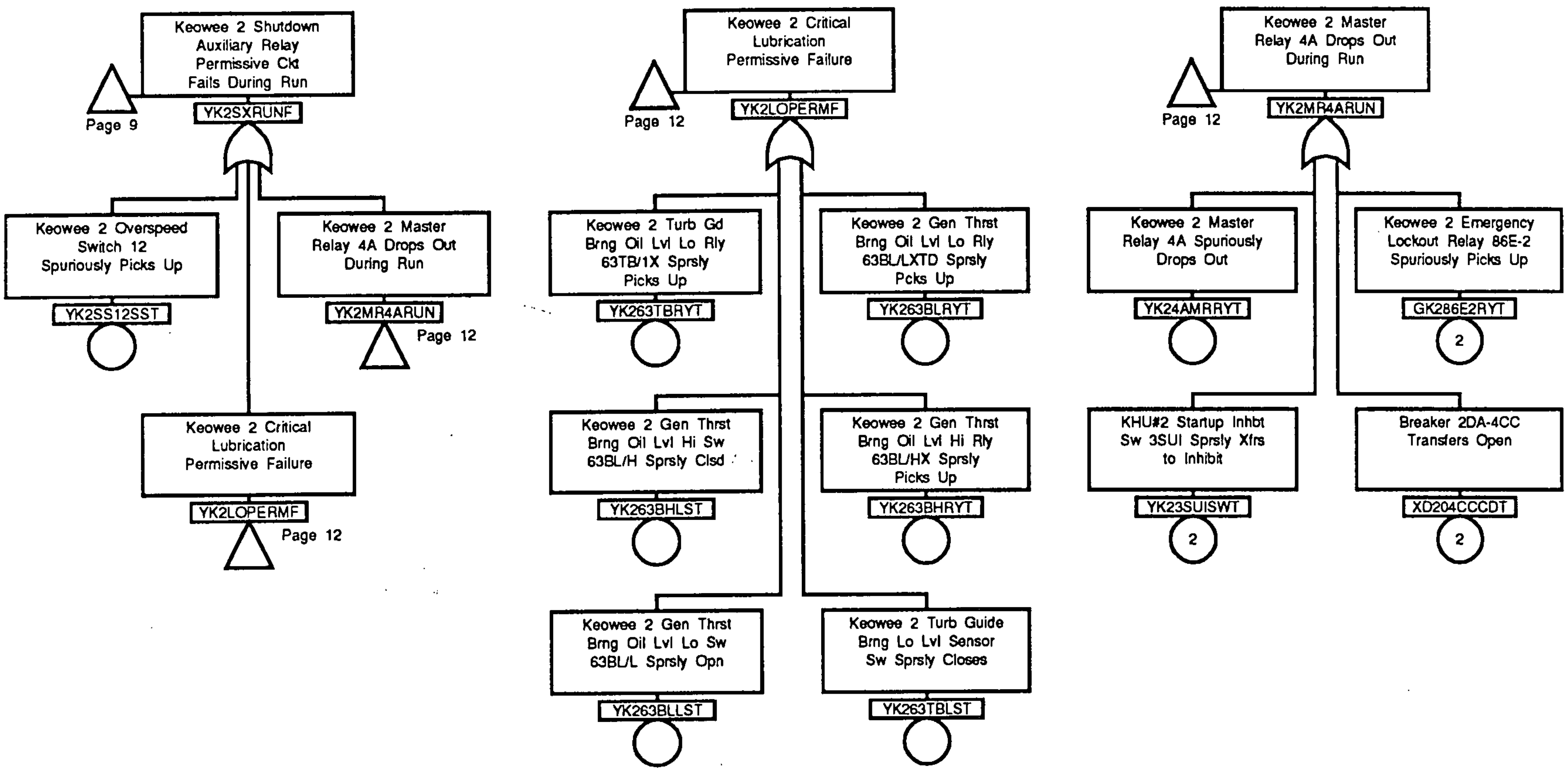
Keowee 1 Governor Control Fails During Run
YK1RUNCNTL
Operator Error Causes Loss Of Keowee 1 Governor Control
YK1OPFAIL
Page 10
Loss Of Power On Keowee 1 125 Vdc Distribution Center 1DA During Run
XD1DAR
Shutdown Auxiliary Relay 99SX Spuriously Drops Out
YK199SXRYT
Breaker 3BR In 125V dc Distribution Center 1DA Transfers Open
ED13BR2CDT
Keowee 1 Shutdown Aux Rly Permissive Ckt Fails During Run
YK1SXRUNF
Page 11
Keowee 1 Shutdown Solenoid Spuriously Drops Out
YK199SDRYT
Emergency Load Solenoid 99SN Spuriously Drops Out
YK199SNRYT
Keowee 2 Governor Control Fails During Run
YK2RUNCNTL
Operator Error Causes Loss Of Unit 2 Governor Control
YK2OPFAIL
Page 10
Loss Of Power On Keowee 2 125 Vdc Distribution Center 2DA During Run
XD2DAR
Shutdown Auxiliary Relay 99SX Spuriously Drops Out
YK299SXRYT
Keowee 2 Shutdown Solenoid Spuriously Drops Out
YK299SDRYT
Keowee 2 Shutdown Auxiliary Relay Permissive Ckt Fails During Run
YK2SXRUNF
Page 12
Breaker 3BR In 125V dc Distribution Center 2DA Transfers Open
ED23BR2CDT
Emergency Load Solenoid 99SN Spuriously Drops Out
YK299SNRYT



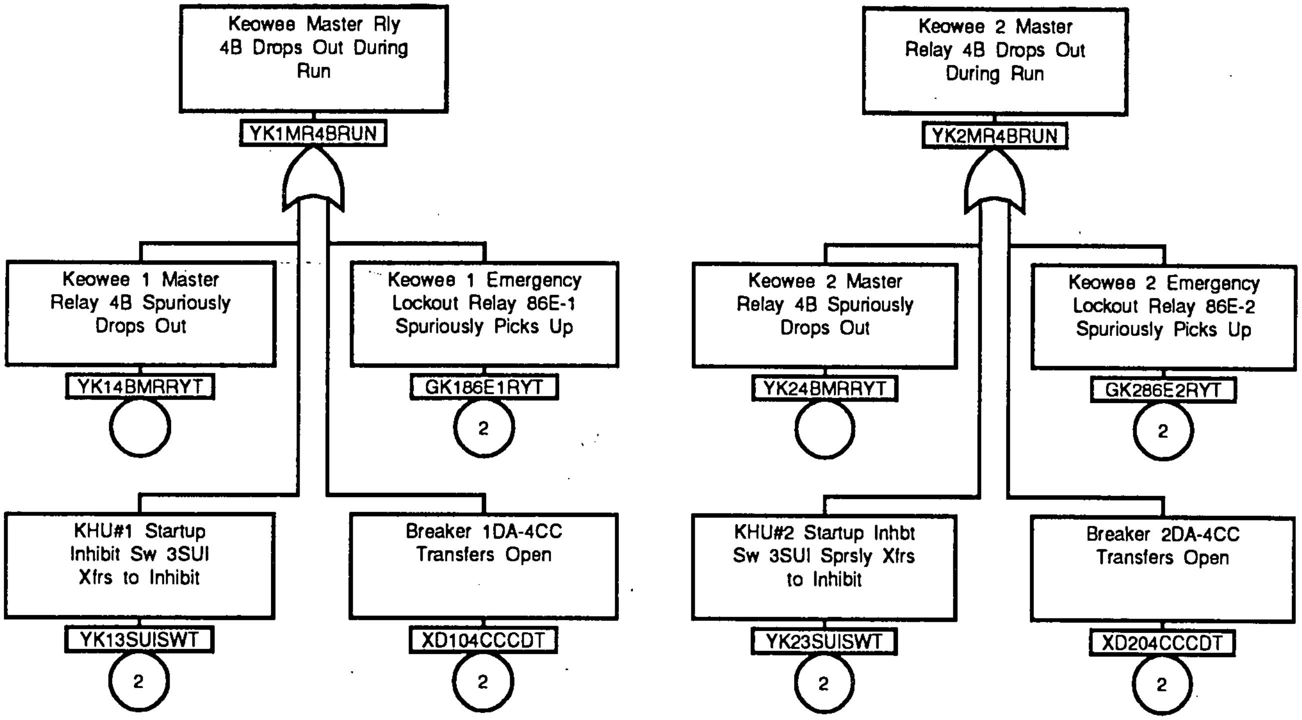
Keowee (Emergency) Start/Run Fault Tree | FIGURE A.5-2 |



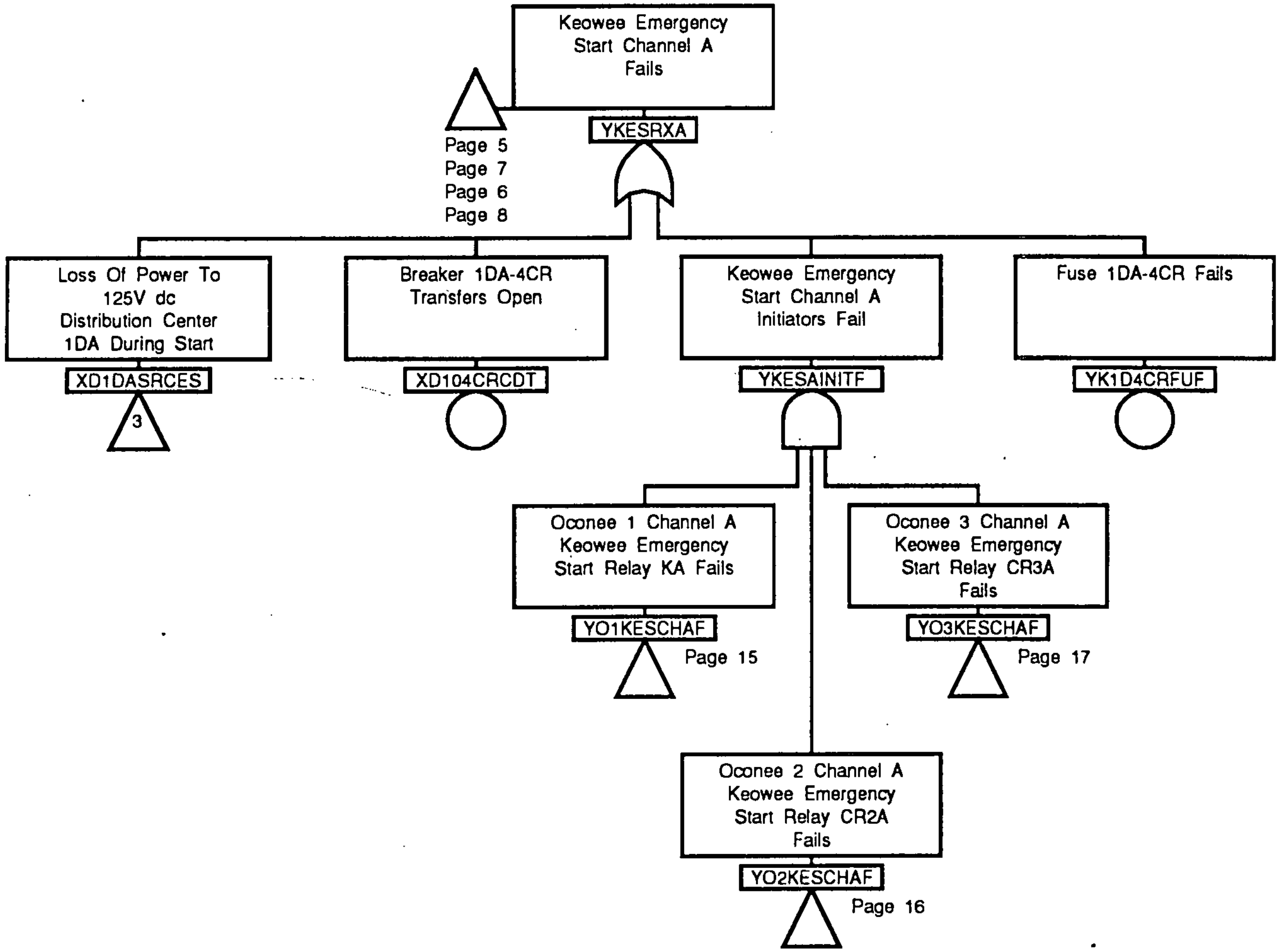
Keowee (Emergency) Start/Run Fault Tree | FIGURE A.5-2 |



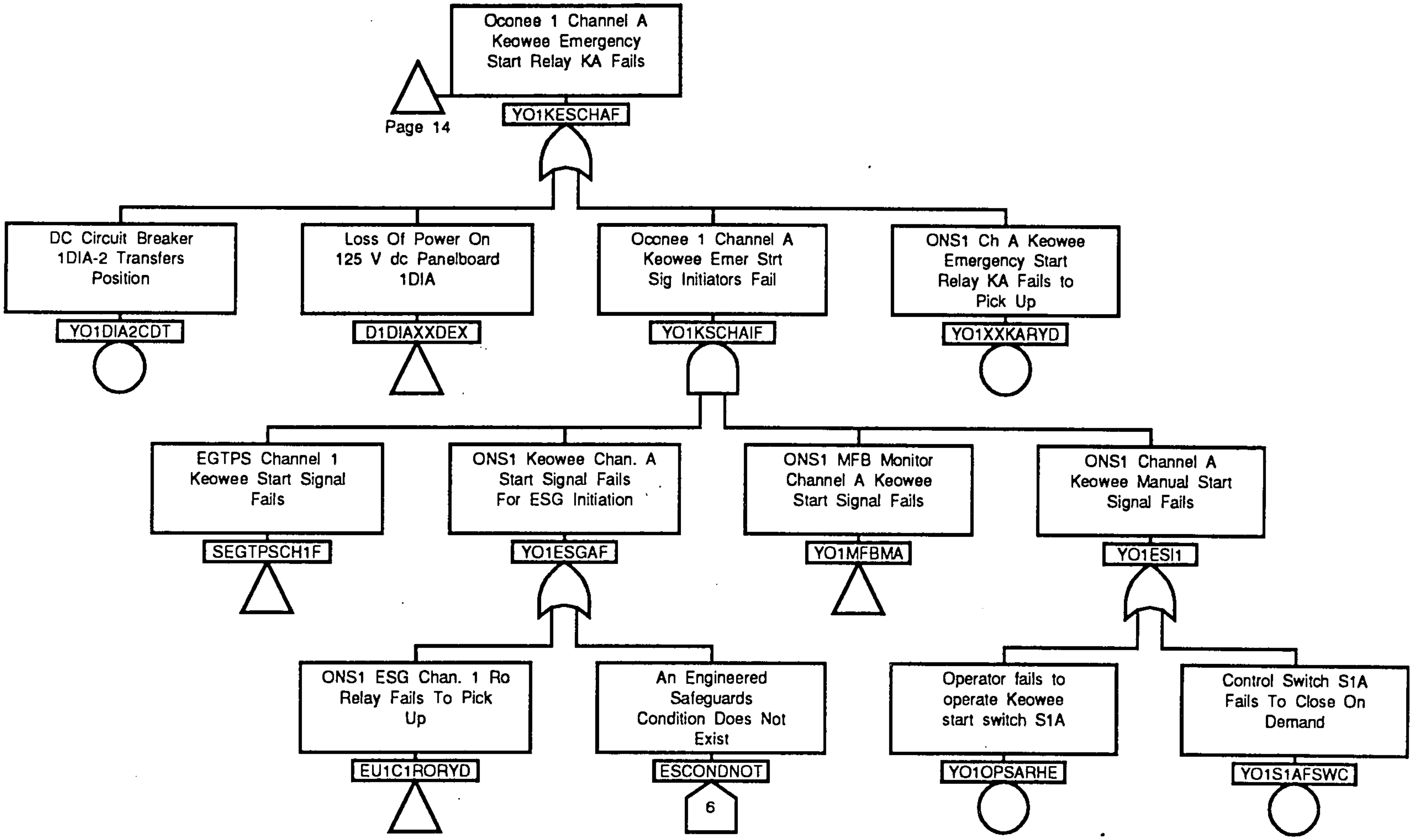
Keowee (Emergency) Start/Run Fault Tree | FIGURE A.5-2 |



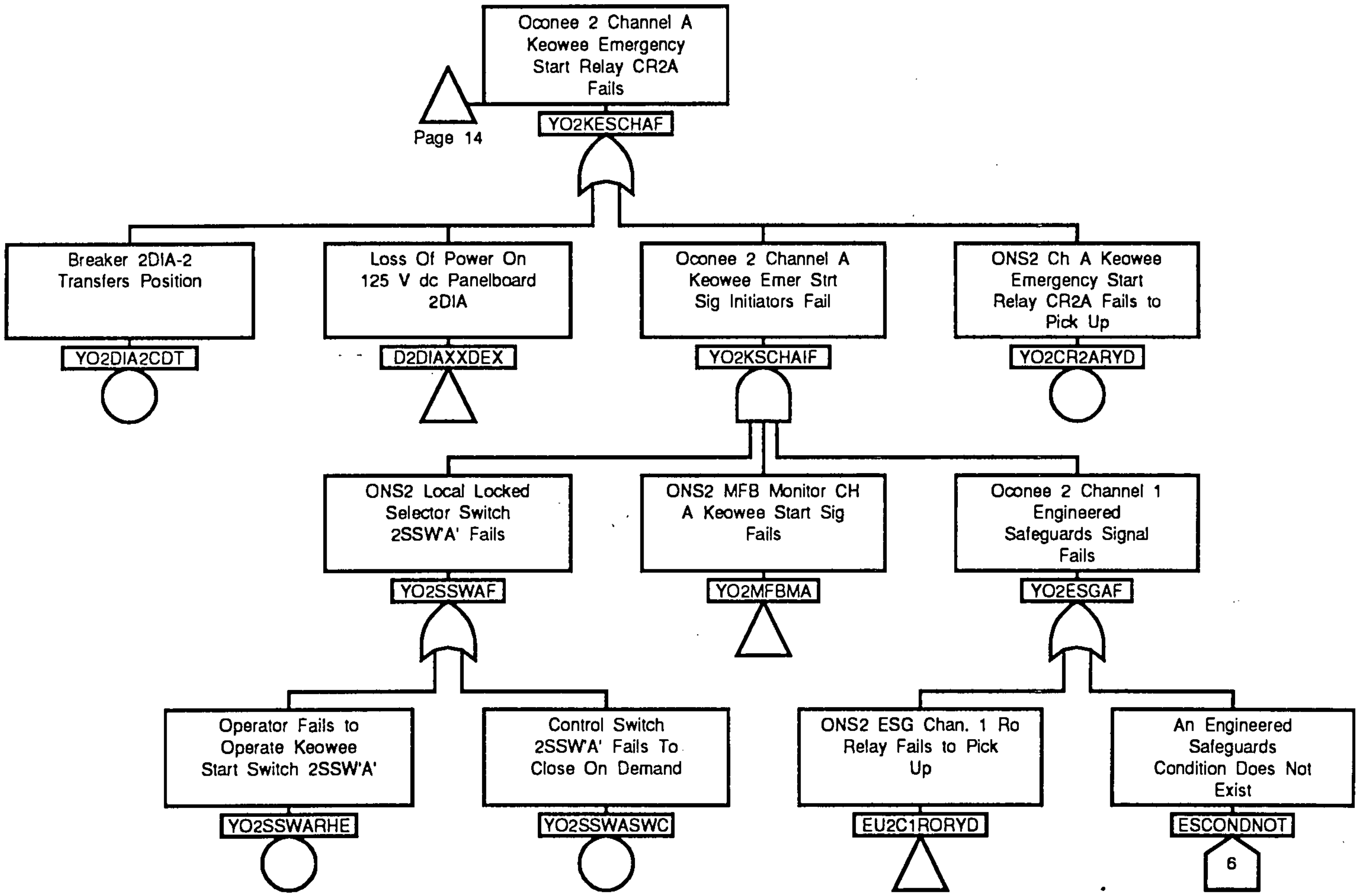
Keowee (Emergency) Start/Run Fault Tree	FIGURE A.5-2	Page 13



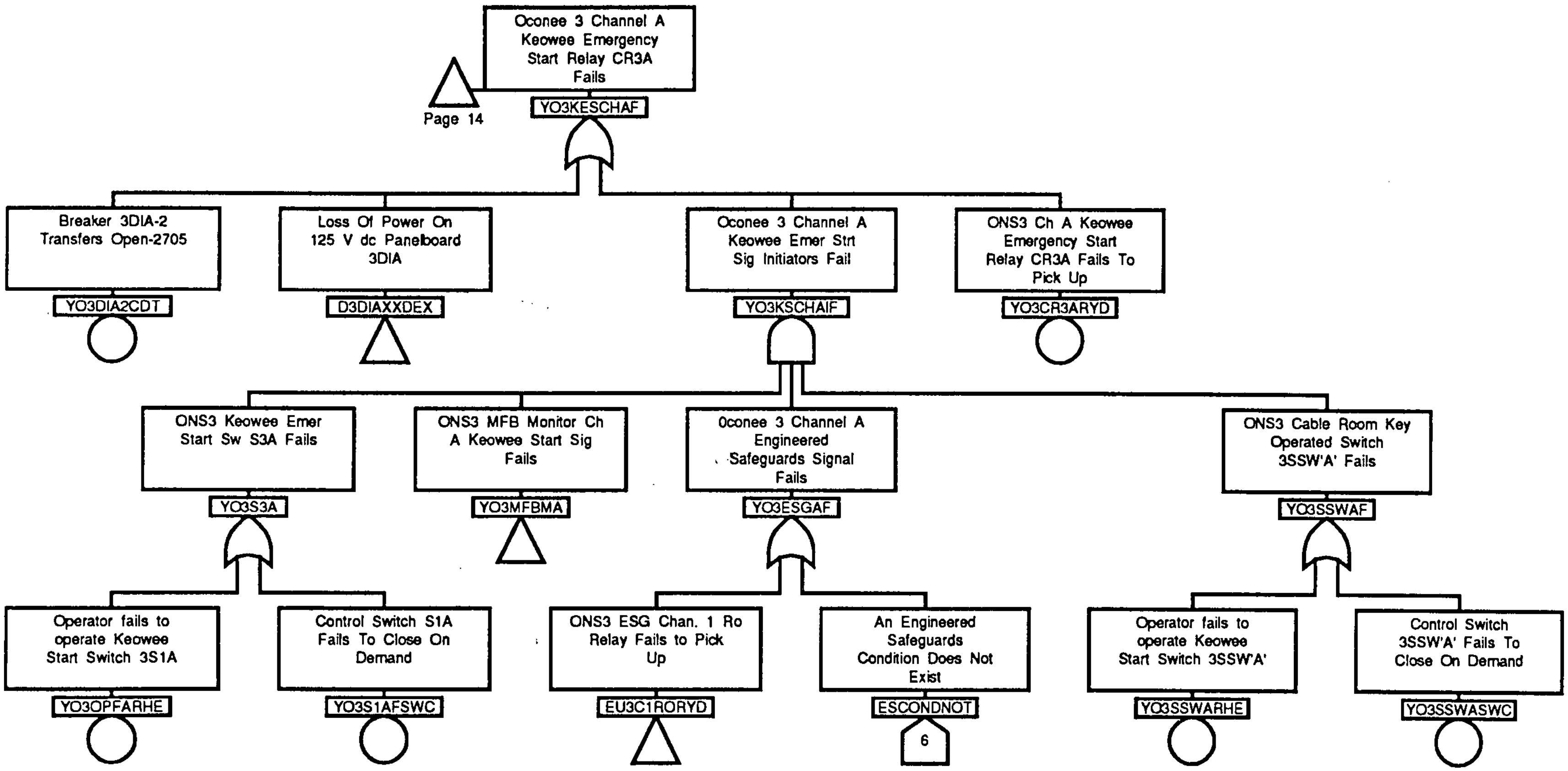
Keowee Emergency Start Channel A Fails
YKESRXA
Page 5
Page 7
Page 6
Page 8
Loss Of Power To 125V dc Distribution Center 1DA During Start
XD1DASRCES
3
Breaker 1DA-4CR Transfers Open
XD104CRCDT
Keowee Emergency Start Channel A Initiators Fail
YKESAINITF
Fuse 1DA-4CR Fails
YK1D4CRFUF
Oconee 1 Channel A Keowee Emergency Start Relay KA Fails
YO1KESCHAF
Page 15
Oconee 3 Channel A Keowee Emergency Start Relay CR3A Fails
YO3KESCHAF
Page 17
Oconee 2 Channel A Keowee Emergency Start Relay CR2A Fails
YO2KESCHAF
Page 16

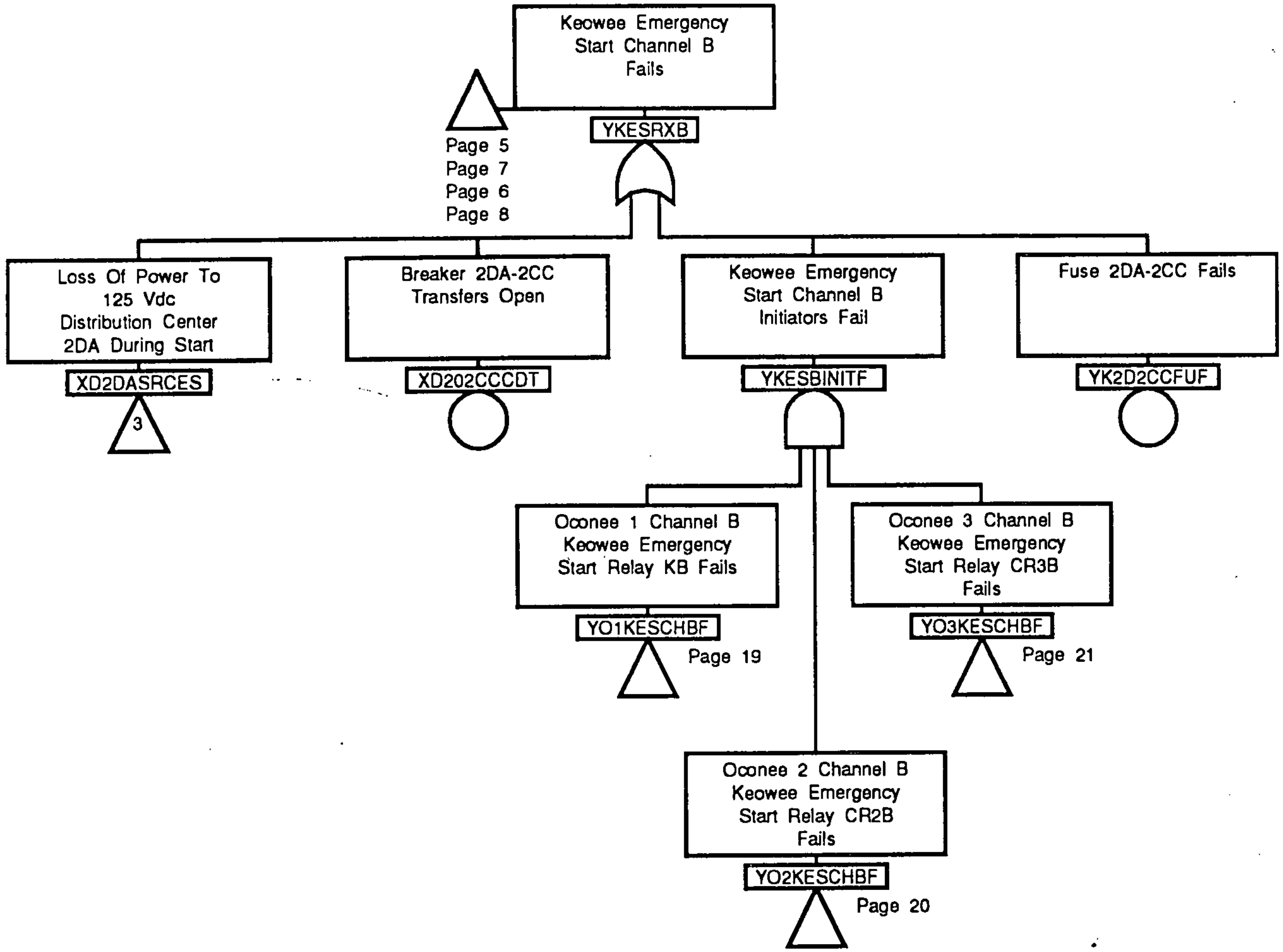


Keowee (Emergency) Start/Run Fault Tree | FIGURE A.5-2 |

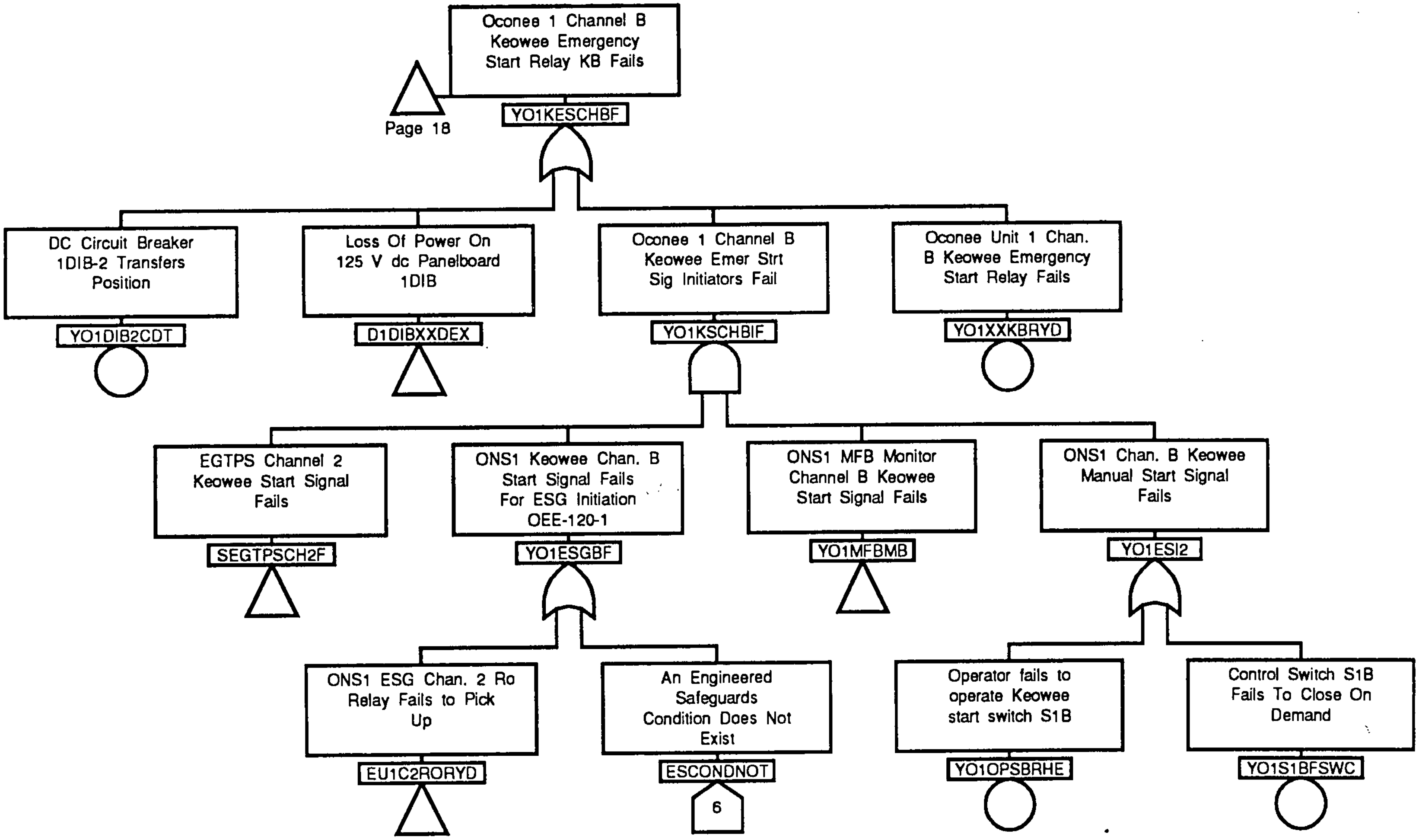


Keowee (Emergency) Start/Run Fault Tree | FIGURE A.5-2 |

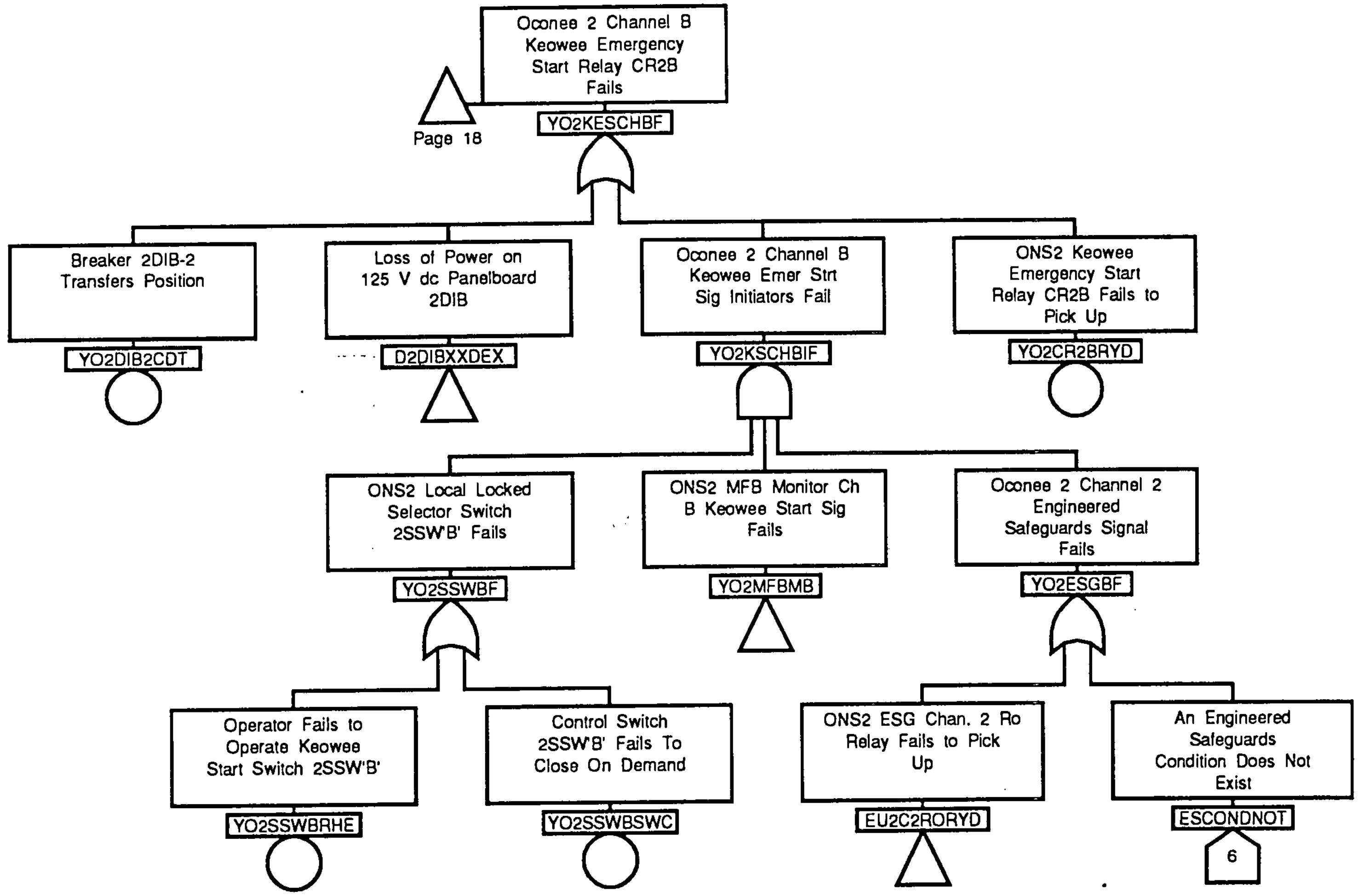

Oconee 3 Channel A Keowee Emergency Start Relay CR3A Fails
YO3KESCHAF
Page 14
Breaker 3DIA-2 Transfers Open-2705
YO3DIA2CDT
Loss Of Power On 125 V dc Panelboard 3DIA
D3DIAXXDEX
Oconee 3 Channel A Keowee Emer Strt Sig Initiators Fail
YO3KSCHAIF
ONS3 Ch A Keowee Emergency Start Relay CR3A Fails To Pick Up
YO3CR3ARYD
ONS3 Keowee Emer Start Sw S3A Fails
YO3S3A
ONS3 MFB Monitor Ch A Keowee Start Sig Fails
YO3MFBMA
Oconee 3 Channel A Engineered Safeguards Signal Fails
YO3ESGAF
ONS3 Cable Room Key Operated Switch 3SSW'A' Fails
YO3SSWAF
Operator fails to operate Keowee Start Switch 3S1A
YO3OPFARHE
Control Switch S1A Fails To Close On Demand
YO3S1AFSWC
ONS3 ESG Chan. 1 Ro Relay Fails to Pick Up
EU3C1RORYD
An Engineered Safeguards Condition Does Not Exist
ESCONDNOT
6
Operator fails to operate Keowee Start Switch 3SSW'A'
YO3SSWARHE
Control Switch 3SSW'A' Fails To Close On Demand
YO3SSWASWC



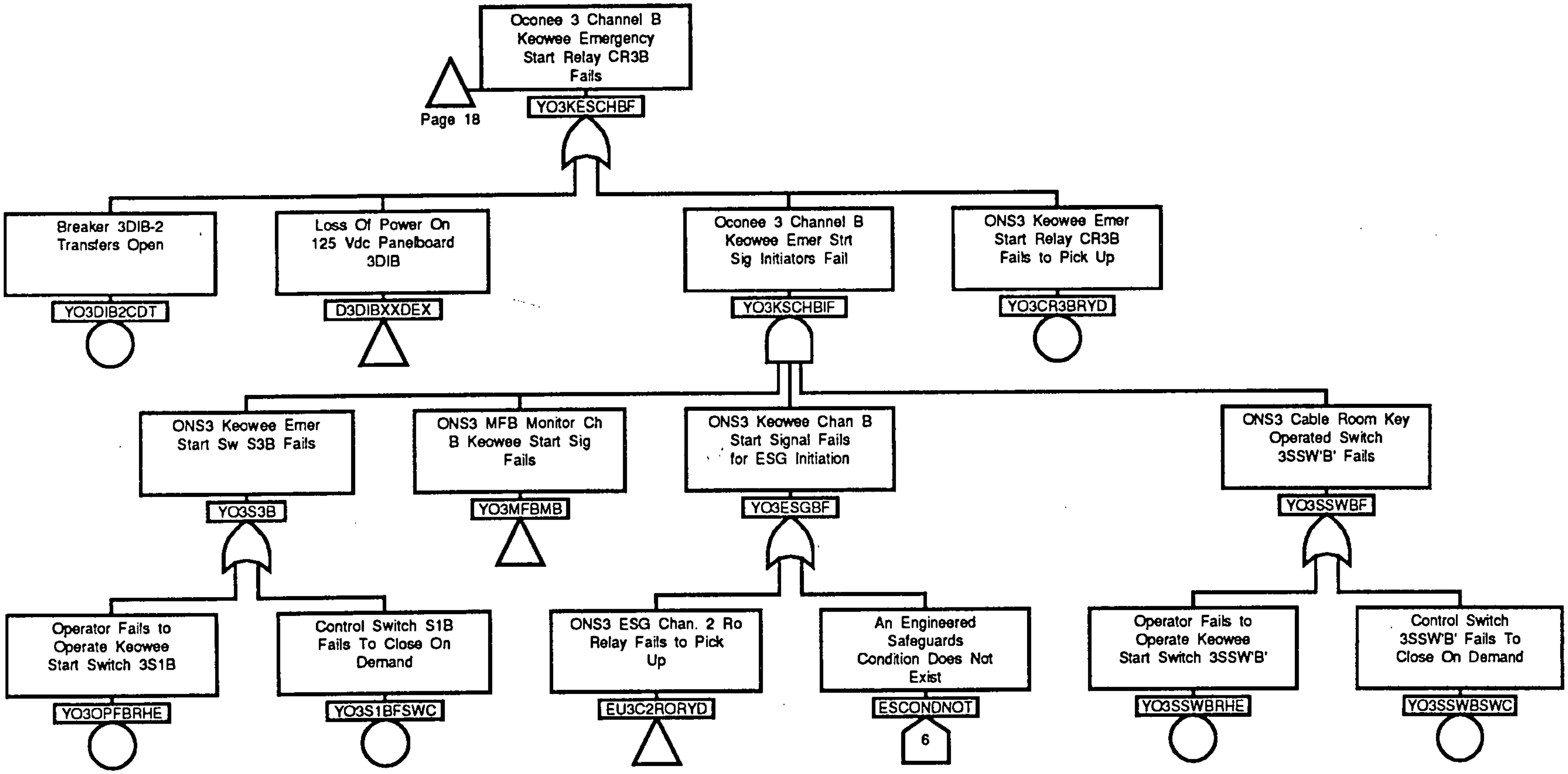
Keowee (Emergency) Start/Run Fault Tree	FIGURE A.5-2	Page 18



Keowee (Emergency) Start/Run Fault Tree	FIGURE A.5-2	Page 19



Keowee (Emergency) Start/Run Fault Tree | FIGURE A.5-2 |



Keowee (Emergency) Start/Run Fault Tree | FIGURE A.5-2 |

Gate/Event Name	Page	Zone
D1DIAXXDEX	15	
D1DIBXXDEX	19	
D2DIAXXDEX	16	
D2DIBXXDEX	20	
D3DIAXXDEX	17	
D3DIBXXDEX	21	
ED13BR2CDT	9	
ED23BR2CDT	9	
ESCONDNOT	15	
ESCONDNOT	16	
ESCONDNOT	17	
ESCONDNOT	19	
ESCONDNOT	20	
ESCONDNOT	21	
EU1C1RORYD	15	
EU1C2RORYD	19	
EU2C1RORYD	16	
EU2C2RORYD	20	
EU3C1RORYD	17	
EU3C2RORYD	21	
GK186E1RYT	11	
GK186E1RYT	13	
GK286E2RYT	12	
GK286E2RYT	13	
SEGTPSCH1F	15	
SEGTPSCH2F	19	
XD104CCCDT	11	
XD104CCCDT	13	
XD104CRCDT	14	
XD1DAR	9	
XD1DASRCES	1	
XD1DASRCES	2	
XD1DASRCES	14	
XD1DASRCES	18	
XD202CCCDT	18	
XD204CCCDT	12	
XD204CCCDT	13	
XD2DAR	9	
XD2DASRCES	1	

Gate/Event Name	Page	Zone
XD2DASRCES	2	
XD2DASRCES	18	
YK114X3SSD	3	
YK13SUISWT	11	
YK13SUISWT	13	
YK14AMRRYT	11	
YK14BMRRYT	13	
YK163BHLST	11	
YK163BHRYT	11	
YK163BLLST	11	
YK163BLRYT	11	
YK163TBLST	11	
YK163TBRYT	11	
YK186N1DEX	10	
YK199SDRYD	1	
YK199SDRYT	9	
YK199SNCF	1	
YK199SNCF	3	
YK199SNRYD	3	
YK199SNRYD	3	
YK199SNRYD	3	
YK199SNRYT	9	
YK199SNSRT	3	
YK199SXRYD	3	
YK199SXRYT	9	
YK199SXSRT	3	
YK1CLDSRTF	1	
YK1CLDSTRT	1	
YK1D4CRFUF	14	
YK1ES1ARYD	5	
YK1ES1BRYD	5	
YK1ES2ARYD	7	
YK1ES2BRYD	7	
YK1ESRX1A	5	
YK1ESRX1B	5	
YK1ESRX2A	7	
YK1ESRX2B	7	
YK1HOTSTRT	2	

Gate/Event Name	Page	Zone
YK1LOPERMF	11	
YK1LOPERMF	11	
YK1MR4ARUN	11	
YK1MR4ARUN	11	
YK1MR4ARYD	3	
YK1MR4ASRT	3	
YK1MR4BRUN	13	
YK1OPFAIL	9	
YK1OPFAIL	10	
YK1RUNCNTL	9	
YK1S122RPM	3	
YK1SS12SST	11	
YK1SS13SSD	3	
YK1SS65RPM	3	
YK1STR2INT	3	
YK1STR2INT	7	
YK1STRTINT	2	
YK1STRTINT	3	
YK1STRTINT	5	
YK1SXRUNF	9	
YK1SXRUNF	11	
YK214X3SSD	4	
YK23SUISWT	12	
YK23SUISWT	13	
YK24AMRRYT	12	
YK24BMRRYT	13	
YK263BHLST	12	
YK263BHRYT	12	
YK263BLLST	12	
YK263BLRYT	12	
YK263TBLST	12	
YK263TBRYT	12	
YK286N2DEX	10	
YK299SDRYD	1	
YK299SDRYT	9	
YK299SNCF	1	
YK299SNCF	4	
YK299SNRYD	4	

Gate/Event Name	Page	Zone
YK299SNRYD	4	
YK299SNRYD	4	
YK299SNRYT	9	
YK299SNSRT	4	
YK299SXRYD	4	
YK299SXRYT	9	
YK299SXSRT	4	
YK2CLDSRTF	1	
YK2CLDSTRT	1	
YK2D2CCFUF	18	
YK2ES1ARYD	6	
YK2ES1BRYD	6	
YK2ES2ARYD	8	
YK2ES2BRYD	8	
YK2ESRX1A	6	
YK2ESRX1B	6	
YK2ESRX2A	8	
YK2ESRX2B	8	
YK2HOTSTRT	2	
YK2LOPERMF	12	
YK2LOPERMF	12	
YK2MR4ARUN	12	
YK2MR4ARUN	12	
YK2MR4ARYD	4	
YK2MR4ASRT	4	
YK2MR4BRUN	13	
YK2OPFAIL	9	
YK2OPFAIL	10	
YK2RUNCNTL	9	
YK2S122RPM	4	
YK2SS12SST	12	
YK2SS13SSD	4	
YK2SS65RPM	4	
YK2STR2INT	4	
YK2STR2INT	8	
YK2STRTINT	2	
YK2STRTINT	4	
YK2STRTINT	6	

Gate/Event Name	Page	Zone
YK2SXRUNF	9	
YK2SXRUNF	12	
YKEMSRTCHE	10	
YKEMSRTCHE	10	
YKESAINITF	14	
YKESBINITF	18	
YKESRXA	5	
YKESRXA	6	
YKESRXA	7	
YKESRXA	8	
YKESRXA	14	
YKESRXB	5	
YKESRXB	6	
YKESRXB	7	
YKESRXB	8	
YKESRXB	18	
YO1DIA2CDT	15	
YO1DIB2CDT	19	
YO1ESGAF	15	
YO1ESGBF	19	
YO1ESI1	15	
YO1ESI2	19	
YO1KESCHAF	14	
YO1KESCHAF	15	
YO1KESCHBF	18	
YO1KESCHBF	19	
YO1KSCHAIF	15	
YO1KSCHBIF	19	
YO1MFBMA	15	
YO1MFBMB	19	
YO1OPSARHE	15	
YO1OPSBRHE	19	
YO1S1AFSWC	15	
YO1S1BFSWC	19	
YO1XXKARYD	15	
YO1XXKBRYD	19	
YO2CR2ARYD	16	
YO2CR2BRYD	20	
YO2DIA2CDT	16	
YO2DIB2CDT	20	
YO2ESGAF	16	
YO2ESGBF	20	
YO2KESCHAF	14	
YO2KESCHAF	16	
YO2KESCHBF	18	
YO2KESCHBF	20	
YO2KSCHAIF	16	
YO2KSCHBIF	20	
YO2MFBMA	16	
YO2MFBMB	20	
YO2SSWAF	16	
YO2SSWARHE	16	
YO2SSWASWC	16	
YO2SSWBF	20	
YO2SSWBRHE	20	
YO2SSWBSWC	20	
YO3CR3ARYD	17	
YO3CR3BRYD	21	
YO3DIA2CDT	17	
YO3DIB2CDT	21	
YO3ESGAF	17	
YO3ESGBF	21	
YO3KESCHAF	14	
YO3KESCHAF	17	
YO3KESCHBF	18	
YO3KESCHBF	21	
YO3KSCHAIF	17	
YO3KSCHBIF	21	
YO3MFBMA	17	
YO3MFBMB	21	
YO3OPFARHE	17	
YO3OPFBRHE	21	
YO3S1AFSWC	17	
YO3S1BFSWC	21	
YO3S3A	17	
YO3S3B	21	
YO3SSWAF	17	
YO3SSWARHE	17	
YO3SSWASWC	17	
YO3SSWBF	21	
YO3SSWBRHE	21	
YO3SSWBSWC	21	

APPENDIX A.6
GENERATOR EXCITATION

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A.6 GENERATOR EXCITATION

A.6.1 OBJECTIVES

The main objective of this analysis is to develop a logic model of the Generator Excitation system. This model is combined with the high-level model and remaining system models to form an integrated model for assessing the reliability of Keowee. Other objectives are to identify major contributors to component unreliability, significant potential human errors and common cause failure modes.

The scope of this analysis is limited to generator excitation equipment required to support a Keowee emergency start (no Keowee Auxiliary ac Power available) and run under load for the required mission.

A.6.2 SYSTEM DESIGN

A simplified diagram of the generator excitation subsystem is shown in Figure A.6-1. This subsystem consists primarily of three breakers (field, field flashing, and field supply) and the excitation cabinets containing the voltage and base adjust equipment.

Generator output voltage is regulated by applying a variable dc voltage to the generator field. Initial generator output is established by providing 125 V dc to the generator field from the station auxiliary dc power system. Once generator output is available, the generator output voltage is stepped down and rectified in order to maintain the required field necessary to assure proper generator output. The rectification and regulation is accomplished in the voltage regulator.

The voltage regulator consists of two primary subsystems, the base adjust and the voltage adjust. The base adjust provides a pre-set voltage to the field that is sufficient to establish the design output generator voltage, 13.8 kV. The voltage adjust provides the means to monitor the generator output and adjust the voltage applied to the field in order to maintain the design voltage over varying load conditions. The range of the voltage adjust is approximately ±10% of the rated output. The dc voltage to the field is controlled by varying the firing angle on the thyristors that rectify the output of the excitation transformer for use in generator excitation.

The setting of the base adjust is such that the Keowee output voltage is sufficient to supply power for the Oconee loads even if the voltage adjust subsystem fails to perform as designed.

A.6.2.1 GENERATOR FIELD BREAKER

The generator field breaker provides the connection to apply a dc voltage to the generator field. This dc voltage may be provided by one of two sources. The Keowee dc distribution center via the field flashing breaker, or from the voltage regulator cabinets. The field breaker closes on a start signal and remains closed as long as the generator is required.

A.6.2.2 GENERATOR FIELD FLASHING BREAKER

The generator field flashing breaker provides the connection to the excitation system from the Keowee auxiliary dc power system. The field flashing breaker closes on a generator start in order to provide the initial field voltage needed to establish generator output. Once the generator is able to supply itself, the field flashing breaker trips in order to prevent over-excitation of the generator or failure of the dc system.

A.6.2.3 GENERATOR FIELD SUPPLY BREAKER

The generator supply breaker provides the connection to the excitation system from the generator output. The generator output is supplied to the excitation transformer and from there to the regulator cabinets. This breaker closes on a generator start signal and remains closed as long as the generator is required.

A.6.2.4 BASE ADJUST

The base adjust provides a pre-set voltage to the field that is sufficient to establish the design output generator voltage, 13.8 kV. The setting of the base adjust is such that the Keowee output voltage is sufficient to supply power for the Oconee loads even if the voltage adjust subsystem fails to perform as designed.

A.6.2.5 VOLTAGE ADJUST

The voltage adjust provides the means to monitor the generator output and adjust the voltage applied to the field in order to maintain the design voltage over varying load conditions. The range of the voltage adjust is approximately ±10% of the rated output. The dc voltage to the field is controlled by varying the firing angle on the thyristors that rectify the output of the excitation transformer for use in generator excitation. Successful operation of the voltage adjust is not required in order to supply emergency power to Oconee.

A.6.3 <u>SYSTEM BOUNDARIES</u>

<u>Electrical Power Supplies</u>
Control and field flashing power is furnished from 125 V dc distribution centers 1DA (Unit 1) and 2DA (Unit 2). The power supplies for the modeled components are listed in Table A.6-1.

<u>External Control Systems</u>
All three (per unit) excitation breakers receive emergency start signals. The field breakers also receive a close permissive from the unit master relay 4A. The field and field flashing breakers also receive generator emergency lockout signals. The effect of these signals on breaker function is further described in Section A.6.4, Instrumentation and Controls. External controls are listed in Table A.6-2.

<u>Other System Boundaries</u>
The excitation transformer is connected to the generator output and thereby receives power for maintenance of the field voltage. The excitation system connects to the generator in order to supply the field voltage.

A.6.4 <u>INSTRUMENTATION AND CONTROLS</u>

A.6.4.1 EMERGENCY START RELAYS

The field, field flashing, and supply breakers all receive two trains of emergency start signals to close.

A.6.4.2 LOCKOUT RELAYS

Generator lockout auxiliary relay 86EX-1, one per unit, provides trip signals to the field and field flashing breakers on an emergency lockout following an emergency start. The normal lockout also trip the breakers on non-emergency starts.

A.6.4.3 INTERLOCKS WITH OTHER KEOWEE SYSTEMS/COMPONENTS

The generator field breaker is interlocked with of its respective overhead supply breaker, ACB-1 or ACB-2, such that the ACB can not close unless the generator field breaker is closed.

A.6.5 LOCATION WITHIN THE PLANT

The excitation system equipment is located within the Keowee powerhouse on the operating floor, elevation 702'.

A.6.6 NORMAL OPERATION

During a normal start, all three excitation breakers close. The field flashing breaker is controlled by a time delay relay and a voltage build-up relay which trip the breaker. The time delay is long enough for the system to establish generator output so that the field supply is self sustaining. Back-up is provided by the voltage adjust and by the voltage build-up relay to trip the breaker if trouble is sensed.

The supply and field breakers then remain closed as long as generator operation is required.

A.6.7 PERFORMANCE DURING KEOWEE EMERGENCY OPERATION

During an emergency start all three excitation breakers close on receipt of the emergency start signal. The field flashing breaker is controlled by a time delay relay which trips the breaker. This time delay is long enough for the system to establish generator output so that the field supply is self sustaining. Back-up is provided by the voltage adjust and by the voltage build-up relay to trip the breaker if trouble is sensed.

The supply and field breakers then remain closed as long as generator operation is required. The normal lockouts are bypassed during emergency operation.

A.6.8 TEST AND MAINTENANCE

Testing

The test procedures applicable to the generator excitation system are detailed in Table A.6-3.

Maintenance

The maintenance procedures applicable to the generator excitation system are detailed in Table A.6-4.

A.6.9 OPERATING EXPERIENCE

A summary of significant operating events is provided in Table A.6-5.

A.6.10 ASSUMPTIONS

A.6.10.1 SYSTEM DESIGN ASSUMPTIONS

1. The voltage adjust is not required to be operational for a successful emergency start and run. The base adjust portion of the voltage regulator is sufficient for the emergency load requirement.

2. The voltage build-up relay functions as a backup to the trip timer on the field flashing breaker. If the field flashing breaker fails to trip from the time delay, excessive volts at the generator output would be sensed for the corresponding frequency and result in actuation of the voltage build-up relay.

A.6.10.2 OPERATIONAL ASSUMPTIONS

1. The underground and overhead unit assignments are swapped at least every 30 days.

2. The overhead unit is operated daily and the underground unit is tested weekly.

A.6.10.3 MODELING ASSUMPTIONS

The following assumptions have been made in the development of the fault trees for the Excitation System.

1. The breaker failure type codes (CHO, CHT, CHC) are not included as they would be redundant to modeling the failures of the breaker component parts.

2. Having the Field Flashing Breaker remain closed at inappropriate times results in excitation failure.

3. The Voltage build-up Relay SV only has power available to it when the unit is generating. This should eliminate the potential for spurious operation prior to a unit start. This failure is not included in the field flashing breaker fails to close logic.

4. The Voltage build-up Relay SV provides a back-up to the 31/TD relay for tripping the Field Flashing Breaker (FFB). That is, should the 31/TD fail to trip the breaker, the generator voltage would exceed the allowed level at rated speed and an FFB trip signal would be generated by the SV relay.

5. Following generation from Keowee to the grid, a failure of the voltage adjust "as is" does not result in failure of that unit to supply Oconee. Voltages on the Oconee power system have been adequate prior to the loss of power and should continue to be adequate when power is restored from Keowee.

6. Transfer of the voltage adjust into auto is <u>not</u> required, since a base adjust setting of 13.8 kV provides adequate voltage to supply the Oconee loads.

7. The above assumptions preclude the need for a hot start failure of the excitation system.

8. The excitation cabinet fan failures are assumed to be dominated by the component failures that fail both the main and reserve fans. Independent failures of the main and reserve fans themselves to start or run are not included.

9. If a trip signal is present when a close signal is received a breaker will close and then trip immediately. This failure is included in the fail to close logic.

10. The excitation breakers have their dc control power monitored and alarmed. If the dc control power breaker were to transfer open this would be immediately known by the operators. Breaker spurious operation prior to the mission is not included in the fault tree.

A.6.11 FAULT TREE ANALYSIS

A.6.11.1 TOP EVENT SUCCESS CRITERIA

1. The Supply Breaker and Field Breaker should close and remain closed.

2. The Field Flashing Breaker should close, subsequently open and remain open.

A.6.11.2 DETAILED FAILURE CRITERIA

N/A

A.6.11.3 DESCRIPTION OF FAULT TREE

The Generator Excitation System fault tree is shown in Figure A.6-5. The Fault Tree Modeling Guidelines (Appendix B) were followed in developing the fault tree. A list of all fault tree top events is presented in Table A.6-8. A list of all fault tree transfers is presented in Table A.6-6.

There are four top events in the system fault tree. These are the failure to "cold start", and the failure to run, for each unit.

Failure events considered in the tree include breaker failures due to either mechanical or electrical problems. In general, data are available for electrical components, relays, switches, and fuses. These failures are modeled explicitly through the basic events involving failures of these components. The mechanical failures have been developed from the plant specific data collected on the Keowee breakers (Refer to Section A.6.11.5). These generally are modeled as undeveloped events in the fault trees.

The development of the tree provides for the analysis of the Keowee reliability following the implementation of NSM-ON-52966. Some branches of the tree only have an impact on the solution when the event defining the inclusion of this modification is set appropriately.

Human events impacting the model are described in Section A.6.11.4.

Common cause events impacting the model are described in Section A.6.11.6.

A.6.11.4 HUMAN INTERACTIONS

The success or failure of the Generator Excitation System to perform its function is impacted by several human actions. Those events explicitly included in the system fault tree are discussed below. Quantification of the human error events is presented in Section 5.5 and Appendix C.3.

<u>EKXYYYCLHE</u>
(X = unit number, YYY = breaker designator)

These basic events account for the potential for plant personnel to fail to properly restore the excitation breakers to a condition for proper closing. Post-maintenance testing is expected to detect the majority of errors. However, some errors may escape detection and fail the breaker.

EKXFLSOLHE
(X = unit number)

This basic event accounts for the potential for plant personnel to fail to properly restore the field flashing breaker to a condition for proper opening. Post-maintenance testing is expected to detect the majority of errors. However, some errors may escape detection and fail the breaker.

EKXBASELHE
(X = unit number)

This basic event accounts for the potential for the base adjust to be set incorrectly.

EKXBASEREC
(X = unit number)

The recovery events consider the potential for the operators to identify and correct an incorrect base adjust setting. Unit voltage is readily observable and the base adjust setting is changeable from the control room.. The recoveries are applied to the final cut sets and are not included in the tree.

A.6.11.5 RELIABILITY DATA

Reliability data used in the Generator Excitation System analysis are listed in Table A.6-9.

Section 5.3 and Appendix C.1 discuss development of the reliability data. For the base case solution, the plant-specific failure rate data and generic failure rate data are combined using a Bayesian update.

A.6.11.5.1 Exposure Times

Time dependent failures require an exposure time for determination of the failure probability. Failure times have been established based on the consideration of the time since the last test or operation of the component. Table A.6-9 contains a brief explanation of the rational used in determining the exposure time for each time dependent failure.

A.6.11.5.2 Undeveloped Events

The following undeveloped events are included in the generator excitation fault tree. Each of the three breakers (field, field flashing, and supply) are considered to be in a separate component population for quantifying the undeveloped events. The Unit 1 and Unit 2 breakers, performing the same function, are considered to be in the same population. The base and voltage adjust equipment are considered as separate component populations. As with the breakers the two units are combined within the population.

EK1SPYMDEX (EK2SPYMDEX): Keowee Unit 1(2) Supply Breaker Fails To Close Due To Mechanical Failure

The 9/16/93, 4/23/86, and 4/24/86 events, from Table A.6-5, are all failures of the supply breaker to close.

EK1SPYMDEX and EK2SPYMDEX are quantified by considering the three component failure to close in the population over the total demands for the population.

3/(Unit 1 starts + Unit 2 starts) = 4.62E-04/demand

With one breaker demand for the emergency operation of Keowee, EK1SPYMDEX = EK2SPYMDEX = 4.62E-04

EK1FLDMDEX (EK2FLDMDEX): Keowee Unit 1(2) Field Breaker Fails To Close Due To Mechanical Failure

No failures of the generator field breakers are found in the data of Table A.6-5.

EK1FLDMDEX and EK2FLDMDEX are quantified by considering one component failure to close in the population over twice the total demands for the population.

1/(2x(Unit 1 starts + Unit 2 starts)) = 7.71E-05/demand

With one breaker demand for the emergency operation of Keowee, EK1FLDMDEX = EK2FLDMDEX = 7.71E-05

EK1FLSMDEX (EK2FLSMDEX): Keowee Unit 1(2) Field Breaker Fails To Close Due To Mechanical Failure

No failures of the generator field flashing breakers are found in the data of Table A.6-5.

EK1FLSMDEX and EK2FLSMDEX are quantified by considering one component failure to close in the population over twice the total demands for the population.

1/(2x(Unit 1 starts + Unit 2 starts)) = 7.71E-05/demand

With one breaker demand for the emergency operation of Keowee, EK1FLSMDEX = EK2FLSMDEX = 7.71E-05

EK1BASEDEX (EK2BASEDEX): Keowee Unit 1(2) Base Adjust Fails To Establish Correct Unit Voltage

The 2/24/87, 3/27/90, 9/20/92, and 9/20/93 events, from Table A.6-5, are failures of the base adjust to set the correct voltage.

EK1BASEDEX and EK2BASEDEX are quantified by considering four component failure in the population over the total demands for the population.

4/(combined unit starts) = 6.17E-04/demand

With one demand for the emergency operation of Keowee, EK1BASEDEX = EK2BASEDEX = 6.17E-04

EK1BAS2DEX (EK2BAS2DEX): KHU-1(2) Base Adjust Fails To Maintain Generator Output Within Acceptable Range

There are no events, from Table A.6-5, that are failures of the base adjust to maintain correct voltage.

EK1BAS2DEX and EK2BAS2DEX are quantified by considering four component failure in the population over the total demands for the population.

1/(2x(combined unit run hours)) = 5.15E-05/hour

With a 24 hour mission for emergency operation of Keowee, EK1BAS2DEX = EK2BAS2DEX = 1.24E-03

EK1VREGDEX (EK2VREGDEX): KHU-1(2) Voltage Adjust Failure Drives Generator Output Too High/Low

The 5/4/93 event, from Table A.6-5, seem to be a failure where the voltage adjust drives the generator voltage outside the necessary range.

EK1VREGDEX and EK2VREGDEX are quantified by considering one component failure in the population over the total run hours for the population.

1/(2x(combined unit run hours)) = 1.03E-4/hour

With a 24 hour mission for emergency operation of Keowee, EK1VREGDEX = EK2VREGDEX = 2.47E-03

EK1DIODDEX (EK2DIODDEX): Keowee Unit 1(2) Exciter Fan Supply Diode Bridge Fails

The diode bridge is a group of 5 diodes. EK1DIODDEX and EK2DIODDEX are quantified by assuming a failure rate 5 times the diode failure rate from the data base.

5 x 2.4E-06/hour = 1.20E-05/hour

With a 24 hour mission for emergency operation of Keowee, EK1DIODDEX = EK2DIODDEX = 2.88E-04.

A.6.11.6 COMMON CAUSE ASSESSMENT

Refer to Section 5.4 and Appendix C.2 for detailed information on the quantification of the common cause events. All of the Excitation System common cause events are included in the high level logic model and not in the system fault tree.

E12EXCTCOM

This event considers the potential for both Keowee units to fail because the excitation breakers do not perform as required due to a common cause.

EKSTARTCOM

This event represents the potential for both Keowee units to fail to start due to common cause failure of the excitation systems.

EK00RUNCOM

This event represents the potential for both Keowee units to fail to run due to common cause failure of the excitation systems.

A.6.12 RESULTS

Tables A.6-10 through A.6 -13 lists the dominant minimal cut sets (failure sequences) for the Generator Excitation System top events. A list of dominant contributors to unavailability is given in Tables A.6-14 through A.6-17. The dominant contributors to the unavailability of the Generator Excitation System are the latent human errors and the undeveloped events.

A.6.13 REFERENCES

A.6.13.1 DOCUMENTS

1. OSS-0254.00-00-2005, Keowee Emergency Power Design Basis Document

2. EP-1020-19V, Westinghouse Instruction Manual - Vertical Waterwheel Generator

A.6.13.2 PROCEDURES

1. PT/0/A/0620/016, Keowee Hydro Emergency Start Test

2. PT/0/A/0620/016, Keowee Hydro Operation

3. OP/0/A/2000/013, Generator No. 1

4. OP/0/A/2000/041, Keowee Modes Of Operation

A.6.13.3 DRAWINGS

1. K-700 Rev. 9, One Line Diagram, Relays and Meters 13.8-230kV.

2. KEE-112, Rev. 7A, Keowee Hydro Station Unit No. 1, Elementary Diagram, Excitation System Generator Supply Breaker.

3. KEE-112-1, Rev. 6A, Keowee Hydro Station Unit No. 1, Elementary Diagram, Excitation System Generator Field Flashing Breaker.

4. KEE-112-2, Rev. 9, Keowee Hydro Station Unit No. 1, Elementary Diagram, Excitation System Generator Field Breaker.

5. KEE-112-3, Rev. 7, Keowee Hydro Station Unit No. 1, Elementary Diagram, Exciter Lockout And Fan Control.

6. KEE-112-4, Rev. 6, Keowee Hydro Station Unit No. 1, Elementary Diagram, Max. Excit. Pnl & M. O. Base Adj..

7. KEE-112-5, Rev. 6, Keowee Hydro Station Unit No. 1, Elementary Diagram, M. O. Auto Voltage Adjuster.

8. KEE-112-6, Rev. 6, Keowee Hydro Station Unit No. 1, Elementary Diagram, Regulator Controls.

9. KEE-112-7, Rev. 6, Keowee Hydro Station Unit No. 1, Elementary Diagram, Regulator Controls.

10. KEE-212, Rev. 6, Keowee Hydro Station Unit No. 1, Elementary Diagram, Excitation System Generator Supply Breaker.

11. KEE-212-1, Rev. 5, Keowee Hydro Station Unit No. 2, Elementary Diagram, Excitation System Generator Field Flashing Breaker.

12. KEE-212-2, Rev. 6, Keowee Hydro Station Unit No. 2, Elementary Diagram, Excitation System Generator Field Breaker.

13. KEE-212-3, Rev. 4, Keowee Hydro Station Unit No. 2, Elementary Diagram, Exciter Lockout And Fan Control.

14. KEE-212-4, Rev. 3, Keowee Hydro Station Unit No. 2, Elementary Diagram, Max. Excit. Pnl & M. O. Base Adj..

15. KEE-212-5, Rev. 4, Keowee Hydro Station Unit No. 2, Elementary Diagram, M. O. Auto Voltage Adjuster.

16. KEE-212-6, Rev. 4, Keowee Hydro Station Unit No. 2, Elementary Diagram, Regulator Controls.

17. KEE-212-7, Rev. 4, Keowee Hydro Station Unit No. 2, Elementary Diagram, Regulator Controls.

18. KEE-113, Rev. 8, Keowee Hydro Station Unit No. 1, Elementary Diagram, Master Control System Start-up Controls.

19. KEE-213, Rev. 8, Keowee Hydro Station Unit No. 2, Elementary Diagram, Master Control System Start-up Controls.

20. KEE-113-5, Rev. 8, Keowee Hydro Station Unit No. 1, Elementary Diagram, Master Control System Turbine Miscellaneous Relaying.

21. KEE-213,-5 Rev. 5, Keowee Hydro Station Unit No. 2, Elementary Diagram, Master Control System Turbine Miscellaneous Relaying.

22. KEE-114, Rev. 12, Keowee Hydro Station Unit No. 1, Elementary Diagram, Generator Control ACB-1 Control Circuit.

23. KEE-214, Rev. 9, Keowee Hydro Station Unit No. 2, Elementary Diagram, Generator Control ACB-2 Control Circuit.

24. KEE-114-3, Rev. 11, Keowee Hydro Station Unit No. 1, Elementary Diagram, Generator Control Normal and Emergency Lockout.

25. KEE-214-3, Rev. 8, Keowee Hydro Station Unit No. 2, Elementary Diagram, Generator Control Normal and Emergency Lockout.

Table A.6-1

Generator Excitation Power Supplies

Component	Power Supply[1]	Compartment Number
Generator Field Breaker (Unit 1)	125 V dc DC 1DA	4DR
Generator Field Flashing Breaker (Unit 1)	125 V dc DC 1DA	4DR
Generator Field Supply Breaker (Unit 1)	125 V dc DC 1DA	4DR
Generator Field Breaker (Unit 2)	125 V dc DC 2DA	
Generator Field Flashing Breaker (Unit 2)	125 V dc DC 2DA	
Generator Field Supply Breaker (Unit 2)	125 V dc DC 2DA	
Base Adjust (Unit 1)	125 V dc DC 1DA	4DR
Base Adjust (Unit 2)	125 V dc DC 2DA	
Field Flashing Supply (Unit 1)	125 V dc DC 1DA	3D
Field Flashing Supply (Unit 2)	125 V dc DC 2DA	2D

[1] DC = Distribution Center

Table A.6-2

Generator Excitation External Controls

Component	Signal
All Unit 1 Breakers	Emergency Start Relays 1ESRX/1A and 1ESRX/1B to Close
All Unit 2 Breakers	Emergency Start Relays 2ESRX/1A and 2ESRX/1B to Close
Unit 1 Master Relay 4A	Close Unit 1 Field Breaker
Unit 2 Master Relay 4A	Close Unit 2 Field Breaker

Table A.6-3

Generator Excitation Test Procedures

Procedure	Test Frequency	Description
PT/0/A/0620/016 Keowee Hydro Emergency Start Test	Periodic	Demonstrate the operability of each Keowee unit's emergency start circuitry from each control room.
PT/0/A/0620/016 Keowee Hydro Operation	Periodic	Periodically test the operation of the Keowee Hydro Units From The Oconee Control Room.

Table A.6-4

<u>Generator Excitation Maintenance Procedures</u>

Procedure	Maintenance Frequency	Description
OP/0/A/2000/013 Generator No. 1	As needed	Removal from service and restoration to service of Generator No. 1

Table A.6-5

Generator Excitation Significant Operating Events

Date	Unit	Component	Event Summary
2-24-87	2	Voltage Regulator	Unit 2 was started for system generation but it tripped due to no VARs. Keowee received a Hi Limit light on the Voltage Adjust. Found reset switch on the Base Adjust not running back to reset position.
3-27-90	1	Voltage Regulator	Started Unit 2 for system generation but unit would not start. Found problem to be due to the 70B cam switch not resetting to its preset position. This caused the 70BX relay to drop out.
9-20-92	2	Voltage Regulator	Unit 2 started from Keowee for system generation but voltage regulator did not come on. Unit 2 started in manual and paralled from Keowee. 70BX relay wasn't picked up so this stopped unit from starting.
9-20-93	1	Voltage Regulator	During Keowee Emer. Start test , unit 1 failed to reach rated voltage of 13.8 during test, only 13.3 KV. The base adjuster had failed and was replaced.
5-7-84	2	Voltage Regulator	Unit 2 started for system generation but received a Normal Lockout. The voltage regulator would not come on in auto (unit would run in manual). The cause of the problem was determined to be due to the Base Adjuster having a preset position (S3-S4) which gave a low no-load machine voltage (12.8kV instead of rated 13.8kV) which did not match the Volts Adjust setting of 13.8kV setting when the voltage reg. came on in auto. The mismatch caused a time delay greater than the Volts-Hertz time delay relay setting which shut down the unit. The Base Adjust was reset to 13.8kV and the unit started several times successfully.

Table A.6-5

Generator Excitation Significant Operating Events

Date	Unit	Component	Event Summary
5-22-89	2	Voltage Regulator	Started Unit 2 for system generation. After the unit paralled the operator could not get the VARs to come up. Received a #2 incomplete start statalarm and the unit tripped.
10-17-90	2	Voltage Regulator	Unit 2 started and paralleled but the Voltage Regulator did not come on.
10-18-90	2	Voltage Regulator	Started Unit 2 for system generation but the Voltage Regulator did not come on.
9-6-92	2	Voltage Regulator	Started Unit 2 for system generation but the Voltage Regulator failed to come on.
7-4-84	2	Voltage Regulator	Unit 2 started for system generation but received a Normal Lockout due to Regulator problems. The Voltage Regulator went into automatic before the generator was up to rated speed (ie. rated volts at less than rated frequency). This caused the V/Hz relay to operate which in time tripped the lockout after a time delay.
10-4-91	2	Voltage Regulator	Unit 2 started for system generation. Unit shut down by incomplete start.
4-12-93	2	Voltage Regulator #2 Field Flash Breaker	Unit 2 Keowee Alarm lockout due to Field Flash Breaker failure during startup for system generation. Closing coil had burned.
9-6-91	2	Voltage Regulator Field Breaker	Started Unit 2 for system generation. Field Breaker failed to close. Problem was due to the 99SY relay being open.

Table A.6-5

Generator Excitation Significant Operating Events

Date	Unit	Component	Event Summary
4-23-86	2	Voltage Regulator #2 Supply Breaker	At 1540 Oconee started Unit 2 to check operability, but ACB-2 failed to close. Started the unit from Keowee and observed that the Supply Breaker did not close.Upon inspection, the breaker did not appear to be jacked all the way in. The breaker had moved back in its slot enough to break contact.
4-24-86	2	Voltage Regulator #2 Supply Breaker	At 0649 Oconee attempted to start Unit 2 for system generation, but the Supply Breaker did not close. The unit was then started from Keowee. The Field breaker closed but the Supply Breaker failed to close. The next start attempt from Keowee was successful but the following attempt from Oconee was not. The problem was determined to be due to a corroded latch release plunger in the Generator Supply Breaker. This latch release plunger prevented the breaker from operating as expected.
9-16-93	1	Voltage Regulator #1 Field Supply Breaker	Keowee unit 1 failed to emergency start per PT/0A/0620/16 due to the Field Supply and Field Flashing breakers failing to close. The supply breaker did not close due to a'trip free' operation caused by a missing cotter pin in the pin that connects the close solenoid armature to the breaker toggle mechanism. As a result, the closing coil remained energized because the auxiliary contacts did not function to energize the y-relay to drop out the x-relay which de-energizes the close coil.

Table A.6-5

Generator Excitation Significant Operating Events

Date	Unit	Component	Event Summary
5-4-93	1	Voltage Regulator	Keowee unit 1 Voltage Regulator OOS. Unit 1 was shut down while generating to the grid due to VARs going in the hole. The unit did not respond to the Voltage Adjust or the Base Adjust controls.
5-28-86	1	Voltage Regulator Field Breaker	Oconee started Unit 1 for system generation but the Field Breaker did not close. The unit was started and ran in local / manual satisfactorily. Oconee performed an operability test on unit 1and it worked fine. No problem was identified.
2-6-88	1	Voltage Regulator Field Breaker	Started Unit 1 for system generation. The unitrolled off but excitation did not close. Abortedstart on #1. Started Unit 1 again and everythingworked okay.
3-15-88	1	Voltage Regulator Field Breaker	Started Unit 1 for system generation but theExcitation Breakers failed to close. Aborted start.Started, paralleled, placed Unit 1 on LFC. Unitstarted fine this start.
5-23-88	1	Voltage Regulator Field Breaker	When doing retest on Unit 1 the unit came on but the excitation supply did not close. The unit shutdown due to an incomplete sequence. Did anotherstart and the unit worked okay.
9-28-88	1	Voltage Regulator	Started Unit 1 for weekly PM. Unit would not start up. Shut down unit. Started unit and paralled. Shut down unit. Started Unit 1 but it did not parallel. Shut unit down. Unit 1 started, paralled, and on LFC.
6-3-91	2	Voltage Regulator	Unit 2 started for system generation but the Voltage Regulator failed to come on. Attempted a 2nd start and the regulator worked fine.

Table A.6-5

Generator Excitation Significant Operating Events

Date	Unit	Component	Event Summary
11-20-84	2	#2 Supply Breaker X Relay Coil	Oconee started Unit 2 for operability test to take Unit 1 out of service for annual PMG inspection but the #2 Supply Breaker failed to close. The breaker was removed and inspected but the cause of the problem was not found. Unit 2 was run several times successfully with no re-occurrence of the problem.
12-4-84	2	#2 Supply Breaker X Relay Coil	Oconee attempted an auto start of Unit 2 but the Supply Breaker failed to close. Replaced X-relay coil and adjusted mechanical linkage to relay. Tested breaker successfully 15 times.
7-28-87	1	#1 Supply Breaker X Relay	With both units shut down, the Keowee operator discovered that the unit 1 Supply Breaker closing coil was burning. Replaced closing coil and 41 AX relay (x relay).
2-9-89	1	#1 Field Supply Breaker X Relay	Oconee started Unit 1 to test the Overhead Path, but the Supply Breaker did not close. Problem was determined to be due to the X Relay sticking. Replaced relay and the worked fine.
2-12-90	1	#1 Field Breaker X Relay	Started Unit 1 for system generation but excitation breakers did not close. Problem was found to be due to X Relay coil sticking. Replaced X Relay unit tested satisfactorily.
12-26-90	1	Field Breaker (X-Relay)	Started Unit 1 for system generation but Generator Excitation Breakers did not close in. A 2nd start attempt was successful.
1-16-91	1	Field Breaker (X-Relay)	Started Unit 1 for weekly preventative maintenance but Generator Excitation Breakers did not close in. A 2nd start attempt was successful.
1-21-91	1	Field Breaker (X-Relay)	Oconee started Unit 1 for test but Generator Excitation Breakers did not close in. A 2nd start attempt was successful.

Table A.6-5

Generator Excitation Significant Operating Events

Date	Unit	Component	Event Summary
2-1-91	1	Field Breaker (X-Relay)	Started Unit 1 for system generation but Generator Excitation Breakers did not close in.A 2nd start attempt was successful.
3-31-91	1	Field Breaker (X-Relay)	Started Unit 1 for system generation but Generator Excitation Breakers did not close in.A 2nd start attempt was successful.
4-7-91	1	Field Breaker (X-Relay)	Started Unit 1 for system generation. The Field Supply Breaker did not close in. A 2nd startattempt was successful. Supply Breaker wasreplaced with spare breaker and both testedsatisfactorily. Cause of problem unknown.
5-31-91	1	Field Breaker (X-Relay)	Unit 1 started for system generation. Unit rolled off but the Supply, Field, and Field FlashingBreakers failed to close.
6-7-91	1	Field Breaker (X-Relay)	Started Unit 1 for system generation but excitation didn't close in. Immediately attemptedanother start and unit started and closed insatisfactorily.
6-11-91	1	#1 Field Supply Breaker X Relay	Oconee started Unit 1 for PT. The Field Supply Breaker failed to close. The problem was found to be due to the X Relay not resetting after thelast shutdown. Relay was reset and Unit 1 ran satisfactorily.
1-29-92	1	Field Supply Breaker (X -Relay)	Started Unit 1 for system generation but the generator excitation did not close in. Checked circuitry with no problems found. Restarted unitand everything worked as designed. Keowee operators to check that X-Coil has reset aftereach Unit 1 and Unit 2 shutdown.

Table A.6-5

Generator Excitation Significant Operating Events

Date	Unit	Component	Event Summary
2-13-92	1	Voltage Regulator Field Breaker X-Relay	After a normal shutdown of Unit 1 for system generation on 2/13/92, it was discovered that the Unit 1 Field Flashing Breaker X-Relay had not reset as designed. This made Unit 1 inoperable. Checking the X-Relay within 14 minutes after the occurrence revealed that the X-Relay coil had reset on its own. Unit 1 was operability tested satisfactorily.
2-20-92	1	Voltage Regulator Field Breaker X-Relay	After a normal shutdown of Unit 1 for system generation on 2/20/92, it was discovered that the Unit 1 Field Flashing Breaker X-Relay had not reset as designed. This made Unit 1 inoperable. Unit 1 was taken out of service to troubleshoot problem with X-Relay failing to reset. The Field Breaker was removed and cleaned and some burrs were removed from the X-Relay cylinder. Unit 1 was operability tested satisfactorily.
3-17-92	1	Voltage Regulator Field Breaker X-Relay	Replaced X-Relay on Unit 1 Field Breaker per procedure MP/0/A/2001/3 and per Gary Edens request. Relay installed failed during functional test. Failed relay was replaced by another relay and functionally tested satisfactorily.
5-1-92	1	Voltage Regulator Field Breaker X-Relay	After a normal shutdown of Unit 1 for system generation on 5/1/92, it was discovered that the Unit 1 Field Flashing Breaker X-Relay had not reset as designed. This made Unit 1 inoperable. Checking the X-Relay within 30 minutes after the occurrence revealed that the X-Relay coil had reset on its own. Unit 1 was operability tested satisfactorily.
6-12-92	1	Voltage Regulator Field Breaker X-Relay	After a normal shutdown of Unit 1 for system generation on 6/12/92, it was discovered that the Unit 1 Field Flashing Breaker X-Relay had not reset as designed. This made Unit 1 inoperable. The relay was manually reset and Unit 1 was operability tested satisfactorily.

Table A.6-6

Generator Excitation Fault Tree Transfers

Transfer Gate Name	Description	Components Supplied
YK1STRTINT	Keowee 1 Emergency Start Aux Relays 1ESRX/1A & 1ESRX/1B Fail	KU-1 Field Breaker
YK2STRTINT	Keowee 2 Emergency Start Aux Relays 2ESRX/1A & 2ESRX/1B Fail	KU-2 Field Breaker
XD1DASRCES	Loss of Power to 125 V dc Distribution Center 1DA During Start	All Unit 1 equipment
XD2DASRCES	Loss of Power to 125 V dc Distribution Center 2DA During Start	All Unit 2 equipment
GK186E1	Keowee Unit 1 Emergency Lock Out Due To Spurious Actuation Of Generator Protective Relay	KU-1 Field Breaker
GK286E2	Keowee Unit 2 Emergency Lock Out Due To Spurious Actuation Of Generator Protective Relay	KU-2 Field Breaker
YK1MR4ASRT	Keowee 1 Master Relay 4A Fails To Picks Up On Start	KU-1 Field Breaker
YK2MR4ASRT	Keowee 2 Master Relay 4A Fails To Picks Up On Start	KU-2 Field Breaker
NTACB4MOD	NSM-ON-52966 Is In Service	KU-1 and KU-2 Field Breakers

Table A.6-7

Generator Excitation Statalarms

Point No.	Alarm	Actuator
1SA2-31	GEN. #1 REGULATOR TRIP	94RB/1X
1SA2-33	GEN. #1 EXCITATION LOW	40X
1SA2-34	GEN. #1 MAX EXCITATION TIMING	76TX
1SA2-35	GEN. #1 MAX EXCITATION LIMITING	76LX
1SA2-36	GEN. #1 REG COOLING FAILURE	74F
1SA2-37	GEN. #1 VOLTS/CYCLE LIMITING	K1
1SA2-38	GEN. #1 REG. BLOWN FUSE ALARM	74B
1SA2-39	GEN. #1 EXCITATION RES FAN RUNNING	2BR
2SA2-31	GEN. #2 REGULATOR TRIP	94RB/1X
2SA2-33	GEN. #2 EXCITATION LOW	40X
2SA2-34	GEN. #2 MAX EXCITATION TIMING	76TX
2SA2-35	GEN. #2 MAX EXCITATION LIMITING	76LX
2SA2-36	GEN. #2 REG COOLING FAILURE	74F
2SA2-37	GEN. #2 VOLTS/CYCLE LIMITING	K1
2SA2-38	GEN. #2 REG. BLOWN FUSE ALARM	74B
2SA2-39	GEN. #2 EXCITATION RES FAN RUNNING	2BR

Table A.6-8

Generator Excitation Fault Tree Top Events

Gate Name	Description
KU1GEXCLD	Keowee Unit 1 Generator Excitation Fails During A Cold Start
KU1GEXRUN	Keowee Unit 1 Generator Excitation Fails While The Unit Runs
KU2GEXCLD	Keowee Unit 2 Generator Excitation Fails During A Cold Start
KU2GEXRUN	Keowee Unit 2 Generator Excitation Fails While The Unit Runs

Table A.6-9

Generator Excitation Reliability Data

Event Name	Description	Failure Rate [1]	Factor	Rational For Factor [2]	Failure Probability
ACB4MOD	NSM-ON-52966 Is Not In Service		0.5		5.00E-01
ED11D3DCDT	Breaker 3D In 125V dc Distribution Center 1DA Transfers Open	7.50E-08 /H	84 H	Rule 5: Would prevent field from flashing.	6.30E-06
ED13BR2CDT	Breaker 3BR In 125V dc Distribution Center 1DA Transfers Open	7.50E-08 /H	24 H	Rule 1 : Would result in field breaker trip.	1.80E-06
ED22D3DCDT	Breaker 2D In 125V dc Distribution Center 2DA Transfers Open	7.50E-08 /H	24 H	Rule 5: Would prevent field from flashing.	1.80E-06
ED23BR2CDT	Breaker 3BR In 125V dc Distribution Center 2DA Transfers Open	7.50E-08 /H	24 H	Rule 1 : Would result in field breaker trip.	1.80E-06
EK131TDRYD	Keowee Unit 1 Field Flashing Breaker Time Delay Relay 31/TD Fails To Operate	3.30E-05 /D	1 D	1 demand on unit start.	3.30E-05
EK131TDRYT	Keowee Unit 1 Field Flashing Breaker Time Delay Relay 31/TD Spurious Operation	3.60E-07 /H	84 H	Rule 5: Would prevent field flashing breaker from closing in and staying closed.	3.02E-05
EK14152SWT	KHU1 Generator Supply Breaker Trip Control Switch 141-52/T Spurious Operation	7.00E-08 /H	84 H	Rule 5: Failure prior to start would keep supply breaker from closing in and staying closed.	5.88E-06
EK1415TSWT	Spurious Operation Of The KHU1 Supply Breaker Trip Switch	7.00E-08 /H	24 H	Rule 1: Failure during mission fails run.	1.68E-06
EK1415YRYD	KHU1 Generator Supply Breaker Y-relay Failed To Drop-out At Last Operation	3.30E-05 /D	1 D	1 demand on unit start.	3.30E-05
EK1415YRYT	KHU1 Generator Supply Breaker Y-relay Spurious Operation	3.60E-07 /H	84 H	Rule 5: Failure prior to start would keep supply breaker from closing.	3.02E-05
EK141AXR6D	Keowee Unit 1 Relay 41/AX Fails To Pick-up And Latch	2.49E-04 /D	1 D	1 demand on unit start.	2.49E-04
EK141AXR6T	Keowee Unit 1 Relay 41/AX Spuriously Resets	3.63E-07 /H	24 H	Rule 1: Results in run failure.	8.71E-06
EK141CFRYD	Keowee Unit 1 Field Flashing Breaker Close Coil Fails To Operate On Demand	3.30E-05 /D	1 D	1 demand on unit start.	3.30E-05
EK186E2RYT	Keowee Unit 1 Lockout Auxiliary Relay 86EX-2 Is Picked-up	3.60E-07 /H	6 H	Rule 2: Indicated by computer point.	2.16E-06

1 D=Demand H=Hour

2 Rules for assigning basic event factors are discussed in Table C.1-4

Table A.6-9

Generator Excitation Reliability Data

Event Name	Description	Failure Rate [1]	Factor	Rational For Factor [2]	Failure Probability
EK186EXRYT	Keowee Unit 1 Gen Lockout Auxiliary Relay 86EX-1 Spurious Actuation	3.60E-07 /H	84 H	Rule 5: Would prevent field flashing breaker from closing in and staying closed.	3.02E-05
EK186X2RYT	Keowee Unit 1 Generator Lockout Auxiliary Relay 86EX-1 Spurious Actuation	3.60E-07 /H	24 H	Rule 1: Results in run failure.	8.64E-06
EK188SVRYD	Keowee Unit 1 Fan Control Relay 88SV Fails On Demand	3.30E-05 /D	1 D	1 demand on unit start.	3.30E-05
EK188SVRYT	Keowee Unit 1 Fan Control Relay 88SV Prior To Or During The Run	3.60E-07 /H	108 H	Rule 6: Excitation cabinet overheating fails run.	3.89E-05
EK1901ARYT	Keowee Unit 1 Relay 90X1A Spurious Operation	3.60E-07 /H	84 H	Rule 5: Failure prior to start would keep field flashing breaker from closing.	3.02E-05
EK199SXRYD	Auxiliary Relay 99SX1 Fails To Pick-up	3.30E-05 /D	1 D	1 demand on unit start.	3.30E-05
EK199SYRYD	Keowee Unit 1 Relay 99SY Fails To Pick-up	3.30E-05 /D	1 D	1 demand on unit start.	3.30E-05
EK199SYRYT	Keowee Unit 1 Relay 99SY Drops Out	3.60E-07 /H	24 H	Rule 1: Trips field breaker, fails unit run.	8.64E-06
EK1BAS2DEX	KHU-1 Base Adjust Fails To Maintain Generator Output Within Acceptable Range		1.24E-03		1.24E-03
EK1BASEDEX	Keowee Unit 1 Base Adjust Fails To Establish Correct Unit Voltage		6.17E-04		6.17E-04
EK1BASELHE	Keowee Unit 1 Base Adjust Is Set Incorrectly		3.20E-03		3.20E-03
EK1DIODDEX	Keowee Unit 1 Exciter Fan Supply Diode Bridge Fails		2.88E-04		2.88E-04
EK1EXC1TGF	Keowee Unit 1 Gen Excitation Transformer Is Failed	9.80E-07 /H	84 H	Rule 5: Failure prior to mission fails the unit start.	8.23E-05
EK1EXC2TGF	Keowee Unit 1 Generator Excitation Transformer Fails	9.80E-07 /H	24 H	Rule 1: Failure during the mission fails the unit run.	2.35E-05
EK1F30AFUF	Keowee Unit 1 Excitation Cabinet Fan Fuses Fail	3.60E-06 /H	24 H	Rule 1: Failure during the mission fails the unit run.	8.64E-05
EK1F31XRYD	Keowee Unit 1 Field Flashing Breaker Relay 31/X Fails To Pick-up On Demand	3.30E-05 /D	1 D	1 demand on unit start.	3.30E-05

1 D=Demand H=Hour

2 Rules for assigning basic event factors are discussed in Table C.1-4

Table A.6-9

Generator Excitation Reliability Data

Event Name	Description	Failure Rate [1]	Factor	Rational For Factor [2]	Failure Probability
EK1F41CRYD	Keowee Unit 1 Field Breaker Close Coil Fails To Operate On Demand	3.30E-05 /D	1 D	1 demand on unit start.	3.30E-05
EK1FAN1TLF	Keowee Unit 1 Generator Excitation Fan Power Transformer Fails	7.50E-07 /H	24 H	Rule 1: Fails the unit run due to overheating of the excitation cabinets.	1.80E-05
EK1FLDCLHE	Keowee Unit 1 Field Breaker Fails To Close Due To Latent Human Error		2.60E-04		2.60E-04
EK1FLDMDEX	Keowee Unit 1 Field Breaker Fails To Close Due To Mechanical Failure		7.71E-05		7.71E-05
EK1FLSCLHE	Keowee Unit 1 Field Flashing Breaker Fails To Close Due To Latent Human Error		2.60E-04		2.60E-04
EK1FLSMDEX	Keowee Unit 1 Field Flashing Breaker Fails To Close Due To Mechanical Failure		7.71E-05		7.71E-05
EK1FLSOLHE	Keowee Unit 1 Field Flashing Breaker Fails To Open Due To Latent Human Error		2.60E-04		2.60E-04
EK1R31TRYD	Keowee Unit 1 Field Flashing Breaker Trip Coil 31/T Fails To Operate	3.30E-05 /D	1 D	1 demand on unit start.	3.30E-05
EK1R31YRYD	KHU1 Gen Field Flashing Breaker Y-relay Failed To Drop Out At Last Operation	3.30E-05 /D	1 D	1 demand on unit start.	3.30E-05
EK1R31YRYT	KHU1 Generator Field Flashing Breaker Y-relay Spurious Operation	3.60E-07 /H	84 H	Rule 5: Fails unit start by preventing closure of the field flashing breaker.	3.02E-05
EK1R41XRYD	Keowee Unit 1 Field Breaker Relay 41/X Fails To Pick-up On Demand	3.30E-05 /D	1 D	1 demand on unit start.	3.30E-05
EK1R41YRYD	KHU1 Generator Field Breaker Y-relay Failed To Drop-out At Last Operation	3.30E-05 /D	1 D	1 demand on unit start.	3.30E-05
EK1R41YRYT	Keowee Unit 1 Generator Field Breaker Y-relay Spurious Operation	3.60E-07 /H	84 H	Rule 5: Fails unit start by preventing closure of the field breaker.	3.02E-05
EK1R9A1RYT	Keowee Unit 1 Relay 90X1A/TD	3.60E-07 /H	84 H	Rule 5: Fails unit start by	3.02E-05

1 D=Demand H=Hour

2 Rules for assigning basic event factors are discussed in Table C.1-4

Table A.6-9

Generator Excitation Reliability Data

Event Name	Description	Failure Rate [1]	Factor	Rational For Factor [2]	Failure Probability
	Spurious Operation			preventing closure of the field flashing breaker.	
EK1R9C1R6T	Keowee Unit 1 Relay 90X1C Spurious Operation	3.63E-07 /H	84 H	Rule 5: Fails unit start by preventing closure of the field flashing breaker.	3.05E-05
EK1S141SWT	KHU1 Field Breaker Trip Control Switch 141/T Spurious Operation	7.00E-08 /H	84 H	Rule 5: Fails unit start by preventing closure of the field breaker.	5.88E-06
EK1S31TSWT	KHU1 Field Flashing Breaker Trip Control Switch 131/T Spurious Operation	7.00E-08 /H	84 H	Rule 5: Fails unit start by preventing closure of the field flashing breaker.	5.88E-06
EK1S41CRYD	Keowee Unit 1 Supply Breaker Close Coil Fails To Operate On Demand	3.30E-05 /D	1 D	1 demand on unit start.	3.30E-05
EK1S41TSWT	Keowee Unit 1 Field Breaker Trip Control Switch Transfers Position	7.00E-08 /H	24 H	Rule 1: Causes field breaker to transfer open during the run.	1.68E-06
EK1S41XRYD	Keowee Unit 1 Supply Breaker Relay 41-52X Fails To Pick-up On Demand	3.30E-05 /D	1 D	1 demand on unit start.	3.30E-05
EK1SPYCLHE	Keowee Unit 1 Supply Breaker Fails To Close Due To Latent Human Error		2.60E-04		2.60E-04
EK1SPYMDEX	Keowee Unit 1 Supply Breaker Fails To Close Due To Mehanical Failure		4.62E-04		4.62E-04
EK1VHSVRYD	Keowee Unit 1 Voltage Build-up Relay Fails To Trip Field Flashing Breaker	3.30E-05 /D	1 D	1 demand on unit start.	3.30E-05
EK1VREGDEX	KHU-1 Voltage Adjust Failure Drives Generator Output Too High/Low		2.47E-03		2.47E-03
EK231TDRYD	Keowee Unit 2 Field Flashing Breaker Time Delay Relay 31/TD Fails To Operate	3.30E-05 /D	1 D	1 demand on unit start.	3.30E-05
EK231TDRYT	Keowee Unit 2 Field Flashing Breaker Time Delay Relay 31/TD Spurious Operation	3.60E-07 /H	12 H	Rule 5: Fails unit start by preventing closure of the field flashing breaker.	4.32E-06
EK24152SWT	KHU2 Generator Supply Breaker	7.00E-08 /H	12 H	Rule 5: Fails unit start by	8.40E-07

1 D=Demand H=Hour

2 Rules for assigning basic event factors are discussed in Table C.1-4

Table A.6-9

Generator Excitation Reliability Data

Event Name	Description	Failure Rate [1]		Factor		Rational For Factor [2]	Failure Probability
	Trip Control Switch Spurious Operation					preventing closure of the supply breaker.	
EK2415TSWT	Spurious Operation Of The KHU2 Supply Breaker Trip Switch	7.00E-08	/H	24	H	Rule 1: Fails unit run by causing the supply breaker to transfer open.	1.68E-06
EK2415YRYD	KHU2 Gen Supply Breaker Y-relay Failed To Drop-out At Last Operation	3.30E-05	/D	1	D	1 demand on unit start.	3.30E-05
EK2415YRYT	KHU2 Generator Supply Breaker Y-relay Spurious Operation	3.60E-07	/H	12	H	Rule 5: Fails unit start by preventing closure of the supply breaker.	4.32E-06
EK241AXR6D	Keowee Unit 2 Relay 41/AX Fails To Pick-up And Latch	2.49E-04	/D	1	D	1 demand on unit start.	2.49E-04
EK241AXR6T	Keowee Unit 2 Relay 41/AX Spuriously Resets	3.63E-07	/H	24	H	Rule 1: Fails unit run by causing the excitation cabinet fans to fail.	8.71E-06
EK241CFRYD	Keowee Unit 2 Field Flashing Breaker Close Coil Fails To Operat On Demand	3.30E-05	/D	1	D	1 demand on unit start.	3.30E-05
EK286E2RYT	Keowee Unit 2 Lockout Auxiliary Relay 86EX-2 Is Picked-up	3.60E-07	/H	6	H	Rule 2: Fails unit start by preventing closure of the supply breaker. Indicated by computer point.	2.16E-06
EK286EXRYT	Keowee Unit 2 Generator Lockout Auxiliary Relay 86EX-1 Spurious Actuation	3.60E-07	/H	12	H	Rule 5: Fails unit start by preventing closure of the field flashing breaker.	4.32E-06
EK286X2RYT	Keowee Unit 2 Generator Lockout Auxiliary Relay 86EX-1 Spurious Actuation	3.60E-07	/H	24	H	Rule 1: Fails the unit rin by tripping the supply breaker.	8.64E-06
EK288SVRYD	Keowee Unit 2 Fan Control Relay 88SV Fails On Demand	3.30E-05	/D	1	D	1 demand on unit start.	3.30E-05
EK288SVRYT	Keowee Unit 2 Fan Control Relay 88SV Prior To Or During The Run	3.60E-07	/H	36	H	Rule 6: Fails unit run by failing the excitation cabinet fans.	1.30E-05
EK2901ARYT	Keowee Unit 2 Relay 90X1A Spurious Operation	3.60E-07	/H	12	H	Rule 5: Fails unit start by preventing closure of the field flashing breaker.	4.32E-06
EK299SXRYD	Auxiliary Relay 99SX2 Fails To	3.30E-05	/D	1	D	1 demand on unit start.	3.30E-05

1 D=Demand H=Hour

2 Rules for assigning basic event factors are discussed in Table C.1-4

Table A.6-9

Generator Excitation Reliability Data

Event Name	Description	Failure Rate [1]	Factor	Rational For Factor [2]	Failure Probability
	Pick-up				
EK299SYRYD	Keowee Unit 2 Relay 99SY Fails To Pick-up	3.30E-05 /D	1 D	1 demand on unit start.	3.30E-05
EK299SYRYT	Keowee Unit 2 Relay 99SY Drops Out	3.60E-07 /H	24 H	Rule 1: Fails unit run by tripping the field breaker.	8.64E-06
EK2BAS2DEX	KHU-2 Base Adjust Fails To Maintain Generator Output Within Acceptable Range		1.24E-03		1.24E-03
EK2BASEDEX	Keowee Unit 2 Base Adjust Fails To Establish Correct Unit Voltage		6.17E-04		6.17E-04
EK2BASELHE	Keowee Unit 2 Base Adjust Is Set Incorrectly		3.20E-03		3.20E-03
EK2DIODDEX	Keowee Unit 2 Exciter Fan Supply Diode Bridge Fails		2.88E-04		2.88E-04
EK2EXC1TGF	Keowee Unit 2 Generator Excitation Transformer Is Failed	9.80E-07 /H	12 H	Rule 5: Fails the unit start by failing excitiation.	1.18E-05
EK2EXC2TGF	Keowee Unit 2 Generator Excitation Transformer Fails	9.80E-07 /H	24 H	Rule 5: Fails the unit run by failing excitiation.	2.35E-05
EK2F30AFUF	Keowee Unit 2 Excitation Cabinet Fan Fuses Fail	3.60E-06 /H	24 H	Rule 5: Fails the unit run by failing excitiation.	8.64E-05
EK2F31XRYD	Keowee Unit 2 Field Flashing Breaker Relay 31/X Fails To Pick-up On Demand	3.30E-05 /D	1 D	1 demand on unit start.	3.30E-05
EK2F41CRYD	Keowee Unit 2 Field Breaker Close Coil Fails To Operate On Demand	3.30E-05 /D	1 D	1 demand on unit start.	3.30E-05
EK2FAN1TLF	Keowee Unit 2 Generator Excitation Fan Power Transformer Fails	7.50E-07 /H	24 H	Rule 5: Fails the unit run by failing excitiation.	1.80E-05
EK2FLDCLHE	Keowee Unit 2 Field Breaker Fails To Close Due To Latent Human Error		2.60E-04		2.60E-04
EK2FLDMDEX	Keowee Unit 2 Field Breaker Fails To Close Due To Mechanical Failure		7.71E-05		7.71E-05
EK2FLSCLHE	Keowee Unit 2 Field Flashing Breaker Fails To Close Due To Latent Human Error		2.60E-04		2.60E-04

1 D=Demand H=Hour

2 Rules for assigning basic event factors are discussed in Table C.1-4

Table A.6-9

Generator Excitation Reliability Data

Event Name	Description	Failure Rate [1]		Factor		Rational For Factor [2]	Failure Probability
EK2FLSMDEX	Keowee Unit 2 Field Flashing Breaker Fails To Close Due To Mechanical Failure			7.71E-05			7.71E-05
EK2FLSOLHE	Keowee Unit 2 Field Flashing Breaker Fails To Open Due To Latent Human Error			2.60E-04			2.60E-04
EK2R31TRYD	Keowee Unit 2 Field Flashing Breaker Trip Coil 31/T Fails To Operate	3.30E-05	/D	1	D	1 demand on unit start.	3.30E-05
EK2R31YRYD	KHU2 Gen Field Flashing Breaker Y-relay Failed To Drop At Last Operation	3.30E-05	/D	1	D	1 demand on unit start.	3.30E-05
EK2R31YRYT	KHU2 Generator Field Flashing Breaker Y-relay Spurious Operation	3.60E-07	/H	12	H	Rule 5: Operation prior to start signal prevents closure of the field flashing breaker.	4.32E-06
EK2R41XRYD	Keowee Unit 2 Field Breaker Relay 41/X Fails To Pick-up On Demand	3.30E-05	/D	1	D	1 demand on unit start.	3.30E-05
EK2R41YRYD	KHU2 Generator Field Breaker Y-relay Failed To Drop-out At Last Operation	3.30E-05	/D	1	D	1 demand on unit start.	3.30E-05
EK2R41YRYT	KHU2 Generator Field Breaker Y-relay Spurious Operation	3.60E-07	/H	12	H	Rule 5: Operation prior to start signal prevents closure of the field breaker.	4.32E-06
EK2R9A2RYT	Keowee Unit 2 Relay 90X1A/TD Spurious Operation	3.60E-07	/H	12	H	Rule 5: Operation prior to start signal prevents closure of the field flashing breaker.	4.32E-06
EK2R9C2R6T	Keowee Unit 2 Relay 90X1C Spurious Operation	3.63E-07	/H	12	H	Rule 5: Operation prior to start signal prevents closure of the field flashing breaker.	4.36E-06
EK2S141SWT	KHU2 Field Breaker Trip Control Switch Spurious Operation	7.00E-08	/H	12	H	Rule 5: Operation prior to start signal prevents closure of the field breaker.	8.40E-07
EK2S31TSWT	KHU2 Field Flashing Breaker Trip Control Switch 131/T Spurious Operation	7.00E-08	/H	12	H	Rule 5: Operation prior to start signal prevents closure of the field flashing breaker.	8.40E-07
EK2S41CRYD	Keowee Unit 2 Supply Breaker Close Coil Fails To Operate On Demand	3.30E-05	/D	1	D	1 demand on unit start.	3.30E-05

1 D=Demand H=Hour

2 Rules for assigning basic event factors are discussed in Table C.1-4

Table A.6-9

Generator Excitation Reliability Data

Event Name	Description	Failure Rate [1]		Factor		Rational For Factor [2]	Failure Probability
EK2S41TSWT	Keowee Unit 2 Field Breaker Trip Control Switch Transfers Position	7.00E-08	/H	24	H	Rule 1: Fails unit by tripping the field breaker.	1.68E-06
EK2S41XRYD	Keowee Unit 2 Supply Breaker Relay 41-52X Fails To Pick-up On Demand	3.30E-05	/D	1	D	1 demand on unit start.	3.30E-05
EK2SPYCLHE	Keowee Unit 2 Supply Breaker Fails To Close Due To Latent Human Error			2.60E-04			2.60E-04
EK2SPYMDEX	Keowee Unit 2 Supply Breaker Fails To Close Due To Mehanical Failure			4.62E-04			4.62E-04
EK2VHSVRYD	Keowee Unit 2 Voltage Build-up Relay Fails To Trip Field Flashing Breaker	3.30E-05	/D	1	D		3.30E-05
EK2VREGDEX	KHU-2 Voltage Adjust Failure Drives Generator Output Too High/Low			2.47E-03			2.47E-03
GK186E1	Keowee Unit 1 Emergency Lockout Due To Actuation Of Generator Protective Relay			0			0.00E+00
GK286E2	Keowee Unit 2 Emergency Lockout Due To Spurious Actuation Of Gen Protect Relay			0			0.00E+00
XD1DASRCES	Loss Of Power To 125V dc Distribution Center 1DA During Start			0			0.00E+00
XD2DASRCES	Loss Of Power To 125 Vdc Distribution Center 2DA During Start			0			0.00E+00
YK1MR4ASRT	Keowee 1 Master Relay 4A Fails to Pick Up On Start			0			0.00E+00
YK1STR2INT	Keowee 1 Emergency Start Aux Relays 1ESRX/2A & 1ESRX/2B Fail			0			0.00E+00
YK1STRTINT	Keowee 1 Emergency Start Aux Relays 1ESRX/1A & 1ESRX/1B Fail			0			0.00E+00
YK2MR4ASRT	Keowee 2 Master Relay 4A Fails to Pick Up On Start			0			0.00E+00
YK2STR2INT	Keowee 2 Emergency Start Aux			0			0.00E+00

1 D=Demand H=Hour

2 Rules for assigning basic event factors are discussed in Table C.1-4

Table A.6-9

Generator Excitation Reliability Data

Event Name	Description	Failure Rate [1]	Factor	Rational For Factor [2]	Failure Probability
	Relays 2ESRX/2A & 2ESRX/2B Fail				
YK2STRTINT	Keowee 2 Emergency Start Aux Relays 2ESRX/1A & 2ESRX/1B Fail		0		0.00E+00

1 D=Demand H=Hour

2 Rules for assigning basic event factors are discussed in Table C.1-4

Table A.6-10

Generator Excitation Dominant Minimal Cut Sets

Cut Sets for Gate KU1GEXRUN: Keowee Unit 1 Fails To Cold Start

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
1)	3.20E-03	49.8%	EK1BASELHE	3.20E-03	Keowee Unit 1 Base Adjust Is Set Incorrectly
2)	6.17E-04	9.6%	EK1BASEDEX	6.17E-04	Keowee Unit 1 Base Adjust Fails To Establish Correct Unit Voltage
3)	4.62E-04	7.2%	EK1SPYMDEX	4.62E-04	Keowee Unit 1 Supply Breaker Fails To Close Due To Mechanical Failure
4)	2.60E-04	4.0%	EK1FLDCLHE	2.60E-04	Keowee Unit 1 Field Breaker Fails To Close Due To Latent Human Error
5)	2.60E-04	4.0%	EK1FLSCLHE	2.60E-04	Keowee Unit 1 Field Flashing Breaker Fails To Close Due To Latent Human Error
6)	2.60E-04	4.0%	EK1FLSOLHE	2.60E-04	Keowee Unit 1 Field Flashing Breaker Fails To Open Due To Latent Human Error
7)	2.60E-04	4.0%	EK1SPYCLHE	2.60E-04	Keowee Unit 1 Supply Breaker Fails To Close Due To Latent Human Error
8)	2.49E-04	3.9%	EK141AXR6D	2.49E-04	Keowee Unit 1 Relay 41/AX Fails To Pick-up And Latch
9)	8.23E-05	1.3%	EK1EXC1TGF	8.23E-05	Keowee Unit 1 Gen Excitation Transformer Is Failed
10)	7.71E-05	1.2%	EK1FLDMDEX	7.71E-05	Keowee Unit 1 Field Breaker Fails To Close Due To Mechanical Failure
11)	7.71E-05	1.2%	EK1FLSMDEX	7.71E-05	Keowee Unit 1 Field Flashing Breaker Fails To Close Due To Mechanical Failure

Total Event Probability = 6.42E-03

Table A.6-11

Generator Excitation Dominant Minimal Cut Sets

Cut Sets for Gate KU1GEXRUN: Keowee Unit 1 Fails While Unit Runs

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
1)	2.47E-03	55.3%	EK1VREGDEX	2.47E-03	KHU-1 Voltage Adjust Failure Drives Generator Output Too High/Low
2)	1.24E-03	27.7%	EK1BAS2DEX	1.24E-03	KHU-1 Base Adjust Fails To Maintain Generator Output Within Acceptable Range
3)	2.88E-04	6.4%	EK1DIODDEX	2.88E-04	Keowee Unit 1 Exciter Fan Supply Diode Bridge Fails
4)	2.49E-04	5.6%	EK141AXR6D	2.49E-04	Keowee Unit 1 Relay 41/AX Fails To Pick-up And Latch
5)	8.64E-05	1.9%	EK1F30AFUF	8.64E-05	Keowee Unit 1 Excitation Cabinet Fan Fuses Fail
6)	3.89E-05	0.9%	EK188SVRYT	3.89E-05	Keowee Unit 1 Fan Control Relay 88SV Prior To Or During The Run
7)	3.30E-05	0.7%	EK188SVRYD	3.30E-05	Keowee Unit 1 Fan Control Relay 88SV Fails On Demand
8)	2.35E-05	0.5%	EK1EXC2TGF	2.35E-05	Keowee Unit 1 Generator Excitation Transformer Fails
9)	1.80E-05	0.4%	EK1FAN1TLF	1.80E-05	Keowee Unit 1 Generator Excitation Fan Power Transformer Fails
10)	8.71E-06	0.2%	EK141AXR6T	8.71E-06	Keowee Unit 1 Relay 41/AX Spuriously Resets
11)	8.64E-06	0.2%	EK186X2RYT	8.64E-06	Keowee Unit 1 Generator Lockout Auxiliary Relay 86EX-1 Spurious Actuation
12)	8.64E-06	0.2%	EK199SYRYT	8.64E-06	Keowee Unit 1 Relay 99SY Drops Out

Total Event Probability = 4.47E-03

Table A.6-12

Generator Excitation Dominant Minimal Cut Sets

Cut Sets for Gate KU2GEXCLD: Keowee Unit 2 Fails To Cold Start

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
1)	3.20E-03	52.3%	EK2BASELHE	3.20E-03	Keowee Unit 2 Base Adjust Is Set Incorrectly
2)	6.17E-04	10.1%	EK2BASEDEX	6.17E-04	Keowee Unit 2 Base Adjust Fails To Establish Correct Unit Voltage
3)	4.62E-04	7.5%	EK2SPYMDEX	4.62E-04	Keowee Unit 2 Supply Breaker Fails To Close Due To Mechanical Failure
4)	2.60E-04	4.2%	EK2FLDCLHE	2.60E-04	Keowee Unit 2 Field Breaker Fails To Close Due To Latent Human Error
5)	2.60E-04	4.2%	EK2FLSCLHE	2.60E-04	Keowee Unit 2 Field Flashing Breaker Fails To Close Due To Latent Human Error
6)	2.60E-04	4.2%	EK2FLSOLHE	2.60E-04	Keowee Unit 2 Field Flashing Breaker Fails To Open Due To Latent Human Error
7)	2.60E-04	4.2%	EK2SPYCLHE	2.60E-04	Keowee Unit 2 Supply Breaker Fails To Close Due To Latent Human Error
8)	2.49E-04	4.1%	EK241AXR6D	2.49E-04	Keowee Unit 2 Relay 41/AX Fails To Pick-up And Latch
9)	7.71E-05	1.3%	EK2FLDMDEX	7.71E-05	Keowee Unit 2 Field Breaker Fails To Close Due To Mechanical Failure
10)	7.71E-05	1.3%	EK2FLSMDEX	7.71E-05	Keowee Unit 2 Field Flashing Breaker Fails To Close Due To Mechanical Failure

Total Event Probability = 6.12E-03

Table A.6-13

Generator Excitation Dominant Minimal Cut Sets

Cut Sets for Gate KU2GEXRUN: Keowee Unit 2 Fails While Unit Runs

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
1)	2.47E-03	55.5%	EK2VREGDEX	2.47E-03	KHU-2 Voltage Adjust Failure Drives Generator Output Too High/Low
2)	1.24E-03	27.9%	EK2BAS2DEX	1.24E-03	KHU-2 Base Adjust Fails To Maintain Generator Output Within Acceptable
3)	2.88E-04	6.5%	EK2DIODDEX	2.88E-04	Keowee Unit 2 Exciter Fan Supply Diode Bridge Fails
4)	2.49E-04	5.6%	EK241AXR6D	2.49E-04	Keowee Unit 2 Relay 41/AX Fails To Pick-up And Latch
5)	8.64E-05	1.9%	EK2F30AFUF	8.64E-05	Keowee Unit 2 Excitation Cabinet Fan Fuses Fail
6)	3.30E-05	0.7%	EK288SVRYD	3.30E-05	Keowee Unit 2 Fan Control Relay 88SV Fails On Demand
7)	2.35E-05	0.5%	EK2EXC2TGF	2.35E-05	Keowee Unit 2 Generator Excitation Transformer Fails
8)	1.80E-05	0.4%	EK2FAN1TLF	1.80E-05	Keowee Unit 2 Generator Excitation Fan Power Transformer Fails
9)	1.30E-05	0.3%	EK288SVRYT	1.30E-05	Keowee Unit 2 Fan Control Relay 88SV Prior To Or During The Run
10)	8.71E-06	0.2%	EK241AXR6T	8.71E-06	Keowee Unit 2 Relay 41/AX Spuriously Resets
11)	8.64E-06	0.2%	EK286X2RYT	8.64E-06	Keowee Unit 2 Generator Lockout Auxiliary Relay 86EX-1 Spurious Actuation
12)	8.64E-06	0.2%	EK299SYRYT	8.64E-06	Keowee Unit 2 Relay 99SY Drops Out
13)	1.80E-06	0.0%	ED23BR2CDT	1.80E-06	Breaker 3BR In 125V dc Distribution Center 2DA Transfers Open
14)	1.68E-06	0.0%	EK2S41TSWT	1.68E-06	Keowee Unit 2 Field Breaker Trip Control Switch Transfers Position
15)	1.68E-06	0.0%	EK2415TSWT	1.68E-06	Spurious Operation Of The KHU2 Supply Breaker Trip Switch

Total Event Probability = 4.45E-04

Table A.6-14

Generator Excitation Dominant Contributors To Unavailability

Rank	Event Description	Mean Unavailability[1]	Approximate Unavailability Contribution[2]
	Keowee Unit 1 Generator Excitation Fails To Cold Start		
1	EK1BASELHE Keowee Unit 1 Base Adjust Is Set Incorrectly	3.19E-03	49.7%
2	EK1BASEDEX Keowee Unit 1 Base Adjust Fails To Establish Correct Unit Voltage	6.13E-04	9.6%
3	EK1SPYMDEX Keowee Unit 1 Supply Breaker Fails To Close Due To Mechanical Failure	4.59E-04	7.2%
4	EK1FLSOLHE Keowee Unit 1 Field Flashing Breaker Fails To Open Due To Latent Human Error	2.58E-04	4.0%
5	EK1FLSCLHE Keowee Unit 1 Field Flashing Breaker Fails To Close Due To Latent Human Error	2.58E-04	4.0%
6	EK1FLDCLHE Keowee Unit 1 Field Breaker Fails To Close Due To Latent Human Error	2.58E-04	4.0%
7	EK1SPYCLHE Keowee Unit 1 Supply Breaker Fails To Close Due To Latent Human Error	2.58E-04	4.0%
8	EK141AXR6D Keowee Unit 1 Relay 41/AX Fails To Pick-up And Latch	2.47E-04	3.9%

[1] The mean unavailability is the summation of the values of all cut sets in which the event appears

[2] The contribution to unavailability is calculated by dividing the mean unavailability by the overall system unavailability and then multiplying by 100 percent

Table A.6-15

Generator Excitation Dominant Contributors To Unavailability

Rank	Event Description	Mean Unavailability[1]	Approximate Unavailability Contribution[2]
Keowee Unit 1 Generator Excitation Fails While Unit Runs			
1	EK1VREGDEX KHU-1 Voltage Adjust Failure Drives Generator Output Too High/Low	2.46E-03	55.1%
2	EK1BAS2DEX KHU-1 Base Adjust Fails To Maintain Generator Output Within Acceptable Range	1.23E-03	27.6%
3	EK1DIODDEX Keowee Unit 1 Exciter Fan Supply Diode Bridge Fails	2.87E-04	6.4%
4	EK141AXR6D Keowee Unit 1 Relay 41/AX Fails To Pick-up And Latch	2.48E-04	5.5%
5	EK1F30AFUF Keowee Unit 1 Excitation Cabinet Fan Fuses Fail	8.58E-05	1.9%

[1] The mean unavailability is the summation of the values of all cut sets in which the event appears

[2] The contribution to unavailability is calculated by dividing the mean unavailability by the overall system unavailability and then multiplying by 100 percent

Table A.6-16

Generator Excitation Dominant Contributors To Unavailability

Rank	Event Description	Mean Unavailability[1]	Approximate Unavailability Contribution[2]
Keowee Unit 2 Generator Excitation Fails To Cold Start			
1	EK2BASELHE Keowee Unit 2 Base Adjust Is Set Incorrectly	3.19E-03	52.1%
2	EK2BASEDEX Keowee Unit 2 Base Adjust Fails To Establish Correct Unit Voltage	6.12E-04	10.0%
3	EK2SPYMDEX Keowee Unit 2 Supply Breaker Fails To Close Due To Mechanical Failure	4.59E-04	7.5%
4	EK2FLDCLHE Keowee Unit 2 Field Breaker Fails To Close Due To Latent Human Error	2.58E-04	4.2%
5	EK2SPYCLHE Keowee Unit 2 Supply Breaker Fails To Close Due To Latent Human Error	2.58E-04	4.2%
6	EK2FLSOLHE Keowee Unit 2 Field Flashing Breaker Fails To Open Due To Latent Human E	2.58E-04	4.2%
7	EK2FLSCLHE Keowee Unit 2 Field Flashing Breaker Fails To Close Due To Latent Human	2.58E-04	4.2%
8	EK241AXR6D Keowee Unit 2 Relay 41/AX Fails To Pick-up And Latch	2.47E-04	4.0%
9	EK2FLSMDEX Keowee Unit 2 Field Flashing Breaker Fails To Close Due To Mechanical Failure	7.65E-05	1.3%
10	EK2FLDMDEX Keowee Unit 2 Field Breaker Fails To Close Due To Mechanical Failure	7.65E-05	1.3%

[1] The mean unavailability is the summation of the values of all cut sets in which the event appears

[2] The contribution to unavailability is calculated by dividing the mean unavailability by the overall system unavailability and then multiplying by 100 percent

Table A.6-17

Generator Excitation Dominant Contributors To Unavailability

Rank	Event Description	Mean Unavailability[1]	Approximate Unavailability Contribution[2]
Keowee Unit 2 Generator Excitation Fails While Unit Runs			
1	EK2VREGDEX KHU-2 Voltage Adjust Failure Drives Generator Output Too High/Low	2.47E-03	55.4%
2	EK2BAS2DEX KHU-2 Base Adjust Fails To Maintain Generator Output Within Acceptable	1.24E-03	27.8%
3	EK2DIODDEX Keowee Unit 2 Exciter Fan Supply Diode Bridge Fails	2.87E-04	6.5%
4	EK241AXR6D Keowee Unit 2 Relay 41/AX Fails To Pick-up And Latch	2.48E-04	5.6%
5	EK2F30AFUF Keowee Unit 2 Excitation Cabinet Fan Fuses Fail	8.59E-05	1.9%

[1] The mean unavailability is the summation of the values of all cut sets in which the event appears

[2] The contribution to unavailability is calculated by dividing the mean unavailability by the overall system unavailability and then multiplying by 100 percent

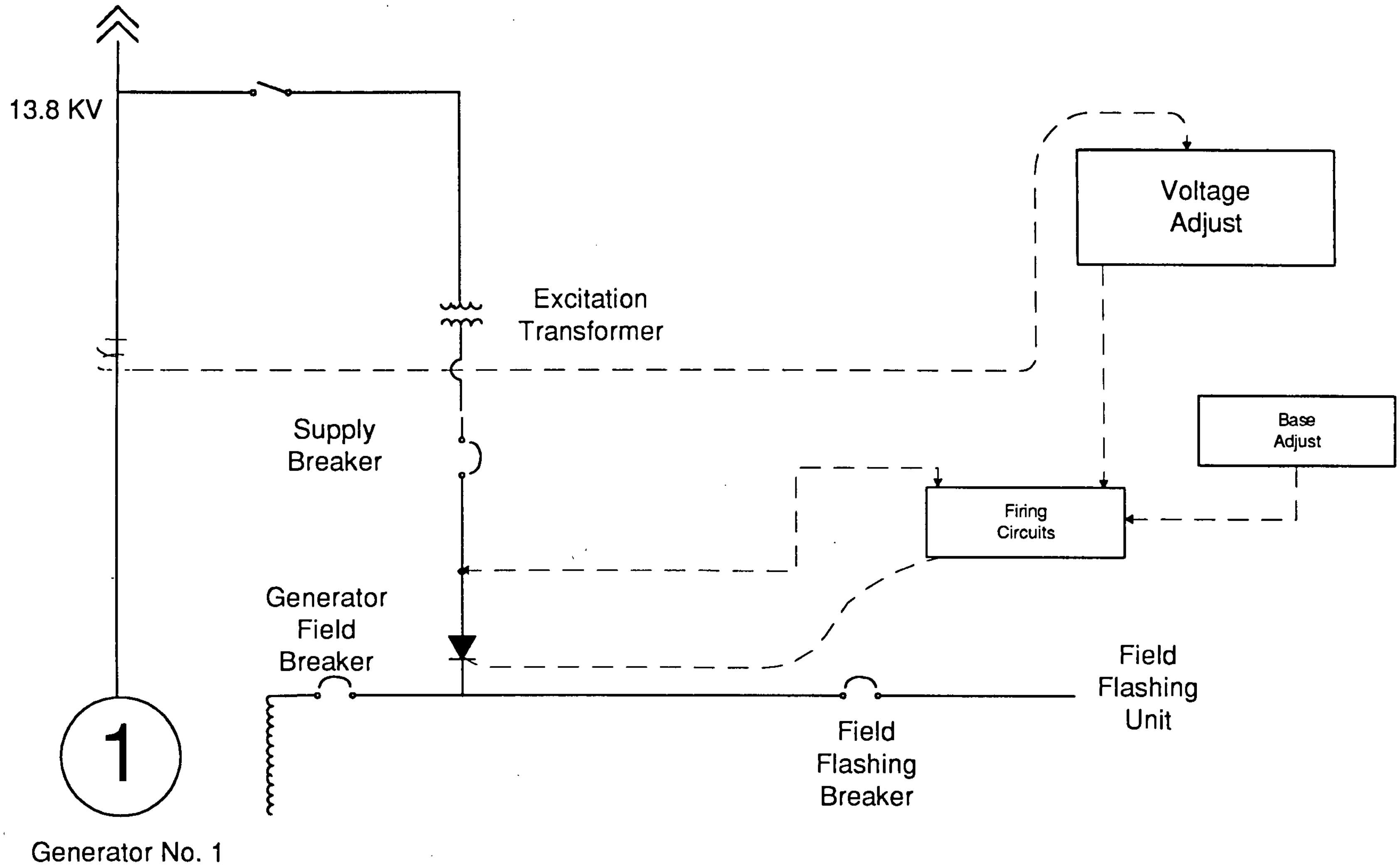


Figure A.6-1 Generator Excitation Simplified Diagram

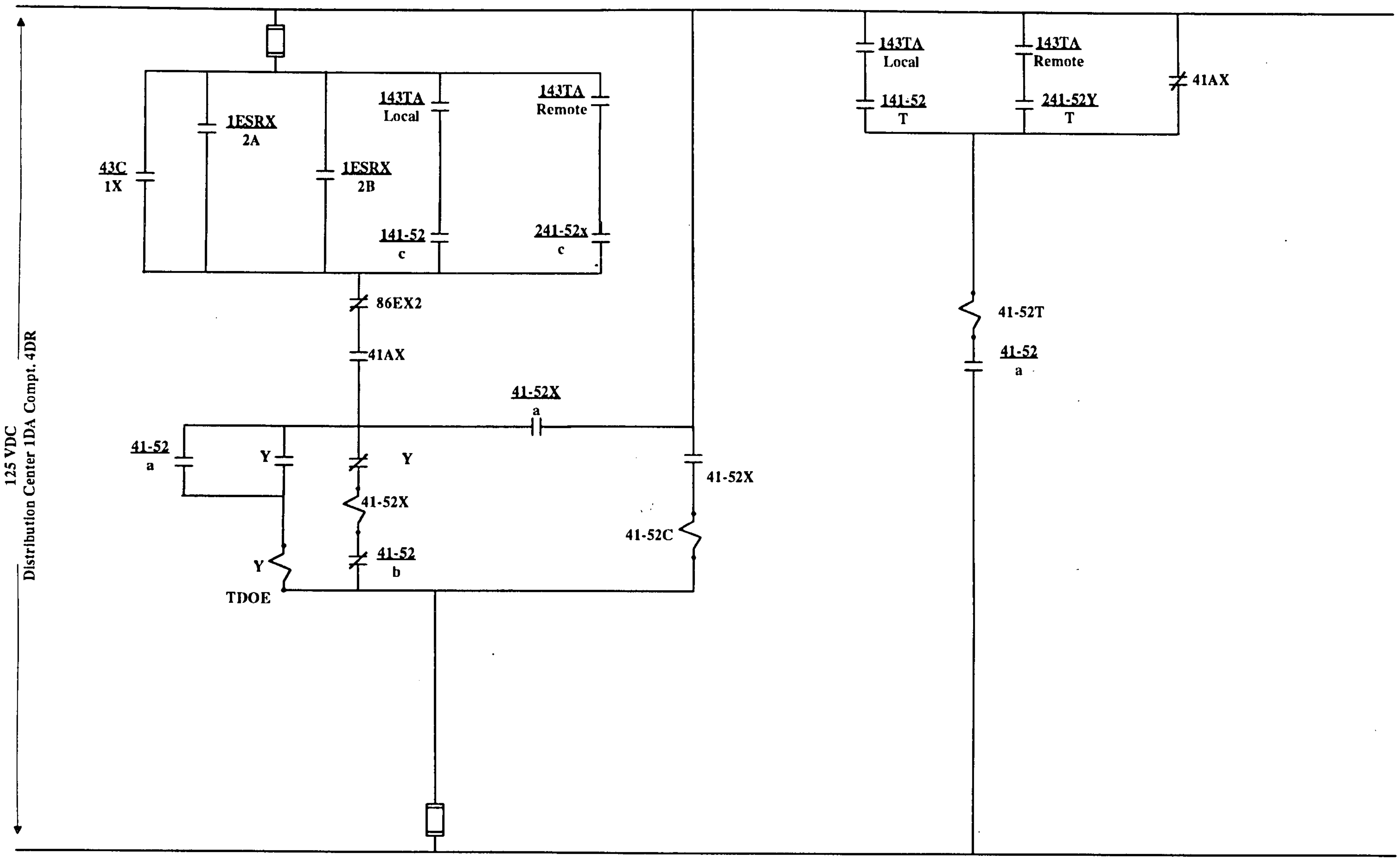


Figure A.6-2 Simplified Generator Supply Breaker Elementary Diagram

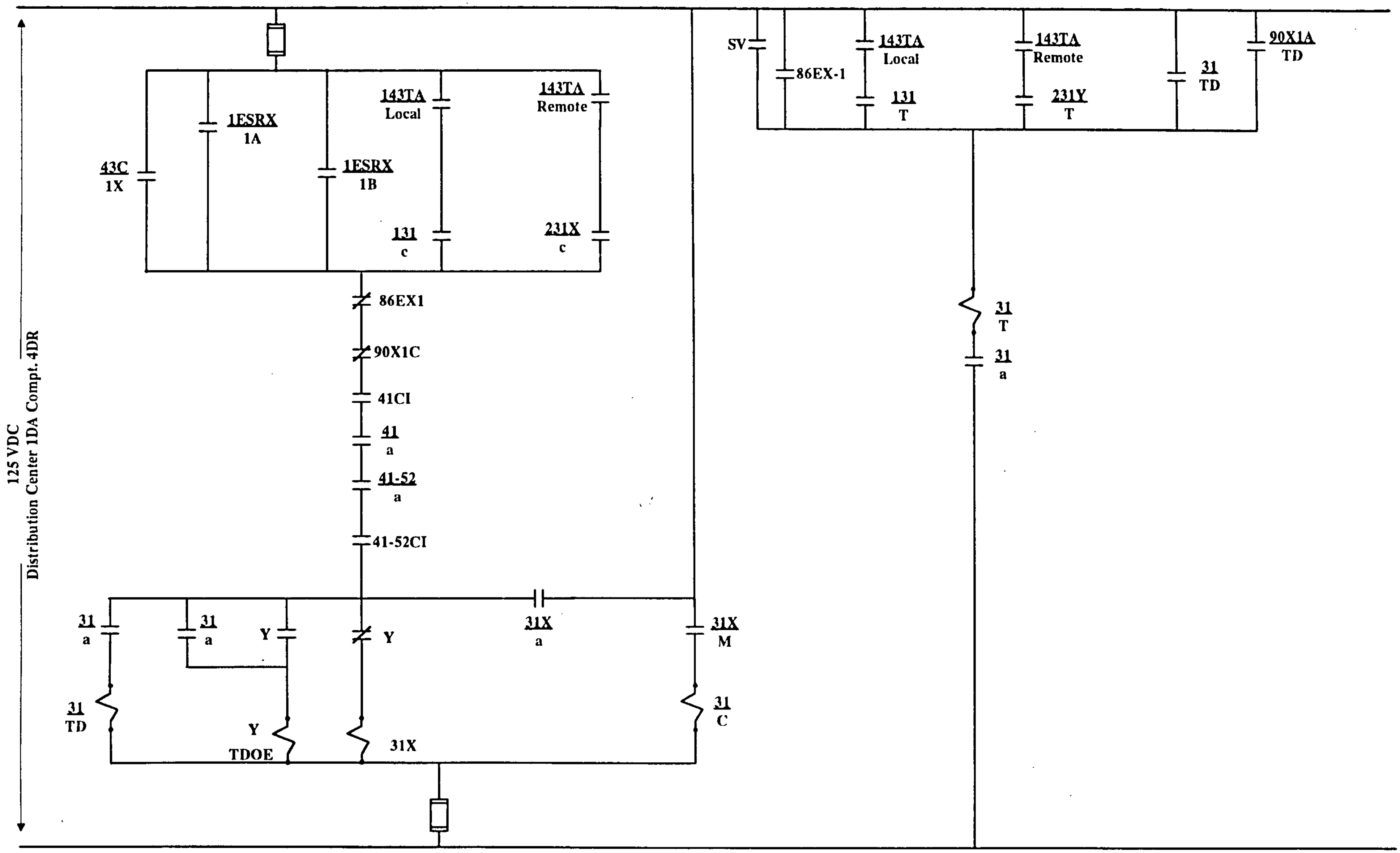


Figure A.6-3 Simplified Generator Field Flashing Breaker Elementary Diagram

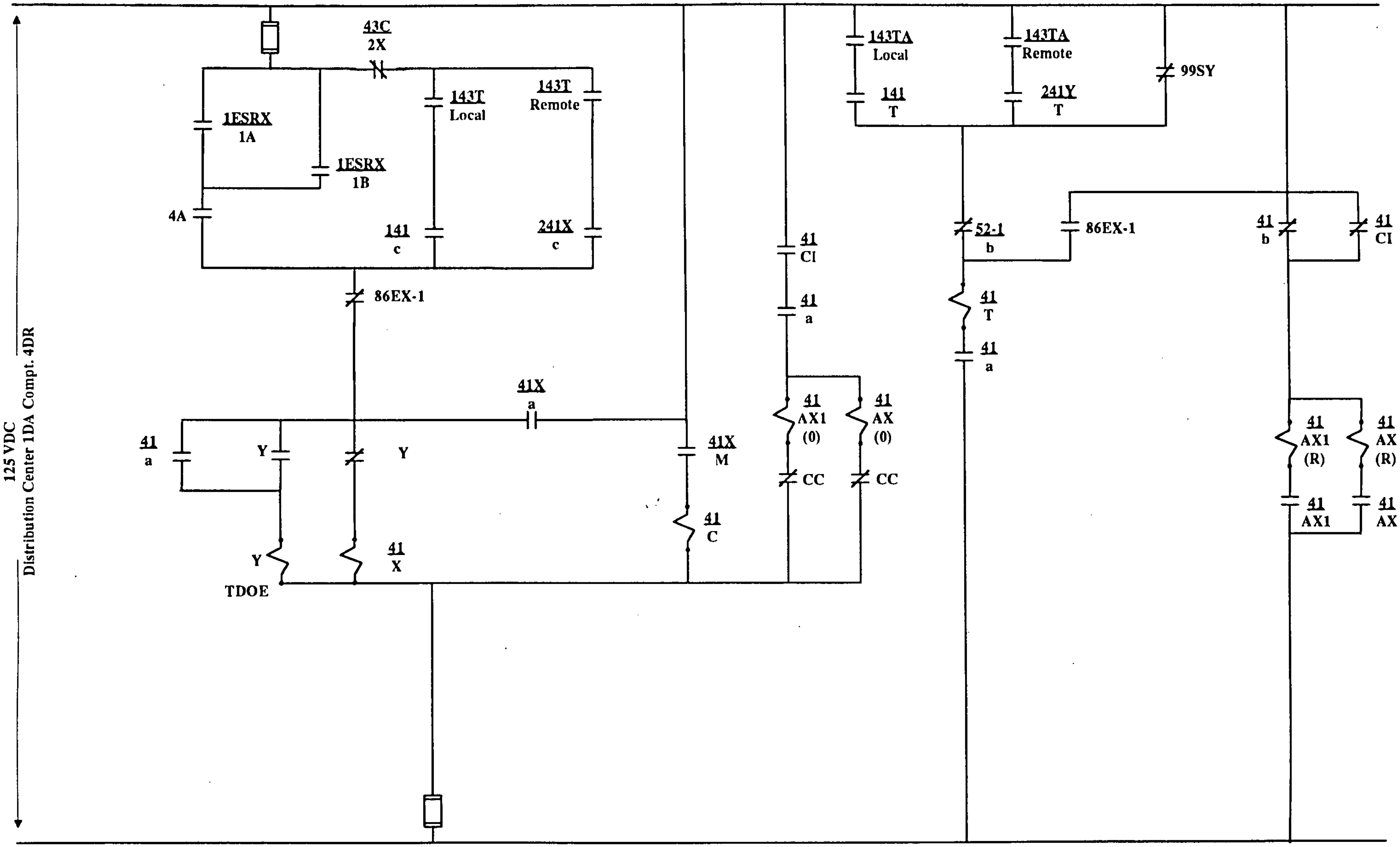
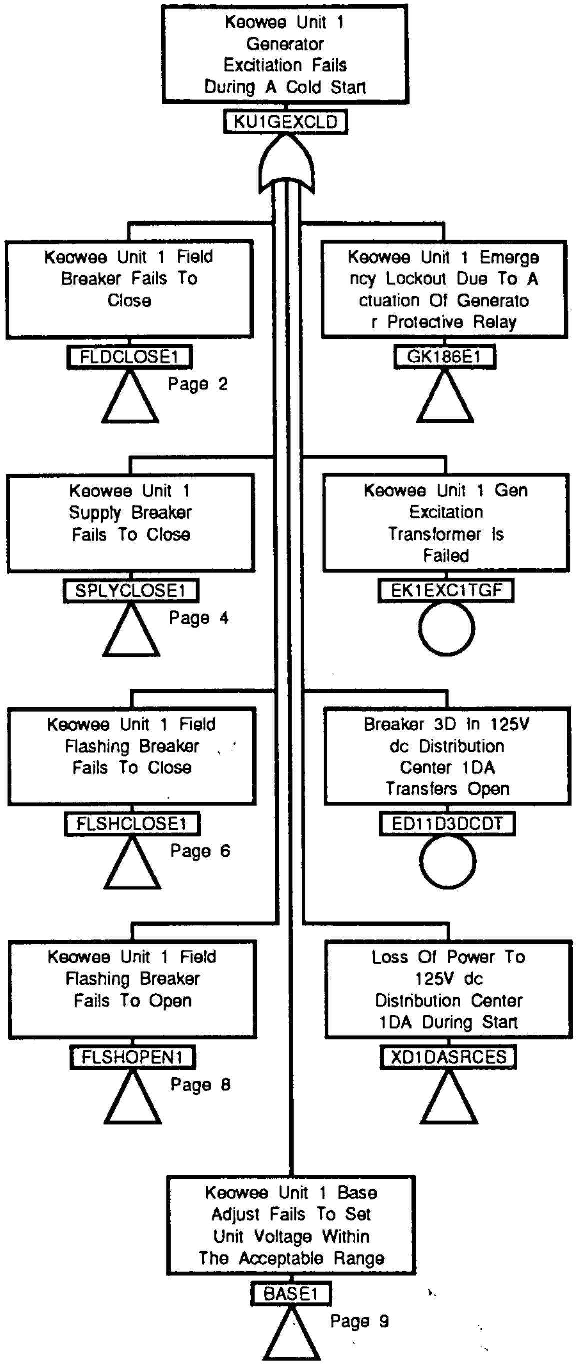
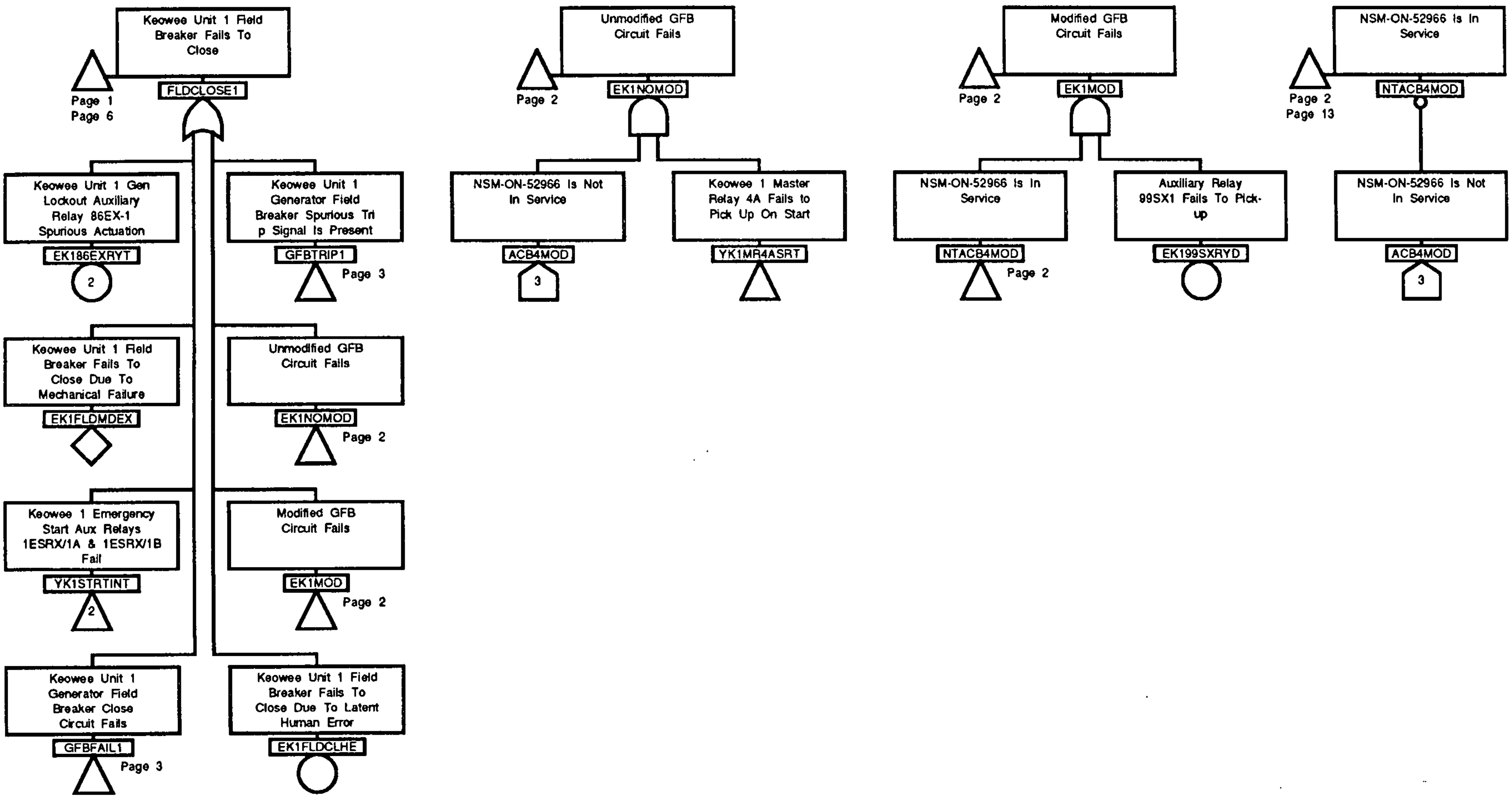
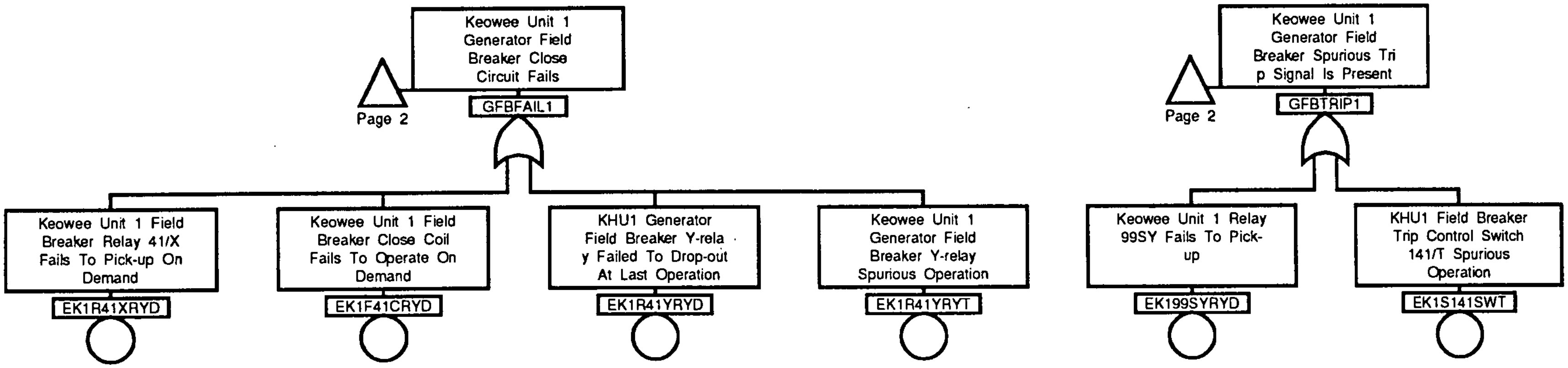


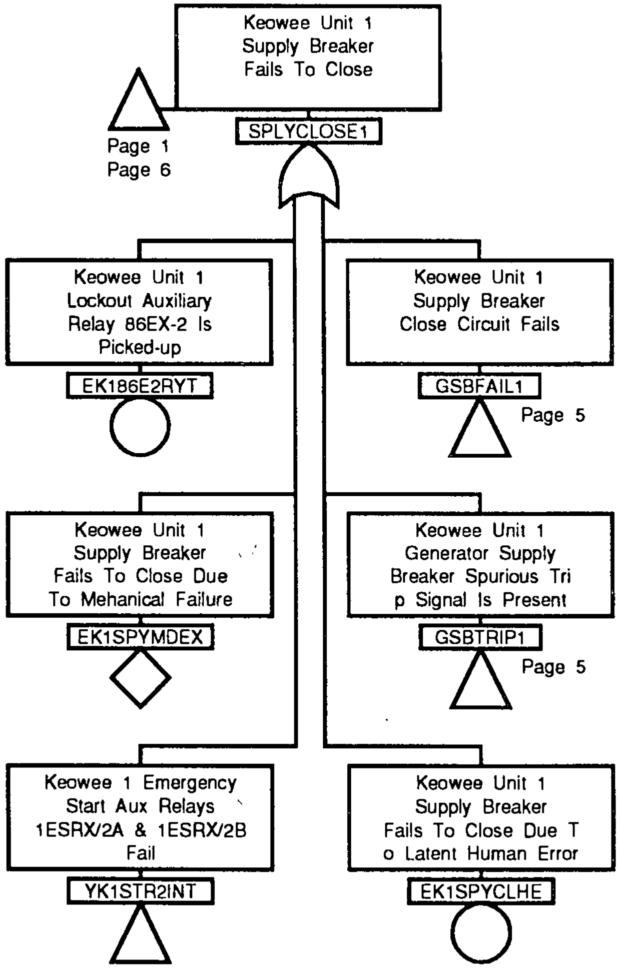
Figure A.6-4 Simplified Generator Field Breaker Elementary Diagram


Keowee Unit 1 Generator Excitiation Fails During A Cold Start
KU1GEXCLD
Keowee Unit 1 Field Breaker Fails To Close
FLDCLOSE1
Page 2
Keowee Unit 1 Emergency Lockout Due To Actuation Of Generator Protective Relay
GK186E1
Keowee Unit 1 Supply Breaker Fails To Close
SPLYCLOSE1
Page 4
Keowee Unit 1 Gen Excitation Transformer Is Failed
EK1EXC1TGF
Keowee Unit 1 Field Flashing Breaker Fails To Close
FLSHCLOSE1
Page 6
Breaker 3D In 125V dc Distribution Center 1DA Transfers Open
ED11D3DCDT
Keowee Unit 1 Field Flashing Breaker Fails To Open
FLSHOPEN1
Page 8
Loss Of Power To 125V dc Distribution Center 1DA During Start
XD1DASRCES
Keowee Unit 1 Base Adjust Fails To Set Unit Voltage Within The Acceptable Range
BASE1
Page 9

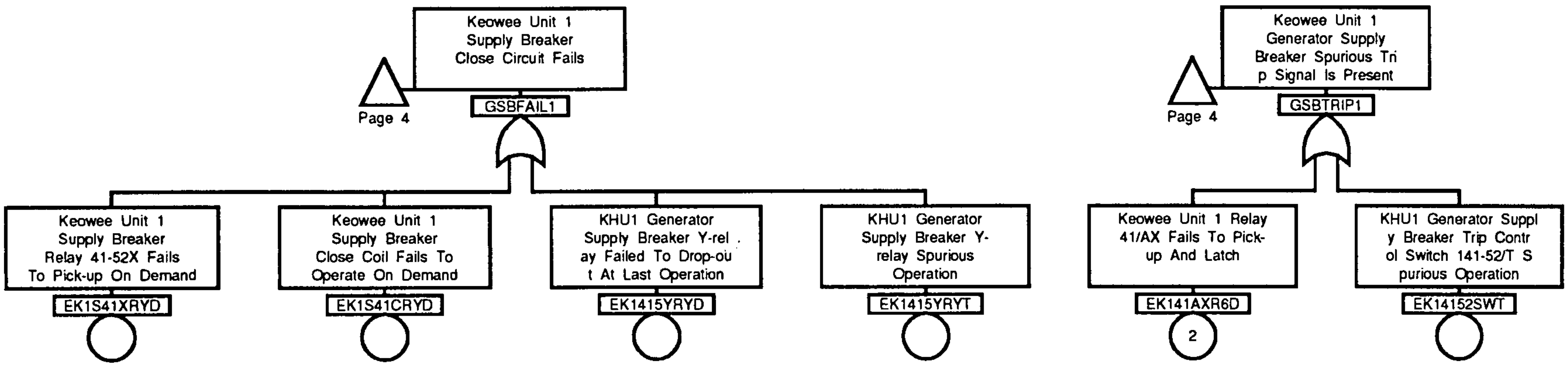

Keowee Unit 1 Field Breaker Fails To Close
FLDCLOSE1
Page 1
Page 6
Keowee Unit 1 Gen Lockout Auxiliary Relay 86EX-1 Spurious Actuation
EK186EXRYT
2
Keowee Unit 1 Generator Field Breaker Spurious Tri p Signal Is Present
GFBTRIP1
Page 3
Keowee Unit 1 Field Breaker Fails To Close Due To Mechanical Failure
EK1FLDMDEX
Unmodified GFB Circuit Fails
EK1NOMOD
Page 2
Keowee 1 Emergency Start Aux Relays 1ESRX/1A & 1ESRX/1B Fail
YK1STRTINT
2
Modified GFB Circuit Fails
EK1MOD
Page 2
Keowee Unit 1 Generator Field Breaker Close Circuit Fails
GFBFAIL1
Page 3
Keowee Unit 1 Field Breaker Fails To Close Due To Latent Human Error
EK1FLDCLHE
Unmodified GFB Circuit Fails
EK1NOMOD
Page 2
NSM-ON-52966 Is Not In Service
ACB4MOD
3
Keowee 1 Master Relay 4A Fails to Pick Up On Start
YK1MR4ASRT
Modified GFB Circuit Fails
EK1MOD
Page 2
NSM-ON-52966 Is In Service
NTACB4MOD
Page 2
Auxiliary Relay 99SX1 Fails To Pick-up
EK199SXRYD
NSM-ON-52966 Is In Service
NTACB4MOD
Page 2
Page 13
NSM-ON-52966 Is Not In Service
ACB4MOD
3



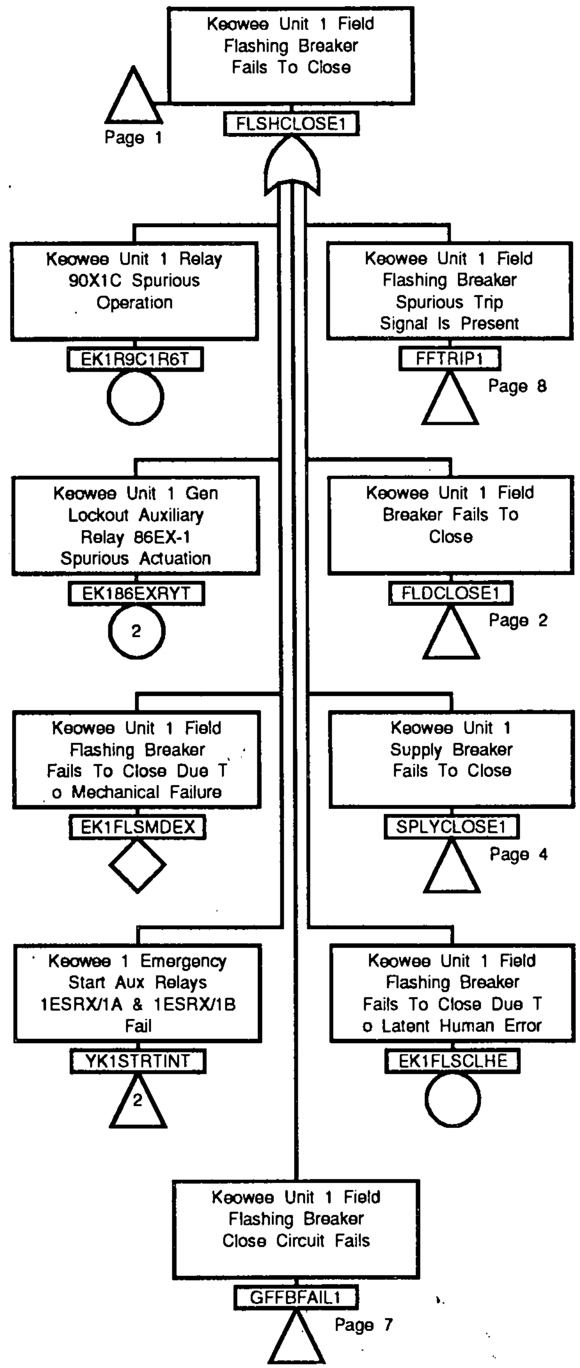
Keowee Unit 1 Generator Field Breaker Close Circuit Fails
Page 2
GFBFAIL1
Keowee Unit 1 Field Breaker Relay 41/X Fails To Pick-up On Demand
EK1R41XRYD
Keowee Unit 1 Field Breaker Close Coil Fails To Operate On Demand
EK1F41CRYD
KHU1 Generator Field Breaker Y-rela y Failed To Drop-out At Last Operation
EK1R41YRYD
Keowee Unit 1 Generator Field Breaker Y-relay Spurious Operation
EK1R41YRYT
Keowee Unit 1 Generator Field Breaker Spurious Tri p Signal Is Present
Page 2
GFBTRIP1
Keowee Unit 1 Relay 99SY Fails To Pick-up
EK199SYRYD
KHU1 Field Breaker Trip Control Switch 141/T Spurious Operation
EK1S141SWT

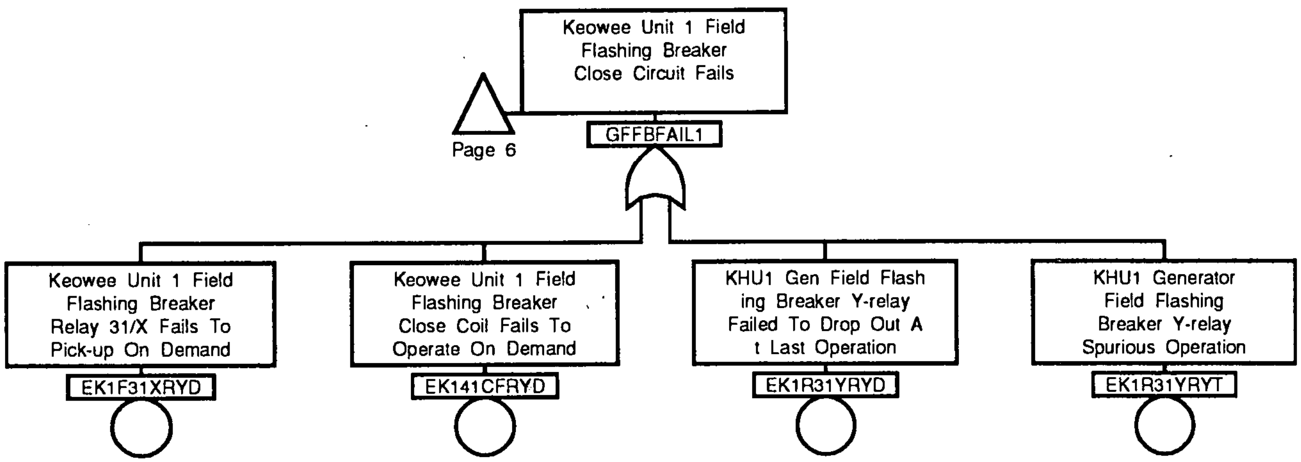


Keowee Units 1 & 2 Excitation Fault Tree	FIGURE A.6-5	Page 4

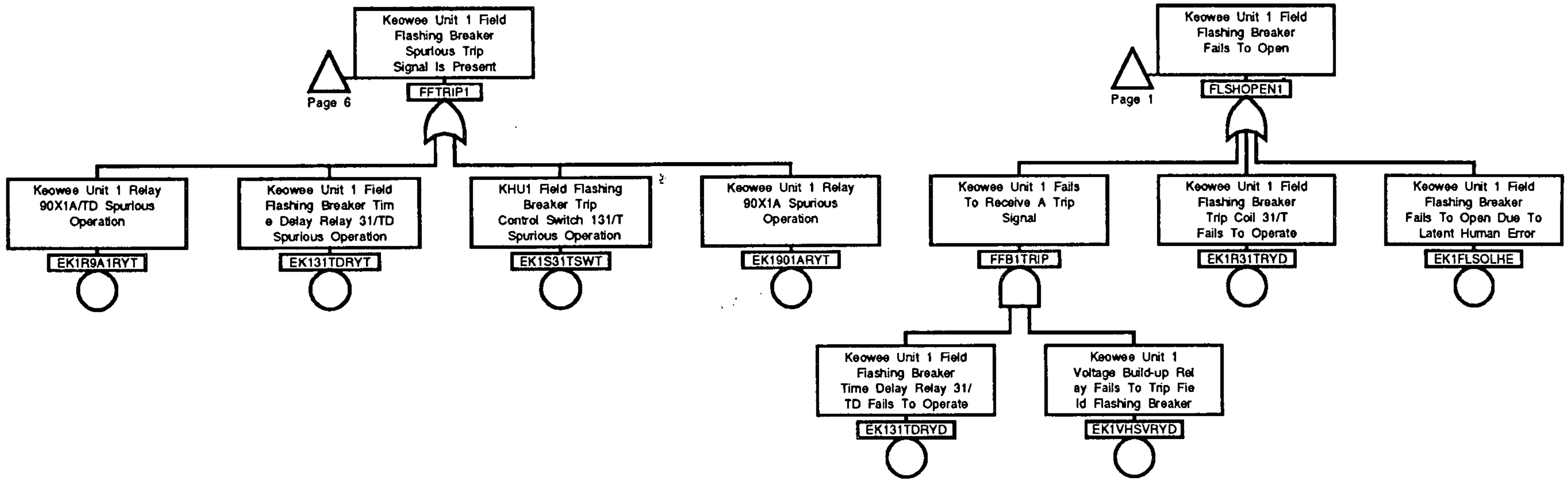


Keowee Units 1 & 2 Excitation Fault Tree	FIGURE A.6-5	Page 5

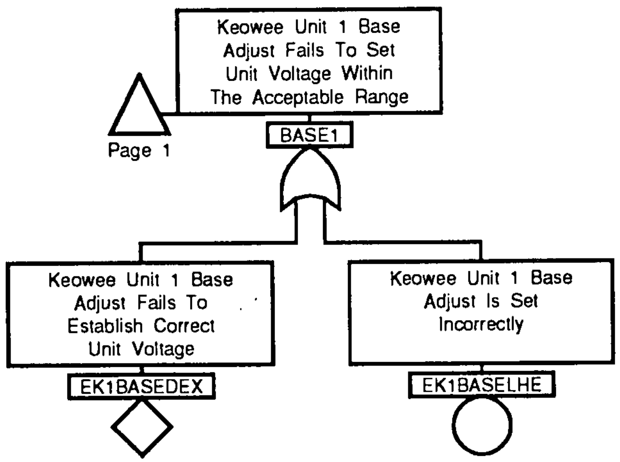

Keowee Unit 1 Field Flashing Breaker Fails To Close
Page 1
FLSHCLOSE1
Keowee Unit 1 Relay 90X1C Spurious Operation
EK1R9C1R6T
Keowee Unit 1 Field Flashing Breaker Spurious Trip Signal Is Present
FFTRIP1
Page 8
Keowee Unit 1 Gen Lockout Auxiliary Relay 86EX-1 Spurious Actuation
EK186EXRYT
2
Keowee Unit 1 Field Breaker Fails To Close
FLDCLOSE1
Page 2
Keowee Unit 1 Field Flashing Breaker Fails To Close Due T o Mechanical Failure
EK1FLSMDEX
Keowee Unit 1 Supply Breaker Fails To Close
SPLYCLOSE1
Page 4
Keowee 1 Emergency Start Aux Relays 1ESRX/1A & 1ESRX/1B Fail
YK1STRTINT
2
Keowee Unit 1 Field Flashing Breaker Fails To Close Due T o Latent Human Error
EK1FLSCLHE
Keowee Unit 1 Field Flashing Breaker Close Circuit Fails
GFFBFAIL1
Page 7

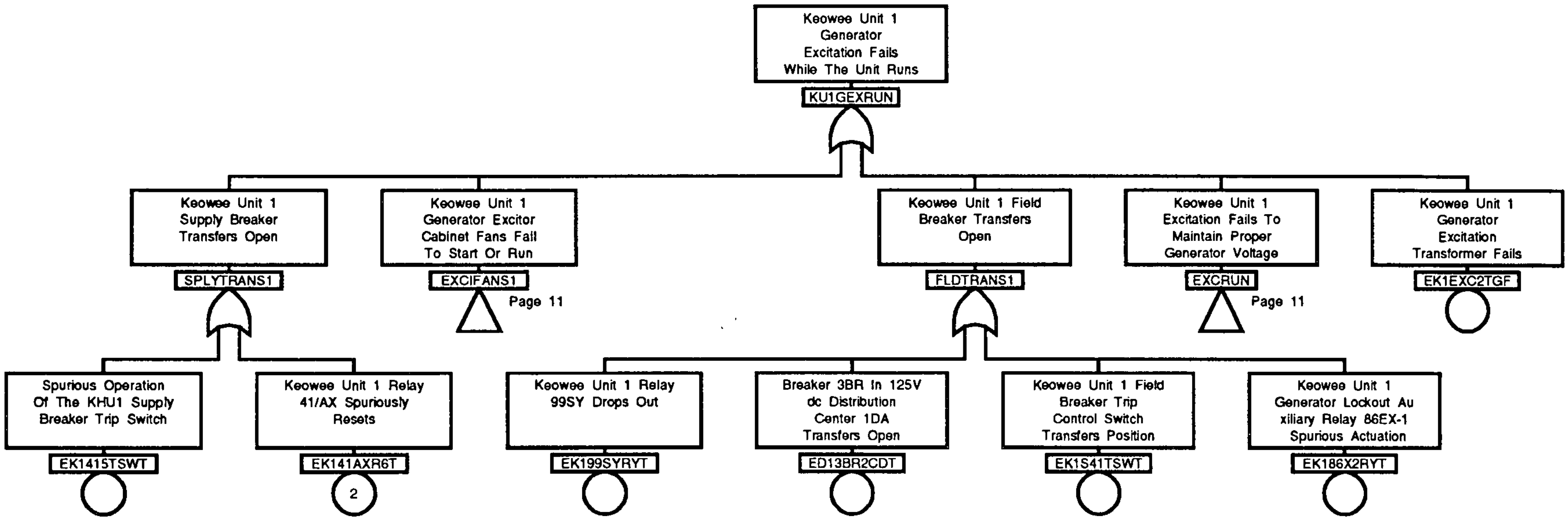


Keowee Unit 1 Field Flashing Breaker Close Circuit Fails
GFFBFAIL1
Page 6
Keowee Unit 1 Field Flashing Breaker Relay 31/X Fails To Pick-up On Demand
EK1F31XRYD
Keowee Unit 1 Field Flashing Breaker Close Coil Fails To Operate On Demand
EK141CFRYD
KHU1 Gen Field Flash ing Breaker Y-relay Failed To Drop Out A t Last Operation
EK1R31YRYD
KHU1 Generator Field Flashing Breaker Y-relay Spurious Operation
EK1R31YRYT

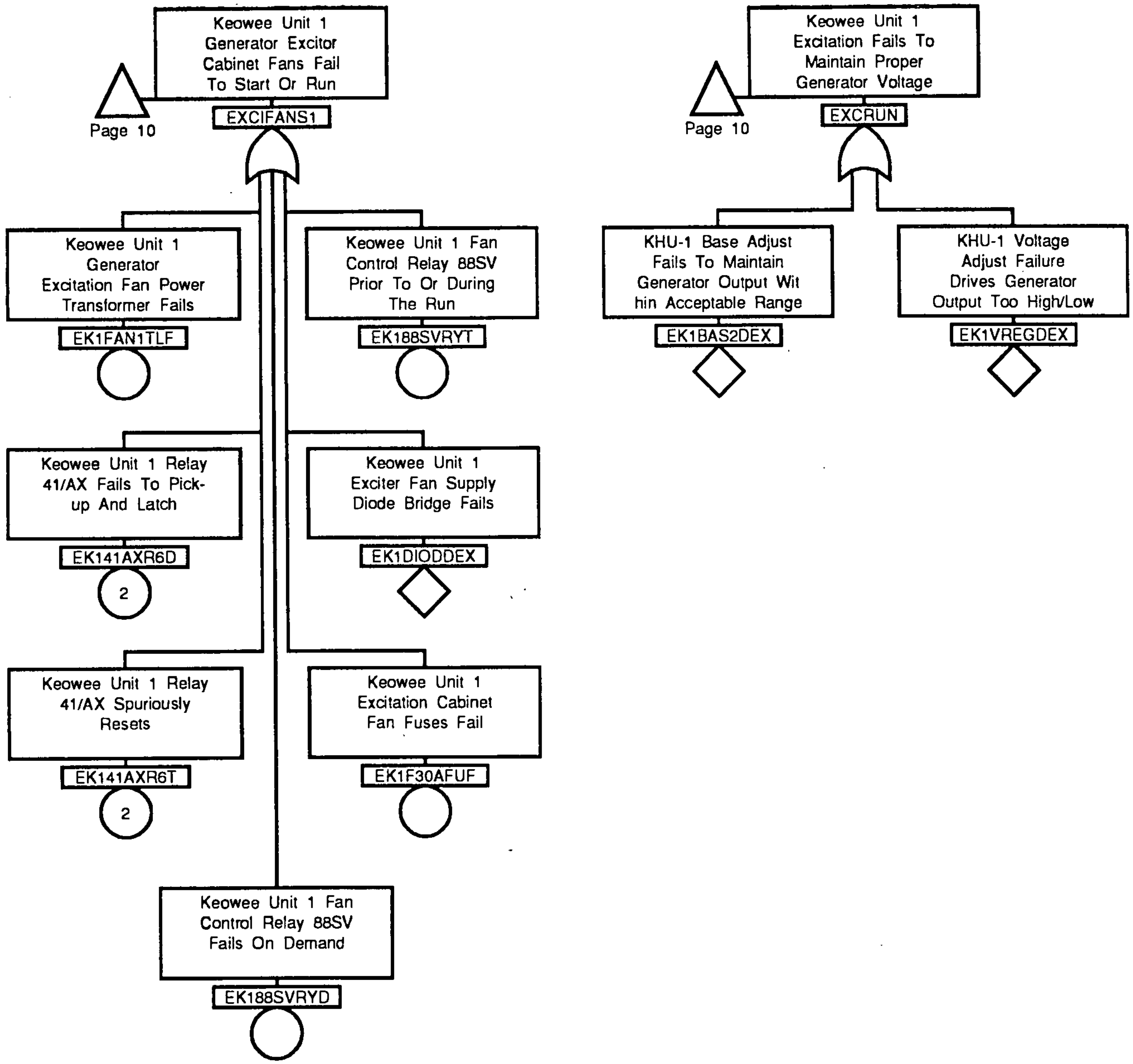


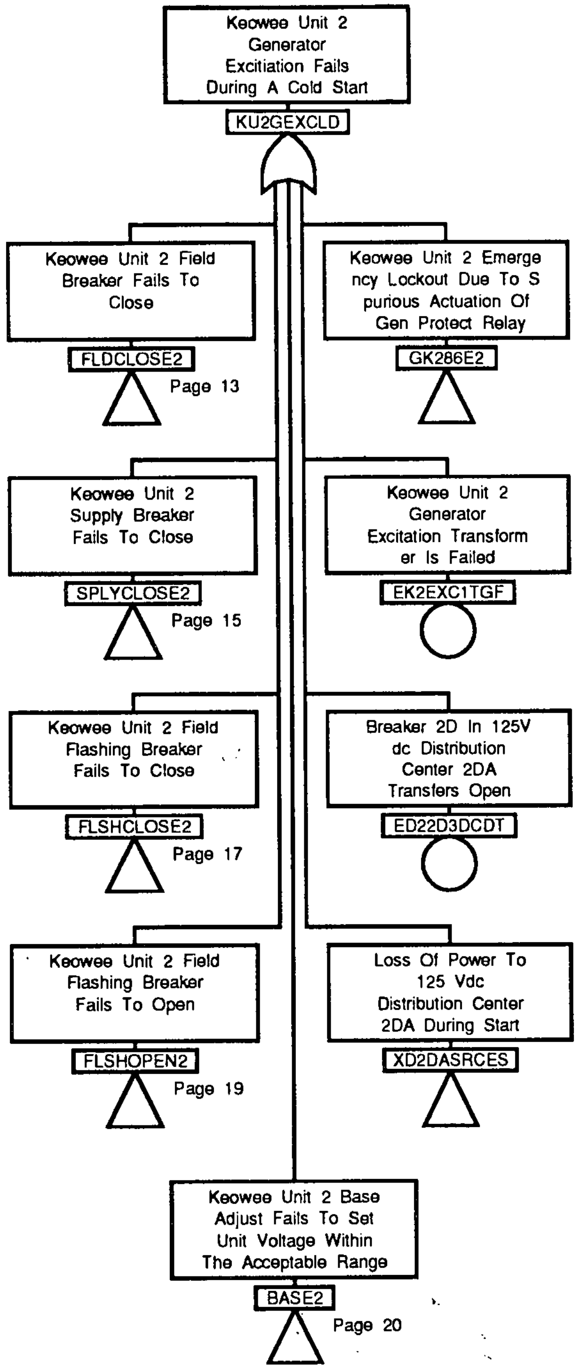
Keowee Units 1 & 2 Excitation Fault Tree | FIGURE A.6-5 |


Keowee Unit 1 Base Adjust Fails To Set Unit Voltage Within The Acceptable Range
BASE1
Page 1
Keowee Unit 1 Base Adjust Fails To Establish Correct Unit Voltage
EK1BASEDEX
Keowee Unit 1 Base Adjust Is Set Incorrectly
EK1BASELHE



Keowee Unit 1 Generator Excitation Fails While The Unit Runs
KU1GEXRUN
Keowee Unit 1 Supply Breaker Transfers Open
SPLYTRANS1
Keowee Unit 1 Generator Excitor Cabinet Fans Fail To Start Or Run
EXCIFANS1
Page 11
Keowee Unit 1 Field Breaker Transfers Open
FLDTRANS1
Keowee Unit 1 Excitation Fails To Maintain Proper Generator Voltage
EXCRUN
Page 11
Keowee Unit 1 Generator Excitation Transformer Fails
EK1EXC2TGF
Spurious Operation Of The KHU1 Supply Breaker Trip Switch
EK1415TSWT
Keowee Unit 1 Relay 41/AX Spuriously Resets
EK141AXR6T
2
Keowee Unit 1 Relay 99SY Drops Out
EK199SYRYT
Breaker 3BR In 125V dc Distribution Center 1DA Transfers Open
ED13BR2CDT
Keowee Unit 1 Field Breaker Trip Control Switch Transfers Position
EK1S41TSWT
Keowee Unit 1 Generator Lockout Au xiliary Relay 86EX-1 Spurious Actuation
EK186X2RYT


Keowee Unit 1 Generator Excitor Cabinet Fans Fail To Start Or Run
Page 10
EXCIFANS1
Keowee Unit 1 Generator Excitation Fan Power Transformer Fails
EK1FAN1TLF
Keowee Unit 1 Fan Control Relay 88SV Prior To Or During The Run
EK188SVRYT
Keowee Unit 1 Relay 41/AX Fails To Pick-up And Latch
EK141AXR6D
2
Keowee Unit 1 Exciter Fan Supply Diode Bridge Fails
EK1DIODDEX
Keowee Unit 1 Relay 41/AX Spuriously Resets
EK141AXR6T
2
Keowee Unit 1 Excitation Cabinet Fan Fuses Fail
EK1F30AFUF
Keowee Unit 1 Fan Control Relay 88SV Fails On Demand
EK188SVRYD
Keowee Unit 1 Excitation Fails To Maintain Proper Generator Voltage
Page 10
EXCRUN
KHU-1 Base Adjust Fails To Maintain Generator Output Wit hin Acceptable Range
EK1BAS2DEX
KHU-1 Voltage Adjust Failure Drives Generator Output Too High/Low
EK1VREGDEX



Keowee Unit 2 Generator Excitiation Fails During A Cold Start
KU2GEXCLD
Keowee Unit 2 Field Breaker Fails To Close
FLDCLOSE2
Page 13
Keowee Unit 2 Emerge ncy Lockout Due To S purious Actuation Of Gen Protect Relay
GK286E2
Keowee Unit 2 Supply Breaker Fails To Close
SPLYCLOSE2
Page 15
Keowee Unit 2 Generator Excitation Transform er Is Failed
EK2EXC1TGF
Keowee Unit 2 Field Flashing Breaker Fails To Close
FLSHCLOSE2
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Breaker 2D In 125V dc Distribution Center 2DA Transfers Open
ED22D3DCDT
Keowee Unit 2 Field Flashing Breaker Fails To Open
FLSHOPEN2
Page 19
Loss Of Power To 125 Vdc Distribution Center 2DA During Start
XD2DASRCES
Keowee Unit 2 Base Adjust Fails To Set Unit Voltage Within The Acceptable Range
BASE2
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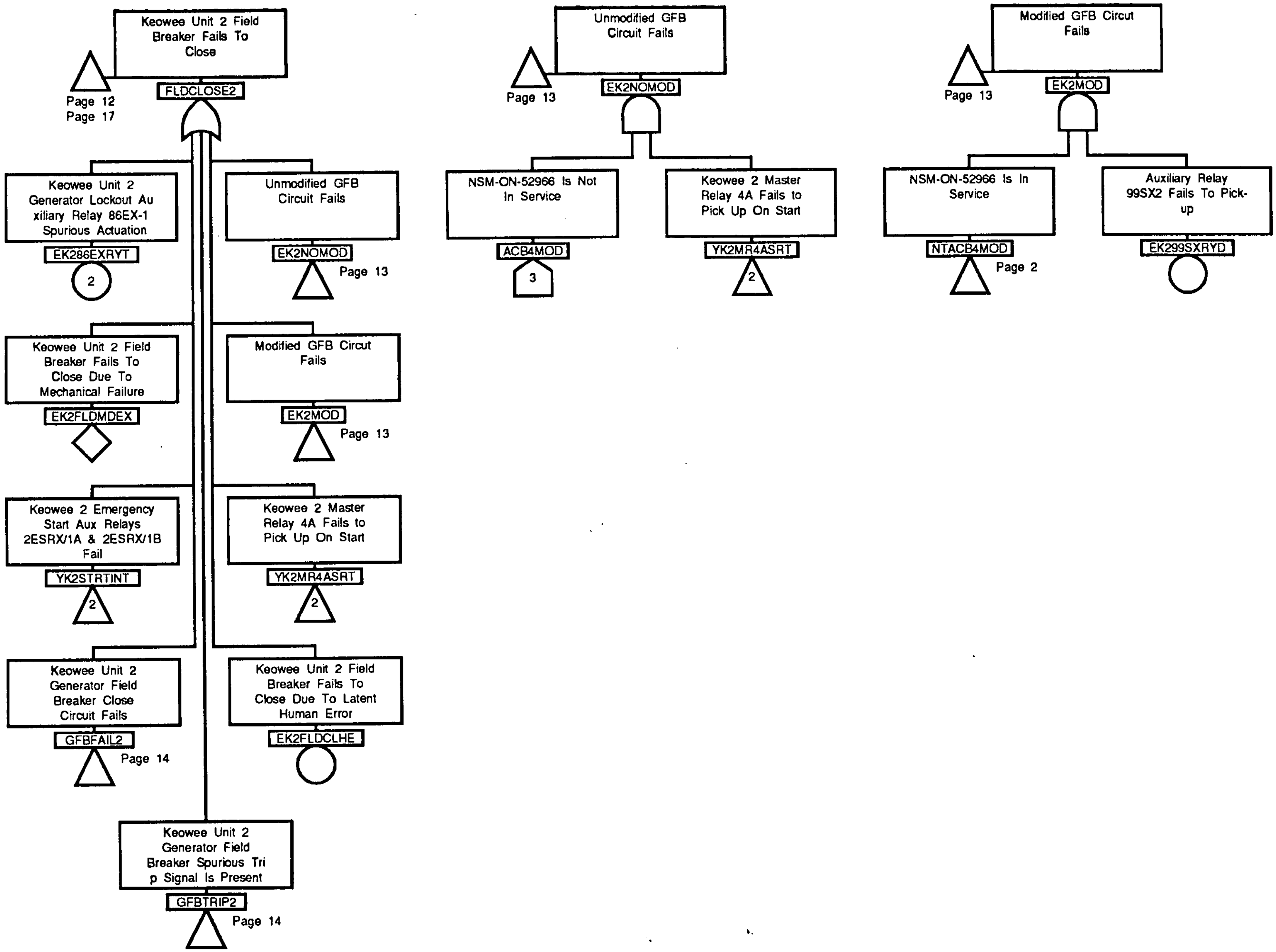
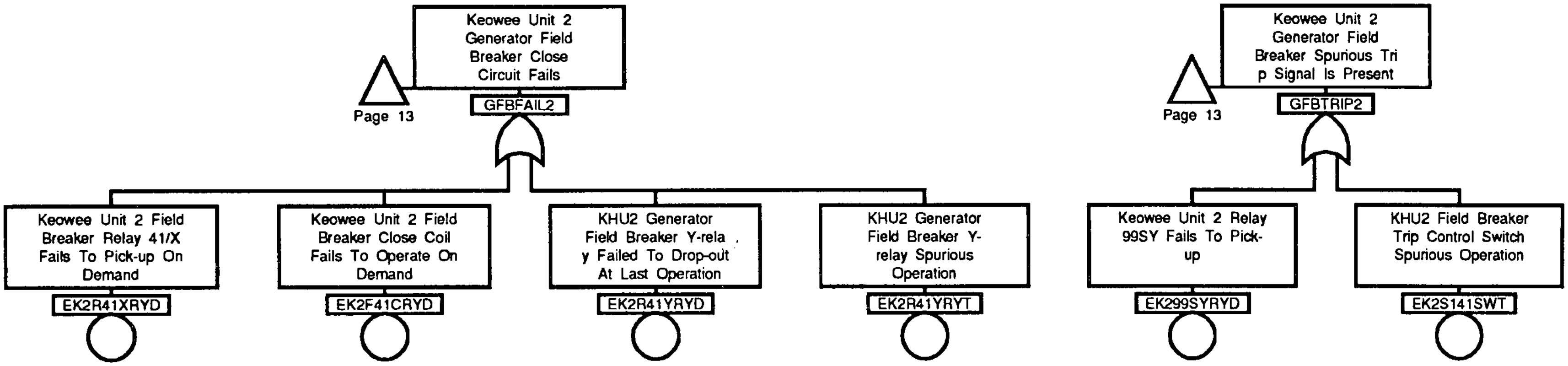
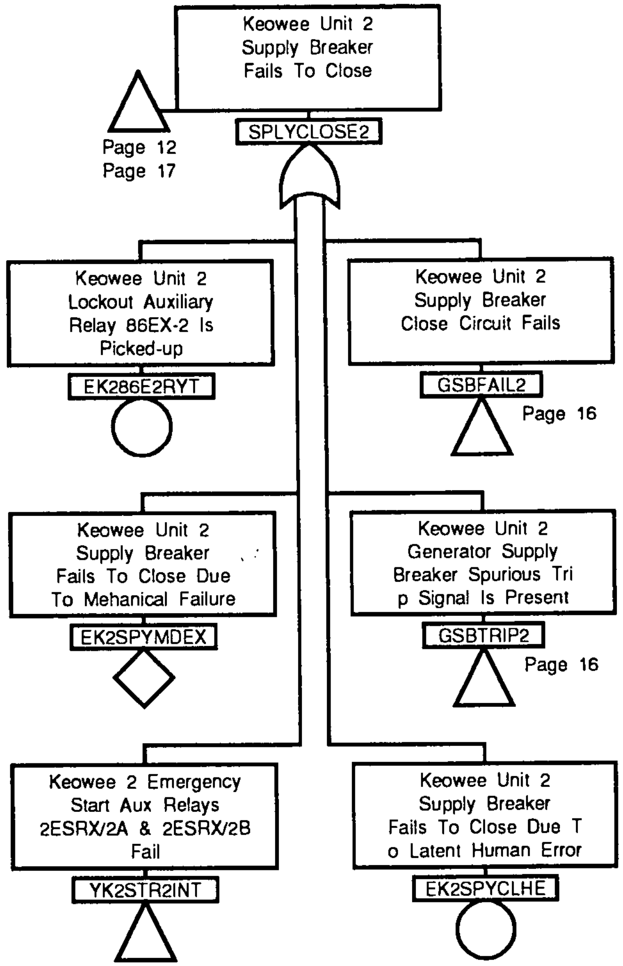


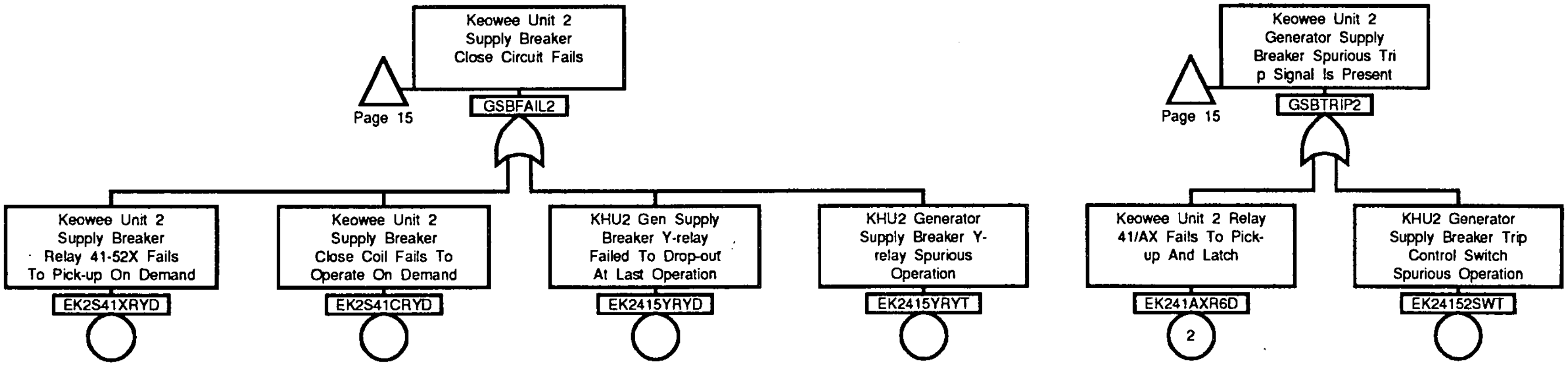
Keowee Units 1 & 2 Excitation Fault Tree	FIGURE A.6-5	Page 13



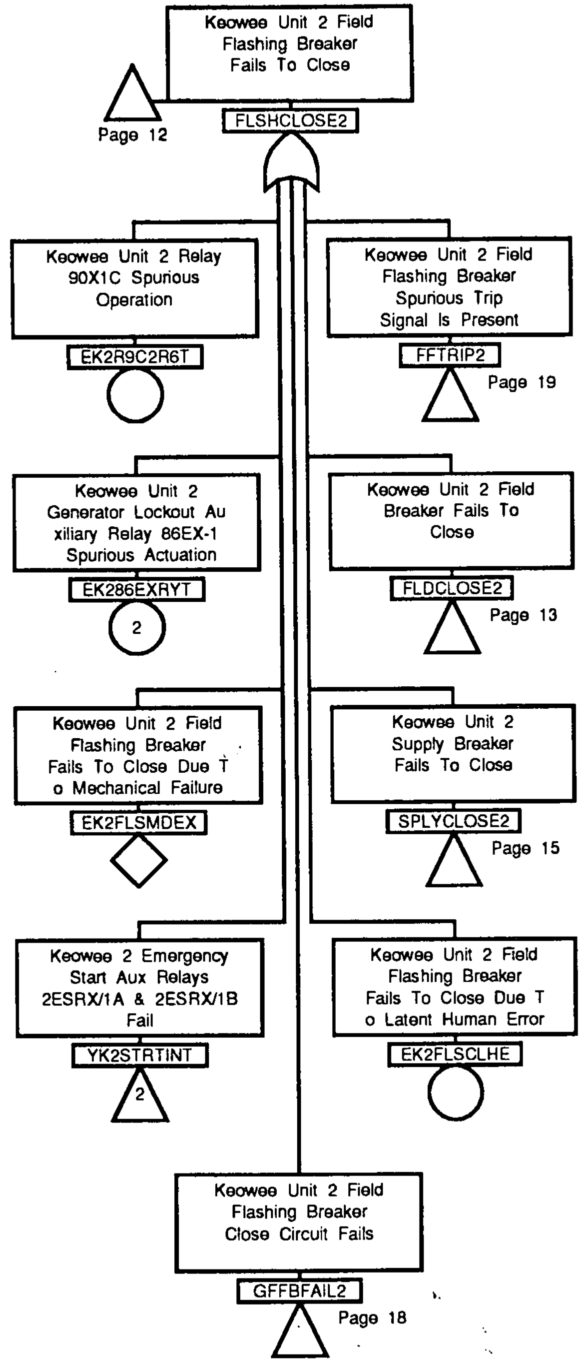
Keowee Units 1 & 2 Excitation Fault Tree	FIGURE A.6-5	Page 14



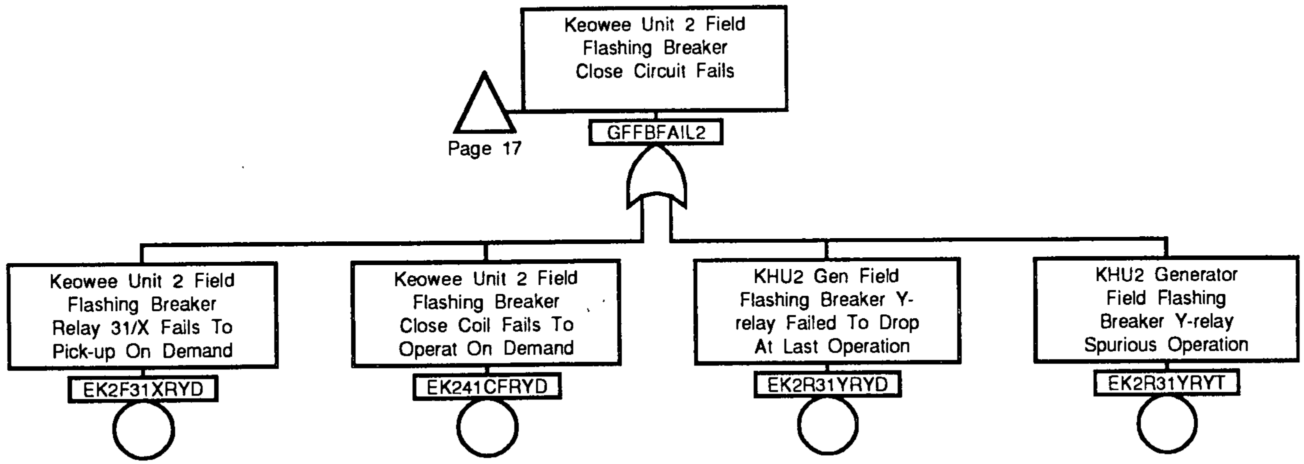
Keowee Unit 2 Supply Breaker Fails To Close
SPLYCLOSE2
Page 12
Page 17
Keowee Unit 2 Lockout Auxiliary Relay 86EX-2 Is Picked-up
EK286E2RYT
Keowee Unit 2 Supply Breaker Close Circuit Fails
GSBFAIL2
Page 16
Keowee Unit 2 Supply Breaker Fails To Close Due To Mehanical Failure
EK2SPYMDEX
Keowee Unit 2 Generator Supply Breaker Spurious Tri p Signal Is Present
GSBTRIP2
Page 16
Keowee 2 Emergency Start Aux Relays 2ESRX/2A & 2ESRX/2B Fail
YK2STR2INT
Keowee Unit 2 Supply Breaker Fails To Close Due T o Latent Human Error
EK2SPYCLHE

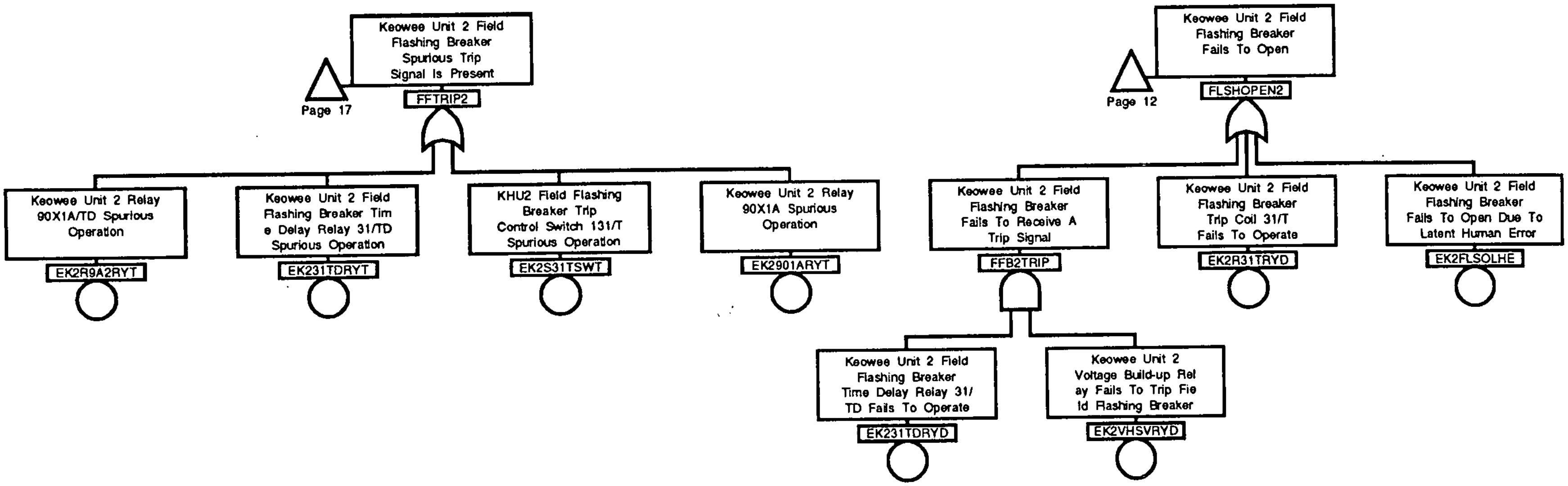


Keowee Units 1 & 2 Excitation Fault Tree | FIGURE A.6-5

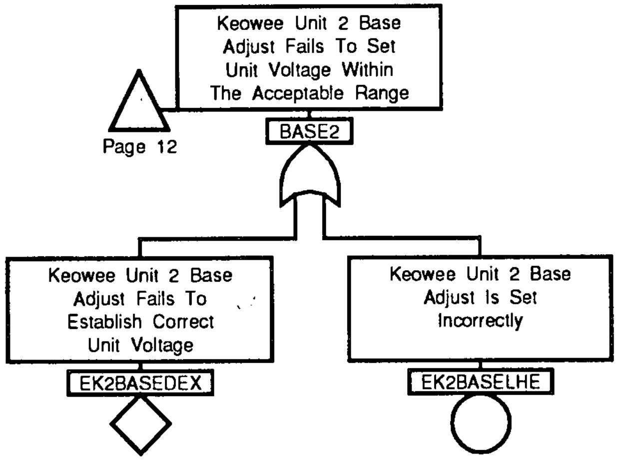


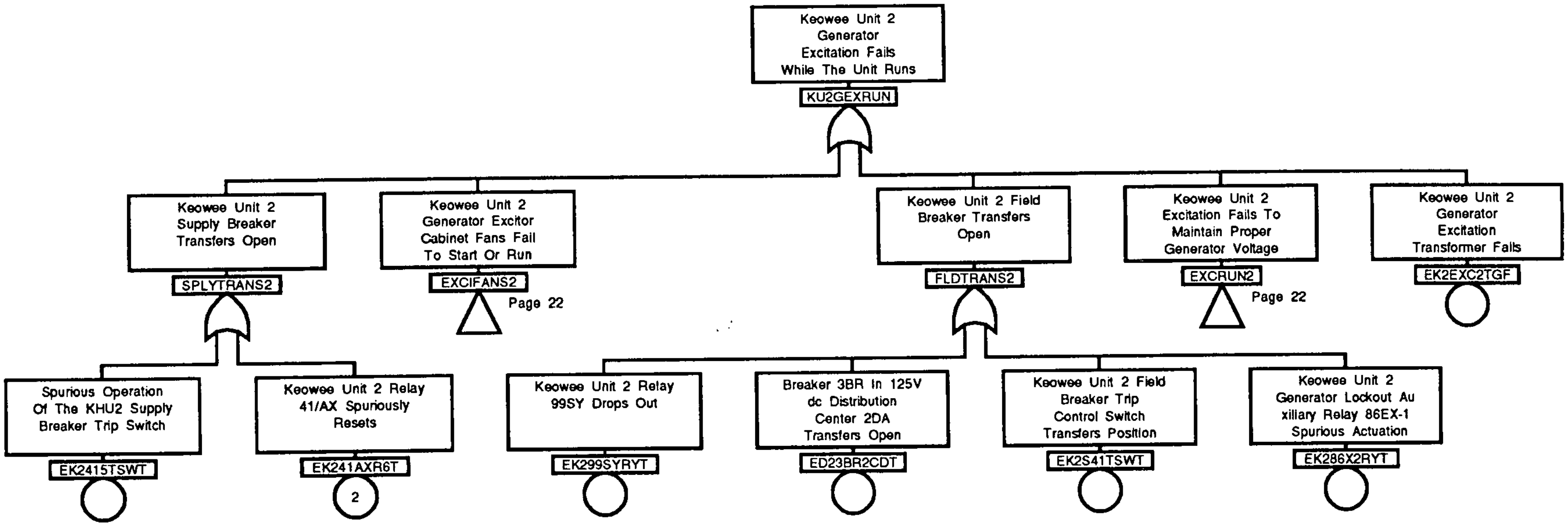
Keowee Units 1 & 2 Excitation Fault Tree | FIGURE A.6-5 |


Keowee Unit 2 Field Flashing Breaker Close Circuit Fails
GFFBFAIL2
Page 17
Keowee Unit 2 Field Flashing Breaker Relay 31/X Fails To Pick-up On Demand
EK2F31XRYD
Keowee Unit 2 Field Flashing Breaker Close Coil Fails To Operat On Demand
EK241CFRYD
KHU2 Gen Field Flashing Breaker Y-relay Failed To Drop At Last Operation
EK2R31YRYD
KHU2 Generator Field Flashing Breaker Y-relay Spurious Operation
EK2R31YRYT

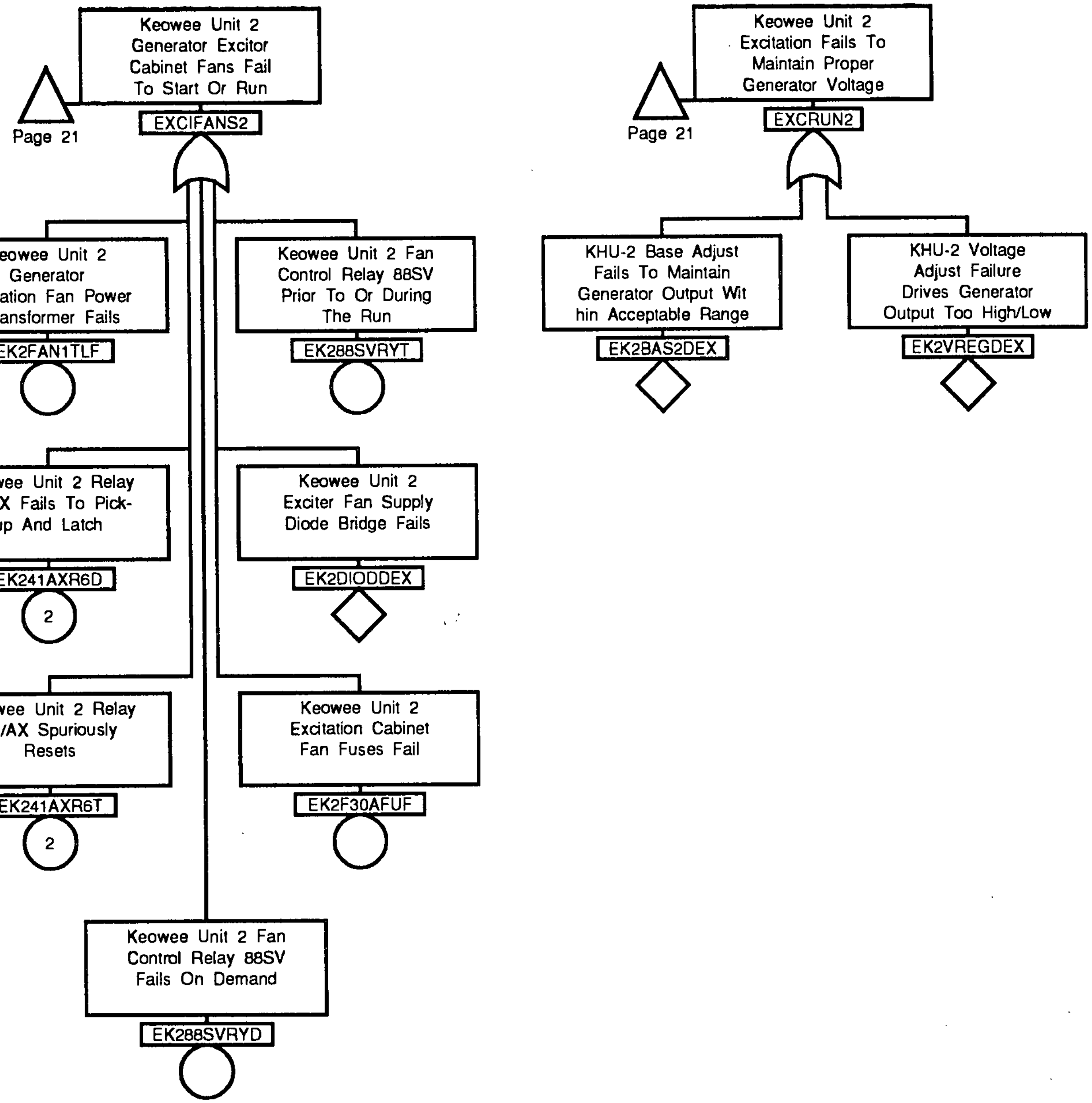


Keowee Units 1 & 2 Excitation Fault Tree	FIGURE A.6-5	Page 19


Keowee Unit 2 Base Adjust Fails To Set Unit Voltage Within The Acceptable Range
BASE2
Page 12
Keowee Unit 2 Base Adjust Fails To Establish Correct Unit Voltage
EK2BASEDEX
Keowee Unit 2 Base Adjust Is Set Incorrectly
EK2BASELHE



Keowee Units 1 & 2 Excitation Fault Tree | FIGURE A.6-5 |



Keowee Unit 2 Generator Excitor Cabinet Fans Fail To Start Or Run
EXCIFANS2
Page 21
Keowee Unit 2 Generator Excitation Fan Power Transformer Fails
EK2FAN1TLF
Keowee Unit 2 Fan Control Relay 88SV Prior To Or During The Run
EK288SVRYT
Keowee Unit 2 Relay 41/AX Fails To Pick-up And Latch
EK241AXR6D
2
Keowee Unit 2 Exciter Fan Supply Diode Bridge Fails
EK2DIODDEX
Keowee Unit 2 Relay 41/AX Spuriously Resets
EK241AXR6T
2
Keowee Unit 2 Excitation Cabinet Fan Fuses Fail
EK2F30AFUF
Keowee Unit 2 Fan Control Relay 88SV Fails On Demand
EK288SVRYD
Keowee Unit 2 Excitation Fails To Maintain Proper Generator Voltage
EXCRUN2
Page 21
KHU-2 Base Adjust Fails To Maintain Generator Output Wit hin Acceptable Range
EK2BAS2DEX
KHU-2 Voltage Adjust Failure Drives Generator Output Too High/Low
EK2VREGDEX

Gate/Event Name	Page	Zone
ACB4MOD	2	
ACB4MOD	2	
ACB4MOD	13	
BASE1	1	
BASE1	9	
BASE2	12	
BASE2	20	
ED11D3DCDT	1	
ED13BR2CDT	10	
ED22D3DCDT	12	
ED23BR2CDT	21	
EK131TDRYD	8	
EK131TDRYT	8	
EK14152SWT	5	
EK1415TSWT	10	
EK1415YRYD	5	
EK1415YRYT	5	
EK141AXR6D	5	
EK141AXR6D	11	
EK141AXR6T	10	
EK141AXR6T	11	
EK141CFRYD	7	
EK186E2RYT	4	
EK186EXRYT	2	
EK186EXRYT	6	
EK186X2RYT	10	
EK188SVRYD	11	
EK188SVRYT	11	
EK1901ARYT	8	
EK199SXRYD	2	
EK199SYRYD	3	
EK199SYRYT	10	
EK1BAS2DEX	11	
EK1BASEDEX	9	
EK1BASELHE	9	
EK1DIODDEX	11	
EK1EXC1TGF	1	
EK1EXC2TGF	10	

Gate/Event Name	Page	Zone
EK1F30AFUF	11	
EK1F31XRYD	7	
EK1F41CRYD	3	
EK1FAN1TLF	11	
EK1FLDCLHE	2	
EK1FLDMDEX	2	
EK1FLSCLHE	6	
EK1FLSMDEX	6	
EK1FLSOLHE	8	
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EK1R31YRYT	7	
EK1R41XRYD	3	
EK1R41YRYD	3	
EK1R41YRYT	3	
EK1R9A1RYT	8	
EK1R9C1R6T	6	
EK1S141SWT	3	
EK1S31TSWT	8	
EK1S41CRYD	5	
EK1S41TSWT	10	
EK1S41XRYD	5	
EK1SPYCLHE	4	
EK1SPYMDEX	4	
EK1VHSVRYD	8	
EK1VREGDEX	11	
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EK231TDRYT	19	
EK24152SWT	16	
EK2415TSWT	21	
EK2415YRYD	16	
EK2415YRYT	16	
EK241AXR6D	16	
EK241AXR6D	22	

Gate/Event Name	Page	Zone
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EK241AXR6T	22	
EK241CFRYD	18	
EK286E2RYT	15	
EK286EXRYT	13	
EK286EXRYT	17	
EK286X2RYT	21	
EK288SVRYD	22	
EK288SVRYT	22	
EK2901ARYT	19	
EK299SXRYD	13	
EK299SYRYD	14	
EK299SYRYT	21	
EK2BAS2DEX	22	
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EK2DIODDEX	22	
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EK2F30AFUF	22	
EK2F31XRYD	18	
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EK2R31TRYD	19	
EK2R31YRYD	18	
EK2R31YRYT	18	
EK2R41XRYD	14	
EK2R41YRYD	14	
EK2R41YRYT	14	

Gate/Event Name	Page	Zone
EK2R9A2RYT	19	
EK2R9C2R6T	17	
EK2S141SWT	14	
EK2S31TSWT	19	
EK2S41CRYD	16	
EK2S41TSWT	21	
EK2S41XRYD	16	
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EK2SPYMDEX	15	
EK2VHSVRYD	19	
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EXCIFANS1	11	
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EXCRUN	10	
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FFB2TRIP	19	
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FLDCLOSE2	12	
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FLDTRANS1	10	
FLDTRANS2	21	
FLSHCLOSE1	1	
FLSHCLOSE1	6	
FLSHCLOSE2	12	
FLSHCLOSE2	17	
FLSHOPEN1	1	

Gate/Event Name	Page	Zone	Gate/Event Name	Page	Zone	Gate/Event Name	Page	Zone	Gate/Event Name	Page	Zone
FLSHOPEN1	8		SPLYTRANS1	10							
FLSHOPEN2	12		SPLYTRANS2	21							
FLSHOPEN2	19		XD1DASRCES	1							
GFBFAIL1	2		XD2DASRCES	12							
GFBFAIL1	3		YK1MR4ASRT	2							
GFBFAIL2	13		YK1STR2INT	4							
GFBFAIL2	14		YK1STRTINT	2							
GFBTRIP1	2		YK1STRTINT	6							
GFBTRIP1	3		YK2MR4ASRT	13							
GFBTRIP2	13		YK2MR4ASRT	13							
GFBTRIP2	14		YK2STR2INT	15							
GFFBFAIL1	6		YK2STRTINT	13							
GFFBFAIL1	7		YK2STRTINT	17							
GFFBFAIL2	17										
GFFBFAIL2	18										
GK186E1	1										
GK286E2	12										
GSBFAIL1	4										
GSBFAIL1	5										
GSBFAIL2	15										
GSBFAIL2	16										
GSBTRIP1	4										
GSBTRIP1	5										
GSBTRIP2	15										
GSBTRIP2	16										
KU1GEXCLD	1										
KU1GEXRUN	10										
KU2GEXCLD	12										
KU2GEXRUN	21										
NTACB4MOD	2										
NTACB4MOD	2										
NTACB4MOD	13										
SPLYCLOSE1	1										
SPLYCLOSE1	4										
SPLYCLOSE1	6										
SPLYCLOSE2	12										
SPLYCLOSE2	15										
SPLYCLOSE2	17										

APPENDIX A.7
KEOWEE GENERATOR

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A.7 KEOWEE GENERATOR

A.7.1 OBJECTIVES

The main objective of this analysis is to develop a logic model of the Keowee Generator. This model is combined with the high-level model and remaining system models to form an integrated model for assessing the reliability of Keowee. Other objectives are to identify major contributors to system unreliability, significant potential human errors and common-cause failure modes.

The scope of this analysis is limited to Generator equipment required to support a Keowee emergency start and run under load following a loss of offsite power event.

A.7.2 SYSTEM DESIGN

The Keowee Hydroelectric Station contains two vertical waterwheel driven electric generators rated at 87.5 MVA at a voltage of 13.8 kV. The generators are salient pole synchronous machines that operate at a speed of 128.6 rpm. A totally enclosed ventilation system with air to water heat exchangers removes the heat produced by the generator. The generators are of the "umbrella" design which utilizes a combined thrust and guide bearing located below the rotor. The bearings are completely submerged in an oil bath which both lubricates and cools the bearings. Heat is removed from the oil pot by water cooled heat exchangers.

A simplified diagram showing the generator with its major components is provided in Figure A.7-1. The following paragraphs briefly describe the major components of the generator.

High Pressure Oil Lift System

The generator is equipped with a high pressure oil lift system which provides a positive oil film between the thrust bearing shoes and the runner during starting and stopping. However, this oil lift function is not required during an emergency start of the unit and once the unit begins operation, the bearings are self lubricating. A simplified diagram of the high pressure oil lift system is shown in Figure A.7-2.

Ventilation System

The cooling air circulation pattern for the generator is shown in Figure A.7-1. The air discharged from the surface air coolers is drawn upward into the upper bracket area of the unit. The air circulation is achieved by paddle type blowers mounted on the top and bottom of the rotor. The air from the upper bracket passes directly into the main machine just behind the rotor rim from the top and bottom of the rotor. The entire air volume passes over the field copper of the rotor and into the vent ducts of the stator. To complete the ventilation cycle, the air discharges into the frame behind the stator core and again passes through the surface air coolers.

The generator is supplied with six water to air coolers evenly spaced about the generator enclosure which are capable of removing the heat due to machine losses to the air. The coolers are of the multipass type with air flow counter-current to the water flow. The cooling water is supplied by the Turbine Generator Cooling Water System (WL). The cooling water flow paths and valve arrangements are shown in Figure A.7-3.

Thrust and Guide Bearings

The generator has a flat pad, pivoted Kingsbury type bearing. The shoes of the bearing assembly are made of steel plate finished on the surface so that the babbit may be metallurgically bonded to the surface of the shoes. These shoes are capable of supporting the weight of the rotating parts of the unit and the external thrust created by the unit as it operates. Operating in conjunction with the thrust bearing is a segmental shoe type guide bearing. The guide bearing shoes are mounted on a shoe support ring and are properly positioned radially by means of individual jack screws.

Lubrication of the bearings is provided by completely submerging the thrust and guide bearing assemblies in an oil bath. The oil is kept at a safe operating temperature by means of cooling coils within the oil pot. Cooling water to the coils is provided by the WL system. The bearing oil cooling flow path and associated valves are shown in Figure A.7-4.

Fire Protection Equipment

The generator is protected from fires by a carbon dioxide fire protection system, which consists of initial and delayed discharge nozzles and thermostats located around the generator. In order to provide relief to prevent excessive pressure build-up within the air housing during CO2 discharge, two doors in the upper bracket top deck serve as weight loaded CO2 relief doors. The weight of each door is sufficient to maintain tight closure in normal operation. A pressure sensor in each CO2 discharge line will lockout the generator upon CO2 discharge. A simplified flow diagram of the generator fire protection system is shown in Figure A.7-5.

Brake and Jack System

The generator also has a combination air brake/oil jack system. The brakes have individually renewable wearing surfaces which operate against a segmental, renewable steel brake ring. Using compressed air, the brakes are used to slow and stop the unit during shutdown. The brake assemblies also serve as hydraulic jacks which can be used during maintenance to lift the entire rotor at least one inch.

Protective Relays

Keowee has three types of lockout relays. They are referred to as "emergency lockout," "normal lockout," and "alarm lockout" relays and are denoted by 86E, 86N and 30X respectively. The emergency lockout relay (86E) will prevent the Keowee unit from starting in either normal or emergency mode and trip the unit if it is running in either mode. The normal lockout relay (86N) will prevent the Keowee unit from starting in normal mode. It will not prevent an emergency start. This relay will also trip the unit if running in normal mode, not emergency mode. The alarm lockout relay (30X) will prevent the Keowee unit from starting in normal mode. It will not prevent an emergency start. This relay will not trip the unit if it is already running. Only the emergency lockout relay function and the relays that actuate it are modeled in the generator fault tree model.

A.7.3 SYSTEM BOUNDARIES

Turbine Generator Cooling Water System

Cooling water to the Generator air coolers and the Generator thrust bearing oil coolers is provided by the Turbine Generator Cooling Water (WL) System. A significant portion of the WL system supports the generator only, and has been incorporated into the "generator" model. This includes the air coolers, the oil coolers and their associated isolation and drain valves. Figure A.7-3 and A.7-4 show the WL components modeled in the generator model. The rest of the WL System is covered in the WL model and is described in Appendix A.14.

Generator Excitation

The Generator Excitation System supplies dc voltage to the generator field coils. The Generator Excitation System model is described in Appendix A.6.

Air Circuit Breakers

Output of the generator is supplied to the 13.8 kV bus through the Air Circuit Breakers. The Air Circuit Breaker model is described in Appendix A.4

A.7.4 INSTRUMENTATION AND CONTROLS

There are no control functions associated with the actual generator of the Keowee Hydro Station. All control functions are provided through other systems such as the governor, exciter and voltage regulator systems. Instrumentation associated with the generator primarily monitors temperature, cooling water flow, and thrust bearing oil level. Protective trips are provided for fire protection actuation, bus differential voltage, generator ground faults, and high or low bearing oil level. Control room statalarms associated with the generator are listed in Table A.7-5.

A.7.5 LOCATION WITHIN THE PLANT

The Keowee generators are located within the generator enclosures which are between the operating floor and the turbine pit.

A.7.6 NORMAL OPERATION

During normal operation, the Keowee generators are rated at 87.5 MVA at a voltage of 13.8 kV, and operate at a speed of 128.6 rpm. The totally enclosed ventilation system with air to water heat exchangers removes the heat produced by generating electricity. The generators are run on a combined thrust and guide bearing located below the rotor. The bearings are completely submerged in an oil bath which both lubricates and cools the bearings. Heat is removed from the oil pot by water cooled heat exchangers.

A.7.7 PERFORMANCE DURING KEOWEE EMERGENCY OPERATION

Keowee Generator operation is the same during normal and emergency operation. However, during an emergency start or run, the normal lockout relay will not prevent a start or trip a running unit.

A.7.8 TEST AND MAINTENANCE

Testing

The Keowee Generator testing requirements are detailed in Table A.7-1.

Maintenance

The Keowee Generator maintenance requirements are listed in Table A.7-2.

A.7.9 OPERATING EXPERIENCE

A summary of significant operating events is provided in Table A.7-3. Three of these events were considered to represent failures that would have resulted in failure of the generator during emergency operation. These were the Unit 2 generator fault that occurred on 11/19/85, the Unit 2 fault that occurred on 12/2/92, and the Unit 2 accidental actuation of the generator CO2 fire suppression system on 7/24/86.

A.7.10 ASSUMPTIONS

A.7.10.1 SYSTEM DESIGN ASSUMPTIONS

1. The High Pressure Oil System is not required during an emergency start. The generator bearings are self lubricating as long as adequate oil level is maintained.

2. To prevent generator failure due to over heating, all six generator air coolers are required to be functioning with full WL flow.

3. To prevent generator failure due to bearing lubrication failure, all eight bearing oil coolers are required to be functioning with full WL flow.

A.7.10.2 OPERATIONAL ASSUMPTIONS

1. It is assumed that the Unit 1 generator is assigned to the underground path, and the Unit 2 generator is assigned to the overhead path. It is also assumed that Unit 2 is operated daily. These assumptions are important when assigning exposure times for the calculation of failure probabilities.

2. Failures of components that would result in a control room alarm need not be modeled as a failure of the generator to start. Failures of this type would alert the operators of a problem and the unit would be declared inoperable.

A.7.10.3 MODELING ASSUMPTIONS

1. The High Pressure Oil System is not required during an emergency start. The generator bearings are self lubricating as long as adequate oil level is maintained. However, if the High Pressure Oil system were to leak, proper oil level could not be maintained and the generator would fail due to inadequate bearing lubrication. Therefore, the High Pressure Oil system must remain leak tight during the running of the Keowee generator.

2. The generator braking system is used to slow the generator following a unit shutdown. However, the braking system does not have adequate resistance to

prevent the starting or running of the generator. Therefore, spurious actuation of the braking system need not be modeled.

3. If the Generator CO2 Fire Protection system were to spuriously actuate, a generator emergency lockout would occur. Since the CO2 system is self contained, spurious actuation will be treated as an undeveloped event. The exception will be the pressure sensor and relay in the CO2 discharge line that generates the generator emergency lockout signal. These two components will be explicitly modeled.

4. Failures of components that would result in a control room alarm need not be modeled as a failure of the generator to start. Failures of this type would alert the operators of a problem and the unit would be declared inoperable. These type failures are already captured by the maintenance or testing basic event. However, these failures should be modeled as a cause of a generator run failure. Examples of this type of component are spurious or actual high generator bearing oil level, or spurious operation of any of the generator lockout relays.

5. If a generator air cooler should leak or if there is a failure of the cooler drain valves, water from the WL system could leak into the generator enclosure. It is assumed that this would result in failure of the generator.

6. It is possible that the generator enclosure space heaters may be spuriously actuated and overheat the generator and its enclosure . Since the generator coolers operate only while the unit is running, they would not remove the heat produced by the heaters. This could lead to actuation of the generator fire suppression system, which would cause a generator lockout and prevent an emergency start of the unit. However, the likelihood of the coincident spurious actuation of the heaters and the need for Keowee to emergency start is very low. Additionally, generator stator high temperature is alarmed and would alert the Keowee operator of problems prior to initiation of the CO2 fire suppression system. Therefore, spurious actuation of the generator enclosure space heaters will not be modeled as a failure mode for the generator failing to start.

7. It is not necessary to model the inadvertent actuation of the space heaters as a way to fail the generator while running. The generator enclosure space heaters produce

a small fraction of the heat produced by the generator while running. The generator coolers could easily remove the small amount of excess heat produced by the heaters.

8. It is assumed that the weekly test will uncover the failures that result in water leaking into the generator compartment (i.e. some valve transfers and heat exchanger leaks).

9. It is assumed that the weekly test is not of sufficient duration to detect those failure that would result in eventual generating overheating (e.g. cooling water valve transfers).

A.7.11 FAULT TREE ANALYSIS

A.7.11.1 TOP EVENT SUCCESS CRITERIA

Success of the Keowee Generator requires that:

- One of the two Keowee Generators starts and supplies adequate power to the Oconee station for twenty-four hours following a loss of offsite power.

- To prevent generator failure due to overheating, all six generator air coolers are required to be functioning with full WL flow. Therefore, failure of any one of the coolers, or failure of any one of the manual valves in the cooler flow path will result in inadequate cooling and failure of the generator.

- To prevent generator failure due to bearing lubrication failure, all eight bearing oil coolers are required to be functioning with full WL flow. Therefore, failure of any of the bearing oil coolers, or failure of any one of the manual valves in the cooler flow path will result in inadequate cooling of the bearing oil and failure of the generator.

A.7.11.2 DETAILED FAILURE CRITERIA

1. Actuation of any of the relays that cause "Emergency Lockout" will cause the generator to trip.

2. Spurious actuation of the generator fire suppression system will cause an "Emergency Lockout" and trip the operating unit.

3. Failure to cool the generator enclosure will result in overheating and either failure or trip of the unit.

4. Loss of the generator bearing oil will result in trip or failure of the generator. Also, failure to cool the generator bearing oil will result in failure of the generator.

5. A cooling water leak in the generator enclosure will result in failure of the generator.

6. The generator will not start if the neutral ground disconnect is open.

A.7.11.3 DESCRIPTION OF FAULT TREE

The Keowee Generator fault tree is shown in Figure A.7-6. The Keowee Generator fault tree contains four top events which serve as transfer points for the Keowee top logic model described in Appendix A.1. The top events of the generator fault tree are:

KU1GENCLD	Keowee Unit 1 Generator Fails During Cold Start
KU2GENCLD	Keowee Unit 2 Generator Fails During Cold Start
KU1GENRUN	Keowee Unit 1 Generator Fails While the Unit Runs
KU2GENRUN	Keowee Unit 2 Generator Fails While the Unit Runs

The Fault Tree Modeling Guidelines (Appendix B) were followed in developing the fault tree. A list of all fault tree transfers is presented in Table A.7-4. Modules were not developed for the Keowee fault trees.

Human reliability analysis was performed as described in Section 5.5 and Appendix C.3. Human events impacting the model are described in Section A.7.11.4.

Common-cause analysis was performed as described in Section 5.4 and Appendix C.2. Common-cause events impacting the model are described in Section A.7.11.6.

A.7.11.4 HUMAN INTERACTIONS

Human actions by the maintenance technicians and operators can adversely affect Keowee Generator reliability. Those events explicitly included in the system fault tree are discussed below.

GK1BRGVLHE, GK2BRGVLHE

These basic events account for the potential of the maintenance technicians to fail to properly restore the Generator Thrust Bearing Cooler isolation valves following maintenance. These valves are repositioned during maintenance on the thrust bearing heat exchangers. Post-maintenance testing is expected to detect the majority of errors. However, since the coolers would not be required until the generator is operating, there is a possibility that a latent human error could exist that will not be discovered until an emergency start is required.

These events were assigned a value of 2.6E-4 based on Figure C.3-1.

GK1COOLLHE, GK1COOLLHE

These basic events account for the potential of the maintenance technicians to fail to properly restore the generator air cooler isolation valves following maintenance or testing. These valves are repositioned during maintenance on the generator air cooler heat exchangers. Post-maintenance testing is expected to detect the majority of errors. However, since the generator coolers would not be required until the generator is operating, there is a possibility that a latent human error could exist that will not be discovered until an emergency start is required.

These events were assigned a value of 2.6E-4 based on Figure C.3-2.

GK1NGDCLHE, GK2NGDCLHE

These events represent a failure to close the neutral ground disconnects following maintenance or testing. These disconnects are opened and tagged per the procedures to remove the generators from service (OP/0/A/2000/13 and OP/0/A/2000/14 for Units 1 and 2 respectively). These procedures include independent verification, and include a post-maintenance operability verification.

During quantification of this event, credit was taken for the tag clearing being another level of verification.

These events were assigned a value of 5.2E-5 based on Figure C.3-3.

A.7.11.5 RELIABILITY DATA

Significant events associated with the Keowee Generators are listed in Table A.7-3. Two of these events were considered to represent failures that would have resulted in failure during emergency operation of the Keowee station. These were the Unit 2 generator fault that occurred on 11/19/85 and the Unit 2 fault that occurred on 12/2/92. An additional event, the Unit 2 accidental actuation of the generator CO2 fire suppression system on 7/24/86, would have resulted in a failure, but was associated with a human error rather than equipment failure. This event was considered as a potential error of commission but was screened out because of the low likelihood of allowing maintenance on the fire protection system during a loss of power event.

Section 5.3 of the main report discusses development of the reliability data. For the base case solution, the plant-specific failure rate data and generic failure rate data were combined using a Bayesian update.

There are three basic events in the generator model which do not represent failure of a component, but instead represent "undeveloped events." These are, AB1FALTDEX, GK1FIREDEX, and GK2FIREDEX.

AB1FALTDEX, Fault Occurs at ACB 1

This event represents the probability that a fault will occur on ACB1 when the unit has been operating on the grid. The probability of this event is set to zero for the

base case solution, since the underground unit is not allowed to generate to the grid. There have been no observed faults on any of the ACBs during the operating history of Keowee. Therefore, for sensitivity studies associated with operating the underground unit to the grid, the probability of AB1FALTDEX is calculated as follows;

AB1FALTDEX = .455/[2*(open and close demands)]
= .455/[2*(2*(Unit 1 Starts + Unit 2 Starts))]
= .455/[2*(2*(3390+3098))]
= 1.75E-5/demand

<u>GK1FIREDEX (GK2FIREDEX), Spurious Actuation of Unit 1 (Unit 2) Gen. CO2 Fire Suppression System</u>

This event represents the spurious action of the generator CO2 fire suppression system. It is intended to represent the combination of any failures that would cause discharge of the CO2 which would cause an Emergency Lockout. This would include instrumentation and control failures or valves which could transfer open. Not included are the pressure sensor in the CO2 discharge line or the generator fire relay, which are explicitly modeled. As described above, there has been one inadvertent actuation of the CO2 system, however this event was due to human error and was treated as a potential error of commission. Therefore, there have been no spurious actuations of the CO2 system during the operating history of Keowee and the probability of this undeveloped event is calculated as follows;

GK1FIREDEX = 24 Hours*.455/[2(Unit 1 Avail. Hrs + Unit 2 Avail. Hrs)]
= 24 * .455/[2(85,755 + 85,657)]
= 3.19E-5

As discussed in Section 5.3, consideration of relevant statalarms is part of the process of determining each basic event factor. Keowee Generator statalarms are listed in Table A.7-5.

System reliability data is listed in Table A.7-6.

A.7.11.6 COMMON-CAUSE ASSESSMENT

Common cause failures associated with the Keowee Generator are represented in the high-level fault tree by events :

GK0COOLCOM	Common Cause Failure of Generator Air Cooling
GK0LOCKCOM	Common Cause Actuation of Generator Lockouts
GKHPOILCOM	Common Cause Failure of Generator Thrust Bearings

Detailed descriptions of these events and their quantification are included in Appendix C.2.

A.7.12 RESULTS

Reliability of the Keowee Generator is defined as the probability that the system will succeed in supporting Keowee emergency operation (black start plus a 24 hour run). The Keowee Generator Unit 1 model yields a failure to start probability of approximately 2.06E-04 and a failure to run probability of approximately 4.09E-3. The Keowee Generator Unit 2 model yields a failure to start probability of approximately 2.06E-04 and a failure to run probability of approximately 3.22E-3. Thus the reliability of the Keowee Generators to start and run for the required mission time are computed to be :

Unit 1	99.57%
Unit 2	99.66%

Tables A.7-7 through A.7-9 list the dominant minimal cut sets (failure sequences) for the Keowee Generators. Lists of dominant contributors to unavailability are shown in Tables A.7-10 through A.7-12. The dominant contributors to the unavailability of the Keowee Generators are generator faults, followed by latent human errors associated with restoring the generator following maintenance or testing.

A.7.13 <u>REFERENCES</u>

A.7.13.1 DOCUMENTS

1. OP-OC-EL-KGH, Rev. 8, <u>Operations Training Module, Keowee Hydro Generators</u>, 11/1/93.

2. EP-1020-19V, <u>Westinghouse Instruction Manual - Vertical Waterwheel Generator.</u>

A.7.13.2 PROCEDURES

1. IP/1/B/0400/005, Change 2, <u>Moore Model 33 Nullmatic Temperature Transmitter Calibration.</u>

2. IP/1/A/0400/023, Change 1, <u>Unit No. 1 CO2 Fire Protection Pressure Switch Calibration.</u>

3. IP/1/B/0400/003, Change 2, <u>Barton Model 258 Indicating Switch Calibration.</u>

4. MP/0/A/2000/026, Change 8, <u>Weighing CO2 Cylinders.</u>

5. MP/0/A/2000/059, Change 7, <u>Periodic Test of CO2 System Generator No. 1.</u>

6. MP/1/A/2000/019, Change 5, <u>Periodic Inspection of Generator No. 1.</u>

7. MP/0/A/2000/030, Change 4, <u>Generator - Fire Extinguishing System - CO2 Cylinders - Removal and Installation.</u>

8. MP/1/A/2000/017, Change 5, <u>Unit No. 1 Turbine, Governor, and Generator Weekly Preventative Maintenance.</u>

9. MP/1/A/2000/054, Change 2, <u>Cleaning of Generator No. 1.</u>

10. MP/1/A/2200/007, Change 1, <u>Unit No.1 Generator Brake Maintenance.</u>

11. OP/0/A/2000/041, Keowee Modes Of Operation

12. AP/0/A/2000/002, Keowee Hydro Station - Emergency Start

A.7.13.3 DRAWINGS (Unit 1)

1. KEE-11, Rev 5, Elem. Diagram, Generator Controls, Gen #1 CO2 Fire Protection System.

2. KEE-32, Rev 2, Elem. Diagram, Fire Alarm System.

3. KFD-100A-1.1, Rev. 1, Flow Diagram of Turbine Generator Cooling Water System.

4. KFD-103A-1.1, Rev. 1, Flow Diagram of High Pressure Oil System.

5. KEE-106, Rev 3, Tabulation, Statalarm List #1SA1, T-G System Condition Alarm.

6. KEE-106-1, Rev 3, Tabulation, Statalarm List #1SA2, T-G System Running Alarm.

Table A.7-1

Keowee Generator Test Procedures

Procedure	Test Frequency	Description
IP/1/B/0400/005, Moore Model 33 Nullmatic Temperature Transmitter Calibration	Annual	Calibration of Generator Guide Bearing, Generator Thrust Bearing and Generator Bearing Oil Temperature Transmitters
IP/1/A/0400/023, Unit No. 1 CO2 Fire Protection Pressure Switch Calibration	18 Months	Calibration of the Generator CO2 Fire Protection System Pressure Switch
IP/1/B/0400/003, Barton Model 258 Indicating Switch Calibration	Annual	Calibration of Generator Cooling Water Flow Indicator and Generator Thrust Bearing Cooling Water Flow Indacator
MP/0/A/2000/026, Weighing CO2 Cylinders	Semi-Annual	Verify Adequacy of CO2 Weight for Generator CO2 Fire Protection System

Table A.7-1

Keowee Generator Test Procedures

Procedure	Test Frequency	Description
MP/0/A/2000/059, Periodic Test of CO2 System Generator No. 1	18 Months	Verify Operability of Generator CO2 Fire Protection System
MP/1/A/2000/019, Periodic Inspection of Generator No. 1	Quarterly	Inspection and Maintenance of Generator Collector Ring, Brushes, Braking System and Change HP Oil Filter

Table A.7-2

Keowee Generator Maintenance Procedures

Procedure	Test Frequency	Description
MP/0/A/2000/030, Generator - Fire Extinguishing System - CO2 Cylinders - Removal and Installation	As Required	Removal and Installation of Generator Fire Extinguishing System CO2 Cylinders
MP/1/A/2000/017, Unit No. 1 Turbine, Governor, and Generator Weekly Preventative Maintenance	Weekly	Preventive Maintenance and Inspection of the Turbine, Governor and Generator
MP/1/A/2000/054, Cleaning of Generator No. 1	As Required	Preventive Maintenance, Cleaning and Inspection of the Generator
MP/1/A/2200/007, Unit No.1 Generator Brake Maintenance	As Required	Preventive Maintenance and Inspection of the Generator Braking System

Table A.7-3

Keowee Generator Significant Operating Events

Date	Unit	Component	Event Summary
6-15-85	1	Generator Air Brake System. Speed Switch, 14/2.	Oconee received a #1 Generator Air Brake failure alarm. The unit was not running at the time. The problem was determined to be due to mercury speed switch, 14/2 not working properly. The switch was replaced.
11-19-85	2	Generator	Unit 2 was generating to the grid when it received a Normal Lockout due to a Generator Field Ground. The problem was due to the electrical connection between two generator rotor field poles having burned out. The root cause of the burned out connection was believed to be due to vibration.

Table A.7-3

Keowee Generator Significant Operating Events

Date	Unit	Component	Event Summary
7-24-86	2	Generator CO2 Fire Supression System	Received #2 Keowee Emergency Lockout due to CO2 actuation caused by electricians at Oconee performing NSM on Keowee Unit 1 CO2 switches. Event occurred when the wires were lifted for unit one but when testing the switch, the Unit 2 switch was depressed.
8-1-88	2	Generator Cooling Water Flow Indicator Swtich	Unit 2 tripped while generating to the grid due to Generator Cooling Water Alarm lockout. Operator readjusted cooling water flow which seemed to correct the problem.
8-18-88	2	Generator Cooling Water Alarm Circuit. Timer, 63GCAT	Unit 2 tripped while generating to the grid due to Generator Cooling Alarm lockout. Jumpered out 63CT Timer contacts and restarted unit. Replaced 63CT Timer because it had a bad coil.

Table A.7-3

Keowee Generator Significant Operating Events

Date	Unit	Component	Event Summary
12-2-92	2	Generator	Unit 2 started for operability test. The unit tripped by emergency lockout on #2 generator ground fault overcurrent (59GN2). Found nicked wire (53) between 290-1X and 290-4X with a nick in the insulation from a screw used to attach the cover plate of the Voltage Regulator. Problem was caused by I & E technicians as they were completing a Configuration Control Inspection of Safety Related cabinet wiring.

Table A.7-4

Keowee Generator Fault Tree Transfers

Transfer Gate Name	Description	Components Supplied
NTACB4MOD	NSM-ON-52966 Is In Service	Unit 1 Generator Protective Relays
FK1300	WL Fails To Supply Unit 1 Generator Thrust Bearing Cooling	Unit 1 Generator Thrust Bearing Oil Coolers
FK2300	WL Fails To Supply Unit 2 Generator Thrust Bearing Cooling	Unit 2 Generator Thrust Bearing Oil Coolers
FK1400	WL Fails To Supply Unit 1 Generator Air Coolers	Unit 1 Generator Air Coolers
FK2400	WL Fails To Supply Unit 2 Generator Air Coolers	Unit 2 Generator Air Coolers

Table A.7-5

Keowee Unit 1 Generator Statalarms
(Unit 2 Alarms are Similar)

Point No.	Alarm	Actuator
1SA1-31	GEN. #1 BRG OIL LEVEL HIGH	63PL/HX
1SA1-32	GEN. #1 BRG OIL LEVEL LOW	63BL/LX
1SA1-33	GEN. #1 AIR BRAKE PRESS. LOW	63AX
1SA1-34	GEN. #1 CO2 SYS. FAULT	63FTX1
1SA1-35	GEN. #1 FIRE CO2 RELEASE	63FX
1SA1-38	GEN. #1 CO2 ISOLATION VALVES OPEN	NA
1SA1-39	GEN. #1 CO2 ISOLATION VALVES CLOSED	NA
1SA1-40	GEN. NO. 1 FIRE	ZIU-2
1SA2-21	GEN. #1 BRG. OIL TEMP. HIGH	26GBX
1SA2-22	GEN. #1 THRUST BRG. TEMP. HIGH	38B2X
1SA2-23	GEN. #1 GUIDE BRG. TEMP. HIGH	38G2X
1SA2-25	GEN. #1 COOLER WTR. DISC. TEMP. HIGH	30GWX
1SA2-26	GEN. #1 COOLER AIR DISC. TEMP. HIGH	30GAX
1SA2-27	GEN. #1 COOLER WTR. DISC. TEMP. HIGH	63BC/ATX
1SA2-28	GEN. #1 COOLER WATER FLOW FAIL	63GC/ATX
1SA2-29	GEN. #1 GROUND	64FX
1SA2-30	GEN. #1 STATOR TEMP. HIGH	30SX
1SA2-43	GEN. #1 RELAY POTS. VOLTAGE FAIL.	60R
1SA2-44	GEN. #1 METER POTS. VOLTAGE FAIL.	60M
1SA2-2	UNIT NO. 1 NORMAL LOCKOUT	86N-1
1SA2-3	UNIT NO. 1 EMERGENCY LOCKOUT	86E-1

Table A.7-6

Keowee Generator Reliability Data

Event Name	Description	Failure Rate[1]		Factor		Rationale For Factor[2]	Failure Probability
AB1FALTDEX	Fault Occurs at ACB 1						0.0
GK10001HGR	Keowee Unit 1 Generator Fault While the Unit Runs	9.46E-05	/H	24	H	Rule 1: Generates Emergency Lockout Alarm	2.27E-03
GK10001HGS	Keowee Unit 1 Generator Fault Causes Unit Start Failure	1.54E-04	/D	1	D	Chalenged Each Time the Unit Starts	1.54E-04
GK1063FPST	Keowee 1 Gen CO2 Sys Press Switch 63F Spurious Operation	5.30E-07	/H	24	H	Rule 1: Generates Emergency Lockout Alarm and Fire CO2 Release Alarm	1.27E-05
GK112TDRYT	Time Delay Relay 12XTD/1 Spuriously Picks-up	5.20E-07	/H	24	H	Rule 1: Generates Emergency Lockout Alarm	1.25E-05
GK112X1RYT	Relay 12X/1 Spuriously Picks-up	5.20E-07	/H	24	H	Rule 1: Generates Emergency Lockout Alarm	1.25E-05
GK13SUIRYT	Keowee Unit 1 Startup Inhibit Switch Auxiliary Relay S3SUIX Spurious Actuation	5.20E-07	/H	24	H	Rule 1: Generates Emergency Lockout Alarm	1.25E-05
GK13SUISWT	Keowee Unit 1 Startup Inhibit Switch 3SUI Spurious Operation	7.30E-08	/H	24	H	Rule 1: Generates Emergency Lockout Alarm	1.75E-06
GK140G1RYT	Keowee Unit 1 Loss Of Generator Field Relay 40G1 Spurious Actuation	5.20E-07	/H	24	H	Rule 1: Generates Emergency Lockout Alarm	1.25E-05
GK159GNRYT	Keowee Unit 1 Generator Ground Fault Relay 59GN1 Spurious Actuation	5.20E-07	/H	24	H	Rule 1: Generates Emergency Lockout Alarm	1.25E-05
GK162TDRYT	Keowee Unit 1 Generator Backup Trip Timer 62-1TD Spurious Operation	5.20E-07	/H	24	H	Rule 1: Generates Emergency Lockout Alarm	1.25E-05
GK163FXRYT	Keowee Unit 1 Generator Fire Relay 63FX Spurious Actuation	5.20E-07	/H	24	H	Rule 1: Generates Emergency Lockout Alarm	1.25E-05
GK186E1RYT	Keowee 1 Emergency Lockout Relay 86E-1 Spuriously Picks Up	5.20E-07	/H	24	H	Rule 1: Generates Emergency Lockout Alarm	1.25E-05
GK187G1RYT	Keowee Unit 1 Generator Differential Relay 87G-1 Spurious Actuation	5.20E-07	/H	24	H	Rule 1: Generates Emergency Lockout Alarm	1.25E-05
GK187GBRYT	Keowee Unit 1 Generator Bus Differential Relay 87GB Spurious Actuation	5.20E-07	/H	24	H	Rule 1: Generates Emergency Lockout Alarm	1.25E-05

[1] D = Demand, H = Hour

[2] Rules for assigning basic event factors are discussed in Table C.1-4.

Table A.7-6

Keowee Generator Reliability Data

Event Name	Description	Failure Rate[1]		Factor		Rationale For Factor[2]	Failure Probability
GK187TERYT	Keowee Unit 1 Exitation Transformer Differential Relay 87T-1E Spur. Actuation	5.20E-07	/H	24	H	Rule 1: Generates Emergency Lockout Alarm	1.25E-05
GK1BRGVLHE	Keowee 1 Gen. Brng Oil Cooling Flow Path Vlvs Mispositioned After Maintenance						2.60E-04
GK1COOLLHE	Keowee 1 Gen. Air Cooler WL Flow Path Vlvs Mispositioned After Maintenance						2.60E-04
GK1FIREDEX	Spurious Actuation of Unit 1 Gen. CO2 Fire Supression System						7.00E-05
GK1GAC1HXF	Generator Air Cooler 1GAHW-1 Fails	4.40E-07	/H	24	H	Can Only Occur While the Unit is Running	1.06E-05
GK1GAC1HXL	Heat Exchanger 1GAC1 Leaks	2.60E-07	/H	108	H	Rule 6	9.98E-05
GK1GAC2HXF	Generator Air Cooler 1GAHW-2 Fails	4.40E-07	/H	24	H	Can Only Occur While the Unit is Running	1.06E-05
GK1GAC2HXL	Heat Exchanger 1GAC2 Leaks	2.60E-07	/H	108	H	Rule 6	9.98E-05
GK1GAC3HXF	Generator Air Cooler 1GAHW-3 Fails	4.40E-07	/H	24	H	Can Only Occur While the Unit is Running	1.06E-05
GK1GAC3HXL	Heat Exchanger 1GAC3 Leaks	2.60E-07	/H	108	H	Rule 6	9.98E-05
GK1GAC4HXF	Generator Air Cooler 1GAHW-4 Fails	4.40E-07	/H	24	H	Can Only Occur While the Unit is Running	1.06E-05
GK1GAC4HXL	Heat Exchanger 1GAC4 Leaks	2.60E-07	/H	108	H	Rule 6	9.98E-05
GK1GAC5HXF	Generator Air Cooler 1GAHW-5 Fails	4.40E-07	/H	24	H	Can Only Occur While the Unit is Running	1.06E-05
GK1GAC5HXL	Heat Exchanger 1GAC5 Leaks	2.60E-07	/H	108	H	Rule 6	9.98E-05
GK1GAC6HXF	Generator Air Cooler 1GAHW-6 Fails	4.40E-07	/H	24	H	Can Only Occur While the Unit is Running	1.06E-05

[1] D = Demand, H = Hour
[2] Rules for assigning basic event factors are discussed in Table C.1-4.

Table A.7-6

Keowee Generator Reliability Data

Event Name	Description	Failure Rate[1]		Factor		Rationale For Factor[2]	Failure Probability
GK1GAC6HXL	Heat Exchanger 1GAC6 Leaks	2.60E-07	/H	108	H	Rule 6	9.98E-05
GK1HPO1HXF	Generator Thrust Bearing Cooler 1HPOHX-1 Fails	4.40E-07	/H	24	H	Can Only Occur While the Unit is Running	1.06E-05
GK1HPO2HXF	Generator Thrust Bearing Cooler 1HPOHX-2 Fails	4.40E-07	/H	24	H	Can Only Occur While the Unit is Running	1.06E-05
GK1HPO3HXF	Generator Thrust Bearing Cooler 1HPOHX-3 Fails	4.40E-07	/H	24	H	Can Only Occur While the Unit is Running	1.06E-05
GK1HPO4HXF	Generator Thrust Bearing Cooler 1HPOHX-4 Fails	4.40E-07	/H	24	H	Can Only Occur While the Unit is Running	1.06E-05
GK1HPO5HXF	Generator Thrust Bearing Cooler 1HPOHX-5 Fails	4.40E-07	/H	24	H	Can Only Occur While the Unit is Running	1.06E-05
GK1HPO6HXF	Generator Thrust Bearing Cooler 1HPOHX-6 Fails	4.40E-07	/H	24	H	Can Only Occur While the Unit is Running	1.06E-05
GK1HPO6VVT	Genrator Bearing Oil Leak Because Manual Valve 1HPO-6 Transfers Position	1.60E-08	/H	24	H	Rule 1: Generates an Emergency Lockout Alrm and Brg. Oil Level Low Alarm	3.84E-07
GK1HPO7HXF	Generator Thrust Bearing Cooler 1HPOHX-7 Fails	4.40E-07	/H	24	H	Can Only Occur While the Unit is Running	1.06E-05
GK1HPO8HXF	Generator Thrust Bearing Cooler 1HPOHX-8 Fails	4.40E-07	/H	24	H	Can Only Occur While the Unit is Running	1.06E-05
GK1NGDCLHE	Failure to Close the Unit 1 Neutral Ground Disconnect Following Maintenance						5.20E-05
GK1O121SST	Speed Switch 12/1 Falsely Indicates High Speed	4.30E-06	/H	24	H	Rule 1: Generates Emergency Lockout Alarm	1.03E-04
GK1WL16VVT	Manual Valve 1WL-16 Transfers Position	1.60E-08	/H	384	H	Rule 6	6.14E-06
GK1WL17VVT	Manual Valve 1WL-17 Transfers Position	1.60E-08	/H	384	H	Rule 6	6.14E-06
GK1WL18VVT	Manual Valve 1WL18 Transfers Position	1.60E-08	/H	108	H	Rule 6	6.14E-06

1 D = Demand, H = Hour

2 Rules for assigning basic event factors are discussed in Table C.1-4.

Table A.7-6

Keowee Generator Reliability Data

Event Name	Description	Failure Rate[1]		Factor		Rationale For Factor[2]	Failure Probability
GK1WL19VVT	Manual Valve 1WL19 Transfers Position	1.60E-08	/H	108	H	Rule 6	6.14E-06
GK1WL20VVT	Manual Valve 1WL-20 Transfers Position	1.60E-08	/H	384	H	Rule 6	6.14E-06
GK1WL21VVT	Manual Valve 1WL-21 Transfers Position	1.60E-08	/H	384	H	Rule 6	6.14E-06
GK1WL22VVT	Manual Valve 1WL22 Transfers Position	1.60E-08	/H	108	H	Rule 6	6.14E-06
GK1WL23VVT	Manual Valve 1WL23 Transfers Position	1.60E-08	/H	108	H	Rule 6	6.14E-06
GK1WL24VVT	Manual Valve 1WL-24 Transfers Position	1.60E-08	/H	384	H	Rule 6	6.14E-06
GK1WL25VVT	Manual Valve 1WL-25 Transfers Position	1.60E-08	/H	384	H	Rule 6	6.14E-06
GK1WL26VVT	Manual Valve 1WL26 Transfers Position	1.60E-08	/H	108	H	Rule 6	6.14E-06
GK1WL27VVT	Manual Valve 1WL27 Transfers Position	1.60E-08	/H	108	H	Rule 6	6.14E-06
GK1WL28VVT	Manual Valve 1WL-28 Transfers Position	1.60E-08	/H	384	H	Rule 6	6.14E-06
GK1WL29VVT	Manual Valve 1WL-29 Transfers Position	1.60E-08	/H	384	H	Rule 6	6.14E-06
GK1WL30VVT	Manual Valve 1WL30 Transfers Position	1.60E-08	/H	108	H	Rule 6	6.14E-06
GK1WL31VVT	Manual Valve 1WL31 Transfers Position	1.60E-08	/H	108	H	Rule 6	6.14E-06
GK1WL32VVT	Manual Valve 1WL-32 Transfers Position	1.60E-08	/H	384	H	Rule 6	6.14E-06
GK1WL33VVT	Manual Valve 1WL-33 Transfers Position	1.60E-08	/H	384	H	Rule 6	6.14E-06
GK1WL34VVT	Manual Valve 1WL34 Transfers Position	1.60E-08	/H	108	H	Rule 6	6.14E-06
GK1WL35VVT	Manual Valve 1WL35 Transfers Position	1.60E-08	/H	108	H	Rule 6	6.14E-06
GK1WL36VVT	Manual Valve 1WL-36 Transfers Position	1.60E-08	/H	384	H	Rule 6	6.14E-06
GK1WL37VVT	Manual Valve 1WL-37 Transfers Position	1.60E-08	/H	384	H	Rule 6	6.14E-06

[1] D = Demand, H = Hour

[2] Rules for assigning basic event factors are discussed in Table C.1-4.

Table A.7-6

Keowee Generator Reliability Data

Event Name	Description	Failure Rate[1]		Factor		Rationale For Factor[2]	Failure Probability
GK1WL38VVT	Manual Valve 1WL38 Transfers Position	1.60E-08	/H	108	H	Rule 6	6.14E-06
GK1WL39VVT	Manual Valve 1WL39 Transfers Position	1.60E-08	/H	108	H	Rule 6	6.14E-06
GK1WL41VVT	Keowee 1 Manual Valve 1WL-41 Transfers Position to Block Discharge Path	1.60E-08	/H	384	H	Rule 6	6.14E-06
GK1WL44VVT	Manual Valve 1WL-44 Transfers Position	1.60E-08	/H	384	H	Rule 6	6.14E-06
GK1WL45VVT	Manual Valve 1WL-45 Transfers Position	1.60E-08	/H	384	H	Rule 6	6.14E-06
GK1WL46VVT	Manual Valve 1WL-46 Transfers Position	1.60E-08	/H	108	H	Rule 6	6.14E-06
GK1WL47VVT	Manual Valve 1WL-47 Transfers Position	1.60E-08	/H	108	H	Rule 6	6.14E-06
GK1WL48VVT	Manual Valve 1WL-48 Transfers Position	1.60E-08	/H	384	H	Rule 6	6.14E-06
GK1WL49VVT	Manual Valve 1WL-49 Transfers Position	1.60E-08	/H	384	H	Rule 6	6.14E-06
GK1WL50VVT	Manual Valve 1WL-50 Transfers Position	1.60E-08	/H	108	H	Rule 6	6.14E-06
GK1WL51VVT	Manual Valve 1WL-51 Transfers Position	1.60E-08	/H	108	H	Rule 6	6.14E-06
GK1WL52VVT	Manual Valve 1WL-52 Transfers Position	1.60E-08	/H	384	H	Rule 6	6.14E-06
GK1WL53VVT	Manual Valve 1WL-53 Transfers Position	1.60E-08	/H	384	H	Rule 6	6.14E-06
GK1WL54VVT	Manual Valve 1WL-54 Transfers Position	1.60E-08	/H	108	H	Rule 6	6.14E-06
GK1WL55VVT	Manual Valve 1WL-55 Transfers Position	1.60E-08	/H	108	H	Rule 6	6.14E-06
GK1WL56VVT	Manual Valve 1WL-56 Transfers Position	1.60E-08	/H	384	H	Rule 6	6.14E-06
GK1WL57VVT	Manual Valve 1WL-57 Transfers Position	1.60E-08	/H	384	H	Rule 6	6.14E-06
GK1WL58VVT	Manual Valve 1WL-58 Transfers Position	1.60E-08	/H	108	H	Rule 6	6.14E-06
GK1WL59VVT	Manual Valve 1WL-59 Transfers Position	1.60E-08	/H	108	H	Rule 6	6.14E-06

[1] D = Demand, H = Hour
[2] Rules for assigning basic event factors are discussed in Table C.1-4.

Table A.7-6

Keowee Generator Reliability Data

Event Name	Description	Failure Rate[1]		Factor		Rationale For Factor[2]	Failure Probability
GK1WL60VVT	Manual Valve 1WL-60 Transfers Position	1.60E-08	/H	384	H	Rule 6	6.14E-06
GK1WL61VVT	Manual Valve 1WL-61 Transfers Position	1.60E-08	/H	384	H	Rule 6	6.14E-06
GK1WL62VVT	Manual Valve 1WL-62 Transfers Position	1.60E-08	/H	108	H	Rule 6	6.14E-06
GK1WL63VVT	Manual Valve 1WL-63 Transfers Position	1.60E-08	/H	108	H	Rule 6	6.14E-06
GK1WL64VVT	Manual Valve 1WL-64 Transfers Position	1.60E-08	/H	384	H	Rule 6	6.14E-06
GK1WL65VVT	Manual Valve 1WL-65 Transfers Position	1.60E-08	/H	384	H	Rule 6	6.14E-06
GK1WL66VVT	Manual Valve 1WL-66 Transfers Position	1.60E-08	/H	108	H	Rule 6	6.14E-06
GK1WL67VVT	Manual Valve 1WL-67 Transfers Position	1.60E-08	/H	108	H	Rule 6	6.14E-06
GK1WL68VVT	Manual Valve 1WL-68 Transfers Position	1.60E-08	/H	384	H	Rule 6	6.14E-06
GK1WL69VVT	Manual Valve 1WL-69 Transfers Position	1.60E-08	/H	384	H	Rule 6	6.14E-06
GK1WL70VVT	Manual Valve 1WL-70 Transfers Position	1.60E-08	/H	108	H	Rule 6	6.14E-06
GK1WL71VVT	Manual Valve 1WL-71 Transfers Position	1.60E-08	/H	108	H	Rule 6	6.14E-06
GK1WL72VVT	Manual Valve 1WL-72 Transfers Position	1.60E-08	/H	384	H	Rule 6	6.14E-06
GK1WL73VVT	Manual Valve 1WL-73 Transfers Position	1.60E-08	/H	384	H	Rule 6	6.14E-06
GK1WL74VVT	Manual Valve 1WL-74 Transfers Position	1.60E-08	/H	108	H	Rule 6	6.14E-06
GK1WL75VVT	Manual Valve 1WL-75 Transfers Position	1.60E-08	/H	108	H	Rule 6	6.14E-06
GK1WL76VVT	Manual Valve 1WL76 Transfers Position and Blocks Discharge Path	1.60E-08	/H	384	H	Rule 6	6.14E-06
GK1WL78VVT	Manual Valve 1WL78 Transfers Position and Blocks Discharge Path	1.60E-08	/H	384	H	Rule 6	6.14E-06

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2 Rules for assigning basic event factors are discussed in Table C.1-4.

Table A.7-6

Keowee Generator Reliability Data

Event Name	Description	Failure Rate[1]		Factor		Rationale For Factor[2]	Failure Probability
GK20001HGR	Keowee Unit 2 Generator Fault While the Unit Runs	9.46E-05	/H	24	H	Rule 1: Generates Emergency Lockout Alarm	2.27E-03
GK20002HGS	Keowee Unit 2 Generator Fault Causes Unit Start Failure	1.54E-04	/D	1	D	Chalenged Each Time the Unit Starts	1.54E-04
GK2063FPST	Keowee 2 Gen CO2 Sys Press Switch 63F Spurious Operation	5.30E-07	/H	24	H	Rule 1: Generates Emergency Lockout Alarm and Fire CO2 Release Alarm	1.27E-05
GK212TDRYT	Time Delay Relay 12XTD/2 Spuriously Picks-up	5.20E-07	/H	24	H	Rule 1: Generates Emergency Lockout Alarm	1.25E-05
GK212X2RYT	Relay 12X/2 Spuriously Picks-up	5.20E-07	/H	24	H	Rule 1: Generates Emergency Lockout Alarm	1.25E-05
GK23SUIRYT	Keowee Unit 2 Startup Inhibit Switch Auxiliary Relay S3SUIX Spurious Actuation	5.20E-07	/H	24	H	Rule 1: Generates Emergency Lockout Alarm	1.25E-05
GK23SUISWT	Keowee Unit 2 Startup Inhibit Swtich 3SUI Spurious Operation	7.30E-08	/H	24	H	Rule 1: Generates Emergency Lockout Alarm	1.75E-06
GK240G1RYT	Keowee Unit 2 Loss Of Generator Field Relay 40G1 Spurious Actuation	5.20E-07	/H	24	H	Rule 1: Generates Emergency Lockout Alarm	1.25E-05
GK259GNRYT	Keowee Unit 2 Generator Ground Fault Relay 59GN2 Spurious Actuation	5.20E-07	/H	24	H	Rule 1: Generates Emergency Lockout Alarm	1.25E-05
GK262TDRYT	Keowee Unit 2 Generator Backup Trip Timer 62-2TD Spurious Operation	5.20E-07	/H	24	H	Rule 1: Generates Emergency Lockout Alarm	1.25E-05
GK263FXRYT	Keowee Unit 2 Generator Fire Relay 63FX Spurious Actuation	5.20E-07	/H	24	H	Rule 1: Generates Emergency Lockout Alarm	1.25E-05
GK286E2RYT	Keowee 2 Emergency Lockout Relay 86E-2 Spuriously Picks Up	5.20E-07	/H	24	H	Rule 1: Generates Emergency Lockout Alarm	1.25E-05
GK287G2RYT	Keowee Unit 2 Generator Differential Relay 87G-2 Spurious Actuation	5.20E-07	/H	24	H	Rule 1: Generates Emergency Lockout Alarm	1.25E-05
GK287GBRYT	Keowee Unit 2 Generator Bus Differential Relay 87GB Spurious Actuation	5.20E-07	/H	24	H	Rule 1: Generates Emergency Lockout Alarm	1.25E-05
GK287TERYT	Keowee Unit 2 Excitation Transformer Differential Relay 87T-2E Spur. Actuation	5.20E-07	/H	24	H	Rule 1: Generates Emergency Lockout Alarm	1.25E-05

[1] D = Demand, H = Hour

[2] Rules for assigning basic event factors are discussed in Table C.1-4.

Table A.7-6

Keowee Generator Reliability Data

Event Name	Description	Failure Rate[1]		Factor		Rationale For Factor[2]	Failure Probability
GK2BRGVLHE	Keowee 2 Gen. Brng Oil Cooling Flow Path Vlvs Mispositioned After Maintenance						2.60E-04
GK2COOLLHE	Keowee 2 Gen. Air Cooler WL Flow Path Vlvs Mispositioned After Maintenance						2.60E-04
GK2FIREDEX	Spurious Actuation of Unit 2 Gen. CO2 Fire Supression System						7.00E-05
GK2GAC1HXF	Generator Air Cooler 2GAHW-1 Fails	4.40E-07	/H	24	H	Can Only Occur While the Unit is Running	1.06E-05
GK2GAC1HXL	Heat Exchanger 2GAC1 Leaks	2.60E-07	/H	36	H	Rule 6	9.36E-06
GK2GAC2HXF	Generator Air Cooler 2GAHW-2 Fails	4.40E-07	/H	24	H	Can Only Occur While the Unit is Running	1.06E-05
GK2GAC2HXL	Heat Exchanger 2GAC2 Leaks	2.60E-07	/H	36	H	Rule 6	9.36E-06
GK2GAC3HXF	Generator Air Cooler 2GAHW-3 Fails	4.40E-07	/H	24	H	Can Only Occur While the Unit is Running	1.06E-05
GK2GAC3HXL	Heat Exchanger 2GAC3 Leaks	2.60E-07	/H	36	H	Rule 6	9.36E-06
GK2GAC4HXF	Generator Air Cooler 2GAHW-4 Fails	4.40E-07	/H	24	H	Can Only Occur While the Unit is Running	1.06E-05
GK2GAC4HXL	Heat Exchanger 2GAC4 Leaks	2.60E-07	/H	36	H	Rule 6	9.36E-06
GK2GAC5HXF	Generator Air Cooler 2GAHW-5 Fails	4.40E-07	/H	24	H	Can Only Occur While the Unit is Running	1.06E-05
GK2GAC5HXL	Heat Exchanger 2GAC5 Leaks	2.60E-07	/H	36	H	Rule 6	9.36E-06
GK2GAC6HXF	Generator Air Cooler 2GAHW-6 Fails	4.40E-07	/H	24	H	Can Only Occur While the Unit is Running	1.06E-05
GK2GAC6HXL	Heat Exchanger 2GAC6 Leaks	2.60E-07	/H	36	H	Rule 6	9.36E-06

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2 Rules for assigning basic event factors are discussed in Table C.1-4.

Table A.7-6

Keowee Generator Reliability Data

Event Name	Description	Failure Rate[1]		Factor		Rationale For Factor[2]	Failure Probability
GK2HPO1HXF	Generator Thrust Bearing Cooler 2HPOHX-1 Fails	4.40E-07	/H	24	H	Can Only Occur While the Unit is Running	1.06E-05
GK2HPO2HXF	Generator Thrust Bearing Cooler 2HPOHX-2 Fails	4.40E-07	/H	24	H	Can Only Occur While the Unit is Running	1.06E-05
GK2HPO3HXF	Generator Thrust Bearing Cooler 2HPOHX-3 Fails	4.40E-07	/H	24	H	Can Only Occur While the Unit is Running	1.06E-05
GK2HPO4HXF	Generator Thrust Bearing Cooler 2HPOHX-4 Fails	4.40E-07	/H	24	H	Can Only Occur While the Unit is Running	1.06E-05
GK2HPO5HXF	Generator Thrust Bearing Cooler 2HPOHX-5 Fails	4.40E-07	/H	24	H	Can Only Occur While the Unit is Running	1.06E-05
GK2HPO6HXF	Generator Thrust Bearing Cooler 2HPOHX-6 Fails	4.40E-07	/H	24	H	Can Only Occur While the Unit is Running	1.06E-05
GK2HPO6VVT	Genrator Bearing Oil Leak Because Manual Valve 2HPO-6 Transfers Position	1.60E-08	/H	24	H	Rule 1: Generates an Emergency Lockout Alrm and Brg. Oil Level Low Alarm	3.84E-07
GK2HPO7HXF	Generator Thrust Bearing Cooler 2HPOHX-7 Fails	4.40E-07	/H	24	H	Can Only Occur While the Unit is Running	1.06E-05
GK2HPO8HXF	Generator Thrust Bearing Cooler 2HPOHX-8 Fails	4.40E-07	/H	24	H	Can Only Occur While the Unit is Running	1.06E-05
GK2NGDCLHE	Failure to Close the Unit 2 Neutral Ground Disconnect Following Maintenance						5.20E-05
GK2O121SST	Speed Switch 12/2 Falsely Indicates High Speed	4.30E-06	/H	24	H	Rule 1: Generates Emergency Lockout Alarm	1.03E-04
GK2WL16VVT	Manual Valve 2WL-16 Transfers Position	1.60E-08	/H	36	H	Rule 6	5.76E-07
GK2WL17VVT	Manual Valve 2WL-17 Transfers Position	1.60E-08	/H	36	H	Rule 6	5.76E-07
GK2WL18VVT	Manual Valve 2WL18 Transfers Position	1.60E-08	/H	36	H	Rule 6	5.76E-07
GK2WL19VVT	Manual Valve 2WL19 Transfers Position	1.60E-08	/H	36	H	Rule 6	5.76E-07

1 D = Demand, H = Hour
2 Rules for assigning basic event factors are discussed in Table C.1-4.

Table A.7-6

Keowee Generator Reliability Data

Event Name	Description	Failure Rate[1]		Factor		Rationale For Factor[2]	Failure Probability
GK2WL20VVT	Manual Valve 2WL-20 Transfers Position	1.60E-08	/H	36	H	Rule 6	5.76E-07
GK2WL21VVT	Manual Valve 2WL-21 Transfers Position	1.60E-08	/H	36	H	Rule 6	5.76E-07
GK2WL22VVT	Manual Valve 2WL22 Transfers Position	1.60E-08	/H	36	H	Rule 6	5.76E-07
GK2WL23VVT	Manual Valve 2WL23 Transfers Position	1.60E-08	/H	36	H	Rule 6	5.76E-07
GK2WL24VVT	Manual Valve 2WL-24 Transfers Position	1.60E-08	/H	36	H	Rule 6	5.76E-07
GK2WL25VVT	Manual Valve 2WL-25 Transfers Position	1.60E-08	/H	36	H	Rule 6	5.76E-07
GK2WL26VVT	Manual Valve 2WL26 Transfers Position	1.60E-08	/H	36	H	Rule 6	5.76E-07
GK2WL27VVT	Manual Valve 2WL27 Transfers Position	1.60E-08	/H	36	H	Rule 6	5.76E-07
GK2WL28VVT	Manual Valve 2WL-28 Transfers Position	1.60E-08	/H	36	H	Rule 6	5.76E-07
GK2WL29VVT	Manual Valve 2WL-29 Transfers Position	1.60E-08	/H	36	H	Rule 6	5.76E-07
GK2WL30VVT	Manual Valve 2WL30 Transfers Position	1.60E-08	/H	36	H	Rule 6	5.76E-07
GK2WL31VVT	Manual Valve 2WL31 Transfers Position	1.60E-08	/H	36	H	Rule 6	5.76E-07
GK2WL32VVT	Manual Valve 2WL-32 Transfers Position	1.60E-08	/H	36	H	Rule 6	5.76E-07
GK2WL33VVT	Manual Valve 2WL-33 Transfers Position	1.60E-08	/H	36	H	Rule 6	5.76E-07
GK2WL34VVT	Manual Valve 2WL34 Transfers Position	1.60E-08	/H	36	H	Rule 6	5.76E-07
GK2WL35VVT	Manual Valve 2WL35 Transfers Position	1.60E-08	/H	36	H	Rule 6	5.76E-07
GK2WL36VVT	Manual Valve 2WL-36 Transfers Position	1.60E-08	/H	36	H	Rule 6	5.76E-07
GK2WL37VVT	Manual Valve 2WL-37 Transfers Position	1.60E-08	/H	36	H	Rule 6	5.76E-07
GK2WL38VVT	Manual Valve 2WL38 Transfers Position	1.60E-08	/H	36	H	Rule 6	5.76E-07

[1] D = Demand, H = Hour

[2] Rules for assigning basic event factors are discussed in Table C.1-4.

Table A.7-6

Keowee Generator Reliability Data

Event Name	Description	Failure Rate[1]		Factor		Rationale For Factor[2]	Failure Probability
GK2WL39VVT	Manual Valve 2WL39 Transfers Position	1.60E-08	/H	36	H	Rule 6	5.76E-07
GK2WL41VVT	Keowee 2 Manual Valve 2WL-41 Transfers Position to Block Discharge Path	1.60E-08	/H	36	H	Rule 6	5.76E-07
GK2WL44VVT	Manual Valve 2WL-44 Transfers Position	1.60E-08	/H	36	H	Rule 6	5.76E-07
GK2WL45VVT	Manual Valve 2WL-45 Transfers Position	1.60E-08	/H	36	H	Rule 6	5.76E-07
GK2WL46VVT	Manual Valve 2WL-46 Transfers Position	1.60E-08	/H	36	H	Rule 6	5.76E-07
GK2WL47VVT	Manual Valve 2WL-47 Transfers Position	1.60E-08	/H	36	H	Rule 6	5.76E-07
GK2WL48VVT	Manual Valve 2WL-48 Transfers Position	1.60E-08	/H	36	H	Rule 6	5.76E-07
GK2WL49VVT	Manual Valve 2WL-49 Transfers Position	1.60E-08	/H	36	H	Rule 6	5.76E-07
GK2WL50VVT	Manual Valve 2WL-50 Transfers Position	1.60E-08	/H	36	H	Rule 6	5.76E-07
GK2WL51VVT	Manual Valve 2WL-51 Transfers Position	1.60E-08	/H	36	H	Rule 6	5.76E-07
GK2WL52VVT	Manual Valve 2WL-52 Transfers Position	1.60E-08	/H	36	H	Rule 6	5.76E-07
GK2WL53VVT	Manual Valve 2WL-53 Transfers Position	1.60E-08	/H	36	H	Rule 6	5.76E-07
GK2WL54VVT	Manual Valve 2WL-54 Transfers Position	1.60E-08	/H	36	H	Rule 6	5.76E-07
GK2WL55VVT	Manual Valve 2WL-55 Transfers Position	1.60E-08	/H	36	H	Rule 6	5.76E-07
GK2WL56VVT	Manual Valve 2WL-56 Transfers Position	1.60E-08	/H	36	H	Rule 6	5.76E-07
GK2WL57VVT	Manual Valve 2WL-57 Transfers Position	1.60E-08	/H	36	H	Rule 6	5.76E-07
GK2WL58VVT	Manual Valve 2WL-58 Transfers Position	1.60E-08	/H	36	H	Rule 6	5.76E-07
GK2WL59VVT	Manual Valve 2WL-59 Transfers Position	1.60E-08	/H	36	H	Rule 6	5.76E-07
GK2WL60VVT	Manual Valve 2WL-60 Transfers Position	1.60E-08	/H	36	H	Rule 6	5.76E-07

[1] D = Demand, H = Hour
[2] Rules for assigning basic event factors are discussed in Table C.1-4.

Table A.7-6

Keowee Generator Reliability Data

Event Name	Description	Failure Rate[1]		Factor		Rationale For Factor[2]	Failure Probability
GK2WL61VVT	Manual Valve 2WL-61 Transfers Position	1.60E-08	/H	36	H	Rule 6	5.76E-07
GK2WL62VVT	Manual Valve 2WL-62 Transfers Position	1.60E-08	/H	36	H	Rule 6	5.76E-07
GK2WL63VVT	Manual Valve 2WL-63 Transfers Position	1.60E-08	/H	36	H	Rule 6	5.76E-07
GK2WL64VVT	Manual Valve 2WL-64 Transfers Position	1.60E-08	/H	36	H	Rule 6	5.76E-07
GK2WL65VVT	Manual Valve 2WL-65 Transfers Position	1.60E-08	/H	36	H	Rule 6	5.76E-07
GK2WL66VVT	Manual Valve 2WL-66 Transfers Position	1.60E-08	/H	36	H	Rule 6	5.76E-07
GK2WL67VVT	Manual Valve 2WL-67 Transfers Position	1.60E-08	/H	36	H	Rule 6	5.76E-07
GK2WL68VVT	Manual Valve 2WL-68 Transfers Position	1.60E-08	/H	36	H	Rule 6	5.76E-07
GK2WL69VVT	Manual Valve 2WL-69 Transfers Position	1.60E-08	/H	36	H	Rule 6	5.76E-07
GK2WL70VVT	Manual Valve 2WL-70 Transfers Position	1.60E-08	/H	36	H	Rule 6	5.76E-07
GK2WL71VVT	Manual Valve 2WL-71 Transfers Position	1.60E-08	/H	36	H	Rule 6	5.76E-07
GK2WL72VVT	Manual Valve 2WL-72 Transfers Position	1.60E-08	/H	36	H	Rule 6	5.76E-07
GK2WL73VVT	Manual Valve 2WL-73 Transfers Position	1.60E-08	/H	36	H	Rule 6	5.76E-07
GK2WL74VVT	Manual Valve 2WL-74 Transfers Position	1.60E-08	/H	36	H	Rule 6	5.76E-07
GK2WL75VVT	Manual Valve 2WL-75 Transfers Position	1.60E-08	/H	36	H	Rule 6	5.76E-07
GK2WL76VVT	Manual Valve 2WL76 Transfers Position and Blocks Discharge Path	1.60E-08	/H	36	H	Rule 6	5.76E-07
GK2WL78VVT	Manual Valve 2WL78 Transfers Position and Blocks Discharge Path	1.60E-08	/H	36	H	Rule 6	5.76E-07

[1] D = Demand, H = Hour
[2] Rules for assigning basic event factors are discussed in Table C.1-4.

Table A.7-7

Keeowee Generator Dominant Minimal Cut Sets

Cut Sets for Gates KU1GENCLD/KU2GENCLD - Keowee Unit 1/2 Generator Fails During Cold Start

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
KU1GENCLD - Keowee Unit 1 Generator Fails During A Cold Start					
1)	1.54E-04	74.8%	GK10001HGS	1.54E-04	Keowee Unit 1 Generator Fault Causes Unit Start Failure
2)	5.20E-05	25.2%	GK1NGDCLHE	5.20E-05	Failure to Close the Unit 1 Neutral Ground Disconnect Following
Total Event Probability = 2.06E-04					
KU2GENCLD - Keowee Unit 2 Generator Fails During A Cold Start					
1)	1.54E-04	74.8%	GK20002HGS	1.54E-04	Keowee Unit 2 Generator Fault Causes Unit Start Failure
2)	5.20E-05	25.2%	GK2NGDCLHE	5.20E-05	Failure to Close the Unit 2 Neutral Ground Disconnect Following Maintena
Total Event Probability = 2.06E-04					

Table A.7-8

Keeowee Generator Dominant Minimal Cut Sets

Cut Sets for Gate KU1GENRUN - Keowee Unit 1 Generator Fails While the Unit Runs

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
1)	2.27E-03	66.0%	GK10001HGR	2.27E-03	Keowee Unit 1 Generator Fault While the Unit Run
2)	2.60E-04	7.6%	GK1BRGVLHE	2.60E-04	Keowee 1 Gen. Brng Oil Cooling Flow Path Vlvs Mi
3)	2.60E-04	7.6%	GK1COOLLHE	2.60E-04	Keowee 1 Gen. Air Cooler WL Flow Path Vlvs Mispo

Total Event Probability = 3.44E-03

Table A.7-9

Keowee Generator Dominant Minimal Cut Sets

Cut Sets for Gate KU2GENRUN - Keowee Unit 2 Generator Fails While the Unit Runs

CS No.	Cut Set Frequency	Percent of Total	Event Name	Probability	Description
1)	2.27E-03	70.5%	GK20001HGR	2.27E-03	Keowee Unit 2 Generator Fault While the Unit Runs
2)	2.60E-04	8.1%	GK2BRGVLHE	2.60E-04	Keowee 2 Gen. Brng Oil Cooling Flow Path Vlvs Mispositioned After Mainte
3)	2.60E-04	8.1%	GK2COOLLHE	2.60E-04	Keowee 2 Gen. Air Cooler WL Flow Path Vlvs Mispositioned After Maint
4)	7.00E-05	2.2%	GK2FIREDEX	7.00E-05	Spurious Actuation of Unit 2 Gen. CO2 Fire Supression System

Total Probability = 3.22E-03

Table A.7-10

Keowee Generator Dominant Contributors To Unavailability
For Gates KU1GENCLD/KU2GENCLD - Keowee Unit 1/2 Generator Fails During Cold Start

Rank	Event Description	Mean Unavailability[1]	Approximate Unavailability Contribution[2]
1	GK10001HGS/ GK20002HGS Keowee Unit 1/2 Generator Fault Causes Unit Start Failure	1.54E-04	74.8%
2	GK1NGDCLHE/ GK2NGDCLHE Failure to Close the Unit 1/2 Neutral Ground Disconnect Following Maintenance	5.20E-05	25.2%

[1] Mean unavailability is defined as the summation of the values of all cut sets in which the event appears.

[2] The contribution to unavailability is calculated by dividing the mean unavailability by the overall system unavailability and then multiplying by 100 percent.

Table A.7-11

Keowee Generator Dominant Contributors To Unavailability
For Gate KU1GENRUN - Keowee Unit 1 Generator Fails While the Unit Runs

Rank	Event Description	Mean Unavailability[1]	Approximate Unavailability Contribution[2]
1	GK10001HGR Keowee Unit 1 Generator Fault While the Unit Run	2.27E-03	65.9%
2	GK1COOLLHE Keowee 1 Gen. Air Cooler WL Flow Path Vlvs Mispositioned	2.59E-04	7.5%
3	GK1BRGVLHE Keowee 1 Gen. Brng Oil Cooling Flow Path Vlvs Mispositioned	2.59E-04	7.5%

1 Mean unavailability is defined as the summation of the values of all cut sets in which the event appears.

2 The contribution to unavailability is calculated by dividing the mean unavailability by the overall system unavailability and then multiplying by 100 percent.

Table A.7-12

Keowee Generator Dominant Contributors To Unavailability
For Gate KU2GENRUN - Keowee Unit 2 Generator Fails While the Unit Runs

Rank	Event Description	Mean Unavailability[1]	Approximate Unavailability Contribution[2]
1	GK20001HGR Keowee Unit 2 Generator Fault While the Unit Runs	2.27E-03	70.4%
2	GK2BRGVLHE Keowee 2 Gen. Brng Oil Cooling Flow Path Vlvs Mispositioned After Mainte	2.59E-04	8.1%
3	GK2COOLLHE Keowee 2 Gen. Air Cooler WL Flow Path Vlvs Mispositioned After Maint	2.59E-04	8.1%
4	GK2FIREDEX Spurious Actuation of Unit 2 Gen. CO2 Fire Supression System	6.99E-05	2.2%

[1] Mean unavailability is defined as the summation of the values of all cut sets in which the event appears.

[2] The contribution to unavailability is calculated by dividing the mean unavailability by the overall system unavailability and then multiplying by 100 percent.

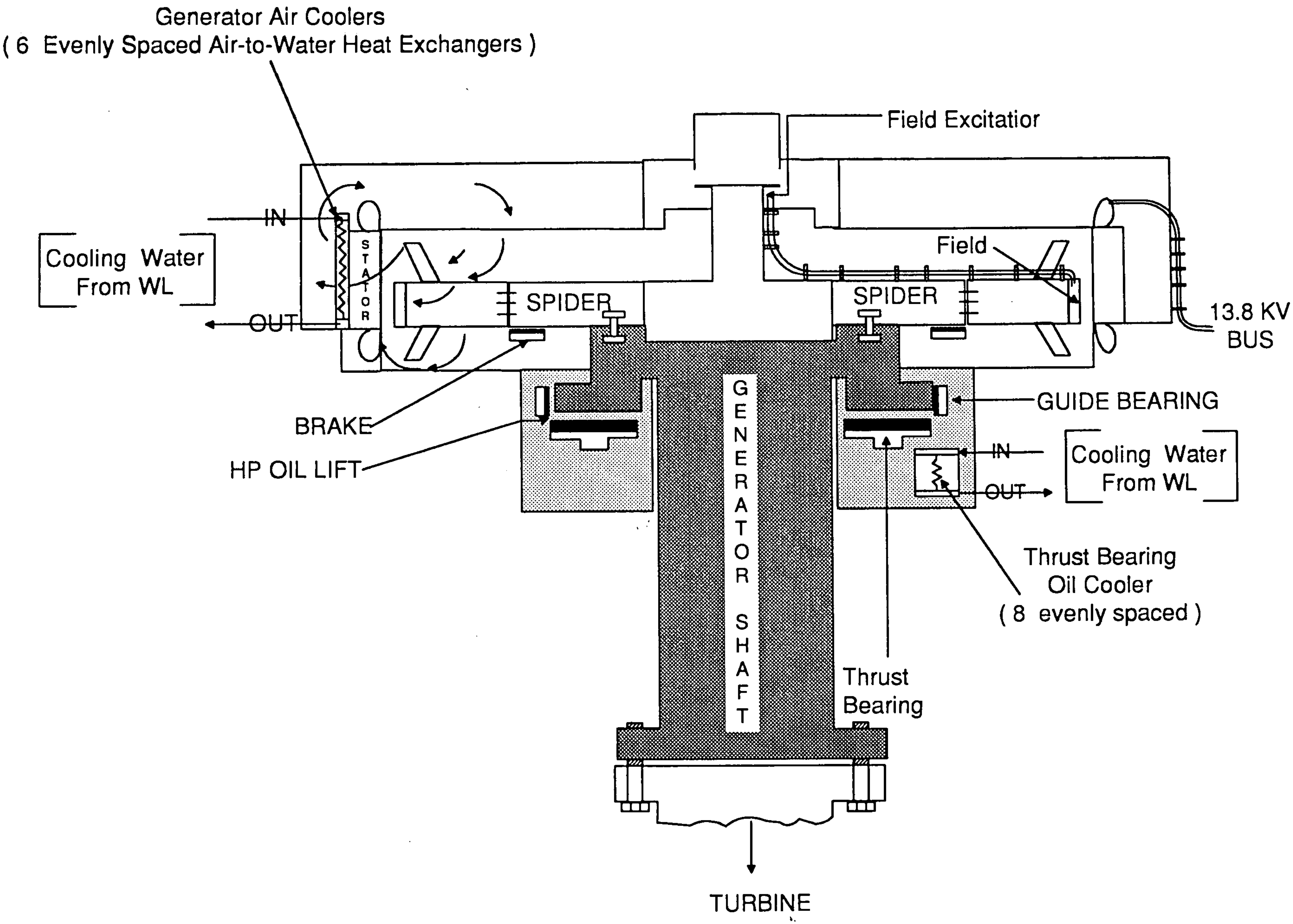


Figure A.7-1 Simplified Diagram of the Keowee Generator

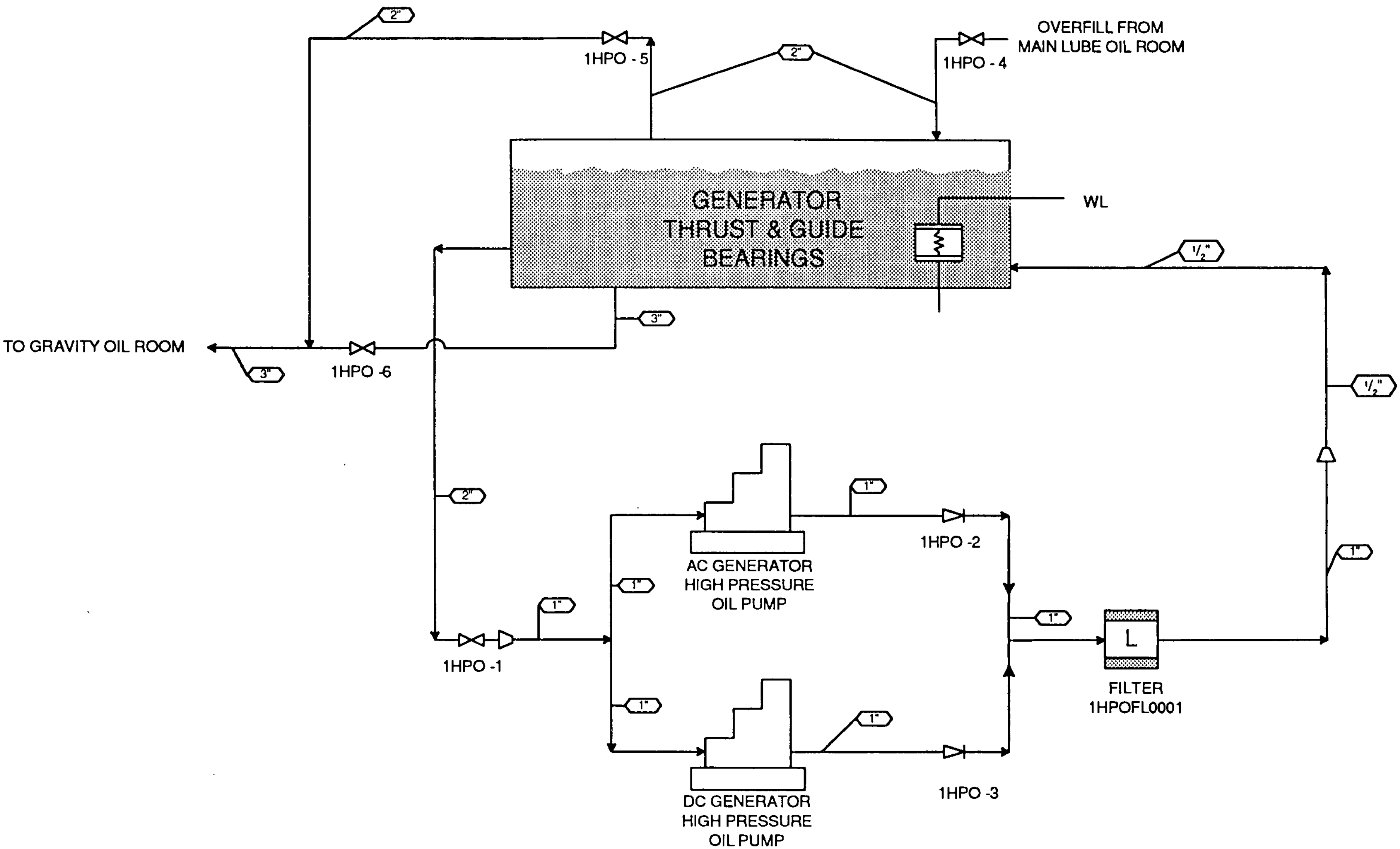


Figure A.7-2 Simplified Diagram of High Pressure Oil System

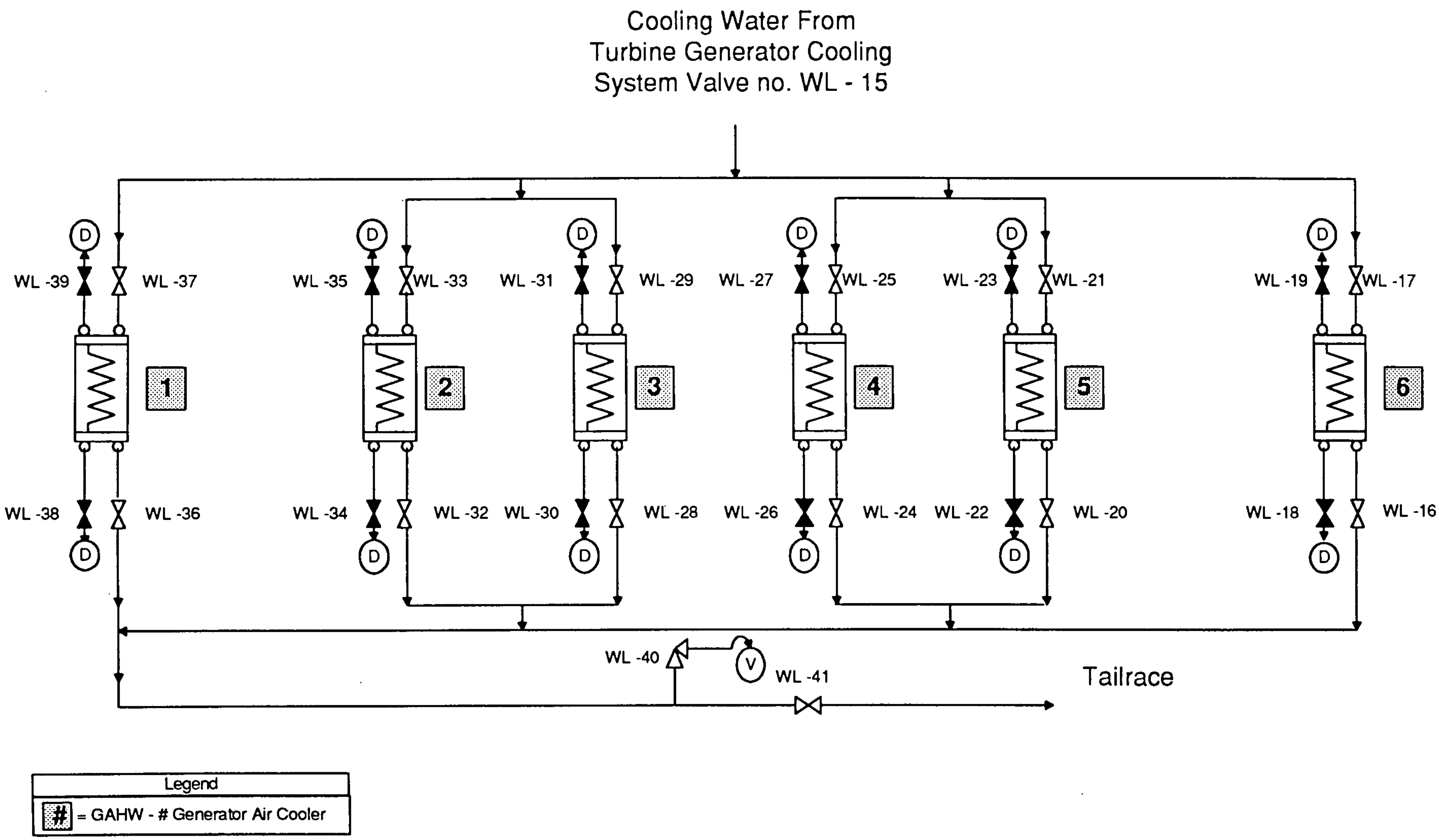


Figure A.7-3 Simplified Flow Diagram of the Keowee Generator Air Coolers

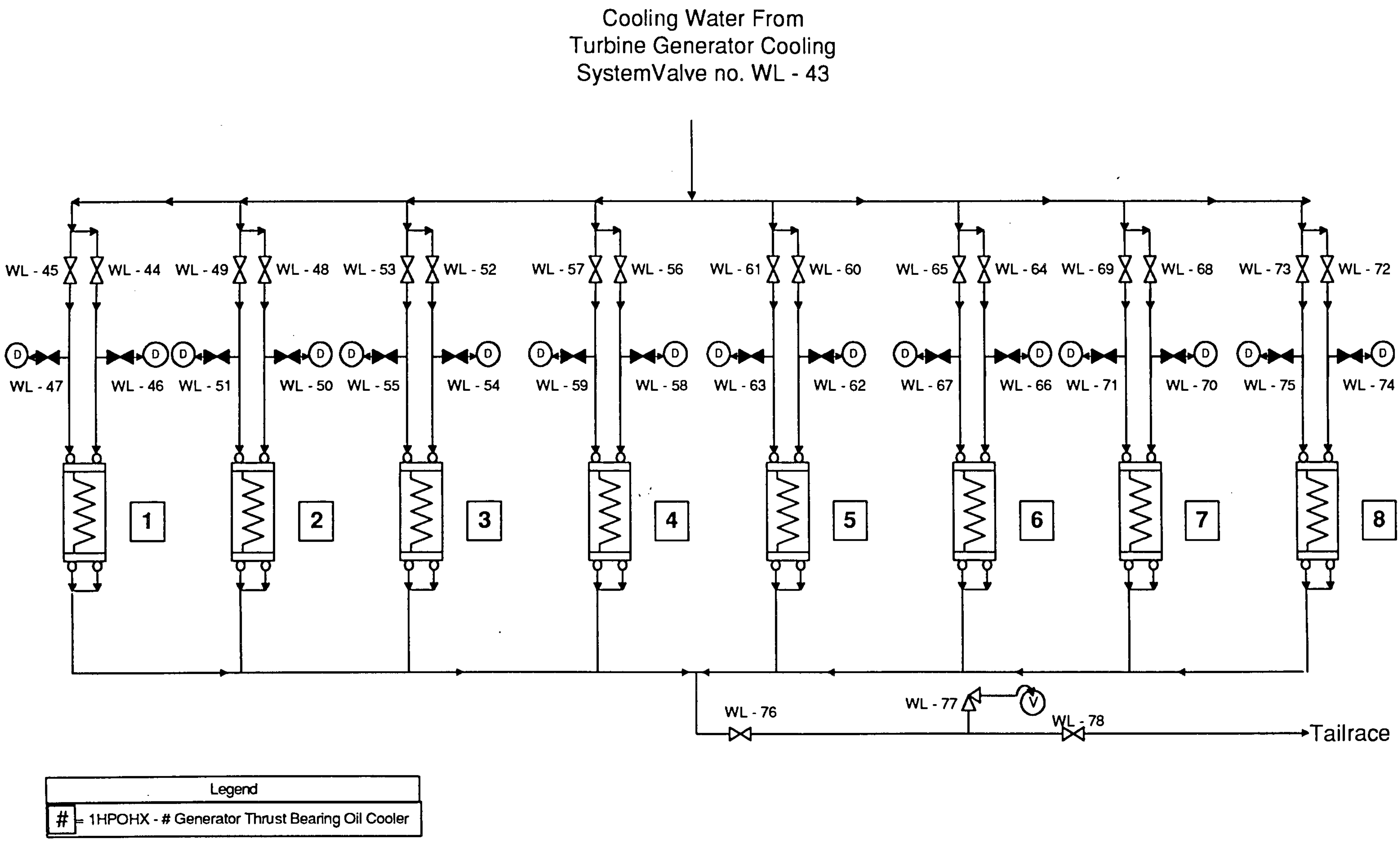


Figure A.7-4 Simplified Flow Diagram of the Keowee Generator Thrust Bearing Oil Coolers

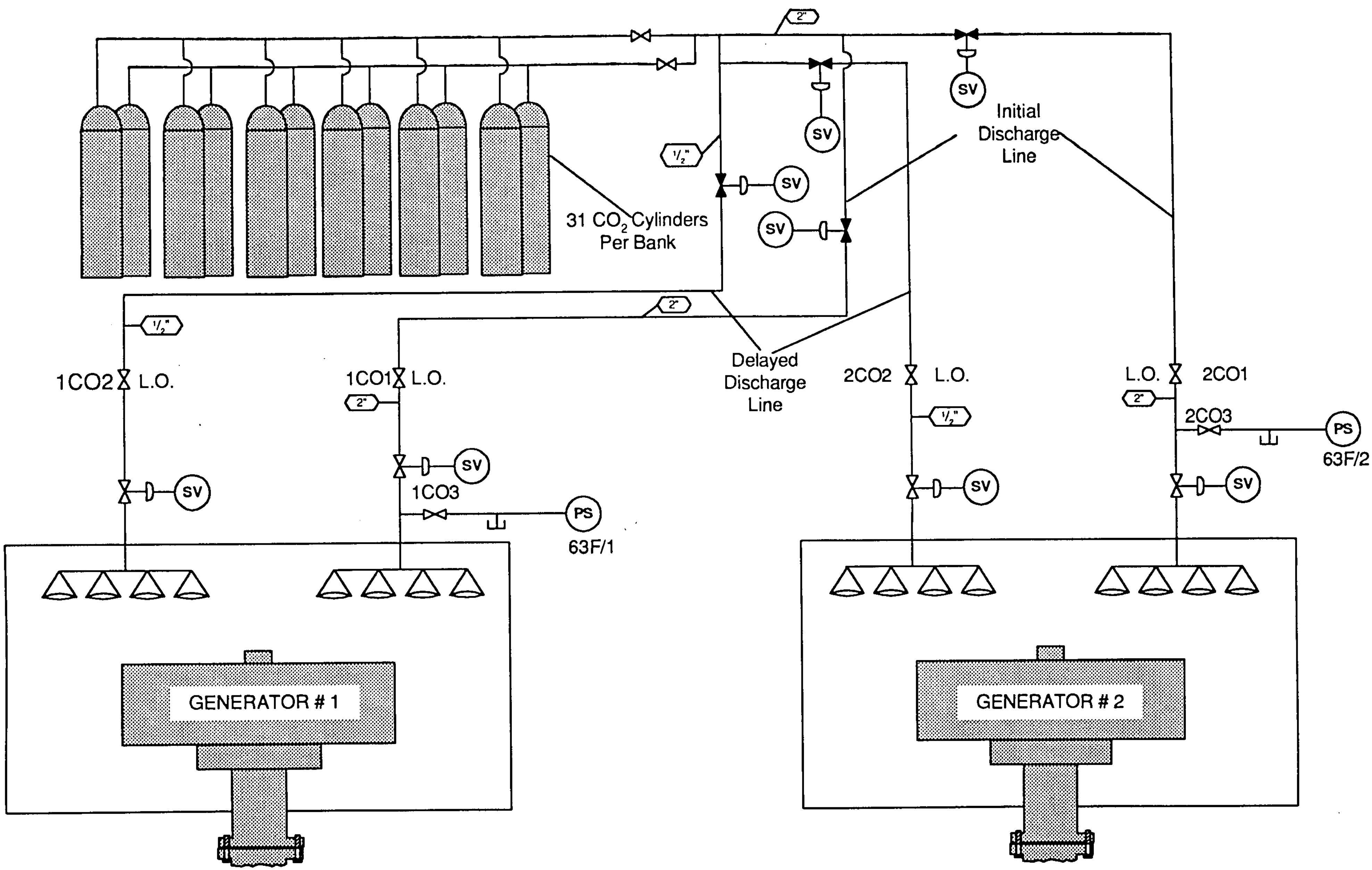
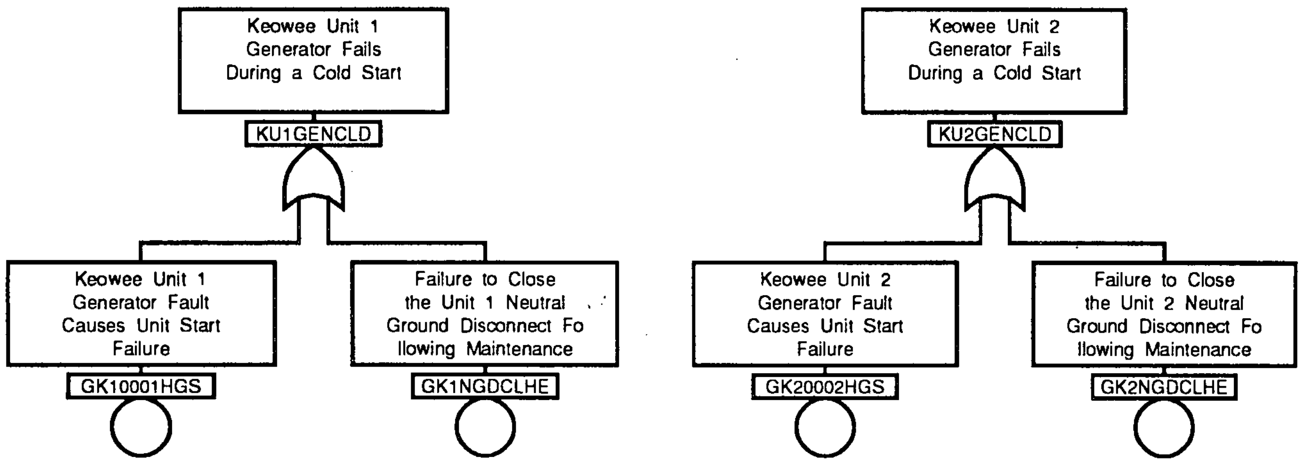
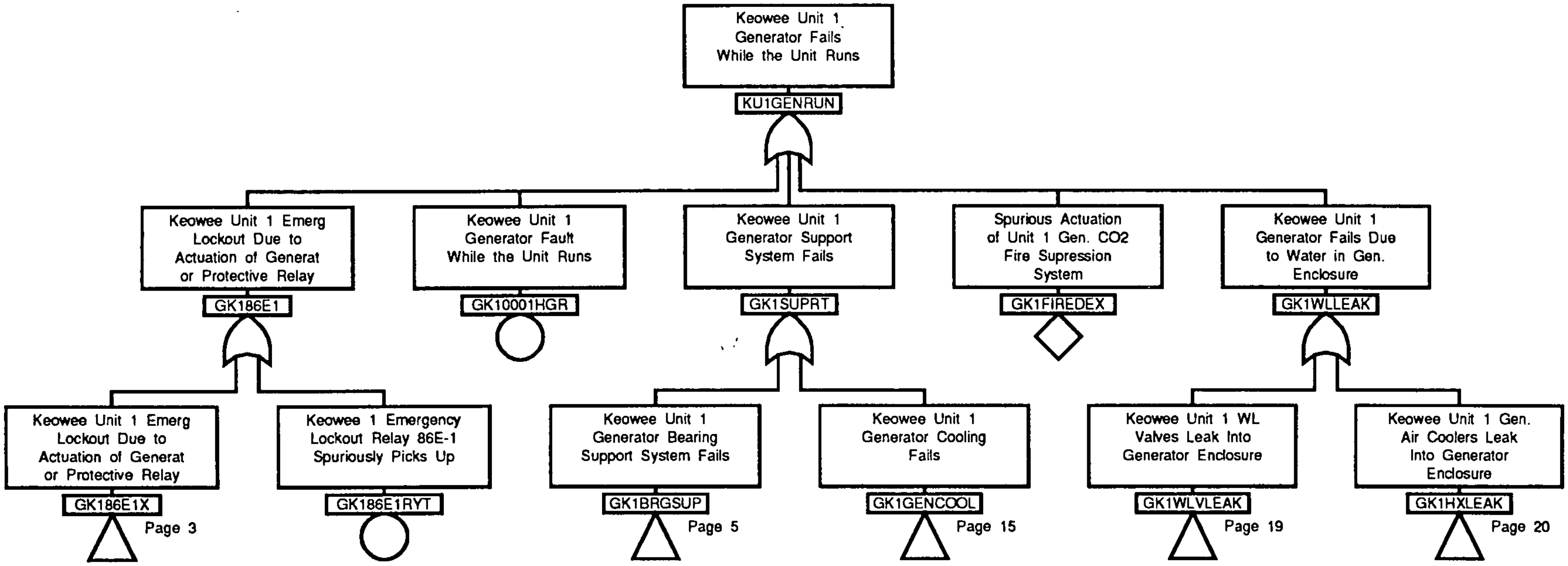


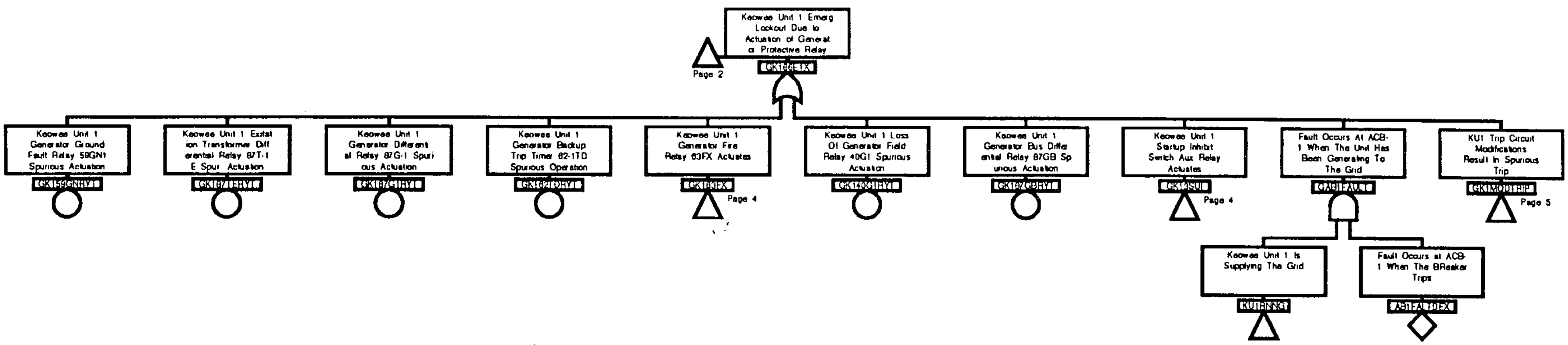
Figure A.7-5 Simplified Diagram of the Keowee Generator $C0_2$ Fire Supression System

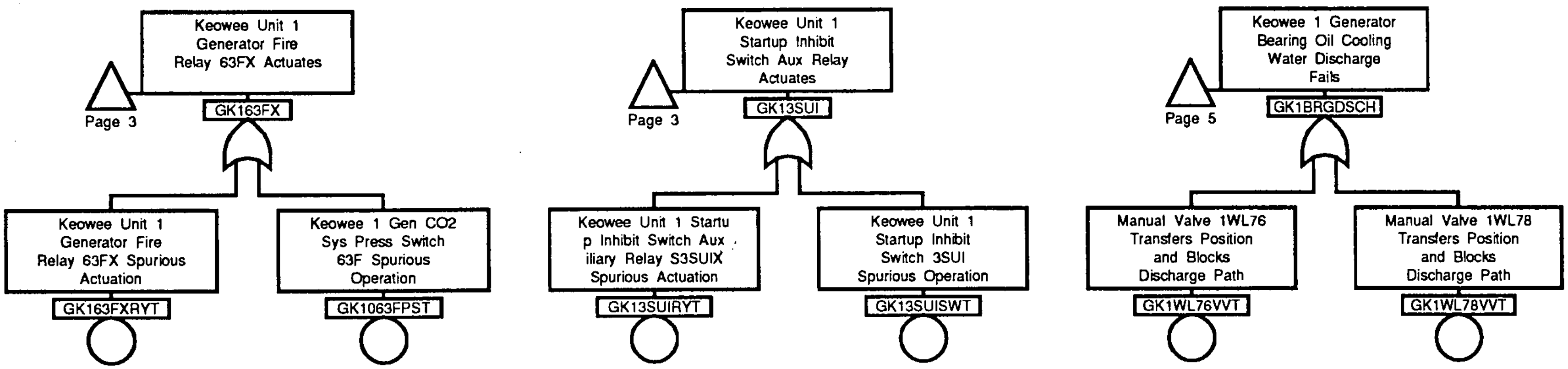


Keowee Generator Fault Tree | FIGURE A.7-6 |

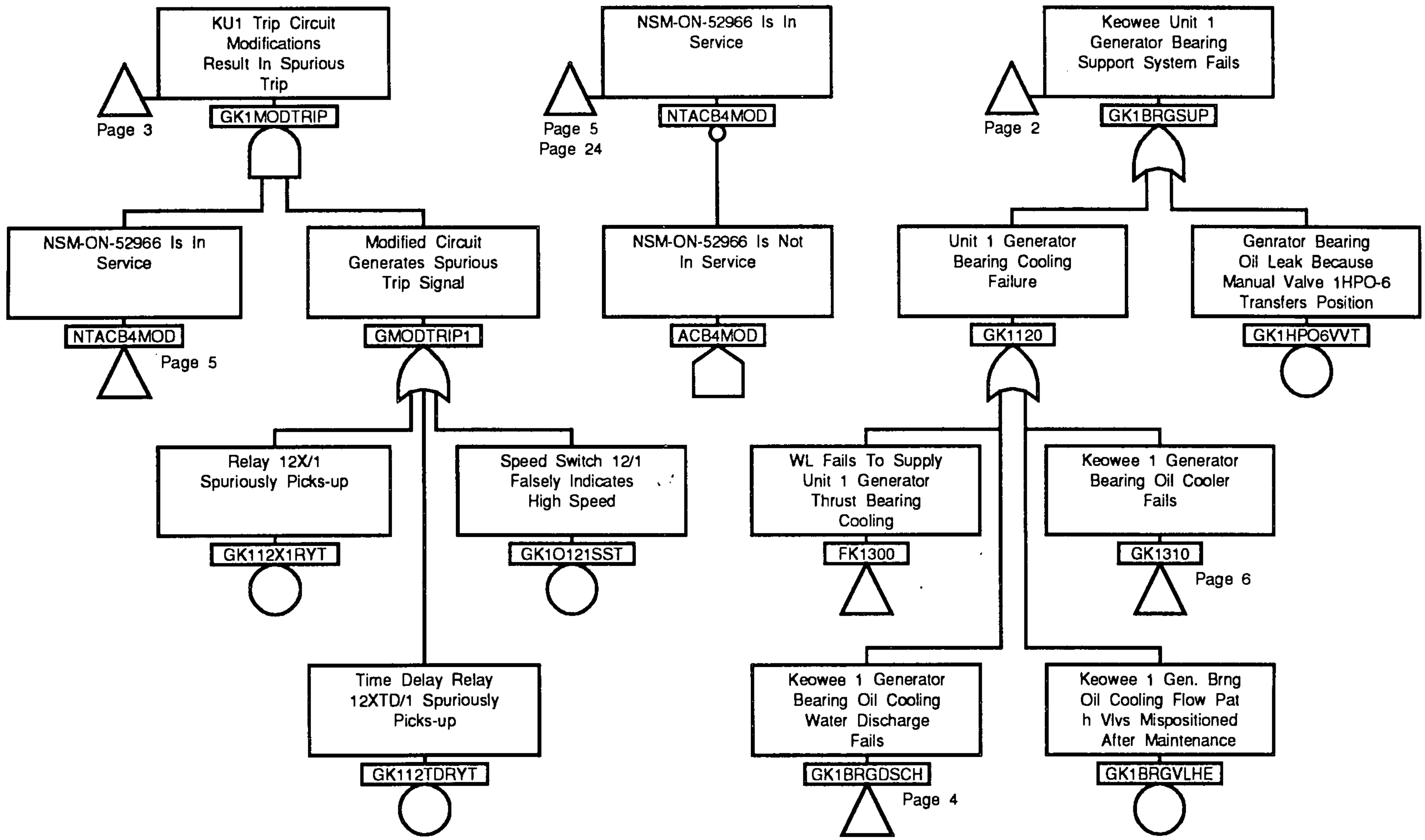


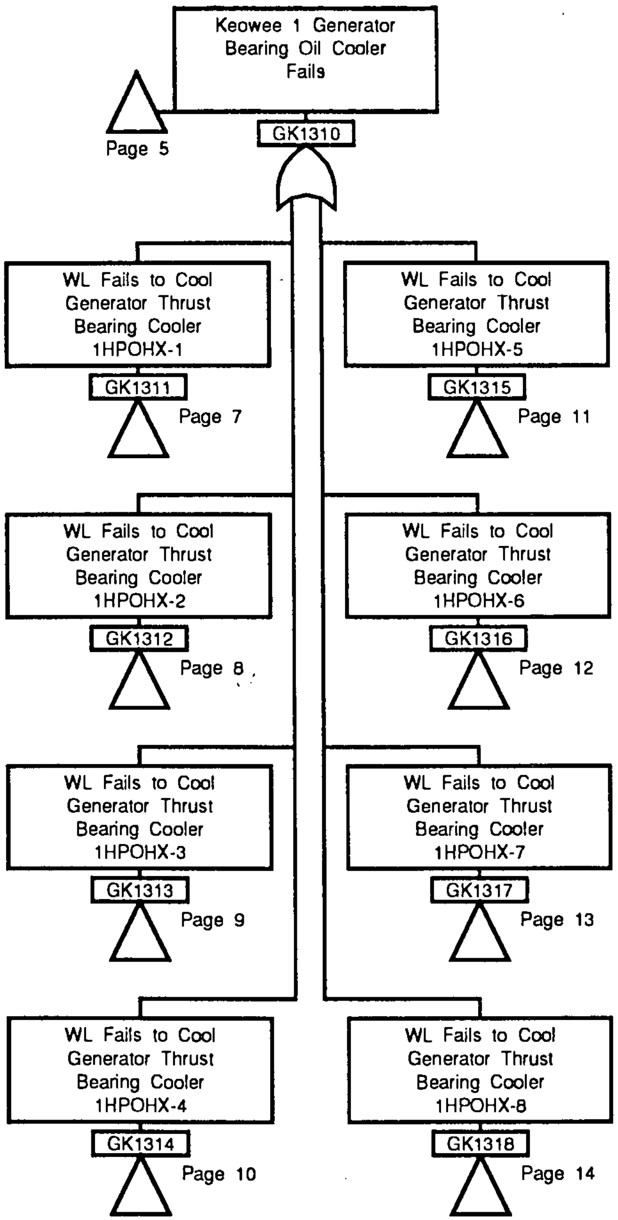
Keowee Generator Fault Tree	FIGURE A.7-6	Page 2


Keowee Unit 1 Emerg Lockout Due to Actuation of Generator Protective Relay
Page 2
Keowee Unit 1 Generator Ground Fault Relay 59GN1 Spurious Actuation
Keowee Unit 1 Excitation Transformer Differential Relay 87T-1 E Spur Actuation
Keowee Unit 1 Generator Differential Relay 87G-1 Spurious Actuation
Keowee Unit 1 Generator Backup Trip Timer 62-1TD Spurious Operation
Keowee Unit 1 Generator Fire Relay 63FX Actuates
Page 4
Keowee Unit 1 Loss Of Generator Field Relay 40G1 Spurious Actuation
Keowee Unit 1 Generator Bus Differential Relay 87GB Spurious Actuation
Keowee Unit 1 Startup Inhibit Switch Aux Relay Actuates
Page 4
Fault Occurs At ACB-1 When The Unit Has Been Generating To The Grid
KU1 Trip Circuit Modifications Result In Spurious Trip
Page 5
Keowee Unit 1 Is Supplying The Grid
Fault Occurs at ACB-1 When The BReaker Trips

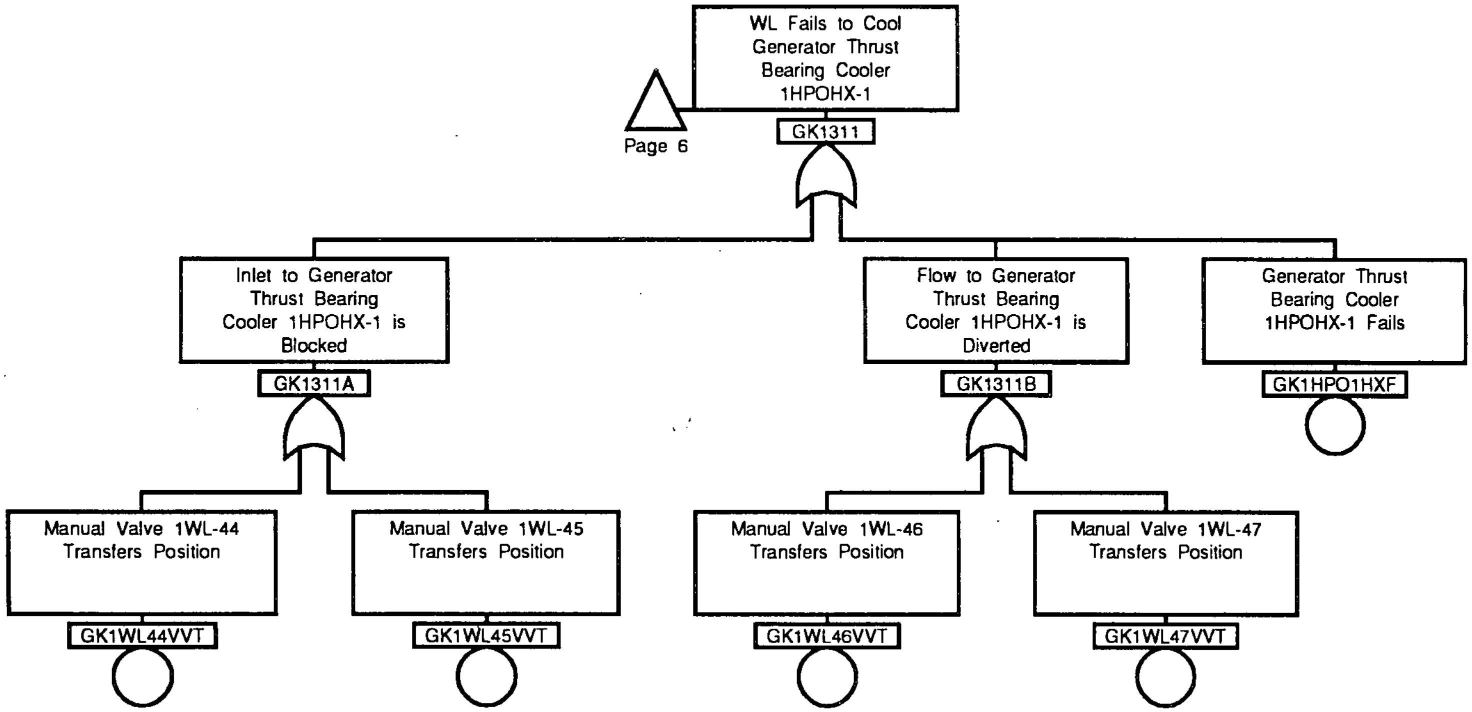


Keowee Generator Fault Tree | FIGURE A.7-6 |

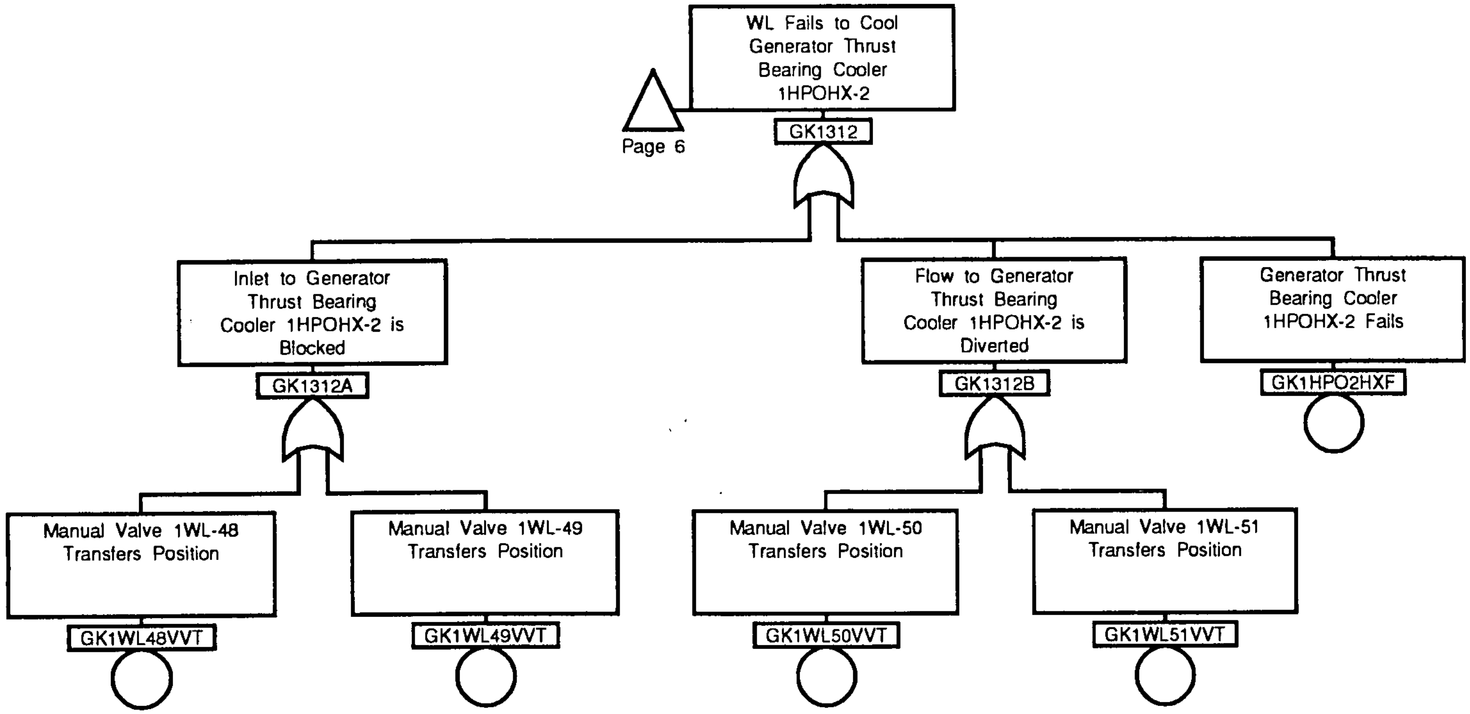

KU1 Trip Circuit Modifications Result In Spurious Trip
GK1MODTRIP
Page 3
NSM-ON-52966 Is In Service
NTACB4MOD
Page 5
Page 24
Keowee Unit 1 Generator Bearing Support System Fails
GK1BRGSUP
Page 2
NSM-ON-52966 Is In Service
NTACB4MOD
Page 5
Modified Circuit Generates Spurious Trip Signal
GMODTRIP1
NSM-ON-52966 Is Not In Service
ACB4MOD
Unit 1 Generator Bearing Cooling Failure
GK1120
Genrator Bearing Oil Leak Because Manual Valve 1HPO-6 Transfers Position
GK1HPO6VVT
Relay 12X/1 Spuriously Picks-up
GK112X1RYT
Speed Switch 12/1 Falsely Indicates High Speed
GK1O121SST
WL Fails To Supply Unit 1 Generator Thrust Bearing Cooling
FK1300
Keowee 1 Generator Bearing Oil Cooler Fails
GK1310
Page 6
Time Delay Relay 12XTD/1 Spuriously Picks-up
GK112TDRYT
Keowee 1 Generator Bearing Oil Cooling Water Discharge Fails
GK1BRGDSCH
Page 4
Keowee 1 Gen. Brng Oil Cooling Flow Pat h Vlvs Mispositioned After Maintenance
GK1BRGVLHE



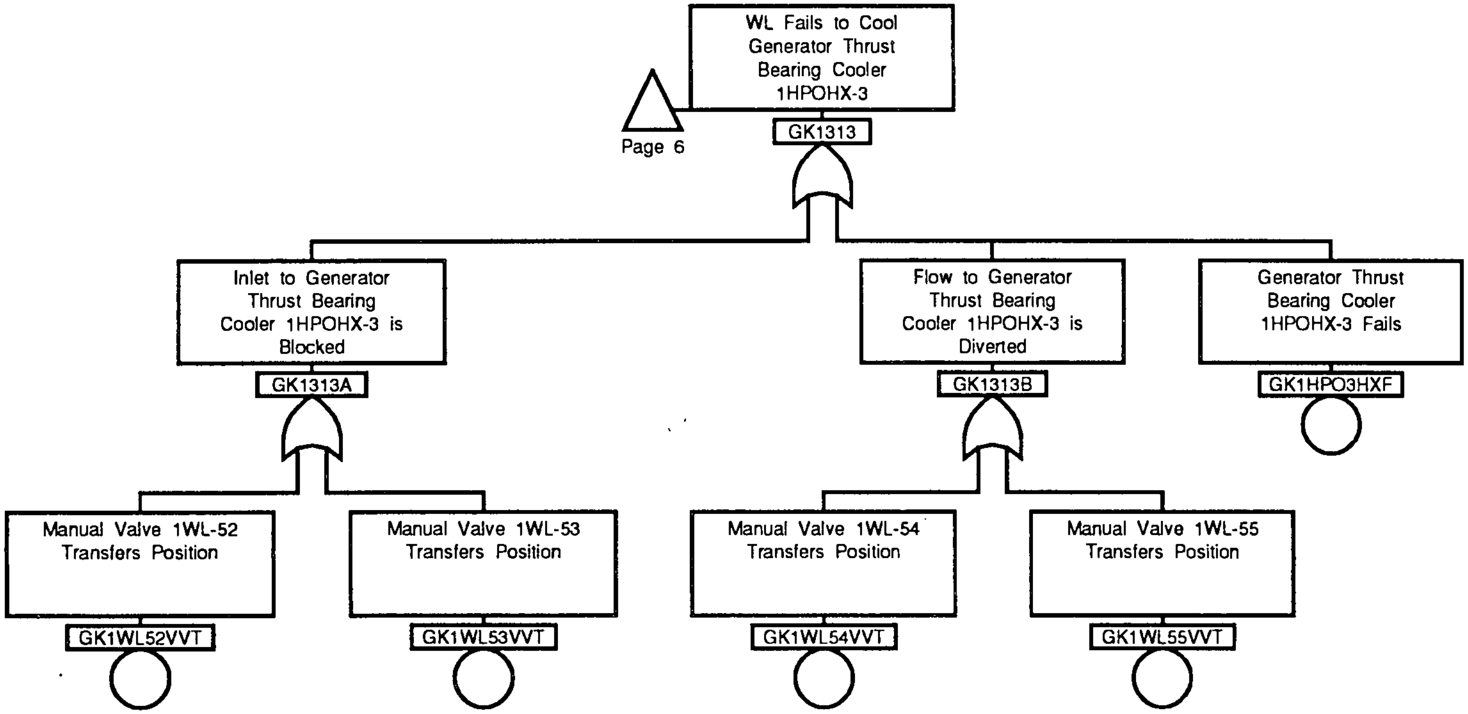
Keowee Generator Fault Tree	FIGURE A.7-6	Page 6

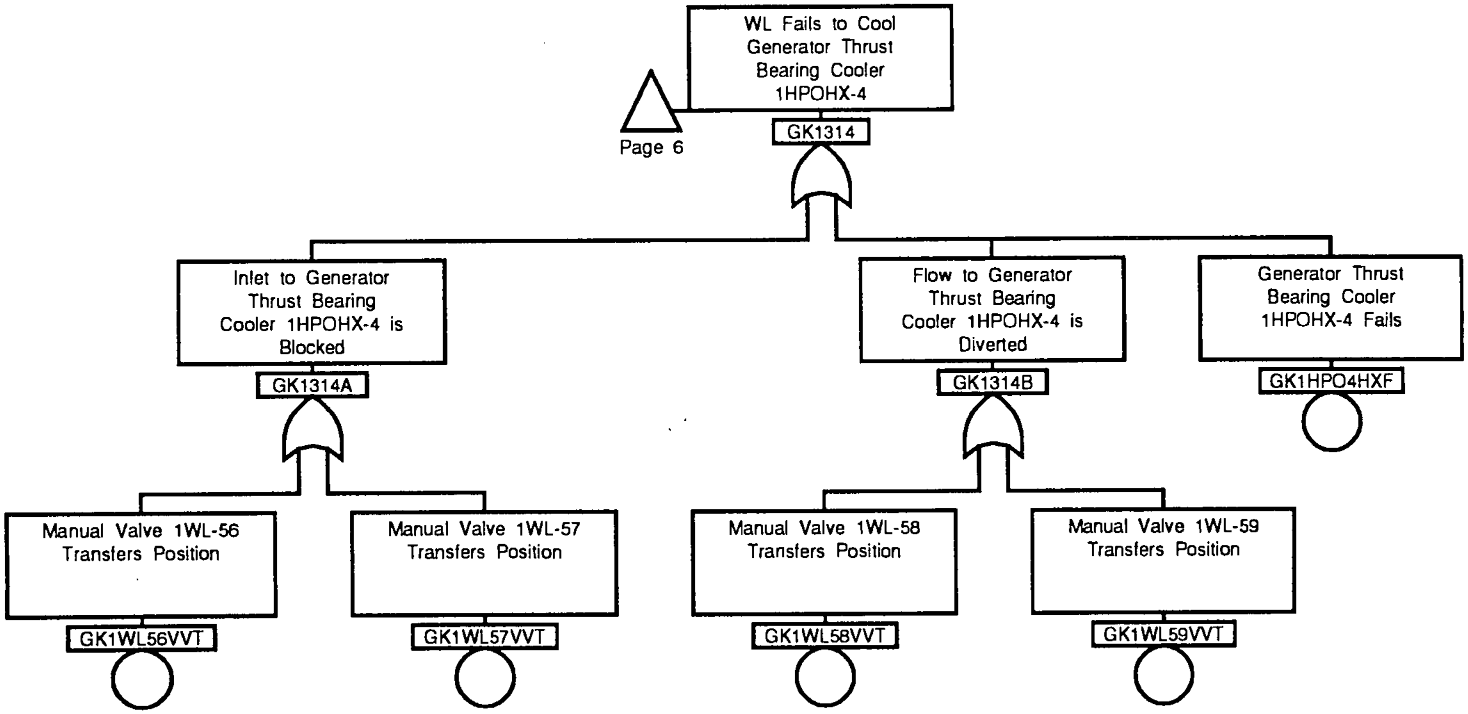


Keowee Generator Fault Tree | FIGURE A.7-6 |

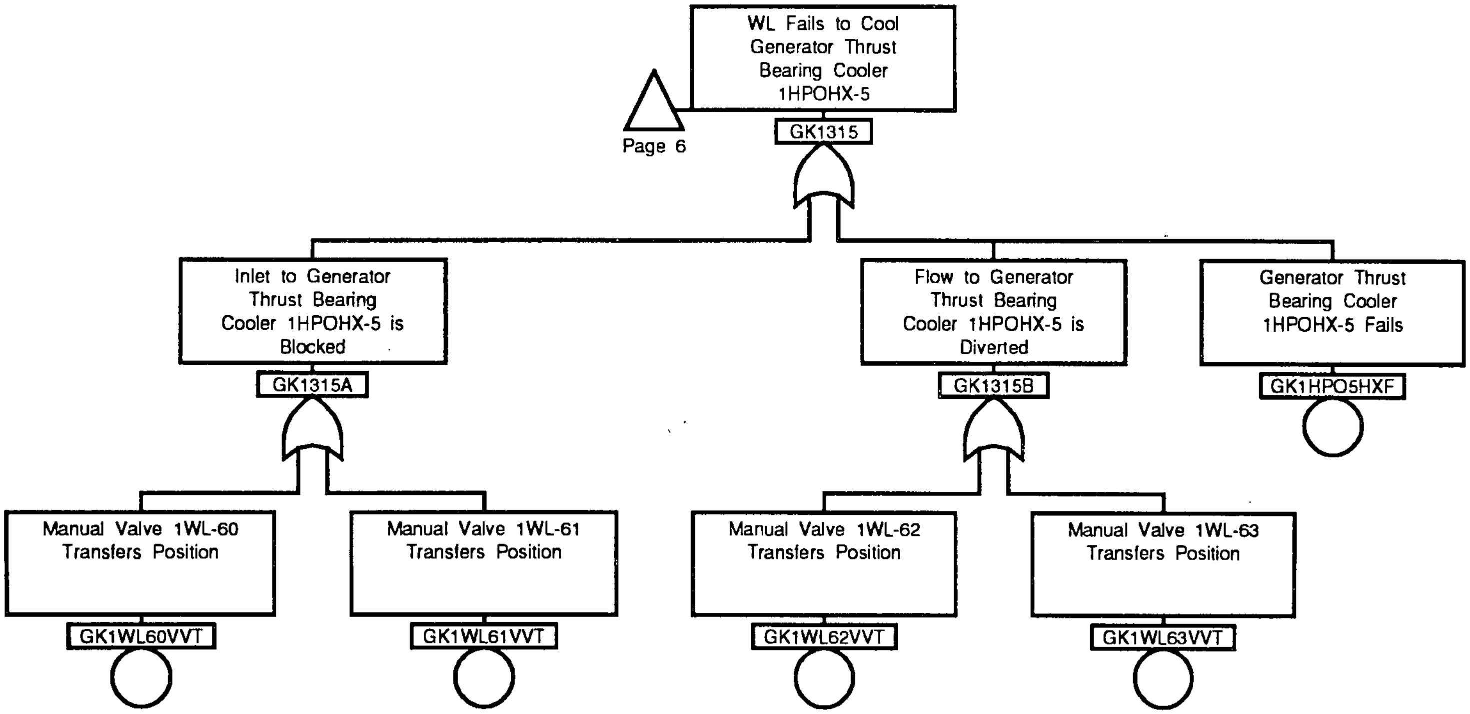


WL Fails to Cool Generator Thrust Bearing Cooler 1HPOHX-2
GK1312
Page 6
Inlet to Generator Thrust Bearing Cooler 1HPOHX-2 is Blocked
GK1312A
Flow to Generator Thrust Bearing Cooler 1HPOHX-2 is Diverted
GK1312B
Generator Thrust Bearing Cooler 1HPOHX-2 Fails
GK1HPO2HXF
Manual Valve 1WL-48 Transfers Position
GK1WL48VVT
Manual Valve 1WL-49 Transfers Position
GK1WL49VVT
Manual Valve 1WL-50 Transfers Position
GK1WL50VVT
Manual Valve 1WL-51 Transfers Position
GK1WL51VVT

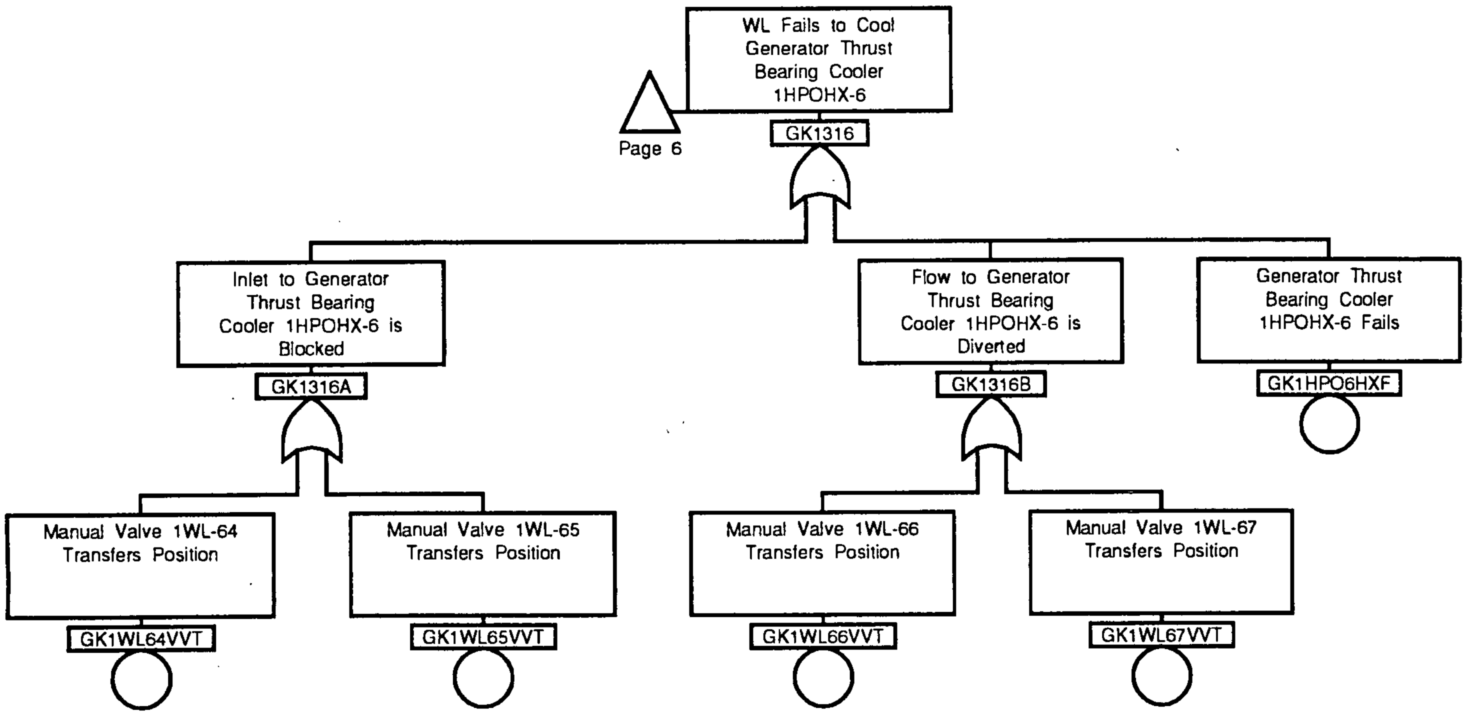

WL Fails to Cool Generator Thrust Bearing Cooler 1HPOHX-3
GK1313
Page 6
Inlet to Generator Thrust Bearing Cooler 1HPOHX-3 is Blocked
GK1313A
Flow to Generator Thrust Bearing Cooler 1HPOHX-3 is Diverted
GK1313B
Generator Thrust Bearing Cooler 1HPOHX-3 Fails
GK1HPO3HXF
Manual Valve 1WL-52 Transfers Position
GK1WL52VVT
Manual Valve 1WL-53 Transfers Position
GK1WL53VVT
Manual Valve 1WL-54 Transfers Position
GK1WL54VVT
Manual Valve 1WL-55 Transfers Position
GK1WL55VVT



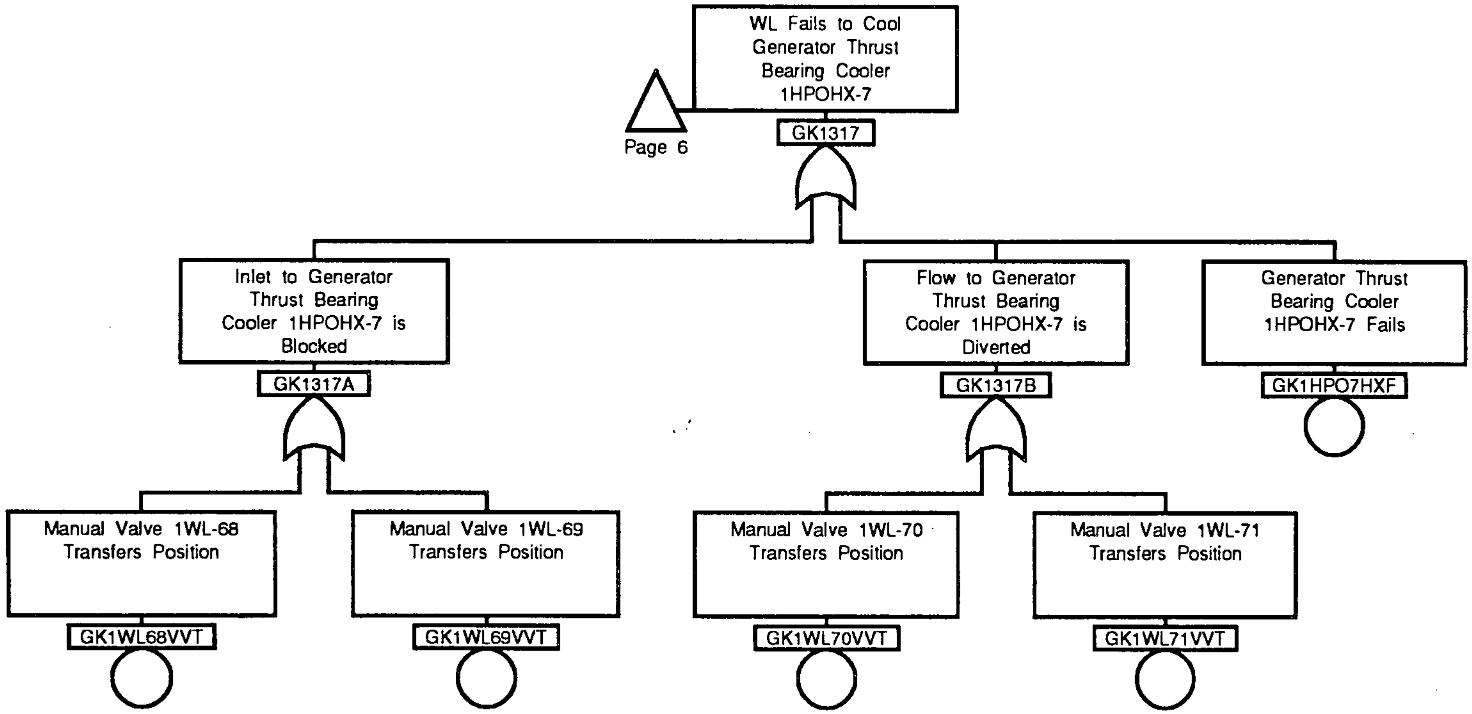
Keowee Generator Fault Tree | FIGURE A.7-6 |



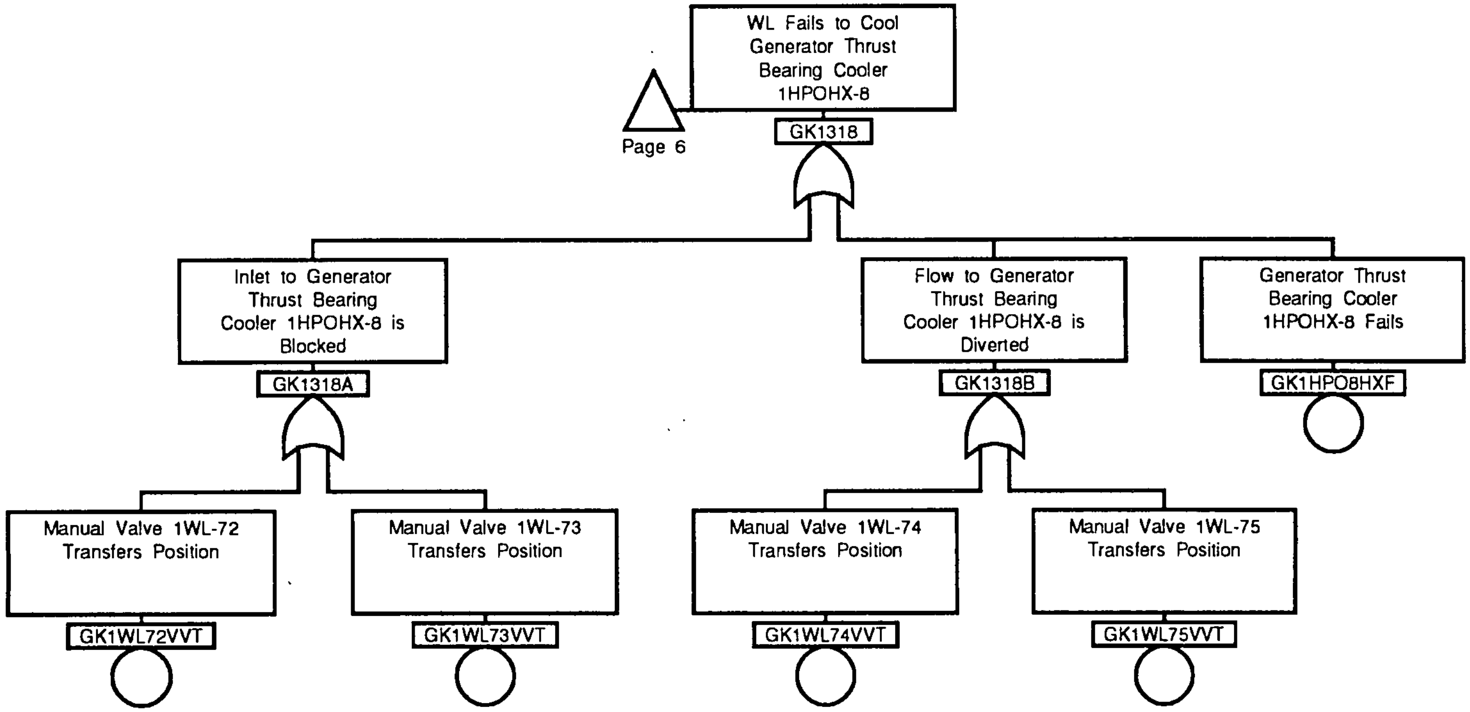
WL Fails to Cool Generator Thrust Bearing Cooler 1HPOHX-5
GK1315
Page 6
Inlet to Generator Thrust Bearing Cooler 1HPOHX-5 is Blocked
GK1315A
Flow to Generator Thrust Bearing Cooler 1HPOHX-5 is Diverted
GK1315B
Generator Thrust Bearing Cooler 1HPOHX-5 Fails
GK1HPO5HXF
Manual Valve 1WL-60 Transfers Position
GK1WL60VVT
Manual Valve 1WL-61 Transfers Position
GK1WL61VVT
Manual Valve 1WL-62 Transfers Position
GK1WL62VVT
Manual Valve 1WL-63 Transfers Position
GK1WL63VVT

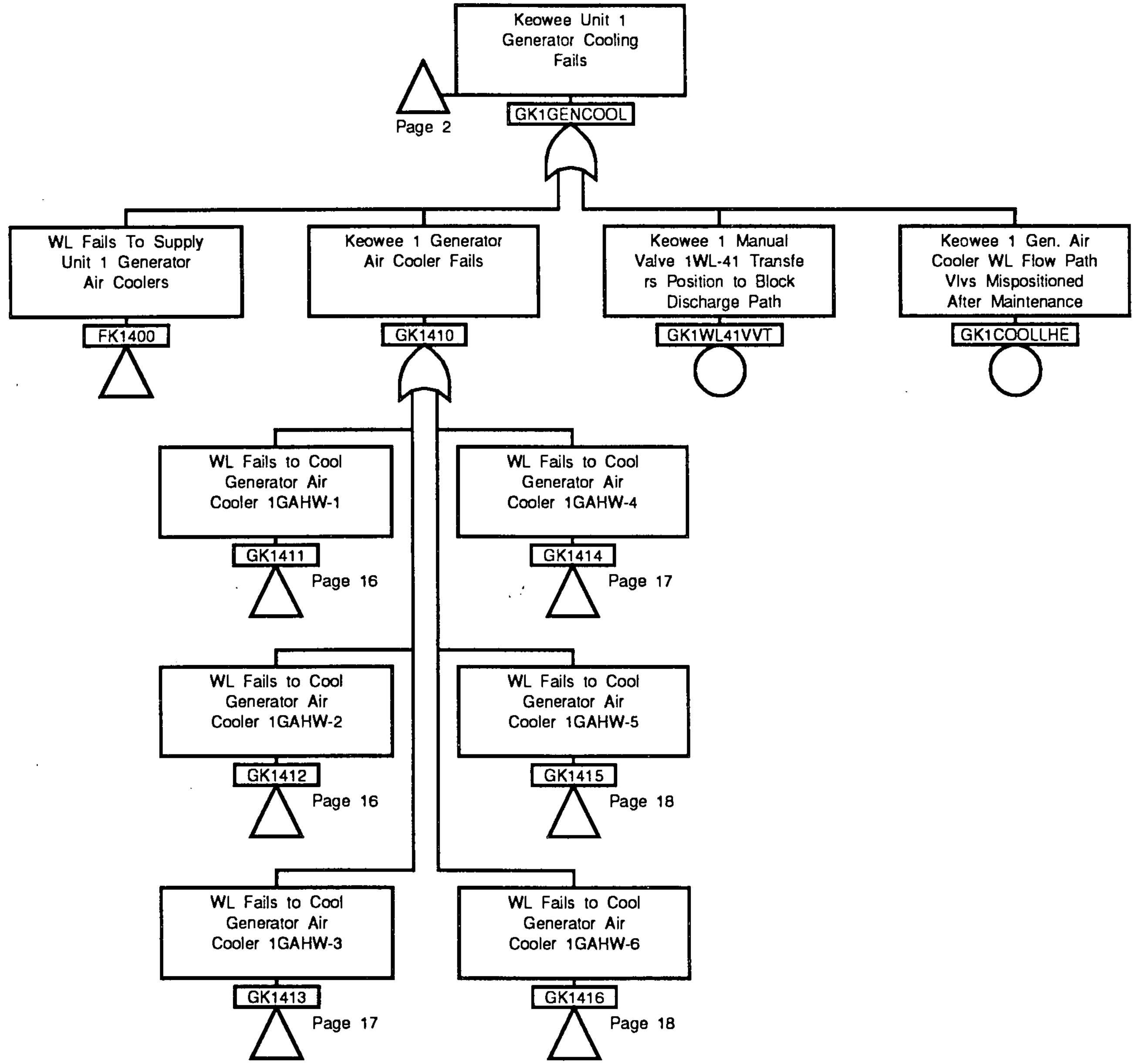


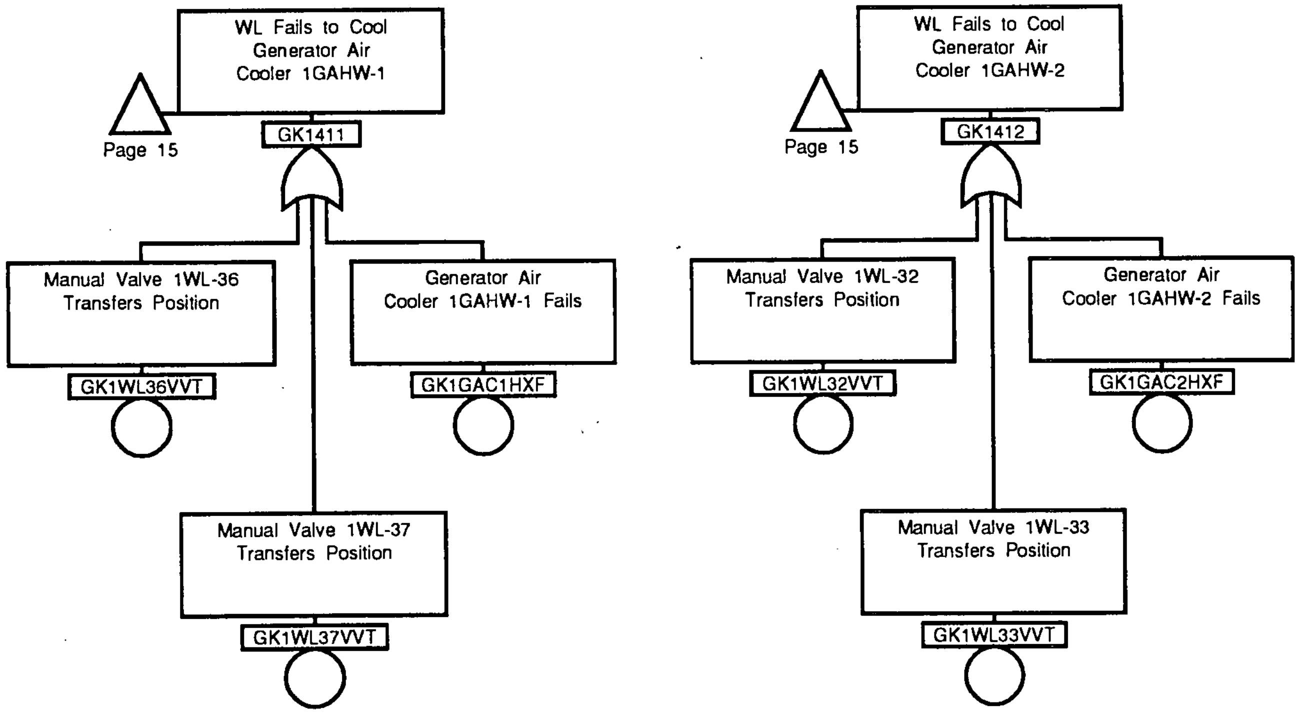
Keowee Generator Fault Tree	FIGURE A.7-6	Page 12

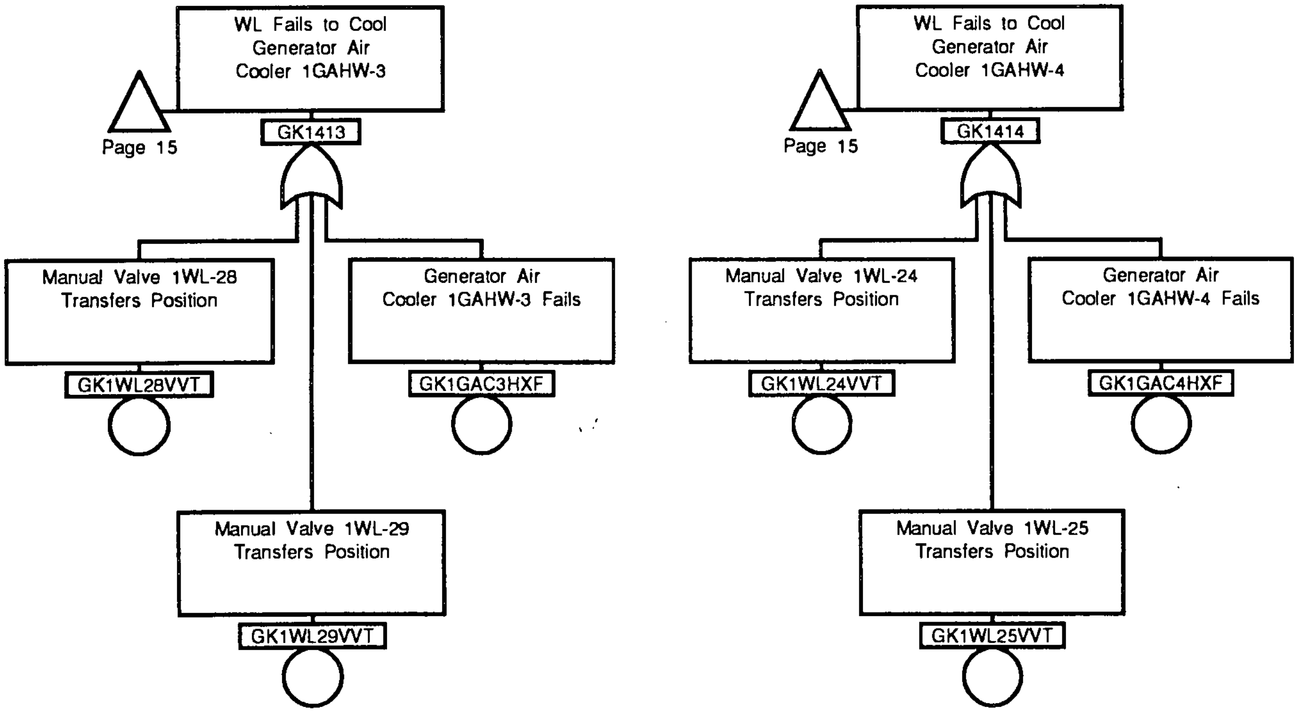


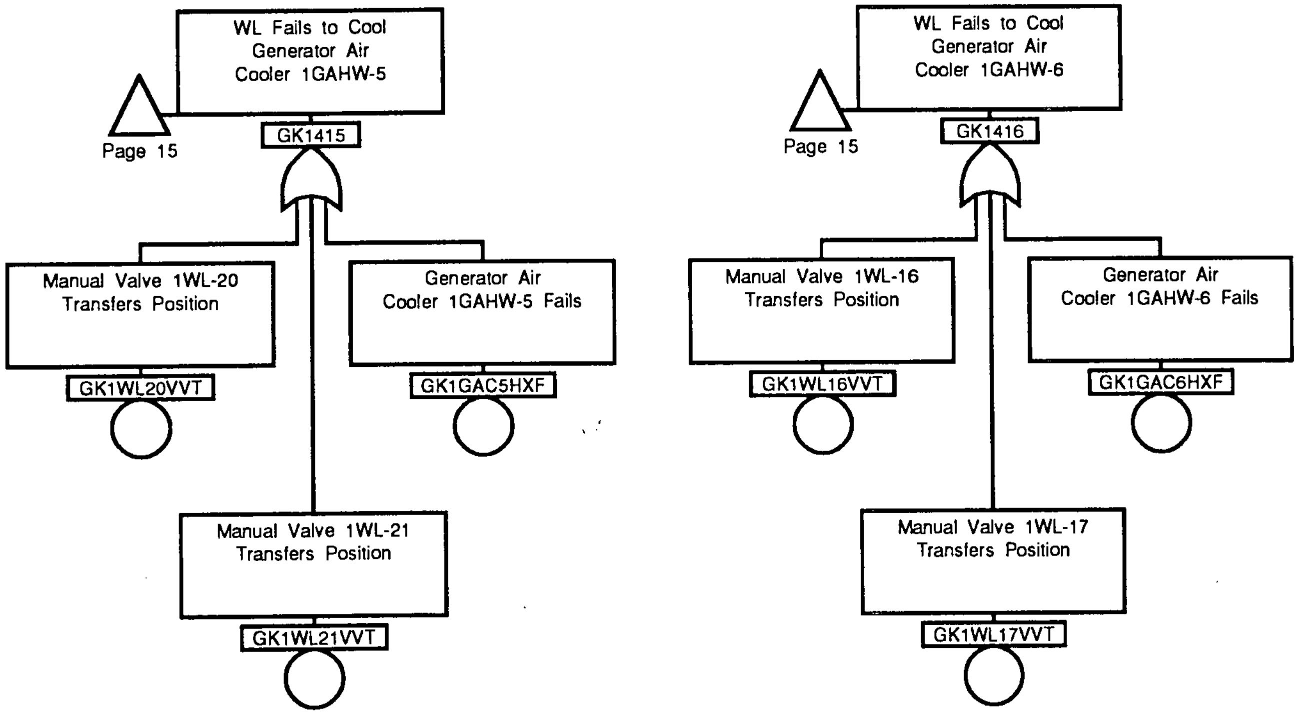
Keowee Generator Fault Tree | FIGURE A.7-6 |


WL Fails to Cool Generator Thrust Bearing Cooler 1HPOHX-8
GK1318
Page 6
Inlet to Generator Thrust Bearing Cooler 1HPOHX-8 is Blocked
GK1318A
Flow to Generator Thrust Bearing Cooler 1HPOHX-8 is Diverted
GK1318B
Generator Thrust Bearing Cooler 1HPOHX-8 Fails
GK1HPO8HXF
Manual Valve 1WL-72 Transfers Position
GK1WL72VVT
Manual Valve 1WL-73 Transfers Position
GK1WL73VVT
Manual Valve 1WL-74 Transfers Position
GK1WL74VVT
Manual Valve 1WL-75 Transfers Position
GK1WL75VVT

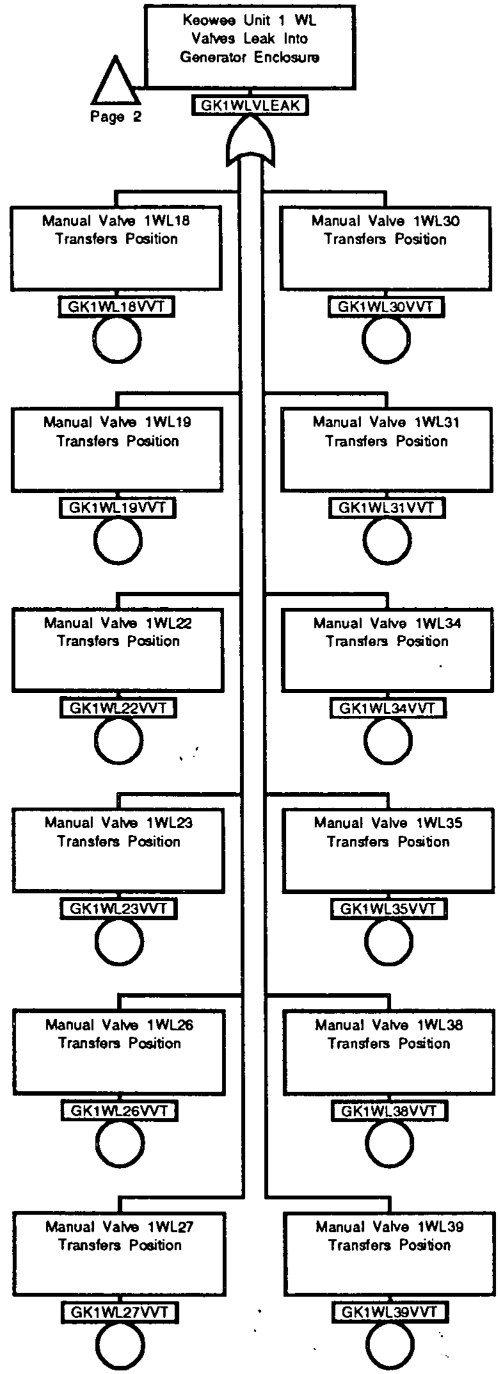

Keowee Unit 1 Generator Cooling Fails
Page 2
GK1GENCOOL
WL Fails To Supply Unit 1 Generator Air Coolers
FK1400
Keowee 1 Generator Air Cooler Fails
GK1410
Keowee 1 Manual Valve 1WL-41 Transfers Position to Block Discharge Path
GK1WL41VVT
Keowee 1 Gen. Air Cooler WL Flow Path Vlvs Mispositioned After Maintenance
GK1COOLLHE
WL Fails to Cool Generator Air Cooler 1GAHW-1
GK1411
Page 16
WL Fails to Cool Generator Air Cooler 1GAHW-4
GK1414
Page 17
WL Fails to Cool Generator Air Cooler 1GAHW-2
GK1412
Page 16
WL Fails to Cool Generator Air Cooler 1GAHW-5
GK1415
Page 18
WL Fails to Cool Generator Air Cooler 1GAHW-3
GK1413
Page 17
WL Fails to Cool Generator Air Cooler 1GAHW-6
GK1416
Page 18


WL Fails to Cool Generator Air Cooler 1GAHW-1
Page 15
GK1411
Manual Valve 1WL-36 Transfers Position
GK1WL36VVT
Generator Air Cooler 1GAHW-1 Fails
GK1GAC1HXF
Manual Valve 1WL-37 Transfers Position
GK1WL37VVT
WL Fails to Cool Generator Air Cooler 1GAHW-2
Page 15
GK1412
Manual Valve 1WL-32 Transfers Position
GK1WL32VVT
Generator Air Cooler 1GAHW-2 Fails
GK1GAC2HXF
Manual Valve 1WL-33 Transfers Position
GK1WL33VVT

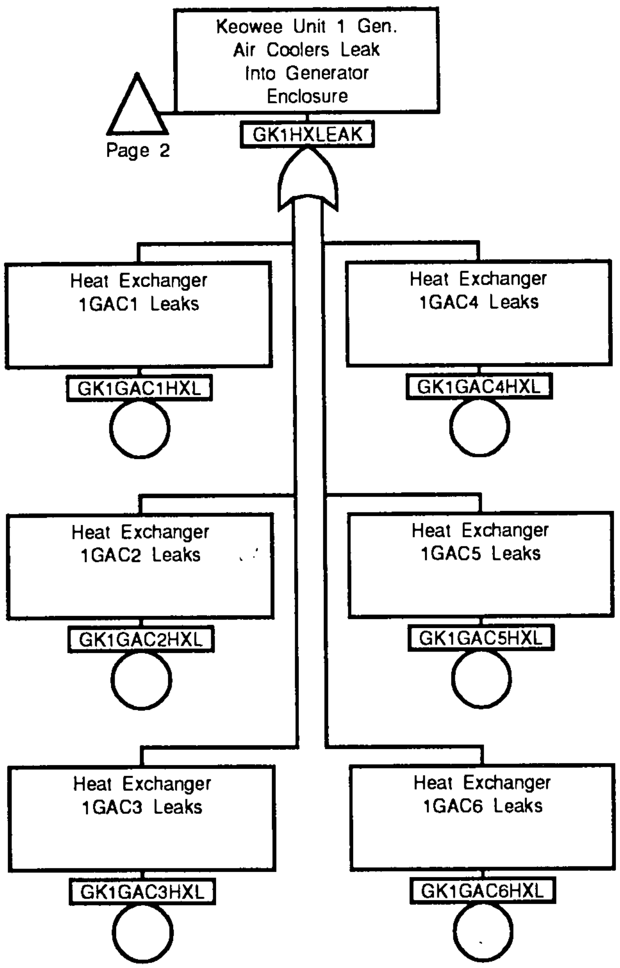

WL Fails to Cool Generator Air Cooler 1GAHW-3
Page 15
GK1413
Manual Valve 1WL-28 Transfers Position
GK1WL28VVT
Generator Air Cooler 1GAHW-3 Fails
GK1GAC3HXF
Manual Valve 1WL-29 Transfers Position
GK1WL29VVT
WL Fails to Cool Generator Air Cooler 1GAHW-4
Page 15
GK1414
Manual Valve 1WL-24 Transfers Position
GK1WL24VVT
Generator Air Cooler 1GAHW-4 Fails
GK1GAC4HXF
Manual Valve 1WL-25 Transfers Position
GK1WL25VVT



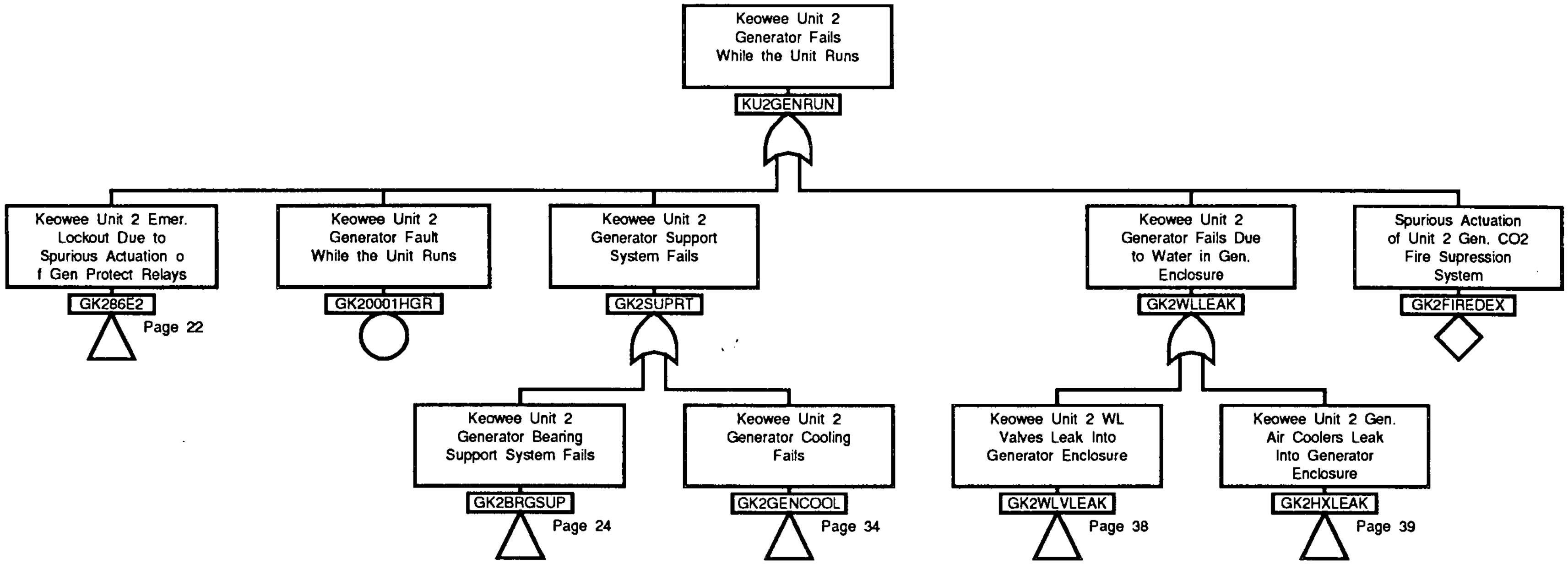
Keewee Generator Fault Tree | FIGURE A.7-6 |



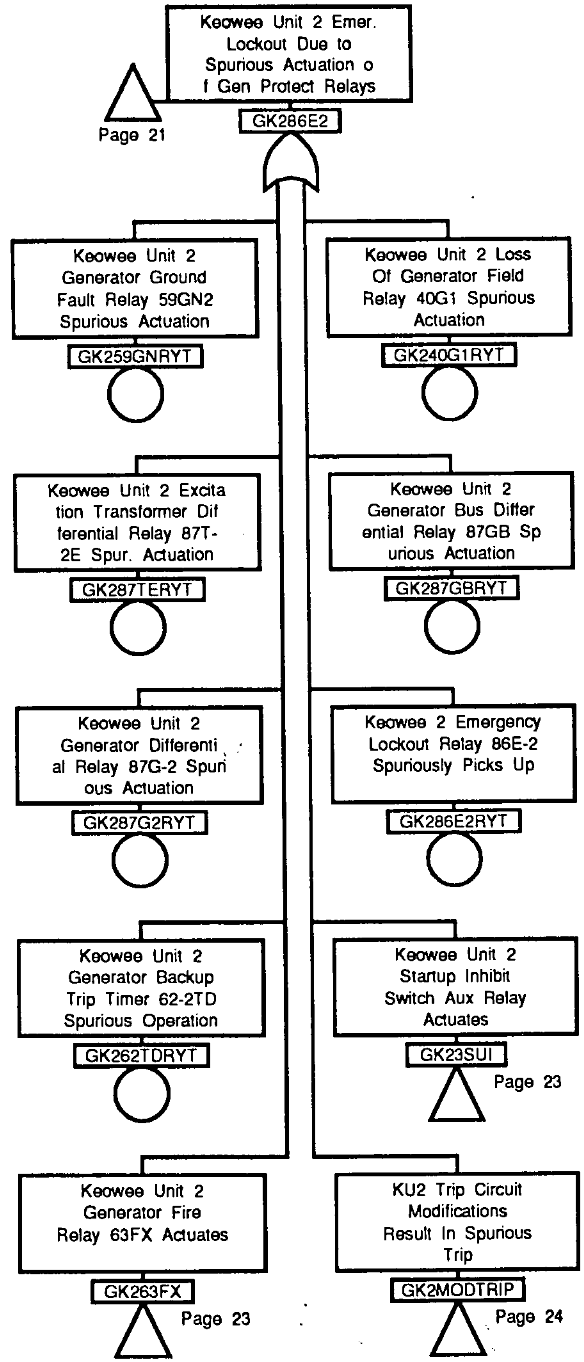
Keowee Generator Fault Tree | FIGURE A.7-6 |



Keowee Unit 1 Gen. Air Coolers Leak Into Generator Enclosure
GK1HXLEAK
Page 2
Heat Exchanger 1GAC1 Leaks
GK1GAC1HXL
Heat Exchanger 1GAC4 Leaks
GK1GAC4HXL
Heat Exchanger 1GAC2 Leaks
GK1GAC2HXL
Heat Exchanger 1GAC5 Leaks
GK1GAC5HXL
Heat Exchanger 1GAC3 Leaks
GK1GAC3HXL
Heat Exchanger 1GAC6 Leaks
GK1GAC6HXL

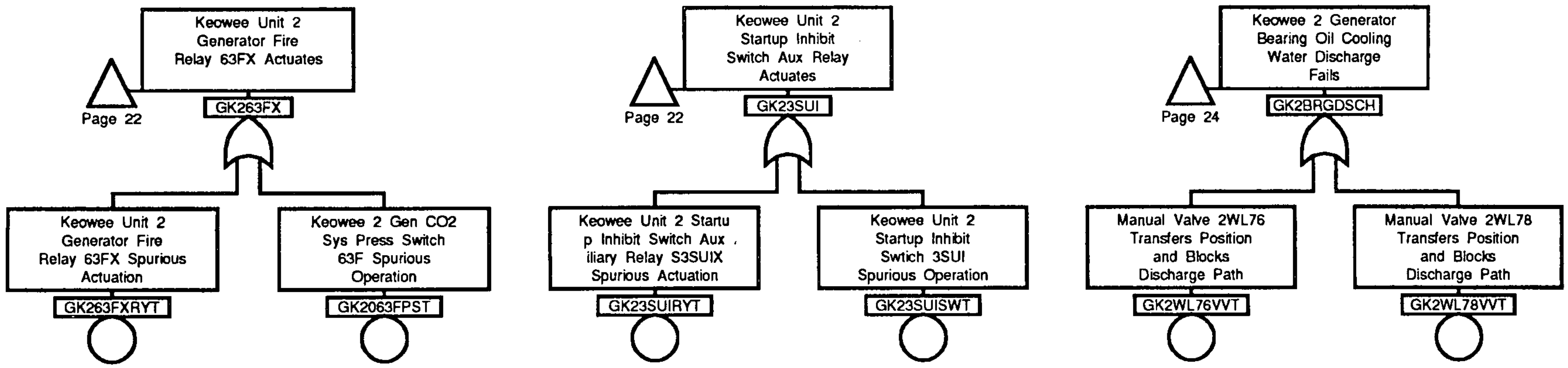


Keowee Generator Fault Tree	FIGURE A.7-6	Page 21

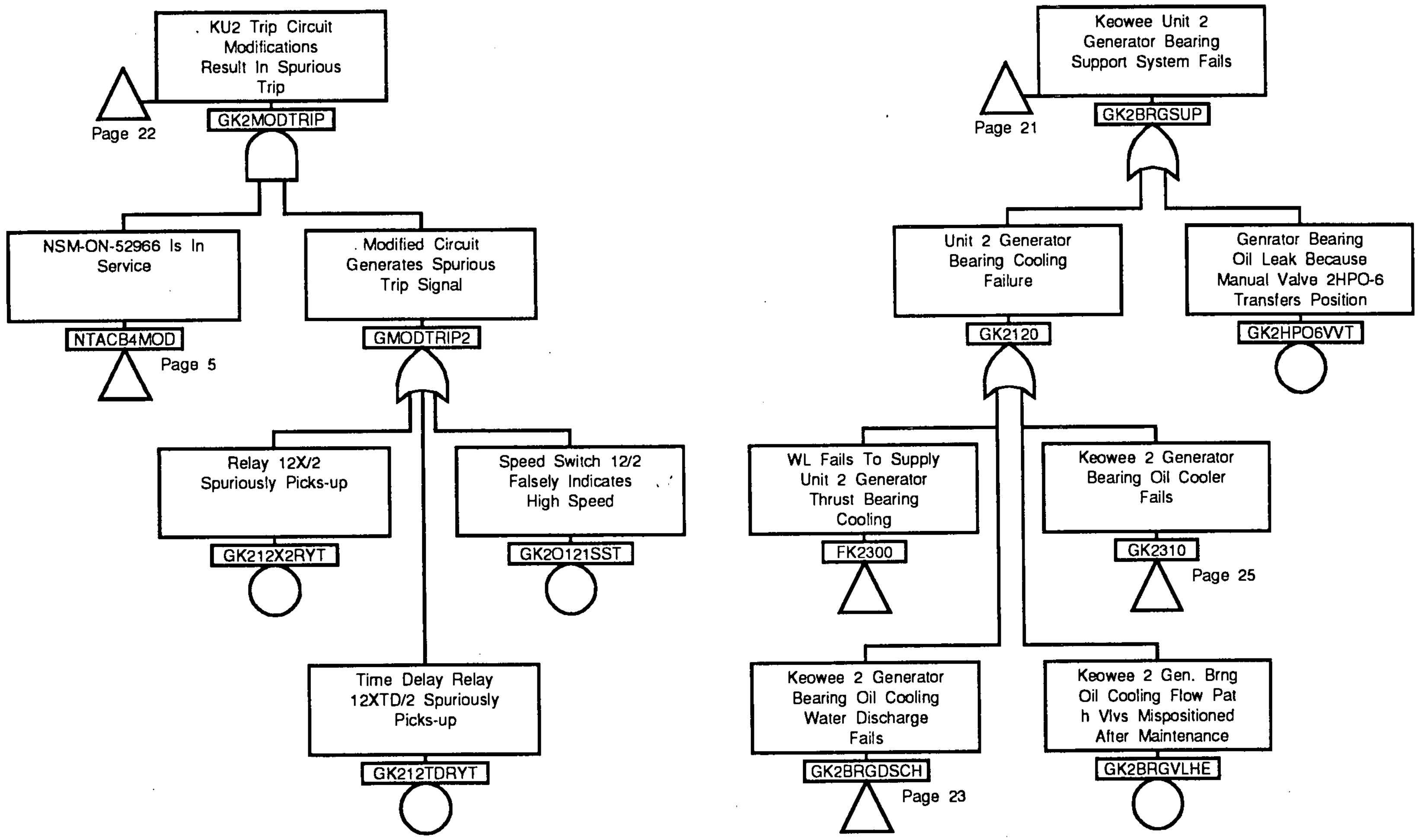


Keowee Generator Fault Tree

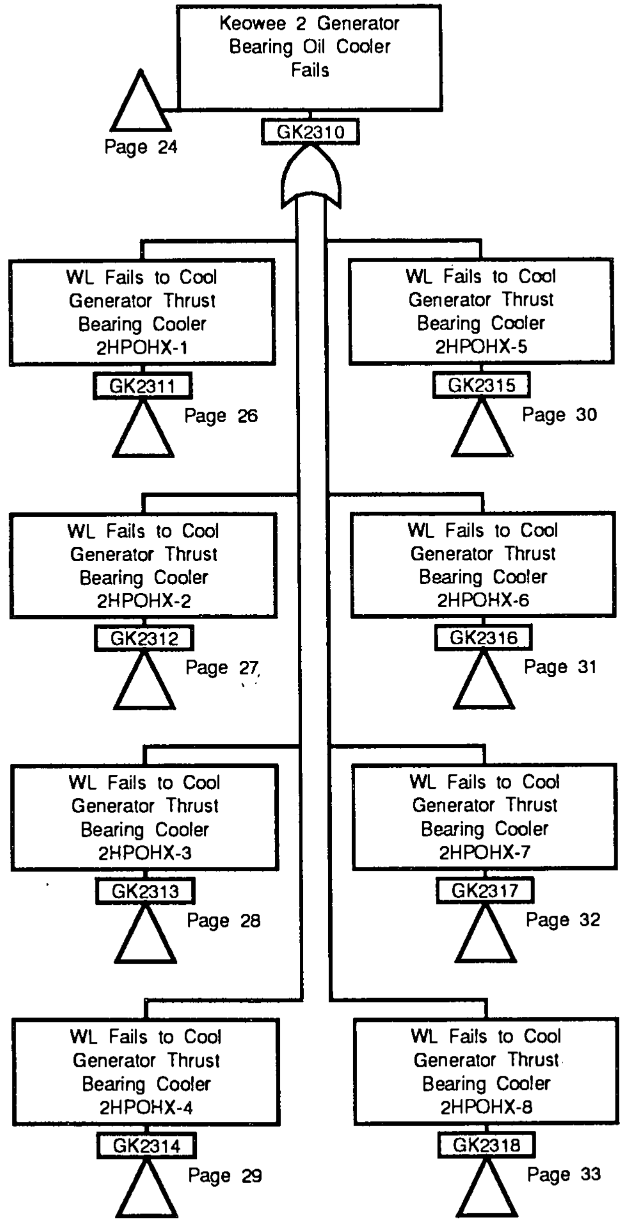
FIGURE A.7-6



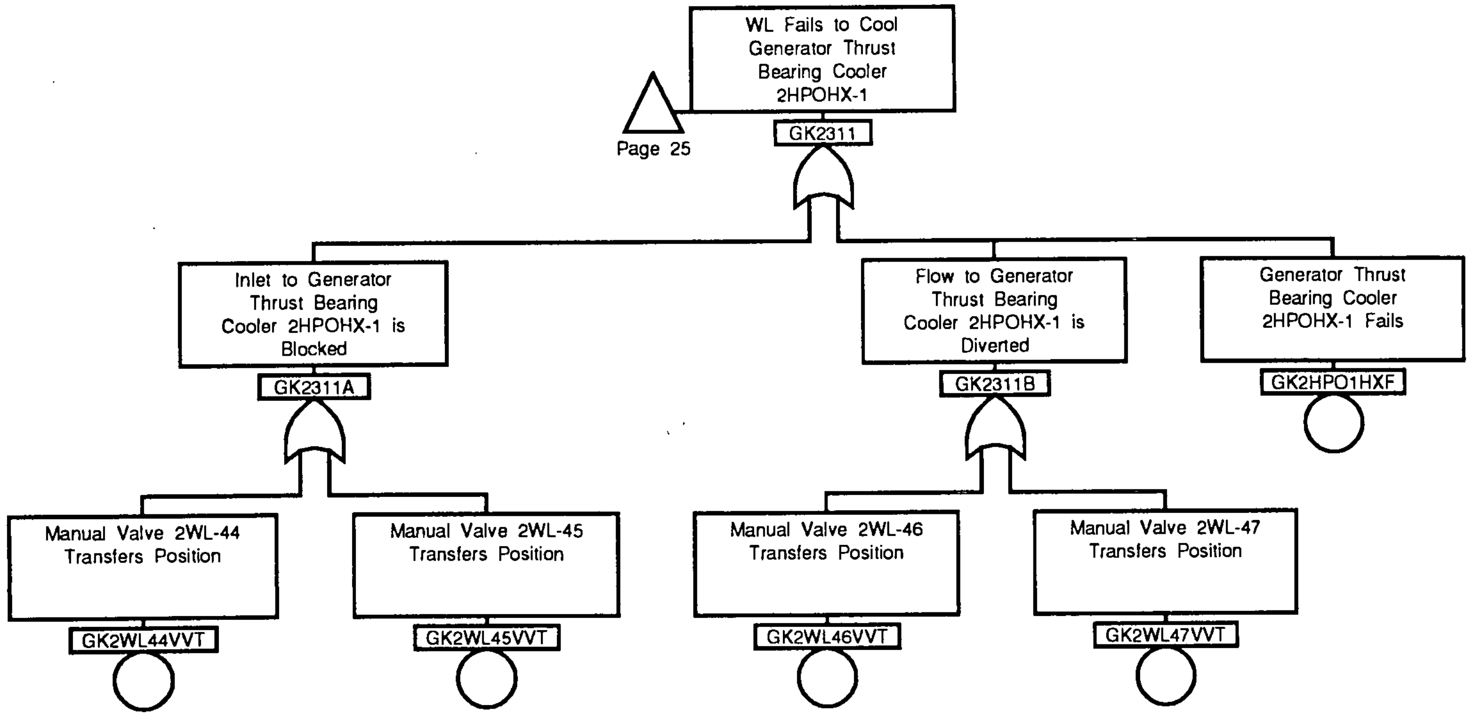
Keowee Generator Fault Tree	FIGURE A.7-6	Page 23



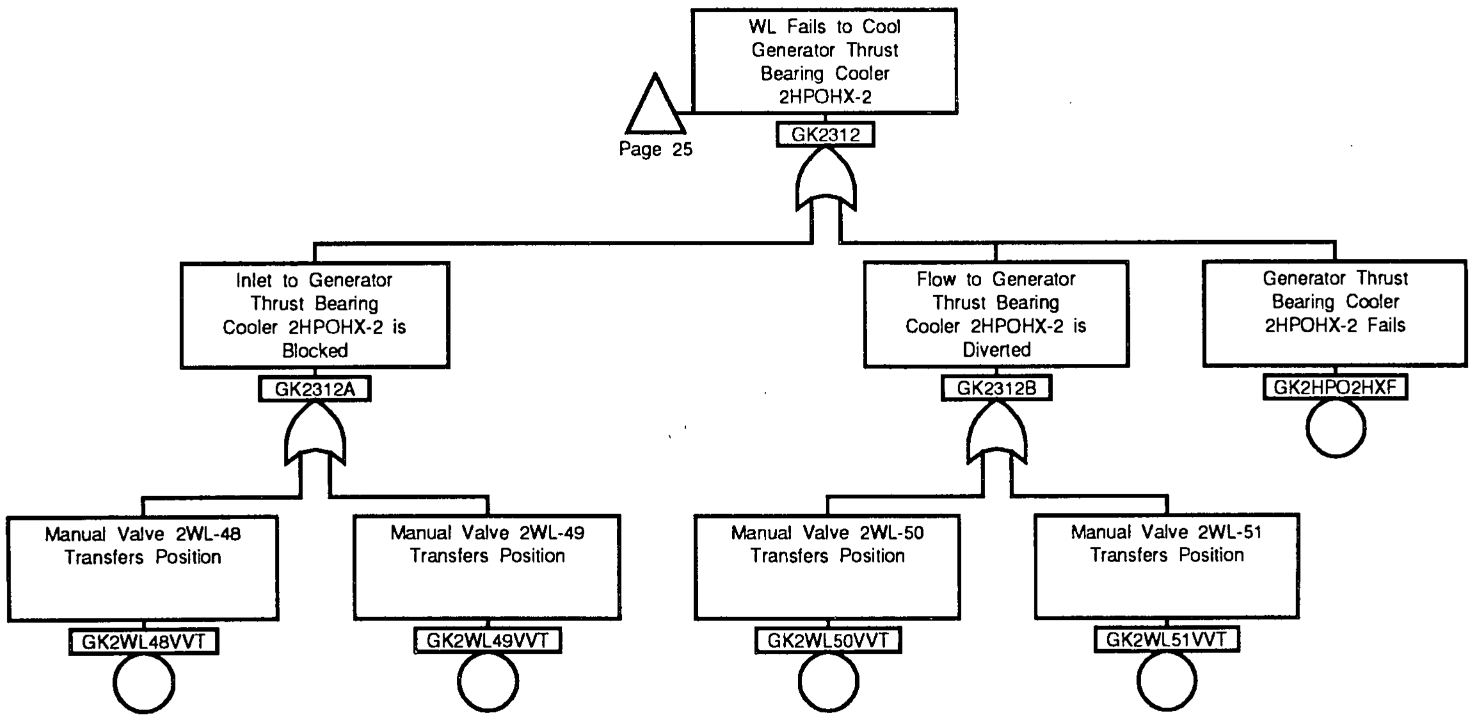
Keowee Generator Fault Tree | FIGURE A.7-6 |

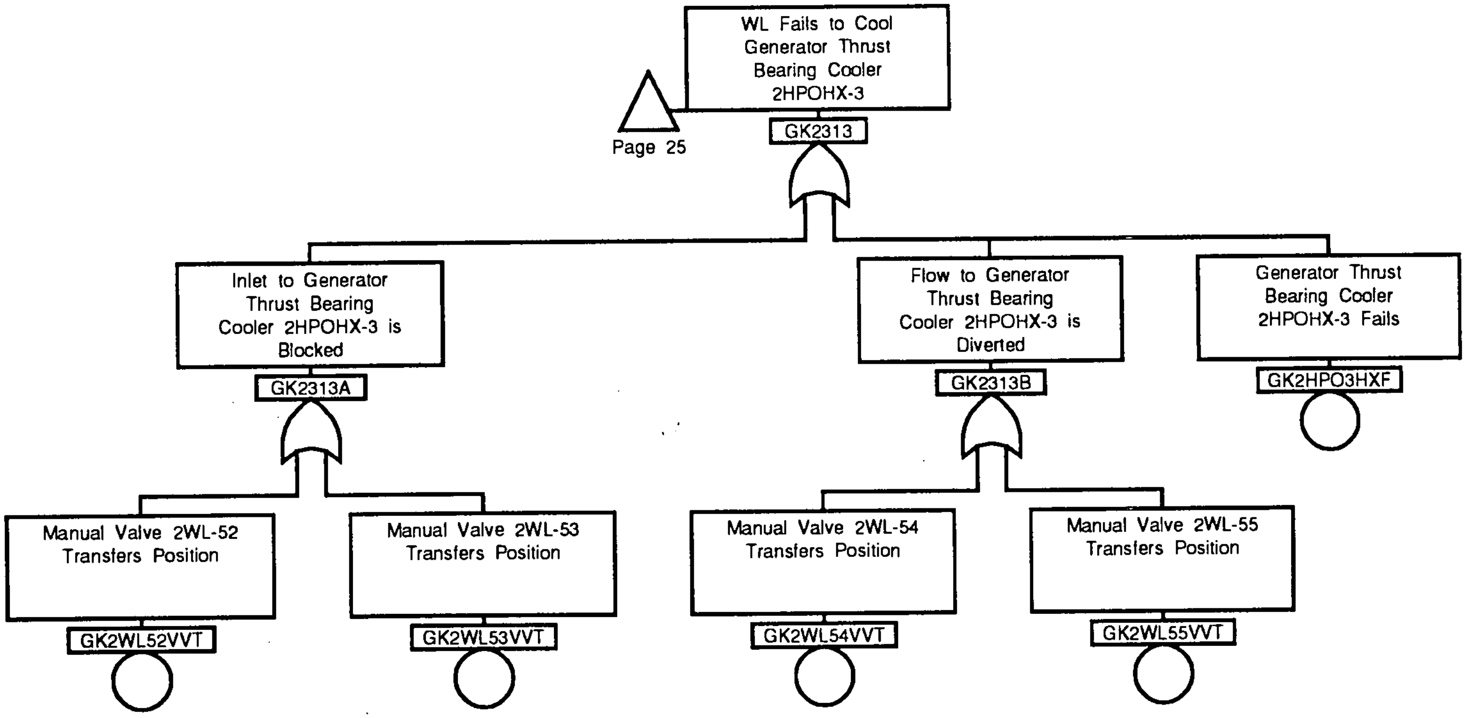


Keowee Generator Fault Tree	FIGURE A.7-6	Page 25

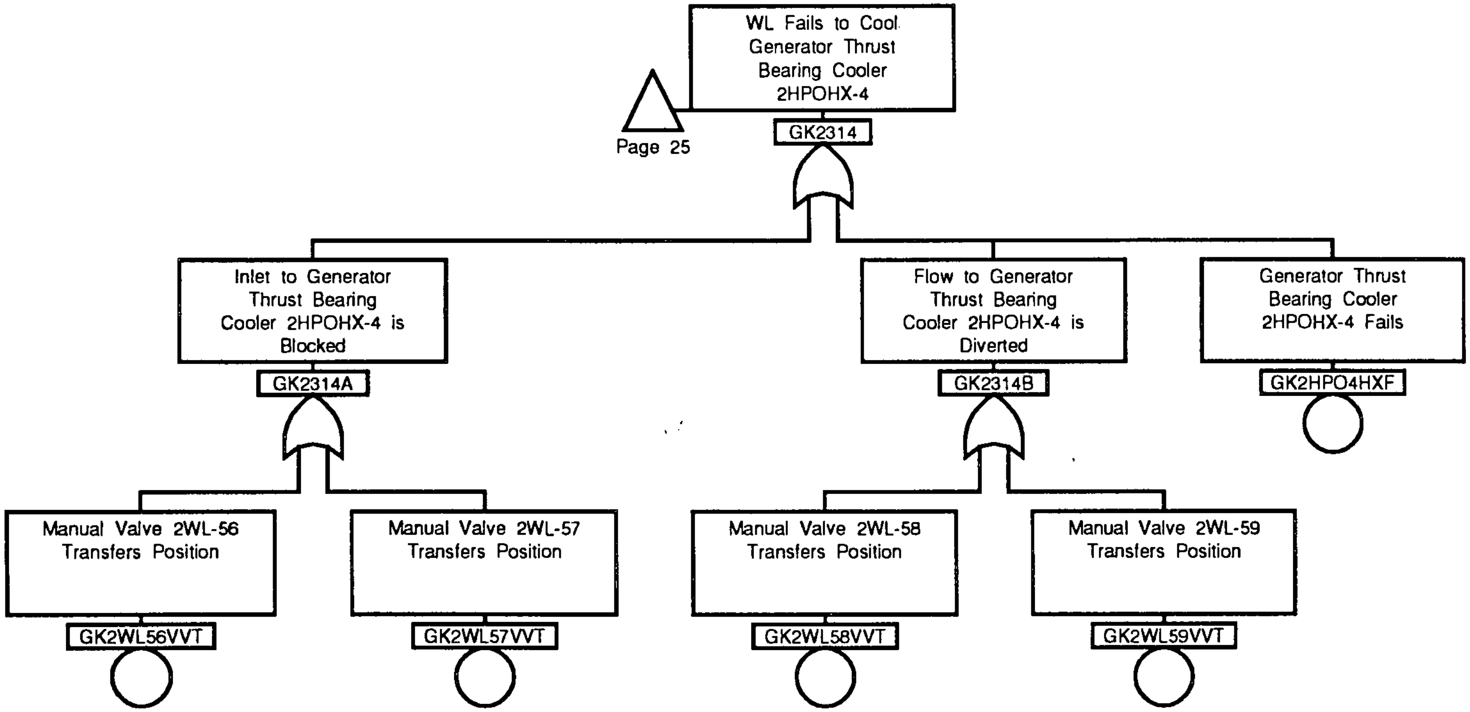


Keowee Generator Fault Tree | FIGURE A.7-6 |


WL Fails to Cool Generator Thrust Bearing Cooler 2HPOHX-2
GK2312
Page 25
Inlet to Generator Thrust Bearing Cooler 2HPOHX-2 is Blocked
GK2312A
Flow to Generator Thrust Bearing Cooler 2HPOHX-2 is Diverted
GK2312B
Generator Thrust Bearing Cooler 2HPOHX-2 Fails
GK2HPO2HXF
Manual Valve 2WL-48 Transfers Position
GK2WL48VVT
Manual Valve 2WL-49 Transfers Position
GK2WL49VVT
Manual Valve 2WL-50 Transfers Position
GK2WL50VVT
Manual Valve 2WL-51 Transfers Position
GK2WL51VVT

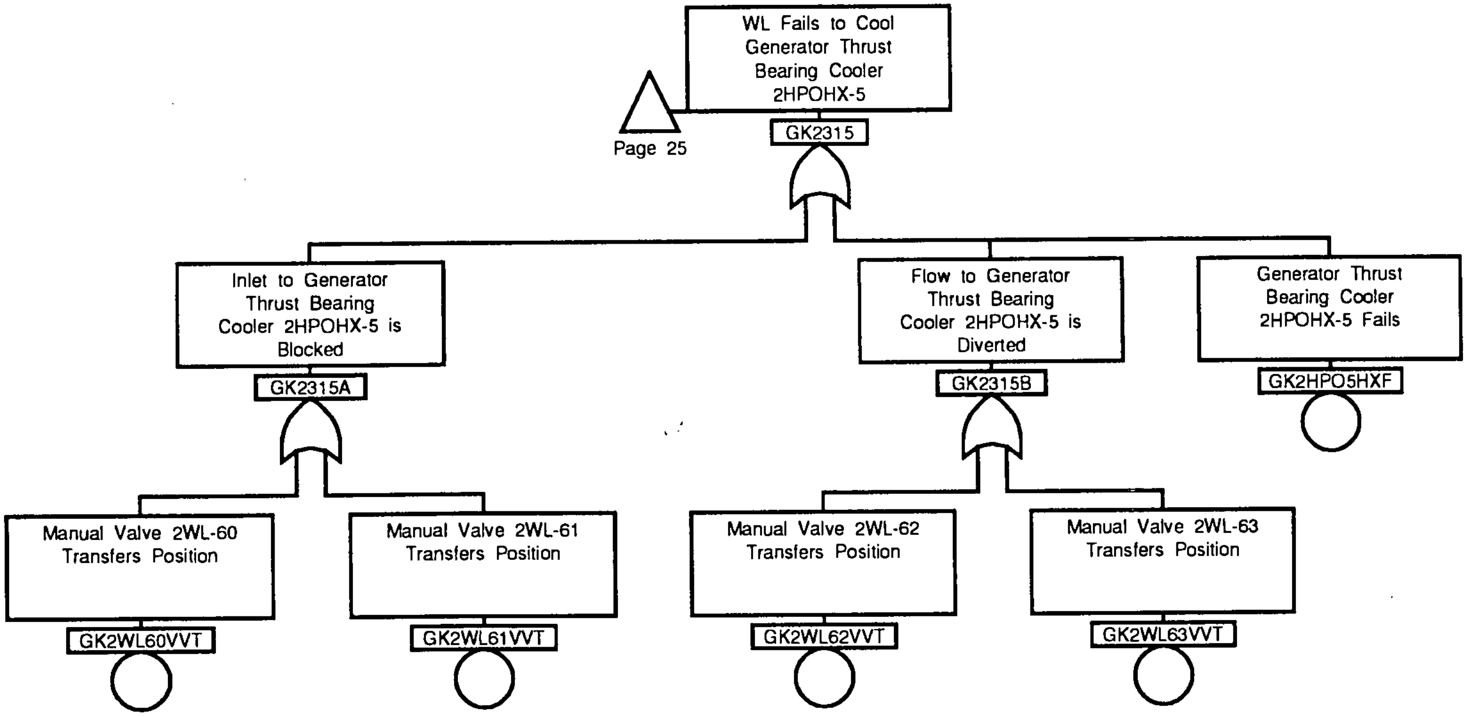


Keowee Generator Fault Tree | FIGURE A.7-6 |

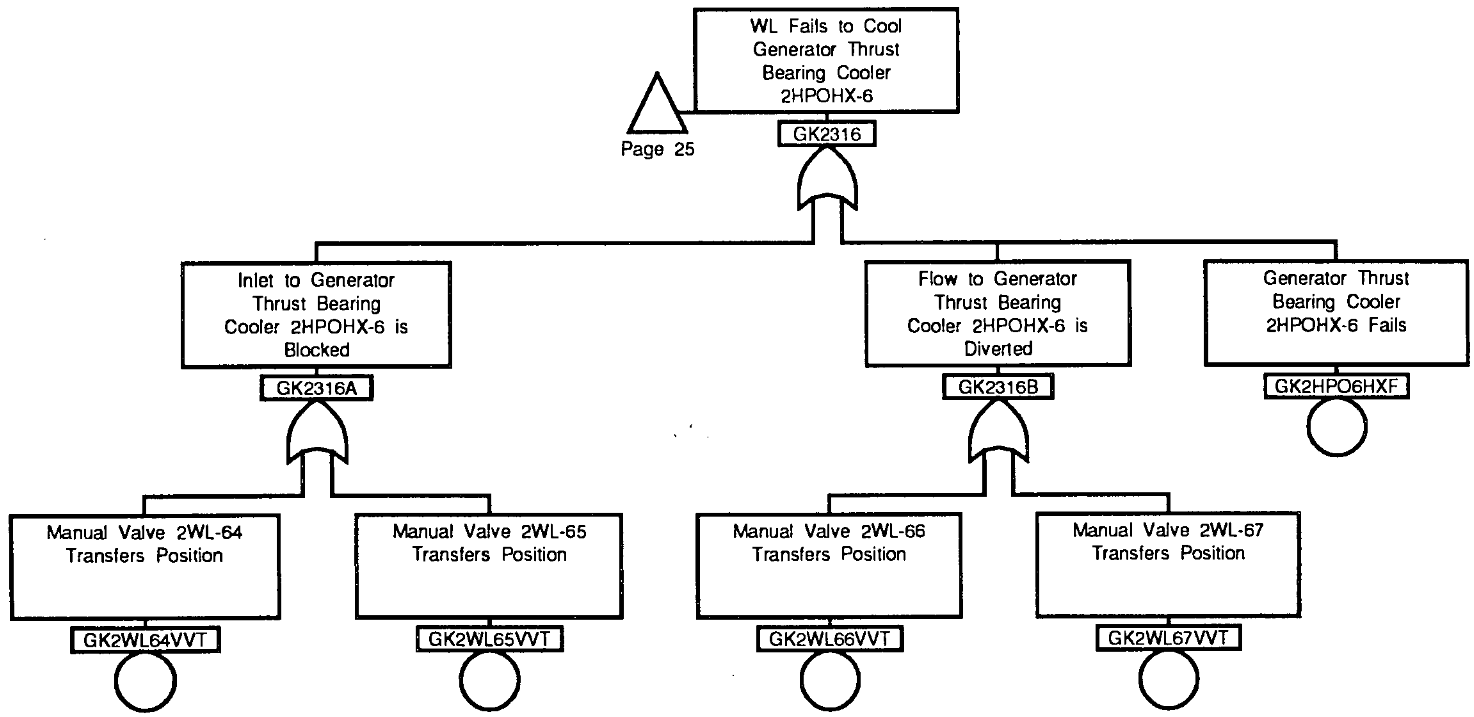


Keowee Generator Fault Tree

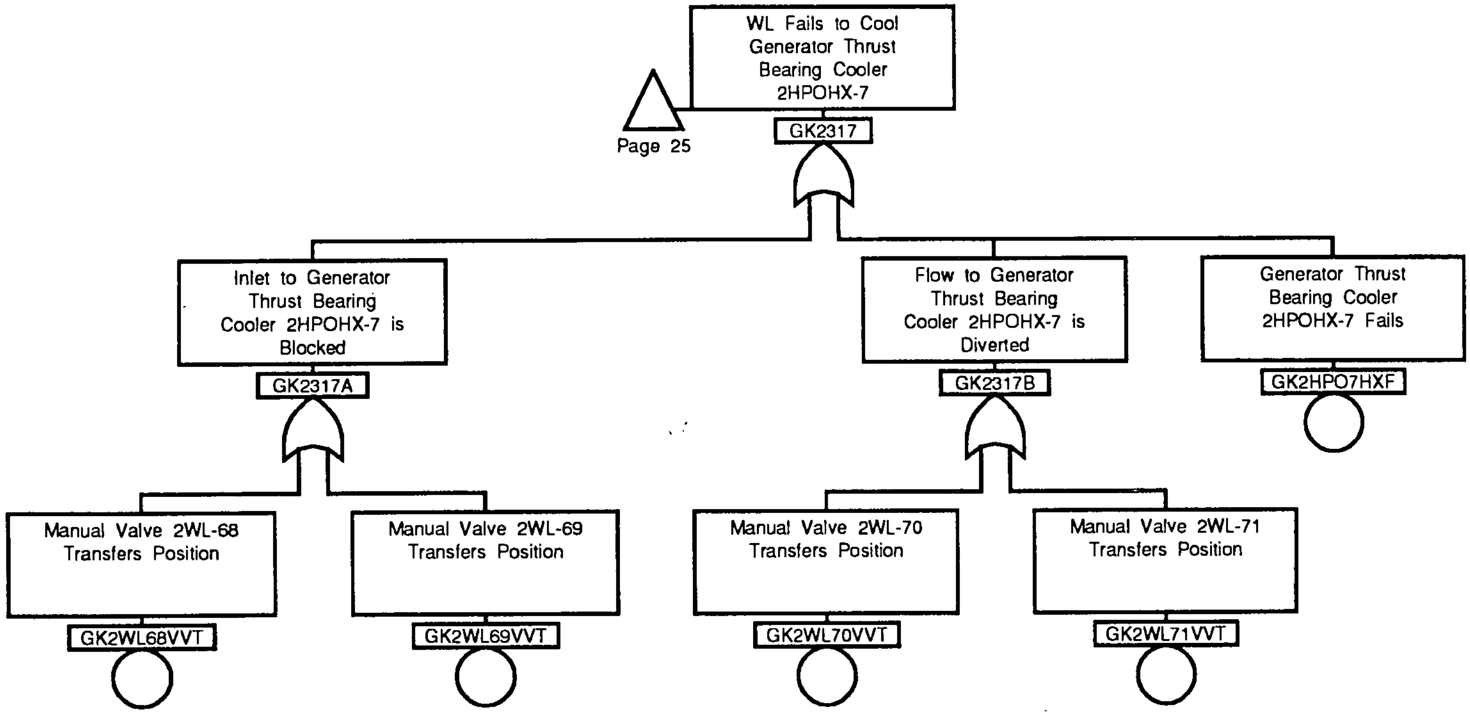
FIGURE A.7-6



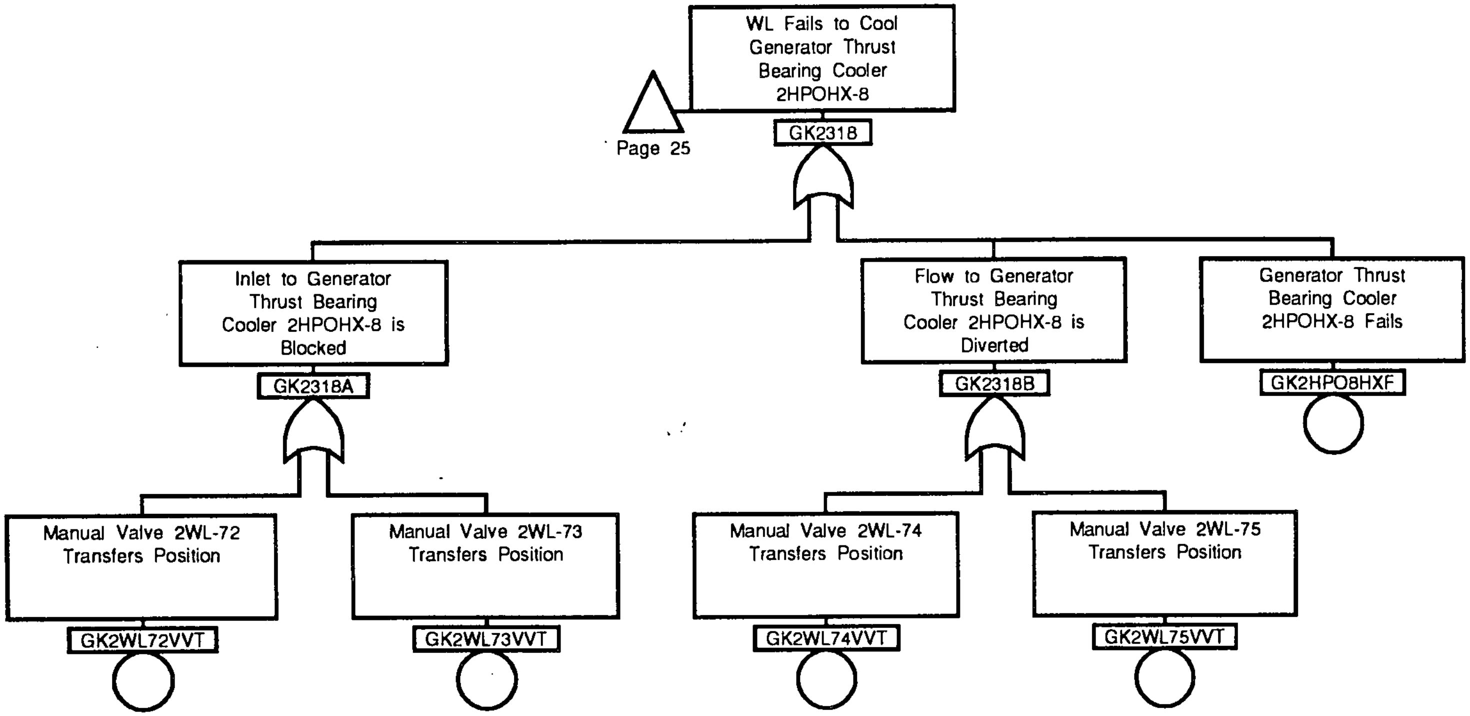
WL Fails to Cool Generator Thrust Bearing Cooler 2HPOHX-5
GK2315
Page 25
Inlet to Generator Thrust Bearing Cooler 2HPOHX-5 is Blocked
GK2315A
Flow to Generator Thrust Bearing Cooler 2HPOHX-5 is Diverted
GK2315B
Generator Thrust Bearing Cooler 2HPOHX-5 Fails
GK2HPO5HXF
Manual Valve 2WL-60 Transfers Position
GK2WL60VVT
Manual Valve 2WL-61 Transfers Position
GK2WL61VVT
Manual Valve 2WL-62 Transfers Position
GK2WL62VVT
Manual Valve 2WL-63 Transfers Position
GK2WL63VVT



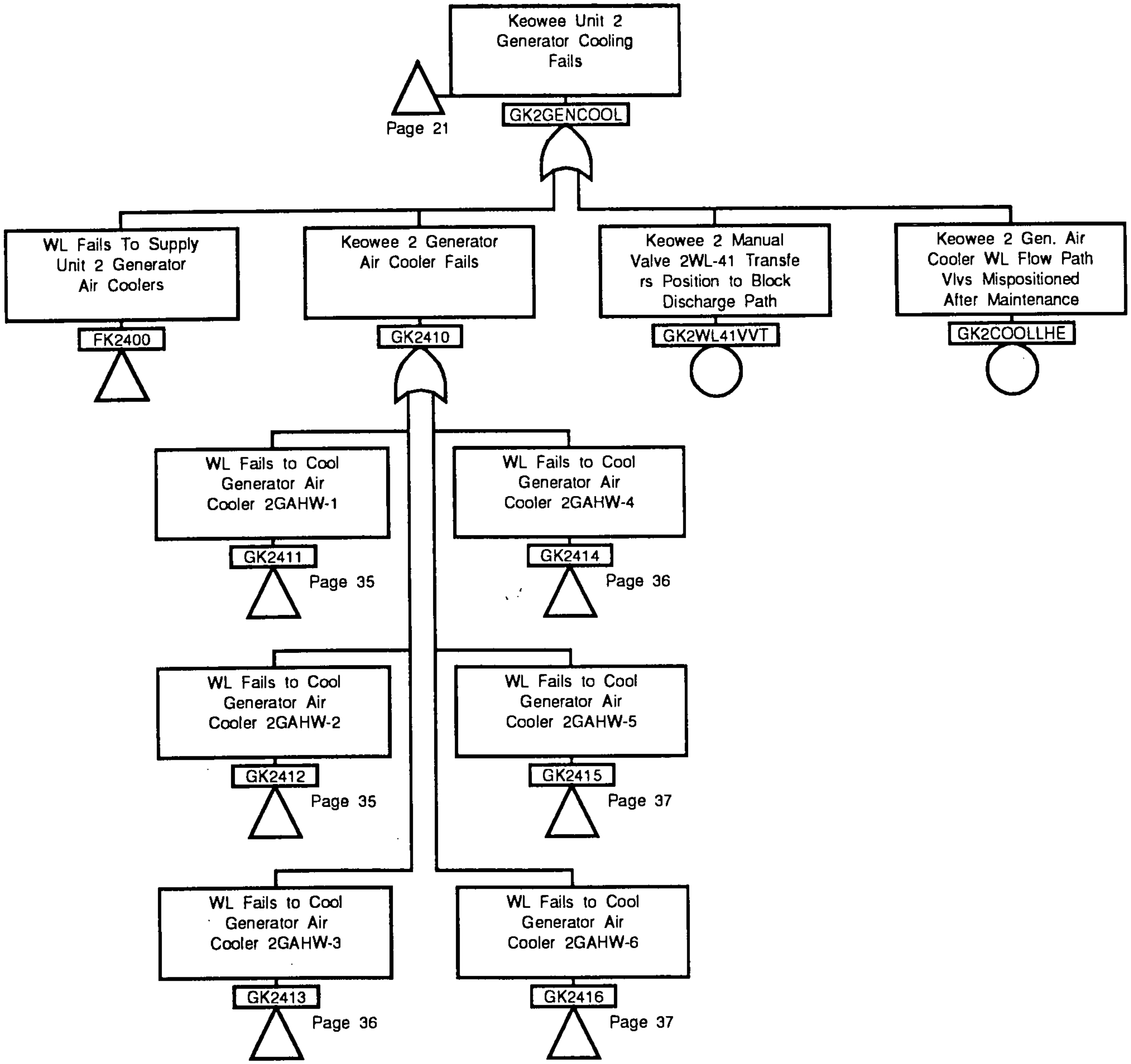
WL Fails to Cool Generator Thrust Bearing Cooler 2HPOHX-6
GK2316
Page 25
Inlet to Generator Thrust Bearing Cooler 2HPOHX-6 is Blocked
GK2316A
Flow to Generator Thrust Bearing Cooler 2HPOHX-6 is Diverted
GK2316B
Generator Thrust Bearing Cooler 2HPOHX-6 Fails
GK2HPO6HXF
Manual Valve 2WL-64 Transfers Position
GK2WL64VVT
Manual Valve 2WL-65 Transfers Position
GK2WL65VVT
Manual Valve 2WL-66 Transfers Position
GK2WL66VVT
Manual Valve 2WL-67 Transfers Position
GK2WL67VVT



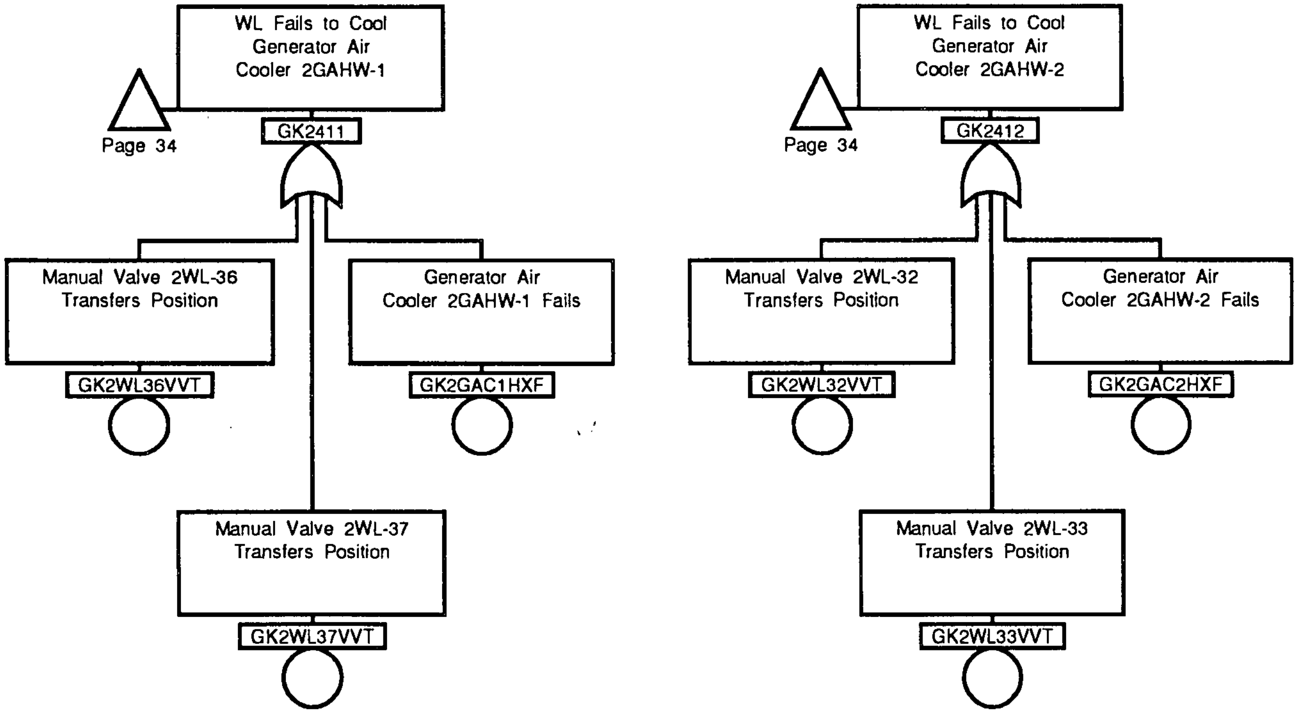
Keowee Generator Fault Tree | FIGURE A.7-6 |



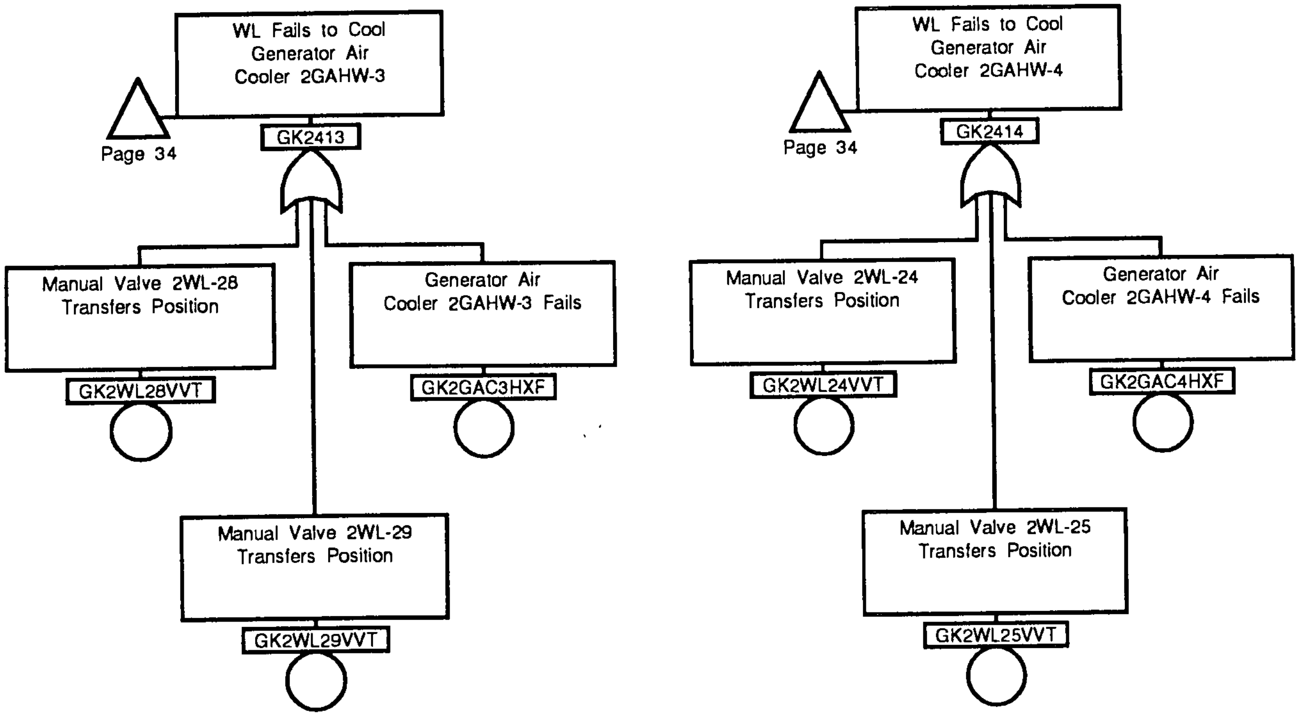
Keowee Generator Fault Tree | FIGURE A.7-6



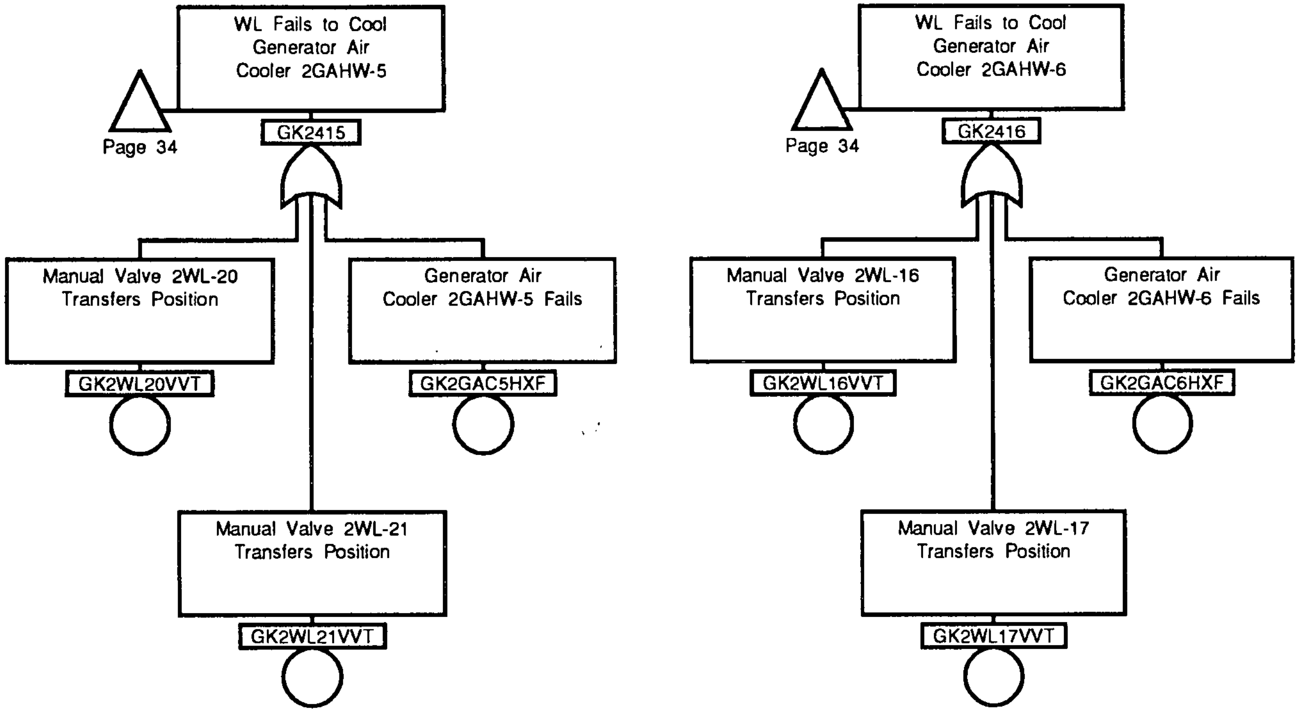
Keowee Generator Fault Tree | FIGURE A.7-6 |

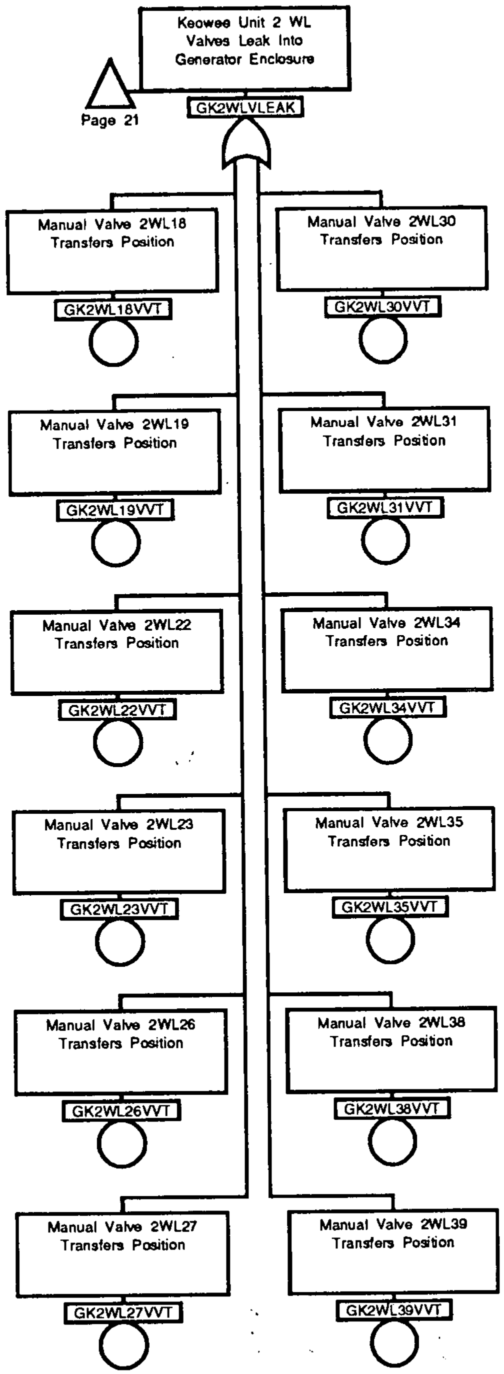


Keowee Generator Fault Tree	FIGURE A.7-6	Page 35

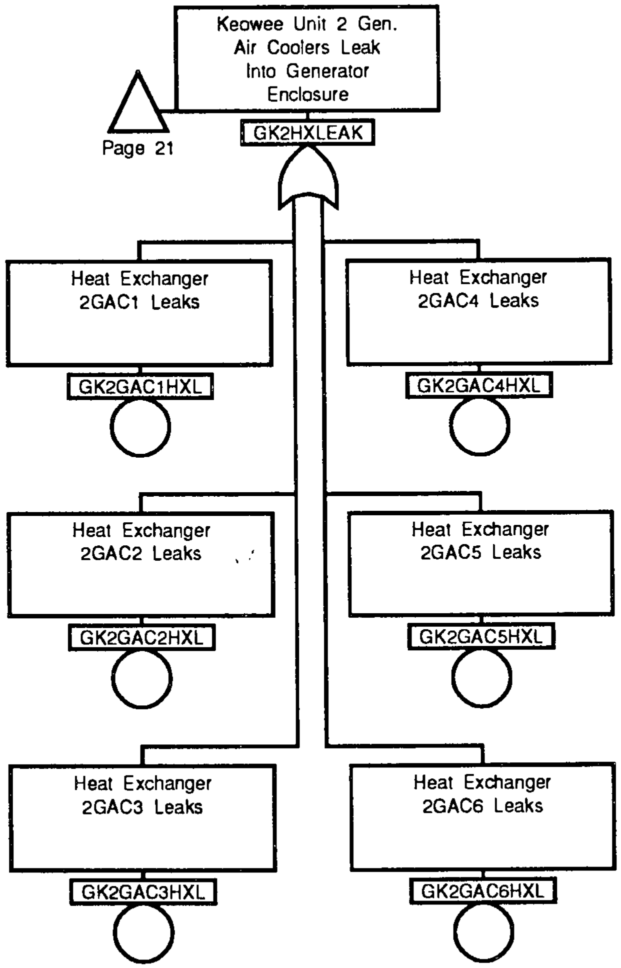


WL Fails to Cool Generator Air Cooler 2GAHW-3
Page 34
GK2413
Manual Valve 2WL-28 Transfers Position
GK2WL28VVT
Generator Air Cooler 2GAHW-3 Fails
GK2GAC3HXF
Manual Valve 2WL-29 Transfers Position
GK2WL29VVT
WL Fails to Cool Generator Air Cooler 2GAHW-4
Page 34
GK2414
Manual Valve 2WL-24 Transfers Position
GK2WL24VVT
Generator Air Cooler 2GAHW-4 Fails
GK2GAC4HXF
Manual Valve 2WL-25 Transfers Position
GK2WL25VVT


WL Fails to Cool Generator Air Cooler 2GAHW-5
GK2415
Page 34
Manual Valve 2WL-20 Transfers Position
GK2WL20VVT
Generator Air Cooler 2GAHW-5 Fails
GK2GAC5HXF
Manual Valve 2WL-21 Transfers Position
GK2WL21VVT
WL Fails to Cool Generator Air Cooler 2GAHW-6
GK2416
Page 34
Manual Valve 2WL-16 Transfers Position
GK2WL16VVT
Generator Air Cooler 2GAHW-6 Fails
GK2GAC6HXF
Manual Valve 2WL-17 Transfers Position
GK2WL17VVT



Keowee Generator Fault Tree	FIGURE A.7-6	



Keowee Generator Fault Tree | FIGURE A.7-6 |

Gate/Event Name	Page	Zone	Gate/Event Name	Page	Zone	Gate/Event Name	Page	Zone	Gate/Event Name	Page	Zone
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ACB4MOD	5		GK1317	6		GK1BRGDSCH	4		GK1WL17VVT	18	
FK1300	5		GK1317	13		GK1BRGDSCH	5		GK1WL18VVT	19	
FK1400	15		GK1317A	13		GK1BRGSUP	2		GK1WL19VVT	19	
FK2300	24		GK1317B	13		GK1BRGSUP	5		GK1WL20VVT	18	
FK2400	34		GK1318	6		GK1BRGVLHE	5		GK1WL21VVT	18	
GAB1FAULT	3		GK1318	14		GK1COOLLHE	15		GK1WL22VVT	19	
GK10001HGR	2		GK1318A	14		GK1FIREDEX	2		GK1WL23VVT	19	
GK10001HGS	1		GK1318B	14		GK1GAC1HXF	16		GK1WL24VVT	17	
GK1063FPST	4		GK13SUI	3		GK1GAC1HXL	20		GK1WL25VVT	17	
GK1120	5		GK13SUI	4		GK1GAC2HXF	16		GK1WL26VVT	19	
GK112TDRYT	5		GK13SUIRYT	4		GK1GAC2HXL	20		GK1WL27VVT	19	
GK112X1RYT	5		GK13SUISWT	4		GK1GAC3HXF	17		GK1WL28VVT	17	
GK1310	5		GK140G1RYT	3		GK1GAC3HXL	20		GK1WL29VVT	17	
GK1310	6		GK1410	15		GK1GAC4HXF	17		GK1WL30VVT	19	
GK1311	6		GK1411	15		GK1GAC4HXL	20		GK1WL31VVT	19	
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Gate/Event Name	Page	Zone	Gate/Event Name	Page	Zone	Gate/Event Name	Page	Zone	Gate/Event Name	Page	Zone
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GK2WL44VVT	26		GMODTRIP2	24							
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GK2WL46VVT	26		KU1GENRUN	2							
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GK2WLLEAK	21										