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Sue,

Please process for Darlene Higgs.

Thanks,
Melissa Wyatt

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Calculation Cover Sheet

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CONTENTS

1. PURPOSE

The purpose of this engineering calculation is to estimate the probability of an unfiltered release to the environment due to failure of the Heating, Ventilation, and Air Conditioning (HVAC) system in the Waste Handling Building (WHB). The scope of the calculation is limited to the function of the WHB HVAC system to maintain its "once-through" capability, that is, the ability to draw air through the various confinement areas through the (high-efficiency particulate air) HEPA filters, before exhausting the air to the atmosphere through the exhaust air stack. The ability to draw air through the WHB also maintains negative pressure between confinement areas (causing air flow inward, rather than toward the environment). Other functions of the HVAC system, e.g., room heating and cooling for comfort, were not considered in this analysis. The probability of an unfiltered release to the environment due to failure of the HVAC system will be used to evaluate off-normal conditions, such as a dropped fuel assembly, loss of offsite power (LOOP), etc.

2. METHOD

A fault tree was developed for the HVAC system to estimate the probability of *an unfiltered release to the environment*. This objective is quantified as the "top event" of the fault tree, and is discussed in more detail in Section 5.4. A fault tree is developed down to "basic events," each of which is quantified with a failure probability. Basic events include equipment failures, human errors, and equipment maintenance unavailability. The overall failure probability from a fault tree analysis is the sum of the failure probabilities of the individual cutsets; a cutset is a group of basic events, whose failures taken collectively cause the top event (of the fault tree) to occur. The fault tree method is discussed in detail in Reference 7.1.

3. ASSUMPTIONS

3.1 The fault tree failure logic assumes that when failures reduce the HVAC system's capacity (i.e., lost or significantly reduced "once-through" flow), its ability to maintain negative pressure is lost, and the air is free to flow in any direction. The basis for this assumption is that the diminished or lost capacity results from the normal feedback designed into the system. For example, loss of exhaust air fan capacity will result in pressure changes that will open or close dampers, which will (if left unchecked) affect the air supply fans, and ultimately affect the total flow through the WHB as well as maintaining negative pressure between confinement areas. Accordingly, any failure that can change or disrupt the confinement area pressure can ultimately cause, via design feedback controls, the failure of the HVAC system *as defined for this fault*. This assumption is used throughout the calculation, specifically in Section 5.2.

3.2 Since neither operating (nor emergency) procedures have been developed for the HVAC system, the human error probabilities (HEPs) used in the fault tree are all assumed to have a screening value 0.1. The basis for this screening value is that similar HEPs from Reference 7.2 (Chapter 20) are on the order of 0.001 to 0.005; accordingly, the assumed screening value of 0.1 is selected very conservatively. Without performing a detailed human reliability analysis, there is no way to distinguish the actions the operator would take to detect or mitigate a faulted state. The screening HEP allows the inclusion of these important human actions without either overwhelming the cutsets (e.g., with a higher screening value), or not observing the human actions at all. This assumption is used throughout the calculation, specifically in Section 5.4.

3.3 For this analysis, an operating period of 24 hours (see Reference 7.3, Attachment VIII) is assumed for all components except those related to loss of power, in that case, a quicker recovery of 8 hours is assumed. (See Attachment IV.) The basis for the 8 hours is that the loss of power-related events would be self-annunciating and should get quicker attention from the operations personnel. While the other failures have the potential to be discovered (a human detection event is included in the fault tree), these failures may not be as obvious as a loss of power event. The time (of 24 hours) may also be considered to be the mission time for the system (e.g., during an off-normal event). This assumption is used throughout the calculation, specifically in Section 5.5.

3.4 In the absence of maintenance procedures developed for the WHB, it is assumed that, on average, major components (e.g., air handling units, air supply fans, exhaust air fans, and HEPA filters) would be unavailable for three days during the course of one year. This is based on allowed outage times for major components at commercial nuclear power plants that generally range from three to seven days; accordingly, a conservative assumption has been made concerning major HVAC component. The maintenance unavailability is equal to $3/365 = 8.2\times10^{-3}$. This unavailability may be due to planned maintenance or corrective maintenance. These major components (for each confinement area) have sufficient redundancy so that maintenance can occur on-line; in addition, it is possible for maintenance of multiple components to occur. Technical Specifications for on-line maintenance (while ensuring adequate reliability) need to be developed. The model did not restrict the number of concurrent maintenance acts, however, cutsets will be examined and possibly deleted if the number of maintenance acts seems unreasonably high. This assumption is used throughout the calculation.

3.5 All of the failure probabilities used for barrier leakage are conservative. The WHB is divided into three confinement areas (primary, secondary, and tertiary), defined in Section 4.1.4.2 of Reference 7.4. Between the primary confinement area (PCA) and secondary confinement area (SCA), it is assumed that leakage exists that is normally controlled by the negative pressure between the PCA and SCA (causing air to flow, via a leak path, into the PCA), therefore the leakage probability is conservatively estimated at

1.0 (leakage is certain). Between the PCA and tertiary confinement area (TCA), even though there is a sealed plug, conservatively assume that some leakage will occur (i.e., failure probability is 1.0). There are no direct interfaces between the PCA and the environment, so no leakage is possible (i.e., the leakage probability is 0.0). Between the SCA and TCA, it is assumed that leakage exists that is normally controlled by the negative pressure between the two confinement areas, therefore the leakage probability is conservatively estimated at 1.0 (leakage is certain). Between the SCA and the environment, there are no direct interfaces, so no leakage possible (i.e., leakage probability is 0.0). Between the TCA and the environment, there are many direct interfaces, so the leakage probability is assumed to be 1.0 (leakage is certain). It is also assumed that the leakage paths exist due to existing doors, windows, dampers, vents, plugs, trapdoors, etc.; the model does not assume a leakage path through cracked structural components (e.g., floors, walls, ceilings). This assumption is used throughout the calculation.

3.6 It is assumed that there is no credible failure of the outside air intake structure. This is based on an over-capacity design, protection from wind-generated missiles, large free area bird screen, elevation above ground level to avoid debris, and assuming that icing does not occur at Yucca Mountain site. This assumption is used throughout the calculation.

3.7 It is assumed that there is no significant leakage from any of the ductwork (e.g., outside air duct plenum, air handling duct plenum, exhaust air plenum, etc.). Accordingly, these passive failures are not modeled in the fault tree. The basis for this assumption is that all ductwork is designed to maintain structural integrity during and after a seismic event, as well as withstand design operational high positive and negative pressures. (This assumes no possibility of internal explosion.) This assumption is used throughout the calculation.

3.8 The fault tree only considers the HVAC function of being able to draw air through the confinement area, through the HEPA filters, and out the exhaust air stack. The basis for this is that the HVAC system other functions are assumed not to contribute to the probability of an unfiltered release. For example, the HVAC system is responsible for raising or lowering the temperature to maintain a reasonable comfort zone for the workers in the building. This assumption is used throughout the calculation. (See also assumption 3.1.)

3.9 It is assumed that there are no credible failure modes that can completely obstruct the flow path in the air exhaust stack. This assumption is used throughout the calculation.

3.10 Due to the large number of redundant components in the various "subsystems" of the HVAC (e.g., air handling units, air supply fans, HEPA filters, tornado dampers, etc.), it is assumed that "one-half plus one" of the redundant components would have to fail to

impact the subsystem's ability to perform its function(s) [TBV (to be verified)]. If **n** (number of redundant components) is odd, then the number of failures would be integer[**n**/2] + 1, if **n** is even, then the number of failures would be **n**/2 +1. For example, for a nine-train subsystem, the failure criterion is assumed to be 5-of-9 for failure; for a 10-train subsystem, the failure criterion is assumed to be 6-of-10 for failure. This assumption is used throughout the calculation, specifically in Section 5.5.

3.11 The return air system (in the TCA) was not explicitly modeled in the fault tree. It is assumed that it would not have a significant effect on the results. The basis for this assumption is that if there are some contaminants in the return air system, the TCA would go to a "once-through" mode providing exhaust to the air exhaust stack via the HEPA filters. Accordingly, the continuous air emission monitoring (CAEM) system would alert the operators. For contaminants to be in the TCA, they must come from the PCA or SCA in the first place (due to other failures). This assumption is used throughout the calculation.

3.12 For the base model, the electrical power system does not include any components whose failure would result in the complete loss of power for the WHB. Loss of offsite power (LOOP) is an off-normal initiating event and treated separately from the base fault tree analysis. (See Section 6 and Attachment VI for discussion of a LOOP initiator.) This assumption is used throughout the calculation.

3.13 Due to the lack of design information, the electrical power system is modeled very simply. This is based on the assumption that the transformers and motor control center (480V bus) included in the fault tree model will adequately represent the electrical power supply system. Similarly, no other system dependencies are modeled (e.g., component cooling). This assumption is used throughout the calculation.

3.14 It is assumed that there is an emergency path associated with the supply-side of the PCA. This is based on planned enhancements to the HVAC system design. See Attachment VI for preliminary sketch. It is further assumed that the number of major components in the emergency train will be the same as the number of major components in the normal train. This assumption is used through the calculation, specifically in Section 5.2.

3.15 For common cause failure of two components, a beta (β) factor of 0.1 is assumed based on values used in the Davis-Besse Individual Plant Examination (IPE) (Reference 7.6, Part 3, Table 3-5) for air compressors. For common cause failure of three or more components, the multiple Greek letter method is used, and beta (β) is assumed to be 0.1, and gamma (γ) is assumed to be 0.5. This is also based on values used in the Davis-Besse IPE (Reference 7.6, Part 3, Table 3-5) for similar equipment (e.g., air compressors).

4. USE OF COMPUTER SOFTWARE AND MODELS

4.1 SOFTWARE APPROVED FOR QA WORK

This calculation uses no software that needs to be approved for QA work.

4.2 SOFTWARE ROUTINES

To support this engineering calculation, Microsoft's spreadsheet package Excel (Version: Microsoft Excel 97) is used. The spreadsheet program is executed on a personal computer (PC) under the Windows NT 4.0 operating system. All calculations performed by the Excel spreadsheet are verified by visual inspection and/or hand calculations. The combinatorial calculations used to estimate the number of cut sets for large combination gates are set up and quantified using Excel.

To support this engineering calculation, Scientific Applications International Corporation's (SAIC's) fault tree program CAFTA (Computer-Aided Fault Tree Analysis) for Windows (CAFTA-W) is used. CAFTA-W is executed on a PC (Dell Pentium II OptiPlex GXi) under the Windows-95 operating system. Four modules of the CAFTA-W (version 3.2.b) code are used to develop and quantify the WHB HVAC fault tree. These are:

1. Fault Tree Editor, version 3.2b
2. Reliability Database Editor, version 3.2b
3. Cutset Editor, version 3.2b
4. Cut386, version 2.3

In addition, the following dynamic linked libraries (DLL) version numbers were used:

FTAPI – 1.3b
CSAPI – 1.3dx
RDAPI – 1.3b
Btrieve – 5.10W

The actual input file to CAFTA-W (whbhvac5.caf) is not readable as a text file. The essence of the input is in the graphical representation of the fault tree, which is provided in Attachment I. (Some of the gates show a "See x-ref" after a page reference, which refers to the cross-reference table that is not provided in Attachment I.) The data used for the basic events is provided in Attachment IV. The output (cutsets) for a truncation probability of 10^{-11} is given in Attachment II. The information in Attachment I, Attachment IV, and Attachment II are sufficient to allow an independent repetition of the software use, and verification of the results.

The modules of CAFTA-W used in this analysis are available from Configuration Management. The use of CAFTA-W is appropriate to develop and quantify the HVAC fault tree. CAFTA-W is only used with its range of validation. Cutsets (output) are visually examined to ensure reasonableness of results.

EXCEL and CAFTA-W are considered software routines; see Reference 7.8.

5. CALCULATION

5.1 INTRODUCTION

The purpose of this section is to describe the analytical scope, development of the fault tree, and development of the data used to quantify the fault. The calculation includes more than just the Boolean reduction of the fault tree into minimal cutsets. The calculation includes the construction of the fault tree, represented by the gate and basic event logic, and the development of the failure data used. Section 5.3 discusses the development of the fault tree, but does not examine every logic gate. However, Section 5.4 identifies every basic event used, and the source and development of the failure probability used.

5.2 SCOPE

A fault tree is constructed (see Attachment I) to model the WHB HVAC system with the objective of determining the probability of an unfiltered release from the primary confinement area (PCA) to the environment. The PCA, as well as the secondary confinement area (SCA) and the tertiary confinement area (TCA) are defined and discussed in Section 4.1.4.2 of Reference 7.4.

The fault tree only considers the HVAC function of being able to draw air through the confinement area, through the HEPA filters, and out the exhaust air stack. While in operation in a "once-through" mode, the HVAC also maintains a negative differential pressure between confinement zones such that air would flow from the environment into the TCA, flow from the TCA into the SCA, and finally, flow from the SCA into the PCA. It is assumed that when failures significantly reduce the HVAC system's capacity, its ability to maintain negative pressure is lost, and air is free to flow in any direction. (See assumption 3.1.)

The HVAC system does have other functions that are not being evaluated in this analysis. For example, the HVAC system is responsible for raising or lowering the temperature to maintain a reasonable comfort zone for the workers in the building. (See assumption 3.8.)

The HVAC design for the fault tree development is the one prepared for the Viability Study [TBV] (see Section 4.1.4.2 of Reference 7.4). The following drawings from Attachment IV of Reference 7.5 are also used to establish the design configuration:

Fig. RD-1, Repository Design Symbols and Legend, p. IV-1
Fig. WH-1A, WHB-HVAC Flow Diagram, Composite Key, p. IV-2
Fig. WH-1B, WHB-HVAC Flow Diagram, Primary/Secondary Confinement Supply, p. IV-3
Fig. WH-1C, WHB-HVAC Flow Diagram, Primary/Secondary Confinement Areas, p. IV-4
Fig. WH-1D, WHB-HVAC Flow Diagram, Primary/Secondary Confinement Exhaust, p. IV-5
Fig. WH-1E, WHB-HVAC Flow Diagram, HVAC Exhaust Stack, p. IV-6
Fig. WH-2A, WHB-HVAC Flow Diagram, Tertiary Confinement Supply, p. IV-7
Fig. WH-2B, WHB-HVAC Flow Diagram, Tertiary Confinement Areas, p. IV-8
Fig. WH-2C, WHB-HVAC Flow Diagram, Tertiary Confinement Exhaust, p. IV-9

A design variant (inclusion of the supply-side emergency train for the PCA) was added. See assumption 3.14 and Attachment VI. As the design changes or design alternatives are being considered, the fault tree can (and should) be modified and requantified.

5.3 HVAC SYSTEM DESCRIPTION

The HVAC system for the WHB is responsible for maintaining flow through three separate confinement areas: primary, secondary, and tertiary. This air flow is established to maintain a negative pressure differential between confinement areas to prevent flow out of the PCA (and eventually into the environment). Each confinement area has its own train of HVAC equipment. All confinement areas draw air from the outside air intake via independent suction locations. Then for each confinement area, air passes through tornado dampers, air handling unit subsystems, supply air fan subsystems, the confinement area itself, then through the HEPA filter subsystems, and the exhaust air fan subsystems. The "subsystems" refer to the major component plus surrounding components, for example, for the supply air fan subsystem, in addition to the supply air fan, there is an inlet butterfly damper, and two downstream (exit) dampers. These associated components are modeled in the fault tree and are identified from the drawings listed in Section 5.2.

The HVAC train in the PCA has some redundancy upstream and downstream of the confinement area. There is an emergency air handling unit subsystem and emergency air supply fan subsystem, as well as an emergency HEPA filter subsystem and an emergency exhaust air fan subsystem. Flow to the emergency flow path is controlled by two isolation (automatically controlled) dampers; one is normally open permitting air flow into the "normal" train, the second is normally closed preventing flow into the "emergency" train. At loss of power, these isolation dampers change state to redirect flow. The "normal" and "emergency" PCA trains are powered by different internal electrical busses. Further, the "emergency" PCA train is backed by a diesel generator.

Air exiting the exhaust air fan subsystems for the PCA (normal), SCA, and TCA is directed through a common set of (exhaust) tornado dampers. From there, the air is released to the environment through an exhaust air stack. The stack has a continuous air emission monitoring (CAEM) system to detect any radioactivity. Air exiting the exhaust air fan subsystem for the PCA (emergency) is directed through (separate) tornado dampers and then goes out the common exhaust air stack.

5.4 FAULT TREE DEVELOPMENT

The top event of the fault tree is "unfiltered releases from the primary confinement area (PCA) to the environment." This can occur in one of two ways:

- there is a failure of the HVAC system and subsequent breach of barrier integrity (H014)
- there is an HEPA filter defect with subsequent CAEM failures (H015)

These input "gates" to the top event are then developed by adding additional gates and basic events to logically represent how these failures can occur. The fully-developed fault tree is provided in Attachment I. The fault tree's top-level logic is described in Section 5.4.1 and the lexicon of the cutsets is provided in Section 5.4.2.

5.4.1 Fault Tree Top-Level Logic

Attachment III shows the top-level logic of the fault tree, with diamond basic events representing where gates are developed in the full fault tree (see Attachment I). The top-level logic fault tree in Attachment III provides an overview of the entire fault tree that can be lost with the details of individual component failures.

The top event (UNFIL_REL) can occur due to the failures cited above, and represented in the fault tree as H014 and H015. The development of H015 (a single element cutset in this top-logic fault tree) can be easily followed in the full fault tree in Attachment I; however, the development H014 requires some elaboration. This portion of the fault tree deals with two basic failure modes: HVAC system failure or barrier failure. There are four different HVAC systems (that can fail): normal PCA, emergency PCA, normal SCA, and normal TCA. In the top-level logic fault tree, the two PCA HVAC systems are "lumped" into a single diamond basic event (PHVACF). Failure of the SCA HVAC system is represented by SHVACF, and the failure of the TCA HVAC system is represented by THVACF.

There are six barrier integrity breaches that are theoretically possible. These are listed in the table below with the corresponding diamond basic event identifier and the assigned failure probability used in the fault tree quantification.

Barrier Interface	Identifier	Assigned Failure Prob.	Comments
PCA to SCA	PBATSCAF	1.0	
PCA to TCA	PBATTCAF	1.0	Conservatively account for plug.
PCA to environment	-----	0.0	No direct path exists. Not used in fault tree.
SCA to TCA	SBATTCAF	1.0	
SCA to environment	SBATENVF	0.0	No direct path exists.
TCA to environment	TBATENVF	1.0	

The barrier integrity probabilities have been assigned either 0.0 or 1.0 and included in the fault tree such that less conservative values may be used in subsequent analyses. No basic event for barrier integrity breach from the PCA to the environment is included in the fault tree model. A basic event for the SCA to environment is included (even though it is assigned a zero failure probability).

To get an unfiltered release, both the normal and emergency PCA HVAC systems must fail (PHVACF) **AND** there must be a breach of the PCA to the environment via either the SCA **or** the TCA (H003). Basic event PHVACF is fully developed in Attachment I. Gate H003 develops a breach to the environment via the SCA (H004) **OR** via the TCA (H005). Examining the TCA breach to the environment, three events must occur: failure of the TCA HVAC system (THVACF), failure of the PCA/TCA barrier (PBATTCAF), and failure of the TCA/environment barrier (TBATENVF). These events concurrent with the PCA HVAC failure produce the following cutset leading to the top event failure:

PHVACF THVACF PBATTCAF TBATENVF

Examining the SCA breach to the environment, three events must occur: failure of the SCA HVAC system (SHVACF), failure of the PCA/SCA barrier (PBATSCAF), and breach of the SCA barrier via either the TCA **or** the environment (H010). Gate H010 is expanded as a failure of the SCA/environment barrier (SBATENVF) **OR** the following three events: failure of the TCA HVAC system (THVACF), failure of the SCA/TCA barrier (SBATTCAF), **and** failure of the TCA/environment barrier (TBATENVF). Since basic event SBATENVF has an assigned failure probability of 0.0, only one cutset results:

PHVACF SHVACF PBATSCAF THVACF SBATTCAF TBATENVF

Note that *if* the failure probability of SBATENVF was *not* 0.0, an additional cutset would result:

PHVACF SHVACF PBATSCAF SBATENVF

5.4.2 Cutset Description and Nomenclature

To better follow the fault tree and understand the resulting cutsets, the following describes the nomenclature rules in naming gates and basic events. Typically, gates (i.e., OR gates, AND gates) are named arbitrary by CAFTA-W as H###, where ### represents a number (e.g., 011). The gate identifiers are not used to interpret the results, but may be useful in "working" through the fault tree.

The basic events take several forms (see Reference 7.1): circles, diamonds, and double-diamonds. The circle basic events generally represent a single component's failure mode. For example, there are different circle basic events for a diesel generator fails to start and fails to run. The diamond basic events generally represent the human errors modeled in the fault tree. Diamond basic events traditionally identify a basic event that requires more development. Since the operating procedures (or emergency procedures) have not yet been developed for the operators, no detailed human reliability analysis is performed to develop the human error probabilities (HEPs). The HEPs are actually just a screening value of 0.1, i.e., the probability that the operator will fail to detect (any) failure and take the correct mitigative action(s) is set conservatively high at 0.1. (See assumption 3.2.)

Double-diamonds also represent basic events that require more development. In this case, double-diamond basic event are used to represent the development of combination gates (**n**-of-**m** gates), where **m** is four or greater (e.g., 5-of-9, 8-of-15). Due to the number of (cutset) combinations that would be generated if these gates were fully developed, these gates were instead approximated by multiplying the number of cutsets by the approximate failure probability of a single cutset. The development of the failure probabilities is discussed in more detail in Section 5.5.

In general, the circle and diamond basic event identifiers are eight to ten. The double-diamond identifiers range from three characters to ten characters. The circle/diamond basic event identifiers convey information as defined by the following syntax:

basic event identifier - {s}{xx}{zz...zz}{f}

where:

{s} = area/location of component or action
- P = primary confinement area
- E = emergency (for primary confinement area)
- S = secondary confinement area
- T = tertiary confinement area
- C = common element (used by all three confinement areas)

{xx} = equipment code

AH = air handling unit
BA = barrier
CN = controller (e.g., pressure)
DM = damper (any kind but isolation)
DG = (emergency) diesel generator
FG = used as a flag
FL = filter (e.g., HEPA)
FN = fan
HU = human action
ID = isolation damper
MC = motor control center
MN = monitoring system
SW = switch
TR = transformer

{zz...zz} = equipment identification (generally four, five, or six characters)

{f} = failure code/mechanism (these are associated with the equipment code)

Equipment Code {yy}	Failure Code {f}
AH	B - blocked (impede air flow) M - in maintenance X - common cause (two elements) Y - common cause (three or more elements)
BA	F - fails (loss of integrity)
CN	F - fails
DG	M - in maintenance R - fails to run S - fails to start
DM	C - spuriously closes F - fails (to change state) X - common cause (two elements) Y- common cause (three or more elements)
FG	(not applicable)
FL	B - blocked (impede air flow) D - defective or torn filter M - in maintenance X - common cause (two elements) Y - common cause (three or more elements)

Equipment Code {yy}	Failure Code {f}
FN	F - fails (to run) M - in maintenance P - loss of power (to be developed) X - common cause (two elements) Y - common cause (three or more elements)
HU	F - fails to detect and mitigate
ID	F - fails (to change state)
MC	F - fails
MN	F - fails
SW	F - fails
TR	F - fails

For example, a circle basic event on page I-3 of Attachment I has the identifier PDMTD1AC. The identifier can be interpreted as a damper (DM) in the PCA (P), identified as TD1A (tornado damper TD-1A), that spuriously closes (C).

A concept used in the development of the fault tree is assigning a set of HVAC components into a subsystem. A subsystem consists of its major component (e.g., air handling unit, exhaust air pump) and any associated components (e.g., isolation butterfly dampers, parallel blade dampers). Components within a subsystem are treated individually with respect to equipment failure; however, maintenance unavailability and human errors related to detection and mitigation are treated on a subsystem basis. Also, the failure probabilities for the double-diamond basic events are estimated on a subsystem basis.

One of the equipment codes is a flag (FG); this does not correspond to either hardware or a human action, but rather establishes a condition that might be true or false. There are two (complementary) flags used in the HVAC fault tree. These are:

PFGEXHTO - in the PCA, the "normal" HEPA filter/exhaust air fan train is operational
EFGEXHTO - in the PCA, the "emergency" HEPA filter/exhaust air fan train is operational

These are logical mutually exclusive events: if PFGEXHTO is true, then EFGEXHTO must be false, and vice versa. They are only used in the portion of the fault tree that considers release via a detective or torn HEPA filter and out the exhaust air stack without alarming. In this portion of the fault tree, both trains can not be considered operational simultaneously. (In the HVAC failure/barrier integrity portion of the fault tree, failure is defined with both trains are unavailable.) The flags can be used several ways:

1. Set the probabilities in the fault tree as 1.0 (*true*) or 0.0 (*false*). When quantified, the cutsets with the *false* flag will be truncated (since 0.0 will be below the truncation

probability of 10^{-11}). No cutsets with the *true* flag will be truncated due to the value of the flag. The resulting cutsets will then represent one (of the two) state as specified by the flag.

2. Set the probabilities in the fault tree as 1.0 for both flags. Use the Cutset Editor to change one of the flags to *false*. This will "zero" out those cutsets.

For the cutsets reported in Attachment II, method 1 was used with the failure probability of PFGEXHT0 set to 1.0. This case was selected since the results bound both cases.

5.5 FAILURE DATA DEVELOPMENT

To quantify the fault tree, each basic event needs a failure probability (unavailability or demand failure). The data used in this analysis is considered accepted data, as it is taken from the Davis-Besse IPE (see Reference 7.6, Part 3, Table 3-2), which is a probabilistic analysis submitted to and accepted by the Nuclear Regulatory Commission, therefore these data can be considered to be generally accepted by the engineering and scientific community. Some data are also obtained from a generic database, which is generally accepted by the engineering and scientific community, presented in Reference 7.7.

In Attachment IV, the first two tables (Table IV-1 and Table IV-2) show the development of the failure probabilities for CAFTA-W type codes, and specific basic events (not associated with the type codes). A CAFTA-W type code is used to simplify the entry of failure rate data. The type code used for the HVAC fault tree is a combination of the equipment code {yy}and the failure code {f}. Thus, {yy-c} represents the type code; for each {yy-c} type code, there is one failure rate established.

Most failure databases provide either a demand failure (failures per demand) or a failure rate (failures/time). To develop a failure probability from a failure rate, the failure probability must be considered over a period of time (e.g., time until component will be restored or the length of time a component is expected to be used). For this analysis, a period of 24 hours is assumed for all components except those related to loss of power, in that case, a quicker recovery of 8 hours is assumed. (See assumption 3.3.)

Common cause failures (CCFs) are modeled in the fault tree for the major subsystem components (e.g., fans, dampers, filters, and air handling units). Two types are included in the model: CCF for failure of two components, and CCF for failure of three or more components. The first set of CCFs is used for the developed logic of the normal and emergency PCA trains. The second set of CCFs is used for the surrogate logic of the SCA and TCA trains. For two failures, the beta factor methods is used, and $\beta = 0.1$ (see assumption 3.15); for three or more failures, the multiple Greek letter method was used, and $\beta = 0.1$ and $\gamma = 0.5$. Subsequent Greek letters would be equal to 1.0 (see assumption 3.15).

The third table (Table IV-3) in Attachment IV shows the determination of the surrogate failure probability for the double-diamond basic event (m-of-n combination gates). To perform this calculation, the number of cutset combinations needs to be determined. A spreadsheet showing all the different cases used in the HVAC fault tree is given in Attachment V. In the HVAC fault tree, the combination gates have a large number of ORed inputs, resulting in a large number of cutsets. Accordingly, these combination gates are approximated by a double-diamond event with a failure probability approximately equal to the number of combinations (of cutsets) multiplied by the average failure probability of the individual elements raised to the order of the cutset. This approach, as demonstrated below, is conservative.

Below is an example calculation showing the number of cutsets that would result from the evaluation of a 5-of-9 combination gate. For this case, the 5-of-9 combination gate has nine input OR gates, where each OR gate has four inputs. See, for example, the 2-of-3 logic for the PCA AHU subsystems (gate identifier H038). Each of the input OR gates has effectively four inputs; for gate H060, the input basic events would be PAHAH1AM, PDMINAH1AC, PAHAH1AB, and PDMEXAH1AC. See the fault tree for more details. If the OR gate inputs are designated as a1, a2, a3, a4 (first OR gate), b1, b2, b3, b4 (second OR gate), etc., then following table can be constructed representing the logic:

Combination Gate: failure is 5-of-9									
OR1	OR2	OR3	OR4	OR5	OR6	OR7	OR8	OR9	
a1	b1	c1	d1	e1	f1	g1	h1	i1	Row 1
a2	b2	c2	d2	e2	f2	g2	h2	i2	Row 2
a3	b3	c3	d3	e3	f3	g3	h3	i3	Row 3
a4	b4	c4	d4	e4	f4	g4	h4	i4	Row 4

Consider the necessary five failures just coming from Row 1, the number of combinations would be "9 things taken 5 at a time," represented by the term:

$$\binom{9}{5} = 126$$

Expanding this to the remaining rows yields 126 x 4 combinations of five failures. Next consider failures (total of five) occurring across two rows. Starting with Row 1, imagine four failures of the nine possible OR gates, followed by one failure of the remaining five OR gates in Row 2 (an OR gate already suffering a failure is not "eligible" for a failure in Row 2). Of course, the remaining single failure could be in Row 3 or Row 4 (creating a multiplier of '3'). Algebraically, this would be:

$$\binom{9}{4}\binom{5}{1}x\,3 = 126x5x3 = 630x3 = 1890$$

It is possible for there to be two failures in Row 1 (out of the nine possible OR gates), followed by three failures of the remaining six OR gates. Again, the subsequent three failures can also occur in Row 3 or Row 4. Algebraically, this would be:

$$\binom{9}{3}\binom{6}{2}x\,3 = 84x15x3 = 1260x3 = 3780$$

Continuing with the same logic for failures on two rows, results in the following two terms.

$$\binom{9}{2}\binom{7}{3}x\,3 = 36x35x3 = 1260x3 = 3780$$

$$\binom{9}{1}\binom{8}{4}x\,3 = 9x70x3 = 630x3 = 1890$$

Extending this logic for failures over three rows, yields the following terms:

$$\binom{9}{3}\binom{6}{1}\binom{5}{1}x\,2 = 84x6x5x3 = 2520x2 = 5040$$

$$\binom{9}{2}\binom{7}{2}\binom{5}{1}x\,2 = 36x21x5x3 = 3780x2 = 7560$$

$$\binom{9}{2}\binom{7}{1}\binom{6}{2}x\,2 = 36x7x15x3 = 3780x2 = 7560$$

$$\binom{9}{1}\binom{8}{3}\binom{5}{1}x\,2 = 9x56x5x3 = 2520x2 = 5040$$

$$\binom{9}{1}\binom{8}{2}\binom{6}{2} x\,2 = 9x28x15x3 = 3780x2 = 7560$$

$$\binom{9}{1}\binom{8}{1}\binom{7}{3} x\,2 = 9x8x35x3 = 2520x2 = 5040$$

Extending the logic one last time to consider failures across all four rows, yields the following terms:

$$\binom{9}{2}\binom{7}{1}\binom{6}{1}\binom{5}{1} x\,1 = 36x7x6x5x1 = 7560x1 = 7560$$

$$\binom{9}{1}\binom{8}{2}\binom{6}{1}\binom{5}{1} x\,1 = 9x28x6x5x1 = 7560x1 = 7560$$

$$\binom{9}{1}\binom{8}{1}\binom{7}{2}\binom{5}{1} x\,1 = 9x8x21x5x1 = 7560x1 = 7560$$

$$\binom{9}{1}\binom{8}{1}\binom{7}{1}\binom{6}{2} x\,1 = 9x8x7x15x1 = 7560x1 = 7560$$

With only four rows available, there are no more combinations. Summing all of the combinations above results in 79,884 combinations.

The following is then used to evaluate the probability for an individual cut set:

$$\lambda_1 * \lambda_2 * \lambda_3 * \lambda_4 * \lambda_5$$

where λ_i is the failure probability of the ith element in the cut set. Since each of the four inputs has a different failure rate, it is cumbersome to determine the exact failure probability for all of the combinations. Instead define λ_S as a substitute value of the nine failure probabilities, and compute the total failure probability as:

$$79884 * (\lambda_S)^5$$

In most cases, λ_S can be approximated (worst case bounding value) as the maximum failure probability, as the exponentiation of the failure probability more than compensates for a large

number of combinations. The calculation for all the double-diamond basic events is given in Attachment IV.

6. RESULTS

Since unqualified inputs were used in the development of the results presented in this section, they should be considered TBV (to be verified). This document will not directly support any construction, fabrication, or procurement activity, and therefore, the inputs and results are not required to be procedurally controlled as TBV. However, use of any data from this analysis for input into documents supporting procurement, fabrication, or construction is required to be controlled as TBV in accordance with appropriate procedures.

The results of a fault tree analysis are the failure probability of the top event (unfiltered release to the environment) and the cutsets that contribute to the top event failure probability. Attachment II shows the cutsets that result from quantifying the HVAC fault tree with a truncation probability of 10^{-11} (i.e., all cut sets with probabilities less than 10^{-11} were eliminated). The truncation probability was selected to be approximately three to four orders of magnitude less than the total cutset probability.

The quantification was performed with the PFGEXHTO flag set at a value of 1.0 (condition set) and the EFGEXHTO flag set a value of 0.0 (condition not set); this is the more conservative configuration. The failure probability of an unfiltered release from the PCA to the environment is estimated at 1.72×10^{-7}. This indicates that the system is highly reliable. Considering the extensive redundancy, it is not a surprising result. Greater insight into the system can be gained by looking at the cutsets (see Section 6.1 for this discussion). The top event probability value is to be used when evaluating sequences starting with an off-normal event (e.g., dropped fuel assembly, loss of power) (see Section 6.2 for a discussion of how this model can be used with off-normal events). Possible models changes and enhancements are discussed in Section 6.3.

The results of this analysis must be carefully considered with the effects of an off-normal initiator. For example, when considering LOOP, the model should be modified to account for the failure of the normal busses and reliance on the diesel generator. In other cases, such as a human error-initiated dropped fuel assembly, the off-normal initiating event has no direct affect on the operability of the HVAC system (and therefore the results reported in this analysis could be used directly).

6.1 CUTSETS

The cutsets for this WHB HVAC fault tree are presented in Attachment II. It is noteworthy that approximately 90% of the failure probability contribution is contained in the first 15 cutsets. These cuts are:

CDM8TDEY	CHUTDEXF	EIDNCEXF	PBATSCAF	SBATTCAF	TBATENVF
CDM8TDEY	CHUTDEXF	EIDNCEXF	PBATTCAF	TBATENVF	
CDM8TDEY	CHUTDEXF	PBATSCAF	PIDNOEXF	SBATTCAF	TBATENVF
CDM8TDEY	CHUTDEXF	PBATTCAF	PIDNOEXF	TBATENVF	

CHUCAEMF	CMNCAEMF	PFGEXHTO	PFLHF1AD
CHUCAEMF	CMNCAEMF	PFGEXHTO	PFLHF1BD
CHUCAEMF	CMNCAEMF	PFGEXHTO	PFLHF1CD

CDM8TDEY	CHUTDEXF	EFLHF1TM	EHUHEPAF	PBATSCAF	SBATTCAF	TBATENVF
CDM8TDEY	CHUTDEXF	EFLHF1TM	EHUHEPAF	PBATTCAF	TBATENVF	
CDM8TDEY	CHUTDEXF	EFLHF1UM	EHUHEPAF	PBATSCAF	SBATTCAF	TBATENVF
CDM8TDEY	CHUTDEXF	EFLHF1UM	EHUHEPAF	PBATTCAF	TBATENVF	
CDM8TDEY	CHUTDEXF	EFNEF1MM	EHUHEPAF	PBATSCAF	SBATTCAF	TBATENVF
CDM8TDEY	CHUTDEXF	EFNEF1MM	EHUHEPAF	PBATTCAF	TBATENVF	
CDM8TDEY	CHUTDEXF	EFNEF1NM	EHUHEPAF	PBATSCAF	SBATTCAF	TBATENVF
CDM8TDEY	CHUTDEXF	EFNER1NM	EHUHEPAF	PBATTCAF	TBATENVF	

These cutsets will be examined as three different groups. In the first group, there is a common cause failure of the exit tornado dampers which will affect the normal trains of the PCA, SCA, and the TCA (and its associated human failure), failure of the one of the two isolation dampers redirecting air flow from the normal PCA path to the emergency PCA path, plus failures with establish a leakage path from the PCA to the environment. Note that two of the cutsets require a path through each of the confinement areas, while the other two cutsets require a path from the PCA to the TCA to the environment.

The three cutsets in the second group are essentially the same cutset, each with a different train of the HEPA filter (normal train in the PCA) subsystem failing (defective or torn). Further, these are actually three-element cutsets since PFGEXHTO is simply a flag to set the operating condition. So, there is a failure of the CAEM monitoring system, a human error to failure to detect and correct the failure of the CAEM coincident with a torn or defective HEPA filter in the PCA exhaust path. This will send contaminated particles up the exhaust air stack undetected into the atmosphere. The CAEM is modeled in the fault as a single string of sensor, transmitter, and switch.

The third group of cutsets is similar to the first group; in this case, the emergency train is defeated by failure of (one-of-two) of the HEPA filters (and its associated human failure) or failure of (one-of-two) of the exhaust air fans (and its associated human failure).

The remaining cutsets, which contribute about 10% of the total failure probabilities, will not be examined individually. The largest of the remaining cutsets contributes less than 0.5% of the total failure probability.

6.2 OFF-NORMAL EVENTS

This analysis does not explicitly consider off-normal events. When an initiating event has no dependence with the HVAC system, the failure probability can be used as multiplier in the event sequence analysis. For example, a human error-initiated dropped fuel assembly may put contaminants in the air, but this failure is independent of the operation of the HVAC system. It is possible that a dropped fuel assembly results from an external event that may also affect the HVAC system (e.g., an earthquake); in this case, failures to the HVAC (from the earthquake) would have to be explicitly considered.

When there is a dependency, some additional analysis might be necessary. For example, for loss of offsite power (LOOP), the fans in the SCA and TCA will stop running, as well as the fans in the normal train of the PCA, and the ability to filter contaminants will depend solely on the emergency train of the PCA. The fault tree model was modified to "simulate" failures in the PCA, SCA, and TCA due to a LOOP. The cutsets from this case are presented in Attachment VII.

The LOOP event has been set to a failure probability of 1.0, so the results, 4.1×10^{-2}, estimate a conditional failure probability of the HVAC system given a LOOP (and not a frequency). The relatively high conditional probability is expected, given the apparent single element cutsets (e.g., isolation dampers, and failure of the diesel generator). The first four cutsets (1-4) represent failures of the isolation dampers, effectively defeating the ability to switch to the emergency train. The next eight cutsets (5-12) represent a diesel generator failure (either fails to start or fails to run) coupled with a human error that fails to recognize either an air supply fan or exhaust air fan (subsystem) failure. (These particular human errors are present since loss of power, e.g., failed diesel generator, will fail the fans.) For these cutsets, the human error could be reasonably substituted with a failure to detect and mitigate the LOOP (rather than just a fan subsystem failure). The next eight cutsets (13-20) represent failures of the (one-of-two) HEPA filter subsystems or the (one-of-two) exhaust air fan subsystems (with the associated human failures). The next eight cutsets (21-28) continue with diesel generator or fan failures. These 28 cutsets account for nearly 99% of the failure probability. The next largest cutset accounts for less than 0.05% of the total failure probability.

6.3 FUTURE MODEL CONSIDERATIONS

In performing this analysis, some system simplifications are made. This is usually due to incomplete information. There are two TBVs in this analysis that refer to (1) the WHB HVAC design and (2) the **n**/2 + 1 mission success criteria. Small changes in the design should not have

an impact on subsequent results. Since the **n**/2 +1 criteria is considered conservative, when this criteria is better quantified, the results may improve, though such improvement would be expected to be small. There are several items that should be considered in more detail as the design continues to develop.

1. The electrical power model in the fault tree lacks detail due to the current level of design. Currently, there is only a dependency on power for the air supply fans and the exhaust air fans. In actuality, there are power dependencies for many other components (e.g., sensors, switches, dampers, etc.); these dependencies can be quite complex, and their modeling relies on detailed knowledge of the electrical power system and the powered equipment. There may be other support system dependencies (e.g., component cooling water) that are not yet identified.

2. The HEPA filters are modeled conservatively as a single filter; there is actually a two-stage filter design.

3. The CAEM system also lacks detail in the fault tree. A more detailed treatment plus consideration of radiation monitors in other positions in the HVAC system (e.g., exhaust plenums) would be a reasonable enhancement.

4. The confinement area barrier interface leakage probabilities are treated conservatively in the fault tree model. The leakage probabilities, assumed to be 1.0, can probably be reduced given further justification, particularly the PCA/TCA interface.

7. REFERENCES

7.1 Vesely, W.E.; Goldberg, F.F.; Roberts, N.H.; Haasl, D.F. 1981. *Fault Tree Handbook.* NUREG-0492. Washington, D.C.: U.S. Nuclear Regulatory Commission. TIC: 208328.

7.2 Swain, A.D. and Guttmann, H.E. 1980. *Handbook of Human Reliability Analysis with Emphasis on Nuclear Power Plant Applications*. NUREG/CR-1278. Washington, D.C.: Sandia National Laboratories for U.S. Nuclear Regulatory Commission. TIC: 234354.

7.3 Civilian Radioactive Waste Management System (CRWMS) Management and Operations Contractor (M&O) 1998. *Preliminary Preclosure Design Basis Event Calculations for the Monitored Geologic Repository*. BC0000000-01717-0210-00001 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19981002.0001.

7.4 Office of Civilian Radioactive Waste Management (OCRWM) 1998. *Viability Assessment of a Repository at Yucca Mountain, Volume 2: Preliminary Design Concept for the Repository and Waste Package.* DOE/RW-0508/V2. Washington, D.C.: U.S. Department of Energy. ACC: MOL.19981007.0029.

7.5 CRWMS M&O 1997. *Surface Nuclear Facilities HVAC Analysis*. BCBD00000-01717-0200-00013 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19980112.0189.

7.6 Toledo Edison 1993. *Individual Plant Examination for the Davis-Besse Nuclear Power Station*. pp. 224-229, 234-240. Toledo, Ohio: Toledo Edison Company. TIC: 243475.

7.7 Modarres, M. 1993. *What Every Engineer Should Know about Reliability and Risk Analysis*. pp. 336-341 (Appendix B). New York, New York: Marcel Dekker, Inc. TIC: 243442.

7.8 D.W. Gwyn to D.E. Calloway 3-9-99. "Industry Standard Software Package Qualification." IOC.LV.SA.LEB.03/99-026. CRWMS M&O interoffice correspondence (IOC). ACC: MOL.19990326.0166.

8. ATTACHMENTS

The following attachments are provided to support this engineering calculation:

Attachment I – Waste Handling Building HVAC Fault Tree

Attachment II – Waste Handling Building HVAC Cutsets

Attachment III – Waste Handling Building HVAC Fault Tree Top Logic

Attachment IV – Data Tables

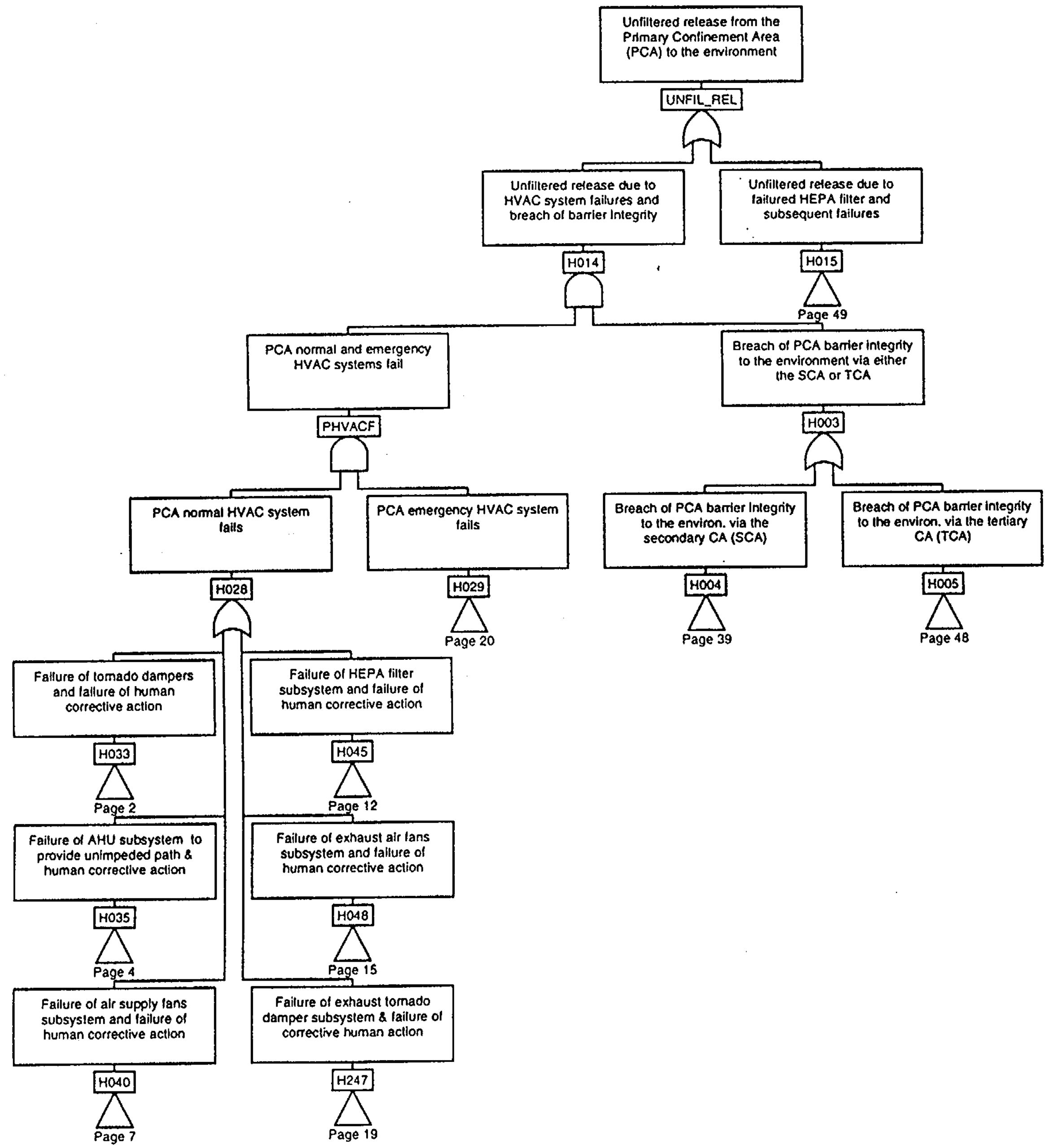
Attachment V – Combinatorial Calculations

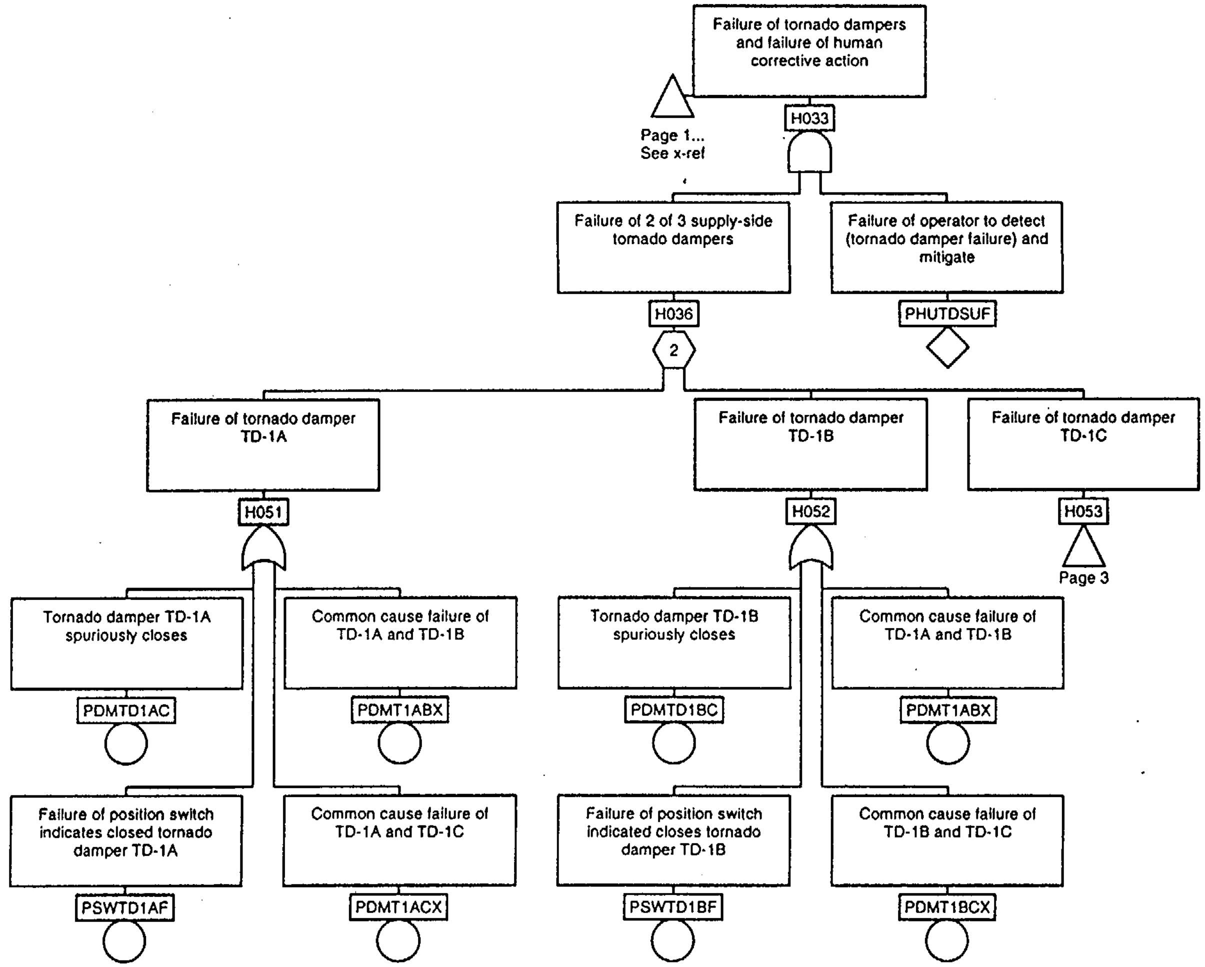
Attachment VI – High Level HVAC Design with Emergency Supply-Side Train

Attachment VII – LOOP Initiating Event Cutsets

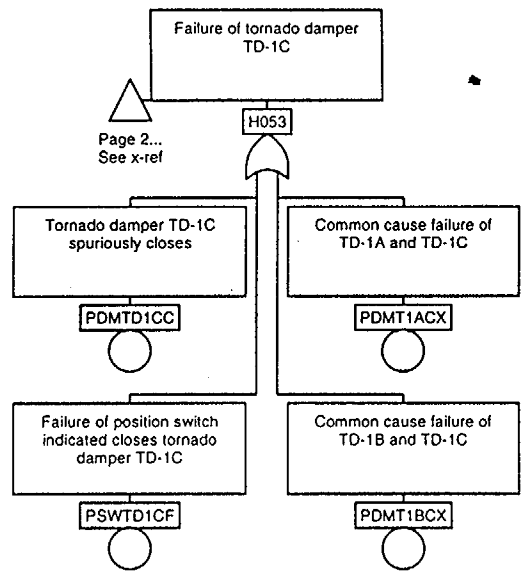
ATTACHMENT I

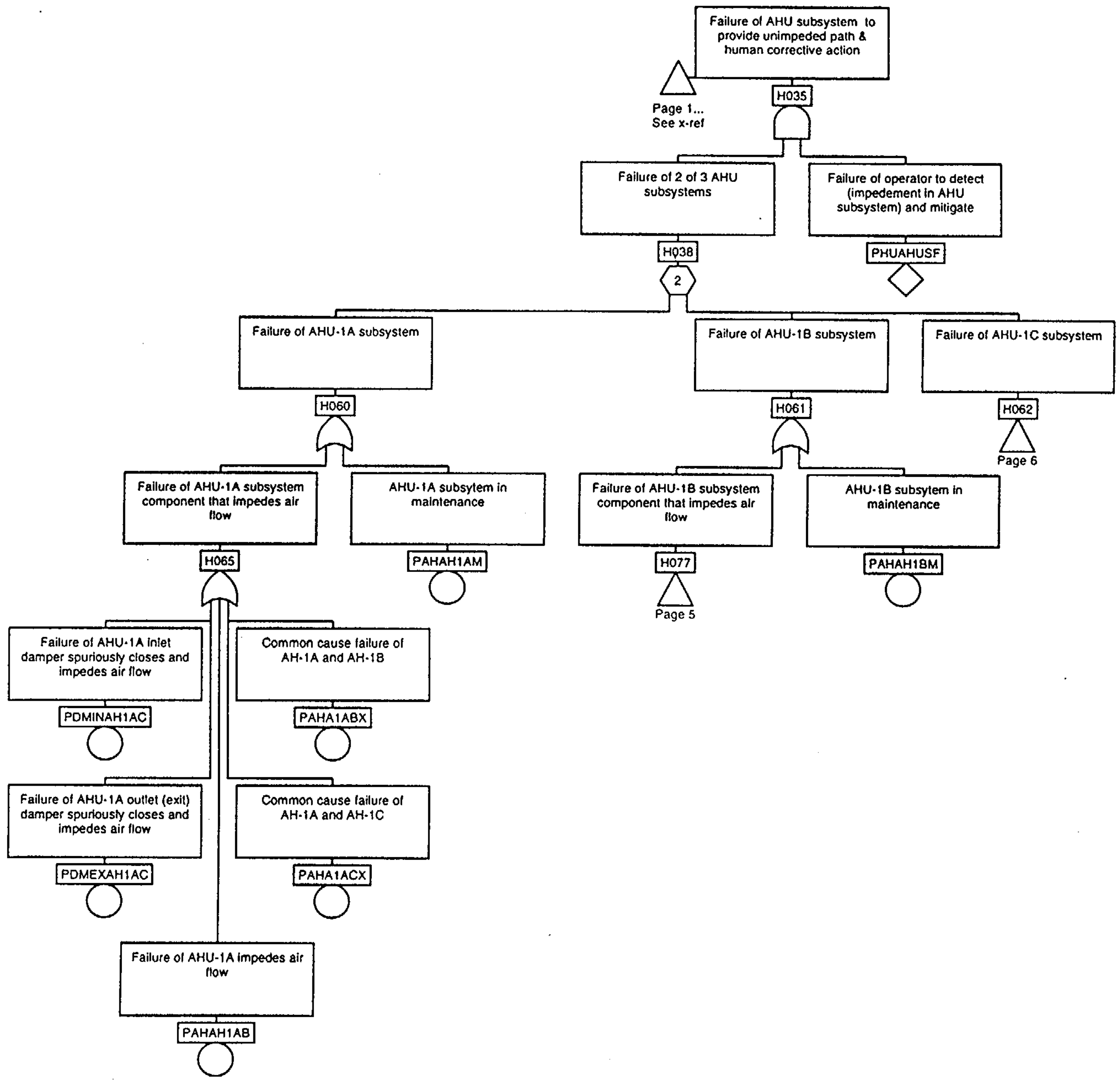
WASTE HANDLING BUILDING HVAC FAULT TREE

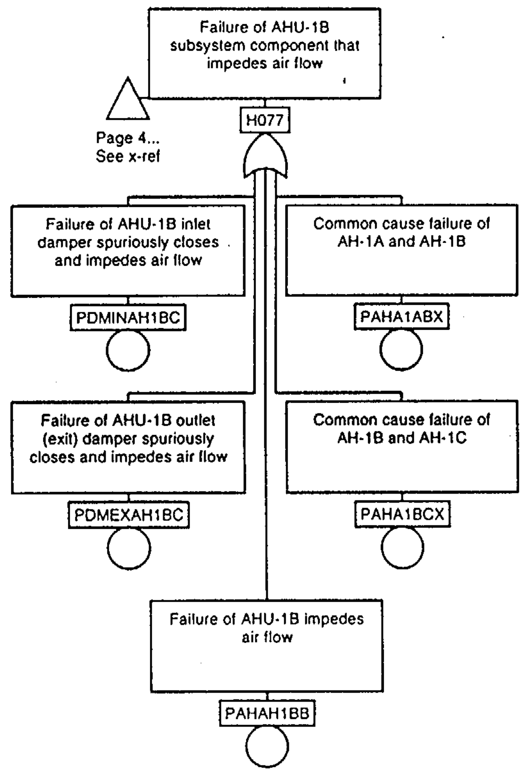

Unfiltered release from the Primary Confinement Area (PCA) to the environment
UNFIL_REL
Unfiltered release due to HVAC system failures and breach of barrier integrity
H014
Unfiltered release due to failured HEPA filter and subsequent failures
H015
Page 49
PCA normal and emergency HVAC systems fail
PHVACF
Breach of PCA barrier integrity to the environment via either the SCA or TCA
H003
PCA normal HVAC system fails
H028
PCA emergency HVAC system fails
H029
Page 20
Breach of PCA barrier integrity to the environ. via the secondary CA (SCA)
H004
Page 39
Breach of PCA barrier integrity to the environ. via the tertiary CA (TCA)
H005
Page 48
Failure of tornado dampers and failure of human corrective action
H033
Page 2
Failure of HEPA filter subsystem and failure of human corrective action
H045
Page 12
Failure of AHU subsystem to provide unimpeded path & human corrective action
H035
Page 4
Failure of exhaust air fans subsystem and failure of human corrective action
H048
Page 15
Failure of air supply fans subsystem and failure of human corrective action
H040
Page 7
Failure of exhaust tornado damper subsystem & failure of corrective human action
H247
Page 19

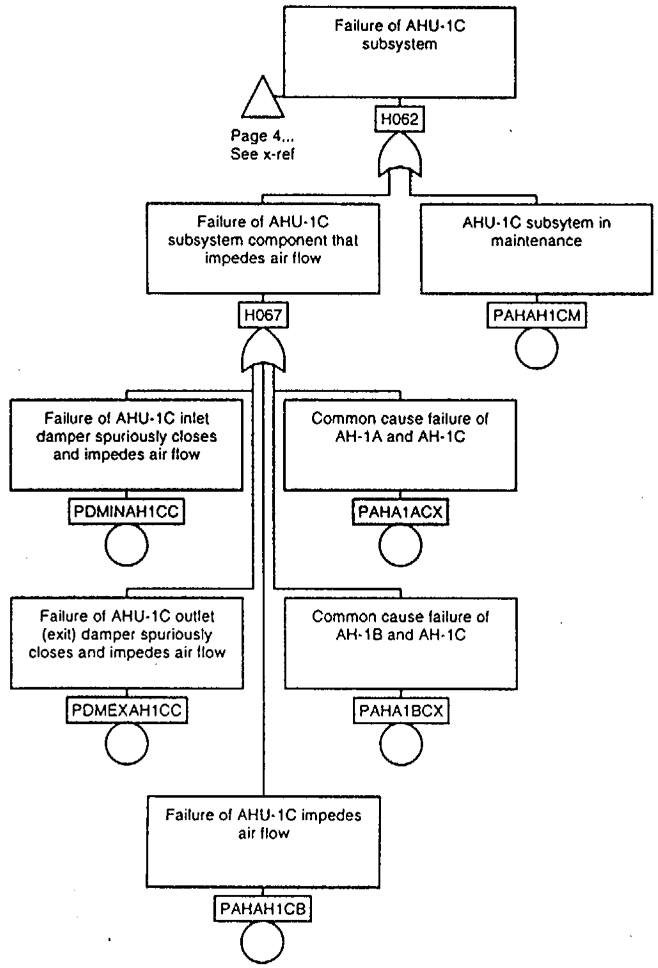


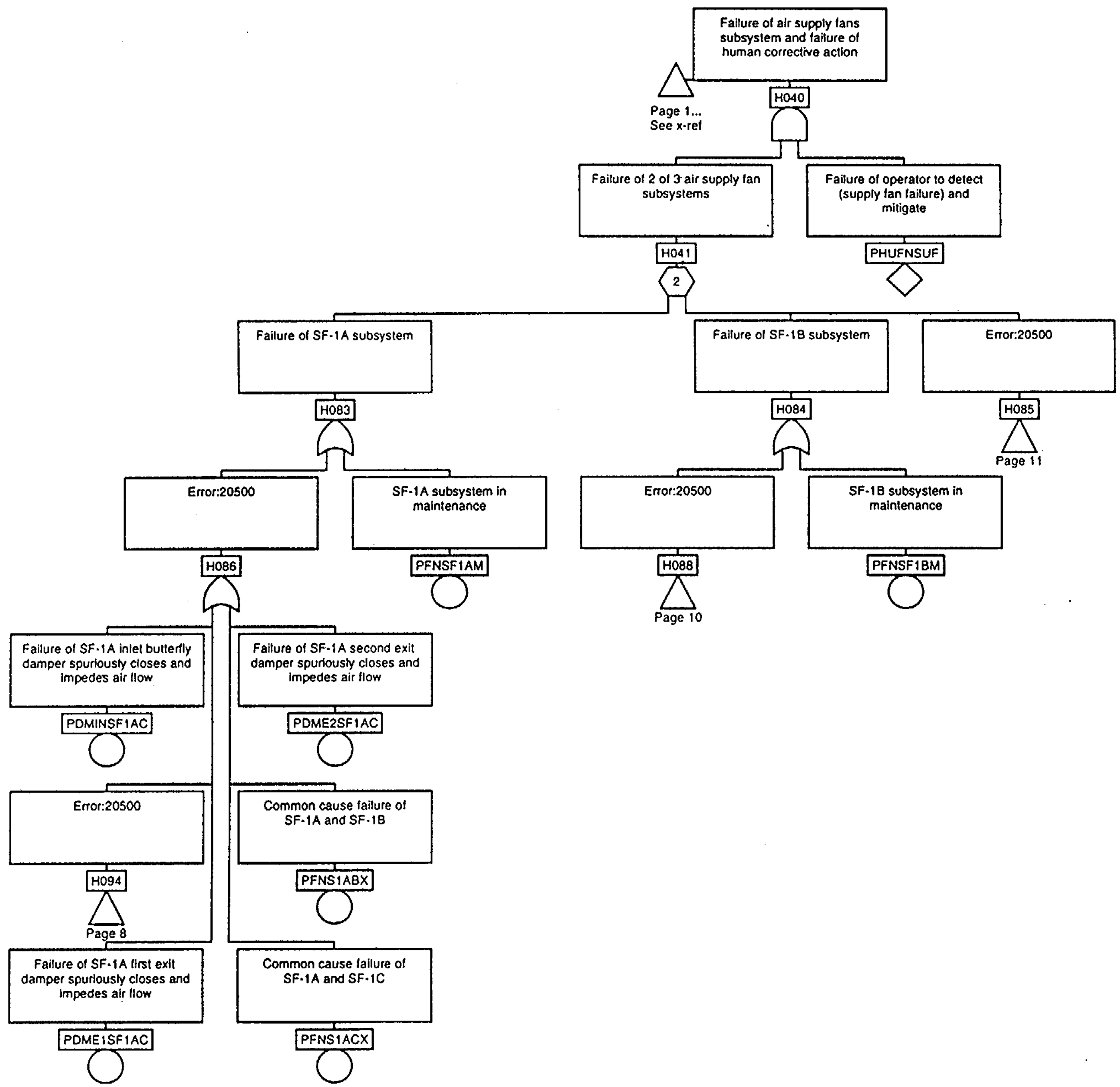
WHB HVAC	A:\WHBHVAC5.CAF	5/4/99	Page 2

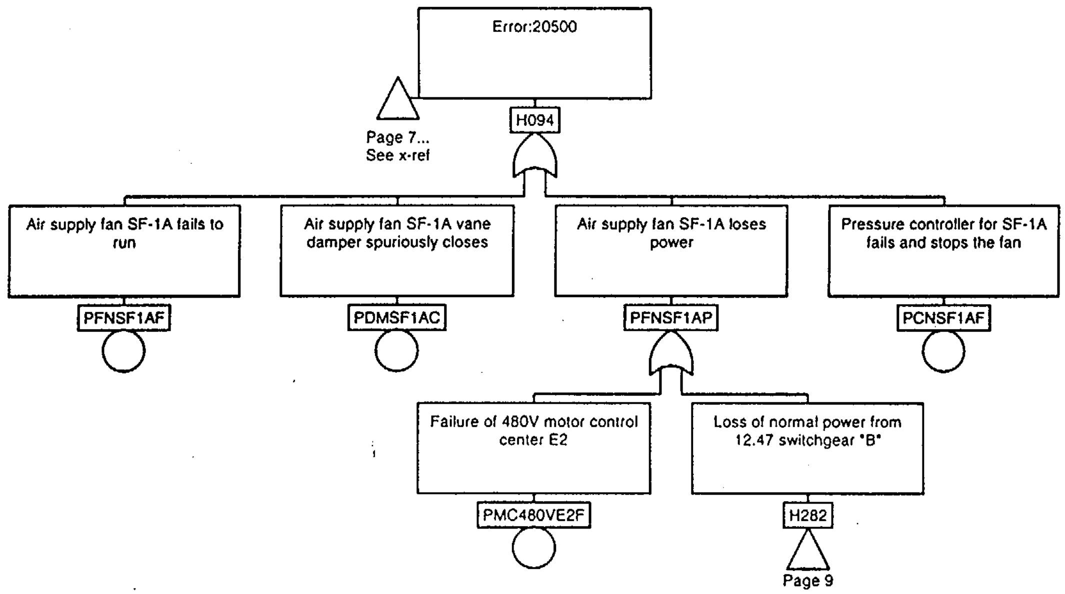

Failure of tornado damper TD-1C
H053
Page 2...
See x-ref
Tornado damper TD-1C spuriously closes
PDMTD1CC
Common cause failure of TD-1A and TD-1C
PDMT1ACX
Failure of position switch indicated closes tornado damper TD-1C
PSWTD1CF
Common cause failure of TD-1B and TD-1C
PDMT1BCX

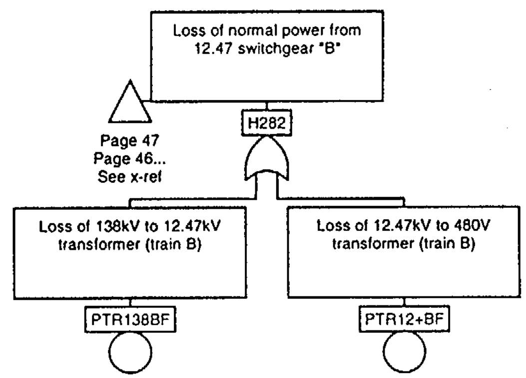

Failure of AHU subsystem to provide unimpeded path & human corrective action
H035
Page 1... See x-ref
Failure of 2 of 3 AHU subsystems
H038
2
Failure of operator to detect (impedement in AHU subsystem) and mitigate
PHUAHUSF
Failure of AHU-1A subsystem
H060
Failure of AHU-1B subsystem
H061
Failure of AHU-1C subsystem
H062
Page 6
Failure of AHU-1A subsystem component that impedes air flow
H065
AHU-1A subsytem in maintenance
PAHAH1AM
Failure of AHU-1B subsystem component that impedes air flow
H077
Page 5
AHU-1B subsystem in maintenance
PAHAH1BM
Failure of AHU-1A inlet damper spuriously closes and impedes air flow
PDMINAH1AC
Common cause failure of AH-1A and AH-1B
PAHA1ABX
Failure of AHU-1A outlet (exit) damper spuriously closes and impedes air flow
PDMEXAH1AC
Common cause failure of AH-1A and AH-1C
PAHA1ACX
Failure of AHU-1A impedes air flow
PAHAH1AB

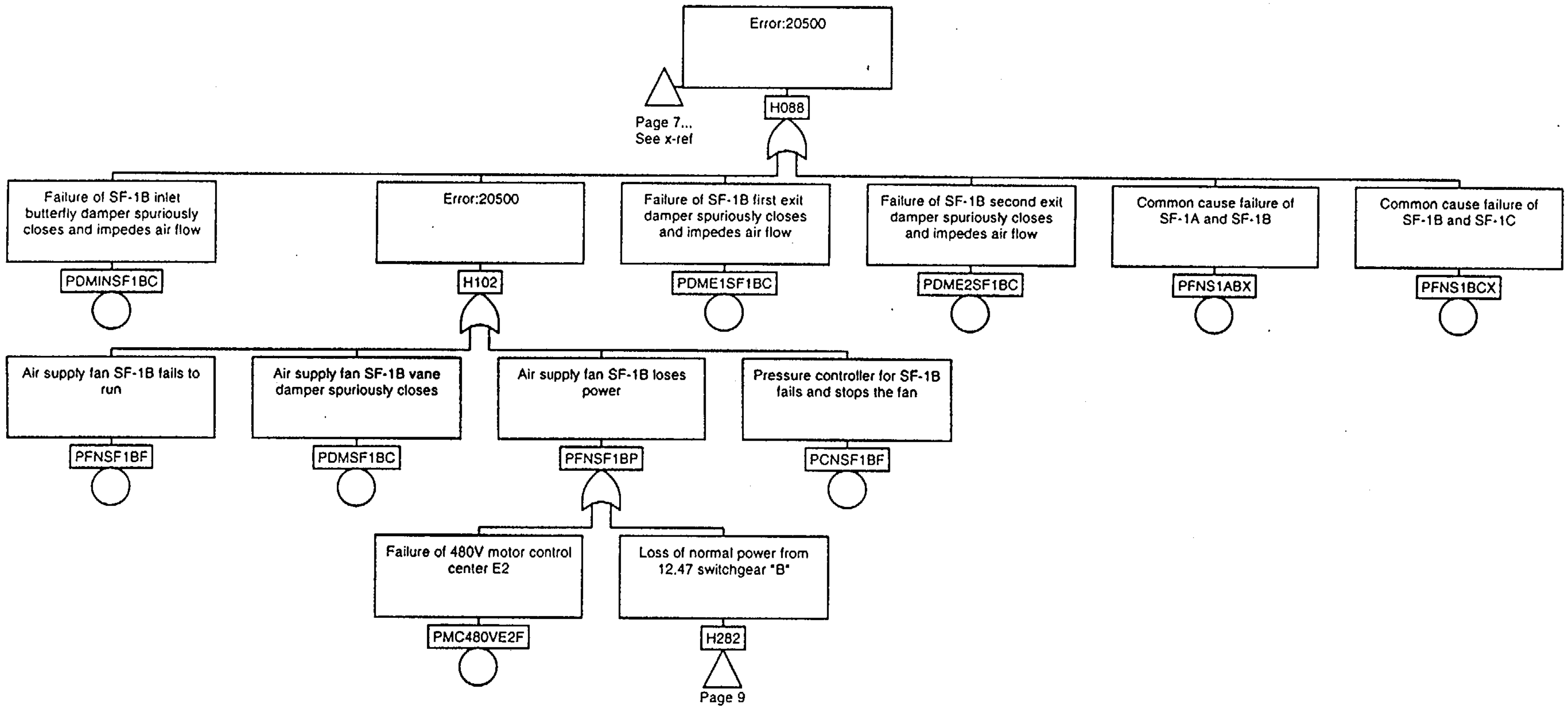

Failure of AHU-1B subsystem component that impedes air flow
H077
Page 4...
See x-ref
Failure of AHU-1B inlet damper spuriously closes and impedes air flow
PDMINAH1BC
Common cause failure of AH-1A and AH-1B
PAHA1ABX
Failure of AHU-1B outlet (exit) damper spuriously closes and impedes air flow
PDMEXAH1BC
Common cause failure of AH-1B and AH-1C
PAHA1BCX
Failure of AHU-1B impedes air flow
PAHAH1BB

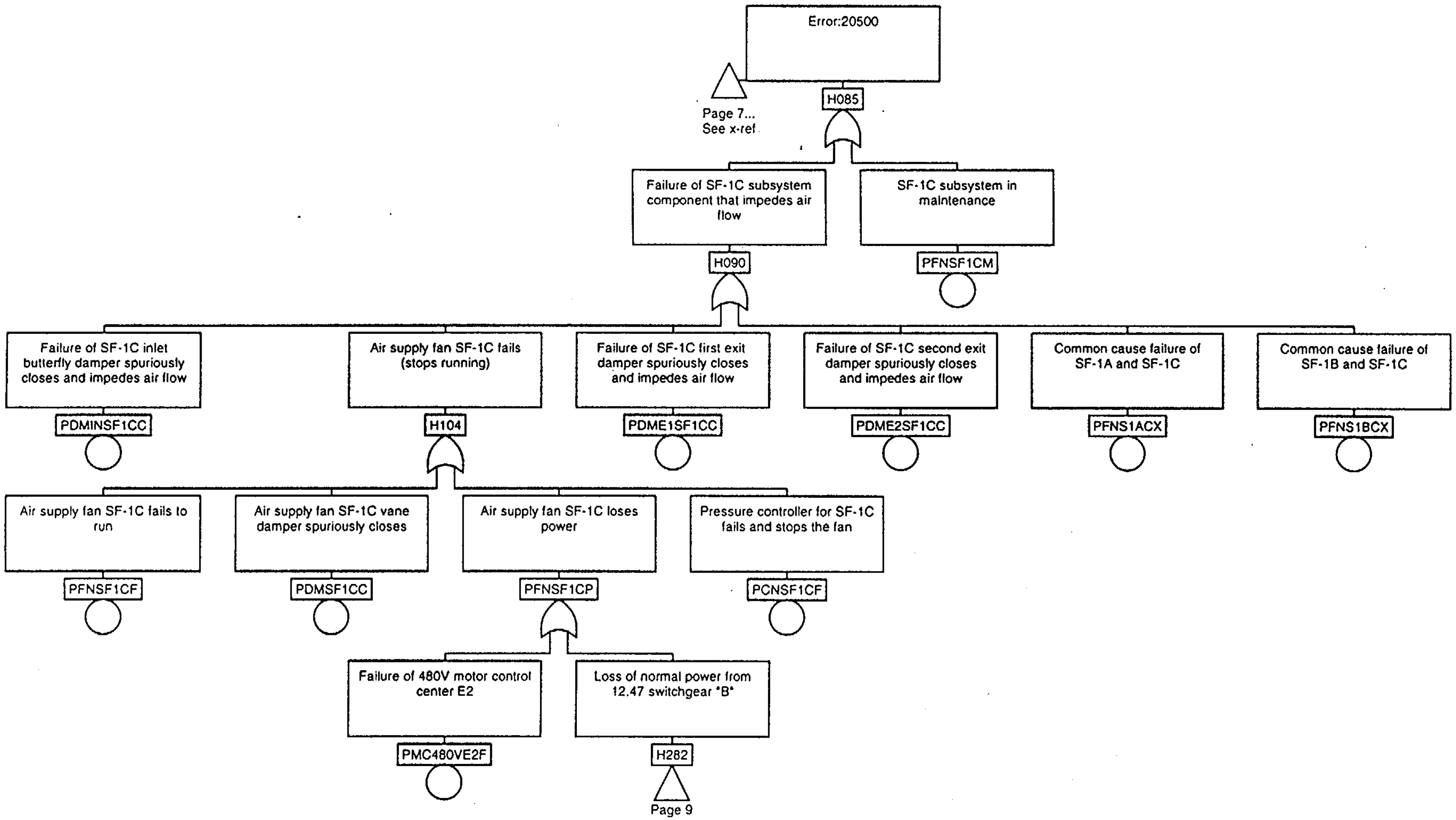

Failure of AHU-1C subsystem
Page 4...
See x-ref
H062
Failure of AHU-1C subsystem component that impedes air flow
AHU-1C subsytem in maintenance
H067
PAHAH1CM
Failure of AHU-1C inlet damper spuriously closes and impedes air flow
Common cause failure of AH-1A and AH-1C
PDMINAH1CC
PAHA1ACX
Failure of AHU-1C outlet (exit) damper spuriously closes and impedes air flow
Common cause failure of AH-1B and AH-1C
PDMEXAH1CC
PAHA1BCX
Failure of AHU-1C impedes air flow
PAHAH1CB


Failure of air supply fans subsystem and failure of human corrective action
Page 1...
See x-ref
H040
Failure of 2 of 3 air supply fan subsystems
Failure of operator to detect (supply fan failure) and mitigate
H041
2
PHUFNSUF
Failure of SF-1A subsystem
Failure of SF-1B subsystem
Error:20500
H083
H084
H085
Page 11
Error:20500
SF-1A subsystem in maintenance
Error:20500
SF-1B subsystem in maintenance
H086
PFNSF1AM
H088
Page 10
PFNSF1BM
Failure of SF-1A inlet butterfly damper spuriously closes and impedes air flow
Failure of SF-1A second exit damper spuriously closes and impedes air flow
PDMINSF1AC
PDME2SF1AC
Error:20500
Common cause failure of SF-1A and SF-1B
H094
Page 8
PFNS1ABX
Failure of SF-1A first exit damper spuriously closes and impedes air flow
Common cause failure of SF-1A and SF-1C
PDME1SF1AC
PFNS1ACX


Error:20500
Page 7...
See x-ref
H094
Air supply fan SF-1A fails to run
PFNSF1AF
Air supply fan SF-1A vane damper spuriously closes
PDMSF1AC
Air supply fan SF-1A loses power
PFNSF1AP
Pressure controller for SF-1A fails and stops the fan
PCNSF1AF
Failure of 480V motor control center E2
PMC480VE2F
Loss of normal power from 12.47 switchgear "B"
H282
Page 9


Loss of normal power from 12.47 switchgear "B"
H282
Page 47
Page 46...
See x-ref
Loss of 138kV to 12.47kV transformer (train B)
PTR138BF
Loss of 12.47kV to 480V transformer (train B)
PTR12+BF


Error:20500
H088
Page 7...
See x-ref
Failure of SF-1B inlet butterfly damper spuriously closes and impedes air flow
PDMINSF1BC
Error:20500
H102
Failure of SF-1B first exit damper spuriously closes and impedes air flow
PDME1SF1BC
Failure of SF-1B second exit damper spuriously closes and impedes air flow
PDME2SF1BC
Common cause failure of SF-1A and SF-1B
PFNS1ABX
Common cause failure of SF-1B and SF-1C
PFNS1BCX
Air supply fan SF-1B fails to run
PFNSF1BF
Air supply fan SF-1B vane damper spuriously closes
PDMSF1BC
Air supply fan SF-1B loses power
PFNSF1BP
Pressure controller for SF-1B fails and stops the fan
PCNSF1BF
Failure of 480V motor control center E2
PMC480VE2F
Loss of normal power from 12.47 switchgear "B"
H282
Page 9


Error:20500
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H085
Failure of SF-1C subsystem component that impedes air flow
SF-1C subsystem in maintenance
H090
PFNSF1CM
Failure of SF-1C inlet butterfly damper spuriously closes and impedes air flow
Air supply fan SF-1C fails (stops running)
Failure of SF-1C first exit damper spuriously closes and impedes air flow
Failure of SF-1C second exit damper spuriously closes and impedes air flow
Common cause failure of SF-1A and SF-1C
Common cause failure of SF-1B and SF-1C
PDMINSF1CC
H104
PDME1SF1CC
PDME2SF1CC
PFNS1ACX
PFNS1BCX
Air supply fan SF-1C fails to run
Air supply fan SF-1C vane damper spuriously closes
Air supply fan SF-1C loses power
Pressure controller for SF-1C fails and stops the fan
PFNSF1CF
PDMSF1CC
PFNSF1CP
PCNSF1CF
Failure of 480V motor control center E2
Loss of normal power from 12.47 switchgear "B"
PMC480VE2F
H282
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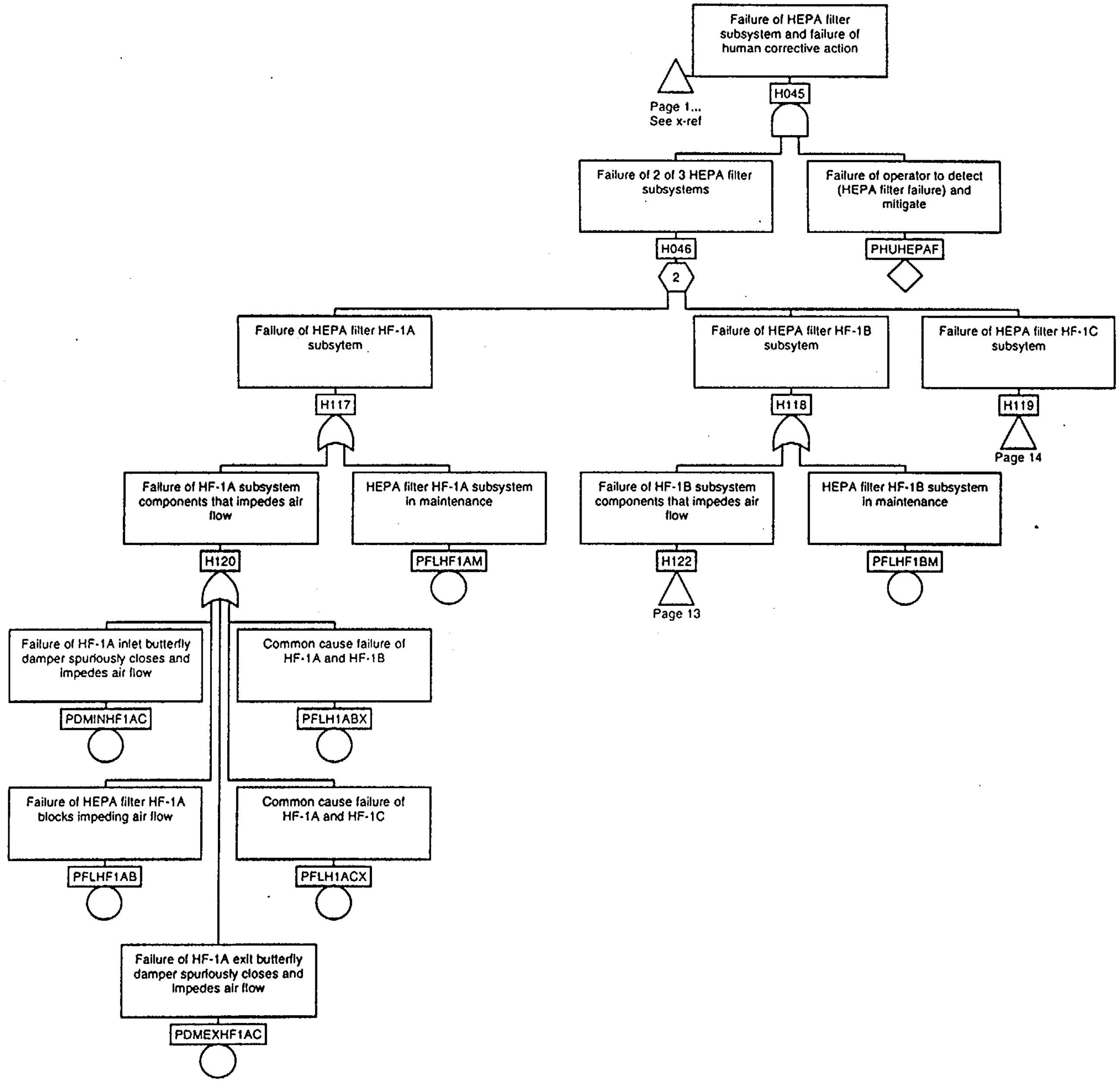
Failure of HEPA filter subsystem and failure of human corrective action
H045
Page 1... See x-ref
Failure of 2 of 3 HEPA filter subsystems
H046
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Failure of operator to detect (HEPA filter failure) and mitigate
PHUHEPAF
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H117
Failure of HEPA filter HF-1B subsytem
H118
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PFLHF1AM
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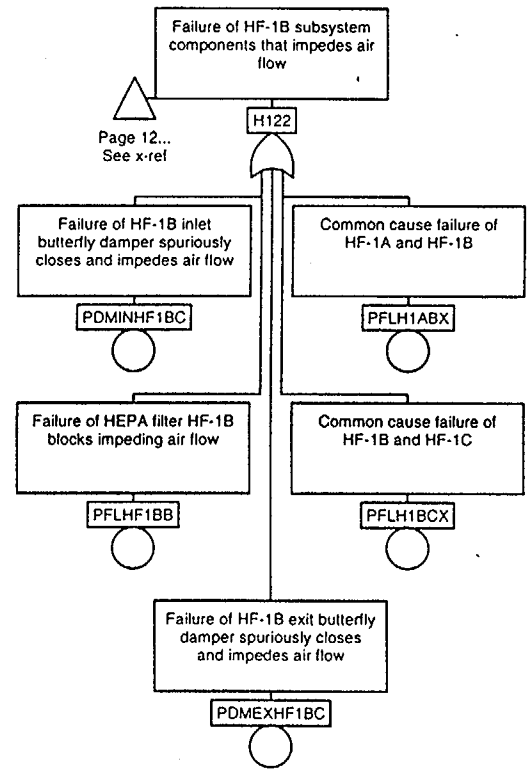
PFLHF1BM
Failure of HF-1A inlet butterfly damper spuriously closes and impedes air flow
PDMINHF1AC
Common cause failure of HF-1A and HF-1B
PFLH1ABX
Failure of HEPA filter HF-1A blocks impeding air flow
PFLHF1AB
Common cause failure of HF-1A and HF-1C
PFLH1ACX
Failure of HF-1A exit butterfly damper spuriously closes and impedes air flow
PDMEXHF1AC


Failure of HF-1B subsystem components that impedes air flow
H122
Page 12...
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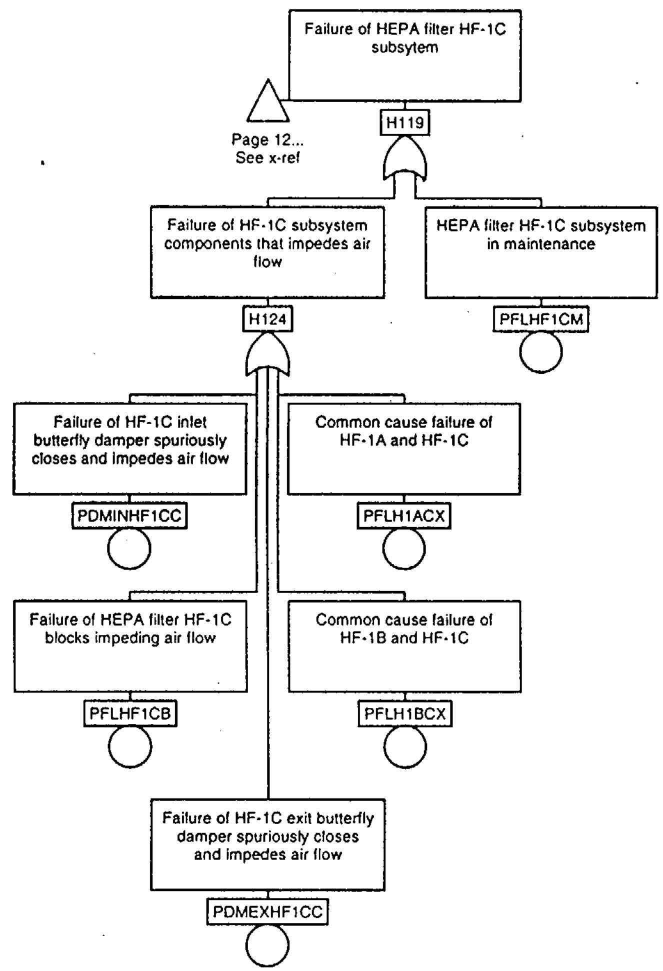
Failure of HF-1B inlet butterfly damper spuriously closes and impedes air flow
PDMINHF1BC
Common cause failure of HF-1A and HF-1B
PFLH1ABX
Failure of HEPA filter HF-1B blocks impeding air flow
PFLHF1BB
Common cause failure of HF-1B and HF-1C
PFLH1BCX
Failure of HF-1B exit butterfly damper spuriously closes and impedes air flow
PDMEXHF1BC


Failure of HEPA filter HF-1C subsytem
H119
Page 12...
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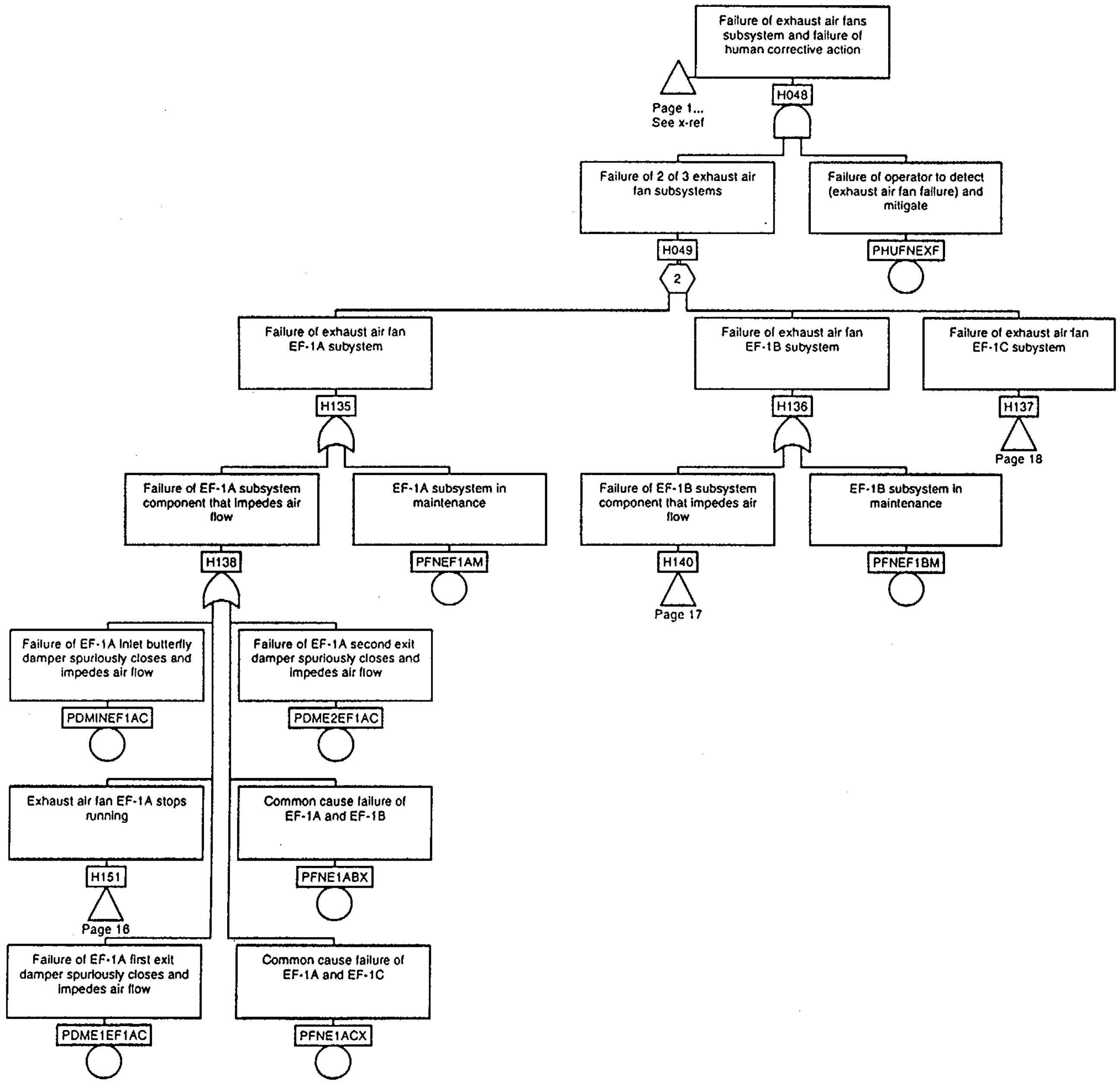
Failure of HF-1C subsystem components that impedes air flow
HEPA filter HF-1C subsystem in maintenance
H124
PFLHF1CM
Failure of HF-1C inlet butterfly damper spuriously closes and impedes air flow
Common cause failure of HF-1A and HF-1C
PDMINHF1CC
PFLH1ACX
Failure of HEPA filter HF-1C blocks impeding air flow
Common cause failure of HF-1B and HF-1C
PFLHF1CB
PFLH1BCX
Failure of HF-1C exit butterfly damper spuriously closes and impedes air flow
PDMEXHF1CC


Failure of exhaust air fans subsystem and failure of human corrective action
Page 1...
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H048
Failure of 2 of 3 exhaust air fan subsystems
H049
2
Failure of operator to detect (exhaust air fan failure) and mitigate
PHUFNEXF
Failure of exhaust air fan EF-1A subystem
H135
Failure of exhaust air fan EF-1B subystem
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Failure of exhaust air fan EF-1C subystem
H137
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H138
EF-1A subsystem in maintenance
PFNEF1AM
Failure of EF-1B subsystem component that impedes air flow
H140
Page 17
EF-1B subsystem in maintenance
PFNEF1BM
Failure of EF-1A inlet butterfly damper spuriously closes and impedes air flow
PDMINEF1AC
Failure of EF-1A second exit damper spuriously closes and impedes air flow
PDME2EF1AC
Exhaust air fan EF-1A stops running
H151
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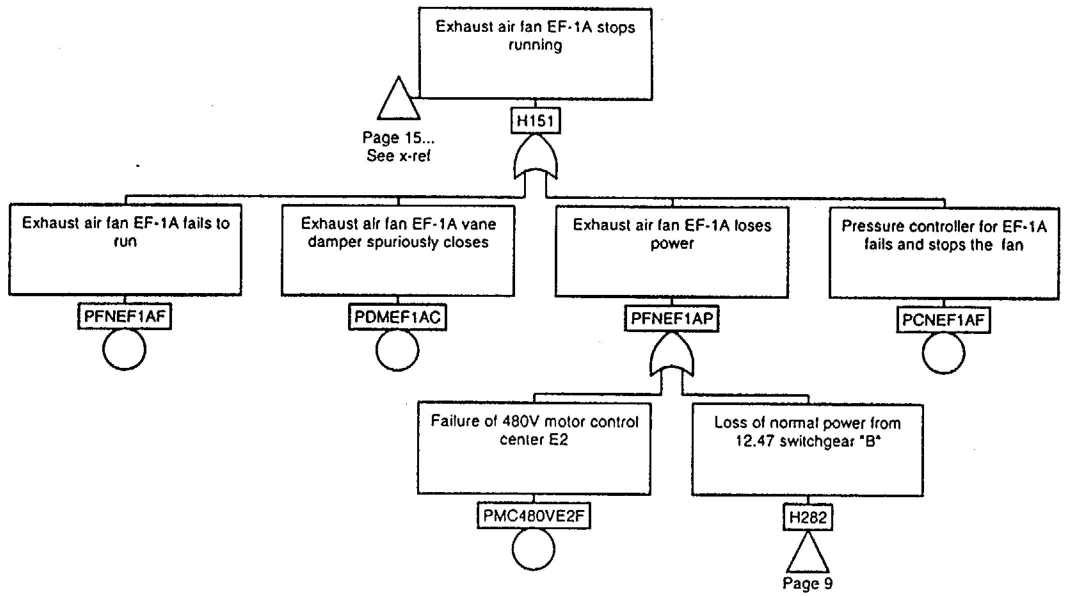
Common cause failure of EF-1A and EF-1B
PFNE1ABX
Failure of EF-1A first exit damper spuriously closes and impedes air flow
PDME1EF1AC
Common cause failure of EF-1A and EF-1C
PFNE1ACX


Exhaust air fan EF-1A stops running
Page 15... See x-ref
H151
Exhaust air fan EF-1A fails to run
PFNEF1AF
Exhaust air fan EF-1A vane damper spuriously closes
PDMEF1AC
Exhaust air fan EF-1A loses power
PFNEF1AP
Pressure controller for EF-1A fails and stops the fan
PCNEF1AF
Failure of 480V motor control center E2
PMC480VE2F
Loss of normal power from 12.47 switchgear "B"
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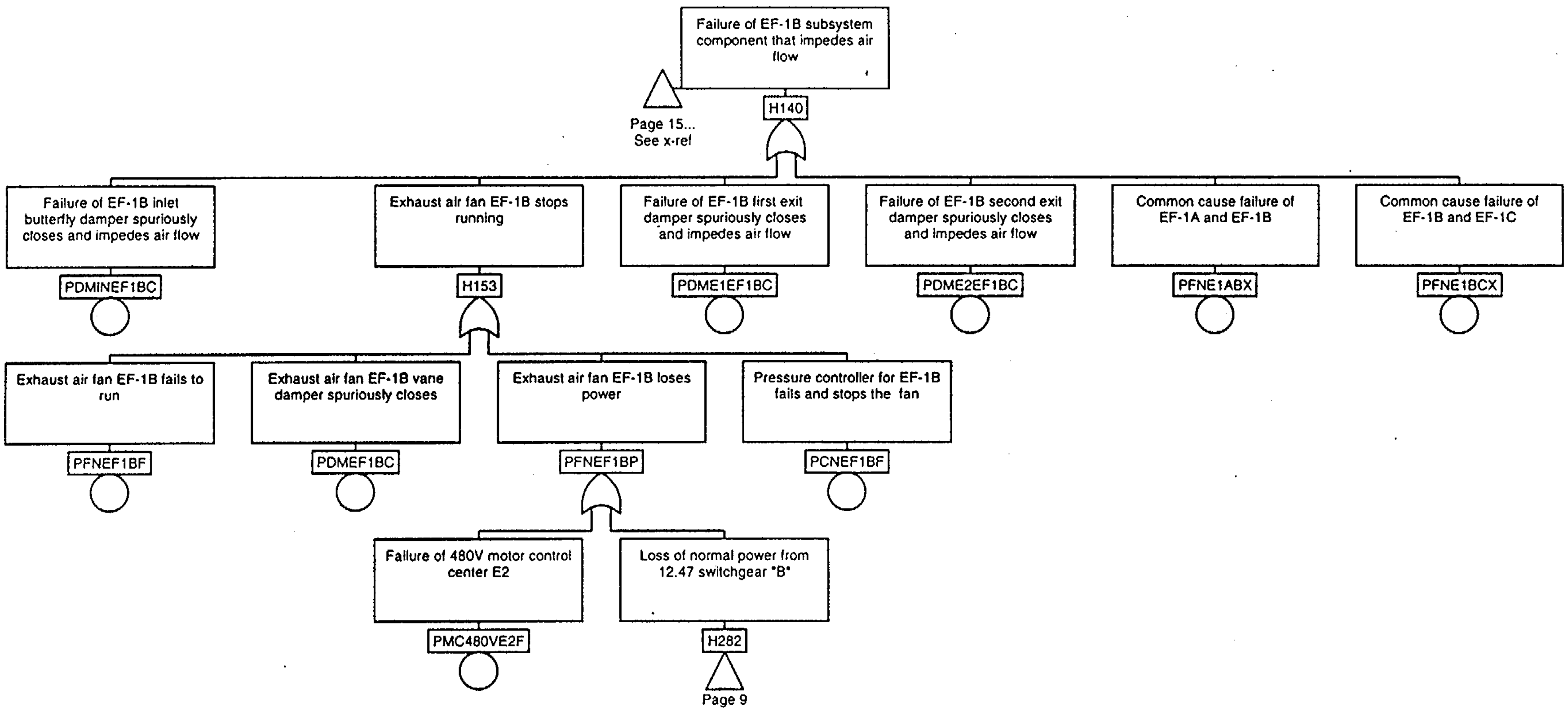
Failure of EF-1B subsystem component that impedes air flow
H140
Page 15... See x-ref
Failure of EF-1B inlet butterfly damper spuriously closes and impedes air flow
PDMINEF1BC
Exhaust air fan EF-1B stops running
H153
Failure of EF-1B first exit damper spuriously closes and impedes air flow
PDME1EF1BC
Failure of EF-1B second exit damper spuriously closes and impedes air flow
PDME2EF1BC
Common cause failure of EF-1A and EF-1B
PFNE1ABX
Common cause failure of EF-1B and EF-1C
PFNE1BCX
Exhaust air fan EF-1B fails to run
PFNEF1BF
Exhaust air fan EF-1B vane damper spuriously closes
PDMEF1BC
Exhaust air fan EF-1B loses power
PFNEF1BP
Pressure controller for EF-1B fails and stops the fan
PCNEF1BF
Failure of 480V motor control center E2
PMC480VE2F
Loss of normal power from 12.47 switchgear "B"
H282
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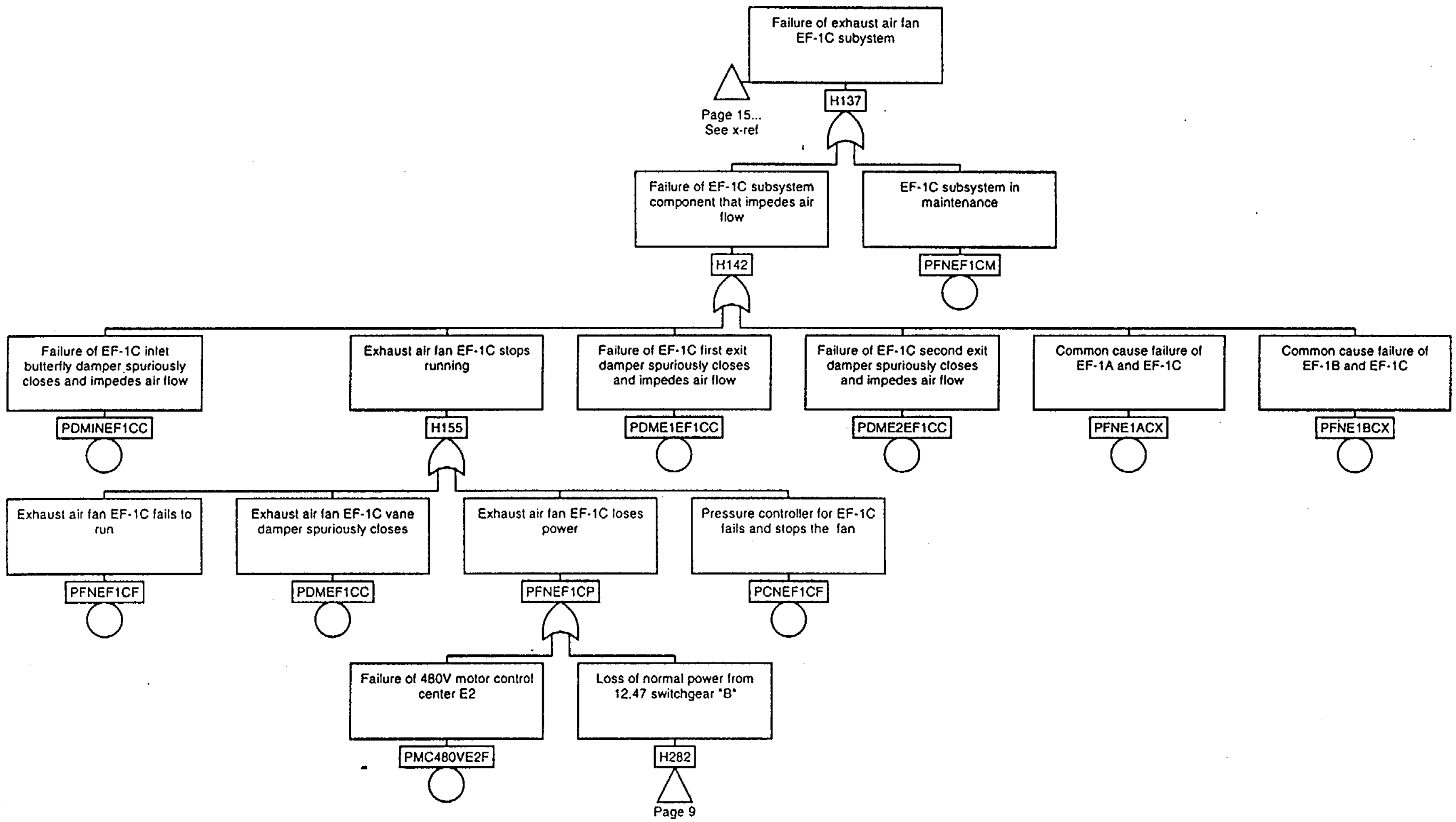
Failure of exhaust air fan EF-1C subsystem
Page 15... See x-ref
H137
Failure of EF-1C subsystem component that impedes air flow
EF-1C subsystem in maintenance
H142
PFNEF1CM
Failure of EF-1C inlet butterfly damper spuriously closes and impedes air flow
Exhaust air fan EF-1C stops running
Failure of EF-1C first exit damper spuriously closes and impedes air flow
Failure of EF-1C second exit damper spuriously closes and impedes air flow
Common cause failure of EF-1A and EF-1C
Common cause failure of EF-1B and EF-1C
PDMINEF1CC
H155
PDME1EF1CC
PDME2EF1CC
PFNE1ACX
PFNE1BCX
Exhaust air fan EF-1C fails to run
Exhaust air fan EF-1C vane damper spuriously closes
Exhaust air fan EF-1C loses power
Pressure controller for EF-1C fails and stops the fan
PFNEF1CF
PDMEF1CC
PFNEF1CP
PCNEF1CF
Failure of 480V motor control center E2
Loss of normal power from 12.47 switchgear "B"
PMC480VE2F
H282
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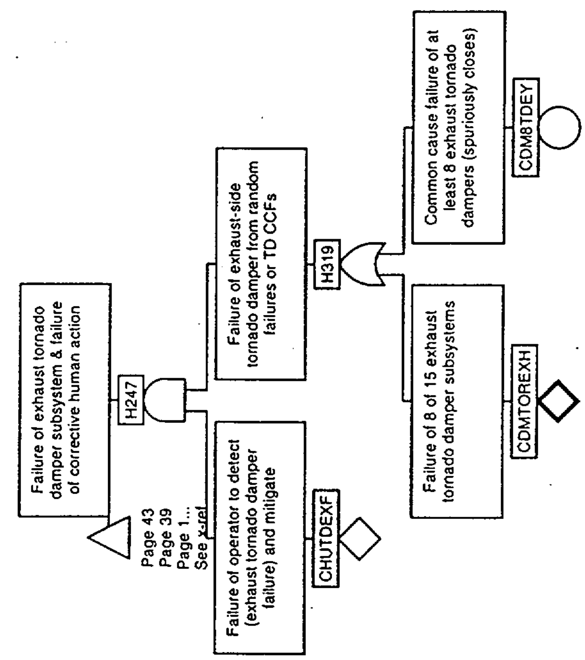
Failure of exhaust tornado damper subsystem & failure of corrective human action
H247
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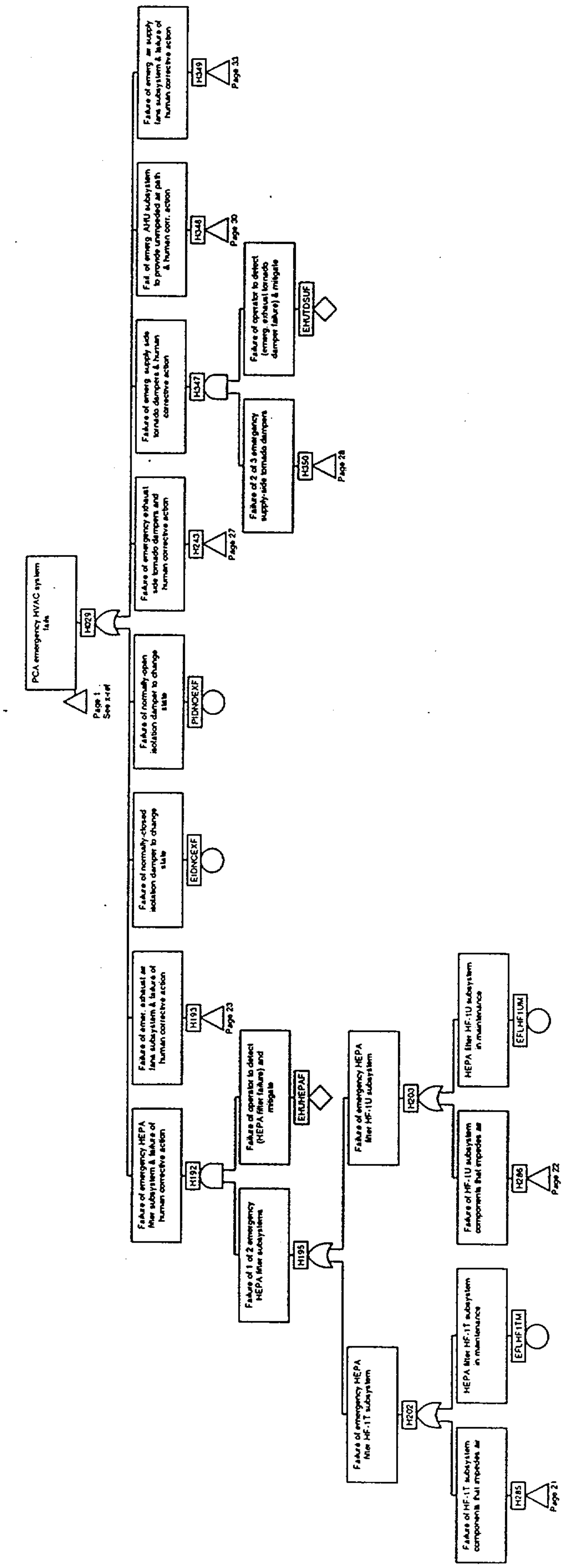
Failure of exhaust-side tornado damper from random failures or TD CCFs
H319
Failure of operator to detect (exhaust tornado damper failure) and mitigate
CHUTDEXF
Common cause failure of at least 8 exhaust tornado dampers (spuriously closes)
CDM8TDEY
Failure of 8 of 15 exhaust tornado damper subsystems
CDMTOREXH


PCA emergency HVAC system fails
Page 1: See x-ref
H329
Failure of emerg. HEPA filter subsystem & failure of human corrective action
H192
Failure of operator to detect (HEPA filter failure) and mitigate
EHUHEPAF
Failure of 1 of 2 emergency HEPA filter subsystems
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EFLHF1UM
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H202
Failure of HF-1T subsystem components that impedes air
H285
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HEPA filter HF-1T subsystem in maintenance
EFLHF1TM
Failure of emer. exhaust air fans subsystem & failure of human corrective action
H193
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Failure of normally-closed isolation damper to change state
EIDNCEXF
Failure of normally-open isolation damper to change state
PIDNOEXF
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Failure of emerg. supply side tornado dampers & human corrective action
H347
Failure of 2 of 3 emergency supply-side tornado dampers
H350
Page 28
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EHUTDSUF
Fail. of emerg. AHU subsystem to provide unimpeded air path & human corr. action
H348
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Failure of emerg. air supply fans subsystem & failure of human corrective action
H349
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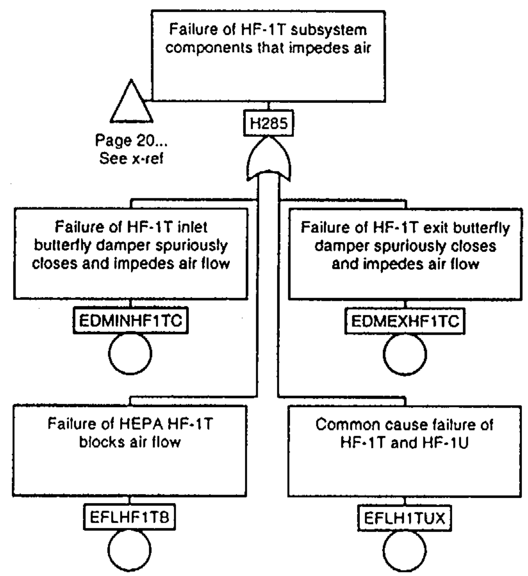
Failure of HF-1T subsystem components that impedes air
H285
Page 20...
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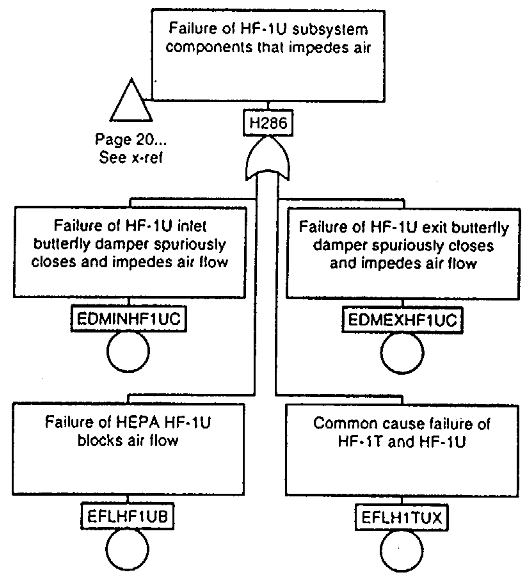
Failure of HF-1T inlet butterfly damper spuriously closes and impedes air flow
EDMINHF1TC
Failure of HF-1T exit butterfly damper spuriously closes and impedes air flow
EDMEXHF1TC
Failure of HEPA HF-1T blocks air flow
EFLHF1TB
Common cause failure of HF-1T and HF-1U
EFLH1TUX


Failure of HF-1U subsystem components that impedes air
H286
Page 20...
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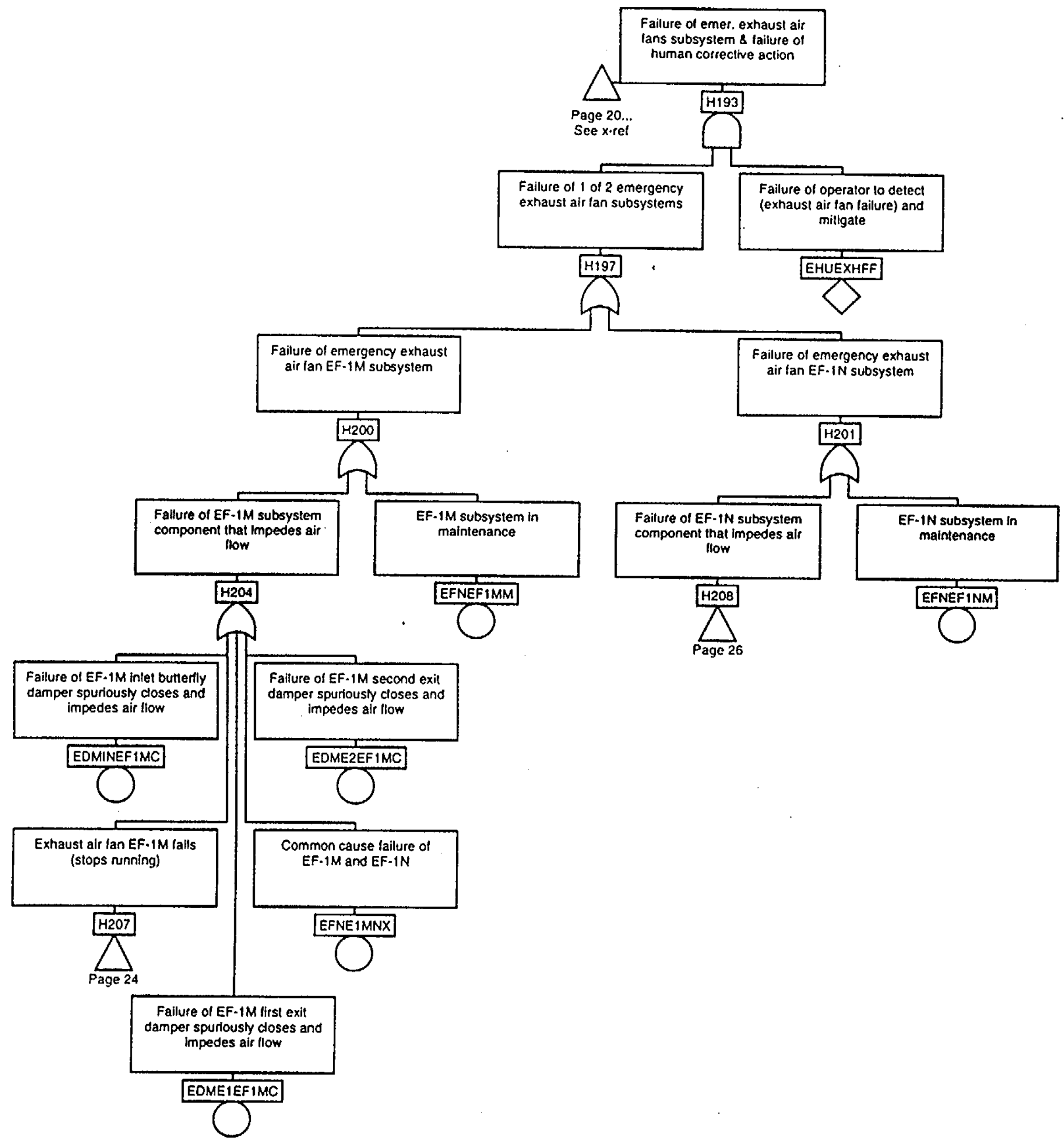
Failure of HF-1U inlet butterfly damper spuriously closes and impedes air flow
EDMINHF1UC
Failure of HF-1U exit butterfly damper spuriously closes and impedes air flow
EDMEXHF1UC
Failure of HEPA HF-1U blocks air flow
EFLHF1UB
Common cause failure of HF-1T and HF-1U
EFLH1TUX


Failure of emer. exhaust air fans subsystem & failure of human corrective action
Page 20... See x-ref
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Failure of 1 of 2 emergency exhaust air fan subsystems
Failure of operator to detect (exhaust air fan failure) and mitigate
H197
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Failure of emergency exhaust air fan EF-1N subsystem
H200
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EF-1M subsystem in maintenance
Failure of EF-1N subsystem component that impedes air flow
EF-1N subsystem in maintenance
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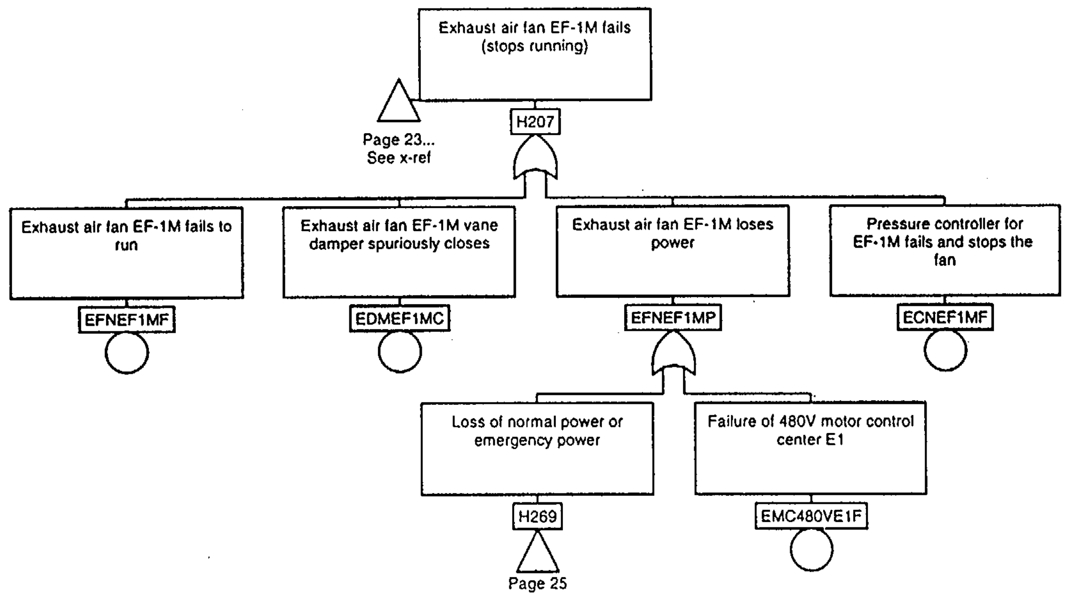
Failure of EF-1M inlet butterfly damper spuriously closes and impedes air flow
Failure of EF-1M second exit damper spuriously closes and impedes air flow
EDMINEF1MC
EDME2EF1MC
Exhaust air fan EF-1M fails (stops running)
Common cause failure of EF-1M and EF-1N
H207
Page 24
EFNE1MNX
Failure of EF-1M first exit damper spuriously closes and impedes air flow
EDME1EF1MC


Exhaust air fan EF-1M fails (stops running)
H207
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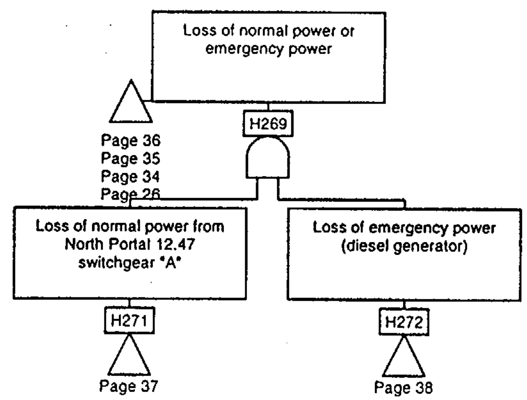
Exhaust air fan EF-1M fails to run
EFNEF1MF
Exhaust air fan EF-1M vane damper spuriously closes
EDMEF1MC
Exhaust air fan EF-1M loses power
EFNEF1MP
Pressure controller for EF-1M fails and stops the fan
ECNEF1MF
Loss of normal power or emergency power
H269
Page 25
Failure of 480V motor control center E1
EMC480VE1F


Loss of normal power or emergency power
H269
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Loss of normal power from North Portal 12.47 switchgear "A"
Loss of emergency power (diesel generator)
H271
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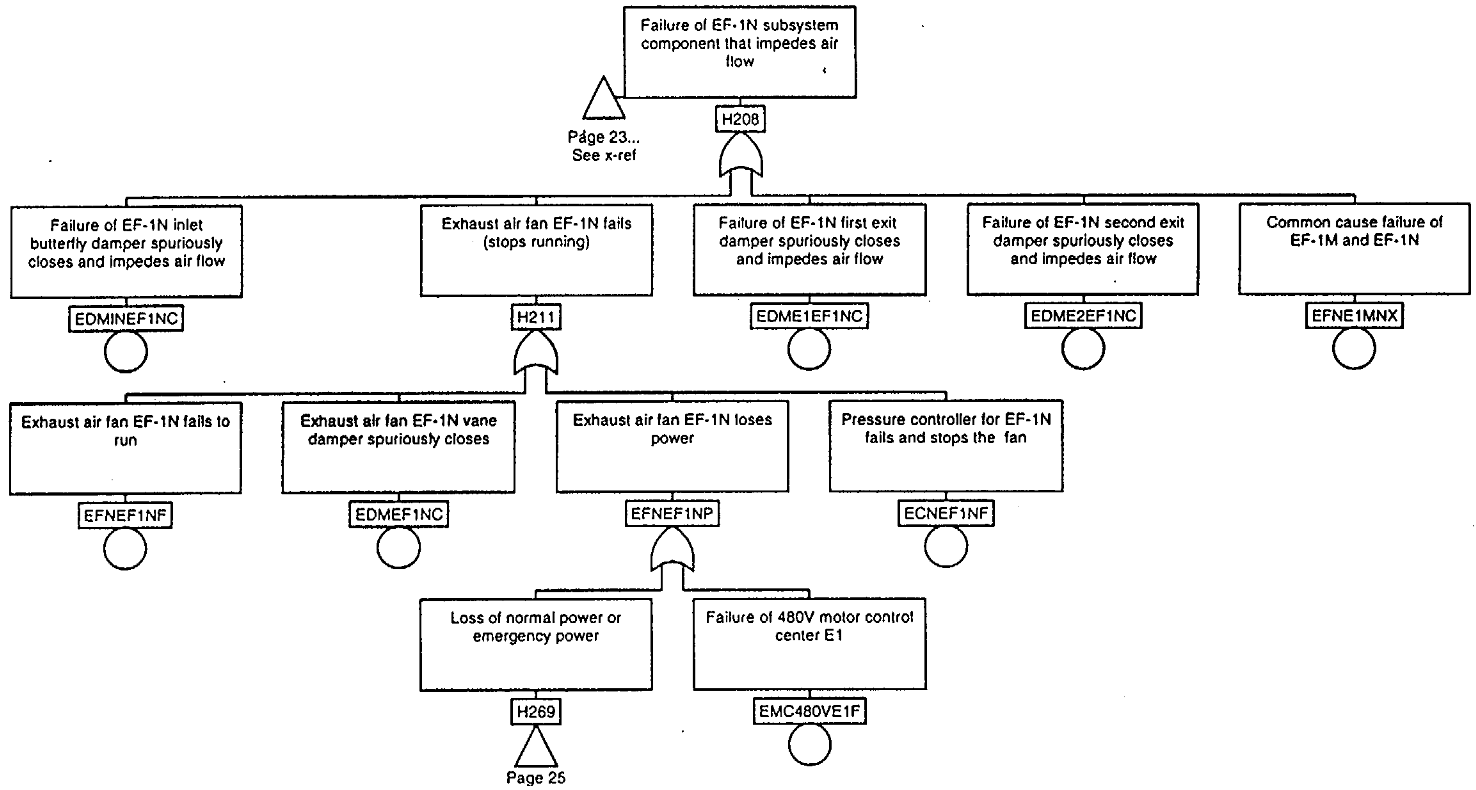
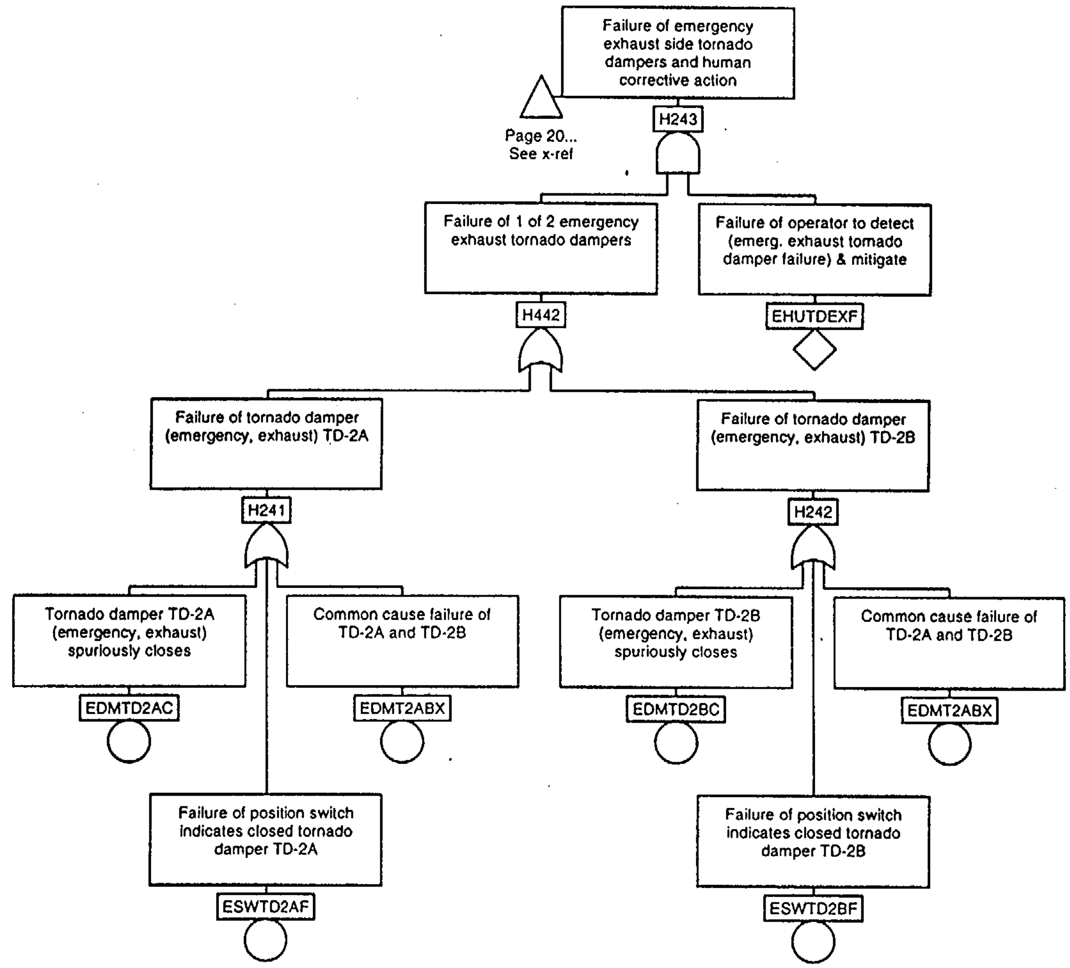

Failure of EF-1N subsystem component that impedes air flow
H208
Page 23... See x-ref
Failure of EF-1N inlet butterfly damper spuriously closes and impedes air flow
EDMINEF1NC
Exhaust air fan EF-1N fails (stops running)
H211
Failure of EF-1N first exit damper spuriously closes and impedes air flow
EDME1EF1NC
Failure of EF-1N second exit damper spuriously closes and impedes air flow
EDME2EF1NC
Common cause failure of EF-1M and EF-1N
EFNE1MNX
Exhaust air fan EF-1N fails to run
EFNEF1NF
Exhaust air fan EF-1N vane damper spuriously closes
EDMEF1NC
Exhaust air fan EF-1N loses power
EFNEF1NP
Pressure controller for EF-1N fails and stops the fan
ECNEF1NF
Loss of normal power or emergency power
H269
Page 25
Failure of 480V motor control center E1
EMC480VE1F


Failure of emergency exhaust side tornado dampers and human corrective action
H243
Page 20...
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Failure of 1 of 2 emergency exhaust tornado dampers
H442
Failure of operator to detect (emerg. exhaust tornado damper failure) & mitigate
EHUTDEXF
Failure of tornado damper (emergency, exhaust) TD-2A
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Failure of tornado damper (emergency, exhaust) TD-2B
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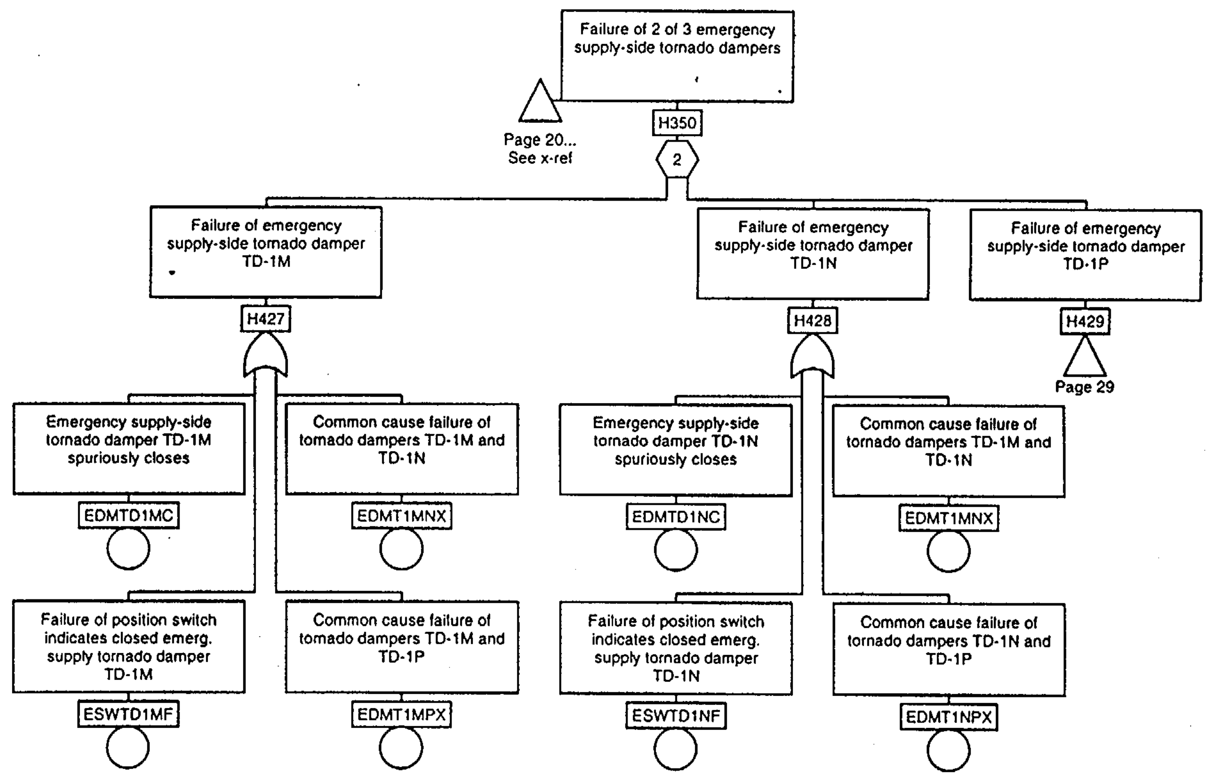
Tornado damper TD-2A (emergency, exhaust) spuriously closes
EDMTD2AC
Common cause failure of TD-2A and TD-2B
EDMT2ABX
Tornado damper TD-2B (emergency, exhaust) spuriously closes
EDMTD2BC
Common cause failure of TD-2A and TD-2B
EDMT2ABX
Failure of position switch indicates closed tornado damper TD-2A
ESWTD2AF
Failure of position switch indicates closed tornado damper TD-2B
ESWTD2BF


Failure of 2 of 3 emergency supply-side tornado dampers
Page 20...
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2
Failure of emergency supply-side tornado damper TD-1M
H427
Failure of emergency supply-side tornado damper TD-1N
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Failure of emergency supply-side tornado damper TD-1P
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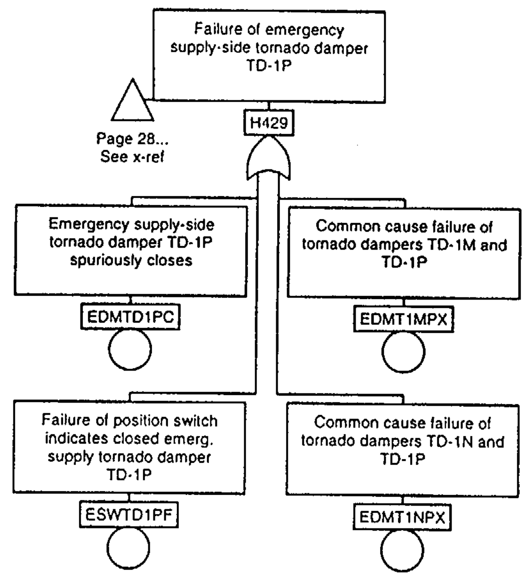
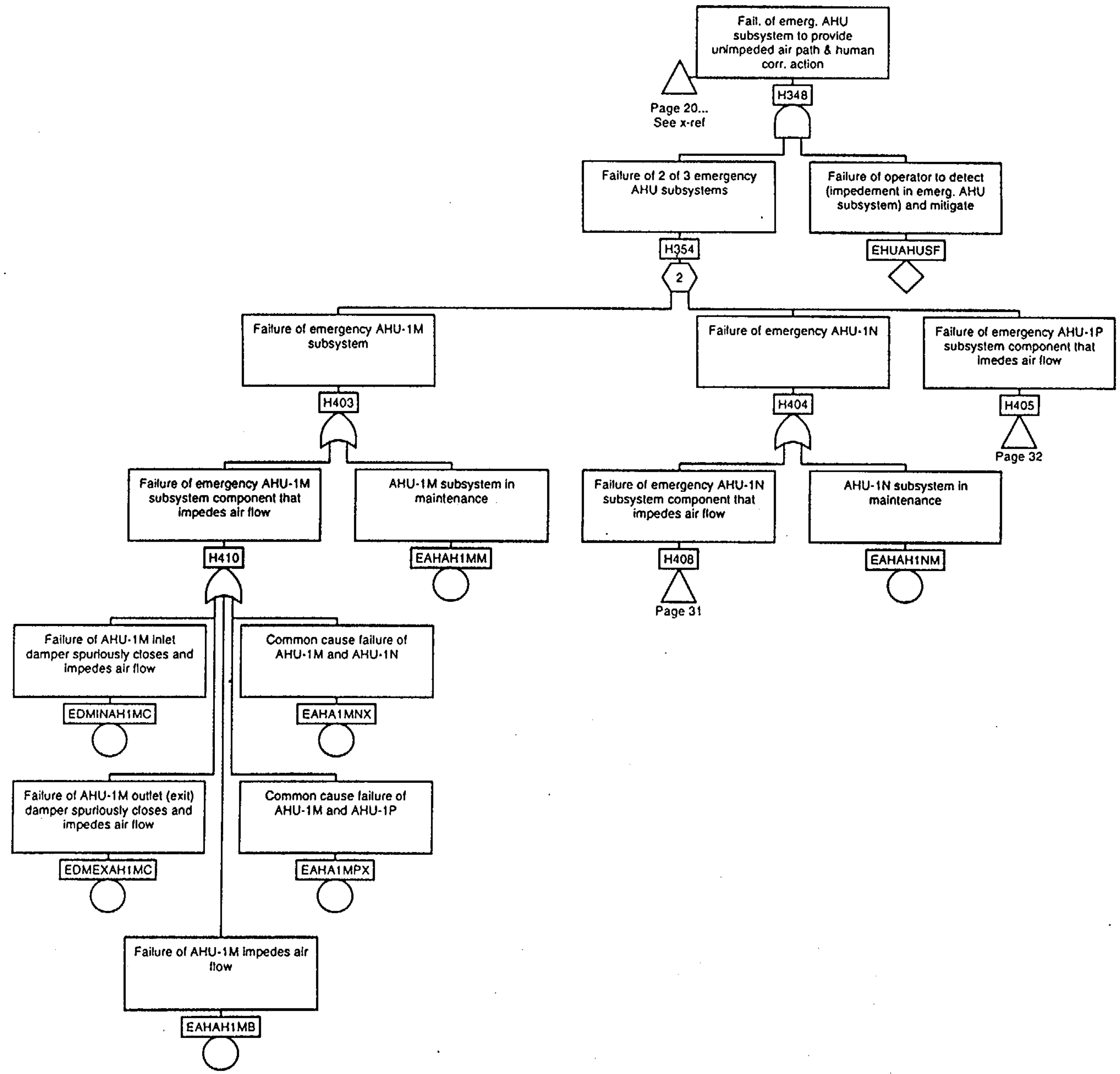
EDMTD1MC
Common cause failure of tornado dampers TD-1M and TD-1N
EDMT1MNX
Failure of position switch indicates closed emerg. supply tornado damper TD-1M
ESWTD1MF
Common cause failure of tornado dampers TD-1M and TD-1P
EDMT1MPX
Emergency supply-side tornado damper TD-1N spuriously closes
EDMTD1NC
Common cause failure of tornado dampers TD-1M and TD-1N
EDMT1MNX
Failure of position switch indicates closed emerg. supply tornado damper TD-1N
ESWTD1NF
Common cause failure of tornado dampers TD-1N and TD-1P
EDMT1NPX


Failure of emergency supply-side tornado damper TD-1P
H429
Page 28... See x-ref
Emergency supply-side tornado damper TD-1P spuriously closes
EDMTD1PC
Common cause failure of tornado dampers TD-1M and TD-1P
EDMT1MPX
Failure of position switch indicates closed emerg. supply tornado damper TD-1P
ESWTD1PF
Common cause failure of tornado dampers TD-1N and TD-1P
EDMT1NPX


Fail. of emerg. AHU subsystem to provide unimpeded air path & human corr. action
H348
Page 20... See x-ref
Failure of 2 of 3 emergency AHU subsystems
H354
2
Failure of operator to detect (impedement in emerg. AHU subsystem) and mitigate
EHUAHUSF
Failure of emergency AHU-1M subsystem
H403
Failure of emergency AHU-1N
H404
Failure of emergency AHU-1P subsystem component that imedes air flow
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H410
AHU-1M subsystem in maintenance
EAHAH1MM
Failure of emergency AHU-1N subsystem component that impedes air flow
H408
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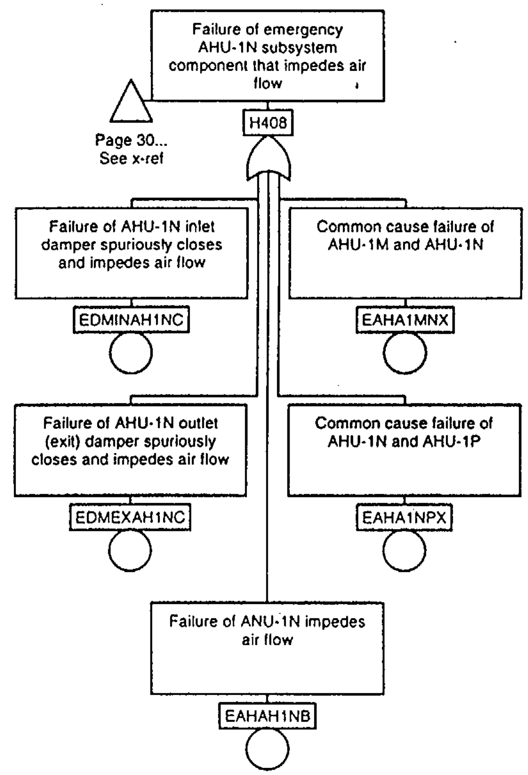
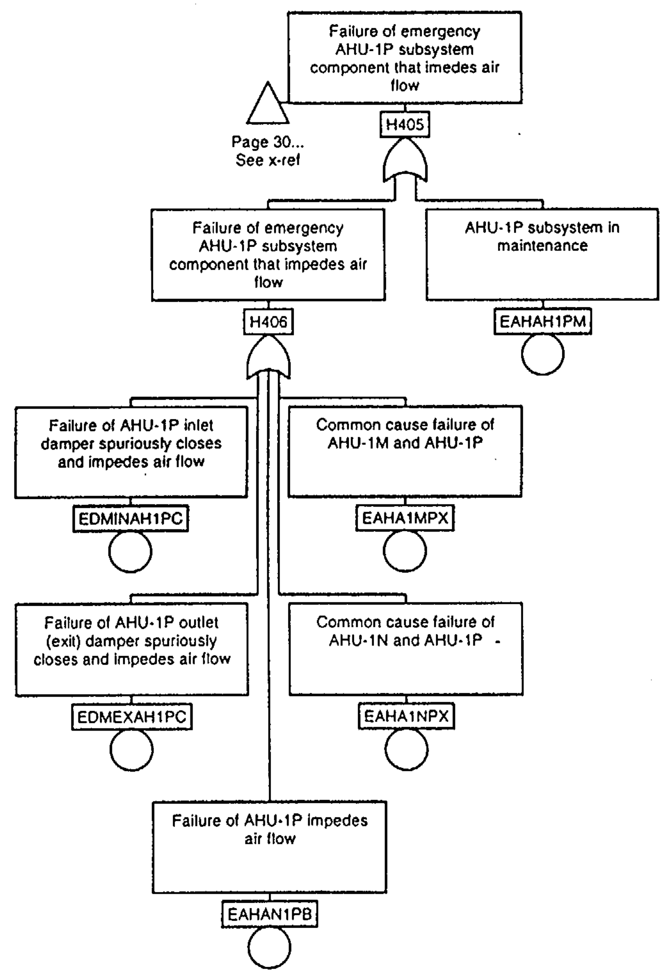
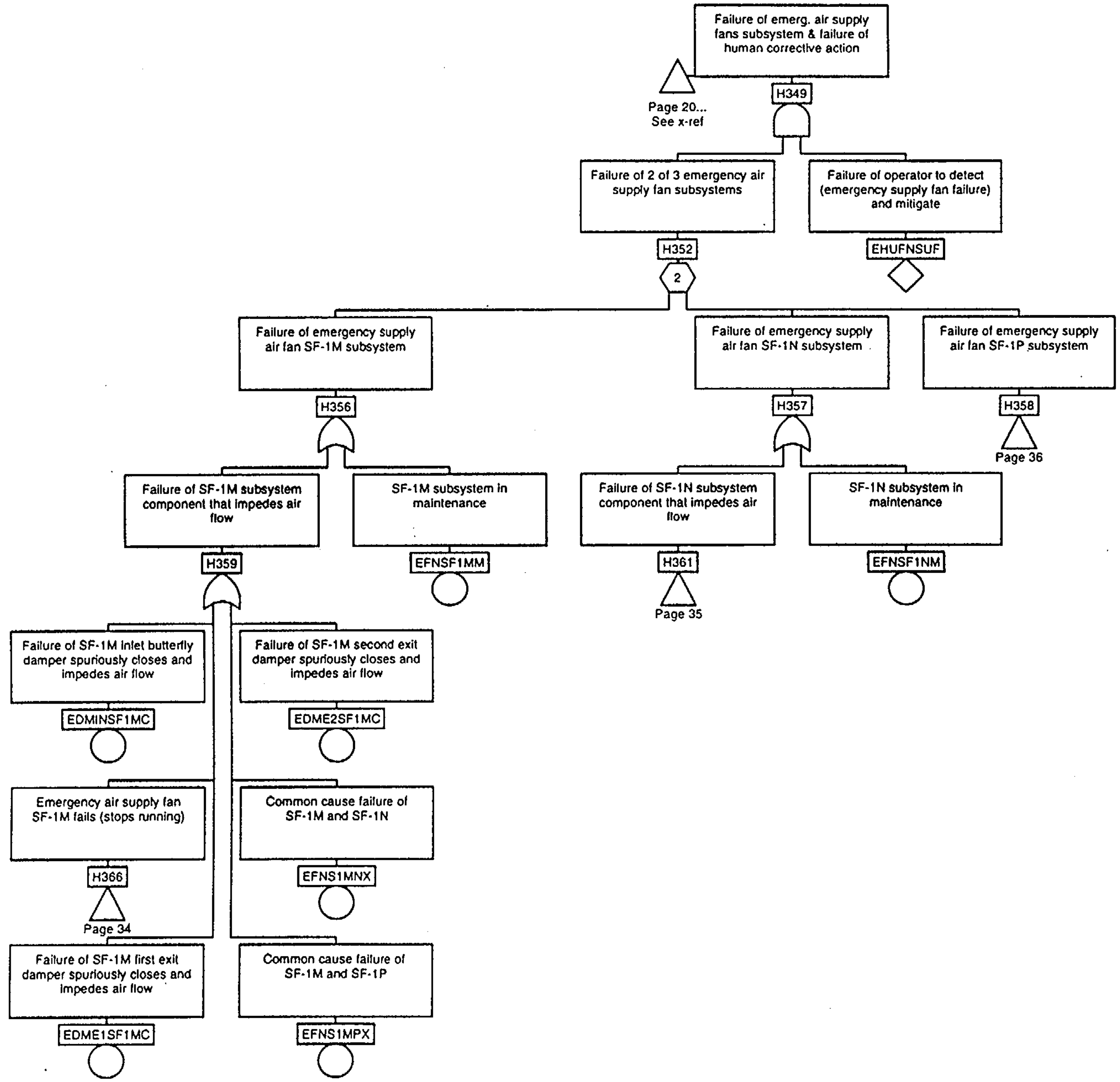
AHU-1N subsystem in maintenance
EAHAH1NM
Failure of AHU-1M inlet damper spuriously closes and impedes air flow
EDMINAH1MC
Common cause failure of AHU-1M and AHU-1N
EAHA1MNX
Failure of AHU-1M outlet (exit) damper spuriously closes and impedes air flow
EDMEXAH1MC
Common cause failure of AHU-1M and AHU-1P
EAHA1MPX
Failure of AHU-1M impedes air flow
EAHAH1MB


Failure of emergency AHU-1N subsystem component that impedes air flow
H408
Page 30...
See x-ref
Failure of AHU-1N inlet damper spuriously closes and impedes air flow
EDMINAH1NC
Common cause failure of AHU-1M and AHU-1N
EAHA1MNX
Failure of AHU-1N outlet (exit) damper spuriously closes and impedes air flow
EDMEXAH1NC
Common cause failure of AHU-1N and AHU-1P
EAHA1NPX
Failure of ANU-1N impedes air flow
EAHAH1NB


Failure of emergency AHU-1P subsystem component that imedes air flow
H405
Page 30... See x-ref
Failure of emergency AHU-1P subsystem component that impedes air flow
H406
AHU-1P subsystem in maintenance
EAHAH1PM
Failure of AHU-1P inlet damper spuriously closes and impedes air flow
EDMINAH1PC
Common cause failure of AHU-1M and AHU-1P
EAHA1MPX
Failure of AHU-1P outlet (exit) damper spuriously closes and impedes air flow
EDMEXAH1PC
Common cause failure of AHU-1N and AHU-1P
EAHA1NPX
Failure of AHU-1P impedes air flow
EAHAN1PB


Failure of emerg. air supply fans subsystem & failure of human corrective action
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H349
Failure of 2 of 3 emergency air supply fan subsystems
H352
2
Failure of operator to detect (emergency supply fan failure) and mitigate
EHUFNSUF
Failure of emergency supply air fan SF-1M subsystem
H356
Failure of emergency supply air fan SF-1N subsystem
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Failure of emergency supply air fan SF-1P subsystem
H358
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Failure of SF-1M subsystem component that impedes air flow
H359
SF-1M subsystem in maintenance
EFNSF1MM
Failure of SF-1N subsystem component that impedes air flow
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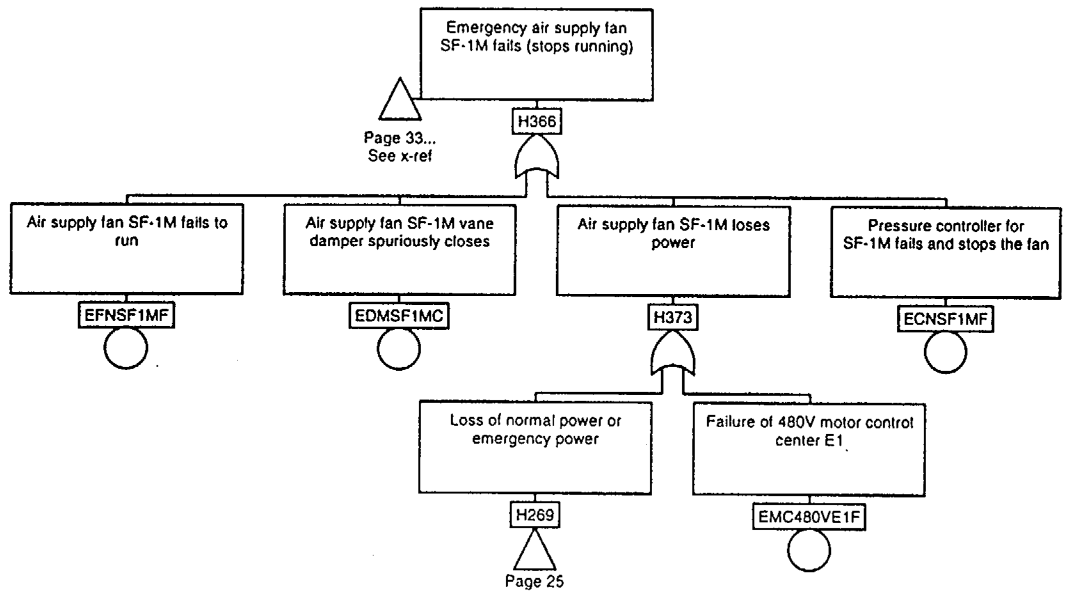
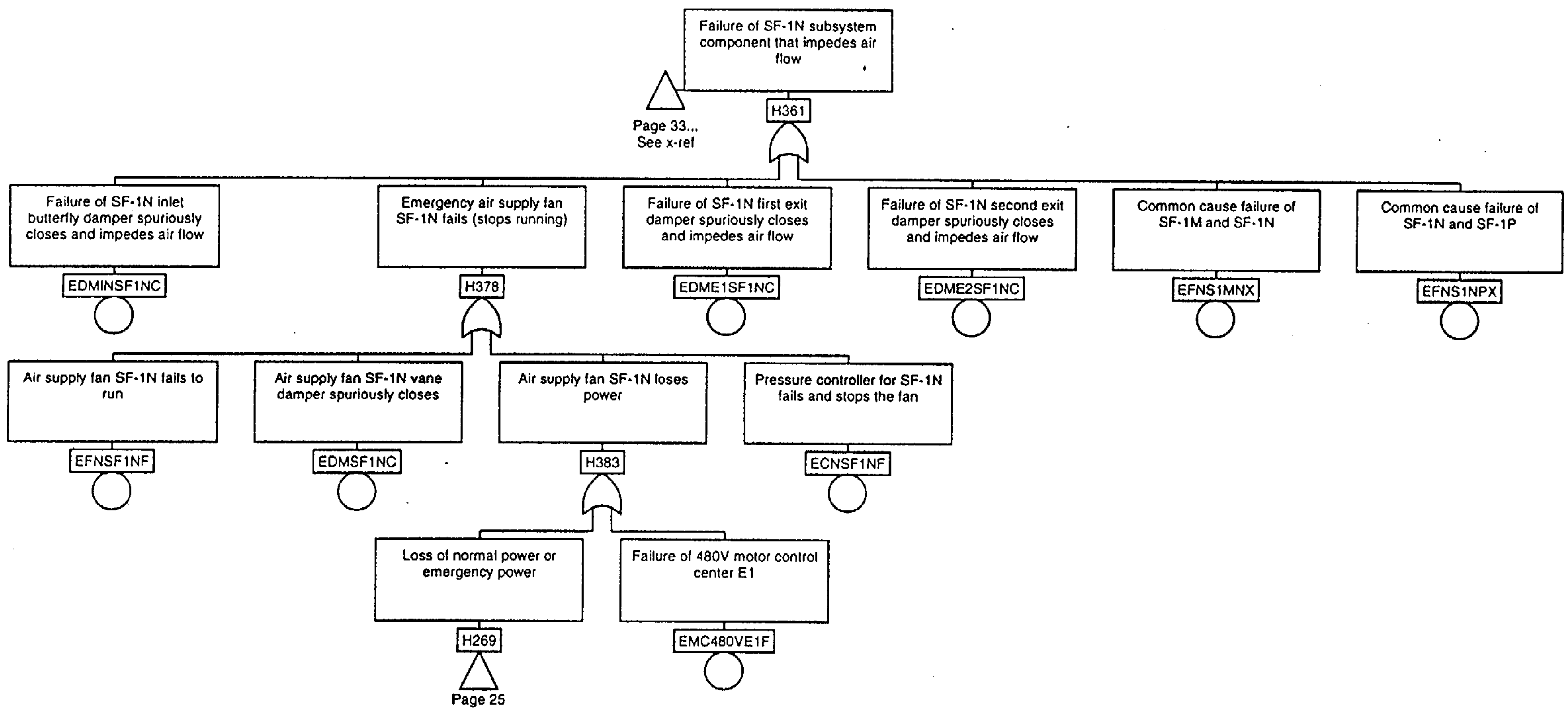
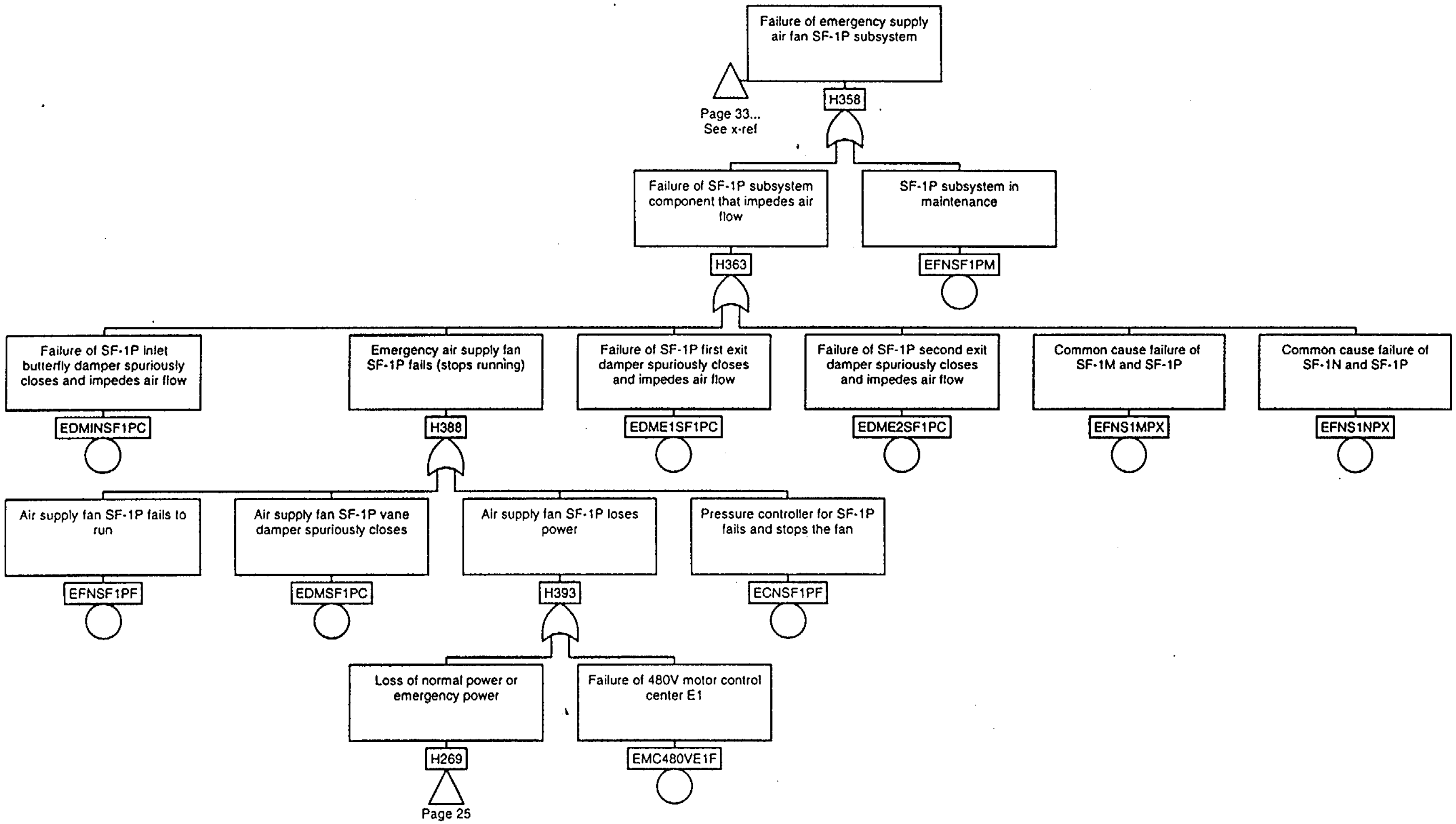
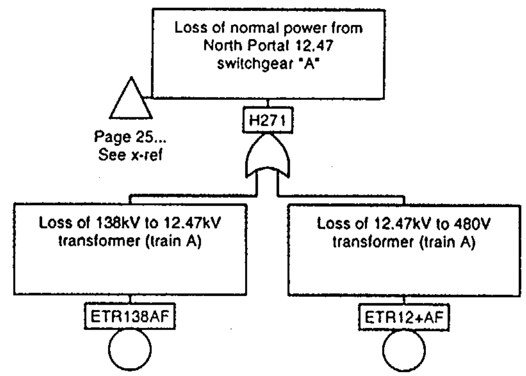
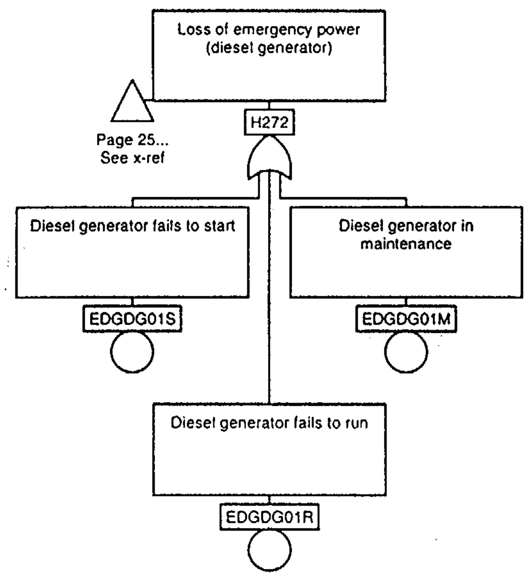
Page 35
SF-1N subsystem in maintenance
EFNSF1NM
Failure of SF-1M inlet butterfly damper spuriously closes and impedes air flow
EDMINSF1MC
Failure of SF-1M second exit damper spuriously closes and impedes air flow
EDME2SF1MC
Emergency air supply fan SF-1M fails (stops running)
H366
Page 34
Common cause failure of SF-1M and SF-1N
EFNS1MNX
Failure of SF-1M first exit damper spuriously closes and impedes air flow
EDME1SF1MC
Common cause failure of SF-1M and SF-1P
EFNS1MPX

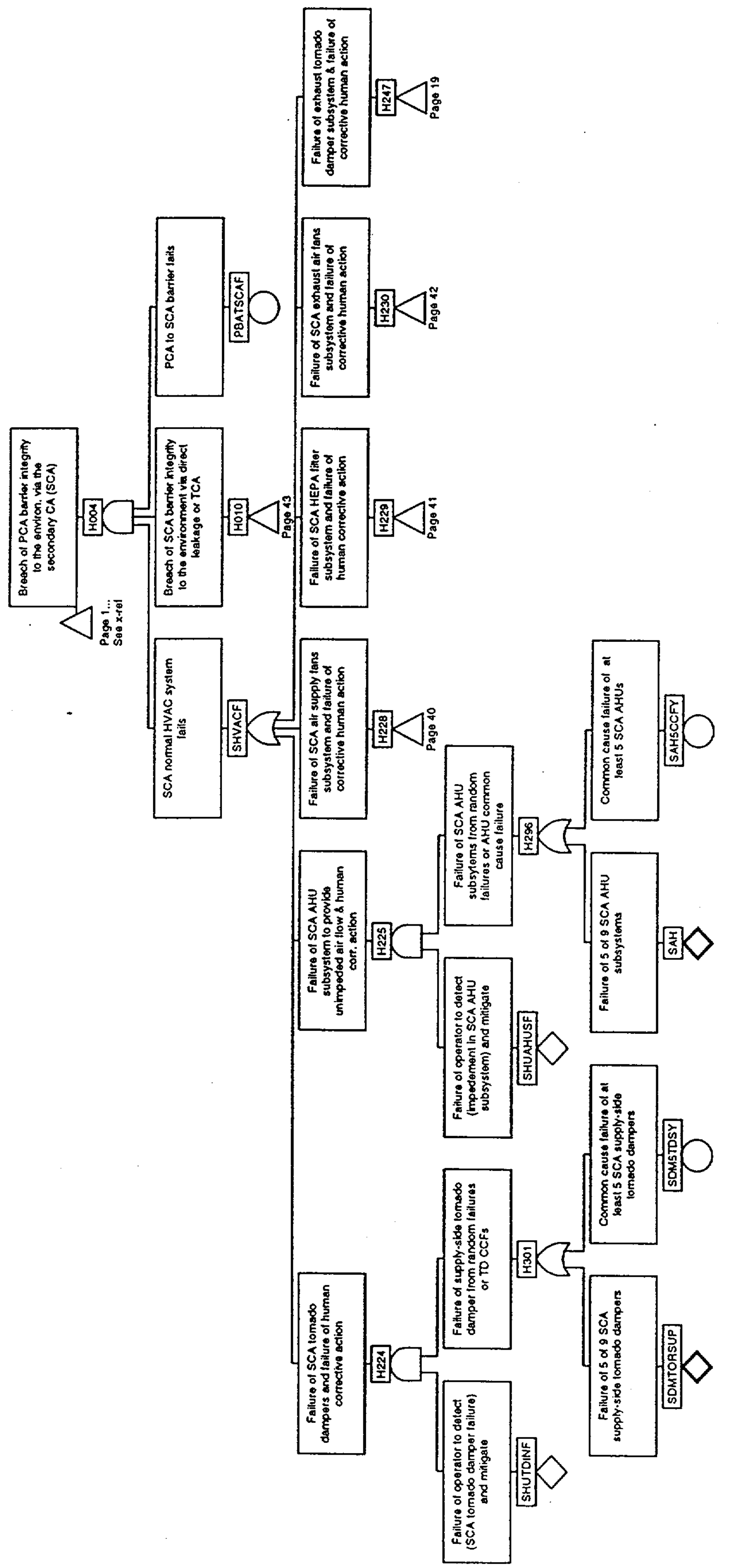

Emergency air supply fan SF-1M fails (stops running)
Page 33... See x-ref
H366
Air supply fan SF-1M fails to run
EFNSF1MF
Air supply fan SF-1M vane damper spuriously closes
EDMSF1MC
Air supply fan SF-1M loses power
H373
Pressure controller for SF-1M fails and stops the fan
ECNSF1MF
Loss of normal power or emergency power
H269
Page 25
Failure of 480V motor control center E1
EMC480VE1F

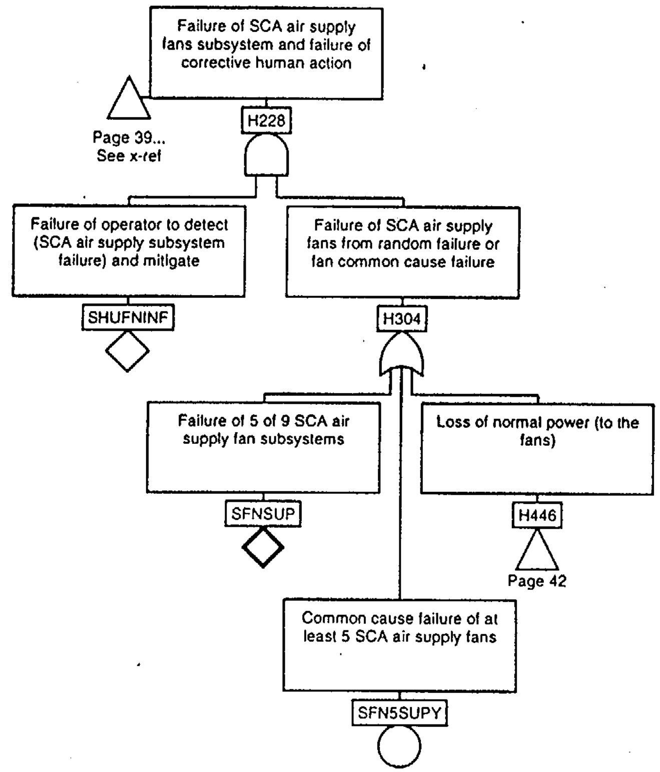

Failure of SF-1N subsystem component that impedes air flow
H361
Page 33... See x-ref
Failure of SF-1N inlet butterfly damper spuriously closes and impedes air flow
EDMINSF1NC
Emergency air supply fan SF-1N fails (stops running)
H378
Failure of SF-1N first exit damper spuriously closes and impedes air flow
EDME1SF1NC
Failure of SF-1N second exit damper spuriously closes and impedes air flow
EDME2SF1NC
Common cause failure of SF-1M and SF-1N
EFNS1MNX
Common cause failure of SF-1N and SF-1P
EFNS1NPX
Air supply fan SF-1N fails to run
EFNSF1NF
Air supply fan SF-1N vane damper spuriously closes
EDMSF1NC
Air supply fan SF-1N loses power
H383
Pressure controller for SF-1N fails and stops the fan
ECNSF1NF
Loss of normal power or emergency power
H269
Page 25
Failure of 480V motor control center E1
EMC480VE1F

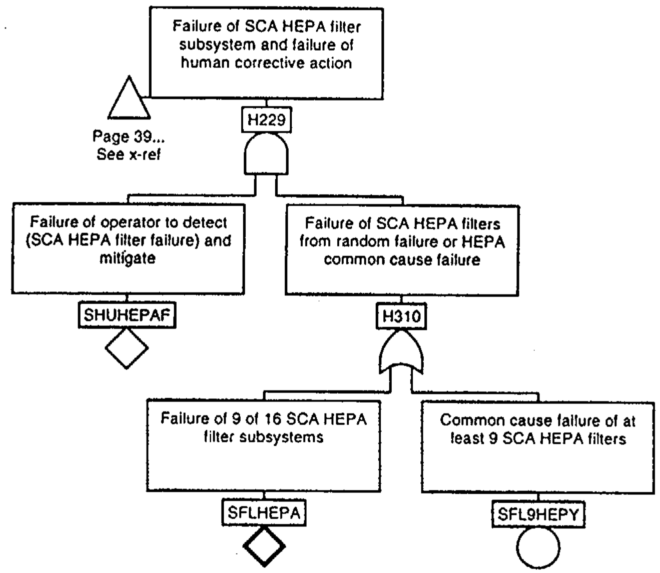

Failure of emergency supply air fan SF-1P subsystem
Page 33... See x-ref
H358
Failure of SF-1P subsystem component that impedes air flow
H363
SF-1P subsystem in maintenance
EFNSF1PM
Failure of SF-1P inlet butterfly damper spuriously closes and impedes air flow
EDMINSF1PC
Emergency air supply fan SF-1P fails (stops running)
H388
Failure of SF-1P first exit damper spuriously closes and impedes air flow
EDME1SF1PC
Failure of SF-1P second exit damper spuriously closes and impedes air flow
EDME2SF1PC
Common cause failure of SF-1M and SF-1P
EFNS1MPX
Common cause failure of SF-1N and SF-1P
EFNS1NPX
Air supply fan SF-1P fails to run
EFNSF1PF
Air supply fan SF-1P vane damper spuriously closes
EDMSF1PC
Air supply fan SF-1P loses power
H393
Pressure controller for SF-1P fails and stops the fan
ECNSF1PF
Loss of normal power or emergency power
H269
Page 25
Failure of 480V motor control center E1
EMC480VE1F

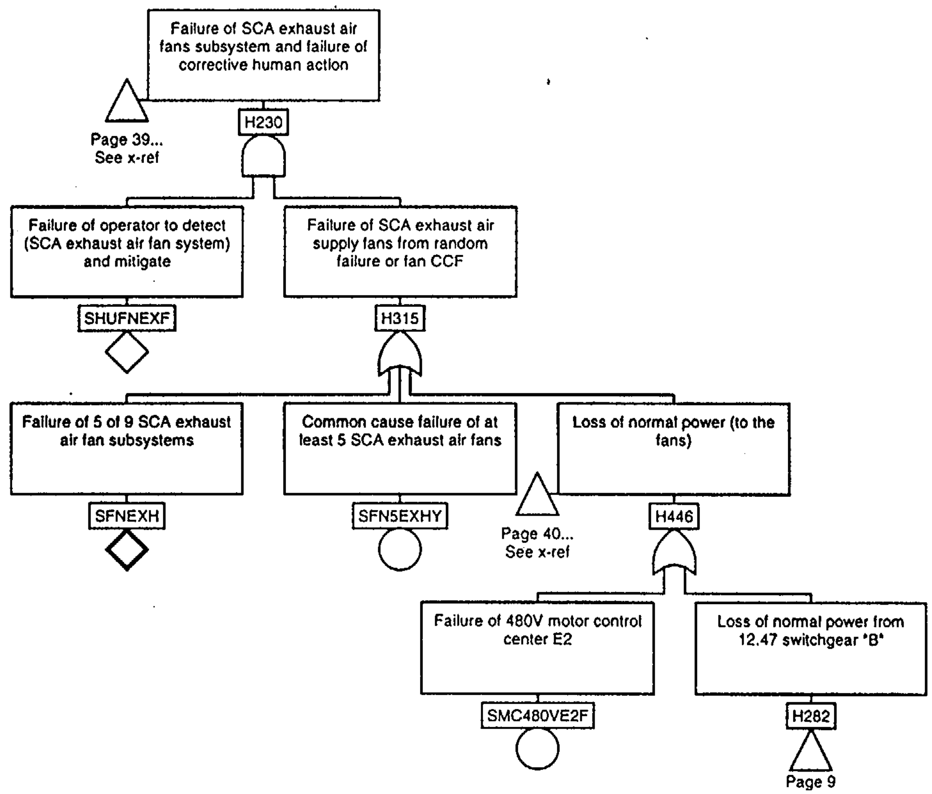

Loss of normal power from North Portal 12.47 switchgear "A"
H271
Page 25... See x-ref
Loss of 138kV to 12.47kV transformer (train A)
ETR138AF
Loss of 12.47kV to 480V transformer (train A)
ETR12+AF

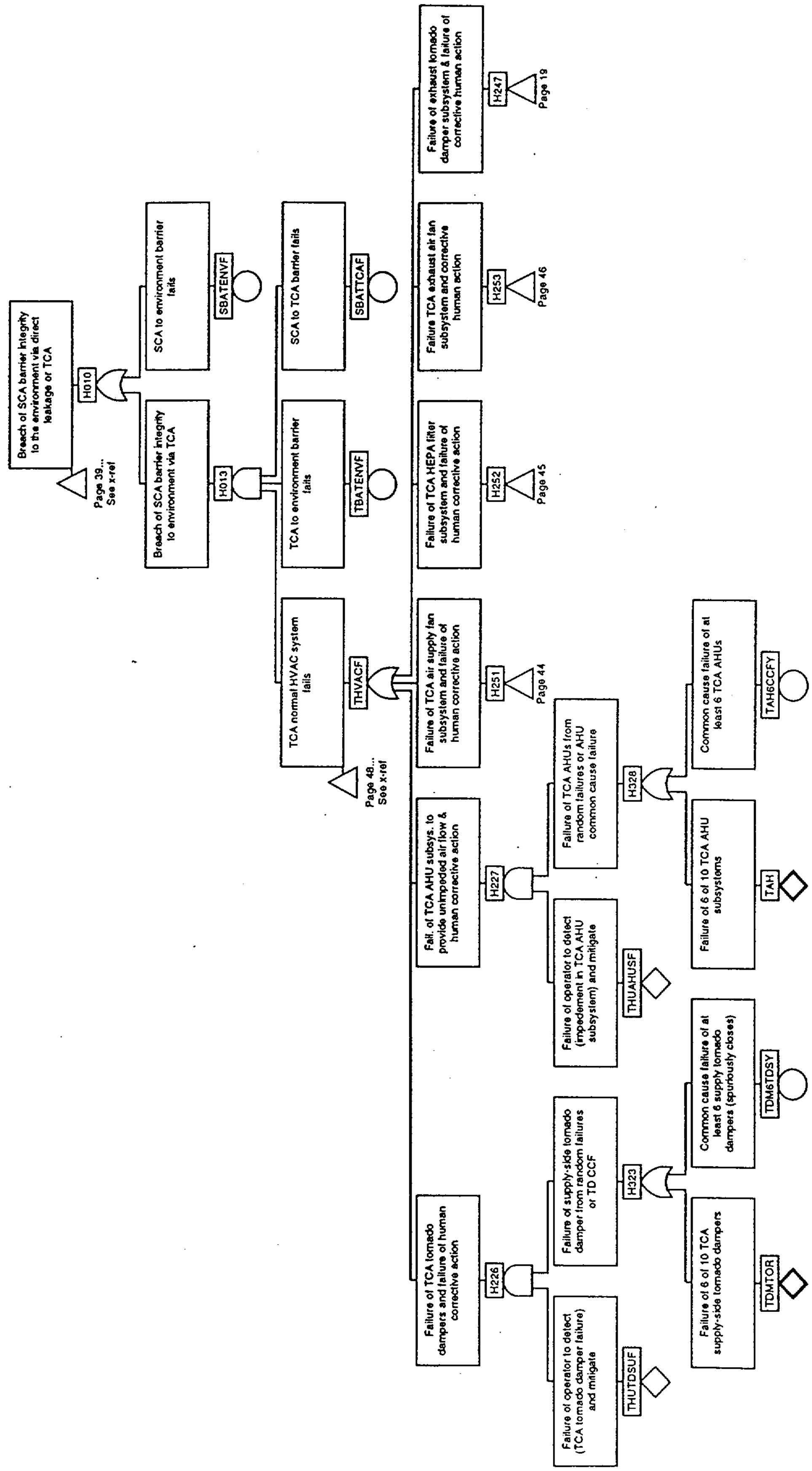

Loss of emergency power (diesel generator)
H272
Page 25...
See x-ref
Diesel generator fails to start
EDGDG01S
Diesel generator in maintenance
EDGDG01M
Diesel generator fails to run
EDGDG01R

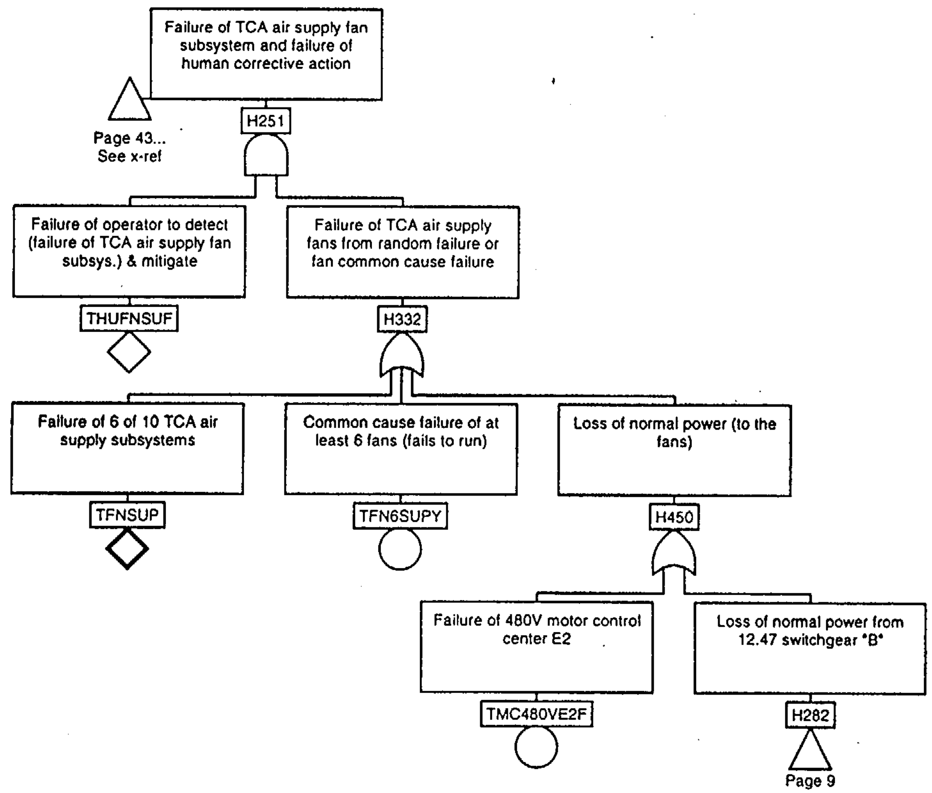

Breach of PCA barrier integrity to the environ. via the secondary CA (SCA)
H004
Page 1... See x-ref
SCA normal HVAC system fails
SHVACF
Breach of SCA barrier integrity to the environment via direct leakage or TCA
H010
Page 43
PCA to SCA barrier fails
PBATSCAF
Failure of SCA tornado dampers and failure of human corrective action
H224
Failure of SCA AHU subsystem to provide unimpeded air flow & human corr. action
H225
Failure of SCA air supply fans subsystem and failure of corrective human action
H228
Page 40
Failure of SCA HEPA filter subsystem and failure of human corrective action
H229
Page 41
Failure of SCA exhaust air fans subsystem and failure of corrective human action
H230
Page 42
Failure of exhaust tornado damper subsystem & failure of corrective human action
H247
Page 19
Failure of operator to detect (SCA tornado damper failure) and mitigate
SHUTDINF
Failure of supply-side tornado damper from random failures or TD CCFs
H301
Failure of 5 of 9 SCA supply-side tornado dampers
SDMTORSUP
Common cause failure of at least 5 SCA supply-side tornado dampers
SDM5TDSY
Failure of operator to detect (impedement in SCA AHU subsystem) and mitigate
SHUAHUSF
Failure of SCA AHU subsystems from random failures or AHU common cause failure
H296
Failure of 5 of 9 SCA AHU subsystems
SAH
Common cause failure of at least 5 SCA AHUs
SAH5CCFY

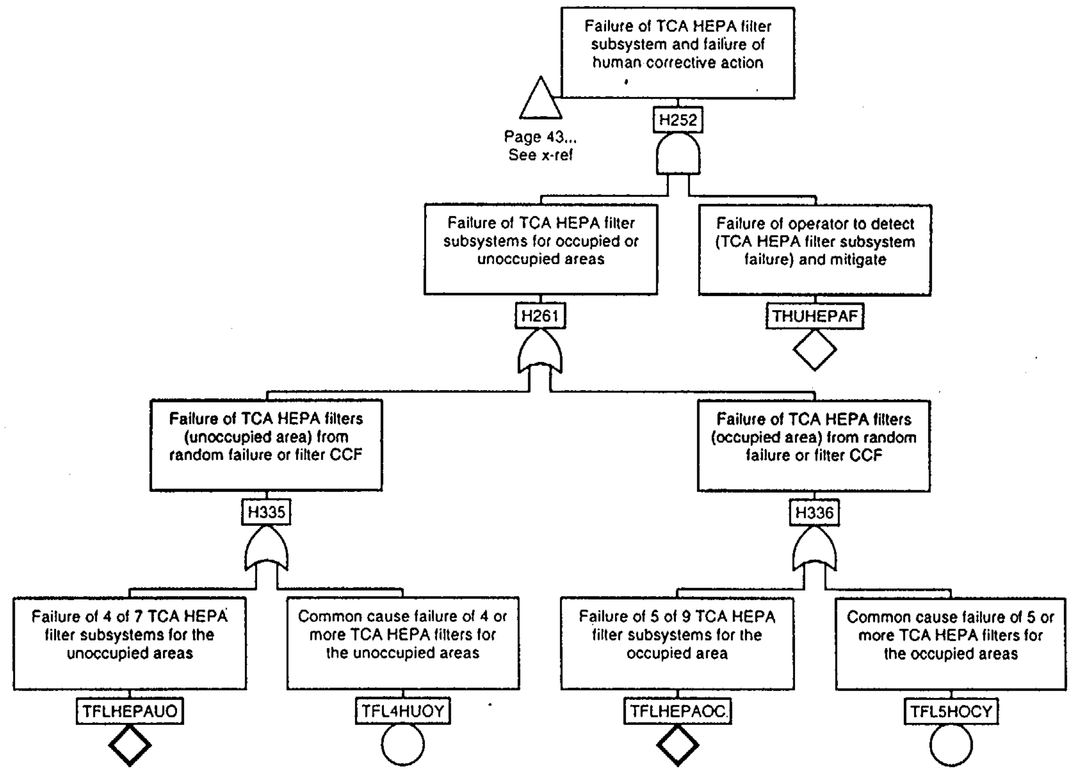

Failure of SCA air supply fans subsystem and failure of corrective human action
H228
Page 39... See x-ref
Failure of operator to detect (SCA air supply subsystem failure) and mitigate
SHUFNINF
Failure of SCA air supply fans from random failure or fan common cause failure
H304
Failure of 5 of 9 SCA air supply fan subsystems
SFNSUP
Loss of normal power (to the fans)
H446
Page 42
Common cause failure of at least 5 SCA air supply fans
SFN5SUPY

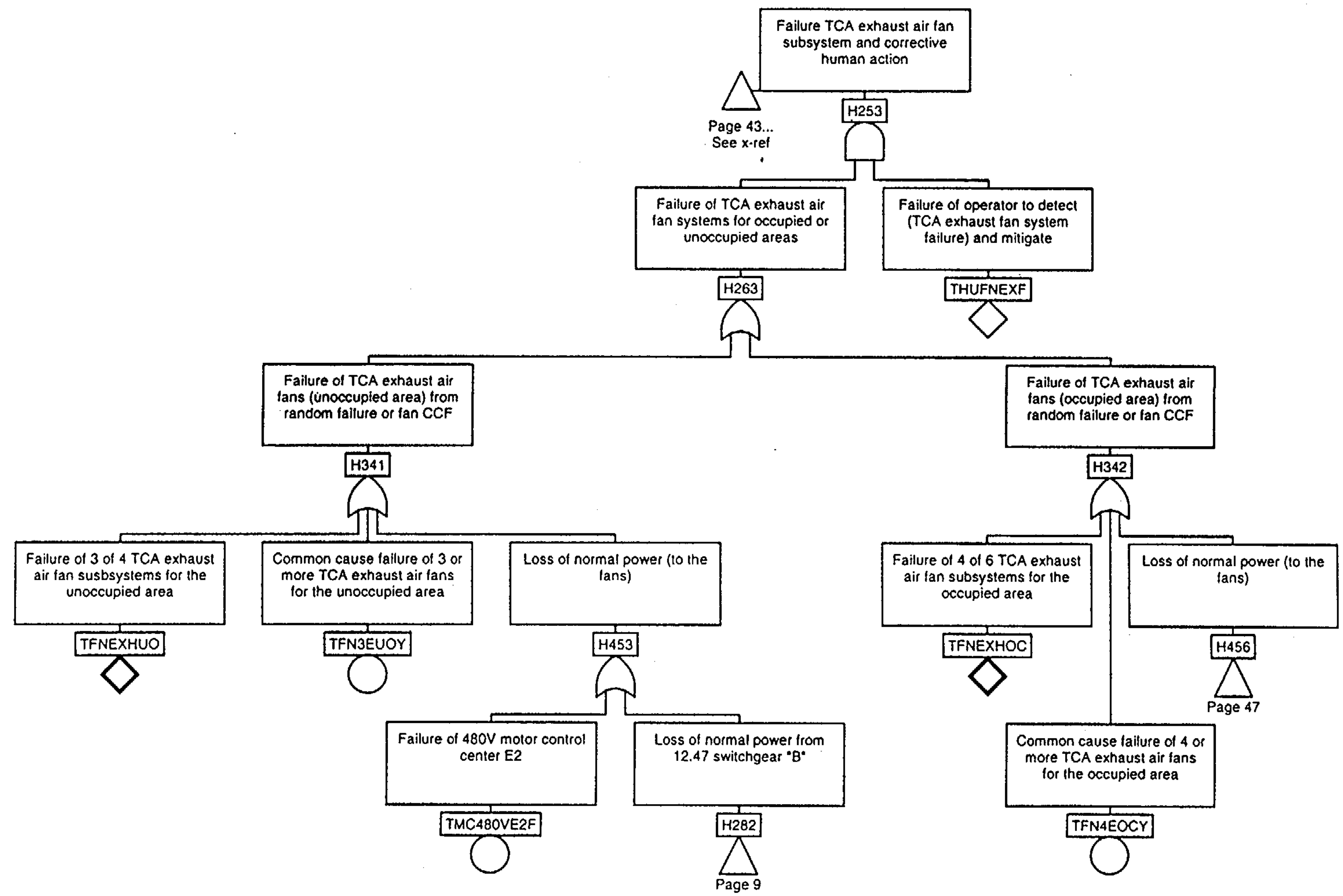

Failure of SCA HEPA filter subsystem and failure of human corrective action
Page 39...
See x-ref
H229
Failure of operator to detect (SCA HEPA filter failure) and mitigate
SHUHEPAF
Failure of SCA HEPA filters from random failure or HEPA common cause failure
H310
Failure of 9 of 16 SCA HEPA filter subsystems
SFLHEPA
Common cause failure of at least 9 SCA HEPA filters
SFL9HEPY

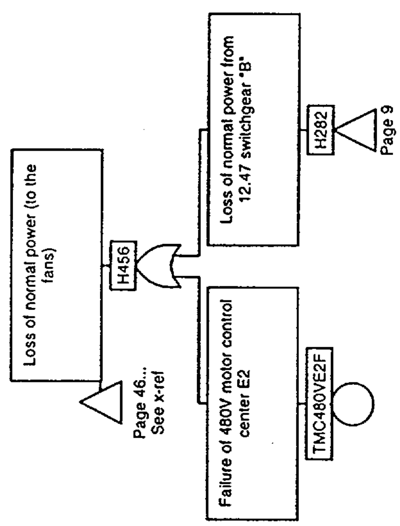

Failure of SCA exhaust air fans subsystem and failure of corrective human action
H230
Page 39... See x-ref
Failure of operator to detect (SCA exhaust air fan system) and mitigate
SHUFNEXF
Failure of SCA exhaust air supply fans from random failure or fan CCF
H315
Failure of 5 of 9 SCA exhaust air fan subsystems
SFNEXH
Common cause failure of at least 5 SCA exhaust air fans
SFN5EXHY
Page 40... See x-ref
Loss of normal power (to the fans)
H446
Failure of 480V motor control center E2
SMC480VE2F
Loss of normal power from 12.47 switchgear "B"
H282
Page 9

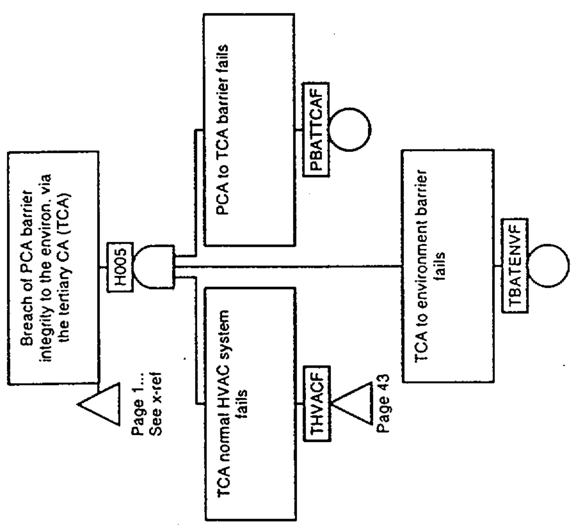

Breach of SCA barrier integrity to the environment via direct leakage or TCA
H010
Page 39... See x-ref
Breach of SCA barrier integrity to environment via TCA
H013
SCA to environment barrier fails
SBATENVF
TCA to environment barrier fails
TBATENVF
SCA to TCA barrier fails
SBATTCAF
TCA normal HVAC system fails
THVACF
Page 48... See x-ref
Failure of TCA air supply fan subsystem and failure of human corrective action
H251
Page 44
Failure of TCA HEPA filter subsystem and failure of human corrective action
H252
Page 45
Failure TCA exhaust air fan subsystem and corrective human action
H253
Page 46
Failure of exhaust tornado damper subsystem & failure of corrective human action
H247
Page 19
Fail. of TCA AHU subsys. to provide unimpeded air flow & human corrective action
H227
Failure of TCA AHUs from random failures or AHU common cause failure
H328
Common cause failure of at least 6 TCA AHUs
TAH6CCFY
Failure of 6 of 10 TCA AHU subsystems
TAH
Failure of operator to detect (impedement in TCA AHU subsystem) and mitigate
THUAHUSF
Failure of TCA tornado dampers and failure of human corrective action
H226
Failure of supply-side tornado damper from random failures or TD CCF
H323
Common cause failure of at least 6 supply tornado dampers (spuriously closes)
TDM6TDSY
Failure of 6 of 10 TCA supply-side tornado dampers
TDMTOR
Failure of operator to detect (TCA tornado damper failure) and mitigate
THUTDSUF


Failure of TCA air supply fan subsystem and failure of human corrective action
H251
Page 43... See x-ref
Failure of operator to detect (failure of TCA air supply fan subsys.) & mitigate
THUFNSUF
Failure of TCA air supply fans from random failure or fan common cause failure
H332
Failure of 6 of 10 TCA air supply subsystems
TFNSUP
Common cause failure of at least 6 fans (fails to run)
TFN6SUPY
Loss of normal power (to the fans)
H450
Failure of 480V motor control center E2
TMC480VE2F
Loss of normal power from 12.47 switchgear "B"
H282
Page 9

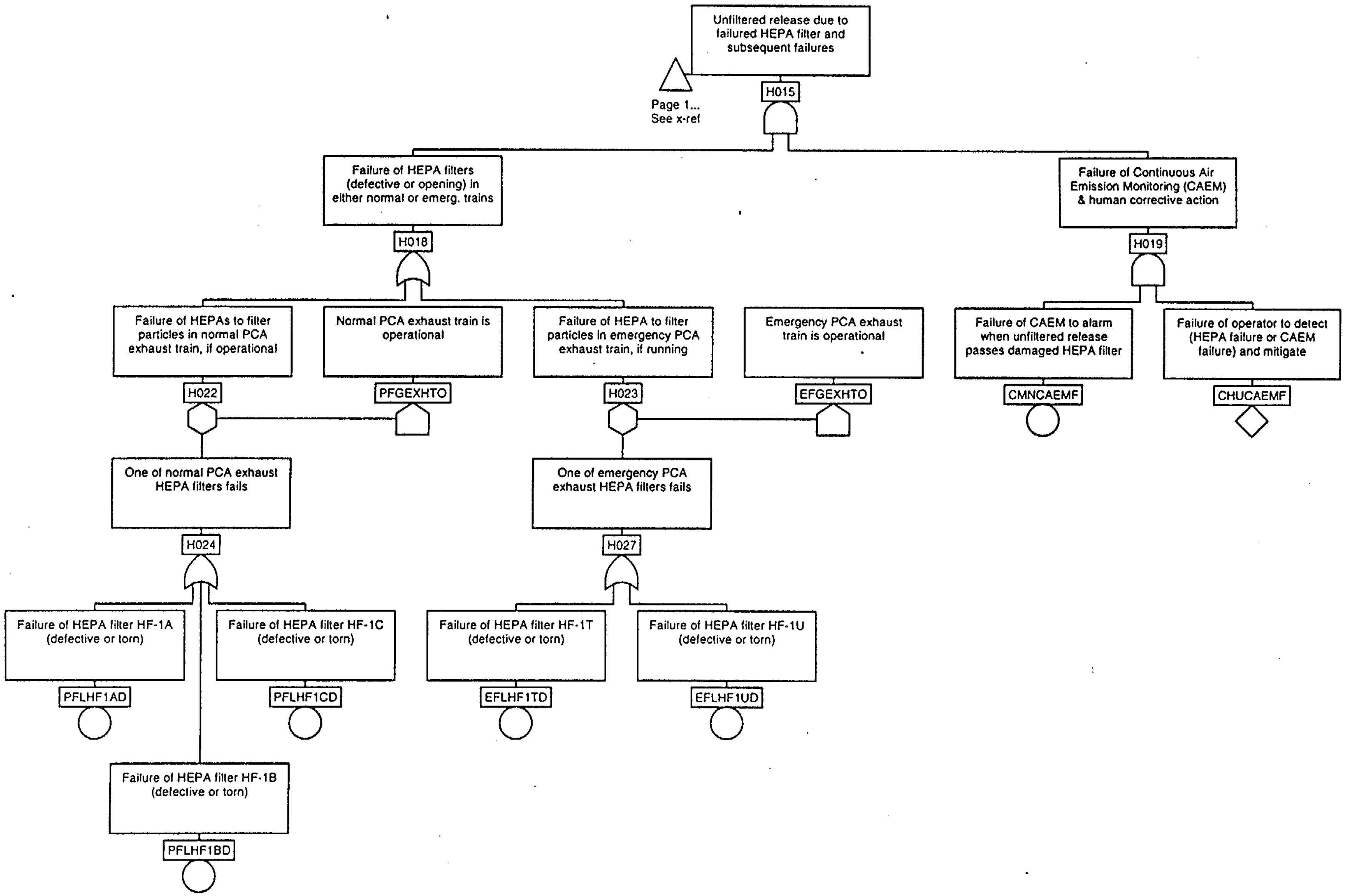

Failure of TCA HEPA filter subsystem and failure of human corrective action
Page 43... See x-ref
H252
Failure of TCA HEPA filter subsystems for occupied or unoccupied areas
H261
Failure of operator to detect (TCA HEPA filter subsystem failure) and mitigate
THUHEPAF
Failure of TCA HEPA filters (unoccupied area) from random failure or filter CCF
H335
Failure of TCA HEPA filters (occupied area) from random failure or filter CCF
H336
Failure of 4 of 7 TCA HEPA filter subsystems for the unoccupied areas
TFLHEPAUO
Common cause failure of 4 or more TCA HEPA filters for the unoccupied areas
TFL4HUOY
Failure of 5 of 9 TCA HEPA filter subsystems for the occupied area
TFLHEPAOC
Common cause failure of 5 or more TCA HEPA filters for the occupied areas
TFL5HOCY


Failure TCA exhaust air fan subsystem and corrective human action
H253
Page 43... See x-ref
Failure of TCA exhaust air fan systems for occupied or unoccupied areas
H263
Failure of operator to detect (TCA exhaust fan system failure) and mitigate
THUFNEXF
Failure of TCA exhaust air fans (unoccupied area) from random failure or fan CCF
H341
Failure of TCA exhaust air fans (occupied area) from random failure or fan CCF
H342
Failure of 3 of 4 TCA exhaust air fan susbsystems for the unoccupied area
TFNEXHUO
Common cause failure of 3 or more TCA exhaust air fans for the unoccupied area
TFN3EUOY
Loss of normal power (to the fans)
H453
Failure of 4 of 6 TCA exhaust air fan subsystems for the occupied area
TFNEXHOC
Loss of normal power (to the fans)
H456
Page 47
Failure of 480V motor control center E2
TMC480VE2F
Loss of normal power from 12.47 switchgear "B"
H282
Page 9
Common cause failure of 4 or more TCA exhaust air fans for the occupied area
TFN4EOCY


Loss of normal power (to the fans)
H456
Page 46... See x-ref
Loss of normal power from 12.47 switchgear "B"
H282
Page 9
Failure of 480V motor control center E2
TMC480VE2F



Breach of PCA barrier integrity to the environ. via the tertiary CA (TCA)
H005
Page 1... See x-ref
PCA to TCA barrier fails
PBATTCAF
TCA normal HVAC system fails
THVACF
Page 43
TCA to environment barrier fails
TBATENVF



Unfiltered release due to failured HEPA filter and subsequent failures
H015
Page 1... See x-ref
Failure of HEPA filters (defective or opening) in either normal or emerg. trains
H018
Failure of Continuous Air Emission Monitoring (CAEM) & human corrective action
H019
Failure of HEPAs to filter particles in normal PCA exhaust train, if operational
H022
Normal PCA exhaust train is operational
PFGEXHTO
Failure of HEPA to filter particles in emergency PCA exhaust train, if running
H023
Emergency PCA exhaust train is operational
EFGEXHTO
Failure of CAEM to alarm when unfiltered release passes damaged HEPA filter
CMNCAEMF
Failure of operator to detect (HEPA failure or CAEM failure) and mitigate
CHUCAEMF
One of normal PCA exhaust HEPA filters fails
H024
One of emergency PCA exhaust HEPA filters fails
H027
Failure of HEPA filter HF-1A (defective or torn)
PFLHF1AD
Failure of HEPA filter HF-1C (defective or torn)
PFLHF1CD
Failure of HEPA filter HF-1T (defective or torn)
EFLHF1TD
Failure of HEPA filter HF-1U (defective or torn)
EFLHF1UD
Failure of HEPA filter HF-1B (defective or torn)
PFLHF1BD

ATTACHMENT II

WASTE HANDLING BUILDING HVAC CUTSETS

Cutset Report

UNFIL_REL = 1.72E-07 (Probability)

Probability	%	Class	Inputs						
2.18E-08	12.7%		CDM8TDEY	CHUTDEXF	EIDNCEXF	PBATSCAF	SBATTCAF	TBATENVF	
2.18E-08	25.5%		CDM8TDEY	CHUTDEXF	EIDNCEXF	PBATTCAF	TBATENVF		
2.18E-08	38.2%		CDM8TDEY	CHUTDEXF	PBATSCAF	PIDNOEXF	SBATTCAF	TBATENVF	
2.18E-08	50.9%		CDM8TDEY	CHUTDEXF	PBATTCAF	PIDNOEXF	TBATENVF		
8.29E-09	55.8%		CHUCAEMF	CMNCAEMF	PFGEXHTO	PFLHF1AD			
8.29E-09	60.6%		CHUCAEMF	CMNCAEMF	PFGEXHTO	PFLHF1BD			
8.29E-09	65.4%		CHUCAEMF	CMNCAEMF	PFGEXHTO	PFLHF1CD			
5.12E-09	68.4%		CDM8TDEY	CHUTDEXF	EFLHF1TM	EHUHEPAF	PBATSCAF	SBATTCAF	TBATENVF
5.12E-09	71.4%		CDM8TDEY	CHUTDEXF	EFLHF1TM	EHUHEPAF	PBATTCAF	TBATENVF	
5.12E-09	74.4%		CDM8TDEY	CHUTDEXF	EFLHF1UM	EHUHEPAF	PBATSCAF	SBATTCAF	TBATENVF
5.12E-09	77.4%		CDM8TDEY	CHUTDEXF	EFLHF1UM	EHUHEPAF	PBATTCAF	TBATENVF	
5.12E-09	80.4%		CDM8TDEY	CHUTDEXF	EFNEF1MM	EHUEXHFF	PBATSCAF	SBATTCAF	TBATENVF
5.12E-09	83.3%		CDM8TDEY	CHUTDEXF	EFNEF1MM	EHUEXHFF	PBATTCAF	TBATENVF	
5.12E-09	86.3%		CDM8TDEY	CHUTDEXF	EFNEF1NM	EHUEXHFF	PBATSCAF	SBATTCAF	TBATENVF
5.12E-09	89.3%		CDM8TDEY	CHUTDEXF	EFNEF1NM	EHUEXHFF	PBATTCAF	TBATENVF	
5.22E-10	89.6%		EIDNCEXF	PBATTCAF	PHUFNEXF	PTR12+BF	TBATENVF	THUFNEXF	
5.22E-10	89.9%		EIDNCEXF	PBATTCAF	PHUFNEXF	PTR12+BF	TBATENVF	THUFNSUF	
5.22E-10	90.2%		EIDNCEXF	PBATTCAF	PHUFNEXF	PTR138BF	TBATENVF	THUFNEXF	
5.22E-10	90.5%		EIDNCEXF	PBATTCAF	PHUFNEXF	PTR138BF	TBATENVF	THUFNSUF	
5.22E-10	90.8%		EIDNCEXF	PBATTCAF	PHUFNSUF	PTR12+BF	TBATENVF	THUFNEXF	
5.22E-10	91.1%		EIDNCEXF	PBATTCAF	PHUFNSUF	PTR12+BF	TBATENVF	THUFNSUF	
5.22E-10	91.4%		EIDNCEXF	PBATTCAF	PHUFNSUF	PTR138BF	TBATENVF	THUFNEXF	
5.22E-10	91.7%		EIDNCEXF	PBATTCAF	PHUFNSUF	PTR138BF	TBATENVF	THUFNSUF	
5.22E-10	92.0%		PBATTCAF	PHUFNEXF	PIDNOEXF	PTR12+BF	TBATENVF	THUFNEXF	
5.22E-10	92.4%		PBATTCAF	PHUFNEXF	PIDNOEXF	PTR12+BF	TBATENVF	THUFNSUF	
5.22E-10	92.7%		PBATTCAF	PHUFNEXF	PIDNOEXF	PTR138BF	TBATENVF	THUFNEXF	
5.22E-10	93.0%		PBATTCAF	PHUFNEXF	PIDNOEXF	PTR138BF	TBATENVF	THUFNSUF	
5.22E-10	93.3%		PBATTCAF	PHUFNSUF	PIDNOEXF	PTR12+BF	TBATENVF	THUFNEXF	
5.22E-10	93.6%		PBATTCAF	PHUFNSUF	PIDNOEXF	PTR12+BF	TBATENVF	THUFNSUF	
5.22E-10	93.9%		PBATTCAF	PHUFNSUF	PIDNOEXF	PTR138BF	TBATENVF	THUFNEXF	
5.22E-10	94.2%		PBATTCAF	PHUFNSUF	PIDNOEXF	PTR138BF	TBATENVF	THUFNSUF	
1.36E-10	94.3%		CDM8TDEY	CHUTDEXF	EFNEF1MF	EHUEXHFF	PBATSCAF	SBATTCAF	TBATENVF
1.36E-10	94.3%		CDM8TDEY	CHUTDEXF	EFNEF1MF	EHUEXHFF	PBATTCAF	TBATENVF	
1.36E-10	94.4%		CDM8TDEY	CHUTDEXF	EFNEF1NF	EHUEXHFF	PBATSCAF	SBATTCAF	TBATENVF
1.36E-10	94.5%		CDM8TDEY	CHUTDEXF	EFNEF1NF	EHUEXHFF	PBATTCAF	TBATENVF	
1.22E-10	94.6%		EFLHF1TM	EHUHEPAF	PBATTCAF	PHUFNEXF	PTR12+BF	TBATENVF	THUFNEXF
1.22E-10	94.6%		EFLHF1TM	EHUHEPAF	PBATTCAF	PHUFNEXF	PTR12+BF	TBATENVF	THUFNSUF
1.22E-10	94.7%		EFLHF1TM	EHUHEPAF	PBATTCAF	PHUFNEXF	PTR138BF	TBATENVF	THUFNEXF
1.22E-10	94.8%		EFLHF1TM	EHUHEPAF	PBATTCAF	PHUFNEXF	PTR138BF	TBATENVF	THUFNSUF
1.22E-10	94.9%		EFLHF1TM	EHUHEPAF	PBATTCAF	PHUFNSUF	PTR12+BF	TBATENVF	THUFNEXF
1.22E-10	94.9%		EFLHF1TM	EHUHEPAF	PBATTCAF	PHUFNSUF	PTR12+BF	TBATENVF	THUFNSUF

Probability	%	Class	Inputs						
1.22E-10	95.1%		EFLHF1TM	EHUHEPAF	PBATTCAF	PHUFNSUF	PTR138BF	TBATENVF	THUFNEXF
1.22E-10	95.1%		EFLHF1TM	EHUHEPAF	PBATTCAF	PHUFNSUF	PTR138BF	TBATENVF	THUFNSUF
1.22E-10	95.2%		EFLHF1UM	EHUHEPAF	PBATTCAF	PHUFNEXF	PTR12+BF	TBATENVF	THUFNEXF
1.22E-10	95.3%		EFLHF1UM	EHUHEPAF	PBATTCAF	PHUFNEXF	PTR12+BF	TBATENVF	THUFNSUF
1.22E-10	95.3%		EFLHF1UM	EHUHEPAF	PBATTCAF	PHUFNEXF	PTR138BF	TBATENVF	THUFNEXF
1.22E-10	95.4%		EFLHF1UM	EHUHEPAF	PBATTCAF	PHUFNEXF	PTR138BF	TBATENVF	THUFNSUF
1.22E-10	95.5%		EFLHF1UM	EHUHEPAF	PBATTCAF	PHUFNSUF	PTR12+BF	TBATENVF	THUFNEXF
1.22E-10	95.6%		EFLHF1UM	EHUHEPAF	PBATTCAF	PHUFNSUF	PTR12+BF	TBATENVF	THUFNSUF
1.22E-10	95.6%		EFLHF1UM	EHUHEPAF	PBATTCAF	PHUFNSUF	PTR138BF	TBATENVF	THUFNEXF
1.22E-10	95.7%		EFLHF1UM	EHUHEPAF	PBATTCAF	PHUFNSUF	PTR138BF	TBATENVF	THUFNSUF
1.22E-10	95.8%		EFNEF1MM	EHUEXHFF	PBATTCAF	PHUFNEXF	PTR12+BF	TBATENVF	THUFNEXF
1.22E-10	95.8%		EFNEF1MM	EHUEXHFF	PBATTCAF	PHUFNEXF	PTR12+BF	TBATENVF	THUFNSUF
1.22E-10	95.9%		EFNEF1MM	EHUEXHFF	PBATTCAF	PHUFNEXF	PTR138BF	TBATENVF	THUFNEXF
1.22E-10	96.0%		EFNEF1MM	EHUEXHFF	PBATTCAF	PHUFNEXF	PTR138BF	TBATENVF	THUFNSUF
1.22E-10	96.1%		EFNEF1MM	EHUEXHFF	PBATTCAF	PHUFNSUF	PTR12+BF	TBATENVF	THUFNEXF
1.22E-10	96.1%		EFNEF1MM	EHUEXHFF	PBATTCAF	PHUFNSUF	PTR12+BF	TBATENVF	THUFNSUF
1.22E-10	96.2%		EFNEF1MM	EHUEXHFF	PBATTCAF	PHUFNSUF	PTR138BF	TBATENVF	THUFNEXF
1.22E-10	96.3%		EFNEF1MM	EHUEXHFF	PBATTCAF	PHUFNSUF	PTR138BF	TBATENVF	THUFNSUF
1.22E-10	96.3%		EFNEF1NM	EHUEXHFF	PBATTCAF	PHUFNEXF	PTR12+BF	TBATENVF	THUFNEXF
1.22E-10	96.4%		EFNEF1NM	EHUEXHFF	PBATTCAF	PHUFNEXF	PTR12+BF	TBATENVF	THUFNSUF
1.22E-10	96.5%		EFNEF1NM	EHUEXHFF	PBATTCAF	PHUFNEXF	PTR138BF	TBATENVF	THUFNEXF
1.22E-10	96.6%		EFNEF1NM	EHUEXHFF	PBATTCAF	PHUFNEXF	PTR138BF	TBATENVF	THUFNSUF
1.22E-10	96.6%		EFNEF1NM	EHUEXHFF	PBATTCAF	PHUFNSUF	PTR12+BF	TBATENVF	THUFNEXF
1.22E-10	96.7%		EFNEF1NM	EHUEXHFF	PBATTCAF	PHUFNSUF	PTR12+BF	TBATENVF	THUFNSUF
1.22E-10	96.8%		EFNEF1NM	EHUEXHFF	PBATTCAF	PHUFNSUF	PTR138BF	TBATENVF	THUFNEXF
1.22E-10	96.8%		EFNEF1NM	EHUEXHFF	PBATTCAF	PHUFNSUF	PTR138BF	TBATENVF	THUFNSUF
7.61E-11	96.9%		CDM8TDEY	CHUTDEXF	EDME1EF1MC	EHUEXHFF	PBATSCAF	SBATTCAF	TBATENVF
7.61E-11	96.9%		CDM8TDEY	CHUTDEXF	EDME1EF1MC	EHUEXHFF	PBATTCAF	TBATENVF	
7.61E-11	97.0%		CDM8TDEY	CHUTDEXF	EDME1EF1NC	EHUEXHFF	PBATSCAF	SBATTCAF	TBATENVF
7.61E-11	97.0%		CDM8TDEY	CHUTDEXF	EDME1EF1NC	EHUEXHFF	PBATTCAF	TBATENVF	
7.61E-11	97.1%		CDM8TDEY	CHUTDEXF	EDME2EF1MC	EHUEXHFF	PBATSCAF	SBATTCAF	TBATENVF
7.61E-11	97.1%		CDM8TDEY	CHUTDEXF	EDME2EF1MC	EHUEXHFF	PBATTCAF	TBATENVF	
7.61E-11	97.2%		CDM8TDEY	CHUTDEXF	EDME2EF1NC	EHUEXHFF	PBATSCAF	SBATTCAF	TBATENVF
7.61E-11	97.2%		CDM8TDEY	CHUTDEXF	EDME2EF1NC	EHUEXHFF	PBATTCAF	TBATENVF	
7.61E-11	97.2%		CDM8TDEY	CHUTDEXF	EDMEF1MC	EHUEXHFF	PBATSCAF	SBATTCAF	TBATENVF
7.61E-11	97.3%		CDM8TDEY	CHUTDEXF	EDMEF1MC	EHUEXHFF	PBATTCAF	TBATENVF	
7.61E-11	97.3%		CDM8TDEY	CHUTDEXF	EDMEF1NC	EHUEXHFF	PBATSCAF	SBATTCAF	TBATENVF
7.61E-11	97.4%		CDM8TDEY	CHUTDEXF	EDMEF1NC	EHUEXHFF	PBATTCAF	TBATENVF	
7.61E-11	97.4%		CDM8TDEY	CHUTDEXF	EDMEXHF1TC	EHUHEPAF	PBATSCAF	SBATTCAF	TBATENVF
7.61E-11	97.5%		CDM8TDEY	CHUTDEXF	EDMEXHF1TC	EHUHEPAF	PBATTCAF	TBATENVF	
7.61E-11	97.5%		CDM8TDEY	CHUTDEXF	EDMEXHF1UC	EHUHEPAF	PBATSCAF	SBATTCAF	TBATENVF
7.61E-11	97.6%		CDM8TDEY	CHUTDEXF	EDMEXHF1UC	EHUHEPAF	PBATTCAF	TBATENVF	
7.61E-11	97.6%		CDM8TDEY	CHUTDEXF	EDMINEF1MC	EHUEXHFF	PBATSCAF	SBATTCAF	TBATENVF
7.61E-11	97.6%		CDM8TDEY	CHUTDEXF	EDMINEF1MC	EHUEXHFF	PBATTCAF	TBATENVF	
7.61E-11	97.7%		CDM8TDEY	CHUTDEXF	EDMINEF1NC	EHUEXHFF	PBATSCAF	SBATTCAF	TBATENVF
7.61E-11	97.7%		CDM8TDEY	CHUTDEXF	EDMINEF1NC	EHUEXHFF	PBATTCAF	TBATENVF	
7.61E-11	97.8%		CDM8TDEY	CHUTDEXF	EDMINHF1TC	EHUHEPAF	PBATSCAF	SBATTCAF	TBATENVF
7.61E-11	97.8%		CDM8TDEY	CHUTDEXF	EDMINHF1TC	EHUHEPAF	PBATTCAF	TBATENVF	
7.61E-11	97.9%		CDM8TDEY	CHUTDEXF	EDMINHF1UC	EHUHEPAF	PBATSCAF	SBATTCAF	TBATENVF

Probability	%	Class	Inputs
7.61E-11	97.9%		CDM8TDEY CHUTDEXF EDMINHF1UC EHUHEPAF PBATTCAF TBATENVF
7.61E-11	97.9%		CDM8TDEY CHUTDEXF EDMTD2AC EHUTDEXF PBATSCAF SBATTCAF TBATENVF
7.61E-11	98.0%		CDM8TDEY CHUTDEXF EDMTD2AC EHUTDEXF PBATTCAF TBATENVF
7.61E-11	98.0%		CDM8TDEY CHUTDEXF EDMTD2BC EHUTDEXF PBATSCAF SBATTCAF TBATENVF
7.61E-11	98.1%		CDM8TDEY CHUTDEXF EDMTD2BC EHUTDEXF PBATTCAF TBATENVF
5.22E-11	98.1%		EIDNCEXF PBATSCAF PHUFNEXF PTR12+BF SBATTCAF SHUFNEXF TBATENVF THUFNEXF
5.22E-11	98.1%		EIDNCEXF PBATSCAF PHUFNEXF PTR12+BF SBATTCAF SHUFNEXF TBATENVF THUFNSUF
5.22E-11	98.2%		EIDNCEXF PBATSCAF PHUFNEXF PTR12+BF SBATTCAF SHUFNINF TBATENVF THUFNEXF
5.22E-11	98.2%		EIDNCEXF PBATSCAF PHUFNEXF PTR12+BF SBATTCAF SHUFNINF TBATENVF THUFNSUF
5.22E-11	98.2%		EIDNCEXF PBATSCAF PHUFNEXF PTR138BF SBATTCAF SHUFNEXF TBATENVF THUFNEXF
5.22E-11	98.2%		EIDNCEXF PBATSCAF PHUFNEXF PTR138BF SBATTCAF SHUFNEXF TBATENVF THUFNSUF
5.22E-11	98.3%		EIDNCEXF PBATSCAF PHUFNEXF PTR138BF SBATTCAF SHUFNINF TBATENVF THUFNEXF
5.22E-11	98.3%		EIDNCEXF PBATSCAF PHUFNEXF PTR138BF SBATTCAF SHUFNINF TBATENVF THUFNSUF
5.22E-11	98.3%		EIDNCEXF PBATSCAF PHUFNSUF PTR12+BF SBATTCAF SHUFNEXF TBATENVF THUFNEXF
5.22E-11	98.4%		EIDNCEXF PBATSCAF PHUFNSUF PTR12+BF SBATTCAF SHUFNEXF TBATENVF THUFNSUF
5.22E-11	98.4%		EIDNCEXF PBATSCAF PHUFNSUF PTR12+BF SBATTCAF SHUFNINF TBATENVF THUFNEXF
5.22E-11	98.4%		EIDNCEXF PBATSCAF PHUFNSUF PTR12+BF SBATTCAF SHUFNINF TBATENVF THUFNSUF
5.22E-11	98.5%		EIDNCEXF PBATSCAF PHUFNSUF PTR138BF SBATTCAF SHUFNEXF TBATENVF THUFNEXF
5.22E-11	98.5%		EIDNCEXF PBATSCAF PHUFNSUF PTR138BF SBATTCAF SHUFNEXF TBATENVF THUFNSUF
5.22E-11	98.5%		EIDNCEXF PBATSCAF PHUFNSUF PTR138BF SBATTCAF SHUFNINF TBATENVF THUFNEXF
5.22E-11	98.5%		EIDNCEXF PBATSCAF PHUFNSUF PTR138BF SBATTCAF SHUFNINF TBATENVF THUFNSUF
5.22E-11	98.6%		PBATSCAF PHUFNEXF PIDNOEXF PTR12+BF SBATTCAF SHUFNEXF TBATENVF THUFNEXF
5.22E-11	98.6%		PBATSCAF PHUFNEXF PIDNOEXF PTR12+BF SBATTCAF SHUFNEXF TBATENVF THUFNSUF
5.22E-11	98.6%		PBATSCAF PHUFNEXF PIDNOEXF PTR12+BF SBATTCAF SHUFNINF TBATENVF THUFNEXF
5.22E-11	98.7%		PBATSCAF PHUFNEXF PIDNOEXF PTR12+BF SBATTCAF SHUFNINF TBATENVF THUFNSUF
5.22E-11	98.7%		PBATSCAF PHUFNEXF PIDNOEXF PTR138BF SBATTCAF SHUFNEXF TBATENVF THUFNEXF
5.22E-11	98.7%		PBATSCAF PHUFNEXF PIDNOEXF PTR138BF SBATTCAF SHUFNEXF TBATENVF THUFNSUF

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Probability	%	Class	Inputs							
5.22E-11	98.7%		PBATSCAF	PHUFNEXF	PIDNOEXF	PTR138BF	SBATTCAF	SHUFNINF	TBATENVF	THUFNEXF
5.22E-11	98.8%		PBATSCAF	PHUFNEXF	PIDNOEXF	PTR138BF	SBATTCAF	SHUFNINF	TBATENVF	THUFNSUF
5.22E-11	98.8%		PBATSCAF	PHUFNSUF	PIDNOEXF	PTR12+BF	SBATTCAF	SHUFNEXF	TBATENVF	THUFNEXF
5.22E-11	98.8%		PBATSCAF	PHUFNSUF	PIDNOEXF	PTR12+BF	SBATTCAF	SHUFNEXF	TBATENVF	THUFNSUF
5.22E-11	98.9%		PBATSCAF	PHUFNSUF	PIDNOEXF	PTR12+BF	SBATTCAF	SHUFNINF	TBATENVF	THUFNEXF
5.22E-11	98.9%		PBATSCAF	PHUFNSUF	PIDNOEXF	PTR12+BF	SBATTCAF	SHUFNINF	TBATENVF	THUFNSUF
5.22E-11	98.9%		PBATSCAF	PHUFNSUF	PIDNOEXF	PTR138BF	SBATTCAF	SHUFNEXF	TBATENVF	THUFNEXF
5.22E-11	99.0%		PBATSCAF	PHUFNSUF	PIDNOEXF	PTR138BF	SBATTCAF	SHUFNEXF	TBATENVF	THUFNSUF
5.22E-11	99.0%		PBATSCAF	PHUFNSUF	PIDNOEXF	PTR138BF	SBATTCAF	SHUFNINF	TBATENVF	THUFNEXF
5.22E-11	99.0%		PBATSCAF	PHUFNSUF	PIDNOEXF	PTR138BF	SBATTCAF	SHUFNINF	TBATENVF	THUFNSUF
4.49E-11	99.0%		CDM8TDEY	CHUTDEXF	EHUTDEXF	ESWTD2AF	PBATSCAF	SBATTCAF	TBATENVF	
4.49E-11	99.1%		CDM8TDEY	CHUTDEXF	EHUTDEXF	ESWTD2AF	PBATTCAF	TBATENVF		
4.49E-11	99.1%		CDM8TDEY	CHUTDEXF	EHUTDEXF	ESWTD2BF	PBATSCAF	SBATTCAF	TBATENVF	
4.49E-11	99.1%		CDM8TDEY	CHUTDEXF	EHUTDEXF	ESWTD2BF	PBATTCAF	TBATENVF		
4.20E-11	99.1%		CDM8TDEY	CHUTDEXF	EAHAH1MM	EAHAH1NM	EHUAHUSF	PBATSCAF	SBATTCAF	TBATENVF
4.20E-11	99.2%		CDM8TDEY	CHUTDEXF	EAHAH1MM	EAHAH1NM	EHUAHUSF	PBATTCAF	TBATENVF	
4.20E-11	99.2%		CDM8TDEY	CHUTDEXF	EAHAH1MM	EAHAH1PM	EHUAHUSF	PBATSCAF	SBATTCAF	TBATENVF
4.20E-11	99.2%		CDM8TDEY	CHUTDEXF	EAHAH1MM	EAHAH1PM	EHUAHUSF	PBATTCAF	TBATENVF	
4.20E-11	99.2%		CDM8TDEY	CHUTDEXF	EAHAH1NM	EAHAH1PM	EHUAHUSF	PBATSCAF	SBATTCAF	TBATENVF
4.20E-11	99.3%		CDM8TDEY	CHUTDEXF	EAHAH1NM	EAHAH1PM	EHUAHUSF	PBATTCAF	TBATENVF	
4.20E-11	99.3%		CDM8TDEY	CHUTDEXF	EFNSF1MM	EFNSF1NM	EHUFNSUF	PBATSCAF	SBATTCAF	TBATENVF
4.20E-11	99.3%		CDM8TDEY	CHUTDEXF	EFNSF1MM	EFNSF1NM	EHUFNSUF	PBATTCAF	TBATENVF	
4.20E-11	99.3%		CDM8TDEY	CHUTDEXF	EFNSF1MM	EFNSF1PM	EHUFNSUF	PBATSCAF	SBATTCAF	TBATENVF
4.20E-11	99.4%		CDM8TDEY	CHUTDEXF	EFNSF1MM	EFNSF1PM	EHUFNSUF	PBATTCAF	TBATENVF	
4.20E-11	99.4%		CDM8TDEY	CHUTDEXF	EFNSF1NM	EFNSF1PM	EHUFNSUF	PBATSCAF	SBATTCAF	TBATENVF
4.20E-11	99.4%		CDM8TDEY	CHUTDEXF	EFNSF1NM	EFNSF1PM	EHUFNSUF	PBATTCAF	TBATENVF	
2.70E-11	99.4%		CDM8TDEY	CHUTDEXF	EFLHF1TB	EHUHEPAF	PBATSCAF	SBATTCAF	TBATENVF	
2.70E-11	99.5%		CDM8TDEY	CHUTDEXF	EFLHF1TB	EHUHEPAF	PBATTCAF	TBATENVF		
2.70E-11	99.5%		CDM8TDEY	CHUTDEXF	EFLHF1UB	EHUHEPAF	PBATSCAF	SBATTCAF	TBATENVF	
2.70E-11	99.5%		CDM8TDEY	CHUTDEXF	EFLHF1UB	EHUHEPAF	PBATTCAF	TBATENVF		
1.36E-11	99.5%		CDM8TDEY	CHUTDEXF	EFNE1MNX	EHUEXHFF	PBATSCAF	SBATTCAF	TBATENVF	
1.36E-11	99.5%		CDM8TDEY	CHUTDEXF	EFNE1MNX	EHUEXHFF	PBATTCAF	TBATENVF		
1.36E-11	99.5%		CDM8TDEY	CHUTDEXF	EFNS1MNX	EHUFNSUF	PBATSCAF	SBATTCAF	TBATENVF	

Probability	%	Class	Inputs
1.36E-11	99.5%		CDM8TDEY CHUTDEXF EFNS1MNX EHUFNSUF PBATTCAF TBATENVF
1.36E-11	99.5%		CDM8TDEY CHUTDEXF EFNS1MPX EHUFNSUF PBATSCAF SBATTCAF TBATENVF
1.36E-11	99.5%		CDM8TDEY CHUTDEXF EFNS1MPX EHUFNSUF PBATTCAF TBATENVF
1.36E-11	99.5%		CDM8TDEY CHUTDEXF EFNS1NPX EHUFNSUF PBATSCAF SBATTCAF TBATENVF
1.36E-11	99.5%		CDM8TDEY CHUTDEXF EFNS1NPX EHUFNSUF PBATTCAF TBATENVF
1.27E-11	99.5%		CDM8TDEY CHUTDEXF ECNEF1MF EHUEXHFF PBATSCAF SBATTCAF TBATENVF
1.27E-11	99.5%		CDM8TDEY CHUTDEXF ECNEF1MF EHUEXHFF PBATTCAF TBATENVF
1.27E-11	99.5%		CDM8TDEY CHUTDEXF ECNEF1NF EHUEXHFF PBATSCAF SBATTCAF TBATENVF
1.27E-11	99.6%		CDM8TDEY CHUTDEXF ECNEF1NF EHUEXHFF PBATTCAF TBATENVF
1.22E-11	99.6%		EFLHF1TM EHUHEPAF PBATSCAF PHUFNEXF PTR12+BF SBATTCAF SHUFNEXF TBATENVF THUFNEXF
1.22E-11	99.6%		EFLHF1TM EHUHEPAF PBATSCAF PHUFNEXF PTR12+BF SBATTCAF SHUFNEXF TBATENVF THUFNSUF
1.22E-11	99.6%		EFLHF1TM EHUHEPAF PBATSCAF PHUFNEXF PTR12+BF SBATTCAF SHUFNINF TBATENVF THUFNEXF
1.22E-11	99.6%		EFLHF1TM EHUHEPAF PBATSCAF PHUFNEXF PTR12+BF SBATTCAF SHUFNINF TBATENVF THUFNSUF
1.22E-11	99.6%		EFLHF1TM EHUHEPAF PBATSCAF PHUFNEXF PTR138BF SBATTCAF SHUFNEXF TBATENVF THUFNEXF
1.22E-11	99.6%		EFLHF1TM EHUHEPAF PBATSCAF PHUFNEXF PTR138BF SBATTCAF SHUFNEXF TBATENVF THUFNSUF
1.22E-11	99.6%		EFLHF1TM EHUHEPAF PBATSCAF PHUFNEXF PTR138BF SBATTCAF SHUFNINF TBATENVF THUFNEXF
1.22E-11	99.6%		EFLHF1TM EHUHEPAF PBATSCAF PHUFNEXF PTR138BF SBATTCAF SHUFNINF TBATENVF THUFNSUF
1.22E-11	99.6%		EFLHF1TM EHUHEPAF PBATSCAF PHUFNSUF PTR12+BF SBATTCAF SHUFNEXF TBATENVF THUFNEXF
1.22E-11	99.6%		EFLHF1TM EHUHEPAF PBATSCAF PHUFNSUF PTR12+BF SBATTCAF SHUFNEXF TBATENVF THUFNSUF
1.22E-11	99.6%		EFLHF1TM EHUHEPAF PBATSCAF PHUFNSUF PTR12+BF SBATTCAF SHUFNINF TBATENVF THUFNEXF
1.22E-11	99.6%		EFLHF1TM EHUHEPAF PBATSCAF PHUFNSUF PTR12+BF SBATTCAF SHUFNINF TBATENVF THUFNSUF
1.22E-11	99.6%		EFLHF1TM EHUHEPAF PBATSCAF PHUFNSUF PTR138BF SBATTCAF SHUFNEXF TBATENVF THUFNEXF
1.22E-11	99.7%		EFLHF1TM EHUHEPAF PBATSCAF PHUFNSUF PTR138BF SBATTCAF SHUFNEXF TBATENVF THUFNSUF
1.22E-11	99.7%		EFLHF1TM EHUHEPAF PBATSCAF PHUFNSUF PTR138BF SBATTCAF SHUFNINF TBATENVF THUFNEXF
1.22E-11	99.7%		EFLHF1TM EHUHEPAF PBATSCAF PHUFNSUF PTR138BF SBATTCAF SHUFNINF TBATENVF THUFNSUF
1.22E-11	99.7%		EFLHF1UM EHUHEPAF PBATSCAF PHUFNEXF PTR12+BF SBATTCAF SHUFNEXF TBATENVF THUFNEXF
1.22E-11	99.7%		EFLHF1UM EHUHEPAF PBATSCAF PHUFNEXF PTR12+BF SBATTCAF SHUFNEXF TBATENVF THUFNSUF
1.22E-11	99.7%		EFLHF1UM EHUHEPAF PBATSCAF PHUFNEXF PTR12+BF SBATTCAF SHUFNINF TBATENVF THUFNEXF
1.22E-11	99.7%		EFLHF1UM EHUHEPAF PBATSCAF PHUFNEXF PTR12+BF SBATTCAF SHUFNINF TBATENVF THUFNSUF

Probability	%	Class	Inputs
1.22E-11	99.7%		EFLHF1UM EHUHEPAF PBATSCAF PHUFNEXF PTR138BF SBATTCAF SHUFNEXF TBATENVF THUFNEXF
1.22E-11	99.7%		EFLHF1UM EHUHEPAF PBATSCAF PHUFNEXF PTR138BF SBATTCAF SHUFNEXF TBATENVF THUFNSUF
1.22E-11	99.7%		EFLHF1UM EHUHEPAF PBATSCAF PHUFNEXF PTR138BF SBATTCAF SHUFNINF TBATENVF THUFNEXF
1.22E-11	99.7%		EFLHF1UM EHUHEPAF PBATSCAF PHUFNEXF PTR138BF SBATTCAF SHUFNINF TBATENVF THUFNSUF
1.22E-11	99.7%		EFLHF1UM EHUHEPAF PBATSCAF PHUFNSUF PTR12+BF SBATTCAF SHUFNEXF TBATENVF THUFNEXF
1.22E-11	99.7%		EFLHF1UM EHUHEPAF PBATSCAF PHUFNSUF PTR12+BF SBATTCAF SHUFNEXF TBATENVF THUFNSUF
1.22E-11	99.7%		EFLHF1UM EHUHEPAF PBATSCAF PHUFNSUF PTR12+BF SBATTCAF SHUFNINF TBATENVF THUFNEXF
1.22E-11	99.8%		EFLHF1UM EHUHEPAF PBATSCAF PHUFNSUF PTR12+BF SBATTCAF SHUFNINF TBATENVF THUFNSUF
1.22E-11	99.8%		EFLHF1UM EHUHEPAF PBATSCAF PHUFNSUF PTR138BF SBATTCAF SHUFNEXF TBATENVF THUFNEXF
1.22E-11	99.8%		EFLHF1UM EHUHEPAF PBATSCAF PHUFNSUF PTR138BF SBATTCAF SHUFNEXF TBATENVF THUFNSUF
1.22E-11	99.8%		EFLHF1UM EHUHEPAF PBATSCAF PHUFNSUF PTR138BF SBATTCAF SHUFNINF TBATENVF THUFNEXF
1.22E-11	99.8%		EFLHF1UM EHUHEPAF PBATSCAF PHUFNSUF PTR138BF SBATTCAF SHUFNINF TBATENVF THUFNSUF
1.22E-11	99.8%		EFNEF1MM EHUEXHFF PBATSCAF PHUFNEXF PTR12+BF SBATTCAF SHUFNEXF TBATENVF THUFNEXF
1.22E-11	99.8%		EFNEF1MM EHUEXHFF PBATSCAF PHUFNEXF PTR12+BF SBATTCAF SHUFNEXF TBATENVF THUFNSUF
1.22E-11	99.8%		EFNEF1MM EHUEXHFF PBATSCAF PHUFNEXF PTR12+BF SBATTCAF SHUFNINF TBATENVF THUFNEXF
1.22E-11	99.8%		EFNEF1MM EHUEXHFF PBATSCAF PHUFNEXF PTR12+BF SBATTCAF SHUFNINF TBATENVF THUFNSUF
1.22E-11	99.8%		EFNEF1MM EHUEXHFF PBATSCAF PHUFNEXF PTR138BF SBATTCAF SHUFNEXF TBATENVF THUFNEXF
1.22E-11	99.8%		EFNEF1MM EHUEXHFF PBATSCAF PHUFNEXF PTR138BF SBATTCAF SHUFNEXF TBATENVF THUFNSUF
1.22E-11	99.8%		EFNEF1MM EHUEXHFF PBATSCAF PHUFNEXF PTR138BF SBATTCAF SHUFNINF TBATENVF THUFNEXF
1.22E-11	99.8%		EFNEF1MM EHUEXHFF PBATSCAF PHUFNEXF PTR138BF SBATTCAF SHUFNINF TBATENVF THUFNSUF
1.22E-11	99.8%		EFNEF1MM EHUEXHFF PBATSCAF PHUFNSUF PTR12+BF SBATTCAF SHUFNEXF TBATENVF THUFNEXF
1.22E-11	99.9%		EFNEF1MM EHUEXHFF PBATSCAF PHUFNSUF PTR12+BF SBATTCAF SHUFNEXF TBATENVF THUFNSUF
1.22E-11	99.9%		EFNEF1MM EHUEXHFF PBATSCAF PHUFNSUF PTR12+BF SBATTCAF SHUFNINF TBATENVF THUFNEXF
1.22E-11	99.9%		EFNEF1MM EHUEXHFF PBATSCAF PHUFNSUF PTR12+BF SBATTCAF SHUFNINF TBATENVF THUFNSUF

Probability	%	Class	Inputs
1.22E-11	99.9%		EFNEF1MM EHUEXHFF PBATSCAF PHUFNSUF PTR138BF SBATTCAF SHUFNEXF TBATENVF THUFNEXF
1.22E-11	99.9%		EFNEF1MM EHUEXHFF PBATSCAF PHUFNSUF PTR138BF SBATTCAF SHUFNEXF TBATENVF THUFNSUF
1.22E-11	99.9%		EFNEF1MM EHUEXHFF PBATSCAF PHUFNSUF PTR138BF SBATTCAF SHUFNINF TBATENVF THUFNEXF
1.22E-11	99.9%		EFNEF1MM EHUEXHFF PBATSCAF PHUFNSUF PTR138BF SBATTCAF SHUFNINF TBATENVF THUFNSUF
1.22E-11	99.9%		EFNEF1NM EHUEXHFF PBATSCAF PHUFNEXF PTR12+BF SBATTCAF SHUFNEXF TBATENVF THUFNEXF
1.22E-11	99.9%		EFNEF1NM EHUEXHFF PBATSCAF PHUFNEXF PTR12+BF SBATTCAF SHUFNEXF TBATENVF THUFNSUF
1.22E-11	99.9%		EFNEF1NM EHUEXHFF PBATSCAF PHUFNEXF PTR12+BF SBATTCAF SHUFNINF TBATENVF THUFNEXF
1.22E-11	99.9%		EFNEF1NM EHUEXHFF PBATSCAF PHUFNEXF PTR12+BF SBATTCAF SHUFNINF TBATENVF THUFNSUF
1.22E-11	99.9%		EFNEF1NM EHUEXHFF PBATSCAF PHUFNEXF PTR138BF SBATTCAF SHUFNEXF TBATENVF THUFNEXF
1.22E-11	99.9%		EFNEF1NM EHUEXHFF PBATSCAF PHUFNEXF PTR138BF SBATTCAF SHUFNEXF TBATENVF THUFNSUF
1.22E-11	99.9%		EFNEF1NM EHUEXHFF PBATSCAF PHUFNEXF PTR138BF SBATTCAF SHUFNINF TBATENVF THUFNEXF
1.22E-11	100.0%		EFNEF1NM EHUEXHFF PBATSCAF PHUFNEXF PTR138BF SBATTCAF SHUFNINF TBATENVF THUFNSUF
1.22E-11	100.0%		EFNEF1NM EHUEXHFF PBATSCAF PHUFNSUF PTR12+BF SBATTCAF SHUFNEXF TBATENVF THUFNEXF
1.22E-11	100.0%		EFNEF1NM EHUEXHFF PBATSCAF PHUFNSUF PTR12+BF SBATTCAF SHUFNEXF TBATENVF THUFNSUF
1.22E-11	100.0%		EFNEF1NM EHUEXHFF PBATSCAF PHUFNSUF PTR12+BF SBATTCAF SHUFNINF TBATENVF THUFNEXF
1.22E-11	100.0%		EFNEF1NM EHUEXHFF PBATSCAF PHUFNSUF PTR12+BF SBATTCAF SHUFNINF TBATENVF THUFNSUF
1.22E-11	100.0%		EFNEF1NM EHUEXHFF PBATSCAF PHUFNSUF PTR138BF SBATTCAF SHUFNEXF TBATENVF THUFNEXF
1.22E-11	100.0%		EFNEF1NM EHUEXHFF PBATSCAF PHUFNSUF PTR138BF SBATTCAF SHUFNEXF TBATENVF THUFNSUF
1.22E-11	100.0%		EFNEF1NM EHUEXHFF PBATSCAF PHUFNSUF PTR138BF SBATTCAF SHUFNINF TBATENVF THUFNEXF
1.22E-11	100.0%		EFNEF1NM EHUEXHFF PBATSCAF PHUFNSUF PTR138BF SBATTCAF SHUFNINF TBATENVF THUFNSUF

Report Summary:
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Print date: 5/5/99 2:54 PM
Not sorted
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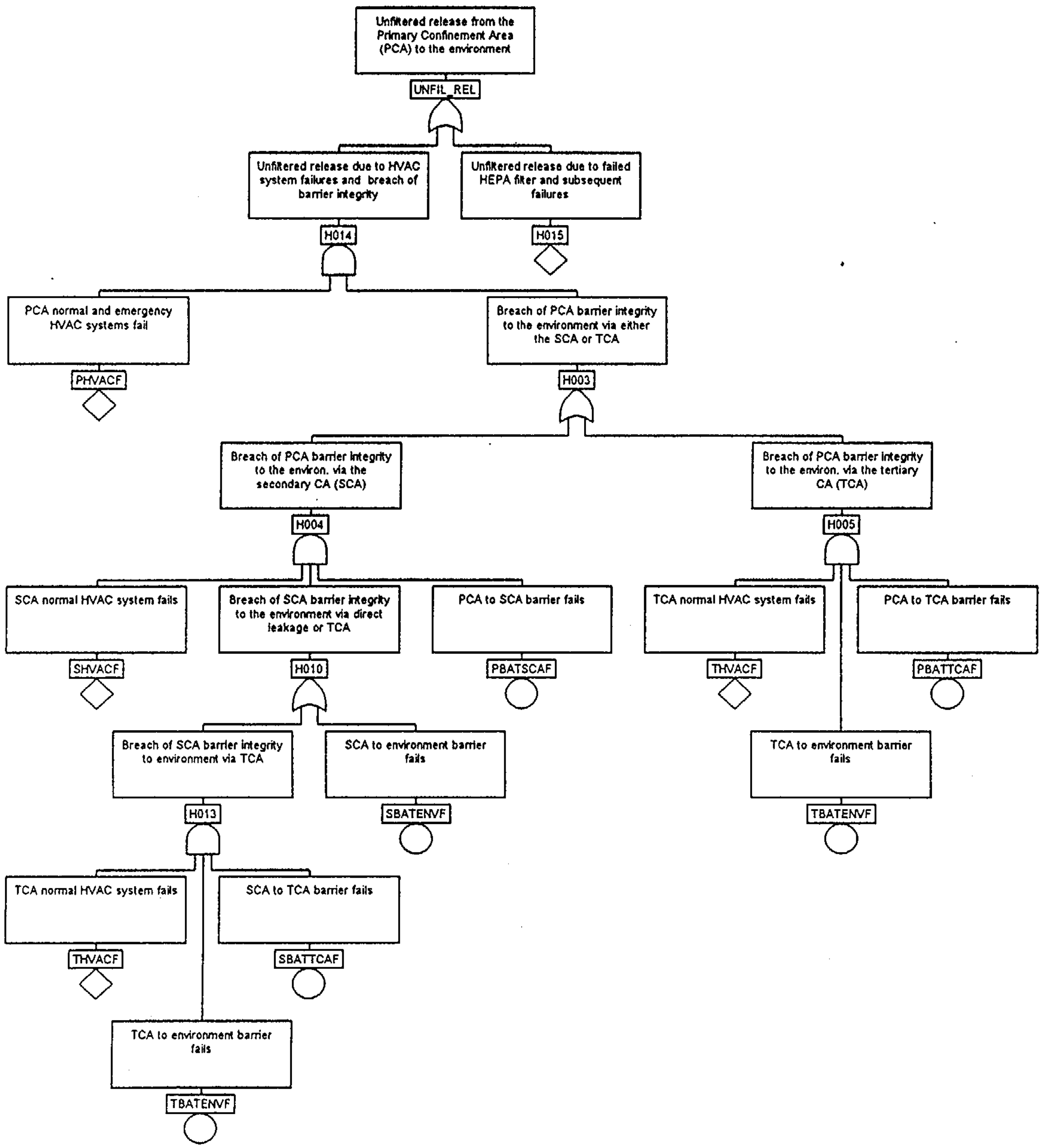
ATTACHMENT III

WASTE HANDLING BUILDING HVAC FAULT TREE TOP LOGIC


Unfiltered release from the Primary Confinement Area (PCA) to the environment
UNFIL_REL
Unfiltered release due to HVAC system failures and breach of barrier integrity
H014
Unfiltered release due to failed HEPA filter and subsequent failures
H015
PCA normal and emergency HVAC systems fail
PHVACF
Breach of PCA barrier integrity to the environment via either the SCA or TCA
H003
Breach of PCA barrier integrity to the environ. via the secondary CA (SCA)
H004
Breach of PCA barrier integrity to the environ. via the tertiary CA (TCA)
H005
SCA normal HVAC system fails
SHVACF
Breach of SCA barrier integrity to the environment via direct leakage or TCA
H010
PCA to SCA barrier fails
PBATSCAF
TCA normal HVAC system fails
THVACF
PCA to TCA barrier fails
PBATTCAF
Breach of SCA barrier integrity to environment via TCA
H013
SCA to environment barrier fails
SBATENVF
TCA to environment barrier fails
TBATENVF
TCA normal HVAC system fails
THVACF
SCA to TCA barrier fails
SBATTCAF
TCA to environment barrier fails
TBATENVF

ATTACHMENT IV

DATA TABLES

Table IV-1
Failure Data Table (by Type Code)

Type Code	Failure rate (/hr)	Time (hrs)	Failure probability (Demand probability)	Source	Comments/Assumptions
AH B	3.4×10^{-6}	24	8.2×10^{-5}	D-B IPE [7.6]	Blocked air handing unit impedes air flow; use failure rate for heat exchanger plugs during operation.
AH M	n/a	n/a	8.2×10^{-3}	Assumed	Without any developed maintenance procedures, air handling units are assumed to be unavailable due to maintenance for three days during the course of one year. (See assumption 3.4.)
AH X	3.4×10^{-7}	24	8.2×10^{-6}	D-B IPE [7.6]	Common cause failure of two AHUs (impedes air flow).
AH Y	1.7×10^{-7}	24	4.1×10^{-6}	D-B IPE [7.6]	Common cause failure of three or more AHUs (impedes air flow).
CN F	8.5×10^{-7}	24	2.0×10^{-5}	D-B IPE [7.6]	Pressure switch fails low.
DM C DM 1 (10)[a]	5.1×10^{-6}	24	1.2×10^{-2}	D-B IPE [7.6]	Damper spuriously closes (or fails to remain open).
DM X	5.1×10^{-7}	24	1.2×10^{-5}	D-B IPE [7.6]	Common cause failure of two dampers (spuriously closes).
DM Y	2.6×10^{-7}	24	6.2×10^{-6}	D-B IPE [7.6]	Common cause failure of three or more dampers (spuriously closes).
DG M	n/a	n/a	6.0×10^{-3}	Modarres [7.7]	Use maintenance unavailability from Reference 7.4 instead of value in assumption 3.4.
DG R	2.0×10^{-3}	8	1.6×10^{-2}	Modarres [7.7]	Diesel generator fails to run. Affects power; use 8 hours.
DG S	n/a	n/a	3.0×10^{-2}	Modarres [7.7]	Diesel generator fails to start (demand probability).
FL B	1.8×10^{-6}	24	4.3×10^{-5}	D-B IPE [7.6]	Blocked HEPA filter impedes air flow, use failure rate for air filter plugs during operation.

Table IV-1
Failure Data Table (by Type Code)

Type Code	Failure rate (/hr)	Time (hrs)	Failure probability (Demand probability)	Source	Comments/Assumptions
FL D	1.8×10^{-5}	24	4.3×10^{-4}	D-B IPE [7.6]	No information available on defective filters, so conservatively use 10 times the failure rate for plugged air filter.
FL M	n/a	n/a	8.2×10^{-3}	Assumed	Without any developed maintenance procedures, HEPA filters are assumed to be unavailable due to maintenance for three days during the course of one year. (See assumption 3.4.)
FL X	1.8×10^{-7}	24	4.3×10^{-6}	D-B IPE [7.6]	Common cause failure of two filters.
FL Y	9.0×10^{-8}	24	2.2×10^{-6}	D-B IPE [7.6]	Common cause failure of three or more filters.
FN F	9.1×10^{-6}	24	$2.2. \times 10^{-4}$	D-B IPE [7.6]	Air supply or exhaust air fan fails, use failure rate for motor-driven fan fails to continue operation.
FN M	n/a	n/a	8.2×10^{-3}	Assumed	Without any developed maintenance procedures, air supply fans are assumed to be unavailable due to maintenance for three days during the course of one year. (See assumption 3.4.)
FN X	9.1×10^{-7}	24	2.2×10^{-5}	D-B IPE [7.6]	Common cause failure of two fans (fails to continue operation).
FN Y	4.6×10^{-7}	24	1.1×10^{-5}	D-B IPE [7.6]	Common cause failure of three or more AHUs (fails to continue operation).
HU F	n/a	n/a	0.1	Assumed	Screening value (see assumption 3.2).
ID F	n/a	n/a	3.5×10^{-3}	D-B IPE [7.6]	Motor-operated damper fails.
MC F MC E (10)[a]	1.0×10^{-7}	8	8.0×10^{-7}	Modarres [7.7]	Motor Control Center fails; use failure rate for buswork (480V) fails. Affects power, so use 8 hours.
MN F	3.0×10^{-6}	8	2.4×10^{-6}	Modarres [7.7]	No information is available on the CAEM system, use failure rate for sensor, transmitter, and process switch. This failure should be self-annunciating; use 8 hours.

Table IV-1
Failure Data Table (by Type Code)

Type Code	Failure rate (/hr)	Time (hrs)	Failure probability (Demand probability)	Source	Comments/Assumptions
SW F	3.0×10^{-6}	24	7.2×10^{-5}	Modarres [7.7]	While this is nominally a switch failure, it is a switch that requires a sensing element and transmission, use failure rate that includes sensor, transmitter, and process switch.
TR F	1.9×10^{-6}	8	1.5×10^{-5}	D-B IPE [7.6]	Operational failure of a transformer. Affects power; use 8 hours.

[a] Indicates a 10-chararacter basic event identifier.

Table IV-2
Failure Data Table (Specific Basic Events)

Basic Event Identifier	Failure probability (Demand probability)	Source	Comments/Assumptions
PBATSCAF	1.0	Assumed	Basic event identifier reads **P**rimary (confinement area) **BA**rrier **T**o **SCA F**ails. It is assumed that there is leakage between the PCA and SCA. See assumption 3.5.
PBATTCAF	1.0	Assumed	Primary (confinement area) barrier to TCA fails. There is a plug between the PCA and TCA. Conservatively assume this interface will permit leakage. See assumption 3.5.
PBATENVF	0.0	Assumed	Primary (confinement area) barrier to environment fails. It is assumed there are no direct interfaces between the PCA and the environment, so no leakage is possible. See assumption 3.5.
SBATTCAF	1.0	Assumed	Secondary (confinement area) barrier to TCA fails. It is assumed that there is leakage between the SCA and TCA. See assumption 3.5.
SBATENVF	0.0	Assumed	Secondary (confinement area) barrier to environment fails. It is assumed there are no direct interfaces between the SCA and the environment, so no leakage is possible. See assumption 3.5.
TBATENVF	1.0	Assumed	Tertiary (confinement area) barrier to environment fails. It is assumed that there is leakage between the TCA and the environment. See assumption 3.5.

Table IV-3
Development of Surrogate Failure Rates for Double-Diamond Basic Events

Basic Event Identifier	Combination Gate Logic (for failure)	Inputs		Number of combinations (cutsets) [1]	Substitute Failure Probability	Surrogate Failure Prob. [2]	Comments [3]
		Basic Event (representative)	Failure Probability				
CDMTOREXH	8-of-15	PDMTD1AC PDWTD1AF	$1.22x10^{-4}$ $7.20x10^{-5}$	1,055,340	$1.22x10^{-4}$	$5.2x10^{-26}$	Use maximum failure probability as the substitute failure prob.
SDMTOR	5-of-9	PDMTD1AC PDWTD1AF	$1.22x10^{-4}$ $7.20x10^{-5}$	4,032	$1.22x10^{-4}$	$1.1x10^{-16}$	Use maximum failure probability as the substitute failure prob.
SAH	5-of-9	PAHAH1AM PDMINAH1AC PAHAH1AB PDMEXAH1A C	$8.20x10^{-3}$ $1.22x10^{-4}$ $8.20x10^{-5}$ $1.22x10^{-4}$	79,884	$8.2x10^{-3}$	$3.1x10^{-6}$	Use maximum failure probability as the substitute failure prob.
SFLHEPA	9-of-16	PFLHF1AM PDMINHF1AC PFLHF1AB PDMEXHF1A C	$8.20x10^{-3}$ $1.22x10^{-4}$ $4.30x10^{-5}$ $1.22x10^{-4}$	114,933,867	$8.2x10^{-3}$	$1.9x10^{-11}$	Use maximum failure probability as the substitute failure prob.
SFNSUP SFNEXH	5-of-9	PFNEF1BM PDMINEF1BC PDME1EF1BC PDME1EF1BC PFNEF1BF PDMEF1BC PCNEF1BF PMC480VE2F Loss of Power	$8.20x10^{-3}$ $1.22x10^{-4}$ $1.22x10^{-4}$ $1.22x10^{-4}$ $2.20x10^{-4}$ $1.22x10^{-4}$ $2.00x10^{-5}$ $8.00x10^{-7}$ $2.98x10^{-5}$	420714	$8.2x10^{-3}$	$1.7x10^{-5}$	Use maximum failure probability as the substitute failure prob.

Table IV-3
Development of Surrogate Failure Rates for Double-Diamond Basic Events

Basic Event Identifier	Combination Gate Logic (for failure)	Inputs		Number of combinations (cutsets) [1]	Substitute Failure Probability	Surrogate Failure Prob. [2]	Comments [3]
		Basic Event (representative)	Failure Probability				
TDMTOR	6-of-10	PDMTD1AC PDWTD1AF	1.22×10^{-4} 7.20×10^{-5}	12,180	1.22×10^{-4}	4.0×10^{-20}	Use maximum failure probability as the substitute failure prob.
TAH	6-of-10	PAHAH1AM PDMINAH1AC PAHAH1AB PDMEXAH1A C	8.20×10^{-3} 1.22×10^{-4} 8.20×10^{-5} 1.22×10^{-4}	594,300	8.20×10^{-3}	1.8×10^{-7}	Use maximum failure probability as the substitute failure prob.
TFLHEPAUO	4-of-7	PFLHF1AM PDMINHF1AC PFLHF1AB PDMEXHF1A C	8.20×10^{-3} 1.22×10^{-4} 4.30×10^{-5} 1.22×10^{-4}	4,970	8.20×10^{-3}	2.2×10^{-5}	Use maximum failure probability as the substitute failure prob.
TFLHEPAOC	5-of-9	PFLHF1AM PDMINHF1AC PFLHF1AB PDMEXHF1A C	8.20×10^{-3} 1.22×10^{-4} 4.30×10^{-5} 1.22×10^{-4}	79,884	8.20×10^{-3}	3.0×10^{-6}	Use maximum failure probability as the substitute failure prob.

Table IV-3
Development of Surrogate Failure Rates for Double-Diamond Basic Events

Basic Event Identifier	Combination Gate Logic (for failure)	Inputs		Number of combinations (cutsets) **[1]**	Substitute Failure Probability	Surrogate Failure Prob. **[2]**	Comments **[3]**
		Basic Event (representative)	Failure Probability				
TFNSUP	6-of-10	PFNEF1BM PDMINEF1BC PDME1EF1BC PDME1EF1BC PFNEF1BF PDMEF1BC PCNEF1BF PMC480VE2F Loss of Power	$8.20x10^{-3}$ $1.22x10^{-4}$ $1.22x10^{-4}$ $1.22x10^{-4}$ $2.20x10^{-4}$ $1.22x10^{-4}$ $2.00x10^{-5}$ $8.00x10^{-7}$ $2.98x10^{-5}$	5,360,250	$8.20x10^{-3}$	$1.6x10^{-6}$	Use maximum failure probability as the substitute failure prob.
TFNEXHUO	3-of-4	PFNEF1BM PDMINEF1BC PDME1EF1BC PDME1EF1BC PFNEF1BF PDMEF1BC PCNEF1BF PMC480VE2F Loss of Power	$8.20x10^{-3}$ $1.22x10^{-4}$ $1.22x10^{-4}$ $1.22x10^{-4}$ $2.20x10^{-4}$ $1.22x10^{-4}$ $2.00x10^{-5}$ $8.00x10^{-7}$ $2.98x10^{-5}$	396	$8.20x10^{-3}$	$2.2x10^{-4}$	Use maximum failure probability as the substitute failure prob.

Table IV-3
Development of Surrogate Failure Rates for Double-Diamond Basic Events

Basic Event Identifier	Combination Gate Logic (for failure)	Inputs		Number of combinations (cutsets) [1]	Substitute Failure Probability	Surrogate Failure Prob. [2]	Comments [3]
		Basic Event (representative)	Failure Probability				
TFNEXHOC	4-of-6	PFNEF1BM PDMINEF1BC PDME1EF1BC PDME1EF1BC PFNEF1BF PDMEF1BC PCNEF1BF PMC480VE2F Loss of Power	8.20×10^{-3} 1.22×10^{-4} 1.22×10^{-4} 1.22×10^{-4} 2.20×10^{-4} 1.22×10^{-4} 2.00×10^{-5} 8.00×10^{-7} 2.98×10^{-5}	5,595	8.20×10^{-3}	2.5×10^{-5}	Use maximum failure probability as the substitute failure prob.

Notes for Table IV-3

[1] See Attachment V for the calculation of the number of combinations. See Section 5.5 for a detailed example of one calculation.

[2] This is calculated as (*Number of combinations*) x (*Average failure probability*)$^{(Number\ of\ cutset\ elements)}$. The *number of cutset elements* is the **m** in the **m-of-n** combination gate logic.

[3] Using the maximum failure probability of the all the inputs is conservative, since there are clearly many cutsets with a smaller overall failure probability. If the estimated surrogate value appears too high, or contributes significantly to the quantified cutsets, different assumptions can be used to estimate the surrogate failure probability less conservatively.

ATTACHMENT V

COMBINATORIAL CALCULATIONS

Note:

See Section 5.5 for a detailed calculation of **4 Rows of 9 Gates (5-of-9 for failure)**, the first case shown in this attachment. The numbers shown in the spreadsheet are the combinations discussed in Section 5.5. It should be clear how to extrapolate the information in the spreadsheet to the other cases provided. The number of combinations is used in Table IV-3 of Attachment IV.

4 Rows of 9 Gates (5-of-9 for failure)								
126						4		504
126	5					3		1890
84	15					3		3780
36	35					3		3780
9	70					3		1890
84	6	5				2		5040
36	21	5				2		7560
36	7	15				2		7560
9	56	5				2		5040
9	28	15				2		7560
9	8	35				2		5040
36	7	6	5			1		7560
9	28	6	5			1		7560
9	8	21	5			1		7560
9	8	7	15			1		7560
								79884
2 Rows of 9 Gates (5-of-9 for failure)								
126						2		252
	-							
126	5					1		630
84	15					1		1260
36	35					1		1260
9	70					1		630
								4032
9 Rows of 9 (5-of-9 for failure)								
126						9		1134
126	5					8		5040
84	15					8		10080
36	35					8		10080
9	70					8		5040
84	6	5				7		17640
36	21	5				7		26460
36	7	15				7		26460
9	56	5				7		17640
9	28	15				7		26460
9	8	35				7		17640
36	7	6	5			6		45360
9	28	6	5			6		45360
9	8	21	5			6		45360
9	8	7	15			6		45360
9	8	7	6	5		5		75600
								420714

2 Rows of 15 (8-of-15 for failure)								
6435						2		12870
6435	8					1		51480
5005	36					1		180180
3003	120					1		360360
1365	330					1		450450
455	792					1		360360
105	1716					1		180180
15	3432					1		51480
								1055340
2 Rows of 10 (6-of-10 for failure)								
210						2		420
252	5					1		1260
210	15					1		3150
120	35					1		4200
45	70					1		3150
10	126					1		1260
								12180
4 Rows of 10 (6-of-10 for failure)								
210						4		840
252	5					3		3780
210	15					3		9450
120	35					3		12600
45	70					3		9450
10	126					3		3780
210	6	5				2		12600
120	21	5				2		25200
120	7	15				2		25200
45	56	5				2		25200
45	28	15				2		37800
45	8	35				2		25200
10	126	5				2		12600
10	84	15				2		25200
10	36	35				2		25200
10	9	70				2		12600
120	7	6	5			1		25200
45	28	6	5			1		37800
45	8	21	5			1		37800
45	8	7	15			1		37800
10	84	6	5			1		25200
10	36	21	5			1		37800
10	36	7	15			1		37800
10	9	56	5			1		25200
10	9	28	15			1		37800
10	9	8	35			1		25200
								594300

9 Rows of 10 (6-of-10 for failure)								
210						9		1890
252	5					8		10080
210	15					8		25200
120	35					8		33600
45	70					8		25200
10	126					8		10080
210	6	5				7		44100
120	21	5				7		88200
120	7	15				7		88200
45	56	5				7		88200
45	28	15				7		132300
45	8	35				7		88200
10	126	5				7		44100
10	84	15				7		88200
10	36	35				7		88200
10	9	70				7		44100
120	7	6	5			6		151200
45	28	6	5			6		226800
45	8	21	5			6		226800
45	8	7	15			6		226800
10	84	6	5			6		151200
10	36	21	5			6		226800
10	36	7	15			6		226800
10	9	56	5			6		151200
10	9	28	15			6		226800
10	9	8	35			6		151200
45	8	7	6	5		5		378000
10	36	7	6	5		5		378000
10	9	28	6	5		5		378000
10	9	8	21	5		5		378000
10	9	8	7	15		5		378000
10	9	8	7	6	5	4		604800
								5360250
4 Rows of 7 (4-of-7 for failure)								
35						4		140
35	4					3		420
21	10					3		630
7	20					3		420
21	5	4				2		840
7	15	4				2		840
7	6	10				2		840
7	6	5	4			1		840
								4970

9 Rows of 4 (3-of-4 for failure)								
4						9		36
6	2					8		96
4	3					8		96
4	3	2				7		168
								396
9 Rows of 6 (4-of-6 for failure)								
15						9		135
20	3					8		480
15	6					8		720
6	10					8		480
15	4	3				7		1260
6	10	3				7		1260
6	5	6				7		1260
								5595
4 Rows of 16 Gates (9-of-16 for failure)								
11440						4		45760
12870	8					3		308880
11440	36					3		1235520
8008	120					3		2882880
4368	330					3		4324320
1820	792					3		4324320
560	1716					3		2882880
120	3432					3		1235520
16	6435							
								17240080
								114933866.7
			This case is not fully developed (like the preceding ones). Instead the total number of combinations is estimated by taking the sum of the one-row and two-row cases as 15% of the total number of combinations. This was not much of a concern since failure would require a nine-element cutset.					

ATTACHMENT VI

HIGH LEVEL HVAC DESIGN WITH EMERGENCY SUPPLY-SIDE TRAIN

Intentional obliterations do not impact the technical meaning or content of the record.

JM 5/25/99

~~Title:Surface Nuclear Facilities HVAC Analysis~~ [redacted]

JM 5/25/99

~~DOCUMENT IDENTIFIER: BCBD00000-01717-0200-00013 Rev 01~~ [redacted]

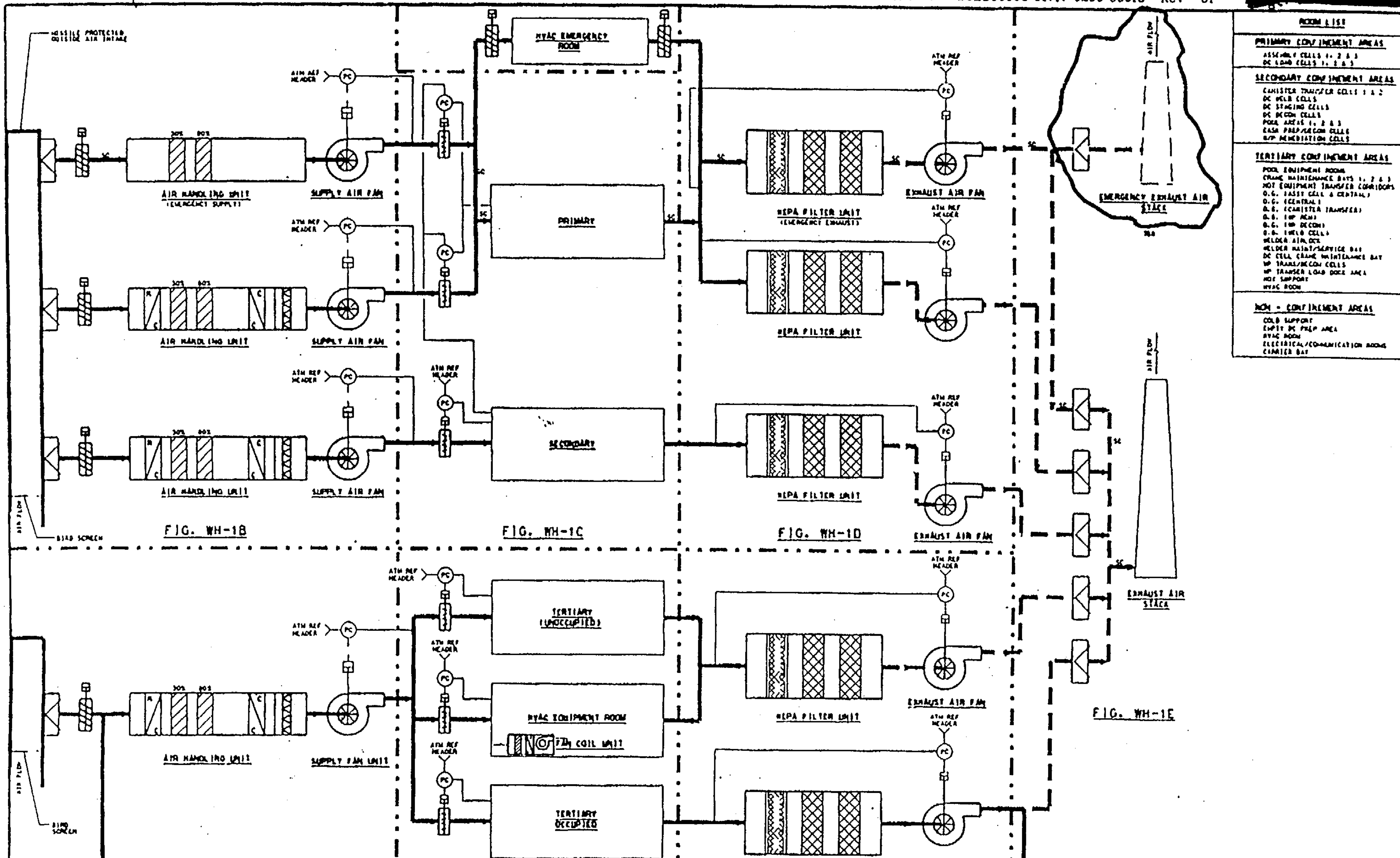


FIG. WH-1A
WHB-HVAC FLOW DIAGRAM
COMPOSITE KEY

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ATTACHMENT VII

LOOP INITIATING EVENT CUTSETS

Cutset Report

UNFIL_REL = 4.11E-02 (Probability)

Probability	%	Class	Inputs					
3.50E-03	8.5%		EIDNCEXF	LOOP	PBATSCAF	SBATTCAF	TBATENVF	
3.50E-03	17.0%		EIDNCEXF	LOOP	PBATTCAF	TBATENVF		
3.50E-03	25.4%		LOOP	PBATSCAF	PIDNOEXF	SBATTCAF	TBATENVF	
3.50E-03	33.8%		LOOP	PBATTCAF	PIDNOEXF	TBATENVF		
3.00E-03	41.0%		EDGDG01S	EHUEXHFF	LOOP	PBATSCAF	SBATTCAF	TBATENVF
3.00E-03	48.2%		EDGDG01S	EHUEXHFF	LOOP	PBATTCAF	TBATENVF	
3.00E-03	55.3%		EDGDG01S	EHUFNSUF	LOOP	PBATSCAF	SBATTCAF	TBATENVF
3.00E-03	62.5%		EDGDG01S	EHUFNSUF	LOOP	PBATTCAF	TBATENVF	
1.60E-03	66.3%		EDGDG01R	EHUEXHFF	LOOP	PBATSCAF	SBATTCAF	TBATENVF
1.60E-03	70.0%		EDGDG01R	EHUEXHFF	LOOP	PBATTCAF	TBATENVF	
1.60E-03	73.8%		EDGDG01R	EHUFNSUF	LOOP	PBATSCAF	SBATTCAF	TBATENVF
1.60E-03	77.6%		EDGDG01R	EHUFNSUF	LOOP	PBATTCAF	TBATENVF	
8.20E-04	79.5%		EFLHF1TM	EHUHEPAF	LOOP	PBATSCAF	SBATTCAF	TBATENVF
8.20E-04	81.4%		EFLHF1TM	EHUHEPAF	LOOP	PBATTCAF	TBATENVF	
8.20E-04	83.4%		EFLHF1UM	EHUHEPAF	LOOP	PBATSCAF	SBATTCAF	TBATENVF
8.20E-04	85.3%		EFLHF1UM	EHUHEPAF	LOOP	PBATTCAF	TBATENVF	
8.20E-04	87.2%		EFNEF1MM	EHUEXHFF	LOOP	PBATSCAF	SBATTCAF	TBATENVF
8.20E-04	89.1%		EFNEF1MM	EHUEXHFF	LOOP	PBATTCAF	TBATENVF	
8.20E-04	91.1%		EFNEF1NM	EHUEXHFF	LOOP	PBATSCAF	SBATTCAF	TBATENVF
8.20E-04	93.0%		EFNEF1NM	EHUEXHFF	LOOP	PBATTCAF	TBATENVF	
6.00E-04	94.4%		EDGDG01M	EHUEXHFF	LOOP	PBATSCAF	SBATTCAF	TBATENVF
6.00E-04	95.8%		EDGDG01M	EHUEXHFF	LOOP	PBATTCAF	TBATENVF	
6.00E-04	97.2%		EDGDG01M	EHUFNSUF	LOOP	PBATSCAF	SBATTCAF	TBATENVF
6.00E-04	98.6%		EDGDG01M	EHUFNSUF	LOOP	PBATTCAF	TBATENVF	
2.18E-05	98.6%		EFNEF1MF	EHUEXHFF	LOOP	PBATSCAF	SBATTCAF	TBATENVF
2.18E-05	98.7%		EFNEF1MF	EHUEXHFF	LOOP	PBATTCAF	TBATENVF	
2.18E-05	98.7%		EFNEF1NF	EHUEXHFF	LOOP	PBATSCAF	SBATTCAF	TBATENVF
2.18E-05	98.8%		EFNEF1NF	EHUEXHFF	LOOP	PBATTCAF	TBATENVF	
1.22E-05	98.8%		EDME1EF1MC	EHUEXHFF	LOOP	PBATSCAF	SBATTCAF	TBATENVF
1.22E-05	98.8%		EDME1EF1MC	EHUEXHFF	LOOP	PBATTCAF	TBATENVF	
1.22E-05	98.9%		EDME1EF1NC	EHUEXHFF	LOOP	PBATSCAF	SBATTCAF	TBATENVF
1.22E-05	98.9%		EDME1EF1NC	EHUEXHFF	LOOP	PBATTCAF	TBATENVF	
1.22E-05	98.9%		EDME2EF1MC	EHUEXHFF	LOOP	PBATSCAF	SBATTCAF	TBATENVF
1.22E-05	99.0%		EDME2EF1MC	EHUEXHFF	LOOP	PBATTCAF	TBATENVF	
1.22E-05	99.0%		EDME2EF1NC	EHUEXHFF	LOOP	PBATSCAF	SBATTCAF	TBATENVF
1.22E-05	99.0%		EDME2EF1NC	EHUEXHFF	LOOP	PBATTCAF	TBATENVF	
1.22E-05	99.0%		EDMEF1MC	EHUEXHFF	LOOP	PBATSCAF	SBATTCAF	TBATENVF
1.22E-05	99.1%		EDMEF1MC	EHUEXHFF	LOOP	PBATTCAF	TBATENVF	
1.22E-05	99.1%		EDMEF1NC	EHUEXHFF	LOOP	PBATSCAF	SBATTCAF	TBATENVF
1.22E-05	99.1%		EDMEF1NC	EHUEXHFF	LOOP	PBATTCAF	TBATENVF	
1.22E-05	99.2%		EDMEXHF1TC	EHUHEPAF	LOOP	PBATSCAF	SBATTCAF	TBATENVF

Probability	%	Class	Inputs						
1.22E-05	99.2%		EDMEXHF1TC	EHUHEPAF	LOOP	PBATTCAF	TBATENVF		
1.22E-05	99.2%		EDMEXHF1UC	EHUHEPAF	LOOP	PBATSCAF	SBATTCAF	TBATENVF	
1.22E-05	99.3%		EDMEXHF1UC	EHUHEPAF	LOOP	PBATTCAF	TBATENVF		
1.22E-05	99.3%		EDMINEF1MC	EHUEXHFF	LOOP	PBATSCAF	SBATTCAF	TBATENVF	
1.22E-05	99.3%		EDMINEF1MC	EHUEXHFF	LOOP	PBATTCAF	TBATENVF		
1.22E-05	99.4%		EDMINEF1NC	EHUEXHFF	LOOP	PBATSCAF	SBATTCAF	TBATENVF	
1.22E-05	99.4%		EDMINEF1NC	EHUEXHFF	LOOP	PBATTCAF	TBATENVF		
1.22E-05	99.4%		EDMINHF1TC	EHUHEPAF	LOOP	PBATSCAF	SBATTCAF	TBATENVF	
1.22E-05	99.4%		EDMINHF1TC	EHUHEPAF	LOOP	PBATTCAF	TBATENVF		
1.22E-05	99.5%		EDMINHF1UC	EHUHEPAF	LOOP	PBATSCAF	SBATTCAF	TBATENVF	
1.22E-05	99.5%		EDMINHF1UC	EHUHEPAF	LOOP	PBATTCAF	TBATENVF		
1.22E-05	99.5%		EDMTD2AC	EHUTDEXF	LOOP	PBATSCAF	SBATTCAF	TBATENVF	
1.22E-05	99.6%		EDMTD2AC	EHUTDEXF	LOOP	PBATTCAF	TBATENVF		
1.22E-05	99.6%		EDMTD2BC	EHUTDEXF	LOOP	PBATSCAF	SBATTCAF	TBATENVF	
1.22E-05	99.6%		EDMTD2BC	EHUTDEXF	LOOP	PBATTCAF	TBATENVF		
7.20E-06	99.6%		EHUTDEXF	ESWTD2AF	LOOP	PBATSCAF	SBATTCAF	TBATENVF	
7.20E-06	99.6%		EHUTDEXF	ESWTD2AF	LOOP	PBATTCAF	TBATENVF		
7.20E-06	99.7%		EHUTDEXF	ESWTD2BF	LOOP	PBATSCAF	SBATTCAF	TBATENVF	
7.20E-06	99.7%		EHUTDEXF	ESWTD2BF	LOOP	PBATTCAF	TBATENVF		
6.72E-06	99.7%		EAHAH1MM	EAHAH1NM	EHUAHUSF	LOOP	PBATSCAF	SBATTCAF	TBATENVF
6.72E-06	99.7%		EAHAH1MM	EAHAH1NM	EHUAHUSF	LOOP	PBATTCAF	TBATENVF	
6.72E-06	99.7%		EAHAH1MM	EAHAH1PM	EHUAHUSF	LOOP	PBATSCAF	SBATTCAF	TBATENVF
6.72E-06	99.7%		EAHAH1MM	EAHAH1PM	EHUAHUSF	LOOP	PBATTCAF	TBATENVF	
6.72E-06	99.8%		EAHAH1NM	EAHAH1PM	EHUAHUSF	LOOP	PBATSCAF	SBATTCAF	TBATENVF
6.72E-06	99.8%		EAHAH1NM	EAHAH1PM	EHUAHUSF	LOOP	PBATTCAF	TBATENVF	
6.72E-06	99.8%		EFNSF1MM	EFNSF1NM	EHUFNSUF	LOOP	PBATSCAF	SBATTCAF	TBATENVF
6.72E-06	99.8%		EFNSF1MM	EFNSF1NM	EHUFNSUF	LOOP	PBATTCAF	TBATENVF	
6.72E-06	99.8%		EFNSF1MM	EFNSF1PM	EHUFNSUF	LOOP	PBATSCAF	SBATTCAF	TBATENVF
6.72E-06	99.8%		EFNSF1MM	EFNSF1PM	EHUFNSUF	LOOP	PBATTCAF	TBATENVF	
6.72E-06	99.9%		EFNSF1NM	EFNSF1PM	EHUFNSUF	LOOP	PBATSCAF	SBATTCAF	TBATENVF
6.72E-06	99.9%		EFNSF1NM	EFNSF1PM	EHUFNSUF	LOOP	PBATTCAF	TBATENVF	
4.32E-06	99.9%		EFLHF1TB	EHUHEPAF	LOOP	PBATSCAF	SBATTCAF	TBATENVF	
4.32E-06	99.9%		EFLHF1TB	EHUHEPAF	LOOP	PBATTCAF	TBATENVF		
4.32E-06	99.9%		EFLHF1UB	EHUHEPAF	LOOP	PBATSCAF	SBATTCAF	TBATENVF	
4.32E-06	99.9%		EFLHF1UB	EHUHEPAF	LOOP	PBATTCAF	TBATENVF		
2.18E-06	99.9%		EFNE1MNX	EHUEXHFF	LOOP	PBATSCAF	SBATTCAF	TBATENVF	
2.18E-06	99.9%		EFNE1MNX	EHUEXHFF	LOOP	PBATTCAF	TBATENVF		
2.18E-06	99.9%		EFNS1MNX	EHUFNSUF	LOOP	PBATSCAF	SBATTCAF	TBATENVF	
2.18E-06	99.9%		EFNS1MNX	EHUFNSUF	LOOP	PBATTCAF	TBATENVF		
2.18E-06	99.9%		EFNS1MPX	EHUFNSUF	LOOP	PBATSCAF	SBATTCAF	TBATENVF	
2.18E-06	99.9%		EFNS1MPX	EHUFNSUF	LOOP	PBATTCAF	TBATENVF		
2.18E-06	99.9%		EFNS1NPX	EHUFNSUF	LOOP	PBATSCAF	SBATTCAF	TBATENVF	
2.18E-06	99.9%		EFNS1NPX	EHUFNSUF	LOOP	PBATTCAF	TBATENVF		
2.04E-06	100.0%		ECNEF1MF	EHUEXHFF	LOOP	PBATSCAF	SBATTCAF	TBATENVF	
2.04E-06	100.0%		ECNEF1MF	EHUEXHFF	LOOP	PBATTCAF	TBATENVF		
2.04E-06	100.0%		ECNEF1NF	EHUEXHFF	LOOP	PBATSCAF	SBATTCAF	TBATENVF	
2.04E-06	100.0%		ECNEF1NF	EHUEXHFF	LOOP	PBATTCAF	TBATENVF		
1.22E-06	100.0%		EDMT1MNX	EHUTDSUF	LOOP	PBATSCAF	SBATTCAF	TBATENVF	
1.22E-06	100.0%		EDMT1MNX	EHUTDSUF	LOOP	PBATTCAF	TBATENVF		

Probability	%	Class	Inputs						
1.22E-06	100.0%		EDMT1MPX	EHUTDSUF	LOOP	PBATSCAF	SBATTCAF	TBATENVF	
1.22E-06	100.0%		EDMT1MPX	EHUTDSUF	LOOP	PBATTCAF	TBATENVF		
1.22E-06	100.0%		EDMT1NPX	EHUTDSUF	LOOP	PBATSCAF	SBATTCAF	TBATENVF	
1.22E-06	100.0%		EDMT1NPX	EHUTDSUF	LOOP	PBATTCAF	TBATENVF		
1.22E-06	100.0%		EDMT2ABX	EHUTDEXF	LOOP	PBATSCAF	SBATTCAF	TBATENVF	
1.22E-06	100.0%		EDMT2ABX	EHUTDEXF	LOOP	PBATTCAF	TBATENVF		
8.16E-07	100.0%		EAHA1MNX	EHUAHUSF	LOOP	PBATSCAF	SBATTCAF	TBATENVF	
8.16E-07	100.0%		EAHA1MNX	EHUAHUSF	LOOP	PBATTCAF	TBATENVF		
8.16E-07	100.0%		EAHA1MPX	EHUAHUSF	LOOP	PBATSCAF	SBATTCAF	TBATENVF	
8.16E-07	100.0%		EAHA1MPX	EHUAHUSF	LOOP	PBATTCAF	TBATENVF		
8.16E-07	100.0%		EAHA1NPX	EHUAHUSF	LOOP	PBATSCAF	SBATTCAF	TBATENVF	
8.16E-07	100.0%		EAHA1NPX	EHUAHUSF	LOOP	PBATTCAF	TBATENVF		
4.32E-07	100.0%		EFLH1TUX	EHUHEPAF	LOOP	PBATSCAF	SBATTCAF	TBATENVF	
4.32E-07	100.0%		EFLH1TUX	EHUHEPAF	LOOP	PBATTCAF	TBATENVF		
1.79E-07	100.0%		EFNSF1MF	EFNSF1NM	EHUFNSUF	LOOP	PBATSCAF	SBATTCAF	TBATENVF
1.79E-07	100.0%		EFNSF1MF	EFNSF1NM	EHUFNSUF	LOOP	PBATTCAF	TBATENVF	
1.79E-07	100.0%		EFNSF1MF	EFNSF1PM	EHUFNSUF	LOOP	PBATSCAF	SBATTCAF	TBATENVF
1.79E-07	100.0%		EFNSF1MF	EFNSF1PM	EHUFNSUF	LOOP	PBATTCAF	TBATENVF	
1.79E-07	100.0%		EFNSF1MM	EFNSF1NF	EHUFNSUF	LOOP	PBATSCAF	SBATTCAF	TBATENVF
1.79E-07	100.0%		EFNSF1MM	EFNSF1NF	EHUFNSUF	LOOP	PBATTCAF	TBATENVF	
1.79E-07	100.0%		EFNSF1MM	EFNSF1PF	EHUFNSUF	LOOP	PBATSCAF	SBATTCAF	TBATENVF
1.79E-07	100.0%		EFNSF1MM	EFNSF1PF	EHUFNSUF	LOOP	PBATTCAF	TBATENVF	
1.79E-07	100.0%		EFNSF1NF	EFNSF1PM	EHUFNSUF	LOOP	PBATSCAF	SBATTCAF	TBATENVF
1.79E-07	100.0%		EFNSF1NF	EFNSF1PM	EHUFNSUF	LOOP	PBATTCAF	TBATENVF	
1.79E-07	100.0%		EFNSF1NM	EFNSF1PF	EHUFNSUF	LOOP	PBATSCAF	SBATTCAF	TBATENVF
1.79E-07	100.0%		EFNSF1NM	EFNSF1PF	EHUFNSUF	LOOP	PBATTCAF	TBATENVF	
1.00E-07	100.0%		EAHAH1MM	EDMEXAH1NC	EHUAHUSF	LOOP	PBATSCAF	SBATTCAF	TBATENVF
1.00E-07	100.0%		EAHAH1MM	EDMEXAH1NC	EHUAHUSF	LOOP	PBATTCAF	TBATENVF	
1.00E-07	100.0%		EAHAH1MM	EDMEXAH1PC	EHUAHUSF	LOOP	PBATSCAF	SBATTCAF	TBATENVF
1.00E-07	100.0%		EAHAH1MM	EDMEXAH1PC	EHUAHUSF	LOOP	PBATTCAF	TBATENVF	
1.00E-07	100.0%		EAHAH1MM	EDMINAH1NC	EHUAHUSF	LOOP	PBATSCAF	SBATTCAF	TBATENVF
1.00E-07	100.0%		EAHAH1MM	EDMINAH1NC	EHUAHUSF	LOOP	PBATTCAF	TBATENVF	
1.00E-07	100.0%		EAHAH1MM	EDMINAH1PC	EHUAHUSF	LOOP	PBATSCAF	SBATTCAF	TBATENVF
1.00E-07	100.0%		EAHAH1MM	EDMINAH1PC	EHUAHUSF	LOOP	PBATTCAF	TBATENVF	
1.00E-07	100.0%		EAHAH1NM	EDMEXAH1MC	EHUAHUSF	LOOP	PBATSCAF	SBATTCAF	TBATENVF
1.00E-07	100.0%		EAHAH1NM	EDMEXAH1MC	EHUAHUSF	LOOP	PBATTCAF	TBATENVF	
1.00E-07	100.0%		EAHAH1NM	EDMEXAH1PC	EHUAHUSF	LOOP	PBATSCAF	SBATTCAF	TBATENVF
1.00E-07	100.0%		EAHAH1NM	EDMEXAH1PC	EHUAHUSF	LOOP	PBATTCAF	TBATENVF	
1.00E-07	100.0%		EAHAH1NM	EDMINAH1MC	EHUAHUSF	LOOP	PBATSCAF	SBATTCAF	TBATENVF
1.00E-07	100.0%		EAHAH1NM	EDMINAH1MC	EHUAHUSF	LOOP	PBATTCAF	TBATENVF	
1.00E-07	100.0%		EAHAH1NM	EDMINAH1PC	EHUAHUSF	LOOP	PBATSCAF	SBATTCAF	TBATENVF
1.00E-07	100.0%		EAHAH1NM	EDMINAH1PC	EHUAHUSF	LOOP	PBATTCAF	TBATENVF	
1.00E-07	100.0%		EAHAH1PM	EDMEXAH1MC	EHUAHUSF	LOOP	PBATSCAF	SBATTCAF	TBATENVF
1.00E-07	100.0%		EAHAH1PM	EDMEXAH1MC	EHUAHUSF	LOOP	PBATTCAF	TBATENVF	
1.00E-07	100.0%		EAHAH1PM	EDMEXAH1NC	EHUAHUSF	LOOP	PBATSCAF	SBATTCAF	TBATENVF
1.00E-07	100.0%		EAHAH1PM	EDMEXAH1NC	EHUAHUSF	LOOP	PBATTCAF	TBATENVF	
1.00E-07	100.0%		EAHAH1PM	EDMINAH1MC	EHUAHUSF	LOOP	PBATSCAF	SBATTCAF	TBATENVF
1.00E-07	100.0%		EAHAH1PM	EDMINAH1MC	EHUAHUSF	LOOP	PBATTCAF	TBATENVF	
1.00E-07	100.0%		EAHAH1PM	EDMINAH1NC	EHUAHUSF	LOOP	PBATSCAF	SBATTCAF	TBATENVF

Probability	%	Class	Inputs						
1.00E-07	100.0%		EAHAH1PM	EDMINAH1NC	EHUAHUSF	LOOP	PBATTCAF	TBATENVF	
1.00E-07	100.0%		EDME1SF1MC	EFNSF1NM	EHUFNSUF	LOOP	PBATSCAF	SBATTCAF	TBATENVF
1.00E-07	100.0%		EDME1SF1MC	EFNSF1NM	EHUFNSUF	LOOP	PBATTCAF	TBATENVF	
1.00E-07	100.0%		EDME1SF1MC	EFNSF1PM	EHUFNSUF	LOOP	PBATSCAF	SBATTCAF	TBATENVF
1.00E-07	100.0%		EDME1SF1MC	EFNSF1PM	EHUFNSUF	LOOP	PBATTCAF	TBATENVF	
1.00E-07	100.0%		EDME1SF1NC	EFNSF1MM	EHUFNSUF	LOOP	PBATSCAF	SBATTCAF	TBATENVF
1.00E-07	100.0%		EDME1SF1NC	EFNSF1MM	EHUFNSUF	LOOP	PBATTCAF	TBATENVF	
1.00E-07	100.0%		EDME1SF1NC	EFNSF1PM	EHUFNSUF	LOOP	PBATSCAF	SBATTCAF	TBATENVF
1.00E-07	100.0%		EDME1SF1NC	EFNSF1PM	EHUFNSUF	LOOP	PBATTCAF	TBATENVF	
1.00E-07	100.0%		EDME1SF1PC	EFNSF1MM	EHUFNSUF	LOOP	PBATSCAF	SBATTCAF	TBATENVF
1.00E-07	100.0%		EDME1SF1PC	EFNSF1MM	EHUFNSUF	LOOP	PBATTCAF	TBATENVF	
1.00E-07	100.0%		EDME1SF1PC	EFNSF1NM	EHUFNSUF	LOOP	PBATSCAF	SBATTCAF	TBATENVF
1.00E-07	100.0%		EDME1SF1PC	EFNSF1NM	EHUFNSUF	LOOP	PBATTCAF	TBATENVF	
1.00E-07	100.0%		EDME2SF1MC	EFNSF1NM	EHUFNSUF	LOOP	PBATSCAF	SBATTCAF	TBATENVF
1.00E-07	100.0%		EDME2SF1MC	EFNSF1NM	EHUFNSUF	LOOP	PBATTCAF	TBATENVF	
1.00E-07	100.0%		EDME2SF1MC	EFNSF1PM	EHUFNSUF	LOOP	PBATSCAF	SBATTCAF	TBATENVF
1.00E-07	100.0%		EDME2SF1MC	EFNSF1PM	EHUFNSUF	LOOP	PBATTCAF	TBATENVF	
1.00E-07	100.0%		EDME2SF1NC	EFNSF1MM	EHUFNSUF	LOOP	PBATSCAF	SBATTCAF	TBATENVF
1.00E-07	100.0%		EDME2SF1NC	EFNSF1MM	EHUFNSUF	LOOP	PBATTCAF	TBATENVF	
1.00E-07	100.0%		EDME2SF1NC	EFNSF1PM	EHUFNSUF	LOOP	PBATSCAF	SBATTCAF	TBATENVF
1.00E-07	100.0%		EDME2SF1NC	EFNSF1PM	EHUFNSUF	LOOP	PBATTCAF	TBATENVF	
1.00E-07	100.0%		EDME2SF1PC	EFNSF1MM	EHUFNSUF	LOOP	PBATSCAF	SBATTCAF	TBATENVF
1.00E-07	100.0%		EDME2SF1PC	EFNSF1MM	EHUFNSUF	LOOP	PBATTCAF	TBATENVF	
1.00E-07	100.0%		EDME2SF1PC	EFNSF1NM	EHUFNSUF	LOOP	PBATSCAF	SBATTCAF	TBATENVF
1.00E-07	100.0%		EDME2SF1PC	EFNSF1NM	EHUFNSUF	LOOP	PBATTCAF	TBATENVF	
1.00E-07	100.0%		EDMINSF1MC	EFNSF1NM	EHUFNSUF	LOOP	PBATSCAF	SBATTCAF	TBATENVF
1.00E-07	100.0%		EDMINSF1MC	EFNSF1NM	EHUFNSUF	LOOP	PBATTCAF	TBATENVF	
1.00E-07	100.0%		EDMINSF1MC	EFNSF1PM	EHUFNSUF	LOOP	PBATSCAF	SBATTCAF	TBATENVF
1.00E-07	100.0%		EDMINSF1MC	EFNSF1PM	EHUFNSUF	LOOP	PBATTCAF	TBATENVF	
1.00E-07	100.0%		EDMINSF1NC	EFNSF1MM	EHUFNSUF	LOOP	PBATSCAF	SBATTCAF	TBATENVF
1.00E-07	100.0%		EDMINSF1NC	EFNSF1MM	EHUFNSUF	LOOP	PBATTCAF	TBATENVF	
1.00E-07	100.0%		EDMINSF1NC	EFNSF1PM	EHUFNSUF	LOOP	PBATSCAF	SBATTCAF	TBATENVF
1.00E-07	100.0%		EDMINSF1NC	EFNSF1PM	EHUFNSUF	LOOP	PBATTCAF	TBATENVF	
1.00E-07	100.0%		EDMINSF1PC	EFNSF1MM	EHUFNSUF	LOOP	PBATSCAF	SBATTCAF	TBATENVF
1.00E-07	100.0%		EDMINSF1PC	EFNSF1MM	EHUFNSUF	LOOP	PBATTCAF	TBATENVF	
1.00E-07	100.0%		EDMINSF1PC	EFNSF1NM	EHUFNSUF	LOOP	PBATSCAF	SBATTCAF	TBATENVF
1.00E-07	100.0%		EDMINSF1PC	EFNSF1NM	EHUFNSUF	LOOP	PBATTCAF	TBATENVF	
1.00E-07	100.0%		EDMSF1MC	EFNSF1NM	EHUFNSUF	LOOP	PBATSCAF	SBATTCAF	TBATENVF
1.00E-07	100.0%		EDMSF1MC	EFNSF1NM	EHUFNSUF	LOOP	PBATTCAF	TBATENVF	
1.00E-07	100.0%		EDMSF1MC	EFNSF1PM	EHUFNSUF	LOOP	PBATSCAF	SBATTCAF	TBATENVF
1.00E-07	100.0%		EDMSF1MC	EFNSF1PM	EHUFNSUF	LOOP	PBATTCAF	TBATENVF	
1.00E-07	100.0%		EDMSF1NC	EFNSF1MM	EHUFNSUF	LOOP	PBATSCAF	SBATTCAF	TBATENVF
1.00E-07	100.0%		EDMSF1NC	EFNSF1MM	EHUFNSUF	LOOP	PBATTCAF	TBATENVF	
1.00E-07	100.0%		EDMSF1NC	EFNSF1PM	EHUFNSUF	LOOP	PBATSCAF	SBATTCAF	TBATENVF
1.00E-07	100.0%		EDMSF1NC	EFNSF1PM	EHUFNSUF	LOOP	PBATTCAF	TBATENVF	
1.00E-07	100.0%		EDMSF1PC	EFNSF1MM	EHUFNSUF	LOOP	PBATSCAF	SBATTCAF	TBATENVF
1.00E-07	100.0%		EDMSF1PC	EFNSF1MM	EHUFNSUF	LOOP	PBATTCAF	TBATENVF	
1.00E-07	100.0%		EDMSF1PC	EFNSF1NM	EHUFNSUF	LOOP	PBATSCAF	SBATTCAF	TBATENVF
1.00E-07	100.0%		EDMSF1PC	EFNSF1NM	EHUFNSUF	LOOP	PBATTCAF	TBATENVF	

Probability	%	Class	Inputs						
8.00E-08	100.0%		EHUEXHFF	EMC480VE1F	LOOP	PBATSCAF	SBATTCAF	TBATENVF	
8.00E-08	100.0%		EHUEXHFF	EMC480VE1F	LOOP	PBATTCAF	TBATENVF		
8.00E-08	100.0%		EHUFNSUF	EMC480VE1F	LOOP	PBATSCAF	SBATTCAF	TBATENVF	
8.00E-08	100.0%		EHUFNSUF	EMC480VE1F	LOOP	PBATTCAF	TBATENVF		
6.69E-08	100.0%		EAHAH1MB	EAHAH1NM	EHUAHUSF	LOOP	PBATSCAF	SBATTCAF	TBATENVF
6.69E-08	100.0%		EAHAH1MB	EAHAH1NM	EHUAHUSF	LOOP	PBATTCAF	TBATENVF	
6.69E-08	100.0%		EAHAH1MB	EAHAH1PM	EHUAHUSF	LOOP	PBATSCAF	SBATTCAF	TBATENVF
6.69E-08	100.0%		EAHAH1MB	EAHAH1PM	EHUAHUSF	LOOP	PBATTCAF	TBATENVF	
6.69E-08	100.0%		EAHAH1MM	EAHAH1NB	EHUAHUSF	LOOP	PBATSCAF	SBATTCAF	TBATENVF
6.69E-08	100.0%		EAHAH1MM	EAHAH1NB	EHUAHUSF	LOOP	PBATTCAF	TBATENVF	
6.69E-08	100.0%		EAHAH1MM	EAHAN1PB	EHUAHUSF	LOOP	PBATSCAF	SBATTCAF	TBATENVF
6.69E-08	100.0%		EAHAH1MM	EAHAN1PB	EHUAHUSF	LOOP	PBATTCAF	TBATENVF	
6.69E-08	100.0%		EAHAH1NB	EAHAH1PM	EHUAHUSF	LOOP	PBATSCAF	SBATTCAF	TBATENVF
6.69E-08	100.0%		EAHAH1NB	EAHAH1PM	EHUAHUSF	LOOP	PBATTCAF	TBATENVF	
6.69E-08	100.0%		EAHAH1NM	EAHAN1PB	EHUAHUSF	LOOP	PBATSCAF	SBATTCAF	TBATENVF
6.69E-08	100.0%		EAHAH1NM	EAHAN1PB	EHUAHUSF	LOOP	PBATTCAF	TBATENVF	
2.18E-08	100.0%		CDM8TDEY	CHUTDEXF	EIDNCEXF	PBATSCAF	SBATTCAF	TBATENVF	
2.18E-08	100.0%		CDM8TDEY	CHUTDEXF	EIDNCEXF	PBATTCAF	TBATENVF		
2.18E-08	100.0%		CDM8TDEY	CHUTDEXF	PBATSCAF	PIDNOEXF	SBATTCAF	TBATENVF	
2.18E-08	100.0%		CDM8TDEY	CHUTDEXF	PBATTCAF	PIDNOEXF	TBATENVF		
1.67E-08	100.0%		ECNSF1MF	EFNSF1NM	EHUFNSUF	LOOP	PBATSCAF	SBATTCAF	TBATENVF
1.67E-08	100.0%		ECNSF1MF	EFNSF1NM	EHUFNSUF	LOOP	PBATTCAF	TBATENVF	
1.67E-08	100.0%		ECNSF1MF	EFNSF1PM	EHUFNSUF	LOOP	PBATSCAF	SBATTCAF	TBATENVF
1.67E-08	100.0%		ECNSF1MF	EFNSF1PM	EHUFNSUF	LOOP	PBATTCAF	TBATENVF	
1.67E-08	100.0%		ECNSF1NF	EFNSF1MM	EHUFNSUF	LOOP	PBATSCAF	SBATTCAF	TBATENVF
1.67E-08	100.0%		ECNSF1NF	EFNSF1MM	EHUFNSUF	LOOP	PBATTCAF	TBATENVF	
1.67E-08	100.0%		ECNSF1NF	EFNSF1PM	EHUFNSUF	LOOP	PBATSCAF	SBATTCAF	TBATENVF
1.67E-08	100.0%		ECNSF1NF	EFNSF1PM	EHUFNSUF	LOOP	PBATTCAF	TBATENVF	
1.67E-08	100.0%		ECNSF1PF	EFNSF1MM	EHUFNSUF	LOOP	PBATSCAF	SBATTCAF	TBATENVF
1.67E-08	100.0%		ECNSF1PF	EFNSF1MM	EHUFNSUF	LOOP	PBATTCAF	TBATENVF	
1.67E-08	100.0%		ECNSF1PF	EFNSF1NM	EHUFNSUF	LOOP	PBATSCAF	SBATTCAF	TBATENVF
1.67E-08	100.0%		ECNSF1PF	EFNSF1NM	EHUFNSUF	LOOP	PBATTCAF	TBATENVF	

Report Summary:
Filename: C:\CAFTA-W\WHB_HVAC\WHBHVACL.CUT
Print date: 5/5/99 2:55 PM
Not sorted
Printed in full