APR1400
DESIGN CONTROL DOCUMENT TIER 2

CHAPTER 19
PROBABILISTIC RISK ASSESSMENT AND SEVERE ACCIDENT EVALUATION

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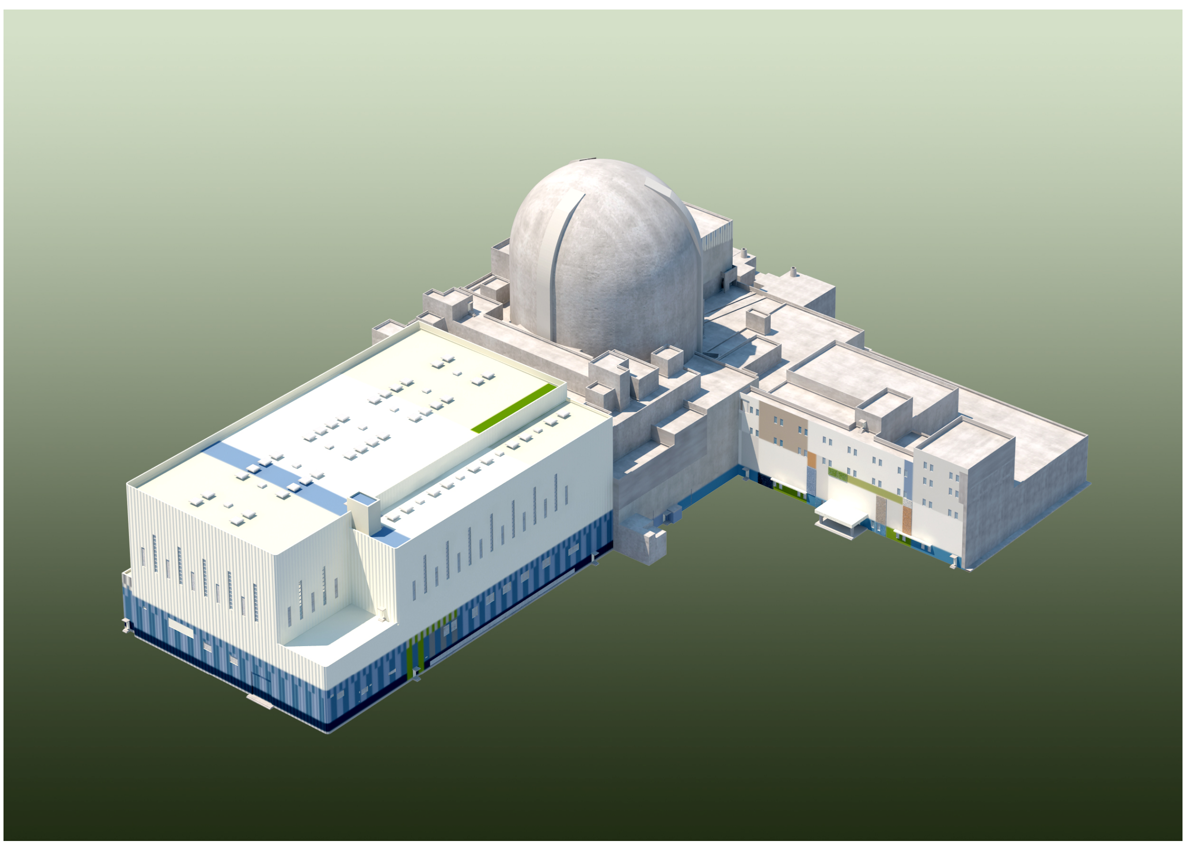

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CHAPTER 19 – PROBABILISTIC RISK ASSESSMENT AND SEVERE ACCIDENT EVALUATION

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ACRONYM AND ABBREVIATION LIST

AAC	Alternate Alternating Current
AC	Alternating Current
ACU	Air Cleaning Units
ADV	Atmospheric Dump Valve
AF	Auxiliary Feedwater
AFAS	Auxiliary Feedwater Actuation Signal
AFW	Auxiliary Feedwater
AFWS	Auxiliary Feedwater System
AFWST	Auxiliary Feedwater Storage Tank
AHU	Air Handling Units
AICC	Adiabatic Isochoric Complete Combustion
AM	Accident Management
ANS	American Nuclear Society
ANSI	American National Standards Institute
AOC	Averted Off-site Property Damage Costs
AOE	Averted Occupational Exposures
AOO	Anticipated Operational Occurrence
AOSC	Averted On-site Costs
AOV	Air Operated Valve
APE	Averted Public Exposure
ARM	Annunciator Response Model
AS	1) Accident Sequence Analysis 2) Auxiliary Steam
ASD	Alternate Shutdown
ASEP	Accident Sequence Evaluation Program
ASME	American Society of Mechanical Engineers
ATWS	Anticipated Transient Without Scram
BAST	Boric Acid Storage Tank
BAMP	Boric Acid Makeup Pump

BDD	Binary Decision Diagram
BMT	Basemat Melt Through
BOP	Balance of Plant
BWR	Boiling Water Reactor
CAP	Corrective Action Program
CBDTM	Cause-Based Decision Tree Methodology
CCDP	Conditional Core Damage Probability
CC	Component Cooling Water
CCF	Common Cause Failure
CCFP	Conditional Containment Failure Probability
CCI	Corium Concrete Interaction
CCS	Component Control System
CCW	Component Cooling Water
CCWS	Component Cooling Water System
CD	1) Complete Dependence (HRA) 2) Condensate System
CDF	Core Damage Frequency
CDI	Conceptual Design Information
CET	1) Containment Event Tree 2) Core-Exit Thermocouple
CF	Cavity Flooding
CFF	Containment Failure Frequency
CFR	Code of Federal Regulations
CFS	Cavity Flooding System
CHR	Containment Heat Removal
CI	Containment Isolation
CIS	Containment Isolation System
CIAS	Containment Isolation Actuation Signal
COE	Cost of Enhancement
COL	Combined License
COLA	Combined License Application

CRTF	Central Receiver Test Facility
CS	Containment Spray
CSAS	Containment Spray Actuation Signal
CSS	Containment Spray System
CT	Condensate Storage and Transfer System
CV	Chemical Volume Control System
CVCS	Chemical Volume Control System
CW	Circulating Water System
DA	Data Analysis
DC	Direct current
DCD	Design Control Document
DCF	Dynamic Containment Failure
DCH	Direct Containment Heating
DDT	Deflagration to Detonation Transition
DET	Decomposition Event Tree
DG	Diesel Generator
DPS	Diverse Protection System
DVI	Direct Vessel Injection
DNBR	Departure from Nucleate Boiling Ration
EBS	Estimated Break Size
ECCS	Emergency Core Cooling System
ECF	Early Containment Failure
ECSBS	Emergency Containment Spray Backup System
ECWS	Essential Chilled Water System
EDG	Emergency Diesel Generator
EF	Error Factor
EF	Engineered Safety Features Actuation System
EOL	Emergency Overflow Line
EOP	Emergency Operating Procedure
EPA	Electrical Penetration Assembly
EQ	Equipment Qualification

EPRI	Electric Power Research Institute
ERVC	External Reactor Vessel Cooling
ES	Equipment Survivability
ESF	Engineered Safety Features
ESF-CCS	Engineered Safety Feature – Component Control System
ESFAS	Engineered Safety Features Actuation System
ESW	Essential Service Water
ESWS	Essential Service Water System
ET	Event Tree
EVSE	Ex-Vessel Steam Explosion
FA	Flame Acceleration
FCI	Fuel-Coolant Interaction
FLC	Factored Load Category
FME	Foreign Material Exclusion
FMEA	Failure Modes and Effects Analysis
FP	Fire Protection
FSAR	Final Safety Analysis Report
FT	Fault Tree
FV	Fussell-Vesely
FW	Feedwater
FWCV	Feedwater Control Valve
FWLB	Feedwater Line Break
GRID-LOOP	Grid-Centered Loss of Offsite Power
GRID-SBO	Grid-Centered Station Blackout
GTG	Gas Turbine Generator
GTRN	General Transient
H2	Hydrogen
HCLPF	High Confidence of Low Probability of Failure
HCOG	Hydrogen Control Owner’s Group
HCR/ORE	Human Cognitive Reliability / Operator Reliability Experiment

HD	High Dependence (HRA)
HE	Human Error
HFE	Human Failure Events
HELB	High-Energy Line Break
HEP	Human Error Probability
HG	Containment Hydrogen Control System
HJTC	Heated Junction Thermocouple
HLI	Hot Leg Injection
HPME	High Pressure Melt Ejection
HRA	Human Reliability Analysis
HRR	Heat Release Rate
HT	High Temperature
HVAC	Heating, Ventilation, and Air conditioning
HVT	Holdup Volume Tank
HX	Heat Exchanger
IA	Instrument Air
IAS	Instrument Air System
I&C	Instrumentation and Control
ICDP	Incremental Core Damage Probability
ICI	In-Core Instrumentation
IE	Initiating Events Analysis
IEEE	Institute of Electrical and Electronic Engineers
IEPRA	Internal Events Probabilistic Risk Assessment
IF	Internal Flooding Analysis
IRWST	In-Containment Refueling Water Storage Tank
ISLOCA	Interfacing System Loss of Coolant Accident
ITAAC	Inspection, Test, Analysis, and Acceptance Criteria
INVINJ	In-Vessel Injection
IVSE	In-Vessel Steam Explosion
IW	In-Containment Refueling Water Storage System
IWSS	In-Containment Refueling Water Storage System

IRWST	In-Containment Refueling Water Storage Tank
KHNP	Korean Hydro and Nuclear Power Company
LD	Low Dependence (HRA)
LBLOCA	Large Break Loss of Coolant Accident
LCF	Late Containment Failure
LCL	Local Coincidence Logic
LE	LERF Analysis
LERF	Large Early Release Frequency
LHS	Latin Hypercube Sampling
LL	Large LOCA
LOCA	Loss-of-Coolant Accident
LOCCW	Loss of Component Cooling Water
LOCV	Loss of Condenser Vacuum
LODC	Loss of DC Power
LOESW	Loss of Essential Service Water
LOFW	Loss of Main Feedwater
LOIA	Loss of Instrument Air
LOLA	Loss of Large Areas
LOOP	Loss of Offsite Power
LPSD	Low Power and Shutdown
LPD	Local Power Density
LRF	Large Release Frequency
LSSB	Large Secondary Side Break
LT	Low Temperature
LWR	Light Water Reactor
MAAP	Modular Accident Analysis Program
MBLOCA	Medium Break Loss of Coolant Accident
MCA	Multiple Compartment Analysis
MCC	Motor Control Center
MCCI	Molten Core Concrete Interaction
MCR	Main Control Room

MFW	Main Feedwater
MELB	Moderate-Energy Line Break
MFIV	Main Feedwater Isolation Valve
ML	Medium LOCA
MOV	Motor Operated Valve
MS	Main Steam
MSADV	Main Steam Atmospheric Dump Valve
MSIS	Main Steam Isolation Signal
MSIV	Main Steam Isolation Valve
MSPI	Mitigating Systems Performance Index
MSSV	Main Steam Safety Valves
MSS	Main Steam System
NEI	Nuclear Energy Institute
NFPA	1)National Fire Protection Association 2)National Environmental Policy Act
NP	Non-Class 1E 13.8kV Auxiliary Power System
NPV	Net Present Value
NPSH	Net Positive Suction Head
NRC	U.S. Nuclear Regulatory Commission
NSSS	Nuclear Steam Supply System
NTS	Nevada Test Site
NUREG	NRC Technical Report Designation
OECD	Organization for Economic Cooperation and Development
P&ID	Piping and Instrument Diagram
PAL	Personnel Air Lock
PAR	Passive Autocatalytic Recombiners
PASS	Post-Accident Sampling System
PAU	Physical Analysis Unit
PDS	Plant Damage State
PF	4.16kV Class 1E Auxiliary Power
PGA	Peak Ground Acceleration

PIS	Post Indicating Valve
PLOCCW	Partial Loss of Component Cooling Water
PLOESW	Partial Loss of Essential Service Water
PAU	Physical Analysis Units
POS	Plant Operational State(s)
POSRV	Pilot-Operated Safety Relief Valve
PRA	Probabilistic Risk Assessment
PRCSCD	RCS Pressure at the time of Core Damage
PPS	Plant Protection System
PSA	Probabilistic Safety Assessment
PWR	Pressurized-Water Reactor
PZR	Pressurizer
QU	Quantification
RAP	Reliability Assurance Program
RAW	Risk Achievement Worth
RB	Reactor Building
RC	Reactor Coolant System
RCB	Reactor Containment Building
RCS	Reactor Coolant System
RCY	Reactor Critical-Year
RCP	Reactor Coolant Pump
RD	Rapid Depressurization
RG	Regulatory Guide
RCGV	Reactor Coolant Gas Vent
RCGVS	Reactor Coolant Gas Vent System
RLE	Review Level Earthquake
RMI	Reflective Metallic Insulation
RMTS	Risk-Managed Technical Specifications
RP	Reactor Protection
RPCS	Reactor Power Cutback System
RPS	Reactor Protection System

RPV	Reactor Pressure Vessel
RRS	Reactor Regulating System
RSC	Remote Shutdown Console
RSF	RCP Seal LOCA
RSG	Rapid Ex-Vessel Steam Generation
RTD	Resistance Temperature Detector
RTNSS	Regulatory Treatment of Non-Safety-related Systems
RTSS	Reactor Trip Switchgear System
RV	Reactor Vessel
RVLMS	Reactor Vessel Level Monitoring System
RVR	Reactor Vessel Rupture
RY	Reactor-Year
SAMA	Severe Accident Mitigation Alternative
SAMDA	Severe Accident Mitigation Design Alternative
SAMG	Severe Accident Management Guideline
SAT	Standby Auxiliary Transformers
SBCS	Steam Bypass Control System
SBLOCA	Small Break Loss of Coolant Accident
SBO	Station Blackout
SCETCh	Severe Combined Environment Test Chamber
SFD	Spent Fuel Damage
SFP	Spent Fuel Pool
SFPCCS	Spent Fuel Pool Cooling and Cleanup System
SC	Success Criteria Analysis
SC	Shutdown Cooling
SCP	Shutdown Cooling Pump
SCS	Shutdown Cooling System
SG	Steam Generator
SGTR	Steam Generator Tube Rupture
SI	Safety Injection
SIAS	Safety Injection Actuation Signal

SIP	Safety Injection Pump
SIS	Safety Injection System
SIT	Safety Injection Tank
SLB	Steam Line Break
SLOCA	Small Break Loss of Coolant Accident
SKN	Shin-Kori Nuclear Power Plant
SL	Small LOCA
SMA	Seismic Margin Analysis
SOV	Solenoid Operated Valve
SPND	Self-Powered Neutron Detector
SPAR-H	Standardized Plant Analysis Risk – Human Reliability
SRM	Staff Requirement Memorandum
SRP	Standard Review Plan
SSC	Structures, Systems and Components
SSE	Safe-Shutdown Earthquake
SSIE	Supporting System Initiating Event
STC	Source Term Category
STP	Standard Temperature and Pressure
SX	Essential Service Water System
SY	Systems Analysis
T&M	Test and Maintenance
TB	Turbine Building
TBV	Turbine Bypass Valve
TCE	Two-Cell Equilibrium
THERP	Technique for Human Error Rate Prediction
TI-SGTR	Temperature-Induced Steam Generator Tube Rupture
TLOCCW	Total Loss of Component Cooling Water
TLOESW	Total Loss of Essential Service Water
TLOFW	Total Loss of Feed Water
TMI	Three Mile Island
TRAN	Transient

TS	Technical Specification
UAT	Unit Auxiliary Transformers
UHS	Ultimate Heat Sink
VB	Vessel Breach
VCT	Volume Control Tank
VD	Emergency Diesel Generator Area HVAC
VEWFDS	Very Early Warning Fire Detection System
VG	ESW Intake Structure/CCW Heat Exchanger Building HVAC
VK	Auxiliary Building Controlled Area HVAC
VO	Auxiliary Building Clean Area HVAC
VOPT	Variable Over-Power Trip (Signal)
VU	Miscellaneous Building HVAC
WH	Turbine Generator Building Open Cooling Water System
WO	Chilled Water System
WT	Turbine Generator Building Closed Cooling Water System
ZD	Zero Dependence (HRA)

CHAPTER 19 – PROBABILISTIC RISK ASSESSMENT AND SEVERE ACCIDENT EVALUATION

19.0 Probabilistic Risk Assessment and Severe Accident Evaluation

This chapter summarizes information related to the probabilistic risk assessment (PRA) and the severe accident evaluations performed to support design certification of the APR1400. The primary objectives of this chapter during the design phase are as follows:

a. Identify and address potential design features and plant operational vulnerabilities, where a small number of failures could lead to core damage, containment failure, or large releases (e.g., assumed individual or common-cause failures could drive plant risk to unacceptable levels with respect to the Nuclear Regulatory Commission’s (NRC’s) goals, as presented below).

b. Reduce or eliminate the significant risk contributors of existing operating plants that are applicable to the new design by introducing appropriate features and requirements.

c. Select among alternative features, operational strategies, and design options to demonstrate that the design poses an acceptably low risk of core damage accidents.

The PRA also identifies risk-informed safety insights based on systematic evaluations of the risk associated with the design, construction, and operation of the plant such that the following can be identified and described from Regulatory Guide (RG) 1.206 (Reference 1):

a. Describe the design robustness, levels of defense-in-depth, and tolerance of severe accidents initiated by either internal or external events.

b. Describe the risk significance of specific human errors associated with the design, including a characterization of the significant human errors that may be used as an input to operator training programs and procedure refinement.

c. Demonstrate how the risk associated with the design compares against the NRC’s goals of less than 1×10^{-4}/year for core damage frequency (CDF) and less than 1×10^{-6}/year for large release frequency (LRF). In addition, compare the design against the NRC’s approved use of a containment performance goal, which includes: (1) a deterministic goal that containment integrity be maintained for

approximately 24 hours following the onset of core damage for the more likely severe accident challenges and (2) a probabilistic goal that the conditional containment failure probability be less than approximately 0.1 for the composite of all core damage sequences assessed in the PRA.

d. Assess the balance of preventive and mitigative features of the design, including consistency with the NRC's guidance in SECY-93-087 (Reference 2) and the associated SRM.

e. Demonstrate whether the plant design, including the impact of site-specific characteristics, represents a reduction in risk compared to existing operating plants.

f. Demonstrate that the design addresses known issues related to the reliability of core and containment heat removal systems at some operating plants (i.e., the additional TMI-related requirements in 10 CFR 50.34(f) (Reference 3)).

The results and insights of the PRA are used to support other programs as follows:

a. Support the process used to demonstrate whether the Regulatory Treatment of Non-Safety-Related Systems (RTNSS) is sufficient and, if appropriate, identify the structures, systems, and components (SSCs) included in RTNSS.

b. Support regulatory oversight processes such as the Mitigating Systems Performance Index (MSPI) and the significance determination process (SDP); and other programs that are associated with plant operations (e.g., Technical Specifications, reliability assurance, human factors, Maintenance Rule implementation).

c. Identify and support the development of specifications and performance objectives for the plant design, construction, inspection, and operation, such as the inspections, tests, analysis, and acceptance criteria (ITAACs), the reliability assurance program (RAP), the Technical Specifications, and Combined License (COL) action items and interface requirements.

A COL applicant that references the APR1400 design certification is to confirm that the PRA in the design certification bounds the site-specific design information and any design changes or departures, or update the PRA to reflect the site-specific design information and any design changes or departures.

19.0.1 NRC Regulatory Requirements and Related Policies

The primary requirements, guidance, policies, and standards utilized to complete the PRA and severe accident evaluations are as follows:

a. 10 CFR 52.47 (Reference 4)

b. 10 CFR 50.34

c. NRC Policy Statement 50 FR 32138 (Reference 5)

d. NRC Policy Statement 51 FR 28044 (Reference 6)

e. NRC Policy Statement 52 FR 34884 (Reference 7)

f. NRC Policy Statement 59 FR 35461 (Reference 8)

g. NRC Policy Statement 60 FR 42622 (Reference 9)

h. RG 1.200 (Reference 10)

i. RG 1.206

j. SECY-90-016 (Reference 11)

k. SECY-93-087

l. SECY-06-0220 (Reference 12)

m. NUREG-0800, Section 19.0 (Reference 13)

n. American Society of Mechanical Engineers (ASME)/American Nuclear Society (ANS) RA-S-2008 (Reference 14)

o. ASME/ANS RA-Sa-2009 (Reference 15)

19.0.2 Structure of Chapter 19

This chapter is structured in the following manner:

a. PRA results and insights are addressed including internal and external event evaluation during full-power operations and during low power and shutdown operations (Section 19.1). External events that are evaluated include seismic, internal fire, and internal flood. Level 1 and Level 2 results are reported. This section also describes the uses and applications of the PRA, PRA quality, design, and operational features that are intended to improve plant safety, and PRA input to design programs and processes.

b. Severe accident evaluations are provided including an assessment of preventive and mitigative features (Section 19.2). This section also describes containment performance capability, accident management, and considerations of potential design improvements under 10 CFR 50.34 (f).

c. Reserved (Section 19.3).

d. Evaluation of loss of large areas (LOLAs) as required by 10 CFR 52.80(d) (Reference 16) and 10 CFR 50.54(hh)(2) (Reference 17) (Section 19.4).

e. Evaluation of the aircraft impact assessment (AIA) as required by 10 CFR 50.150 (Reference 18) (Section 19.5).

19.0.3 Combined License Information

COL 19.0(1) The COL applicant is either to confirm that the PRA in the design certification bounds the site-specific design information and any design changes or departures, or to update the PRA to reflect the site-specific design information and any design changes or departures.

19.0.4 References

1. Regulatory Guide 1.206, “Combined License Applications for Nuclear Power Plants (LWR) Edition,” U.S. Nuclear Regulatory Commission, Rev. 0, June 2007.

2. SECY-93-087, “Policy, Technical, and Licensing Issues Pertaining to Evolutionary and Advanced Light-Water Reactor Designs,” U.S. Nuclear Regulatory Commission, Washington, DC, letter issued April 2, 1993 and Staff Requirements Memoranda issued July 21, 1993.

3. 10 CFR 50.34, "Contents of Applications; Technical Information," U.S. Nuclear Regulatory Commission, June 2009.

4 10 CFR 52.47, "Contents of Applications; Technical Information," U.S. Nuclear Regulatory Commission, June 2009.

5. "Severe Reactor Accidents Regarding Future Designs and Existing Plants," NRC Policy Statement 50 FR 32138, U.S. Nuclear Regulatory Commission, August 1985.

6. "Safety Goals for the Operations of Nuclear Power Plants," NRC Policy Statement 51 FR 28044, U.S. Nuclear Regulatory Commission, August 1986.

7. "Nuclear Power Plant Standardization," NRC Policy Statement 52 FR 34884, U.S. Nuclear Regulatory Commission, September 1987.

8. "Regulation of Advanced Nuclear Power Plants," NRC Policy Statement 59 FR 35461, U.S. Nuclear Regulatory Commission, July 1994.

9. "The Use of Probabilistic Risk Assessment Methods in Nuclear Regulatory Activities," NRC Policy Statement 60 FR 42622, U.S. Nuclear Regulatory Commission, August 1995.

10. Regulatory Guide 1.200, "An Approach for Determining the Technical Adequacy of Probabilistic Risk Assessment Results for Risk-Informed Activities," Rev. 2, U.S. Nuclear Regulatory Commission, March 2009.

11. SECY-90-016, "Evolutionary Light-Water Reactor (LWR) Certification Issues and Their Relationship to Current Regulatory Requirements," U.S. Nuclear Regulatory Commission, Letter issued January 12, 1990 and Staff Requirements Memoranda issued June 26, 1990.

12. SECY-06-0220, "Licenses, Certifications, and Approvals for Nuclear Power Plants," Final Rule to update 10 CFR Part 52, (RIN AG24), U.S. Nuclear Regulatory Commission, Letter issued October 31, 2006.

13. NUREG-0800, "Probabilistic Risk Assessment and Severe Accident Evaluation for New Reactors," Section 19.0, Rev. 2, U.S. Nuclear Regulatory Commission, June 2007.

14. ASME/ANS RA-S-2008, "Standard for Level 1/Large Early Release Frequency Probabilistic Risk Assessment for Nuclear Power Plant Applications," (Revision 1 RA-S-2002), American Society of Mechanical Engineers, April 2008.

15. ASME/ANS RA-Sa-2009, Addenda to ASME/ANS RA-S-2008, American Society of Mechanical Engineers, February 2009.

16. 10 CFR 52.80, "Contents of applications; additional technical information," U.S. Nuclear Regulatory Commission, March 2009.

17. 10 CFR 50.54, "Conditions of licenses," U.S. Nuclear Regulatory Commission, June 2013.

18. 10 CFR 50.150, "Aircraft impact assessment," U.S. Nuclear Regulatory Commission, July 2009.

19.1 Probabilistic Risk Assessment

The scope of the APR1400 PRA includes a Level 1 and Level 2 PRA for internal and external events (including internal flooding and internal fire) at full-power, as well as low-power and shutdown (LPSD) conditions.

The Level 1 and 2 evaluations of internal events at full-power conditions are based on the basic elements and approaches given in ASME/ANS RA-S-2008 and ASME/ANS RA-Sa-2009 (References 1 and 2), as endorsed by and NRC RG 1.200 (Reference 3), and the primary methodological guidance NUREG/CR-2300 (Reference 4) and NUREG-1150 (Reference 5).

Level 1 PRA evaluation is comprised of the following technical elements:

- Initiating event analysis
- Event tree analysis
- System dependencies
- Success criteria analysis
- System analysis
- Data analysis
- Common cause analysis
- Human reliability analysis (HRA)
- Quantification and insights

The Level 2 PRA results are produced in terms of LRF for internal events at full power and the evaluation involves the following:

- Plant damage state (PDS) analysis
- Accident progression analysis

- Quantification

The Level 2 evaluation of the flooding and fire external events at full-power conditions is based on the same approach as for internal events. Fault trees are modified to take into account flood/fire induced failures of severe accident mitigation features and these fault trees are mapped into the internal events through the associated PDSs.

The evaluation of internal fire events is based on the basic methodology and approach given in NUREG/CR-6850 (Reference 6). A qualitative evaluation identifies fire compartments and susceptible components and a quantitative analysis evaluates initiating events and fire scenarios.

The evaluation of a seismic external event is based on a seismic margin analysis (SMA) guidance in ASME/ANS PRA Standard (i.e., ASME/ANS RA-Sa-2009). The PRA-based SMA model is based on the internal events of the PRA model expanded to account for structural dependencies.

The evaluation of internal flooding is based on the basic methodology and approach given in ASME/ANS PRA Standard. A qualitative evaluation identifies flood areas and sources and a quantitative analysis evaluates initiating events and flood scenarios.

Other external events (i.e., high winds and tornadoes, external floods, transportation accidents, nearby facility accidents, etc.) are subject to screening criteria consistent with ASME/ANS PRA Standard.

The evaluation of internal events at LPSD conditions uses the same basic methods as the evaluation of internal events at full-power. A representative set of initiating events is chosen and modeled for a set of plant operational states (POSs).

The APR1400 PRA is developed from the available design information. If sufficient information is not available, then the information from the reference plants is utilized. The reference plants for APR1400 PRA are Shin-Kori Units 3 and 4.

19.1.1 Uses and Applications of the PRA

19.1.1.1 Design Phase

The APR1400 PRA is an integral part of the design process and is used to optimize the plant design with respect to safety. The PRA models and results influence the selection of design alternatives.

The APR1400 is designed to perform better than currently operating plants in the area of severe accident performance, since prevention and mitigation of severe accidents are evaluated during the design phase, taking advantage of PRA results and severe accident analysis. The PRA results indicate that the APR1400 design results in a low level of risk and meets the CDF, LRF, and containment performance goals for new generation PWRs.

At the design phase, the PRA results are used as information providing input to technical specifications (Chapter 16), reliability assurance program (RAP) (Section 17.4), human factor engineering (Section 18.6), severe accident evaluation (Section 19.2) and other design areas.

19.1.1.2 Combined License Application Phase

Uses of the PRA that would be related to a specific COL application are not addressed at this stage. A COL applicant that references the APR1400 design certification needs to describe the uses of PRA in support of licensee programs and identify and describe risk-informed applications being implemented during the combined license application phase.

19.1.1.3 Construction Phase

Uses of the PRA that would be related to a specific COL application and associated construction activities are not addressed at this stage. A COLA that references the APR1400 design certification needs to describe the uses of PRA in support of licensee programs and identify and describe risk-informed applications being implemented during the construction phase.

19.1.1.4 Operational Phase

Uses of the PRA that would be related to the operating phase for the APR1400 are not addressed at this stage. A COLA that references the APR1400 design certification needs to describe the uses of PRA in support of licensee programs and identify and describe risk-informed applications being implemented during the operational phase.

19.1.2 Quality of PRA

This section identifies the attributes of the PRA that make it suitable for use in support of the design process and design certification. The provisions of 10 CFR 50, Appendix B, do not apply to the PRA for design certification. The PRA, however, is performed using the quality assurance attributes and methods to achieve and maintain an appropriate quality level. The quality methods include the following:

- Use of qualified personnel: Qualified analysts perform each of the technical elements of the PRA. Analysts complete technical tasks in areas in which they are knowledgeable and understand the approach, methods and limitations of the respective analyses.

- Use of procedures to control documentation: Each element of the PRA is formally documented in a calculation prepared according to the procedures. Each PRA calculation is reviewed by a qualified staff. Any change or addition to a PRA calculation is also governed by procedure to control the configuration of the PRA. Each document revision requires review consistent with that performed for the original version. The PRA calculations are controlled documents and are maintained in archival form, including the regulatory submittal documents.

- Use of procedures to control corrective actions: The conduct of the PRA is governed by the Corrective Action Program (CAP), which establishes requirements for promptly identifying and resolving errors or conditions that are adverse to quality. In addition to corrective action requirements, the design control process provides a mechanism for changes in design, assumptions and supporting analyses to be reviewed by PRA personnel for potential impact on the PRA.

The above listed items are general but essential steps to ensure the technical quality of the PRA. With respect to producing a PRA adequate to meet the needs of the design certification process, Subsection 19.1.2.1 defines the scope of the PRA completed for the APR1400 design. Subsection 19.1.2.2 addresses the level of detail reflected in the models and other elements of the PRA. Subsection 19.1.2.3 describes the standards and other guidance that is used to provide a PRA that is technically adequate to support the applications described in Subsection 19.1.1. Subsection 19.1.2.4 outlines the steps that are taken to maintain the PRA as the design has evolved and to guide future updates to the PRA.

19.1.2.1 PRA Scope

The APR1400 PRA consists of a Level 1 and Level 2 PRA; an assessment of the potential for core damage, an assessment of the containment response to these accidents, and characterization of the magnitude and frequencies of radionuclide releases. The PRA includes applicable internal and external initiating events and all plant operating modes. Some initiating events are screened from detailed analysis based on their applicability to the design phase while others are treated qualitatively (e.g., other external events).

The approach used for risk evaluation of seismic events includes a PRA-based seismic margins assessment (SMA) rather than a seismic PRA. The PRA-based SMA is an acceptable methodology according to NRC guidance and SECY 93-087 (Reference 8). Although the PRA-based SMA does not result in the estimation of CDF or LRF, it does yield valuable information regarding the ruggedness of the seismic design with respect to the potential for severe accidents.

The scope is sufficient for the discussion of risk insights and results, and severe accident evaluation during the design phase.

19.1.2.2 PRA Level of Detail

To be effective in supporting the design process and to provide meaningful results with regard to judging the overall risk posed by the design, the PRA reflects a level of detail limited by the following:

- The availability of certain design details, operating procedures, and other information.

- The level at which useful reliability data are available.

At the present time, elements of the detailed design and other supporting information that are not available to support the PRA include the following:

- The specific routing of piping - relevant to an assessment of internal flooding events.

- The routing of control and power cables - relevant to an assessment of internal fire events.

- The specific location of key equipment within the rooms - relevant to assessments of internal flooding and fire events.

- Emergency and other operating procedures - relevant to human reliability analysis.

- The conceptual design information (CDI) which are not finalized during the design phase.

Analysis has been performed that is consistent with the level of design detail available. In the case of internal fire events, the frequencies and the evaluation of equipment that could be affected reflect bounding assumptions. These assumptions have been refined, within the context of the available information, to avoid masking risk contributors from other sources due to overly conservative treatment.

A COL applicant that references the APR1400 design certification is required to review as-designed and as-built information and conduct walk-downs as necessary to confirm that the assumptions used in the PRA, including PRA inputs to RAP and severe accident mitigation design alternatives (SAMDA), remain valid with respect to internal events, internal flooding and fire events (routings and locations of pipe, cable and conduit), and HRA (i.e., development of normal operating procedures, emergency operating procedures and training), external events (including PRA-based SMA based upon high confidence, low probability of failure (HCLPF) seismic fragilities), and low power shutdown (LPSD) procedures.

The level of detail in the APR1400 PRA is commensurate with the guidance set forth in the ASME/ANS PRA Standard and the NRC RG 1.200. Where detailed design information is not available, appropriate bounding assumptions are utilized consistent with the guidelines in the ASME/ANS PRA Standard and the NRC RG 1.200.

19.1.2.3 PRA Technical Adequacy

The content of the PRA and the steps taken to provide for its technical quality are consistent with the guidance in the ASME/ANS PRA Standard and the NRC RG 1.200. This PRA Standard presents high-level requirements (HLRs) for various PRA technical elements and, for each HLR, a set of more detailed supporting requirements (SRs). The supporting requirements are related to the three capability categories addressed in the standard.

These requirements were formulated for application to operating nuclear power plants, and in some cases cannot be explicitly satisfied for a PRA performed in the design phase. Table 19.1-1 provides a summary of the degree to which the APR1400 PRA relates to the capability categories for the nine technical elements addressed in the ASME/ANS PRA Standard.

A COL applicant that references the APR1400 design certification should conduct a peer review of the PRA relative to the ASME/ANS PRA Standard prior to use of the PRA to support risk-informed applications or before fuel load. The findings from this review should be dispositioned after the review in as expeditious a manner as practical (as informed by regulatory deadlines and commitments) to ensure that issues which were captured are addressed. Changes that are made to the PRA model and associated documentation as a result of this resolution process are to be conducted in a manner consistent with Subsection 19.1.2.4.

The ASME/ANS PRA Standard does not fully address LPSD modes of operation (the standard is still in draft form). For analyses where the ASME/ANS PRA Standard does not directly apply, the APR1400 PRA has used the latest NRC guidance available to perform assessments commensurate with the uses of the PRA. This additional guidance includes the following:

- Internal fire analysis: The internal fire analysis for the APR1400 PRA uses the guidance provided in NUREG/CR-6850. This report documents the latest methodology available for practical assessment of internal fires in nuclear power plants. Limitations in applying this methodology because some design details are not yet available are addressed in Subsection 19.1.5.2.

- LPSD analysis: The ASME/ANS PRA Standard and the associated NRC guidance on PRA adequacy apply only to accidents initiated from power operation. The APR1400 PRA also addresses LPSD modes. The LPSD PRA methodology and level of detail is consistent with industry practice and is state of the art. The LPSD methodology and modeling is designed to meet the requirements of draft ANSI/ANS LPSD PRA Standard (Reference 9).

- PRA-based seismic margins assessment: The APR1400 PRA uses a margins approach to evaluate potential vulnerabilities to seismic events. The approach as implemented for the U.S. is consistent with guidance in SECY-93-087 and follows the general approach delineated in the ASME/ANS PRA Standard.

- Other external events: The APR1400 PRA for design certification uses a screening method to address other external events that could represent challenges to safe operation. The screening approach follows guidance provided in the ASME/ANS PRA Standard.

19.1.2.4 PRA Maintenance and Upgrade

The objective of the PRA maintenance and upgrade program is to ensure that the PRA is maintained and upgraded so that its representation of the as-designed, as-to-be-built and as-to-be-operated plant is sufficient to support the risk-informed applications for which the PRA is being used. PRA maintenance involves updating of PRA models to reflect plant changes such as modifications, procedure changes, or plant performance. A PRA upgrade involves the incorporation into the PRA model new methodologies or significant changes in scope or capability.

The APR1400 PRA model and supporting documentation are to be maintained so that they continue to reflect the as-designed characteristics of the plant. Consistent with the ASME/ANS PRA Standard, and the NRC RG 1.200, a process is in place to perform the following as applicable to the certified design:

- Monitor PRA inputs and collect any new information relevant to the PRA.
- Maintain and upgrade the PRA to be consistent with the design.
- Consider cumulative impacts of pending changes when applying the PRA.
- Consider impacts of changes for previously implemented risk-informed decisions that used the PRA (e.g., RAP).
- Maintain configuration control of the computational methods used to support the PRA.
- Document the PRA model and processes.

To meet the guidance of NRC RG 1.206 (Reference 10), the PRA should be maintained to ensure that it reasonably reflects as-designed, as-to-be-built, and as-to-be-operated conditions. A COL applicant that references the APR1400 design certification needs to describe the plant-specific PRA maintenance and upgrade program.

19.1.3 Special Design/Operational Features

Design and operational characteristics of the APR1400 that result in improved plant safety as compared to currently operating nuclear power plants, include the following:

- An in-containment refueling water storage tank (IRWST)
- A four train safety injection system that injects borated water directly into the reactor vessel through direct vessel injection (DVI) nozzles
- Four pumps for component cooling water and essential service water systems
- An emergency containment spray backup system (ECSBS)
- A cavity flooding system (CFS)
- A hydrogen control system (HG)

The PRA has influenced the selection of design changes such as:

- Four emergency diesel generators (EDGs)
- The inclusion of an alternate ac source (AAC) gas turbine generator (GTG) which can be used as an independent ac source to cope with Station Blackout (SBO) scenarios following Loss of Offsite Power (LOOP)

Table 19.1-2 provides a summary of the APR1400 systems. The table includes the system's key SSCs and the key functional descriptions with respect to the design features for preventing core damage, mitigating the consequences of core damage and preventing releases from containment, and mitigating the consequences of releases from containment.

19.1.3.1 Design/Operational Features for Preventing Core Damage

Key preventive features that are intended to minimize initiation of plant transients, mitigate the progression of plant transients, and prevent severe accidents include the following safety systems:

a. Safety Injection System (SIS)

The SIS consists of four independent trains. Each pump train takes its suction from the IRWST. The safety injection pumps inject borated water from the IRWST into the RCS through DVI lines which are shared with SITs. Two of the trains can also be aligned to inject water to the RCS hot legs through the shutdown cooling lines. The SITs are a subsystem within the SI system. The SITs are a self-actuating, passive system that injects borated water directly into the reactor vessel through DVI nozzles. A simplified diagram of SIS is shown in Figure 19.1-1.

The function of the SIS is to inject borated water into the RCS to restore and maintain RCS inventory during accident conditions. This injection ensures core decay heat removal thereby preventing core damage in addition to maintaining RCS inventory.

The functions of the SIS are to:

- Inject borated water into the RCS through DVI nozzles to flood and cool the core following a LOCA, thus preventing significant cladding failures and subsequent releases of fission products into the containment, and maintaining the core subcritical.

- Provide removal of heat from the core for extended periods of time following a LOCA.

- Inject borated water into the RCS to increase shutdown margin following a rapid cooldown of the system due to a steam line break.

- Provide supplementary emergency boration capabilities and prevent boron precipitation in the RCS during the long term cooling mode of operation.

- Provide water injection during bleed and feed operation in conjunction with the POSRVs to remove decay heat.

The IRWST stores refueling water and provides a single source of water for safety injection pumps (SIPs), shutdown cooling pumps (SCPs) and containment spray pumps (CSPs), and serve as a heat sink for steam discharged from the pressurizer. The holdup volume tank (HVT) provides a low collection point in reactor containment to collect water released from pipe breaks and containment sprays during a design basis accident. The IRWST and HVT are considered to be integral parts of the reactor containment building internal structure.

During normal power operation, the IRWST provides storage of borated water for refueling. For refueling, water from the IRWST is transferred to the refueling pool using the SCPs and is cooled by the shutdown cooling heat exchanger. Following refueling, water is transferred from the refueling pool to the IRWST by diverting a portion of the SCP discharge downstream of the Shutdown Cooling (SC) heat exchanger to the IRWST. The remaining water in the refueling pool is drained down to the flange of reactor vessel. Subsequent draining of the refueling pool is performed by using the spent fuel pool cleanup pumps directly to the IRWST.

During accident conditions, the IRWST provides the borated water for injection into the RCS by the SIS and for containment spray by the containment spray

system (CSS). The IRWST also provides storage of borated water for quenching the steam discharged from POSRVs. The IRWST is cooled by the containment spray heat exchangers during LOCA or secondary side pipe break. The CSPs take suction from the IRWST and pump water to the containment spray heat exchangers where it is cooled and then sprayed through the spray nozzles into the containment atmosphere. Heat transfer from the containment atmosphere to the falling spray droplets provides containment decay heat removal. The water from the LOCA breaks and containment sprays is drained and collected in the HVT until the water level in the HVT reaches the main spillways at which point water flows back into the IRWST.

b. Shutdown Cooling System (SCS)

The SCS consists of two independent trains each containing suction and discharge connections to the RCS. Each train contains a pump, a heat exchanger, a mini-flow line with a heat exchanger, and associated valves and piping. A simplified diagram of SCS is shown in Figure 19.1-2.

During a small break LOCA or a SGTR event, borated water from the IRWST is injected into the reactor core by the safety injection pumps. However, if these pumps are unavailable, the RCS can be depressurized rapidly and the SCPs can be used to inject the borated water. This operation is referred to as shutdown cooling system injection mode.

The SCS is used to cool the RCS during normal shutdowns or emergency shutdowns. During shutdown cooling operation, the SCPs take suction from the hot legs of the RCS and discharge the reactor coolant through the SC heat exchangers. The flow is then returned to the RCS through the DVI nozzles. The CSPs can be used to circulate the reactor coolant during shutdown cooling operation if the SCPs are not available. This operation is considered as a long-term decay heat removal.

During an accident condition, the steam generators are used early in plant shutdown followed by the SCS as the preferred mode to remove decay heat. IRWST cooling is accomplished by circulating the water from the IRWST through

the shutdown cooling heat exchangers and then back to the IRWST, during the feed and bleed operation using the POSRVs and SIPs.

c. Containment Spray System (CSS)

The CSS is designed to remove heat and fission products from the containment atmosphere in the event of a LOCA or MSLB inside the containment and thereby limiting the leakage of airborne activity from the containment. The CSS takes the borated water from the IRWST. A simplified diagram of CSS is shown in Figure 19.1-3.

The CSS consists of two trains. Each train includes a CSP, a containment spray heat exchanger, a containment spray minimum flow heat exchanger, a main spray header with nozzles, an auxiliary spray header with nozzles, and associated valves, piping and instrumentation. The CSPs are designed to be functionally interchangeable with the SCPs. Therefore, the SCPs can be utilized as backup for the CSPs (or the CSPs as backup for the SCPs).

The functions of the CSS are to:

- Reduce the containment atmosphere pressure and temperature below containment design limits with margin in the event of a postulated LOCA or MSLB inside containment, by removing heat from the containment atmosphere,
- Limit airborne iodine and particulate fission product inventory in the containment atmosphere in the event of an accident,
- Provide a backup to the SCS for decay heat removal and cooling of the IRWST during feed and bleed operations utilizing the SIS and the POSRVs,
- Ensure an appropriate spray water chemical composition after an accident, which is required for hydrogen control, material compatibility, and long-term iodine control against re-evaporation,
- Provide long term cooling of the IRWST to remove the decay heat if the containment spray operation through spray header is not available to protect

the equipment located inside the containment for a long period of time following the accident.

In addition, containment spray may be accomplished using the ECSBS. The function of the ECSBS is to provide sprays of water from external water sources to the dedicated ECSBS containment spray header for reducing containment pressure during emergency conditions when all CSPs are unavailable.

d. Pilot Operated Safety Relief Valves (POSRVs)

The four POSRVs are a once-through depressurization system which has the capabilities to provide overpressure protection, and to depressurize the primary system. The four POSRVs act as the primary safety valves located on the top of the pressurizer.

In the event that and auxiliary feedwater and startup feedwater are unavailable to remove decay heat through the steam generators, the POSRVs are used to perform feed and bleed operation. To perform the depressurization of the primary system, the POSRVs are actuated by manually opening the normally closed double motor operated pilot valves. The double motor operated pilot valves consist of two MOVs installed in series to allow each valve to be used as a backup in case that the other valve fails to close. The POSRVs are designed to be operated even when normal ac power is not available, where the MOVs are powered from an emergency dc power source with a battery backup. During feed and bleed operation, POSRVs discharge to the IRWST through underwater spargers, and the SIPs provide feed flow to the RCS. The POSRVs are considered to be a part of the reactor coolant system in the PRA. A simplified diagram of POSRVs and the discharge paths to IRWST is shown in Figure 19.1-4.

e. Auxiliary Feedwater System (AFWS)

The function of the AFWS is to provide an independent means of supplying makeup water to the SGs for removal of decay heat from the reactor core during an accident. The AFWS is a dedicated safety system that has no functions during normal operation.

The AFWS consists of two redundant trains. Each train consists of one auxiliary feedwater storage tank (AFWST), one motor-driven pump, one turbine-driven pump, and the associated valves, piping, instrumentation and controls. A simplified diagram of AFWS is shown in Figure 19.1-5.

Each auxiliary feedwater pump takes suction from its associated AFWST and discharges to its own discharge path. Each discharge header contains a pump discharge check valve, modulating valve, isolation valve, and a SG isolation check valve. The motor-driven auxiliary feedwater pump line and the turbine driven auxiliary feedwater pump line are joined together inside containment to feed the SG through a common header which connects to the SG downcomer feedwater line. Each common auxiliary feedwater header contains a cavitating venturi to restrict the maximum flow rate to each steam generator. The cavitating venturi restricts the magnitude of the two pump flow as well as the magnitude of individual pump runout.

If the AFWS is unavailable to provide the decay removal, then the startup feedwater pump can be used. The startup feedwater pump takes its suction from the deaerator storage tank (DST) which is connected to the condensate system, condensate storage and transfer system, and condenser, where the steam is condensed from SGs through turbine bypass valves (TBVs).

f. Chemical Volume Control System (CVCS)

The CVCS is a non-safety system (except for portions of the system which form part of the reactor coolant pressure boundary) consisting of a number of subsystems which, when operated together, function to control the RCS chemistry and volume against the established specifications. The CVCS maintains the required volume of water in the RCS together with the pressurizer level control system. The CVCS also maintains reactor coolant purity and chemical conditions by processing the coolant through filters and ion exchangers.

The CVCS consists of two centrifugal charging pumps (CCP), one auxiliary charging pump (ACP), regenerative heat exchanger, letdown heat exchanger, ion exchangers, filters, pumps, tanks, and associated valves, piping and instrumentation. A simplified diagram of CVCS is shown in Figure 19.1-6.

The CVCS provides four key functions for accident mitigation in the unlikely event of an accident. The first accident mitigation function is to support the auxiliary pressurizer spray function. This function is accomplished by the centrifugal charging pumps drawing suction from either the volume control tank (VCT) or boric acid storage tank (BAST) and discharging to the pressurizer spray nozzle via the auxiliary spray line. Successful delivery of the BAST contents to the charging pump suction is accomplished either via the boric acid makeup pumps (BAMPs) or via gravity drain.

The second accident mitigation function is the emergency boration that provides an independent means of supplying borated water to the RCS for reactivity control following an ATWS. This is done by delivering the contents of the BAST via the charging pumps to the RCS via the normal charging line.

The third accident mitigation function is to replenish the inventory in the IRWST. This is done by delivering the contents of the BAST to the IRWST using the BAMPs.

The fourth accident mitigation function is RCP seal cooling. RCP seal cooling is normally accomplished using the CVCS centrifugal charging pumps taking suction from the BAST via gravity drain and discharging to the individual RCP seal packages via the RCP seal injection filters.

The ACP is a positive displacement pump that is placed in parallel with the CVCS centrifugal charging pumps. The ACP is manually started and supplies injection water when RCP seal injection is not available through the two centrifugal charging pumps. The ACP takes suction from the VCT or the BAST and supplies seal injection water to the RCPs through the normal CVCS seal injection flow path. The ACP is considered as a diverse capability from the two centrifugal pumps.

g. Reactor Protection System (RPS)

The RPS is a part of the plant protection system (PPS). NSSS parameters and containment conditions are monitored by the PPS continuously. If monitored conditions approach specific safety limits, the PPS through the RPS rapidly shuts down the reactor to protect the fuel design limits and prevent a breach of the RCS

pressure boundary. The PPS also communicates with the engineered safety features-component control system (ESF-CCS) which actuates mitigating systems.

The PPS is based on a digital I&C which includes plant parameter bistable comparator functions, coincidence logic functions and initiation logic functions to actuate a reactor trip and operation of engineered safety features.

The coincidence trip signals are used in the initiation of the reactor trip switchgear system (RTSS) and the ESF-CCS. A coincidence of two-out-of-four like trip signals is required to generate a reactor trip signal.

A trip is generated when a coincidence of two like trip signals of the monitored plant parameters or containment conditions reach a pre-set safety limit. The RPS initiates a reactor trip for the following conditions:

- Variable overpower trip signal (VOPT)
- High logarithmic power level trip signal
- High local power density (LPD) trip signal
- Low departure from nucleate boiling ratio (DNBR) trip signal
- High pressurizer pressure trip signal
- Low pressurizer pressure trip signal
- Low steam generator water level trip signal
- High steam generator water level trip signal
- Low steam generator pressure trip signal
- High containment pressure trip signal
- Low reactor coolant flow trip signal
- Manual trip

The APR1400 design includes the diverse actuation system (DAS). The DAS consists of the diverse protection system (DPS), the diverse manual ESF actuation (DMA) switches, and the diverse indication system (DIS). The DPS provides additional trip capability to the RPS.

h. Engineered Safety Features Actuation System (ESFAS)

The engineered safety features (ESF) instrumentation and control consists of sensors, auxiliary process cabinet-safety (APC-S), the ESFAS portion of the PPS and ESF-CCS.

The ESFAS monitors selected parameters to initiate the operation of necessary ESF systems to prevent damage to the core and the RCS components. It also ensures containment integrity and prevents unacceptable levels of radioactivity release to the environment as well as protects the control room operators during fuel handling accidents. The system utilizes bistable trip functions and coincidence logic in the PPS and component control logic in the ESF-CCS to generate actuation signals. The following actuation signals are generated by the ESFAS:

- Safety Injection Actuation Signal (SIAS)
- Containment Isolation Actuation Signal (CIAS)
- Containment Spray Actuation Signal (CSAS)
- Main Steam Isolation Signal (MSIS)
- Auxiliary Feedwater Actuation Signal (AFAS)

i. AC Power System

The AC power system is comprised of two qualified circuits from the offsite transmission network to the switchyard, two qualified circuits from the switchyard to the onsite Class 1E distribution system, four diesel generators (each capable of supplying one train of the onsite Class 1E ac distribution system, and automatic load sequencing for four trains of supported equipment which must be operable in Modes 1, 2, 3, and 4).

The non-Class 1E 13.8 kV power system consists of four non-safety switchgears. Each of two unit auxiliary transformers (UATs) normally supplies two of the 13.8 kV switchgears. The non-Class 1E 13.8 kV power system furnishes power to large motors such as the RCP motors, condensate pump motors, circulating water pump motors and associated 480 V load centers.

The Class 1E safety systems are divided into four redundant and independent distribution systems. Each distribution system can be powered from the following sources:

- Unit auxiliary transformer (UAT)
- Standby auxiliary transformer (SAT)
- Emergency diesel generator (EDG)
- Alternate AC (AAC)

If both the offsite power sources and the standby EDGs are unavailable, 4.16 kV ac buses may be powered from the AAC power source. The AAC provides an independent and diverse power source, which is furnished with a battery and charger to provide power to its associated dc loads.

The unit has four independent 4.16 kV Class 1E auxiliary power systems, (identified as safety train A, B, C, and D) which normally receive power from the UATs. The incoming source breakers trip upon loss of normal power, and emergency power is provided to each of the redundant 4.16 kV Class 1E auxiliary power system trains by four EDGs.

All safety-related SSCs powered from the Class 1E 4.16 kV power system, either directly or through transformers if a lower voltage is needed. The arrangement of EDGs, electrical distribution system and supported loads is completely independent of each other. If power from both the UATs and SATs is lost, the normal power source to the Class 1E power system is also lost, and the Class 1E buses are provided by the EDGs. In addition, the non-safety AAC power source is provided to cope with an SBO condition.

When the main generator is isolated from the transmission system due to an out-of-step condition, system disturbance, or operator action; the plant can be aligned for house load operation (HLO). During HLO, both the non-Class 1E and Class 1E power systems are fed from the main generator through the UATs if the main generator is not connected to the grid. The HLO is intended as a temporary measure when the transmission system is unavailable due to a short duration system disturbance. Once the transmission system is restored, the main generator is resynchronized to the transmission system and normal operation is resumed.

j. Emergency Diesel Generators (EDGs)

Four redundant Class 1E EDGs are provided to supply onsite power to the Class 1E power system. Following the loss of voltage or prolonged degraded voltage condition on a Class 1E bus, the incoming breaker for the Class 1E switchgear is tripped, all the loads (except the 480 V load center) are shed, including the non-Class 1E loads fed from the Class 1E bus before the EDG is started. Once the EDG has reached rated voltage and speed, it is connected to the bus, restoring power in a sequence. Non-Class 1E loads fed from Class 1E bus with isolation breakers may be reconnected manually, if sufficient spare capacity is available.

Each EDG has its own fuel oil transfer system to refill the day tanks as needed. Each system consists of a separate fuel oil storage tank and two redundant pumps.

k. Alternate AC (AAC) Source

The alternate ac (AAC) source is a non-safety power source which can be used as an additional onsite emergency ac power source during SBO condition. The AAC gas turbine generator (GTG) is independent and diverse from the EDGs. The AAC GTG and supporting auxiliaries are non-safety related, and are provided as a packaged unit, mounted in a self-contained metal enclosure. The AAC facility is located within the plant protected area, outside of the turbine missile impact zone.

The AAC can be physically connected to any one of four Class 1E 4.16 kV ac buses, but the connection is administratively controlled to replace the EDG A or B only.

l. DC Power System

The dc power system provides dc power to various dc loads. The dc power system also provides power to selected emergency lighting circuits.

The dc power system is powered by the 480 V power system through battery and battery chargers. The safety related 125 V dc system is an ungrounded Class 1E system consisting of four independent physically separated trains; each corresponding to one of the four reactor protection instrumentation channels. There are two safety related dc trains per safety related electrical division. Trains A and C correspond to Division I, while trains B and D correspond to Division II. Each Class 1E dc train consists of a battery, a battery charger, and a 125 V dc control center. Each dc control center receives power from its respective battery and/or battery charger, depending on plant conditions. The safety related 125 V dc system provides power to the NSSS control and instrumentation systems, the vital bus inverters, solenoid valves, dc motor operated valves, EDG field flashing and miscellaneous BOP control systems.

m. Condensate and Feedwater System

For the purposes of discussion with respect to the APR1400 PRA there are six systems included under the system grouping referred to as the condensate and feedwater system:

- Feedwater system
- Condensate system
- Condensate storage and transfer system
- Turbine generator building closed cooling water system
- Turbine generator building open cooling water system
- Circulating water system

1) Feedwater System

The feedwater system supplies feedwater from the deaerator storage tanks (DSTs) to the SGs. A motor-driven startup feedwater pump provides feedwater to the SGs during startup, shutdown and hot standby operation. The startup feedwater is also used if the auxiliary feedwater pumps are not available. A simplified diagram of feedwater system is shown in Figure 19.1-7.

2) Condensate System and Condensate Storage and Transfer System

The condensate system consists of the condensers, condensate pumps, low-pressure feedwater heaters, deaerators, DSTs, a gland seal water collection tank, overboard pump, associated piping, valves, and instrumentation and controls. The condensate storage and transfer system consists of two condensate storage tanks (CSTs) and associated valves, piping, instrumentation and controls. The condensate system condenses steam in the condenser, collects condensate in the hotwell, and pumps it to the DSTs through condensate polishing demineralizers and three low pressure feedwater heaters and a deaerator, thus supplying condensate to the feedwater system. The CSTs provide a backup source of water for various plant systems including the condenser hotwell and AFWS. A simplified diagram of the condensate and condensate storage and transfer system is shown in Figure 19.1-8.

The condensate system and condensate storage and transfer system discharge to the DST which routes feedwater to the feedwater booster pumps or the startup feedwater pump.

3) Turbine Generator Building Closed Cooling Water System

The turbine generator building closed cooling water system is a closed loop system which consists of two pumps, three heat exchangers, one surge tank, one chemical addition tank, valves, piping, instrumentation and controls. The turbine generator building closed cooling water system provides a continuous supply of cooling water to various turbine generator building equipment. The heated water is returned through the return header and then pumped through the turbine generator building closed cooling water heat

exchangers, where the heat is dissipated to the turbine generator open cooling water system.

4) Turbine Generator Building Open Cooling Water System

The turbine generator open cooling water system consists of redundant strainers, three turbine generator building closed cooling water heat exchangers, valves, piping, instrumentation and controls. The turbine generator open cooling water system supplies cooling water to the cold side of the turbine generator building closed cooling water heat exchangers in the turbine generator building. The heated cooling water is discharged to the circulating water discharge conduit.

5) Circulating Water System

The circulating water system is a closed loop, cooling water system utilizing the cooling tower as a heat sink. The system is designed to reject the waste heat from the main condenser to the circulating water and supply cooling water to the turbine generator open cooling water system during all modes of power operation.

n. Main Steam System (MSS)

The MSS delivers the steam generated in the SG to the high pressure turbine where the thermal energy of the steam is converted to mechanical energy to drive the main turbine generator. The MSS also provides steam to the turbine-driven auxiliary feedwater pumps.

The key components of the MSS are: main steam isolation valves (MSIVs), MSIV bypass valves (MSIVBVs), main steam atmospheric dump valves (MSADVs), main steam safety valves (MSSVs), and TBVs. A simplified diagram of MSS is shown in Figure 19.1-9.

A MSADV is provided on each main steam line upstream of the MSSVs. Five spring-loaded MSSVs are provided for each individual main steam line for

protection against overpressurization of the shell side of the SGs and the main steam line piping up to the inlet of the turbine stop valve.

Each main steam line is provided with a MSIV for steam line isolation. Each MSIV can be bypassed for warm-up of the steam lines downstream of the isolation valves and for pressure equalization prior to admitting steam to the turbine. Downstream from the MSIVs, the four main steam lines are connected to an equalization header.

There are eight TBVs that originate from the main steam header. The TBVs are controlled by the steam bypass control system (SBCS). Steam can be bypassed through these valves to the condenser.

The SBCS in conjunction with the reactor power cutback system (RPCS) and reactor regulating system (RRS) dissipates excess energy in NSSS by regulating steam flow through the TBVs following the load rejection of any magnitude including a turbine trip from 100 percent power without a reactor trip or lifting the POSRVs or MSSVs.

The TBVs close automatically or are blocked from opening whenever the condenser is not available. If a load rejection occurs concurrently with condenser unavailability, the spring-loaded MSSVs sequentially open with increasing pressure and discharge the required amount of steam to the atmosphere to prevent system pressure from exceeding the maximum pressure of the main steam line.

For a main steam line break inside the containment, the faulted SG discharges directly into the containment. The unaffected SG discharges steam into the containment through the inter-connected equalization header and broken line, unless the broken steam line is isolated. All MSIVs are signaled to close automatically upon receipt of a main steam isolation signal (MSIS).

o. Essential Service Water System (ESWS)

The ESWS is a once-through cooling water system which supplies filtered water for cooling the component cooling water (CCW) heat exchangers during all modes of plant operation.

The ESWS transfers heat from the component cooling water system (CCWS) to the ultimate heat sink (UHS) during all operation modes. The ESWS is safety-related and consists of two independent divisions. Each division consists of two pumps, one supply line, three debris filters, three CCW heat exchangers and one discharge line. A simplified diagram of an ESWS is shown in Figure 19.1-10.

Each pump is equipped with a discharge check valve and a motor operated discharge isolation valve. Two pumps of each division discharge to a common line which then divides three lines, one line for each same train CCW heat exchanger. In each of the three lines, there is a manual isolation valve, a debris filter, a second manual isolation valve, a CCW heat exchanger and an outlet manual isolation valve. The three lines in each train discharge into a common train discharge line and passes through a motor operated flow control valve which is locked in the throttled position. Each division discharges to a dedicated essential service water (ESW) cooling tower. A simplified diagram of ESW cooling tower is shown in Figure 19.1-11.

The functions of the ESWS are to:

- Be capable of removing heat from the CCWS through the CCW heat exchangers.
- Supply service water to two of three CCW heat exchangers of each division using a pump within the division during an accident condition.

p. Component Cooling Water System (CCWS)

The CCWS is a closed loop system that provides cooling water to remove heat released from plant SSCs, including both the safety-related and non-safety-related loads. Heat transferred by these SSCs to the CCWS is rejected to the ESWS through the CCW heat exchangers. A simplified diagram of CCWS is shown in Figure 19.1-12.

The CCWS is capable of removing heat from safety-related components required for emergency shutdown of the plant and mitigation of the design basis events and the beyond design basis events. The CCWS provides an intermediate barrier

between potentially radioactive systems and the ESWS to reduce any potential of radioactivity leakage to the environment.

The CCWS is a key accident mitigating support system, and the system is also assessed as a potential source of initiators. The CCWS consists of two independent divisions. Each division consists of two CCW pumps, one CCW surge tank, three CCW heat exchangers and one discharge line.

q. Essential Chilled Water System (ECWS)

The ECSW is a closed loop system that cools the cubicle coolers in specific plant rooms. The ECWS consists of two divisions, where each division consists of two chillers, two chilled water pumps, one air separator, one compression tank, one chemical additive tank, and one chilled water makeup pump. The ECWS provides a diverse means of providing room cooling, along with the HVAC systems. A simplified diagram of ECWS is shown in Figure 19.1-13.

r. HVAC Systems

The HVAC systems include five subsystems: emergency diesel generator area HVAC, ESW intake structure/CCW heat exchanger building HVAC, auxiliary building controlled area HVAC, auxiliary building clean area HVAC and AAC GTG room HVAC. The HVAC systems provide a diverse room cooling capability, along with the ECWS.

s. Instrument Air System (IAS)

The IAS supplies clean, oil free, dry air to all air operated valves and instruments in the plant. The IAS is used during normal plant operation and after the plant is shutdown. The IAS provides air to TBVs, AOVs in CVCS and AOVs in the condensate system which are modeled in PRA.

t. Reactor Coolant Gas Vent System (RCGVS)

The RCGVS provides a means of remotely venting non-condensable gases from the reactor vessel closure head and the pressurizer steam space during accident

conditions when large quantities of non-condensable gases may collect in these high points. The RCVGS discharges to the IRWST.

Another function of the RCGVS System is to provide a means of remotely removing steam from the pressurizer steam space or the reactor vessel for reactor coolant system pressure control purposes in the event that pressurizer main spray and auxiliary spray are unavailable during accident conditions.

u. In-Containment Water Storage Tank (IRWST)

The IRWST is a steel-lined annular tank that resides entirely within containment. The functions of this system include:

- Safety-grade water source for safety injection and containment spray
- Heat sink for feed and bleed operation and rapid RCS depressurization

The IRWST eliminates the ECCS switch-over operation during LOCA, and minimizes contamination of the reactor containment building by scrubbing the released steam through the IRWST spargers. A simplified diagram of IRWST and HVT is shown in Figure 19.1-14.

v. Digital Control Room

The APR1400 MCR is a highly integrated control room. The control room includes:

- Large display panel (LDP)
- Integrated alarm system
- Visual display unit (VDU) based information display
- Computer-based procedures (CBPs)
- Soft control
- Safety console

x. Auxiliary Building

The auxiliary building is designed to provide a physical separation for the potential propagation of internal flooding. Floor drains in the auxiliary building are physically separated into quadrants (two in each division) and there are no common floor drain lines among quadrants.

The two EDGs located in the auxiliary building are spatially separated and located at opposite corners of the building. The auxiliary building also houses the MCR and supporting facilities. The remote shutdown room (RSR) located in a separate fire area from the MCR contains all controls necessary to safely achieve cold shutdown.

19.1.3.2 Design/Operational Features for Mitigating the Consequences of Core Damage and Preventing Releases from Containment

The containment features, mitigating systems, and human actions that are provided to mitigate the consequences of a core damage event and to prevent containment failure are discussed in this section.

The following are key design features of the APR1400 containment and cavity region that reduce the potential for releases from containment:

a. The containment is a large pre-stressed concrete structure.

b. The containment inner surface is steel-lined to promote leak-tightness.

c. The reactor cavity is configured to promote retention of core debris during a severe accident. Corium retention in the core debris chamber virtually eliminates the potential for direct containment heating (DCH) challenges.

d. The cavity is designed to maximize the unobstructed floor area available to the spreading of corium debris. Uniform distribution of the corium debris within the reactor cavity results in a relatively shallow debris bed.

e. The cavity is designed with adequate distance between the floor elevation and the embedded portion of the containment steel liner to delay core debris contact with the liner in core melt scenarios.

The following systems are provided to mitigate the consequences of a core damage event and to prevent containment failure.

a. Containment Isolation System (CIS)

The CIS provides the means of isolating fluid systems that pass through the containment penetrations in order to confine the release of any radioactivity from the containment following an accident.

The components that insure containment isolation are part of the system that utilizes the penetration while the instrumentation and controls that cause actuation of the isolation device (i.e. a valve) are part of the CIS. The containment penetrations include piping penetrations, personnel and equipment access hatches, and electrical penetrations. The containment penetrations and the structures and components that maintain containment integrity are designed to withstand post-accident conditions.

b. Containment Spray System

The CSS is described in Subsection 19.1.3.1 with respect to its capabilities to mitigate core damage. The CSS is designed to reduce containment pressure and temperature during an accident and to remove iodine radionuclides and aerosols from the containment atmosphere.

The CSS functions beneficial to the severe accident progression are containment heat removal and fission product scrubbing in the containment.

The emergency containment spray backup system (ECSBS) is used to provide an independent means of supplying water to the dedicated spray header for reducing containment pressure during emergency conditions when the CSPs or the backup SCPs are not available.

c. Pilot Operated Safety Relief Valves (POSRVs)

The POSRVs can rapidly depressurize the primary system to prevent high pressure core damage sequences that can result in severe accident induced failures of the hot leg/surge line or steam generator tubes, high pressure melt ejection and so on.

The POSRVs and associated discharge SSCs can be also used to control the hydrogen accumulation in the IRWST during the RCS depressurization. In this case, two of POSRVs and its three-ways valve located in the POSRV discharge path are manually operated to redirect the steam release to the containment atmosphere via the SG compartment.

d. Containment Hydrogen Control System (HG)

The containment hydrogen control system (HG) is designed to control combustible gas (primarily hydrogen gas) inside the containment and IRWST within acceptable limits. The passive autocatalytic recombiners (PARs) and hydrogen igniters are installed in the containment to remove hydrogen or limit hydrogen generation, which maintain hydrogen concentration in the containment below 10 percent by volume.

e. External Reactor Vessel Cooling (ERVC)

The ERVC function submerges the reactor vessel lower head to cool and retain the molten core in the reactor vessel. The ERVC is not credited in the Level 2 PRA.

f. Cavity Flooding System (CFS)

The function of the CFS is to flood the reactor cavity in the event of a severe accident for the purpose of covering core debris in the reactor cavity with water. This facilitates the cooling and stabilization of the debris.

The CFS interconnects with the IRWST, HVT and reactor cavity. The system is used in conjunction with the CSS to form a closed or recirculating water cooling system by providing a continuous cooling water supply to the corium debris in the reactor cavity. The quenching of the corium produces steam which is condensed by the containment spray flow. The CFS takes water from the IRWST and directs

it to the reactor cavity. The water flows first into the HVT via the HVT flooding lines and then into the reactor cavity via the reactor cavity flooding lines.

19.1.3.3 Design/Operational Features for Mitigating the Consequences of Releases from Containment

Key mitigating features that are intended to minimize offsite doses/consequences include the following safety systems:

a. Containment Spray System

Fission product removal mechanism is provided so that in the event of containment leakage, the radiation dose at the site boundary due to airborne fission products is reduced. The spray solution mixed with Tri-sodium Phosphate (TSP) minimizes the iodine radionuclides and fission product aerosols in the building atmosphere by the removal through the absorption of airborne fission products by the spray droplets.

b. In-containment Refueling Water Storage Tank

The IRWST located inside the containment minimizes spread of radioactive contamination outside of the containment building, where the potential contamination from the circulated water through the piping located outside the containment is minimized.

The IRWST is also equipped with the underwater spargers to promote the fission product scrubbing, where the fluids discharged through POSRVs are discharged through spargers.

19.1.3.4 Uses of the PRA in the Design Process

This subsection describes the uses of PRA in the design process to achieve the following objectives:

- Identify features and requirements introduced to reduce or eliminate the known weakness/vulnerabilities in current rector designs.

- Indicate the effect of new design features and operational strategies on plant risk.
- Identify PRA-based insights and assumptions used to develop design requirements.

The basic design concept of the APR1400 is similar to current PWRs (specifically the Combustion Engineering System 80+ design). However, additional design features are introduced to enhance safety of the plant. The design features are described in the previous Subsections 19.1.3.1 through 19.1.3.3.

The features and requirements introduced to reduce or eliminate the known weakness and vulnerabilities in current rector designs are summarized in Table 19.1-3. The table also includes the effect of new design features found in APR1400 on plant risk.

Design improvements to reduce or eliminate weaknesses in current plants were investigated for each categorized cause of core damage or large release. Major improved design features adopted in the APR1400 to reduce or eliminate weaknesses in previous plant designs are as follows:

- Design change from two EDGs to four EDGs
- Extension of 125 V dc battery life to 16 hours from 8 hours

These changes are both related to mitigation of an SBO event, which is an important risk contributor.

19.1.4 Safety Insights from the Internal Events PRA for Operations at Power

The internal events PRA for operations at power, including its results are described in this subsection. Level 1 PRA is discussed in Subsection 19.1.4.1 and Level 2 PRA is discussed in Subsection 19.1.4.2.

19.1.4.1 Level 1 Internal Events PRA for Operations at Power

A description of the Level 1 internal events PRA for operations at power including the results of the PRA analysis is provided in the following subsections.

19.1.4.1.1 Description of Level 1 Internal Events PRA for Operations at Power

The Level 1 PRA uses a small event tree method supported by a linked fault tree approach. The major steps of the methodology are defined below:

a. Identification of potential accident initiating events:

- Plant initiating events are identified based on previous industry experience, supplemented with a system failure modes and effects analysis (FMEA) which is focused on the identification of plant-specific initiators.

- Plant initiating events with similar accident mitigation requirements are grouped together.

- The annual frequency is estimated for each initiating event or initiating event group.

b. Accident sequence analysis:

- An evaluation of the plant response is developed for each type of initiating event, by identifying the key safety functions that are necessary to reach a safe and stable state and to prevent core damage.

- Systems and operator actions that affect the key safety functions are identified.

- Event trees are developed as a graphical representation of the potential core damage accident sequences for each initiating event. The top functional events in these event trees reflect failures of the systems and of the operator actions required to mitigate these initiating events.

- Success criteria are developed for each key safety function considered in the plant event trees. For each event tree top functional event, the minimum set of components/trains required in order for the system to adequately perform its accident mitigation function is identified.

c. System analysis:

- For each system considered in the accident sequence event trees, a fault tree is constructed to allow for quantification of the system unavailability to perform the required accident mitigation function.

- The system fault trees identify the various combinations of equipment failures that may result in failure of system function. Intra-system dependencies and CCFs of components are considered.

- Fault trees are constructed for the systems represented in the top functional events in the event trees (the front-line systems) and various systems needed to support these systems (support systems). The system dependencies are explicitly considered.

d. Data analysis:

- Available generic data sources are compiled and reviewed to allow for selection of the failure parameters associated with components modelled in the system fault trees. This generic data is used to quantify the fault trees.

- CCF parameters are also considered for groups of components with similar design, environmental and service conditions. CCF factors, developed from generic data sources, are used to quantify the fault trees.

e. Human reliability analysis:

- Human actions that, if not completed correctly, may impact the availability of equipment necessary to perform system function modelled in the PRA are identified (pre-initiator HRA).

- Human actions that are required for different accident sequences modelled in the PRA are identified (post-initiator HRA).

- Human recovery actions are considered in the cases where it could be demonstrated that the action is plausible and feasible.

- Acceptable methods are applied to estimate the probabilities of failure for the human actions. Estimates of probabilities of failure consider dependency on prior human failures in the scenario.

f. Quantification:

- Fault trees and event trees are solved in an integrated manner to quantify CDF and LRF.
- Quantification is performed by using the PRA software SAREX and the FTREX quantification engine.
- The quantification results are reviewed and significant contributors to CDF, such as initiating events, cutsets, basic events (equipment unavailabilities and human failure events) are identified.
- Uncertainties in the results are identified and characterized. Key sources of model uncertainty derived from key assumptions are identified. Their potential impact on the results is assessed by performing a sensitivity analysis.

Each of these elements is described in greater detail in the sections to follow.

19.1.4.1.1.1 Initiating Events

An initiating event is defined as a disturbance which causes an upset condition of the plant, challenging systems and requiring operator performance of safety functions that are necessary and sufficient to prevent core damage. Such events result in challenges to plant safety functions, and postulated failures in the systems, equipment and operator response could lead to an end state involving core damage and radionuclide release. Table 19.1-5 summarizes the impact on the key safety functions and plant systems by the initiating event types.

A thorough and systematic search is performed to define the spectrum of initiating events that could occur at an APR1400 plant. This list of accidents includes both design-basis events (e.g., loss of coolant accidents, SGTR and loss of offsite power), as well as beyond-design basis events (e.g., ATWS and SBO).

Potential initiating events are identified based on generic industry lists of initiating events, review of plant-specific system and design features, system interfaces, spatial interactions, and common cause failure potentials. For each of the potential initiating events identified,

a qualitative evaluation is performed to assess the applicability of the event to the APR1400 design.

New initiators unique to the APR1400 design are also identified. Initiating events that are the result of support system failures or transients, called special initiators, are also considered through review of the existing design information.

The list of potential initiating events is grouped into similar functional categories to reduce the complexity of the PRA. The initiating event frequency for each of these groups is then quantified. The grouping is based either on the use of a bounding initiating event (i.e., an event whose impacts on the plant is more severe than those of the other initiating events in the group) or by the selection of a representative event (i.e., one that has essentially the same characteristics as the other events in the group). However, when selecting a bounding event for a given group of initiators, care is taken when grouping less severe events (with a higher frequency of occurrence) with an infrequently-occurring, very severe event so that an appropriate overall initiating event frequency is used in the PRA. For example, a small break LOCA initiating event includes random small break LOCA, inadvertent opening of the POSRVs and RCP seal catastrophic failure.

Potential initiating events can be screened from consideration if the frequency of occurrence of the event is sufficiently low. The ASME/ANS PRA Standard allows screening of initiating events that have a frequency less than 1×10^{-7} per reactor year and do not involve interfacing systems LOCA, containment bypass or reactor vessel rupture. No initiating events for the APR1400 PRA were screened based on frequency.

Once the initiating events are identified with preliminary definitions, the final initiating event groups are developed with the final group definitions.

As these initiating events are similar to those of existing nuclear power plants, the frequency for each initiating event is calculated based on generic estimates for current power plants from references such as NUREG/CR-6928 (Reference 11).

Initiating events identified by this process, along with the frequencies and the uncertainties of the events, are shown in Table 19.1-6. Initiating event development for the internal

flooding model is discussed in Subsection 19.1.5.3, and initiating event development during low power and shutdown (LPSD) states are identified and evaluated in Subsection 19.1.6.

19.1.4.1.1.2 Accident Sequence Analysis

The accident sequences that result from the initiating events are modeled in the form of event trees. The event trees are time sequences which show the response of the plant to a postulated disturbance. The response is depicted as nodes that represent the non-safety and safety systems potential response or use. The model includes support systems and operator actions that either respond to the initiating events or mitigate failure of other systems (note that this detail may also be reflected in the system or functional fault trees).

Accident sequence development involves, for each functional initiating event category, defining the safety functions and the systems and operator actions that potentially are available to support each safety function included in the event trees. Event trees are developed that trace the event sequences from initiating event to end states. The event trees are defined so as to capture the diversity of plant response and severity. Table 19.1-7 provides the list of event trees used.

The success criteria for each event tree top event are defined in order to support the development of fault trees for the system functions and human reliability evaluations (for those top events that include operator actions), see Table 19.1-8.

An event sequence model structure is developed that facilitates the identification of functional, physical, and human dependencies between the causes of the initiating events and the causes of system and operator action failures that violate any of the event tree top event success criteria.

The event sequence development begins, from a plant response perspective, with all equipment available and operating normally and then progresses to display critical and important failure paths in a logical progression. Event depictions are left to right decisions in the time order of plant response.

An event tree based sequence modeling approach is used with each event type based upon the initiator being developed in a unique tree. Safety functions necessary to achieve safe

shutdown are modeled. Safety functions are derived from past PWR PRAs and from an evaluation of the plant response to the initiating event.

Event trees developed for each initiating event group are shown in Figures 19.1-15 through 19.1-39.

The results of the accident sequence analysis are the identification of the individual core damage sequences, and the analysis requirements for determining the timing and progression of each accident sequence. The timing information is required in order to evaluate the impact of the operator actions, and the time of occurrence of the automatic systems initiation signals.

The key safety functions are listed below:

- Reactivity control
- RCS pressure control
- Preservation of RCS Integrity
- RCS inventory control
- RCS heat removal
- Containment heat removal

Each of these functions is described in further detail below:

a. Reactivity control – Directly influences the amount of heat being generated within the reactor core, which dictates the rate at which energy must be removed from the core and the RCS. Failure to control reactivity may cause core power generation to exceed the plant's capacity to remove it. Failure to limit core power may also challenge the RCS integrity, depending on how well the other functions are performed.

b. RCS pressure control – This function is necessary to ensure that RCS design pressures are not exceeded during certain events (such as an ATWS or a loss of all secondary heat removal). RCS depressurization capability must also be provided

to allow the use of the ECCS systems for non-LOCA events and to limit primary-to-secondary leakage after SGTR.

c. Preservation of RCS integrity – This function is closely related to the RCS pressure control function (i.e., if pressure control is not provided, then integrity cannot be maintained). However, failure of the RCS integrity function can occur if the RCS pressure control features fail to re-isolate the RCS after pressure relief was actuated following an initiating event. For example, if the POSRV fails to re-seat following a demand, then RCS integrity would be compromised. RCS integrity will also be compromised if a LOCA occurs.

d. RCS inventory control – This function is crucial for maintaining core heat removal, since core damage is assumed to occur for any significant duration of core uncovery. Inventory control is of particular concern during LOCA events; however, inventory loss can also occur in other accident scenarios that result in an induced LOCA.

e. RCS heat removal – This function can be achieved by secondary heat removal to relieve steam and inject feedwater into the SGs. The bleed and feed operation may be able to perform this function.

f. Containment heat removal – This function is needed in those scenarios in which RCS heat is transferred to the containment, either due to a LOCA or due to use of the POSRVs.

For each initiating event, progression of potential scenarios leading to either a safe state or to core damage is modeled using an event tree. Functions required for mitigating the accident and for preventing core damage are included across the top of the event tree. Fault trees are used to quantify the probability of failure of each of the functions.

The order of system and operator functional responses are ordered in the event trees in sequential order based on the timing of the accident scenarios as they develop. In selected cases, events may be ordered differently to simplify the event tree structure while retaining the proper functional relationships.

The internal flooding, while considered to be internal events, is discussed separately in Subsection 19.1.5.3.

Each Level 1 event tree sequence is assigned to an end state. The possible end states (for Level 1 analysis) are:

- OK – the key safety functions have been performed successfully so that core damage is prevented during the mission time or a safe stable state is reached at a time beyond the 24 hour mission time;
- CD – one or more key safety functions have failed such that core damage will occur; or
- TR – the accident progression has resulted in a transfer to another event tree which will define additional success requirements (e.g., a transient which results in a failure to scram the reactor will be transferred to the ATWS event tree).

Further classification of the core damage end states into specific Plant Damage States (PDSs) is performed in the Level 2 PRA analysis (see Subsection 19.1.4.2).

19.1.4.1.1.3 Dependency Analysis

The systems that are included in the systems analysis for internal events are provided in Table 19.1-9. Simplified diagrams of major systems are shown in Figure 19.1-1 through Figure 19.1-14. Tables are provided to summarize the initiator-to-system dependencies.

- Dependency between Initiating Events and Front Line Systems (Table 19.1-10)
- Dependency between Initiating Events and Support Systems (Table 19.1-11)

19.1.4.1.1.4 Success Criteria Analysis

The approach used in this success criteria analysis is based on the ASME/ANS PRA Standard requirements. The technical portions of the success criteria determination are based on the following:

a. The definition of core damage

Core damage is defined as the uncovery and heat-up of the reactor core to the point at which prolonged oxidation and severe fuel damage involving a large fraction of the core is anticipated.

b. The specific plant parameter of core damage

The ASME/ANS PRA Standard defines core damage as the uncovery and heatup of the reactor core to the point at which prolonged oxidation and severe fuel damage are anticipated and involving enough of the core, if released, to result in offsite public health effects. For the purpose of the APR1400 PRA success criteria analysis, core damage commences at a peak clad temperature of 1,204.4 °C (2,200 °F) or greater. In the APR1400 success criteria analyses, a limit of 1800 °F at the hottest core location was used to indicate the onset of core damage when calculated by MAAP. This value is deliberately less than the 10 CFR 50.46(b)(1) limit of 1,204.4 °C (2,200 °F) because the MAAP code used lumped core modeling and is used to compensate for some of the MAAP code simplifying assumptions, consistent with ASME/ANS PRA Standard requirement SC-A2. In all cases, core heat removal was either clearly lost or clearly maintained with respect to this 982.2 °C (1,800 °F) threshold.

Some success criteria calculations were performed using the RELAP code. Because the RELAP code has a detailed core model, these calculations used an acceptance criteria limit of 1,204.4 °C (2,200 °F) to identify the onset of core damage.

A containment failure could interfere with injection pathways to the point where the injection may be terminated. Containment failure is therefore considered to cause core damage.

c. The specification of core protection functions for core damage

Five safety functions are identified and specified for each initiating event. The general safety functions specified for meeting the success criteria are as follows:

- Control of reactivity

- Control of RCS pressure
- Preservation of RCS integrity
- Preservation of RCS inventory
- Heat removal from the RCS and containment.

Table 19.1-8 shows the relation of these plant safety functions and the initiating events.

d. The identification of mitigating systems and operator actions

Mitigating event tree nodes (composed from system fault tree top gates) and associated success criteria are summarized in Table 19.1-8. The key operator actions are as follows:

Nodes	Operator Action
ASC	Operators to perform aggressive secondary cooldown
BLEED	Operators to open POSRVs for feed and bleed operation
EBR	Operators to perform emergency boration
ECLDN	Operators to cooldown primary early phase during SGTR
HIN	Operators to realign SIS for hot leg injection
ISOL	Operators to isolate secondary line break
LCLDN	Operators to cooldown primary late phase during SGTR
RF	Operators to refill IRWST
SCSI	Operators to perform injection using SCS
SDC	Operators to align SDC operation

e. The specification of appropriate mission time

A mission time of 24 hours is specified for each success criterion. The 24 mission time provides sufficient time for the initiating event to either be

successfully mitigated or for the event to progress to a core damage state. If a stable plant condition cannot be achieved within 24 hours for a specific sequence, additional evaluation of that sequence is performed to determine an appropriate end state, to extend the mission time, and/or to model additional system recovery.

f. The bases for features and operating procedures

The main bases for features and operating procedures are the APR1400 emergency operating guidelines (EOGs). The additional bases are very similar to the reference plants, which incorporates current existing PWR plant experience.

g. Plant thermal/hydraulic analysis for success criteria

Plant thermal/hydraulic analysis for PRA success criteria is performed. The minimum required thermal/hydraulic analysis for basic determination of success criteria and design support thermal/hydraulic analysis is conducted to specify the final success criteria.

h. The use of engineering judgment

In the design phase of the APR1400 design, many aspects of the detailed design have not been determined and the operational procedures have not been developed. Therefore, engineering judgment is used in areas where thermal hydraulic analysis cannot be performed for success criteria determination.

i. The initiating events grouping and thermal/hydraulic analysis

An initiating event group for thermal/hydraulic analysis is determined for individual initiating events. The approach of the representative thermal/hydraulic analyses used to determine success criteria is to evaluate the most severe event among initiating events in a group and the available mitigating functions by considering minimum requirements for system functionality.

j. The analysis model and computer codes

The MAAP 4.0.8 code, the RELAP5 code, as well as analysis results described in Chapter 15 of this submittal are used to determine success criteria. It is

recognized that the RELAP5 code modeling is more detailed than the MAAP code modeling. However, the MAAP code can be used to model certain phenomenology that RELAP 5 cannot. Engineering judgment is used to determine the appropriate code for the particular success criteria or scenario being examined.

k. The results of the thermal/hydraulic analysis

Representative results of the thermal/hydraulic analysis are given in Table 19.1-12 and Table 19.1-13.

l. Determination of success criteria

Final success criteria, shown in Table 19.1-8, are determined from the design, engineering judgment and thermal/hydraulic analysis results in a manner that allows a margin for the uncertainties in the models of the thermal/hydraulic analyses and grouping of initiating events.

The success criteria were determined in terms of initiating events that are modeled for the APR1400. The initiating events that are considered in full power Level 1 PRA are:

- Large/Medium/Small break LOCA
- SGTR
- Large secondary steam line side break (LSSB)
- General transients
- Loss of main feedwater (LOFW)
- Feedwater line break (FWLB)
- Loss of condenser vacuum (LOCV)
- Loss of instrument air (LOIA)
- Loss of 125V DC (LODC)

- Loss of component cooling water / essential service water (LOCCW/LOESW)
  - PLOCCW/PLOESW
  - TLOCCW/TLOESW
- LOOP (i.e., grid-related, weather-related, switchyard-centered, plant-centered)
- Interfacing system LOCA (ISLOCA)

The followings are induced events considered in full power Level 1 PRA.

- Consequential LOOP (GRID-LOOP)
- SBO and Consequential SBO (GRID-SBO)
- ATWS
- Induced Stuck Open POSRV (PR-A-SL)

19.1.4.1.1.5 Systems Analysis

The systems analysis provides for treatment of the causes of system failure and unavailability modes represented in the initiating events analysis and sequence definition.

The fault tree models include contributions due to the following:

- Random component failures
- Outages for maintenance and testing
- Support systems
- CCFs
- Human errors involving failure to restore equipment to its operable state
- Human errors involving failure to perform procedural actions

Fault trees are developed to the level of detail for which existing data can be applied. For active systems, passive failures that are potentially significant are included.

General assumptions and conditions applied to system analysis are summarized below.

a. General modeling conditions:

- Models reflect the design as-designed and as-to-be-built to the extent possible.
- Systems which participate in the necessary response to events or which provide critical support to such systems are modeled.
- Models reflect the success criteria for the systems to mitigate each identified accident sequence.
- Models capture the impact of dependencies, including support systems and harsh environmental impacts.
- Operator errors of commission are not included in the system model.

b. Conditions concerning level of detail

- The level of detail in the model matches one for one the simplified diagrams and includes key active components and potential misaligned components based upon data availability.
- Models include contributions due to random component failures, outages for maintenance and test, support systems, CCFs, human errors to restore equipment to its operable state, and human errors involving failure to perform procedural actions.
- Models include both failure modes of active and passive components that impact the function of the system.
- A thorough treatment of CCFs, intra-system dependencies and selected intersystem dependencies is provided.
- The fault tree is developed to the level of detail for which existing data can support.

c. Failure modes of components modeled are summarized below:

- Reduced or single data value modeling is performed for systems that are best characterized from system failure data.

- Valve plugging - For valves that are passive (normally open) components in standby, the spurious transfer closure failure mode applies. For components that are normally closed, plugging is not explicitly modelled. The origin of this assumption is NUREG/CR-1363 (Reference 12) which describes valve plugging as an event that would stop or limit flow through a normally open valve.

- Plugging in flow lines are likely to occur in components such as valves and orifices, rather than in piping. Therefore, pipe plugging is not modeled.

- Probabilities of failures that occur during standby states are evaluated from test and maintenance intervals. Test and maintenance intervals are assumed to be bounded by the technical specifications in Chapter 16.

- Failure rate data includes partial failures of components. For example, the data for a valve failing to open includes failures where the valve opens, but not completely. If a basic event is true (failed), it may be completely failed, or it may be degraded. It is conservatively assumed that if a component fails, it fails in a manner that prevents it from performing its function. As such, if the fault tree reflects a train being successful, the train is available to perform its function at the normal (not degraded) level.

- When components such as fuses, breakers, relays, etc. function to serve only one pump, valve, compressor, or diesel, etc. their failure is considered to be accommodated as part of the failure rates associated with the equipment they serve. Shared devices are explicitly modeled to account for inter-component dependencies.

- Components or specific component failure modes may be screened from the PRA model according to the following criteria (SY-A15 in the ASME/ANS PRA Standard):

- A component may be excluded from the system model if the total failure probability of the component failure modes resulting in the same effect on system operation is at least two orders of magnitude lower than the highest failure probability of the other components in the same system train that results in the same effect on system operation.

- One or more failure modes for a component may be excluded from the systems model if the contribution of them to the total failure rate or probability is less than 1 percent of the total failure rate or probability for that component, when their effects on system operation are the same.

In implementing the requirements of SY-A15, the following generic criteria are used:

- In general, the probability of a passive failure of a manual valve is not included in the PRA model on the assumption that the manual valve failure probability is at least two orders of magnitude less than the failure probability of an active component.

- When applying this screening criteria, special consideration must be given in cases where the valve failure would cause an initiating event or an interfacing systems LOCA, or where there are multiple manual valves (in series or parallel) lined up in such a way that the failure of any one valve would cause system failure (e.g. open manual valves in series that must remain open, or closed manual valves in parallel that must remain closed).

- Passive failures (SY-A11) such as heat exchangers, piping and tanks should be included where necessary; except when using the screening criteria in SY-A15.

- Flow diversion (SY-A13) is considered a potential system failure if the flow diversion pathway occurs due to failures that do not meet the screening criteria of SY-A15 and can result in failure to meet the system success criteria. The flow diversion paths which are excluded are documented.

19.1.4.1.1.6 Data Analysis

The purpose of the data analysis task is to tabulate estimates of the failure rates, demand failure probabilities, and unavailability data for basic events in PRA model. The data developed during this task includes:

- Component unreliability data
- Component unavailability data due to test and maintenance
- Common cause failure data
- Special event data including recovery action failures

For each component type and failure mode identified in the system analysis, the failure rates are extracted from available generic data sources. Potential sources of generic failure data are:

a. NUREG/CR-6928, "Industry-Average Performance for Components and Initiating Events at U.S. Commercial Nuclear Power Plants," U.S. Nuclear Regulatory Commission, "Industry Average Parameter Estimates, 2010 Update."

c. NUREG/CR-5500, Vol. 10, "Reliability Study: Combustion Engineering Reactor Protection System, 1984-1998", U.S. Nuclear Regulatory Commission, November 2001 (Reference 13).

d. NUREG/CR-5485, "Guidelines on Modeling Common-Cause Failures in Probabilistic Risk Assessment," U.S. Nuclear Regulatory Commission, November 1998 (Reference 14).

e. NUREG/CR-5497, "CCF Parameter Estimations, 2010 Update," http://nrcoe.inl.gov/results/CCF/ParamEst2010/ccfparamest.htm, U.S. Nuclear Regulatory Commission, January 2012 (Reference 15).

f. NUREG/CR-6890, "Reevaluation of Station Blackout Risk at Nuclear Power Plants," (Vol. 1, Analysis of Offsite Power Events: 1986 – 2004), U.S. Nuclear Regulatory Commission, December 2005 (Reference 16).

g. EPRI Interim Technical Report, “Treatment of Loss of Offsite Power (LOOP) in Probabilistic Risk Assessments: Technical Basis and Guidelines,” September 2009 (Reference 17).

A list of component types, failure modes, failure rates and parametric uncertainty parameters is developed. Table 19.1-14 provides the component failure data for the APR1400 PRA. The majority of the failure data and unavailability data are taken from NUREG/CR-6928. When failure data are not available in NUREG/CR-6928, then the data are taken from other sources such as NUREG/CR-5500.

The component boundaries are consistent with corresponding basic event definitions. Component boundaries, given in Table 19.1-15 are defined by generic data sources, so that the boundaries of the basic events are set to be consistent with the component boundaries.

In the PRA, beta and gamma distributions are used for the random component failure data taken from NUREG/CR-6928. Unavailability due to test and maintenance is derived from NUREG/CR-6928. Other data set sources tend to use lognormal distributions.

Component Unreliability Data

The components which are modeled in the APR1400 range from small items such as transmitters and breakers to large equipment such as pump and their motors. These components can fail due to random causes, related or common cause failures (CCFs), or being unavailable due to test and maintenance activities. The APR1400 plant specific data is not yet available and the data used in this analysis is based upon generic sources.

Component Unavailability Data

Component unavailability means that a component is in an out-of-service state due to T&M (test and maintenance). In the APR1400 PRA, these T&M events are modeled in each system fault tree to account for the fact that certain components may be disabled due to maintenance (either preventive or corrective) or testing while the plant is in operation. While technical specifications allowed outage times, fuel cycles, and maintenance practices can vary significantly between plants and cause T&M events to be very plant-specific, the absence of plant data resulted in the use of generic component unavailability data (which is derived from NUREG/CR-6928).

Common Cause Analysis

The Alpha Factor methodology is applied to calculate the probability of common cause events. The Alpha Factor parameters are estimated by applying impact vectors based on generic industry data. To develop uncertainty distributions for the Alpha Factor parameters, a Bayesian framework in accordance with NUREG/CR-5485 is used.

The methodology for CCF analysis is based on NUREG/CR-4780 (Reference 18) and NUREG/CR-5485. Generic data for CCF reported in NUREG/CR-5497 and the latest CCF parameter updates from the NRC Reactor Operational Experience Results and Databases (Reference 19) are applied to evaluate the CCF parameters.

CCFs can result from various mechanisms. The causes of these events correspond to failure mechanisms that have been determined from analysis of nuclear plant service experience and fall into several broad categories such as the following:

- Design/manufacturing/construction
- Procedural error
- Human actions/plant staff error
- Maintenance and test
- Abnormal environmental stress

Redundant and active components as well as groups of non-identical active components that have the potential for CCF mechanisms are prime candidates for the CCF analysis. The component types that are considered for common cause analysis include those for which there is documented evidence of common cause experience as well as those that have the characteristics of redundant active components. The components considered are as follows:

- Electrical systems: Emergency power generators, circuit breakers, batteries, battery chargers, and inverters

- Reactor trip system and ESF system: Bi-stables, reactor trip breakers, relays, shunt trip coils, sensors, logic modules, and control rods
- HVAC systems: Chiller units (including compressors), dampers, air handling units, fans, and reactor containment fan coolers units
- Mechanical systems: Pumps, motor-operated valves, air-operated valves, check valves, relief valves, safety valves, heat exchangers, strainers, and traveling screens.

Common cause events for other component groups in a system may be defined if the event is an important contributor to system reliability and if the components in the group can be linked to conceivable CCFs such as those defined previously.

A set of components are defined as a common cause component group when they are of the same type (pumps, valves, etc.), and when they meet the following conditions:

a. Same initial conditions (such as normally open, normally closed, energized, and de-energized)

b. Same use or function (such as system isolation, flow modulation, parameter sensing, and motive force)

c. Same failure mode (such as failure to open on demand, and failure to start on demand)

d. Same minimal cutset (failure of multiple components that appear in the same cutset)

Treatment of intersystem CCFs is consistent with capability Category I and II of ASME/ANS PRA Standard. CCFs across systems are not included in the CCF model, because they are quite different in terms of the environment, operation or service, design, and maintenance.

Some component dependencies are explicitly modeled as separate events in the fault trees to avoid double counting. Such dependencies are not included in the common cause analysis. Dependencies that are not considered in the common cause analysis are functional dependencies, human errors, maintenance and testing unavailability, and external events.

Once the common cause groups of components are defined, the fault tree is modified so that each fault tree basic event representing the failure of a member of a common cause group is expanded to include additional events which are combined under an “OR” gate.

Special Event Data

In the course of developing the fault tree models, special events were developed to more accurately reflect potential plant scenarios. Special events may consist of adjusting or correction factors used to modify a specific basic event probability for particular accident sequence conditions. These events and their associated probabilities are listed in Table 19.1-16.

19.1.4.1.1.7 Human Reliability Analysis (HRA)

The human reliability analysis (HRA) provides a structured approach to identify potential human failure events (HFEs) and to systematically estimate the probability of those events using data, models or expert judgment. The HRA conforms to the ASME/ANS PRA Standard requirements, as clarified by NRC RG 1.200. This assessment evaluates both pre-initiator HFEs (errors that occur prior to the initiation of an accident, such as during maintenance) and post-initiator HFEs (errors committed during actions performed in response to an accident initiator).

Pre-Initiators

The assessment of HFEs is an important task in a comprehensive PRA. The overall approach to pre-initiator development in the HRA is consistent with the Accident Sequence Evaluation Program (ASEP) framework described in NUREG/CR-4772 (Reference 20). Pre-initiator HFEs constitute one of the four categories of HFEs:

a. Pre-Initiator Human Failure Events (Type A or Latent). These events take place prior to an initiating event, and usually leave a component or a system in an undesired state that does not manifest itself until an initiating event occurs. Miscalibration of instrumentation and misalignment of a manual valve on a standby system are examples of Type A HFEs.

b. Human Induced Initiating Events. These events are human actions that contribute to the occurrence of an initiating event. Human induced initiating events are implicitly included in the initiating events, therefore they are not considered in detail.

c. Initiating Event-Related HFEs (Type B). A failure to perform a Type B action results in the occurrence of an initiating event.

d. Post-Initiator HFEs (Type C or Dynamic). These events describe the response of operating staff to an initiating event or other plant upset event.

Therefore, the pre-initiator HRA for the APR1400 PRA models the Type A, or latent, HFEs.

The general process for conducting the pre-initiator HRA is as follows:

a. Identify individual maintenance, test, and/or calibration activities which might cause a pre-initiator. An example is the identification of an activity that requires an alignment change or a calibration.

b. Screen activities which are determined to have a negligible impact on CDF due to a low probability of occurrence. However, activities which affect redundant trains or diverse systems are not screened.

c. Define the HFEs from the resultant unscreened activities.

d. Quantify the HEPs using the ASEP methodology as a first pass.

e. Quantify HEPs using the THERP methodology for those events that have a Fussell-Vesely importance greater than 0.005 or a risk-achievement worth greater than 2.

The ASEP methodology (i.e., NUREG/CR-4772) is utilized to quantify the pre-initiator HRA using screening values. For significant HFEs, a detailed assessment for the quantification of the pre-initiator HEP using THERP is utilized. Significant HFEs are defined according to NRC RG 1.200 as a basic event which has a Fussell-Vesely importance greater than 0.005 or a risk-achievement worth greater than 2.

The ASEP methodology uses 3 levels to assess dependency between multiple human errors: complete dependence (CD), high dependence (HD), and zero dependence (ZD). The dependency calculations used in the ASEP methodology originated in NUREG/CR-1278 (Reference 21). However, Supporting Requirements HR-A3 and HR-B2 from the ASME/ANS PRA Standard state:

- HR-A3: IDENTIFY the work practices identified above (HR-A1, HR-A2) that involve a mechanism that simultaneously affects equipment either in different trains of a redundant system or in diverse systems (e.g., use of common calibration equipment by the same crew on the same shift, a maintenance or test activity that requires realignment of an entire system).

- HR-B2: DO NOT screen activities that could simultaneously have an impact on multiple trains of a redundant system or diverse systems.

There are cases of ZD assigned by the original ASEP methodology that, in effect, would screen activities that impact more than one system train. To address these conditions, the enhanced methodology used in the APR1400 PRA assigns low dependence (LD), rather than ZD. For example, to account for dependencies arising from miscalibrating multiple trains of equipment, such as using the same calibration equipment for multiple components, LD is applied instead of ZD. The enhanced method ensures that activities impacting more than one system train are not screened.

Post-Initiators

The scenarios analyzed in the APR1400 PRA include the potential for human errors related to detection, diagnosis, and decision-making for the event (cognitive errors), as well as errors related to performing the required actions (execution errors). For the scenarios considered in this PRA, operator actions occur as part of an overall response to mitigate plant events and, therefore, aspects such as cue availability, procedural direction, timing, man power limitations, and response prioritization needs to be considered. The HRA modeling techniques used to quantify HEPs for each HFE should be able to account for these complexities. The operator actions considered for this PRA primarily involve in-control-room actions. However, some ex-control-room activities may be directed from the control room based on procedurally-directed requirements, such as: locally manipulating a

valve, resetting equipment, or locating a source for a leak. It is also desired to use HRA methodologies which are commonly used in the nuclear industry.

Given these considerations, this PRA uses the caused-based decision tree methodology (CBDTM) (Reference 22), the human cognitive reliability / operator reliability experiment (HCR/ORE) methodology (Reference 22), or the annunciator response model (ARM) (Reference 21), depending on the particular scenario under analysis. The advantage of using these HRA methods is that these methods evaluate fundamental aspects and factors affecting human performance and are capable of addressing the detailed analyses needed for the scenarios considered. Alternate HRA methodologies that could be used are described in NUREG/CR-1842 (Reference 23). These other methods were not used because they either are simplified techniques that would likely result in overly conservative results or are inappropriate for the scenarios modeled.

The HCR/ORE methodology is used for immediate, memorized actions or time-critical actions and addresses event detection, diagnosis, and decision-making implicitly via time-reliability correlations to estimate the cognitive error component of the overall probability. Performance shaping factors (PSFs) are implicitly including within this technique. Time-critical actions are defined as those actions for which the time available for cognition is relatively short compared to the median crew response time. The crew nonresponse probability represents the probability than an operating crew, while making the correct decision, takes longer than the available time to respond. This contribution to the crew overall non-response is particularly important for situations where a relatively fast response to an initiator is required. The HCR/ORE correlation is a representation of the probability of crew non-response as a function of normalized time, a dimensionless unit which reflects the ratio of time available to crew median response time.

For simplicity and conservatism, the HFEs evaluated for the APR1400 PRA use the HCR/ORE methodology for those situations in which cognition must occur within a short time frame and for which the proposed scenarios are similar to the original scenarios, as proposed by the authors of the methodology:

For those HFEs in which cognition can occur at some time greater than 30 minutes, the CBDTM was chosen because the CBDTM more accurately represents the HEP for actions which are primarily procedurally-directed or require transitions to another procedure. There is no guidance for using the method under time limited conditions because the

methodology was not intended to address such situations. The CBDTM is appropriately applied in situations where the operators characterize the event as they work through the procedures and must make a decision to initiate some process.

The annunciator response model (ARM) can be used to estimate the cognitive portion of the HEP for either pre-initiators or post-initiators. The ARM is suggested for those parts of an HRA in which the primary interest is in responding to the annunciators, without emphasis on interpretation. However, if the alarm occurs after an initiating event, then a sufficient amount of time must have passed such that a stable plant condition is considered to be re-established before the use of the ARM can be considered an appropriate methodology for the scenario. A stable plant condition is considered to be the point at which the operators have achieved a stable path towards plant shutdown and responses to annunciators that arose from the plant initiating event have been addressed.

To estimate the failure probability for the execution steps, the CBDTM, HCR/ORE, and ARM methodologies use the THERP methodology.

19.1.4.1.1.8 Computer Codes Utilized

SAREX

The PRA code package that was utilized for the creation of the Level 1 event and fault trees is SAREX (Reference 24). SAREX is an integrated PRA software package that provides the user with the ability to create and evaluate fault trees and event trees using a personal computer. The SAREX package provides tools for graphical fault tree constructions and editing, the fault tree cutset generation and quantification, the fault tree uncertainty analysis and fault tree importance analysis, event tree analysis including accident sequence definition, accident sequence cutset generation via fault tree linking, quantification of accident sequence cutsets and uncertainty analysis for the accident sequences.

FTREX

FTREX (Reference 25) is a computational engine that takes as input a reliability model in the form of a Boolean fault tree, including the supporting basic event probabilities and

other options such as initiator events and house events. FTREX has advanced features to significantly improve the quantification speed for large models.

HRA Calculator

The EPRI HRA Calculator (Reference 26) is used to calculate the HEPs.

RELAP5

RELAP5/MOD3 (Reference 27) is used to analyze the thermal-hydraulic behavior of light water systems.

MAAP

The modular accident analysis program (MAAP) 4.0.8 (Reference 28) is used to evaluate the success criteria.

19.1.4.1.1.9 Sequence Quantification

This section summarizes the process used to quantify the frequency of core damage.

The frequencies of the core-damage sequences are calculated by obtaining sequence level minimal cutsets. Post-processing of these cutsets is performed to account for factors that are not readily incorporated into the fault trees themselves. For example, this post-processing allows the identification of cutsets that contain more than one post-initiator HFE. The dependencies between multiple HFEs are assessed as appropriate, and included in the cutsets in post-processing. The event trees and fault trees were developed using the SAREX computer code and solved using the FTREX computer code. The SAREX model for the APR1400 constitutes a large, detailed set of event trees and fault trees. The model whose results are described in this report consists of the following:

- 25 event trees
- ~ 50 fault trees
- ~ 3,400 basic events

The model is quantified using a 1×10^{-13} truncation limit.

19.1.4.1.2 Results of Level 1 Internal Events PRA for Operations at Power

The results of the Level 1 internal events model are described in the following subsections.

19.1.4.1.2.1 Risk Metrics

Total CDF from internal events is 1.3×10^{-6}/year. It should be noted that the "year" unit in the full power internal events section (Subsection 19.1.4) refers to a reactor calendar year (rcy). This is well below the probabilistic safety goal of 1×10^{-4}/year. The initiating event contributions to CDF for Level 1 internal events at full power can be found in Figure 19.1-40.

19.1.4.1.2.2 Significant Initiating Events

The significant initiating events and their contribution to the internal CDF are given in Table 19.1-17. Only those initiating events that contribute more than one percent to the total internal events CDF are listed in the table. The LOOP initiating event strongly dominates the internal events CDF. In order to illustrate in more detail the total LOOP contribution to CDF, the LOOP sequences were divided into four categories.

- LOOP events (no SBO, not grid centered) contribute approximately 20 percent to the total CDF.
- SBO events (not grid centered) contribute 16 percent to the total CDF.
- LOOP events (no SBO, grid centered) contribute approximately 1 percent to the total CDF.
- SBO events (grid centered) contribute approximately 3 percent to the total CDF.

The above results reflect the fact that SBO risk is low due to the presence of robust onsite power capabilities plus an alternate source of ac power (AAC GTG).

The next largest contributors to plant risk are loss of cooling water events (TLOCCW and TLOESW).

- TLOCCW/TLOESW contribution can be attributed to the loss of mitigating systems due to lack of component cooling as well as the induced RCP seal LOCA and the challenges that this configuration presents.

Medium break LOCA contribution is also significant.

19.1.4.1.2.3 Significant Cutsets and Sequences

The significant accident sequences are listed in Table 19.1-18. The accident sequences are dominated by loss of offsite power (LOOP), station blackout (SBO), loss of component cooling water (LOCCW), and loss of essential service water (LOESW). Only one accident sequence contributes over 10 percent of the CDF; this sequence involves the following elements:

a. LOOP

b. Success of reactor trip

c. No POSRV challenge

d. Success of one or more EDGs

e. Failure of secondary heat removal

f. Failure of bleed for Feed and Bleed operation.

The significant cutsets for the internal events are illustrated in Table 19.1-19. The top 100 cutsets contribute approximately 39 percent of the total CDF. Cutset contribution to the internal events CDF is equally distributed. Only eight (8) of the top cutsets contribute more than one percent to the total CDF. The number of cutsets that contribute to 95 percent of the CDF is over 200,000. These results show that there are no significant outliers in the APR1400 internal events CDF.

19.1.4.1.2.4 Significant SSC, Operator Actions and Common Cause Events

Table 19.1-20 shows the risk-significant SSCs based on the RAW importance measure. The most important pieces of equipment are DC-MC01A/1B (Class 1E 125V dc Bus 1A/1B) and CC-TK01B (component cooling water surge tank). Their high RAW rank can

be explained by their high reliability and by a high consequence of their failures. The 125V dc Bus 1A/1B is an electrical support for several key safety systems; failure would result in the inability to operate these systems. A failure (significant leak) in the component cooling water surge tank would disable component cooling water. Table 19.1-21 shows the significant SSCs based on the FV importance measure.

Table 19.1-22 shows the significant common cause events based on RAW importance. The highest CCF events are the reactor trip circuit breakers and the 125 V dc batteries. Table 19.1-23 shows the significant common cause events based on FV importance.

Table 19.1-24 shows the risk-significant human actions based on the RAW importance.

Table 19.1-25 shows the risk-significant human actions based on the FV importance. The most important action is the failure to open the POSRVs during the early phase for feed and bleed operation.

19.1.4.1.2.5 Assumptions

Assumptions in the PRA development are divided into two groups:

- Assumptions in response to key sources of uncertainty
- Modeling assumptions made because of limitations in the PRA logic models or software

The most important assumptions from these two groups are listed below.

Key Assumptions

a. EDGs and AAC power source are assigned to different common-cause groups. This assumption will be confirmed by assuring diversity between EDGs and AAC source (different model, control power, HVAC, engine cooling, fuel system, location).

b. The HRA is performed under assumptions that the operating procedures and guidelines will be prepared and that operator training will be similar to existing operating plants.

c. Different operator actions HEPs are estimated for the SBO conditions (LOOP and all EDGs not available) versus non-SBO conditions (LOOP and at least one EDG available). It was assumed that operators will have clear direction about the crosstie of buses and equipment, in SBO conditions, when no emergency power is available. This assumption will be evaluated when the operating procedures and guidelines are available.

d. CVCS is not credited for an injection function to make up the lost inventory.

e. RCP seal LOCA probability, given a total loss of seal cooling and the RCP trip, is assumed to be equal to 1×10^{-3}.

f. The entire year was used for evaluation of the initiating event frequencies at power. It was not adjusted for time assumed to be spent at shutdown. For the current assumption on the shutdown duration (28.5 days), an adjustment factor would be 0.95. This assumption will be evaluated when plant-specific shutdown information is available.

Major Modeling Assumptions

a. For the initiating events (IEs) whose frequencies were calculated using fault trees, the point estimates (not mean values) were used in the model.

b. In the calculation of the IE frequencies by fault trees, the entire year mission time was used for the running pump common cause events. However, running and stand-by pumps were modeled in different common cause groups with appropriate mission times.

c. Consequential LOOP is modeled. It is assumed that the consequential LOOP probability as a result of plant trips and LOCA events are different.

d. A failure to trip reactor during a small break LOCA or SGTR event is assumed to lead to core damage, and no further model development was made.

e. The plant capacity factor is assumed to be 0.95.

19.1.4.1.2.6 Uncertainty Analysis

Uncertainty on the Level 1 Internal Events PRA results is quantified using the built-in uncertainty analysis software capabilities of SAREX. The results of parametric uncertainty for Level 1 internal events CDF are summarized below:

- 5 percent Value: 4.5×10^{-7}/year.
- Mean Value: 1.9×10^{-6}/year.
- 95 percent Value: 3.8×10^{-6}/year.

This ninety-fifth percentile CDF value is more than an order of magnitude below the NRC goal of 1×10^{-4}/year.

The results for parametric uncertainty, the mean value from Monte Carlo simulation is larger than the point estimate. This is due to the “state of knowledge correlation” as defined in the ASME/ANS PRA Standards, which is important for cutsets that contain multiple basic events whose probabilities are based on the same data, particularly when the uncertainty of the parameter value is large. Given the redundancy of the APR1400 safety trains, such cutsets are expected in the APR1400 PRA model. In this case, in the Monte Carlo sampling approach, the same value is used for each basic event probability, since the “state of knowledge” about the parameter value is the same for each event. This results in a mean value for the joint probability that is larger than the product of the mean values of the event probabilities.

Importance of the redundant equipment and the state-of-knowledge dependencies is limited for the equipment where common cause failures dominate the results. The impact of the redundant equipment is more important in the case where equipment single failures are also significant contributors to the results.

More detailed discussion on parametric and modeling uncertainty is as follows:

Parametric uncertainty was quantified by selecting an uncertainty distribution for each input parameter. Distributions applied are Lognormal, Beta, and Gamma, as described below for each type of parameter:

a. Initiating Events: Uncertainty distributions were obtained from the same source as the mean values. For initiating events evaluated by fault trees, lognormal distribution was assumed.

b. Failure Rates: Uncertainty distributions were obtained from the used data source.

c. Common Cause Parameters: Uncertainty parameters were obtained from the same source as CC factors.

d. LOOP Related Basic Events: Lognormal distribution was assumed.

e. Human Error Probabilities: For pre-accident HEPs, a lognormal distribution with an error factor of 10 was used, as recommended in the ASEP method. For post-accident HEPs, a constrained non-informative prior (Beta) distribution was used, as recommended in the SPAR-H method (Reference 29).

f. Various Parameters & Undeveloped Events: Constrained non-informative prior (Beta) distribution was used to account for the limited state of knowledge.

g. Time Related Parameters: For time-related parameters, like preventive maintenance duration (and corresponding unavailability), a lognormal distribution was used; an error factor was estimated from upper and lower bounds, corresponding to upper and lower time estimates.

Modeling uncertainty was also specifically treated, but limited to four cases selected to illustrate a specific lack of modeling design details. These cases are described below:

CASE 1: The case is based on the uncertainty of room cooling requirements for some of the electrical equipment rooms. An assumption was made such that the room cooling is not required even without the room cubicle coolers operating. Room heatup calculations need to be performed to ensure that the assumption is valid. A sensitivity analysis is to be performed with a room cooling requirement, assuming that electrical equipment will fail if the associated room

cubicle coolers become unavailable.

CASE 2: The case is related to the hot leg injection (HLI) requirement where the base PRA model assumes that HLI is not needed for a medium break LOCA. HLI is used to prevent the boron precipitation potentially plugging up the core upper channels, and it is required for a large break LOCA. For a medium break LOCA where the upper break size, it was assumed that HLI is not needed. A sensitivity analysis is to be performed assuming that HLI is required for a medium break LOCA.

CASE 3: The case is related to the RCP seal LOCA model, which is currently modeled as a single basic event with the event probability based on an engineering judgment. A sensitivity analysis is to be performed to characterize the sensitivity of this event that represents the RCP seal LOCA. The seal LOCA model complexity will depend on the RCP seal leakage rate.

CASE 4: The case is related to GSI-191 resolution, where the base model assumes that the downstream chemical effect in the core is negligible with the use of a reflective metallic insulation (RMI) in the containment. The PRA model includes an event for the potential sump blockage due to the containment debris, but it does not include a potential blocking of water pathway due to the downstream chemical effects. A sensitivity analysis is to be performed with an assumption that the chemical effects could cause a blockage.

19.1.4.1.2.7 Sensitivity Analysis

A sensitivity analysis was performed to evaluate the impact of a series of modeling assumptions, including the above assumptions, on the internal events CDF. Several insights can be drawn from the sensitivity cases analyzed.

a. TLOCCW/TLOESW Initiating Event Sensitivity Case: The initiating event frequencies for TLOCCW and TLOESW are based on the generic frequencies shown below. These support system initiating events were evaluated using fault trees, and the calculated initiating event frequencies were significantly lower than the generic frequencies. Therefore, a decision was made to use the generic frequencies in the PRA model.

	Generic	SSIE FT	Factor
TLOCCW	2.34×10^{-4}	1.33×10^{-5}	17.5
TLOESW	2.34×10^{-4}	6.63×10^{-5}	3.5

A sensitivity case was evaluated using the initiating event frequencies calculated from the support system initiating event fault trees, and the result showed that CDF decreases by 13 percent to 1.1×10^{-6}/year.

b. RCP Seal LOCA Sensitivity Case: The base model assumes that the RCP seal LOCA probability to be 1×10^{-3} per RCP, based on an engineering judgment, which is judged to be somewhat conservative. A sensitivity case was evaluated by setting the seal LOCA probability to zero, and the result showed that CDF decreases by 11 percent to 1.2×10^{-6}/year.

c. GSI-191 Sensitivity Case: The base model assumes that the probability associated with downstream chemical effects is zero based on the usage of reflective metallic insulation (RMI) in the containment. A sensitivity case was performed by setting the chemical effect basic event to 1×10^{-3}, based on an engineering judgment; and the result showed that the CDF increases by about 200 percent to 3.8×10^{-6}/year.

d. SBO Sensitivity Case: The base model does not credit any mobile equipment that may be available as a result of Fukushima accident action items. A sensitivity case was evaluated to see potential impact of crediting the mobile SSCs in the PRA model. This was accomplished by decreasing the operator action to connect AAC power source by a factor of ten, and the result showed that there is only a minor decrease in CDF. This sensitivity case impacts only SBO sequences.

e. Hot Leg Injection Sensitivity Case: For medium break LOCA, a Hot Leg Injection (HLI) is assumed not needed. A sensitivity case was performed that require HLI for a medium break LOCA, and the result showed the CDF increases by 10 percent to 1.4×10^{-6}/year.

19.1.4.1.2.8 Risk Insights

The APR1400 is an evolutionary PWR plant, and CDF is dominated by LOOP events (approximately 39 percent). Still, total LOOP CDF is small at less than 1.5×10^{-7}/year.

This small contribution is a result of the high redundancy in trains and diversity in emergency power supplies.

Loss of cooling systems (CCW system and ESW system) and seal LOCA contributions to CDF are approximately 26 percent, which includes the total/partial losses of CCW or ESW. This relatively large contribution, which contributes to RCP seal LOCA, is a result of the APR1400 redundancy in the cooling trains but lacking diversity.

The top cutsets show that the plant risk is strongly influenced by the performance of support systems (i.e., CCW system and ESW system). This is because the support systems are common dependencies of highly redundant safety systems.

19.1.4.2 Level 2 Internal Events PRA for Operations at Power

A description of the Level 2 internal events PRA for operations at power, including the results of the analysis, is provided in the following subsections.

19.1.4.2.1 Description of Level 2 Internal Events PRA for Operations at Power

The PRA is comprised of two major areas of analysis: 1) the identification of sequences of events that could lead to core damage and the estimation of their frequencies of occurrence (the Level 1 analysis); and 2) the evaluation of the potential response of containment to these sequences, with emphasis on the possible modes of containment failure and the corresponding radionuclide source terms (the Level 2 analysis).

The Level 2 analysis begins with the end point of the Level 1 analysis (i.e., core damage). The Level 2 analysis uses both deterministic and probabilistic analysis tools to follow the progression of the core-damage accidents. Computer analysis codes were used to simulate the meltdown of the core, the failure of the reactor vessel due to contact with molten core materials, and the transport and interactions of core debris in the containment. Because of the large uncertainties associated with the progression of a core-damage accident, these deterministic calculations were supplemented with assessments that considered the potential for phenomena different from or more severe than those treated in the analysis codes. The results of this part of the analysis include an assessment of the potential for a

variety of containment failure modes for each type of core-damage sequence, and an estimate of the magnitude of the radionuclide release that would be associated with each.

It is impractical to evaluate the accident progression associated with each of the Level 1 core damage sequences. The binning of the sequences into plant damage states (PDSs) allows sequences exhibiting similar characteristics to be analyzed in detail in the Level 2 analysis, while keeping the total number of PDSs to be analyzed at a manageable level.

After the PDSs have been established, each is evaluated for probabilistic accident progression in the containment event tree (CET). The CET probabilistically evaluates the accident progression to calculate the likelihood of various end states ranging from an intact containment to small releases to large releases.

The PDS and CET quantitative solution tool is the SAREX. The bridge event tree evaluation in SAREX is similar to the functions utilized in the Level 1 portion of the PRA. The Level 2 portion of the SAREX was used to create the PDS binning diagram, CET, the CET's supporting decomposition event trees (DETs), and the release category binning diagram. MAAP is utilized for phenomenological evaluation of the accident progression and for calculation of source term releases from containment.

The following sections describe the PDS and CET analyses.

19.1.4.2.1.1 Plant Damage State Analysis

At several stages in the PRA, elements of the accident sequences have been grouped according to similarities in characteristics. For example, many of the initiating events defined for the core-damage sequences in the Level 1 analyses actually represent groups of different specific initiators that have similar effects on the systems required to respond to them. This grouping process is used primarily to make the overall analysis process more efficient and tractable by limiting the number of discrete events and scenarios that must be considered, while retaining the degree of discrimination needed to capture differences in potential accident sequences. The PDS binning approach follows the same philosophy.

The process of the PDS analysis is as follows:

a. Define the PDS characteristics to identify the physical characteristics and the accident sequence characteristics of the core damage sequences.

b. Develop the PDS Event Tree logic diagram.

c. Extend the Level 1 event trees to PDS event trees by questioning the status of functions that can affect containment integrity.

d. Group the extended core damage sequences (i.e., the end point of the PDS event trees) into the plant damage states by using systematic logic diagram.

The PDSs are defined by developing possible combinations of the PDS parameters (core-melt bins and containment safeguard states), and in some cases conservatively combining some PDSs if the frequency is negligible. A PDS logic diagram is used to systematically bin core-damage sequences into PDSs. This logic diagram is constructed with PDS grouping parameters as decision branches, to aid in the assembly of specific PDS characteristics from the matrix of possible combinations allowed by the grouping parameters.

Identifying the sequence characteristics necessary to delineate PDS bins requires a thorough understanding of the unique characteristics of the Level 2 systems of the containment itself, and of the accident progression phenomena to be considered. Therefore, the PDS identification interfaces heavily with the CET analysis. The intent of PDS binning is such that given a specific PDS, its progression through the CET would not require additional system analysis.

The nine sequence characteristics determined to be relevant to the APR1400 PDS bins are presented in Table 19.1-26 and described in detail in the text that follows in this section. A discussion of each follows, and the PDS binning diagram is presented graphically in Figure 19.1-41.

a. Containment Bypass (CONBYPASS)

The first parameter is “Containment Bypass.” This parameter is used to divide the Level 1 core damage sequences into bypass and non-bypass groups. The containment bypass sequences are further subdivided into ISLOCAs and SGTR groups. Three branches are considered for this parameter:

- NO BYPASS
- ISLOCA
- SGTR

The containment bypass sequences are distinctly different from the non-bypass sequences in that there is a direct flow pathway from the primary system to outside the containment boundary, bypassing the main containment region. Therefore, there is no holdup or attenuation of radionuclides (released from the core/primary system prior to vessel failure) by the natural processes and/or engineered safety systems in the containment. Consequently, bypass sequences can result in relatively large source term releases after the onset of core damage.

The ISLOCA and SGTR events are separated into different groups because the radionuclide release pathway for these sequences is different from those of non-bypass sequences.

For the SGTR sequences, the release pathway is from the RCS to the ruptured SG secondary side to the secondary steam line and safety/relief valves (i.e., MSSV and ADV). The SGTR sequences considered to be significant bypasses are those for which broken SG isolation is not achieved. If the SGTR event occurs and the ruptured SG is not isolated, it results in the large radionuclide releases regardless of severe accident phenomena inside the containment, so the CET may not be required for those sequences. However, for SGTR sequences, the CET considers the potential for fission product scrubbing if the ruptured tube is submerged in the SG.

In the APR1400 Level 2 PRA, the SGTR sequences are categorized as follows:

- Spontaneous SGTR initiated sequences
- Transients leading to increased pressure differential across the tubes, including
  - Secondary side depressurization sequences with induced tube ruptures

- Anticipated transient without scram (ATWS) sequences with induced tube ruptures

• Severe accident induced tube rupture (including pressure induced SGTR and thermal induced SGTR)

In this parameter, the SGTR branch includes the first two sequences. All the unisolated SGTR sequences are assigned to PDS 1 and PDS 2. The third sequences are not considered in this parameter, but are considered based on the severe accident progression in the CET/DET analysis.

For the ISLOCA sequences, the pathway is from the RCS to the SC/CSS piping to the auxiliary building. Strictly speaking, a containment event tree (CET) is not required for those sequences since containment phenomena are largely irrelevant. However, for ISLOCA sequences, a CET which considers important auxiliary building phenomena (such as whether or not the break location is submerged) may be necessary to assess the effectiveness of auxiliary building in attenuating radionuclides. All ISLOCA sequences are assigned to PDS 3 and 4 by a rule-sorted option determined by the initiator.

b. Containment Isolation (CONISOL)

The second parameter is “Containment Isolation.” This parameter is used to define three sequence groups based upon the status of containment building isolation at the time of core damage. If the containment is not isolated, early and relatively large releases of radionuclides from the plant are possible. Three branches are considered as follows:

• NOT ISOLATED

• ISOLATED

• RBCM (Rupture Before Core Melt)

Containment isolation failure is not dependent on other systems considered in other PDS event trees. The containment isolation failure sequences could be evaluated using PDS event trees by the Containment Isolation (CI) system analysis.

The extended core damage sequences with containment isolation failure are classified into NOT_ISOLATED. These sequences are assigned into PDSs 5 and 6. The most important consideration regarding additional systems (from the viewpoint of the radionuclide source term) is whether the containment spray systems function.

RBCM sequences can also result from long-term loss of containment heat removal even though core damage is initially prevented. These sequences require that injection into the RCS be successful and that containment heat removal be failed. Therefore, the sequences with injection success and containment heat removal failure are classified into the RBCM group, and these sequences are assigned into PDS 7.

The sequences which are containment isolated and not in the RBCM group are classified into the ISOLATED state.

c. LOCA or Transient (LOCATRAN)

This parameter is "LOCA or TRANSIENT." The RCS leakage rate prior to vessel failure is important because it affects core melt timing, the hydrogen generation and release rates, and fission product retention in the primary system. This parameter is strongly related to the next parameter, "RCS Pressure at the time of Core Damage." Five RCS leakage rates are considered:

- Large LOCA (LL)
- Medium LOCA (ML)
- Small LOCA (SL)
- RCP Seal LOCA (RSF)
- Transient (TRAN)

The large break LOCA sequences result from a primary system break of greater than 15.24 cm (6 inch) diameter. The large break LOCA sequences correspond

to sequences which would result in RCS pressure in the low pressure range, less than 17.6 kg/cm^2 (250 psia).

The medium break LOCA sequences result from a primary system break of between 15.24 cm (6 inch) diameter and 5.08 cm (2 inch) diameter. The medium break LOCA sequences correspond to sequences which would result in RCS pressure in the medium pressure range, 17.6 kg/cm^2 (250 psia) to 84.4 kg/cm^2 (1,200 psia), at the time of core damage.

The small break LOCA sequences include break area equivalent to those that would result from primary system breaks of less than 5.08 cm (2 inch) diameter. This group also includes events initiated by one POSRV stuck open (fails to reclose). The small break LOCA sequences correspond to sequences which would result in RCS pressure in the high pressure range, greater than 84.4 kg/cm^2 (1,200 psia), at the time of core damage.

The RCP seal LOCA sequences include the event in which the mechanical failure of a RCP seal occurs. In terms of break size, the RCP seal LOCA sequence is similar to a small break LOCA. However, the accident progression of RCP seal LOCA events is expected to be different from the small break LOCA. Following NUREG-1570 (Reference 30), the loss of a loop seal due to a RCP seal LOCA increases the potential for a TI-SGTR for High RCS pressure / Dry secondary sequences, because it results in increasing the potential for an unidirectional convection flow between the degrading core and the relatively cool SG in the affected RCP loop. Hence, the small break LOCA and the RCP seal LOCA are considered separately in this parameter. The seal LOCA sequences correspond to sequences which would result in an RCS pressure of a high pressure range, greater than 84.4 kg/cm^2 (1,200 psia), at the time of core damage.

The transient sequences correspond to sequences having a cycling primary relief valve leakage rate (i.e., a rate with characteristic of a cycling POSRV). The RCS pressure in the transient sequences is maintained about the set-point pressure of the POSRV which is near 75.8 kg/cm^2 (2,500 psia).

d. RCS Pressure at the time of Core Damage (PRCSCD)

This parameter is "RCS Pressure at the time of Core Damage." The RCS pressure during core damage can have a major impact on several potentially important containment events. This parameter segregates the extended core damage sequences into several groups, depending on the RCS pressure at the time of core damage. This parameter has three values:

- High Pressure (HIGH, Pressure $\geq$ 84.4 kg/cm^2 (1,200 psia))
- Medium Pressure (MED, 17.6 kg/cm^2 (250 psia) $\leq$ Pressure $<$ 84.4 kg/cm^2 (1,200 psia))
- Low Pressure (LOW, Pressure $<$ 17.6 kg/cm^2 (250 psia))

High pressure events are those events with an RCS pressure greater than approximately 84.4 kg/cm^2 (1,200 psia) at the time of core damage. High pressure sequences are the sequences that were assigned to be the TRAN, SL and RSF sequences in the former parameter, LOCATRAN. These sequences are the events with a small break LOCA leakage rate or a cycling primary relief valve leakage rate.

The high RCS pressure during core heatup and core damage facilitates natural circulation heat transfer from the core to the upper plenum, hot leg, surge line and steam generators, which increases the potential for thermally induced hot leg, surge line or steam generator tube creep failure. The high pressure events are also have the potential for high pressure melt ejection (HPME) and direct containment heating (DCH), because elevated pressure at the time of reactor vessel rupture may result in entrainment of the core debris out of the reactor cavity, and may increase the potential for debris fragmentation and dispersal into the containment atmosphere, thus increasing the potential for DCH.

Medium pressure is defined to be a pressure between approximately 17.6 kg/cm^2 (250 psia) and 84.4 kg/cm^2 (1,200 psia) at the time of core damage. Medium pressure sequences are the sequences that were assigned to be the ML sequences in the former parameter, LOCATRAN. These sequences are the events with a medium break LOCA leakage rate. For medium pressure events, some potential for DCH is considered in CET analysis.

Low pressure is defined to be primary system pressure less than approximately 17.6 kg/cm^2 (250 psia) at the time of core damage. Events with a large break LOCA leakage rate would have low RCS pressure. For these events, DCH is considered to be very unlikely. However, the potential for steam explosion in the low pressure is greater than that of the high pressure. Low pressure sequences are the sequences that were assigned to be the LL sequences in the former parameter, LOCATRAN. These sequences are the events with a large break LOCA leakage rate or two more primary relief valves manually open.

e. Cavity Condition (CAVCOND)

The "Cavity Condition" parameter defines whether or not the cavity is flooded prior to vessel failure. The amount of water available in the cavity affects debris bed coolability, fission product production via core-concrete interaction (CCI), the aerosol production rate, the containment pressurization rate, the potential for DCH, and the mode of containment failure. If the cavity is flooded, the water in the cavity acts as an obstacle, and the amount of corium ejected out of reactor cavity will decrease. This parameter has three values:

- ERVC (only for sensitivity study)
- WET
- DRY

The cavity is defined to be WET if cavity flooding is manually initiated by operators, or if the initiating event is a vessel rupture with subsequent success of safety injection. For external reactor vessel cooling, if the outside of the reactor pressure vessel is flooded up to the bottom of the RCS loop piping, the cavity is defined as ERVC. All other cavity conditions are classified into DRY.

In this parameter, the WET sequences are the events that the cavity is mainly flooded by the cavity flooding (CF) system operation. For the wet sequences, the potential for external reactor vessel cooling during severe accidents is not credited because the reactor vessel lower head is not submerged. The ERVC sequences are the events in which the cavity is flooded initially by one SCP injection, and the cavity water is maintained by the boric acid makeup pumps (BAMPs) operation.

However, in-vessel retention by external reactor vessel cooling is not credited for the APR1400 PRA due to the uncertainty surrounding the phenomena. Therefore, the ERVC branch in this parameter is included only for sensitivity study.

f. In-Vessel Injection (INVINJ)

The "In-Vessel Injection" parameter defines the status of in-vessel injection before reactor vessel breach. Three branches are considered:

- Success of in-vessel injection by operating SIS (ON)
- In-vessel injection available but failure due to high RCS pressure (DEADHEADED)
- In-vessel injection is not available (FAILED)

The status of in-vessel injection at the time of core damage is important for several reasons. If in-vessel injection is available during the period of core damage (ON), core damage may be limited and vessel failure prevented. If the RCS pressure is elevated above the SI pump's shutoff head and the SI system is available (DEADHEADED), then it could provide in-vessel injection if the RCS depressurizes prior to reactor vessel breach (e.g., by an induced hot leg rupture). In addition, with the in-vessel injection operating, an additional source of cooling water is available to the cavity debris following reactor vessel failure.

g. Release Point (RELPOINT)

The "Release Point" parameter defines the path by which the reactor coolant fluid is released from the reactor coolant system prior to vessel failure. This parameter affects the hydrogen concentrations in the IRWST and the upper containment. For this analysis, two "Release Points" values are defined:

- To containment (INC)
- To IRWST (IRWST)

The first value is "Release to containment", and the reactor coolant may be released directly into the containment as typified by large or medium break

LOCAs. In this case, the hydrogen produced in vessel is released directly to the containment without passing through the IRWST (where it may be trapped). The first value also includes the events in which the rapid depressurization function is successful. The POSRVs and its discharge 3-way valves can provide rapid depressurization after core damage. To do this, operators would open two out of four POSRVs and their related discharge 3-way valves after severe accident initiation. This results in decreasing the RCS pressure rapidly and changing the release point from the IRWST to the containment atmosphere.

The second value is “Release to IRWST”, and this release path is applicable to transients in which the reactor coolant is discharged to the IRWST via the POSRVs. In this case, the hydrogen generated in vessel is concentrically discharged to the IRWST area. This may lead to the buildup of flammable pockets of hydrogen in the IRWST area, and this increases the potential for burning or detonation of these pockets of hydrogen. The second value also includes releases both to the containment and to the IRWST. This type of release point is applicable to small break LOCAs in which some reactor coolant is discharged to the containment via the primary system break and some reactor coolant is discharged to the IRWST via the POSRVs. The hydrogen produced in vessel is released both inside the IRWST and directly to the containment. In this analysis, however, this release type is classified into the IRWST category for simplicity and conservatism. The change of the assignment, as classified into INC, slightly affects CET quantification results.

h. Containment Heat Removal (CHR)

This parameter determines whether the containment heat removal by the CSS is available or not. Three branches are considered:

- CSS operation (YES)
- Failure of CSS (NO)
- CSS recovered (RECOVERED).

The CSS, working in conjunction with the CCWS and ESWS, provides the active containment heat removal function. The containment spray flow is pumped from

the IRWST, through the containment spray heat exchangers, and finally discharged into the containment atmosphere via the containment spray headers. The component cooling water cools the containment spray flow through the containment spray heat exchangers, thus removing the decay heat from containment. If the decay heat is not removed from containment, the containment pressure will gradually increase until the containment fails due to over-pressurization. Thus, the status of containment heat removal is important with respect to determining the containment failure mode and timing. Containment heat removal is defined to be available if the flow from one containment spray pump is being delivered to containment via one containment spray header and the component cooling water and essential service water systems are cooling the containment spray flow in the containment heat exchanger.

In SBO sequences, if power is recovered, the containment heat removal may become available. These sequences are classified into RECOVERED.

Note that the ECSBS operation is not considered in this parameter. If the CSS is not available but ECSBS is available, the potential for containment over-pressurization may be reduced significantly. However, the effectiveness of ECSBS is discussed in CET analysis.

i. SG Feedwater Available (SG)

This parameter determines the status of feedwater from the core damage sequence. Two branches are considered:

- SGs are wet at the time of core damage (WET)
- SGs are dry at the time of core damage (DRY)

The availability of feedwater could influence the progression of the severe accident as discussed below.

First, the availability of feedwater to the SGs is important in determining the fission product retention in the RCS and the core melt timing. A transient or SLOCA event with a successful AFW system operation would result in relatively

late core damage, but a transient or SLOCA event without the AFW system would result in relatively fast core damage.

Second, the availability of feedwater during accident progressions plays an important role on the significance of pressure induced and thermally induced steam generator tube ruptures. A "wet" SG will prevent creep damage to the SG tubes avoiding the conditions for a TI-SGTR. (i.e., thermally induced SGTR is not credible during severe accidents for the sequences in which feedwater is available to the SGs.) A PI-SGTR could potentially occur in the presence of high RCS pressure (i.e., POSRV setpoint) coupled with a fully depressurized SG (i.e., atmospheric pressure). A fully (an unintentionally) depressurized SG can occur following a MSLB or transient with a stuck open ADV or MSSV. If primary-secondary heat removal remains available following the blowdown, the RCS will continue to cooldown. Thus, the high differential pressure (175.8 kg/cm^2-differential (2,500 psid)) necessary for a pressure induced SGTR will not occur even if a SG is depressurized. The differential pressure across the SG tubes could increase to be as high as about 175.8 kg/cm^2-differential (2,500 psid) only after primary-secondary heat removal fails.

Third, if a SGTR event occurs, the availability of feedwater to the ruptured SG impacts the fission product release significantly. If the water level of the ruptured SG is maintained to be at the normal level above the top of U-tube sheet, a large amount of particulate fission products may be scrubbed. Following EPRI TR-101869 (Reference 31), if the point of release were submerged under a few meters of subcooled water, it could result in at least of an order of magnitude of reduction of the fission product release.

As the Level 1 analysis only evaluates CDF, some containment systems relevant only to the Level 2 analysis must be added to the Level 1 sequences in order to generate the PDSs. These expanded event trees are called PDS Event Trees (also known as Bridge Trees). Linking of such system models is performed using the SAREX software in the same manner as is performed in the Level 1 analysis. By physically linking the Level 1 models with the Level 2 system models, system dependencies are explicitly captured by the software. The inclusion of additional systems for the Level 2 analysis is important to evaluate accident progression beyond core damage. For example, given core damage, the

availability of containment sprays has the potential to maintain containment integrity or, at the least, scrub particulate fission product releases.

The top events added to Level 1 event trees to create the PDS event trees are as follows. Note that the discussion of each notes the inter-system dependencies of each.

a. CIS – Containment Isolation System. This event assesses the containment isolation system operation to isolate all of the containment penetrations to prevent fission product release. The success criterion of CIS is the isolation of all of the required containment penetrations. The containment isolation system fault tree model dependencies include CIAS actuation logic and 120V ac for valves that need to change position other than check valves, and 480V ac for some MOVs.

b. SDR – Rapid Depressurization using the POSRVs. This event assesses the availability of the function of rapid RCS depressurization after core damage. The high pressure core damage sequences could be changed into the low pressure core damage sequences by operating the POSRVs. Operators can change the release point from the IRWST to the containment atmosphere by using the 3-way valves downstream of the POSRVs. The success criterion of SDR is that greater than two out of four POSRVs and the associated 3-way valves are manually opened after severe accident initiation.

c. INJ – Injection Status. This event assesses the injection of IRWST water into the reactor vessel by SI pump trains. The success criterion of INJ is that at least one out of four SI pumps injects the IRWST water into the reactor vessel. The event queries the status of safety injection (called as SIS or FEED), which is already considered in the Level 1 ETs. For some core damage sequences where the branch of SIS or FEED is not split in the Level 1 ETs, the branch of INJ is split in the PDS ETs.

d. ERVC – External Reactor Vessel Cooling. This event assesses the availability of ERVC function. After severe accident initiation, operators can flood the cavity by operating one SCP and maintain the water level by operating two BAMPs. However, in the baseline Level 2 model, the ERVC is not credited for the severe-accident mitigation features due to uncertainty surrounding in-vessel retention by ex-vessel cooling. The impact of ERVC on the Level 2 PRA results is considered in a sensitivity study.

e. CFS – Cavity Flood System. This event assesses the availability of the CFS system. The success criterion of CFS is that IRWST water flows into the reactor cavity via at least one spillway after severe accident initiation. The CFS relies on 120V ac power for the signal to open the valves, and on Class 1E 125V dc power for MOV operation.

f. CSR1 – Containment Heat Removal. This event assesses the containment heat removal by the CS system. The success criterion of CSR1 is that at least either one CS pump or one SC pump provides the spray of water into the containment atmosphere. The event about containment heat removal (called CSR or LHR) is already considered in the Level 1 ETs. For some core damage sequences where the branch of CSR or LHR is not split in the Level 1 ETs, the branch of CSR1 is split in the PDS ETs. The CSS relies upon Class 1E 4.16kV ac power for pump operation, 125V dc power for control, 120V ac for signaling, and pump room cooling.

g. SGISO – Ruptured Steam Generator Isolation. This event assesses the capability of isolation of a ruptured SG when SGTR occurs. If an unisolable path exists from the ruptured steam generator to the atmosphere, the ruptured generator could be at or near atmospheric pressure and there would be a direct path to the atmosphere for the release of radioactive material. The SG isolation components have dependency or partial dependency on instrument air, 125V dc power and 120V ac power.

   However, prior to evaluating the isolation capability of a leak path, it is necessary to consider that the RCS pressure control is established before the ruptured SG is overfilled. If the RCS pressure is above the MSSV setpoint pressure and the ruptured SG is overfilled, the MSSVs will lift and pass water. In this analysis, if the MSSVs pass water, they are assumed to be stuck open and there is no means to isolate the ruptured SG. Thus, for the sequences in which the RCS pressure control is failed (called as ECLDN or SDR), the SG isolation is assumed to be failed, and those sequences are considered to be containment bypass sequences.

h. SHR1 – Feedwater Injection into Steam Generators. This event assesses the status of feedwater injection into SGs. The success criterion of FW is that at least either one motor driven AFW pump or turbine driven AFW pump provides the feedwater into the SGs, including steam removal. The secondary heat

removal (SHR or SHR-TDP or ASC) is considered in the Level 1 ETs. For some core damage sequences where the secondary heat removal is not considered in the Level 1 ETs, the branch of FW is split in the PDS ETs.

i. RACV – Offsite AC Power Recovery before battery depletion. This event, RACV, assesses the probability of offsite ac power restored late before the 125V dc batteries run out. In the Level 2 PRA, it is assumed that there is no chance to recover the offsite power after battery depletion, since the battery depletion time is 16 hours.

j. PI-SGTR – Pressure-Induced SGTR may occur in ATWS/MSLB/FWLB events. This event assesses the conditional probability of pressure induced SG tube rupture due to the characteristics of some initiating events which result in the high differential pressure between primary side and secondary side. In the MSLB and FWLB events, the secondary pressure in the broken loop would rapidly decrease to nearly atmospheric pressure, while the RCS pressure would increase and reach the set-point pressure of POSRV cycling. If the POSRVs do not stuck open, the differential pressure between the primary and secondary side is approximately 175.8 kg/cm^2-differential (2,500 psid). This high differential pressure could result in a PI-SGTR.

k. RSF1 – RCP seals remain intact. This event assesses whether or not the RCP seals remain intact given a loss of RCP seal cooling. The event about the RCP seal integrity (called RCPSEAL) is already considered in the Level 1 ETs. However, in some core damage sequences in which there is a loss of RCP seal cooling, the branch of RCPSEAL is not split in the Level 1 ETs. If the branch of RCPSEAL is not split in the Level 1 ETs, the branch of RSF1 is split in the PDS ETs.

l. FW-ISOL- FW line isolation during a FWLB event. If a pressure induced SGTR occurs in the FWLB events, the check valves in the feedwater line of the ruptured SG can prevent a fission product release to the environment. In the APR1400 plant, each steam generator has two downcomer feedwater line check valves, one economizer feedwater line valve and two auxiliary feedwater line check valves. Therefore, the success criterion of this event is that the feedwater line of the ruptured SG must be isolated by the check valves.

The dominant PDSs and the PDS event tree sequences largely contributing to them are presented in Table 19.1-27.

19.1.4.2.1.2 Containment Event Tree Analysis

19.1.4.2.1.2.1 CET Overview

Containment event trees (CETs) are developed to model the containment response during severe accident progressions. These CETs depict the various phenomenological progress, containment conditions, and containment failure modes that could occur under severe accident conditions.

To model containment responses for most accident sequences, a general CET is developed. Special CETs are developed for containment bypass and for containment isolation failure. These general and special CETs properly consider pertinent containment failure modes identified for the APR1400. The important phenomena, which can affect the containment failure mode and source terms, are also addressed in the CETs.

These CETs depict the various phenomenological processes, containment conditions, and containment failure modes that could occur under severe accident conditions. The purpose of the CET is to quantify the probabilities of containment failure modes and radionuclide releases. The various containment failure modes and the major phenomena that have a significant impact on the radionuclide release fractions are represented as top events on the CET. Detailed evaluation of phenomena which affect containment failure timing, fission product releases or which may have an impact on downstream top events are treated through the use of decomposition event trees (DETs). The containment ultimate pressure capacity and severe accident phenomena analysis results are needed for quantification of the DETs. This CET/DET approach allows a relatively detailed treatment of the phenomena affecting containment performance while maintaining a relatively simple and easily understood CET. The CET sequences are grouped into a manageable number of distinct source term release categories for source term estimation.

The CETs use the plant damage states as input. The paths that a given PDS can take through the CETs depend on how the specific PDS is affected by the various events modeled in the CET or the DETs. Each PDS can contribute to more than one CET

endpoint (containment status) with varying frequencies, and each CET endpoint can have more than one PDS contributing to its total frequency.

The potential severe accident progression for each PDS is unique and would be represented by a specific CET. For most PDSs, however, the potential severe accident progressions are very similar and can be represented by a general CET. For the rest of PDSs which are pertaining to containment bypass and isolation failure, special CETs represent their accident progression. The important phenomena, which can affect the containment failure modes and the source term, are also addressed as top events in the CETs.

The Level 2 analysis considers the possibility of the containment building failure under various accident scenarios. In order to be comprehensive, failures resulting from the spectrum of possible pressures must be considered. The NUREG-1150 study characterized containment failure using four parameters: a) likelihood of failure, the primary parameter of interest in the study, as a function of containment pressure, b) failure size, important because the larger the hole, the faster the release of radionuclides following an accident, c) location of failure, important because the retention of radioactive materials can be dependent on this parameter, and d) timing, the longer the radioactive materials can be retained inside the containment before escaping, the larger the reduction in source term to the environment since the radionuclides are removed from the containment atmosphere by natural processes and ESFs. For a similar reason, timing is also important. These factors are considered in the CETs.

NUREG-1335 (Reference 32) gives a list of potential containment failure modes and mechanisms that should be considered in this report, and states that these failure modes and mechanisms were included in the NUREG-1150 analysis. The following discusses how each of these items was evaluated in the APR1400 PRA.

a. Direct Bypass

Direct containment bypass is considered in the NUREG-1150 analysis and also in the APR1400 PRA. In each analysis, the bypass sequences include both V sequence (ISLOCA) and unisolated steam generator tube rupture (SGTR) sequences.

b. Containment Isolation Failure

NUREG/CR-4550 (Reference 33) discusses failure to isolate containment. Since containment isolation failure can lead to direct release of radioactive material, it is of obvious importance. In NUREG/CR-4550, the probability of containment isolation failure was determined on the basis of analytical significance rather than fault tree analysis. A leak size greater than 9.29×10^{-3} m^2 (0.1 ft^2) is required to prevent containment over-pressurization (from long term steam generation).

The NUREG/CR-4550 analysis did not consider failure of containment isolation from a source term perspective. However, a leak in containment at the time of severe accident with the failure of the isolation paths to close may result in a significant release pathway especially if the path is in direct contact with the containment atmosphere. The APR1400 PRA has considered this issue. A detailed screening analysis for containment isolation paths was performed and a fault tree was developed for the unscreened isolation paths. The effects of failure to isolate are considered in the CET.

c. Steam Explosion

NUREG-1150 considered steam explosions originating in vessel (the classic Alpha mode failure) or ex-vessel, with Alpha mode failures considered by the Steam Explosion Review Group. The estimate for probability of Alpha mode containment failures is considered through a heading in the DET.

Ex-vessel steam explosions were dismissed for the Surry plant and the Zion plant in NUREG-1150 because steam explosions in the cavity would not directly contact structures that are both vulnerable and essential to the containment function. Nonetheless, ex-vessel steam explosions (as well as in-vessel steam explosions) were considered in the APR1400 PRA for model completeness purpose.

d. Combustion Processes

The combustion of hydrogen prior to reactor vessel breach was treated in NUREG-1150 as an expert elicitation issue. However, it was decided that hydrogen combustion is of much greater concern for lower capacity containment (BWR plants and PWR ice condenser plants) than it is for large dry high capacity containment such as the APR1400. In the words of NUREG-1150: "... the

importance of early hydrogen combustion to the uncertainty in reactor risk for these plants is minor in comparison to that observed in the Grand Gulf and Sequoyah analyses."

Nonetheless, hydrogen combustion was considered for the Surry plant in NUREG-1150 accident progression analysis. Both early and late combustion were considered. Since the Surry and Zion containment buildings were found to be robust by the structural experts, the possibility of containment failure prior to reactor vessel failure is so remote as to be considered negligible and was not included in the NUREG/CR-4551 (Reference 34) containment building event analysis. The failure of containment due to a hydrogen burn at the time of reactor vessel failure was considered likely enough to be included. In the APR1400 PRA containment analyses, the impact of hydrogen combustion on containment over-pressurization is considered at vessel failure and late in the accident sequence after vessel failure.

e. Steam Over-pressurization

Gradual pressurization of the containment building would result from the protracted generation of steam or non-condensable gases from the interaction of molted core material with water on the containment floor or with the concrete basemat. This pressurization process could last from several hours to several days, depending upon accident specific factors such as the availability of water in the containment and the operability of engineered safety features.

Gradual containment pressurization by steam production and from the non-condensable gases generated during debris concrete attack is considered explicitly in the APR1400 PRA.

f. Molten Core Concrete Interaction (Basemat Melt-through)

After vessel failure, the core debris is discharged into containment. Once there, MCCI begins, leading to erosion of the concrete in the reactor vessel cavity. This threatens the integrity of the containment pressure boundary due to the possibility of melt-through of containment liners and the concrete basemat. Concrete ablation also generates combustible/non-condensable gases which can lead to

containment challenges due to pressurization and hydrogen burn. In order to prevent and mitigate the MCCI, the reactor cavity can be filled with water by using the CFS. This allows heat to be transferred from the corium pool into the overlying pool of water, eventually stopping MCCI. Therefore, for the wet cavity sequences, the probability of a severe MCCI and eventually to melt through the containment basemat is expected to be very small.

g. Blowdown Forces (Vessel Thrust Force or Rocket Mode Failure)

Failure of the containment building as a result of gross displacement of the reactor vessel (above the shield wall) was considered in the NUREG/CR-4551 accident progression analysis. However, the assigned probability for this event was very small, making a negligible contribution to the probability of early containment failure.

h. Liner Melt Through (Direct Contact of Containment Shell with Fuel Debris)

This issue is of primary concern to BWR plants because of the drywell design. For completeness of PRA, this mode of failure was considered in the APR1400 PRA even though the pathways for debris transport out of the reactor cavity are to interior containment building compartments away from the containment wall. The probability of this failure mode was assigned a negligible value.

i. Failure of Containment Building Penetrations

Failure of containment building penetrations (electrical, fluid, equipment hatch, personnel hatch, etc.) was explicitly evaluated in the analysis of the containment overpressure capacity and found to be significantly less important than over pressure failure of the cylinder wall. Temperature induced penetration failures were treated in the APR1400 PRA.

To model containment responses for most accident sequences, a general CET is developed. Special CETs developed for the containment bypass, containment isolation failure and containment failure before reactor vessel breach. These CETs properly considered all pertinent containment failure modes identified for APR1400 containment. The important phenomena, which can affect the containment failure modes and the source terms, are also

addressed in the CETs. The questions and the important events, which are used in significant references (ex, NUREG-1150, and the previous Level 2 PRA for other plants), are reviewed and included in the APR1400 PRA CETs.

The containment event trees are shown in Figure 19.1-42 through Figure 19.1-46.

19.1.4.2.1.2.2 Containment Ultimate Pressure Capacity Analysis

In order to evaluate the likelihood of containment failure for various accident progression phenomena, it is necessary to determine a realistic pressure at which the containment would fail. In nuclear power plants, the containment design failure pressure is 2 to 3 times less than the realistic, as-built failure pressure. Therefore, an assessment of the APR1400 containment was performed. This section summarizes the evaluation and results.

A plant specific containment structural analysis has been performed to determine the ultimate pressure capacity of the APR1400 containment building, and to identify the failure modes. Potential modes considered include:

- Membrane failure
- Cylindrical wall at the basemat
- Failure of the basemat
- Failure of the equipment hatch
- Failure of the personnel access airlock
- Failure of the personnel emergency exit airlock
- Failure of the fuel transfer tube

In this analysis, the several failure modes which are identified in the containment structural analysis can be classified by their failure sizes into two groups, which are defined in NUREG-1150 and NUREG/CR-6906 (Reference 35).

- A leak is defined as a containment breach that would arrest a gradual pressure buildup, but would not result in containment depressurization in less than 2 hours. The typical leak size is evaluated to be on the order of 9.29×10^{-3} m^2 (0.1 ft^2).

- A rupture is defined as a containment breach that would arrest a gradual pressure buildup and would depressurize the containment within 2 hours. The typical rupture size is evaluated to be of the order of approximately 9.29×10^{-2} m^2 (1.0 ft^2).

The failure modes and their results are as presented in Table 19.1-28.

A probability density function was calculated for each potential failure mode, and summed together to estimate a total fragility curve. The results of this analysis are presented in Figure 19.1-47. These results were utilized in the Level 2 phenomenological evaluations for leak and rupture failure pressures of the containment.

19.1.4.2.1.2.3 CET Phenomenological Evaluations

The MAAP code was utilized to support many of the CET phenomenological evaluations. MAAP evaluations included evaluations of core melt, RCS failure, containment pressurization, ex-vessel core-concrete interactions, and releases from the containment. Containment failure due to overpressurization was considered using the results of the containment ultimate capacity Evaluation. Many other calculations were performed to support the CET. Referring to the General CET presented in Figure 19.1-42, the following top events are discussed:

- RCSFAIL – Mode of RCS Failure Before Vessel Breach

- MELTSTOP – In-vessel Core Melt Arrest

- DCF – Dynamic Containment Failure

- ECF – Early Containment Failure

- CSLATE – Late Containment Heat Removal Recovery Failure

- DBCOOL – Ex-vessel Debris Coolability

- LCF – Late Containment Failure

- BMT – Basemat Melt-through

    a. RCSFAIL – Mode of RCS Failure Before Vessel Breach

    The question posed in this DET is whether there is a severe accident induced failure of the hot leg or steam generator tubes during severe accident progression. For high pressure core damage sequences, natural circulation of superheated gases can occur in the reactor coolant system after the core has uncovered. Natural circulation is a result of differences in gas density between the various regions of the reactor coolant system. Natural circulation of gases in the reactor coolant system during the severe accident is a significant phenomenon because it transports heat from the overheating core into the structure of the upper plenum, hot leg, surge line and SG tubes. If the natural circulation flow of gases continues, it can cause the failure of hot leg, surge line or SG tubes due to creep. However, if the SG tubes are cooled by water from the secondary side, the high temperature in the SG tubes will not occur. The induced SGTR event is possible only for dry and depressurized SG sequences.

    The consequence of the induced primary system failures depends on the failure location. If the hot leg or surge line fails, the RCS is depressurized and many phenomena resulting from high RCS pressure at vessel breach, which threaten the containment integrity, are prevented. If the steam generator tubes fail, the direct release path of fission products from the RCS to the environment would be available. Note that these failure modes are mutually exclusive. Once failure occurs at any location, the resulting depressurization and reduction in stress on other components precludes subsequent failures. (i.e., if the induced SGTR occurs, the induced hot leg or surge line failure will not occur. If the induced hot leg or surge line fails first, the induced STGR will not occur.) By considering the source term release consequences of each induced failure location, the induced SGTR is assumed to occur prior to hot leg or surge line failure in this analysis.

    In terms of severe accident induced SGTR, two unique induced tube rupture modes are possible during severe accident progression:

    Pressure induced SGTR (PI-SGTR): PI-SGTR results from a high differential pressure across the steam generator tubes occurring when RCS pressure is at the

pressurizer relief valve (i.e., POSRV) set point and a SG is fully depressurized via a stuck open ADV or MSSV. Note that core damage events which are expected to occur early in the sequence such as a MSLB or ATWS that involves induced SGTR are not included in this category. Such events were treated as bypass events previously in PDS analysis.

Thermally induced SGTR (TI-SGTR): TI-SGTR addresses the probability that high tube temperatures caused by the natural convection process after core damage, coupled with a significant RCS/SG pressure differential will induce a rupture of SG tubes prior to hot leg and surge line failures.

b. MELTSTOP – In-vessel Core Melt Arrest

This question determines whether the damaged core can be cooled in-vessel, thereby terminating the accident progression before reactor vessel rupture. Four possibilities are considered:

- The RPV lower head fails prior to the containment failure.
- Arrest of core melt progression before reactor vessel rupture
- Containment failure before vessel rupture (Leak)
- Containment failure before vessel rupture (Rupture)

The core melt can be arrested and the damaged core can be safely and continually cooled in the reactor vessel by the introduction of cooling water into the reactor vessel or the reactor cavity. There are two probable approaches for in-vessel core melt retention: Injection of a large amount of water (1) into the reactor vessel to completely submerge the damaged core or (2) into the reactor cavity to completely submerge the reactor lower head.

The safety injection system (SIS) can deliver sufficient water into the reactor vessel to cool the core when the intact core geometry is maintained or the core debris configuration is favorable for cooling. Once the core configuration becomes less favorable for cooling (e.g. after loss of original configuration and generation of obstacles in the core), substantially higher injection flow rates

(several thousand gpm) may not be effective to cool the debris in-vessel because of low heat transfer rate from the core material.

There are two probable scenarios in which the core may be damaged in spite of injection being available. The first is a sequence in which the injection flow is insufficient to prevent core damage. The second is a sequence in which there is no coolant injection prior to core uncovery and incipient core damage, but some form of injection is recovered or initiated prior to vessel failure. In grouping the PDS ET sequences into PDSs, the safety injection flow is one of the grouping parameters.

If the reactor vessel lower head is submerged by water injected into the reactor cavity, the reactor vessel lower head can be maintained intact. The core can be cooled in the reactor vessel by cooling of the outer wall of the reactor vessel. The severe accident phenomena which occurred outside the reactor vessel and threaten the containment integrity would be prevented.

When the vessel failure is prevented by effectively cooling the core by in-vessel injection or external reactor vessel cooling, the containment may eventually fail due to steam-induced overpressurization if the containment heat removal is lost.

If core melt is arrested before vessel failure and the containment heat removal is available, only limited hydrogen production would be expected and containment overpressurization would be limited. DCH would not be a threat. As a result, containment failure is extremely unlikely. Furthermore, radionuclide release from the debris would be limited and long term revaporization of radionuclides deposited on RCS surfaces would be largely avoided. Hence, because the containment does not fail and the radionuclide release is limited, the environmental source terms for core-damage sequences that are successfully terminated in-vessel are expected to be very small. The sequences of this type are very similar to the accident at Three Mile Island Unit 2 (TMI-2).

c. DCF – Dynamic Containment Failure

This event determines whether the very energetic phenomena only depending on the RCS pressure at vessel breach occurs and results in early containment failure at

the time of vessel breach. This event can be included in the next event (Early Containment Failure). For convenience's sake, however, these phenomena are considered separately from Early Containment Failure. Two possibilities are considered:

- No dynamic containment failure
- Dynamic containment failure.

In this top event, three energetic phenomena are considered:

- In-vessel Steam Explosion ("Alpha-mode" containment failure)
- Rocket-induced containment failure
- High Pressure Melt Ejection-Induced Containment Failure by Liner Attack

In-vessel steam explosion: The in-vessel steam explosion or "Alpha" mode containment failure refers to the scenario whereby a large quantity of molten corium is relocated in-vessel from the core/lower support structure to a water pool in the RV lower plenum. The superheated corium is postulated to rapidly transfer its thermal energy into kinetic energy by creating a rapidly expanding steam region within a liquid pool. This rapidly accelerating bubble generates a shock wave in the liquid (steam explosion) which subsequently disassembles the RV and propels the upper head (as a blunt missile) against the containment upper dome. The consequences of an "Alpha" mode containment failure will be a large area containment failure in the containment upper dome. This containment failure mode was determined to have a negligible potential to fail the containment, but was conservatively given a small (0.001) probability of containment failure in low pressure sequences (zero in high pressure sequences).

Rocket-induced containment failure: The "Rocket Induced Containment Failure" event addresses the potential for containment failure due to rocketing (lift-off) of the RPV and damaging containment. A possible scenario consists of a gross failure of the RPV bottom head failure with the gases inside at high or intermediate pressure. This results in a short duration (impulsive) pressure load

on the RPV, the load which is transmitted to the upper portion of the vessel and to the connective piping that support the vessel. After several inches of movement, the hot legs and the cold legs will hit the cavity at the top nozzle cutout elevation. The piping walls, piping junctions, and restraints will resist further upward movement of the vessel. If the upward impulsive load on the RPV exceeds the restraining capability of the RCS piping, then a lift-off occurs. The ensuing projectile can either collide with the missile shield, the manipulator crane, or polar crane above the RPV. The missile impact on the cranes can possibly tear the containment. This potential is considered to be negligible. However, the analysis conservatively assigned a small (0.001) probability of containment failure in high and medium pressure sequences (zero in low pressure sequences).

Containment failure by direct liner attack: This event addresses the potential for a containment failure due to the direct impact of corium particles ejected from the RCS at high pressure. This potential containment challenge results from a high pressure RPV discharge of energetic corium debris interacting with the containment shell (concrete and steel liner). Direct containment shell attack by high temperature core debris requires that the debris be relocated from the RCS to the containment. An ex-vessel distribution of the debris leading to direct contact with the containment shell is a minimal requirement for the occurrence of this postulated failure mechanism. Low pressure vessel failure events will lead to the deposition of core debris entirely within the reactor cavity. This would preclude direct contact with the containment shell liner. Thus, only high pressure vessel failure events need to be assessed for direct shell attack. A high pressure vessel failure can lead to debris dispersal and potential ejection of a portion of the debris from the reactor cavity into adjacent containment shells.

For the APR1400, this issue was found to be negligible because even if the RPV were to fail at high RCS pressure, the containment geometry of the APR1400 strongly inhibits the possibility of debris entrainment to the containment shell. However, the analysis conservatively assigned a small (0.001) probability of containment failure in high pressure sequences (zero in medium and low pressure sequences).

d. ECF – Early Containment Failure

This event determines whether a gross failure of containment occurs at or soon after reactor vessel failure. Four possibilities are considered:

- No early containment failure without hydrogen burn
- No early containment failure with hydrogen burn
- Early Containment Failure (Leak)
- Early Containment Failure (Rupture)

For sequences defined as early, it is assumed that insufficient core concrete interaction can occur so that the hydrogen contribution due to CCI is small. This results in a maximum hydrogen production during the core melt progression equivalent to 100 percent oxidation of the active cladding.

The phenomena that could potentially contribute to early containment failure are:

- Hydrogen burn before reactor vessel failure
- Direct containment heating (DCH)
- Hydrogen burn after reactor vessel failure
- Rapid ex-vessel steam generation (RSG) and ex-vessel steam explosion (EVSE).

Hydrogen burn before vessel failure: This issue considers the potential for a deflagration to occur in containment prior to vessel breach. Early in a severe accident sequence, hydrogen is primarily generated by the oxidation of zirconium. If only a small fraction of the available zirconium is oxidized early in the accident sequence, burnable concentrations of hydrogen would not be produced in the containment even, if the PARs or igniters are not available. After hydrogen concentration reaches a concentration to be burnable, hydrogen burns occurring at this phase of the accident are highly likely. The analysis assumes oxidation of 75 percent of the active core cladding inventory. This value is a reasonable upper bound for “in-vessel” hydrogen production prior to vessel breach and is used to

establish the containment performance to a hydrogen burn occurring while the RPV remains intact.

Early hydrogen burns prior to vessel breach (VB) can occur when (1) an ignition source is available, (2) appropriate burn conditions above the lower flammability limit of hydrogen are established, and (3) the ignition source successfully ignites the mixture.

The probability of containment failure due to pre-VB hydrogen burns was found to be negligible. If pre-VB hydrogen burns occur and containment failure does not occur, the pre-VB hydrogen burns decrease a threat of post-VB hydrogen burn due to a limited hydrogen amount being present. Therefore, in this analysis, pre-VB hydrogen burns are assumed NOT to occur, and all of the hydrogen generated prior to vessel breach is conservatively assumed to participate in post-VB hydrogen burns.

Post-vessel breach deflagration: Early hydrogen burns following vessel breach can occur when both an ignition source is available and appropriate burn conditions above the lower flammability limit of hydrogen is established. This event is also considered in the late containment failure section.

The probability of containment failure due to a hydrogen burn within a few hours after the reactor vessel failure is calculated by determining the potential containment pressure rise due to a hydrogen burn before vessel breach, and calculating the appropriate containment failure probability for that pressure using the containment fragility curve.

The failure potential for the post-VB hydrogen burn is quantified by assuming that the amount of hydrogen available for combustion is equivalent to the hydrogen produced following a 100 percent complete oxidation of the zircaloy cladding in the active core.

The post-VB “early” hydrogen burn is assumed to be suppressed if one of the following is true:

- Containment sprays are not available regardless of release point into the containment
- A burn event has already occurred in the containment. This includes:
  - DCH event
  - Pre-VB burn
  - Continuous hydrogen removal by PARs

In this analysis, because pre-VB hydrogen burn is conservatively ignored, all the hydrogen generated prior to vessel breach always participates in post-VB hydrogen burns.

Post-Vessel Breach Detonation: Detonations can develop from two sources: a DCH or a deflagration to detonation transition (DDT). DDT is defined to be a detonation resulting from a flame acceleration and subsequent shock development.

The possibility for a detonation to occur in containment is far more unlikely to develop than a simple deflagration. This is a result of several factors:

- The ignition source required to directly initiate hydrogen deflagration is over 10 orders of magnitude lower than that required for a direct initiation of a detonation.
- Detonations are more likely for conditions of a highly reactive mixture and restricted geometry. The APR1400 potential hydrogen concentrations and geometry are not conducive to detonation formation.
- Steam concentrations necessary to inert the containment to a hydrogen detonation are far lower than that required to inert the containment to deflagrations.

For the APR1400 Level 2 analysis, the potential for containment failure due to hydrogen deflagration or detonation was found to be negligible.

Direct Containment Heating: Direct containment heating is considered for sequences in which core damage is initiated while the primary system is at high pressure. It has been hypothesized that the corium would be ejected from the reactor vessel under high pressure and would be dispersed into the containment atmosphere as finely fragmented particles. The airborne particulate debris could then rapidly release chemical and thermal energy to the containment atmosphere. This would result in a rapid increase in containment pressure very soon after vessel failure. A more recent understanding of the DCH issue now suggests that the high pressure melt ejection (HPME) and fragmentation process provide little direct transfer of the heat generated in the corium-steam exothermic reactions or stored in the corium debris, to the containment atmosphere. Instead the DCH process is one of hydrogen generation and combustion coupled with the RCS post-severe accident steam/water blowdown to containment.

The DCH issue as related to the APR1400 has been evaluated. The APR1400 cavity has been configured to retain most of the core debris within the reactor cavity. It is estimated that even under the most adverse high pressure discharge, much of the ejected corium debris would be retained within the reactor cavity. For purposes of the PRA, the DCH loading was characterized by: 1) a combined high pressure melt ejection (HPME) loading associated with introduction of RCS steam/water inventory into containment, 2) an unconditional hydrogen burn associated with the combined unburned hydrogen generated prior to and during the HPME process, and 3) a direct debris-containment heat transfer associated with corium dispersal process. In the context of the APR1400 PRA, DCH loadings are associated with dry cavity HPME conditions only. HPME into a flooded the APR1400 reactor cavity is considered predominately a containment threat associated with rapid steam generation.

Rapid Steam Generation and Ex-Vessel Steam Explosion: For sequences in which water is present in the cavity at the time of reactor vessel failure, the interaction of the corium with the water in the cavity can rapidly generate large amounts of steam. If the steam generation is sufficiently rapid to exceed the ability of the water to acoustically relieve the expansion, a shock wave will develop in the water. This process is referred to as a steam explosion. Steam explosion loads can be very large and are impulsive in nature. If an explosive interaction between the

corium and the water does not result, the rapid steam generation may produce quasi-static pressure loads that can challenge containment integrity.

The relationships between the various factors that influence the potential for an early containment failure due to rapid steam generation are modeled. The issue of rapid steam generation has been divided into two related containment threats. These are the ex-vessel steam explosion induced containment failure and the quasi-static steam pressurization containment failure event. It should be noted that the rapid steam generation containment failure mode presumes that the cavity is water filled so that DCH loadings are insignificant and that the steam atmosphere is sufficient to inert post-VB hydrogen burns.

In the APR1400 Level 2 analysis, the probability of containment failure due to the above phenomena was found to be negligible. Despite the negligible potential for any of these challenges to fail the APR1400 containment, a small probability was conservatively assigned to each phenomenon. These small probabilities do not adversely skew the results, but allow for sensitivity evaluations, which are performed in the results section.

e. CSLATE – Late Containment Heat Removal Recovery Failure

This event determines if containment heat removal is available late (after vessel breach) in the accident sequence. It is assumed that late overpressurization can be avoided if containment heat removal is available. In this analysis, the containment spray system and the emergency containment spray backup system (ECSBS) are considered to function for containment spray. The branches for this event are:

- No late containment spray available
- Late containment spray available.

For containment heat removal to be available after vessel breach, the containment heat removal function should be available early in the accident scenario and the function maintained after vessel failure, or the early failed containment heat removal should be recovered. Failure of equipment inside containment is

considered to be 100 percent non-recoverable. For cases where the containment heat removal was unavailable because the operator had failed to initiate containment spray, containment spray would be initiated before containment failure given the available time and indications. In cases that ac power was unavailable, containment spray would be operated if the power is recovered prior to containment failure.

f. DBCOOL – Ex-vessel Debris Coolability

This event determines whether the core debris relocated into the reactor cavity is rapidly quenched by an overlying water pool. Though the APR1400 has been designed with a large cavity area and the cavity flooding system, in this analysis, it is considered that the corium may not be well cooled by an overlying water pool. Three possibilities are considered:

- Ex-vessel debris not cooled without an overlying water pool
- Ex-vessel debris not cooled with an overlying water pool
- Ex-vessel debris cooled

The debris in the reactor cavity can be submerged by water if safety injection is operating after vessel failure or the reactor cavity flooding system operates. If the debris is cooled, its only subsequent challenge to the containment is steam overpressurization due to the continued addition of decay heat to the cooling water and hence to the containment.

Physically, the debris is not cooled if the debris surfaces that are exposed to the heat-removing medium are not large enough with respect to the heat generating volume to prevent high temperatures from being attained. High surface-to-volume ratios indicate that the debris is being spread thinly over a large surface area. The geometry of the cavity (floor area) is an important factor.

g. LCF – Late Containment Failure

This event determines whether a gross failure of containment due to overpressurization and/or over-temperature occurs late in the accident sequence

("Late" is defined as being greater than after a few hours or a few days following reactor vessel failure.) This event is similar to the event for early containment failure, with the accident in progress for a significant amount of time as the obvious difference. Three possibilities are considered as follows:

- No containment failure
- Late Containment Failure (Rupture)
- Late Containment Failure (Leak)

The phenomena that could potentially contribute to a late containment failure are:

- Overpressurization caused by production of steam and/or non-condensable gases
- Late hydrogen burn
- Over-temperature failure of containment penetration sealants

The primary cause of failure of the containment is the steam overpressurization resulting from the loss of the containment heat removal. If the containment sprays (including ECSBS) are not available and the reactor cavity is flooded with water, the containment would finally fail due to steam overpressurization. The steam overpressurization process is slow and it takes long time to reach the containment failure pressure. The containment pressurization may stop if a small leakage path exists.

The possibility of late containment failure due to a late hydrogen burn was evaluated with conservative assumptions that an ignition source is available when the maximum hydrogen concentration is reached. Pressure resulting from a late hydrogen burn through the Adiabatic Isochoric Complete Combustion (AICC) process was calculated using the MAAP code for various accident sequences. The probability of containment rupture, leak or no containment failure was calculated based on the resultant pressure and the containment ultimate pressure capacity (UPC).

Over-temperature failure of containment seals is also considered, and was found to be negligible. However, the analysis conservatively assigned a small probability of containment failure in sequences with failed containment sprays and a dry cavity.

h. BMT – Basemat Melt-through

This event determines whether or not the containment can fail due to basemat melt-through. Two branches are considered:

- No basemat melt-through
- Basemat melt-through.

The containment can fail due to basemat melt-through (even if the cavity is filled with water) if the molten debris is not coolable. Note that if the containment heat removal function is not available and the reactor cavity is wet, it is assumed that overpressure failure occurs and basemat melt-through is neglected since the offsite consequences of basemat melt-through would be small compared with those of overpressure failure.

Successful cooling of the cavity debris bed implies that erosion-induced containment failure modes will not occur and that the radiological releases are attributable to either an alternate failure mode or containment leakage (assuming no other containment failure mode is identified).

19.1.4.2.1.2.4 Release Category Evaluations

The end points of the containment event tree (CET) represent the outcomes of possible accident progression sequences. These end points describe complete severe accident sequences from initiating event to release of radionuclides to the environment. The number of CET end points is large, and a detailed source term analysis for all of the end points is not feasible. In addition, such analyses for all accident sequences are not necessary because the amount and timing of the fission product release to the environment are similar for many of the accident sequences. Therefore, to reduce the source term

evaluation effort, the CET accident sequences will be grouped into a representative number of release categories that exhibit similar characteristics.

A particular release category consists of a group of CET end points which have similar source term governing characteristics. Once the release categories are determined, various accident sequences will be allocated to each category. The APR1400 specific source terms are evaluated using the MAAP computer code for one sequence which best represents the release category. The MAAP cases are used to predict the source term characteristics, including the release fraction and the release timing.

The analysis for the source term categories (STCs), also called release categories (RCs) was performed through the following steps:

- Define the STC grouping parameters (or headings)
- Develop the source term category logic diagram
- Quantify the logic diagram based on the results of the CET quantification
- Discuss the frequency and the dominant sequences of each release category
- Discuss the source term characteristics for each category using MAAP code

The quantitative definition of a "large" release in the APR1400 Level 2 analysis is that the release fractions of the volatile/semi-volatile fission products (Iodine, Cesium, Tellurium) are greater than 0.025 (2.5 percent). Of the 12 MAAP fission product groups, the higher of CsI, TeO_2, CsOH and TE_2 is taken to represent the volatile/semi-volatile fission product release fraction for each STC.

The definition of an "early" release is one in which the large release occurs prior to effective evacuation of the surrounding public. In the Level 2 PRA, an effective evacuation is assumed to be evacuation of a 16 km (10 mile) radius surrounding the plant. The time for effective evacuation is assumed to be 4 hours after declaration of a general emergency. The criterion for the declaration is loss of two of three fission product barriers, with the potential loss of the third. As the emergency planning procedures have not yet been developed, the criteria for evaluation of the three fission product barriers, the best estimate evaluations were taken from guidance in NEI 99-01 (Reference 36).

In order to set up the release categories, binning parameters are selected. These parameters are defined on the basis of appropriate attributes that impact fission product release and accident consequences. The selected set of parameters is used as grouping criteria to define the release categories and the associated source term magnitude, composition, and timing. Although these parameters are plant- and containment type-specific, and there is no unique way to perform a binning process, recent PRA studies suggest a list of important binning parameters.

The containment sequence characteristics selected for use in definition of the source term release categories are:

- Containment Bypass (CONBYPASS)
- Containment Isolation Status (CONISOL)
- In-vessel Melt Retention (MELTSTOP)
- Time of Containment Failure (TIMECF)
- Mode of Containment Failure (MODECF)
- Containment Spray System (CSS)
- Cavity Condition (CAVCOND)
- Fission Product Scrubbing for Bypass (SCRUB)

The STC binning diagram delineating these issues is presented in Figure 19.1-48. Each of the above parameters is directly based on the CET sequence characteristics from Figures 19.1-42 through 19.1-46.

A particular release category consists of a group of CET end points which have similar source term governing characteristics. Once the release categories are determined, various accident sequences will be allocated to that category. Among these sequences, the APR1400 specific source terms are evaluated using the MAAP computer program for the one sequence which best represents the release category.

A source term category can be fully characterized by the following parameters;

- The frequency of occurrence,
- The isotopic content and magnitude of the release (release fractions of the fission products),
- The energy of the release to the environment,
- The time of the release to the environment,
- The duration of the release, and
- The location of the release (release point of the release height)

Source term characteristics such as the isotopic content, magnitude, and the time of the release were calculated with the MAAP code for each release category. To select the representative sequence for the specific release category, the following process was used:

- Select the PDS with the largest contribution to the release category's total frequency
- Among the accident sequences corresponding to the PDS, choose the dominant sequence for the release category. This defines the initiating event and the status of the various plant systems.
- The definitions of the CET sequence (i.e., accident progression sequence) are retrieved to determine if any special phenomenological conditions have to be specified.
- A containment failure pressure, failure time and failure condition are specified based on the release category definition.

By definition, a release category characterizes the unique source term characteristics for each of the release categories as mentioned as above. Therefore, the representative sequences of the release categories for the APR1400 specific source term evaluation were determined based on the results of the internal events.

The release of the fission products can occur through the containment design leakage or a breach of the containment. The assumed pre-existing containment design leakage is a rate of 0.10 volume-percent per day at the design pressure and temperature. This design

leakage was assumed to be from the containment to the environment. In this analysis, this design leakage was applied to all source term categories including those categories in which the containment does not fail.

The release categories from Figure 19.1-48 are summarized here:

RC 1 - This category is characterized as a SGTR bypass of containment without fission product scrubbing. In this release category, it is expected that the significant releases occur in the early time period (i.e., prior to effective evacuation)

RC 2 - This category is characterized as a SGTR bypass of containment with fission product scrubbing. In this release category, the fission products can be scrubbed with overlying water pool in a ruptured SG.

RC 3 - This category represents ISLOCAs without successful scrubbing of fission product releases. In this release category, it is expected that the significant releases occurs in the early time period (i.e., prior to effective evacuation).

RC 4 - This category represents ISLOCAs with successful scrubbing of fission product releases. If the break outside containment occurs in an area where there would be significant pooling of water to submerge the break, the fission product particles released to the environment would be scrubbed.

RC 5 - This category represents the containment isolation failure with successful containment spray. The largest penetrations which were modeled in the CI system fault tree are the CVCS IRWST boron recovery return line and non-condensable gas exhaust line excluding the entrance doors (personal airlock) and the equipment hatch.

RC 6 - This category represents the containment isolation failure without containment spray. This category is very similar to RC 5, except that the containment spray system is not available.

RC 7 - This category represents the containment failure before core damage, and containment fails with leak failure size. The phenomenon of CFBRB may occur

when containment pressure keeps increasing due to the loss of containment sprays, while in-vessel injection is maintained during the accident.

RC 8 - This category represents the containment failure before core damage, and containment fails with rupture failure size. This category is very similar to RC 7, except for the failure size of the containment.

RC 9 - This category represents those sequences in which the core melt progression will be stopped before reactor vessel failure. In this category, the integrity of the containment and the reactor vessel are maintained. Therefore, there is no significant release of ex-vessel fission products. The fission products are released from the containment to the environment at the design leak rate.

RC 10 - This category represents those sequences in which the containment does not fail after reactor vessel failure. In this category, there is a release of fission products after reactor vessel failure. However, the fission products are released from the containment to the environment at the design leak rate because the integrity of containment is maintained.

RC 11 - This category represents those sequences in which the containment fails late due to basemat melt-through. In this category, there are significant corium concrete interaction (CCI) and concrete erosion after reactor vessel failure. Since the containment failure occurs below the containment basemat, there is a very small release of airborne fission products to the environment, and the release characteristics of this category are expected to be as an underground water release. However, due to MAAP limitations for underground release evaluation, the basemat failures are conservatively treated as airborne releases at ground elevation. This conservatism does not significantly impact the source terms because the releases of this category are late and small.

RC 12 - This category represents those sequences in which the containment fails early with a leak failure size. However, no sequences are assigned to this release category based on the quantification results of the PDSs and CET/DETs.

RC 13 - This category represents those sequences in which the containment fails early with a rupture failure size. The release characteristics of this category are as same as that of RC 12 except for the failure size of the containment. The early containment failure modes include an early hydrogen detonation/deflagration failing containment, an ex-vessel steam explosion, a DCH-induced containment failure, and several dynamic containment failures (i.e., alpha-mode containment failure, rocket mode containment failure and the containment shell attack by HPME-induced corium particles.) In this category, the containment would fail approximately at the time of reactor vessel failure. Therefore, the fission products were significantly released into the environment before successful evacuation.

RC 14 - This category represents those sequences that the containment fails late with a leak failure size, the containment spray functions and the cavity condition is dry. This represents the containment failure modes that include a late hydrogen detonation/deflagration failing containment. In this category, there may be significant fission product releases to the environment due to a dry cavity. However, these releases could be scrubbed by the containment sprays until the containment failure occurs.

RC 15 - This category represents those sequences in which the containment fails late with a leak failure size, the containment spray functions and the cavity condition is wet. However, no sequences are assigned to this release category based on the quantification results of the PDSs and CET/DETs.

RC 16 - This category represents those sequences in which the containment fails late with a leak failure size, the containment spray does not function, and the cavity condition is dry. This represents the containment failure modes that include a containment seal failure due to over-temperature. In this category, there may be a significant fission product release to the environment due to a dry cavity and an unavailable containment sprays.

RC 17 - This category represents those sequences in which the containment fails late with a leak failure size, the containment spray does not function and the cavity condition is wet. This represents the containment failure modes that include a containment failure due to steam over-pressurization. In this category, there is no significant

fission product release to the environment due to a wet cavity. However, the releases are not scrubbed by the containment sprays.

RC 18 - This category represents those sequences in which the containment fails late with a rupture failure size, the containment spray functions and the cavity condition is dry. The release characteristics of this category are the same as that of RC 14, except for the failure size of the containment. This represents the containment failure modes that include a late hydrogen detonation/deflagration failing containment. In this category, there may be significant fission product releases to the environment due to a dry cavity. However, these releases can be scrubbed by the containment sprays until the containment failure occurs.

RC 19 - This category represents those sequences in which the containment fails late with a rupture failure size, the containment spray functions and the cavity condition is wet. The release characteristics of this category are as same as that of RC 15, except for the failure size of the containment. This represents the containment failure modes that include a late hydrogen detonation/deflagration failing containment. In this category, there is no significant fission product release to the environment because the releases can be scrubbed by the containment sprays until the containment failure occurs and a wet cavity.

RC 20 - This category represents those sequences in which the containment fails late with a rupture failure size, the containment spray functions and the cavity condition is dry. The release characteristics of this category are same as that of RC 16, except for the containment failure size. This represents the containment failure modes that include a late hydrogen detonation/deflagration failing containment. After the containment failure, the fission products are released into the environment through a containment failure location. In this category, there may be a significant fission product release to the environment due to a dry cavity and an unavailable containment sprays.

RC 21 - This category represents those sequences in which the containment fails late with a rupture failure size, the containment spray does not function and the cavity condition is wet. The release characteristics of this category are as same as that of RC 17, except for the failure size of the containment. This represents the containment failure modes that include a containment failure due to steam over-

pressurization. In this category, there is no significant fission product release to the environment due to a wet cavity. However, the releases are not scrubbed by the containment sprays.

The summary of the MAAP results (release magnitude and timing) and release categorization (i.e., large release, large early release, or not large release) is presented in Table 19.1-29 and Table 19.1-30.

19.1.4.2.2 Results of Level 2 Internal Events PRA for Operations at Power

19.1.4.2.2.1 Risk Metrics (LRF, CCFP)

Total LRF from internal events is 1.1×10^{-7}/year. It should be noted that the "year" unit in the full power internal events Level 2 section (Subsection 19.1.4.2) refers to a reactor calendar year (RCY). This is well below the NRC goal for LRF below 1×10^{-6}/year. Mean value and associated uncertainty distribution can be found in Subsection 19.1.4.2.2.7.

The CCFP from all internal events (at power) large release sequences is 0.084. This meets the NRC goal of no more than approximately 0.1 for conditional containment failure probability (CCFP).

19.1.4.2.2.2 Internal Events Core Damage Release Category Results

The relative contributions of the release categories to the total STC frequency are shown in Figure 19.1-49. Figure 19.1-50 groups the categories further into no contailmnet failure, large release, and small release.

Approximately 49 percent of the LRF for internal events is from STC 1, which are unmitigated, unisolated SGTR releases (both SGTR initiating event and induced SGTR). The next highest frequency STC is a late rupture with no containment sprays (27 percent), followed by containment failure (rupture) prior to core damage (12 percent), and containment failure (leak) prior to core damage (10 percent). Early containment rupture with no sprays contributes 1.6 percent to the LRF, and containment isolation failure with no spray contributes 1.1 percent. The remaining STCs have a negligible contribution to the LRF.

19.1.4.2.2.3 Significant Level 2 Cutsets and Sequences

The significant LRF cutsets for the internal events Level 2 PRA are illustrated in Table 19.1-31. This table provides the top 100 LRF cutsets, and does not exclude any cutset that contributes over 0.1 percent to the total LRF.

Cutsets that contribute one percent or more to large release for internal events are described as follows.

The first six cutsets are all pressure-induced SGTR. The first is an ATWS, in which the high RCS pressure induces the rupture. The next five are all main steam line break (downstream of MSIVs) with a failure to close the MSIVs, where the rapid decrease in secondary side pressure creates a large pressure differential across the tubes, inducing the break. The LSSB-D cutsets each have success of safety injection and rapid depressurization (SDR) in their event tree sequence logic, making them conservative in a classification as “large” releases.

LRF cutsets 7 and 8 are a total loss of ESW or CCW, a resulting RCP seal LOCA, and failure to run of the auxiliary charging pump. Containment sprays are unavailable because of the cooling water system failures, and late containment rupture results.

Cutsets 9 through 12 are similar to cutsets 2 through 6, with different common cause failures of the MSIVs.

Cutset 13 involves containment failure prior to core damage. It is a medium break LOCA with failure of the containment sprays to provide containment heat removal. The eventual overpressurization of the containment causes the containment failure that is assumed to fail the systems that would prevent core damage (e.g., loss of NPSH for the SI pumps).

19.1.4.2.2.4 Significant Core Damage End States, Initiating Events, Phenomena and Basic Events

Table 19.1-32 and Figure 19.1-51 present the LRF contribution by internal initiating events. The largest contributor with 27 percent is a steam line break inside the containment (downstream of the MSIVs). This contribution arises because of the steam line break

inside containment sequence described in Subsection 19.1.4.2.2.3. The second and third largest contributing initiating events are LOOP and SBO, each with failure of containment heat removal and a flooded cavity, leading to late containment overpressurization. The fourth largest contributing initiating event is medium break LOCA, with the containment failure before core damage sequences. ATWS-induced SGTR is fifth in frequency.

Table 19.1-33 presents the significant plant damage states (PDSs) that contribute to LRF.

Table 19.1-34 presents the important basic events to LRF, ranked by RAW. Table 19.1-35 presents the same, ranked by FV.

Table 19.1-36 presents the common cause event importance to LRF, ranked by RAW. Table 19.1-37 presents the same, ranked by FV.

Table 19.1-38 presents the human action importance, accounting for both pre-initiators and post-initiators, ranked by RAW. Table 19.1-39 presents the same, ranked by FV.

19.1.4.2.2.5 Key Assumptions

a. If the MSSVs pass water in a SGTR, they are assumed to be stuck open and there is no means to isolate the ruptured SG. Thus, for the sequences in which the RCS pressure control is failed (called as ECLDN or SDR), the SG isolation is conservatively assumed to be failed and those sequences are directly considered as containment bypass sequences.

b. The conditional probability of PI-SGTR, given ATWS and MSLB/FWLB sequences without feedwater, is assumed to be 0.027 based on engineering judgment of applicable industry references for this probability.

c. For calculation of hydrogen mass generated in a severe accident in the first few hours after core damage, it is assumed that insufficient core concrete interaction can occur so that the hydrogen contribution due to CCI is small. This leads a maximum hydrogen production during the time window concerned is equivalent to 100 percent oxidation of the active cladding.

d. For late hydrogen burns resulting in a “late” containment failure, the hydrogen burn pressures are assumed to result from AICC process. Those hydrogen burn pressures for various conditions (such as the cavity condition, the operation of PARs, and so on) are estimated by using the MAAP code.

e. For the evaluation of hydrogen burns and detonations in an SBO, it is assumed that an ignition source is available when the burnable condition is established in containment.

f. In the evaluation of induced SGTR during a core melt at high RCS pressure and dry steam generators, the conditional probabilities of tube failure for moderately degraded SG tubes from NUREG-1570 are utilized. This is considered to be a conservative assumption.

g. In the induced SGTR modeling, it was assumed that any RCP seal LOCA failure under high RCS pressure with a dry SG would result in a cleared RCS loop seal. This is very conservative per the NUREG-1570 guidance and EPRI research, but the conservatism did not significantly impact the LRF.

h. External Reactor Vessel Cooling is conservatively not credited in the baseline Level 2 analysis, but is evaluated in a sensitivity analysis.

i. It is assumed that the core can be recovered by early in-vessel injection before corium relocation.

j. The ECSBS is credited in the long term for preventing containment failure due to steam overpressurization, even though it does not provide decay heat removal and is only designed to operate for 24 to 72 hours after core damage. This is based on MAAP calculations that indicate that containment failure pressures would not be reached until long after the ECSBS stopped operating at 72 hours, at a point where it is assumed that failure to recover equipment would no longer be credible.

k. The quantitative definition of a “large” release in the Level 2 analysis is if the release fractions of the volatile/semi-volatile fission products (Iodine, Cesium, Tellurium) are greater than 0.025 (2.5percent). Of the 12 MAAP FP groups, the higher of CsI, TeO_2, CsOH, and Te_2 is taken to represent the volatile/semi-volatile fission product release fraction for each STC.

l. The definition of an "early" release is one in which the large release occurs prior to effective evacuation of the surrounding public. In the Level 2 PRA, an effective evacuation is assumed to be evacuation of a 16 km (10 mile) radius surrounding the plant. The time for effective evacuation is assumed to be 4 hours after declaration of a general emergency. The criterion for the declaration is loss of two of three fission product barriers, with the potential loss of the third. As the emergency planning procedures have not yet been developed, the criteria for evaluation of the three fission product barriers, the best estimate evaluations were taken from guidance in NEI 99-01.

m. As applied to the MAAP analyses, the containment is assumed to be failed when the containment pressure reaches at 11.4kg/cm^{2}g (162.7 psig). This is the median pressure of the containment ultimate pressure capacity. For those categories in which containment fails with a rupture mode, the release location is assumed to be near the midpoint of the containment cylindrical wall. For those categories in which containment fails with a leak mode, the release location is assumed to be near the equipment hatch.

n. If a pressure induced SGTR occurs due to LSSB-D, LSSB-U, FWLB and ATWS, it is assumed that the feedwater injection to the ruptured SG is unavailable.

o. In the analysis of severe accident induced SGTR, the induced SGTR is assumed to occur prior to induced hot-leg failure.

p. Once core damage occurs, fission products can be released at the design leakage rate, even when containment has not yet failed. The assumed pre-existing containment design leakage is a rate of 0.10 volume-percent per day at the design pressure and temperature. In this analysis, this design leakage was applied to all source term categories including those categories which assessed as an intact containment release category.

q. In the Level 2 analysis, the model assumes that the ex-vessel core debris coolability for wet cavity condition is 0.5.

r. In the Level 2 analysis, the model assumes that the ignition source inside the containment always exists in both early phase and late phase.

s. In the Level 2 analysis, the model assumes that the probability of low heat transfer rate from ex-vessel core debris to water, which cause an ultimate basemat melt-through, is 0.01.

19.1.4.2.2.6 Sensitivity Analysis

In the containment performance analysis, several assumptions were made regarding the progression of severe accident phenomena. Sensitivity analyses were performed to assess the potential impact on the Level 2 results due to the potentially significant assumptions. Quantitative sensitivity studies can be performed where propagation of uncertainties is not practical or where the uncertain issues do not readily lend themselves to quantitative treatment.

These analyses assessed the impact of specified assumptions on the containment failure modes and the overall conditional containment failure probability. These analyses involved changing certain conditions or assumptions that are modeled in the CETs/DETs and then re-quantifying the Level 2 models to ascertain the impact.

These sensitivity analyses also provide significant insights into the dominant containment phenomena in terms of their contribution to LRF and the total containment failure frequency.

The following cases were analyzed for the Level 2 PRA:

- Case R1 – Failure of ECSBS: For this case, the containment spray recovery (operation of ECSBS) was assumed to always fail (i.e. P(YES) = 0.0 for CSRECSBS branch in the CSLATE DET, MELTSTOP DET and RBCM DET).

- Case R2 - Failure of Cavity Flood System: The CFS was assumed to always be failed.

- Case R3 – Failure of PARs: The PARs are assumed to always fail to control hydrogen.

- Case R4 – Failure of Rapid Depressurization: Rapid depressurization is assumed to always fail.

- Case R5 – Level 2 operator actions are always successful.

- Case R6 – External reactor vessel cooling is credited to prevent reactor vessel failure.

- Case R7 – Effects of Induced SGTR with "Pristine" SG tubes: The baseline analysis assumed an average level of tube degradation (as may be the case after many years of operation). This sensitivity examined the effect of assuming the tubes are in a new or well-maintained condition.

- Case R8 – No Induced Hot Leg or Surge Line Failure before Vessel Failure: No credit given to induced hot leg or surge line failure before vessel failure.

The results of these sensitivity analyses are presented in Table 19.1-40. As seen in the table, the case demonstrating by far the greatest LRF sensitivity is Case R1. This demonstrates that the ECSBS credit in preventing containment overpressurization is very important to the LRF. If ECSBS were not credited for long term containment pressure control, the LRF would increase from 8.4 percent of the CDF to 43.2 percent, and the total containment failure frequency would increase from 13.8 percent to 66.6 percent.

Case R2 demonstrates that the unavailability of the cavity flood system actually causes a slight drop in the LRF because it eliminates the steam overpressure failure, but the total containment failure frequency increases substantially, mainly due to basemat melt-through. If the cavity flood system were not credited, the LRF would decrease from 8.4 percent of the CDF to 6.2 percent, and the total containment failure frequency would increase from 13.8 percent to 60.1 percent.

Case R7 identifies that the conservative assumption that the SG tubes are in an "average" condition (which is used to define the conditional failure probabilities for induced SGTR) has a significant contribution to the baseline LRF. If credit were given to considering the tubes "pristine" and well maintained, the LRF would drop significantly. The LRF would

decrease from 8.4 percent of the CDF to 5.8 percent and the total containment failure frequency would decrease from 13.8 percent to 11.4 percent.

The remaining sensitivity cases demonstrate that the remaining Level 2 phenomenological uncertainties have a relatively small or no impact on the LRF.

19.1.4.2.2.7 Uncertainty Analysis

The results of the uncertainty evaluation for the Level 2 internal events LRF are as follows:

- 5 percent Value: 4.7×10^{-8}/year
- Mean Value: 1.6×10^{-7}/year
- 95 percent Value: 2.9×10^{-7}/year

19.1.4.2.2.8 Risk Insights

The sensitivity analyses provide the best insights into the APR1400 Level 2 model. The analyses demonstrate that the LRF is very sensitive to the operation of the ECSBS to prevent long term containment overpressurization. If ECSBS were not credited to prevent long term overpressurization, the LRF would rise significantly.

The cavity flood system is important in maintaining an intact containment. Unavailability of the cavity flood system actually causes a slight drop in the LRF because it eliminates the steam overpressure failure, but the total containment failure frequency increases substantially, mainly due to basemat melt-through.

Finally, the conservative assumption that the SG tubes are in an “average” condition (which is used to define the conditional failure probabilities for induced SGTR) has a significant contribution to the baseline the APR1400 LRF and LERF. If credit were given to considering the tubes as being “pristine” and well maintained, the APR1400 LRF and LERF would drop significantly.

19.1.5 Safety Insights from the External Events PRA for Operations at Power

This section addresses the following hazard groups:

- Seismic
- Internal fire
- Internal flooding
- "Other" external events (based upon those listed in the ASME/ANS PRA Standard).

Explicit quantitative PRA modeling has been performed for Internal Fire and Internal Flooding hazard groups. A PRA-based Seismic Margin Assessment (SMA) has been performed to address the seismic hazard group.

A screening evaluation is presented in Subsection 19.1.5.4 for the "other" external events listed for consideration in the ASME/ANS PRA Standard.

19.1.5.1 Seismic Risk Evaluation

The following subsections describe the seismic risk evaluation including the results of the evaluation.

19.1.5.1.1 Description of the Seismic Risk Evaluation

The seismic margin methodology has been applied to estimate the plant-level seismic margin and accident sequences. The seismic margin for the APR1400 is evaluated by using PRA-based SMA. This methodology satisfies the recommendation of SECY-93-087 approved by the NRC for a seismic risk evaluation. SMA identifies potential vulnerabilities and demonstrates seismic margins beyond the design-level safe-shutdown earthquake (SSE). The capacity of components required to bring the plant to a safe and stable conditions is assessed. The SSCs identified as important to seismic risk are addressed.

a. Selection of review level earthquake

The starting point to perform SMA is to select a review level earthquake. SMA demonstrates that sufficient margin in seismic design exists by showing the high confidence of low probability of failures (HCLPFs) of the plant and components are greater than review level earthquake (RLE). The RLE of the APR1400 is 0.5g.

b. Development of seismic equipment list

The seismic equipment list is provided from the internal events PRA model. Also, earthquake-specific SSCs such as passive components and structures related to a safety function, which are not addressed in the internal events PRA model, are involved for the fragility analysis and system analysis.

c. Identification of seismic initiating event category

Initiating events due to a seismic event are identified from the internal events analysis. However there are some major differences between the seismic and internal events for purpose of identifying initiating event category, which are as follows: 1) seismic events may damage passive plant components and structures (e.g., SGs, auxiliary building) that are not explicitly modeled in the internal events PRA; and 2) seismic events may simultaneously damage multiple redundant systems and components at the plant. Identified seismic initiating event categories are modeled as hierarchy structures.

d. Development of system models

The SMA system models are developed from the internal events PRA model to include the important accident sequences. This model also contains random failures and human errors from the internal events PRA. System models are modified to accommodate a seismic event. The model is used to estimate seismic margins and to identify vulnerabilities in the design.

e. Fragility analysis

At the design certification phase, specific design data such as material properties, analysis results, qualification test information, etc. are not available. Where available, information from the reference plant’s analysis is used for the

component fragility of the APR1400 components. The generic data used for the APR1400 are based on the fragilities provided by the electric power research institute (EPRI) Utility Requirements Document (Reference 37).

f. Evaluation for the plant seismic capacity

There are two acceptable approaches to evaluate the plant seismic margin as described in NUREG/CR-4482 (Reference 38).

- "Min-max" method, in which HCLPF is assessed for accident sequences by taking the lower HCLPF value for components operating under OR logic and the highest HCLPF value for components operating under AND logic.
- "Convolution" method in which probabilities of non-seismic and operator failures are included in the calculation as well as the component fragilities. This is a fully quantitative approach where the importance and contribution of seismic as well as non-seismic failures can be assessed quantitatively.

The "min-max" method is selected as the appropriate method at the design certification phase since detailed plant-specific data is unavailable. This method is accomplished by calculating HCLPFs for each seismic event tree top event that represents a safety-related system or function. HCLPFs of systems are calculated in conjunction with random and/or human factors.

g. Demonstration of seismic margin in the design

The objective is to demonstrate that there is sufficient seismic margin in the design. If the plant HCLPF is less than the review level earthquake, modification of the design or the model is required.

A fragility evaluation is performed to obtain the seismic margin of components and structures that could have an effect on safe shutdown of the plant following a seismic event. In this evaluation, the seismic margin values of components and structures modeled in the accident sequences are obtained. The seismic margin is expressed in terms of HCLPF values.

$$HCLPF = A_m \times \exp(-1.65 \times (\beta_R + \beta_U))$$

or

$$HCLPF = A_m \times \exp(-2.33 \times \beta_C)$$

A_m: median capacity

β_R: logarithmic standard deviation representing the randomness

β_U: logarithmic standard deviation representing the uncertainty

β_C: composite logarithmic standard deviation

The median capacities and HCLPFs are expressed in terms of the peak ground acceleration (PGA). An earthquake of 0.5g PGA is defined as the review level earthquake for the APR1400.

19.1.5.1.1.1 Development of Seismic Equipment List

The SEL provides a documented list of the plant structures, systems, and components (SSCs) that could be used to respond to an earthquake or mitigate potential reactor plant damage initiated by a seismic event. This design certification SEL then is used to develop the SMA systems logic model (event trees and fault trees).

While the objectives of the internal events PRA and SMA are similar, there are differences between the SSCs included in each of the models. As a result, not all SSCs included in the internal events PRA model are included in the SEL. For example, many balance-of-plant components, such as the feedwater system, are not considered in the SMA since they depend on offsite power, which is expected to be unavailable after a seismic event. Also, some SSCs are not modeled in the internal events PRA but must be considered in the SMA and, therefore, in the SEL. Examples include distribution systems such as piping, cable trays, ventilation ducts, and structural items such as masonry block walls that could fail and damage nearby safety equipment.

The first step in developing the SEL was to determine the potential initiating events that could occur as a result of a seismic event. Initiating events considered could occur either directly as a result of the earthquake or due to random or consequential events that occur

subsequent to the earthquake. Identification of potential initiating events used the internal events PRA for guidance.

The scope of this analysis is at-power operation. Low-power and shutdown states are not considered.

The safety functions that would be required to respond to initiating events identified above were determined based on EPRI NP-6041 (Reference 39) and NUREG-1407 (Reference 40). These safety functions are:

- Reactivity control
- RCS pressure control
- RCS inventory control
- Decay heat removal
- Containment integrity

The frontline systems used to meet the five safety functions were identified from the internal events PRA. In addition to the frontline systems, the required support systems were identified. However, unlike the internal events PRA, only systems that do not require offsite power were selected. Because the offsite power grid, switchyard insulators, and large transformers have relatively low seismic capacity, they cannot be relied on to provide power after a major earthquake. Only systems that can be supported by the onsite emergency ac power sources are considered.

The initial list of equipment for the SEL is then identified using the following data sources:

- Internal events PRA list of basic events
- P&IDs
- Electrical diagrams (for offsite power, and emergency power)
- Plant arrangement drawings

- Systems notebooks for the internal events PRA
- Emergency Operating Guidelines

For the APR1400 SMA, the initial list of equipment was identified beginning with the internal events PRA and reviewing the system P&IDs and electrical diagrams to ensure that all necessary components are on the SEL. For example, components needed to ensure system integrity or electrical isolation was examined. When appropriate, these components were identified and added to the SEL.

However, the following items are not included on the SEL based on the assumption that they are seismically rugged:

- Check valves and backdraft dampers
- Manual valves and dampers, including fire dampers
- Small relief valves
- Small passive in-line filters that are supported only by the piping or ducting
- Instrumentation that is not required for mitigation of the seismic accident sequence (generally local instrumentation may be excluded, unless it is part of a plant procedure that would be implemented during a seismic event)

As a check on the SEL, the list of basic events in the internal events PRA was reviewed to identify additional systems and equipment that should be included in the SMA and the SEL. Systems and components that rely on offsite power were excluded.

The following assumptions were used to develop the SMA SEL:

a. The following components are considered to be seismically rugged capacity, i.e., having a HCLPF much greater than 0.5g)

    - Piping and supports
    - HVAC ducting, supports, and dampers
    - Cable trays and supports

- Valves
- Motor-operated valves
- Air-operated valves
- Solenoid-operated valves
- Pilot-operated safety relief valves
- Relief valves
- Manual valves
- Check valves
- Electrical conduit
- Instrumentation such as resistance temperatures detectors, pressure transmitters, etc.
- Electrical components/Relays/Circuit Breakers (not specifically analyzed in Table 19.1-42)

b. Since the formal evaluation of the EDG building has not been completed, it is assumed that the building fragility is greater than the diesel generators and associated equipment contained in the building.

19.1.5.1.1.2 Seismic Fragility Analysis

Seismic fragilities are calculated for components groups developed from the SEL. For the APR1400 SMA, component fragility values from the reference plants are assumed to apply. The exception to the use of fragility information from the reference plants is when a component has a HCLPF of less than 0.5g. In such cases, it is assumed that the APR1400 design will be modified to increase the capacity of components to at least a 0.5g HCLPF.

The seismic fragilities (mean failure probabilities) for the component groups are calculated based on values of A_M, β_R, β_U for these components at a HCLPF value of 0.5g and a relative acceleration of 1.0g.

The equation for HCLPF is:

$$= A_m \times e^{[(-1.645)*(\beta_R+\beta_U)]}$$

The equation for mean failure probability is:

$$= \text{Normal distribution of } \left[\frac{(\ln 1.0g)-(\ln A_m)}{\sqrt{(\beta_R{}^2+\beta_U{}^2)}}\right]$$

The major assumptions for the SMA model are as follows:

a. It is assumed that the seismic event would result in a LOOP, since offsite power equipment is not seismic Category I. (The insulators on the offsite power feed lines can fail in a seismic event such that a LOOP occurs.)

b. No credit is taken for non-safety-related systems. They are assumed in the model to have failed or to be non-functional due to the seismic event.

c. In the SMA system fault trees, the operator actions in the random failure cutsets from the internal events PRA are assumed to apply, and the HEPs are reevaluated considering the seismic events.

d. As a conservative assumption, if one component fails due to the seismic event, the same type components of the system will fail as well.

e. Failure of the reactor trip signal is not modeled since the control rod motor generator sets would be de-energized following a LOOP due to a seismic event thereby causing the release of control rods into the core even if the reactor trip function fails.

f. Failure of buildings that are not seismic Category I (e.g., turbine building and compound building) does not impact SSCs designed to be seismic Category I. Seismic spatial interactions between SSCs design to be seismic Category I and any other buildings will be avoided by proper equipment layout and design. The

following seismic Category I buildings and structures are identified as buildings and structures that involve safety-related SSCs to prevent core damage.

- Containment
- Auxiliary building
- CCW heat exchanger building
- Emergency diesel generator building
- ESW intake structure

g. Relay chatter does not occur or does not affect safety functions during and after seismic event.

Six seismically induced initiating event categories have been identified, and are listed below in order of greatest to least "challenges."

- Direct to core damage scenarios, e.g., gross structural collapse of buildings
- Loss of all instrumentation and control
- Large break LOCA
- ATWS
- SBO
- Small break LOCA
- SGTR
- LOOP

19.1.5.1.2 Results from the Seismic Risk Evaluation

19.1.5.1.2.1 Seismic Equipment List

The APR1400 plant has a number of systems that are available for safe shutdown after a seismic event. In selecting the systems, the following potential seismic initiating event scenarios were considered:

- LOOP
- Small break LOCA
- Large break LOCA
- Loss of all instrumentation and control
- Direct to core damage scenarios such as building collapse
- SGTR
- ATWS
- SBO

As with other SMAs, the APR1400 analysis considers equipment needed to supply offsite power to be of very low seismic capacity. If offsite power is available after an earthquake, then the earthquake was relatively mild and such events would cause very little damage. In particular, virtually all of the safety systems would be available for accident mitigation following such a mild event. Furthermore, it is expected that much of the balance of plant systems would also be undamaged.

The following scenarios are not considered further for the SEL:

- Interfacing systems LOCA (ISL) - The active ISL related valves are on the SEL, and the potential for relay chatter to cause an ISL will be included in the relay chatter analysis. Check valves have very high seismic capacity, and a potential ISL from these valves following a seismic event is considered not significant.

- Yearly initiating events - Internal events such as loss of a dc or ac bus or loss of cooling water are not considered as seismically-induced initiators. However, the seismic failure and random failure of this equipment is considered after a seismic event.

Table 19.1-41 lists the systems that were evaluated for the SMA with their associated plant designators. Note that only specific portions of these systems are included in the SEL and SMA models. Because the support systems provide support functions for multiple front line systems, their availability after an earthquake is critical for successful mitigation of the seismic event.

As described in Subsection 19.1.5.1, the APR1400 P&IDs and electrical single line diagrams were used as the initial input to the SEL. The internal events PRA basic events were then reviewed to ensure that all appropriate equipment was included in the SEL.

The SELs for the APR1400 are presented in Table 19.1-42, and consists of approximately 350 components.

The structures associated with the SEL equipment are:

- Auxiliary building
- Reactor containment building
- CCW heat exchanger building
- Emergency diesel generator building
- ESW intake structure

19.1.5.1.2.2 Seismic Fragility Analysis Results and Risk Insights

The SKN fragility information is shown in Table 19.1-43. Components shown in Table 19.1-43 with a HCLPF of "S/O" are assumed to be seismically rugged. Component groups that were not screened out (S/O) include, and have a mean failure probability calculated are:

- Safety Injection Tanks
- Emergency Diesel Generators
- ESF-CCS Cabinet and Load Center
- Plant Protection System Cabinet
- 4.16 kV Main Control Switchgear (MCSG)
- Off-Site Power
- Containment Building Exterior Walls
- Containment Building Internal Structure
- Auxiliary Building
- Emergency Diesel Generator Building

The HCLPF for the APR1400 design is 0.5 g. The dominant contributors to the plant HCLPF are provided in Table 19.1-44. The seismic induced failure probabilities are the mean failure probabilities calculated at 1.0 g.

The following dominant sequences were identified for the seismic event.

a. The dominant contributor to the plant is failure of the ESF and RPS cabinets which have an assumed HCLPF of 0.50 g. Failure of these cabinets causes a loss of all instrumentation and control. Without indication and control available to the operators, core damage is assumed to occur.

b. The second most dominant contributor to the plant HCLPF is seismically-induced failure of the 4.16 kV Class 1E buses. The 4.16 kV Class 1E buses have an assumed HCLPF of 0.50 g. Loss of the electrical buses results in a station blackout and, therefore, a loss of all decay heat removal and RCS inventory control. Because the seismic event is assumed to have damaged the switchyard, offsite power cannot be recovered and core damage occurs.

c. Failure of the containment exterior, which is assumed to result directly in core damage is the third highest contributor. The HCLPF for containment exterior wall failure is estimated to be 0.66 g. The failure of the containment would directly lead to core damage.

d. The auxiliary building has a HCLPF of 0.67 g and is the fourth highest contributor to seismic core damage. As with the containment, failure of the auxiliary building is assumed to directly lead to core damage.

e. Operator alignment of shutdown cooling for long-term heat removal is needed because of the finite capacity of the AFW storage tanks. If no seismic or random equipment failures occur, then this operator action is significant. Seismic-induced failure of the 120 V instrumentation system, which is assumed to be a loss of all instrumentation and control, is the sixth highest contributor. Failure of the 120 V inverters along with their backup regulating transformers occurs.

f. In addition, there are cutsets with a seismically-induced LLOCA and failure of two EDGs. These failures preclude adequate injection for the success criteria specified in the internal events PRA model.

A COL applicant that references the APR1400 design certification is to confirm that the APR1400 PRA-based seismic margin assessment is bounding for their specific site, and will update the SMA to include site-specific SSC and soil effects (including sliding, overturning liquefaction and slope failure).

19.1.5.2 Internal Fire Risk Evaluation

The following subsections describe the internal fires risk evaluation and its results.

19.1.5.2.1 Methodology and Approach

The fire PRA methodology for the APR1400 is based on NUREG/CR-6850 and NUREG/CR-6850, Supplement 1 (Reference 41). NUREG/CR-6850 provides a state-of-the-art methodology for fire PRAs. The fire PRA methodology is composed of 16 tasks, described below.

Task 1: Plant Boundary Definition and Partitioning - The purpose of this task is to define the Global Plant Analysis Boundary, and to divide the Global Plant Analysis Boundary into discrete physical analysis units (fire compartments).

Task 2: Fire PRA Component Selection - The purpose of the component selection task is to select the plant equipment that will be included and/or credited in the fire PRA. This task sets the analytical scope of the fire PRA Model and provides input to Task 3, Cable Selection.

Task 3: Fire PRA Cable Selection - The purpose of this task is to identify the cables associated with all Fire PRA components, and their physical routing throughout the plant. This data supports the subsequent task of quantification for the fire PRA.

Task 4: Qualitative Screening - The objective of qualitative screening is to identify physical analysis units whose potential fire risk contribution can be judged negligible without quantitative analysis. Fire compartments are retained if they contain any fire PRA components or cables, or 2) where it can be shown that a fire in the compartment might require a manual or automatic plant trip or a controlled manual shutdown based on plant technical specifications. All other fire compartments can be qualitatively screened.

Task 5: Plant Fire-Induced Risk Model - The purpose of this task is to create the fire PRA model that will be used in estimating the fire risk. The initiating events and system models from the internal events model are examined for applicability to fire events, and amended as required to include fire induced initiators, fire specific accident sequences, fire induced failures and failure modes, and fire related operator actions.

Task 6: Fire Ignition Frequency Development - The purpose of this task is to determine the fire ignition frequencies for fixed and transient ignition sources on a fire compartment basis. The scope includes determining the compartment fire ignition frequencies using generic fire ignition frequencies, fixed ignition source counts, and transient combustible considerations such as room usage, cable loading and other influencing factors.

Task 7: Quantitative Screening - The purpose of the quantitative screening task is to screen physical analysis units located within the Global Plant Analysis Boundary from further consideration based on preliminary conservative estimates of fire risk contribution using

established quantitative screening criteria. The intent of the quantitative screening process is to limit the scope of detailed fire modeling and/or detailed circuit analysis by identifying the significant fire compartments. Quantitative screening does not eliminate the risk contribution for the screened out compartments; the risk contribution of all screened out fire compartments remain in the fire PRA.

Task 8: Scoping Fire Modeling - The purpose of this task is eliminate or reduce the frequency of those fixed ignition sources in a fire compartment that do not pose a threat to any fire PRA target. This task has two main objectives: 1) to screen out those fixed ignition sources that do not pose a threat to the fire PRA targets within a specific fire compartment, and 2) to assign severity factors to unscreened fixed ignition sources if possible. The goal of this task is to reduce the level of effort of the detailed analysis (Task 11).

Task 9: Detailed Circuit Failure Analysis - For risk-significant fire compartments, more detailed circuit analysis than performed in the Task 3 analysis is used to eliminate some of the cables in the compartments. The purpose of this task is to conduct a more detailed analysis of circuit operation and functionality to determine equipment responses to specific fire induced cable failure modes. This information is then used to screen out cables that cannot prevent a component from completing its credited function.

Task 10: Circuit Failure Mode Likelihood Analysis - The purpose of this task is to quantify the probabilities for fire induced hot short circuit failures that lead to component failure modes of interest. The failure mode probabilities are estimated for the cables of risk-significant components. The methodology used is provided in NUREG/CR-6850, which is based on knowledge gained from recent cable fire tests.

Task 11: Detailed Fire Modeling - In prior tasks, the analyses assumed that a fire would have widespread impact within the fire compartment. In this task, for those fire compartments found to be potentially risk-significant (i.e., unscreened compartments), a detailed analysis approach is provided. As part of the detailed analysis, fire growth and propagation may be modeled. Furthermore, the possibility of fire suppression before damage to a specific target set is analyzed. This task is composed of the following three sub-tasks:

a. Detailed fire modeling of single fire compartments

The purpose of this sub-task is to re-evaluate the risk significant (unscreened) fire compartments in more detail. In this analysis, fire scenarios are defined in terms of ignition sources, target sets, fire growth, propagation pattern and fire detection and suppression features.

b. MCR fire analysis

Although simply another single fire compartment analysis, this sub-task is focused on fires occurring in the MCR taking into consideration issues specific to the MCR, such as main control board fires, continuous manning of the MCR (and how that impacts manual suppression), MCR abandonment criteria, and the estimation of the probability of failure of alternate shutdown given MCR abandonment.

c. Multi-compartment fire analysis

This sub-task analyzes all fire scenarios where it is postulated that a fire may spread from one compartment to another and damage target elements in multiple compartments. In this category of scenarios, damaging effects of a fire are assumed to spread beyond the compartment of fire origin.

This analysis may use a set of screening criteria to reduce the scope of detailed multi-compartment analyses. The screening criteria include lack of additional fire PRA equipment in the adjacent fire compartment, low fire load in the exposing fire compartment, fire scenario frequency of occurrence, and finally CDF. Scenarios surviving the screening are analyzed using the same method as for the single fire compartment case.

Task 12: Post-Fire HRA - In this task, human failure events (HFEs) associated with the fire scenarios are identified, and associated human error probabilities (HEPs) are estimated. Operator actions after fire ignition are assumed to be affected by the fire unless it can be clearly shown otherwise.

Task 13: Seismic Fire Interactions - The main purpose of this task is to identify and correct any weaknesses in the fire protection systems and vulnerabilities in the ignition sources due to seismic events. This is the qualitative evaluation of the potential for: 1) seismically induced fires, 2) degradation of fire suppression systems and features, 3) spurious actuation

of fire suppression and/or detection systems, and 4) degradation of manual firefighting effectiveness. No risks are computed.

Task 14: Fire Risk Quantification - In this task of the analysis process, the fire PRA model is quantified for each final fire scenario, the associated risk values (i.e., CDF and LRF) are computed and risk contributors are identified.

Task 15: Uncertainty and Sensitivity Analyses - The purpose of this task is to determine, characterize and assess the impact of uncertainty on the CDF and LRF estimates. In addition, sensitivity analyses are used to identify and understand the impact of risk significant modeling assumptions.

Task 16: Fire PRA Documentation - The intent of this task is to ensure that the previous analyses are documented in a manner which facilitates review and update. Each task is documented in one or more notebooks which describe the purpose, methodology (including assumptions) and results of the analyses used to complete the associated task.

19.1.5.2.1.1 Deviations from the NUREG/CR-6850 Methodology

Note that not all of the Tasks described above are required to perform a fire PRA. These Tasks involve various types of screening to eliminate assessment of non-risk significant fire scenarios. However, due to the plant being in the design stage, some specific plant details are not yet known, so some of these screening tasks cannot be applied with a high degree of certainty. These tasks include the following:

- Task 4 has not been applied since it is currently not possible to verify that a fire in any one fire compartment will not result in a plant trip in accordance with the qualitative screening criteria identified for that task. The impact of not performing this screening is small since qualitatively screened fire compartments should have no PRA credited components or cables; hence, even if the fire started in one of these compartments, there would be no additional damage to mitigation systems.

- Task 8 has not been applied since specific relational location information between ignition sources and targets are either not known or cannot be confirmed via walkdown. The main unknown factors include intervening combustibles and

conduit. Major plant equipment can be identified on plant general arrangement drawings, and cable tray locations and elevations can be identified on raceway drawings, but the distance between the potential ignition sources and the cable trays is not known. In addition, the location of conduits is not currently available, and walkdowns cannot be performed to identify intervening combustibles.

In addition, portions of Task 11, relating to fire growth and propagation modeling have not been applied for the same reasons described for Task 8, above.

Regarding Task 12, the HRA has been performed using the screening analysis described in NUREG-1921 (Reference 42). After the initial quantification, detailed HEP analysis was performed on the top ten HFEs when ranked by Fussell-Vesely importance. These ten HEPs were incorporated in the final quantification.

19.1.5.2.1.2 Key Assumptions

Various assumptions and engineering judgments provide a basis for the internal fire analysis. Key assumptions and engineering judgments used in this analysis are as follows:

a. All fire doors identified in the Fire Protection Boundary drawings are assumed to be closed during normal operation. Failure of the doors (and other fire barriers) is modeled during the multi compartment analysis (Task 11).

b. Only "credited" equipment is considered in this analysis. No exceptions were made. Credited equipment is defined as equipment required for safe shutdown following postulated fire initiators which has a known location including the location of necessary cables used to operate, or maintain position of the component. Non-credited components are assumed to fail for any fire (Tasks 2 and 3).

c. For the purpose of cable selection, components are assumed to be in their normal expected position or condition at the onset of the fire (with the plant at power operation). In cases where the status of a component is indeterminate or could change as a result of expected plant conditions, worst case initial conditions are assumed (Task 3 and 9).

d. The plant is designed with properly sized and coordinated electrical protective devices (i.e., fuses, molded case circuit breakers, and load center breakers with solid state trip units) which function in accordance with their design tripping characteristics, thereby preventing loss of a common power supply or initiation of secondary fires through circuit faults created by the initiating fire (Task 3 and 9).

e. Fire damage to control cables is assumed to result in the worst case failure mode for the affected component (e.g., failure to operate, or spurious operation, whichever is worse with respect to system function) (Task 3 and 9).

f. Fire damage to fiber-optic cables results in failure to operate the associated component, but does not cause a spurious operation, or prevent normally operating equipment from continuing to operate (Task 3 and 9).

g. If the power cables of a component are located in the same area as the cable identified as potentially causing a spurious operation, it is assumed that the spurious operation will occur before power is lost (Task 3 and 9).

h. Any fire included in this analysis is at least sufficient to trip the plant resulting in a general transient. The trip may be automatic or may be the result of manual trip based on operators following procedures. The fire itself is the initiating event; however, "conditional" initiators (e.g., fire induced loss of feedwater) are identified and analyzed for each fire scenario. The resultant accident sequence progression is the same regardless of whether the event starts due to random occurrences or it is fire induced. Fire induced failures may fail a system, train or component, but the impact on the accident sequence progression is no different than if the system, train or component failed due to random events. Therefore, since the fire does not change the progression of the accident, the internal events event trees can be used for fire accident sequence progression (Task 5).

i. Fire induced direct equipment failure is assumed to be non-recoverable within the time frame of the analysis. Fire induced direct equipment failure refers to components directly impacted by a fire's sphere of influence. However, recovery by other means is acceptable, if possible. For example, manual opening of an alternative undamaged path may be used as a recovery for a fire induced direct valve failure closed, or closing an undamaged redundant upstream or downstream

valve may be used as a recovery for a fire induced flow diversion due to direct valve failure open (Task 5).

j. Fire induced indirect equipment failure is assumed to be recoverable under certain conditions. Fire induced indirect equipment failure refers to components which are failed due to cable failures. If the component can be manually operated (e.g., an MOV with power cable damage can be manually operated by disengaging the clutch on the motor operator), then a recovery may be considered. One notable exception is fire induced spurious operation. The spurious operation may prevent clutch disengagement, or may physically damage the valve (e.g., hot short bypasses torque and/or limit switches). Each spurious operation must be evaluated individually to determine the impact on the component (Task 5).

k. Mechanical equipment that do not require a power source such as manual valves, check valves, mechanical relief valves, safety valves, vacuum breakers, tanks and pipes are not impacted by the fire (Task 5).

l. It is assumed that every fire compartment in the scope of this analysis will at a minimum have an assigned transient ignition frequency. As there is industry evidence of failures to follow administrative control procedures, administrative controls impact the likelihood of transients but do not prevent their occurrence (Task 6).

m. The main turbine building fire compartment (F000-TB) is too large, and has a large amount of roof ventilation such as the formation of hot gas layers. Furthermore, equipment with large sources of lube oil has adequate curbing to prevent the spread of oil, and therefore limit the spread of oil fires. Therefore, fire spread to adjacent fire compartments from the turbine building is not considered credible. Likewise hot gases entering the turbine building from an adjacent fire compartment via a failed barrier will be directed upwards and out the numerous roof vents; hence fire spread to F000-TB is not considered credible (Task 11).

n. Due to the size of the containment building, F000-C01, any hot gas layer formed would be near the top of the dome. This is true regardless of whether the fire originated within containment, or entered containment via a failed barrier from the Auxiliary Building. The top of the dome is well over 45.7 m (150 feet) above the

highest cable tray in containment and the highest penetrations to the Auxiliary Building. Therefore, any hot gas layer formation in the containment would not be located where it is credible to assume: 1) damage to cables within containment, and 2) spread into the Auxiliary Building. Therefore, potential fire spread scenarios from or to F000-C01 are not considered credible (Task 11).

o. It is assumed that automatic suppression systems are designed such that, if successfully activated, will extinguish the fire prior to additional damage beyond the ignition source itself. Hence, if the ignition source is not a fire PRA credited component, successful operation of the automatic suppression system will result in a general transient (likely a manual trip) with no PRA credited equipment damaged. If the ignition source is a PRA credited component, and the automatic suppression system successfully operates, the fire induced initiator will be dependent upon the ignition source (e.g., fire in DC Bus A will result in LODCA initiator), but will only involve the failure of the ignition source. Failure of an automatic suppression system is assumed to result in full room burnout and possible spread to adjacent compartments.

19.1.5.2.1.3 Analysis Details

Task 1, Plant Boundary and Partitioning, is conducted in two parts. The first activity involves definition of the Global Plant Analysis Boundary which is defined for the APR1400 to be the Plant Protected Area and Switchyard; however, it does not include all of the Licensee-Controlled Areas. Notable facilities that are located within the Licensee-Controlled Area but not in the Global Plant Analysis Boundary include the Engineering Building, Wastewater Treatment Facility and Sanitary Water Treatment Facility. Miscellaneous support structures and parking lots are also located throughout the Licensee-Controlled Area, but not included in the Global Plant Analysis Boundary.

Meaningful fire analysis within the Global Plant Analysis Boundary requires establishment of realistic bounds that describe the expected extent of individual fires. The Plant Boundary and Partitioning task establishes these analysis areas by dividing the Global Plant Analysis Boundary into discrete physical analysis units (PAU) or fire compartments. A fire compartment is a well-defined volume within the plant that is expected to substantially contain the effects of fire within the compartment. This volume is typically considered to be a room or clearly distinguishable area of the plant which is separated from other plant

areas by substantial construction or other features that would contain the damaging effects of a fire within the compartment. Almost all fire compartments are completely enclosed by 3 hour fire barriers (or equivalent); however, a few fire compartments have one or more barriers which have only a 1 or 2 hour fire rating. A total of 391 fire compartments were identified (Table 19.1-45).

Task 2 identifies the components to be included in the fire PRA. Components were selected mainly based on a review of the internal events PRA, Fire Safe Shutdown Analysis and the Post-Fire Human Reliability Analysis (Task 12) and included:

- Equipment that if damaged as a result of fire will lead to a plant trip either directly or as a result of operator action,
- Equipment needed to respond to the initiating events identified, and
- Equipment whose spurious operation as a result of fire will either cause a fire induced initiating event or adversely affect the response of systems or operator actions required to respond to a fire.

As part of Task 2, the internal events PRA model for the APR1400 was reviewed to identify the accident sequences that should potentially be included in the fire PRA model. Some of the sequences included in the internal events PRA were eliminated from the fire PRA model. The elimination criteria of the sequences are as follows:

- Sequences associated with initiating events involving a passive/mechanical failure that can be assumed not to occur as a direct result of a fire. Therefore, initiating events that are caused by primary or secondary side pipe breaks, vessel failure, and SGTRs can be eliminated from the PRA model.
- Sequences associated with events that, while it is possible that a fire could cause the events, a low-frequency of occurrence argument could be justified. For example, the anticipated transient without scram sequence has not been treated in the fire PRA because fire-induced failures will almost certainly remove power from the control rods (resulting in a trip), rather than cause a “failure-to-scram” condition. Additionally, fire frequencies multiplied by the independent failure-to-scram probability can be seen as small contributors to fire risk.

As a result, the following accident sequences have been eliminated from the fire PRA model.

- LOCAs (from pipe breaks)
- Reactor vessel rupture
- SGTR
- Feedwater / Main Steam Line Break
- ATWS
- Spurious safety injection signal

The fire PRA credited components and their locations (i.e., fire compartments) within the plant were entered into a Fire PRA database.

In Tasks 3 and 9, the cables associated with fire PRA components were identified, and failure modes for the associated equipment were assigned using Assumptions 2 to 7, above as guidance. All cables for fire PRA equipment are included in the Fire PRA database which also contains cable routing information on a fire compartment and raceway basis. The internal events PRA model was then edited as necessary to incorporate the additional components and failure modes unique to the Fire PRA.

In the next step, Task 6, a fire ignition frequency is estimated for each identified ignition source, and each fire compartment. This task is conducted in accordance with the methodology and information provided in Task 6 of NUREG/CR-6850. Deviations from the methodology of NUREG/CR-6850 have been necessary as a result of further clarifications documented in Supplement 1 of NUREG/CR-6850. Furthermore, the generic fire frequencies provided in NUREG/CR-6850 are not used in this analysis; rather the updated generic fire frequencies from EPRI 1016375 (Reference 43) were used.

Regarding Bin 2, RCP fires, Table 6-1 of NUREG/CR-6850 divides the total RCP fire frequency into electrical (14 percent) and oil (86 percent) fires. An RCP oil collection system is provided to collect lubricating oil that may leak from each RCP motor and route it to a collection tank. Therefore, the likelihood of large RCP oil fires spreading throughout

containment is assumed to be not credible. Regardless, these fire scenarios have not been screened out; rather their impact is assumed to be limited to the local RCP pump area.

There is no Bin 4 (Main Control Room Main Control Boards) in the internal Fire PRA. This bin is the number of control boards that are included in the main control area (i.e., the horse shoe area), as clarified in FAQ 06-0018 (Reference 44). There is no control board/panel in the main control room which meets the definition of a MCB from FAQ 06-0018 which states that the MCB is defined as "the main horseshoe and little else." The backup control is in the form of a safety console which is a group of two cabinets. One cabinet contains only fiber optic cable and control equipment, the other has traditional control equipment. The safety console is counted in Bin 15.1 as an electrical panel.

The FAQ resolution as described in NUREG/CR-6850, Supplement 1, notes that an exception to the described guidance may include "bench-board" panels that were detached from, but directly in front of, the main horseshoe (at some plants such panels are referred to as "consoles"). These bench-board-type cabinets, usually one or two per control room, may be counted as part of the main control board if these panels were (1) serving as an integral part of the main plant monitoring and control functions; (2) located in the center of the operators' main work area; and (3) manned on a nearly continuous basis. But, the Safety Console in the APR1400 is:

- NOT in front of the main horseshoe,
- Does NOT serve as an integral part of the main plant monitoring and control functions as it is only used as a backup given failure of the normal controls,
- Is NOT located in the center of the operators' main work area; it is located on the side wall, and
- Is NOT manned on a nearly continuous basis as it is only used as a backup given failure of the normal controls.

Given that the Safety Console does not meet any of the MCB criteria, it is considered to be an electrical panel and included in Bin 15.1.

Bin 12 (self-ignited cable fires) are not applicable to the APR1400 since all cables are qualified cable, or fiber-optic cable. This is consistent with Appendix R of NUREG/CR-6850.

For Bin 19 (Miscellaneous Hydrogen Fires), the entire generic ignition frequency is split between the fire compartments which contain the miscellaneous piping (System codes GY and HY) and the volume control tank (VCT). For design certification, the miscellaneous hydrogen piping present in each room is assumed to the same as those of the reference plants. The apportioning was made based on the total number of rooms in the plant which contain either miscellaneous hydrogen piping (system codes GW and HY) or the VCT (40 rooms total = 40 counts in the plant). One count is given for each room in each fire compartment which contains the miscellaneous hydrogen piping or the VCT. Therefore, if a fire compartment contains 3 of these rooms, 3/40 of the total ignition frequency is apportioned to that fire compartment.

Bin 20 (Off-Gas/H2 Recombiner) is only applicable to BWRs and is therefore not applicable to the APR1400.

For Bin 35 (T/G Oil), the entire generic ignition frequency is placed in the Turbine Lube Oil Reservoir Room (100-T11) which corresponds to Fire Compartment F100-T11.

Task 7 screens fire compartments from further detailed analysis. The intention of quantitative screening (in conjunction with qualitative screening) is to preclude unnecessary resources being spent doing more detailed analysis for fire compartments which are not risk significant.

There are no set screening criteria for fire induced CDF or LRF. Rather the criteria chosen for the APR1400 was with the intent of achieving Capability Category II in accordance with Table 4-2.8-4(c) of ASME/ANS PRA Standard which suggest that the criteria should not screen the highest risk fire areas, and the sum of the CDF as well as LRF contributors for all screened compartments is less than 10 percent of the total fire CDF as well as LRF. The process is iterative in that performing detailed analysis generally decreases the overall CDF as well as LRF resulting in the need to perform detailed analysis on additional Fire Compartments.

Based on initial screening quantifications, detailed analysis was performed on 38 fire compartments including the MCR, reactor containment building and turbine building. The results of the fire compartment screening are listed in Table 19.1-45. Unscreened fire compartments were evaluated resulting in the development of two or more unique fire scenarios. All total, there were 481 single compartment analyses (SCA) scenarios developed of which 128 were the result of detailed analysis; the remaining 353 scenarios were the screened Fire Compartment full room burnout scenarios. The CDF sum of all screened fire compartments is 1.6×10^{-7}/year, which is less than 10 percent of the total fire CDF of 1.9×10^{-6}/year (and 10 percent of the total single compartment CDF of 1.6×10^{-6}/year). The LRF sum of all screened fire compartments is 1.1×10^{-8}/year which is less than 10 percent of the total fire LRF of 1.7×10^{-7}/year (and less than 10 percent of the total single compartment LRF of 1.5×10^{-7}/year). In addition, the highest unscreened CDF and LRF scenario (both were the complete room burnout of the AAC Building, FN-N00) resulted in about 0.6 percent (9.2×10^{-9}/year) of the total CDF, and about 0.7 percent (1.0×10^{-9}/year) of the total LRF. This indicates that the highest risk fire areas were not screened.

As previously stated, no fire modeling was performed due to lack of sufficient data related to the relational location of the ignition sources and their targets (including intervening combustibles). Therefore, for single compartment fire analyses, all unsuppressed fires are assumed to propagate throughout the entire compartment damaging all PRA credited equipment within. For multi-compartment scenarios, in addition to propagating throughout the exposing compartment (i.e., compartment in which the fire initiated), fire spread is assumed to propagate through barriers at the probabilities associated with the respective barriers under consideration. Generic barrier failure probabilities from NUREG/CR-6850 were used to calculate barrier failure probabilities between adjacent compartments.

Detailed analysis involved taking credit for installed automatic fire suppression systems, and manual suppression for continuously occupied areas (MCR only) and welding and cutting fires (due to the assumed presence of a fire watch during these activities).

Automatic suppression is only credited in fire compartments where it exists, and can be applicable to both fixed and transient ignition sources. Fixed or transient fires suppressed by an automatic suppression system are assumed to result in a plant trip with no damage to fire PRA credited equipment or cables (e.g., general transient fire induced event) unless the ignition source is a fixed ignition source which is a fire PRA credited component. In that

case, the damage state is dependent upon the impact of the failed component. Generic failure probabilities for automatic suppression systems including the impact of automatic detection, if required, were derived from NUREG/CR-6850 (also see Key Assumption o., above).

Outside the MCR, prompt manual suppression is only credited for hotwork fires (i.e., either transient fires due to welding or cutting operations, or cable fires due to welding or cutting operations). From NUREG/CR-6850 Supplement 1, fire growth for transients assume a t^2 growth reaching the peak heat release rate (HRR) at 8 minutes for common trashcan fires to as low as 2 minutes for other common types of plant trash (paper, plastics, and other solid materials) that are contained in plastic trash bags but that are not contained within a plastic or metal receptacle. It is assumed that any of the fire compartments may contain either type (with the possible exception of the MCR where transient combustibles is likely in the form of trash in a receptacle).

However, for the case of hotwork fires, there is at least one person (the person doing the hotwork), and usually a second person (a fire watch) at the fire scene at the start of the fire. Therefore, it is very likely to manually detect the fire in its incipient stage (which is prior to the fire growth stage). There is no industry guidance on the duration of the incipient stage; therefore, a reasonable total time for the manual detection and extinguishment of hotwork fires prior to any damage to fire PRA credited equipment and cables of 10 minutes is assumed. Five minutes for the incipient fire stage, and 5 minutes for the fire growth stage (which is the average of the 2 and 8 minute fire growth times for the two types of transient fires discussed in the preceding paragraph).

Promptly suppressed hotwork fires are assumed to result in a plant trip with no damage to fire PRA credited equipment or cables (e.g., general transient fire induced event). The basis for this assumption is that due to the likelihood of manual detection of the fire during its incipient stage, it is unlikely to burn for a sufficient duration and HRR to damage nearby targets. Furthermore, during hotwork any nearby equipment or transient combustibles are likely protected by welding blankets, or other heat shielding.

For MCR fires, prompt manual suppression is credited if the fire can be extinguished in 8 minutes. The shorter 8 minute timeframe is driven by MCR abandonment criteria, and was chosen based on the time for a common trash can fire to reach its peak HRR. Earlier testing on the effects of fires in enclosed rooms determined that the most significant impact

on the test enclosure was dense smoke which in all cases resulted in total obscuration within 6 to 15 minutes of fire ignition in NUREG/CR-4527 (Reference 45). The size of the test enclosure is about 55 percent of the volume of the APR1400 MCR volume. A larger volume would result in longer obscuration times, so the abandonment times of 8 minutes falls well within the range of this specific set of experiments, and is considered reasonable average abandonment times.

Manual suppression probabilities were derived from Chapter 14 of NUREG-CR/6850 Supplement 1.

Turbine Generator fires were evaluated in accordance with Appendix O of NUREG/CR-6850.

Since the location of intervening combustibles is not known, unsuppressed fires, fixed or transient are assumed to result in the "full room burnout" damage state.

Multiple compartment analysis (MCA) considers the potential for fire spread from one compartment to an adjacent compartment via a failed fire barrier. Screening was performed to eliminate non-minimal MCA scenarios, or scenarios deemed unlikely to happen due to lack of a credible fire spreading mechanism (e.g., hot gas layer, oil spill fire, etc.). Potential MCA compartments were screened if the exposed compartment has no PRA credited equipment since the resulting cutsets will be non-minimal to the exposing single compartment scenario. In addition, potential scenarios involving either the main turbine building (Fire Compartment F000-TB) or the Containment Building (Fire Compartment F000-C01) were screened due to the size and geometry which preclude the formation of a hot gas layer or oil fire spread (see Key Assumptions m. and n.). In total, 1055 unscreened MCA scenarios were identified and evaluated. MCA scenarios account for about 14 percent of the CDF and 13 percent of the LRF.

19.1.5.2.2 <u>Results from the Internal Fire Risk Evaluation</u>

The internal fire risk evaluation of the APR1400 is performed using the design specific fire protection features on the Chapter 9 Appendix 9A and the internal events PRA model of Subsection 19.1.4. Quantification was performed using the SAREX.

The fire CDF and LRF for the APR1400 are as follows:

- Fire CDF : 1.9×10^{-6}/year
  - Single Compartment Fire CDF : 1.6×10^{-6}/year
  - Multi-Compartment Fire CDF : 2.6×10^{-7}/year
- Fire LRF : 1.7×10^{-7}/year
  - Single Compartment Fire LRF : 1.5×10^{-7}/year
  - Multi-Compartment Fire LRF : 2.2×10^{-8}/year
- Conditional Large Release Probability : 0.09

It should be noted that the "year" unit in the full power internal fire section (Subsection 19.1.5.2) refers to a reactor calendar year (rcy).

19.1.5.2.2.1 Fire Induced Initiators

In Fire PRA, the fire is the initiating event. Some fires damage equipment which put the plant in a state equivalent to an internal events initiator. For example, a fire may damage cables resulting in a loss of feedwater event.

Table 19.1-46 shows the percentages of fires resulting in each identified fire induced internal event initiators ranked highest to lowest.

In addition, the following tables indicate the percentage of core damage as a result of each fire induced initiator. Table 19.1-47 and Table 19.1-48 present the CDF and LRF, respectively, for each fire induced initiator ranked from highest to lowest.

The above results clearly show that the vast majority of the plant fire frequency result in general transients with the remaining initiators fairly evenly distributed. This demonstrates the effectiveness of the highly compartmentalized nature of the APR1400 auxiliary building wherein most fires will result in damage to only a few components.

Review of the fire induced initiator impact on CDF and LRF reveals that the vast majority (approximately 60 percent) of all fire induced CDF and LRF is from a MCR Evacuation and Loss of DC Bus “B”; General Transients and LOOPs make up the next significant impact with approximately 30 percent of fire induced CDF and LRF. The remaining fire induced initiators are well distributed and not significant contributors. However, note that the MCR evacuation cases impact is all from a single fire compartment (the MCR). This disproportionate amount is somewhat due to the fact that at the plant design stage there are no procedures governing safe shutdown during MCR evacuation; hence, an estimate of 0.1 is used as a CCDP. A CLRP of 0.01 was used based on the CCDP estimate, 0.1, and the calculated overall conditional large release probability, 0.09.

Finally, note the difference in the CDF impact of LODCB and LODCA initiators. The LODCB contribution is about 10 times greater than the LODCA fire induced initiator.

19.1.5.2.2.2 Fire Scenarios

The top 100 fire PRA CDF cutsets are presented in Table 19.1-49.

The top 4 dominant CDF fire scenarios are described below:

#1 - F157-AMCR-4-4 Trans Fire, Supp. Fails, ASD

Scenario F157-AMCR-4-4 involves unsuppressed transient fires in fire compartment F157-AMCR, the MCR. The MCR analysis assumes the operators have approximately 8 minutes to extinguish a transient fire before visual obscuration results in the need to evacuate the MCR and shutdown from the remote shutdown console (RSC). The 8 minute time frame is based on the estimated time to the peak heat release rate common trashcan fires and a review of room effects testing published in NUREG/CR-4527. An estimated CCDP of 0.1 is assumed for alternate shutdown (ASD) from the RSC. Note that due to the lack of fire PRA credited equipment in the MCR, and use of fiber optic cable for almost all MCR controls, the resulting initiator is likely a simple transient as no PRA credited equipment is directly damaged by the fire and spurious operations resulting in more complicated initiators is unlikely.

#2 - F157-AMCR-3-4 Safety Console Fire, Supp. Fails, ASD

Scenario F157-AMCR-3-4 involves an unsuppressed Safety Console (PM05) fire in fire compartment F157-AMCR, the MCR. The MCR analysis assumes the operators have approximately 10 minutes to extinguish the fire before visual obscuration results in the need to evacuate the MCR and shutdown from the RSC. The 10 minute time frame is based on the estimated time to reach about 70 percent peak heat release rate for cabinet fires which from Appendix G of NUREG/CR-6850 have a 12 minute growth period with a t^2 growth profile and a review of room effects testing published in NUREG/CR-4527. An estimated CCDP of 0.1 is assumed for alternate shutdown (ASD) from the RSC. Note that due to the lack of fire PRA credited equipment in the MCR, and use of fiber optic cable for almost all MCR controls, the resulting initiator is likely a simple transient as no PRA credited equipment is directly damaged by the fire and spurious operations resulting in more complicated initiators is unlikely.

#3 - F157-AMCR-2-4 MCR Fire Control Panel Fire, Supp. Fails, ASD

Scenario F157-AMCR-2-4 involves an unsuppressed MCR Fire Control Panel fire in fire compartment F157-AMCR, the MCR. The MCR analysis assumes the operators have approximately 10 minutes to extinguish the fire before visual obscuration results in the need to evacuate the MCR and shutdown from the RSC. The 10 minute time frame is based on the estimated time to reach about 70 percent peak heat release rate for cabinet fires which from Appendix G of NUREG/CR-6850 have a 12 minute growth period with a t^2 growth profile and a review of room effects testing published in NUREG/CR-4527. An estimated CCDP of 0.1 is assumed for alternate shutdown (ASD) from the RSC. Note that due to the lack of fire PRA credited equipment in the MCR, and use of fiber optic cable for almost all MCR controls, the resulting initiator is likely a simple transient as no PRA credited equipment is directly damaged by the fire and spurious operations resulting in more complicated initiators is unlikely.

#4 - F157-AMCR-1-4 MCR CCTV Subconsole Fire, Supp. Fails, ASD

Scenario F157-AMCR-1-4 involves an unsuppressed MCR CCTV subconsole fire in fire compartment F157-AMCR, the MCR. The MCR analysis assumes the operators have approximately 10 minutes to extinguish the fire before visual obscuration results in the need to evacuate the MCR and shutdown from the RSC. The 10 minute time frame is

based on the estimated time to reach about 70 percent peak heat release rate for cabinet fires which from Appendix G of NUREG/CR-6850 have a 12 minute growth period with a t2 growth profile and a review of room effects testing published in NUREG/CR-4527. An estimated CCDP of 0.1 is assumed for alternate shutdown (ASD) from the RSC. Note that due to the lack of fire PRA credited equipment in the MCR, and use of fiber optic cable for almost all MCR controls, the resulting initiator is likely a simple transient as no PRA credited equipment is directly damaged by the fire and spurious operations resulting in more complicated initiators is unlikely.

The top 100 fire PRA LRF cutsets are presented in Table 19.1-50.

The top 4 dominant LRF fire scenarios are described below:

#1 - F157-AMCR-4-4 Trans Fire, Supp. Fails, ASD

Scenario F157-AMCR-4-4 involves unsuppressed transient fires in fire compartment F157-AMCR, the MCR. The MCR analysis assumes the operators have approximately 8 minutes to extinguish a transient fire before visual obscuration results in the need to evacuate the MCR and shutdown from the RSC. The 8 minute time frame is based on the estimated time to the peak heat release rate from common trashcan fires and a review of room effects testing published in NUREG/CR-4527. An estimated CLRP of 0.01 is assumed for alternate shutdown (ASD) from the RSC. Note that due to the lack of fire PRA credited equipment in the MCR, and use of fiber optic cable for almost all MCR controls, the resulting initiator is likely a simple transient as no PRA credited equipment is directly damaged by the fire and spurious operations resulting in more complicated initiators is unlikely.

#2 - F157-AMCR-3-4 Safety Console Fire, Supp. Fails, ASD

Scenario F157-AMCR-3-4 involves an unsuppressed Safety Console (PM05) fire in fire compartment F157-AMCR, the MCR. The MCR analysis assumes the operators have approximately 10 minutes to extinguish the fire before visual obscuration results in the need to evacuate the MCR and shutdown from the RSC. The 10 minute time frame is based on the estimated time to reach about 70 percent peak heat release rate for cabinet fires which from Appendix G of NUREG/CR-6850 have a 12 minute growth period with a

t^2 growth profile and a review of room effects testing published in NUREG/CR-4527. An estimated CLRP of 0.1 is assumed for alternate shutdown (ASD) from the RSC. Note that due to the lack of fire PRA credited equipment in the MCR, and use of fiber optic cable for almost all MCR controls, the resulting initiator is likely a simple transient as no PRA credited equipment is directly damaged by the fire and spurious operations resulting in more complicated initiators is unlikely.

#3 - F157-AMCR-1-4 MCR CCTV Subconsole Fire, Supp. Fails, ASD

Scenario F157-AMCR-1-4 involves an unsuppressed MCR CCTV subconsole fire in fire compartment F157-AMCR, the MCR. The MCR analysis assumes the operators have approximately 10 minutes to extinguish the fire before visual obscuration results in the need to evacuate the MCR and shutdown from the RSC. The 10 minute time frame is based on the estimated time to reach about 70 percent peak heat release rate for cabinet fires which from Appendix G of NUREG/CR-6850 have a 12 minute growth period with a t^2 growth profile and a review of room effects testing published in NUREG/CR-4527. An estimated CLRP of 0.01 is assumed for alternate shutdown (ASD) from the RSC. Note that due to the lack of fire PRA credited equipment in the MCR, and use of fiber optic cable for almost all MCR controls, the resulting initiator is likely a simple transient as no PRA credited equipment is directly damaged by the fire and spurious operations resulting in more complicated initiators is unlikely.

#4 - F157-AMCR-2-4 MCR Fire Control Panel Fire, Supp. Fails, ASD

Scenario F157-AMCR-2-4 involves an unsuppressed MCR Fire Control Panel fire in fire compartment F157-AMCR, the MCR. The MCR analysis assumes the operators have approximately 10 minutes to extinguish the fire before visual obscuration results in the need to evacuate the MCR and shutdown from the RSC. The 10 minute time frame is based on the estimated time to reach about 70 percent peak heat release rate for cabinet fires which from Appendix G of NUREG/CR-6850 have a 12 minute growth period with a t^2 growth profile and a review of room effects testing published in NUREG/CR-4527. An estimated CLRP of 0.01 is assumed for alternate shutdown (ASD) from the RSC. Note that due to the lack of fire PRA credited equipment in the MCR, and use of fiber optic cable for almost all MCR controls, the resulting initiator is likely a simple transient as no PRA credited equipment is directly damaged by the fire and spurious operations resulting in more complicated initiators is unlikely.

19.1.5.2.2.3 Event Importance

The high importance equipment basic events by RAW and FV for the CDF are presented in Table 19.1-51 and Table 19.1-52, respectively.

The high importance CCF Events by RAW and FV for the CDF are presented in Table 19.1-53 and Table 19.1-54, respectively.

The high importance human actions by RAW and FV for the CDF are presented in Table 19.1-55 and Table 19.1-56, respectively.

The high importance basic events by RAW and FV for the LRF are presented in Table 19.1-57 and Table 19.1-58, respectively.

The high importance CCF Events by RAW and FV for the LRF are presented in Table 19.1-59 and Table 19.1-60, respectively.

The high importance human actions by RAW and FV for the LRF are presented in Table 19.1-61 and Table 19.1-62, respectively.

Review of both the event and operator action FV importance demonstrates the importance of LOOP scenarios. Most of the events with high FV (e.g., grid collapse, EDG failures, TDAFW pump failures) are directly associated with LOOP scenarios, or other partial loss of power scenarios. The top and most dominant operator action (by FV) is the action to restore power to the Class 1E SWGR via the AAC generator.

The dominant basic event RAWs show high reliability equipment which supports multiple trains or systems. These include water tanks and electric busses. Although water tanks will generally not be impacted by fires, these results demonstrate the importance of protecting electrical buses from fire.

The RAW gives an indication of the importance by estimating the increase in CDF given failure of the event. With respect to operator actions, this indicates which actions are most critical to perform correctly. Regarding operator actions, the RAW values are relatively low due to the fact that screening values from NUREG/CR-1921 were used for the analysis,

and therefore the HEPs are quite high. Regardless, the action to transfer the auxiliary feedwater source to an alternate source is still clearly dominant. This is expected as all fire induced initiators modeled credited AFWS.

19.1.5.2.2.4 PRA Based Insights

The APR1400 design features which promote reduced fire risk are as follows.

a. The APR1400 has two divisions each consisting of two trains of safety systems. Each division is segregated with physical fire barriers so as to protect the safety function of safety systems from fires impacting the opposite division.

b. The Auxiliary Building is divided into four quadrants, two quadrants per division. Each quadrant contains the equipment for a safety train.

c. The APR1400 has a highly compartmentalized auxiliary building comprised of many fire areas with 3 hour fire rating barriers so as to minimalize the impact from any single fire in the auxiliary building.

d. The APR1400 uses fiber optic cables between the MCR Safety Console, the group controllers and loop controllers thereby minimizing the impact from fire induced spurious hot shorts.

e. The APR1400, alternate ac (AAC) power source is a non-Class 1E power source which can be used as a common ac source to cope with SBO scenarios. This standby gas turbine generator unit is independent and diverse from the Class 1E standby EDGs.

The fire PRA was used to identify potential design features and plant operational vulnerabilities, where a small number of failures could lead to core damage, containment failure, or large releases. Based on this analysis, the plant design was altered as follows:

a. The cable routes connecting yard transformers to the SWGR within the turbine building had a high risk because the fire frequency of the turbine building is high and its fire severity is large. Therefore, the cable route has been designed to not pass through the turbine building, but rather enter the turbine building directly into

the switchgear area, Fire Compartment F073-T11. This routing minimizes the ignition sources which in the Turbine Building which can impact offsite power.

b. Several cables have been identified as requiring fire protection features to prevent damage or spurious operation of related components.

19.1.5.2.2.5 Insights from the Uncertainty, Importance, and Sensitivity Analyses

The results of the internal fire risk assessment show that internal fire events pose a low risk to the APR1400 design. The major contribution to internal fire risk is MCR evacuation which uses an estimated CCDP and CLRP due to lack of fire procedures. To better understand the impact of the MCR results, a sensitivity analysis was performed assuming the MCR cabinets had very early warning fire detection systems (VEWFDS). Following the procedure in NUREG/CR-6850, Supplement 1, the total CDF for all MCR cabinet fire cases dropped from about 3×10^{-7}/year to about 6×10^{-9}/year. The overall CDF would drop to about 1.6×10^{-6}/year from 1.9×10^{-6}/year.

19.1.5.3 Internal Flooding Risk Evaluation

The following subsections describe the internal flooding risk evaluation including the results of the evaluation.

19.1.5.3.1 Methodology and Approach

The annual probability of core damage from internally initiated floods varies significantly for nuclear plants primarily due to design-specific features that serve to either increase or eliminate the potential for internal flooding events to impact safety-related equipment.

The APR1400 design emphasizes the elimination and minimization of potential flood sources within safety-related areas as a means of flood protection. Therefore, internal flooding events should not be significant contributors to risk for the APR1400. However, past PSAs have shown that internal floods could contribute significantly to core damage. Hence, an evaluation of the risk for the internal flood at power operation was performed for the APR1400.

The objectives of the internal flood risk analysis for the APR1400 are to estimate the contribution of an internal flood to overall plant's core damage frequency at full power operation, to identify any plant-specific vulnerability to flood-induced accidents, and to provide necessary information for plant designs.

The APR1400 Plant includes a number of design features that provide flood protection to safety-related structures, systems and components. These flood protection measures are designed in accordance with NRC RG 1.102 (Reference 46).

Because sufficient plant design information such as location of terminal boxes, valves, instruments, drain capacities and locations and other flood mitigation devices like emergency overflow (EOF) paths, are not available at the time of the analysis, the plant risk due to flooding originating in several buildings was estimated by using conservative assumptions and simple flood scenarios as described in following subsections.

The internal flooding analysis for the APR1400 was performed in the following broad stages:

- Identification of flood sources and target equipment.
- Definition of flood areas
- Qualitative screening
- Accident sequence definition
- Initiating event analysis
- Internal flooding human action development
- Quantification of flooding sequences

19.1.5.3.1.1 Identification of Flood Sources and Target Equipment

The major flood sources in the APR1400 were identified from the review of design calculations, system functional descriptions and general arrangement drawings. The potential flood sources in plant buildings are described below and the flood sources that

cannot damage the equipment used for accident mitigation or to lead to an initiating event are screened out from further consideration.

The internal flooding analysis considers any uncontrolled release of fluid from any plant system. However, from a practical point of view, release of fluid from some systems does not present a credible potential to damage equipment or result in a reactor shutdown. Such systems can be identified and screened from consideration as flood sources.

Systems and equipment used mitigate accident sequences were determined in the internal events PSA; therefore, those systems and equipment that were identified in the internal events analysis were reviewed to select the susceptible equipment by internal flooding. Major equipment, such as pumps, essential water chillers, diesel generators, electrical equipment, valves and instruments were selected from reviewing the general arrangement drawings, P&IDs, and single line diagrams.

19.1.5.3.1.2 Definition of Flood Areas

The development of the internal flood area definitions consists of the following steps:

a. Identify plant systems which could contribute to internal flooding. The APR1400 design contains many fluid systems. While the uncontrolled release of fluid from every system should be considered, in practice, some systems do not present a credible potential to damage equipment. Such systems can be identified and screened from consideration as flood sources.

b. Summarize and describe the areas considered for internal flooding. Include the boundaries for each area and how each area interfaces with adjoining areas. Summarize the penetrations and any associated barriers in each of the area boundaries and how the boundaries interface with adjoining areas. Include this summary flood mitigation features in each area. Identify the flood-susceptible, PRA-related equipment in each area. Identify flood sources in each area.

c. Assess and tabulate communication or propagation paths. Identify each normally-open communication path leading from each area. Tabulate barriers to communication or propagation paths. Assess the ability of each barrier to withstand flooding events. Determine if accumulation in the walkdown room

could cause failure of the barrier. Determine if propagation following failure of a barrier could cause failure of PRA related equipment in the adjoining walkdown room.

The following key assumptions were made during the development of internal flood area definitions:

a. Minor leakage under and around doors will not directly impact equipment on the opposite side unless otherwise noted.

b. All junction boxes are gasketed and not vulnerable to spray or splash unless otherwise noted.

c. Flood-induced failure of MOVs involves the valve operator's loss of function, but does not involve the MOV changing position. The MOV is expected to remain in its original position.

d. Flood-induced failure of AOV involves the valve operator's loss of function and could also involve the AOV failing to its fail-safe position.

e. Sealed penetrations are assumed to pass no fluid provided flood levels remain within the design limits of the seals.

f. Cable insulation is not subject to failure from submergence or spray.

g. Walls and engineered barriers are assumed to remain intact throughout a flooding event.

19.1.5.3.1.3 Qualitative Screening

A screening process was developed to eliminate from further consideration flood areas that do not truly represent flooding risks. Screening criteria were developed using criteria from ASME/ANS PRA Standard as endorsed by NRC RG 1.200. Considering the criteria in these documents and accounting for plant-specific system capabilities, the APR1400 Flooding Analysis screens flood areas and flood sources based on the following criteria:

a. The zone contains no flood source and no flood source can propagate into the zone either through normal pathways or through failure of barriers from other zones resulting in equipment damage.

b. Flooding of the zone would not cause an initiating event or need for immediate plant shutdown and the zone contains no mitigating equipment modeled in the PRA.

c. Flooding of the zone would not cause an initiating event or need for immediate plant shutdown and no flood source, either internal to the zone or by propagation into the zone, can cause failure of mitigating equipment modeled in the PRA.

d. The flood zone contains flooding mitigation systems (e.g., drains or sump pumps) capable of preventing unacceptable flood levels, and the nature of the flood does not cause equipment failure (e.g., through spray, immersion, or other applicable failure mechanisms).

e. The flood only affects the system that is the flood source and the systems analysis addresses this and need not be treated as a separate internal flooding initiating event.

f. Human actions can mitigate the flooding event and the flood source therefore may be screened as long as all the following can be shown:

    1) Flood indication is available in the control room;

    2) The flood source can be isolated; and

    3) The mitigating action can be performed with high reliability for the worst flood from that source. High reliability is established by demonstrating, for example, that the actions are procedurally directed, that adequate time is available for response, that the area is accessible, and that there is sufficient manpower available to perform the actions.

19.1.5.3.1.4 Accident Sequence Definition

The analysis of the internal flooding accident sequences consists of the following steps:

a. Review information collected from the internal flooding design documentation review (and the previously listed analysis steps), including flood areas, possible flood sources, critical flood heights for equipment modeled in the PRA, drainage capacities and paths, flood detection instrumentation, interconnecting areas, and potential barriers (curbs, dikes, doors, etc.).

b. Extract the information needed to develop flooding scenarios. Such information includes: flood area identifier, possible flood sources and the flood hazard presented by each source, modeled PRA equipment in each area, critical flood heights for modeled PRA equipment, drainage paths and capacities, interconnecting areas, flood barriers, and flood detection instrumentation.

c. Collect other necessary information, including floor area of the flood area, and identification of which system trains have piping in each flood area.

d. Identify any areas which may be qualitatively screened.

e. Determine the potential flood scenarios for each flood area, including damage within the area, flood egress from the area, damage to connecting areas and associated flood heights, detection of the flood, potential means of isolation, and potential for unisolated floods to fill multiple flood areas.

f. Calculate the timing associated with flood detection and isolation, based on break flow rate, location of detection instrumentation and PRA equipment, floor area or the associated areas, flood level alarm depths, and equipment critical flood heights

Following development of the flood scenarios and corresponding accident progression, the accident sequence and system fault trees constructed for the APR1400 Internal Events PRA are then modified and requantified in order to evaluate the effects of flooding in each flood area in terms of the resulting accident sequence frequencies.

The assumptions listed below are used in the flood source screening and accident scenario development.

a. Sump pumps have a flow capacity of 22.7 m^3/hr (100 gpm) or less.

b. Alarm response procedures will direct prompt operator action to investigate locally any room flooding alarm and isolate any leaks that are causing the flooding.

c. Where they exist, room flooding alarms will be actuated with water level in the affected room at 0.30 m (1 foot) or less.

d. Motor-operated valves are assumed to fail due to submergence when water level reaches 0.91 m (3 feet) in the room where the valve is located. This height is based on experience and is considered a minimum height. If this assumption becomes risk significant for a specific scenario, it can be examined on a case-by-case basis.

e. Vertical pumps are assumed to fail due to submergence when water level reaches 0.91 m in the room where the pump is located. This height is based on experience and is considered a minimum height. If this assumption becomes risk significant for a specific scenario, it can be examined on a case-by-case basis.

f. Horizontal pumps are assumed to fail due to submergence when water level reaches 0.46 m (18 inches) in the room where the pump is located. This height is based on experience and is considered a minimum height. If this assumption becomes risk significant for a specific scenario, it can be examined on a case-by-case basis.

g. For areas with an EOL to a lower elevation, it is assumed that no PRA-related equipment will fail for flood levels below the design flood level for the EOL.

h. Leak tight HELB barriers are assumed to prevent flood propagation.

i. Where propagation exacerbates the accident scenario, door failure is assumed to occur at a differential water height of 0.30 m.

j. Batteries for the 125 V dc systems are assumed to fail when the terminals become submerged. The height of terminals is assumed to be 0.91 m above the floor.

k. Any break of a pipe containing water at conditions that exceed atmospheric saturation conditions has the potential to cause a pressure transient in the room and challenge barriers to adjoining areas. Unless specific analyses of the pipe break are available, it is assumed that any significant break of a pipe containing fluid above saturated conditions will cause a pressure transient resulting in failure of all doors to the immediately-adjoining areas. Other barriers, for example, sealed

piping penetration, are assumed to be capable of withstanding the steam pressure transient.

l. Unless explicitly analyzed, failure of a pipe containing water above saturated conditions is assumed to actuate all fire protection systems in the room in which the break occurs as well as in any room where significant propagation occurs.

m. Significant propagation of steam is assumed to occur only through failed doors, open passageways, open stairwells, HVAC ducting, and open floor grating. While some propagation of steam would occur through open pipe and cable penetrations or EOL lines, this propagation is not considered significant and fire protection system actuation is not considered.

n. Failure of auxiliary steam (AS) or steam generator blowdown (SGB) system piping in the auxiliary building is assumed to be incapable of resulting in pipe whip or unique jet impingement failures.

o. Minor leakage under and around doors will not directly impact equipment on the opposite side unless otherwise noted.

p. All junction boxes are gasketed and not vulnerable to spray or splash unless otherwise noted.

q. Flood-induced failure of MOVs involves the valve operator's loss of function, but does not involve the MOV changing position. The MOV is expected to remain in its original position, however any new change in position is assumed to be failed unless otherwise noted.

r. Flood-induced failure of AOV involves the valve operator's loss of function and the AOV failing to the undesired position.

s. Sealed floor penetrations are assumed to pass no fluid provided flood levels remain within the design limits of the seals.

t. Cable insulation is not subject to failure from submergence or spray.

u. Walls and engineered barriers are assumed to remain intact throughout a flooding event.

v. Lines that are not normally pressurized or charged such as drain lines or abandoned in-place systems are not considered as credible flood or spray sources. Note that relief lines downstream of a relief valve are not normally pressurized and are not included.

19.1.5.3.1.5 Initiating Event Analysis

The accident sequence documentation is examined to ascertain the initiating events for which frequency estimates must be obtained.

The flooding induced initiating events developed for the APR1400 are divided into three categories of causes:

- Tank rupture events causing flooding
- Maintenance related events causing flooding
- System pipe rupture events causing flooding

No tank ruptures were identified as causing unique effects or contributing to internal flooding events.

Maintenance induced flooding events were considered in the analysis. However, a bounding analysis was performed to demonstrate that the maintenance-induced flooding event is a negligible contributor to the overall initiating event frequency.

A limited number of flood-vulnerable plant systems were identified for inclusion as potential flood sources and are listed in below along with their corresponding rupture rate group as defined in EPRI 1021086 (Reference 47). Reasons for using these systems included:

- The system possesses adequate inventory to present an obvious submergence threat.
- The system piping is in close proximity to equipment that is important to accident mitigation.

- The system itself is important to accident mitigation and could be made unavailable by a system pipe rupture.

- A rupture of the system piping could result in the initiation of a system that could cause flooding.

All other plant systems were screened from consideration as flooding sources due to the reasons stated separately. Screening justifications included:

- The system does not transport fluid (e.g., a compressed air system).

- The system piping is normally dry and is a flooding source only during accident mitigation.

- The system or piping is isolated during operation.

- A rupture in the system piping would disable only that system and no reactor trip would result.

Calculation of system pipe break frequency values uses the methodology described in EPRI 1021086. For each internal flooding initiating event, the zones that include each system are identified in the accident sequence analysis and the length of pipe to be considered is identified.

The size groups in this analysis are designated as:

Size Group 1 : 0 cm ≤ ID ≤ 5.08 cm (2.0 inches)

Size Group 2 : 5.08 cm (2.0 inches) < ID ≤ 10.16 cm (4.0 inches)

Size Group 3 : 10.16 cm (4.0 inches) < ID ≤ 15.24 cm (6.0 inches)

Size Group 4 : 15.24 cm (6.0 inches) < ID ≤ 25.4 cm (10.0 inches)

Size Group 5 : 25.4 cm (10.0 inches) < ID ≤ 60.96 cm (24.0 inches)

Size Group 6 : ID > 60.96 cm (24.0 inches)

Flood induced initiating events for the APR1400 were defined. The pipe lengths used to develop the frequency values were primarily identified using plant isometric and piping arrangement drawings to develop overall pipe location drawings for each system.

Given the lack of operational data for the reactor design, the generic data of EPRI 1021086 is applicable to the APR1400. The categories and the values for the generic rupture rates used for the APR1400 internal flooding use EPRI 1021086 data as the basis for the initiating event frequency.

Each flood frequency is a statistical estimate with an associated uncertainty, which is characterized by its error factor (EF). The EF is an appropriate risk metric for failure rates, which often have a log-normal distribution. The EF is similar to the standard deviation for normally distributed data.

The error factors (EFs) are identified as range factors (RF) in EPRI 1021086. The rupture frequency for each pipe segment has an associated EF which is found by linear interpolation, at intermediate break sizes, from the EPRI 1021086. Calculations that involve the difference of rupture frequencies, at different break sizes, may have two different EF values; in such a case the larger EF in utilized.

Each Initiating Event consists of at least one (and frequently many) different pipe segments. The overall Error Factor for each IE is assumed to be the largest EF for any segment with a contribution to that IE.

The following assumptions were utilized in the definition of internal flooding initiating event frequencies:

a. The fire protection (FP) and circulating water (CW) systems are assumed to have an infinite volume of water. All remaining systems that represent internal flooding sources are considered to have finite sources of water supply.

b. A minimum break size of 0.082 cm (0.032 inches) is used when any break flow range does not include a lower limit.

c. Each pipe segment is evaluated against its minimum and maximum estimated break size (EBS) for consistency. If the nominal pipe size is too small to

contribute to flooding at the minimum EBS rate for any segment, then the segment screens out. For example, if a nominal pipe diameter D is 10.16 cm (4.0 inches) and the minimum EBS is 7.62 cm (3 inches), then the segment's flood frequency will be retained. Pipe segments that cannot cause flooding at the minimum EBS rate are screened out.

d. Some systems are vulnerable to a double-ended "guillotine" break and can flood from both ends of a pipe. This vulnerability is assumed to exist for recirculating, closed-loop systems (e.g., component cooling water system), "ring header" systems (e.g., fire protection system) and systems with cross-tied trains (e.g., main steam system). Although portions of double-ended vulnerable system will branch off of the main header (e.g., FP piping from normally closed valves to the spray nozzles), those segments will be treated conservatively and all of the piping in a given system will be treated consistently. Thus all of the FP piping will be treated as double-ended rupture vulnerable, for example.

e. A $\sqrt{2}$ factor is applied to account for the possibility of flow through both sides of a double-ended "guillotine" break. If [$\sqrt{2} \times D$] is larger than the minimum EBS, it will be included in the calculations. The segment is screened out otherwise. For example, if a nominal pipe diameter D is 2.54 cm (1.0 inch), and the minimum EBS is 3.30 cm (1.3 inches), then $D \times \sqrt{2}$ is 3.56 cm (1.4 inches) and the segment will be retained.

f. Some segments of normally pressurized systems are normally isolated and have been screened out. These segments may include drain lines downstream of an isolation valve, for example.

g. The EBS calculation is conservatively treated, in some cases, as a simplifying assumption. For example, if a 25.4 cm (10 inches) pipe is analyzed for minimum and maximum break sizes between 10.16 cm (4 inches) and 20.32 cm (8 inches), the calculation is straightforward and the difference in relative frequencies is best estimate. However, a 12.7 cm (5 inches) diameter pipe may be analyzed for breaks between 10.16 cm and 20.32 cm, or any break larger than 10.16 cm, even though it can only experience a maximum rupture size of $\sqrt{2} \times 5$ inches, assuming the segment is double-ended vulnerable. This approximation conservatively results in a slight over-estimation of flood frequency for some segments.

h. The water density will be assumed to be 999.6 kg/m^3 (62.4 lbm/ft^3) (using the ASME steam table value at standard temperature and pressure [STP] for most systems). This value will be assumed to vary negligibly at all system conditions which can be potential flood contributors, with the following exceptions:

- Feedwater discharge: 829.8 kg/m^3 at 232.2 °C and 91.4 kg/cm^{2}g (51.8 lbm/ft^3 at 450 °F and 1300 psig)
- Main Steam and connected systems: 35.2 kg/m^3 at 69.3 kg/cm^{2}g (2.20 lbm/ft^3 at 985 psig)

i. Several FP segments are normally dry until a trip signal opens an upstream isolation valve. These lines were screened out.

Table 19.1-63 lists all of the initiators and their associated frequencies. The Adjusted Initiating Event Frequency (“Adjusted IE Freq” column) is based upon an assumed 95 percent unit capacity factor.

19.1.5.3.1.6 Internal Flooding Human Action Development

The internal flooding HRA analysis consists of two separate analyses. The first analysis is the development of internal flooding human error probability basic events for the isolation of flooding sources. The second portion of the analysis involves the modification of HEP values for operator actions in the initiating events model which result in a different failure probability than for internal events.

The first portion of the analysis is carried forward with methods similar to those utilized for internal events (but for a different hazard group). See Subsection 19.1.4.1.1.6 for the details of this methodology.

The second portion of the analysis is the analysis of non-flood mitigation HEPs when a flooding event is the initiator. Post-flood HFEs unrelated to flood mitigation were evaluated as required per the ASME/ANS PRA Standard. Flooding events were segregated into two categories:

a) Operator actions performed outside the main control room (MCR).

b) Operator actions performed within the MCR.

If the action is entirely performed inside the MCR, the only possible effect on the operators from the flooding scenario is an increased level of stress. Credited operator actions performed from within the MCR, however, are almost completely procedurally driven and are symptom based (not scenario based). This implies that the operators will respond in the same manner to mitigating functions failed by flooding as they would to those failed by random equipment failures and/or maintenance unavailability. Furthermore, many of the initiating events in the reactor building do not cause a plant trip but are modeled as initiators because they will require a controlled plant shutdown due to technical specification requirements or other operational considerations. In this case, the operators are actually under less stress than is implied by the baseline HEP values. Many of the credited operator actions with short scenario times (e.g. ATWS mitigation) already have a high stress level associated with them and the addition of a flood scenario results in a minimal increase in stress level.

Sufficient staffing is present for the operating crew to investigate the cause of flooding symptoms and respond to events in the control room without compromising the ability to perform either function.

The effect of flooding on the HEP values for human actions performed within the MCR is considered to have a negligible effect on the overall HEP value. An examination of all credited human actions performed inside the main control room was performed and no outliers were found that warranted further analysis.

If a portion of the action is performed outside the main control room, limited or no credit should be taken for those flood scenarios in which the location of the action performance may be affected by the flooding effects. Therefore, an analysis was performed to determine which human actions performed outside of the control room should be failed as a result of flooding. The approach used was conservative in that, unless otherwise stated, a human action deemed to have a significantly degraded probability of success was modeled as being failed.

If the areas where a portion of the human actions are performed are subjected to spray or contain standing water as a result of direct deposition or propagation in a flood scenario, the human actions performed in that area are conservatively assumed to fail.

19.1.5.3.1.7 Quantification of Flooding Sequences

Quantification refers to the solution of the internal flooding accident sequences in order to generate an estimated frequency of core damage. For each postulated internal flooding scenario, the flood-induced equipment failures are included in the logic models. Then each scenario is quantified a process similar to that used for the internal events PRA quantification.

19.1.5.3.2 Results of Internal Flooding Evaluation

19.1.5.3.2.1 Risk Metrics

The total CDF from internal flooding events is 2.2×10^{-7}/year. Total LRF from internal flooding events is 1.7×10^{-8}/year. It should be noted that the “year” unit in the full power internal flooding section (Subsection 19.1.5.3) of this chapter refers to a reactor calendar year (rcy).

19.1.5.3.2.2 Significant Initiating Events

Significant flooding initiating events that contribute to the CDF and the LRF are shown in Table 19.1-64 and Table 19.1-65, respectively.

All of the significant events that contribute to CDF are flooding events in the auxiliary building. Furthermore, all the events that contribute to CDF are breaks which are larger than the design basis break. The vast majority of initiating events that contribute to internal flooding core damage risk are caused by breaks in the fire protection system.

The largest contributor to CDF is a large fire protection system break in Quadrant B. This event begins with a break that propagates to and causes failure of Train B electrical equipment. Accumulation of water causes failure of the door between Quadrants B and D and the subsequent surge of water causes loss of Train D electrical equipment. Failure of secondary cooling and failure of equipment needed to support feed and bleed cooling results in core damage.

The second largest contributor to CDF is a major beak of FP piping on the 100-feet elevation that propagates to Train A and Train C switchgear before operator action to isolate the break is successful. Otherwise, the accident progression for this event is similar to the progression described for the second event above.

The third largest contributor to CDF is similar to the first, but the initiating event occurs in Quadrant A and propagates to Quadrant C.

The fourth largest event contributing to CDF is a major break of FP piping on the 78-feet elevation that cannot be isolated before propagation causes failure of equipment. Although the specific equipment failures vary slightly, the accident progression for this event is similar to the first event described above.

The significant events and cutsets and sequences that contribute to LRF are the same as the significant contributors to CDF. This can be seen by comparing the dominant flooding events in Table 19.1-64 (CDF) with Table 19.1-65 (LRF), and by comparing the dominant flooding cutsets in Table 19.1-66 (CDF) with Table 19.1-67 (LRF).

19.1.5.3.2.3 Significant Cutsets

The top 100 internal flooding CDF cutsets are shown in Table 19.1-66. Although the specific initiating event and hardware failures vary slightly between each cutset, the overall accident progression is the same. That is, a flooding event occurs and cannot be isolated before barriers to adjoining areas are challenged. Propagation causes flood-induced failure of two trains of electrical power. The resulting hardware failures result in a general transient or require an immediate reactor shutdown per technical specifications. Random hardware failures then preclude operation of secondary cooling and feed and bleed cooling for decay heat removal.

The top 100 LRF cutsets are shown in Table 19.1-67.

19.1.5.3.2.4 Risk-Significant Functions/Features, Phenomena/Challenges, and Human Actions

Importance measures for SSCs and human actions for the internal flooding analysis with respect to CDF are contained in Table 19.1-68 through Table 19.1-73.

Importance measures for SSCs and human actions for the internal flooding analysis with respect to LRF are contained in Table 19.1-74 through Table 19.1-79.

Because nearly all internal flooding events result in a general transient, the important event with respect to FV and RAW are related to maintaining decay heat removal. The most important events are related to loss of electrical power to the safety-related buses followed by equipment failures in the AFWS. Support systems such as chilled water that ensure availability of multiple front-line systems are also important.

The dominant equipment RAWs show that high reliability equipment, such as electrical buses, which support multiple trains or systems can cause a significant increase in risk. These failures are particularly important with respect to common cause failures.

19.1.5.3.2.5 Insights from the Uncertainty, Importance, and Sensitivity Analyses

The results of the internal flood risk assessment show that internal flooding events pose a low risk to the APR1400 design. The major contributors to internal flooding risk are beyond-design-basis breaks of the fire protection system. Such breaks, which contribute to over 90 percent of the internal flooding CDF, are significant because fire protection is the only system in the auxiliary building with sufficient volume to result in inter-quadrant propagation and damage to equipment needed for accident mitigation. Flooding caused by other systems are of finite volume or low flow rate and do not present a significant potential for propagating across quadrants.

The results of the internal flood risk analysis for at-power operation showed that internal flooding poses a small risk in the APR1400 design. The low risk from internal flooding events is due to physical separation provided by the plant layout and the design features implemented for the APR1400.

The results of the quantification show that beyond-design-basis flooding events in the auxiliary building represent nearly all of the risk for internal flooding accident sequences. The primary contribution to auxiliary building flooding risk is from failure of the fire protection piping. Flooding in other buildings is an insignificant contribution to overall risk.

The APR1400 design includes a number of features which provide flood protection to safety-related structures, system and components. These features (listed below) influence the low overall risk significance of internal flooding for the APR1400.

a. Divisional Separation

   In the auxiliary building, flood barriers have been integrated into the design to provide further flood protection while minimizing the impact on maintenance accessibility. The primary means of flood control in the auxiliary building is provided by the structural wall which serves as a barrier between redundant divisions of safe shutdown systems and components. At the lowest elevation, this structural wall contains no doors or passages, and the limited penetrations through the wall will be sealed. These design confines flood water to one division on the lowest elevation. Thus, one division will be unaffected by flooding originating in the other division.

b. Quadrant Separation

   In the auxiliary building, each half of the division is compartmentalized into separate redundant safe shutdown components to the practical extent, while maintaining accessibility requirements. The bottom of the auxiliary building, which houses the front line safety systems, is compartmentalized into quadrants, with two quadrants on either side of the divisional structure wall. Flood barriers with a flood door provide separation between the quadrants. This design confines flood water to one quadrant up to elevation of 78 feet. As preliminary calculated in the deterministic design for the flood protection volumes, the potential flood sources are less than the free volume for each quadrant. Therefore, the volume of water contained in one quadrant of these systems would not rise above the lowest elevation. Thus, the equipment in the adjacent quadrants will be unaffected by the flood. The flood door installed between the quadrants in a

division will be provided with open and close sensors and alarmed in the control room. A flood door will be designed to withstand the static pressure from the maximum flood elevation as determined in the design.

c. Control Complex

The APR1400 control complex is protected from flooding such that no water lines are routed above and through the control room or computer room. Water lines routed to HVAC air handling units around the control room are contained in the rooms with curbs, which prevent any potential water leakage from entering the control room or computer room.

d. Safety-Related Electrical Equipment

At higher elevations electrical equipment will be elevated above the floors so that flooding events will not affect the components. Additional barriers (curbs, ramps, sealed penetrations, etc.) will be provided to mitigate the effects of the postulated pipe ruptures. Elevated equipment pads also prevent equipment from being inundated in the events of flooding.

e. Cooling Water System

AFWS, CCWS, ECWS, ESWS, etc., are separated by division with no open cross connections, thus a single pipe break resulting from a division of those systems does not affect the other division.

f. Piping Routing

Lengths of high energy and moderate energy piping will be minimized by equipment location. Equipment is located in quadrants around the bottom of auxiliary building to minimize the lengths of piping runs. This arrangement provides further close proximity of equipment to reduce piping runs from containment.

g. Floor Drainage Systems

Flood protection is also integrated into the floor drainage systems. The floor drainage systems are separated by quadrant and valves which prevent the backflow of water to areas containing safety-related equipment. Each quadrant contains its own separate sump equipped with redundant sump pumps and associated instrumentation. These pumps are also powered from the diesel generator in the event of loss of offsite power. The auxiliary building also has its own quadrant separate drainage system, having no common drain lines between quadrants. Floors are gently sloping to allow good drainage to the quadrant sumps. Floor drains will be routed to the lowest elevation to prevent flooding of the upper elevations. The lower elevation in each quadrant has adequate volume to collect water from a break in any system without flooding the other quadrant. In addition, potential discharges of fixed fire suppression systems and fire hoses is considered in the sizing of floor drains to preclude flooding of areas should the fire protection systems be initiated.

h. Emergency Flow Paths

In some flood areas of the auxiliary building, normal floor drains would not have sufficient capacity to accommodate design basis flooding. In case that, emergency drain paths will be provided; emergency drain paths from upper to lower elevations within a quadrant will be routed to the section of the radioactive drain sump area dedicated to that quadrant. In the bottom of auxiliary building, overflow provisions between safety-related area and non-safety-related area in each quadrant will be provided to hold the maximum flood source within each quadrant. In the turbine building, design base flooding is designed to accommodate by appropriately sized openings.

i. CC Heat Exchanger Building and SX Intake Structure/Pump House

Flood protection will be incorporated into the CC heat exchanger building and SX intake structure/pump house. SX pumps and CC heat exchangers are located outside the auxiliary building. These structures are divisionally separated by walls such that a flood in one division cannot propagate to the other division.

j. Condenser Circulating Water

The Circulating Water System's piping is confined to the Turbine Building. Therefore, this unlimited flood source in the Turbine Building is not permitted to flow into the Auxiliary Building.

k. Flood Protection Features between Auxiliary Building and Turbine Building

   Doors between the auxiliary building and turbine building are located above the maximum turbine building flood elevation.

The major reasons for the low risk from flooding are as follows:

a. The flood protection design effectively eliminates the possibility that a turbine building flood can propagate to other buildings and damage equipment.

b. Equipment needed to mitigate internal flooding sequences is not located in the turbine building.

c. Potential flood sources in the auxiliary building are of finite volume such that the potential for propagation between flood areas is minimized or the potential flow rate from a system is limited thereby providing time for operator action to terminate a flood.

d. The auxiliary building is separated into quadrants with flood barriers between quadrants. This separation minimizes the potential for propagation resulting from a flood to impact multiple trains of equipment used to mitigate accident scenarios.

e. The APR1400 design uses emergency overflow lines (EOLs) to ensure that fluid released on the upper elevations of the auxiliary building is directed to the lowest elevation within the quadrant. This feature minimizes the potential for accumulation and propagation to impact equipment in the auxiliary building.

f. The lowest flood areas in each quadrant of the auxiliary building are designed to contain over 2,271 m^3 (600,000 gallons) of water without impacting equipment in adjoining quadrants. Watertight barriers, designed to withstand at least nine feet of accumulation, are provided between quadrants on the lowest elevation of the auxiliary building.

As mentioned above, significant internal flooding events are caused by beyond-design-basis breaks in fire protection piping. Because of the large volume that could be released from the fire protection system, operator actions to identify and isolate any fire protection system break are credited in the analysis. Because of the holdup capacity of the lower elevation in the auxiliary building, significant time is available for operators to isolate these breaks in most scenarios. Clear and compelling cues from quadrant sump alarms, quadrant flooding alarms, and fire pump running alarms ensure that the actions are initiated promptly.

19.1.5.4 Other External Events Risk Evaluation

External events considered in the APR1400 PRA are those whose cause is external to all systems associated with normal and emergency operations situations, with the exception of internal fires and floods. Some external events may not pose a significant threat of a severe accident. Some external events are considered at the design stage and have a sufficiently low contribution to CDF or plant risk.

The set of external events was taken from the ASME/ANS PRA Standard and represent a consensus listing of external events for nuclear power plant PRAs. Table 19.1-80 presents the screening analysis of these external events (based upon recommendations in the ASME/ANS Standard). Those events that were not screened or subsumed within other hazard categories must be addressed in a site-specific PRA.

Chapter 2 contains site-specific parameters for following attributes.

- Nearby industrial, transportation, and military facilities
- Meteorology
- Hydrologic engineering
- Geology, seismology, and geotechnical engineering

Evaluation of potential accidents for the nearby industrial, transportation, and military facilities in Chapter 2 is a probabilistic and predictive approach that will be followed and documented in the COLA to verify that a 1×10^{-7}/year occurrence rate has been demonstrated. For low probability events, where data may not be available, a 1×10^{-6}/

year occurrence rate can be utilized when combined with reasonable qualitative arguments. Otherwise, a PRA may need to be performed to comply with the guidance of the ASME/ANS PRA Standard. The screening criteria for other external events need to be determined at COL phase confirming that the screening criteria are below the plant specific risk target.

19.1.6 Safety Insights from the PRA for Other Modes of Operation

This section summarizes the low power and shutdown (LPSD) analysis, results and associated insights.

19.1.6.1 Description of Low-Power and Shutdown Operations PRA

19.1.6.1.1 Methodology

The primary objective of the probabilistic risk assessment during low power and shutdown operation is to provide insights into potential plant vulnerabilities. This information may be used during the design process to implement risk-beneficial changes. In addition, shutdown risk information also may be used to support the development of outage risk management guidelines. Finally, a shutdown risk assessment may be compared to that of other, next-generation plants to demonstrate that the design and safety features are consistent with the current state of the art in reactor safety.

The scope of this analysis included quantitative evaluation of internal events during low power and shutdown modes.

The full development of the Low Power and Shutdown (LPSD) PRA includes the following nine major technical tasks.

- Plant Operating State Development
- Initiating Events Analysis
- Accident Sequence Analysis
- Success Criteria Analysis

- Systems Analysis
- Data Analysis
- Human Reliability Analysis
- Analysis of Large Early Release
- Quantification

While the PRA relies on information and experience gained from the current generation of reactors, the unique aspects of the APR1400 design require various new analyses to support the PRA development process. The draft ANS LPSD PRA Standard (Reference 9) was used as a guideline for the requirements for these technical tasks. The draft standard was developed to support the analysis of operating reactors, and some of the specific requirements cannot be met in a DCD-phase PRA. However, each of the requirements of the Standard is addressed to the extent practical during the APR1400 reactor's design. For example, the Standard requires the review and incorporation of plant-specific operating experience into the PRA, interviews with plant operations and other personnel, plant walkdowns, etc., which cannot be performed for a plant in the design stage.

19.1.6.1.2 Plant Operating State Definition

The first step in evaluating each core damage sequence is the determination of Plant Operating States (POS). In the POS analysis, a thorough and systematic search was performed to define the spectrum of potential POSs for an APR1400 plant. Although the scope of shutdown PRAs for current generation PWRs is limited, the available studies were reviewed to identify potential APR1400 shutdown states. In addition, the design control documents for the next-generation reactors were also reviewed to determine whether the current generation POS list is expected to remain applicable.

The Plant Operating States are actual operating conditions. These states are already common among PWRs and the APR1400 design does not change these states. The challenge for a sound LPSD PRA is to ensure that these states are adequately defined to encompass the full scope of potential shutdown conditions and facilitate their analysis.

The draft ANS LPSD PRA Standard presents a specific set of requirements concerning the development of Plant Operating States which will be considered in the APR1400 PRA. Although the draft ANS LPSD PRA Standard is still in draft form and has not yet been endorsed by the NRC or formally issued, it still provides the best available guideline for identifying potential shutdown concerns.

The identification of POS benefits from the fact that the US industry alone has significant experience with outage evolutions. These evolutions include planned shutdown refueling as well as unplanned shutdowns for unexpected maintenance and other causes. As a result, the scope of potential states has already been established. The task is therefore to determine how to best characterize them for the subsequent PRA.

The characterization of POS began with a review of available shutdown PRA studies for current generation plants. Since a LPSD PRA is not required for operating plants, the scope of publicly available studies is limited. However, the next-generation plants have design certification documents, submitted for NRC review, which also were reviewed for POS development.

Although the APR1400 reactor is a new design, many aspects are similar to existing PWR designs, so a review of information from existing plants is appropriate. Plant-specific operating experience is not available for the APR1400.

The APR1400 POS are defined in a manner that is consistent with the draft ANS LPSD PRA Standard.

NUREG/CR-6144 (Reference 48) documented a shutdown PRA for Surry Unit 1 in 1994. It included a comprehensive set of POS that correlate well with those selected for the next-generation plants.

The POS defined for the APR1400 are summarized in Table 19.1-81.

19.1.6.1.3 Initiating Events

The second task to develop a LPSD PRA is the determination of potential initiating events. In the initiating event analysis, a thorough and systematic search was performed to define

the spectrum of initiating events that could occur at an APR1400 plant. Although the scope of LPSD PRAs for current generation PWRs is limited, the available studies were reviewed to identify potential APR1400 shutdown initiating events. In addition, available design control documents for the next-generation reactors also were reviewed to ensure the completeness of the initiating events defined for the APR1400.

Initiating events that result from support system failures or transients, called special initiators, also are considered through a review of industry PRAs and actual shutdown events.

The potential initiating events for the APR1400 PRA are grouped into similar functional categories to reduce the complexity of the PRA. The initiating event frequency for each of these groups then is quantified.

The draft ANSI/ANS LPSD PRA Standard presents a specific set of requirements concerning the identification, grouping, and calculation of the frequency of the initiating events to be considered in the APR1400 PRA. The identification of potential initiating events considers generic information sources, information from other similar plants, plant-specific operating experience, and a systematic review of the APR1400 design to identify unique initiating events. Although the APR1400 reactor is a new design, many aspects are similar to existing PWR designs, so a review of information from existing plants is appropriate. In addition, a detailed failure modes and effects analysis (FMEA) also was performed to identify potential initiating events.

Once the initiating events are identified with preliminary definitions, the final initiating event groups are developed with the final group definitions.

As these initiating events are similar to those of existing nuclear power plants, the frequency for each initiating event is based on generic estimates for current power plants for most events. When generic estimates are not available or the APR1400 design indicates that a different frequency is more appropriate, engineering judgment is used to estimate the initiating event frequency.

Based upon this review of LPSD PRAs for industry PWRs, the following transition and shutdown initiating events were selected for the APR1400:

- S1 - Recoverable loss of shutdown cooling system
- S2 - Unrecoverable Loss of Shutdown Cooling System
- SO – Over-drainage during Reduced inventory Operation
- SL – Failure to Maintain Water Level during Reduced Inventory Operation
- SL – Small Break LOCA
- SL1 – Small Break LOCA during Reduced inventory Operation
- SL2 – Small Break LOCA above Reduced inventory Operation
- SG – Steam Generator Tube Rupture
- JL – Unrecoverable LOCA (CVCS Letdown Line)
- PL – POSRV Fails to Reclose
- RL – LTOP Safety Valve Fails to Reclose
- LX – Station Blackout
- LP – Loss of Offsite Power
- CC/ES – Partial Loss of Component Cooling/Essential Service Water
- TC/TS - Total Loss of Component Cooling/Essential Service Water
- KV – Loss of 4 kV Emergency Bus (SCS Power Supply)
- DC – Loss of 125 VDC Bus
- LLOCA – Large Break LOCA in transition mode
- MLOCA – Medium Break LOCA in transition mode
- SLOCA – Small Break LOCA in transition mode

The LPSD initiating event analyses for the above initiators are contained in Table 19.1-82 through Table 19.1-87.

19.1.6.1.4 Accident Sequence

The third task of the LPSD PRA is the analysis of potential Accident Sequences (AS). This AS analysis has been developed after an initial review of corresponding sequences for other PWRs for current and next-generation plant designs. Although the scope of shutdown PRAs for current-generation plants is limited, the available studies were reviewed to identify the major elements of accident progression. In addition, available design control documents for the next-generation reactors were also reviewed to identify any insight into accident sequence analysis, relative to older studies.

The ASME/ANS PRA Standard was written to address at-power, internal events PRA. It explicitly notes that shutdown events will be addressed under separate cover. The draft ANS LPSD PRA Standard presents a specific set of requirements concerning shutdown Accident Sequence analysis which were considered in the APR1400 LPSD PRA. Although draft ANS LPSD PRA Standard has not been formally issued, it still provides the best available guideline for identifying likely shutdown concerns.

The accident sequence analysis is consistent with the ASME/ANS Standard.

Other than the transition modes, shutdown conditions are characterized by low temperatures, low or depressurized conditions, and decreasing decay heat. The plant configuration, including primary coolant inventory, primary system temperature and pressure, and status (i.e., whether the primary system is intact or not), and mitigation system availability, can differ significantly from one POS to the next. The reactor core vulnerability to inventory boil-off and fuel uncovery can differ substantially as well.

The time between boiling inception and fuel uncovery is a strong function of the decay heat level and the primary system inventory. Thus the potential accident sequences are highly dependent upon the plant configuration and timing, as characterized for each POS. Thus there is a broad range of potential states to address shutdown risk more accurately.

The important safety functions for LPSD are inventory control and decay heat removal, as well as their support systems. A core damage sequence typically will occur following the failure of at least one of these functions. Conversely, core protection is maintained by ensuring that both of these functions are established for long term operation. A function

may be achieved by more than one system. For example, decay heat removal in the transition and shutdown modes may be accomplished by the Shutdown Cooling System, the Main Steam System if it is available, or by Safety Injection for feed and bleed.

The accident sequence progression reflects the phenomenological response which is unique to each operating state. For example, on a loss of decay heat removal, the primary system will heat up. If the RCS is open then inventory will begin to boil off at atmospheric pressure. If the RCS is closed, then the heat-up will pressurize the primary system until the low temperature overpressure protection (LTOP) valves open in the SCS suction lines.

Due to differences in mitigation system availability and plant conditions (e.g., configuration and decay heat) at each unique Plant Operating State, different event trees were developed for some states even though they had the same Initiating Events.

The LPSD core damage sequences are summarized in Table 19.1-88. This table does not include the large, medium and small break LOCA, steam generator tube rupture and dc bus failure sequences, which were already discussed for the at-power analysis.

The detailed LPSD event trees for POS 5 which is during mid-loop operation are contained in Figure 19.1-52 to Figure 19.1-63.

19.1.6.1.5 Success Criteria Analysis

In general, plant conditions evaluated in the LPSD PRA are characterized by low temperatures, low or depressurized conditions, and decreasing decay heat. Plant configuration changes during an outage are conducted in a controlled and deliberate manner according to outage plans. However, in the transition modes, e.g., technical specifications modes 2 and 3, plant conditions more closely resemble at-power conditions. This section addresses success criteria for all shutdown POS, including transition modes.

Development of success criteria makes use standard computer codes, e.g., RELAP5/MOD3, and models developed specifically for the APR1400. The success criteria and models used to evaluate them are intended to be realistic and developed within the capabilities of computer codes and models. In addition, the development considers uncertainty associated with the models if that uncertainty could influence conclusions. If overly

conservative assumptions and analyses are used, the capability of the plant will be understated. Conversely, use of optimistic success criteria could result in overstating the potential for preventing core damage because some recovery actions may have limited time windows.

The ASME/ANS PRA Standard defines core damage as the uncovery and heatup of the reactor core to the point at which prolonged oxidation and severe fuel damage are anticipated and involving enough of the core, if released, to result in offsite public health effects. For the purpose of the APR1400 at-power PRA success criteria analysis, core damage is defined to commence at a peak clad temperature of 1,204.4 °C (2,200°F) or greater. However, for LPSD PRAs, the standard analyses in NUREG/CR-6144 uses 1,340 °F as the definition of core damage based on phenomena of clad oxidation and ballooning. Furthermore, Inspection Manual Chapter 0609 (Reference 49) specifies a definition of core damage of 726.7 °C (1,340 °F) for LPSD PRAs confirming that the core damage definition used for at-power PRAs is not appropriate for LPSD PRAs. Therefore, the APR1400 PRA will use 704.4 °C (1,300 °F) clad temperature as the definition of core damage.

Success criteria are primarily dependent upon the initiating event, POS, equipment response, and operator actions that can occur in response to an event. In order to determine the success criteria for a given initiating event and POS, system-level success criteria must be considered. Furthermore, success criteria for the LPSD PRA consider the time available to actuate equipment needed to mitigate an event in conjunction with the time that cues would be generated to alert the operators that actions are needed. Timing can vary significantly from POS to POS and is considered in the success criteria development.

For the LPSD model, each accident sequence must achieve and maintain a safe stable state which is defined in the ASME/ANS PRA Standard as “a plant condition, following an initiating event, in which RCS conditions are controllable at or near desired values.” The ASME/ANS PRA Standard further specifies that accident sequences should be evaluated for a minimum mission time of 24 hours. A 24 hour mission time is used for the LPSD PRA. In some circumstances, however, core damage may not occur within the initial 24 hour period after the initiating event but, without additional actions, core damage would be expected at a later time. In such a case, the scenario is not considered safe and stable and the additional equipment or actions are included in the success criteria. In general, a

mission time of 24 hours is specified for each success criterion. Where different mission times are appropriate for specific success criteria, these are identified in the discussion below.

Success criteria for the LPSD PRA are based on thermal-hydraulic analysis performed to evaluate the specific conditions specified in the accident sequence analysis. For events analyzed as occurring in the transition modes (POS 1, 2, 14, and 15), these criteria generally are based on the criteria developed for the at-power PRA. For the remaining POS, success criteria are analyzed using the RELAP5/MOD3, where the thermal-hydraulic analyses consider the initiating event, limiting plant conditions for each POS, and equipment availability specified for each accident sequence. Evaluation of containment performance is performed using the MAAP code.

Plant conditions in the transition modes, i.e., POS1, POS2, POS14, and POS15, are similar to those considered in the at-power internal events PRA. Furthermore, the accident sequence progression developed for each initiating event analyzed in the transition modes is based on the accident sequence progression that occurs from an event initiated from full power. Therefore, the success criteria for frontline systems in transitions modes uses the same criteria specified for the at-power internal events PRA.

The followings are general assumptions and notes applicable to the success criteria development:

a. Success criteria for systems considered in the accident sequence development for POS1, POS2, POS14, and POS15 are assumed to be the same as for the at-power internal events PRA. Decay heat levels would be lower for an event initiated in these POS than for an event occurring at full-power and RCS temperature and pressure could be lower. However, these factors would provide additional time for actions to prevent core damage thereby providing conservatism in the success criteria. Since the time spent in transition modes is small, this assumption is considered acceptable.

b. Failure to begin secondary cooling before RCS pressure reaches the LTOP relief valve lift setpoint is assumed to result in failure of secondary cooling.

c. Failure to begin secondary cooling before RCS level drops below the top of the hot leg is assumed to result in failure of secondary cooling.

d. One SG is assumed to be rendered unavailable by planned outage activities when the plant enters POS4A.

e. The success criteria and time available for operator actions and events occurring in POS3B is assumed to be the same as for events that occur in POS3A. Since RCS temperature is lower in POS3B, the timing for events is expected to take longer and, therefore, this assumption will result in conservative results.

f. If feed and bleed cooling is used in POS3A, containment design pressure would be exceeded after 24 hours. Although containment ultimate pressure capability will not be exceeded within 24 hours, operator action to begin IRWST cooling is assumed to be required to ensure safe, stable conditions.

g. Success criteria for JL events are analyzed assuming that the maximum break is the 34.1m^3/hr (150 gpm) flow rate of the CVCS letdown line that occurs at power.

h. Success criteria for RL events are based on the relief capacity of one LTOP relief valve.

Tables for the success criteria for LPSD various initiating event categories and operating states are shown in Table 19.1-89 through Table 19.1-92.

19.1.6.1.6 <u>Operator Actions in Shutdown</u>

The HRA for the LPSD PRA is performed using the same methods as the at-power PRA described in section 19.1.4.1.1.7.

Operator actions that respond to events that occur in reactor Mode 2 or Mode 3 are assumed to be the same as the response to events that occur at power. Although the time available for response to an event in Mode 2 or Mode 3 is expected to be longer, thereby resulting in a lower HEP, this conservatism is considered to be negligible to overall risk because the time spent in these modes is short.

Operator actions for response to events that occur in reactor Modes 4, 5 or 6 are summarized below in the following groups:

- Actions to restore SCS
- Actions to ensure secondary cooling
- Actions to initiate feed and bleed cooling
- Actions to isolate RCS leakage and restore inventory
- Actions to align the AAC power source

The time available to perform each of these categories of actions will vary from POS to POS. As a result, the HEPs for each event will vary with POS. Also, some actions will not be applicable to all initiators and timing can be affected by specific initiating events. For example, actions to isolate RCS leakage and restore inventory are not applicable to loss of SCS initiating events.

19.1.6.1.7 Systems Analysis

The following summarizes differences in LPSD system models versus at-power modeling:

a. Safety Injection System

- The SITs are isolated in the late POS 2 (TS Mode 3) and below. They are considered unavailable during all of POS 3 through POS 13.
- Maintenance on SI train B is assumed to be performed in POS 7 and 8. Maintenance on SI train A is performed after completion of maintenance on Train B in POS 8 and 9. Maintenance on SI trains C and D is performed at the same time as maintenance on the associated emergency diesel generator (EDG) as described in section 10. The associated trains are modeled as unavailable during periods of maintenance.
- Manual actuation of the SI pumps is assumed to be required in Mode 4 (POS 3) and below. Automatic actuation is not credited.

b. Shutdown Cooling System

- The system is modelled as aligned for shutdown with one train in operation and one train in standby. It is assumed that train A is operating in POS 3A through 7 and that train B is operating in POS 9 through 13.

- No maintenance is performed on the SC system when operation of the system is required.

- Although the containment spray pump could be aligned and used as a backup for the SC pump in the division, no credit is taken for use of the CS pump if the SC pump fails

c. Containment Spray System

- This system is assumed to be unavailable in reactor Mode 5 and below when operability is not required. The unavailability is assumed because it is expected that foreign material exclusion (FME) covers will be installed over the trash racks on the inlet to the holdup volume tank (HVT) during refueling outages or that equipment, material, or trash present in the containment during the outage will result in clogging the trash racks or sump screens.

- There are no system changes to this system's configuration in the transition modes and thus the LPSD model uses the at-power model in the transition modes.

d. Pilot Operated Safety Relief Valves

- The success criterion for feed and bleed cooling in Mode 2 or Mode 3 (POS 1, 2, 14, or 15) is the same as for the at-power internal events PRA model, i.e., two of four POSRVs are required to open. When in Mode 4 or lower with RCS intact (POS 3A, 4A, 12B through 13), the success criterion for feed and bleed cooling is that one of four POSRVs must open.

e. Chemical and Volume Control System

- There are no CVCS model changes required for LPSD analysis.

f. Auxiliary Feedwater System

- Automatic AF actuation is credited in Modes 1-3 but the AF system must be initiated manually if used in Mode 4. Secondary heat removal is not credited in the shutdown modes after the primary system is vented. Therefore, AF flow is not required if the RCS is vented.

- The turbine-driven AF pumps are not credited in POS 3A to POS 13 due to reduced secondary steam pressure.

- One AF train is assumed to be unavailable for maintenance when in POS 4 to POS 12. Maintenance on AF train B is assumed to be performed in POS 7 and 8. Maintenance on AF train A is performed after completion of maintenance on Train B in POS 8 and 9.

g. Feedwater System

- The feedwater system is modeled as a makeup source for the SGs in POS 1, 2, 14 and 15 only. There are no system changes to this system's configuration in the transition modes and thus the LPSD model uses the at-power model in the transition mode.

h. Main Steam System

- The MS system is the preferred system for heat removal in POS 1, 2, 14, and 15. There are no changes to the at-power PRA model for use in those POS.

- With the reactor in Mode 5, the MS system is used for heat removal if the RCS is intact. However, the ADVs are the only steam removal pathway because the MSIVs will be closed and SG pressure well below the lift pressure of the MSSVs. Also, one SG is assumed to be unavailable in POS 4A and all SGs in POS 4B to POS 12B.

- MS is unavailable in POS 4B-12B because the primary system is open and unable to transfer heat to the secondary system.

i. Electrical Distribution System

- Because the main generator is not operating, the failure of the main generator breaker to open is eliminated from the model.

- One EDG may be unavailable for maintenance. Maintenance is assumed to occur as follows: EDG D is unavailable for maintenance from POS 3A to the first half of POS 8. EDG C is unavailable for maintenance from the second half of POS 8 to POS 10. During the refueling outage, no maintenance is performed on EDG A and B which provide emergency power to the SC system.

j. Component Cooling Water System

- No changes to the at-power CC system model are needed for POS 1, 2, 14, or 15. With the reactor in POS 3A through 13, the CC valves to the SC heat exchangers are open and the fail-to-open failure mode is not applicable. CC system maintenance can be performed during outages. Maintenance is avoided when the CC system is required by TS or needed to support use of the SC system for decay heat removal. Therefore, it is assumed that all CC trains are available in POS 1-6 and 10-15. Maintenance is assumed to render Train A unavailable in POS 7-8. Maintenance is assumed to render train B unavailable in POS 8-9 after Train A is returned to service.

k. Essential Service Water System

- The LPSD model reflects the alignment to three CC heat exchangers during the transition modes. Although three heat exchangers may be placed in service, two heat exchangers, by design, are capable of meeting the decay heat removal requirements. Therefore, the model assumes, conservatively, that the third CC heat exchanger is in standby.

- No changes to the at-power SX system model are needed for the LPSD PRA. SX system maintenance can be performed during outages. Maintenance is avoided when the SX system is required by TS or needed to support use of the SC system for decay heat removal. Therefore, it is assumed that all SX trains are available in POS 1-6 and 10-15. Maintenance is assumed to render Train A unavailable in POS 7-8. Maintenance is assumed to render train B unavailable in POS 8-9 after Train A is returned to service.

l. Essential Chilled Water System

- No changes to the at-power WO system model are needed for POS 1, 2, 14, or 15. WO system maintenance can be performed during outages. Maintenance is avoided when the WO system is required by TS or needed to support use of the SC system for decay heat removal. Therefore, it is assumed that all WO trains will be available in POS 1-6 and 10-15. Maintenance is assumed to render Train A unavailable in POS 7-8. Maintenance is assumed to render train B unavailable in POS 8-9 after Train A is returned to service

m. Heating, Ventilation and Air Conditioning System

- No changes to the at-power HVAC system models are required for use in the LPSD PRA.

n. Instrument Air System

- No changes to the at-power IA system models are required for use in the LPSD PRA.

19.1.6.1.8 Fire & Flooding Events in Shutdown

A qualitative evaluation of internal fire and flooding events was performed for LPSD conditions. This evaluation was based on the at-power evaluations of these events which showed no significant vulnerabilities to fire or flooding. Further, the quadrant separation in the auxiliary building ensures that systems needed for decay heat removal will not be impacted by any single initiating event, thereby minimizing risk from fire or flood during LPSD conditions.

Based on the bounding nature of the at-power fire and flood evaluations and on the low risk impact of shutdown-specific internal hazards, the risk from fire and flood events during at-power operation is assumed to bound the risk during shutdown.

19.1.6.1.9 Data Analysis

The approach to assigning failure rate data for components unique to the shutdown model is the same as that used in the at-power Level 1 internal events model (See Subsection

19.1.4.1). The approach for constructing component unavailability data is the same as that for the at-power Level 1 internal events model as well.

19.1.6.1.10 Accident Sequence Quantification

Quantification refers to the solution of the Level 1 LPSD accident sequences in order to generate an estimated frequency of core damage. The Level 1 LPSD PRA quantification process is similar to that used for the internal events PRA.

19.1.6.2 Results from the Low-Power and Shutdown Operations PRA

The following insights may be drawn from the APR1400 LPSD PRA:

a. Many systems are manually started or aligned during shutdown modes. Training is especially important at shutdown because operator error is often a significant risk contributor in shutdown sequences.

b. The operation and maintenance personnel must have procedures, training and spare parts to restore DHR in a timely manner. Successful SCS operation is the preferred end-state for all shutdown sequences.

c. The concept of defense in depth applies to shutdown as well as full power operation (i.e., the availability of multiple options to maintain coolant inventory and remove decay heat will lower shutdown risk). The availability of SIS capability during shutdown is an example of added defense in depth.

d. The ability of the operator to align the SCS for makeup or feed and bleed operation is important for defense in depth.

e. Configuration control is necessary because significant plant risk can occur during adverse configurations. If configurations are managed so that critical, high-risk configurations do not occur or occur infrequently, then their associated risks will also be reduced. For example, the SCS and its support systems are required to be available during shutdown operation. The COL applicant should limit planned maintenance that can potentially impair one or both SC trains during the shutdown modes. An effective configuration management program will optimize the reliability of the SC system.

f. If one train of the SC system is unavailable for any reason during shutdown, the shutdown cooling function is dependent upon the remaining train and its support systems. The COL applicant should develop procedures and a configuration management strategy to handle the period of time when one DHR train is unexpectedly unavailable. Any testing or maintenance that can affect the remaining train must be terminated, and all equipment restored immediately to its nominal availability.

g. During plant shutdown, risk can be minimized by appropriate outage management, administrative controls, procedures and operator knowledge of plant configuration.

h. During plant shutdown operation, the integrity of fire and flood barriers between areas in the same division, such as quadrants, where systems comprising the alternate shutdown are located should be maintained. A configuration control program should require that, during Modes 4, 5, and 6, the water tight flood doors and fire doors are maintained closed on at least one quadrant (containing either a SC or CS pump) to help prevent common-mode failures from internal floods or fires. The SC or CS pump in this quadrant shall be operable. If the flood or fire doors to this quadrant must be opened for reasons other than normal ingress/egress, a flood or fire watch should be established for the affected door.

19.1.6.2.1 <u>Risk Metrics</u>

The total CDF from LPSD events is 2.7×10^{-6}/year. The mean value and associated uncertainty distribution are discussed in Subsection 19.1.6.2.7. It should be noted that the "year" unit in the LPSD section (Subsection 19.1.6) of this chapter refers to a reactor calendar year (rcy).

19.1.6.2.2 <u>Significant Initiating Events</u>

The CDF contributions by each initiating event are presented in Table 19.1-93. The top LPSD CDF contributor is an Overdrain event at 55 percent. Loss of offsite power and SBO events together contribute 11 percent, followed by a Level Control failure at reduced inventory, which contributes 9 percent. The Overdrain and Level Control failure events thus contribute a combined 64 percent of the total shutdown risk.

Loss of shutdown cooling events contribute approximately 13 percent to LPSD risk. This group includes heat sink failures and a loss of the Class 1E 4.16 kV bus that powers the running SC pump but not the LOSP events noted above.

LOCA events, including a letdown line LOCA, small break LOCA at reduced inventory and above reduced inventory, POSRV and LTOP fail-open faults, and a medium break LOCA contribute approximately 12 percent to the LPSD CDF.

The CDF contributions by initiating events for the reduced inventory POS are presented in Table 19.1-94. The CDF contributions by POS are presented in Table 19.1-95.

19.1.6.2.3 Top Cutsets

The top 100 cutsets for the low-power and shutdown events are illustrated in Table 19.1-96, contributing 90 percent of the total CDF. The top 1,000 cutsets contribute 95 percent and the top 10,000 contribute 98 percent. The top three cutsets, and four of the top five, begin with the Overdrain initiating event, contributing 49 percent and 53 percent of the total CDF respectively. These cutsets reflect the domination of this initiator. Only thirteen cutsets individually contribute more than 1 percent of the total.

Table 19.1-97 lists the top 100 cutsets in the reduced inventory states, which are the highest contributors to the CDF. Once again, the top three and four of the top five events begin with the Overdrain initiating event, contributing 66 percent and 72 percent of the reduced inventory CDF, respectively. These 100 cutsets contribute 99 percent of the CDF in POS 5 and 11.

19.1.6.2.4 Significant SSC, Operator Actions, and Common Cause Events

Table 19.1-98 and Table 19.1-99 list the risk significant basic events, based upon RAW, for the full LPSD model solution and for the reduced inventory states only. The full model results are dominated by the IRWST, and failures of the electrical-related components. The reduced inventory states are dominated by various controller and safety injection check valve failures.

There are no basic events in the full model with a FV statistics in excess of 0.5 percent (0.005). Table 19.1-100 lists the FV-risk significant components for the reduced inventory operation only. Only two components (the two shutdown cooling pump room coolers) have a FV statistic of 0.5 percent or greater. Several other components, such as the diesel generators, are included in this table although their FV statistics are less than 0.5 percent.

Table 19.1-101 lists the risk significant CCFs for the LPSD PRA. These results include various 120 VAC inverter failures and diesel generator failures, among others.

There are no CCFs with a FV statistic of 0.5 percent or larger in the full model. However, the WO system chillers and the service water pump room fans have FV statistics that are slightly less than 0.5 percent. Table 19.1-102 lists the CCFs with the top ten FV statistics.

Table 19.1-103 lists the risk significant common cause failures for the reduced inventory states only. These results are dominated by various SI check valve failures.

There are no CCFs that have a FV of more than 0.5 percent in the reduced inventory states and, therefore, these results are not included.

Table 19.1-104 and Table 19.1-105 list the risk significant operator actions for the LPSD PRA. The tables are based upon a RAW statistic of 2.0 or greater and a FV statistic of 0.5 percent or greater, respectively. The results consist entirely of failures to recover shutdown cooling, establish makeup or perform a feed & bleed following an Overdrain or a reduced inventory level control failure, all of which occur in the reduced inventory states. As a result, separate tables for high-FV and high-RAW actions at reduced inventory-only were not generated.

19.1.6.2.5 Key Assumptions

General modeling assumptions are similar to those used in the at-power PRA. Additional shutdown assumptions are listed below.

a. The decay heat load is assumed to be constant during each state. The decrease in decay heat over time is conservatively neglected. Thus the calculated time to boil off coolant is conservatively underestimated.

b. IRWST cooling is not required when the RPV head is removed, but makeup for boil-off is assumed to be required when heat removal is lost. It takes more than three days to deplete the IRWST if steam is not condensed in the containment and returned to the IRWST. This conservative treatment provides the basis for neglecting IRWST cooling when the RPV head is removed.

c. Possible transient LOCA events through the RPV and PZR vents are not considered. The pressurizer vent is normally open during shutdown. The RPV vent is open during reduced inventory operation and plant startup after refueling. Given RCS temperatures and pressures, a loss of inventory as steam was evaluated after a loss of RHR cooling. The pressurizer vent contains a flow restrictor, which significantly limits the flow to well below the makeup capacity of the CVCS. The RPV vent is a one-inch line, and it would take a large amount of time to uncover the core by venting steam through this line. The risk from this event is not considered significant because the operators have more than enough time to isolate the vent or to provide makeup to the RCS. Therefore these events were screened out as potential initiating events.

d. It is assumed that a transient-induced LOCA response requires feed-and-bleed cooling success, utilizing the pressurizer relief valves, because the LOCA size may not be large enough to provide sufficient bleed flow.

e. The probability of IRWST suction strainer plugging was not increased relative to the power operation PRA model. The IRWST design (e.g., large, separation between suction lines, debris filtering capability) and plant procedures (e.g., foreign material control) are expected to ensure that this probability is low.

f. Risk with a water-solid pressurizer was not considered. The inadvertent start of a reactor coolant pump or a SI pump could cause an overpressure event when the pressurizer is solid. The SCS relief valves will protect the system from overpressure during this period and the exposure time is small. Thus, overfill events that could lead to a low temperature overpressure event have been screened out as potential initiating events that could significantly contribute to shutdown risk.

19.1.6.2.6 Sensitivity Analyses

Sensitivity calculations may be performed by increasing select parameters, one or several at a time, and re-quantifying the PRA model. These calculations are performed to identify potential vulnerabilities to increased or under-estimated failure rates.

No additional LPSD calculations were performed to evaluate sensitivities. The LPSD FV statistics tabled below quantify the CDF contribution due to individual component failures, CCFs or HFEs. The CCFs include the concurrent failure of multiple trains, and often entire functions, as compared to the rates for individual components. The FV statistic may thus be used to evaluate a potential change in the value for any of these basic events. For example, any term with a 0.5 percent FV statistic contributes 0.5 percent to the LPSD CDF; if that term's failure rate doubles, then the CDF contribution will double to 1.0 percent.

Similarly, the RAW statistic quantifies the CDF impact due to a large increase in these same parameters. The RAW statistic quantifies the CDF impact if any term is guaranteed to fail; i.e., if its failure rate is increased to 1.0. The FV and RAW statistics therefore quantify the CDF sensitivity due to changes in each, modeled basic event.

Sensitivity calculations using full model re-quantification can identify effects that might not be captured by the risk statistics, due to truncated cutsets. However, the extremely low APR1400 LPSD truncation (1×10^{-13}/year), more than seven orders of magnitude below the LPSD CDF, means that it is highly unlikely that any such effects might be present. Thus no additional LPSD sensitivity calculations have been performed.

19.1.6.2.7 Uncertainty Analyses

The uncertainty results for Level 1 internal events CDF during LPSD are summarized below:

- 5 percent Value: 1.1×10^{-6}/year
- Mean Value: 2.8×10^{-6}/year
- 95 percent Value: 6.1×10^{-6}/year

Uncertainty in the Level 1 Shutdown PRA results is quantified with a process similar to that described for internal events in Subsection 19.1.4.1.2.6. Parametric uncertainty was represented by selecting an uncertainty distribution for each parameter type, as described in Subsection 19.1.4.1.2.6. Modeling uncertainty was not represented in the shutdown model.

19.1.6.2.8 PRA Insights

The LPSD PRA results show that an Overdrain is the dominant initiating event, contributing 54.9 percent of the total shutdown CDF. Loss of offsite power events (including the Station Blackout) contribute a combined 10.9 percent, followed by a Level Control Failure at reduced inventory, which contribute 9.4 percent. The Overdrain and Level Control events thus contribute a combined 64.3 percent of the total shutdown risk. The reduced inventory states before and after refueling, which include the draindown initiator, dominate all other states with 73.7 percent of shutdown risk.

Loss of shutdown cooling events (including partial and total heat sink failures) contribute approximately 12.8 percent to LPSD risk. This general grouping includes failures of the 4.16 kV bus that powers the running SC pump but not LOSP events as discussed above.

LOCA events, including a letdown line LOCA, POSRV and LTOP fail-open faults, and a medium break LOCA contribute approximately 11.9 percent.

19.1.6.3 Description of Level 2 PRA for Low-Power and Shutdown Operations

The Large Release Frequency (LRF) was not quantitatively evaluated for Low-Power and Shutdown (LPSD) operation. The LRF is evaluated qualitatively, with insights from screening calculations, using the LPSD CDF results.

These results are compared to the at-power Conditional Containment Failure Probability (CCFP) of 0.084, which is less than the containment performance goal of no more than approximately 0.1.

The LPSD LRF has been conservatively estimated as follows. Table 19.1-106 lists the LPSD CDF results for each Plant Operating State (POS). These data have been

supplemented by an assumed CCFP for each POS. The CCFP uses a screening value of 1.0, for states in which the equipment hatch can be open, and a value of 0.1 otherwise. The CDF in each state is multiplied by its corresponding CCFP to obtain a LRF estimate for each state. Where appropriate, results are summed.

Using this method, the screening estimate for the LPSD LRF is 4.6×10^{-7}/year, which means that the overall LPSD CCFP for the LRF is 0.17. This value is higher than the containment performance goal in a rigorous analysis but this screening method is deliberately conservative due to the following reasons:

- The use of a 0.1 screening value for the CCFP, in most LPSD states, is conservatively high. During these states, the equipment hatch is closed and the exponentially decreasing decay heat reflects the continuously diminishing ability to expel any radionuclides from containment. This analysis has not attempted to quantify the time after which the reactor core can no longer overpressurize the containment.
- Nearly half (approximately 45 percent) of the LRF estimate occurs during states when the CCFP is assumed to be 1.0 and no credit is claimed for containment.
- More than 20 percent of the LRF estimate occurs after refueling, when the many radioactive fuel assemblies have been replaced with fresh fuel and the remainder is generating very low decay heat. It is questionable whether this energy level could result in core damage (or pressurize containment for a subsequent release).

This approach is consistent with the methodology used for the evolutionary generation of PWRs.

In summary, conservative estimates of the APR1400 shutdown LRF suggest that a rigorous calculation would be one to two orders of magnitude smaller than the shutdown CDF, consistent with the containment performance goal for this metric.

19.1.7 PRA-Related Input to Other Programs and Processes

The APR1400 is expected to perform better than current operating plants in the area of severe accident safety performance since prevention and mitigation of severe accidents, as

shown in Table 19.1-2 and Table 19.1-3, have been addressed during the design stage, taking advantage of PRA results and severe accident analysis. The PRA results indicate that the APR1400 design results in a low level of risk and meets the CDF, LRF, and containment performance goals for new generation PWRs. Key assumptions and the associated potential impacts are summarized in Table 19.1-4.

19.1.7.1 PRA Input to Design Programs and Processes

The APR1400 PRA is an integral part of the design process and has been used to optimize the plant design with respect to safety. The PRA models and results have influenced the selection of design features such as four EDGs and battery depletion time extension.

19.1.7.2 PRA Input to the Maintenance Rule Implementation

PRA input is provided as required to develop the Maintenance Rule, discussed in Section 17.6.

The PRA is not used to support Maintenance Rule implementation at the design certification stage. As stated in Subsection 19.1.1.4, the COL applicant is responsible for describing the uses of PRA in support of licensee programs such as Maintenance Rule implementation during the operational phase.

19.1.7.3 PRA Input to the Reactor Oversight Process

Ultimately, the site-specific PRA models and results in the COLA phase are utilized to support elements of the reactor oversight process including the mitigating systems performance index and the significance determination process.

At the design certification stage, the PRA is not used to support the Reactor Oversight Process. As stated in Subsection 19.1.1.4, the COL applicant is responsible for describing the uses of PRA in support of licensee programs such as the Reactor Oversight Process during the operational phase.

19.1.7.4 PRA Input to the Reliability Assurance Program

Risk significant SSCs are identified for the RAP (Section 17.4). Key risk significant SSCs are organized by a FV importance greater than 0.005, RAW greater than 2.0 for independent events, and RAW greater than 20 for CCF events in accordance with NUMARC 93-01 (Reference 50). These thresholds are consistent with NEI 00-04 (Reference 51). In addition, risk significant information based on LPSD PRA and external PRA, SSCs related initiating events, and key assumptions are identified. PRA input is provided as required to develop the RAP, discussed in Subsection 17.4.

The PRA is used to provide input to the RAP. Specifically, the PRA is used to identify SSC that are potentially risk-significant, and therefore should be considered by the RAP expert panel as candidate SSC under the RAP program. The probabilistic approach to determining SSC risk significance is based on assessment of PRA importance measures. The PRA importance measures do not provide the only insight to SSC risk significance determination. In addition to the PRA importance measures, the expert panel also considers deterministic, safety analysis insights and appropriate operating experience when making the final determination of the RAP scope. Refer to Subsection 17.4 for a description of the Reliability Assurance Program. As stated in Subsection 19.1.1.4, the COL applicant is responsible for describing the uses of PRA in support of licensee programs such as RAP implementation during the operational phase.

19.1.7.5 PRA Input to the Regulatory Treatment of Non-Safety-Related Systems Program

The APR1400 design is an evolutionary ALWR, and the RTNSS is not applicable to this design.

19.1.8 Conclusions and Findings

The APR1400 PRA, as demonstrated through the preceding subsections, has been used to achieve the following:

a. To identify and address potential design and operational vulnerabilities (i.e., failures or combinations of failures that are significant risk contributors that could

drive the risk to unacceptable levels with respect to NRC safety goals: Subsections 19.1.4, 19.1.5, and 19.1.6.

b. To reduce or eliminate known weaknesses of existing operating plants that are applicable to the new design, by introducing appropriate features and requirements: Subsection 19.1.3.

c. To select among alternative features, operational strategies, and design options: Subsection 19.1.3.

d. To develop an in-depth understanding of the design's robustness and tolerance of severe accidents initiated by either internal or external events: Subsections 19.1.4, 19.1.5, and 19.1.6.

e. To examine the risk-significance of specific human errors associated with the design, and characterize the significant human errors in preparation for better training and more refined procedures: Subsections 19.1.4, 19.1.5, and 19.1.6.

f. To determine how the risk associated with the design compares against the NRC safety goals of less than 1×10^{-4}/year for core damage frequency (CDF) and less than 1×10^{-6}/year for large release frequency (LRF): Subsections 19.1.4, 19.1.5, and 19.1.6.

g. To determine containment performance against the NRC containment performance goal, which includes a deterministic goal that containment integrity be maintained for approximately 24 hours following the onset of core damage for the more likely severe accident challenges and a probabilistic goal that the conditional containment failure probability (CCFP) be less than approximately 0.1 for the composite of core damage sequences assessed in the PRA: Subsection 19.1.4.

h. To assess the balance of preventive and mitigate features of the design, including consistency with guidance in SECY-93-087 and the associated staff requirements memoranda: Subsection 19.1.3.

i. To demonstrate that the plant design represents a reduction in risk compared to existing operating plants: Subsection 19.1.3.

j. To demonstrate that the design addresses known issues related to the reliability of core and containment heat removal systems at some operating plants: Subsection 19.1.3.

k. To support regulatory oversight processes and programs that is associated with plant operations (e.g., technical specifications, reliability assurance, maintenance rule, etc.): Subsection 19.1.7.

l. To identify and support the development of design requirements, such as inspection, tests, analysis, and acceptance criteria (ITAAC), reliability assurance program (RAP), technical specifications, and Combined License (COL) action items and interface requirements: Subsection 19.1.7 and Section 19.6.

19.1.9 Combined License Information

COL 19.1(1) The COL applicant is to describe the uses of PRA in support of licensee programs and, to identify and describe risk-informed applications being implemented during the combined license application phase.

19.1.10 References

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21. NUREG/CR-1278, “Handbook of Human Reliability Analysis with Emphasis on Nuclear Power Plants,” U.S. Nuclear Regulatory Commission, August 1983.

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Table 19.1-1 (1 of 3)

Characterization of PRA Relative to Supporting Requirements in ASME PRA Standard

Technical Area	APR1400 PRA Characteristics
Initiating Events Analysis (IE)	Comprehensive, systematic search made for initiating events. Most aspects of the IE analysis satisfy Capability Category II or greater. Elements of the PRA that cannot meet at least Category II until later stages of design, construction and operation include the following: Plant-specific operating experience is not available for review, although experience of current plants was considered (IE-A3, IE-A7). Operators are not yet available to be interviewed (IE-A6). Initiating event frequencies reflect generic data (IE-C1). The ability to capture plant-specific information in the assessment of recovery actions is limited (IE-C9).
Accident Sequence Analysis (AS)	Response to the initiating events was first delineated via the use of event sequence diagrams (ESD), and these were used to define core-damage sequences via the construction of event trees. Most aspects of the accident sequence analysis satisfy Capability Category II. Elements of the PRA that cannot meet at least Category II until later stages of design, construction and operation include the following: The functions and structure of the accident-sequence models reflect expectations of plant-specific operating practices, based on those of current plants (AS-A5).
Success Criteria (SC)	Success criteria reflect design-specific calculations performed using the MAAP4 and RELAP5 computer codes. These calculations are equivalent to the requirements for Capability Category II. An exception is as follows: Plant-specific operating philosophy and procedures are not available to confirm the bases for success criteria (SC-A6).

Table 19.1-1 (2 of 3)

Technical Area	APR1400 PRA Characteristics
Systems Analysis (SY)	The systems analyses were accomplished via the construction of detailed fault trees. These fault trees reflect the design details available. Aspects that do not meet at least Capability Category II because of the state of the design include the following: Since the plant has not yet been constructed, it is not possible to collect information on the as-built, as-operated systems (SY-A2). Although it is reasonable to infer testing and maintenance practices and system operating procedures from operating plants, these elements do not yet exist (SY-A3). Plant walkdowns cannot be conducted until the plant is constructed (SYA4). The ability to address spatial and environmental hazards is limited for a plant in the design phase (SY-B8). There is not yet operating procedures or actual system operating experience that can be documented (SY-C2).
Human Reliability Analysis (HRA)	HRA necessarily relies on significant plant-specific information that is not yet available. The nature of the human reliability analysis and the areas in which compensatory steps are addressed is summarized in Section 19.1.2.
Data Analysis (DA)	Parameter estimates necessarily reflect generic data. These data were obtained from available relevant sources. Specific requirements for which the data analysis does not meet at least Capability Category II include the following: The lack of plant-specific operating experience precludes the development and use of a plant-specific database or of specialization of generic data based on plant experience via Bayesian analysis (DA-C2 through DA-C13; DA-D1 & DA-D4).

Table 19.1-1 (3 of 3)

Technical Area	APR1400 PRA Characteristics
Internal Flooding (IF)	Some aspects of the internal flooding analysis are limited by the lack of plant specific details. Specific areas in which the internal flooding analysis does not meet at least Category II include the following: Plant information reflecting as-built, as-operated conditions does not yet exist (IF-A3). Walkdowns cannot be conducted until the plant is constructed (IF-A4, IFB3a). Some sources of flooding will account for plant/site-specific features not yet available (IF-B1). Conservative assumptions were made with respect to propagation pathways and areas that could be affected (IF-C1 & IF-C2).
Quantification (QU)	The quantification was performed by solving the overall core-damage model using the linked fault-tree approach. The quantification satisfies at least Category II for each of the supporting requirements.
LERF (LE)	A detailed assessment of containment response and release frequency has been conducted. The assessment satisfies at least Capability Category II for the supporting requirements, except for such aspects as system failure analysis and human reliability analysis, as addressed for technical areas SY, HF and DA above.

Table 19.1-2 (1 of 10)

Key Design Features in APR1400

System	SSC Configuration	Key Functional Description	Design Features
Safety Injection Tank	• Four independent passive trains • Equipped with a fluidic device	• Rapid reflooding of the core following Large break LOCA • RCS inventory makeup during rapid cooldown in Small break LOCA	• Prevent core damage
In-containment refueling water storage tank (IRWST)	• Located in the containment • Equipped with hold-up volume tank (HVT) • Two independent ECCS sump strainers	• Single source of water for ECCS, CSS and refueling • Primary heat sink to condense the steam discharged during feed and bleed operation • Fission product scrubbing • Eliminates ECCS and CSS recirculation operation • Screens out containment debris	• Prevent core damage • Mitigate core damage consequences • Prevent containment release • Mitigate release consequences
Safety Injection System	• Four independent trains with direct vessel injection (DVI) nozzles • Two independent Hot Leg Injection paths (1 path per 2 trains) • Two independent return lines to IRWST (1 path per 2 trains)	• RCS inventory makeup • RCS heat removal (long-term cooling) • Feed and bleed operation	• Prevent core damage • Mitigate core damage consequences • Prevent containment release

Table 19.1-2 (2 of 10)

System	SSC Configuration	Key Functional Description	Design Features
Shutdown Cooling System	• Two independent trains • Two independent heat exchangers (1 per train)	• RCS inventory makeup • RCS heat removal (long-term cooling and IRWST cooling) • Backup for containment spray pump	• Prevent core damage • Mitigate core damage consequences • Prevent containment release
Containment Spray System	• Two independent divisions • Two independent heat exchangers (1 per division) • Two independent containment spray nozzle rings	• Containment heat removal • Containment pressure control • Fission product scrubbing • Backup for shutdown cooling pump	• Mitigate core damage consequences • Prevent containment release • Mitigate release consequences
Emergency Containment Spray Backup System	• Single independent division with external water source • Dedicated ECSBS spray nozzle ring	• Diverse containment pressure control	• Prevent containment release
Chemical and Volume Control System	• Two charging pumps and two boric acid makeup pumps with suction from boric acid storage tank	• Emergency boration • RCP seal cooling • IRWST inventory makeup	• Prevent core damage • Mitigate core damage consequences

Table 19.1-2 (3 of 10)

System	SSC Configuration	Key Functional Description	Design Features
Auxiliary Feedwater	• One motor-driven pump train and one turbine-driven pump train per SG • One AFW storage tank per SG • Alternative water sources for AFW pumps	• RCS secondary heat removal • RCS depressurization with MSADV • Fission product scrubbing during SGTR	• Prevent core damage • Mitigate core damage consequences • Mitigate release consequences
Startup Feedwater	• One non-safety pump train with suction from deaerator storage tanks (DSTs) from condensate system	• Diverse RCS secondary heat removal	• Prevent core damage
Main Steam	• Two main steam lines per SG • One MSIV per main steam line with MSIVBV • One MSADV and five MSSVs per main steam line • Eight non-safety TBVs	• RCS secondary heat removal • RCS depressurization • Secondary side pressure relief • Mitigate RCS pressure transient • SG isolation during SGTR and secondary side pipe breaks	• Prevent core damage • Mitigate core damage consequences • Prevent containment release • Mitigate release consequences
Reactor Protection System	• Four independent channels • Two-out-of-four coincidence logic • Two sets of four reactor trip switchgears (RTSGs)	• Provides redundant and diverse reactor trip signals	• Prevent core damage

Table 19.1-2 (4 of 10)

System	SSC Configuration	Key Functional Description	Design Feature
Diverse Protection System	• Non-safety four channels • Two-out-of-four coincidence logic	• Provides diverse means for reactor trip signal, turbine trip, SIAS, and AFAS • Diverse ATWS mitigation system	• Prevent core damage • Mitigate core damage consequences
ESFAS	• Four independent channels • Two-out-of-four coincidence logic	• Provides redundant signals to SIAS, CSAS, CIAS, MSIS, and AFAS	• Prevent core damage • Mitigate core damage consequences • Prevent containment release • Mitigate release consequences
Reactor Coolant System – POSRV subsystem	• Four POSRVs • POSRV discharge lines to IRWST • Spargers in IRWST • Two three-way valve for POSRV discharge lines to IRWST	• RCS overpressure protection • Provides bleed capability for feed and bleed operation • Discharge from POSRVs is routed to the IRWST - eliminates potential for containment debris entrainment to clog sump strainers during feed and bleed operation • Provides rapid depressurization capability • Prevents severe accident induced SGTR • Mitigates potential high hydrogen concentration buildup in IRWST during severe accidents to prevent potential hydrogen explosion • Fission product scrubbing	• Prevent core damage • Mitigate core damage consequences • Prevent containment release • Mitigate release consequences

Table 19.1-2 (5 of 10)

System	SSC Configuration	Key Functional Description	Design Feature
Reactor Coolant Gas Vent System (RCGVS)	• Single vent path with two valve lines from reactor pressure vessel head • Single vent path with two valve lines from pressurizer	• Vents non-condensable gases from RCS • Discharges to IRWST for safety functions or to RDT for startup/shutdown operation • RCS pressure control	• Prevent core damage • Mitigate core damage consequences
Hydrogen Mitigation System	• 30 PARs and 8 igniters	• Hydrogen control	• Prevent containment release
Cavity Flooding System	• Two independent divisions with suction from IRWST via HVT	• Pre-flooding of reactor cavity • Mitigates MCCI progression • Fission product scrubbing	• Prevent containment release • Mitigate release consequences
Essential Service Water System	• Two independent divisions with two pumps per division • Two separate cooling towers • Located in ESW building	• Provides ultimate heat sink • Provides cooling water to CCW heat exchangers to remove heat released by SSCs	• Prevent core damage • Mitigate core damage consequences • Prevent containment release • Mitigate release consequences

Table 19.1-2 (6 of 10)

System	SSC Configuration	Key Functional Description	Design Feature
Component Cooling Water System	• Two independent divisions with two pumps per division • Three heat exchangers per division located in CCW building	• Provides cooling water to the safety-related and non-safety-related loads • Division I provides cooling water to RCP seals	• Prevent core damage • Mitigate core damage consequences • Prevent containment release • Mitigate release consequences
Essential Chilled Water System	• Two independent divisions with two pumps/chillers per division	• Provides chilled water to safety-related cooling coils of air handling units (AHUs) and cubicle coolers	• Prevent core damage • Mitigate core damage consequences • Prevent containment release • Mitigate release consequences
Class 1E ac power system	• Four independent Class 1E 4.16kV Switchgears • Powered from offsite power via two unit auxiliary transformers (UATs) or standby auxiliary transformers (SATs) • UATs are powered from the main generator or offsite power	• Provides power to the loads for safe shutdown • Provides house load operation (HLO) capability • Provides a fast transfer from the UAT supply to the SAT supply	• Prevent core damage • Mitigate core damage consequences • Prevent containment release • Mitigate release consequences

Table 19.1-2 (7 of 10)

System	SSC Configuration	Key Functional Description	Design Feature
Emergency Diesel Generator	• Four independent EDGs • One 7-day fuel oil capacity storage tank per EDG	• Each EDG supplies emergency onsite power to respective Class 1E 4.16 kV bus	• Prevent core damage • Mitigate core damage consequences • Prevent containment release • Mitigate release consequences
Alternative AC Power	• One non-Class 1E train of AAC Gas Turbine Generator with independent room cooling system and independent dc power supply	• Provides diverse onsite emergency power to Class 1E SWGR during SBO • Eliminates the potential of common cause failures between AAC and EDGs	• Prevent core damage • Mitigate core damage consequences • Prevent containment release • Mitigate release consequences
125V dc power system	• Four Class 1E dc batteries with two battery chargers per dc bus • 4-hour capacity for trains A and B • 16-hour capacity for trains C and D	• Provide control dc power for operation of safety related equipment or equipment important to safety • Provides extended time for recovery of offsite power following a SBO	• Prevent core damage • Mitigate core damage consequences • Prevent containment release • Mitigate release consequences

Table 19.1-2 (8 of 10)

System	SSC Configuration	Key Functional Description	Design Feature
120V ac power system	• Four Class 1E ac trains with associated inverter or regulating transformer per train	• Provide uninterruptible control ac power for operation of safety related equipment or equipment important to safety	• Prevent core damage • Mitigate core damage consequences • Prevent containment release • Mitigate release consequences
Instrument air	• Three compressors, three air receivers, and two dryer packages	• Provides instrument air to key SSCs	• Prevent core damage • Mitigate core damage consequences
HVAC systems	• Emergency diesel generator area HVAC system • ESW intake structure/CCW heat exchanger building HVAC system • Auxiliary building controlled area HVAC system • Auxiliary building clean area HVAC system	• Provide room and equipment cooling capability	• Prevent core damage • Mitigate core damage consequences • Prevent containment release • Mitigate release consequences

Table 19.1-2 (9 of 10)

System	SSC Configuration	Key Functional Description	Design Feature
Auxiliary Building	• Four physical quadrant design • System layout and design utilizing the principles of physical separation • Emergency overflow lines (EOLs) and flood barriers	• Limits impacts from internal and external hazards to the relevant quadrant • Minimizes impact of aircraft crash	• Prevent core damage • Mitigate core damage consequences
Reactor containment building	• Post-tensioned cylindrical concrete wall with a steel liner, and reinforced concrete internal structures • Containment isolation • Large reactor cavity floor area • Reactor cavity with core debris chamber and a convoluted vent path	• Minimizes containment overpressure failure • Minimizes fission products release • Enhances ex-vessel core debris coolability • Minimizes impact of direct containment heating • Minimizes impact of aircraft crash	• Prevent core damage • Mitigate core damage consequences • Prevent containment release • Mitigate release consequences
Fire protection system	• Fire detection system • Water supply system including fire tank, pump and yare fire main and distribution system • Automatic fire fighting systems • Manual firefighting systems	• Prevents fires from starting • Rapidly detects, controls, and extinguishes fires • Provides protection for SSCs important to safety from fires • Minimizes adverse impact of inadvertent operation from fires	• Prevent core damage • Mitigate core damage consequences

Table 19.1-2 (10 of 10)

System	SSC Configuration	Key Functional Description	Design Features
Main control room	• Highly integrated control room (HICR) design • Digitalized I&C with soft controls and displays • Safety console with diverse manual ESF actuation (DMA) switches and diverse indication system (DIS)	Complies with GDC 19: • Provides an indication and control function for the safe and reliable operation of the plant • Provides a diverse indication and control function for safe shutdown and accident mitigation • Provides an indication and control for safety functions during and following a seismic event • Provides reasonable assurance of an adequate human-system interface (HSI)	• Prevent core damage • Mitigate core damage consequences • Prevent containment release • Mitigate release consequences
Remote shutdown room (RSR)	• Remote shutdown console (RSC) with soft controls and displays	• Allows emergency shutdown from outside the main control room	• Prevent core damage • Mitigate core damage consequences • Prevent containment release • Mitigate release consequences
Remote control center (RCC)	• Panel with channelized Class 1E control and the associated signals and the non-Class 1E signals routed from hardwired switches to the P-CCS loop controller and the motor control center (MCC) • Located separately from the MCR and RSR	• Maintains the reactor for 24 hours to accomplish hot standby plant condition against aircraft impact	• Prevent core damage • Mitigate core damage consequences • Prevent containment release • Mitigate release consequences

Table 19.1-3 (1 of 5)

Design Features Addressing Potential Risk Challenges

Potential Risk Challenges	Design features and operational strategies
Design Features for Preventing Core Damage	
Loss of offsite power (LOOP)/Station blackout (SBO): • LOOP event occurrence • Onsite emergency power capability • RCP seal cooling	• House load operation (HLO) minimizes reactor trip during LOOP event • Improvements on the onsite emergency power capability - Four EDGs with large fuel storage capacity - A diverse AAC using combustion gas turbine - Extended battery life to 16 hours - Mobile EDGs - Mobile battery chargers and batteries • Improvements on RCP seal challenges - Advanced seal design - Improved seal injection cooling system - Auxiliary charging pump in addition to two CHPs
LOCA: • ECCS recirculation for long-term operation • RCS inventory makeup for LOCAs • Challenges associated with long-term cooling • Containment heat removal and pressure control	• Elimination of ECCS recirculation phase - IRWST integrated into containment with a continual makeup via hold-up tank • Improvements to deal with any sizes of LOCAs - Four redundant SI pump trains - Improved SIT design with fluidic device (FD) • Improvements made for long-term cooling - Shutdown cooling pumps capable of long term injection or SDC operation

Table 19.1-3 (2 of 5)

Potential Risk Challenges	Design features and operational strategies
Design Features for Preventing Core Damage	
(Cont'd)	• Improvements made for containment heat removal - IRWST cooling by SCS - Containment spraying by CSS - SC pumps designed to backup CS pumps • Improvements made for containment pressure control - Diverse independent ECSBS
Transients: • Secondary heat removal capability • Initial pressure transients mitigation	• Improvements to deal with secondary heat removal - Two divisions with a motor-driven AFW pump and a turbine-driven AFW pump per division - Large capacity of AFW storage tanks - Alternative sources for AFW pumps - Advanced POSRV design to enhance the feed and bleed operation - Independent startup feedwater operation • Improvements to deal with initial pressure transients - Additional pressure relief capabilities using MSSVs, TBVs and MSADVs
SGTR:	• Addition of main steam line and associated SSCs per steam generator provides additional pressure relief and steam removal capabilities • POSRVs provide a rapid RCS depressurization capability which prevents severe accident induced SGTR

Table 19.1-3 (3 of 5)

Potential Risk Challenges	Design features and operational strategies
Design Features for Preventing Core Damage	
Internal Flooding: • Flooding in auxiliary building • Flooding in turbine building	• Improvements to deal with auxiliary building flooding - Four physically separated quadrant design - Elimination of a large water source into auxiliary building - Installation of emergency overflow line (EOL) to redirect flood water to lowest level of auxiliary building • Improvements to deal with turbine building flooding - Relocation of all SSCs with safety functions away from turbine building
Internal Fire: • Fire in auxiliary building • Fire in turbine building	• Improvements to deal with fires in auxiliary building - Four physically separated quadrant design - Separation of key SSCs into four quadrants - Cable separation at the division level - Highly compartmentalized where many fire areas with 3 hour fire rating barriers - Employ fiber optic cables between the MCR Safety Console, the group controllers and loop controllers thereby minimizing the impact from fire induced spurious hot shorts • Improvements to deal with fires in turbine building - Relocation of all SSCs with safety functions away from turbine building

Table 19.1-3 (4 of 5)

Potential Risk Challenges	Design features and operational strategies
Design Features for Mitigating the Consequences of Core Damage and Preventing Releases from Containment	
High pressure melt ejection	• Improvements to deal with high pressure melt ejection - Rapid RCS depressurization by POSRVs - Reactor cavity with core debris chamber and a convoluted vent path - Reactor cavity with adequate distance between the floor elevation and the embedded portion of the containment steel liner to delay core debris contact with the liner
Ex-vessel debris cooling and MCCI	• Improvements to deal with debris cooling in reactor cavity - Addition of cavity flooding system to pre-flood reactor cavity - Large reactor cavity floor area
Hydrogen accumulation	• Addition of passive autocatalytic recombiners (PARs) to limit hydrogen concentration in the containment • Igniters to supplement PARs for accidents where rapid hydrogen release rates are expected • Large volume of the containment • Prevention of hydrogen accumulation in the IRWST by operating POSRV’s 3-way valve

Table 19.1-3 (5 of 5)

Potential Risk Challenges	Design features and operational strategies
Design Features for Mitigating the Consequences of Core Damage and Preventing Releases from Containment	
Containment overpressure	• Large and robust containment • Containment heat removal to prevent containment overpressure - SCPs designed to backup CSPs - Addition of emergency containment spray backup system (ECSBS) provides a diverse and independent to control containment pressure
Design Features for Mitigating the Consequences of Releases from Containment	
Radionuclide release reduction	• Improvements to reduce radionuclide releases - Additional fission product scrubbing in IRWST via POSRV spargers - Additional fission product scrubbing in cavity flooding system that pre-floods reactor cavity

Table 19.1-4 (1 of 3)

PRA Key Assumptions

Assumption		Impact on Risk
1	The external events, such as internal fire, internal flooding and seismic assessments are based on the APR1400 design information where available, and the information from the reference plants where information is not available.	This general assumption enables more refined evaluation of the associated hazards, and eliminates unnecessary conservatisms. Overall risk matrices and risk insights are not expected to be different.
2	Since there is no technical basis whether reactor trip is required for MLOCA, the reactor trip is conservatively assumed to be required for the MLOCA which is reflected in the MLOCA event tree. In the MLOCA event tree, the branch that fails reactor trip can be mapped to either ‘Core Damage’ or transferred to ATWS event tree. A preferred mapping is the ‘Core Damage.’	The assumption has a minimal impact on the core damage frequency.

Table 19.1-4 (2 of 3)

Assumption		Impact on Risk
3	During SBO condition, AAC connection is assumed on one ESF 4.16 kV bus only. However, it is also assumed that the operators will connect the AAC where it is most needed among four ESF 4KV buses, by considering availability of the turbine driven AF pumps and the battery life.	The assumption has a moderate impact on the SBO sequences where SBO risk contribution decreased.
4	Containment sump plugging is included in the PRA model, and this event represents plugging by debris in the containment during accident. However, the downstream chemical effects are assumed to be negligible, in accordance with GSI-191 resolution where RMI usage will eliminate the chemical effects.	The downstream chemical effects could add a moderate risk impact for LOCA and feed and bleed sequences.

Table 19.1-4 (3 of 3)

Assumption		Impact on Risk
5	The model for the digital I&C system from the reference plants is assumed to be applicable to APR1400 and the current model retained the fault tree models from the reference plants, but excludes the software events and the communication link models. Current model will be retained as-is with a single event representing the software/communication links as a black-box event. The event probability will be based on the engineering judgment.	It is expected that this assumption will not have a significant impact on the risk, compare to the conventional I&C system. The dependency between hardware and software (including communication links) is not evaluated at this stage, but will be evaluated during next phase when the design details become available.
6	Creditability of ECCS equipment room exhaust ACU in the Aux Building is assumed in the PRA as a diverse room cooling capability to room cooling coils cooled by ECW. It is assumed that there will be sufficient capacity to remove the heat from the affected rooms during the accident condition and a loss of ECW.	Creditability of the emergency HVAC has a significant impact on the risk, since the operability of most ECCS SSCs depends on it. The room heatup calculations may be needed to show that the emergency HVAC alone is adequate to remove the heat.
7	Room cooling is assumed not needed for the following rooms when the ECW are unavailable. 125V dc Battery/Battery Charger rooms 120V dc/120V ac Distribution Areas Class 1E ESF 480V Load Center rooms Class 1E ESF 480V MCC rooms Electrical equipment rooms (i.e., loop controllers, group controllers)	It is expected that the heat generation in these rooms are not as severe as other rooms. If necessary, a door(s) can be opened and portable fans installed to remove the heat from the impact rooms. However, such local operator action was not credited in this PRA.

Table 19.1-5 (1 of 3)

Relation of the Plant Safety Functions and the Initiating Events

Initiator Type	Impact on Core Performance Functions				Impact on Plant System Performance	Level 2 Analysis Considerations
	Reactivity Control	RCS Pressure Control	RCS Inventory Control	RCS Heat Removal		
LOCAs	None; LOCAs followed by reactor protection system (RPS) failure are grouped under the ATWS category.	None; the LOCA will depressurize the RCS eliminating potential to exceed upper RCS design pressure limit. RCS inventory control response will provide necessary lower limit pressure control.	Major impact. LOCA break size dictates the amount of RCS makeup required to ensure that the reactor core is covered.	Potential Major impact, depending on the break size and the occurrence of transient induced LOCAs. For medium and large LOCAs, the systems used to provide RCS inventory control are also used for RCS heat removal.	Potential major impact, depending on the location of the LOCA. LOCAs in SI or SC injection piping will partially fail these systems. ISLOCAs may fail plant systems due to dynamic effects (e.g., pipe whip) or steam flooding.	LOCAs are subdivided according to their ability to bypass the containment: • No bypass • Bypass - ISLOCAs - SGTRs

Table 19.1-5 (2 of 3)

Initiator Type	Impact on Core Performance Functions				Impact on Plant System Performance	Level 2 Analysis Considerations
	Reactivity Control	RCS Pressure Control	RCS Inventory Control	RCS Heat Removal		
Secondary Piping Break	Steam/feed line breaks followed by RPS failure are treated separately in the secondary pipe break accident sequence analysis.	Feed line break and isolation may require pressure control.	RCS inventory control is required. RCS integrity impacted if POSRVs fail to reclose.	Steam/feed line break will isolate steam and feedwater flow and actuate ECCS. The systems used to provide RCS inventory control are also used for RCS heat removal.	Potential major impact, depending on the location of the steam/feed line break. High energy line breaks (HELBs) may fail plant systems due to dynamic effects (e.g., pipe whip) or steam flooding.	No specific effects. HELBs that fail plant systems designed to prevent core damage may also fail containment systems.
Transients (including Special Initiators)	None; Transients followed by RPS failure are grouped under the ATWS category.	Potential major impact, depending on the specific initiator involved (e.g., LOOP).	None. Transient induced LOCAs (e.g., RCP seal LOCAs and safety relief valve LOCAs) are grouped under the LOCA category.	Potential major impact, depending on the specific initiator involved (e.g., loss of MFW).	Potential major impact, depending on the specific initiator involved. Special initiators are defined, in part, by their impact on post-trip plant system operation.	No specific effects. Special initiators that fail plant systems designed to prevent core damage may also fail containment systems.

Table 19.1-5 (3 of 3)

Initiator Type	Impact on Core Performance Functions				Impact on Plant System Performance	Level 2 Analysis Considerations
	Reactivity Control	RCS Pressure Control	RCS Inventory Control	RCS Heat Removal		
ATWS	ATWS represents failure of the RPS.	Major impact since RCS pressure should be maintained below design limit.	Major impact if the peak pressure exceeds the RCS design limit.	Potential major impact, depending on the specific initiator involved (e.g., LOFW).	No specific effects. Plant system impacts related to transients, secondary breaks, and LOCAs apply to ATWS as well.	No specific effects. Level 2 considerations related to transients, secondary breaks, and LOCAs apply to ATWS as well.

Table 19.1-6 (1 of 3)

Internal Events PRA Initiating Event Frequencies

Designator	Initiating Event Description	Mean Frequency (Per Rx Critical Year)(1)	Mean Frequency (Per Rx Calendar Year)(2)	Error Factor
LLOCA(3)	Large LOCA (Rupture greater than 15.24 cm dia.)	1.33E-06	1.26E-06	10.7
MLOCA(3)	Medium LOCA (Rupture of 5.08 cm to 15.24 cm dia.)	5.10E-04	4.85E-04	10.0
SLOCA(3)	Small LOCA (Rupture of 5.08 cm dia. or less) (Total of SLOCA + RCP Seal LOCA + IOSRV Frequencies)	2.09E-03	1.99E-03	8.4
SGTR	Steam Generator Leakage/Tube Rupture	2.07E-03	1.97E-03	2.5
LSSB-U	Large Secondary Side Breaks Upstream of MSIV	3.67E-04	3.49E-04	8.4
LSSB-D	Large Secondary Side Breaks downstream of MSIV	7.70E-03	7.32E-03	1.6
LODCA	Loss of Class 1E 125V DC A	7.37E-04	7.00E-04	3.3
LODCB	Loss of Class 1E 125V DC B	7.37E-04	7.00E-04	3.3

Table 19.1-6 (2 of 3)

Designator	Initiating Event Description	Mean Frequency (Per Rx Critical Year)(1)	Mean Frequency (Per Rx Calendar Year)(2)	Error Factor
GTRN	General Transient	6.90E-01	6.56E-01	1.7
LOFW	Loss of Main Feedwater	6.89E-02	6.55E-02	2.7
FWLB	Main Feedwater Line Break	1.83E-03	1.74E-03	2.5
LOCV	Loss of Condenser Vacuum	5.86E-02	5.57E-02	2.2
ATWS	Anticipated Transient without SCRAM	Transferred from each Event Tree (including RT)		N/A
LOOP	Loss of Offsite Power:	-		-
LOOP-PL	Plant-centered	1.93E-03	1.83E-03	2.5
LOOP-SW	Switchyard-centered	1.04E-02	9.88E-03	1.5
LOOP-GR	Grid-related	1.22E-02	1.16E-02	11.6
LOOP-WE	Weather-related	3.91E-03	3.71E-03	1.7
SBO	Station Blackout	Transferred from LOOP Event Tree		1.7
LOIA(3)	Loss of Instrument Air System	2.48E-02	2.69E-02	2.1
TLOCCW(3)	Total Loss of Component Cooling Water System	2.46E-04	2.34E-04	8.4
PLOCCW(3)	Partial Loss of Component Cooling Water System	4.59E-03	4.36E-03	2.0

Table 19.1-6 (3 of 3)

Designator	Initiating Event Description	Mean Frequency (Per Rx Critical Year)(1)	Mean Frequency (Per Rx Calendar Year)(2)	Error Factor
TLOESW(3)	Total Loss of Essential Service Water System	2.46E-04	2.34E-04	8.4
PLOESW(3)	Partial Loss of Essential Service Water System	1.72E-3	2.52E-03	2.6
RVR(4)	Reactor Vessel Rupture	3.22E-08	3.06E-08	67.5
ISLOCA(5)	Interfacing System Loss of Coolant Accident	1.24E-10	1.18E-10	10.0

(1) The mean frequencies for these initiating events are values presented in Reference 11 in units of per reactor critical year (rcry). (Excludes frequencies for ISLOCA, and reactor vessel rupture, which a separately calculated.)

(2) The mean frequencies for these initiating events were adjusted to an APR1400 specific per reactor calendar year (rcy). Converting to APR1400 specific reactor calendar year (rcy), it was assumed the reactor is critical 95% of the year.

Converting to rcy, the result is:

(Mean Initiating Event Frequency/rcry) × (0.95 rcry/rcy) = Mean Initiating Event Frequency/rcy

(3) APR1400 LOCA break size from generic industry data. These LOCA initiating event frequencies are used as an estimate for APR1400 LOCA frequencies.

Support system initiating event frequencies (/rcry) for LOIA, TLOCCW, PLOCCW, TLOESW, and PLOESW are calculated using fault trees in the initiating event analysis for information purposes. However, industry values for these parameters are utilized in the quantified PRA model.

(4) Reactor Vessel Rupture frequency (2.90E-08/rcy) was taken from NUREG-1829, Volume 1, Table 7.19, for break sizes > 31 inches (Reference 52). This value was treated similarly to other LOCA frequencies, converting to per reactor critical year by multiplying by 1 rcy/0.9 rcry.

(5) The ISLOCA initiating event frequency (/rcy) is taken from calculation. No Error Factor (EF) is calculated for this initiating event frequency and thus an EF of 10 is assumed.

Table 19.1-7 (1 of 2)

Level 1 Internal Events PRA Event Tree List

Initiator Group	Event Tree Name
1. Large Break Loss of Coolant Accident	LLOCA
2. Medium Break Loss of Coolant Accident	MLOCA
3. Small Break Loss of Coolant Accident	SLOCA
4. Stuck Open POSRV	PR-SL
5. Steam Generator Tube Rupture	SGTR
6. Interfacing System LOCA	ISLOCA
7. Reactor Vessel Rupture	RVR
8. General Transient	GTRN
9. Loss of Condenser Vacuum	LOCV
10. Loss of 125V DC - Bus A	LODCA
11. Loss of 125V DC - Bus B	LODCB

Table 19.1-7 (2 of 2)

Initiator Group	Event Tree Name
12. Loss of Main Feedwater	LOFW
13. Loss of Instrument Air	LOIA
14. Large Secondary Steam Line Break Upstream of MSIV	LSSB-U
15. Large Secondary Steam Line Break Downstream of MSIV	LSSB-D
16. Feedwater Line Break	FWLB
17. Loss of Offsite Power (Grid-related, plant-centered, switchyard-centered, weather-related)	LOOP
18. Consequential LOOP	GRID-LOOP
19. Station Blackout	SBO
20. Consequential SBO	GRID-SBO
21. Partial Loss of Component Cooling Water System	PLOCCW
22. Total Loss of Component Cooling Water System	TLOCCW
23. Partial Loss of Essential Service Water System	PLOESW
24. Total Loss of Essential Service Water System	TLOESW
25. Anticipated Without Scram	ATWS

Table 19.1-8 (1 of 8)

Event Tree Top Events and Success Criteria

Top Event	Top Event Description	Success Criteria	Event Trees
Reactivity Control			
RT	Reactor scram	All CEAs except the most reactive element are fully inserted into the core	FWLB, GTRN, LOCV, LODCA, LODCB, LOFW, LOIA, LOOP, LSSB-D, LSSB-U, MLOCA, SGTR, SLOCA
	Reactor scram and RCP trip	All CEAs except the most reactive element are fully inserted into the core and operators trip RCP manually	PLOCCW, PLOESW, TLOCCW, TLOESW
MTC	Sufficient negative moderator temperature coefficient (MTC) during ATWS	Negative MTC provides reactivity feedback to reduce power such that the primary system does not rupture on high pressure	ATWS
EBR	Emergency boration for long-term reactivity control during ATWS	1 of 2 charging pumps provides emergency boration	ATWS

Table 19.1-8 (2 of 8)

Top Event	Top Event Description	Success Criteria	Event Trees
RCS Pressure Control			
PFO	RCS pressure relief during ATWS	All four POSRVs must open	ATWS
BLEED	RCS bleed using POSRV for feed and bleed decay heat removal	2 of 4 POSRVs need to open	FWLB, GRID-LOOP, GTRN, LOCV, LOFW, LOIA, LOOP, LSSB-D, LSSB-U, PLOCCW, PLOESW, SBO, SGTR, SLOCA
		2 of 2 POSRVs need to open	LODCA, LODCB
		At least 2 POSRVs need to open	PR-SL
ASC	RCS is rapidly depressurized by aggressive secondary cooldown to enable shutdown cooling injection	• 1 of 2 AF pumps provides AFW to the intact SG, and • RCS is rapidly depressurized using 1 of 2 MSADVs on associated SG on associated SG to enable shutdown cooling injection	SGTR
		• 1 of 4 AF pumps provides AFW to 1 of 2 SGs, • 1 of 4 SITs injects borated water into RCS, and • RCS is rapidly depressurized using 1 of 2 MSADVs on associated SG on associated SG to enable shutdown cooling injection	SLOCA

Table 19.1-8 (3 of 8)

Top Event	Top Event Description	Success Criteria	Event Trees
RCS Pressure Control			
ECLDN	RCS is depressurized to stop primary-to-secondary leakage before ruptured SG overfill occurs.	• RCS is depressurized to less than the MSSV lift pressure using 1 of 2 MSADVs on intact SG, • RCS pressure is controlled using auxiliary spray or RCGVS, and • AF pumps are throttled to prevent SG overfill in ruptured SG	LSSB-D, SGTR
LCLDN	RCS is depressurized after ruptured SG overfill occurs.	RCS is depressurized to less than SCS initiation limit using 1 of 2 MSADVs on intact SG	LSSB-D, SGTR

Table 19.1-8 (4 of 8)

Top Event	Top Event Description	Success Criteria	Event Trees
RCS Integrity			
PRC	RCS integrity after challenge to POSRVs (No challenge to POSRVs, or if challenged, all POSRVs reclose after reducing RCS pressure)	All POSRVs must reclose	ATWS
		Primary pressure transient limited by steam relief using one MSSV or one TBV to below POSRV lift setting or all opened POSRV must reclose.	GTRN, LOFW
		All POSRVs must reclose	LOCV, LODCA, LODCB, LSSB-D, LSSB-U
		Primary pressure transient limited by steam relief using one MSSV to below POSRV lift setting or all opened POSRV must reclose.	LOIA, LOOP
PISGTR	SGTR due to pressure difference between primary and secondary side	Pressure difference between primary and secondary side does not result in SGTR	ATWS, FWLB, LSSB-D, LSSB-U
RCPSEAL	RCP seal integrity	RCP seal remains intact given RCP seal injection or auxiliary charging pump provides seal cooling	GRID-SBO, PLOCCW, PLOESW, SBO, TLOCCW, TLOESW
ISLOCA	Interfacing system LOCA	N/A	ISLOCA
RVR	RCS breaks which cannot be mitigated by ECCS	N/A	RVR

Table 19.1-8 (5 of 8)

Top Event	Top Event Description	Success Criteria	Event Trees
RCS Heat Removal			
SIT	Safety Injection Tanks inject borated water	2 of 4 SITs inject borated water	LLOCA
SIS	SI pumps provides high pressure injection to make up lost RCS inventory	1 of 4 SI pumps provides DVI injection	FWLB, LSSB-D, LSSB-U, MLOCA, SGTR, SLOCA, PR-SL
		1 of 2 SI pumps provide DVI injection	PLOCCW, PLOESW
		3 of 4 SI pumps provide DVI injection	LLOCA
SCSI	SC pump injection to RCS	1 of 2 SCS pumps provides injection from IRWST	SGTR, SLOCA
RF	IRWST refill during SGTR	Refill IRWST with borated water using CVCS	LSSB-D, SGTR
	SI pump injection for feed and feed decay heat removal	1 of 4 SI pumps provides DVI injection	FWLB, GRID-LOOP, GTRN, LOCV, LOFW, LOIA, LSSB-D, LSSB-U LOOP, SBO, PLOCCW, PLOESW
		1 of 3 SI pumps provides DVI injection	LODCA, LODCB
HIN	Hot leg injection to prevent boron precipitation	1 of 2 SI pumps provides hot leg injection	LLOCA
SDC	Shutdown cooling for long-term heat removal	1 of 2 SCS pumps provides injection from hot leg	LSSB-D, SGTR

Table 19.1-8 (6 of 8)

Top Event	Top Event Description	Success Criteria	Event Trees
RCS Heat Removal			
SHR	Auxiliary feedwater provides adequate flow to the steam generator to remove decay heat	1 of 4 AF pumps or Startup feedwater pump to associated SG, and 1 MSADV or 1 MSSV on associated SG or 1 TBV	GTRN
		1 of 4 AF pumps or Startup feedwater pump to 1 of 2 SGs, and 1 MSADV or 1 MSSV on associated SG	LOIA
		1 of 4 AF pumps to 1 of 2 SGs, and 1 MSADV or 1 MSSV on associated SG	LOCV, LOFW, LOOP, PR-SL, SLOCA
		1 of 2 AF TDPs or 1 AF MDP (only Division I AF MDP is lost) or Startup feedwater pump to associated SG, and 1 MSADV or 1 MSSV on associated SG or 1 TBV	PLOCCW, PLOESW
		1 of 2 AF TDPs or 1 AF MDP (only Division I AF MDP is lost) and 1 MSADV or 1 MSSV on associated	LODCA, LODCB
		1 of 2 AF TDPs or Startup feedwater pump to associated SG, and 1 MSADV or 1 MSSV on associated SG or 1 TBV	TLOESW, TLOCCW
		1 AF TDPs or 1 AF MDP with AAC to associated SG, and 1 MSADV or 1 MSSV on associated SG	SBO, GRID-SBO
		1 of 2 AF pumps to 2 of 2 SGs, and 1 MSSV or 1 ADV per SG	ATWS

Table 19.1-8 (7 of 8)

Top Event	Top Event Description	Success Criteria	Event Trees
RCS Heat Removal			
SHR1	Auxiliary feedwater provides adequate flow to the steam generator to remove decay heat with onsite emergency power supplied by EDGs	1 of 4 AF pumps to 1 of 2 SGs, and 1 MSADV or 1 MSSV on associated SG	GRID-LOOP
SHR-RAC	Auxiliary feedwater provides adequate flow to the steam generator to remove decay heat with offsite power recovered	1 of 4 AF pumps to 1 of 2 SGs, and 1 MSADV or 1 MSSV on associated SG	GRID-SBO, SBO
Containment Heat Removal			
CSR	Containment heat removal – long-term cooling of containment via CS heat exchangers	1 of 2 CS pumps provides long-term heat removal in recirculation mode	LLOCA, MLOCA
LHR	Long-term RCS cooling	1 of 2 CS pumps provides containment cooling or 1 of 2 SC pumps provides IRWST cooling	FWLB, GRID-LOOP, GTRN, LOCV, LOFW, PR-SL, SBO, SGTR, SLOCA, LOIA, LOOP, LSSB-D, LSSB-U
		1 of 2 CS pump provides containment cooling or 1 of 1 SC pump provides IRWST cooling	LODCA, LODCB
		1 of 1 CS pump provides containment cooling or 1 of 1 SC pump provides IRWST cooling	PLOCCW, PLOESW

Table 19.1-8 (8 of 8)

Top Event	Top Event Description	Success Criteria	Event Trees
General			
AAC	AAC power source	AAC power source aligned to one Class 1E 4.16 kV ac bus	GRID-SBO, SBO
DG	Standby emergency diesel generators provide AC power	1 of 4 EDGs provides ac power to Class 1E 4.16 kV ac bus	GRID-LOOP, LOOP
GRID	Offsite power available after reactor trip	Offsite power remains available after reactor trip	GTRN, LOCV, LODCA, LODCB, LOFW, LOIA, TLOCCW, TLOESW
ISOL	Steam generator isolation following secondary break	Both steam lines on at least one SG isolated by closing the MSIVs	FWLB, LSSB-D, LSSB-U
RAC-16HR	Offsite power recovery	Offsite power restored within 16 hours following an LOOP event	GRID-SBO, SBO

Table 19.1-9 (1 of 4)

PRA Modeled Systems

System Code	System Description/Title
RC	Reactor Coolant System
RG	Reactor Coolant Gas Vent System
SI	Safety Injection/Shutdown Cooling System
CS	Containment Spray System
HG	Containment Hydrogen Control System
PC	Containment Isolation System
IW	In-Containment Water Storage System
CV	Chemical and Volume Control System
SD	Steam Generator Blowdown System
CC	Component Cooling Water System
SX	Essential Service Water System
MS	Main Steam System
AT	Auxiliary Feedwater Pump Turbine System
MS	Main Steam System
AT	Auxiliary Feedwater Pump Turbine System
CD	Condensate System

Table 19.1-9 (2 of 4)

System Code	System Description/Title
CT	Condensate Storage and Transfer System
FW	Feedwater System
AF	Auxiliary Feedwater System
AX	Auxiliary Feedwater Storage and Transfer System
CW	Circulating Water System
WH	Turbine Generator Building Open Cooling Water System
WT	Turbine Generator Building Closed Cooling Water System
WL	Raw Water System
WM	Makeup Demineralizer System
DG	Emergency Diesel Generator System
DA	AAC Diesel Generator
DO	Diesel Fuel Oil Transfer System
IA	Instrument Air System
VC	Control Room HVAC
VD	Emergency Diesel Generator Area HVAC
VE	Electrical and I&C Equipment Areas HVAC
VG	ESW Intake Structure/CCW Hx Building HVAC

Table 19.1-9 (3 of 4)

System Code	System Description/Title
VK	Auxiliary Building Controlled Area HVAC
VO	Auxiliary Building Clean Area HVAC
VP	Reactor Containment Building HVAC
VQ	Reactor Containment Building Purge
VH	CW Intake Structure HVAC
VU	Miscellaneous Building HVAC
WI	Plant Chilled Water System
WO	Essential Chilled Water System
RP	Reactor Protection System
EF	Engineering Safety Features Actuation System
DP	Diverse Protection System
NR	Ex-Core Neutron Flux Monitoring System
PE	ESF-Component Control System
PO	Process-Component Control System
PA	I&C Equipment Room and Computer Room Panels and Cabinets
NP	13.8kV Power System
NB	4.16kV Non Class-1E System

Table 19.1-9 (4 of 4)

System Code	System Description/Title
PF	4.16kV Class-1E System
NG	480V Load Center Non Class-1E System
PG	480V Load Center Class-1E System
NH	480V MCC & Low Voltage Non Class-1E System
PH	480V MCC & Low Voltage Class-1E System
AP	Auxiliary Power System
MP	Main Power System
DC	DC Distribution System
IP	Instrument Power System

Table 19.1-10 (1 of 2)

Dependency between Initiating Events and Front Line Systems

Initiator		LLOCA			MLOCA	SLOCA	SGTR	LSSB-U	LSSB-D	LOFW	FWLB	LOCV	LOIA	PLOCCW	TLOCCW	PLOESW	TLOESW	LODCA	LODCB	LOOP	SBO	GTRN	ATWS
System	SSC	C.L	H.L	DVI	C.L	C.L	SG2	SG2	SG2	-	SG2	-	-	A/C	A/B/C/D	A/C	A/B/C/D	MC01A	MC01B	-	-	-	-
RP	Shutdown rod																					P	T
RCS	Cold Leg (C.L)	T/X			T	T																P	
	Hot Leg (H.L2)		T/X																			P	
	DVI (1B)			T/X																		P	
SG	SG1 (MS line)	*	*	*	*	*																P	
	SG2 (MS line)	*	*	*	*	*	T/X	T/X	T		T/X											P	
SI	PP02A (SIT A)													X	X	X	X	X		E	X	P	
	PP02B (SIT B)														X		X		X	E	X	P	
	PP02C (SIT C)													X	X	X	X			E	X	P	
	PP02D (SIT D)		X	X											X		X			E	X	P	
SC	Train A													X	X	X	X	X		E	X	P	
	Train B														X		X		X	E	X	P	
CS	Train A													X	X	X	X			E	X	P	
	Train B														X		X			E	X	P	
RC	POSRV200	*	*	*	*													X		E	B	P	
	POSRV201	*	*	*	*														X	E	B	P	
	POSRV202	*	*	*	*													X		E	B	P	
	POSRV203	*	*	*	*														X	E	B	P	

Table 19.1-10 (2 of 2)

Initiator		LLOCA			MLOCA	SLOCA	SGTR	LSSB-U	LSSB-D	LOFW	FWLB	LOCV	LOIA	PLOCCW	TLOCCW	PLOESW	TLOESW	LODCA	LODCB	LOOP	SBO	GTRN	ATWS
System	SSC	C.L	H.L	DVI	C.L	C.L	SG2	SG2	SG2	-	SG2	-	-	A/C	A/B/C/D	A/C	A/B/C/D	MC01A	MC01B	-	-	-	-
AF	TDP01A	*	*	*	*															E	B	P	
	MDP02A	*	*	*	*									X	X	X	X	X		E	B	P	
	TDP01B	*	*	*	*		X	X	I		X									E	B	P	
	MDP02B	*	*	*	*		X	X	I		X				X		X		X	E	B	P	
MF	PP07	*	*	*	*	X		X	X	X	X	X						X	X	X	X	P	X
MS	MSADV101	*	*	*	*														X	E	B	P	
	MSADV102	*	*	*	*													X		E	B	P	
	MSADV103	*	*	*	*		I	X	I		X								X	E	B	P	
	MSADV104	*	*	*	*		I	X	I		X							X		E	B	P	
	TBVs	*	*	*	*	X		X	X		X	X	X							X	X	P	X
	MSSVs	*	*	*	*																	P	
CV	PP01A	*	*	*	*	*		*	*	*	*	*	*	X	X	X	X	*	*	*	X	P	
	PP01B	*	*	*	*	*		*	*	*	*	*	*	*	X	*	X	*	*	*	X	P	
	PP03	*	*	*	*	*	*	*	*	*	*	*	*					*	*	*	X	P	*
	PP05	*	*	*	*	*		*	*	*	*	*	*	*	*	*	*	*	*	*	*	P	
	PP06	*	*	*	*	*		*	*	*	*	*	*	*	*	*	*	*	*	*	*	P	

T - Loss of SSC(s) will cause an initiating event.

P - A partial loss of SSC(s) may cause transient.

X - Unavailable during the onset of accident condition.

B - Limited availability due to the battery capacity during SBO condition with AAC available.

E - Emergency power supplied from the each dedicated EDG.

I - Availability depends on the successful isolation of impacted SG.

* - Not considered in the event tree top events.

Table 19.1-11 (1 of 3)

Dependency between Initiating Events and Support Systems

Initiator		LLOCA			MLOCA	SLOCA	SGTR	LSSB-U	LSSB-D	LOFW	FWLB	LOCV	LOIA	PLOCCW	TLOCCW	PLOESW	TLOESW	LODCA	LODCB	LOOP	SBO	GTRN	ATWS
System	SSC	C.L	H.L	DVI	C.L	C.L	SG2	SG2	SG2	-	SG2	-	-	A/C	A/B/C/D	A/C	A/B/C/D	MC01A	MC01B	-	-	-	-
NP	Offsite power																			T/X		P	
DG	DG01A													X	X	X	X	X			T/X	P	
	DG01B														X		X		X		T/X	P	
	DG01C													X	X	X	X				T/X	P	
	DG01D														X		X				T/X	P	
PF	SW01A																			E	B	P	
	SW01B																			E	B	P	
	SW01C																			E	B	P	
	SW01D																			E	B	P	
DC	MC01A																	T/X		E	B	P	
	MC01B																		T/X	E	B	P	
	MC01C																			E	B	P	
	MC01D																			E	B	P	
SX	Train A													X	X	X	X	X		E	B	P	
	Train B														X		X		X	E	B	P	
	Train C													X	X	X	X			E	B	P	
	Train D														X		X			E	B	P	

Table 19.1-11 (2 of 3)

Initiator		LLOCA			MLOCA	SLOCA	SGTR	LSSB-U	LSSB-D	LOFW	FWLB	LOCV	LOIA	PLOCCW	TLOCCW	PLOESW	TLOESW	LODCA	LODCB	LOOP	SBO	GTRN	ATWS
System	SSC	C.L	H.L	DVI	C.L	C.L	SG2	SG2	SG2	-	SG2	-	-	A/C	A/B/C/D	A/C	A/B/C/D	MC01A	MC01B	-	-	-	-
CC	Train A													X	X	X	X	X		E	B	P	
	Train B														X		X		X	E	B	P	
	Train C													X	X	X	X			E	B	P	
	Train D														X		X			E	B	P	
WO	PP01A/CH01A													X	X	X	X	X		E	B	P	
	PP01B/CH01B														X		X		X	E	B	P	
	PP02A/CH02A													X	X	X	X			E	B	P	
	PP02B/CH02B														X		X			E	B	P	
VD	HV12/13A													X	X	X	X	X		E	B	P	
	HV12/13B														X		X		X	E	B	P	
	HV12/13C													X	X	X	X			E	B	P	
	HV12/13D														X		X			E	B	P	
VG	AH01/2A													X	X	X	X	X		E	B	P	
	AH01/2B														X		X		X	E	B	P	
	AH01/2C													X	X	X	X			E	B	P	
	AH01/2D														X		X			E	B	P	
VK	CC: HV13/14A													X	X	X	X	X		E	B	P	
	CC: HV13/14B														X		X		X	E	B	P	
	CV: HV18A	*	*	*	*	*		*	*	*	*	*	*	X	X	X	X	*	*	*	*	P	
	CV: HV18B	*	*	*	*	*		*	*	*	*	*	*		X		X	*	*	*	*	P	
	CV: HV34	*	*	*	*	*		*	*	*	*	*	*		*		*	*	*	*	*	*	*
	SI: HV12A													X	X	X	X	X		E	B	P	
	SI: HV12B														X		X		X	E	B	P	
	SI: HV12C													X	X	X	X			E	B	P	
	SI: HV12D														X		X			E	B	P	
	SC: HV16A													X	X	X	X	X		E	B	P	
	SC: HV16B														X		X		X	E	B	P	
	CS: HV10A													X	X	X	X			E	B	P	
	CS: HV10B														X		X			E	B	P	

Table 19.1-11 (3 of 3)

Initiator		LLOCA			MLOCA	SLOCA	SGTR	LSSB-U	LSSB-D	LOFW	FWLB	LOCV	LOIA	PLOCCW	TLOCCW	PLOESW	TLOESW	LODCA	LODCB	LOOP	SBO	GTRN	ATWS
System	SSC	C.L	H.L	DVI	C.L	C.L	SG2	SG2	SG2	-	SG2	-	-	A/C	A/B/C/D	A/C	A/B/C/D	MC01A	MC01B	-	-	-	-
IA	IA												T/X							X	X	P	
CD	CD	*	*	*	*	*		*	*	*	*	T/X								X	X	P	
CW	CW	*	*	*	*	*		*	*	*	*	T								X	X		
WT	WT	*	*	*	*	*		*	*	*	*									X	X	T	
WH	WH	*	*	*	*	*		*	*	*	*									X	X	T	

T - Loss of SSC(s) will cause an initiating event.

P - A partial loss of SSC(s) may cause transient.

X - Unavailable during the onset of accident condition.

B - Limited availability due to the battery capacity during SBO condition with AAC available.

E - Emergency power supplied from the each dedicated EDG.

I - Availability depends on the successful isolation of impacted SG.

* - Not considered in the event tree top events.

Table 19.1-12

RELAP Thermal-Hydraulic Run Summaries

Case	LOCA Size	Available Components	Other Initial and Boundary Conditions	Peak Fuel Temperature	Results	ASC Initiation
Large Break Loss of Coolant Accident – Safety Injection						
1(a)	Double-ended rupture (30 inch diameter)	Three Safety Injection pumps Two Injection tanks	No Charging pumps No Auxiliary Feedwater pumps No Containment Spray pumps No Shutdown Cooling pumps (Sensitivity analysis with location is performed)	< 1400 K (< 2060°F)	Core damage prevented	N/A
Small Break Loss of Coolant Accident – ASC Timing						
1(b)	2 inch (0.02 ft^2)	One Safety Injection tank	One AFW pump One SC pump One Atmospheric Dump Valve No Safety Injection pumps No Charging pumps No Containment Spray pumps	< 998.4 K	Core damage prevented	40 min
Double Ended Steam Generator Tube Rupture – ASC Timing						
1(c)	0.75 inch (one U-tube double-ended rupture)	MSSVs	One AFW pump One SC pump One Atmospheric Dump Valve No Safety Injection pumps No Charging pumps No Containment Spray pumps No Safety Injection Tanks	< 640 K	Core damage prevented	23 hrs
1(d)		One ADV opens on the ruptured SG		< 640 K	Core damage prevented	5 hrs

Table 19.1-13 (1 of 8)

MAAP Thermal-Hydraulic Run Summaries

Case	Available Components	Other Initial and Boundary Conditions	Peak Fuel Temperature	Results	ASC Initiation	Notes
6 inch Medium Break Loss of Coolant Accident – Safety Injection						
1(a)	One SI pump	No Charging pumps No AFW pumps No Containment Spray pumps No Shutdown Cooling pumps No Safety Injection Tanks	~1400°F at t=0	Core damage prev ented	N/A	N/A

Table 19.1-13 (2 of 8)

Case	Available Components	Other Initial and Boundary Conditions	Peak Fuel Temperature	Results	ASC Initiation and Rate	Notes
2 inch Small Break Loss of Coolant Accident – Hot Leg Break –SC Injection Timing						
2(a)	One SC pump at 7.5 hrs	One AFW pump One Shutdown Cooling pump One Safety Injection Tank No Safety Injection Pump No Charging pumps No Containment Spray pumps	~1400°F at t=0	Core damage prevented	40 minutes (100°F/hr)	N/A
2 inch Small Break Loss of Coolant Accident – Cold Leg Break – Early Feed & Bleed Timing						
2(b)	One SI pump and two POSRV used for F&B at 80 min	No Charging pumps No AFW pumps No Containment Spray pumps No Shutdown Cooling pumps No Safety Injection Tanks	~1400°F	Core damage prevented	N/A	N/A
3/8 inch Small Break Loss of Coolant Accident – Cold Leg Break – Late Feed & Bleed Timing						
2(c)	One SI pumps and two POSRVs used for F&B at 12.5 hrs	One AFW pump One Atmospheric Dump Valve No Charging pumps No Containment Spray pumps No Shutdown Cooling pumps No Safety Injection Tanks	~1400°F at t=0	Core damage prevented	N/A	Secondary Heat Removal available for 8 hrs

Table 19.1-13 (3 of 8)

Case	Available Components	Other Initial and Boundary Conditions	Peak Fuel Temperature	Results	ASC Initiation and Rate	Notes
Double Ended Steam Generator Tube Rupture – Steam Generator Overfill						
3(a)	One ADV opens on ruptured SG	Four Safety Injection pumps Four Safety Injection tanks Two AFW pumps No Charging pumps No Containment Spray pumps No Shutdown Cooling pumps	N/A	N/A	N/A	3.7 hrs to SG overfi ll with AFW flow t hrottled
Double Ended Steam Generator Tube Rupture – IRWST depletion timing						
3(b)	One SI pump (One ADV does not open on rupture d SG)	One AFW pump No Charging pumps No Containment Spray pumps No Shutdown Cooling pumps No Safety Injection Tanks	N/A	N/A	N/A	IRWST depleted in 31.6 hrs
3(c)	Four SI pumps (One ADV opens on ruptured SG)					IRWST depleted in 15.8 hrs
Double Ended Steam Generator Tube Rupture – SCP injection timing						
3(d)	One SC pump at 11 hrs	One AFW pump No Safety Injection Tanks No Safety Injection pumps No Charging pumps No Containment Spray pumps	~1700^{o}F	Core damage prevented	7.5 hrs (100^{o}F/hr)	N/A

Table 19.1-13 (4 of 8)

Case	Available Components	Other Initial and Boundary Conditions	Peak Fuel Temperature	Results	ASC Initiation and Rate	Notes
General Transient – Early Feed & Bleed						
4(a)	One SI pump and two POSRVs used for F&B at 90 min	No Charging pumps No AFW pumps No Containment Spray pumps No Shutdown Cooling pumps No Safety Injection Tanks	~1600°F	Core damage prevented	N/A	N/A
General Transient – Late Feed & Bleed						
4(b)	One SI pump and two POSRVs used for F&B at 12.5 hrs	One AFW pump One Atmospheric Dump Valve No Charging pumps No Containment Spray pumps No Shutdown Cooling pumps No Safety Injection Tanks	~1600°F	Core damage prevented	N/A	Secondary Heat Removal available for 8.0 hrs
General Transient – Secondary Heat Removal						
4(c)	One AFW pump	No Charging pumps No Containment Spray pumps No Shutdown Cooling pumps No Safety Injection Tanks	>5000°F after SG dryout	Core damage limit exceeded	N/A	AFWST depletion at t= 19.0 hrs
General Transient – Steam Generator Dry-out timing						
4(d)	One ADV RCPs tripped at 20 min	No Charging pumps No Containment Spray pumps No Safety Injection pumps No Safety Injection tanks No Shutdown Cooling pumps	>5000°F after RCS boildown	Core damage limit exceeded	N/A	SG dryout at 54 min (Rapid temperature rise begins at 1.6 hrs)

Table 19.1-13 (5 of 8)

Case	Available Components	Other Initial and Boundary Conditions	Peak Fuel Temperature	Results	ASC Initiation and Rate	Notes
Loss of Feedwater - Early Feed & Bleed						
5(a)	One SI pump and two POSRVs used for F&B at 70 min	No Charging pumps No AFW pumps No Containment Spray pumps No Shutdown Cooling pumps No Safety Injection tanks	>1720°F	Core damage pre vented	N/A	N/A
Loss of Feedwater - Late Feed & Bleed						
5(b)	One SI pump and two POSRVs used for F&B at 12.5 hrs	One AFW pump One Atmospheric Dump Valve No Charging pumps No Containment Spray pumps No Shutdown Cooling pumps No Safety Injection Tanks	~1400°F	Core damage pre vented	N/A	Secondary Heat Removal available for 8.0 hrs

Table 19.1-13 (6 of 8)

Case	Available Components	Other Initial and Boundary Conditions	Peak Fuel Temperature	Results	ASC Initiation and Rate	Notes
Loss of Feedwater - AFWST depletion						
5(c)	One ADV, MSSVs RCPs tripped at 30 min	One AFW pump No Charging pumps No Containment Spray pumps No Safety Injection pumps No Safety Injection tanks No Shutdown Cooling pumps	~1400°F at t=0	Core damage prevented	N/A	AFWST depletion at 32.0 hrs
5(d)	One ADV		>5100°F	Core damage limit exceeded	N/A	AFWST depletion at 16.6 hrs
Loss of Feedwater – Steam Generator Dryout timing						
5(e)	One ADV RCPs tripped at 20 min	No Charging pumps No AFW pumps No Containment Spray pumps No Safety Injection pumps No Safety Injection tanks No Shutdown Cooling pumps	>5000°F	Core damage limit exceeded	N/A	SG dryout at 34 min (Rapid temperature rise begins at 65 min)
Loss of Feedwater – IRWST cooling						
5(f)	One SI pump and two POSRVs used for F&B at 70 min	No Charging pumps No AFW pumps No Containment Spray pumps No Shutdown Cooling pumps No Safety Injection tanks	N/A	N/A	N/A	IRWST is saturated at t = 2.6 hrs

Table 19.1-13 (7 of 8)

Case	Available Components	Other Initial and Boundary Conditions	Peak Fuel Temperature	Results	ASC Initiation and Rate	Notes
Station Blackout – AFWST depletion timing						
6(a)	One ADV, MSSVs	One AFW pump No Charging pumps No Containment Spray pumps No Safety Injection pumps No Safety Injection Tanks No Shutdown Cooling pumps	~1400°F at t=0	Core damage prevented	N/A	AFWST depletion at 33 hrs
6(b)	MSSVs				N/A	AFWST depletion at 42 hrs
Station Blackout – Steam Generator Dry-out timing						
6(c)	No components available	No Charging pumps No AFW pumps No Containment Spray pumps No Safety Injection pumps No Safety Injection tanks No Shutdown Cooling pumps	>5000°F	Core damage lim it exceeded	N/A	SG dryout at 81 minutes (Rapid temperature rise begins at 2 hrs)

Table 19.1-13 (8 of 8)

Case	Available Components	Other Initial and Boundary Conditions	Peak Fuel Temperature	Results	ASC Initiation and Rate	Notes
FWLB – AF Isolation Valve Cycling						
7(a)	One ADV, MSSVs RCPs tripped at 20 min	One AFW pump No Charging pumps No Containment Spray pumps No Safety Injection pumps No Safety Injection tanks No Shutdown Cooling pumps	~1400^{o}F at t=0	Core damage prevented	N/A	Cycling number of 37 (Open/Close of 74)
7(b)	MSSVs RCPs tripped at 20 min		~1400^{o}F at t=0	Core damage prevented	N/A	Cycling number of 57 (Open/Close of 114)

Table 19.1-14 (1 of 19)

Component Failure Rate Data

Type Code[1]	Description	Unit	Mean	α	β	EF[2]	Distribution (Source)	Data Source[4]
--ADY	Fail to Operate of Air Dryer	h	5.00E-06	0.30	6.00E+04	18.8	Gamma	Table 10-5, ADU FTOP, Running
--AHL	Fail to Load and Run of Fan (≤1h)	h	1.07E-03	33.50	3.13E+04	1.3	Beta	Table 9-13, FAN FTR, Standby
--AHR	Fail to Run of Fan (>1h)	h	4.54E-05	4.50	9.92E+04	2.0	Gamma	Table 9-13, FAN FTR, Standby
--AHS	Fail to Start of Fan	d	8.42E-04	34.50	4.09E+04	1.3	Beta	Table 9-13, FAN FTR, Standby
SXAHR	Fail to Run of ESW Cooling Tower Fan	h	2.30E-06	2.50	1.09E+06	2.5	Gamma	Table 10-11, CTF FTR, Running/Alternating
SXAHS	Fail to Start of ESW Cooling Tower Fan	d	7.73E-04	1.50	1.94E+03	3.3	Beta	Table 10-11, CTF FTS, Running/Alternating
VGAHR	Fail to Run of Fan	h	5.88E-06	0.53	9.02E+04	7.9	Gamma	Table 9-13, FAN FTR, Running/Alternating

Table 19.1-14 (2 of 19)

Type Code[1]	Description	Unit	Mean	α	β	EF[2]	Distribution (Source)	Data Source[4]
VGAHS	Fail to Start of Fan	d	7.09E-04	42.50	5.99E+04	1.3	Beta	Table 9-13, FAN FTS, Running/Alternating
--AVC	Fail to Close of Air Operated Valve	d	9.51E-04	1.11	1.17E+03	4.0	Beta	Table 1-4, AOV FTO/C, All
--AVO	Fail to Open of Air Operated Valve	d	9.51E-04	1.11	1.17E+03	4.0	Beta	Table 1-4, AOV FTO/C, All
--AVT	Fail to Remain Open of Air Operated Valve	h	1.31E-07	0.68	5.21E+06	6.0	Gamma	Table 1-4, AOV SOP, All
MSAVC	Fail to Close of Turbine Bypass Valve	d	2.47E-04	0.50	2.02E+03	8.5	Beta	Table 1-22, TBV FTC, All
MSAVO	Fail to Open of Turbine Bypass Valve	d	4.20E-03	8.50	2.02E+03	1.7	Beta	Table 1-22, TBV FTO, All
--BCY	Fail to Operate of Battery Charger	h	2.71E-06	1.28	4.73E+05	3.6	Gamma	Table 5-4, BCH FTOP, All
--BDY	Failure of Isolable Phase Bus Duct	h	1.39E-06	0.70	5.07E+05	5.8	Gamma	Table 5-19, BUS FTOP, AC

Table 19.1-14 (3 of 19)

Type Code[1]	Description	Unit	Mean	α	β	EF[2]	Distribution (Source)	Data Source[4]
--BSY	Fail to Operate of Electrical AC Bus	h	1.39E-06	0.70	5.07E+05	5.8	Gamma	Table 5-19, BUS FTOP, AC
DCBSY	Fail to Operate of Electrical DC Bus	h	2.35E-07	1.50	6.38E+06	3.3	Gamma	Table 5-19, BUS FTOP, DC
NHBSY	Fail to Operate of Electrical MCC Bus (Non-Class 1E)	h	2.61E-07	0.84	3.23E+06	4.9	Gamma	Table 5-22, MCC FTOP, All
PHBSY	Fail to Operate of Electrical MCC Bus (Class 1E)	h	2.61E-07	0.84	3.23E+06	4.9	Gamma	Table 5-22, MCC FTOP, All
--BTY	Fail to Provide Output of Battery	h	5.86E-07	1.88	3.21E+06	2.9	Gamma	Table 5-7, BAT FTOP, All
--CCT	Fail to Proper Output of Core Protection Calculator	h	2.19E-06	-	-	2.0	Lognormal	IEEE Standard 500
--CHR	Fail to Run of Chiller Unit	h	3.05E-05	180.50	5.91E+06	1.1	Gamma	Table 9-10, CHL FTR, All
--CHS	Fail to Start of Chiller Unit	d	1.30E-02	0.58	4.41E+01	6.9	Beta	Table 9-10, CHL FTS, All

Table 19.1-14 (4 of 19)

Type Code[1]	Description	Unit	Mean	α	β	EF[2]	Distribution (Source)	Data Source[4]
--CMR	Fail to Run of Air Compressor	h	8.50E-05	2.00	2.36E+04	2.8	Gamma	Table 10-4, CMP FTR, Motor-driven
--CMS	Fail to Start of Air Compressor	d	1.71E-02	0.59	3.37E+01	6.8	Beta	Table 10-4, CMP FTS, Motor-driven
--CVC	Fail to Close of Check Valve	d	2.38E-04	0.81	3.38E+03	5.1	Beta	Table 1-28, CKV FTC, All
--CVO	Fail to Open of Check Valve	d	1.07E-05	0.50	4.68E+04	8.4	Beta	Table 1-28, CKV FTO, All
--DGL	Fail to Load and Run of Diesel Generator (≤1h)	d	3.78E-03	2.77	7.31E+02	2.4	Beta	Table 3-4, EDG FTLR, All
--DGR	Fail to Run of Diesel Generator (>1h)	h	1.10E-03	4.49	4.09E+03	2.0	Gamma	Table 3-4, EDG FTR, All
--DGS	Fail to Start of Diesel Generator	d	2.89E-03	8.11	2.80E+03	1.7	Beta	Table 3-4, EDG FTS, All
--TGL	Fail to Run of Alternate AC Generator (≤1h)	d	1.60E-05	2.50	1.56E+05	2.5	Beta	Table 3-8, CTG FTLR, All

Table 19.1-14 (5 of 19)

Type Code[1]	Description	Unit	Mean	α	β	EF[2]	Distribution (Source)	Data Source[4]
--TGR	Fail to Run of Alternate AC Gas Turbine Generator (>1h)	h	7.40E-03	3.50	4.73E+02	2.2	Gamma	Table 3-8, CTG FTR, All
--TGS	Fail to Start of Alternate AC Gas Turbine Generator	d	1.56E-02	10.50	6.63E+02	1.6	Beta	Table 3-8, CTG FTS, All
--DPL	Fail to Load and Run of Positive Displacement Pump (≤1H)	h	7.09E-04	2.50	3.53E+03	2.5	Beta	Table 2-13, PDP FTR≤ 1H, Standby
--DPR	Fail to Run of Positive Displacement Pump (>1H)	h	2.13E-03	2.50	1.18E+03	2.5	Gamma	Table 2-13, PDP FTR>1H, Standby
--DPS	Fail to Start of Positive Displacement Pump	d	1.79E-03	14.50	8.07E+03	1.5	Beta	Table 2-13, PDP FTS, Standby
--EVC	Fail to Close of Electro-Hydraulic Valve	d	1.20E-03	24.50	2.05E+04	1.4	Beta	Table 1-10, HOV FTO/C, All
--EVO	Fail to Open of Electro-Hydraulic Valve	d	1.20E-03	24.50	2.05E+04	1.4	Beta	Table 1-10, HOV FTO/C, All
MSEVC	Fail to Close of Main Steam Isolation Valve	d	7.79E-04	23.50	3.02E+04	1.4	Beta	Table 1-25, MSV FTO/C, All

Table 19.1-14 (6 of 19)

Type Code[1]	Description	Unit	Mean	α	β	EF[2]	Distribution (Source)	Data Source[4]
--FLP	Fail to Operate of Filter due to Plug	h	3.10E-07	3.50	1.13E+07	2.2	Gamma	Table 6-4, FLT PG, FLT
SXFLP	Fail to Operate of ESW Debris Filter due to Plug	h	2.32E-06	44.50	1.91E+07	1.3	Gamma	Table 6-6, FLTSC PG, Self-Cleaning
SISPP-S-IRWST	Fail to Operate of Sump Strainer due to Plug	h	5.08E-07	5.50	1.08E+07	1.9	Gamma	Table 6-8, SMP PG, Sump
SISPP-S-CHEMICAL	Debris Induced Loss of Long Term Cooling (Downstream/Chemical Effect)	d	1.00E-05	-	-	10.0	Lognormal	Engineering Judgment
--FMY	Fail to Operate of ESW Debris Filter Motor	h	4.00E-06	76.50	1.91E+07	1.2	Gamma	Table 6-6, FLTSC FTOP, Self-Cleaning
--GDT	Failure of Log Power Calculator in Ex-core Drawer	h	2.64E-06	-	-	2.0	Lognormal	IEEE Standard 500
--HBC	Fail to Close of High Voltage Circuit Breaker	d	6.66E-03	1.09	1.63E+02	4.0	Beta	Table 5-13, CBK FTO/C, HV
--HBO	Fail to Open of High Voltage Circuit Breaker	d	6.66E-03	1.09	1.63E+02	4.0	Beta	Table 5-13, CBK FTO/C, HV

Table 19.1-14 (7 of 19)

Type Code(1)	Description	Unit	Mean	α	β	EF(2)	Distribution (Source)	Data Source(4)
--HBI	Open Spuriously of High Voltage Circuit Breaker	h	8.08E-07	1.37	1.70E+06	3.5	Gamma	Table 5-13, CBK SOP, HV
--HEY	Fail to Operate of Heat Exchanger	h	4.57E-07	0.53	1.17E+06	7.8	Gamma	Table 10-22, HTX LOHT, All
CCHEY	Fail to Operate of CC Heat Exchanger	h	5.23E-07	16.50	3.16E+07	1.5	Gamma	Table 10-22, HTX LOHT, CCW
--HTR	Fail to Run of H2 Igniter	-	-	-	-	-	-	Igniter data may be used for sensitivity analysis for Level 2 PSA if required. The final value and source of igniter data are not determined yet.
--HTS	Fail to Start of H2 Igniter	-	-	-	-	-	-	
HGPAR	Fail to Operate of PAR	h	1.00E-05	-	-	10.0	Lognormal	Engineering Judgment (for Level 2 PSA)
--HVL	Fail to Load and Run of Cubicle Cooler (Standby) (≤1H)	h	1.07E-03	33.50	3.13E+04	1.3	Beta	Table 9-13, FAN FTR, Standby
--HVR	Fail to Run of Cubicle Cooler (Standby) (>1H)	h	5.88E-06	0.53	9.02E+04	7.9	Gamma	Table 9-13, FAN FTR, Standby
--HVS	Fail to Start of Cubicle Cooler (Standby)	d	7.09E-04	42.50	6.00E+04	1.3	Beta	Table 9-13, FAN FTR, Standby

Table 19.1-14 (8 of 19)

Type Code[1]	Description	Unit	Mean	α	β	EF[2]	Distribution (Source)	Data Source[4]
VKHVR-A -HV18A	Fail to Run of Cubicle Cooler (Running)	h	5.88E-06	0.53	9.02E+04	7.9	Gamma	Table 9-13, FAN FTR, Running/Alternating
VKHVR-B -HV18B	Fail to Run of Cubicle Cooler (Running)	h	5.88E-06	0.53	9.02E+04	7.9	Gamma	Table 9-13, FAN FTR, Running/Alternating
VKHVR1 A-HV13A	Fail to Run of Cubicle Cooler (Running)	h	5.88E-06	0.53	9.02E+04	7.9	Gamma	Table 9-13, FAN FTR, Running/Alternating
VKHVR1 B-HV13B	Fail to Run of Cubicle Cooler (Running)	h	5.88E-06	0.53	9.02E+04	7.9	Gamma	Table 9-13, FAN FTR, Running/Alternating
VKHVR2 A-HV14A	Fail to Run of Cubicle Cooler (Running)	h	5.88E-06	0.53	9.02E+04	7.9	Gamma	Table 9-13, FAN FTR, Running/Alternating
VKHVR2 B-HV14B	Fail to Run of Cubicle Cooler (Running)	h	5.88E-06	0.53	9.02E+04	7.9	Gamma	Table 9-13, FAN FTR, Running/Alternating
VKHVS-A -HV18A	Fail to Run of Cubicle Cooler (Running)	d	7.09E-04	42.50	6.00E+04	1.3	Beta	Table 9-13, FAN FTS, Running/Alternating
VKHVS-B -HV18B	Fail to Run of Cubicle Cooler (Running)	d	7.09E-04	42.50	6.00E+04	1.3	Beta	Table 9-13, FAN FTS, Running/Alternating

Table 19.1-14 (9 of 19)

Type Code(1)	Description	Unit	Mean	α	β	EF(2)	Distribution (Source)	Data Source(4)
VKHVS1 A-HV13A	Fail to Run of Cubicle Cooler (Running)	d	7.09E-04	42.50	6.00E+04	1.3	Beta	Table 9-13, FAN FTS, Running/Alternating
VKHVS1B -HV13B	Fail to Run of Cubicle Cooler (Running)	d	7.09E-04	42.50	6.00E+04	1.3	Beta	Table 9-13, FAN FTS, Running/Alternating
VKHVS2 A-HV14A	Fail to Run of Cubicle Cooler (Running)	d	7.09E-04	42.50	6.00E+04	1.3	Beta	Table 9-13, FAN FTS, Running/Alternating
VKHVS2B -HV14B	Fail to Run of Cubicle Cooler (Running)	d	7.09E-04	42.50	6.00E+04	1.3	Beta	Table 9-13, FAN FTS, Running/Alternating
--INY	Fail to Operate of Inverter	h	5.60E-06	1.18	2.11E+05	3.8	Gamma	Table 5-16, INV FTOP, All
LBC	Fail to Open of Low Voltage Circuit Breaker	d	2.72E-03	0.56	2.05E+02	7.4	Beta	Table 5-13, CBK FTO/C, MV
DCLBC	Fail to Close of DC Power Circuit Breaker	d	5.73E-04	7.50	1.31E+04	1.7	Beta	Table 5-13, CBK FTO/C, DC
DCLBI	Open Spuriously of DC Power Circuit Breaker	h	4.94E-08	4.50	9.12E+07	2.0	Gamma	Table 5-13, CBK SOP, DC

Table 19.1-14 (10 of 19)

Type Code[1]	Description	Unit	Mean	α	β	EF[2]	Distribution (Source)	Data Source[4]
DCLBO	Fail to Open of DC Power Circuit Breaker	d	5.73E-04	7.50	1.31E+04	1.7	Beta	Table 5-13, CBK FTO/C, DC
--LTY	Fail to Operate of Level Transmitter	h	1.02E-07	0.50	4.92E+06	8.4	Gamma	Table 7-7, STL FTOP, All
--PTY	Fail to Operate of Pressure Transmitter	h	8.22E-07	0.50	6.08E+05	8.4	Gamma	Table 7-7, STP FTOP, All
--TTY	Fail to Operate of Temperature Transmitter	h	8.40E-07	0.50	5.95E+05	8.5	Gamma	Table 7-7, STT FTOP, All
--MPL	Fail to Load and Run of Motor Driven Pump (≤ 1h)	h	1.23E-04	1.82	1.48E+04	3.0	Beta	Table 2-4, MDP FTR≤ 1H, Standby
--MPR	Fail to Run of Motor Driven Pump (>1h)	h	3.53E-06	2.29	6.50E+05	2.6	Gamma	Table 2-4, MDP FTR, Running/Alternating
--MPS	Fail to Start of Motor Driven Pump	d	1.36E-03	3.28	2.41E+03	2.3	Beta	Table 2-4, MDP FTS, Running/Alternating
AFMPR	Fail to Run of Aux. Feedwater Motor-Driven Pump	h	1.04E-05	0.78	7.50E+04	5.3	Gamma	Table 2-4, MDP FTR>1H, Standby

Table 19.1-14 (11 of 19)

Type Code[(1)]	Description	Unit	Mean	α	β	EF[(2)]	Distribution (Source)	Data Source[(4)]
AFMPS	Fails to Start of Aux. Feedwater Motor-Driven Pump	d	9.47E-04	1.95	2.05E+03	2.9	Beta	Table 2-4, MDP FTS, Standby
AFTPS	Fail to Start of Aux. Feedwater Turbine-Driven Pump	d	6.48E-03	0.94	1.44E+02	4.5	Beta	Table 2-7, TDP FTS, Standby
CSMPR	Fail to Run of Containment Spray Pump	h	1.04E-05	0.78	7.50E+04	5.3	Gamma	Table 2-4, MDP FTR>1H, Standby
CSMPS	Fail to Start of Containment Spray Pump	d	9.47E-04	1.95	2.05E+03	2.9	Beta	Table 2-4, MDP FTS, Standby
--XPL	Fail to Load and Run of Diesel Driven Pump (≤1h)	h	1.26E-03	0.55	4.41E+02	7.4	Gamma	Table 2-10, EDP FT≤1H, Standby
--XPR	Fail to Run of Diesel Driven Pump (>1h)	h	2.27E-03	9.50	4.18E+03	1.6	Gamma	Table 2-10, EDP FTR>1H, Standby
--XPS	Fail to Start of Diesel Driven Pump	d	5.09E-03	0.73	1.43E+02	5.6	Beta	Table 2-10, EDP FTS, Standby
DAMPS	Fail to Start of Motor Driven Pump	d	9.47E-04	1.95	2.05E+03	2.9	Beta	Table 2-4, MDP FTS, Standby

Table 19.1-14 (12 of 19)

Type Code[1]	Description	Unit	Mean	α	β	EF[2]	Distribution (Source)	Data Source[4]
DOMPR	Fail to Run of Motor Driven Pump	h	1.04E-05	0.78	7.50E+04	5.3	Gamma	Table 2-4, MDP FTR>1H, Standby
DOMPS	Fail to Start of Motor Driven Pump	d	9.47E-04	1.95	2.05E+03	2.9	Beta	Table 2-4, MDP FTS, Standby
SIMPR	Fail to Run of Safety Injection Pump	h	1.04E-05	0.78	7.50E+04	5.3	Gamma	Table 2-4, MDP FTR>1H, Standby
SIMPS	Fail to Start of Safety Injection Pump	d	9.47E-04	1.95	2.05E+03	2.9	Beta	Table 2-4, MDP FTS, Standby
SIMPR1A-SCPP01A	Fail to Run of Shutdown Cooling Pump	h	1.04E-05	0.78	7.50E+04	5.3	Gamma	Table 2-4, MDP FTR>1H, Standby
SIMPR1B-SCPP01B	Fail to Run of Shutdown Cooling Pump	h	1.04E-05	0.78	7.50E+04	5.3	Gamma	Table 2-4, MDP FTR>1H, Standby
SIMPS1A-SCPP01A	Fail to Start of Shutdown Cooling Pump	d	9.47E-04	1.95	2.05E+03	2.9	Beta	Table 2-4, MDP FTS, Standby
SIMPS1B-SCPP01B	Fail to Start of Shutdown Cooling Pump	d	9.47E-04	1.95	2.05E+03	2.9	Beta	Table 2-4, MDP FTS, Standby

Table 19.1-14 (13 of 19)

Type Code(1)	Description	Unit	Mean	α	β	EF(2)	Distribution (Source)	Data Source(4)
--MVC	Fail to Close of Motor Operated Valve	d	9.63E-04	2.05	2.12E+03	2.8	Beta	Table 1-7, MOV FTO/C, All
--MVO	Fail to Open of Motor Operated Valve	d	9.63E-04	2.05	2.12E+03	2.8	Beta	Table 1-7, MOV FTO/C, All
--MVR	Fail to Control of Motor Operated Valve	h	6.62E-08	1.46	2.21E+07	3.4	Gamma	Table 1-7, MOV FC, All
--MVT	Fail to Remain Open Of Motor Operated Valve	h	3.39E-08	0.57	1.68E+07	7.2	Gamma	Table 1-7, MOV SOP, All
AFMVC(3)	Fail to Close of AF Isolation Valve for Cycling Operation	d	5.78E-02	130.30	2.12E+03	1.1	Beta	Engineering Judgment with Table 1-7, MOV FTO/C, All
AFMVO(3)	Fail to Open of AF Isolation Valve for Cycling Operation	d	5.78E-02	130.30	2.12E+03	1.1	Beta	Engineering Judgment with Table 1-7, MOV FTO/C, All
--MWA	Manual Pushbutton (Hand Switch) Failure to Transfer	d	1.26E-04	0.50	3.96E+03	8.4	Beta	Table 7-12, MSW FTO/C, All
--NET	Ex-core Detector (Neutron Flux Detector) Improper Output	h	5.00E-06	-	-	5.0	Lognormal	WSRC-TR-83-262, Rev.1, Table 1f, Radiation Failure (Reference 15)

Table 19.1-14 (14 of 19)

Type Code[(1)]	Description	Unit	Mean	α	β	EF[(2)]	Distribution (Source)	Data Source[(4)]
--NZP	Fail to Operate of Spray Nozzle due to Plug	d	1.00E-06	0.30	3.00E+05	18.7	Gamma	Table 10-15, ORF PG, Running
--PVO	Fail to Open of Pilot Operated Safety Relief Valve (POSRV)	d	3.54E-03	16.50	4.64E+03	1.5	Beta	Table 4-10, PORV FTO, RCS
AFPVR	Fail to Run of AF TDP/MDP due to Volute Failure	h	6.57E-05	7.50	1.14E+05	1.7	Gamma	Table 2-16, PMP FTR, AFW
--RBO	Fail to Open of Reactor Trip Circuit Breaker	d	1.54E-05	0.50	3.25E+04	8.4	Beta	Table 7-10, RTB BME FTOP, All
--RVO	Fail to Open of Safety Valve	d	4.51E-04	0.50	1.12E+03	8.4	Beta	Table 4-7, SVV FTO, PWR MSS
--SDT	Failure of Sub-channel Power Calculator in Ex-core Drawer	h	2.19E-06	-	-	2.0	Lognormal	IEEE Standard 500
--SQA	Fail to Operate of DG Sequencer	d	1.76E-03	3.50	1.98E+03	2.2	Beta	Table 5-27, SEQ FTOP, All
--STE	Fail to Energize of Shunt Trip Device	d	3.29E-04	0.50	1.52E+03	8.4	Beta	Table 7-10, RTB BSN FTOP, All

Table 19.1-14 (15 of 19)

Type Code[1]	Description	Unit	Mean	α	β	EF[2]	Distribution (Source)	Data Source[4]
--SVO	Fail to Open of Solenoid Operated Valve	d	1.19E-03	30.50	2.56E+04	1.3	Beta	Table 1-13, SOV FTO/C, All
--SVC	Fail to Close of Solenoid Operated Valve	d	1.19E-03	30.50	2.56E+04	1.3	Beta	Table 1-13, SOV FTO/C, All
--SVR	Fail to Control of Solenoid Operated Valve	h	4.68E-07	61.50	1.31E+08	1.2	Gamma	Table 1-13, SOV FC, All
AFSVI	Spurious Close of AFW Modulation Valve	h	3.43E-08	4.50	1.31E+08	0.2	Gamma	Table 1-13, SOV SOP, All
--TKB	Fail to Operate of Pressurized Liquid Tank	h	3.26E-07	6.50	1.99E+07	1.7	Gamma	Table 10-14, TNK ELS, Liquid & Pressurized
CDTKB	Fail to Operate of Unpressurized Liquid Tank	h	2.60E-07	6.50	2.50E+07	1.1	Gamma	Table 10-14, TNK ELS, Liquid & Unpressurized
CTTKB	Fail to Operate of Unpressurized Liquid Tank	h	2.60E-07	6.50	2.50E+07	1.1	Gamma	Table 10-14, TNK ELS, Liquid & Unpressurized
IATKB	Fail to Operate of Gas Tank	h	6.86E-07	2.50	3.65E+06	2.5	Gamma	Table 10-14, TNK ELS & ELL, Gas

Table 19.1-14 (16 of 19)

Type Code[1]	Description	Unit	Mean	α	β	EF[2]	Distribution (Source)	Data Source[4]
--TWY	Fail to Operate of Temperature Switch	h	1.00E-06	-	-	3.0	Lognormal	WSRC-TR-83-262, Rev.1, Table 1f, Temperature Failure (Reference 15)
--UVD	Fail to De-energize of Under-voltage Trip Device	d	4.13E-04	0.50	1.21E+03	8.4	Beta	Table 7-10, RTB BUV FTOP, All
--VVC	Fail to Close of Manual Valve	d	1.92E-04	0.50	2.61E+03	8.4	Beta	Table 1-31, XVM FTO/C, All
--VVO	Fail to Open of Manual Valve	d	1.92E-04	0.50	2.61E+03	8.4	Beta	Table 1-31, XVM FTO/C, All
--VVT	Transfer Closed of Manual Valve	h	8.42E-08	8.50	1.01E+08	1.6	Gamma	Table 1-31, XVM SOP, All
--XHY	Fail to Operate of High Voltage Transformer	h	9.44E-07	0.96	1.01E+06	4.5	Gamma	Table 5-25, TFM FTOP, All
--XLY	Fail to Operate of Low Voltage Transformer	h	9.44E-07	0.96	1.01E+06	4.5	Gamma	Table 5-25, TFM FTOP, All
--XMY	Fail to Operate of Medium Voltage Transformer	h	9.44E-07	0.96	1.01E+06	4.5	Gamma	Table 5-25, TFM FTOP, All

Table 19.1-14 (17 of 19)

Type Code[1]	Description	Unit	Mean	α	β	EF[2]	Distribution (Source)	Data Source[4]
--XOY	Fail to Operate of Main Transformer	h	9.44E-07	0.96	1.01E+06	4.5	Gamma	Table 5-25, TFM FTOP, All
--XWA	Failure of Automatic Transfer Switch	d	1.60E-03	0.50	3.12E+02	8.4	Beta	Table 5-10, ABT FF, All
--ZVO	Fail to Open of Power Operated Check Valve	h	1.07E-05	0.50	4.68E+04	8.4	Beta	Table 1-28, CKV FTO, All
DPTCA	Fail to Actuate (Open) of Trip Contractor for MG Set-X (DPS-X)	d	2.48E-05	0.50	2.01E+04	3.8	Beta	Table 7-14, RLY FTOP, All
I-ATWS-RPMCF	Failure to Scram due to Mechanical Failures	d	2.98E-07	28.50	9.56E+07	1.3	Gamma	Table 8-6, ROD FTOP, ROD
--AIY	Failure of Analog Input Module	h	8.89E-06	-	-	2.8	Lognormal	Reference plant data
--BPT	Fail to Operate of RP Bi-stable Processor (PM646)	h	3.95E-06	-	-	2.8	Lognormal	Reference plant data
--CIY	Fail to Operate of Communication Module (CI631)	h	7.78E-07	-	-	2.8	Lognormal	Reference plant data
--CPT	Fail to Operate of Computational Module for LCL (PM646)	h	3.95E-06	-	-	2.8	Lognormal	Reference plant data

Table 19.1-14 (18 of 19)

Type Code[1]	Description	Unit	Mean	α	β	EF[2]	Distribution (Source)	Data Source[4]
--DIY	Failure of Ovation Digital Input Module	h	2.65E-06	-	-	2.8	Lognormal	Reference plant data
--DOY	Failure of Ovation Digital Output Module	h	2.65E-06	-	-	2.8	Lognormal	Reference plant data
--GCT	Fail to Operate of ESFAS logic controller (PM646)	h	3.95E-06	-	-	2.8	Lognormal	Reference plant data
--GXY	Fail to Operate of Group Controller (PM646)	h	3.95E-06	-	-	2.8	Lognormal	Reference plant data
--IAT	Failure of Bistable Analog Input Module	h	8.89E-06	-	-	2.8	Lognormal	Reference plant data
--IOT	Failure of Digital Output Module (DI-630)	h	1.00E-06	-	-	2.8	Lognormal	Reference plant data
RPIDY	Failure of Trip Signal from Bi-stable Input Module	h	1.00E-06	-	-	2.8	Lognormal	Reference plant data
--IRE	Fail to De-energized of Interposing Relay	d	9.50E-06	-	-	4.6	Lognormal	Reference plant data
--LPT	Fail to Operate of DPS Channel Processor (PM646)	h	3.95E-06	-	-	2.8	Lognormal	Reference plant data

Table 19.1-14 (19 of 19)

Type Code[1]	Description	Unit	Mean	α	β	EF[2]	Distribution (Source)	Data Source[4]
--LPY	Fail to Operate of Local Panel (PM646)	h	3.95E-06	-	-	2.8	Lognormal	Reference plant data
--LXY	Fail to Operate of Loop Controller (PM646)	h	3.95E-06	-	-	2.8	Lognormal	Reference plant data
--ORT	Fail to Operate of Fiber Optic Receiver	h	5.36E-06	-	-	2.8	Lognormal	Reference plant data
--OTT	Fail to Operate of Fiber Optic Transmitter	h	5.36E-06	-	-	2.8	Lognormal	Reference plant data
--WDA	Fail to Open of Watchdog Timer Switch	d	1.00E-07	-	-	2.8	Lognormal	Reference plant data
--WDY	Fail to Operate of Watchdog Timer	d	1.00E-07	-	-	2.8	Lognormal	Reference plant data

(1) Refer to the type codes in Table 19.1-15.
(2) The error factor is the 95th percentile divided by the median provided in each data source.
(3) AF isolation valve cycles are estimated to be 60 based on MAAP evaluation, which is multiplied with 9.63E-04 of MOV fail to open/close data provided in NUREG/CR-6928 (Reference 11).
(4) The table numbers designate the table numbers in the NUREG/CR-6928 (Reference 11).

Table 19.1-15 (1 of 13)

Component Boundaries

Type Code	Description	Unit	Grouping	Equipment Boundary Definition
--ADY	Fail to Operate of Air Dryer	h	Air dryer package for IA system	Air dryer package
--AHL	Fail to Run of Fan (≤1h)	h	Fans in IA, VU systems	Fan, motor, local circuit breaker, local lubrication or cooling systems, and local instrumentation and control circuitry
--AHR	Fail to Run of Fan (>1h)	h		
--AHS	Fail to Start of Fan	d		
SXAHR	Fail to Run of ESW Cooling Tower Fan	h	Cooling tower fans for SX system	Fan, motor, local circuit breaker, local lubrication or cooling systems, local instrumentation and control circuitry
SXAHS	Fail to Start of ESW Cooling Tower Fan	d		
VGAHR	Fail to Run of Fan	h	ESW pump room cooling fans	Fan, motor, local circuit breaker, local lubrication or cooling systems, local instrumentation and control circuitry
VGAHS	Fail to Start of Fan	d		
--AVC	Fail to Close of Air Operated Valve	d	Air operated valves for AT, CD, CV, IA systems	Valve, valve operator (including the associated solenoid operated valves), local instrumentation and control circuitry
--AVO	Fail to Open of Air Operated Valve	d		
--AVT	Fail to Remain Open of Air Operated Valve	h		
MSAVC	Fail to Close of Turbine Bypass Valve	d	Turbine bypass valves for MS system	Valve, valve operator (including the associated solenoid operated valves), local instrumentation and control circuitry
MSAVO	Fail to Open of Turbine Bypass Valve	d		

Table 19.1-15 (2 of 13)

Type Code	Description	Unit	Grouping	Equipment Boundary Definition
--BCY	Fail to Operate of Battery Charger	h	Class 1E battery chargers for DC power	Battery charger
--BDY	Failure of Isolable Phase Bus	h	Isolable phase bus	Bus component itself including the bus bar, fuses, and control circuitry
--BSY	Fail to Operate of Electrical AC Bus	h	Bus for AC power	Bus component itself including the bus bar, fuses, and control circuitry
DCBSY	Fail to Operate of Electrical DC Bus	h	Bus for DC power	Bus component itself including the bus bar, fuses, and control circuitry
NHBSY	Fail to Operate of Non Class 1E Electrical MCC Bus	h	Bus for MCC power	MCC cabinet, the bus bars, fuses, and protection equipment
PHBSY	Fail to Operate of Class 1E Electrical MCC Bus	h	Bus for MCC power	MCC cabinet, the bus bars, fuses, and protection equipment
--BTY	Fail to Provide Output of Battery	h	Class 1E batteries for DC power	Battery cells
--BTY	Fail to Provide Output of Battery	h		
--CCT	Fail to Proper Output of Core Protection Calculator	h	Core protection calculators for RPS/ESFAS	Core protection calculator
--CHR	Fail to Run of Chiller Unit	h	Essential chillers for WO system	Compressor, motor, evaporator, condenser, control unit, local instrumentations, local panel, valves and breakers
--CHS	Fail to Start of Chiller Unit	d		
--CMR	Fail to Run of Air Compressor	h	Motor driven centrifugal air compressors for IA system	Compressor, driver, local circuit breaker, local lubrication or cooling systems, and local instrumentation and control circuitry
--CMS	Fail to Start of Air Compressor	d		

Table 19.1-15 (3 of 13)

Type Code	Description	Unit	Grouping	Equipment Boundary Definition
--CVC	Fail to Close of Check Valve	d	Check valves or check dampers	Valve only
--CVO	Fail to Open of Check Valve	d		
FWCVO	Fail to Open of Check Valve	d		
--DGL	Fail to Run of Diesel Generator (≤1h)	d	Class 1E emergency diesel generators	Diesel engine with all components in the exhaust path, electrical generator, generator exciter, output breaker, combustion air, lube oil systems, fuel oil feed pump, diesel fuel oil day tank and starting compressed air system, and local instrumentation and control circuitry, cooling flow control valves for the EDG HX.
--DGR	Fail to Run of Diesel Generator (>1h)	h		
--DGS	Fail to Start of Diesel Generator	d		
--TGL	Fail to Run of Alternate AC Gas Turbine Generator (≤1h)	d	Non-1E alternate AC gas turbine generator	Gas turbine, generator, circuit breaker, local lubrication or cooling systems, and local instrumentation and control circuitry
DATGR-S-AACTG	Fail to Run of Alternate AC Gas Turbine Generator (>1h)	h		
DATGS-S-AACTG	Fail to Start of Alternate AC Gas Turbine Generator	d		
--DMO	Fails to Open of Pneumatic Operated Damper	d	Pneumatic Operated Damper	Valve, valve operator, and local instrumentation and control circuitry
VKDMT	Transfer Closed of Hydraulic Operated Damper	h	Hydraulic Operated Damper	Valve, valve operator, and local instrumentation and control circuitry

Table 19.1-15 (4 of 13)

Type Code	Description	Unit	Grouping	Equipment Boundary Definition
--DPL	Fail to Run of Positive Displacement Pump (≤ 1h)	h	Positive displacement pumps for CV systems	Pump, motor, local circuit breaker, local lubrication or cooling systems, and local instrumentation and control circuitry
--DPR	Fail to Run of Positive Displacement Pump (>1h)	h		
--DPS	Fail to Start of Positive Displacement Pump	d		
--EVC	Fail to Close of Electro-Hydraulic Valve	d	Main feedwater isolation valves for FW system	Valve, valve operator, and local instrumentation and control circuitry
--EVO	Fail to Open of Electro-Hydraulic Valve	d		
MSEVC	Fail to Close of Main Steam Isolation Valve	d	Main steam isolation valves for MS system	Valve, valve operator, local circuit breaker, and local instrumentation and control circuitry
--FLP	Fail to Operate of Filter due to Plug	h	Filters for CV, IA, VG, WH, WT systems	Filter
SXFLP	Fail to Operate of ESW Debris Filter due to Plug	h	ESW debris filters for SX system	Strainer, rotating assembly, backwash valves, and control circuitry
SISPP-S-IRWST	Fail to Operate of Sump Strainer due to Plug	h	Sump strainer for IRWST	Strainer
--FMY	Fail to Operate of ESW Debris Filter Motor	h	ESW debris filter motors for SX system	Debris filter motor
--GDT	Failure of Log Power Calculator in Ex-core Drawer	h	Log power calculators	Calibrated avg. power calculator in ex-core drawer
--HBC	Fail to Close of High Voltage Circuit Breaker	d	Circuit Breakers ≥ 4.16kV	Breaker itself and local instrumentation and control circuitry
--HBO	Fail to Open of High Voltage Circuit Breaker	d		

Table 19.1-15 (5 of 13)

Type Code	Description	Unit	Grouping	Equipment Boundary Definition
--HEY	Fail to Operate of Heat Exchanger	h	Heat exchangers for CS, CV, IA, SI, WT systems	Heat exchanger shell and tubes
CCHEY	Fail to Operate of CC Heat Exchanger	h	Heat exchangers for CC system	Heat exchanger shell and tubes
--HVL	Fail to Run of Cubicle Cooler (≤1h)	h	Room cubicle coolers for standby systems	Fan, cooling unit, valves, control circuitry, and breakers
--HVR	Fail to Run of Cubicle Cooler (>1h)	h		
--HVS	Fail to Start of Cubicle Cooler	d		
VKHVR-A-HV18A	Fails to Run of Cubicle Cooler	h	Room cubicle coolers for normally running systems	Fan, cooling unit, valves, control circuitry, and breakers
VKHVR-B-HV18B	Fails to Run of Cubicle Cooler	h		
VKHVR1A-HV13A	Fails to Run of Cubicle Cooler	h		
VKHVR1B-HV13B	Fails to Run of Cubicle Cooler	h		
VKHVR2A-HV14A	Fails to Run of Cubicle Cooler	h		
VKHVR2B-HV14B	Fails to Run of Cubicle Cooler	h		
VKHVS-B-HV18B	Fails to Start of Cubicle Cooler	d		
VKHVS1A-HV13A	Fails to Start of Cubicle Cooler	d		

Table 19.1-15 (6 of 13)

Type Code	Description	Unit	Grouping	Equipment Boundary Definition
VKHVS 1B-HV1 3B	Fails to Start of Cubicle Cooler	d	Room cubicle coolers for normally running systems	Fan, cooling unit, valves, control circuitry, and breakers
VKHVS 2A-HV1 4A	Fails to Start of Cubicle Cooler	d		
VKHVS 2B-HV1 4B	Fails to Start of Cubicle Cooler	d		
VOHVR 1A-HV3 1A	Fails to Run of Cubicle Cooler	h		
VOHVR 1B-HV3 1B	Fails to Run of Cubicle Cooler	h		
VOHVR 2A-HV3 2A	Fails to Run of Cubicle Cooler	h		
VOHVR 2B-HV3 2B	Fails to Run of Cubicle Cooler	h		
VOHVS 1A-HV3 1A	Fails to Start of Cubicle Cooler	d		
VOHVS 1B-HV3 1B	Fails to Start of Cubicle Cooler	d		
VOHVS 2A-HV3 2A	Fails to Start of Cubicle Cooler	d		
VOHVS 2B-HV3 2B	Fails to Start of Cubicle Cooler	d		
--INY	Fail to Operate of Inverter	h	Inverters	Inverter unit
--LBC	Fails to Close of Low Voltage Circuit Breaker	d	Circuit breakers < 4.16kV	Breaker itself and local instrumentation and control circuitry

Table 19.1-15 (7 of 13)

Type Code	Description	Unit	Grouping	Equipment Boundary Definition
--LTT	Fail to Operate of Level Transmitter	h	Level transmitters	Sensor and transmitter
--LTY	Fail to Operate of Level Transmitter	h	Level transmitters	Sensor and transmitter
--PTT	Fail to Operate of Pressure Transmitter	h	Pressure transmitters	Sensor and transmitter
--PTY	Fail to Operate of Pressure Transmitter	h	Pressure transmitters	Sensor and transmitter
--TTY	Fail to Operate of Temperature Transmitter	h	Temperature transmitters	Sensor and transmitter
--MPR	Fail to Run of Motor Driven Pump	h	Motor driven pumps for normally running systems	Pump, motor, local circuit breaker, local lubrication or cooling systems, and local instrumentation and control circuitry
--MPS	Fail to Start of Motor Driven Pump	d	Motor driven pumps for normally running systems	Pump, motor, local circuit breaker, local lubrication or cooling systems, and local instrumentation and control circuitry
CCMPR	Fail to Run of Component Cooling Water Pump	h	Motor driven pumps for normally running systems	Pump, motor, local circuit breaker, local lubrication or cooling systems, and local instrumentation and control circuitry
CCMPS	Fail to Start of Component Cooling Water Pump	d	Motor driven pumps for normally running systems	Pump, motor, local circuit breaker, local lubrication or cooling systems, and local instrumentation and control circuitry
--MPL	Fail to Run of Motor Driven Pump (≤1h)	h	Motor driven pumps for standby systems	Pump, motor, local circuit breaker, local lubrication or cooling systems, and local instrumentation and control circuitry
AFMPR	Fail to Run of Aux. Feedwater Motor-Driven Pump (>1h)	h	Motor driven pumps for standby systems	Pump, motor, local circuit breaker, local lubrication or cooling systems, and local instrumentation and control circuitry
AFMPS	Fail to Start of Aux. Feedwater Motor-Driven Pump	d	Motor driven pumps for standby systems	Pump, motor, local circuit breaker, local lubrication or cooling systems, and local instrumentation and control circuitry
CSMPR	Fail to Run of Containment Spray Pump (>1h)	h	Motor driven pumps for standby systems	Pump, motor, local circuit breaker, local lubrication or cooling systems, and local instrumentation and control circuitry
CSMPS	Fail to Start of Containment Spray Pump	d	Motor driven pumps for standby systems	Pump, motor, local circuit breaker, local lubrication or cooling systems, and local instrumentation and control circuitry

Table 19.1-15 (8 of 13)

Type Code	Description	Unit	Grouping	Equipment Boundary Definition
DOMPR	Fail to Run of Motor Driven Pump (>1h)	h	Motor driven pumps for standby systems	Pump, motor, local circuit breaker, local lubrication or cooling systems, and local instrumentation and control circuitry
DOMPS	Fail to Start of Motor Driven Pump	d		
SIMPR	Fail to Run of Safety Injection System Pump (>1h)	h		
SIMPS	Fail to Start of Safety Injection System Pump	d		
AFTPL	Fail to Run of Aux. Feedwater Turbine-Driven Pump (≤1h)	h	Turbine driven pumps for AF system	Pump, turbine, governor control, steam emission valve, local lubrication or cooling systems, and local instrumentation and controls
AFTPR	Fail to Run of Aux. Feedwater Turbine-Driven Pump (>1h)	h		
AFTPS	Fail to Start of Aux. Feedwater Turbine-Driven Pump	d		
--XPL	Fail to Load and Run of Diesel Driven Pump (≤1h)	h	Diesel driven pump	Pump, diesel engine, local lubrication or cooling systems, and local instrumentation and control circuitry
--XPR	Fail to Run of Diesel Driven Pump (>1h)	h		
--XPS	Fail to Start of Diesel Driven Pump	d		
--MVC	Fail to Close of Motor Operated Valve	d	Motor operated valves	Valve, valve operator, local circuit breaker, and local instrumentation and control circuitry
--MVO	Fail to Open of Motor Operated Valve	d		
--MVR	Fail to Control of Motor Operated Valve	h		
--MVT	Fail to Remain Open Of Motor Operated Valve	h		

Table 19.1-15 (9 of 13)

Type Code	Description	Unit	Grouping	Equipment Boundary Definition
--MWA	Manual Pushbutton (Hand Switch) Failure to Transfer	d	Manual hand switch	Switch itself
--NET	Ex-core Detector (Neutron Flux Detector) Improper Output	h	Ex-core detector (neutron flux detector)	Ex-core detector
AFMVC	Fail to Close of AF Motor Operated Isolation Valve for Cycling Operation	d	Motor operated valves for cycling operation in AF system	Valve, valve operator, local circuit breaker, and local instrumentation and control circuitry
AFMVO	Fail to Open of AF Motor Operated Isolation Valve for Cycling Operation	d		
--NZP	Fail to Operate of Spray Nozzle due to Plug	h	Containment spray nozzle	Containment spray nozzle
--PVC	Fail to Close of Pilot Operated Safety Relief Valve (POSRV)	d	Pilot operated safety relief valves for RC system	Spring loaded safety valves, and its operator
--PVO	Fail to Open of POSRV	d		
AFPVR	Fail to Run of AF TDP/MDP due to Volute Failure	h	Pump volutes for AF system	Pump volute portion of AFW MDPs and TDPs
--RBO	Fails to Open of Reactor Trip Circuit Breaker	d	Main/Bypass trip breakers including all related mechanical components	Entire trip breaker (mechanical portion of the breaker)
--RVO	Fail to Open of Safety Valve	d	Main steam safety valves	Valve and valve operator
--SDT	Failure of Sub-channel Power Calculator in Ex-core Drawer	h	Sub-channel power calculator in ex-core drawer	Calibrated avg. power calculator in ex-core drawer
--SQA	Fail to Operate of DG Sequencer	d	DG sequencers	Relays, logic modules, etc. that comprise the sequencer function of the EDG load process

Table 19.1-15 (10 of 13)

Type Code	Description	Unit	Grouping	Equipment Boundary Definition
--STE	Shunt Trip Device Fails to energize	d	Shunt trip devices	Shunt trip device
--SVO	Fails to Open of Solenoid Operated Valve	d	Solenoid operated valves for AF, CV, RG systems	Valve, valve operator, and local instrumentation and control circuitry
--SVR	Fail to Control of Solenoid Operated Valve	h		
AFSVI	Spurious Close of AFW Modulation Valve	h	Solenoid operated valves for AF system	Valve, valve operator, and local instrumentation and control circuitry
--TKB	Fail to Operate of Pressurized Liquid Tank	h	Pressurized liquid tanks	Tank
CDTKB	Fail to Operate of Unpressurized Tank	h	Unpressurized liquid tanks	Tank
CTTKB	Fail to Operate of Unpressurized Tank	h		
IATKB	Fail to Operate of Gas Tank	h	Gas tanks for IA system	Tank
--TWY	Fail to Operate of Temperature Switch	h	Temperature switch	Temperature switch
--UVD	Under-voltage Trip Device fails to de-energize	d	Under-voltage trip devices	Under-voltage trip device
--VVC	Fail to Close of Manual Valve	d	Manual valves	Valve, valve operator
--VVO	Fail to Open of Manual Valve	d		
--VVR	Transfer Closed (SOP)	h		
--VVT	Transfer Close of Manual Valve	h		

Table 19.1-15 (11 of 12)

Type Code	Description	Unit	Grouping	Equipment Boundary Definition
--XHY	Fails to Operate of High Voltage Transformer	h	Transformers (UATs/SATs)	Transformer unit including the wiring, cooling and protection equipment
--XLY	Fails to Operate of Low Voltage Transformer	h	Transformers (480-120V)	Transformer unit including the wiring, cooling and protection equipment
--XMY	Fails to Operate of Medium Voltage Transformer	h	Transformers (4160-480V)	Transformer unit including the wiring, cooling and protection equipment
--XOY	Fails to Operate of Main Transformer	h	Main transformer	Transformer unit including the wiring, cooling and protection equipment
--XWA	Failure of Automatic Transfer Switch	d	Automatic/Manual transfer switch	Automatic/Manual transfer switch
--ZVO	Fail to Open of Power Operated Check Valve	h	Startup feedwater pump discharge stop check valve for FW system	Valve only
I-ATWS -RPMCF	Failure to Scram due to Mechanical Failures	d	Control rod	Control rod excluding the drive mechanism
--AIY	Failure of Analog Input Module	h	Analog input modules for RPS/ESFAS and VU system	Analog Input Module
--BPT	Fail to Operate of RP Bi-stable Processor (PM646)	h	Bi-stables for RPS/ESFAS	Bistable processor
--CIT	Fail to Operate of Communication Module (CI631)	h	Communication modules for RPS/ESFAS	Communication module
--CPT	Fail to Operate of RP LCL Processor (PM646)	h	LCL processors	LCL processor
--DIY	Failure of Digital Input Module	h	Digital input modules for RPS/ESFAS	Digital input module

Table 19.1-15 (12 of 13)

Type Code	Description	Unit	Grouping	Equipment Boundary Definition
--DOY	Failure of Digital Output Module	h	Digital output modules for RPS/ESFAS	Digital output module
--GCT	Fail to Operate of ESFAS Logic Controller (PM646)	h	Group controllers for RPS/ESFAS	Group controller
--GDT	Failure of Log Power Calculator in Ex-core Drawer	h	Log Power Calculator	Log Power Calculator
--GXT	Fail to Operate of Group Controller (PM646)	h	Group controllers for components	Group controller
--GXY	Fail to Operate of Group Controller (PM646)	h		
--IAT	Failure of Bistable Analog Input Module	h	Bistable analog input modules	Analog input module
--IOT	Failure of Digital Output Module (DI-630)	h	Digital output module(DI-630)	Digital output module
RPIDY	Failure of Trip Signal from Bi-stable Input Module	h	Bi-stable input module	Bi-stable input module
--IRE	Fail to De-energized of Interposing Relay	d	Interposing relay	Interposing relay
--LDT	Failure of Calibrated Avg. Power Calculator in Ex-core Drawer	h	Calibrated Average Power Calculator	Calibrated Average Power Calculator
--LPT	Fail to Operate of DPS Channel Processor (PM646)	h	DPS processors	DPS processor
--LPY	Fail to Operate of Local Panel (PM646)	h	Local panels	Local panel
--LXY	Fail to Operate of Loop Controller (PM646)	h	Loop controllers	Loop controller
--ORT	Fail to Operate of Fiber Optic Receiver	h	Fiber optic receiver	Fiber optic receiver

Table 19.1-15 (13 of 13)

Type Code	Description	Unit	Grouping	Equipment Boundary Definition
--OTT	Fail to Operate of Fiber Optic Transmitter	h	Fiber optic transmitter	Fiber optic transmitter
--WDA	Fail to Open of Watchdog Timer Switch	d	Watch dog switch	Watch dog switch
--WDY	Fail to Operate of Watchdog Timer	d	Watch dog timers	Watch dog timer

Table 19.1-16

Special Basic Events

Basic Event	Value	Description	Data Source
MTC-ATWS	1.60E-01	No Adverse Moderator Temperature Coefficient	Engineering Judgment
SEAL-AFSUC	4.00E-03	RCP Seal LOCA Probability after success of secondary heat removal	Engineering Judgment
RAC16H-PL	3.03E-03	Non-recoverable probability of Offsite power within 16 hours after plant-centered LOOP	NUREG/CR-6890, Volume 1, Table 4-1
RAC16H-SW	5.89E-03	Non-recoverable probability of Offsite power within 16 hours after switchyard-centered LOOP	NUREG/CR-6890, Volume 1, Table 4-1
RAC16H-GR	1.01E-02	Non-recoverable probability of Offsite power within 16 hours after grid-related LOOP	NUREG/CR-6890, Volume 1, Table 4-1
RAC16H-WE	1.59E-01	Non-recoverable probability of Offsite power within 16 hours after weather-related LOOP	NUREG/CR-6890, Volume 1, Table 4-1
PFLOOP-TRANS	2.40E-03	Conditional LOOP upon Transients	EPRI Interim Technical Report (Reference 11)
PFLOOP-LOCA	2.40E-02	Conditional LOOP upon LOCA initiators	EPRI Interim Technical Report

Table 19.1-17

Level 1 Internal Events CDF Contribution by Initiating Events

Initiator	Frequency (/yr)	Percent Contribution (%)
SBO+LOOP	5.11E-07	39.4
TLOCCW+TLOESW	1.58E-07	12.2
MLOCA	1.23E-07	9.5
PLOCCW	1.22E-07	9.4
PLOESW	7.04E-08	5.4
ATWS	5.57E-08	4.3
SLOCA	4.93E-08	3.8
SGTR	4.88E-08	3.8
LSSB-D	4.55E-08	3.5
RVR	3.06E-08	2.4
FWLB	1.89E-08	1.5
GTRN	1.68E-08	1.3

Table 19.1-18 (1 of 10)

Level 1 Internal Events Top Accident Sequences

Rank	Sequence No.	Sequence Frequency (/yr)	Cumulative Contribution	Sequence Cutsets	Sequence Description
1	LOOP_005	1.73E-07	13.4	LOOP * /RT-LOOP * /PRC-MSSV * /DG * SHR-E12LO * PO-E24LO	LOOP * Success of reactor trip * No POSRV challenge * Success of one or more EDGs * Failure of secondary heat removal * Failure of bleed for F&B operation
2	SBO_009	1.14E-07	22.2	SBO * AAC * /SHR1-E12TD * /RSF-SBO-AFSUC * RAC-16HR	SBO * Failure of AAC * Success of secondary heat removal with AF TDPs * No RCP seal LOCA * Failure of offsite power recovery within 16hours
3	PLOCCW_007	1.13E-07	30.9	PLOCCW * /RT-LOCCW * SHR-E12CC * /PO-E24CC * SIF-I12CC	PLOCCW * Success of reactor trip * Failure of secondary heat removal * Success of bleed for F&B operation * Failure of SI feed for F&B operation
4	MLOCA_002	1.10E-07	39.4	MLOCA * /RT-MLOCA * /SI-I14 * CS-S12	MLOCA * Success of reactor trip * Success of SI injection * Failure of CS operation
5	PLOESW_007	6.53E-08	44.4	PLOESW * /RT-LOESW * SHR-E12CC * /PO-E24CC * SIF-I12CC	PLOESW * Success of reactor trip * Failure of secondary heat removal * Success of bleed for F&B operation * Failure of SI feed for F&B operation
6	SBO_004	6.27E-08	49.3	SBO * /AAC * SHR-12AC * /PO-E22 * /SIF-I12SBO * SCR12CSS12SBO	SBO * Success of AAC * Failure of secondary heat removal * Success of F&B operation * Failure of long term cooling with SC/CS

Table 19.1-18 (2 of 10)

Rank	Sequence No.	Sequence Frequency (/yr)	Cumulative contribution	Sequence Cutsets	Sequence Description
7	TLOCCW_002	5.86E-08	53.8	TLOCCW * /RT-LOCCW * /GTRN-GRID * /SHR-E12TC * RSF-TC-AFSUC	TLOCCW * Success of reactor trip * No consequential LOOP * Success of secondary heat removal * RCP seal LOCA occurs
8	TLOESW_002	5.86E-08	58.3	TLOESW * /RT-LOCCW * /GTRN-GRID * /SHR-E12TC * RSF-TC-AFSUC	TLOESW * Success of reactor trip * No consequential LOOP * Success of secondary heat removal * RCP seal LOCA occurs
9	LOOP_004	5.07E-08	62.2	LOOP * /RT-LOOP * /PRC-MSSV * /DG * SHR-E12LO * /PO-E24LO * SIF-I14LO	LOOP * Success of reactor trip * No POSRV challenge * Success of one or more EDGs * Failure of secondary heat removal * Success of bleed for F&B operation * Failure of SI feed for F&B operation
10	SLOCA_007	4.50E-08	65.7	SLOCA * /RT-SLOCA * SI-I14 * /ASC-12SL * SC-I12SL	SLOCA * Success of reactor trip * Failure of SI injection * Success of aggressive secondary cooling operation * Failure of shutdown cooling injection
11	ATWS_007	4.13E-08	68.9	ATWS * MTC-ATWS	ATWS * Adverse MTC (Moderator Temperature Coefficient)
12	GRID-SBO_003	3.63E-08	71.7	GRID-SBO * /AAC * SHR-E12AC	GRID-SBO * Success of AAC * Failure of secondary heat removal
13	RVR_001	3.06E-08	74.0	RVR	Reactor vessel rupture

Table 19.1-18 (3 of 10)

Rank	Sequence No.	Sequence Frequency (/yr)	Cumulative contribution	Sequence Cutsets	Sequence Description
14	LOOP_003	2.87E-08	76.3	LOOP * /RT-LOOP * /PRC-MSSV * /DG * SHR-E12LO * /PO-E24LO * /SIF-I14LO * SCR12CSS12LO	LOOP * Success of reactor trip * No POSRV challenge * Success of one or more EDGs * Failure of secondary heat removal * Success of F&B operation * Failure of long term cooling with SC/CS
15	LSSB-D_019	2.63E-08	78.3	LSSB-D * /RT-LSSB * /PRC-LSSB * PISGTR * /SI-I14SG * ISOL-LSSBD	LSSB * Success of reactor trip * No POSRV challenge * Pressure-induced SGTR occurs * Success of SI injection * Failure of steam line isolation
16	TLOCCW_003	2.04E-08	79.9	TLOCCW * /RT-LOCCW * /GTRN-GRID * SHR-E12TC	TLOCCW * Success of reactor trip * No consequential LOOP * Failure of secondary heat removal
17	TLOESW_003	2.04E-08	81.4	TLOESW * /RT-LOCCW * /GTRN-GRID * SHR-E12TC	TLOESW * Success of reactor trip * No consequential LOOP * Failure of secondary heat removal
18	SGTR_006	1.83E-08	82.9	SGTR * /RT-SGTR * /SI-I14SG * /SHR-E11SG * ECLDN * LCLDN * CV-IRWST	SGTR * Success of reactor trip * Success of SI injection * Success of secondary heat removal * Failure of initial RCS cooldown and late cooldown * Failure of IRWST refill

Table 19.1-18 (4 of 10)

Rank	Sequence No.	Sequence Frequency (/yr)	Cumulative contribution	Sequence Cutsets	Sequence Description
19	SGTR_009	1.77E-08	84.2	SGTR * /RT-SGTR * /SI-I14SG * SHR-E11SG * PO-E24	SGTR * Success of reactor trip * Success of SI injection * Failure of secondary heat removal * Failure of bleed for F&B operation
20	GTRN_005	1.64E-08	85.5	GTRN * /RT-GTRN * /PRC-GTRN * /GTRN-GRID * SHR-E12GT * PO-E24	GTRN * Success of reactor trip * No POSRV challenge * No consequential LOOP * Failure of secondary heat removal * Failure of bleed for F&B operation
21	FWLB_005	1.56E-08	86.7	FWLB * /RT-LOFW * /PISGTR * /ISOL * SHR-E11FB * PO-E24	FWLB * Success of reactor trip * No Pressure-induced SGTR * Success of steam line isolation * Failure of secondary heat removal * Failure of bleed for F&B operation
22	MLOCA_003	1.35E-08	87.7	MLOCA * /RT-MLOCA * SI-I14	MLOCA * Success of reactor trip * Failure of SI injection
23	LSSB-D_009	1.21E-08	88.7	LSSB-D * /RT-LSSB * /PRC-LSSB * /PISGTR * ISOL-LSSBD * PO-E24ISOL	LSSB * Success of reactor trip * No POSRV challenge * No Pressure-induced SGTR * Failure of steam line isolation * Failure of bleed for F&B operation
24	SBO_011	1.03E-08	89.5	SBO * AAC * SHR1-E12TD	SBO * Failure of AAC * Failure of secondary heat removal with AF TDPs

Table 19.1-18 (5 of 10)

Rank	Sequence No.	Sequence Frequency (/yr)	Cumulative contribution	Sequence Cutsets	Sequence Description
25	GRID-LOOP_005	1.01E-08	90.2	GRID-LOOP * /DG * SHR1-E12LO * PO-E24LO	GRID-LOOP * Success of one or more EDGs * Failure of secondary heat removal * Failure of bleed for F&B operation
26	LOFW_005	9.77E-09	91.0	LOFW * /RT-LOFW * /PRC-GTRN * /LOFW-GRID * SHR-E12GT * PO-E24	LOFW * Success of reactor trip * No POSRV challenge * No consequential LOOP * Failure of secondary heat removal * Failure of bleed for F&B operation
27	LLOCA_003	9.56E-09	91.7	LLOCA * /ST-I24LL * /SI-I34LL * SI-HL-LL	LLOCA * Success of SIT injection * Success of SI injection * Failure of SI hot leg injection
28	LOCV_005	9.17E-09	92.4	LOCV * /RT-LOCV * /PRC-POSRV * /LOCV-GRID * SHR-E12GT * PO-E24	LOCV * Success of reactor trip * No POSRV challenge * No consequential LOOP * Failure of secondary heat removal * Failure of bleed for F&B operation
29	SBO_010	8.57E-09	93.1	SBO * AAC * /SHR1-E12TD * RSF-SBO-AFSUC	SBO * Failure of AAC * Success of secondary heat removal with AF TDPs * RCP seal LOCA occurs
30	SBO_005	7.78E-09	93.7	SBO * /AAC * SHR-12AC * /PO-E22 * SIF-I12SBO	SBO * Success of AAC * Failure of secondary heat removal * Success of bleed for F&B operation * Failure of SI feed for F&B operation

Table 19.1-18 (6 of 10)

Rank	Sequence No.	Sequence Frequency (/yr)	Cumulative contribution	Sequence Cutsets	Sequence Description
31	ATWS_004	5.85E-09	94.2	ATWS * /MTC-ATWS * /PFO-ATWS * /PRC-ATWS * PISGTR	ATWS * No adverse MTC (Moderator Temperature Coefficient) * Success of POSRVs open * Success of POSRVs reseat * Pressure-induced SGTR occurs
32	SGTR_004	5.06E-09	94.5	SGTR * /RT-SGTR * /SI-I14SG * /SHR-E11SG * ECLDN * /LCLDN * SC-C12 * CV-IRWST	SGTR * Success of reactor trip * Success of SI injection * Success of secondary heat removal * Failure of initial RCS cooldown * Success of late RCS cooldown * Failure of shutdown cooling operation * Failure of IRWST refill
33	ATWS_002	4.07E-09	94.9	ATWS * /MTC-ATWS * /PFO-ATWS * /PRC-ATWS * /PISGTR * /SHR-E22FW * EBR	ATWS * No adverse MTC (Moderator Temperature Coefficient) * Success of POSRVs open * Success of POSRVs reseat * No Pressure-induced SGTR * Success of secondary heat removal * Failure of boron injection via charging pump
34	SGTR_012	3.80E-09	95.2	SGTR * /RT-SGTR * SI-I14SG * /ASC-11SG * SC-I12SL	SGTR * Success of reactor trip * Failure of SI injection * Success of aggressive secondary cooling operation * Failure of shutdown cooling injection
35	PLOCCW_008	3.31E-09	95.4	PLOCCW * /RT-LOCCW * SHR-E12CC * PO-E24CC	PLOCCW * Success of reactor trip * Failure of secondary heat removal * Failure of bleed for F&B operation

Table 19.1-18 (7 of 10)

Rank	Sequence No.	Sequence Frequency (/yr)	Cumulative contribution	Sequence Cutsets	Sequence Description
36	ATWS_006	3.07E-09	95.6	ATWS * /MTC-ATWS * PFO-ATWS	ATWS * No adverse MTC (Moderator Temperature Coefficient) * Failure of POSRVs open
37	LSSB-U_005	3.06E-09	95.9	LSSB-U * /RT-LSSB * /PRC-LSSB * /PISGTR * /ISOL-LSSBU * SHR1-E11LS * PO-E24	LSSB * Success of reactor trip * No POSRV challenge * No Pressure-induced SGTR * Success of steam line isolation * Failure of secondary heat removal * Failure of bleed for F&B operation
38	SLOCA_004	3.02E-09	96.1	SLOCA * /RT-SLOCA * /SI-I14 * SHR1-E12SL * PO-E24	SLOCA * Success of reactor trip * Success of SI injection * Failure of secondary heat removal * Failure of bleed for F&B operation
39	LODCA_005	2.81E-09	96.3	LODCA * /RT-LODC * /PRC-POSRV * /LODCA-GRID * SHR-E12DA * PO-E22DA	LODC * Success of reactor trip * No POSRV challenge * No consequential LOOP * Failure of secondary heat removal * Failure of bleed for F&B operation
40	LODCB_005	2.81E-09	96.5	LODCB * /RT-LODC * /PRC-POSRV * /LODCB-GRID * SHR-E12DB * PO-E22DB	LOCV * Success of reactor trip * No POSRV challenge * No consequential LOOP * Failure of secondary heat removal * Failure of bleed for F&B operation

Table 19.1-18 (8 of 10)

Rank	Sequence No.	Sequence Frequency (/yr)	Cumulative contribution	Sequence Cutsets	Sequence Description
41	SGTR_013	2.69E-09	96.8	SGTR * /RT-SGTR * SI-I14SG * ASC-11SG	SGTR * Success of reactor trip * Failure of SI injection * Failure of aggressive secondary cooling operation
42	LSSB-D_022	2.44E-09	96.9	LSSB-D * RT-LSSB	LSSB * Failure of reactor trip
43	PLOCCW_006	2.40E-09	97.1	PLOCCW * /RT-LOCCW * SHR-E12CC * /PO-E24CC * /SIF-I12CC * SCR11CSS11-SI	PLOCCW * Success of reactor trip * Failure of secondary heat removal * Success of F&B operation * Failure of long term cooling with SC/CS
44	LSSB-D_020	2.23E-09	97.3	LSSB-D * /RT-LSSB * /PRC-LSSB * PISGTR * SI-I14SG	LSSB * Success of reactor trip * No POSRV challenge * Pressure-induced SGTR occurs * Failure of SI injection
45	SBO_002	2.20E-09	97.5	SBO * /AAC * /SHR-12AC * RCPSEAL	SBO * Success of AAC * Success of secondary heat removal * RCP seal LOCA occurs
46	PLOCCW_009	2.16E-09	97.6	PLOCCW * RT-LOCCW	PLOCCW * Failure of reactor trip
47	LLOCA_004	2.06E-09	97.8	LLOCA * /ST-I24LL * SI-I34LL	LLOCA * Success of SIT injection * Failure of SI injection

Table 19.1-18 (9 of 10)

Rank	Sequence No.	Sequence Frequency (/yr)	Cumulative contribution	Sequence Cutsets	Sequence Description
48	PLOESW_008	1.86E-09	97.9	PLOESW * /RT-LOESW * SHR-E12CC * PO-E24CC	PLOESW * Success of reactor trip * Failure of secondary heat removal * Failure of bleed for F&B operation
49	LSSB-D_015	1.82E-09	98.1	LSSB-D * /RT-LSSB * /PRC-LSSB * PISGTR * /SI-I14SG * /ISOL-LSSBD * /SHR1-E12LS-SI * ECLDN * LCLDN * CV-IRWST	LSSB * Success of reactor trip * No POSRV challenge * Pressure-induced SGTR occurs * Success of SI injection * Success of steam line isolation * Success of secondary heat removal * Failure of initial RCS cooldown and late cooldown * Failure of IRWST refill
50	GRID-SBO_007	1.51E-09	98.2	GRID-SBO * AAC * /SHR1-E12TD * RSF-SBO-AFSUC	GRID-SBO * Failure of AAC * Success of secondary heat removal with AF TDPs * RCP seal LOCA occurs
51	SBO_006	1.45E-09	98.3	SBO * /AAC * SHR-12AC * PO-E22	SBO * Success of AAC * Failure of secondary heat removal * Failure of bleed for F&B operation
52	PLOESW_006	1.33E-09	98.4	PLOESW * /RT-LOESW * SHR-E12CC * /PO-E24CC * /SIF-I12CC * SCR11CSS11-SI	PLOESW * Success of reactor trip * Failure of secondary heat removal * Success of F&B operation * Failure of long term cooling with SC/CS

Table 19.1-18 (10 of 10)

Rank	Sequence No.	Sequence Frequency (/yr)	Cumulative contribution	Sequence Cutsets	Sequence Description
53	GRID-SBO_008	1.33E-09	98.5	GRID-SBO * AAC * SHR1-E12TD	GRID-SBO * Failure of AAC * Failure of secondary heat removal with AF TDPs
54	FWLB_004	1.25E-09	98.6	FWLB * /RT-LOFW * /PISGTR * /ISOL * SHR-E11FB * /PO-E24 * SIF-I14	FWLB * Success of reactor trip * No Pressure-induced SGTR * Success of steam line isolation * Failure of secondary heat removal * Success of bleed for F&B operation * Failure of SI feed for F&B operation
55	PLOESW_009	1.24E-09	98.7	PLOESW * RT-LOESW	PLOESW * Failure of reactor trip
56	ATWS_003	1.23E-09	98.8	ATWS * /MTC-ATWS * /PFO-ATWS * /PRC-ATWS * /PISGTR * SHR-E22FW	ATWS * No adverse MTC (Moderator Temperature Coefficient) * Success of POSRVs open * Success of POSRVs reseat * No Pressure-induced SGTR * Failure of secondary heat removal
57	PLOCCW_003	1.07E-09	98.9	PLOCCW * /RT-LOCCW * /SHR-E12CC * RSF-CC-AFSUC * /SI-I12CC * SCR11CSS11-SI	PLOCCW * Success of reactor trip * Success of secondary heat removal * RCP seal LOCA occurs * Success of SI injection * Failure of long term cooling with SC/CS
58	LOIA_005	1.04E-09	99.0	LOIA * /RT-LOIA * /PRC-MSSV * /LOIA-GRID * SHR-E12GT * PO-E24	LOIA * Success of reactor trip * No POSRV challenge * No consequential LOOP * Failure of secondary heat removal * Failure of bleed for F&B operation

Table 19.1-19 (1 of 40)

Level 1 Internal Events Top 100 CDF Cutsets

Rank	Cutset Frequency	Cutsets			Contribution to CDF (%)	
		Cutset	Basic Event Probability	Cutset Description	Cutset	Cumulative
1	4.47E-08	%TLOCCW	2.34E-04	TOTAL LOSS OF COMPONANT COOLING WATER	3.4	3.4
		CVDPR-S-PP03	4.78E-02	AUXILIARY CHARGING PUMP (PP03) FAILS TO RUN		
		SEAL-AFSUC	4.00E-03	SEAL FAILURE PROBABILITY (SECONDARY HEAT REMOVAL SUCCESS)		
2	4.47E-08	%TLOESW	2.34E-04	TOTAL LOSS OF ESSENTIAL SERVICE WATER	3.4	6.9
		CVDPR-S-PP03	4.78E-02	AUXILIARY CHARGING PUMP (PP03) FAILS TO RUN		
		SEAL-AFSUC	4.00E-03	SEAL FAILURE PROBABILITY (SECONDARY HEAT REMOVAL SUCCESS)		

Table 19.1-19 (2 of 40)

Rank	Cutset Frequency	Cutsets			Contribution to CDF (%)	
		Cutset	Basic Event Probability	Cutset Description	Cutset	Cumulative
3	3.13E-08	%GTRN	6.56E-01	GENERAL TRANSIENT	2.4	9.3
		I-ATWS-RPMCF	2.98E-07	FAILURE TO SCRAM DUE TO MECHANICAL FAILURES		
		MTC-ATWS	1.60E-01	ADEVERSE MODERATE TEMPERATURE COEFFICIENT		
4	3.06E-08	%RVR	3.06E-08	REACTOR VESSEL RUPTURE	2.4	11.6
5	2.43E-08	%SLOCA	1.99E-03	SMALL LOSS OF COOLANT ACCIDENT	1.9	13.5
		SISPP-S-IRWST	1.22E-05	FAILURE OF IRWST SUMP DUE TO PLUGGING		
6	1.64E-08	%LOOP-GR	1.16E-02	GRID-RELATED LOSS OF OFFSITE POWER	1.3	14.8
		PFHBWQ4-SW2OUAT	2.71E-05	CCF OF CLASS 1E 4.16KV SWITCHGEAR PCBS (UAT) FAIL TO OPEN		
		PFOPH-S-UATBKR-LOCAL	5.20E-02	OPERATOR FAIL TO RECOVER PCBS FOR 1E 4.16KV SW01A,B,C,D AT LOCAL		

Table 19.1-19 (3 of 40)

Rank	Cutset Probability	Cutsets			Contribution to CDF (%)	
		Cutset	Basic Event Probability	Cutset Description	Cutset	Cumulative
7	1.47E-08	%MLOCA	4.85E-04	MEDIUM LOSS OF COOLANT ACCIDENT	1.1	15.9
		CSMVWD2-003/004	3.04E-05	CCF OF CONTAINMENT SPRAY HEAT EXCHANGERS DISCHARGE ISOLATION VALVES FAIL TO OPEN		
8	1.39E-08	%LOOP-SW	9.88E-03	SWITCHYARD-CENTERED LOSS OF OFFSITE POWER	1.1	17.0
		PFHBWQ4-SW2OUAT	2.71E-05	CCF OF CLASS 1E 4.16KV SWITCHGEAR PCBS (UAT) FAIL TO OPEN		
		PFOPH-S-UATBKR-LOCAL	5.20E-02	OPERATOR FAIL TO RECOVER PCBS FOR 1E 4.16KV SW01A,B,C,D AT LOCAL		
9	1.03E-08	%TLOCCW	2.34E-04	TOTAL LOSS OF COMPONANT COOLING WATER	0.8	17.8
		CVOPH-S-RCPSEAL	1.10E-02	OPERATOR FAILS TO RECOVER RCP SEAL COOLING (AUX. CHG PUMP)		
		SEAL-AFSUC	4.00E-03	SEAL FAILURE PROBABILITY (SECONDARY HEAT REMOVAL SUCCESS)		

Table 19.1-19 (4 of 40)

Rank	Cutset Probability	Cutsets			Contribution to CDF (%)	
		Cutset	Basic Event Probability	Cutset Description	Cutset	Cumulative
10	1.03E-08	%TLOESW	2.34E-04	TOTAL LOSS OF ESSENTIAL SERVICE WATER	0.8	18.6
		CVOPH-S-RCPSEAL	1.10E-02	OPERATOR FAILS TO RECOVER RCP SEAL COOLING (AUX. CHG PUMP)		
		SEAL-AFSUC	4.00E-03	SEAL FAILURE PROBABILITY (SECONDARY HEAT REMOVAL SUCCESS)		
11	8.98E-09	%MLOCA	4.85E-04	MEDIUM LOSS OF COOLANT ACCIDENT	0.7	19.2
		CCMVWD2-097/8	1.85E-05	CCF OF CCW INLET VALVE FAIL TO OPEN FOR CS HEAT EXCHANGERS		
12	7.23E-09	%MLOCA	4.85E-04	MEDIUM LOSS OF COOLANT ACCIDENT	0.6	19.8
		DGDGR-C-DGC	2.49E-02	EMERGENCY DIESEL GENERATOR C FAILS TO RUN		
		DGDGR-D-DGD	2.49E-02	EMERGENCY DIESEL GENERATOR D FAILS TO RUN		
		PFLOOP-LOCA	2.40E-02	CONDITIONAL LOSS OF OFFSITE POW ER UPON LOCA INITIATORS		

Table 19.1-19 (5 of 40)

Rank	Cutset Probability	Cutsets			Contribution to CDF (%)	
		Cutset	Basic Event Probability	Cutset Description	Cutset	Cumulative
13	6.62E-09	%SGTR	1.97E-03	STEAM GENERATOR TUBE RUPTURE	0.5	20.3
		HR-RCSCD1-ISOL	1.40E-03	OPERATOR FAILS TO TAKE ACTION FOR SG COOLDOWN, RCS DEPRESS PRIOR TO OVERFILL		
		HR-RCSCD2-CD	1.00E+00	OPERATOR FAILS TO TAKE ACTION FOR SG COOLDOWN, RCS DEPRESS AFTER OVERFILL		
		PFLOOP-TRANS	2.40E-03	CONDITIONAL LOSS OF OFFSITE POWER UPON TRANSIENTS		
14	6.50E-09	%PLOCCW	4.36E-03	PARTIAL LOSS OF COMPONANT COOLING WATER	0.5	20.8
		DGDGR-B-DGB	2.49E-02	EMERGENCY DIESEL GENERATOR B FAILS TO RUN		
		DGDGR-D-DGD	2.49E-02	EMERGENCY DIESEL GENERATOR D FAILS TO RUN		
		PFLOOP-TRANS	2.40E-03	CONDITIONAL LOSS OF OFFSITE POWER UPON TRANSIENTS		

Table 19.1-19 (6 of 40)

Rank	Cutset Probability	Cutsets			Contribution to CDF (%)	
		Cutset	Basic Event Probability	Cutset Description	Cutset	Cumulative
15	5.91E-09	%MLOCA	4.85E-04	MEDIUM LOSS OF COOLANT ACCIDENT	0.5	21.3
		SISPP-S-IRWST	1.22E-05	FAILURE OF IRWST SUMP DUE TO PLUGGING		
16	5.23E-09	%LOOP-WE	3.71E-03	WEATHER-RELATED LOSS OF OFFSITE POWER	0.4	21.7
		PFHBWQ4-SW2OUAT	2.71E-05	CCF OF CLASS 1E 4.16KV SWITCHGEAR PCBS (UAT) FAIL TO OPEN		
		PFOPH-S-UATBKR-LOCAL	5.20E-02	OPERATOR FAIL TO RECOVER PCBS FOR 1E 4.16KV SW01A,B,C,D AT LOCAL		
17	5.15E-09	%PLOCCW	4.36E-03	PARTIAL LOSS OF COMPONANT COOLING WATER	0.4	22.1
		DGDGR-B-DGB	2.49E-02	EMERGENCY DIESEL GENERATOR B FAILS TO RUN		
		PFLOOP-TRANS	2.40E-03	CONDITIONAL LOSS OF OFFSITE POWER UPON TRANSIENTS		
		WOCHM2B-CH02B	1.98E-02	ESSENTIAL CHILLED WATER CHILLER 2B UNAVAILABLE DUE TO T&M		

Table 19.1-19 (7 of 40)

Rank	Cutset Probability	Cutsets			Contribution to CDF (%)	
		Cutset	Basic Event Probability	Cutset Description	Cutset	Cumulative
18	5.15E-09	%LOOP-WE	3.71E-03	WEATHER-RELATED LOSS OF OFFSITE POWER	0.4	22.5
		DATGR-S-AACTG	1.56E-01	AAC GAS TURBINE GENERATOR FAILS TO RUN		
		RAC-16H-WE	1.59E-01	NON-RECOVERY PROBABILITY OF OFFSITE POWER WITHIN 16HR (WEATHER RELATED)		
		SXFLP-S-FT0123AB	5.58E-05	ESSENTIAL SERVICE WATER DEBRIS FILTERS PLUGGED		
19	4.43E-09	%GTRN	1.60E-01	GENERAL TRANSIENT	0.3	22.8
		MTC-ATWS	6.56E-01	ADEVERSE MODERATE TEMPERATURE COEFFICIENT		
		I-ATWS-RPMCF	2.98E-07	FAILURE TO SCRAM DUE TO MECHANICAL FAILURES		
		PI-SGTR	2.70E-02	PRESSURE INDUECD SGTR PROBABILITY		
20	4.31E-09	%LOOP-GR	1.16E-02	GRID-RELATED LOSS OF OFFSITE POWER	0.3	23.1
		PFHBC2A-SW01C-E2	6.66E-03	CLASS 1E 4.16KV SWITCHGEAR PCB SW01C-E2 (AAC) FAILS TO CLOSE		
		SXFLP-S-FT0123AB	5.58E-05	ESSENTIAL SERVICE WATER DEBRIS FILTERS PLUGGED		

Table 19.1-19 (8 of 40)

Rank	Cutset Probability	Cutsets			Contribution to CDF (%)	
		Cutset	Basic Event Probability	Cutset Description	Cutset	Cumulative
21	4.31E-09	%LOOP-GR	1.16E-02	GRID-RELATED LOSS OF OFFSITE POWER	0.3	23.5
		NBHBC2A-SW03N-F2	6.66E-03	NON-1E 4.16KV AAC SWITCHGEAR PCB SW03N-F2 FOR SW01C FAILS TO CLOSE		
		SXFLP-S-FT0123AB	5.58E-05	ESSENTIAL SERVICE WATER DEBRIS FILTERS PLUGGED		
22	4.28E-09	%LOOP-WE	3.71E-03	WEATHER-RELATED LOSS OF OFFSITE POWER	0.3	23.8
		DATGR-S-AACTG	1.56E-01	AAC GAS TURBINE GENERATOR FAILS TO RUN		
		DGDGKQ4-DG01ABCD	4.63E-05	CCF OF EMERGENCY DIESEL GENERATORS FAIL TO RUN		
		RAC-16H-WE	1.59E-01	NON-RECOVERY PROBABILITY OF OFFSITE POWER WITHIN 16HR (WEATHER RELATED)		
23	4.25E-09	%LSSB-D	7.32E-03	LARGE SECONDARY SIDE BREAK (MSIV DOWNDSTREAM)	0.3	24.1
		MSEVXQ2-012/14	2.15E-05	CCF OF MAIN STEAM ISOLATION VALVES 012 AND 014 FAIL TO CLOSE		
		PI-SGTR	2.70E-02	PRESSURE INDUECD SGTR PROBABILITY		

Table 19.1-19 (9 of 40)

Rank	Cutset Probability	Cutsets			Contribution to CDF (%)	
		Cutset	Basic Event Probability	Cutset Description	Cutset	Cumulative
24	4.25E-09	%LSSB-D	7.32E-03	LARGE SECONDARY SIDE BREAK (MSIV DOWNDSTREAM)	0.3	24.4
		MSEVXQ2-012/13	2.15E-05	CCF OF MAIN STEAM ISOLATION VALVES 012 AND 013 FAIL TO CLOSE		
		PI-SGTR	2.70E-02	PRESSURE INDUECD SGTR PROBABILITY		
25	4.25E-09	%LSSB-D	7.32E-03	LARGE SECONDARY SIDE BREAK (MSIV DOWNDSTREAM)	0.3	24.8
		MSEVXQ2-011/13	2.15E-05	CCF OF MAIN STEAM ISOLATION VALVES 011 AND 013 FAIL TO CLOSE		
		PI-SGTR	2.70E-02	PRESSURE INDUECD SGTR PROBABILITY		
26	4.25E-09	%LSSB-D	7.32E-03	LARGE SECONDARY SIDE BREAK (MSIV DOWNDSTREAM)	0.3	25.1
		MSEVXQ2-011/14	2.15E-05	CCF OF MAIN STEAM ISOLATION VALVES 011 AND 014 FAIL TO CLOSE		
		PI-SGTR	2.70E-02	PRESSURE INDUECD SGTR PROBABILITY		

Table 19.1-19 (10 of 40)

Rank	Cutset Probability	Cutsets			Contribution to CDF (%)	
		Cutset	Basic Event Probability	Cutset Description	Cutset	Cumulative
27	4.18E-09	%MLOCA	4.85E-04	MEDIUM LOSS OF COOLANT ACCIDENT	0.3	25.4
		DGDGM-C-DGC	1.44E-02	EMERGENCY DIESEL GENERATOR C UNAVAILABLE DUE TO T&M		
		DGDGR-D-DGD	2.49E-02	EMERGENCY DIESEL GENERATOR D FAILS TO RUN		
		PFLOOP-LOCA	2.40E-02	CONDITIONAL LOSS OF OFFSITE POWER UPON LOCA INITIATORS		
28	4.18E-09	%MLOCA	4.85E-04	MEDIUM LOSS OF COOLANT ACCIDENT	0.3	25.7
		DGDGM-D-DGD	1.44E-02	EMERGENCY DIESEL GENERATOR D UNAVAILABLE DUE TO T&M		
		DGDGR-C-DGC	2.49E-02	EMERGENCY DIESEL GENERATOR C FAILS TO RUN		
		PFLOOP-LOCA	2.40E-02	CONDITIONAL LOSS OF OFFSITE POWER UPON LOCA INITIATORS		

Table 19.1-19 (11 of 40)

Rank	Cutset Probability	Cutsets			Contribution to CDF (%)	
		Cutset	Basic Event Probability	Cutset Description	Cutset	Cumulative
29	4.04E-09	%LOOP-WE	3.71E-03	WEATHER-RELATED LOSS OF OFFSITE POWER	0.3	26.1
		DATGR-S-AACTG	1.56E-01	AAC GAS TURBINE GENERATOR FAILS TO RUN		
		RAC-16H-WE	1.59E-01	NON-RECOVERY PROBABILITY OF OFFSITE POWER WITHIN 16HR (WEATHER RELATED)		
		WOCHWQ4-CH01A/2A/1B/2B	4.38E-05	CCF OF ESSENTIAL CHILLED WATER CHILLERS FAIL TO START		
30	3.75E-09	%PLOESW	2.52E-03	PARTIAL LOSS OF ESSENTIAL SERVICE WATER	0.3	26.3
		DGDGR-B-DGB	2.49E-02	EMERGENCY DIESEL GENERATOR B FAILS TO RUN		
		DGDGR-D-DGD	2.49E-02	EMERGENCY DIESEL GENERATOR D FAILS TO RUN		
		PFLOOP-TRANS	2.40E-03	CONDITIONAL LOSS OF OFFSITE POWER UPON TRANSIENTS		

Table 19.1-19 (12 of 40)

Rank	Cutset Probability	Cutsets			Contribution to CDF (%)	
		Cutset	Basic Event Probability	Cutset Description	Cutset	Cumulative
31	3.75E-09	%PLOCCW	4.36E-03	PARTIAL LOSS OF COMPONANT COOLING WATER	0.3	26.6
		DGDGM-D-DGD	1.44E-02	EMERGENCY DIESEL GENERATOR D UNAVAILABLE DUE TO T&M		
		DGDGR-B-DGB	2.49E-02	EMERGENCY DIESEL GENERATOR B FAILS TO RUN		
		PFLOOP-TRANS	2.40E-03	CONDITIONAL LOSS OF OFFSITE POWER UPON TRANSIENTS		
32	3.75E-09	%PLOCCW	4.36E-03	PARTIAL LOSS OF COMPONANT COOLING WATER	0.3	26.9
		DGDGM-B-DGB	1.44E-02	EMERGENCY DIESEL GENERATOR B UNAVAILABLE DUE TO T&M		
		DGDGR-D-DGD	2.49E-02	EMERGENCY DIESEL GENERATOR D FAILS TO RUN		
		PFLOOP-TRANS	2.40E-03	CONDITIONAL LOSS OF OFFSITE POWER UPON TRANSIENTS		

Table 19.1-19 (13 of 40)

Rank	Cutset Probability	Cutsets			Contribution to CDF (%)	
		Cutset	Basic Event Probability	Cutset Description	Cutset	Cumulative
33	3.74E-09	%TLOCCW	2.34E-04	TOTAL LOSS OF COMPONANT COOLING WATER	0.3	27.2
		PFHBC2A-SW01C-E2	6.66E-03	CLASS 1E 4.16KV SWITCHGEAR PCB SW01C-E2 (AAC) FAILS TO CLOSE		
		PFLOOP-TRANS	2.40E-03	CONDITIONAL LOSS OF OFFSITE POWER UPON TRANSIENTS		
34	3.74E-09	%TLOESW	2.34E-04	TOTAL LOSS OF ESSENTIAL SERVICE WATER	0.3	27.5
		PFHBC2A-SW01C-E2	6.66E-03	CLASS 1E 4.16KV SWITCHGEAR PCB SW01C-E2 (AAC) FAILS TO CLOSE		
		PFLOOP-TRANS	2.40E-03	CONDITIONAL LOSS OF OFFSITE POWER UPON TRANSIENTS		
35	3.74E-09	%TLOCCW	2.34E-04	TOTAL LOSS OF COMPONANT COOLING WATER	0.3	27.8
		NBHBC2A-SW03N-F2	6.66E-03	NON-1E 4.16KV AAC SWITCHGEAR PCB SW03N-F2 FOR SW01C FAILS TO CLOSE		
		PFLOOP-TRANS	2.40E-03	CONDITIONAL LOSS OF OFFSITE POWER UPON TRANSIENTS		

Table 19.1-19 (14 of 40)

Rank	Cutset Probability	Cutsets			Contribution to CDF (%)	
		Cutset	Basic Event Probability	Cutset Description	Cutset	Cumulative
36	3.74E-09	%TLOESW	2.34E-04	TOTAL LOSS OF ESSENTIAL SERVICE WATER	0.3	28.1
		NBHBC2A-SW03N-F2	6.66E-03	NON-1E 4.16KV AAC SWITCHGEAR PCB SW03N-F2 FOR SW01C FAILS TO CLOSE		
		PFLOOP-TRANS	2.40E-03	CONDITIONAL LOSS OF OFFSITE POWER UPON TRANSIENTS		
37	3.67E-09	%LOOP-SW	9.88E-03	SWITCHYARD-CENTERED LOSS OF OFFSITE POWER	0.3	28.4
		NBHBC2A-SW03N-F2	6.66E-03	NON-1E 4.16KV AAC SWITCHGEAR PCB SW03N-F2 FOR SW01C FAILS TO CLOSE		
		SXFLP-S-FT0123AB	5.58E-05	ESSENTIAL SERVICE WATER DEBRIS FILTERS PLUGGED		
38	3.67E-09	%LOOP-SW	9.88E-03	SWITCHYARD-CENTERED LOSS OF OFFSITE POWER	0.3	28.6
		PFHBC2A-SW01C-E2	6.66E-03	CLASS 1E 4.16KV SWITCHGEAR PCB SW01C-E2 (AAC) FAILS TO CLOSE		
		SXFLP-S-FT0123AB	5.58E-05	ESSENTIAL SERVICE WATER DEBRIS FILTERS PLUGGED		

Table 19.1-19 (15 of 40)

Rank	Cutset Probability	Cutsets			Contribution to CDF (%)	
		Cutset	Basic Event Probability	Cutset Description	Cutset	Cumulative
39	3.44E-09	%PLOCCW	4.36E-03	PARTIAL LOSS OF COMPONANT COOLING WATER	0.3	28.9
		DGDGR-B-DGB	2.49E-02	EMERGENCY DIESEL GENERATOR B FAILS TO RUN		
		PFLOOP-TRANS	2.40E-03	CONDITIONAL LOSS OF OFFSITE POWER UPON TRANSIENTS		
		SXMPM2B-PP02B	1.32E-02	ESSENTIAL SERVICE WATER PUMP 2B UNAVAILABLE DUE TO T&M		
40	3.39E-09	%PLOCCW	4.36E-03	PARTIAL LOSS OF COMPONANT COOLING WATER	0.3	29.2
		DGDGR-B-DGB	2.49E-02	EMERGENCY DIESEL GENERATOR B FAILS TO RUN		
		PFLOOP-TRANS	2.40E-03	CONDITIONAL LOSS OF OFFSITE POWER UPON TRANSIENTS		
		WOCHS2B-CH02B	1.30E-02	ESSENTIAL CHILLED WATER CHILLER 2B FAILS TO START		

Table 19.1-19 (16 of 40)

Rank	Cutset Probability	Cutsets			Contribution to CDF (%)	
		Cutset	Basic Event Probability	Cutset Description	Cutset	Cumulative
41	3.12E-09	%LOFW	6.55E-02	LOSS OF MAIN FEEDWATER	0.2	29.4
		I-ATWS-RPMCF	2.98E-07	FAILURE TO SCRAM DUE TO MECHANICAL FAILURES		
		MTC-ATWS	1.60E-01	ADEVERSE MODERATE TEMPERATURE COEFFICIENT		
42	2.98E-09	%LOOP-WE	3.71E-03	WEATHER-RELATED LOSS OF OFFSITE POWER	0.2	29.6
		DATGR-S-AACTG	1.56E-01	AAC GAS TURBINE GENERATOR FAILS TO RUN		
		RAC-16H-WE	1.59E-01	NON-RECOVERY PROBABILITY OF OFFSITE POWER WITHIN 16HR (WEATHER RELATED)		
		VDHVZO8-HV12/13ABCD	3.23E-05	CCF OF ALL EDG ROOM CUBICLE COOLERS FAIL TO RUN FOR 1HR		

Table 19.1-19 (17 of 40)

Rank	Cutset Probability	Cutsets			Contribution to CDF (%)	
		Cutset	Basic Event Probability	Cutset Description	Cutset	Cumulative
43	2.98E-09	%PLOESW	2.52E-03	PARTIAL LOSS OF ESSENTIAL SERVICE WATER	0.2	29.9
		DGDGR-B-DGB	2.49E-02	EMERGENCY DIESEL GENERATOR B FAILS TO RUN		
		PFLOOP-TRANS	2.40E-03	CONDITIONAL LOSS OF OFFSITE POWER UPON TRANSIENTS		
		WOCHM2B-CH02B	1.98E-02	ESSENTIAL CHILLED WATER CHILLER 2B UNAVAILABLE DUE TO T&M		
44	2.98E-09	%PLOCCW	4.36E-03	PARTIAL LOSS OF COMPONANT COOLING WATER	0.2	30.1
		DGDGM-B-DGB	1.44E-02	EMERGENCY DIESEL GENERATOR B UNAVAILABLE DUE TO T&M		
		PFLOOP-TRANS	2.40E-03	CONDITIONAL LOSS OF OFFSITE POWER UPON TRANSIENTS		
		WOCHM2B-CH02B	1.98E-02	ESSENTIAL CHILLED WATER CHILLER 2B UNAVAILABLE DUE TO T&M		

Table 19.1-19 (18 of 40)

Rank	Cutset Probability	Cutsets			Contribution to CDF (%)	
		Cutset	Basic Event Probability	Cutset Description	Cutset	Cumulative
45	2.91E-09	%LOOP-WE	3.71E-03	WEATHER-RELATED LOSS OF OFFSITE POWER	0.2	30.3
		DATGR-S-AACTG	1.56E-01	AAC GAS TURBINE GENERATOR FAILS TO RUN		
		RAC-16H-WE	1.59E-01	NON-RECOVERY PROBABILITY OF OFFSITE POWER WITHIN 16HR (WEATHER RELATED)		
		VDHVKO8-HV12/13ABCD	3.15E-05	CCF OF ALL EDG ROOM CUBICLE COOLERS FAIL TO RUN		
46	2.76E-09	%SGTR	1.97E-03	STEAM GENERATOR TUBE RUPTURE	0.2	30.5
		CVOPH-S-IRWST	1.00E-03	OPERATOR FAILS TO REFILL THE IRWST VIA CVCS		
		HR-RCSCD1-ISOL	1.40E-03	OPERATOR FAILS TO TAKE ACTION FOR SG COOLDOWN, RCS DEPRESS PRIOR TO OVERFILL		
		HR-RCSCD2-CD	1.00E+00	OPERATOR FAILS TO TAKE ACTION FOR SG COOLDOWN, RCS DEPRESS AFTER OVERFILL		

Table 19.1-19 (19 of 40)

Rank	Cutset Probability	Cutsets			Contribution to CDF (%)	
		Cutset	Basic Event Probability	Cutset Description	Cutset	Cumulative
47	2.72E-09	%LOOP-GR	1.16E-02	GRID-RELATED LOSS OF OFFSITE POWER	0.2	30.7
		MSAVO-B-110	4.20E-03	AUXILIARY FEEDWATER PUMP TURBINE STEAM SUPPLY VALVE 110 FAILS TO OPEN		
		SXFLP-S-FT0123AB	5.58E-05	ESSENTIAL SERVICE WATER DEBRIS FILTERS PLUGGED		
48	2.66E-09	%SLOCA	1.99E-03	SMALL LOSS OF COOLANT ACCIDENT	0.2	30.9
		PFLOOP-LOCA	2.40E-02	CONDITIONAL LOSS OF OFFSITE POWER UPON LOCA INITIATORS		
		SXFLP-S-FT0123AB	5.58E-05	ESSENTIAL SERVICE WATER DEBRIS FILTERS PLUGGED		
49	2.66E-09	%SGTR	1.97E-03	STEAM GENERATOR TUBE RUPTURE	0.2	31.1
		CVMVO-S-509	9.65E-04	IRWST RETURN LINE ISOLATION VALVE FAILS TO OPEN		
		HR-RCSCD1-ISOL	1.40E-03	OPERATOR FAILS TO TAKE ACTION FOR SG COOLDOWN, RCS DEPRESS PRIOR TO OVERFILL		
		HR-RCSCD2-CD	1.00E+00	OPERATOR FAILS TO TAKE ACTION FOR SG COOLDOWN, RCS DEPRESS AFTER OVERFILL		

Table 19.1-19 (20 of 40)

Rank	Cutset Probability	Cutsets			Contribution to CDF (%)	
		Cutset	Basic Event Probability	Cutset Description	Cutset	Cumulative
50	2.66E-09	%LOCV	5.57E-02	LOSS OF CONDENCER VACCUM	0.2	31.3
		I-ATWS-RPMCF	2.98E-07	FAILURE TO SCRAM DUE TO MECHANICAL FAILURES		
		MTC-ATWS	1.60E-01	ADEVERSE MODERATE TEMPERATURE COEFFICIENT		
51	2.58E-09	%LOOP-PL	1.83E-03	PLANT-CENTERED LOSS OF OFFSITE POWER	0.2	31.5
		PFHBWQ4-SW2OUAT	2.71E-05	CCF OF CLASS 1E 4.16KV SWITCHGEAR PCBS (UAT) FAIL TO OPEN		
		PFOPH-S-UATBKR-LOCAL	5.20E-02	OPERATOR FAIL TO RECOVER PCBS FOR 1E 4.16KV SW01A,B,C,D AT LOCAL		
52	2.52E-09	%SLOCA	1.99E-03	SMALL LOSS OF COOLANT ACCIDENT	0.2	31.7
		AFOPH-S-ALT-LT	9.10E-04	OPERATOR FAIL TO ALIGN FOR SUPPLYING AN ALTERNATE SOURCE		
		PFLOOP-LOCA	2.40E-02	CONDITIONAL LOSS OF OFFSITE POWER UPON LOCA INITIATORS		
		RCOPH-S-SDSL-LD	5.79E-02	FAILURE OF POSRVS LATE PHASE OPEN WITH LOW DEPENDENCY		

Table 19.1-19 (21 of 40)

Rank	Cutset Probability	Cutsets			Contribution to CDF (%)	
		Cutset	Basic Event Probability	Cutset Description	Cutset	Cumulative
53	2.50E-09	%LSSB-D	7.32E-03	LARGE SECONDARY SIDE BREAK (MSIV DOWNSTREAM)	0.2	31.9
		MSOPV-S-MSIS	1.00E-01	OPERATOR FAILS TO RECOVERY FOR MSIS		
		PELXKD2-LX09A11B	3.41E-06	CCF OF SAFETY RELATED LOOP CONTROLLER LX09A & LX11B FAIL TO OPERATE		
		RCOPH-S-SDSE-FW-CD	1.00E+00	FAILURE OF POSRVS EARLY PHASE OPEN WITH COMPLETE DEPENDENCY		
54	2.45E-09	%LOFW	6.55E-02	LOSS OF MAIN FEEDWATER	0.2	32.1
		AFPVKQ4-TP01A/B/MP02A/B	4.12E-06	CCF OF ALL AF PUMPS FAIL DUE TO THE VOLUTE FAIL TO RUN		
		RCOPH-S-SDSE-FW	9.10E-03	FAILURE OF POSRVS EARLY PHASE OPEN		

Table 19.1-19 (22 of 40)

Rank	Cutset Probability	Cutsets			Contribution to CDF (%)	
		Cutset	Basic Event Probability	Cutset Description	Cutset	Cumulative
55	2.41E-09	%MLOCA	4.85E-04	MEDIUM LOSS OF COOLANT ACCIDENT	0.2	32.3
		DGDGM-C-DGC	1.44E-02	EMERGENCY DIESEL GENERATOR C UNAVAILABLE DUE TO T&M		
		DGDGM-D-DGD	1.44E-02	EMERGENCY DIESEL GENERATOR D UNAVAILABLE DUE TO T&M		
		PFLOOP-LOCA	2.40E-02	CONDITIONAL LOSS OF OFFSITE POWER UPON LOCA INITIATORS		
56	2.36E-09	%LOOP-WE	3.71E-03	WEATHER-RELATED LOSS OF OFFSITE POWER	0.2	32.5
		AFMVO1A-045	5.78E-02	AF TURBINE-DRIVEN PUMP 1A DISCHARGE ISOLATION VALVE 045 FAIL TO OPEN		
		RAC-12H-WE	1.97E-01	NON-RECOVERY PROBABILITY OF OFFSITE POWER WITHIN 12HR (WEATHER RELATED)		
		SXFLP-S-FT0123AB	5.58E-05	ESSENTIAL SERVICE WATER DEBRIS FILTERS PLUGGED		

Table 19.1-19 (23 of 40)

Rank	Cutset Probability	Cutsets			Contribution to CDF (%)	
		Cutset	Basic Event Probability	Cutset Description	Cutset	Cumulative
57	2.36E-09	%LOOP-WE	3.71E-03	WEATHER-RELATED LOSS OF OFFSITE POWER	0.2	32.7
		AFMVC1A-045	5.78E-02	AF TURBINE-DRIVEN PUMP 1A DISCHARGE ISOLATION VALVE 045 FAIL TO CLOSE		
		RAC-12H-WE	1.97E-01	NON-RECOVERY PROBABILITY OF OFFSITE POWER WITHIN 12HR (WEATHER RELATED)		
		SXFLP-S-FT0123AB	5.58E-05	ESSENTIAL SERVICE WATER DEBRIS FILTERS PLUGGED		
58	2.36E-09	%TLOCCW	2.34E-04	TOTAL LOSS OF COMPONANT COOLING WATER	0.2	32.9
		MSAVO-B-110	4.20E-03	AUXILIARY FEEDWATER PUMP TURBINE STEAM SUPPLY VALVE 110 FAILS TO OPEN		
		PFLOOP-TRANS	2.40E-03	CONDITIONAL LOSS OF OFFSITE POWER UPON TRANSIENTS		

Table 19.1-19 (24 of 40)

Rank	Cutset Probability	Cutsets			Contribution to CDF (%)	
		Cutset	Basic Event Probability	Cutset Description	Cutset	Cumulative
59	2.36E-09	%TLOESW	2.34E-04	TOTAL LOSS OF ESSENTIAL SERVICE WATER	0.2	33.0
		MSAVO-B-110	4.20E-03	AUXILIARY FEEDWATER PUMP TURBINE STEAM SUPPLY VALVE 110 FAILS TO OPEN		
		PFLOOP-TRANS	2.40E-03	CONDITIONAL LOSS OF OFFSITE POWER UPON TRANSIENTS		
60	2.31E-09	%LOOP-SW	9.88E-03	SWITCHYARD-CENTERED LOSS OF OFFSITE POWER	0.2	33.2
		MSAVO-B-110	4.20E-03	AUXILIARY FEEDWATER PUMP TURBINE STEAM SUPPLY VALVE 110 FAILS TO OPEN		
		SXFLP-S-FT0123AB	5.58E-05	ESSENTIAL SERVICE WATER DEBRIS FILTERS PLUGGED		
61	2.30E-09	%GTRN	1.60E-01	GENERAL TRANSIENTCOEFFICIENT	0.2	33.4
		MTC-ATWS	6.56E-01	ADEVERSE MODERATE TEMPERATURE COEFFICIENT		
		CVOPH-S-BORATION	1.40E-02	OPERATOR FAILS TO INITIATE EMERGENCY BORATION TO RCS		
		I-ATWS-RPMCF	2.98E-07	FAILURE TO SCRAM DUE TO MECHANICAL FAILURES		

Table 19.1-19 (25 of 40)

Rank	Cutset Probability	Cutsets			Contribution to CDF (%)	
		Cutset	Basic Event Probability	Cutset Description	Cutset	Cumulative
62	2.29E-09	%SGTR	1.97E-03	STEAM GENERATOR TUBE RUPTURE	0.2	33.6
		AFMPM2A-MDP02A	3.63E-03	AF MOTOR-DRIVEN PUMP 2A UNAVAILABLE DUE TO T&M		
		AFTPR1A-TDP01A	3.52E-02	AF TURBINE-DRIVEN PUMP 1A FAILS TO RUN		
		RCOPH-S-SDSE-FW	9.10E-03	FAILURE OF POSRVS EARLY PHASE OPEN		
63	2.24E-09	%GTRN	6.56E-01	GENERAL TRANSIENT	0.2	33.7
		AFPVKQ4-TP01A/B/MP02A/B	4.12E-06	CCF OF ALL AF PUMPS FAIL DUE TO THE VOLUTE FAIL TO RUN		
		FWOPH-S-ERY	5.50E-03	OPERATOR FAILS TO ALIGN STARTUP FEEDWATER PUMP PP07 (EARLY PHASE)		
		RCOPH-S-SDSE-FW-MD	1.51E-01	FAILURE OF POSRVS EARLY PHASE OPEN WITH MEDIUM DEPENDENCY		

Table 19.1-19 (26 of 40)

Rank	Cutset Probability	Cutsets			Contribution to CDF (%)	
		Cutset	Basic Event Probability	Cutset Description	Cutset	Cumulative
64	2.21E-09	%SLOCA	1.99E-03	SMALL LOSS OF COOLANT ACCIDENT	0.2	33.9
		DGDGKQ4-DG01ABCD	4.63E-05	CCF OF EMERGENCY DIESEL GENERATORS FAIL TO RUN		
		PFLOOP-LOCA	2.40E-02	CONDITIONAL LOSS OF OFFSITE POWER UPON LOCA INITIATORS		
65	2.20E-09	%LSSB-D	7.32E-03	LARGE SECONDARY SIDE BREAK (MSIV DOWNDSTREAM)	0.2	34.1
		MSEVXQ4-011/12/13/14	1.11E-05	CCF OF MAIN STEAM ISOLATION VALVES FAIL TO CLOSE		
		PI-SGTR	2.70E-02	PRESSURE INDUECD SGTR PROBABILITY		
66	2.18E-09	%LSSB-D	7.32E-03	LARGE SECONDARY SIDE BREAK (MSIV DOWNDSTREAM)	0.2	34.2
		I-ATWS-RPMCF	2.98E-07	FAILURE TO SCRAM DUE TO MECHANICAL FAILURES		

Table 19.1-19 (27 of 40)

Rank	Cutset Probability	Cutsets			Contribution to CDF (%)	
		Cutset	Basic Event Probability	Cutset Description	Cutset	Cumulative
67	2.17E-09	%PLOESW	2.52E-03	PARTIAL LOSS OF ESSENTIAL SERVICE WATER	0.2	34.4
		DGDGM-D-DGD	1.44E-02	EMERGENCY DIESEL GENERATOR D UNAVAILABLE DUE TO T&M		
		DGDGR-B-DGB	2.49E-02	EMERGENCY DIESEL GENERATOR B FAILS TO RUN		
		PFLOOP-TRANS	2.40E-03	CONDITIONAL LOSS OF OFFSITE POWER UPON TRANSIENTS		
68	2.17E-09	%PLOESW	2.52E-03	PARTIAL LOSS OF ESSENTIAL SERVICE WATER	0.2	34.6
		DGDGM-B-DGB	1.44E-02	EMERGENCY DIESEL GENERATOR B UNAVAILABLE DUE TO T&M		
		DGDGR-D-DGD	2.49E-02	EMERGENCY DIESEL GENERATOR D FAILS TO RUN		
		PFLOOP-TRANS	2.40E-03	CONDITIONAL LOSS OF OFFSITE POWER UPON TRANSIENTS		

Table 19.1-19 (28 of 40)

Rank	Cutset Probability	Cutsets			Contribution to CDF (%)	
		Cutset	Basic Event Probability	Cutset Description	Cutset	Cumulative
69	2.17E-09	%PLOCCW	4.36E-03	PARTIAL LOSS OF COMPONANT COOLING WATER	0.2	34.7
		DGDGM-B-DGB	1.44E-02	EMERGENCY DIESEL GENERATOR B UNAVAILABLE DUE TO T&M		
		DGDGM-D-DGD	1.44E-02	EMERGENCY DIESEL GENERATOR D UNAVAILABLE DUE TO T&M		
		PFLOOP-TRANS	2.40E-03	CONDITIONAL LOSS OF OFFSITE POWER UPON TRANSIENTS		
70	2.09E-09	%LOCV	5.57E-02	LOSS OF CONDENCER VACCUM	0.2	34.9
		AFPVKQ4-TP01A/B/MP02A/B	4.12E-06	CCF OF ALL AF PUMPS FAIL DUE TO THE VOLUTE FAIL TO RUN		
		RCOPH-S-SDSE-FW	9.10E-03	FAILURE OF POSRVS EARLY PHASE OPEN		
71	2.02E-09	%FWLB	1.74E-03	FEEDWATER LINE BREAK	0.2	35.1
		AFMPM2A-MDP02A	3.63E-03	AF MOTOR-DRIVEN PUMP 2A UNAVAILABLE DUE TO T&M		
		AFTPR1A-TDP01A	3.52E-02	AF TURBINE-DRIVEN PUMP 1A FAILS TO RUN		
		RCOPH-S-SDSE-FW	9.10E-03	FAILURE OF POSRVS EARLY PHASE OPEN		

Table 19.1-19 (29 of 40)

Rank	Cutset Probability	Cutsets			Contribution to CDF (%)	
		Cutset	Basic Event Probability	Cutset Description	Cutset	Cumulative
72	2.00E-09	%TLOESW	2.34E-04	TOTAL LOSS OF ESSENTIAL SERVICE WATER	0.2	35.2
		AFTPR1A-TDP01A	3.52E-02	AF TURBINE-DRIVEN PUMP 1A FAILS TO RUN		
		AFTPR1B-TDP01B	3.52E-02	AF TURBINE-DRIVEN PUMP 1B FAILS TO RUN		
		FWMPM-S-PP07	6.90E-03	STARTUP FEEDWATER PUMP UNAVAILABLE DUE TO T&M		
73	2.00E-09	%TLOCCW	2.34E-04	TOTAL LOSS OF COMPONANT COOLING WATER	0.2	35.4
		AFTPR1A-TDP01A	3.52E-02	AF TURBINE-DRIVEN PUMP 1A FAILS TO RUN		
		AFTPR1B-TDP01B	3.52E-02	AF TURBINE-DRIVEN PUMP 1B FAILS TO RUN		
		FWMPM-S-PP07	6.90E-03	STARTUP FEEDWATER PUMP UNAVAILABLE DUE TO T&M		

Table 19.1-19 (30 of 40)

Rank	Cutset Probability	Cutsets			Contribution to CDF (%)	
		Cutset	Basic Event Probability	Cutset Description	Cutset	Cumulative
74	1.99E-09	%PLOESW	2.52E-03	PARTIAL LOSS OF ESSENTIAL SERVICE WATER	0.2	35.5
		DGDGR-B-DGB	2.49E-02	EMERGENCY DIESEL GENERATOR B FAILS TO RUN		
		PFLOOP-TRANS	2.40E-03	CONDITIONAL LOSS OF OFFSITE POWER UPON TRANSIENTS		
		SXMPM2B-PP02B	1.32E-02	ESSENTIAL SERVICE WATER PUMP 2B UNAVAILABLE DUE TO T&M		
75	1.99E-09	%PLOCCW	4.36E-03	PARTIAL LOSS OF COMPONANT COOLING WATER	0.2	35.7
		DGDGM-B-DGB	1.44E-02	EMERGENCY DIESEL GENERATOR B UNAVAILABLE DUE TO T&M		
		PFLOOP-TRANS	2.40E-03	CONDITIONAL LOSS OF OFFSITE POWER UPON TRANSIENTS		
		SXMPM2B-PP02B	1.32E-02	ESSENTIAL SERVICE WATER PUMP 2B UNAVAILABLE DUE TO T&M		

Table 19.1-19 (31 of 40)

Rank	Cutset Probability	Cutsets			Contribution to CDF (%)	
		Cutset	Basic Event Probability	Cutset Description	Cutset	Cumulative
76	1.97E-09	%SGTR	1.97E-03	STEAM GENERATOR TUBE RUPTURE	0.2	35.8
		C-RCD1-SCLT-RFIR	1.00E-06	COMBINED OPERATOR ERROR FOR HR-RCSCD1-ISOL, SIOPH-S-LTC-SC and CVOPH-S-IRWST		
77	1.96E-09	%PLOESW	2.52E-03	PARTIAL LOSS OF ESSENTIAL SERVICE WATER	0.2	36.0
		DGDGR-B-DGB	2.49E-02	EMERGENCY DIESEL GENERATOR B FAILS TO RUN		
		PFLOOP-TRANS	2.40E-03	CONDITIONAL LOSS OF OFFSITE POWER UPON TRANSIENTS		
		WOCHS2B-CH02B	1.30E-02	ESSENTIAL CHILLED WATER CHILLER 2B FAILS TO START		
78	1.96E-09	%PLOCCW	4.36E-03	PARTIAL LOSS OF COMPONANT COOLING WATER	0.2	36.1
		DGDGM-B-DGB	1.44E-02	EMERGENCY DIESEL GENERATOR B UNAVAILABLE DUE TO T&M		
		PFLOOP-TRANS	2.40E-03	CONDITIONAL LOSS OF OFFSITE POWER UPON TRANSIENTS		
		WOCHS2B-CH02B	1.30E-02	ESSENTIAL CHILLED WATER CHILLER 2B FAILS TO START		

Table 19.1-19 (32 of 40)

Rank	Cutset Probability	Cutsets			Contribution to CDF (%)	
		Cutset	Basic Event Probability	Cutset Description	Cutset	Cumulative
79	1.93E-09	%MLOCA	4.85E-04	MEDIUM LOSS OF COOLANT ACCIDENT	0.1	36.3
		DGDGR-D-DGD	2.49E-02	EMERGENCY DIESEL GENERATOR D FAILS TO RUN		
		PFHBO2A-SW01C-C2	6.66E-03	CLASS 1E 4.16KV SWITCHGEAR PCB SW01C-C2 (UAT) FAILS TO OPEN		
		PFLOOP-LOCA	2.40E-02	CONDITIONAL LOSS OF OFFSITE POWER UPON LOCA INITIATORS		
80	1.93E-09	%MLOCA	4.85E-04	MEDIUM LOSS OF COOLANT ACCIDENT	0.1	36.4
		DGDGR-C-DGC	2.49E-02	EMERGENCY DIESEL GENERATOR C FAILS TO RUN		
		PFHBO2B-SW01D-G2	6.66E-03	CLASS 1E 4.16KV SWITCHGEAR PCB SW01D-G2 (UAT) FAILS TO OPEN		
		PFLOOP-LOCA	2.40E-02	CONDITIONAL LOSS OF OFFSITE POWER UPON LOCA INITIATORS		

Table 19.1-19 (33 of 40)

Rank	Cutset Probability	Cutsets			Contribution to CDF (%)	
		Cutset	Basic Event Probability	Cutset Description	Cutset	Cumulative
81	1.91E-09	%LOFW	6.55E-02	LOSS OF MAIN FEEDWATER	0.1	36.6
		AFOPH-S-ALT-LT	9.10E-04	OPERATOR FAIL TO ALIGN FOR SUPPLYING AN ALTERNATE SOURCE		
		RCOPH-S-SDSL-LD	5.79E-02	FAILURE OF POSRVS LATE PHASE OPEN WITH LOW DEPENDENCY		
		WMVVT-S-V1700	5.53E-04	DEMI. WATER TRANSFER PUMPS DISCHARGE MANUAL VALVE TRANSFER CLOSE		
82	1.80E-09	%PLOCCW	4.36E-03	PARTIAL LOSS OF COMPONANT COOLING WATER	0.1	36.7
		DGDGR-B-DGB	2.49E-02	EMERGENCY DIESEL GENERATOR B FAILS TO RUN		
		PFLOOP-TRANS	2.40E-03	CONDITIONAL LOSS OF OFFSITE POWER UPON TRANSIENTS		
		WOMPM2B-PP02B	6.90E-03	ESSENTIAL CHILLED WATER PUMP 2B UNAVAILABLE DUE TO T&M		
83	1.74E-09	%LLOCA-HL2	5.05E-07	LARGE LOCA IN HOT LEG 2	0.1	36.8
		SIMPM2A-PP02C	3.45E-03	SAFETY INJECTION PUMP 2C UNAVAILABLE DUE TO T&M		

Table 19.1-19 (34 of 40)

Rank	Cutset Probability	Cutsets			Contribution to CDF (%)	
		Cutset	Basic Event Probability	Cutset Description	Cutset	Cumulative
84	1.74E-09	%LOOP-WE	3.71E-03	WEATHER-RELATED LOSS OF OFFSITE POWER	0.1	37.0
		DATGR-S-AACTG	1.56E-01	AAC GAS TURBINE GENERATOR FAILS TO RUN		
		RAC-16H-WE	1.59E-01	NON-RECOVERY PROBABILITY OF OFFSITE POWER WITHIN 16HR (WEATHER RELATED)		
		VDHVWO8-HV12/13ABCD	1.89E-05	CCF OF ALL EDG ROOM CUBICLE COOLERS FAIL TO START		
85	1.74E-09	%PLOCCW	4.36E-03	PARTIAL LOSS OF COMPONANT COOLING WATER	0.1	37.1
		DGDGR-B-DGB	2.49E-02	EMERGENCY DIESEL GENERATOR B FAILS TO RUN		
		PFHBO2B-SW01D-G2	6.66E-03	CLASS 1E 4.16KV SWITCHGEAR PCB SW01D-G2 (UAT) FAILS TO OPEN		
		PFLOOP-TRANS	2.40E-03	CONDITIONAL LOSS OF OFFSITE POWER UPON TRANSIENTS		

Table 19.1-19 (35 of 40)

Rank	Cutset Probability	Cutsets			Contribution to CDF (%)	
		Cutset	Basic Event Probability	Cutset Description	Cutset	Cumulative
86	1.74E-09	%PLOCCW	4.36E-03	PARTIAL LOSS OF COMPONANT COOLING WATER	0.1	37.2
		DGDGR-D-DGD	2.49E-02	EMERGENCY DIESEL GENERATOR D FAILS TO RUN		
		PFHBO1B-SW01B-H2	6.66E-03	CLASS 1E 4.16KV SWITCHGEAR PCB SW01B-H2 (UAT) FAILS TO OPEN		
		PFLOOP-TRANS	2.40E-03	CONDITIONAL LOSS OF OFFSITE POWER UPON TRANSIENTS		
87	1.72E-09	%PLOESW	2.52E-03	PARTIAL LOSS OF ESSENTIAL SERVICE WATER	0.1	37.4
		DGDGM-B-DGB	1.44E-02	EMERGENCY DIESEL GENERATOR B UNAVAILABLE DUE TO T&M		
		PFLOOP-TRANS	2.40E-03	CONDITIONAL LOSS OF OFFSITE POWER UPON TRANSIENTS		
		WOCHM2B-CH02B	1.98E-02	ESSENTIAL CHILLED WATER CHILLER 2B UNAVAILABLE DUE TO T&M		

Table 19.1-19 (36 of 40)

Rank	Cutset Probability	Cutsets			Contribution to CDF (%)	
		Cutset	Basic Event Probability	Cutset Description	Cutset	Cumulative
88	1.70E-09	%MLOCA	4.85E-04	MEDIUM LOSS OF COOLANT ACCIDENT	0.1	37.5
		SIMPWQ4-CSP1A/B/SCP1A/B	3.50E-06	CCF OF CONTAINMENT SPRAY PUMPS AND SHUTDOWN COOLING PUMPS FAIL TO START		
89	1.68E-09	%TLOESW	2.34E-04	TOTAL LOSS OF ESSENTIAL SERVICE WATER	0.1	37.6
		CVDPS-S-PP03	1.79E-03	AUXILIARY CHARGING PUMP (PP03) FAIL TO START		
		SEAL-AFSUC	4.00E-03	SEAL FAILURE PROBABILITY (SECONDARY HEAT REMOVAL SUCCESS)		
90	1.68E-09	%TLOCCW	2.34E-04	TOTAL LOSS OF COMPONANT COOLING WATER	0.1	37.8
		CVDPS-S-PP03	1.79E-03	AUXILIARY CHARGING PUMP (PP03) FAIL TO START		
		SEAL-AFSUC	4.00E-03	SEAL FAILURE PROBABILITY (SECONDARY HEAT REMOVAL SUCCESS)		

Table 19.1-19 (37 of 40)

Rank	Cutset Probability	Cutsets			Contribution to CDF (%)	
		Cutset	Basic Event Probability	Cutset Description	Cutset	Cumulative
91	1.65E-09	%LSSB-D	7.32E-03	LARGE SECONDARY SIDE BREAK (MSIV DOWNDSTREAM)	0.1	37.9
		MSEVXQ3-011/12/13	8.33E-06	CCF OF MAIN STEAM ISOLATION VALVES 011, 012 AND 013 FAIL TO CLOSE		
		PI-SGTR	2.70E-02	PRESSURE INDUECD SGTR PROBABILITY		
92	1.65E-09	%LSSB-D	7.32E-03	LARGE SECONDARY SIDE BREAK (MSIV DOWNDSTREAM)	0.1	38.0
		MSEVXQ3-012/13/14	8.33E-06	CCF OF MAIN STEAM ISOLATION VALVES 012, 013 AND 014 FAIL TO CLOSE		
		PI-SGTR	2.70E-02	PRESSURE INDUECD SGTR PROBABILITY		
93	1.65E-09	%LSSB-D	7.32E-03	LARGE SECONDARY SIDE BREAK (MSIV DOWNDSTREAM)	0.1	38.1
		MSEVXQ3-011/13/14	8.33E-06	CCF OF MAIN STEAM ISOLATION VALVES 011, 013 AND 014 FAIL TO CLOSE		
		PI-SGTR	2.70E-02	PRESSURE INDUECD SGTR PROBABILITY		

Table 19.1-19 (38 of 40)

Rank	Cutset Probability	Cutsets			Contribution to CDF (%)	
		Cutset	Basic Event Probability	Cutset Description	Cutset	Cumulative
94	1.65E-09	%LSSB-D	7.32E-03	LARGE SECONDARY SIDE BREAK (MSIV DOWNDSTREAM)	0.1	38.3
		MSEVXQ3-011/12/14	8.33E-06	CCF OF MAIN STEAM ISOLATION VALVES 011, 012 AND 014 FAIL TO CLOSE		
		PI-SGTR	2.70E-02	PRESSURE INDUECD SGTR PROBABILITY		
95	1.65E-09	%LOOP-WE	3.71E-03	WEATHER-RELATED LOSS OF OFFSITE POWER	0.1	38.4
		DATGM-S-AACTG	5.00E-02	AAC GAS TURBINE GENERATOR UNAVAILABLE DUE TO T&M		
		RAC-16H-WE	1.59E-01	NON-RECOVERY PROBABILITY OF OFFSITE POWER WITHIN 16HR (WEATHER RELATED)		
		SXFLP-S-FT0123AB	5.58E-05	ESSENTIAL SERVICE WATER DEBRIS FILTERS PLUGGED		

Table 19.1-19 (39 of 40)

Rank	Cutset Probability	Cutsets			Contribution to CDF (%)	
		Cutset	Basic Event Probability	Cutset Description	Cutset	Cumulative
96	1.62E-09	%LOCV	5.57E-02	LOSS OF CONDENCER VACCUM	0.1	38.5
		AFOPH-S-ALT-LT	9.10E-04	OPERATOR FAIL TO ALIGN FOR SUPPLYING AN ALTERNATE SOURCE		
		RCOPH-S-SDSL-LD	5.79E-02	FAILURE OF POSRVS LATE PHASE OPEN WITH LOW DEPENDENCY		
		WMVVT-S-V1700	5.53E-04	DEMI. WATER TRANSFER PUMPS DISCHARGE MANUAL VALVE TRANSFER CLOSE		
97	1.59E-09	%TLOESW	2.34E-04	TOTAL LOSS OF ESSENTIAL SERVICE WATER	0.1	38.6
		AFTPR1A-TDP01A	3.52E-02	AF TURBINE-DRIVEN PUMP 1A FAILS TO RUN		
		AFTPR1B-TDP01B	3.52E-02	AF TURBINE-DRIVEN PUMP 1B FAILS TO RUN		
		FWOPH-S-ERY	5.50E-03	OPERATOR FAILS TO ALIGN STARTUP FEEDWATER PUMP PP07 (EARLY PHASE)		

Table 19.1-19 (40 of 40)

Rank	Cutset Probability	Cutsets			Contribution to CDF (%)	
		Cutset	Basic Event Probability	Cutset Description	Cutset	Cumulative
98	1.59E-09	%TLOCCW	2.34E-04	TOTAL LOSS OF COMPONANT COOLING WATER	0.1	38.8
		AFTPR1A-TDP01A	3.52E-02	AF TURBINE-DRIVEN PUMP 1A FAILS TO RUN		
		AFTPR1B-TDP01B	3.52E-02	AF TURBINE-DRIVEN PUMP 1B FAILS TO RUN		
		FWOPH-S-ERY	5.50E-03	OPERATOR FAILS TO ALIGN STARTUP FEEDWATER PUMP PP07 (EARLY PHASE)		
99	1.54E-09	%SLOCA	1.99E-03	SMALL LOSS OF COOLANT ACCIDENT	0.1	38.9
		PFLOOP-LOCA	2.40E-02	CONDITIONAL LOSS OF OFFSITE POWER UPON LOCA INITIATORS		
		VDHVZO8-HV12/13ABCD	3.23E-05	CCF OF ALL EDG ROOM CUBICLE COOLERS FAIL TO RUN FOR 1HR		
100	1.50E-09	%SLOCA	1.99E-03	SMALL LOSS OF COOLANT ACCIDENT	0.1	39.0
		PFLOOP-LOCA	2.40E-02	CONDITIONAL LOSS OF OFFSITE POWER UPON LOCA INITIATORS		
		VDHVKO8-HV12/13ABCD	3.15E-05	CCF OF ALL EDG ROOM CUBICLE COOLERS FAIL TO RUN		

Table 19.1-20 (1 of 9)

Level 1 Internal Events Key Components by RAW (CDF)

Rank	Equipment ID	Equipment Description	RAW
1	DC-MC01A/1B	CLASS 1E 125V DC BUS 1A/1B	34.1
2	CC-TK01B	COMPONENT COOLING WATER SURGE TANK 1B	19.7
3	DC-BT01B	CLASS 1E 125V DC BATTERY 1B	19.7
4	DC-BT01A	CLASS 1E 125V DC BATTERY 1A	17.6
5	WO-TK01B/2B	ESSENTIAL CHILLED WATER COMPRESSION TANK 1B/2B	17.3
6	SX-MV073/74	ULTIMATE HEAT SINK COOLING TOWER 1B DISCHARGE LINE CONTROL AND BYPASS VALVE	16.0
7	IP-IN01B	CLASS 1E 120V AC INVERTER 1B	15.7
8	IP-IN01A	CLASS 1E 120V AC INVERTER 1A	14.5
9	CC-HE01B/2B	COMPONENT COOLING WATER HEAT EXCHANGER	13.8
10	CC-HE01A/2A	COMPONENT COOLING WATER HEAT EXCHANGER	11.0
11	VO-TE085A	AUXILIARY FEEDWATER MOTOR-DRIVEN PUMP 2A ROOM TEMPERATURE TRANSMITTER	10.3
12	CC-TK01A	COMPONENT COOLING WATER SURGE TANK 1A	8.5
13	WM-VV1700	DEMINERALIZED WATER PUMPS DISCHARGE MANUAL VALVE	8.2
14	NB-SW01M	NON-1E 4.16KV SWITCHGEAR	8.2
15	NG-LC10M/TR10M	NON-1E 480V LOAD CENTER AND TRANSFORMER	8.2

Table 19.1-20 (2 of 9)

Rank	Equipment ID	Equipment Description	RAW
16	AX-CV1600	DEMINERALIZE WATER LINE CHECK VALVE	8.2
17	NH-MC03M	NON-1E 480V MOTOR CONTROL CENTER (MCC)	8.2
18	WM-VV1201A	DEMINERALIZED WATER PUMP SUCTION ISOLATION MANUAL VALVE	8.1
19	WM-VV1205	DEMINERALIZED WATER PUMPS DISCHARGE MANUAL VALVE	8.1
20	WM-VV1220	DEMINERALIZED WATER PUMPS DISCHARGE MANUAL VALVE	8.0
21	DC-MC01C	CLASS 1E 125V DC BUS 1C	8.0
22	PG-LC01A/TR01A	CLASS 1E 480V LOAD CENTER AND TRANSFORMER	6.6
23	PF-SW01A/C	CLASS 1E 4.16KV SWITCHGEAR	6.6
24	WO-TK01A/2A	ESSENTIAL CHILLED WATER COMPRESSION TANK 1A/2A	6.2
25	PG-LC01C/TR01C	CLASS 1E 480V LOAD CENTER AND TRANSFORMER	6.2
26	DG-EDG B	EMERGENCY DIESEL GENERATOR B	5.6
27	PF-SW01B-H2	CLASS 1E 4.16KV SWITCHGEAR PCB (UAT)	5.4
28	DC-BT01D	CLASS 1E 125V DC BATTERY 1D	5.2
29	PH-MC01A	CLASS 1E 480V MOTOR CONTROL CENTER (MCC)	5.0
30	IP-IN01D	CLASS 1E 120V AC INVERTER 1D	4.9

Table 19.1-20 (3 of 9)

Rank	Equipment ID	Equipment Description	RAW
31	MS-AOV110/ AT-AOV009	AF TURBINE-DRIVEN PUMP 1A TURBINE STEAM SUPPLY AND ISOLATION VALVE	4.8
32	DC-BC01C	CLASS 1E 125V DC BATTERY CHARGER 1C	4.6
33	DC-BT01C	CLASS 1E 125V DC BATTERY 1C	4.3
34	VD-HV12B/13B	EDG ROOM EMERGENCY CUBICLE COOLER - QUADRANT B	4.2
35	AF-MV045	AF TURBINE-DRIVEN PUMP 1A DISCHARGE ISOLATION VALVE	4.0
36	IP-IN01C	CLASS 1E 120V AC INVERTER 1C	4.0
37	PG-LC01D/TR01D	CLASS 1E 480V LOAD CENTER AND TRANSFORMER	4.0
38	PF-SW01D	CLASS 1E 4.16KV SWITCHGEAR	4.0
39	CC-MV192	EDG 1B CCW INLET VALVE	3.9
40	AF-MDP02A	AF MOTOR-DRIVEN PUMP 2A	3.9
41	VO-HV33A	AUXILIARY FEEDWATER MOTOR-DRIVEN PUMP 2A ROOM CUBICLE COOLER	3.8
42	AF-CV1004A	AF TURBINE-DRIVEN PUMP 1A DISCHARGE CHECK VALVE	3.7
43	AF-CV1008A	AF TURBINE-DRIVEN PUMP 1A DISCHARGE CHECK VALVE	3.7
44	AF-CV1014A	AF TURBINE-DRIVEN PUMP 1A MINI-FLOW LINE CHECK VALVE	3.7

Table 19.1-20 (4 of 9)

Rank	Equipment ID	Equipment Description	RAW
45	AT-CV1020A	AF TURBINE-DRIVEN PUMP 1A TURBINE STEAM SUPPLY CHECK VALVE	3.7
46	DG-EDG A	EMERGENCY DIESEL GENERATOR A	3.7
47	PF-SW01B	CLASS 1E 4.16KV SWITCHGEAR	3.6
48	NB-SW03N-F2	NON-1E 4.16KV AAC SWITCHGEAR PCB FOR SW01C	3.6
49	PF-SW01C-E2	CLASS 1E 4.16KV SWITCHGEAR PCB (AAC)	3.6
50	PF-SW01A-H2	CLASS 1E 4.16KV SWITCHGEAR PCB (UAT)	3.5
51	DG-EDG D	EMERGENCY DIESEL GENERATOR D	3.4
52	CV-MV509	IRWST RETURN LINE ISOLATION VALVE	3.4
53	CV-VV126/649	IRWST REFILL LINE MANUAL ISOLATION VALVE	3.4
54	CV-MV553	IRWST RETURN LINE ISOLATION VALVE	3.4
55	IA-TK01/02	INSTRUMENT AIR RECEIVER TK01/02	3.4
56	CC-MV098	CS HEAT EXCHANGER 1B CCW INLET VALVE	3.4
57	CS-MV004	CONTAINMENT SPRAY HEAT EXCHANGER 1B DISCHARGE ISOLATION VALVE	3.4
58	DC-MC01M	NON-CLASS 1E 125V DC BUS 1M	3.4
59	CV-CV189	IRWST RETURN LINE CHECK VALVE	3.4
60	PF-SW01D-G2	CLASS 1E 4.16KV SWITCHGEAR PCB (UAT)	3.3

Table 19.1-20 (5 of 9)

Rank	Equipment ID	Equipment Description	RAW
61	PH-MC01D	CLASS 1E 480V MOTOR CONTROL CENTER (MCC)	3.3
62	PG-LC01B/TR01B	CLASS 1E 480V LOAD CENTER AND TRANSFORMER	3.3
63	CC-MV097	CS HEAT EXCHANGER 1A CCW INLET VALVE	3.2
64	CS-MV003	CONTAINMENT SPRAY HEAT EXCHANGER 1A DISCHARGE ISOLATION VALVE	3.2
65	VD-HV12A/13A	EDG ROOM EMERGENCY CUBICLE COOLER - QUADRANT A	3.1
66	VD-HV12D/13D	EDG ROOM EMERGENCY CUBICLE COOLER - QUADRANT D	3.0
67	SX-MV071/72	ULTIMATE HEAT SINK COOLING TOWER 1B DISCHARGE LINE CONTROL AND BYPASS VALVE	3.0
68	CC-MV182	EDG 1D CCW INLET VALVE	3.0
69	PH-MC01C	CLASS 1E 480V MOTOR CONTROL CENTER (MCC)	3.0
70	AF-SOV0037	AF TURBINE-DRIVEN PUMP 1A DISCHARGE MODULATION VALVE	3.0
71	DC-MC01D	CLASS 1E 125V DC BUS 1D	2.9
72	AF-MV043	AF MOTOR-DRIVEN PUMP 2A DISCHARGE ISOLATION VALVE	2.9
73	CS-HE01B	CONTAINMENT SPRAY HEAT EXCHANGER 1B	2.9
74	CS-HE01A	CONTAINMENT SPRAY HEAT EXCHANGER 1A	2.8

Table 19.1-20 (6 of 9)

Rank	Equipment ID	Equipment Description	RAW
75	CC-MV191	EDG 1A CCW INLET VALVE	2.8
76	AF-CV1003A	AF MOTOR-DRIVEN PUMP 2A DISCHARGE CHECK VALVE	2.8
77	AF-CV1007A	AF MOTOR-DRIVEN PUMP 2A DISCHARGE CHECK VALVE	2.8
78	AF-CV1012A	AF MOTOR-DRIVEN PUMP 2A MINI-FLOW LINE CHECK VALVE	2.8
79	FW-MP07	STARTUP FEEDWATER PUMP	2.8
80	CS-MV002	CONTAINMENT SPRAY HEAT EXCHANGER 1B DISCHARGE VALVE	2.7
81	FW-MV093	STARTUP FEEDWATER PUMP DISCHARGE VALVE	2.7
82	WO-CH02B	ESSENTIAL CHILLER 2B	2.7
83	PF-SW01C-C2	CLASS 1E 4.16KV SWITCHGEAR PCB (UAT)	2.7
84	WO-CH01B	ESSENTIAL CHILLER 1B	2.7
85	CS-MV001	CONTAINMENT SPRAY HEAT EXCHANGER 1A DISCHARGE VALVE	2.7
86	AF-TP01A	AF TURBINE-DRIVEN PUMP 1A	2.7
87	NP-SW02N	NON-1E 13.8KV SWITCHGEAR	2.6
88	CS-CV1007	CONTAINMENT SPRAY CHECK VALVE TO CS HEADER 1	2.6

Table 19.1-20 (7 of 9)

Rank	Equipment ID	Equipment Description	RAW
89	NB-SW02N	NON-1E 4.16KV SWITCHGEAR	2.6
90	CS-CV1008	CONTAINMENT SPRAY CHECK VALVE TO CS HEADER 2	2.6
91	NG-LC05N/TR05N	NON-1E 480V LOAD CENTER AND TRANSFORMER	2.6
92	CV-BAST	BORIC ACID STORAGE TANK	2.6
93	RC-POSRV V200/201/202/203	PILOT OPERATED SAFETY AND RELIEF VALVE	2.6
94	DC-BC01D	CLASS 1E 125V DC BATTERY CHARGER 1D	2.6
95	WO-PP02B	ESSENTIAL CHILLED WATER PUMP 2B	2.5
96	DG-EDG C	EMERGENCY DIESEL GENERATOR C	2.5
97	CV-DP03	AUXILIARY CHARGING PUMP	2.5
98	CV-CV334	AUXILIARY CHARGING PUMP DISCHARGE CHECK VALVE	2.4
99	PG-LC02	CLASS 1E 480V LOAD CENTER	2.4
100	FW-CV1026	STARTUP FEEDWATER PUMP DISCHARGE CHECK VALVE	2.4
101	FW-ZV058	STARTUP FEEDWATER PUMP DISCHARGE STOP CHECK VALVE	2.4
102	CD-TK01/02	DEAERATOR STORAGE TANK A/B	2.4

Table 19.1-20 (8 of 9)

Rank	Equipment ID	Equipment Description	RAW
103	IA-ADP1	INSTRUMENT AIR DRYER PACKAGE 1	2.4
104	DC-MC01N	NON-1E 125V DC BUS 1N	2.4
105	NH-MC20N	NON-1E 480V MOTOR CONTROL CENTER (MCC)	2.4
106	IA-FT03A/4A	INSTRUMENT AIR PREFILTER AND AFTER FILTER	2.4
107	VO-HV31B	ESSENTIAL CHILLED WATER PUMP 1B ROOM CUBICLE COOLER	2.4
108	PH-MC04D	CLASS 1E 480V MOTOR CONTROL CENTER (MCC)	2.4
109	DO-TK01D	DIESEL FUEL OIL STORAGE TANK D	2.4
110	PH-MC01B	CLASS 1E 480V MOTOR CONTROL CENTER (MCC)	2.4
111	SX-PP02B	ESSENTIAL SERVICE WATER PUMP 2B	2.3
112	VO-HV32B	ESSENTIAL CHILLED WATER PUMP 2B ROOM CUBICLE COOLER	2.3
113	AF-TP01B	AF TURBINE-DRIVEN PUMP 1B	2.3
114	IA-AOV1027	AIR PRESSURE REDUCING MODULATION VALVE	2.2
115	CC-MP02B	COMPONENT COOLING WATER MOTOR-DRIVEN PUMP 2B	2.2
116	CS-PP01B	SHUTDOWN COOLING PUMP 1B	2.2
117	SI-PP02C (SIP)	SAFETY INJECTION PUMP 2C	2.2
118	WO-PP01B	ESSENTIAL CHILLED WATER PUMP 1B	2.2

Table 19.1-20 (9 of 9)

Rank	Equipment ID	Equipment Description	RAW
119	CC-MV132	ESSENTIAL CHILLER CONDENSER 2B OUTLET VALVE	2.1
120	AF-MDP02B	AF MOTOR-DRIVEN PUMP 2B	2.1
121	VD-HV12C/13C	EDG ROOM EMERGENCY CUBICLE COOLER - QUADRANT C	2.1
122	VG-AH02B	ESSENTIAL SERVICE WATER PUMP 2B ROOM SUPPLY FAN	2.1
123	SX-AH02B	ESSENTIAL SERVICE WATER COOLING TOWER FAN	2.1
124	CC-MV181	EMERGENCY DIESEL GENERATOR A INLET VALVE	2.0
125	MS-AOV109	AF TURBINE-DRIVEN PUMP 1B TURBINE STEAM SUPPLY VALVE	2.0
126	SX-PP01B	ESSENTIAL SERVICE WATER PUMP 1B	2.0
127	VO-HV33B	AF MOTOR-DRIVEN PUMP 2B ROOM CUBICLE COOLER	2.0

Table 19.1-21 (1 of 2)

Level 1 Internal Events Key Components by FV (CDF)

Rank	Equipment ID	Equipment Description	FV
1	DG-EDG B	EMERGENCY DIESEL GENERATOR B	16.3%
2	DG-EDG D	EMERGENCY DIESEL GENERATOR D	10.2%
3	AF-MV045	AF TURBINE-DRIVEN PUMP 1A DISCHARGE ISOLATION VALVE	8.9%
4	AF-MV046	AF TURBINE-DRIVEN PUMP 1B DISCHARGE ISOLATION VALVE	8.5%
5	AF-TP01A	AF TURBINE-DRIVEN PUMP 1A	8.5%
6	CV-DP03	AUXILIARY CHARGING PUMP	7.4%
7	DA-AACTG	ALTERNATE AC TURBINE GENERATOR	7.0%
8	DG-EDG A	EMERGENCY DIESEL GENERATOR A	6.8%
9	AF-TP01B	AF TURBINE-DRIVEN PUMP 1B	6.3%
10	WO-CH02B	ESSENTIAL CHILLER 2B	5.8%
11	DG-EDG C	EMERGENCY DIESEL GENERATOR C	5.6%
12	DC-BT01B	CLASS 1E 125V DC BATTERY 1B	5.4%
13	DC-BT01A	CLASS 1E 125V DC BATTERY 1A	4.8%
14	IP-IN01B	CLASS 1E 120V AC INVERTER 1B	4.0%
15	IP-IN01A	CLASS 1E 120V AC INVERTER 1A	3.7%
16	WO-CH02A	ESSENTIAL CHILLER 2A	3.1%
17	PF-SW01B-H2	CLASS 1E 4.16KV SWITCHGEAR PCB (UAT)	2.9%
18	SX-PP02B	ESSENTIAL SERVICE WATER PUMP 2B	1.9%
19	NB-SW03N-F2	NON-1E 4.16KV AAC SWITCHGEAR PCB FOR SW01C	1.7%
20	PF-SW01C-E2	CLASS 1E 4.16KV SWITCHGEAR PCB (AAC)	1.7%
21	PF-SW01A-H2	CLASS 1E 4.16KV SWITCHGEAR PCB (UAT)	1.7%
22	MS-AOV110	AF TURBINE-DRIVEN PUMP 1A TURBINE STEAM SUPPLY VALVE	1.6%

Table 19.1-21 (2 of 2)

Rank	Equipment ID	Equipment Description	FV
23	PF-SW01D-G2	CLASS 1E 4.16KV SWITCHGEAR PCB (UAT)	1.6%
24	VD-HV12B/13B	EDG ROOM EMERGENCY CUBICLE COOLER - QUADRANT B	1.5%
25	FW-MP07	STARTUP FEEDWATER PUMP	1.5%
26	WO-CH01B	ESSENTIAL CHILLER 1B	1.4%
27	AF-MDP02A	AF MOTOR-DRIVEN PUMP 2A	1.4%
28	WO-CH01A	ESSENTIAL CHILLER 1A	1.3%
29	WO-PP02B	ESSENTIAL CHILLED WATER PUMP 2B	1.2%
30	DC-BT01D	CLASS 1E 125V DC BATTERY 1D	1.2%
31	PF-SW01C-C2	CLASS 1E 4.16KV SWITCHGEAR PCB (UAT)	1.2%
32	VO-HV33A	MAFP ROOM A/B CUBICLE COOLER HV33A	1.1%
33	IP-IN01D	CLASS 1E 120V AC INVERTER 1D	1.1%
34	VD-HV12D/13D	EDG ROOM EMERGENCY CUBICLE COOLER - QUADRANT D	1.0%
35	VD-HV12A/13A	EDG ROOM EMERGENCY CUBICLE COOLER - QUADRANT A	1.0%
36	DC-BT01C	CLASS 1E 125V DC BATTERY 1C	0.9%
37	CS-PP01B	SHUTDOWN COOLING PUMP 1B	0.9%
38	SX-PP02A	ESSENTIAL SERVICE WATER PUMP 2A	0.8%
39	IP-IN01C	CLASS 1E 120V AC INVERTER 1C	0.8%
40	CS-PP01A	SHUTDOWN COOLING PUMP 1A	0.7%
41	CC-MP02B	COMPONENT COOLING WATER MOTOR-DRIVEN PUMP 2B	0.7%
42	WO-PP02A	ESSENTIAL CHILLED WATER PUMP 2A	0.6%
43	VD-HV12C/13C	EDG ROOM EMERGENCY CUBICLE COOLER - QUADRANT C	0.5%
44	SI-PP02C (SIP)	SAFETY INJECTION PUMP 2C	0.5%
45	AF-MDP02B	AF MOTOR-DRIVEN PUMP 2B	0.5%

Table 19.1-22 (1 of 5)

Level 1 Internal Events Key CCF Events by RAW (CDF)

Rank	Common Cause Events	Component CCF ID Description	RAW
1	RP-TCB-A1/A2/B1/B2/C1/C2/D1/D2	TRIP CIRCUIT BREAKER A1/A2/B1/B2/C1/C2/D1/D2	132022
2	DC-BT01A/1B/1C/1D	CLASS 1E 125V DC BATTERY 1A/1B/1C/1D	5734
3	SI-CV123/143	SAFETY INJECTION PUMP 2A/2B INJECTION LINE CHECK VALVE	3669
4	SI-CV217/227/237/247	SAFETY INJECTION LINE CHECK VALVE - DVI NOZZLE 1A/1B/2A/2B	3669
5	SI-CV541/543	SAFETY INJECTION PUMP 2A/2B DISCHARGE CHECK VALVE	3669
6	VG-AH01A/1B/2A/2B	ESSENTIAL SERVICE PUMP ROOM FAN 1A/1B/2A/2B	2071
7	SX-PP01A/1B/2A/2B	ESSENTIAL SERVICE WATER PUMP 1A/1B/2A/2B	2050
8	SX-AH01A/1B/2A/2B	ULTIMATE HEAT SINK COOLING TOWER FAN 1A/1B/2A/2B	2027
9	CC-MP01A/1B/2A/2B	COMPONENT COOLING WATER PUMP 1A/1B/2A/2B	2005
10	AF-MDP02A/2B	AF MOTOR-DRIVEN PUMP 2A/2B	1701
11	AF-TP01A/1B	AF TURBINE-DRIVEN PUMP 1A/1B	1701
12	AF-CV1003A/3B	AF MOTOR-DRIVEN PUMP 2A/2B DISCHARGE CHECK VALVE	1682
13	AF-CV1004A/4B	AF TURBINE-DRIVEN PUMP 1A/1B DISCHARGE CHECK VALVE	1682

Table 19.1-22 (2 of 5)

Rank	Common Cause Events	Component CCF ID Description	RAW
14	AF-CV1007A/7B	AF MOTOR-DRIVEN PUMP 2A/2B DISCHARGE CHECK VALVE	1682
15	AF-CV1008A/8B	AF TURBINE-DRIVEN PUMP 1A/1B DISCHARGE CHECK VALVE	1682
16	AF-CV1012A/2B	AF MOTOR-DRIVEN PUMP 2A/2B MINI-FLOW LINE CHECK VALVE	1645
17	AF-CV1014A/B	AF TURBINE-DRIVEN PUMP 1A/1B MINI-FLOW LINE CHECK VALVE	1645
18	PF-SW01A-H2/1B-H2/1C-C2/1D-G2	CLASS 1E 4.16KV SWITCH GEAR 1A/1B/1C/1D PCB (UAT)	1165
19	SX-FT01A/1B/2A/2B/3A/3B	ESSENTIAL SERVICE WATER DEBRIS FILTER 1A/1B/2A/2B/3A/3B	964
20	CC-CV1001/1002/1003/1004	COMPONENT COOLING WATER PUMPS DISCHARGE CHECK VALVE	746
21	SX-CV1001/1002/1003/1004	ESSENTIAL SERVICE WATER PUMPS DISCHARGE CHECK VALVE	746
22	SI-MV616/626/636/646	SAFETY INJECTION PUMPS DISCHARGE MOTOR-OPERATED VALVE	668
23	SI-PP02A/B/C/D	SAFETY INJECTION PUMP	667

Table 19.1-22 (3 of 5)

Rank	Common Cause Events	Component CCF ID Description	RAW
24	SI-CV113/133	SAFETY INJECTION PUMP 2C/2D INJECTION LINE CHECK VALVE	663
25	SI-CV404/405/434/446	SAFETY INJECTION PUMP 2A/2B/2C/2D DISCHARGE CHECK VALVE	663
26	SI-CV540/542	SAFETY INJECTION PUMP 2C/2D DISCHARGE CHECK VALVE	663
27	CC-MV143/144/145/146/147/148/149/150	COMPONENT COOLING WATER MOTOR-OPERATE VALVE FOR NON-SAFETY LOADS	607
28	CS-CV1001/1002	CONTAINMENT SPRAY PUMP 1A/1B DISCHARGE CHECK VALVE	458
29	SI-CV157/158/159/160	CONTAINMENT SPRAY AND SHUTDOWN COOLING PUMPS IRWST SUCTION LINE CHECK VALVE	458
30	SI-CV568/569	SHUTDOWN COOLING PUMP 1A/1B DISCHARGE CHECK VALVE	458
31	CS-MV003/004	CONTAINMENT SPRAY HEAT EXCHANGER 1A/1B DISCHARGE ISOLATION VALVE	377
32	CC-MV097/098	COMPONENT COOLING WATER MOTOR-OPERATE VALVE FOR CONTAINMENT SPRAY HEAT EXCHANGER 1A/1B	377
33	CS-PP01A/1B	CONTAINMENT SPRAY PUMP 1A/1B	376
34	SI-PP01A/1B	SHUTDOWN COOLING PUMP 1A/1B	376

Table 19.1-22 (4 of 5)

Rank	Common Cause Events	Component CCF ID Description	RAW
35	CS-CV1007/1008	CONTAINMENT SPRAY HEAT EXCHANGER 1A/B DISCHARGE CHECK VALVE	376
36	CC-MV182/191/192	COMPONENT COOLING WATER MOTRO-OPERATE VALVE FOR EMERGENCY DIESEL GENERATOR A/B/D	351
37	CC-MV181	COMPONENT COOLING WATER MOTRO-OPERATE VALVE FOR EMERGENCY DIESEL GENERATOR C	341
38	WO-CH01A/1B/2A/2B	ESSENTIAL CHILLER 1A/1B/2A/2B	333
39	VO-HV31A/31B/32A/33B	ESSENTIAL CHILLED PUMP 1A/1B/2A/2B ROOM CUBICLE COOLER	309
40	SI-CV100/101	SAFETY INJECTION PUMPS IRWST RETURN LINE CHECK VALVE	288
41	WO-PP01A/1B/2A/2B	ESSENTIAL CHILLED WATER PUMP 1A/1B/2A/2B	281
42	SI-CV424/426/448/451	SAFETY INJECTION PUMP 2A/2B/2C/2D MINI-FLOW LINE CHECK VALVE	281
43	DG-EDG A/B/C/D	EMERGENCY DIESEL GENERATOR A/B/C/D	268
44	VD-HV12A/12B/12C/12D/13A/13B/13C/13D	EMERGENCY DIESEL GENERATOR A/B/C/D ROOM EMERGENCY CUBICLE COOLER	267
45	DO-PP01A/1B/1C/1D/2A/2B/2C/2D	DIESEL FUEL OIL TRANSFER PUMP 1A/1B/1C/1D/2A/2B/2C/2D	262

Table 19.1-22 (5 of 5)

Rank	Common Cause Events	Component CCF ID Description	RAW
46	MS-MSSV	MAIN STEAM SAFETY VALVES (MSSVS)	257
47	DO-CV1005A/1005B/1005C/1005D/1007A/1007B/1007C/1007D	DIESEL FUEL OIL TRANSFER PUMP 1A/1B/1C/1D/2A/2B/2C/2D DISCHARGE CHECK VALVE	222
48	MS-EV011/012/013/014	MAIN STEAM ISOLATION VALVE (MSIV)	209
49	WO-CV1010A/1010B/1014A/1014B	ESSENTIAL CHILLED WATER PUMP 1A/1B/2A/2B DISCHARGE CHECK VALVE	144
50	VO-TE085A/086B	AUXILIARY FEEDWATER MOTOR-DRIVEN PUMP 2A/2B ROOM TEMPERATURE TRANSMITTER	40
51	DC-BC01A/1B/1C/1D/2A/2B/2C/2D	CLASS 1E 125V DC BATTERY CHARGER 1A/1B/1C/1D/2A/2B/2C/2D	30

(1) The cutoff threshold chosen for this table is based upon guidance presented in NEI 00-04 (Reference 51).

Table 19.1-23

Level 1 Internal Events Key CCF Events by FV (CDF)

RANK	Common Cause Events	Component CCF ID Description	FV
1	PF-SW01A-H2/1B-H2/1C-C2/1D-G2	CLASS 1E 4.16KV SWITCH GEAR 1A/1B/1C/1D PCB (UAT)	4.0%
2	DG-EDG A/B/C/D	EMERGENCY DIESEL GENERATOR A/B/C/D	2.7%
3	AF-TP01A/1B	AF TURBINE-DRIVEN PUMP 1A/1B	2.3%
4	VD-HV12A/12B/12C/12D/13A/13B/13C/13D	EMERGENCY DIESEL GENERATOR A/B/C/D ROOM EMERGENCY CUBICLE COOLER	2.3%
5	AF-MV043/44/45/46	AF MOTOR-DRIVEN PUMPS AND TURBINE DRIVEN PUMPS DISCHARGE ISOLATION VALVE	1.9%
6	WO-CH01A/1B/2A/2B	ESSENTIAL CHILLER 1A/1B/2A/2B	1.8%
7	MS-EV011/012/013/014	MAIN STEAM ISOLATION VALVE (MSIV)	1.6%
8	CS-MV003/004	CONTAINMENT SPRAY HEAT EXCHANGER 1A/1B DISCHARGE ISOLATION VALVE	1.1%
9	AF-MDP02A/2B	AF MOTOR-DRIVEN PUMP 2A/2B	0.9%
10	CC-MV097/098	COMPONENT COOLING WATER MOTOR-OPERATE VALVE FOR CONTAINMENT SPRAY HEAT EXCHANGER 1A/1B	0.7%
11	CC-MP01A/1B/2A/2B	COMPONENT COOLING WATER PUMP 1A/1B/2A/2B	0.5%

Table 19.1-24

Level 1 Internal Events Key Operator Actions by RAW (CDF)

Rank	Pre-initiator Events	Description	RAW
1	HR-RCSCD1-ISOL	OPERATORS FAIL TO TAKE ACTION FOR SG COOLDOWN & RCS DEPRESS PRIOR TO OVERFILL	11.53
2	RPOPU-S-LT1113ABCD	MISCALIBRATION OF LO SG1 LEVEL CHANNELS	11.50
3	AFOPH-S-ALT-LT	OPERATORS FAIL TO ALIGN AN ALTERNATE WATER SOURCE FOR PUMPS	9.71
4	RCOPH-S-SDSE-FW	OPERATORS FAIL TO OPEN SDS VALVES DURING EARLY PHASE	9.07
5	RPOPU-S-PT102ABCD	MISCALIBRATION OF LO PZR PRESSURE CHANNELS	8.61
6	AFOPV-S-AFAS-FW	OPERATORS FAIL TO RECOVER AFAS	5.87
7	CVOPH-S-IRWST	OPERATORS FAIL TO REFILL THE IRWST VIA CVCS	3.37
8	FWOPH-S-ERY	OPERATORS FAIL TO ALIGN STARTUP FEEDWATER PUMP PP07 (EARLY PHASE)	3.26
9	CDOPH-S-ALIGN	OPERATORS FAIL TO MANUALLY START CD PUMPS	3.20
10	CVOPH-S-RCPSEAL	OPERATORS FAIL TO RECOVER RCP SEAL COOLING USING AUXILIARY CHARGING PUMP	2.53
11	RPOPU-S-LT1123ABCD	MISCALIBRATION OF LO SG2 LEVEL CHANNELS	2.52

Table 19.1-25

Level 1 Internal Events Key Operator Actions by FV (CDF)

Rank	Operator Action	Description	FV
1	RCOPH-S-SDSE-FW	OPERATORS FAIL TO OPEN POSRVs DURING EARLY PHASE	12.8%
2	PFOPH-S-UATBKR-LOCAL	OPERATORS FAIL TO LOCALLY RECOVER PCB FOR 1E 4.16KV SW01A,B,C,D	4.2%
3	AFOPV-S-AFAS-FW	OPERATORS FAIL TO RECOVER AFAS	3.0%
4	FWOPH-S-ERY	OPERATORS FAIL TO ALIGN STARTUP FEEDWATER PUMP PP07 (EARLY PHASE)	2.5%
5	WOOPH-S-1AB2AB	OPERATORS FAIL TO START ECW PUMPS MANUALLY	1.9%
6	CVOPH-S-RCPSEAL	OPERATORS FAIL TO RECOVER RCP SEAL COOLING USING AUXILIARY CHARGING PUMP	1.7%
7	HR-RCSCD2	OPERATORS FAIL TO TAKE ACTION FOR SG COOLDOWN & RCS DEPRESS AFTER OVERFILL	1.5%
8	HR-RCSCD1-ISOL	OPERATORS FAIL TO TAKE ACTION FOR SG COOLDOWN & RCS DEPRESS PRIOR TO OVERFILL	1.5%
9	AFOPH-S-ALT-LT	OPERATORS FAIL TO ALIGN AN ALTERNATE WATER SOURCE FOR PUMPS	0.8%
10	RCOPH-S-SDSL	OPERATORS FAIL TO OPEN SDS VALVES DURING LATE PHASE	0.8%

Table 19.1-26 (1 of 2)

PDS Grouping Parameters

No	Parameter	Parameter Values	Code
1	Containment Bypass (CONBYPASS)	SGTR	SGTR
		ISLOCA	ISLOCA
		No Containment Bypass	NOBYPASS
2	Containment Isolation (CONISOL)	Not Isolated	NOT_ISOLATED
		Containment Failure Before Core Melt	RBCM
		Containment Isolated	ISOLATED
3	LOCA or Transient (LOCATRAN)	Large LOCA	LL
		Medium LOCA	ML
		Small LOCA	SL
		RCP Seal LOCA	RSF
		Transient	TRAN
4	RCS Pressure at Core Damage (PRCSCD)	Low Pressure	LOW
		Medium Pressure	MED
		High Pressure	HIGH
5	Cavity Condition (CAVCOND)	Cavity Flooded	WET
		External Reactor Vessel Cooling	ERVC
		Cavity Not Flooded	DRY
6	In-Vessel Injection (INVINJ)	In-Vessel Injection	ON
		In-Vessel Injection Available but Not Injected due to High Pressure	DEADHEADED
		Failed	FAILED
7	Release Point (RELPOINT)	Release to Containment	INC
		Release to IRWST only	IRWST

Table 19.1-26 (2 of 2)

No	Parameter	Parameter Values	Code
8	Containment Heat Removal (CHR)	Containment Heat Removal Available	YES
		CHR Recovered Late	RECOVERED
		CHR Not Available	NO
9	SG Feedwater Available (SG)	SGs are wet at the time of core damage	WET
		SGs are dry at the time of core damage	DRY

Table 19.1-27

Frequency of PDS and Dominant PDS ET Sequences

Rank	PDS No.	Frequency (/yr)	Fraction (%)	Cumulative (%)	Contribution	
					PDS ET Sequences	Fraction (%)
1	14	3.12E-07	29.2	29.2	SBO sequence 03 LOOP sequence 03	34.7 13.4
2	8	2.68 E-07	25.1	54.4	LOOP sequence 18 GTRN sequence 26	32.0 31.9
3	13	9.96 E-08	9.3	63.7	RVR sequence 01 LOOP sequence 08	30.7 16.4
4	98	7.55E-08	7.1	70.8	LOOP sequence 26 GTRN sequence 36	60.4 19.8
5	103	4.19E-08	3.9	74.7	ATWS sequence 73 ATWS sequence 60	93.1 6.9
6	2	3.77E-08	3.5	78.3	LSSB-D sequence 62 ATWS sequence 43	59.4 15.2
7	7	3.59E-08	3.4	81.6	MLOCA sequence 02 LLOCA sequence 02	99.7 0.3
8	9	3.51E-08	3.3	84.9	GRID-SBO sequence 03 LOOP sequence 19	39.3 29.5
9	1	3.37E-08	3.2	88.1	SGTR sequence 08 SGTR sequence 10	60.8 10.9
10	17	2.70E-08	2.5	90.6	SBO sequence 05 LOOP sequence 05	70.6 16.7
11	18	2.51E-08	2.4	93.0	SBO sequence 38 SBO sequence 105	67.3 24.0
12	106	1.13E-08	1.0	94.0	LOOP sequence 31 TLOCCW sequence 09 TLOESW sequence 09	35.3 30.9 30.9
13	100	8.63E-09	0.8	94.8	LOOP sequence 27 GRID-SBO sequence 11	71.5 28.4
14	35	5.95E-09	0.6	95.4	SBO sequence 57 SBO sequence 04	51.8 23.4

Table 19.1-28 (1 of 2)

Containment Failure Modes and Results

Failure Mode		Force	Median Pressure (psi)	Logarithmic Standard Deviation	Failure Size Category
Cylinder Wall	Hoop Direction	Membrane	204.79	0.20	Rupture
	Meridional Dire.	Membrane	257.66	0.19	Rupture
Dome	Hoop Dire. (above 45 deg.)	Membrane	221.90	0.23	Rupture
	Meridional Dire. (under 45deg.)	Membrane	237.31	0.18	Rupture
Basemat -Cylinder Wall Junction	Radial Dire.	Shear	214.80	0.29	Rupture
	Meridional Dire.	Moment	224.28	0.16	Rupture
Basemat	Screen out	-	-	-	Rupture
Equipment Hatch	Spherical Hatch Cover	Buckling	225.71	0.15	Rupture
	Welded Stud	Shear	251.69	0.11	Rupture
	Wall-Hatch Junction	Shear	459.10	0.29	Rupture
Personnel Air lock	Spherical Hatch Cover (Bulkhead plate)	Buckling	222.18	0.15	Rupture
	Welded Stud	Shear	253.03	0.11	Rupture
	Wall-Hatch Junction	Shear	443.92	0.24	Rupture
Fuel Transfer Tube	Blind Flange	-	223.08	0.15	Rupture
	Sleeve	-	281.03	0.15	Rupture

Table 19.1-28 (2 of 2)

Member		Force	Median Pressure (psi)	Logarithmic Standard Deviation	Failure Size Category
Fuel Transfer Tube	Welded Stud	Shear	420.55	0.15	Rupture
	Wall-Hatch Junction	Shear	752.43	0.24	Rupture
Liner Tearing of Equipment Hatch	-	-	188.0	0.15	Leak

Table 19.1-29 (1 of 3)

Summary of Source Term Evaluation

	MAAP CASE	STC-01	STC-02	STC-03	STC-04	STC-05	STC-06	STC-07
FP Releases at end of MAAP run	CsI (%)	45.7	0.0017	41.6	25.9	0.76	3.5	16.1
	TeO_2 (%)	16.8	0.00055	30.4	27.8	0.26	2.6	8.5
	CsOH (%)	17.3	0.0012	43.5	27.3	0.16	3.0	8.9
	Te_2 (%)	45.7	0.0017	41.6	25.9	0.76	3.5	16.1
LRF or not		LRF	NOT LRF	LRF	LRF	NOT LRF	LRF	LRF
FP Releases at end of MAAP run 4 hours after a general emergency declaration	CsI (%)	12.2	0.00094	28.4	19.6	0.75	3.4	0.54
	TeO_2 (%)	6.0	0.00044	17.1	18.4	0.26	2.5	0.44
	CsOH (%)	6.1	0.00092	28.3	19.6	0.16	3.0	0.45
	Te_2 (%)	-	-	-	-	0.01	0.018	0.0
LERF or not		LERF	NOT LERF	LERF	LERF	NOT LERF	LERF	NOT LERF

Table 19.1-29 (2 of 3)

	MAAP CASE	STC-08	STC-09	STC-10	STC-11	STC-12	STC-13	STC-14
FP Releases at end of MAAP run	CsI (%)	25.4	0.00088	0.0024	0.0088	No sequence is assigned to STC-12	15.6	0.27
	TeO_2 (%)	18.9	0.00059	0.0023	0.0016		6.7	0.067
	CsOH (%)	19.4	0.00063	0.0015	0.059		4.1	0.060
	Te_2 (%)	0.15	0.0	0.0	0.0017		-	0.026
LRF or not		LRF	NOT LRF	NOT LRF	NOT LRF		LRF	NOT LRF
FP Releases at end of MAAP run 4 hours after a general emergency declaration	CsI (%)	15.3	-	-	0.0024		5.5	0.0018
	TeO_2 (%)	13.8	-	-	0.0016		6.1	0.0017
	CsOH (%)	14.8	-	-	0.012		3.3	0.0012
	Te_2 (%)	-	-	-	-		-	-
LERF or not		LERF	NOT LERF	NOT LERF	NOT LERF		LERF	NOT LERF

Table 19.1-29 (3 of 3)

	MAAP CASE	STC-15	STC-16	STC-17	STC-18	STC-19	STC-20	STC-21
FP Releases at end of MAAP run	CsI (%)		1.5	0.014	0.67	1.2	2.8	5.0
	TeO_2 (%)		0.049	0.0022	0.066	0.013	0.098	0.077
	CsOH (%)		0.20	0.0036	0.094	0.19	0.034	0.049
	Te_2 (%)		0.00061	-	0.027	-	0.0060	-
LRF or not		No sequence is assigned to STC-15	NOT LRF	NOT LRF	NOT LRF	NOT LRF	LRF	LRF
FP Releases at end of MAAP run 4 hours after a general emergency declaration	CsI (%)		0.0021	0.0018	0.0018	0.0017	0.0021	0.0018
	TeO_2 (%)		0.0017	0.0020	0.0017	0.0019	0.0017	0.0020
	CsOH (%)		0.0012	0.0014	0.0012	0.0013	0.0012	0.0014
	Te_2 (%)		-	-	-	-	-	-
LERF or not			NOT LERF	NOT LERF	NOT LERF	NOT LERF	NOT LERF	NOT LERF

Table 19.1-30 (1 of 2)

Source Term Category Frequencies and Contributions to LRF

Source Term Category	Description	LRF, LERF or non-LRF	Frequency	% of total STC freq	% of total LRF
STC 1	SGTR w/o scrubbing	LRF / LERF	5.33E-08	4.1	48.5
STC 21	Late containment failure with a rupture failure size	LRF	2.96E-08	2.3	26.9
STC 8	CFBRB with a rupture failure size	LRF / LERF	1.30E-08	1.0	11.8
STC 7	CFBRB with a leak failure size	LRF	1.14E-08	0.9	10.4
STC 13	Early containment failure with a rupture failure size	LRF / LERF	1.79E-09	0.1	1.6
STC 6	Not isolation w/o CS	LRF / LERF	1.23E-09	0.1	1.1
STC 4	ISLOCA with scrubbing	LRF / LERF	6.49E-11	0.0	5.9E-02
STC 3	ISLOCA w/o scrubbing	LRF / LERF	5.31E-11	0.0	4.8E-02
STC 20	Late containment failure with a rupture failure size	LRF	1.19E-11	0.0	1.1E-02
STC 2	SGTR with scrubbing	Non-LRF	2.41E-08	1.8	
STC 5	Not isolation with CS	Non-LRF	2.46E-09	0.2	
STC 9	Intact containment w/o RPV breach	Non-LRF	3.67E-07	28	
STC 10	Intact containment with RPV breach	Non-LRF	7.64E-07	58.2	
STC 11	Basemat Melt-through	Non-LRF	1.33E-08	1.0	
STC 12	Early containment failure with a leak failure size	Non-LRF	0.00	0.0	
STC 14	Late containment failure with a leak failure size	Non-LRF	4.28E-11	0.0	

Table 19.1-30 (2 of 2)

Source Term Category	Description	LRF, LERF or non-LRF	Frequency	% of total STC freq	% of total LRF
STC 15	Late containment failure with a leak failure size	Non-LRF	0.00	0.0	
STC 16	Late containment failure with a leak failure size	Non-LRF	7.30E-12	0.0	
STC 17	Late containment failure with a leak failure size	Non-LRF	2.70E-08	2.1	
STC 18	Late containment failure with a rupture failure size	Non-LRF	4.19E-10	0.0	
STC 19	Late containment failure with a rupture failure size	Non-LRF	4.01E-09	0.3	
Total frequency of all STCs			1.31E-06		
Total frequency of the Large Release STCs			1.10E-07		

Table 19.1-31 (1 of 41)

Level 2 Internal Events Top 100 LRF Cutsets

Rank	Frequency (/yr)	Cutsets		Contribution to LRF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
1	4.43E-09	-MTC-ATWS	MODERATE COEFFICIENT	4.0	4.0
		%GTRN	GENERAL TRANSIENT		
		I-ATWS-RPMCF	FAILURE TO SCRAM DUE TO MECHANICAL FAILURES		
		PDS_2	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-2		
		PI-SGTR	PRESSURE INDUECD SGTR PROBABILITY UNDER LSSB, ATWS, FWLB		
2	4.25E-09	%LSSB-D	LARGE SECONDARY SIDE BREAK (MSIV DOWNDSTREAM)	3.8	7.8
		MSEVXQ2-012/13	CCF OF 2/4 MSIV 012,013		
		PDS_2	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-2		
		PI-SGTR	PRESSURE INDUECD SGTR PROBABILITY UNDER LSSB, ATWS, FWLB		

Table 19.1-31 (2 of 41)

Rank	Frequency (/yr)	Cutsets		Contribution to LRF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
3	4.25E-09	%LSSB-D	LARGE SECONDARY SIDE BREAK (MSIV DOWNDSTREAM)	3.8	11.6
		MSEVXQ2-011/14	CCF OF 2/4 MSIV 011,014		
		PDS_2	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-2		
		PI-SGTR	PRESSURE INDUECD SGTR PROBABILITY UNDER LSSB, ATWS, FWLB		
4	4.25E-09	%LSSB-D	LARGE SECONDARY SIDE BREAK (MSIV DOWNDSTREAM)	3.8	15.4
		MSEVXQ2-012/14	CCF OF 2/4 MSIV 012,014		
		PDS_2	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-2		
		PI-SGTR	PRESSURE INDUECD SGTR PROBABILITY UNDER LSSB, ATWS, FWLB		
5	4.25E-09	%LSSB-D	LARGE SECONDARY SIDE BREAK (MSIV DOWNDSTREAM)	3.8	19.2
		MSEVXQ2-011/13	CCF OF 2/4 MSIV 011,013		
		PDS_2	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-2		
		PI-SGTR	PRESSURE INDUECD SGTR PROBABILITY UNDER LSSB, ATWS, FWLB		

Table 19.1-31 (3 of 41)

Rank	Frequency (/yr)	Cutsets		Contribution to LRF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
6	2.20E-09	%LSSB-D MSEVXQ4-011/12/13/14 PDS_2 PI-SGTR	LARGE SECONDARY SIDE BREAK (MSIV DOWNSTREAM) CCF OF 4/4 MSIV 011,012,013,014 CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-2 PRESSURE INDUECD SGTR PROBABILITY UNDER LSSB, ATWS, FWLB	2.0	21.2
7	2.05E-09	%TLOESW CVDPR-S-PP03 PDS-FREQ-CFS PDS-FREQ-SDR-PO-3W PDS_14 SEAL-AFSUC	TOTAL LOSS OF ESSENTIAL SERVICE WATER FAILS TO RUN AUX. CHARGING PUMP PP03 PDS FREQUENCY ADJUSTMENT FOR CFS PDS FREQUENCY ADJUSTMENT FOR SDR (3WAY V/V & POSRV OPERATING) CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14 SEAL FAILURE PROBABILITY (SECONDARY HEAT REMOVAL SUCCESS)	1.9	23.1

Table 19.1-31 (4 of 41)

Rank	Frequency (/yr)	Cutsets		Contribution to LRF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
8	2.05E-09	%TLOCCW CVDPR-S-PP03 PDS-FREQ-CFS PDS-FREQ-SDR-PO-3W PDS_14 SEAL-AFSUC	TOTAL LOSS OF COMPONANT COOLING WATER FAILS TO RUN AUX. CHARGING PUMP PP03 PDS FREQUENCY ADJUSTMENT FOR CFS PDS FREQUENCY ADJUSTMENT FOR SDR (3WAY V/V & POSRV OPERATING) CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14 SEAL FAILURE PROBABILITY (SECONDARY HEAT REMOVAL SUCCESS)	1.9	25.0
9	1.65E-09	%LSSB-D MSEVXQ3-011/12/14 PDS_2 PI-SGTR	LARGE SECONDARY SIDE BREAK (MSIV DOWNSTREAM) CCF OF 3/4 MSIV 011,012,014 CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-2 PRESSURE INDUECD SGTR PROBABILITY UNDER LSSB, ATWS, FWLB	1.5	26.5
10	1.65E-09	%LSSB-D MSEVXQ3-011/13/14 PDS_2 PI-SGTR	LARGE SECONDARY SIDE BREAK (MSIV DOWNSTREAM) CCF OF 3/4 MSIV 011,013,014 CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-2 PRESSURE INDUECD SGTR PROBABILITY UNDER LSSB, ATWS, FWLB	1.5	28.0

Table 19.1-31 (5 of 41)

Rank	Frequency (/yr)	Cutsets		Contribution to LRF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
11	1.65E-09	%LSSB-D	LARGE SECONDARY SIDE BREAK (MSIV DOWNDSTREAM)	1.5	29.5
		MSEVXQ3-012/13/14	CCF OF 3/4 MSIV 012,013,014		
		PDS_2	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-2		
		PI-SGTR	PRESSURE INDUECD SGTR PROBABILITY UNDER LSSB, ATWS, FWLB		
12	1.65E-09	%LSSB-D	LARGE SECONDARY SIDE BREAK (MSIV DOWNDSTREAM)	1.5	31.0
		MSEVXQ3-011/12/13	CCF OF 3/4 MSIV 011,012,013		
		PDS_2	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-2		
		PI-SGTR	PRESSURE INDUECD SGTR PROBABILITY UNDER LSSB, ATWS, FWLB		
13	1.47E-09	%MLOCA	MEDIUM LOSS OF COOLANT ACCIDENT	1.3	32.3
		CSMVWD2-003/004	CCF(FTO) OF ISOL. MOV 003/004 IN CS TRS HX DISCH. PATH		
		PDS_7	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-7		

Table 19.1-31 (6 of 41)

Rank	Frequency (/yr)	Cutsets		Contribution to LRF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
14	1.11E-09	%SLOCA	SMALL LOSS OF COOLANT ACCIDENT	1.0	33.3
		ERVC	FAILURE OF ERVC SYSTEM		
		PDS-FREQ-CFS	PDS FREQUENCY ADJUSTMENT FOR CFS		
		PDS-FREQ-SDR-PO-3W	PDS FREQUENCY ADJUSTMENT FOR SDR (3WAY V/V & POSRV OPERATING)		
		PDS_14	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14		
		SISPP-S-IRWST	FAILURE OF IRWST SUMP DUE TO PLUGGING		
15	8.98E-10	%MLOCA	MEDIUM LOSS OF COOLANT ACCIDENT	0.8	34.1
		CCMVWD2-097/8	2/2 CCF OF CCW MOV 097/098 FOR CS HX. HE01A/B INLET		
		PDS_7	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-7		
16	8.90E-10	%LOOP-GR	GRID-RELATED LOOP	0.8	34.9
		PDS_93	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-93		
		PFHBWQ4-SW2OUAT	CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1B,1C,1D FAIL TO OPEN		
		PFOPH-S-UATBKR-LOCAL	OPERATOR FAILS TO RECOVER PCB FOR 1E 4.16KV SW01A,B,C,D AT LOCAL		

Table 19.1-31 (7 of 41)

Rank	Frequency (/yr)	Cutsets		Contribution to LRF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
17	8.45E-10	%GTRN	GENERAL TRANSIENT	0.8	35.7
		I-ATWS-RPMCF	FAILURE TO SCRAM DUE TO MECHANICAL FAILURES		
		MTC-ATWS	MODERATE COEFFICIENT		
		PDS_2	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-2		
		PI-SGTR	PRESSURE INDUECD SGTR PROBABILITY UNDER LSSB, ATWS, FWLB		
18	7.58E-10	%LOOP-SW	SWITCHYARD-CENTERED LOOP	0.7	36.4
		PDS_93	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-93		
		PFHBWQ4-SW2OUAT	CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1B,1C,1D FAIL TO OPEN		
		PFOPH-S-UATBKR-LOCAL	OPERATOR FAILS TO RECOVER PCB FOR 1E 4.16KV SW01A,B,C,D AT LOCAL		
19	7.23E-10	%MLOCA	MEDIUM LOSS OF COOLANT ACCIDENT	0.7	37.1
		DGDGR-C-DGC	FAILS TO RUN OF EMERGENCY DIESEL GENERATOR DG01C		
		DGDGR-D-DGD	FAILS TO RUN OF EMERGENCY DIESEL GENERATOR DG01D		
		PDS_7	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-7		
		PFLOOP-LOCA	CONDITIONAL LOOP UPON LOCA INITIATORS		

Table 19.1-31 (8 of 41)

Rank	Frequency (/yr)	Cutsets		Contribution to LRF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
20	6.64E-10	%LSSB-D	LARGE SECONDARY SIDE BREAK (MSIV DOWNDSTREAM)	0.6	37.7
		HR-RCSCD1-ISOL	OPERATOR FAILS TO TAKE ACTION FOR SG COOLDOWN, RC DEPRESS AND SG ISOLATION		
		HR-RCSCD2-CD	OPERATOR FAILS TO TAKE ACTION FOR SG COOLDOWN, RC DEPRESS WITH COMPLETE DEP.		
		PDS_2	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-2		
		PFLOOP-TRANS	CONDITIONAL LOOP UPON TRANSIENTS		
		PI-SGTR	PRESSURE INDUECD SGTR PROBABILITY UNDER LSSB, ATWS, FWLB		
21	5.87E-10	%SGTR	STEAM GENERATOR TUBE RUPTURE	0.5	38.2
		I-ATWS-RPMCF	FAILURE TO SCRAM DUE TO MECHANICAL FAILURES		
		PDS_2	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-2		

Table 19.1-31 (9 of 41)

Rank	Frequency (/yr)	Cutsets		Contribution to LRF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
22	4.73E-10	%TLOESW	TOTAL LOSS OF ESSENTIAL SERVICE WATER	0.4	38.6
		CVOPH-S-RCPSEAL	OPERATOR FAILS TO RECOVER RCP SEAL COOLING (CCW CONNTECT. OR AUX. CHG PUMP)		
		PDS-FREQ-CFS	PDS FREQUENCY ADJUSTMENT FOR CFS		
		PDS-FREQ-SDR-PO-3W	PDS FREQUENCY ADJUSTMENT FOR SDR (3WAY V/V & POSRV OPERATING)		
		PDS_14	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14		
		SEAL-AFSUC	SEAL FAILURE PROBABILITY (SECONDARY HEAT REMOVAL SUCCESS)		
23	4.73E-10	%TLOCCW	TOTAL LOSS OF COMPONANT COOLING WATER	0.4	39.0
		CVOPH-S-RCPSEAL	OPERATOR FAILS TO RECOVER RCP SEAL COOLING (CCW CONNTECT. OR AUX. CHG PUMP)		
		PDS-FREQ-CFS	PDS FREQUENCY ADJUSTMENT FOR CFS		
		PDS-FREQ-SDR-PO-3W	PDS FREQUENCY ADJUSTMENT FOR SDR (3WAY V/V & POSRV OPERATING)		
		PDS_14	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14		
		SEAL-AFSUC	SEAL FAILURE PROBABILITY (SECONDARY HEAT REMOVAL SUCCESS)		

Table 19.1-31 (10 of 41)

Rank	Frequency (/yr)	Cutsets		Contribution to LRF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
24	4.43E-10	-MTC-ATWS	MODERATE COEFFICIENT	0.4	39.4
		%LOFW	LOSS OF MAIN FEEDWATER		
		I-ATWS-RPMCF	FAILURE TO SCRAM DUE TO MECHANICAL FAILURES		
		PDS_2	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-2		
		PI-SGTR	PRESSURE INDUECD SGTR PROBABILITY UNDER LSSB, ATWS, FWLB		
25	4.31E-10	%LOOP-GR	GRID-RELATED LOOP	0.4	39.8
		PDS_7	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-7		
		PFHBC2A-SW01C-E2	FAILS TO CLOSE OF FEEDER BKR SW01C-E2 FROM AAC BUS SW03N TO 1E BUS SW01C		
		SXFLP-S-FT0123AB	ESW DEBIS FILTER FT01A PLUGGED		
26	4.31E-10	%LOOP-GR	GRID-RELATED LOOP	0.4	40.2
		NBHBC2A-SW03N-F2	FAILS TO CLOSE OF FEEDER BKR SW03N-F2 FROM AAC BUS SW03N TO 1E BUS SW01C		
		PDS_7	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-7		
		SXFLP-S-FT0123AB	ESW DEBIS FILTER FT01A PLUGGED		

Table 19.1-31 (11 of 41)

Rank	Frequency (/yr)	Cutsets		Contribution to LRF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
27	4.18E-10	%MLOCA	MEDIUM LOSS OF COOLANT ACCIDENT	0.4	40.6
		DGDGM-C-DGC	DG 01C UNAVAILABLE DUE TO MAINTENANCE		
		DGDGR-D-DGD	FAILS TO RUN OF EMERGENCY DIESEL GENERATOR DG01D		
		PDS_7	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-7		
		PFLOOP-LOCA	CONDITIONAL LOOP UPON LOCA INITIATORS		
28	4.18E-10	%MLOCA	MEDIUM LOSS OF COOLANT ACCIDENT	0.4	41.0
		DGDGM-D-DGD	DG 01D UNAVAILABLE DUE TO MAINTENANCE		
		DGDGR-C-DGC	FAILS TO RUN OF EMERGENCY DIESEL GENERATOR DG01C		
		PDS_7	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-7		
		PFLOOP-LOCA	CONDITIONAL LOOP UPON LOCA INITIATORS		
29	3.77E-10	-MTC-ATWS	MODERATE COEFFICIENT	0.3	41.3
		%LOCV	LOSS OF CONDENCER VACCUM		
		I-ATWS-RPMCF	FAILURE TO SCRAM DUE TO MECHANICAL FAILURES		
		PDS_2	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-2		
		PI-SGTR	PRESSURE INDUECD SGTR PROBABILITY UNDER LSSB, ATWS, FWLB		

Table 19.1-31 (12 of 41)

Rank	Frequency (/yr)	Cutsets		Contribution to LRF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
30	3.67E-10	%LOOP-SW	SWITCHYARD-CENTERED LOOP	0.3	41.6
		PDS_7	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-7		
		PFHBC2A-SW01C-E2	FAILS TO CLOSE OF FEEDER BKR SW01C-E2 FROM AAC BUS SW03N TO 1E BUS SW01C		
		SXFLP-S-FT0123AB	ESW DEBIS FILTER FT01A PLUGGED		
31	3.67E-10	%LOOP-SW	SWITCHYARD-CENTERED LOOP	0.3	41.9
		NBHBC2A-SW03N-F2	FAILS TO CLOSE OF FEEDER BKR SW03N-F2 FROM AAC BUS SW03N TO 1E BUS SW01C		
		PDS_7	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-7		
		SXFLP-S-FT0123AB	ESW DEBIS FILTER FT01A PLUGGED		
32	3.42E-10	%PLOCCW	PARTIAL LOSS OF COMPONANT COOLING WATER	0.3	42.2
		DGDGR-B-DGB	FAILS TO RUN OF EMERGENCY DIESEL GENERATOR DG01B		
		DGDGR-D-DGD	FAILS TO RUN OF EMERGENCY DIESEL GENERATOR DG01D		
		PDS-FREQ-CFS	PDS FREQUENCY ADJUSTMENT FOR CFS		
		PDS-FREQ-SDR-3W	PDS FREQUENCY ADJUSTMENT FOR SDR (3WAY V/V OPERATING)		
		PDS_14	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14		
		PFLOOP-TRANS	CONDITIONAL LOOP UPON TRANSIENTS		

Table 19.1-31 (13 of 41)

Rank	Frequency (/yr)	Cutsets		Contribution to LRF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
33	3.31E-10	%TLOESW	TOTAL LOSS OF ESSENTIAL SERVICE WATER	0.3	42.5
		CVDPR-S-PP03	FAILS TO RUN AUX. CHARGING PUMP PP03		
		H-SDR-POSRV-3WAY	OPERATOR FAILS TO OPERATION (POSRV & 3-WAY V/V)		
		PDS-FREQ-CFS	PDS FREQUENCY ADJUSTMENT FOR CFS		
		PDS_69	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-69		
		SEAL-AFSUC	SEAL FAILURE PROBABILITY (SECONDARY HEAT REMOVAL SUCCESS)		
34	3.31E-10	%TLOCCW	TOTAL LOSS OF COMPONANT COOLING WATER	0.3	42.8
		CVDPR-S-PP03	FAILS TO RUN AUX. CHARGING PUMP PP03		
		H-SDR-POSRV-3WAY	OPERATOR FAILS TO OPERATION (POSRV & 3-WAY V/V)		
		PDS-FREQ-CFS	PDS FREQUENCY ADJUSTMENT FOR CFS		
		PDS_69	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-69		
		SEAL-AFSUC	SEAL FAILURE PROBABILITY (SECONDARY HEAT REMOVAL SUCCESS)		

Table 19.1-31 (14 of 41)

Rank	Frequency (/yr)	Cutsets		Contribution to LRF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
35	3.20E-10	%SGTR	STEAM GENERATOR TUBE RUPTURE	0.3	43.1
		AFMPM2A-MDP02A	AFW MDP PP02A UNAVAILABLE DUE TO T/M		
		AFTPR1A-TDP01A	FAILS TO RUN AFW TDP PP01A		
		H-SDR-POSRV-3WAY	OPERATOR FAILS TO OPERATION (POSRV & 3-WAY V/V)		
		PDS_2	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-2		
		RCOPH-S-SDSE-FW	FAILURE OF SDS VALVES EARLY PHASE OPEN (1/4)		
36	3.10E-10	%TLOCCW	TOTAL LOSS OF COMPONANT COOLING WATER	0.3	43.4
		NBHBC2A-SW03N-F2	FAILS TO CLOSE OF FEEDER BKR SW03N-F2 FROM AAC BUS SW03N TO 1E BUS SW01C		
		PDS-FREQ-CFS	PDS FREQUENCY ADJUSTMENT FOR CFS		
		PDS-FREQ-SDR-PO-3W	PDS FREQUENCY ADJUSTMENT FOR SDR (3WAY V/V & POSRV OPERATING)		
		PDS_9	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-9		
		PFLOOP-TRANS	CONDITIONAL LOOP UPON TRANSIENTS		

Table 19.1-31 (15 of 41)

Rank	Frequency (/yr)	Cutsets		Contribution to LRF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
37	3.10E-10	%TLOESW	TOTAL LOSS OF ESSENTIAL SERVICE WATER	0.3	43.7
		PDS-FREQ-CFS	PDS FREQUENCY ADJUSTMENT FOR CFS		
		PDS-FREQ-SDR-PO-3W	PDS FREQUENCY ADJUSTMENT FOR SDR (3WAY V/V & POSRV OPERATING)		
		PDS_9	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-9		
		PFHBC2A-SW01C-E2	FAILS TO CLOSE OF FEEDER BKR SW01C-E2 FROM AAC BUS SW03N TO 1E BUS SW01C		
		PFLOOP-TRANS	CONDITIONAL LOOP UPON TRANSIENTS		
38	3.10E-10	%TLOESW	TOTAL LOSS OF ESSENTIAL SERVICE WATER	0.3	44.0
		NBHBC2A-SW03N-F2	FAILS TO CLOSE OF FEEDER BKR SW03N-F2 FROM AAC BUS SW03N TO 1E BUS SW01C		
		PDS-FREQ-CFS	PDS FREQUENCY ADJUSTMENT FOR CFS		
		PDS-FREQ-SDR-PO-3W	PDS FREQUENCY ADJUSTMENT FOR SDR (3WAY V/V & POSRV OPERATING)		
		PDS_9	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-9		
		PFLOOP-TRANS	CONDITIONAL LOOP UPON TRANSIENTS		

Table 19.1-31 (16 of 41)

Rank	Frequency (/yr)	Cutsets		Contribution to LRF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
39	3.10E-10	%TLOCCW	TOTAL LOSS OF COMPONANT COOLING WATER	0.3	44.3
		PDS-FREQ-CFS	PDS FREQUENCY ADJUSTMENT FOR CFS		
		PDS-FREQ-SDR-PO-3W	PDS FREQUENCY ADJUSTMENT FOR SDR (3WAY V/V & POSRV OPERATING)		
		PDS_9	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-9		
		PFHBC2A-SW01C-E2	FAILS TO CLOSE OF FEEDER BKR SW01C-E2 FROM AAC BUS SW03N TO 1E BUS SW01C		
		PFLOOP-TRANS	CONDITIONAL LOOP UPON TRANSIENTS		
40	2.85E-10	%LOOP-WE	WEATHER-RELATED LOOP	0.3	44.6
		PDS_93	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-93		
		PFHBWQ4-SW2OUAT	CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1B,1C,1D FAIL TO OPEN		
		PFOPH-S-UATBKR-LOCAL	OPERATOR FAILS TO RECOVER PCB FOR 1E 4.16KV SW01A,B,C,D AT LOCAL		
41	2.80E-10	%LOOP-WE	WEATHER-RELATED LOOP	0.3	44.9
		DATGR-S-AACTG	AAC GAS TURBINE GENERATOR FAILS TO RUN		
		PDS_93	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-93		
		RAC-16H-WE	NON-RECOVERY PROBABILITY OF OFFSITE POWER WITHIN 16HR (WEATHER RELATED)		
		SXFLP-S-FT0123AB	ESW DEBIS FILTER FT01A PLUGGED		

Table 19.1-31 (17 of 41)

Rank	Frequency (/yr)	Cutsets		Contribution to LRF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
42	2.77E-10	%LSSB-D	LARGE SECONDARY SIDE BREAK (MSIV DOWNDSTREAM)	0.3	45.2
		CVOPH-S-IRWST	OPERATOR FAILS TO REFILL THE IRWST VIA CVCS		
		HR-RCSCD1-ISOL	OPERATOR FAILS TO TAKE ACTION FOR SG COOLDOWN, RC DEPRESS AND SG ISOLATION		
		HR-RCSCD2-CD	OPERATOR FAILS TO TAKE ACTION FOR SG COOLDOWN, RC DEPRESS WITH COMPLETE DEP.		
		PDS_2	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-2		
		PI-SGTR	PRESSURE INDUECD SGTR PROBABILITY UNDER LSSB, ATWS, FWLB		
43	2.72E-10	%LOOP-GR	GRID-RELATED LOOP	0.2	45.4
		MSAVO-B-110	FAILS TO OPEN MS AFW TDP PP01A TBN STM. SUPPLY AOV 110		
		PDS_7	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-7		
		SXFLP-S-FT0123AB	ESW DEBIS FILTER FT01A PLUGGED		

Table 19.1-31 (18 of 41)

Rank	Frequency (/yr)	Cutsets		Contribution to LRF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
44	2.72E-10	%MLOCA	MEDIUM LOSS OF COOLANT ACCIDENT	0.2	45.6
		ERVC	Failure of ERVC system		
		PDS-FREQ-CFS	PDS FREQUENCY ADJUSTMENT FOR CFS		
		PDS-FREQ-SDR-PO-3W	PDS FREQUENCY ADJUSTMENT FOR SDR (3WAY V/V & POSRV OPERATING)		
		PDS_14	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14		
		SISPP-S-IRWST	FAILURE OF IRWST SUMP DUE TO PLUGGING		
45	2.71E-10	%PLOCCW	PARTIAL LOSS OF COMPONANT COOLING WATER	0.2	45.8
		DGDGR-B-DGB	FAILS TO RUN OF EMERGENCY DIESEL GENERATOR DG01B		
		PDS-FREQ-CFS	PDS FREQUENCY ADJUSTMENT FOR CFS		
		PDS-FREQ-SDR-3W	PDS FREQUENCY ADJUSTMENT FOR SDR (3WAY V/V OPERATING)		
		PDS_14	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14		
		PFLOOP-TRANS	CONDITIONAL LOOP UPON TRANSIENTS		
		WOCHM2B-CH02B	ECW CHILLER 02B TRAIN UNAVAILABLE DUE TO T&M		

Table 19.1-31 (19 of 41)

Rank	Frequency (/yr)	Cutsets		Contribution to LRF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
46	2.67E-10	%LSSB-D	LARGE SECONDARY SIDE BREAK (MSIV DOWNDSTREAM)	0.2	46.0
		CVMVO-S-509	IRWST RETURN LINE MOV 509 FAILS TO OPEN ON DEMAND		
		HR-RCSCD1-ISOL	OPERATOR FAILS TO TAKE ACTION FOR SG COOLDOWN, RC DEPRESS AND SG ISOLATION		
		HR-RCSCD2-CD	OPERATOR FAILS TO TAKE ACTION FOR SG COOLDOWN, RC DEPRESS WITH COMPLETE DEP.		
		PDS_2	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-2		
		PI-SGTR	PRESSURE INDUECD SGTR PROBABILITY UNDER LSSB, ATWS, FWLB		
47	2.41E-10	%MLOCA	MEDIUM LOSS OF COOLANT ACCIDENT	0.2	46.2
		DGDGM-C-DGC	DG 01C UNAVAILABLE DUE TO MAINTENANCE		
		DGDGM-D-DGD	DG 01D UNAVAILABLE DUE TO MAINTENANCE		
		PDS_7	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-7		
		PFLOOP-LOCA	CONDITIONAL LOOP UPON LOCA INITIATORS		

Table 19.1-31 (20 of 41)

Rank	Frequency (/yr)	Cutsets		Contribution to LRF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
48	2.36E-10	%LOOP-WE	WEATHER-RELATED LOOP	0.2	46.4
		AFMVO1A-045	AFW ISOL. MOV 045 FAILS TO OPEN FOR CYCLING OPERATION		
		PDS_7	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-7		
		RAC-12H-WE	NON-RECOVERY PROBABILITY OF OFFSITE POWER WITHIN 9.5HR (WEATHER RELATED)		
		SXFLP-S-FT0123AB	ESW DEBIS FILTER FT01A PLUGGED		
49	2.36E-10	%LOOP-WE	WEATHER-RELATED LOOP	0.2	46.6
		AFMVC1A-045	AFW ISOL. MOV 0045 FAILS TO CLOSE FOR CYCLING OPERATION		
		PDS_7	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-7		
		RAC-12H-WE	NON-RECOVERY PROBABILITY OF OFFSITE POWER WITHIN 9.5HR (WEATHER RELATED)		
		SXFLP-S-FT0123AB	ESW DEBIS FILTER FT01A PLUGGED		
50	2.33E-10	%LOOP-WE	WEATHER-RELATED LOOP	0.2	46.8
		DATGR-S-AACTG	AAC GAS TURBINE GENERATOR FAILS TO RUN		
		DGDGKQ4-DG01ABCD	4/4 CCF OF EDG 01A/01B/01C/01D FAIL TO RUN		
		PDS_93	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-93		
		RAC-16H-WE	NON-RECOVERY PROBABILITY OF OFFSITE POWER WITHIN 16HR (WEATHER RELATED)		

Table 19.1-31 (21 of 41)

Rank	Frequency (/yr)	Cutsets		Contribution to LRF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
51	2.31E-10	%LOOP-SW	SWITCHYARD-CENTERED LOOP	0.2	47.0
		MSAVO-B-110	FAILS TO OPEN MS AFW TDP PP01A TBN STM. SUPPLY AOV 110		
		PDS_7	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-7		
		SXFLP-S-FT0123AB	ESW DEBIS FILTER FT01A PLUGGED		
52	2.20E-10	%LOOP-WE	WEATHER-RELATED LOOP	0.2	47.2
		DATGR-S-AACTG	AAC GAS TURBINE GENERATOR FAILS TO RUN		
		PDS_93	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-93		
		RAC-16H-WE	NON-RECOVERY PROBABILITY OF OFFSITE POWER WITHIN 16HR (WEATHER RELATED)		
		WOCHWQ4-CH01A/2A/1B/2B	DEMAND CCF OF ECW CHILLERS 1A/2A/1B/2B		
53	2.03E-10	%LSSB-D	LARGE SECONDARY SIDE BREAK (MSIV DOWNDSTREAM)	0.2	47.4
		I-ATWS-RPMCF	FAILURE TO SCRAM DUE TO MECHANICAL FAILURES		
		PDS_92	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-92		

Table 19.1-31 (22 of 41)

Rank	Frequency (/yr)	Cutsets		Contribution to LRF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
54	1.98E-10	%LSSB-D	LARGE SECONDARY SIDE BREAK (MSIV DOWNDSTREAM)	0.2	47.6
		C-RCD1-SCLT-RFIR	THIS EVENT IS THE HUMAN ERROR COMBINATION OF "HR-RCSCD1", "SIOPH-S-LTC-SC"AND "CVOPH-S-IRWST"		
		PDS_2	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-2		
		PI-SGTR	PRESSURE INDUECD SGTR PROBABILITY UNDER LSSB, ATWS, FWLB		
55	1.98E-10	%PLOESW	PARTIAL LOSS OF ESSENTIAL SERVICE WATER	0.2	47.8
		DGDGR-B-DGB	FAILS TO RUN OF EMERGENCY DIESEL GENERATOR DG01B		
		DGDGR-D-DGD	FAILS TO RUN OF EMERGENCY DIESEL GENERATOR DG01D		
		PDS-FREQ-CFS	PDS FREQUENCY ADJUSTMENT FOR CFS		
		PDS-FREQ-SDR-3W	PDS FREQUENCY ADJUSTMENT FOR SDR (3WAY V/V OPERATING)		
		PDS_14	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14		
		PFLOOP-TRANS	CONDITIONAL LOOP UPON TRANSIENTS		

Table 19.1-31 (23 of 41)

Rank	Frequency (/yr)	Cutsets		Contribution to LRF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
56	1.98E-10	%PLOCCW	PARTIAL LOSS OF COMPONANT COOLING WATER	0.2	48.0
		DGDGM-B-DGB	DG 01B UNAVAILABLE DUE TO MAINTENANCE		
		DGDGR-D-DGD	FAILS TO RUN OF EMERGENCY DIESEL GENERATOR DG01D		
		PDS-FREQ-CFS	PDS FREQUENCY ADJUSTMENT FOR CFS		
		PDS-FREQ-SDR-3W	PDS FREQUENCY ADJUSTMENT FOR SDR (3WAY V/V OPERATING)		
		PDS_14	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14		
		PFLOOP-TRANS	CONDITIONAL LOOP UPON TRANSIENTS		
57	1.98E-10	%PLOCCW	PARTIAL LOSS OF COMPONANT COOLING WATER	0.2	48.2
		DGDGM-D-DGD	DG 01D UNAVAILABLE DUE TO MAINTENANCE		
		DGDGR-B-DGB	FAILS TO RUN OF EMERGENCY DIESEL GENERATOR DG01B		
		PDS-FREQ-CFS	PDS FREQUENCY ADJUSTMENT FOR CFS		
		PDS-FREQ-SDR-3W	PDS FREQUENCY ADJUSTMENT FOR SDR (3WAY V/V OPERATING)		
		PDS_14	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14		
		PFLOOP-TRANS	CONDITIONAL LOOP UPON TRANSIENTS		

Table 19.1-31 (24 of 41)

Rank	Frequency (/yr)	Cutsets		Contribution to LRF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
58	1.95E-10	%TLOCCW	TOTAL LOSS OF COMPONANT COOLING WATER	0.2	48.4
		MSAVO-B-110	FAILS TO OPEN MS AFW TDP PP01A TBN STM. SUPPLY AOV 110		
		PDS-FREQ-CFS	PDS FREQUENCY ADJUSTMENT FOR CFS		
		PDS-FREQ-SDR-PO-3W	PDS FREQUENCY ADJUSTMENT FOR SDR (3WAY V/V & POSRV OPERATING)		
		PDS_9	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-9		
		PFLOOP-TRANS	CONDITIONAL LOOP UPON TRANSIENTS		
59	1.95E-10	%TLOESW	TOTAL LOSS OF ESSENTIAL SERVICE WATER	0.2	48.6
		MSAVO-B-110	FAILS TO OPEN MS AFW TDP PP01A TBN STM. SUPPLY AOV 110		
		PDS-FREQ-CFS	PDS FREQUENCY ADJUSTMENT FOR CFS		
		PDS-FREQ-SDR-PO-3W	PDS FREQUENCY ADJUSTMENT FOR SDR (3WAY V/V & POSRV OPERATING)		
		PDS_9	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-9		
		PFLOOP-TRANS	CONDITIONAL LOOP UPON TRANSIENTS		

Table 19.1-31 (25 of 41)

Rank	Frequency (/yr)	Cutsets		Contribution to LRF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
60	1.93E-10	%MLOCA	MEDIUM LOSS OF COOLANT ACCIDENT	0.2	48.8
		DGDGR-C-DGC	FAILS TO RUN OF EMERGENCY DIESEL GENERATOR DG01C		
		PDS_7	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-7		
		PFHBO2B-SW01D-G2	FAILS TO OPEN OF PCB SW01D-G2 OF 4.16KV SWGR SW01D FROM UAT		
		PFLOOP-LOCA	CONDITIONAL LOOP UPON LOCA INITIATORS		
61	1.93E-10	%MLOCA	MEDIUM LOSS OF COOLANT ACCIDENT	0.2	49.0
		DGDGR-D-DGD	FAILS TO RUN OF EMERGENCY DIESEL GENERATOR DG01D		
		PDS_7	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-7		
		PFHBO2A-SW01C-C2	FAILS TO OPEN OF PCB SW01C-C2 OF 4.16KV SWGR SW01C FROM UAT		
		PFLOOP-LOCA	CONDITIONAL LOOP UPON LOCA INITIATORS		
62	1.82E-10	-MTC-ATWS	MODERATE COEFFICIENT	0.2	49.2
		%LOIA	LOSS OF INTRUMENT AIR		
		I-ATWS-RPMCF	FAILURE TO SCRAM DUE TO MECHANICAL FAILURES		
		PDS_2	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-2		
		PI-SGTR	PRESSURE INDUECD SGTR PROBABILITY UNDER LSSB, ATWS, FWLB		

Table 19.1-31 (26 of 41)

Rank	Frequency (/yr)	Cutsets		Contribution to LRF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
63	1.81E-10	%PLOCCW	PARTIAL LOSS OF COMPONANT COOLING WATER	0.2	49.4
		DGDGR-B-DGB	FAILS TO RUN OF EMERGENCY DIESEL GENERATOR DG01B		
		PDS-FREQ-CFS	PDS FREQUENCY ADJUSTMENT FOR CFS		
		PDS-FREQ-SDR-3W	PDS FREQUENCY ADJUSTMENT FOR SDR (3WAY V/V OPERATING)		
		PDS_14	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14		
		PFLOOP-TRANS	CONDITIONAL LOOP UPON TRANSIENTS		
		SXMPM2B-PP02B	ESW PUMP PP02B UNAVAILABLE DUE TO T/M		
64	1.79E-10	%SLOCA	SMALL LOSS OF COOLANT ACCIDENT	0.2	49.6
		H-SDR-POSRV-3WAY	OPERATOR FAILS TO OPERATION (POSRV & 3-WAY V/V)		
		PDS-FREQ-CFS	PDS FREQUENCY ADJUSTMENT FOR CFS		
		PDS_51	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-51		
		SISPP-S-IRWST	FAILURE OF IRWST SUMP DUE TO PLUGGING		

Table 19.1-31 (27 of 41)

Rank	Frequency (/yr)	Cutsets		Contribution to LRF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
65	1.78E-10	%PLOCCW	PARTIAL LOSS OF COMPONANT COOLING WATER	0.2	49.8
		DGDGR-B-DGB	FAILS TO RUN OF EMERGENCY DIESEL GENERATOR DG01B		
		PDS-FREQ-CFS	PDS FREQUENCY ADJUSTMENT FOR CFS		
		PDS-FREQ-SDR-3W	PDS FREQUENCY ADJUSTMENT FOR SDR (3WAY V/V OPERATING)		
		PDS_14	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14		
		PFLOOP-TRANS	CONDITIONAL LOOP UPON TRANSIENTS		
		WOCHS2B-CH02B	ECW CHILLER CH02B FAILS TO START ON DEMAND		
66	1.76E-10	%SGTR	STEAM GENERATOR TUBE RUPTURE	0.2	50.0
		AFTPR1A-TDP01A	FAILS TO RUN AFW TDP PP01A		
		H-SDR-POSRV-3WAY	OPERATOR FAILS TO OPERATION (POSRV & 3-WAY V/V)		
		PDS_2	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-2		
		RCOPH-S-SDSE-FW	FAILURE OF SDS VALVES EARLY PHASE OPEN (1/4)		
		VOHVM2A-HV33A	CUBICLE COOLER HV33A UNAVAILABLE DUE TO T&M		

Table 19.1-31 (28 of 41)

Rank	Frequency (/yr)	Cutsets		Contribution to LRF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
67	1.70E-10	%MLOCA	MEDIUM LOSS OF COOLANT ACCIDENT	0.2	50.2
		PDS_7	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-7		
		SIMPWQ4-CSP1A/B/SCP1A/B	4/4 CCF OF CSP PP01A, PP01B AND SCP PP01A, PP01B TO START		
68	1.62E-10	%LOOP-WE	WEATHER-RELATED LOOP	0.1	50.3
		DATGR-S-AACTG	AAC GAS TURBINE GENERATOR FAILS TO RUN		
		PDS_93	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-93		
		RAC-16H-WE	NON-RECOVERY PROBABILITY OF OFFSITE POWER WITHIN 16HR (WEATHER RELATED)		
		VDHVZO8-HV12/13ABCD	8/8 CCF OF RUN FOR EDG ROOM CUBICLE COOLER HV12A, 12B, 12C, 12D 13A, 13B, 13C, 14D FOR 1HR		
69	1.58E-10	%LOOP-WE	WEATHER-RELATED LOOP	0.1	50.4
		DATGR-S-AACTG	AAC GAS TURBINE GENERATOR FAILS TO RUN		
		PDS_93	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-93		
		RAC-16H-WE	NON-RECOVERY PROBABILITY OF OFFSITE POWER WITHIN 16HR (WEATHER RELATED)		
		VDHVKO8-HV12/13ABCD	8/8 CCF OF RUN FOR EDG ROOM CUBICLE COOLER HV12A, 12B, 12C, 12D 13A, 13B, 13C, 14D		

Table 19.1-31 (29 of 41)

Rank	Frequency (/yr)	Cutsets		Contribution to LRF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
70	1.57E-10	%PLOESW	PARTIAL LOSS OF ESSENTIAL SERVICE WATER	0.1	50.5
		DGDGR-B-DGB	FAILS TO RUN OF EMERGENCY DIESEL GENERATOR DG01B		
		PDS-FREQ-CFS	PDS FREQUENCY ADJUSTMENT FOR CFS		
		PDS-FREQ-SDR-3W	PDS FREQUENCY ADJUSTMENT FOR SDR (3WAY V/V OPERATING)		
		PDS_14	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14		
		PFLOOP-TRANS	CONDITIONAL LOOP UPON TRANSIENTS		
		WOCHM2B-CH02B	ECW CHILLER 02B TRAIN UNAVAILABLE DUE TO T&M		
71	1.57E-10	%PLOCCW	PARTIAL LOSS OF COMPONANT COOLING WATER	0.1	50.6
		DGDGM-B-DGB	DG 01B UNAVAILABLE DUE TO MAINTENANCE		
		PDS-FREQ-CFS	PDS FREQUENCY ADJUSTMENT FOR CFS		
		PDS-FREQ-SDR-3W	PDS FREQUENCY ADJUSTMENT FOR SDR (3WAY V/V OPERATING)		
		PDS_14	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14		
		PFLOOP-TRANS	CONDITIONAL LOOP UPON TRANSIENTS		
		WOCHM2B-CH02B	ECW CHILLER 02B TRAIN UNAVAILABLE DUE TO T&M		

Table 19.1-31 (30 of 41)

Rank	Frequency (/yr)	Cutsets		Contribution to LRF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
72	1.43E-10	%LOOP-WE	WEATHER-RELATED LOOP	0.1	50.7
		AFTPR1A-TDP01A	FAILS TO RUN AFW TDP PP01A		
		PDS_7	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-7		
		RAC-12H-WE	NON-RECOVERY PROBABILITY OF OFFSITE POWER WITHIN 9.5HR (WEATHER RELATED)		
		SXFLP-S-FT0123AB	ESW DEBIS FILTER FT01A PLUGGED		
73	1.40E-10	%LOOP-PL	PLANT-CENTERED LOOP	0.1	50.8
		PDS_93	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-93		
		PFHBWQ4-SW2OUAT	CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1B,1C,1D FAIL TO OPEN		
		PFOPH-S-UATBKR-LOCAL	OPERATOR FAILS TO RECOVER PCB FOR 1E 4.16KV SW01A,B,C,D AT LOCAL		
74	1.38E-10	%LSSB-D	LARGE SECONDARY SIDE BREAK (MSIV DOWNDSTREAM)	0.1	50.9
		HR-RCSCD1-ISOL	OPERATOR FAILS TO TAKE ACTION FOR SG COOLDOWN, RC DEPRESS AND SG ISOLATION		
		HR-RCSCD2-CD	OPERATOR FAILS TO TAKE ACTION FOR SG COOLDOWN, RC DEPRESS WITH COMPLETE DEP.		
		IAAVO-S-1027	PRESSURE REDUCING VALVE 1027 FAILS TO MODULATE (OPEN)		
		IAOPH-S-ALIGN-LD	OPERATOR FAILS TO OPEN PRESSURE REDUCING BYPASS VALVE 1030 WITH LOW DEP.		
		PDS_2	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-2		

Table 19.1-31 (31 of 41)

Rank	Frequency (/yr)	Cutsets		Contribution to LRF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
75	1.38E-10	%LOOP-WE	WEATHER-RELATED LOOP	0.1	51.0
		PDS_7	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-7		
		PFHBC2A-SW01C-E2	FAILS TO CLOSE OF FEEDER BKR SW01C-E2 FROM AAC BUS SW03N TO 1E BUS SW01C		
		SXFLP-S-FT0123AB	ESW DEBIS FILTER FT01A PLUGGED		
76	1.38E-10	%LOOP-WE	WEATHER-RELATED LOOP	0.1	51.1
		NBHBC2A-SW03N-F2	FAILS TO CLOSE OF FEEDER BKR SW03N-F2 FROM AAC BUS SW03N TO 1E BUS SW01C		
		PDS_7	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-7		
		SXFLP-S-FT0123AB	ESW DEBIS FILTER FT01A PLUGGED		
77	1.22E-10	%SLOCA	SMALL LOSS OF COOLANT ACCIDENT	0.1	51.2
		ERVC	Failure of ERVC system		
		PDS-FREQ-CFS	PDS FREQUENCY ADJUSTMENT FOR CFS		
		PDS-FREQ-SDR-PO-3W	PDS FREQUENCY ADJUSTMENT FOR SDR (3WAY V/V & POSRV OPERATING)		
		PDS_14	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14		
		PFLOOP-LOCA	CONDITIONAL LOOP UPON LOCA INITIATORS		
		SXFLP-S-FT0123AB	ESW DEBIS FILTER FT01A PLUGGED		

Table 19.1-31 (32 of 41)

Rank	Frequency (/yr)	Cutsets		Contribution to LRF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
78	1.20E-10	%LSSB-D	LARGE SECONDARY SIDE BREAK (MSIV DOWNDSTREAM)	0.1	51.3
		MSEVC-C-MSIV011	SG1 MSIV 011 FAILS TO CLOSE		
		MSEVC-D-MSIV014	SG2 MSIV 014 FAILS TO CLOSE		
		PDS_2	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-2		
		PI-SGTR	PRESSURE INDUECD SGTR PROBABILITY UNDER LSSB, ATWS, FWLB		
79	1.20E-10	%LSSB-D	LARGE SECONDARY SIDE BREAK (MSIV DOWNDSTREAM)	0.1	51.4
		MSEVC-C-MSIV013	SG2 MSIV 013 FAILS TO CLOSE		
		MSEVC-D-MSIV012	SG1 MSIV 012 FAILS TO CLOSE		
		PDS_2	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-2		
		PI-SGTR	PRESSURE INDUECD SGTR PROBABILITY UNDER LSSB, ATWS, FWLB		
80	1.20E-10	%LSSB-D	LARGE SECONDARY SIDE BREAK (MSIV DOWNDSTREAM)	0.1	51.5
		MSEVC-C-MSIV011	SG1 MSIV 011 FAILS TO CLOSE		
		MSEVC-C-MSIV013	SG2 MSIV 013 FAILS TO CLOSE		
		PDS_2	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-2		
		PI-SGTR	PRESSURE INDUECD SGTR PROBABILITY UNDER LSSB, ATWS, FWLB		

Table 19.1-31 (33 of 41)

Rank	Frequency (/yr)	Cutsets		Contribution to LRF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
81	1.20E-10	%LSSB-D	LARGE SECONDARY SIDE BREAK (MSIV DOWNDSTREAM)	0.1	51.6
		MSEVC-D-MSIV012	SG1 MSIV 012 FAILS TO CLOSE		
		MSEVC-D-MSIV014	SG2 MSIV 014 FAILS TO CLOSE		
		PDS_2	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-2		
		PI-SGTR	PRESSURE INDUECD SGTR PROBABILITY UNDER LSSB, ATWS, FWLB		
82	1.18E-10	%ISLOCA	INTERFACING LOSS OF COOLANT ACCIDENT	0.1	51.7
		PDS_3	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-3		
83	1.14E-10	%PLOESW	PARTIAL LOSS OF ESSENTIAL SERVICE WATER	0.1	51.8
		DGDGM-B-DGB	DG 01B UNAVAILABLE DUE TO MAINTENANCE		
		DGDGR-D-DGD	FAILS TO RUN OF EMERGENCY DIESEL GENERATOR DG01D		
		PDS-FREQ-CFS	PDS FREQUENCY ADJUSTMENT FOR CFS		
		PDS-FREQ-SDR-3W	PDS FREQUENCY ADJUSTMENT FOR SDR (3WAY V/V OPERATING)		
		PDS_14	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14		
		PFLOOP-TRANS	CONDITIONAL LOOP UPON TRANSIENTS		

Table 19.1-31 (34 of 41)

Rank	Frequency (/yr)	Cutsets		Contribution to LRF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
84	1.14E-10	%PLOESW	PARTIAL LOSS OF ESSENTIAL SERVICE WATER	0.1	51.9
		DGDGM-D-DGD	DG 01D UNAVAILABLE DUE TO MAINTENANCE		
		DGDGR-B-DGB	FAILS TO RUN OF EMERGENCY DIESEL GENERATOR DG01B		
		PDS-FREQ-CFS	PDS FREQUENCY ADJUSTMENT FOR CFS		
		PDS-FREQ-SDR-3W	PDS FREQUENCY ADJUSTMENT FOR SDR (3WAY V/V OPERATING)		
		PDS_14	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14		
		PFLOOP-TRANS	CONDITIONAL LOOP UPON TRANSIENTS		
85	1.14E-10	%PLOCCW	PARTIAL LOSS OF COMPONANT COOLING WATER	0.1	52.0
		DGDGM-B-DGB	DG 01B UNAVAILABLE DUE TO MAINTENANCE		
		DGDGM-D-DGD	DG 01D UNAVAILABLE DUE TO MAINTENANCE		
		PDS-FREQ-CFS	PDS FREQUENCY ADJUSTMENT FOR CFS		
		PDS-FREQ-SDR-3W	PDS FREQUENCY ADJUSTMENT FOR SDR (3WAY V/V OPERATING)		
		PDS_14	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14		
		PFLOOP-TRANS	CONDITIONAL LOOP UPON TRANSIENTS		

Table 19.1-31 (35 of 41)

Rank	Frequency (/yr)	Cutsets		Contribution to LRF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
86	1.12E-10	%MLOCA	MEDIUM LOSS OF COOLANT ACCIDENT	0.1	52.1
		DGDGM-D-DGD	DG 01D UNAVAILABLE DUE TO MAINTENANCE		
		PDS_7	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-7		
		PFHBO2A-SW01C-C2	FAILS TO OPEN OF PCB SW01C-C2 OF 4.16KV SWGR SW01C FROM UAT		
		PFLOOP-LOCA	CONDITIONAL LOOP UPON LOCA INITIATORS		
87	1.12E-10	%MLOCA	MEDIUM LOSS OF COOLANT ACCIDENT	0.1	52.2
		DGDGM-C-DGC	DG 01C UNAVAILABLE DUE TO MAINTENANCE		
		PDS_7	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-7		
		PFHBO2B-SW01D-G2	FAILS TO OPEN OF PCB SW01D-G2 OF 4.16KV SWGR SW01D FROM UAT		
		PFLOOP-LOCA	CONDITIONAL LOOP UPON LOCA INITIATORS		
88	1.10E-10	%MLOCA	MEDIUM LOSS OF COOLANT ACCIDENT	0.1	52.3
		CCMVXO8-143-150	8/8 CCF(DEMAND) OF MOV 143,144,145,146,147,148,149,150 IN NON SAFETY LOAD LINE		
		PDS_7	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-7		

Table 19.1-31 (36 of 41)

Rank	Frequency (/yr)	Cutsets		Contribution to LRF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
89	1.09E-10	%MLOCA	MEDIUM LOSS OF COOLANT ACCIDENT	0.1	52.4
		DGDGL-D-DGD	DG D FAILS TO LOAD AND RUN DURING 1ST 1HR OF OPERATION		
		DGDGR-C-DGC	FAILS TO RUN OF EMERGENCY DIESEL GENERATOR DG01C		
		PDS_7	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-7		
		PFLOOP-LOCA	CONDITIONAL LOOP UPON LOCA INITIATORS		
90	1.09E-10	%MLOCA	MEDIUM LOSS OF COOLANT ACCIDENT	0.1	52.5
		DGDGL-C-DGC	DG 01C FAILS TO LOAD AND RUN DURING 1ST 1HR OF OPERATION		
		DGDGR-D-DGD	FAILS TO RUN OF EMERGENCY DIESEL GENERATOR DG01D		
		PDS_7	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-7		
		PFLOOP-LOCA	CONDITIONAL LOOP UPON LOCA INITIATORS		

Table 19.1-31 (37 of 41)

Rank	Frequency (/yr)	Cutsets		Contribution to LRF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
91	1.05E-10	%PLOESW	PARTIAL LOSS OF ESSENTIAL SERVICE WATER	0.1	52.6
		DGDGR-B-DGB	FAILS TO RUN OF EMERGENCY DIESEL GENERATOR DG01B		
		PDS-FREQ-CFS	PDS FREQUENCY ADJUSTMENT FOR CFS		
		PDS-FREQ-SDR-3W	PDS FREQUENCY ADJUSTMENT FOR SDR (3WAY V/V OPERATING)		
		PDS_14	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14		
		PFLOOP-TRANS	CONDITIONAL LOOP UPON TRANSIENTS		
		SXMPM2B-PP02B	ESW PUMP PP02B UNAVAILABLE DUE TO T/M		
92	1.05E-10	%PLOCCW	PARTIAL LOSS OF COMPONANT COOLING WATER	0.1	52.7
		DGDGM-B-DGB	DG 01B UNAVAILABLE DUE TO MAINTENANCE		
		PDS-FREQ-CFS	PDS FREQUENCY ADJUSTMENT FOR CFS		
		PDS-FREQ-SDR-3W	PDS FREQUENCY ADJUSTMENT FOR SDR (3WAY V/V OPERATING)		
		PDS_14	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14		
		PFLOOP-TRANS	CONDITIONAL LOOP UPON TRANSIENTS		
		SXMPM2B-PP02B	ESW PUMP PP02B UNAVAILABLE DUE TO T/M		

Table 19.1-31 (38 of 41)

Rank	Frequency (/yr)	Cutsets		Contribution to LRF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
93	1.05E-10	%SGTR	STEAM GENERATOR TUBE RUPTURE	0.1	52.8
		AFTPR1A-TDP01A	FAILS TO RUN AFW TDP PP01A		
		H-SDR-POSRV-3WAY	OPERATOR FAILS TO OPERATION (POSRV & 3-WAY V/V)		
		PDS_2	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-2		
		PEAIY-A-LX01A04	FAILURE OF ANALOG INPUT MODULE LX01A BRANCH 04		
		RCOPH-S-SDSE-FW-HD	FAILURE OF SDS VALVES EARLY PHASE OPEN (1/4) WITH HIGH DEP.		
		VOOPV-S-AFMDP	OPERATOR FAILS TO START FOR HV33A,33B(AF MDP) BY HAND SWITCH		
94	1.03E-10	%PLOESW	PARTIAL LOSS OF ESSENTIAL SERVICE WATER	0.1	52.9
		DGDGR-B-DGB	FAILS TO RUN OF EMERGENCY DIESEL GENERATOR DG01B		
		PDS-FREQ-CFS	PDS FREQUENCY ADJUSTMENT FOR CFS		
		PDS-FREQ-SDR-3W	PDS FREQUENCY ADJUSTMENT FOR SDR (3WAY V/V OPERATING)		
		PDS_14	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14		
		PFLOOP-TRANS	CONDITIONAL LOOP UPON TRANSIENTS		
		WOCHS2B-CH02B	ECW CHILLER CH02B FAILS TO START ON DEMAND		

Table 19.1-31 (39 of 41)

Rank	Frequency (/yr)	Cutsets		Contribution to LRF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
95	1.03E-10	%PLOCCW	PARTIAL LOSS OF COMPONANT COOLING WATER	0.1	53.0
		DGDGM-B-DGB	DG 01B UNAVAILABLE DUE TO MAINTENANCE		
		PDS-FREQ-CFS	PDS FREQUENCY ADJUSTMENT FOR CFS		
		PDS-FREQ-SDR-3W	PDS FREQUENCY ADJUSTMENT FOR SDR (3WAY V/V OPERATING)		
		PDS_14	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14		
		PFLOOP-TRANS	CONDITIONAL LOOP UPON TRANSIENTS		
		WOCHS2B-CH02B	ECW CHILLER CH02B FAILS TO START ON DEMAND		
96	1.02E-10	%SLOCA	SMALL LOSS OF COOLANT ACCIDENT	0.1	53.1
		DGDGKQ4-DG01ABCD	4/4 CCF OF EDG 01A/01B/01C/01D FAIL TO RUN		
		ERVC	FAILURE OF ERVC SYSTEM		
		PDS-FREQ-CFS	PDS FREQUENCY ADJUSTMENT FOR CFS		
		PDS-FREQ-SDR-PO-3W	PDS FREQUENCY ADJUSTMENT FOR SDR (3WAY V/V & POSRV OPERATING)		
		PDS_14	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14		
		PFLOOP-LOCA	CONDITIONAL LOOP UPON LOCA INITIATORS		

Table 19.1-31 (40 of 41)

Rank	Frequency (/yr)	Cutsets		Contribution to LRF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
97	9.84E-11	%SGTR	STEAM GENERATOR TUBE RUPTURE	0.1	53.2
		DCBTM-A-BT01A	CLASS 1E 125V DC BATTERY BT01A UNAVAILABLE DUE TO T&M		
		PDS-FREQ-SDR-PO-3W	PDS FREQUENCY ADJUSTMENT FOR SDR (3WAY V/V & POSRV OPERATING)		
		PDS_2	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-2		
		PFLOOP-TRANS	CONDITIONAL LOOP UPON TRANSIENTS		
		RCOPH-S-SDSE-FW-HD	FAILURE OF SDS VALVES EARLY PHASE OPEN (1/4) WITH HIGH DEP.		
		WOOPH-A-1/2A	OPERATOR FAILS TO OPERATE ECW PUMPS PP01/2A		
98	9.61E-11	%SGTR	STEAM GENERATOR TUBE RUPTURE	0.1	53.3
		AFTPR1A-TDP01A	FAILS TO RUN AFW TDP PP01A		
		H-SDR-POSRV-3WAY	OPERATOR FAILS TO OPERATION (POSRV & 3-WAY V/V)		
		PDS_2	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-2		
		RCOPH-S-SDSE-FW	FAILURE OF SDS VALVES EARLY PHASE OPEN (1/4)		
		VOHVR2A-HV33A	FAILS TO RUN OF MAFP ROOM A CUBICLE COOLER HV33A		

Table 19.1-31 (41 of 41)

Rank	Frequency (/yr)	Cutsets		Contribution to LRF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
99	9.47E-11	%LOOP-WE	WEATHER-RELATED LOOP	0.1	53.4
		DATGR-S-AACTG	AAC GAS TURBINE GENERATOR FAILS TO RUN		
		PDS_93	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-93		
		RAC-16H-WE	NON-RECOVERY PROBABILITY OF OFFSITE POWER WITHIN 16HR (WEATHER RELATED)		
		VDHVWO8-HV12/13ABCD	8/8 CCF OF START FOR EDG ROOM CUBICLE COOLER HV12A, 12B, 12C, 12D 13A, 13B, 13C, 14D		
100	9.46E-11	%PLOCCW	PARTIAL LOSS OF COMPONANT COOLING WATER	0.1	53.5
		DGDGR-B-DGB	FAILS TO RUN OF EMERGENCY DIESEL GENERATOR DG01B		
		PDS-FREQ-CFS	PDS FREQUENCY ADJUSTMENT FOR CFS		
		PDS-FREQ-SDR-3W	PDS FREQUENCY ADJUSTMENT FOR SDR (3WAY V/V OPERATING)		
		PDS_14	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14		
		PFLOOP-TRANS	CONDITIONAL LOOP UPON TRANSIENTS		
		WOMPM2B-PP02B	ECW PP02B TRAIN UNAVAILABLE DUE TO T&M		

Table 19.1-32

Level 2 Internal Events LRF Contributions by Initiating Events

Initiator	LRF	Fraction
LSSB-D	2.95E-08	26.7%
LOOP	1.53E-08	13.8%
SBO	1.38E-08	12.5%
MLOCA	1.16E-08	10.5%
ATWS	7.19E-09	6.5%
PLOCCW	6.99E-09	6.3%
TLOCCW	4.49E-09	4.1%
TLOESW	4.49E-09	4.1%
PLOESW	4.02E-09	3.6%
SGTR	4.00E-09	3.6%
GRID-SBO	3.98E-09	3.6%
SLOCA	2.55E-09	2.3%
Others	2.64E-09	2.4%
Total	1.11E-07	100.0%

Table 19.1-33 (1 of 2)

Significant PDS Contributors to LRF

PDS No	Frequency (/yr)	Contribution (%)	Cum (%)	PDS characteristics
PDS-2	4.01E-08	36.3	36.3	SGTR, Dry SG
PDS-14	2.18E-08	19.7	56.0	Depressurized RCS into Low pressure, Wet Cavity, SI unavailable, Release to In-containment, Containment Heat Removal Unavailable
PDS-7	2.11E-08	19.1	75.1	Large and medium LOCAs with successful injection but failure of containment sprays, or transients with failure of secondary heat removal followed by successful feed and bleed cooling but with failure of containment sprays or cooling IRWST.
PDS-86	1.11E-08	10.0	85.1	Not-depressurized RCS(High pressure), Wet Cavity, SI deadheaded, Release to IRWST, Containment Heat Removal Available, Dry SG
PDS-93	6.28E-09	5.7	90.7	Not-depressurized RCS(High pressure), Wet Cavity, SI failed, Release to IRWST, Containment Heat Removal Unavailable, Wet SG
PDS-9	3.39E-09	3.1	93.8	Depressurized RCS into Low pressure, Wet Cavity, SI available, Release to In-containment, Containment Heat Removal Unavailable

Table 19.1-33 (2 of 2)

PDS No	Frequency (/yr)	Contribution (%)	Cum (%)	PDS characteristics
PDS-94	1.26E-09	1.1	95.0	Not-depressurized RCS(High pressure), Wet Cavity, SI failed, Release to IRWST, Containment Heat Removal Unavailable, Dry SG
PDS-6	1.23E-09	1.1	96.1	Containment Not-isolated, Containment Heat Removal Unavailable
PDS-88	1.16E-09	1.1	97.1	Not-depressurized RCS(High pressure), Wet Cavity, SI deadheaded, Release to IRWST, Containment Heat Removal Unavailable, Dry SG
Others	3.18E-09	2.9	100.0	

Table 19.1-34 (1 of 18)

Level 2 Internal Events Key Basic Events by RAW (LRF)

EVENT	DESCRIPTION	RAW
SISPP-S-IRWST	FAILURE OF IRWST SUMP DUE TO PLUGGING	1.32E+03
SXFLP-S-FT0123AB	ESW DEBIS FILTER FT01A PLUGGED	1.02E+03
DCBSY-A-MC01A	BUS FAULTS ON 1E 125VDC BUS MC01A	4.23E+01
DCBSY-B-MC01B	BUS FAULTS ON 1E 125VDC BUS MC01B	3.25E+01
DCBTM-B-BT01B	CLASS 1E 125V DC BATTERY BT01B UNAVAILABLE DUE TO T&M	1.95E+01
DCBTM-A-BT01A	CLASS 1E 125V DC BATTERY BT01A UNAVAILABLE DUE TO T&M	1.80E+01
IPINM-B-IN01B	CLASS 1E 120V AC INVERTER IN01B UNAVAILABLE DUE TO T&M	1.68E+01
PALXY-D-PA06D-P	PRIMARY LOOP CONTROLLER 752-PA06D FAILS TO RUN	1.61E+01
IPINM-A-IN01A	CLASS 1E 120V AC INVERTER IN01A UNAVAILABLE DUE TO T&M	1.58E+01
PADOY-D-PA06D01	FAILURE OF DIGITAL OUTPUT MODULE PA06D BRANCH 01	1.54E+01
PEDOY-D-LX03D01	FAILURE OF DIGITAL OUTPUT MODULE LX03D BRANCH 01	1.54E+01
PADOY-D-PA06D03	FAILURE OF DIGITAL OUTPUT MODULE 752-PA06D BRANCH 03	1.54E+01
CCTKB-B-TK01B	CCW SURGE TANK TK01B FAILS CATASTROPHICALLY	1.40E+01

Table 19.1-34 (2 of 18)

EVENT	DESCRIPTION	RAW
DCBTT-B-BT01B	CLASS 1E 125V DC BATTERY BT01A FAILS BETWEEN TEST INTERVAL	1.33E+01
DCBTT-A-BT01A	CLASS 1E 125V DC BATTERY BT01A FAILS BETWEEN TEST INTERVAL	1.18E+01
SXMVR-B-MV074	LOSS OF SX DIV.II DUE TO THE MOV074 SPURIOUS OPEN (FLOW DIVERSION)	1.16E+01
SXMVR-B-MV073	LOSS OF SX DIV. I DUE TO THE MOV071 SPURIOUS CLOSURE	1.16E+01
WOTKB-B-TK02B	ECW AIR SEPARATOR TK02B FAILS CATASTROPHICALLY	1.12E+01
WOTKB-B-TK01B	ECW COMPRESSION TANK TK01B FAILS CATASTROPHICALLY	1.12E+01
C-AFOP-RCD2-RFIR	COMBINED OPERATOR ACTION FOR AF OPERATION, RCS COOLDOWN/DEPRESSURIZATION AND REFILL IRWST	1.06E+01
C-AFOP-SCLT-RFIR	COMBINED OPERATOR ACTION FOR AF OPERATION, SHUTDOWN COOLONG AND REFILL IRWST	1.06E+01
DCBTY-B-BT01B	BAT. BT01B (125VDC) FAILS TO PROVIDE ADEQUATE OUTPUT	1.01E+01
PEAIY-A-LX01A04	FAILURE OF ANALOG INPUT MODULE LX01A BRANCH 04	9.59E+00
DCBTY-A-BT01A	BAT. BT01A (125VDC) FAILS TO PROVIDE ADEQUATE OUTPUT	9.01E+00
VOTTY-A-TE085A	MAFP ROOM TEMPERATURE TE085A FAILS WHILE OPERATING FOR HV33A INTERLOCK SIGNAL	8.91E+00
PEDOY-D-LX02D04	FAILURE OF DIGITAL OUTPUT MODULE 745-PE-LX02D BRANCH 04	8.34E+00
CCHEY01B-HE01B	CCW Hx. HE01B FAILS WHILE OPERATING	8.17E+00

Table 19.1-34 (3 of 18)

EVENT	DESCRIPTION	RAW
CCHEY02B-HE02B	CCW Hx. HE02B FAILS WHILE OPERATING	8.17E+00
PALXY-C-PA06C-P	PRIMARY LOOP CONTROLLER 752-PA06C FAILS TO RUN	7.45E+00
PEDOY-C-LX03C01	FAILURE OF DIGITAL OUTPUT MODULE LX03C BRANCH 01	7.14E+00
PFBSY2A-SW01C	BUS FAULT ON 4.16KV SWGR SW01C	7.11E+00
C-RCD1-SCLT	COMBINED OPERATOR ACTION FOR RCS COOLDOWN/DEPRESSURIZATION AND SHUTDOWN COOLING	7.03E+00
CCTKB-A-TK01A	CCW SURGE TANK TK01A FAILS CATASTROPHICALLY	7.00E+00
PADOY-C-PA06C04	FAILURE OF DIGITAL OUTPUT MODULE PA06C BRANCH 04	6.75E+00
PADOY-D-PA06C02	FAILURE OF DIGITAL OUTPUT MODULE PA06C BRANCH 02	6.75E+00
C-AFOP-CDP-IRCL-CSOP	COMBINED OPERATOR ACTION FOR AF OPERATION, CD SYSTEM OPERATION, IRWST COOLING AND CS OPERATION	6.73E+00
CCHEY01A-HE01A	CCW Hx. HE01A FAILS WHILE OPERATING	6.32E+00
CCHEY02A-HE02A	CCW Hx. HE02A FAILS WHILE OPERATING	6.32E+00
PGBSY2A-LC01C	BUS FAULT ON 480V LC LC01C	6.22E+00
PELXY-B-LX11B-P	FAILURE OF PRIMARY LOOP CONTROLLER OF 745-PE-LX11B	6.21E+00
PGXMY2A-TR01C	480V LC TRANSFORMER LC-TR01C FAULT	6.13E+00
PFBSY1A-SW01A	BUS FAULT ON 4.16KV SWGR SW01A	5.74E+00
PGBSY1A-LC01A	BUS FAULT ON 480V LC LC01A	5.74E+00

Table 19.1-34 (4 of 18)

EVENT	DESCRIPTION	RAW
DCBSY-C-MC01C	BUS FAULTS ON 1E 125VDC BUS MC01C	5.68E+00
PGXMY1A-TR01A	480V LC TRANSFORMER LC-TR01A FAULT	5.58E+00
IPINM-D-IN01D	CLASS 1E 120V AC INVERTER IN01D UNAVAILABLE DUE TO T&M	5.24E+00
DCBTM-D-BT01D	CLASS 1E 125V DC BATTERY BT01D UNAVAILABLE DUE TO T&M	5.23E+00
MSAVO-B-110	FAILS TO OPEN MS AFW TDP PP01A TBN STM. SUPPLY AOV 110	4.96E+00
PELXY-C-LX02C-P	FAILURE OF PRIMARY LOOP CONTROLLER OF 745-PE-LX02C	4.90E+00
ATAVO-C-009	FAILS TO OPEN AFW TDP PP01A TBN STM. ISOL AOV, 009	4.79E+00
DCBTM-C-BT01C	CLASS 1E 125V DC BATTERY BT01C UNAVAILABLE DUE TO T&M	4.69E+00
IPINM-C-IN01C	CLASS 1E 120V AC INVERTER IN01C UNAVAILABLE DUE TO T&M	4.68E+00
PHBSY1A-MC01A	BUS FAULT ON 480V MCC MC01A	4.53E+00
SICVWQ3-V569/1001/1002	3/4 CSP DISCH LINE 1001, 1002 AND SCP DISCH. LINE CV 569	4.52E+00
AFVVT1A-V1616	AFW TDP PP01A MINI FLOW MANUAL VALVE V1616 TRANSFER CLOSED	4.44E+00
AFVVT1A-V1013A	AFW TDP PP01A MINI FLOW MANUAL VALVE V1013A TRANSFER CLOSED	4.44E+00

Table 19.1-34 (5 of 18)

EVENT	DESCRIPTION	RAW
MSVVT-B-V1151	MS MANUAL VALVE V1151 FOR AFW TDP01A TRANSFER CLOSED	4.44E+00
AFVVT1A-V1006A	AFW TDP01A DISCH. MANUAL VALVE V1006A TRANSFER CLOSED	4.44E+00
AFVVT1A-V1002A	AFW SUCT. MANUAL VALVE V1002A TRANSFER CLOSED	4.44E+00
PELXY-C-LX04C-P	FAILURE OF PRIMARY LOOP CONTROLLER OF 745-PE-LX04C	4.40E+00
PEDOY-C-LX02C04	FAILURE OF DIGITAL OUTPUT MODULE 745-PE-LX02C BRANCH 04	4.37E+00
PEDOY-B-LX11B04	FAILURE OF DIGITAL OUTPUT MODULE 745-PE-LX11B BRANCH 04	4.37E+00
PELXY-D-LX02D-P	FAILURE OF PRIMARY LOOP CONTROLLER OF 745-PE-LX02D	4.32E+00
WOTKB-A-TK01A	ECW COMPRESSION TANK TK01A FAILS CATASTROPHICALLY	4.28E+00
WOTKB-A-TK02A	ECW AIR SEPARATOR TK02A FAILS CATASTROPHICALLY	4.28E+00
AFMVT1A-045	AFW ISOL. MOV V045 TRANSFER CLOSED	4.22E+00
PFHBC2A-SW01C-E2	FAILS TO CLOSE OF FEEDER BKR SW01C-E2 FROM AAC BUS SW03N TO 1E BUS SW01C	4.18E+00
NBHBC2A-SW03N-F2	FAILS TO CLOSE OF FEEDER BKR SW03N-F2 FROM AAC BUS SW03N TO 1E BUS SW01C	4.18E+00
SICVWQ3-V568/569/1002	3/4 CSP DISCH LINE 1002 AND SCP DISCH. LINE CV 568,569	4.10E+00

Table 19.1-34 (6 of 18)

EVENT	DESCRIPTION	RAW
SICVWQ3-V568/569/1001	3/4 CSP DISCH LINE 1001 AND SCP DISCH. LINE CV 568,569	4.10E+00
DCBCY-C-BC01C	CLASS 1E 125V DC BATT. CHARGER BC01C FAILS OPERATING	4.09E+00
MSEVC-D-MSIV014	SG2 MSIV 014 FAILS TO CLOSE	3.94E+00
MSEVC-C-MSIV013	SG2 MSIV 013 FAILS TO CLOSE	3.94E+00
PEDOY-C-LX04C04	FAILURE OF DIGITAL OUTPUT MODULE LX04C BRANCH 04	3.92E+00
CIILRTLINES	LEAK RATE TEST LINES FAIL TO ISOLATE (VQ-2024, 2014, 2016)	3.86E+00
CI-HATCH	HATCH FAILS TO ISOLATE	3.86E+00
MSEVC-C-MSIV011	SG1 MSIV 011 FAILS TO CLOSE	3.85E+00
MSEVC-D-MSIV012	SG1 MSIV 012 FAILS TO CLOSE	3.85E+00
PGBSY2B-LC01D	BUS FAULT ON 480V LC LC01D	3.80E+00
CCMVO-B-098	CS Hx. HE01A INLET MOV 098 FAILS TO OPEN	3.79E+00
CSMVO1B-004	CS ISOL. MOV 004 IN CS TR. B HX DISCH. PATH FAILS TO OPEN	3.79E+00
PFBSY2B-SW01D	BUS FAULT ON 4.16KV SWGR SW01D	3.79E+00
AFCVO1A-V1004A	FAILS TO OPEN AFW TDP01A DISCH. CHECK VALVE V1004A	3.77E+00
AFCVO1A-V1008A	FAILS TO OPEN AFW TDP01A DISCH. CHECK VALVE V1008A	3.77E+00

Table 19.1-34 (7 of 18)

EVENT	DESCRIPTION	RAW
ATCVO-C-V1020A	FAILS TO OPEN AFW TBN SYSTEM CHECK VALVE V1020A FOR AFW TDP01A	3.77E+00
AFCVO1A-V1014A	FAILS TO OPEN AFW TDP01A MINI FLOW CHECK VALVE V1014A	3.77E+00
PELXY-A-LX01A-P	FAILURE OF PRIMARY LOOP CONTROLLER OF 745-PE-LX01A	3.75E+00
PGXMY2B-TR01D	480V LC TRANSFORMER LC-TR01D FAULT	3.74E+00
DGDGM-B-DGB	DG 01B UNAVAILABLE DUE TO MAINTENANCE	3.74E+00
PAGXY-A-PM3-PA03A-P	FAILURE OF PRIMARY GROUP CONTROLLER OF 752-PA-PA03A	3.64E+00
CSMVO1A-003	CS ISOL. MOV 003 IN CS TRAIN A DISCH. PATH FAILS TO OPEN	3.62E+00
CCMVO-A-097	CS Hx. HE01A INLET MOV 097 FAILS TO OPEN	3.62E+00
PELXY-D-LX03D-P	FAILURE OF PRIMARY LOOP CONTROLLER OF 745-J-LX03D	3.57E+00
PEDOY-A-LX03A02	FAILURE OF DIGITAL OUTPUT MODULE LX03A BRANCH 02	3.55E+00
PELXY-A-LX03A-P	FAILURE OF PRIMARY LOOP CONTROLLER OF 745-PE-LX03A	3.55E+00
PEDOY-D-LX03D02	FAILURE OF DIGITAL OUTPUT MODULE LX03D BRANCH 02	3.54E+00
CVMVO-S-509	IRWST RETURN LINE MOV 509 FAILS TO OPEN ON DEMAND	3.54E+00
PODOY-M-LX2501	FAILS TO OPERATE DO MODULE LX25 BRANCH 01	3.54E+00

Table 19.1-40 (8 of 18)

EVENT	DESCRIPTION	RAW
POLXY-M-LX25-P	PRIMARY LOOP CONTROLLER LX25 FAILS TO RUN	3.54E+00
CVVVO-S-V649	BAMPS DISCHARGE VV 649 FAILS TO OPEN	3.54E+00
CVVVO-S-V126	BAMPS DISCHARGE VV 126 FAILS TO OPEN	3.54E+00
CVMVT-S-553	IRWST RETURN LINE MOV 553 FAILS TO REMAIN OPEN	3.54E+00
DEAVC-S-006	CTMT. ISOL. AOV DE-006 FAIL TO CLOSE	3.53E+00
PFHBO1B-SW01B-H2	FAILS TO OPEN OF PCB SW01B-H2 OF 4.16KV SWGR SW01B FROM UAT	3.52E+00
DCBSY-M-MC01M	BUS FAULT ON 125VDC BUS MC01M	3.51E+00
CVCVO-S-V189	IRWST RETURN LINE CV 189 FAILS TO OPEN	3.51E+00
IATKB-S-TK01	INSTRUMENT AIR SYSTEM TANKS TK01 LEAKAGE (EXTERNAL) / RUPTURE / BREAK S	3.51E+00
IATKB-S-TK02	INSTRUMENT AIR SYSTEM TANKS TK02 LEAKAGE (EXTERNAL) / RUPTURE / BREAK S	3.51E+00
DCBTT-D-BT01D	CLASS 1E 125V DC BATTERY BT01D FAILS BETWEEN TEST INTERVAL	3.45E+00
AFMPM2A-MDP02A	AFW MDP PP02A UNAVAILABLE DUE TO T/M	3.44E+00
NPBDY-S-IPB	IPB FAULT	3.38E+00
NPXOY-S-MTR	MAIN TRANSFORMER FAULT	3.37E+00
NPXHY-M-UAT01M	UNIT AUX XFMR TR01M FAILS WHILE OPERATING	3.37E+00

Table 19.1-34 (9 of 18)

EVENT	DESCRIPTION	RAW
NPXHY-N-UAT01N	UNIT AUX XFMR TR01N FAILS WHILE OPERATING	3.37E+00
VOHVM2A-HV33A	CUBICLE COOLER HV33A UNAVAILABLE DUE TO T&M	3.37E+00
DGDGL-B-DGB	DG B FAILS TO LOAD AND RUN DURING 1ST 1HR OF OPERATION	3.34E+00
PHBSY2B-MC01D	BUS FAULT ON 480V MCC MC01D	3.29E+00
VOHVR2A-HV33A	FAILS TO RUN OF MAFP ROOM A CUBICLE COOLER HV33A	3.28E+00
GWSVO-S-002	CTMT. ISOL. SOV GW-002 FAIL TO CLOSE	3.27E+00
AFMPS2A-MDP02A	FAILS TO START AFW MDP PP02A	3.26E+00
CSHEM2B-HE01B	CS HX HE01B FAILS DUE TO TEST/MAINTENANCE	3.25E+00
WTTKB-S-TK01	TGBCCW SURGE TANK TK01 LEAKAGE (EXTERNAL) / RUPTURE / BREAK	3.25E+00
DGDGS-B-DGB	FAILS TO START OF EMERGENCY DIESEL GENERATOR DG01B	3.25E+00
VOHVS2A-HV33A	FAILS TO START OF MAFP ROOM A CUBICLE COOLER HV33A	3.25E+00
CCVVT-B-V1212	CS Hx. HE01B OUTLET MANUAL VALVE V1212 TRANSFER CLOSED	3.19E+00
PELXY-B-LX05B-P	PRIMARY LOOP CONTROLLER LX05B-P FAILS TO RUN	3.19E+00
PELXY-C-LX03C-P	FAILURE OF PRIMARY LOOP CONTROLLERS 745-PE-LX03C	3.14E+00

Table 19.1-34 (10 of 18)

EVENT	DESCRIPTION	RAW
CSHEM2A-HE01A	CS HX HE01A FAILS DUE TO T&M	3.13E+00
AFSVI1A-0037	AFW TDP01A DISCH. MOD. VALVE 037 FAILS SPURIOUSLY CLOSED	3.12E+00
PEDOY-C-LX03C02	FAILURE OF DIGITAL OUTPUT MODULE LX03C BRANCH 02	3.09E+00
CCVVT-A-V1211	CS Hx. HE01A OUTLET MANUAL VALVE V1211 TRANSFER CLOSED	3.09E+00
DGSQA-B-LOADSQ	LOAD SEQUNCER A FAILS TO OPERATE	3.08E+00
CSMVT1B-002	MOV 001 IN CS HX 1 DISCH. PATH FAILS TO REMAIN OPEN	3.05E+00
DGDGM-D-DGD	DG 01D UNAVAILABLE DUE TO MAINTENANCE	3.04E+00
PELXY-A-LX05A-P	PRIMARY LOOP CONTROLLER LX05A FAILS TO RUN	2.98E+00
AFMPR2A-MDP02A	FAILS TO RUN AFW MDP PP02A	2.98E+00
CSMVT1A-001	MOV 001 IN CS HX 1 DISCH. PATH FAILS TO REMAIN OPEN	2.98E+00
PFHBO2B-SW01D-G2	FAILS TO OPEN OF PCB SW01D-G2 OF 4.16KV SWGR SW01D FROM UAT	2.97E+00
CSHEY2A-HE01A	CS HX 1 HE01A FAILS WHILE OPERATING	2.93E+00
CSCVO1A-V1007	CV V1007 IN CSS DISCH. LINE A FAILS TO OPEN	2.93E+00
CSHEY2B-HE01B	CS HX 2 HE01B FAILS WHILE OPERATING	2.92E+00
CSCVO1B-V1008	CV V1008 IN CSS DISCH. LINE B FAILS TO OPEN	2.92E+00

Table 19.1-34 (11 of 18)

EVENT	DESCRIPTION	RAW
DGDGL-D-DGD	DG D FAILS TO LOAD AND RUN DURING 1ST 1HR OF OPERATION	2.91E+00
DCBTY-D-BT01D	BAT. BT01D (125VDC) FAILS TO PROVIDE ADEQUATE OUTPUT	2.89E+00
DCBTT-C-BT01C	CLASS 1E 125V DC BATTERY BT01C FAILS BETWEEN TEST INTERVAL	2.89E+00
AFMPL2A-MDP02A	FAILS TO RUN FOR 1HR AFW MDP PP02A	2.89E+00
DGDGS-D-DGD	FAILS TO START OF EMERGENCY DIESEL GENERATOR DG01D	2.87E+00
AFVVT2A-V1005A	AFW MDP01A DISCH. MANUAL VALVE V1005A TRANSFER CLOSED	2.86E+00
AFVVT2A-V1001A	AFW MDP02A SUCT. MANUAL VALVE V1001A TRANSFER CLOSED	2.86E+00
AFVVT2A-V1011A	AFW MDP02A MINI FLOW LINE MANUAL VALVE V1011A TRANSFER CLOSED	2.86E+00
AFVVT2A-V1603	AFW MDP02A MINI FLOW LINE MANUAL VALVE V1603 TRANSFER CLOSED	2.86E+00
PHBSY2A-MC01C	BUS FAULT ON 480V MCC MC01C	2.86E+00
VDHVM-B-HV13B	CUBICLE COOLER HV13B UNAVAILABLE DUE TO T&M	2.82E+00
VDHVM-B-HV12B	CUBICLE COOLER HV12A UNAVAILABLE DUE TO T&M	2.82E+00
DGSQA-D-LOADSQ	LOAD SEQUNCER D FAILS TO OPERATE	2.81E+00
VDHVM-D-HV13D	CUBICLE COOLER HV13D UNAVAILABLE DUE TO T&M	2.79E+00

Table 19.1-34 (12 of 18)

EVENT	DESCRIPTION	RAW
VDHVM-D-HV12D	CUBICLE COOLER HV12D UNAVAILABLE DUE TO T&M	2.79E+00
VDHVL-D-HV13D	FAILS TO RUN EDG ROOM CUBICLE COOLER HV13D FOR 1HR	2.74E+00
VDHVL-D-HV12D	FAILS TO RUN EDG ROOM CUBICLE COOLER HV12D FOR 1HR	2.74E+00
VDHVR-D-HV12D	FAILS TO RUN EDG ROOM CUBICLE COOLER HV12D	2.74E+00
VDHVR-D-HV13D	FAILS TO RUN EDG ROOM CUBICLE COOLER HV13D	2.74E+00
DCBSY-D-MC01D	BUS FAULTS ON 1E 125VDC BUS MC01D	2.73E+00
CCMVO-D-182	CCW MOV 182 FOR EDG01D INLET FAILS TO OPEN	2.73E+00
VDHVS-D-HV12D	FAILS TO START EDG ROOM CUBICLE COOLER HV12D	2.72E+00
VDHVS-D-HV13D	FAILS TO START EDG ROOM CUBICLE COOLER HV13D	2.72E+00
C-RCD1-SCLT-IAOP	COMBINED OPERATOR ACTION FOR RCS COOLDOWN/DEPRESSURIZATION, SHUTTDOWN COOLING AND IA OPERATION	2.71E+00
PEDOY-A-LX01A04	FAILURE OF DIGITAL OUTPUT MODULE LX01A BRANCH 04	2.68E+00
PFHBO2A-SW01C-C2	FAILS TO OPEN OF PCB SW01C-C2 OF 4.16KV SWGR SW01C FROM UAT	2.66E+00
DGDGR-D-DGD	FAILS TO RUN OF EMERGENCY DIESEL GENERATOR DG01D	2.65E+00
VDHVL-B-HV13B	FAILS TO RUN EDG ROOM CUBICLE COOLER HV13B FOR 1HR	2.65E+00
VDHVL-B-HV12B	FAILS TO RUN EDG ROOM CUBICLE COOLER HV12B FOR 1HR	2.65E+00

Table 19.1-34 (13 of 18)

EVENT	DESCRIPTION	RAW
VDHVR-B-HV12B	FAILS TO RUN EDG ROOM CUBICLE COOLER HV12B	2.64E+00
VDHVR-B-HV13B	FAILS TO RUN EDG ROOM CUBICLE COOLER HV13B	2.64E+00
DGDGR-B-DGB	FAILS TO RUN OF EMERGENCY DIESEL GENERATOR DG01B	2.63E+00
CCMVO-B-192	CCW MOV 192 FOR EDG01B INLET FAILS TO OPEN	2.61E+00
VDHVS-B-HV13B	FAILS TO START EDG ROOM CUBICLE COOLER HV13B	2.56E+00
VDHVS-B-HV12B	FAILS TO START EDG ROOM CUBICLE COOLER HV12B	2.56E+00
IAFLP-A-FT03A	AIR PREFILTER FT03A PLUGGED	2.52E+00
IAFLP-A-FT04A	INSTRUMENT AIR SYSTEM AFTERFILTER FT04A PLUGGED IN TRAIN A	2.52E+00
IAADY-A-ADP1	AIR DRYER PACKAGE1 FAILS TO FLOW INSTRUMENT AIR	2.52E+00
DOVVT-D-V1015D	DIESEL FUEL OIL TRANSFER PUMP DISCH. VALVE V1015D FAILS TO REMAIN OPEN	2.49E+00
DOVVT-D-V1002D	DIESEL FUEL OIL TRANSFER PUMP SUCTION VALVE V1002D FAILS TO REMAIN OPEN	2.49E+00
DOVVT-D-V1010D	DIESEL FUEL OIL TRANSFER PUMP SUCTION VALVE V1010D FAILS TO REMAIN OPEN	2.49E+00
DOVVT-D-V4011D	DIESEL FUEL OIL TRANSFER PUMP DISCH. VALVE V4011D FAILS TO REMAIN OPEN	2.49E+00

Table 19.1-34 (14 of 18)

EVENT	DESCRIPTION	RAW
CCVVT-D-V1282	EDG01D OUTLET MANUAL VALVE V1282 TRANSFER CLOSED	2.49E+00
DOVVT-D-V1009D	DIESEL FUEL OIL TRANSFER PUMP SUCTION VALVE V1009D FAILS TO REMAIN OPEN	2.49E+00
AFMVT2A-043	AFW ISOL. MOV V043 TRANSFER CLOSED	2.49E+00
PFBSY1B-SW01B	BUS FAULT ON 4.16KV SWGR SW01B	2.45E+00
DGDGM-A-DGA	DG 01A UNAVAILABLE DUE TO MAINTENANCE	2.44E+00
CSMPM2B-PP01B	CS PUMP PP01B UNAVAILABLE DUE TO MAINTENANCE	2.42E+00
AFCVO2A-V1007A	FAILS TO OPEN AFW MDP02A DISCH. CHECK VALVE V1017A	2.40E+00
AFCVO2A-V1012A	FAILS TO OPEN AFW MDP02A MINI FLOW CHECK VALVE V1012A	2.40E+00
AFCVO2A-V1003A	FAILS TO OPEN AFW MDP02A DISCH. CHECK VALVE V1003A	2.40E+00
PEDOY-A-LX05A03	FAILURE OF DIGITAL OUTPUT MODULE LX05A BRANCH 03	2.39E+00
DGDGM-C-DGC	DG 01C UNAVAILABLE DUE TO MAINTENANCE	2.38E+00
DCBTY-C-BT01C	BAT. BT01C (125VDC) FAILS TO PROVIDE ADEQUATE OUTPUT	2.34E+00
PFHBO1A-SW01A-H2	FAILS TO OPEN OF PCB SW01A-H2 OF 4.16KV SWGR SW01A FROM UAT	2.34E+00

Table 19.1-34 (15 of 18)

EVENT	DESCRIPTION	RAW
IAAVO-S-1027	PRESSURE REDUCING VALVE 1027 FAILS TO MODULATE (OPEN)	2.33E+00
FWMPM-S-PP07	STARTUP FW PUMP PP07 UNAVAILABLE DUE TO T&M	2.31E+00
FWMPS-S-PP07	STARTUP FW PUMP PP07 FAILS TO START	2.30E+00
AFTPR1A-TDP01A	FAILS TO RUN AFW TDP PP01A	2.29E+00
FWMVO-S-093	STARTUP FW PUMP DISCH.MOV 093 FAILS TO OPEN	2.29E+00
FWVVT-S-V1025	STARTUP FW PUMP SUCTION VV 1025 TRANSFERS CLOSED	2.28E+00
SXMVR-A-MV072	LOSS OF SX DIV.II DUE TO THE MOV072 SPURIOUS OPEN (FLOW DIVERSION)	2.27E+00
SXMVR-A-MV071	LOSS OF SX DIV. I DUE TO THE MOV071 SPURIOUS CLOSURE	2.27E+00
PEDOY-B-LX05B04	FAILURE OF DIGITAL OUTPUT MODULE LX05B BRANCH 04	2.27E+00
WMVVT-S-V1700	WM MANUAL VALVE 1700 TRANFER CLOSED	2.26E+00
DGDGL-C-DGC	DG 01C FAILS TO LOAD AND RUN DURING 1ST 1HR OF OPERATION	2.26E+00
EFGXT-A-PM3-GC1	FAILURE OF CH. A GC-1 OUTPUT GC1-PM3	2.25E+00
PGBSY1B-LC01B	BUS FAULT ON 480V LC LC01B	2.25E+00
AXLTKD2-LS003A/004B	AFST A/B WATER LEVEL SWITCH LS003A/B FAILS TO OPERATE	2.23E+00

Table 19.1-34 (16 of 18)

EVENT	DESCRIPTION	RAW
NBBSY-M-SW01M	BUS FAULTS ON NON-1E 4.16KV SWGR SW01M	2.22E+00
NGBSY1M-LC10M	BUS FAULT ON 480V LC LC10M	2.22E+00
DGDGS-C-DGC	FAILS TO START OF EMERGENCY DIESEL GENERATOR DG01C	2.22E+00
NGXMY1M-TR10M	480V LC TRANSFORMER LC-TR10M FAULT	2.22E+00
AXCVO-S-V1600	FAILS TO OPEN CHECK VALVE V1600	2.21E+00
FWMPL-S-PP07	STARTUP FW PUMP PP07 FAILS TO RUN FOR 1HR	2.20E+00
WOCHM2B-CH02B	ECW CHILLER 02B TRAIN UNAVAILABLE DUE TO T&M	2.20E+00
POLXY-N-LX54-P	PRIMARY LOOP CONTROLLER LX54 FAILS TO RUN	2.19E+00
POLXY-N-LX58-P	PRIMARY LOOP CONTROLLER LX58 FAILS TO RUN	2.19E+00
PODOY-N-LX5802	FAILURE OF DIGITAL OUTPUT MODULE LX58 BRANCH 02	2.19E+00
PODOY-N-LX5402	FAILURE OF DIGITAL OUTPUT MODULE LX54 BRANCH 02	2.19E+00
FWMPR-S-PP07	STARTUP FW PUMP PP07 FAILS TO RUN	2.19E+00
NPBSY2N-SW02N	BUS FAULTS ON NON-1E 13.8KV SWGR SW02N	2.18E+00
NGBSY2N-LC05N	BUS FAULT ON 480V LC LC05N	2.18E+00
NBBSY-N-SW02N	BUS FAULTS ON NON-1E 4.16KV SWGR SW02N	2.18E+00
WOCHR1B-CH01B	ECW CHILLER 01B FAILS TO RUN FOR 24 HOURS	2.17E+00

Table 19.1-34 (17 of 18)

EVENT	DESCRIPTION	RAW
CSMPM2A-PP01A	CS PUMP 1 PP01A UNAVAILABLE DUE TO MAINTENANCE	2.16E+00
DGSQA-C-LOADSQ	LOAD SEQUNCER C FAILS TO OPERATE	2.16E+00
PHBSY2B-MC04D	BUS FAULT ON 480V MCC MC04D	2.16E+00
DOTKB-D-TK01D	DIEDEL FUEL OIL STORAGE TANK D TK01D FAILS CATASTROPHICALLY	2.16E+00
VDHVM-C-HV12C	CUBICLE COOLER HV12C UNAVAILABLE DUE TO T&M	2.16E+00
VDHVM-C-HV13C	CUBICLE COOLER HV13C UNAVAILABLE DUE TO T&M	2.16E+00
PGXMY1B-TR01B	480V LC TRANSFORMER LC-TR01B FAULT	2.15E+00
WOCHS2B-CH02B	ECW CHILLER CH02B FAILS TO START ON DEMAND	2.15E+00
AFTPS1A-TDP01A	FAILS TO START AFW TDP PP01A	2.13E+00
AFTPM1A-TDP01A	AFW TDP PP01A UNAVAILABLE DUE TO T/M	2.12E+00
EFCIT-A-GC1A	FAILURE OF CH. A GC-1 CI631 COMMUNICATION CARD	2.11E+00
VDHVL-C-HV12C	FAILS TO RUN EDG ROOM CUBICLE COOLER HV12C FOR 1HR	2.11E+00
VDHVL-C-HV13C	FAILS TO RUN EDG ROOM CUBICLE COOLER HV13C FOR 1HR	2.11E+00
VDHVR-C-HV12C	FAILS TO RUN EDG ROOM CUBICLE COOLER HV12C	2.11E+00
VDHVR-C-HV13C	FAILS TO RUN EDG ROOM CUBICLE COOLER HV13C	2.11E+00

Table 19.1-34 (18 of 18)

EVENT	DESCRIPTION	RAW
VDHVM-A-HV12A	CUBICLE COOLER HV12A UNAVAILABLE DUE TO T&M	2.11E+00
VDHVM-A-HV13A	CUBICLE COOLER HV13A UNAVAILABLE DUE TO T&M	2.11E+00
AFTPL1A-TDP01A	FAILS TO RUN AFW TDP PP01A FOR 1HR	2.10E+00
CCMVO-C-181	CCW MOV 181 FOR EDG01C INLET FAILS TO OPEN	2.10E+00
VDHVS-C-HV12C	FAILS TO START EDG ROOM CUBICLE COOLER HV12C	2.09E+00
VDHVS-C-HV13C	FAILS TO START EDG ROOM CUBICLE COOLER HV13C	2.09E+00
NGXMY2N-TR05N	480V LC TRANSFORMER LC-TR05N FAULT	2.08E+00
DGDGL-A-DGA	DG A FAILS TO LOAD AND RUN DURING 1ST 1HR OF OPERATION	2.07E+00
DCBCY-D-BC01D	CLASS 1E 125V DC BATT. CHARGER BC01D FAILS OPERATING	2.05E+00
NHBSY1M-MC03M	BUS FAULT ON NON-1E 480V MCC MC03M	2.04E+00
WMVVR-S-V1205	WM MANUAL VALVE 1205 TRANSFER CLOSED	2.04E+00
WMVVR-S-V1201A	MANUAL VALVE V1202B TRANSFER CLOSED	2.04E+00
RCPVC-B-202	POSRV V202 FAILS TO CLOSE (HARDWARE FAIL)	2.02E+00
RCPVC-C-201	POSRV V201 FAILS TO CLOSE (HARDWARE FAIL)	2.02E+00
RCPVC-D-203	POSRV V203 FAILS TO CLOSE (HARDWARE FAIL)	2.02E+00
RCPVC-A-200	POSRV V200 FAILS TO CLOSE (HARDWARE FAIL)	2.02E+00
WOMPM2B-PP02B	ECW PP02B TRAIN UNAVAILABLE DUE TO T&M	2.01E+00

Table 19.1-35 (1 of 4)

Level 2 Internal Events Key Basic Events by FV (LRF)

EVENT	DESCRIPTION	FV
SXFLP-S-FT0123AB	ESW DEBIS FILTER FT01A PLUGGED	5.70E-02
DCBTM-B-BT01B	CLASS 1E 125V DC BATTERY BT01B UNAVAILABLE DUE TO T&M	5.23E-02
DCBTM-A-BT01A	CLASS 1E 125V DC BATTERY BT01A UNAVAILABLE DUE TO T&M	4.82E-02
AFTPR1A-TDP01A	FAILS TO RUN AFW TDP PP01A	4.69E-02
CVDPR-S-PP03	FAILS TO RUN AUX. CHARGING PUMP PP03	4.44E-02
IPINM-B-IN01B	CLASS 1E 120V AC INVERTER IN01B UNAVAILABLE DUE TO T&M	4.34E-02
DGDGR-D-DGD	FAILS TO RUN OF EMERGENCY DIESEL GENERATOR DG01D	4.22E-02
DGDGR-B-DGB	FAILS TO RUN OF EMERGENCY DIESEL GENERATOR DG01B	4.16E-02
IPINM-A-IN01A	CLASS 1E 120V AC INVERTER IN01A UNAVAILABLE DUE TO T&M	4.07E-02
DGDGM-B-DGB	DG 01B UNAVAILABLE DUE TO MAINTENANCE	4.00E-02
AFMVO1A-045	AFW ISOL. MOV 045 FAILS TO OPEN FOR CYCLING OPERATION	3.34E-02
AFMVC1A-045	AFW ISOL. MOV 0045 FAILS TO CLOSE FOR CYCLING OPERATION	3.34E-02
AFTPR1B-TDP01B	FAILS TO RUN AFW TDP PP01B	3.00E-02
DGDGM-D-DGD	DG 01D UNAVAILABLE DUE TO MAINTENANCE	2.98E-02
AFMVC1B-046	AFW ISOL. MOV 046 FAILS TO CLOSE FOR CYCLING OPERATION	2.97E-02

Table 19.1-35 (2 of 4)

EVENT	DESCRIPTION	FV
AFMVO1B-046	AFW ISOL. MOV 046 FAILS TO OPEN FOR CYCLING OPERATION	2.97E-02
DATGR-S-AACTG	AAC GAS TURBINE GENERATOR FAILS TO RUN	2.94E-02
DGDGR-C-DGC	FAILS TO RUN OF EMERGENCY DIESEL GENERATOR DG01C	2.54E-02
WOCHM2B-CH02B	ECW CHILLER 02B TRAIN UNAVAILABLE DUE TO T&M	2.42E-02
PFHBC2A-SW01C-E2	FAILS TO CLOSE OF FEEDER BKR SW01C-E2 FROM AAC BUS SW03N TO 1E BUS SW01C	2.13E-02
NBHBC2A-SW03N-F2	FAILS TO CLOSE OF FEEDER BKR SW03N-F2 FROM AAC BUS SW03N TO 1E BUS SW01C	2.13E-02
DGDGM-A-DGA	DG 01A UNAVAILABLE DUE TO MAINTENANCE	2.10E-02
DGDGM-C-DGC	DG 01C UNAVAILABLE DUE TO MAINTENANCE	2.02E-02
PFHBO1B-SW01B-H2	FAILS TO OPEN OF PCB SW01B-H2 OF 4.16KV SWGR SW01B FROM UAT	1.69E-02
MSAVO-B-110	FAILS TO OPEN MS AFW TDP PP01A TBN STM. SUPPLY AOV 110	1.67E-02
SISPP-S-IRWST	FAILURE OF IRWST SUMP DUE TO PLUGGING	1.61E-02
WOCHS2B-CH02B	ECW CHILLER CH02B FAILS TO START ON DEMAND	1.51E-02
PFHBO2B-SW01D-G2	FAILS TO OPEN OF PCB SW01D-G2 OF 4.16KV SWGR SW01D FROM UAT	1.32E-02
WOCHM2A-CH02A	ECW CHILLER 02A TRAIN UNAVAILABLE DUE TO T&M	1.31E-02

Table 19.1-35 (3 of 4)

EVENT	DESCRIPTION	FV
SXMPM2B-PP02B	ESW PUMP PP02B UNAVAILABLE DUE TO T/M	1.30E-02
DCBTM-D-BT01D	CLASS 1E 125V DC BATTERY BT01D UNAVAILABLE DUE TO T&M	1.20E-02
IPINM-D-IN01D	CLASS 1E 120V AC INVERTER IN01D UNAVAILABLE DUE TO T&M	1.17E-02
PFHBO2A-SW01C-C2	FAILS TO OPEN OF PCB SW01C-C2 OF 4.16KV SWGR SW01C FROM UAT	1.11E-02
DCBTM-C-BT01C	CLASS 1E 125V DC BATTERY BT01C UNAVAILABLE DUE TO T&M	1.04E-02
IPINM-C-IN01C	CLASS 1E 120V AC INVERTER IN01C UNAVAILABLE DUE TO T&M	1.01E-02
CSMPM2B-PP01B	CS PUMP PP01B UNAVAILABLE DUE TO MAINTENANCE	1.01E-02
FWMPM-S-PP07	STARTUP FW PUMP PP07 UNAVAILABLE DUE TO T&M	9.13E-03
WOCHS1B-CH01B	ECW CHILLER CH01B FAILS TO START ON DEMAND	9.01E-03
PFHBO1A-SW01A-H2	FAILS TO OPEN OF PCB SW01A-H2 OF 4.16KV SWGR SW01A FROM UAT	9.01E-03
AFMPM2A-MDP02A	AFW MDP PP02A UNAVAILABLE DUE TO T/M	8.89E-03
DGDGL-B-DGB	DG B FAILS TO LOAD AND RUN DURING 1ST 1HR OF OPERATION	8.88E-03
DATGM-S-AACTG	AAC GTG UNAVAILABLE DUE TO MAINTENANCE	8.57E-03
DGDGR-A-DGA	FAILS TO RUN OF EMERGENCY DIESEL GENERATOR DG01A	8.53E-03

Table 19.1-35 (4 of 4)

EVENT	DESCRIPTION	FV
WOCHS1A-CH01A	ECW CHILLER CH01A FAILS TO START ON DEMAND	8.52E-03
CSMPM2A-PP01A	CS PUMP 1 PP01A UNAVAILABLE DUE TO MAINTENANCE	8.26E-03
WOCHS2A-CH02A	ECW CHILLER CH02A FAILS TO START ON DEMAND	7.92E-03
AFTPS1A-TDP01A	FAILS TO START AFW TDP PP01A	7.38E-03
DGDGL-D-DGD	DG D FAILS TO LOAD AND RUN DURING 1ST 1HR OF OPERATION	7.23E-03
WOMPM2B-PP02B	ECW PP02B TRAIN UNAVAILABLE DUE TO T&M	7.02E-03
DGDGS-B-DGB	FAILS TO START OF EMERGENCY DIESEL GENERATOR DG01B	6.52E-03
RAC-12H-GR	NON-RECOVERY PROBABILITY OF OFFSITE POWER WITHIN 9.5HR (GRID RELATED)	6.44E-03
SXMPM2A-PP02A	ESW PUMP PP02A UNAVAILABLE DUE TO T/M	6.31E-03
AFTPM1A-TDP01A	AFW TDP PP01A UNAVAILABLE DUE TO T/M	5.99E-03
DGDGS-D-DGD	FAILS TO START OF EMERGENCY DIESEL GENERATOR DG01D	5.43E-03
RAC-16H-GR	NON-RECOVERY PROBABILITY OF OFFSITE POWER WITHIN 16HR (GRID RELATED)	5.08E-03

Table 19.1-36 (1 of 13)

Level 2 Internal Events Key CCF Events by RAW (LRF)

EVENT	DESCRIPTION	RAW
RPRBWO8-TCBALL	CCF FAILURE OF ALL TRIP CIRCUIT BRAKER TCB	2.27E+05
RPRBWO4-TCB-AB1BD2	4/8 CCF OF TCB A-1, B-1, B-2 D-2	2.27E+05
RPRBWO4-TCB-AB1AC2	4/8 CCF OF TCB A-1, B-1, A-2, C-2	2.27E+05
RPRBWO4-TCB-CD1AC2	4/8 CCF OF TCB C-1, D-1, A-2 C-2	2.27E+05
RPRBWO4-TCB-CD1BD2	4/8 CCF OF TCB C-1, D-1, B-2, D-2	2.27E+05
DCBTWQ4-BT01ABCD	4/4 CCF OF 125V DC BATTERY BT01A/01B/01C/01D FAILS UPON DEMAND	6.79E+03
DCBTKQ4-BT01ABCD	4/4 CCF OF 125V DC BATTERY BT01A/01B/01C/01D FAILS TO RUN	6.68E+03
DCBTWQ3-BT01ABC	3/4 CCF OF 125V DC BATTERY BT01A/01B/01C FAILS UPON DEMAND	4.69E+03
DCBTWQ3-BT01ABD	3/4 CCF OF 125V DC BATTERY BT01A/01B/01D FAILS UPON DEMAND	4.67E+03
DCBTKQ3-BT01ABD	3/4 CCF OF 125V DC BATTERY BT01A/01B/01D FAILS TO RUN	4.44E+03
DCBTKQ3-BT01ABC	3/4 CCF OF 125V DC BATTERY BT01A/01B/01C FAILS TO RUN	4.42E+03
VGAHKQ4-AH01A/1B/2A/2B	4/4 RUNNING CCF OF ESW PUMP ROOM FAN AH01A/B, 02A/B	2.34E+03
SXMPKQ4-PP01A/B/2A/B	4/4 CCF OF ESW PUMPS PP01A/2A, PP01B/2B TO RUN	2.31E+03
SXAHKQ4-AH01A/02A/01B/02B	4/4 RUNNING CCF OF ESW COOLING TOWER FANS AH01A, 02A, 01B, 02B	2.28E+03
CCMPKQ4-PP01A/B/2A/B	4/4 CCF OF CCW PUMPS PP01A/1B/2A/2B (RUNNING)	2.25E+03

Table 19.1-36 (2 of 13)

EVENT	DESCRIPTION	RAW
DCBTWQ2-BT01AB	2/4 CCF OF 125V DC BATTERY BT01A/01B FAILS UPON DEMAND	1.85E+03
MSEVXQ2-012/13	CCF OF 2/4 MSIV 012,013	1.80E+03
MSEVXQ2-011/13	CCF OF 2/4 MSIV 011,013	1.80E+03
MSEVXQ2-011/14	CCF OF 2/4 MSIV 011,014	1.80E+03
MSEVXQ2-012/14	CCF OF 2/4 MSIV 012,014	1.80E+03
MSEVXQ4-011/12/13/14	CCF OF 4/4 MSIV 011,012,013,014	1.80E+03
MSEVXQ3-011/12/13	CCF OF 3/4 MSIV 011,012,013	1.80E+03
MSEVXQ3-011/12/14	CCF OF 3/4 MSIV 011,012,014	1.80E+03
MSEVXQ3-011/13/14	CCF OF 3/4 MSIV 011,013,014	1.80E+03
MSEVXQ3-012/13/14	CCF OF 3/4 MSIV 012,013,014	1.80E+03
DCBTKQ2-BT01AB	2/4 CCF OF 125V DC BATTERY BT01A/01B FAILS TO RUN	1.46E+03
CCMPWQ4-PP01A/2A/1B/2B	4/4 CCF OF CCW PUMPS PP01A/1B/2A/2B (DEMAND)	9.28E+02
SXMPWQ4-PP01A/B/2A/B	4/4 CCF OF ESW PUMPS PP01A/2A, PP01B/2B TO START	9.21E+02
PELXKQ4-LX05AB3CD	4/4 CCF OF LOOP CONTROLLER LX05A LX05B, LX03C ,LX03D	8.98E+02
PELXKQ4-LX06A04B03C03D	4/4 CCF OF LOOP CONTROLLER LX06A 12, LX04B 12, LX03C 12, LX03D 12	8.98E+02
RPBPWO8-BSALL	CCF ALL BISTABLE PROCESS MODULES	8.44E+02
PFHBWQ4-SW2OUAT	CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1B,1C,1D FAIL TO OPEN	8.00E+02
SXCVWQ4-V1001/2/3/4	4/4 CCF OF ESW PUMP DISCH. CHECK VALVE V1001/2/3/4 TO OPEN (DEMAND)	8.00E+02

Table 19.1-36 (3 of 13)

EVENT	DESCRIPTION	RAW
CCCVWQ4-V1001/2/3/4	4/4 CCF OF CCW PUMP DISCH. CHECK VALVE V1001/2/3/4 TO OPEN	8.00E+02
DCBTWQ3-BT01ACD	3/4 CCF OF 125V DC BATTERY BT01A/01C/01D FAILS UPON DEMAND	7.46E+02
DCBTWQ3-BT01BCD	3/4 CCF OF 125V DC BATTERY BT01B/01C/01D FAILS UPON DEMAND	7.03E+02
CCMVXO8-143-150	8/8 CCF(DEMAND) OF MOV 143,144,145,146,147,148,149,150 IN NON SAFETY LOAD LINE	6.99E+02
RPUVWQ8-UVALL	CCF OF ALL UNDER-VOLTAGE TRIP DEVICES	6.17E+02
RPIOWO8-ALL	CCF ALL LCL DIGITAL OUTPUT MODULES	6.17E+02
PELXKQ4-LX03ABCD	4/4 CCF OF LOOP CONTROLLER LX03A/B/C/D	6.09E+02
DCBTKQ3-BT01BCD	3/4 CCF OF 125V DC BATTERY BT01B/01C/01D FAILS TO RUN	5.45E+02
SICVWQ4-V157/158/159/160	4/4 CCF OF CS CV 157/158 SC CV 159/160	5.39E+02
SICVWQ4-V568/569/1001/1002	CCF TO OPEN CSP DISCH LINE 1001, 1002 AND SCP DISCH. LINE CV 568,569	5.39E+02
DCBTKQ3-BT01ACD	3/4 CCF OF 125V DC BATTERY BT01A/01C/01D FAILS TO RUN	5.31E+02
CSMVWD2-003/004	CCF(FTO) OF ISOL. MOV 003/004 IN CS TRS HX DISCH. PATH	4.43E+02
CCMVWD2-097/8	2/2 CCF OF CCW MOV 097/098 FOR CS HX. HE01A/B INLET	4.42E+02
SIMPWQ4-CSP1A/B/SCP1A/B	4/4 CCF OF CSP PP01A, PP01B AND SCP PP01A, PP01B TO START	4.42E+02
SIMPKQ4-CSP1A/B/SCP1A/B	4/4 CCF OF CSP PP01A, PP01B AND SCP PP01A , PP01B TO RUN	4.42E+02

Table 19.1-36 (4 of 13)

EVENT	DESCRIPTION	RAW
SIMPZQ4-CSP1A/B/SCP1A/B	4/4 CCF OF CSP PP01A, PP01B AND SCP PP01A , PP01B TO RUN FOR 1HR	4.42E+02
CSCVWD2-V1007/1008	CCF(FTO) OF CV V1007/1008 IN CS TRS. 1&2 DISCH. PATHS	4.42E+02
PELXKQ4-LX1A/1B/1C/1D	4/4 CCF OF LOOP CONTROLLER LX01A, LX01B, LX01C, LX01D	3.88E+02
SICVWO8-DVIS	8/8 CCF OF SI LINE CHECK VALVES 123,143,217,227,237,247,541,543 TO OPEN	3.88E+02
SICVWO4-V143/217/27/37	4/8 CCF OF SI LINE CHECK VALVES 143,217,227,237	3.70E+02
SICVWO4-V123/217/37/543	4/8 CCF OF SI LINE CHECK VALVES 123,217,237,543	3.70E+02
SICVWO4-V123/43/217/37	4/8 CCF OF SI LINE CHECK VALVES 123,143,217,237	3.70E+02
SICVWO4-V123/217/37/47	4/8 CCF OF SI LINE CHECK VALVES 123,217,237,247	3.70E+02
SICVWO4-V217/37/541/43	4/8 CCF OF SI LINE CHECK VALVES 217,237,541,543	3.70E+02
SICVWO4-V217/27/37/47	4/8 CCF OF SI LINE CHECK VALVES 217,227,237,247	3.70E+02
SICVWO4-V143/217/37/541	4/8 CCF OF SI LINE CHECK VALVES 143,217,237,541	3.70E+02
SICVWO4-V217/27/37/543	4/8 CCF OF SI LINE CHECK VALVES 217,227,237,543	3.70E+02
SICVWO4-V217/37/47/541	4/8 CCF OF SI LINE CHECK VALVES 217,237,247,541	3.70E+02
AFPVKQ4-TP01A/B/MP02A/B	4/4 CCF OF AFW TDP01A/B, MDP02A/B DUE TO THE VOLUTE FAIL TO RUN	3.41E+02
AFCVWO4-V1007AB/8AB	4/8 CCF OF AF DISCH. CHECK VALVE V1007AB/8AB FAIL TO OPEN	3.17E+02

Table 19.1-36 (5 of 13)

EVENT	DESCRIPTION	RAW
AFCVWO4-V1003AB/4AB	4/8 CCF OF AF DISCH. CHECK VALVE V1003AB/4AB FAIL TO OPEN	3.17E+02
AFCVWO8-V1003AB/4AB/7AB/8AB	8/8 CCF OF AF DISCH. CHECK VALVE V1003AB/4AB/7AB/8AB FAIL TO OPEN	3.14E+02
RPIRWO8-IRALL	CCF OF ALL INTERPOSING R/C Q1 2 3 & 4 ASSOCIATED WITH RPS	3.09E+02
SIMVWQ4-616/26/36/46	4/4 CCF OF DVI LINEMOV 616,626,636,646	3.06E+02
SIMPWQ4-PP02ABCD	4/4 CCF OF START FOR SI PUMP PP02A/B/C/D	3.06E+02
PELXKQ4-LX8A/12B/1C/1D	4/4 CCF OF LOOP CONTROLLER LX08A 12, LX12B 12, LX01C 12, LX01D 12	3.01E+02
SIMPKQ4-PP02ABCD	4/4 CCF OF RUN FOR SI PUMP PP02A/B/C/D	3.01E+02
SIMPZQ4-PP02ABCD	4/4 CCF OF RUN FOR SI PUMP PP02A/B/C/D FOR 1HR	3.01E+02
SICVWO8-SIPUMPS	8/8 CCF OF SI PUMP DISCHARGE LINE CV 113,133,404,405,434,446,540,542 TO OPEN	3.01E+02
SICVWD2-V100/01	2/2 CCF OF CV 100/101 IN TRAIN A&B IRWST RETURN LINES	2.89E+02
PELXKD2-LX09A11B	2/2 CCF OF LOOP CONTROLLER LX09A 12, LX11B 12	2.88E+02
SICVWO4-V404/05/46/542	4/8 CCF OF SI PUMP DISCHARGE LINE CV 404,405,446,542	2.82E+02
SICVWO4-V133/404/05/46	4/8 CCF OF SI PUMP DISCHARGE LINE CV 133,404,405,446	2.82E+02
SICVWO4-V404/05/34/46	4/8 CCF OF SI PUMP DISCHARGE LINE CV 404,405,434,446	2.82E+02
SICVWO4-V404/05/34/540	4/8 CCF OF SI PUMP DISCHARGE LINE CV 404,405,434,540	2.82E+02

Table 19.1-36 (6 of 13)

EVENT	DESCRIPTION	RAW
SICVWO4-V113/404/05/34	4/8 CCF OF SI PUMP DISCHARGE LINE CV 113,404,405,434	2.82E+02
SICVWO4-V113/33/404/05	4/8 CCF OF SI PUMP DISCHARGE LINE CV 113,133,404,405	2.82E+02
SICVWO4-V133/404/05/540	4/8 CCF OF SI PUMP DISCHARGE LINE CV 133,404,405,540	2.82E+02
SICVWO4-V113/404/05/542	4/8 CCF OF SI PUMP DISCHARGE LINE CV 113,404,405,542	2.82E+02
SICVWO4-V404/05/540/42	4/8 CCF OF SI PUMP DISCHARGE LINE CV 404,405,540,542	2.82E+02
RPIAWO8-ALL	CCF ALL ANLOG INPUT MODULES OF BISTABLE	2.79E+02
AFCVWQ4-V1012A/B/4A/B	4/4 CCF OF AFW MINI FLOW CHECK VALVE V1012A/B & 1014A/B FAIL TO OPEN	2.78E+02
SICVWQ4-V424/26/48/51	4/4 CCF OF SI LINE C/V 424,426,448,451 TO OPEN	2.71E+02
DCBTWQ2-BT01BC	2/4 CCF OF 125V DC BATTERY BT01B/01C FAILS UPON DEMAND	2.23E+02
DCBTWQ2-BT01AD	2/4 CCF OF 125V DC BATTERY BT01A/01D FAILS UPON DEMAND	2.22E+02
CCMVWQ3-191/2/182	3/4 CCF OF CCW MOV 191, 192, 182 FOR EDG01A/B/D INLET	2.11E+02
CCMVWQ3-191/2/181	3/4 CCF OF CCW MOV 191, 192, 181 FOR EDG01A/B/C INLET	2.05E+02
WOCHKQ4-CH01A/1B/2A/2B	RUNNING CCF OF ECW CHILLERS 1A/2A/1B/2B	1.99E+02
VOHVKQ4-HV32A/32B/31A/31B	4/4 CCF OF RUN FOR CUBICLE COOLER HV32A/32B/31A/31B	1.80E+02
WOMPKQ4-PP01A/2A/1B/2B	RUNNING CCF OF ECW PUMPS 1A/2A/1B/2B	1.64E+02
EFOTWO8-GCLCALL	CCF OF GC-LC FIBER OPTIC TRANSMITTER	1.61E+02

Table 19.1-36 (7 of 13)

EVENT	DESCRIPTION	RAW
EFORWO8-GCLCALL	CCF OF GC-LC FIBER OPTIC RECEIVER	1.61E+02
DGDGKQ4-DG01ABCD	4/4 CCF OF EDG 01A/01B/01C/01D FAIL TO RUN	1.61E+02
EFGXKO8-PA03ABCD	CCF OF GC TO LC PM646 MODULES	1.60E+02
VDHVZO8-HV12/13ABCD	8/8 CCF OF RUN FOR EDG ROOM CUBICLE COOLER HV12A, 12B, 12C, 12D 13A, 13B, 13C, 14D FOR 1HR	1.60E+02
VDHVKO8-HV12/13ABCD	8/8 CCF OF RUN FOR EDG ROOM CUBICLE COOLER HV12A, 12B, 12C, 12D 13A, 13B, 13C, 14D	1.60E+02
EFOTWO8-FOMCALL	CCF OF GC FIBER OPTIC TRANSMITTER	1.60E+02
EFORWO8-FOMCALL	CCF OF GC FIBER OPTIC RECEIVER	1.60E+02
EFGCWO8-PM12ABCD	CCF OF PM1 (PM646C) GC MODULE	1.59E+02
VDHVWO8-HV12/13ABCD	8/8 CCF OF START FOR EDG ROOM CUBICLE COOLER HV12A, 12B, 12C, 12D 13A, 13B, 13C, 14D	1.58E+02
DGSQWQ4-LOADSQABCD	4/4 CCF OF LOAD SEQUNCER A, B, C, D FAIL TO OPERATE	1.54E+02
DGDGWQ4-DG01ABCD	4/4 CCF OF EDG 01A/01B/01C/01D FAIL TO START	1.54E+02
EFCIKO8-PA03ABCD	CCF OF GC CI MODULES	1.53E+02
DOMPWO8-PP012ABCD	8/8 CCF OF DIESEL FUEL OIL TRANSFER PUMP 012ABCD FAIL TO START	1.53E+02
DGDGZQ4-DG01ABCD-LOAD	4/4 CCF OF EDG 01A/01B/01C/01D FAIL TO LOAD AND RUN DURING 1ST 1HOUR	1.53E+02
PALXKD2-PA06CD	2/2 CCF OF LOOP CONTROLLER PA06C, PA06D	1.53E+02

Table 19.1-36 (8 of 13)

EVENT	DESCRIPTION	RAW
CCMVWQ4-191/2/181/2	4/4 CCF OF CCW MOV 191, 192, 181, 182 FOR EDG01A/B/C/D INLET	1.50E+02
PFHBWQ3-SW2OUATABC	3/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1B,1C FAIL TO OPEN	1.47E+02
DOMPKO8-PP012ABCD	8/8 CCF OF DIESEL FUEL OIL TRANSFER PUMP 012ABCD FAIL TO RUN	1.46E+02
DOMPZO8-PP012ABCD	8/8 CCF OF DIESEL FUEL OIL TRANSFER PUMP 012ABCD FAIL TO RUN FOR 1HR	1.42E+02
DOCVWO8-V1005/7ABCD	8/8 CCF OF DIESEL FUEL OIL TRANSFER PUMP CV V1005/1007 A/B/C/D FAIL TO OPEN	1.27E+02
WOCHWQ4-CH01A/2A/1B/2B	DEMAND CCF OF ECW CHILLERS 1A/2A/1B/2B	1.25E+02
DCBTKQ2-BT01BC	2/4 CCF OF 125V DC BATTERY BT01B/01C FAILS TO RUN	1.23E+02
DCBTKQ2-BT01AD	2/4 CCF OF 125V DC BATTERY BT01A/01D FAILS TO RUN	1.23E+02
WOMPWQ4-PP01A/2A/1B/2B	DEMAND CCF OF ECW PUMPS 1A/2A/1B/2B	1.18E+02
VOHVWQ4-HV32A/32B/31A/31B	4/4 CCF OF START FOR CUBICLE COOLER HV32A/32B/31A/31B	1.13E+02
DGSQWQ3-LOADSQABD	3/4 CCF OF LOAD SEQUNCER A, B, D FAIL TO OPERATE	1.07E+02
DGDGWQ3-DG01ABD	3/4 CCF OF EDG 01A/01B/01D FAIL TO START	1.06E+02
DGDGZQ3-DG01ABD-LOAD	3/4 CCF OF EDG 01A/01B/01D FAIL TO LOAD AND RUN DURING 1ST 1HOUR	1.04E+02
WOLPKQ4-CH01A/2A/1B/2B	4/4 CCF OF ECW CH01A/2A/1B/2B (LP02A/3A/2B/3B) ACTUATING CIRCUIT (RUNNING)	1.03E+02

Table 19.1-36 (9 of 13)

EVENT	DESCRIPTION	RAW
PELXKQ4-LX01A2BCD	4/4 CCF OF LOOP CONTROLLER LX01A, LX02B, LX02C, LX02D	1.03E+02
DGSQWQ3-LOADSQABC	3/4 CCF OF LOAD SEQUNCER A, B, C FAIL TO OPERATE	1.01E+02
PFHBWQ3-SW2OUATACD	3/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1C,1D FAIL TO OPEN	1.00E+02
DGDGWQ3-DG01ABC	3/4 CCF OF EDG 01A/01B/01C FAIL TO START	1.00E+02
DGDGZQ3-DG01ABC-LOAD	3/4 CCF OF EDG 01A/01B/01C FAIL TO LOAD AND RUN DURING 1ST 1HOUR	9.79E+01
WOCVWQ4-V1010A/B/14A/B	CCF OF DISCH. CV 1010A/10B/14A/14B (FAIL TO OPEN)	8.58E+01
SXMPKQ3-PP01A/B/2B	3/4 CCF OF ESW PUMPS PP01A, PP01B, PP02B (RUNNING)	5.50E+01
AFPVKQ3-TP01A/MP02A/B	3/4 CCF OF AFW TDP01A, MDP02A/B DUE TO THE VOLUTE FAIL TO RUN	5.32E+01
PFHBWQ3-SW2OUATBCD	3/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01B,1C,1D FAIL TO OPEN	5.30E+01
WOCHKQ3-CH02A/1B/2B	RUNNING CCF OF ECW CHILLERS 2A/1B/2B	5.20E+01
AFPVKQ3-TP01A/B/MP02A	3/4 CCF OF AFW TDP01A/B, MDP02A DUE TO THE VOLUTE FAIL TO RUN	5.06E+01
SXMPWQ3-PP01A/B/2A	3/4 CCF OF ESW PUMPS PP01A, PP02A, PP01B (START)	4.97E+01
WOCHWQ3-CH02A/1B/2B	DEMAND CCF OF ECW CHILLERS 2A/1B/2B	4.74E+01
MSRVWO8-MSSV-ALL	20/20 CCF OF MSSVs 1301~1320 ON SG 1/2	4.74E+01

Table 19.1-36 (10 of 13)

EVENT	DESCRIPTION	RAW
WOCHWQ3-CH01A/2A/2B	DEMAND CCF OF ECW CHILLERS 1A/2A/2B	4.64E+01
WOCHKQ3-CH01A/2A/2B	RUNNING CCF OF ECW CHILLERS 1A/2A/2B	4.49E+01
CCMPWQ3-PP01A/2A/1B	3/4 CCF OF CCW PUMPS PP01A/2A/1B (DEMAND)	4.48E+01
PFHBWQ3-SW2OUATABD	3/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1B,1D FAIL TO OPEN	4.47E+01
SXMPKQ3-PP01A/B/2A	3/4 CCF OF ESW PUMPS PP01A, PP02A, PP01B (RUNNING)	4.45E+01
CCMPWQ3-PP01A/2A/2B	3/4 CCF OF CCW PUMPS PP01A/2A/2B (DEMAND)	4.31E+01
CCMVWQ3-192/181/2	3/4 CCF OF CCW MOV 192, 181, 182 FOR EDG01B/C/D INLET	4.30E+01
SXMPWQ3-PP01A/B/2B	3/4 CCF OF ESW PUMPS PP01A, PP01B, PP02B (START)	4.24E+01
CCMPKQ3-PP01A/B/2B	3/4 CCF OF CCW PUMPS PP01A/1B/2B (RUNNING)	4.16E+01
VGAHKQ3-AH01A/1B/2B	3/4 RUNNING CCF OF ESW PUMP ROOM FAN AH01A, 01B, 02B	4.15E+01
SXMPWQ3-PP01A/2A/B	3/4 CCF OF ESW PUMPS PP01A, PP02A, PP02B (START)	4.13E+01
WOMPWQ3-PP02A/1B/2B	DEMAND CCF OF ECW PUMPS 2A/1B/2B	4.03E+01
VOHVKQ3-HV32A/32B/31B	3/4 CCF OF RUN FOR CUBICLE COOLER HV32A/32B/31B	3.94E+01
WOMPWQ3-PP01A/2A/2B	DEMAND CCF OF ECW PUMPS 1A/2A/2B	3.94E+01
CCMPWQ3-PP01A/1B/2B	3/4 CCF OF CCW PUMPS PP01A/1B/2B (DEMAND)	3.66E+01
DGSQWQ3-LOADSQBCD	3/4 CCF OF LOAD SEQUNCER B, C, D FAIL TO OPERATE	3.66E+01
VOHVWQ3-HV32A/32B/31B	3/4 CCF OF START FOR CUBICLE COOLER HV32A/32B/31B	3.63E+01

Table 19.1-36 (11 of 13)

EVENT	DESCRIPTION	RAW
DGDGWQ3-DG01BCD	3/4 CCF OF EDG 01B/01C/01D FAIL TO START	3.61E+01
DGDGKQ3-DG01BCD	3/4 CCF OF EDG 01B/01C/01D FAIL TO RUN	3.56E+01
VOHVWQ3-HV32A/32B/31A	3/4 CCF START FOR OF CUBICLE COOLER HV32A/32B/31A	3.55E+01
WOMPKQ3-PP02A/1B/2B	RUNNING CCF OF ECW PUMPS 2A/1B/2B	3.51E+01
AFPVKQ2-TP01A/MP02A	2/4 CCF OF AFW TDP01A, MDP02A DUE TO THE VOLUTE FAIL TO RUN	3.49E+01
DGDGZQ3-DG01BCD-LOAD	3/4 CCF OF EDG 01B/01C/01D FAIL TO LOAD AND RUN DURING 1ST 1HOUR	3.38E+01
PELXKQ4-LX03CD4AB	4/4 CCF OF LOOP CONTROLLER LX03C/D/4A/4B	3.33E+01
SXAHKQ3-AH01A/01B/02B	3/4 RUNNING CCF OF ESW COOLING TOWER FANS AH01A, 01B, 02B	3.32E+01
DGDGKQ3-DG01ABD	3/4 CCF OF EDG 01A/01B/01D FAIL TO RUN	3.22E+01
VOHVKQ3-HV32A/32B/31A	3/4 CCF RUN FOR OF CUBICLE COOLER HV32A/32B/31A	3.17E+01
DGDGKQ3-DG01ACD	3/4 CCF OF EDG 01A/01C/01D FAIL TO RUN	3.16E+01
VGAHKQ3-AH01A/1B/2A	3/4 RUNNING CCF OF ESW PUMP ROOM FAN AH01A, 01B, 02A	3.13E+01
CCMPKQ3-PP01A/B/2A	3/4 CCF OF CCW PUMPS PP01A/1B/2A (RUNNING)	3.11E+01
CCMVWQ3-191/181/2	3/4 CCF OF CCW MOV 191, 181, 182 FOR EDG01A/C/D INLET	3.08E+01
VGAHKQ3-AH01A/2A/2B	3/4 RUNNING CCF OF ESW PUMP ROOM FAN AH01A, 02A, 02B	3.03E+01
WOCHKQ3-CH01A/1B/2B	RUNNING CCF OF ECW CHILLERS 1A/1B/2B	2.84E+01

Table 19.1-36 (12 of 13)

EVENT	DESCRIPTION	RAW
WOCHWQ3-CH01A/1B/2B	DEMAND CCF OF ECW CHILLERS 1A/1B/2B	2.73E+01
WOMPKQ3-PP01A/2A/2B	RUNNING CCF OF ECW PUMPS 1A/2A/2B	2.72E+01
WOLPKQ3-CH02A/1B/2B	3/4 CCF OF ECW CH02A/1B/2B (LP03A/2B/3B) ACTUATING CIRCUIT (RUNNING)	2.72E+01
PELXKQ3-LX01A2CD	3/4 CCF OF LOOP CONTROLLER LX01A, LX02C, LX02D	2.72E+01
PELXKQ3-LX02BCD	3/4 CCF OF LOOP CONTROLLER LX02B, LX02C, LX02D	2.72E+01
WOLPKQ3-CH01A/2A/2B	3/4 CCF OF ECW CH01A/2A/2B (LP02A/3A/3B) ACTUATING CIRCUIT (RUNNING)	2.72E+01
DGSQWQ3-LOADSQACD	3/4 CCF OF LOAD SEQUNCER A, C, D FAIL TO OPERATE	2.61E+01
DCBTWQ2-BT01BD	2/4 CCF OF 125V DC BATTERY BT01B/01D FAILS UPON DEMAND	2.61E+01
CCMPKQ3-PP01A/2A/B	3/4 CCF OF CCW PUMPS PP01A/2A/2B (RUNNING)	2.60E+01
DGDGWQ3-DG01ACD	3/4 CCF OF EDG 01A/01C/01D FAIL TO START	2.57E+01
AFCVWQ2-V1012A/4A	2/4 CCF OF AFW MINI FLOW CHECK VALVE V1012A/4A FAIL TO OPEN	2.57E+01
WOCHWQ3-CH01A/2A/1B	DEMAND CCF OF ECW CHILLERS 1A/2A/1B	2.55E+01
SXMPKQ3-PP01A/2A/B	3/4 CCF OF ESW PUMPS PP01A, PP02A, PP02B (RUNNING)	2.55E+01
DGDGKQ3-DG01ABC	3/4 CCF OF EDG 01A/01B/01C FAIL TO RUN	2.51E+01
AFCVWO2-V1007A/8A	2/8 CCF OF AF DISCH. CHECK VALVE V1007A/8A FAIL TO OPEN	2.38E+01

Table 19.1-36 (13 of 13)

EVENT	DESCRIPTION	RAW
AFCVWO2-V1003A/4A	2/8 CCF OF AF DISCH. CHECK VALVE V1003A/4A FAIL TO OPEN	2.38E+01
AFCVWO2-V1004A/7A	2/8 CCF OF AF DISCH. CHECK VALVE V1004A/7A FAIL TO OPEN	2.38E+01
AFCVWO2-V1003A/8A	2/8 CCF OF AF DISCH. CHECK VALVE V1003A/8A FAIL TO OPEN	2.38E+01
DGDGZQ3-DG01ACD-LOAD	3/4 CCF OF EDG 01A/01C/01D FAIL TO LOAD AND RUN DURING 1ST 1HOUR	2.34E+01
SXAHKQ3-AH01A/02A/01B	3/4 RUNNING CCF OF ESW COOLING TOWER FANS AH01A, 02A, 01B	2.29E+01
SXAHKQ3-AH01A/02A/02B	3/4 RUNNING CCF OF ESW COOLING TOWER FANS AH01A, 02A, 02B	2.21E+01
DCBTWQ2-BT01CD	2/4 CCF OF 125V DC BATTERY BT01C/01D FAILS UPON DEMAND	2.14E+01
AFPVKQ3-TP01B/MP02A/B	3/4 CCF OF AFW TDP01B, MDP02A/B DUE TO THE VOLUTE FAIL TO RUN	2.13E+01
AFPVKQ3-TP01A/B/MP02B	3/4 CCF OF AFW TDP01A/B, MDP02B DUE TO THE VOLUTE FAIL TO RUN	2.11E+01
WOCHKQ3-CH01A/2A/1B	RUNNING CCF OF ECW CHILLERS 1A/2A/1B	2.04E+01

(1) The cutoff threshold chosen for this table is based upon guidance presented in NEI 00-04 (Reference 51).

Table 19.1-37

Level 2 Internal Events Key CCF Events by FV (LRF)

EVENT	DESCRIPTION	FV
MSEVXQ2-012/13	CCF OF 2/4 MSIV 012,013	3.88E-02
MSEVXQ2-011/13	CCF OF 2/4 MSIV 011,013	3.88E-02
MSEVXQ2-011/14	CCF OF 2/4 MSIV 011,014	3.88E-02
MSEVXQ2-012/14	CCF OF 2/4 MSIV 012,014	3.88E-02
PFHBWQ4-SW2OUAT	CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1B,1C,1D FAIL TO OPEN	2.17E-02
MSEVXQ4-011/12/13/14	CCF OF 4/4 MSIV 011,012,013,014	2.01E-02
MSEVXQ3-011/12/13	CCF OF 3/4 MSIV 011,012,013	1.50E-02
MSEVXQ3-011/12/14	CCF OF 3/4 MSIV 011,012,014	1.50E-02
MSEVXQ3-011/13/14	CCF OF 3/4 MSIV 011,013,014	1.50E-02
MSEVXQ3-012/13/14	CCF OF 3/4 MSIV 012,013,014	1.50E-02
CSMVWD2-003/004	CCF(FTO) OF ISOL. MOV 003/004 IN CS TRS HX DISCH. PATH	1.34E-02
CCMVWD2-097/8	2/2 CCF OF CCW MOV 097/098 FOR CS HX. HE01A/B INLET	8.18E-03
AFTPKD2-TDP01A/B	2/2 CCF OF FOR AFW TDP PP01/A/B FAIL TO RUN	8.13E-03
DGDGKQ4-DG01ABCD	4/4 CCF OF EDG 01A/01B/01C/01D FAIL TO RUN	7.40E-03
WOCHWQ4-CH01A/2A/1B/2B	DEMAND CCF OF ECW CHILLERS 1A/2A/1B/2B	5.43E-03
VDHVZO8-HV12/13ABCD	8/8 CCF OF RUN FOR EDG ROOM CUBICLE COOLER HV12A, 12B, 12C, 12D 13A, 13B, 13C, 14D FOR 1HR	5.14E-03
VDHVKO8-HV12/13ABCD	8/8 CCF OF RUN FOR EDG ROOM CUBICLE COOLER HV12A, 12B, 12C, 12D 13A, 13B, 13C, 14D	5.00E-03

Table 19.1-38

Level 2 Internal Events Key Operator Actions by RAW (LRF)

EVENT	DESCRIPTION	RAW
HR-RCSCD1-ISOL	OPERATOR FAILS TO TAKE ACTION FOR SG COOLDOWN, RC DEPRESS AND SG ISOLATION	1.23E+01
RPOPU-S-LT1113ABCD	OPERATOR ERROR: COMMON MISCALIBRATION OF LO SG1 LVL.	9.89E+00
RCOPH-S-SDSE-FW	FAILURE OF SDS VALVES EARLY PHASE OPEN (1/4)	3.84E+00
CVOPH-S-IRWST	OPERATOR FAILS TO REFILL THE IRWST VIA CVCS	3.54E+00
RPOPU-S-PT102ABCD	OPERATOR ERROR: COMMON MISCALIBRATION OF LO PZR PR. CH.A/B/C/D	3.21E+00
AFOPH-S-ALT-LT	OPERATOR FAIL TO ALIGNE FOR SUPPLYING AN ALTERNATE SOURCE	2.96E+00
AFOPV-S-AFAS-FW	OPERATOR FAILS TO RECOVER AFAS	2.80E+00
FWOPH-S-ERY	OPERATOR FAILS TO ALINE STARTUP FEEDWATER PUMP PP07 (EARLY PHASE)	2.39E+00
CDOPH-S-ALIGN	OPERATOR FAILS TO START FOR PP01,02,03 BY HAND SWITCH	2.35E+00

Table 19.1-39

Level 2 Internal Events Key Operator Actions by FV (LRF)

EVENT	DESCRIPTION	FV
H-SDR-POSRV-3WAY	OPERATOR FAILS TO OPERATION (POSRV & 3-WAY V/V)	6.87E-02
PFOPH-S-UATBKR-LOCAL	OPERATOR FAILS TO RECOVER PCB FOR 1E 4.16KV SW01A,B,C,D AT LOCAL	2.99E-02
RCOPH-S-SDSE-FW	FAILURE OF SDS VALVES EARLY PHASE OPEN (1/4)	2.60E-02
HR-RCSCD1-ISOL	OPERATOR FAILS TO TAKE ACTION FOR SG COOLDOWN, RC DEPRESS AND SG ISOLATION	1.58E-02
HR-RCSCD2-CD	OPERATOR FAILS TO TAKE ACTION FOR SG COOLDOWN, RC DEPRESS WITH COMPLETE DEP.	1.58E-02
RCOPH-S-SDSE-FW-HD	FAILURE OF SDS VALVES EARLY PHASE OPEN (1/4) WITH HIGH DEP.	1.39E-02
CVOPH-S-RCPSEAL	OPERATOR FAILS TO RECOVER RCP SEAL COOLING (CCW CONNTECT. OR AUX. CHG PUMP)	1.11E-02
AFOPV-S-AFAS-FW	OPERATOR FAILS TO RECOVER AFAS	1.07E-02
WOOPH-A-1/2A	OPERATOR FAILS TO OPERATE ECW PUMPS PP01/2A	7.98E-03
FWOPH-S-ERY	OPERATOR FAILS TO ALINE STARTUP FEEDWATER PUMP PP07 (EARLY PHASE)	7.68E-03
WOOPH-B-1/2B	OPERATOR FAILS TO OPERATE ECW PUMPS PP01/2B	5.11E-03

Table 19.1-40

Results of LRF Sensitivity Analyses

Case No.	Description	Large Release %	Large, Early Release %	Total Cont. Fail %	Intact Containment %
Baseline	Baseline Results	8.4	5.3	13.8	86.2
R1	Failure of ECSBS	43.2	12.8	66.6	33.4
R2	Failure of Cavity Flood System	6.2	5.2	60.1	39.9
R3	Failure of PARs	9.7	6.6	15.2	84.8
R4	Failure of Rapid Depressurization	10.0	6.8	15.3	84.7
R5	Level 2 Operator Actions are always successful	8.0	4.8	12.6	87.4
R6	External Reactor Vessel Cooling is Credited	8.4	5.3	13.8	86.2
R7	Effects of Induced SGTR with “Pristine” SG tubes	5.8	2.6	11.4	88.6
R8	No Induced Hot Leg or Surge Line Failure before Vessel Failure	8.4	5.3	13.9	86.1

Table 19.1-41 (1 of 2)

Systems Considered for Seismic Equipment List

System	Description
Actuation	Reactor trip
	Safety Injection (SI)
	Containment isolation (CIS)
	Containment ventilation isolation (CVIS)
	Main steam line isolation
	Feedwater line isolation
	AFW start
	EDG start and load sequence
CRD	Control rods
RCS	Reactor Coolant System, including RC Pumps, SG, PZR, POSRVs
MS	Main Steam: MSSVs, MSIVs, MSADVs
AFW	Auxiliary Feedwater (MD and TD)
CVCS	Chemical Volume & Control System: Charging, pressurizer spray, and RCP seal injection
SC	Shutdown Cooling System
CS	Containment Spray
SI	Safety Injection
CCW	Component Cooling Water
ESW	Essential Service Water
ECW	Essential Chilled Water
EDG HVAC	Emergency Diesel Generator Area HVAC System
E-I&C HVAC	Electrical and I&C Equipment Areas HVAC System
ESW/CCW HVAC	ESW Pump Building / CCW HX Building HVAC System
Aux Bldg HVAC	Aux Building Controlled Area HVAC System
Aux Bldg HVAC	Aux Building Clean Area HVAC System

Table 19.1-41 (2 of 2)

System	Description
MCR	Main Control Room Consoles
ESF	ESF Cabinets
RX Trip	Reactor Trip Switchgear
DG Fuel	Diesel Fuel Oil Transfer System
EDG	Emergency Diesel Generators
EP	Electrical power

Table 19.1-42 (1 of 23)

Seismic Equipment List

No.	Equipment ID	Equipment Description	Floor Elevation	Building
1	1-431-M-RV01	Reactor Pressure Vessel	69'-156'	Containment
2	-	Reactor Vessel Internals	69'-156'	Containment
3	1-431-M-SG01	Steam Generator #1	114'-136'	Containment
4	1-431-M-SG02	Steam Generator #2	114'-136'	Containment
5	1-431-M-PZ01	Pressurizer	114'-156'	Containment
6	1-431-M-PP01A	Reactor Coolant Pump #1	114'-136'	Containment
7	1-431-M-PP01B	Reactor Coolant Pump #2	114'-136'	Containment
8	1-431-M-PP01C	Reactor Coolant Pump #3	114'-136'	Containment
9	1-431-M-PP01D	Reactor Coolant Pump #4	114'-136'	Containment
10	1-451-M-HE01	Regenerative Heat Exchanger	128'	Containment
11	1-451-M-PP01A	Charging Pumps #1	55'	A/B
12	1-451-M-PP01B	Charging Pumps #2	55'	A/B
13	1-451-M-HE02	Letdown Heat Exchanger	100'	Containment
14	1-441-M-TK01A	Safety Injection Tank 1	136'	Containment
15	1-441-M-TK01B	Safety Injection Tank 2	136'	Containment
16	1-441-M-TK01C	Safety Injection Tank 3	136'	Containment
17	1-441-M-TK01D	Safety Injection Tank 4	136'	Containment
18	1-521-V-0012	Main Steam Isolation Valve	137'	A/B

Table 19.1-42 (2 of 23)

No.	Equipment ID	Equipment Description	Floor Elevation	Building
19	1-521-V-0011	Main Steam Isolation Valve	137'	A/B
20	1-521-V-0014	Main Steam Isolation Valve	137'	A/B
21	1-521-V-0013	Main Steam Isolation Valve	137'	A/B
22	1-521-V-0102	Main Steam Atmospheric Dump Valve	137'	A/B
23	1-521-V-0101	Main Steam Atmospheric Dump Valve	137'	A/B
24	1-521-V-0104	Main Steam Atmospheric Dump Valve	137'	A/B
25	1-521-V-0103	Main Steam Atmospheric Dump Valve	137'	A/B
26	1-461-M-TK01A	Component Cooling Water Surge Tank	172'	A/B
27	1-461-M-TK01B	Component Cooling Water Surge Tank	172'	A/B
28	1-633-M-CH01A	Essential Chiller (includes Compressor Condenser, Evaporator, controls, RVs, Tanks)	78'	A/B
29	1-633-M-CH02A	Essential Chiller (includes Compressor Condenser, Evaporator, controls, RVs, Tanks)	78'	A/B
30	1-633-M-CH01B	Essential Chiller (includes Compressor Condenser, Evaporator, controls, RVs, Tanks)	78'	A/B
31	1-633-M-CH02B	Essential Chiller (includes Compressor Condenser, Evaporator, controls, RVs, Tanks)	78'	A/B
32	1-607-M-HV33A	MDAFW Pump Room Unit	78'	A/B
33	1-607-M-HV33B	MDAFW Pump Room Unit	78'	A/B
34	1-607-M-CW33A	MDAFW Pump Room Cubical Cooler Cooling Coil	78'	A/B
35	1-607-M-CW33B	MDAFW Pump Room Cubical Cooler Cooling Coil	78'	A/B

Table 19.1-42 (3 of 23)

No.	Equipment ID	Equipment Description	Floor Elevation	Building
36	1-431-V-0200	POSRV 200	136'	Containment
37	1-431-V-0201	POSRV 201	136'	Containment
38	1-431-V-0132	MOV Control Valves (POSRV 201)	136'	Containment
39	1-431-V-0133	MOV Control Valves (POSRV 201)	136'	Containment
40	1-431-V-0202	POSRV 202	136'	Containment
41	1-431-V-0134	MOV Control Valves (POSRV 202)	136'	Containment
42	1-431-V-0135	MOV Control Valves (POSRV 202)	136'	Containment
43	1-431-V-0203	POSRV 203	136'	Containment
44	1-431-V-0136	MOV Control Valves (POSRV 203)	136'	Containment
45	1-431-V-0137	MOV Control Valves (POSRV 203)	136'	Containment
46	1-441-M-PP02A	SI Pump 1	50'	A/B
47	1-441-M-PP01A	SDC Pump 1	50'	A/B
48	1-441-M-HE02A	SDC Miniflow HX 1	50'	A/B
49	1-441-M-HE01A	SDC HX 1	50'	A/B
50	1-441-M-PP02C	SI Pump 3	50'	A/B
51	1-441-M-PP02B	SI Pump 2	50'	A/B
52	1-441-M-PP01B	SDC Pump 2	50'	A/B
53	1-441-M-HE02B	SDC Miniflow HX 2	50'	A/B
54	1-441-M-HE01B	SDC HX 2	50'	A/B

Table 19.1-42 (4 of 23)

No.	Equipment ID	Equipment Description	Floor Elevation	Building
55	1-441-M-PP02D	SI Pump 4	50'	A/B
56	1-442-M-PP01A	Containment Spray Pump 1	50'	A/B
57	1-442-M-HE02A	CS Pump 1 Miniflow Heat Exchanger	50'	A/B
58	1-442-M-HE01A	Containment Spray Line 1 Heat Exchanger	55'	A/B
59	1-442-M-PP01B	Containment Spray Pump 2	50'	A/B
60	1-442-M-HE02B	CS Pump 2 Miniflow Heat Exchanger	50'	A/B
61	1-442-M-HE01B	Containment Spray Line 2 Heat Exchanger	55'	A/B
62	1-451-M-PP03	Auxiliary Charging Pump	55'	A/B
63	1-461-M-PP01A	CCW Pump 1A	55'	A/B
64	1-461-M-PP02A	CCW Pump 2A	55'	A/B
65	1-461-M-HE01A	CCW Heat Exchanger 1A	100'	CCW HX Building
66	1-461-M-HE02A	CCW Heat Exchanger 2A	100'	CCW HX Building
67	1-461-M-HE03A	CCW Heat Exchanger 3A	100'	CCW HX Building
68	1-461-M-PP03B	CCW Makeup Pump 3B	78'	A/B
69	1-461-M-PP01B	CCW Pump 1B	55'	A/B
70	1-461-M-PP02B	CCW Pump 2B	55'	A/B
71	1-461-M-HE01B	CCW Heat Exchanger 1B	100'	CCW HX Building
72	1-461-M-HE02B	CCW Heat Exchanger 2B	100'	CCW HX Building
73	1-461-M-HE03B	CCW Heat Exchanger 3B	100'	CCW HX Building

Table 19.1-42 (5 of 23)

No.	Equipment ID	Equipment Description	Floor Elevation	Building
74	1-451-M-HE04	Charging Pump Mini-Flow Heat Exchanger	55'	A/B
75	1-462-M-PP01A	ESW Pump 1A	69'	ESW Intake Structure
76	1-462-M-PP02A	ESW Pump 2A	69'	ESW Intake Structure
77	1-462-M-PP01B	ESW Pump 1B	69'	ESW Intake Structure
78	1-462-M-PP02B	ESW Pump 2B	69'	ESW Intake Structure
79	1-542-M-PP01A	Aux Feedwater Pump C (Turbine Driven)	78'	A/B
80	1-542-M-PP02A	Aux Feedwater Pump A (Motor Driven)	78'	A/B
81	1-542-M-PP02B	Aux Feedwater Pump B (Motor Driven)	78'	A/B
82	1-542-M-PP01B	Aux Feedwater Pump D (Turbine Driven)	78'	A/B
83	1-591-M-PP22A	Fuel Oil Feed Pump	100'	EDG Building
84	1-591-M-PP22B	Fuel Oil Feed Pump	100'	EDG Building
85	1-591-M-PP22C	Fuel Oil Feed Pump	100'	A/B
86	1-591-M-PP22D	Fuel Oil Feed Pump	100'	A/B
87	1-595-M-TK01A	Diesel Fuel Oil Storage Tank A	63'	EDG Building
88	1-595-M-PP02A	Diesel Fuel Oil Transfer Pump	63'	EDG Building
89	1-595-M-PP01A	Diesel Fuel Oil Transfer Pump	63'	EDG Building
90	1-595-M-TK01B	Diesel Fuel Oil Storage Tank B	63'	EDG Building

Table 19.1-42 (6 of 23)

No.	Equipment ID	Equipment Description	Floor Elevation	Building
91	1-595-M-PP02B	Diesel Fuel Oil Transfer Pump	63'	EDG Building
92	1-595-M-PP01B	Diesel Fuel Oil Transfer Pump	63'	EDG Building
93	1-595-M-TK01C	Diesel Fuel Oil Storage Tank C	65'	A/B
94	1-595-M-PP02C	Diesel Fuel Oil Transfer Pump	65'	A/B
95	1-595-M-PP01C	Diesel Fuel Oil Transfer Pump	65'	A/B
96	1-595-M-TK01D	Diesel Fuel Oil Storage Tank D	65'	A/B
97	1-595-M-PP02D	Diesel Fuel Oil Transfer Pump	65'	A/B
98	1-595-M-PP01D	Diesel Fuel Oil Transfer Pump	65'	A/B
99	1-595-M-TK02A	Diesel Fuel Oil Day Tank A	121'	EDG Building
100	1-595-M-TK02B	Diesel Fuel Oil Day Tank B	121'	EDG Building
101	1-595-M-TK02C	Diesel Fuel Oil Day Tank C	120'	A/B
102	1-595-M-TK02D	Diesel Fuel Oil Day Tank D	120'	A/B
103	1-601-V-Y0011A	Electro-Hydraulic Inlet Damper	172'	A/B
104	1-601-V-Y0011B	Electro-Hydraulic Inlet Damper	172'	A/B
105	1-602-M-HV12A	EDG Room Emergency Cubical Cooler	100'	EDG Building
106	1-602-M-AH02A	EDG Room Exhaust Fan/Motor	100'	EDG Building
107	1-602-M-HV13A	EDG Room Emergency Cubical Cooler	135'	EDG Building
108	1-602-M-HV12B	EDG Room Emergency Cubical Cooler	100'	EDG Building
109	1-602-M-AH12B	EDG Room Emergency Cubical Cooler Fan/Motor	100'	EDG Building

Table 19.1-42 (7 of 23)

No.	Equipment ID	Equipment Description	Floor Elevation	Building
110	1-602-M-AH02B	EDG Room Exhaust Fan/Motor	100'	EDG Building
111	1-602-M-HV13B	EDG Room Emergency Cubical Cooler	135'	EDG Building
112	1-602-M-AH13B	EDG Room Emergency Cubical Cooler Fan/Motor	135'	EDG Building
113	1-602-M-HV12C	EDG Room Emergency Cubical Cooler	100'	A/B
114	1-602-M-AH12C	EDG Room Emergency Cubical Cooler Fan/Motor	100'	A/B
115	1-602-M-AH02C	EDG Room Exhaust Fan/Motor	172'	A/B
116	1-602-M-HV13C	EDG Room Emergency Cubical Cooler	100'	A/B
117	1-602-M-AH13C	EDG Room Emergency Cubical Cooler Fan/Motor	100'	A/B
118	1-602-M-HV12D	EDG Room Emergency Cubical Cooler	100'	A/B
119	1-602-M-AH12D	EDG Room Emergency Cubical Cooler Fan/Motor	100'	A/B
120	1-602-M-AH02D	EDG Room Exhaust Fan/Motor	172'	A/B
121	1-602-M-HV13D	EDG Room Emergency Cubical Cooler	100'	A/B
122	1-602-M-AH13D	EDG Room Emergency Cubical Cooler Fan/Motor	100'	A/B
123	1-603-M-HV11A	ELECT. PENETRATION RM Cubical Cooler	137'	A/B
124	1-603-M-HV10A	480V CLASS-1E MCC 03C RM Cubical Cooler	137'	A/B
125	1-603-M-HV09A	ELECT. PENETRATION RM Cubical Cooler	120'	A/B
126	1-603-M-HV04A	CHANNEL C DC&IP EQUIP. RM Cubical Cooler	78'	A/B
127	1-603-M-HV02A	CLASS 1E LOADCENTER 01C RM Cubical Cooler	78'	A/B
128	1-603-M-HV01A	CLASS 1E SWITCHGEAR 01C RM Cubical Cooler	78'	A/B

Table 19.1-42 (8 of 23)

No.	Equipment ID	Equipment Description	Floor Elevation	Building
129	1-603-M-HV14A	480V CLASS-1E MCC 03A RM Cubical Cooler	137'	A/B
130	1-603-M-HV15A	480V CLASS-1E MCC 04A RM Cubical Cooler	137'	A/B
131	1-603-M-HV12A	PENETRATION MUX A RM Cubical Cooler	137'	A/B
132	1-603-M-HV13A	ELECTRICAL PENETRATION RM(A) Cubical Cooler	137'	A/B
133	1-603-M-AH21A	Class 1E Battery Rm Exhaust Fan	100'	A/B
134	1-603-M-HV03A	CHANNEL A DC&IP EQUIP. RM CC Cubical Cooler	78'	A/B
135	1-603-M-HV05A	MUX A RM Cubical Cooler	78'	A/B
136	1-603-M-HV07A	CLASS-1E SWITCHGEAR 01A RM Cubical Cooler	78'	A/B
137	1-603-M-AH21C	Class 1E Battery Rm Exhaust Fan	78'	A/B
138	1-603-M-HV11B	ELECT. PENETRATION RM (D) Cubical Cooler	137'	A/B
139	1-603-M-HV10B	480V CLASS-1E MCC 03D RM Cubical Cooler	137'	A/B
140	1-603-M-HV15B	480V CLASS-1E MCC 04B RM Cubical Cooler	137'	A/B
141	1-603-M-HV12B	PENETRATION MUX B RM Cubical Cooler	137'	A/B
142	1-603-M-HV13B	ELECTRICAL PENETRATION RM(B) Cubical Cooler	137'	A/B
143	1-603-M-HV18A	RSC RM Cubical Cooler	137'	A/B
144	1-603-M-HV18B	RSC RM Cubical Cooler	137'	A/B
145	1-603-M-HV09B	ELECT. PENETRATION (D) RM Cubical Cooler	120'	A/B

Table 19.1-42 (9 of 23)

No.	Equipment ID	Equipment Description	Floor Elevation	Building
146	1-603-M-HV14B	480V CLASS-1E MCC 03B RM Cubical Cooler	120'	A/B
147	1-603-M-HV06B	480V CLASS 1-E MCC 01B RM Cubical Cooler	100'	A/B
148	1-603-M-HV03B	CHANNEL B DC&IP EQUIP. RM Cubical Cooler	78'	A/B
149	1-603-M-HV05B	MUX B RM Cubical Cooler	78'	A/B
150	1-603-M-HV02B	CLASS 1E LOADCENTER 01D RM Cubical Cooler	78'	A/B
151	1-603-M-HV01B	CLASS 1E SWITCHGEAR 01D RM Cubical Cooler	78'	A/B
152	1-603-M-HV04B	CHANNEL D DC&IP EQUIP. RM Cubical Cooler	78'	A/B
153	1-603-M-HV07B	CLASS-1E SWITCHGEAR 01B RM Cubical Cooler	78'	A/B
154	1-603-M-HV17A	I&C Equipment Room (C) Cubical Cooler	157'	A/B
155	1-603-M-HV16A	I&C Equipment Room (A) Cubical Cooler	157'	A/B
156	1-603-M-HV17B	I&C Equipment Room (D) Cubical Cooler	157'	A/B
157	1-603-M-HV16B	I&C Equipment Room (B) Cubical Cooler	157'	A/B
158	1-605-M-AH03A	CCW Heat Exchanger Room Supply Fan	100'	CCW HX Building
159	1-605-M-AH03B	CCW Heat Exchanger Room Supply Fan	100'	CCW HX Building
160	1-605-M-AH01A	ESW Pump Room Supply Fan	90'	ESW Intake Structure
161	1-605-M-AH02A	ESW Pump Room Supply Fan	90'	ESW Intake Structure
162	1-605-M-AH01B	ESW Pump Room Supply Fan	90'	ESW Intake Structure

Table 19.1-42 (10 of 23)

No.	Equipment ID	Equipment Description	Floor Elevation	Building
163	1-605-M-AH02B	ESW Pump Room Supply Fan	90'	ESW Intake Structure
164	1-606-M-HV14A	CCW PUMP RM Aux Bld Controlled Area HVAC Fan/Motor	55'	A/B
165	1-606-M-HV15A	CS HEAT EXCHANGER RM Aux Bld Controlled Area HVAC Fan/Motor	55'	A/B
166	1-606-M-HV13A	CCW PUMP RM Aux Bld Controlled Area HVAC Fan/Motor	55'	A/B
167	1-606-M-HV16A	SC PUMP & MINIFLOW HEAT EXCHANGER RM Aux Bld Controlled Area HVAC Fan/Motor	50'	A/B
168	1-606-M-HV12A	SI PUMP RM Aux Bld Controlled Area HVAC Fan/Motor	50'	A/B
169	1-606-M-HV17A	SC HEAT EXCHANGER RM Aux Bld Controlled Area HVAC Fan/Motor	55'	A/B
170	1-606-M-HV10A	CS PUMP & MINIFLOW HEAT EXCHANGER RM Aux Bld Controlled Area HVAC Fan/Motor	50'	A/B
171	1-606-M-HV11A	SI PUMP RM Aux Bld Controlled Area HVAC Fan/Motor	50'	A/B
172	1-606-M-HV18A	CHARGING PUMP RM Aux Bld Controlled Area HVAC Fan/Motor	55'	A/B
173	1-606-M-HV10B	CS PUMP & MINIFLOW HEAT EXCHANGER RM Aux Bld Controlled Area HVAC Fan/Motor	50'	A/B
174	1-606-M-HV11B	SI PUMP RM Aux Bld Controlled Area HVAC Fan/Motor	50'	A/B

Table 19.1-42 (11 of 23)

No.	Equipment ID	Equipment Description	Floor Elevation	Building
175	1-606-M-HV12B	SI PUMP RM Aux Bld Controlled Area HVAC Fan/Motor	50'	A/B
176	1-606-M-HV21B	AUX. CHARGING PUMP RM Aux Bld Controlled Area HVAC Fan/Motor	55'	A/B
177	1-606-M-HV18B	CHARGING PUMP RM Aux Bld Controlled Area HVAC Fan/Motor	55'	A/B
178	1-606-M-HV15B	CS HEAT EXCHANGER RM Aux Bld Controlled Area HVAC Fan/Motor	55'	A/B
179	1-606-M-HV14B	CCW PUMP RM Aux Bld Controlled Area HVAC Fan/Motor	55'	A/B
180	1-606-M-HV13B	CCW PUMP RM Aux Bld Controlled Area HVAC Fan/Motor	55'	A/B
181	1-606-M-HV16B	SC PUMP & MINIFLOW HEAT EXCHANGER RM Aux Bld Controlled Area HVAC Fan/Motor	50'	A/B
182	1-606-M-HV17B	SC HEAT EXCHANGER RM Aux Bld Controlled Area HVAC Fan/Motor	55'	A/B
183	1-606-M-HV20A	Mechanical Pen Room HVAC Fan/Motor	120'	A/B
184	1-606-M-HV19A	Mechanical Pen Room HVAC Fan/Motor	100'	A/B
185	1-606-M-HV20B	Mechanical Pen Room HVAC Fan/Motor	120'	A/B
186	1-606-M-HV19B	Mechanical Pen Room HVAC Fan/Motor	100'	A/B
187	1-606-M-AU01A	Aux Building Controlled Area (I) Emergency Exhaust ACU	156'	A/B

Table 19.1-42 (12 of 23)

No.	Equipment ID	Equipment Description	Floor Elevation	Building
188	1-606-M-AH01A	Aux Building Controlled Area (I) Emergency Exhaust ACU Fan/Motor	156'	A/B
189	1-606-V-Y0002A	Aux Building Controlled Area (I) Emergency Exhaust ACU Inlet Damper	156'	A/B
190	1-606-V-Y0001A	Aux Building Controlled Area (I) Emergency Exhaust ACU Outlet Damper	156'	A/B
191	1-606-M-AU01B	Aux Building Controlled Area (II) Emergency Exhaust ACU	195'	A/B
192	1-606-M-AH01B	Aux Building Controlled Area (II) Emergency Exhaust ACU Fan/Motor	195'	A/B
193	1-606-V-Y0002B	Aux Building Controlled Area (II) Emergency Exhaust ACU Inlet Damper	195'	A/B
194	1-606-V-Y0001B	Aux Building Controlled Area (II) Emergency Exhaust ACU Outlet Damper	195'	A/B
195	1-633-M-PP01A	Essential Chilled Water Pump	78'	A/B
196	1-633-M-PP02A	Essential Chilled Water Pump	78'	A/B
197	1-607-M-CW31A	Ess. Chiller Room Cubical Cooler Cooling Coil	78'	A/B
198	1-607-M-CW32A	Ess. Chiller Room Cubical Cooler Cooling Coil	78'	A/B
199	1-603-M-CW02C	Class 1E Load Center 01C Room Cubical Cooler Cooling Coil	78'	A/B
200	1-603-M-CW01C	Class 1E Switchgear 01C Room Cubical Cooler Cooling Coil	78'	A/B

Table 19.1-42 (13 of 23)

No.	Equipment ID	Equipment Description	Floor Elevation	Building
201	1-603-M-CW03A	Channel A DC&IP Equip Room Cubical Cooler Cooling Coil	78'	A/B
202	1-603-M-CW04C	Channel C DC&IP Equip Room Cubical Cooler Cooling Coil	78'	A/B
203	1-606-M-CW10A	CS (Quad C) Mini Flow HX Room Cubical Cooler Cooling Coil	50'	A/B
204	1-606-M-CW15A	CS HX Room Cubical Cooler Cooling Coil	55'	A/B
205	1-606-M-CW14A	CCW Pump (Quad C) Room Cubical Cooler Cooling Coil	55'	A/B
206	1-606-M-CW11A	SI Pump (Quad C) Room Cubical Cooler Cooling Coil	50'	A/B
207	1-603-M-CW07A	Class 1E Switchgear 01A Room Cubical Cooler Cooling Coil	78'	A/B
208	1-607-M-CW33A	MDAFW Pump Room Cubical Cooler Cooling Coil	78'	A/B
209	1-603-M-CW06A	480V Class 1E MCC 01A Room Cubical Cooler Cooling Coil	100'-0"	A/B
210	1-606-M-CW17A	SC HX Room Cubical Cooler Cooling Coil	55'	A/B
211	1-606-M-CW16A	SC Pump & Mini Flow HX Room Cubical Cooler Cooling Coil	50'	A/B
212	1-606-M-CW13A	CCW Pump (Quad A) Room Cubical Cooler Cooling Coil	55'	A/B
213	1-606-M-CW12A	SI Pump (Quad A) Room Cubical Cooler Cooling Coil	55'	A/B

Table 19.1-42 (14 of 23)

No.	Equipment ID	Equipment Description	Floor Elevation	Building
214	1-601-M-CW01A	Control Room Supply AHU Cooling Coil	172'	A/B
215	1-603-M-CW17C	I&C Equip Room C Cubical Cooler Cooling Coil	157'	A/B
216	1-603-M-CW16A	I&C Equip Room A Cubical Cooler Cooling Coil	157'	A/B
217	1-603-M-CW10C	480V Class 1E MCC 03C Room Cubical Cooler Cooling Coil	137'	A/B
218	1-603-M-CW15A	480V Class 1E MCC 04A Room Cubical Cooler Cooling Coil	137'	A/B
219	1-603-M-CW14A	480V Class 1E MCC 03A Room Cubical Cooler Cooling Coil	137'	A/B
220	1-633-M-PP01B	Essential Chilled Water Pump	78'	A/B
221	1-633-M-PP02B	Essential Chilled Water Pump	78'	A/B
222	1-607-M-CW31B	Ess. Chiller Room Cubical Cooler Cooling Coil	78'	A/B
223	1-607-M-CW32B	Ess. Chiller Room Cubical Cooler Cooling Coil	78'	A/B
224	1-603-M-CW02D	Class 1E Load Center 01D Room Cubical Cooler Cooling Coil	78'	A/B
225	1-603-M-CW01D	Class 1E Switchgear 01D Room Cubical Cooler Cooling Coil	78'	A/B
226	1-603-M-CW03B	Channel B DC&IP Equip Room Cubical Cooler Cooling Coil	78'	A/B

Table 19.1-42 (15 of 23)

No.	Equipment ID	Equipment Description	Floor Elevation	Building
227	1-603-M-CW04D	Channel D DC&IP Equip Room Cubical Cooler Cooling Coil	78'	A/B
228	1-606-M-CW10B	CS (Quad D) Mini Flow HX Room Cubical Cooler Cooling Coil	50'	A/B
229	1-606-M-CW14B	CCW Pump (Quad D) Room Cubical Cooler Cooling Coil	55'	A/B
230	1-606-M-CW11B	SI Pump (Quad D) Room Cubical Cooler Cooling Coil	50'	A/B
231	1-603-M-CW06B	480V Class 1E MCC 01B Room Cubical Cooler Cooling Coil	100'	A/B
232	1-607-M-CW33B	MDAFW Pump Room Cubical Cooler Cooling Coil	78'	A/B
233	1-603-M-CW07B	Class 1E Switchgear 01B Room Cubical Cooler Cooling Coil	78'	A/B
234	1-606-M-CW16B	SC Pump & Mini Flow HX Room Cubical Cooler Cooling Coil	50'	A/B
235	1-606-M-CW17B	SC HX Room Cubical Cooler Cooling Coil	55'	A/B
236	1-606-M-CW13B	CCW Pump (Quad B) Room Cubical Cooler Cooling Coil	55'	A/B
237	1-606-M-CW12B	SI Pump (Quad B) Room Cubical Cooler Cooling Coil	50'	A/B
238	1-601-M-CW01B	Control Room Supply AHU Cooling Coil	172'	A/B
239	1-603-M-CW16B	I&C Equip Room B Cubical Cooler Cooling Coil	157'	A/B
240	1-603-M-CW17D	I&C Equip Room D Cubical Cooler Cooling Coil	157'	A/B

Table 19.1-42 (16 of 23)

No.	Equipment ID	Equipment Description	Floor Elevation	Building
241	1-603-M-CW18B	RSC Room Cubical Cooler Cooling Coil	137'	A/B
242	1-603-M-CW10D	480V Class 1E MCC 03D Room Cubical Cooler Cooling Coil	137'	A/B
243	1-603-M-CW15B	480V Class 1E MCC 04B Room Cubical Cooler Cooling Coil	137'	A/B
244	1-603-M-CW12B	Pent. MUX B Room Cubical Cooler Cooling Coil	137'	A/B
245	1-603-M-CW13B	Elect Penetration Room B Cubical Cooler Cooling Coil	137'	A/B
246	1-603-M-CW14B	480V Class 1E MCC 03B Room Cubical Cooler Cooling Coil	120'"	A/B
247	1-606-M-CW20B	Mechanical Penetration Room Cubical Cooler Cooling Coil	120'"	A/B
248	1-591-M-DG01A	4.16KV CLASS 1E DIESEL GENERATORS 1-591-M-DG01A	100'	EDG Building
249	1-591-M-DG01B	4.16KV CLASS 1E DIESEL GENERATORS 1-591-M-DG01B	100'	EDG Building
250	1-591-M-DG01C	4.16KV CLASS 1E DIESEL GENERATORS 1-591-M-DG01C	100'	A/B
251	1-591-M-DG01D	4.16KV CLASS 1E DIESEL GENERATORS 1-591-M-DG01D	100'	A/B
252	1-823-E-SW01A	CLASS 1E AB 4.16KV SWGR 01A	78'	A/B
253	1-823-E-SW01B	CLASS 1E AB 4.16KV SWGR 01B	78'	A/B

Table 19.1-42 (17 of 23)

No.	Equipment ID	Equipment Description	Floor Elevation	Building
254	1-823-E-SW01D	CLASS 1E AB 4.16KV SWGR 01D	78'	A/B
255	1-823-E-SW01C	CLASS 1E AB 4.16KV SWGR 01C	78'	A/B
256	1-825-E-LC01A	CLASS 1E AUX. BLDG 480V LOAD CENTER 1-825-E-LC01A	78'	A/B
257	1-825-E-LC01A-A3	CLASS 1E 480V LOAD CENTER 1A	78'	A/B
258	1-825-E-LC01B	CLASS 1E AUX. BLDG 480V LOAD CENTER 1-825-E-LC01B(DIV.II)	78'	A/B
259	1-825-E-LC01B-A3	CLASS 1E 480V LOAD CENTER 1B	78'	A/B
260	1-825-E-LC01C	CLASS 1E AUX. BLDG 480V LOAD CENTER 1-825-E-LC01C	78'	A/B
261	1-825-E-LC01D	CLASS 1E AUX. BLDG 480V LOAD CENTER 1-825-E-LC01D	78'	A/B
262	1-825-E-LC02	CLASS 1E AUX. BLDG 480V SWING LOAD CENTER 1-825-E-LC02	78'	A/B
263	1-825-E-TR01A	480V LOAD CENTER XFMR	78'	A/B
264	1-825-E-TR01B	480V LOAD CENTER XFMR	78'	A/B
265	1-825-E-TR01C	480V LOAD CENTER XFMR	78'	A/B
266	1-825-E-TR01D	480V LOAD CENTER XFMR	78'	A/B
267	1-827-E-MC01A	CLASS 1E AUX. BLDG 480V MCC 1-827-E-MC01A	100'	A/B
268	1-827-E-MC01A-3	120/208V AC DIST. PNL	100'	A/B

Table 19.1-42 (18 of 23)

No.	Equipment ID	Equipment Description	Floor Elevation	Building
269	1-827-E-MC01B	CLASS 1E AUX. BLDG 480V MCC 1-827-E-MC01B	100'	A/B
270	1-827-E-MC01B-3	120/208V AC DIST. PNL	100'	A/B
271	1-827-E-MC01C	CLASS 1E AUX. BLDG 480V MCC 1-827-E-MC01C	78'	A/B
272	1-827-E-MC01C-3	120/208V AC DIST. PNL	78'	A/B
273	1-827-E-MC01D	CLASS 1E AUX. BLDG 480V MCC 1-827-E-MC01D	78'	A/B
274	1-827-E-MC01D-3	120/208V AC DIST. PNL	78'	A/B
275	1-827-E-MC02A	CLASS 1E ESW STRUCTURE AREA 480V MCC 1-827-E-MC02A	100'	ESW Intake Structure
276	1-827-E-MC02A-3	120/208V AC DIST. PNL	100'	ESW Intake Structure
277	1-827-E-MC02B	CLASS 1E ESW STRUCTURE AREA 480V MCC 1-827-E-MC02B	100'	ESW Intake Structure
278	1-827-E-MC02B-3	120/208V AC DIST. PNL	100'	ESW Intake Structure
279	1-827-E-MC02C	CLASS 1E AUX. BLDG 480V MCC 1-827-E-MC02C	78'	A/B
280	1-827-E-MC02C-3	120/208V AC DIST. PNL	78'	A/B
281	1-827-E-MC02D	CLASS 1E AUX. BLDG 480V MCC 1-827-E-MC02D	78'	A/B

Table 19.1-42 (19 of 23)

No.	Equipment ID	Equipment Description	Floor Elevation	Building
282	1-827-E-MC02D-3	120/208V AC DIST. PNL	78'	A/B
283	1-827-E-MC03A	CLASS 1E AUX. BLDG 480V MCC 1-827-E-MC03A	137'	A/B
284	1-827-E-MC03A-3	120/208V AC DIST. PNL	137'	A/B
285	1-827-E-MC03B	CLASS 1E AUX. BLDG 480V MCC 1-827-E-MC03B	120'	A/B
286	1-827-E-MC03B-3	120/208V AC DIST. PNL	120'	A/B
287	1-827-E-MC03C	CLASS 1E AUX. BLDG 480V MCC 1-827-E-MC03C	137'	A/B
288	1-827-E-MC03C-3	120/208V AC DIST. PNL	137'	A/B
289	1-827-E-MC03D	CLASS 1E A/B 480V MCC 1-827-E-MC03D	137'	A/B
290	1-827-E-MC03D-3	120/208V AC DIST. PNL	137'	A/B
291	1-827-E-MC04A	CLASS 1E AUX. BLDG 480V MCC 1-827-E-MC04A	137'	A/B
292	1-827-E-MC04A-3	120/208V AC DIST. PNL	137'	A/B
293	1-827-E-MC04B	CLASS 1E AUX. BLDG 480V MCC 1-827-E-MC04B	137'	A/B
294	1-827-E-MC04B-3	120/208V AC DIST. PNL	137'	A/B
295	1-827-E-MC04C	CLASS 1E AUX. BLDG 480V MCC 1-827-E-MC04C	100'	A/B
296	1-827-E-MC04C-3	120/208V AC DIST. PNL	100'	A/B

Table 19.1-42 (20 of 23)

No.	Equipment ID	Equipment Description	Floor Elevation	Building
297	1-827-E-MC04D	CLASS 1E AUX. BLDG 480V MCC 1-827-E-MC04D(DIV. II)	100'	A/B
298	1-827-E-MC04D-3	120/208V AC DIST. PNL	100'	A/B
299	1-827-E-MC05A	CLASS 1E EDG-A BLDG 480V MCC 1-827-E-MC05A	100'	EDG Building
300	1-827-E-MC05A-3	120/208V AC DIST. PNL	100'	EDG Building
301	1-827-E-MC05B	CLASS 1E EDG-B BLDG 480V MCC 1-827-E-MC05B	100'	EDG Building
302	1-827-E-MC05B-3	120/208V AC DIST. PNL	100'	EDG Building
303	1-841-E-BC01A	CLASS 1E BATT. CHARGER (A/B)	78'	A/B
304	1-841-E-BC01B	CLASS 1E BATT. CHARGER (A/B)	78'	A/B
305	1-841-E-BC01C	CLASS 1E BATT. CHARGER (A/B)	78'	A/B
306	1-841-E-BC01D	CLASS 1E BATT. CHARGER (A/B)	78'	A/B
307	1-841-E-BC02A	CLASS 1E BATT. CHARGER (STAND-BY) (A/B)	78'	A/B
308	1-841-E-BC02B	CLASS 1E BATT. CHARGER (STAND-BY) (A/B)	78'	A/B
309	1-841-E-BC02C	CLASS 1E BATT. CHARGER (STAND-BY) (A/B)	78'	A/B
310	1-841-E-BC02D	CLASS 1E BATT. CHARGER (STAND-BY) (A/B)	78'	A/B

Table 19.1-42 (21 of 23)

No.	Equipment ID	Equipment Description	Floor Elevation	Building
311	1-841-E-BT01A	CLASS 1E 125V DC BATTERY	100'	A/B
312	1-841-E-BT01B	CLASS 1E 125V DC BATTERY	100'	A/B
313	1-841-E-BT01C	CLASS 1E 125V DC BATTERY	78'	A/B
314	1-841-E-BT01D	CLASS 1E 125V DC BATTERY	78'	A/B
315	1-841-E-MC01A	CLASS 1E 125V DC CONTROL CENTER (A/B)	78'	A/B
316	1-841-E-MC01A-C1	CLASS 1E 125V DC DISTR. PNL 1	78'	A/B
317	1-841-E-MC01A-D1	CLASS 1E 125V DC DISTR. PNL 2	78'	A/B
318	1-841-E-MC01B	CLASS 1E 125V DC CONTROL CENTER (A/B)	78'	A/B
319	1-841-E-MC01B-C1	CLASS 1E 125V DC DISTR. PNL 1	78'	A/B
320	1-841-E-MC01B-D1	CLASS 1E 125V DC DISTR. PNL 2	78'	A/B
321	1-841-E-MC01C	CLASS 1E 125V DC CONTROL CENTER (A/B)	78'	A/B
322	1-841-E-MC01C-D1	CLASS 1E 125V DC DISTR. PNL	78'	A/B
323	1-841-E-MC01D	CLASS 1E 125V DC CONTROL CENTER (A/B)	78'	A/B
324	1-841-E-MC01D-D1	CLASS 1E 125V DC DISTR. PNL 2	78'	A/B
325	1-842-E-IN01A	CLASS 1E CH.A 40KVA INVERTER (A/B)	78'	A/B
326	1-842-E-IN01B	CLASS 1E CH.A 40KVA INVERTER (A/B)	78'	A/B

Table 19.1-42 (22 of 23)

No.	Equipment ID	Equipment Description	Floor Elevation	Building
327	1-842-E-IN01C	CLASS 1E CH.C 40KVA INVERTER (A/B)	78'	A/B
328	1-842-E-IN01D	CLASS 1E CH.C 40KVA INVERTER (A/B)	78'	A/B
329	1-842-E-IN02A	CLASS 1E SAFETY MOV INVERTER (RC SYS ONLY)	78'	A/B
330	1-842-E-IN02B	CLASS 1E SAFETY MOV INVERTER 30KVA	78'	A/B
331	1-842-E-IN02C	CLASS 1E SAFETY MOV INVERTER	78'	A/B
332	1-842-E-IN02D	CLASS 1E SAFETY MOV INVERTER 30KVA	78'	A/B
333	1-842-E-TR01A	CLASS 1E REGULATING TRANSFORMER	78'	A/B
334	1-842-E-TR01B	CLASS 1E REGULATING TRANSFORMER	78'	A/B
335	1-842-E-TR01C	CLASS 1E REGULATING TRANSFORMER	78'	A/B
336	1-842-E-TR01D	CLASS 1E REGULATING TRANSFORMER	78'	A/B
337	1-752-J-PA03B	ESF-CCS Group Controller Cabinet (Ch.BE)	157'	A/B
338	1-752-J-PA03C	ESF-CCS Group Controller Cabinet (Ch.CE)	157'	A/B
339	1-752-J-PA03D	ESF-CCS Group Controller Cabinet (Ch.DE)	157'	A/B
340	1-752-J-PA03A	ESF-CCS Cabinet(A, B, C, D)	157'	A/B
341	1-752-J-PA14B	PPS Cabinet Ch.B-1	157'	A/B
342	1-752-J-PA14C	Plant Protection System Cabinet(C)	157'	A/B
343	1-752-J-PA14D	PPS Cabinet Ch.D-1	157'	A/B

Table 19.1-42 (23 of 23)

No.	Equipment ID	Equipment Description	Floor Elevation	Building
344	1-752-J-PA14A	Plant Protection System Cabinet(A)	157'	A/B
345	1-772-E-SW01C	Reactor Trip Switchgear	137'	A/B
346	1-772-E-SW01A	Reactor Trip Switchgear	137'	A/B
347	1-772-E-SW01D	Reactor Trip Switchgear	137'	A/B
348	1-772-E-SW01B	Reactor Trip Switchgear	137'	A/B
349	1-751-J-PM01	RO Console (Frame)	157'	A/B
350	1-751-J-PM02	TO/EO Console (Frame)	157'	A/B
351	1-751-J-PM03	SS Console (Frame)	157'	A/B
352	1-751-J-PM04	STA Console (Frame)	157'	A/B
353	1-751-J-PM05	Safety Console (Frame)	157'	A/B

Table 19.1-43 (1 of 13)

Seismic Fragility Analysis Results Summary

Component	Location	Freq (Hz)	Failure mode	Am	Br	Bu	HCLPF[1] (g)	Mean Failure Prob	Qualification Method	Remark
Reactor Pressure Vessel	Containment El. 69'~156'	11.28	Support	>1.5	-	-	S/O	-	Analysis	
Reactor Vessel Internal	Containment El. 69'~156'	11.28	Core Support Barrel	>1.5	-	-	S/O	-	Analysis	
Steam Generator	Containment El. 114'~136'06"	11.28	Upper Support	>1.5	-	-	S/O	-	Analysis	
Pressurizer	Containment El. 114'~156'	11.28	Shear Lug	>1.5	-	-	S/O	-	Analysis-	
Reactor Coolant Pumps	Containment El. 114'~136'06"	11.28	Upper Support	>1.5	-	-	S/O	-	Analysis	
Reactor Coolant System Piping	Containment	-	Generic	>1.5	-	-	S/O	-	Generic DB	

Table 19.1-43 (2 of 13)

Component	Location	Freq (Hz)	Failure mode	Am	Br	Bu	HCLPF(1) (g)	Mean Failure Prob	Qualification Method	Remark
Regenerative Heat Exchanger	Containment El. 114'	>33	Foundation bolt	>1.5	-	-	S/O	-	Analysis	
Charging Pumps	A/B El. 55'	-	Nozzle MB	>1.5	-	-	S/O	-	Analysis	
Letdown Heat Exchanger	Containment El. 100'	>33	Base Plate	>1.5	-	-	S/O	-	Analysis	
Auxiliary Charging Pump	A/B El. 55'	>33	Concrete Coning	>1.5	-	-	S/O	-	Analysis	
Safety Injection Tanks	Containment El. 136' 06"	11.86	Concrete Coning	1.79	0.42	0.36	0.50	1.46E-01	Analysis	
Shutdown Cooling Pumps	A/B El. 50'	>33	Concrete Coning	>1.5	-	-	S/O	-	Analysis	
Shutdown Cooling Heat Exchanger	A/B El. 50'	>33	Concrete Coning	>1.5*	-	-	S/O	-	Analysis	
SC Pump Miniflow Heat Exchanger	A/B El. 50'	>33	Saddle Plate	>1.5	-	-	S/O	-	Analysis	

Table 19.1-43 (3 of 13)

Component	Location	Freq (Hz)	Failure mode	Am	Br	Bu	HCLPF (g)	Mean Failure Prob	Qualification Method	Remark
Safety Injection Pump	A/B El. 50'	>33	Concrete Coning	>1.5	-	-	S/O	-	Analysis	
Containment Spray Pump	A/B El. 50'	>33	Concrete Coning	>1.5	-	-	S/O	-	Analysis	
CS Miniflow Hx	A/B El. 50'	7.1	Support	>1.5	-	-	S/O	-	Analysis	
Containment Spray Heat Exchanger	A/B El. 55'	7.43	Concrete Coning	>1.5	-	-	S/O	-	Analysis	
Main Steam Isolation Valves	A/B El. 137' 06"	-	Generic	>1.5	-	-	S/O	-	Generic DB	
Main Steam Atmospheric Valves(ADV)	A/B El. 137'06"	-	Generic	>1.5	-	-	S/O	-	Generic DB	
Main Steam Safety Valves	A/B El. 137'06"	-	Generic	>1.5	-	-	S/O	-	Generic DB	
AFW Pump-Motor Driven	A/B El. 78'	>33	Base Plate	>1.5	-	-	S/O	-	Test/Analysis	

Table 19.1-43 (4 of 13)

Component	Location	Freq (Hz)	Failure mode	Am	Br	Bu	HCLPF(1) (g)	Mean Failure Prob	Qualification Method	Remark
AFW Pump-Turbine Driven	A/B El. 78'	24.5	Foundation Bolt	>1.5	-	-	S/O	-	Analysis	
Emergency Diesel Generators	EDG(2) El. 100' A/B El. 100'	3	Fixation Bolt	1.82	0.42	0.37	0.50	1.42E-01	Analysis	
Emergency Diesel Fuel Oil transfer pump	EDG El. 65' A/B El. 63'	>33	Base Plate	>1.5	-	-	S/O	-	Test/Analysis	
Starting Air Tank	A/B El. 100'	>33	Skirt Support	>1.5	-	-	S/O	-	Analysis	
Diesel Fuel Oil Day Tank	EDG El. 121' A/B El. 120'	>33	Saddle Support	>1.5	-	-	S/O	-	Analysis	
Diesel Fuel Oil Storage Tank	EDG El. 63' A/B El. 65'	4.1	Concrete Coning	>1.5	-	-	S/O	-	Analysis	
Silencer	A/B El. 100'	0.58	Head Plate	>1.5	-	-	S/O	-	Analysis	
Air Intake Filter	A/B El. 109'	11.6	Body	>1.5	-	-	S/O	-	Analysis	
Lube Oil Water Hx	A/B El. 100'	5.84	Concrete Coning	>1.5	-	-	S/O	-	Analysis	

Table 19.1-43 (5 of 13)

Component	Location	Freq (Hz)	Failure mode	Am	Br	Bu	HCLPF(1) (g)	Mean Failure Prob	Qualification Method	Remark
Motor Driven Fuel Oil Feed Pump	EDG El. 100' A/B El. 100'	>33	Pump Pad	>1.5	-	-	S/O	-	Analysis	
Essential Service Water Pump	ESW Intake Structure El. 69'	18	Discharge Head Rib	>1.	-	-	S/O	-	Analysis	
CCW Heat Exchangers	CCW HX Building El. 100'	10.97	Head Plate	>1.5	-	-	S/O	-	Analysis	
CCW Pump	A/B El. 55'	>33	Pump Mt Bolt	>1.5	-	-	S/O	-	Analysis	
CCW Surge Tank	A/B El. 172'	>33	Concrete Coning	>1.5	-	-	S/O	-	Analysis	
Essential Chilled Water Pumps	A/B El. 78'	>33	Pump Mt Bolt	>1.5	-	-	S/O	-	Analysis	
Essential Chillers	A/B El. 78'	>33	Functional	>1.5	-	-	S/O	-	Test	
		>33	Concrete Coning	>1.5	-	-	S/O		Analysis	
ECW Compression Tank	A/B El. 172'	26.1	Vessel Shell	>1.5	-	-	S/O	-	Analysis	

Table 19.1-43 (6 of 13)

Component	Location	Freq (Hz)	Failure mode	Am	Br	Bu	HCLPF(1) (g)	Mean Failure Prob	Qualification Method	Remark
ECW Air Separator	A/B El. 78'	>33	Structure	>1.5	-	-	S/O	-	Analysis	
Essential Chilled Water System Control Panel	A/B El. 78'	15.12	Functional	>1.5	-	-	S/O	-	Test	
			Structural	>1.5	-	-	S/O			
AFWP Room Cubicle Cooler-MD	A/B El. 78'	8.67	Functional	>1.5	-	-	S/O	-	Test	
			Foundation Bolt	>1.5	-	-	S/O		Analysis	
CCWP Room Cubicle Cooler	A/B El. 55'	11.53	Functional	>1.5	-	-	S/O	-	Test	
			Drain Pipe	>1.5	-	-	S/O		Analysis	
SI Room Cubicle Cooler	A/B El. 50' A/B El. 55'	11.53	Functional	>1.5	-	-	S/O	-	Test	
			Drain Pipe	>1.5	-	-	S/O		Analysis	
SC Pump & Mini-flow Hx. Room Cubicle Cooler	A/B El. 50' A/B El. 55'	8.67	Functional	>1.5	-	-	S/O	-	Test	
			Fan/Motor Frame	>1.5	-	-	S/O		Analysis	

Table 19.1-43 (7 of 13)

Component	Location	Freq (Hz)	Failure mode	Am	Br	Bu	HCLPF(1) (g)	Mean Failure Prob	Qualification Method	Remark
Mech. Pen. Room Cubicle Cooler	A/B El. 100' A/B El. 120'	8.67	Functional	>1.5	-	-	S/O	-	Test	
			Fan/Motor Frame	>1.5	-	-	S/O		Analysis	
CS Pump Room Cubicle Cooler	A/B El. 50' A/B El. 55'	8.67	Functional	>1.5	-	-	S/O	-	Test	
			Fan/Motor Frame	>1.5	-	-	S/O		Analysis	
Aux Charging Pump Room Cubicle Cooler	A/B El. 55'	11.53	Functional	>1.5	-	-	S/O	-	Test	
			Outlet End Skin	>1.5	-	-	S/O		Analysis	
Charging Pump Room Cubicle Cooler	A/B El. 55'	11.53	Functional	>1.5	-	-	S/O	-	Test	
			Outlet End Skin	>1.5	-	-	S/O		Analysis	
Elect. Pen. Room Area Cubicle Cooler	A/B El. 120' A/B El. 137' 6"	8.67	Functional	>1.5	-	-	S/O	-	Test	
			Fan/Motor Frame	>1.5	-	-	S/O		Analysis	

Table 19.1-43 (8 of 13)

Component	Location	Freq (Hz)	Failure mode	Am	Br	Bu	HCLPF[(1)] (g)	Mean Failure Prob	Qualification Method	Remark
Essential Chiller & Pump Cubicle Cooler	A/B El. 78'	8.67	Functional	>1.5	-	-	S/O	-	Test	
			Fan/Motor Frame	>1.5	-	-	S/O		Analysis	
CCW Hx. Room Supply Fans	CCW Hx Building El. 100'	17	Functional	>1.5	-	-	S/O	-	Test	
	El. 126'		Structural	>1.5	-	-	S/O		Analysis	
ESW Pump Room Supply Fan	ESW Intake Structure El. 90'	>33	Functional	>1.5	-	-	S/O	-	Test	
			Structural	>1.5	-	-	S/O		Analysis	
EDG Room Emergency Exhaust Fan	EDG El. 100' A/B El. 172'	32	Functional	>1.5	-	-	S/O	-	Test	
			Structural	>1.5	-	-	S/O		Analysis	
Control Room Emergency Makeup ACU	A/B El. 172'	10.13	Functional	>1.5	-	-	S/O	-	Test	
			Housing	>1.5	-	-	S/O		Analysis	

Table 19.1-43 (9 of 13)

Component	Location	Freq (Hz)	Failure mode	Am	Br	Bu	HCLPF(1) (g)	Mean Failure Prob	Qualification Method	Remark
ESF-CCS GC Cabinet	A/B El. 156'	11.9	Functional	1.01	0.25	0.38	0.35		Test	There are no relays to affect the function of the panel.
			Structure	1.5	0.25	0.42	0.50	2.03E-01		
ESF-CCS LC Cabinet	A/B El. 156'	12.14	Functional	1.01	0.25	0.38	0.35	-	Test	
			Structural	1.5	0.25	0.42	0.50	2.03E-01		The structural failure is related to the parts and accessory which are listed in table below.
	A/B El. 137'6"	12.14	Functional	1.2	0.25	0.38	0.42	-		
			Structural	>1.5	-	-	S/O			
Plant Protection System Cabinet	A/B El. 156'	12.1	Functional	1.01	0.25	0.38	0.35	-	Test	There are no relays to affect the function of the panel.
			Structural	1.5	0.25	0.42	0.50	2.03E-01		The structural failure is related to the parts and accessory which are listed in table below.

Table 19.1-43 (10 of 13)

Component	Location	Freq (Hz)	Failure mode	Am	Br	Bu	HCLPF[1] (g)	Mean Failure Prob	Qualification Method	Remark
Reactor Trip Switchgear	A/B El. 137'6"	-	Functional	>1.5	-	-	S/O	-	Test	There are no relays to affect the function of the panel
			Structural	>1.5	-	-	S/O			
MCR Operator Consoles	A/B El. 156'	>33	Functional	1.13	0.36	0.44	0.3	-	Test	There are no relays to affect the function of the panel
			Structural	>1.5	-	-	S/O			
MCR Safety Consoles	A/B El. 156'	>33	Functional	-	-	-	-	-	Test	There are no relays to affect the function of the panel
			Structural	>1.5	-	-	S/O			
125V DC Battery Chargers	A/B El. 78'	13.94	Functional	1.12	0.21	0.36	0.44	-	Test	There are no relays to affect the function of the panel
			Structural	>1.5	-	-	S/O			
SI Inverter	A/B El. 78'	14.07	Functional	1.36	0.21	0.43	0.48	-	Test	There are no relays to affect the function of the pane
			Structural	>1.5	-	-	S/O			
20V AC Inverter(VBPSS)	A/B El. 78'	9	Functional	1.11	0.21	0.33	0.46	-	Test	There are no relays to affect the function of the panel
			Structural	>1.5	-	-	S/O			

Table 19.1-43 (11 of 13)

Component	Location	Freq (Hz)	Failure mode	Am	Br	Bu	HCLPF(1) (g)	Mean Failure Prob	Qualification Method	Remark
Regulating Transformer	A/B El. 78'	9.49	Functional	1.27	0.21	0.41	0.46	-	Test	There are no relays to affect the function of the panel
			Structural	>1.5	-	-	S/O			
125V DC Control Center	A/B El. 78'	6.4	Functional	>1.5	-	-	S/O	-	Test	Relay is the solid state which is inherently rugged
			Structural	>1.5	-	-	S/O			
4.16kV MCSG	A/B El. 78'	6.23	Functional	1.62	0.32	0.4	0.50	1.73E-01	Test	Lockout Relay which can be recoverable by operator
			Structural	>1.5	-	-	S/O			
480V Load Center	A/B El. 78'	7.7	Functional	>1.5	-	-	S/O	-	Test	Relay is the solid state which is inherently rugged
			Structural	>1.5	-	-	S/O			
480V MCC(Aux. EL.137'06")	A/B El. 137'06"	14.32	Functional	>1.5	-	-	S/O	-	Test	Relay is the solid state which is inherently rugged
			Structural	>1.5	-	-	S/O			
480V MCC(Aux. EL.120')	A/B El. 120'	14.32	Functional	>1.5	-	-	S/O	-	Test	Relay is the solid state which is inherently rugged
			Structural	>1.5	-	-	S/O			
480V MCC(Aux. EL.100')	A/B El. 100'	14.32	Functional	>1.5	-	-	S/O	-	Test	Relay is the solid state which is inherently rugged
			Structural	>1.5	-	-	S/O			

Table 19.1-43 (12 of 13)

Component	Location	Freq (Hz)	Failure mode	Am	Br	Bu	HCLPF(1) (g)	Mean Failure Prob	Qualification Method	Remark
480V MCC(Aux. EL.78')	A/B El. 78'	14.32	Functional	>1.5	-	-	S/O	-	Test	Relay is the solid state which is inherently rugged
			Structural	>1.5	-	-	S/O			
480V MCC(ESW IS EL.100')	ESW Intake Structure El. 90'	14.32	Functional	>1.5	-	-	S/O	-	Test	Relay is the solid state which is inherently rugged
			Structural	>1.5	-	-	S/O			
Batteries & Racks	A/B El. 78' A/B El. 100'	25.9	Functional	>1.5	-	-	S/O	-	Test	
			Structural	>1.5	-	-	S/O			
BOP Piping & Supports	various	-	Generic	>1.5	-	-	S/O	-	-	
HVAC Ducting & Dampers	various	-	Generic	>1.5	-	-	S/O	-	-	
Cable Trays & Supports	various	-	Generic	>1.5	-	-	S/O	-	-	
Motor Operated Valves	various	-	Generic	>1.5	-	-	S/O	-	-	
Air Operated Valves	various	-	Generic	>1.5	-	-	S/O	-	-	
Off-Site Power	various	-	Generic	1.7	0.3	0.45	0.50	1.63E-01	-	

Table 19.1-43 (13 of 13)

Component	Location	Freq (Hz)	Failure mode	Am	Br	Bu	HCLPF(1) (g)	Mean Failure Prob	Qualification Method	Remark
Electrical Conduit	various	-	Generic	>1.5	-	-	S/O	-	-	
Relief and Check Valves	various	-	Generic	>1.5	-	-	S/O	-	-	
Resistance Temperature Detectors	various	-	Generic	>1.5	-	-	S/O	-	-	
Pressure Transmitters	various	-	Generic	>1.5	-	-	S/O	-	-	
Containment Building Exterior Walls	-	-	-	1.418	0.153	0.308	0.66	1.55E-01	Analysis	
Containment Building Internal Structure	-	-	-	2.616	0.153	0.427	1.01	1.70E-02	Analysis	
Auxiliary Building	-	-	-	1.492	0.154	0.327	0.67	1.34E-01	Analysis	
Emergency Diesel Generator (EDG) Building	-	-	-	1.492	0.154	0.327	0.67	-	Assumption(3)	

(1) S/O: Screened Out

(2) EDG: EDG Building

(3) Assumed EDG Building fragilities are greater than the associated EDG equipment contained in the building.

Table 19.1-44 (1 of 18)

Dominant Contributors to the Plant HCLPF

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
1	2.03E-01	SEIS-ESF-RPS-FAIL SEISMIC	SEISMIC-INDUCED FAILURE OR ESF CCS CABINETS SEISMIC EVENT CAUSES LOOP	-	-
2	1.70E-01	SEIS-4KV-BUS-FAIL	SEISMIC-INDUCED FAILURE OF 4.16 KVAC SAFETY BUS	-	-
3	1.55E-01	SEIS-CTS-EX-FAIL SEISMIC	SEISMIC FAILURE OF THE CONTAINMENT EXTERIOR SEISMIC EVENT CAUSES LOOP	-	
4	1.34E-01	SEIS-AB-FAIL SEISMIC	SEISMIC FAILURE OF THE AUXILIARY BUILDING SEISMIC EVENT CAUSES LOOP	-	-
5	1.00E-01	SIOPH-S-LTC-SC	OPERATOR FAILS TO ALIGN SCS FOR LONG TERM COOLING	-	-

Table 19.1-44 (2 of 18)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
6	7.14E-02	SEIS-IP-INV-FAIL	SEISMIC FAILURE OF 120 VAC INVERTERS	-	-
		SEIS-IP-REGTR-FAIL	SEISMIC FAILURE OF 120 VAC REGULATING TRANSFORMERS		
		SEISMIC	SEISMIC EVENT CAUSES LOOP		
7	2.17E-02	S-LLOCA	SEISMICALLY-INDUCED LARGE OR MEDIUM LOCA	-	-
		SEIS-DG-AB-FAIL	SEISMIC-INDUCED FAILURE OF EDGS A AND B		
8	2.17E-02	S-LLOCA	SEISMICALLY-INDUCED LARGE OR MEDIUM LOCA	-	-
		SEIS-DG-CD-FAIL	SEISMIC-INDUCED FAILURE OF EDGS C AND D		
9	1.96E-02	SEIS-DG-AB-FAIL	SEISMIC-INDUCED FAILURE OF EDGS A AND B	-	-
		SEIS-DG-CD-FAIL	SEISMIC-INDUCED FAILURE OF EDGS C AND D		

Table 19.1-44 (3 of 18)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
10	1.70E-02	SEIS-CTS-IN-FAIL SEISMIC	CONTAINMENT INTERNAL STRUCTURE FAILS SEISMIC EVENT CAUSES LOOP	-	-
11	1.55E-02	S-LLOCA SIOPH-S-HLI	SEISMICALLY-INDUCED LARGE OR MEDIUM LOCA OPERATOR FAILS TO HOT LEG INJECTION	-	-
12	1.00E-02	AFOPH-S-ALT-LT RCOPH-S-SDSE-FW	TOTAL LOSS OF COMPONANT COOLING WATER OPERATOR FAILS TO RECOVER RCP SEAL COOLING (AUX. CHG PUMP)	-	-
13	1.00E-02	HR-RCSCD1-ISOL HR-RCSCD2	OPERATOR FAILS TO TAKE ACTION FOR SG COOLDOWN, RC DEPRESS AND SG ISOLATION OPERATOR FAILS TO TAKE ACTION FOR SG COOLDOWN, RC DEPRESS	-	-

Table 19.1-44 (4 of 18)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
14	4.28E-03	AFOPH-S-ALT-LT	OPERATOR FAIL TO ALIGNE FOR SUPPLYING AN ALTERNATE SOURCE	-	-
		SEIS-DG-AB-FAIL	SEISMIC-INDUCED FAILURE OF EDGS A AND B		
		SEIS-IP-INV-FAIL	SEISMIC FAILURE OF 120 VAC INVERTERS		
15	4.28E-03	SEIS-DG-CD-FAIL	SEISMIC-INDUCED FAILURE OF EDGS C AND D	-	-
		SEIS-IP-INV-FAIL	SEISMIC FAILURE OF 120 VAC INVERTERS		
		SIOPH-S-IRWSTCOOL	OPERATE FAILS TO COOL THE IRWST WATER		
16	4.28E-03	AFOPH-S-ALT-LT	OPERATOR FAIL TO ALIGNE FOR SUPPLYING AN ALTERNATE SOURCE	-	-
		SEIS-DG-CD-FAIL	SEISMIC-INDUCED FAILURE OF EDGS C AND D		
		SEIS-IP-INV-FAIL	SEISMIC FAILURE OF 120 VAC INVERTERS		

Table 19.1-44 (5 of 18)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
17	2.51E-03	AFTPR1A-TDP01A	FAILS TO RUN AFW TDP PP01A	-	-
		SEIS-IP-INV-FAIL	SEISMIC FAILURE OF 120 VAC INVERTERS		
		SEIS-IP-REGTR-FAIL	SEISMIC FAILURE OF 120 VAC REGULATING TRANSFORMERS		
18	1.40E-03	AFOPH-S-ALT-LT	OPERATOR FAIL TO ALIGNE FOR SUPPLYING AN ALTERNATE SOURCE	-	-
		SEIS-DG-CD-FAIL	SEISMIC-INDUCED FAILURE OF EDGS C AND D		
		SIOPH-S-IRWSTCOOL	OPERATE FAILS TO COOL THE IRWST WATER		
19	4.62E-04	AFTPS1A-TDP01A	FAILS TO START AFW TDP PP01A	-	-
		SEIS-IP-INV-FAIL	SEISMIC FAILURE OF 120 VAC INVERTERS		
		SEIS-IP-REGTR-FAIL	SEISMIC FAILURE OF 120 VAC REGULATING TRANSFORMERS		

Table 19.1-44 (6 of 18)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
20	4.28E-04	SEIS-DG-AB-FAIL	SEISMIC-INDUCED FAILURE OF EDGS A AND B	-	-
		SEIS-IP-INV-FAIL	SEISMIC FAILURE OF 120 VAC INVERTERS		
		WOOPH-A-1/2A	OPERATOR FAILS TO OPERATE ECW PUMPS PP01/2A		
		WOOPH-B-1/2B	OPERATOR FAILS TO OPERATE ECW PUMPS PP01/2B		
21	4.13E-04	AFMVO1B-046	AFW ISOL. MOV 046 FAILS TO OPEN FOR CYCLING OPERATION	-	-
		HR-RCSCD2	OPERATOR FAILS TO TAKE ACTION FOR SG COOLDOWN, RC DEPRESS		
		SEIS-IP-INV-FAIL	SEISMIC FAILURE OF 120 VAC INVERTERS		
		SEIS-IP-REGTR-FAIL	SEISMIC FAILURE OF 120 VAC REGULATING TRANSFORMERS		

Table 19.1-44 (7 of 18)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
22	4.13E-04	AFMVC1B-046	AFW ISOL. MOV 046 FAILS TO CLOSE FOR CYCLING OPERATION	-	-
		HR-RCSCD2	OPERATOR FAILS TO TAKE ACTION FOR SG COOLDOWN, RC DEPRESS		
		SEIS-IP-INV-FAIL	SEISMIC FAILURE OF 120 VAC INVERTERS		
		SEIS-IP-REGTR-FAIL	SEISMIC FAILURE OF 120 VAC REGULATING TRANSFORMERS		
23	3.80E-04	AFTPM1A-TDP01A	AFW TDP PP01A UNAVAILABLE DUE TO T/M	-	-
		SEIS-IP-INV-FAIL	SEISMIC FAILURE OF 120 VAC INVERTERS		
		SEIS-IP-REGTR-FAIL	SEISMIC FAILURE OF 120 VAC REGULATING TRANSFORMERS		
24	3.58E-04	SEIS-IP-INV-FAIL	SEISMIC FAILURE OF 120 VAC INVERTERS	-	-
		SEIS-IP-REGTR-FAIL	SEISMIC FAILURE OF 120 VAC REGULATING TRANSFORMERS		
		SIMPM1B-SCPP01B	SC PUMP PP01B FAILS DUE TO TEST/MAINTENANCE		

Table 19.1-44 (8 of 18)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
25	3.36E-04	PFLOOP-TRANS SEIS-DG-AB-FAIL	CONDITIONAL LOOP UPON TRANSIENTS SEISMIC-INDUCED FAILURE OF EDGS A AND B	-	-
26	3.15E-04	AFTPL1A-TDP01A SEIS-IP-INV-FAIL SEIS-IP-REGTR-FAIL	FAILS TO RUN AFW TDP PP01A FOR 1HR SEISMIC FAILURE OF 120 VAC INVERTERS SEISMIC FAILURE OF 120 VAC REGULATING TRANSFORMERS	-	-
27	3.00E-04	MSAVO-B-110 SEIS-IP-INV-FAIL SEIS-IP-REGTR-FAIL	FAILS TO OPEN MS AFW TDP PP01A TBN STM. SUPPLY AOV 110 SEISMIC FAILURE OF 120 VAC INVERTERS SEISMIC FAILURE OF 120 VAC REGULATING TRANSFORMERS	-	-

Table 19.1-44 (9 of 18)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
28	2.76E-04	DGDGR-B-DGB	FAILS TO RUN OF EMERGENCY DIESEL GENERATOR DG01B	-	-
		S-LLOCA	SEISMICALLY-INDUCED LARGE OR MEDIUM LOCA		
		SEIS-IP-INV-FAIL	SEISMIC FAILURE OF 120 VAC INVERTERS		
		SEIS-IP-REGTR-FAIL	SEISMIC FAILURE OF 120 VAC REGULATING TRANSFORMERS		
29	2.49E-04	DGDGR-B-DGB	FAILS TO RUN OF EMERGENCY DIESEL GENERATOR DG01B	-	-
		SEIS-DG-CD-FAIL	SEISMIC-INDUCED FAILURE OF EDGS C AND D		
		SEIS-IP-INV-FAIL	SEISMIC FAILURE OF 120 VAC INVERTERS		
		SEIS-IP-REGTR-FAIL	SEISMIC FAILURE OF 120 VAC REGULATING TRANSFORMERS		

Table 19.1-44 (10 of 18)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
30	2.40E-04	AFOPH-S-ALT-LT	OPERATOR FAIL TO ALIGNE FOR SUPPLYING AN ALTERNATE SOURCE	-	-
		PFLOOP-TRANS	CONDITIONAL LOOP UPON TRANSIENTS		
31	1.78E-04	AFOPH-S-ALT-LT	OPERATOR FAIL TO ALIGNE FOR SUPPLYING AN ALTERNATE SOURCE	-	-
		DGDGR-B-DGB	FAILS TO RUN OF EMERGENCY DIESEL GENERATOR DG01B		
		SEIS-IP-INV-FAIL	SEISMIC FAILURE OF 120 VAC INVERTERS		
		SEIS-IP-REGTR-FAIL	SEISMIC FAILURE OF 120 VAC REGULATING TRANSFORMERS		
32	1.78E-04	AFOPH-S-ALT-LT	OPERATOR FAIL TO ALIGNE FOR SUPPLYING AN ALTERNATE SOURCE	-	-
		DGDGR-D-DGD	FAILS TO RUN OF EMERGENCY DIESEL GENERATOR DG01D		
		SEIS-IP-INV-FAIL	SEISMIC FAILURE OF 120 VAC INVERTERS		
		SEIS-IP-REGTR-FAIL	SEISMIC FAILURE OF 120 VAC REGULATING TRANSFORMERS		

Table 19.1-44 (11 of 18)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
33	1.59E-04	DGDGM-B-DGB	DG 01B UNAVAILABLE DUE TO MAINTENANCE	-	-
		S-LLOCA	SEISMICALLY-INDUCED LARGE OR MEDIUM LOCA		
		SEIS-IP-INV-FAIL	SEISMIC FAILURE OF 120 VAC INVERTERS		
		SEIS-IP-REGTR-FAIL	SEISMIC FAILURE OF 120 VAC REGULATING TRANSFORMERS		
34	1.44E-04	DGDGM-B-DGB	DG 01B UNAVAILABLE DUE TO MAINTENANCE	-	-
		SEIS-DG-CD-FAIL	SEISMIC-INDUCED FAILURE OF EDGS C AND D		
		SEIS-IP-INV-FAIL	SEISMIC FAILURE OF 120 VAC INVERTERS		
		SEIS-IP-REGTR-FAIL	SEISMIC FAILURE OF 120 VAC REGULATING TRANSFORMERS		

Table 19.1-44 (12 of 18)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
35	1.43E-04	AFMVC1A-045	AFW ISOL. MOV 0045 FAILS TO CLOSE FOR CYCLING OPERATION	-	-
		AFMVO1B-046	AFW ISOL. MOV 046 FAILS TO OPEN FOR CYCLING OPERATION		
		SEIS-DG-AB-FAIL	SEISMIC-INDUCED FAILURE OF EDGS A AND B		
		SEIS-IP-INV-FAIL	SEISMIC FAILURE OF 120 VAC INVERTERS		
36	1.43E-04	AFMVO1A-045	AFW ISOL. MOV 045 FAILS TO OPEN FOR CYCLING OPERATION	-	-
		AFMVO1B-046	AFW ISOL. MOV 046 FAILS TO OPEN FOR CYCLING OPERATION		
		SEIS-DG-AB-FAIL	SEISMIC-INDUCED FAILURE OF EDGS A AND B		
		SEIS-IP-INV-FAIL	SEISMIC FAILURE OF 120 VAC INVERTERS		

Table 19.1-44 (13 of 18)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
37	1.43E-04	AFMVC1A-045	AFW ISOL. MOV 0045 FAILS TO CLOSE FOR CYCLING OPERATION	-	-
		AFMVC1B-046	AFW ISOL. MOV 046 FAILS TO CLOSE FOR CYCLING OPERATION		
		SEIS-DG-AB-FAIL	SEISMIC-INDUCED FAILURE OF EDGS A AND B		
		SEIS-IP-INV-FAIL	SEISMIC FAILURE OF 120 VAC INVERTERS		
38	1.43E-04	AFMVC1B-046	AFW ISOL. MOV 046 FAILS TO CLOSE FOR CYCLING OPERATION	-	-
		AFMVO1A-045	AFW ISOL. MOV 045 FAILS TO OPEN FOR CYCLING OPERATION		
		SEIS-DG-AB-FAIL	SEISMIC-INDUCED FAILURE OF EDGS A AND B		
		SEIS-IP-INV-FAIL	SEISMIC FAILURE OF 120 VAC INVERTERS		

Table 19.1-44 (14 of 18)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
39	1.30E-04	SEIS-DG-CD-FAIL	SEISMIC-INDUCED FAILURE OF EDGS C AND D	-	-
		SEIS-IP-INV-FAIL	SEISMIC FAILURE OF 120 VAC INVERTERS		
		SEIS-IP-REGTR-FAIL	SEISMIC FAILURE OF 120 VAC REGULATING TRANSFORMERS		
		WOCHS1B-CH01B	ECW CHILLER CH01B FAILS TO START ON DEMAND		
40	1.28E-04	AFMPM2A-MDP02A	AFW MDP PP02A UNAVAILABLE DUE TO T/M	-	-
		AFTPR1A-TDP01A	FAILS TO RUN AFW TDP PP01A		
41	1.07E-04	DGDGR-D-DGD	FAILS TO RUN OF EMERGENCY DIESEL GENERATOR DG01D		
		SEIS-DG-AB-FAIL	SEISMIC-INDUCED FAILURE OF EDGS A AND B		
		SEIS-IP-INV-FAIL	SEISMIC FAILURE OF 120 VAC INVERTERS		
		WOOPH-A-1/2A	OPERATOR FAILS TO OPERATE ECW PUMPS PP01/2A		

Table 19.1-44 (15 of 18)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
42	1.07E-04	DGDGR-C-DGC	FAILS TO RUN OF EMERGENCY DIESEL GENERATOR DG01C	-	-
		SEIS-DG-AB-FAIL	SEISMIC-INDUCED FAILURE OF EDGS A AND B		
		SEIS-IP-INV-FAIL	SEISMIC FAILURE OF 120 VAC INVERTERS		
		WOOPH-B-1/2B	OPERATOR FAILS TO OPERATE ECW PUMPS PP01/2B		
43	1.03E-04	PFLOOP-TRANS	CONDITIONAL LOOP UPON TRANSIENTS	-	-
		SEIS-DG-CD-FAIL	SEISMIC-INDUCED FAILURE OF EDGS C AND D		
		SEIS-IP-INV-FAIL	SEISMIC FAILURE OF 120 VAC INVERTERS		

Table 19.1-44 (16 of 18)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
44	1.03E-04	AFOPH-S-ALT-LT	OPERATOR FAIL TO ALIGNE FOR SUPPLYING AN ALTERNATE SOURCE	-	-
		DGDGM-B-DGB	DG 01B UNAVAILABLE DUE TO MAINTENANCE		
		SEIS-IP-INV-FAIL	SEISMIC FAILURE OF 120 VAC INVERTERS		
		SEIS-IP-REGTR-FAIL	SEISMIC FAILURE OF 120 VAC REGULATING TRANSFORMERS		
45	1.03E-04	AFOPH-S-ALT-LT	OPERATOR FAIL TO ALIGNE FOR SUPPLYING AN ALTERNATE SOURCE	-	-
		DGDGM-D-DGD	DG 01D UNAVAILABLE DUE TO MAINTENANCE		
		SEIS-IP-INV-FAIL	SEISMIC FAILURE OF 120 VAC INVERTERS		
		SEIS-IP-REGTR-FAIL	SEISMIC FAILURE OF 120 VAC REGULATING TRANSFORMERS		

Table 19.1-44 (17 of 18)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
46	9.62E-05	DGDGR-A-DGA	FAILS TO RUN OF EMERGENCY DIESEL GENERATOR DG01A	-	-
		DGDGR-B-DGB	FAILS TO RUN OF EMERGENCY DIESEL GENERATOR DG01B		
		S-LLOCA	SEISMICALLY-INDUCED LARGE OR MEDIUM LOCA		
47	9.62E-05	DGDGR-C-DGC	FAILS TO RUN OF EMERGENCY DIESEL GENERATOR DG01C	-	-
		DGDGR-D-DGD	FAILS TO RUN OF EMERGENCY DIESEL GENERATOR DG01D		
		S-LLOCA	SEISMICALLY-INDUCED LARGE OR MEDIUM LOCA		
48	8.71E-05	AFMVC1A-045	AFW ISOL. MOV 0045 FAILS TO CLOSE FOR CYCLING OPERATION	-	-
		AFTPR1B-TDP01B	FAILS TO RUN AFW TDP PP01B		
		SEIS-DG-AB-FAIL	SEISMIC-INDUCED FAILURE OF EDGS A AND B		
		SEIS-IP-INV-FAIL	SEISMIC FAILURE OF 120 VAC INVERTERS		

Table 19.1-44 (18 of 18)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
49	8.71E-05	AFMVO1A-045	AFW ISOL. MOV 045 FAILS TO OPEN FOR CYCLING OPERATION	-	-
		AFTPR1B-TDP01B	FAILS TO RUN AFW TDP PP01B		
		SEIS-DG-AB-FAIL	SEISMIC-INDUCED FAILURE OF EDGS A AND B		
		SEIS-IP-INV-FAIL	SEISMIC FAILURE OF 120 VAC INVERTERS		
50	8.71E-05	AFMVC1B-046	AFW ISOL. MOV 046 FAILS TO CLOSE FOR CYCLING OPERATION RE	-	-
		AFTPR1A-TDP01A	FAILS TO RUN AFW TDP PP01A		
		SEIS-DG-AB-FAIL	SEISMIC-INDUCED FAILURE OF EDGS A AND B		
		SEIS-IP-INV-FAIL	SEISMIC FAILURE OF 120 VAC INVERTERS		

Table 19.1-45 (1 of 22)

Fire Compartment Initiator Development and Screening

Fire Compartment	Description	Fire Induced Initiator	Results of Quant. Screening
F000-C01	REACTOR CONTAINMENT	SLOCA	DETAIL ANALYSIS
F157-AMCR	MAIN CONTROL ROOM	TLOMCR	DETAIL ANALYSIS
F000-TB	TURBINE GENERATOR AREA	LOOP	DETAIL ANALYSIS
F120-A05D	ELECTRICAL EQUIP. RM	GTRN	DETAIL ANALYSIS
F120-A11B	GENERAL ACCESS AREA-120' B	LODCB	DETAIL ANALYSIS
F122-T01	SWITCHGEAR RM	LOOP	DETAIL ANALYSIS
F137-A11C	ELECTRICAL PENETRATION RM (C)	GTRN	DETAIL ANALYSIS
F157-A01D	I & C EQUIP. RM	LODCB	DETAIL ANALYSIS
F157-A25C	I & C EQUIP. RM	GTRN	DETAIL ANALYSIS
F100-T15	SWITCHGEAR RM	LOOP	DETAIL ANALYSIS
F120-A15B	480V CLASS 1E MCC 03B RM	LODCB	DETAIL ANALYSIS
F000-ADGD	DIESEL GENERATOR ROOM	LODCB	DETAIL ANALYSIS
F157-ACPX	COMPUTER RM PACU RM	LODCB	DETAIL ANALYSIS
F078-AEEB	CLASS 1E SWITCHGEAR 01B ROOM	LODCB	DETAILED ANALYSIS
F078-A05D	CHANNEL-D DC & IP EQUIP RM	GTRN	DETAILED ANALYSIS
F067-T02	UNDERGROUND COMMON TUNNEL	LOOP	DETAILED ANALYSIS

Table 19.1-45 (2 of 22)

Fire Compartment	Description	Fire Induced Initiator	Results of Quant. Screening
F120-A05C	ELECTRICAL EQUIP. RM	PLOCCW	DETAILED ANALYSIS
F157-AMAX	MEETING ROOM	PLOCCW	DETAILED ANALYSIS
F100-AEEB	480V CLASS 1E MCC 01B ROOM	LODCB	DETAILED ANALYSIS
F078-A19B	CORRIDOR	LODCB	DETAILED ANALYSIS
FW-W00	CIRCULATING WATER PUMP BUILDING	LOCV	DETAILED ANALYSIS
F120-AMPB	MECHANICAL PENETRATION ROOM	GTRN	DETAILED ANALYSIS
F120-AGAD	GENERAL ACCESS AREA-120' D	LODCB	DETAILED ANALYSIS
F078-AGAD	GENERAL ACCESS AREA	LODCB	DETAILED ANALYSIS
F100-A08C	N1E DC & IP EQUIPMENT RM	PLOCCW	DETAILED ANALYSIS
F157-ATOC	TSC EQUIP. REPAIR & MAINT ROOM	PLOCCW	DETAILED ANALYSIS
F078-A52D	480V N1E MCC RM	LODCB	DETAILED ANALYSIS
F120-A14A	SG BLOWDOWN REGEN HX RM	PLOCCW	DETAILED ANALYSIS
F078-AGAC	GENERAL ACCESS AREA	PLOCCW	DETAILED ANALYSIS
F078-A25A	CLASS 1E SWITCHGEAR 01A RM	PLOCCW	DETAILED ANALYSIS
F100-A08D	N1E DC & IP EQUIPMENT RM	LODCB	DETAILED ANALYSIS
F000-ACVU	CVCS SYSTEM AREA	GTRN	DETAILED ANALYSIS
F055-AGAC	GENERAL ACCESS AREA-55' C	LODCA	DETAILED ANALYSIS

Table 19.1-45 (3 of 22)

Fire Compartment	Description	Fire Induced Initiator	Results of Quant. Screening
F120-A09C	ELECTRICAL PENETRATION ROOM (C)	PLOCCW	DETAILED ANALYSIS
F100-A06D	GENERAL ACCESS AREA	LOFW	DETAILED ANALYSIS
F100-A05D	ELECTRICAL EQUIPMENT RM	LOFW	DETAILED ANALYSIS
F137-A11D	ELECTRICAL PENETRATION RM (D)	GTRN	DETAILED ANALYSIS
F137-A01C	CABLE SPREADING AREA	LODCA	DETAILED ANALYSIS
F157-A17C	CORRIDOR	GTRN	SCREEN OUT
F055-AGAD	GENERAL ACCESS AREA-55' D	GTRN	SCREEN OUT
F120-A09D	ELECTRICAL PENETRATION ROOM (D)	LODCB	SCREEN OUT
F000-RW	ACCESS AREA	GTRN	SCREEN OUT
F078-A03D	CLASS 1E LOADCENTER 01D RM	GTRN	SCREEN OUT
FK-K02	ESW STRUCTURE "B" BUILDING	GTRN	SCREEN OUT
F137-AEPA	ELECTRICAL PENETRATION ROOM (A)	GTRN	SCREEN OUT
F000-ADGC	DIESEL GENERATOR ROOM	PLOCCW	SCREEN OUT
F137-A05D	PCS RM	LOFW	SCREEN OUT
FD-D01A	CCW HEAT EXCHANGER "A" BUILDING	GTRN	SCREEN OUT
FD-D01B	CCW HEAT EXCHANGER "B" BUILDING	GTRN	SCREEN OUT
FX-X00	FIRE PUMP & WATER/WASTEWATER TREATMENT BUILDING	GTRN	SCREEN OUT

Table 19.1-45 (4 of 22)

Fire Compartment	Description	Fire Induced Initiator	Results of Quant. Screening
FW-W01	CW COOLING TOWER STRUCTURE AREA 1	LOCV	SCREEN OUT
F078-A56B	CHANNEL-B DC & IP EQUIP. RM	LODCB	SCREEN OUT
F078-A56A	CHANNEL-A DC & IP EQUIP. RM	LODCA	SCREEN OUT
F120-A01D	PIPING CABLE AREA	LODCB	SCREEN OUT
F078-A05C	CHANNEL-C DC & IP EQUIP RM	PLOCCW	SCREEN OUT
F137-A01D	CABLE SPREADING AREA	LODCB	SCREEN OUT
F078-A04C	MISC. ELECTRICAL EQUIP RM	LODCA	SCREEN OUT
F078-A02D	CLASS 1E SWITCHGEAR 01D RM	LODCB	SCREEN OUT
F078-A03C	CLASS 1E LOADCENTER 01C RM	PLOCCW	SCREEN OUT
F157-A19D	I & C EQUIP. RM	GTRN	SCREEN OUT
F100-AEEA	480V CLASS 1E MCC 01A RM	PLOCCW	SCREEN OUT
F137-AEPB	ELECTRICAL PENETRATION ROOM (B)	GTRN	SCREEN OUT
F000-AFHU	FUEL HANDLING UPPER AREA	GTRN	SCREEN OUT
FK-K01	ESW STRUCTURE "A" BUILDING	PLOCCW	SCREEN OUT
F050-A04B	SC PUMP & MINI FLOW HX RM	LODCB	SCREEN OUT
F055-A02D	CCW PUMP RM	LODCB	SCREEN OUT
FN-N00	AAC BUILDING	GTRN	SCREEN OUT
F100-H02A	EMERGENCY D/G ROOM	GTRN	SCREEN OUT

Table 19.1-45 (5 of 22)

Fire Compartment	Description	Fire Induced Initiator	Results of Quant. Screening
F000-AC	ACCESS AREA	GTRN	SCREEN OUT
F120-AGAA	GENERAL ACCESS AREA-120' A	PLOCCW	SCREEN OUT
F157-A19C	I & C EQUIP. RM	GTRN	SCREEN OUT
F050-A01D	CS PUMP & MINI FLOW HX RM	GTRN	SCREEN OUT
F050-A02D	SI PUMP RM	GTRN	SCREEN OUT
F078-A19A	CORRIDOR	PLOCCW	SCREEN OUT
F078-A04D	MISC. ELECTRICAL EQUIP RM	LODCB	SCREEN OUT
F078-A11C	ESSENTIAL CHILLER RM	LODCA	SCREEN OUT
F137-A09D	GENERAL ACCESS AREA	GTRN	SCREEN OUT
F120-A01C	PIPING CABLE AREA	LODCA	SCREEN OUT
F100-H02B	EMERGENCY D/G ROOM	GTRN	SCREEN OUT
FY-MTR1	MAIN TRANSFORMER 1 AREA	GTRN	SCREEN OUT
FY-MTR2	MAIN TRANSFORMER 2 AREA	GTRN	SCREEN OUT
FY-MTR3	MAIN TRANSFORMER 3 AREA	GTRN	SCREEN OUT
FY-UAT1	UNIT AUX. TRANSFORMER 1 AREA	GTRN	SCREEN OUT
FY-UAT2	UNIT AUX. TRANSFORMER 2 AREA	GTRN	SCREEN OUT
F000-AFHL	FUEL HANDLING LOWER AREA	GTRN	SCREEN OUT
FY-EXTR	EXCITATION TRANSFORMER	GTRN	SCREEN OUT

Table 19.1-45 (6 of 22)

Fire Compartment	Description	Fire Induced Initiator	Results of Quant. Screening
F078-A47B	ELECTRICAL EQUIPMENT RM	GTRN	SCREEN OUT
F137-A10D	480V CLASS 1E MCC 03D RM	GTRN	SCREEN OUT
FS-S01	SWYD CONTROL BUILDING	GTRN	SCREEN OUT
F100-AGAC	GENERAL ACCESS AREA	PLOCCW	SCREEN OUT
F073-T11	SWITCHGEAR AREA	LOFW	SCREEN OUT
F137-A30D	MAIN STEAM ENCLOSURE	LODCB	SCREEN OUT
F120-AGAC	GENERAL ACCESS AREA-120' C	PLOCCW	SCREEN OUT
FK-K03	ESW ULTIMATE HEAT SINK COOLING TOWER 1A AREA	GTRN	SCREEN OUT
F078-AAFC	TURBINE DRIVEN AUX FEEDWATER PUMP ROOM	GTRN	SCREEN OUT
FK-K04	ESW ULTIMATE HEAT SINK COOLING TOWER 1B AREA	GTRN	SCREEN OUT
F078-A11D	ESSENTIAL CHILLER RM	GTRN	SCREEN OUT
FY-SAT2	STAND-BY AUX. TRANSFORMER 2 AREA	GTRN	SCREEN OUT
FY-SAT1	STAND-BY AUX. TRANSFORMER 1 AREA	GTRN	SCREEN OUT
F137-ANEA	ELECTRICAL EQUIPMENT ROOM	GTRN	SCREEN OUT
F100-T11	TURBINE LUBE OIL RESERVIOR RM	GTRN	SCREEN OUT
F137-A02C	ELECTRICAL EQUIPMENT ROOM	GTRN	SCREEN OUT
F137-A03C	CEDM M/G SET RM	GTRN	SCREEN OUT
F078-A01D	PNS SWGR RM	GTRN	SCREEN OUT

Table 19.1-45 (7 of 22)

Fire Compartment	Description	Fire Induced Initiator	Results of Quant. Screening
FB-B01	AUX. BOILER BUILDING	GTRN	SCREEN OUT
F050-A01C	CS PUMP & MINI FLOW HX RM	PLOCCW	SCREEN OUT
F050-A02C	SI PUMP RM	PLOCCW	SCREEN OUT
F078-A20B	MOTOR DRIVEN AUX. FEEDWATER PUMP RM	GTRN	SCREEN OUT
F137-A20A	GENERAL ACCESS AREA	GTRN	SCREEN OUT
F120-A08C	480V N1E MCC RM	GTRN	SCREEN OUT
F174-P01	ELEV. MACHINE RM	GTRN	SCREEN OUT
F078-AAFD	TURBINE DRIVEN AUX FEEDWATER PUMP ROOM	GTRN	SCREEN OUT
F100-A10B	GENERAL ACCESS AREA	LODCB	SCREEN OUT
F078-A01C	PNS SWGR RM	GTRN	SCREEN OUT
F137-A10C	480V CLASS 1E MCC 03C RM	GTRN	SCREEN OUT
F137-A02D	ELECTRICAL EQUIP. RM	GTRN	SCREEN OUT
F137-A31C	MAIN STEAM VALVE RM	GTRN	SCREEN OUT
F137-A31D	MAIN STEAM VALVE RM	GTRN	SCREEN OUT
F078-A02C	CLASS 1E SWITCHGEAR 01C RM	PLOCCW	SCREEN OUT
F100-A10A	GENERAL ACCESS AREA	LODCA	SCREEN OUT
F000-ACVL	CVCS ACCESS AREA	GTRN	SCREEN OUT
F078-A12D	ESSENTIAL WATER CHILLER RM	GTRN	SCREEN OUT

Table 19.1-45 (8 of 22)

Fire Compartment	Description	Fire Induced Initiator	Results of Quant. Screening
F055-AGAA	GENERAL ACCESS AREA-55' A	LODCA	SCREEN OUT
F187-T01	ELEV. MACHINE RM	GTRN	SCREEN OUT
F078-A12C	ESSENTIAL WATER CHILLER RM	GTRN	SCREEN OUT
F100-A05C	ELECTRICAL EQUIPMENT RM	GTRN	SCREEN OUT
F055-A02A	CCW PUMP RM	LODCA	SCREEN OUT
F137-A15A	480V CLASS 1E MCC 04A RM	GTRN	SCREEN OUT
F055-A02B	CCW PUMP RM	LODCB	SCREEN OUT
FW-W02	CW COOLING TOWER STRUCTURE AREA 2	GTRN	SCREEN OUT
F157-A20D	I & C EQUIP. RM	GTRN	SCREEN OUT
FJ-J00	COLD MACHINE SHOP	GTRN	SCREEN OUT
F000-ACV	CVCS ACCESS AREA	GTRN	SCREEN OUT
F100-A04C	CABLE ACCESS AREA	LODCA	SCREEN OUT
F170-A01A	ELEV. MACHINE RM	GTRN	SCREEN OUT
F215-A02B	ELEV. MACHINE RM	GTRN	SCREEN OUT
F216-A01C	ELEV. MACHINE RM	GTRN	SCREEN OUT
F216-A01D	ELEV. MACHINE RM	GTRN	SCREEN OUT
F172-A05C	480V N1E MCC RM	GTRN	SCREEN OUT
F055-A14D	PIPE CHASE & VALVE RM	GTRN	SCREEN OUT

Table 19.1-45 (9 of 22)

Fire Compartment	Description	Fire Induced Initiator	Results of Quant. Screening
FK-K05	ESW ULTIMATE HEAT SINK AREA	GTRN	SCREEN OUT
F072-T02	LUBE OIL STORAGE	GTRN	SCREEN OUT
F073-T06	CAUSTIC/ACID DAY TANK & PUMP RM	GTRN	SCREEN OUT
F055-A14C	PIPE CHASE & VALVE RM	GTRN	SCREEN OUT
F078-ANEC	480V N1E MCC RM	GTRN	SCREEN OUT
F172-A05D	ELECTRICAL EQUIP. RM	GTRN	SCREEN OUT
F100-A04D	CABLE ACCESS AREA	LODCB	SCREEN OUT
FQ-Q01	CHLORINATION BUILDING	GTRN	SCREEN OUT
F172-A13D	480V N1E MCC RM	GTRN	SCREEN OUT
F137-A15B	480V CLASS 1E MCC 04B RM	GTRN	SCREEN OUT
F057-P01	ACCESS AREA	GTRN	SCREEN OUT
F137-A14B	480V N1E MCC RM	GTRN	SCREEN OUT
F100-A37B	GENERAL ACCESS AREA	GTRN	SCREEN OUT
F120-A08D	480V N1E MCC RM	GTRN	SCREEN OUT
F172-A13C	480V N1E MCC RM	GTRN	SCREEN OUT
F055-A02C	CCW PUMP RM	PLOCCW	SCREEN OUT
F100-H03	ELECTICAL EQUIP. RM	GTRN	SCREEN OUT
F055-AGAB	GENERAL ACCESS AREA-55' B	LODCB	SCREEN OUT

Table 19.1-45 (10 of 22)

Fire Compartment	Description	Fire Induced Initiator	Results of Quant. Screening
F072-T01	CHEMICAL HANDLING RM	GTRN	SCREEN OUT
F157-A16D	GENERAL ACCESS AREA	GTRN	SCREEN OUT
F157-A20C	I & C EQUIP. RM	GTRN	SCREEN OUT
F157-A16C	GENERAL ACCESS AREA	GTRN	SCREEN OUT
F050-A04A	SC PUMP & MINI FLOW HX RM	PLOCCW	SCREEN OUT
F078-A20A	MOTOR DRIVEN AUX. FEEDWATER PUMP RM	GTRN	SCREEN OUT
F050-A03B	SI PUMP RM	GTRN	SCREEN OUT
F137-A24B	480V N1E MCC RM	GTRN	SCREEN OUT
F120-P01	ACCESS AREA	GTRN	SCREEN OUT
F100-P09	ACCESS AREA	GTRN	SCREEN OUT
F072-T03	MAIN TURBINE LUBE OIL CONDITIONER RM	GTRN	SCREEN OUT
F100-A13A	MECHANICAL PENETRATION RM	GTRN	SCREEN OUT
F067-T01	ELEV. HOISTWAY	GTRN	SCREEN OUT
F078-A51B	BORIC ACID MAKEUP PUMP RM	GTRN	SCREEN OUT
FB-B02	AUX. BOILER FUEL OIL STORAGE TANK	GTRN	SCREEN OUT
FZ-Z01	LUBE OIL STORAGE TANK & CENTRIFUGE HOUSE	GTRN	SCREEN OUT
F157-A23D	AEB RM	GTRN	SCREEN OUT
F172-A24C	CONTROL RM AREA SUPPLY AHU/ACU RM	GTRN	SCREEN OUT

Table 19.1-45 (11 of 22)

Fire Compartment	Description	Fire Induced Initiator	Results of Quant. Screening
F172-A24D	CONTROL RM AREA SUPPLY AHU/ACU RM	GTRN	SCREEN OUT
F157-A21D	INSTRUMENT MAINTENANCE SHOP	GTRN	SCREEN OUT
F156-A14A	AUX. BLDG CONTROLLED AREA (I) NORMAL/EMERGENCY EXHAUST ACU RM	GTRN	SCREEN OUT
F100-P48	ACCESS AREA	GTRN	SCREEN OUT
F073-T01	STAIR	GTRN	SCREEN OUT
F172-A15B	CONTAINMENT HIGH/LOW VOLUME PURGE ACU RM	GTRN	SCREEN OUT
F063-H03B	DIESEL FUEL OIL STORAGE TANK ROOM	GTRN	SCREEN OUT
F063-H03A	DIESEL FUEL OIL STORAGE TANK ROOM	GTRN	SCREEN OUT
FS-S02	SWITCHYARD AREA	GTRN	SCREEN OUT
F137-A35C	REACTOR TRIP SWITCHGEAR RM	GTRN	SCREEN OUT
F050-A03A	SI PUMP RM	GTRN	SCREEN OUT
F120-A16A	MECHANICAL PENETRATION RM	GTRN	SCREEN OUT
F100-T17	BATTERY RM	GTRN	SCREEN OUT
F100-A20A	GENERAL ACCESS AREA	GTRN	SCREEN OUT
F063-P13	ACCESS AREA	GTRN	SCREEN OUT
F055-A04C	SEISMIC CAT-1 FIRE WATER TANK RM	GTRN	SCREEN OUT
F055-A04D	SEISMIC CAT-1 FIRE WATER TANK RM	GTRN	SCREEN OUT

Table 19.1-45 (12 of 22)

Fire Compartment	Description	Fire Induced Initiator	Results of Quant. Screening
F135-H03A	EDG RM NORMAL SUPPLY AHU RM	GTRN	SCREEN OUT
F135-H03B	EDG RM NORMAL SUPPLY AHU RM	GTRN	SCREEN OUT
F100-P58	ACCESS AREA	GTRN	SCREEN OUT
F055-A55B	CHARGING PUMP RM	GTRN	SCREEN OUT
F073-T07	STAIR	GTRN	SCREEN OUT
F073-T08	STAIR	GTRN	SCREEN OUT
F073-T10	STAIR	GTRN	SCREEN OUT
F120-A06D	PIPE CHASE	GTRN	SCREEN OUT
F055-A42A	CHARGING PUMP RM	GTRN	SCREEN OUT
F055-A54B	AUX. CHARGING PUMP RM	GTRN	SCREEN OUT
F172-A16B	CONTAINMENT HIGH VOLUME PURGE AHU RM	GTRN	SCREEN OUT
F079-P01	ACCESS AREA	GTRN	SCREEN OUT
F120-P10	ACCESS AREA	GTRN	SCREEN OUT
F195-A05C	480V N1E LOADCENTER RM	GTRN	SCREEN OUT
F100-A24A	SFP COOLING HX RM	GTRN	SCREEN OUT
F100-A32B	SFP COOLING HX RM	GTRN	SCREEN OUT
F172-A14C	EDG RM NORMAL SUPPLY AHU RM	GTRN	SCREEN OUT
F174-P02	ACCESS AREA	GTRN	SCREEN OUT

Table 19.1-45 (13 of 22)

Fire Compartment	Description	Fire Induced Initiator	Results of Quant. Screening
FZ-Z02	TANK AREA	GTRN	SCREEN OUT
FZ-Z03	CHEMICAL STORAGE TANK AREA	GTRN	SCREEN OUT
FZ-Z04	CONDENSATE STORAGE TANK	GTRN	SCREEN OUT
FZ-Z05	REACTOR MAKE-UP WATER TANK	GTRN	SCREEN OUT
FZ-Z06	HOLD-UP TANK	GTRN	SCREEN OUT
FZ-Z07	BORIC ACID STORAGE TANK	GTRN	SCREEN OUT
FZ-Z08	N2 & H2 GAS STORAGE AREA	GTRN	SCREEN OUT
FZ-Z09	FRESH WATER STORAGE TANK	GTRN	SCREEN OUT
FZ-Z10	DEMI. WATER STORAGE TANK	GTRN	SCREEN OUT
FZ-Z12	RAW WATER SOURCE INTAKE STRUCTURE	GTRN	SCREEN OUT
F172-A14D	EDG RM NORMAL SUPPLY AHU RM	GTRN	SCREEN OUT
F195-A08B	AUX. BLDG CONTROLLED AREA (II) NORMAL/EMERGENCY EXHAUST ACU ROOM	GTRN	SCREEN OUT
F137-A41A	REMOTE CONTROL CONSOLE ROOM	GTRN	SCREEN OUT
F172-AGAD	GENERAL ACCESS AREA-172' D	GTRN	SCREEN OUT
F120-A35B	BATTERY RM	GTRN	SCREEN OUT
F100-A13B	MECHANICAL PENETRATION RM	GTRN	SCREEN OUT
F065-A01C	DIESEL FUEL OIL STORAGE TANK RM	GTRN	SCREEN OUT

Table 19.1-45 (14 of 22)

Fire Compartment	Description	Fire Induced Initiator	Results of Quant. Screening
F065-A01D	DIESEL FUEL OIL STORAGE TANK RM	GTRN	SCREEN OUT
F055-A21B	PIPE CHASE & VALVE RM	GTRN	SCREEN OUT
F172-AGAC	GENERAL ACCESS AREA-172' C	GTRN	SCREEN OUT
F195-A05D	480V N1E LOADCENTER RM	GTRN	SCREEN OUT
F137-A37C	REACTOR TRIP SWITCHGEAR RM	GTRN	SCREEN OUT
F137-A36C	REACTOR TRIP SWITCHGEAR RM	GTRN	SCREEN OUT
F137-A38C	REACTOR TRIP SWITCHGEAR RM	GTRN	SCREEN OUT
F063-P01	ACCESS AREA	GTRN	SCREEN OUT
F120-A24A	FUEL HANDLING AREA EMER. EXHAUST ACU RM	GTRN	SCREEN OUT
F137-A09C	GENERAL ACCESS AREA	GTRN	SCREEN OUT
F137-A04C	CEDM POWER CONTROL CABINET RM	GTRN	SCREEN OUT
F100-A11A	CHANNEL-A BATTERY RM	GTRN	SCREEN OUT
F120-A21A	FUEL HANDLING AREA EMER. EXHAUST ACU ROOM	GTRN	SCREEN OUT
F055-A21A	PIPE CHASE & VALVE RM	GTRN	SCREEN OUT
F156-AGAB	SST ROOM	GTRN	SCREEN OUT
F120-A03D	DIESEL FUEL OIL DAY TANK RM	GTRN	SCREEN OUT
FZ-Z11	GUARD HOUSE	GTRN	SCREEN OUT

Table 19.1-45 (15 of 22)

Fire Compartment	Description	Fire Induced Initiator	Results of Quant. Screening
F100-P14	ACCESS AREA	GTRN	SCREEN OUT
F120-A31B	GENERAL ACCESS AREA-120' B	GTRN	SCREEN OUT
F172-A01C	EDG RM NORMAL EXHAUST FAN RM	GTRN	SCREEN OUT
F172-A01D	EDG RM NORMAL EXHAUST FAN RM	GTRN	SCREEN OUT
F100-A11B	CHANNEL-B BATTERY RM	GTRN	SCREEN OUT
F172-A23C	AUX. BLDG. CLEAN AREA SUPPLY AHU RM	GTRN	SCREEN OUT
F172-A23D	AUX. BLDG. CLEAN AREA SUPPLY AHU RM	GTRN	SCREEN OUT
F175-A01D	MSIV RM SUPPLY AHU RM	GTRN	SCREEN OUT
F100-A14A	PERSONNEL AIR LOCK ENTRANCE	GTRN	SCREEN OUT
F085-P12	ACCESS AREA	GTRN	SCREEN OUT
F063-P56	ACCESS AREA	GTRN	SCREEN OUT
F085-P18	ACCESS AREA	GTRN	SCREEN OUT
F085-P26	ACCESS AREA	GTRN	SCREEN OUT
F100-P12	ACCESS AREA	GTRN	SCREEN OUT
F100-P13	ACCESS AREA	GTRN	SCREEN OUT
F100-P17	ACCESS AREA	GTRN	SCREEN OUT
F100-P18	ACCESS AREA	GTRN	SCREEN OUT
F100-P19	ACCESS AREA	GTRN	SCREEN OUT

Table 19.1-45 (16 of 22)

Fire Compartment	Description	Fire Induced Initiator	Results of Quant. Screening
F100-P29	ACCESS AREA	GTRN	SCREEN OUT
F100-P40	VESTIBULE	GTRN	SCREEN OUT
F100-P59	ACCESS AREA	GTRN	SCREEN OUT
F078-A06D	N1E BATTERY RM	GTRN	SCREEN OUT
F120-A03C	DIESEL FUEL OIL DAY TANK RM	GTRN	SCREEN OUT
F078-A21A	PIPE CHASE	GTRN	SCREEN OUT
F078-A21B	PIPE CHASE	GTRN	SCREEN OUT
F078-A07C	CHANNEL-C BATTERY RM	GTRN	SCREEN OUT
F078-A06C	N1E BATTERY RM	GTRN	SCREEN OUT
F078-A07D	CHANNEL-D BATTERY RM	GTRN	SCREEN OUT
F078-A40B	BORIC ACID CONC. RM	GTRN	SCREEN OUT
F195-AGAC	GENERAL ACCESS AREA-190' C	GTRN	SCREEN OUT
F195-AGAD	GENERAL ACCESS AREA-190' D	GTRN	SCREEN OUT
F137-ASTD	STAIR	GTRN	SCREEN OUT
F137-A06D	REMOTE SHUTDOWN RM	GTRN	SCREEN OUT
F137-AGAB	GENERAL ACCESS AREA	GTRN	SCREEN OUT
F121-H02B	DIESEL FUEL OIL DAY TANK RM	GTRN	SCREEN OUT
F055-A01C	CS HX RM	GTRN	SCREEN OUT

Table 19.1-45 (17 of 22)

Fire Compartment	Description	Fire Induced Initiator	Results of Quant. Screening
F100-A23A	AUX. BLDG. CONTROLLED AREA I SUPPLY AHU ROOM	GTRN	SCREEN OUT
F063-P66	ACCESS AREA	GTRN	SCREEN OUT
F063-P17	ACCESS AREA	GTRN	SCREEN OUT
F063-P18	ACCESS AREA	GTRN	SCREEN OUT
F063-P20	ACCESS AREA	GTRN	SCREEN OUT
F063-P50	ACCESS AREA	GTRN	SCREEN OUT
F063-P51	ACCESS AREA	GTRN	SCREEN OUT
F063-P76	ACCESS AREA	GTRN	SCREEN OUT
F063-P77	ACCESS AREA	GTRN	SCREEN OUT
F078-A53C	480V N1E LOADCENTER RM	GTRN	SCREEN OUT
F078-A53D	480V N1E LOADCENTER RM	GTRN	SCREEN OUT
F120-A29B	AUX. BLDG CONTROLLED AREA (I) ECCS EQUIP. RM EXHAUST ACU RM	GTRN	SCREEN OUT
F121-H02A	DIESEL FUEL OIL DAY TANK RM	GTRN	SCREEN OUT
F100-A38A	FUEL HANDLING AREA NORMAL EXHAUST ACU RM	GTRN	SCREEN OUT
F120-A06C	PIPE CHASE	GTRN	SCREEN OUT
F055-A10C	TENDON GALLERY ENTRANCE AREA	GTRN	SCREEN OUT
F157-A13C	VESTIBULE	GTRN	SCREEN OUT
F157-A13D	VESTIBULE	GTRN	SCREEN OUT

Table 19.1-45 (18 of 22)

Fire Compartment	Description	Fire Induced Initiator	Results of Quant. Screening
F137-A30C	MAIN STEAM ENCLOSURE	GTRN	SCREEN OUT
F100-A07C	AUX. FEEDWATER(AFW) TANK	GTRN	SCREEN OUT
F100-A07D	AUX. FEEDWATER(AFW) TANK	GTRN	SCREEN OUT
F100-H04A	AIR INTAKE & EXHAUST SHAFT	GTRN	SCREEN OUT
F100-H04B	AIR INTAKE & EXHAUST SHAFT	GTRN	SCREEN OUT
F100-H05A	AIR INTAKE & EXHAUST SHAFT	GTRN	SCREEN OUT
F100-H05B	AIR INTAKE & EXHAUST SHAFT	GTRN	SCREEN OUT
F156-A10A	EQUIPMENT HATCH ACCESS RM	GTRN	SCREEN OUT
F156-A16A	SIS FILLING TANK RM	GTRN	SCREEN OUT
F157-A18C	CLEAN AGENT RM	GTRN	SCREEN OUT
F157-A22D	GUEST RM	GTRN	SCREEN OUT
F157-A27C	GENERAL ACCESS AREA	GTRN	SCREEN OUT
F157-A28D	BREATHING AIR RACK	GTRN	SCREEN OUT
F175-A01C	MSIV RM SUPPLY AHU RM	GTRN	SCREEN OUT
F195-A06C	HVAC VENT RM	GTRN	SCREEN OUT
F195-A06D	HVAC VENT RM	GTRN	SCREEN OUT
F120-A02C	LUBE OIL MAKE-UP TANK RM	GTRN	SCREEN OUT
F120-A02D	LUBE OIL MAKE-UP TANK RM	GTRN	SCREEN OUT

Table 19.1-45 (19 of 22)

Fire Compartment	Description	Fire Induced Initiator	Results of Quant. Screening
F121-H01A	LUBE OIL MAKEUP TANK RM	GTRN	SCREEN OUT
F121-H01B	LUBE OIL MAKEUP TANK RM	GTRN	SCREEN OUT
F137-A32B	PIPE CHASE	GTRN	SCREEN OUT
F156-A04B	CONT. ENTERANCE AREA	GTRN	SCREEN OUT
F078-A23A	BUTTRESS OPNG	GTRN	SCREEN OUT
F137-A25A	AUX. BLDG. CONTROLLED AREA (I) ECCS EQUIPMENT RM EXHAUST ACU RM	GTRN	SCREEN OUT
F137-A44C	ELEV. HALL	GTRN	SCREEN OUT
F137-A44D	ELEV. HALL	GTRN	SCREEN OUT
F156-A13A	ELEV. HALL	GTRN	SCREEN OUT
F156-A13B	ELEV. HALL	GTRN	SCREEN OUT
F156-A15B	PIPE CHASE	GTRN	SCREEN OUT
F172-A17B	ELEV. HALL	GTRN	SCREEN OUT
F172-A18C	ELEV. HALL	GTRN	SCREEN OUT
F172-A18D	ELEV. HALL	GTRN	SCREEN OUT
F172-A22B	HVAC CHASE	GTRN	SCREEN OUT
F172-A25C	HVAC CHASE	GTRN	SCREEN OUT
F195-A07B	ELEV. HALL	GTRN	SCREEN OUT
F078-A23B	BUTTRESS OPNG	GTRN	SCREEN OUT

Table 19.1-45 (20 of 22)

Fire Compartment	Description	Fire Induced Initiator	Results of Quant. Screening
F068-A05A	HVAC CHASE	GTRN	SCREEN OUT
F055-A01D	CS HX RM	GTRN	SCREEN OUT
F078-A13D	DUCT RM	GTRN	SCREEN OUT
F137-A19A	SG BLOWDOWN FLASH TANK RM	GTRN	SCREEN OUT
F078-A14C	BUTTRESS OPNG	GTRN	SCREEN OUT
F100-A21A	NEW RESIN STORAGE RM	GTRN	SCREEN OUT
F100-A42C	D/G OIL STORAGE ACCESS	GTRN	SCREEN OUT
F100-A42D	D/G OIL STORAGE ACCESS	GTRN	SCREEN OUT
F100-A43C	D/G OIL STORAGE ENTRANCE	GTRN	SCREEN OUT
F100-A43D	D/G OIL STORAGE ENTRANCE	GTRN	SCREEN OUT
F100-A44D	VESTIBULE	GTRN	SCREEN OUT
F100-H06A	VALVE RM	GTRN	SCREEN OUT
F100-H06B	VALVE RM	GTRN	SCREEN OUT
F135-H02A	AIR INTAKE FILTER RM	GTRN	SCREEN OUT
F135-H02B	AIR INTAKE FILTER RM	GTRN	SCREEN OUT
F055-A18A	PIPE CHASE & VALVE RM	GTRN	SCREEN OUT
F078-A09C	HVAC CHASE	GTRN	SCREEN OUT
F100-A16C	PIPE CHASE	GTRN	SCREEN OUT
F100-A16D	PIPE CHASE	GTRN	SCREEN OUT

Table 19.1-45 (21 of 22)

Fire Compartment	Description	Fire Induced Initiator	Results of Quant. Screening
F078-A55C	ELEV. HALL	GTRN	SCREEN OUT
F078-A55D	ELEV. HALL	GTRN	SCREEN OUT
F055-A18B	PIPE CHASE & VALVE RM	GTRN	SCREEN OUT
F063-H01	STAIR	GTRN	SCREEN OUT
F078-A09D	HVAC CHASE	GTRN	SCREEN OUT
F078-A16C	HVAC CHASE	GTRN	SCREEN OUT
F078-A16D	HVAC CHASE	GTRN	SCREEN OUT
F078-A54A	ELEV. HALL	GTRN	SCREEN OUT
F078-A54B	ELEV. HALL	GTRN	SCREEN OUT
F100-A45B	ELEV. HALL	GTRN	SCREEN OUT
F100-A46C	ELEV. HALL	GTRN	SCREEN OUT
F100-A46D	ELEV. HALL	GTRN	SCREEN OUT
F120-A13B	STAIR	GTRN	SCREEN OUT
F120-A17A	STAIR	GTRN	SCREEN OUT
F120-A25A	FUEL HANDLING AREA EMER. EXHAUST ACU ROOM	GTRN	SCREEN OUT
F120-A33A	ELEV. HALL	GTRN	SCREEN OUT
F120-A33B	ELEV. HALL	GTRN	SCREEN OUT
F120-A34C	ELEV. HALL	GTRN	SCREEN OUT
F120-A34D	ELEV. HALL	GTRN	SCREEN OUT

Table 19.1-45 (22 of 22)

Fire Compartment	Description	Fire Induced Initiator	Results of Quant. Screening
F137-A16A	ELEV. HALL	GTRN	SCREEN OUT
F137-A16B	ELEV. HALL	GTRN	SCREEN OUT
F049-A01C	ELEV. HOISTWAY	GTRN	SCREEN OUT
F055-A05C	STAIR	GTRN	SCREEN OUT
F049-A01D	ELEV. HOISTWAY	GTRN	SCREEN OUT
F055-A05D	STAIR	GTRN	SCREEN OUT
F049-A02A	ELEV. HOISTWAY	GTRN	SCREEN OUT
F049-A02B	ELEV. HOISTWAY	GTRN	SCREEN OUT
F055-A20A	STAIR	GTRN	SCREEN OUT
F055-A20B	STAIR	GTRN	SCREEN OUT
F055-A22A	PIPE CHASE	GTRN	SCREEN OUT
F055-A22B	PIPE CHASE	GTRN	SCREEN OUT
F055-A60A	ELEV. HALL	GTRN	SCREEN OUT
F055-A60B	ELEV. HALL	GTRN	SCREEN OUT
F055-A61C	ELEV. HALL	GTRN	SCREEN OUT
F055-A61D	ELEV. HALL	GTRN	SCREEN OUT
F100-A45A	ELEV. HALL	GTRN	SCREEN OUT
FY-Y00	CABLE BURIED UNDERGROUND AREA	LOOP	SCREEN OUT

Table 19.1-46

Fires Results in Each Identified Fire Induced Internal Event Initiators

Event	Description	FI-IEF(2) (/yr)	% Total IEF
GTRN	General Transient	1.19E-01	83.3%
LOCV	Loss of Condenser Vacuum	7.68E-03	5.4%
PLOCCW	Partial Loss of CCW	5.62E-03	3.9%
LODCB	Loss of DC Bus "B"	4.90E-03	3.4%
LOFW	Loss of Feedwater	2.03E-03	1.4%
LOOP	Loss of Offsite Power	1.87E-03	1.3%
LODCA	Loss of DC Bus "A"	1.35E-03	0.9%
MCR EVAC (1)	Alternate Shutdown (MCR Evacuation)	5.73E-06	0.0%

(1) MCR EVAC is not truly an initiator, and is based on an assumed "unknown" core damage event as a result of failure to safely shutdown following an MCR fire requiring evacuation.

(2) FI-IEF: Fire Induced - Internal Event Frequency

Table 19.1-47

Internal Fire PRA CDF Contribution by Top Fire Induced Initiators

Event	Description	CDF (/yr)	Contribution
MCR EVAC	Fire Induced Main Control Room Evacuation	6.03E-07	32.4%
LODCB	Fire Induced Loss of DC Bus B	4.80E-07	25.8%
GTRN	Fire Induced General Transient	2.96E-07	15.9%
LOOP	Fire Induced Loss of Offsite Power	2.44E-07	13.1%
PLOCCW	Fire Induced Partial Loss of CCW	1.27E-07	6.8%
LODCA	Fire Induced Loss of DC Bus A	4.86E-08	2.6%
LOCV	Fire Induced Loss of Condenser Vacuum	2.98E-08	1.6%
SLOCA	Fire Induced Small LOCA	1.95E-08	1.0%
LOFW	Fire Induced Loss of Feedwater	9.09E-09	0.5%

Table 19.1-48

Internal Fire PRA LRF Contribution by Fire Induced Initiators

Event	Description	LRF (/yr)	Contribution
MCR EVAC	Fire Induced Main Control Room Evacuation	6.03E-08	35.7%
LODCB	Fire Induced Loss of DC Bus B	5.19E-08	30.7%
GTRN	Fire Induced General Transient	1.60E-08	9.4%
LOOP	Fire Induced Loss of Offsite Power	2.76E-08	16.3%
PLOCCW	Fire Induced Partial Loss of CCW	6.21E-09	3.7%
LODCA	Fire Induced Loss of DC Bus A	4.35E-09	2.6%
LOCV	Fire Induced Loss of Condenser Vacuum	1.73E-09	1.0%
SLOCA	Fire Induced Small LOCA	7.53E-10	0.4%
LOFW	Fire Induced Loss of Feedwater	5.14E-10	0.3%

Table 19.1-49 (1 of 30)

Internal Fire PRA Top 100 CDF Cutsets

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
1	2.36E-07	#F157-AMCR-4-4 ASD-CDF	MCR TRANS FIRE, SUPP. FAILS, ASD ALTERNATE SHUTDOWN FAILURE PROBABILITY FOR CDF	12.7	12.7
2	1.52E-07	#F157-AMCR-3-4 ASD-CDF	MCR SAFETY CONSOLE FIRE, SUPP. FAILS, ASD ALTERNATE SHUTDOWN FAILURE PROBABILITY FOR CDF	8.2	20.9
3	7.56E-08	#F157-AMCR-2-4 ASD-CDF	MCR FIRE CONT PNL FIRE, SUPP. FAILS, ASD ALTERNATE SHUTDOWN FAILURE PROBABILITY FOR CDF	4.1	24.9
4	7.56E-08	#F157-AMCR-1-4 ASD-CDF	MCR CCTV FIRE, SUPP. FAILS, ASD ALTERNATE SHUTDOWN FAILURE PROBABILITY FOR CDF	4.1	29.0
5	3.43E-08	#F157-AMCR-6-4 ASD-CDF	MCR CABLE W/C FIRE, SUPP. FAILS, ASD ALTERNATE SHUTDOWN FAILURE PROBABILITY FOR CDF	1.8	30.8

Table 19.1-49 (2 of 30)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
6	1.96E-08	#F078-AAFD_F078-AGAD	MULTI-COMPARTMENT FIRE FROM F078-AAFD TO F078-AGAD	1.1	31.9
		F-WOOPH-S-CROSSTIE-A	OPERATOR FAILS TO OPEN 1025A AND ALIGN FLOW PATH		
		WOCHM4A-CH04A	ECW CHILLER 04A TRAIN UNAVAILABLE DUE TO T&M		
7	1.37E-08	#F078-AAFD_F078-AGAD	MULTI-COMPARTMENT FIRE FROM F078-AAFD TO F078-AGAD	0.7	32.6
		WOMPM5A-PP05A	ECW PP05A TRAIN UNAVAILABLE DUE TO TEST OR MAINTENANCE		
8	1.32E-08	#F078-AAFD_F078-AGAD	MULTI-COMPARTMENT FIRE FROM F078-AAFD TO F078-AGAD	0.7	33.3
		PFHBO2A-SW01C-C2	FAILS TO OPEN OF PCB SW01C-C2 OF 4.16KV SWGR SW01C FROM UAT		
9	1.29E-08	#F078-AAFD_F078-AGAD	MULTI-COMPARTMENT FIRE FROM F078-AAFD TO F078-AGAD	0.7	34.0
		F-WOOPH-S-CROSSTIE-A	OPERATOR FAILS TO OPEN 1025A AND ALIGN FLOW PATH		
		WOCHS4A-CH04A	ECW CHILLER CH04A FAILS TO START ON DEMAND		

Table 19.1-49 (3 of 30)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
10	1.16E-08	#F137-A03C_F157-AMCR ASD-CDF-MCA	MULTI-COMPARTMENT FIRE FROM F137-A03C TO F157-AMCR ALTERNATE SHUTDOWN FAILURE PROBABILITY FOR MCA CDF	0.6	34.7
11	8.69E-09	#F157-ACPX-U_F157-AMCR ASD-CDF-MCA	MULTI-COMPARTMENT FIRE FROM F157-ACPX TO F157-AMCR ALTERNATE SHUTDOWN FAILURE PROBABILITY FOR MCA CDF	0.5	35.1
12	7.01E-09	#F078-AGAD_F078-AAFD F-WOOPH-S-CROSSTIE-A WOCHM4A-CH04A	MULTI-COMPARTMENT FIRE FROM F078-AGAD TO F078-AAFD OPERATOR FAILS TO OPEN 1025A AND ALIGN FLOW PATH ECW CHILLER 04A TRAIN UNAVAILABLE DUE TO T&M	0.4	35.5
13	4.88E-09	#F078-AGAD_F078-AAFD WOMPM5A-PP05A	MULTI-COMPARTMENT FIRE FROM F078-AGAD TO F078-AAFD ECW PP05A TRAIN UNAVAILABLE DUE TO TEST OR MAINTENANCE	0.3	35.8
14	4.71E-09	#F078-AGAD_F078-AAFD PFHBO2A-SW01C-C2	MULTI-COMPARTMENT FIRE FROM F078-AGAD TO F078-AAFD FAILS TO OPEN OF PCB SW01C-C2 OF 4.16KV SWGR SW01C FROM UAT	0.3	36.0

Table 19.1-49 (4 of 30)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
15	4.65E-09	#F078-A52D-U	F078-A52D UNSUPPRESSED FIRES	0.3	36.3
		AFTPR1A-TDP01A	FAILS TO RUN AFW TDP PP01A		
		AFTPR1B-TDP01B	FAILS TO RUN AFW TDP PP01B		
		WOCHM4A-CH04A	ECW CHILLER 04A TRAIN UNAVAILABLE DUE TO T&M		
		F-WOOPH-S-CROSSTIE-A	OPERATOR FAILS TO OPEN 1025A AND ALIGN FLOW PATH		
16	4.60E-09	#F078-AGAD_F078-AAFD	MULTI-COMPARTMENT FIRE FROM F078-AGAD TO F078-AAFD	0.2	36.5
		F-WOOPH-S-CROSSTIE-A	OPERATOR FAILS TO OPEN 1025A AND ALIGN FLOW PATH		
		WOCHS4A-CH04A	ECW CHILLER CH04A FAILS TO START ON DEMAND		
17	4.26E-09	#F137-A02D_F157-AMCR	MULTI-COMPARTMENT FIRE FROM F137-A02D TO F157-AMCR	0.2	36.7
		ASD-CDF-MCA	ALTERNATE SHUTDOWN FAILURE PROBABILITY FOR MCA CDF		

Table 19.1-49 (5 of 30)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
18	3.39E-09	#F157-A25C_F157-A17C	MULTI-COMPARTMENT FIRE FROM F157-A25C TO F157-A17C	0.2	36.9
		AFOPV-S-AFAS-TR	OPERATOR FAILS TO RECOVER AFAS		
		RCOPH-S-SDSE-SL-MD	FAILURE OF SDS VALVES EARLY PHASE OPEN (2/4) WITH MEDIUM DEPENDENCY		
19	3.39E-09	#F157-A25C_F157-A16C	MULTI-COMPARTMENT FIRE FROM F157-A25C TO F157-A16C	0.2	37.1
		AFOPV-S-AFAS-TR	OPERATOR FAILS TO RECOVER AFAS		
		RCOPH-S-SDSE-SL-MD	FAILURE OF SDS VALVES EARLY PHASE OPEN (2/4) WITH MEDIUM DEPENDENCY		
20	3.24E-09	#F078-A52D-U	F078-A52D UNSUPPRESSED FIRES	0.2	37.3
		AFTPR1A-TDP01A	FAILS TO RUN AFW TDP PP01A		
		AFTPR1B-TDP01B	FAILS TO RUN AFW TDP PP01B		
		WOMPM5A-PP05A	ECW PP05A TRAIN UNAVAILABLE DUE TO TEST OR MAINTENANCE		

Table 19.1-49 (6 of 30)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
21	3.16E-09	#F078-A52D-U	F078-A52D UNSUPPRESSED FIRES	0.2	37.4
		F-WOOPH-S-CROSSTIE-A	OPERATOR FAILS TO OPEN 1025A AND ALIGN FLOW PATH		
		PR	POSRV FAILS TO RECLOSE		
		WOCHM4A-CH04A	ECW CHILLER 04A TRAIN UNAVAILABLE DUE TO T&M		
22	3.05E-09	#F078-A52D-U	F078-A52D UNSUPPRESSED FIRES	0.2	37.6
		AFTPR1A-TDP01A	FAILS TO RUN AFW TDP PP01A		
		AFTPR1B-TDP01B	FAILS TO RUN AFW TDP PP01B		
		WOCHS4A-CH04A	ECW CHILLER CH04A FAILS TO START ON DEMAND		
		F-WOOPH-S-CROSSTIE-A	OPERATOR FAILS TO OPEN 1025A AND ALIGN FLOW PATH		
23	2.69E-09	#F078-AAFD_F078-AGAD	MULTI-COMPARTMENT FIRE FROM F078-AAFD TO F078-AGAD	0.1	37.8
		WOMPS5A-PP05A	FAILS TO START OF ECW PUMP 05A		

Table 19.1-49 (7 of 30)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
24	2.38E-09	#F078-A19B-U	F078-A19B UNSUPPRESSED FIRES	0.1	37.9
		AFOPH-S-ALT-LT	OPERATOR FAIL TO ALIGNE FOR SUPPLYING AN ALTERNATE SOURCE		
		FLAG-L-FNB	FLAG FOR CONSIDERING THE FAILURE OF LONG TERM 2NDARY HEAT REMOVAL		
		RCOPH-S-SDSE-SL-MD	FAILURE OF SDS VALVES EARLY PHASE OPEN (2/4) WITH MEDIUM DEPENDENCY		
		MSOPH-S-SGADV	OPERATOR FAILS TO OPEN ADVS		
25	2.20E-09	#F078-A52D-U	F078-A52D UNSUPPRESSED FIRES	0.1	38.0
		PR	POSRV FAILS TO RECLOSE		
		WOMPM5A-PP05A	ECW PP05A TRAIN UNAVAILABLE DUE TO TEST OR MAINTENANCE		
26	2.07E-09	#F078-A52D-U	F078-A52D UNSUPPRESSED FIRES	0.1	38.1
		PR	POSRV FAILS TO RECLOSE		
		WOCHS4A-CH04A	ECW CHILLER CH04A FAILS TO START ON DEMAND		
		F-WOOPH-S-CROSSTIE-A	OPERATOR FAILS TO OPEN 1025A AND ALIGN FLOW PATH		

Table 19.1-49 (8 of 30)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
27	1.88E-09	#F078-AGAC_F078-AGAD	MULTI-COMPARTMENT FIRE FROM F078-AGAC TO F078-AGAD	0.1	38.2
		AFTPR1A-TDP01A	FAILS TO RUN AFW TDP PP01A		
		AFTPR1B-TDP01B	FAILS TO RUN AFW TDP PP01B		
28	1.84E-09	#F122-T01-U	F122-T01 UNSUPPRESSED FIRES	0.1	38.3
		DAMPR-A-PP02	AAC FUEL OIL FEED PUMP PP02 FAILS TO RUN		
		DGDGKQ4-DG01ABCD	CCF OF EDG 01A/01B/01C/01D FAIL TO RUN		
		SHR1-E12TD	UNRECOVERABLE SBO LEADS TO TDAFW PUMP FAILURE		
29	1.81E-09	#F137-A05D_F157-AMCR	MULTI-COMPARTMENT FIRE FROM F137-A05D TO F157-AMCR	0.1	38.4
		ASD-CDF-MCA	ALTERNATE SHUTDOWN FAILURE PROBABILITY FOR MCA CDF		
30	1.79E-09	#F078-A05D-U	F078-A05D UNSUPPRESSED FIRES	0.1	38.5
		DCBSY-A-MC01A	BUS FAULTS ON 1E 125VDC BUS MC01A		

Table 19.1-49 (9 of 30)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
31	1.77E-09	#F078-A05D-U	F078-A05D UNSUPPRESSED FIRES	0.1	38.6
		FWOPH-S-ERY	OPERATOR FAILS TO ALINE STARTUP FEEDWATER PUMP PP07 (EARLY PHASE)		
		RCOPH-S-SDSE-SL-LD	FAILURE OF SDS VALVES EARLY PHASE OPEN (2/4) WITH LOW DEPENDENCY		
		VOHVS2A-HV33A	FAILS TO START OF MAFP ROOM A CUBICLE COOLER HV33A		
32	1.68E-09	#F100-AEEB-U	F100-AEEB UNSUPPRESSED FIRES	0.1	38.7
		AXVVO-A-V1623	FAILS TO OPEN CT SYSTEM MANUAL VALVE V1623		
		RCOPH-S-SDSE-SL	FAILURE OF SDS VALVES EARLY PHASE OPEN (2/4)		
33	1.67E-09	#F078-A05D-U	F078-A05D UNSUPPRESSED FIRES	0.1	38.8
		AFMPM2A-MDP02A	AFW MDP PP02A UNAVAILABLE DUE TO T/M		
		FWOPH-S-ERY	OPERATOR FAILS TO ALINE STARTUP FEEDWATER PUMP PP07 (EARLY PHASE)		
		RCOPH-S-SDSE-SL-LD	FAILURE OF SDS VALVES EARLY PHASE OPEN (2/4) WITH LOW DEPENDENCY		

Table 19.1-49 (10 of 30)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
34	1.66E-09	#F122-T01-U	F122-T01 UNSUPPRESSED FIRES	0.1	38.9
		DAMPR-A-PP02	AAC FUEL OIL FEED PUMP PP02 FAILS TO RUN		
		SHR1-E12TD	UNRECOVERABLE SBO LEADS TO TDAFW PUMP FAILURE		
		WOCHWQ4-CH01A/2A/1B/2B	DEMAND CCF OF ECW CHILLERS 1A/2A/1B/2B		
35	1.66E-09	#F122-T01-U	F122-T01 UNSUPPRESSED FIRES	0.1	39.0
		DAMPR-A-PP02	AAC FUEL OIL FEED PUMP PP02 FAILS TO RUN		
		SHR1-E12TD	UNRECOVERABLE SBO LEADS TO TDAFW PUMP FAILURE		
		WOCHWQ4-CH03A/4A/3B/4B	DEMAND CCF OF ECW CHILLERS 3A/4A/3B/4B		
36	1.58E-09	#F157-A25C_F157-A17C	MULTI-COMPARTMENT FIRE FROM F157-A25C TO F157-A17C	0.1	39.0

Table 19.1-49 (11 of 30)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
37	1.58E-09	#F157-A25C_F157-A16C	MULTI-COMPARTMENT FIRE FROM F157-A25C TO F157-A16C	0.1	39.1
		AFTPR1B-TDP01B	FAILS TO RUN AFW TDP PP01B		
		RCOPH-S-SDSE-SL	FAILURE OF SDS VALVES EARLY PHASE OPEN (2/4)		
38	1.54E-09	#F137-ASTD_F157-AMCR	MULTI-COMPARTMENT FIRE FROM F137-ASTD TO F157-AMCR	0.1	39.2
		ASD-CDF-MCA	ALTERNATE SHUTDOWN FAILURE PROBABILITY FOR MCA CDF		
39	1.49E-09	#F157-A01D-U	F157-A01D UNSUPPRESSED FIRES	0.1	39.3
		AFOPV-S-AFAS-TR	OPERATOR FAILS TO RECOVER AFAS		
		RCOPH-S-SDSE-SL-MD	FAILURE OF SDS VALVES EARLY PHASE OPEN (2/4) WITH MEDIUM DEPENDENCY		
		VOHVS2A-HV33A	FAILS TO START OF MAFP ROOM A CUBICLE COOLER HV33A		

Table 19.1-49 (12 of 30)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
40	1.48E-09	#F157-A25C-U	F157-A25C UNSUPPRESSED FIRES	0.1	39.4
		AFOPV-S-AFAS-TR	OPERATOR FAILS TO RECOVER AFAS		
		RCOPH-S-SDSE-SL-MD	FAILURE OF SDS VALVES EARLY PHASE OPEN (2/4) WITH MEDIUM DEPENDENCY		
		VOHVS2B-HV33B	FAILS TO START OF MAFP ROOM B CUBICLE COOLER HV33B		
41	1.40E-09	#F157-A01D-U	F157-A01D UNSUPPRESSED FIRES	0.1	39.4
		AFMPM2A-MDP02A	AFW MDP PP02A UNAVAILABLE DUE TO T/M		
		AFOPV-S-AFAS-TR	OPERATOR FAILS TO RECOVER AFAS		
		RCOPH-S-SDSE-SL-MD	FAILURE OF SDS VALVES EARLY PHASE OPEN (2/4) WITH MEDIUM DEPENDENCY		
42	1.39E-09	#F157-A25C-U	F157-A25C UNSUPPRESSED FIRES	0.1	39.5
		AFMPM2B-MDP02B	AFW MDP PP02B UNAVAILABLE DUE TO T/M		
		AFOPV-S-AFAS-TR	OPERATOR FAILS TO RECOVER AFAS		
		RCOPH-S-SDSE-SL-MD	FAILURE OF SDS VALVES EARLY PHASE OPEN (2/4) WITH MEDIUM DEPENDENCY		

Table 19.1-49 (13 of 30)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
43	1.30E-09	#F100-T15-U	F100-T15 UNSUPPRESSED FIRES	0.1	39.6
		DAMPR-A-PP02	AAC FUEL OIL FEED PUMP PP02 FAILS TO RUN		
		DGDGKQ4-DG01ABCD	CCF OF EDG 01A/01B/01C/01D FAIL TO RUN		
		SHR1-E12TD	UNRECOVERABLE SBO LEADS TO TDAFW PUMP FAILURE		
44	1.29E-09	#FK-K01	ESW STRUCTURE "A" BUILDING FIRE	0.1	39.7
		CVOPH-S-RCPSEAL	OPERATOR FAILS TO RECOVER RCP SEAL COOLING (CCW CONNTECT. OR AUX. CHG PUMP)		
		SEAL-AFSUC	SEAL FAILURE PROBABILITY (SECONDARY HEAT REMOVAL SUCCESS)		
		VGAHM2B-AH02B	ESW PUMP B FAN 605-VG-AH02B UNAVAILABLE DUE TO T&M		
45	1.28E-09	#F078-AGAC_F078-AGAD	MULTI-COMPARTMENT FIRE FROM F078-AGAC TO F078-AGAD	0.1	39.7
		PR	POSRV FAILS TO RECLOSE		
43	1.30E-09	#F100-T15-U	F100-T15 UNSUPPRESSED FIRES	0.1	39.6
		DAMPR-A-PP02	AAC FUEL OIL FEED PUMP PP02 FAILS TO RUN		

Table 19.1-49 (14 of 30)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
46	1.24E-09	#F100-AEEB-U	F100-AEEB UNSUPPRESSED FIRES	0.1	39.8
		AFTPR1A-TDP01A	FAILS TO RUN AFW TDP PP01A		
		RCOPH-S-SDSE-SL	FAILURE OF SDS VALVES EARLY PHASE OPEN (2/4)		
		VOHVS2A-HV33A	FAILS TO START OF MAFP ROOM A CUBICLE COOLER HV33A		
47	1.23E-09	#F122-T01-U	F122-T01 UNSUPPRESSED FIRES	0.1	39.9
		AFTPR1A-TDP01A	FAILS TO RUN AFW TDP PP01A		
		WOCHWQ4-CH01A/2A/1B/2B	DEMAND CCF OF ECW CHILLERS 1A/2A/1B/2B		
48	1.23E-09	#F122-T01-U	F122-T01 UNSUPPRESSED FIRES	0.1	39.9
		AFTPR1A-TDP01A	FAILS TO RUN AFW TDP PP01A		
		WOCHWQ4-CH03A/4A/3B/4B	DEMAND CCF OF ECW CHILLERS 3A/4A/3B/4B		
49	1.21E-09	#F078-A52D-U	F078-A52D UNSUPPRESSED FIRES	0.1	40.0
		AFTPR1B-TDP01B	FAILS TO RUN AFW TDP PP01B		
		PELXY-C-LX04C-P	FAILURE OF PRIMARY LOOP CONTROLLER OF 745-PE-LX04C		

Table 19.1-49 (15 of 30)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
50	1.18E-09	#F100-T15-U	F100-T15 UNSUPPRESSED FIRES	0.1	40.1
		DAMPR-A-PP02	AAC FUEL OIL FEED PUMP PP02 FAILS TO RUN		
		SHR1-E12TD	UNRECOVERABLE SBO LEADS TO TDAFW PUMP FAILURE		
		WOCHWQ4-CH03A/4A/3B/4B	DEMAND CCF OF ECW CHILLERS 3A/4A/3B/4B		
51	1.18E-09	#F100-T15-U	F100-T15 UNSUPPRESSED FIRES	0.1	40.1
		DAMPR-A-PP02	AAC FUEL OIL FEED PUMP PP02 FAILS TO RUN		
		SHR1-E12TD	UNRECOVERABLE SBO LEADS TO TDAFW PUMP FAILURE		
		WOCHWQ4-CH01A/2A/1B/2B	DEMAND CCF OF ECW CHILLERS 1A/2A/1B/2B		
52	1.16E-09	#F100-AEEB-U	F100-AEEB UNSUPPRESSED FIRES	0.1	40.2
		AFMPM2A-MDP02A	AFW MDP PP02A UNAVAILABLE DUE TO T/M		
		AFTPR1A-TDP01A	FAILS TO RUN AFW TDP PP01A		
		RCOPH-S-SDSE-SL	FAILURE OF SDS VALVES EARLY PHASE OPEN (2/4)		

Table 19.1-49 (16 of 30)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
53	1.14E-09	#F078-A05D-U	F078-A05D UNSUPPRESSED FIRES	0.1	40.2
		FWOPH-S-ERY	OPERATOR FAILS TO ALINE STARTUP FEEDWATER PUMP PP07 (EARLY PHASE)		
		RCOPH-S-SDSE-SL-LD	FAILURE OF SDS VALVES EARLY PHASE OPEN (2/4) WITH LOW DEPENDENCY		
		VOHVM2A-HV33A	CUBICLE COOLER HV33A UNAVAILABLE DUE TO T&M		
54	1.14E-09	#F000-TB-LOOP2	TB FIRES LEADING TO LOOP WITH ALL OTHER CREDITED EQ. IN TB DAMAGED	0.1	40.3
		DAMPR-A-PP02	AAC FUEL OIL FEED PUMP PP02 FAILS TO RUN		
		DGDGKQ4-DG01ABCD	CCF OF EDG 01A/01B/01C/01D FAIL TO RUN		
		SHR1-E12TD	UNRECOVERABLE SBO LEADS TO TDAFW PUMP FAILURE		
55	1.05E-09	#F000-ADGC_F120-A01C	MULTI-COMPARTMENT FIRE FROM F000-ADGC TO F120-A01C	0.1	40.4
		AFOPH-S-ALT-LT	OPERATOR FAIL TO ALIGNE FOR SUPPLYING AN ALTERNATE SOURCE		
		FLAG-L-FNB	FLAG FOR CONSIDERING THE FAILURE OF LONG TERM 2NDARY HEAT REMOVAL		
		RCOPH-S-SDSE-SL	FAILURE OF SDS VALVES EARLY PHASE OPEN (2/4)		

Table 19.1-49 (17 of 30)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
56	1.04E-09	#F137-A11C-U	F137-A11C UNSUPPRESSED FIRES	0.1	40.4
		AFTPR1B-TDP01B	FAILS TO RUN AFW TDP PP01B		
		FWOPH-S-ERY	OPERATOR FAILS TO ALINE STARTUP FEEDWATER PUMP PP07 (EARLY PHASE)		
		RCOPH-S-SDSE-SL-LD	FAILURE OF SDS VALVES EARLY PHASE OPEN (2/4) WITH LOW DEPENDENCY		
57	1.03E-09	#F122-T01-U	F122-T01 UNSUPPRESSED FIRES	0.1	40.5
		DAMPR-A-PP02	AAC FUEL OIL FEED PUMP PP02 FAILS TO RUN		
		PFHBWQ4-SW2OUAT	CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1B,1C,1D FAIL TO OPEN		
		SHR1-E12TD	UNRECOVERABLE SBO LEADS TO TDAFW PUMP FAILURE		
58	1.03E-09	#F122-T01-U	F122-T01 UNSUPPRESSED FIRES	0.1	40.5
		DAMPR-A-PP02	AAC FUEL OIL FEED PUMP PP02 FAILS TO RUN		
		PFHBWQ4-SW1OSAT	CCF OF PCB BETWEEN SAT & 4.16KV SW01A,1B,1C,1D FAIL TO OPEN		
		SHR1-E12TD	UNRECOVERABLE SBO LEADS TO TDAFW PUMP FAILURE		

Table 19.1-49 (18 of 30)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
59	1.03E-09	#F000-TB-LOOP2	TB FIRES LEADING TO LOOP WITH ALL OTHER CREDITED EQ. IN TB DAMAGED	0.1	40.6
		DAMPR-A-PP02	AAC FUEL OIL FEED PUMP PP02 FAILS TO RUN		
		SHR1-E12TD	UNRECOVERABLE SBO LEADS TO TDAFW PUMP FAILURE		
		WOCHWQ4-CH03A/4A/3B/4B	DEMAND CCF OF ECW CHILLERS 3A/4A/3B/4B		
60	1.03E-09	#F000-TB-LOOP2	TB FIRES LEADING TO LOOP WITH ALL OTHER CREDITED EQ. IN TB DAMAGED	0.1	40.6
		DAMPR-A-PP02	AAC FUEL OIL FEED PUMP PP02 FAILS TO RUN		
		SHR1-E12TD	UNRECOVERABLE SBO LEADS TO TDAFW PUMP FAILURE		
		WOCHWQ4-CH01A/2A/1B/2B	DEMAND CCF OF ECW CHILLERS 1A/2A/1B/2B		

Table 19.1-49 (19 of 30)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
61	1.01E-09	#F078-A19B-U	F078-A19B UNSUPPRESSED FIRES	0.1	40.7
		AFOPH-S-ALT-LT	OPERATOR FAIL TO ALIGNE FOR SUPPLYING AN ALTERNATE SOURCE		
		FLAG-L-FNB	FLAG FOR CONSIDERING THE FAILURE OF LONG TERM 2NDARY HEAT REMOVAL		
		PFHBO2A-SW01C-C2	FAILS TO OPEN OF PCB SW01C-C2 OF 4.16KV SWGR SW01C FROM UAT		
		RCOPH-S-SDSE-SL	FAILURE OF SDS VALVES EARLY PHASE OPEN (2/4)		
62	9.63E-10	#F120-A15B-U	F120-A15B UNSUPPRESSED FIRES	0.1	40.7
		AXVVO-A-V1623	FAILS TO OPEN CT SYSTEM MANUAL VALVE V1623		
		RCOPH-S-SDSE-SL	FAILURE OF SDS VALVES EARLY PHASE OPEN (2/4)		
63	9.63E-10	#F078-AGAD_F078-AAFD	MULTI-COMPARTMENT FIRE FROM F078-AGAD TO F078-AAFD	0.1	40.8
		WOMPS5A-PP05A	FAILS TO START OF ECW PUMP 05A		
64	9.61E-10	#F122-T01-U	F122-T01 UNSUPPRESSED FIRES	0.1	40.8
		DADGR-S-AACTG	AAC T/G FAILS TO RUN		
		DGDGKQ4-DG01ABCD	CCF OF EDG 01A/01B/01C/01D FAIL TO RUN		
		SHR1-E12TD	UNRECOVERABLE SBO LEADS TO TDAFW PUMP FAILURE		

Table 19.1-49 (20 of 30)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
65	9.58E-10	#F078-AEEB-U	F078-AEEB UNSUPPRESSED FIRES	0.1	40.9
		AFTPR1A-TDP01A	FAILS TO RUN AFW TDP PP01A		
		PFHBO1A-SW01A-H2	FAILS TO OPEN OF PCB SW01A-H2 OF 4.16KV SWGR SW01A FROM UAT		
		#F120-A15B-U	FAILURE OF SDS VALVES EARLY PHASE OPEN (2/4)		
66	9.58E-10	#F157-A01D-U	F157-A01D UNSUPPRESSED FIRES	0.1	41.0
		AFOPV-S-AFAS-TR	OPERATOR FAILS TO RECOVER AFAS		
		RCOPH-S-SDSE-SL-MD	FAILURE OF SDS VALVES EARLY PHASE OPEN (2/4) WITH MEDIUM DEPENDENCY		
		VOHVM2A-HV33A	CUBICLE COOLER HV33A UNAVAILABLE DUE TO T&M		
67	9.53E-10	#F078-AAFD_F078-AGAD	MULTI-COMPARTMENT FIRE FROM F078-AAFD TO F078-AGAD	0.1	41.0
		CCMVO-A-392	CCW MOV 392 FOR ECW CHILLER CH04A OUTLET FAIL TO OPEN		
		F-WOOPH-S-CROSSTIE-A	OPERATOR FAILS TO OPEN 1025A AND ALIGN FLOW PATH		

Table 19.1-49 (21 of 30)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
68	9.52E-10	#F157-A25C-U	F157-A25C UNSUPPRESSED FIRES	0.1	41.1
		AFOPV-S-AFAS-TR	OPERATOR FAILS TO RECOVER AFAS		
		RCOPH-S-SDSE-SL-MD	FAILURE OF SDS VALVES EARLY PHASE OPEN (2/4) WITH MEDIUM DEPENDENCY		
		VOHVM1B-HV33B	CUBICLE COOLER HV33B UNAVAILABLE DUE TO T&M		
69	9.41E-10	#F157-A01D-U	F157-A01D UNSUPPRESSED FIRES	0.1	41.1
		AXVVO-A-V1623	FAILS TO OPEN CT SYSTEM MANUAL VALVE V1623		
		RCOPH-S-SDSE-SL	FAILURE OF SDS VALVES EARLY PHASE OPEN (2/4)		
70	9.37E-10	#F078-A52D-U	F078-A52D UNSUPPRESSED FIRES	0.1	41.2
		AFTPKD2-TDP01A/B	2/2 CCF OF RUNNING AFW TDP PP01/A/B		
		F-WOOPH-S-CROSSTIE-A	OPERATOR FAILS TO OPEN 1025A AND ALIGN FLOW PATH		
		WOCHM4A-CH04A	ECW CHILLER 04A TRAIN UNAVAILABLE DUE TO T&M		
71	9.29E-10	#F157-A17C_F157-AMCR	MULTI-COMPARTMENT FIRE FROM F157-A17C TO F157-AMCR	0.0	41.2
		ASD-CDF-MCA	ALTERNATE SHUTDOWN FAILURE PROBABILITY FOR MCA CDF		

Table 19.1-49 (22 of 30)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
72	9.10E-10	#F078-A52D-U	F078-A52D UNSUPPRESSED FIRES	0.0	41.3
		DAMPR-A-PP02	AAC FUEL OIL FEED PUMP PP02 FAILS TO RUN		
		F-WOOPH-S-CROSSTIE-A	OPERATOR FAILS TO OPEN 1025A AND ALIGN FLOW PATH		
		PFGRID	GRID COLLAPSE ON TURBINE TRIP		
		WOCHM4A-CH04A	ECW CHILLER 04A TRAIN UNAVAILABLE DUE TO T&M		
		SHR1-E12TD	UNRECOVERABLE SBO LEADS TO TDAFW PUMP FAILURE		
73	8.98E-10	#F078-A05D-U	F078-A05D UNSUPPRESSED FIRES	0.0	41.3
		AFOPV-S-AFAS-TR	OPERATOR FAILS TO RECOVER AFAS		
		EFORT-A-FOR6-AFAS1A-GC1FR	FAILURE OF GC-1 CH. A FIBER OPTIC RECEIVER FOR LC		
		RCOPH-S-SDSE-SL-LD	FAILURE OF SDS VALVES EARLY PHASE OPEN (2/4) WITH LOW DEPENDENCY		
		FWOPH-S-ERY-CD	OPERATOR FAILS TO ALINE STARTUP FEEDWATER PUMP PP07 (EARLY PHASE) WITH COMPLETE DEPENDENCY		

Table 19.1-49 (23 of 30)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
74	8.98E-10	#F078-A05D-U	F078-A05D UNSUPPRESSED FIRES	0.0	41.4
		AFOPV-S-AFAS-TR	OPERATOR FAILS TO RECOVER AFAS		
		EFORT-A-FOR6-AFAS1A-GC1FT	FAILURE OF GC-1 CH. A FIBER OPTIC TRANSMITTER FOR LC		
		RCOPH-S-SDSE-SL-LD	FAILURE OF SDS VALVES EARLY PHASE OPEN (2/4) WITH LOW DEPENDENCY		
		FWOPH-S-ERY-CD	OPERATOR FAILS TO ALINE STARTUP FEEDWATER PUMP PP07 (EARLY PHASE) WITH COMPLETE DEPENDENCY		
75	8.89E-10	#F000-C01-156-1	CTMT TRANSIENT FIRES EL 156'-0" AREA 1	0.0	41.4
		SISPP-S-IRWST	FAILURE OF IRWST SUMP DUE TO PLUGGING		
76	8.69E-10	#F122-T01-U	F122-T01 UNSUPPRESSED FIRES	0.0	41.4
		DADGR-S-AACTG	AAC T/G FAILS TO RUN		
		WOCHWQ4-CH03A/4A/3B/4B	DEMAND CCF OF ECW CHILLERS 3A/4A/3B/4B		
		SHR1-E12TD	UNRECOVERABLE SBO LEADS TO TDAFW PUMP FAILURE		

Table 19.1-49 (24 of 30)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
77	8.69E-10	#F122-T01-U	F122-T01 UNSUPPRESSED FIRES	0.0	41.5
		DADGR-S- AACTG	AAC T/G FAILS TO RUN		
		WOCHWQ4-CH01A/2A/1B/2B	DEMAND CCF OF ECW CHILLERS 1A/2A/1B/2B		
		SHR1-E12TD	UNRECOVERABLE SBO LEADS TO TDAFW PUMP FAILURE		
78	8.68E-10	#F100-T15-U	F100-T15 UNSUPPRESSED FIRES	0.0	41.5
		AFTPR1A-TDP01A	FAILS TO RUN AFW TDP PP01A		
		WOCHWQ4-CH03A/4A/3B/4B	DEMAND CCF OF ECW CHILLERS 3A/4A/3B/4B		
79	8.68E-10	#F100-T15-U	F100-T15 UNSUPPRESSED FIRES	0.0	41.6
		AFTPR1A-TDP01A	FAILS TO RUN AFW TDP PP01A		
		WOCHWQ4-CH01A/2A/1B/2B	DEMAND CCF OF ECW CHILLERS 1A/2A/1B/2B		
80	8.64E-10	#F000-ACVU-U	F000-ACVU UNSUPPRESSED FIRES	0.0	41.6
		AFTPR1A-TDP01A	FAILS TO RUN AFW TDP PP01A		
		RCOPH-S-SDSE-SL	FAILURE OF SDS VALVES EARLY PHASE OPEN (2/4)		
		VOHVS2B-HV33B	FAILS TO START OF MAFP ROOM B CUBICLE COOLER HV33B		

Table 19.1-49 (25 of 30)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
81	8.37E-10	#F000-TB-LOOP2 AFTPR1A-TDP01A DGDGKQ4-DG01ABCD	TB FIRES LEADING TO LOOP WITH ALL OTHER CREDITED EQ. IN TB DAMAGED FAILS TO RUN AFW TDP PP01A CCF OF EDG 01A/01B/01C/01D FAIL TO RUN	0.0	41.7
82	8.27E-10	#F055-AGAC-U AFTPR1B-TDP01B RCOPH-S-SDSE-SL VOHVS2B-HV33B	F055-AGAC UNSUPPRESSED FIRES FAILS TO RUN AFW TDP PP01B FAILURE OF SDS VALVES EARLY PHASE OPEN (2/4) FAILS TO START OF MAFP ROOM B CUBICLE COOLER HV33B	0.0	41.7
83	8.22E-10	#F078-A52D-U AFTPS1A-TDP01A AFTPR1B-TDP01B WOCHM4A-CH04A F-WOOPH-S-CROSSTIE-A	F078-A52D UNSUPPRESSED FIRES FAILS TO START AFW TDP PP01A FAILS TO RUN AFW TDP PP01B ECW CHILLER 04A TRAIN UNAVAILABLE DUE TO T&M OPERATOR FAILS TO OPEN 1025A AND ALIGN FLOW PATH	0.0	41.8

Table 19.1-49 (26 of 30)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
84	8.22E-10	#F078-A52D-U	F078-A52D UNSUPPRESSED FIRES	0.0	41.8
		AFTPS1B-TDP01B	FAILS TO START AFW TDP PP01B		
		AFTPR1A-TDP01A	FAILS TO RUN AFW TDP PP01A		
		WOCHM4A-CH04A	ECW CHILLER 04A TRAIN UNAVAILABLE DUE TO T&M		
		F-WOOPH-S-CROSSTIE-A	OPERATOR FAILS TO OPEN 1025A AND ALIGN FLOW PATH		
85	8.17E-10	#F000-TB-LOCV2	TB FIRES LEADING TO LOCV WITH ALL OTHER CREDITED EQ. IN TB DAMAGED	0.0	41.9
		DGDGKQ4-DG01ABCD	CCF OF EDG 01A/01B/01C/01D FAIL TO RUN		
		PFGRID	GRID COLLAPSE ON TURBINE TRIP		
		SHR1-E12TD	UNRECOVERABLE SBO LEADS TO TDAFW PUMP FAILURE		
86	8.12E-10	#F000-ACVU-U	F000-ACVU UNSUPPRESSED FIRES	0.0	41.9
		AFMPM2B-MDP02B	AFW MDP PP02B UNAVAILABLE DUE TO T/M		
		AFTPR1A-TDP01A	FAILS TO RUN AFW TDP PP01A		
		RCOPH-S-SDSE-SL	FAILURE OF SDS VALVES EARLY PHASE OPEN (2/4)		

Table 19.1-49 (27 of 30)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
87	8.10E-10	#F000-C01-114-1 SISPP-S-IRWST	CTMT TRANSIENT FIRES EL 114'-0" AREA 1 FAILURE OF IRWST SUMP DUE TO PLUGGING	0.0	41.9
88	8.10E-10	#F000-C01-136-1 SISPP-S-IRWST	CTMT TRANSIENT FIRES EL 136'-6" AREA 1 FAILURE OF IRWST SUMP DUE TO PLUGGING	0.0	42.0
89	8.10E-10	#F000-C01-100-1 SISPP-S-IRWST	CTMT TRANSIENT FIRES EL 100'-0" AREA 1 FAILURE OF IRWST SUMP DUE TO PLUGGING	0.0	42.0
90	7.96E-10	#F100-AEEB-U AFTPR1A-TDP01A RCOPH-S-SDSE-SL VOHVM2A-HV33A	F100-AEEB UNSUPPRESSED FIRES FAILS TO RUN AFW TDP PP01A FAILURE OF SDS VALVES EARLY PHASE OPEN (2/4) CUBICLE COOLER HV33A UNAVAILABLE DUE TO T&M	0.0	42.1
91	7.78E-10	#F055-AGAC-U AFMPM2B-MDP02B AFTPR1B-TDP01B RCOPH-S-SDSE-SL	F055-AGAC UNSUPPRESSED FIRES AFW MDP PP02B UNAVAILABLE DUE TO T/M FAILS TO RUN AFW TDP PP01B FAILURE OF SDS VALVES EARLY PHASE OPEN (2/4)	0.0	42.1

Table 19.1-49 (28 of 30)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
92	7.57E-10	#F000-TB-LOOP2	TB FIRES LEADING TO LOOP WITH ALL OTHER CREDITED EQ. IN TB DAMAGED	0.0	42.2
		AFTPR1A-TDP01A	FAILS TO RUN AFW TDP PP01A		
		WOCHWQ4-CH03A/4A/3B/4B	DEMAND CCF OF ECW CHILLERS 3A/4A/3B/4B		
93	7.57E-10	#F000-TB-LOOP2	TB FIRES LEADING TO LOOP WITH ALL OTHER CREDITED EQ. IN TB DAMAGED	0.0	42.2
		AFTPR1A-TDP01A	FAILS TO RUN AFW TDP PP01A		
		WOCHWQ4-CH01A/2A/1B/2B	DEMAND CCF OF ECW CHILLERS 1A/2A/1B/2B		
94	7.55E-10	#F157-A01D-U	F157-A01D UNSUPPRESSED FIRES	0.0	42.2
		AFOPV-S-AFAS-TR	OPERATOR FAILS TO RECOVER AFAS		
		EFORT-A-FOR6-AFAS1A-GC1FT	FAILURE OF GC-1 CH. A FIBER OPTIC TRANSMITTER FOR LC		
		RCOPH-S-SDSE-SL-MD	FAILURE OF SDS VALVES EARLY PHASE OPEN (2/4) WITH MEDIUM DEPENDENCY		

Table 19.1-49 (29 of 30)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
95	7.55E-10	#F157-A01D-U	F157-A01D UNSUPPRESSED FIRES	0.0	42.3
		AFOPV-S-AFAS-TR	OPERATOR FAILS TO RECOVER AFAS		
		EFORT-A-FOR6-AFAS1A-GC1FR	FAILURE OF GC-1 CH. A FIBER OPTIC RECEIVER FOR LC		
		RCOPH-S-SDSE-SL-MD	FAILURE OF SDS VALVES EARLY PHASE OPEN (2/4) WITH MEDIUM DEPENDENCY		
96	7.50E-10	#F157-A25C-U	F157-A25C UNSUPPRESSED FIRES	0.0	42.3
		AFOPV-S-AFAS-TR	OPERATOR FAILS TO RECOVER AFAS		
		EFORT-B-FOR6-AFAS2B-GC1FT	FAILURE OF GC-1 CH. B FIBER OPTIC TRANSMITTER FOR LC		
		RCOPH-S-SDSE-SL-MD	FAILURE OF SDS VALVES EARLY PHASE OPEN (2/4) WITH MEDIUM DEPENDENCY		
97	7.50E-10	#F157-A25C-U	F157-A25C UNSUPPRESSED FIRES	0.0	42.4
		AFOPV-S-AFAS-TR	OPERATOR FAILS TO RECOVER AFAS		
		EFORT-B-FOR6-AFAS2B-GC1FR	FAILURE OF GC-1 CH. B FIBER OPTIC RECEIVER FOR LC		
		RCOPH-S-SDSE-SL-MD	FAILURE OF SDS VALVES EARLY PHASE OPEN (2/4) WITH MEDIUM DEPENDENCY		

Table 19.1-49 (30 of 30)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
98	7.38E-10	#F000-TB-LOCV2	TB FIRES LEADING TO LOCV WITH ALL OTHER CREDITED EQ. IN TB DAMAGED	0.0	42.4
		PFGRID	GRID COLLAPSE ON TURBINE TRIP		
		SHR1-E12TD	UNRECOVERABLE SBO LEADS TO TDAFW PUMP FAILURE		
		WOCHWQ4-CH03A/4A/3B/4B	DEMAND CCF OF ECW CHILLERS 3A/4A/3B/4B		
99	7.38E-10	#F000-TB-LOCV2	TB FIRES LEADING TO LOCV WITH ALL OTHER CREDITED EQ. IN TB DAMAGED	0.0	42.4
		PFGRID	GRID COLLAPSE ON TURBINE TRIP		
		SHR1-E12TD	UNRECOVERABLE SBO LEADS TO TDAFW PUMP FAILURE		
		WOCHWQ4-CH01A/2A/1B/2B	DEMAND CCF OF ECW CHILLERS 1A/2A/1B/2B		
100	7.29E-10	#F000-C01-156-1	CTMT TRANSIENT FIRES EL 156'-0" AREA 1	0.0	42.5
		SISPP-S-CHEMICAL	DEBRIS INDUCED LOSS OF LONG TERM COOLING (DOWNSTREAM/CHEMICAL EFFECT)		

Table 19.1-50 (1 of 39)

Internal Fire PRA Top 100 LRF Cutsets

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
1	2.36E-08	#F157-AMCR-4-4 ASD-LRF	MCR TRANS FIRE, SUPP. FAILS, ASD ALTERNATE SHUTDOWN FAILURE PROBABILITY FOR LRF	14.0	14.0
2	1.52E-08	#F157-AMCR-3-4 ASD-LRF	MCR SAFETY CONSOLE FIRE, SUPP. FAILS, ASD ALTERNATE SHUTDOWN FAILURE PROBABILITY FOR LRF	9.0	23.0
3	7.56E-09	#F157-AMCR-1-4 ASD-LRF	MCR CCTV FIRE, SUPP. FAILS, ASD ALTERNATE SHUTDOWN FAILURE PROBABILITY FOR LRF	4.5	27.4
4	7.56E-09	#F157-AMCR-2-4 ASD-LRF	MCR FIRE CONT PNL FIRE, SUPP. FAILS, ASD ALTERNATE SHUTDOWN FAILURE PROBABILITY FOR LRF	4.5	31.9
5	3.43E-09	#F157-AMCR-6-4 ASD-LRF	MCR CABLE W/C FIRE, SUPP. FAILS, ASD ALTERNATE SHUTDOWN FAILURE PROBABILITY FOR LRF	2.0	33.9
6	1.16E-09	#F137-A03C_F157-AMCR ASD-LRF-MCA	MULTI-COMPARTMENT FIRE FROM F137-A03C TO F157-AMCR ALTERNATE SHUTDOWN FAILURE PROBABILITY FOR MCA LRF	0.7	34.6

Table 19.1-50 (2 of 39)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
7	1.06E-09	#F078-AAFD_F078-AGAD	MULTI-COMPARTMENT FIRE FROM F078-AAFD TO F078-AGAD	0.6	35.2
		ERVC	EXTERNAL REACTOR VESSEL COOLING FAILS		
		F-WOOPH-S-CROSSTIE-A	OPERATOR FAILS TO OPEN 1025A AND ALIGN FLOW PATH		
		PDS_14	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14		
		WOCHM4A-CH04A	ECW CHILLER 04A TRAIN UNAVAILABLE DUE TO T&M		
8	1.01E-09	#F157-A01D-U	F157-A01D UNSUPPRESSED FIRES	0.6	35.8
		CCOPV-S-NSMV	OPERATOR FAILS TO CLOSE CC MOV 143~150 (NON-ESSENTIAL LOAD)		
		EFOPV-S-SIAS	OPERATOR FAILS TO MANUALLY INITIATE ALL CHANNELS VIA MCR FOR SIAS		
		ERVC	EXTERNAL REACTOR VESSEL COOLING FAILS		
		RPPTM-A-PT102A	LO PZR PR. CH.A IS IN BYPASS (T&M)		
		PDS_14	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14		

Table 19.1-50 (3 of 39)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
9	1.01E-09	#F157-A01D-U	F157-A01D UNSUPPRESSED FIRES	0.6	36.4
		CCOPV-S-NSMV	OPERATOR FAILS TO CLOSE CC MOV 143~150 (NON-ESSENTIAL LOAD)		
		EFOPV-S-SIAS	OPERATOR FAILS TO MANUALLY INITIATE ALL CHANNELS VIA MCR FOR SIAS		
		ERVC	EXTERNAL REACTOR VESSEL COOLING FAILS		
		RPPTM-C-PT102C	LO PZR PR. CH.C IS IN BYPASS (T&M)		
		PDS_14	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14		
10	8.69E-10	#F157-ACPX_F157-AMCR	MULTI-COMPARTMENT FIRE FROM F157-ACPX TO F157-AMCR	0.5	37.0
		ASD-LRF-MCA	ALTERNATE SHUTDOWN FAILURE PROBABILITY FOR MCA LRF		
11	7.40E-10	#F078-AAFD_F078-AGAD	MULTI-COMPARTMENT FIRE FROM F078-AAFD TO F078-AGAD	0.4	37.4
		ERVC	EXTERNAL REACTOR VESSEL COOLING FAILS		
		PDS_14	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14		
		WOMPM5A-PP05A	ECW PP05A TRAIN UNAVAILABLE DUE TO TEST OR MAINTENANCE		

Table 19.1-50 (4 of 39)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
12	7.14E-10	#F078-AAFD_F078-AGAD	MULTI-COMPARTMENT FIRE FROM F078-AAFD TO F078-AGAD	0.4	37.8
		ERVC	EXTERNAL REACTOR VESSEL COOLING FAILS		
		PDS_14	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14		
		PFHBO2A-SW01C-C2	FAILS TO OPEN OF PCB SW01C-C2 OF 4.16KV SWGR SW01C FROM UAT		
13	6.97E-10	#F078-AAFD_F078-AGAD	MULTI-COMPARTMENT FIRE FROM F078-AAFD TO F078-AGAD	0.4	38.2
		ERVC	EXTERNAL REACTOR VESSEL COOLING FAILS		
		F-WOOPH-S-CROSSTIE-A	OPERATOR FAILS TO OPEN 1025A AND ALIGN FLOW PATH		
		PDS_14	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14		
		WOCHS4A-CH04A	ECW CHILLER CH04A FAILS TO START ON DEMAND		

Table 19.1-50 (5 of 39)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
14	6.87E-10	#F157-A01D-U	F157-A01D UNSUPPRESSED FIRES	0.4	38.6
		H-SDR-POSRV-3WAY	OPERATOR FAILS TO OPERATION (POSRV & 3-WAY V/V)		
		PDS_86	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-86		
		RCOPH-S-SDSE-SL	FAILURE OF SDS VALVES EARLY PHASE OPEN (2/4)		
		VOHVS2A-HV33A	FAILS TO START OF MAFP ROOM A CUBICLE COOLER HV33A		
15	6.54E-10	#F078-AEEB-U	F078-AEEB UNSUPPRESSED FIRES	0.4	39.0
		AFTPR1A-TDP01A	FAILS TO RUN AFW TDP PP01A		
		PDS_6	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-6		
		PFHBO1A-SW01A-H2	FAILS TO OPEN OF PCB SW01A-H2 OF 4.16KV SWGR SW01A FROM UAT		
		WOCHM2A-CH02A	ECW CHILLER 02A TRAIN UNAVAILABLE DUE TO T&M		

Table 19.1-50 (6 of 39)

16	6.54E-10	#F078-AEEB-U	F078-AEEB UNSUPPRESSED FIRES	0.4	39.4
		AFTPR1A-TDP01A	FAILS TO RUN AFW TDP PP01A		
		PDS_6	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-6		
		PFHBO1A-SW01A-H2	FAILS TO OPEN OF PCB SW01A-H2 OF 4.16KV SWGR SW01A FROM UAT		
		WOCHM4A-CH04A	ECW CHILLER 04A TRAIN UNAVAILABLE DUE TO T&M		
17	6.46E-10	#F157-A01D-U	F157-A01D UNSUPPRESSED FIRES	0.4	39.8
		AFMPM2A-MDP02A	AFW MDP PP02A UNAVAILABLE DUE TO T/M		
		H-SDR-POSRV-3WAY	OPERATOR FAILS TO OPERATION (POSRV & 3-WAY V/V)		
		PDS_86	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-86		
		RCOPH-S-SDSE-SL	FAILURE OF SDS VALVES EARLY PHASE OPEN (2/4)		

Table 19.1-50 (7 of 39)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
18	4.41E-10	#F157-A01D-U	F157-A01D UNSUPPRESSED FIRES	0.3	40.1
		H-SDR-POSRV-3WAY	OPERATOR FAILS TO OPERATION (POSRV & 3-WAY V/V)		
		PDS_86	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-86		
		RCOPH-S-SDSE-SL	FAILURE OF SDS VALVES EARLY PHASE OPEN (2/4)		
		VOHVM2A-HV33A	CUBICLE COOLER HV33A UNAVAILABLE DUE TO T&M		
19	4.36E-10	#F078-AEEB-U	F078-AEEB UNSUPPRESSED FIRES	0.3	40.4
		AFTPR1A-TDP01A	FAILS TO RUN AFW TDP PP01A		
		PDS_6	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-6		
		PFHBO1A-SW01A-H2	FAILS TO OPEN OF PCB SW01A-H2 OF 4.16KV SWGR SW01A FROM UAT		
		SXMPM2A-PP02A	ESW PUMP PP02A UNAVAILABLE DUE TO T/M		

Table 19.1-50 (8 of 39)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
20	4.30E-10	#F078-AEEB-U	F078-AEEB UNSUPPRESSED FIRES	0.3	40.6
		AFTPR1A-TDP01A	FAILS TO RUN AFW TDP PP01A		
		PDS_6	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-6		
		PFHBO1A-SW01A-H2	FAILS TO OPEN OF PCB SW01A-H2 OF 4.16KV SWGR SW01A FROM UAT		
		WOCHS2A-CH02A	ECW CHILLER CH02A FAILS TO START ON DEMAND		
21	4.30E-10	#F078-AEEB-U	F078-AEEB UNSUPPRESSED FIRES	0.3	40.8
		AFTPR1A-TDP01A	FAILS TO RUN AFW TDP PP01A		
		PDS_6	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-6		
		PFHBO1A-SW01A-H2	FAILS TO OPEN OF PCB SW01A-H2 OF 4.16KV SWGR SW01A FROM UAT		
		WOCHS4A-CH04A	ECW CHILLER CH04A FAILS TO START ON DEMAND		
22	4.26E-10	#F137-A02D_F157-AMCR	MULTI-COMPARTMENT FIRE FROM F137-A02D TO F157-AMCR	0.3	41.1
		ASD-LRF-MCA	ALTERNATE SHUTDOWN FAILURE PROBABILITY FOR MCA LRF		

Table 19.1-50 (9 of 39)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
23	3.80E-10	#F078-AGAD_F078-AAFD	MULTI-COMPARTMENT FIRE FROM F078-AGAD TO F078-AAFD	0.3	40.6
		ERVC	EXTERNAL REACTOR VESSEL COOLING FAILS		
		F-WOOPH-S-CROSSTIE-A	OPERATOR FAILS TO OPEN 1025A AND ALIGN FLOW PATH		
		PDS_14	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14		
		WOCHM4A-CH04A	ECW CHILLER 04A TRAIN UNAVAILABLE DUE TO T&M		
24	2.98E-10	#F078-AEEB-U	F078-AEEB UNSUPPRESSED FIRES	0.3	40.8
		AFTPR1A-TDP01A	FAILS TO RUN AFW TDP PP01A		
		PDS_6	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-6		
		PFHBWQ2-SW2OUATAC	2/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1C FAIL TO OPEN		
		#F078-AGAD_F078-AAFD	MULTI-COMPARTMENT FIRE FROM F078-AGAD TO F078-AAFD		
25	2.65E-10	ERVC	EXTERNAL REACTOR VESSEL COOLING FAILS	0.3	41.1
		PDS_14	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14		
		WOMPM5A-PP05A	ECW PP05A TRAIN UNAVAILABLE DUE TO TEST OR MAINTENANCE		

Table 19.1-50 (10 of 39)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
26	2.64E-10	#F120-A11B-U	F120-A11B UNSUPPRESSED FIRES	0.2	41.8
		AFTPR1A-TDP01A	FAILS TO RUN AFW TDP PP01A		
		PDS_6	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-6		
		PFHBO1A-SW01A-H2	FAILS TO OPEN OF PCB SW01A-H2 OF 4.16KV SWGR SW01A FROM UAT		
		WOCHM2A-CH02A	ECW CHILLER 02A TRAIN UNAVAILABLE DUE TO T&M		
27	2.64E-10	#F120-A11B-U	F120-A11B UNSUPPRESSED FIRES	0.2	41.9
		AFTPR1A-TDP01A	FAILS TO RUN AFW TDP PP01A		
		PDS_6	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-6		
		PFHBO1A-SW01A-H2	FAILS TO OPEN OF PCB SW01A-H2 OF 4.16KV SWGR SW01A FROM UAT		
		WOCHM4A-CH04A	ECW CHILLER 04A TRAIN UNAVAILABLE DUE TO T&M		

Table 19.1-50 (11 of 39)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
28	2.63E-10	#F157-A01D-U	F157-A01D UNSUPPRESSED FIRES	0.2	42.1
		CCOPV-S-NSMV	OPERATOR FAILS TO CLOSE CC MOV 143~150 (NON-ESSENTIAL LOAD)		
		EFOPV-S-SIAS	OPERATOR FAILS TO MANUALLY INITIATE ALL CHANNELS VIA MCR FOR SIAS		
		ERVC	EXTERNAL REACTOR VESSEL COOLING FAILS		
		PDS_14	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14		
29	2.63E-10	#F157-A01D-U	F157-A01D UNSUPPRESSED FIRES	0.2	42.3
		CCOPV-S-NSMV	OPERATOR FAILS TO CLOSE CC MOV 143~150 (NON-ESSENTIAL LOAD)		
		EFOPV-S-SIAS	OPERATOR FAILS TO MANUALLY INITIATE ALL CHANNELS VIA MCR FOR SIAS		
		ERVC	EXTERNAL REACTOR VESSEL COOLING FAILS		
		PDS_14	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14		

Table 19.1-50 (12 of 39)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
30	2.56E-10	#F078-AGAD_F078-AAFD	MULTI-COMPARTMENT FIRE FROM F078-AGAD TO F078-AAFD	0.2	42.4
		ERVC	EXTERNAL REACTOR VESSEL COOLING FAILS		
		PDS_14	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14		
		PFHBO2A-SW01C-C2	FAILS TO OPEN OF PCB SW01C-C2 OF 4.16KV SWGR SW01C FROM UAT		
31	2.55E-10	#F157-A01D-U	F157-A01D UNSUPPRESSED FIRES	0.2	42.6
		CCHEY01A-HE01A	CCW HX. HE01A FAILS WHILE OPERATING		
		CCOPH-S-HX-ALIGN	OPERATOR FAILS TO OPEN CCW HX3A/B ISOL. V1145 /6 /ESW SUPPLYING V1027/8, 3014/5		
		ERVC	EXTERNAL REACTOR VESSEL COOLING FAILS		
		#F157-A01D-U	F157-A01D UNSUPPRESSED FIRES	0.2	42.7
		CCHEY02A-HE02A	CCW HX. HE02A FAILS WHILE OPERATING		
		CCOPH-S-HX-ALIGN	OPERATOR FAILS TO OPEN CCW HX3A/B ISOL. V1145 /6 /ESW SUPPLYING V1027/8, 3014/5		
		ERVC	EXTERNAL REACTOR VESSEL COOLING FAILS		

Table 19.1-50 (13 of 39)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
33	2.52E-10	#F078-A52D-U	F078-A52D UNSUPPRESSED FIRES	0.1	42.9
		AFTPR1A-TDP01A	FAILS TO RUN AFW TDP PP01A		
		AFTPR1B-TDP01B	FAILS TO RUN AFW TDP PP01B		
		ERVC	EXTERNAL REACTOR VESSEL COOLING FAILS		
		PDS_14	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14		
		WOCHM4A-CH04A	ECW CHILLER 04A TRAIN UNAVAILABLE DUE TO T&M		
		F-WOOPH-S-CROSSTIE-A	OPERATOR FAILS TO OPEN 1025A AND ALIGN FLOW PATH		
34	2.50E-10	#F078-AGAD_F078-AAFD	MULTI-COMPARTMENT FIRE FROM F078-AGAD TO F078-AAFD	0.1	43.0
		ERVC	EXTERNAL REACTOR VESSEL COOLING FAILS		
		F-WOOPH-S-CROSSTIE-A	OPERATOR FAILS TO OPEN 1025A AND ALIGN FLOW PATH		
		PDS_14	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14		
		WOCHS4A-CH04A	ECW CHILLER CH04A FAILS TO START ON DEMAND		

Table 19.1-50 (14 of 39)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
35	2.37E-10	#F157-A01D-U	F157-A01D UNSUPPRESSED FIRES	0.1	43.1
		CCOPV-S-NSMV	OPERATOR FAILS TO CLOSE CC MOV 143~150 (NON-ESSENTIAL LOAD)		
		EFOPV-S-SIAS	OPERATOR FAILS TO MANUALLY INITIATE ALL CHANNELS VIA MCR FOR SIAS		
		ERVC	EXTERNAL REACTOR VESSEL COOLING FAILS		
		RPIAT-C-PY102C	LO PZR PR. CONVERTER CH.C PT-102C FAILS TO PROVIDE PROPER OUTPUT		
		PDS_14	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14		
36	2.37E-10	#F157-A01D-U	F157-A01D UNSUPPRESSED FIRES	0.1	43.3
		CCOPV-S-NSMV	OPERATOR FAILS TO CLOSE CC MOV 143~150 (NON-ESSENTIAL LOAD)		
		EFOPV-S-SIAS	OPERATOR FAILS TO MANUALLY INITIATE ALL CHANNELS VIA MCR FOR SIAS		
		ERVC	EXTERNAL REACTOR VESSEL COOLING FAILS		
		RPIAT-A-PY102A	LO PZR PR. CONVERTER CH.A PT-102A FAILS TO PROVIDE PROPER OUTPUT		
		PDS_14	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14		

Table 19.1-50 (15 of 39)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
37	2.28E-10	#F078-AEEB-U	F078-AEEB UNSUPPRESSED FIRES	0.4	43.4
		AFTPR1A-TDP01A	FAILS TO RUN AFW TDP PP01A		
		PDS_6	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-6		
		PFHBO1A-SW01A-H2	FAILS TO OPEN OF PCB SW01A-H2 OF 4.16KV SWGR SW01A FROM UAT		
		WOMPM5A-PP05A	ECW PP05A TRAIN UNAVAILABLE DUE TO TEST OR MAINTENANCE		
38	2.28E-10	#F078-AEEB-U	F078-AEEB UNSUPPRESSED FIRES	0.1	43.6
		AFTPR1A-TDP01A	FAILS TO RUN AFW TDP PP01A		
		PDS_6	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-6		
		PFHBO1A-SW01A-H2	FAILS TO OPEN OF PCB SW01A-H2 OF 4.16KV SWGR SW01A FROM UAT		
		WOMPM2A-PP02A	ECW PP02A TRAIN UNAVAILABLE DUE TO TEST OR MAINTENANCE		

Table 19.1-50 (16 of 39)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
39	2.20E-10	#F078-AEEB-U	F078-AEEB UNSUPPRESSED FIRES	0.1	43.7
		AFTPR1A-TDP01A	FAILS TO RUN AFW TDP PP01A		
		PDS_6	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-6		
		PFHBO1A-SW01A-H2	FAILS TO OPEN OF PCB SW01A-H2 OF 4.16KV SWGR SW01A FROM UAT		
		PFHBO2A-SW01C-C2	FAILS TO OPEN OF PCB SW01C-C2 OF 4.16KV SWGR SW01C FROM UAT		
40	2.15E-10	#F157-A01D-U	F157-A01D UNSUPPRESSED FIRES	0.1	43.8
		PDS_86	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-86		
		RCPVO-A-201	POSRV V201 FAILS TO OPEN (HARDWARE FAIL)		
		VOHVS2A-HV33A	FAILS TO START OF MAFP ROOM A CUBICLE COOLER HV33A		
41	2.15E-10	#F157-A01D-U	F157-A01D UNSUPPRESSED FIRES	0.1	43.9
		PDS_86	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-86		
		RCPVO-A-200	POSRV V200 FAILS TO OPEN (HARDWARE FAIL)		
		VOHVS2A-HV33A	FAILS TO START OF MAFP ROOM A CUBICLE COOLER HV33A		

Table 19.1-50 (17 of 39)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
42	2.02E-10	#F157-A01D-U	F157-A01D UNSUPPRESSED FIRES	0.1	44.1
		AFMPM2A-MDP02A	AFW MDP PP02A UNAVAILABLE DUE TO T/M		
		PDS_86	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-86		
		RCPVO-A-201	POSRV V201 FAILS TO OPEN (HARDWARE FAIL)		
43	2.02E-10	#F157-A01D-U	F157-A01D UNSUPPRESSED FIRES	0.1	44.2
		AFMPM2A-MDP02A	AFW MDP PP02A UNAVAILABLE DUE TO T/M		
		PDS_86	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-86		
		RCPVO-A-200	POSRV V200 FAILS TO OPEN (HARDWARE FAIL)		
44	1.85E-10	#F157-A25C_F157-A17C	MULTI-COMPARTMENT FIRE FROM F157-A25C TO F157-A17C	0.1	44.3
		AFOPV-S-AFAS-TR	OPERATOR FAILS TO RECOVER AFAS		
		H-SDR-POSRV-3WAY	OPERATOR FAILS TO OPERATION (POSRV & 3-WAY V/V)		
		PDS_100	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-100		
		RCOPH-S-SDSE-SL-MD	FAILURE OF SDS VALVES EARLY PHASE OPEN (2/4) WITH MEDIUM DEPENDENCY		

Table 19.1-50 (18 of 39)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
45	1.81E-10	#F137-A05D_F157-AMCR	MULTI-COMPARTMENT FIRE FROM F137-A05D TO F157-AMCR	0.1	44.4
		ASD-LRF-MCA	ALTERNATE SHUTDOWN FAILURE PROBABILITY FOR MCA LRF		
46	1.76E-10	#F120-A11B-U	F120-A11B UNSUPPRESSED FIRES	0.1	44.5
		AFTPR1A-TDP01A	FAILS TO RUN AFW TDP PP01A		
		PDS_6	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-6		
		PFHBO1A-SW01A-H2	FAILS TO OPEN OF PCB SW01A-H2 OF 4.16KV SWGR SW01A FROM UAT		
		SXMPM2A-PP02A	ESW PUMP PP02A UNAVAILABLE DUE TO T/M		
47	1.76E-10	#F078-A52D-U	F078-A52D UNSUPPRESSED FIRES	0.1	44.6
		AFTPR1A-TDP01A	FAILS TO RUN AFW TDP PP01A		
		AFTPR1B-TDP01B	FAILS TO RUN AFW TDP PP01B		
		ERVC	EXTERNAL REACTOR VESSEL COOLING FAILS		
		WOMPM5A-PP05A	ECW PP05A TRAIN UNAVAILABLE DUE TO TEST OR MAINTENANCE		
		PDS_14	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14		

Table 19.1-50 (19 of 39)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
48	1.73E-10	#F120-A11B-U AFTPR1A-TDP01A PDS_6 PFHBO1A-SW01A-H2 WOCHS4A-CH04A	F120-A11B UNSUPPRESSED FIRES FAILS TO RUN AFW TDP PP01A CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-6 FAILS TO OPEN OF PCB SW01A-H2 OF 4.16KV SWGR SW01A FROM UAT ECW CHILLER CH04A FAILS TO START ON DEMAND	0.1	44.7
49	1.73E-10	#F120-A11B-U AFTPR1A-TDP01A PDS_6 PFHBO1A-SW01A-H2 WOCHS2A-CH02A	F120-A11B UNSUPPRESSED FIRES FAILS TO RUN AFW TDP PP01A CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-6 FAILS TO OPEN OF PCB SW01A-H2 OF 4.16KV SWGR SW01A FROM UAT ECW CHILLER CH02A FAILS TO START ON DEMAND	0.1	44.8
50	1.69E-10	#F157-A01D-U AFMPS2A-MDP02A H-SDR-POSRV-3WAY PDS_86 RCOPH-S-SDSE-SL	F157-A01D UNSUPPRESSED FIRES FAILS TO START AFW MDP PP02A OPERATOR FAILS TO OPERATION (POSRV & 3-WAY V/V) CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-86 FAILURE OF SDS VALVES EARLY PHASE OPEN (2/4)	0.1	44.9

Table 19.1-50 (20 of 39)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
51	1.66E-10	#F078-A05D-U DCBSY-A-MC01A PDS_86	F078-A05D UNSUPPRESSED FIRES BUS FAULTS ON 1E 125VDC BUS MC01A CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-86	0.1	45.0
52	1.66E-10	#F078-A52D-U AFTPR1A-TDP01A AFTPR1B-TDP01B ERVC F-WOOPH-S-CROSSTIE-A PDS_14 WOCHS4A-CH04A	F078-A52D UNSUPPRESSED FIRES FAILS TO RUN AFW TDP PP01A FAILS TO RUN AFW TDP PP01B EXTERNAL REACTOR VESSEL COOLING FAILS OPERATOR FAILS TO OPEN 1025A AND ALIGN FLOW PATH CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14 ECW CHILLER CH04A FAILS TO START ON DEMAND	0.1	45.1
53	1.56E-10	#F078-AEEB-U AFTPR1A-TDP01A CCMPM2A-PP02A PDS_6 PFHBO1A-SW01A-H2	F078-AEEB UNSUPPRESSED FIRES FAILS TO RUN AFW TDP PP01A CCW PUMP PP02A UNAVAILABLE DUE TO T/M CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-6 FAILS TO OPEN OF PCB SW01A-H2 OF 4.16KV SWGR SW01A FROM UAT	0.1	45.2

Table 19.1-50 (21 of 39)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
54	1.54E-10	#F157-A25C_F157-A17C	MULTI-COMPARTMENT FIRE FROM F157-A25C TO F157-A17C	0.1	45.3
		AFTPR1B-TDP01B	FAILS TO RUN AFW TDP PP01B		
		ERVC	EXTERNAL REACTOR VESSEL COOLING FAILS		
		PDS_27	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-27		
		RCOPH-S-SDSE-SL	FAILURE OF SDS VALVES EARLY PHASE OPEN (2/4)		
55	1.54E-10	#F137-ASTD_F157-AMCR	MULTI-COMPARTMENT FIRE FROM F137-ASTD TO F157-AMCR	0.1	45.4
		ASD-LRF-MCA	ALTERNATE SHUTDOWN FAILURE PROBABILITY FOR MCA LRF		
56	1.52E-10	#F078-A52D-U	F078-A52D UNSUPPRESSED FIRES	0.1	45.5
		ERVC	EXTERNAL REACTOR VESSEL COOLING FAILS		
		F-WOOPH-S-CROSSTIE-A	OPERATOR FAILS TO OPEN 1025A AND ALIGN FLOW PATH		
		PDS-FREQ-CFS	PDS FREQUENCY ADJUSTMENT FOR CFS		
		PDS_14	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14		
		PR	POSRV FAILS TO RECLOSE		
		WOCHM4A-CH04A	ECW CHILLER 04A TRAIN UNAVAILABLE DUE TO T&M		

Table 19.1-50 (22 of 39)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
57	1.46E-10	#F078-AAFD_F078-AGAD	MULTI-COMPARTMENT FIRE FROM F078-AAFD TO F078-AGAD	0.1	45.6
		ERVC	EXTERNAL REACTOR VESSEL COOLING FAILS		
		PDS_14	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14		
		WOMPS5A-PP05A	FAILS TO START OF ECW PUMP 05A		
58	1.38E-10	#F157-A01D-U	F157-A01D UNSUPPRESSED FIRES	0.1	45.6
		PDS_86	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-86		
		RCPVO-A-200	POSRV V200 FAILS TO OPEN (HARDWARE FAIL)		
		VOHVM2A-HV33A	CUBICLE COOLER HV33A UNAVAILABLE DUE TO T&M		
59	1.38E-10	#F157-A01D-U	F157-A01D UNSUPPRESSED FIRES	0.1	45.7
		PDS_86	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-86		
		RCPVO-A-201	POSRV V201 FAILS TO OPEN (HARDWARE FAIL)		
		VOHVM2A-HV33A	CUBICLE COOLER HV33A UNAVAILABLE DUE TO T&M		

Table 19.1-50 (23 of 39)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
60	1.34E-10	#F078-AEEB-U	F078-AEEB UNSUPPRESSED FIRES	0.1	45.8
		AFTPR1A-TDP01A	FAILS TO RUN AFW TDP PP01A		
		PDS_6	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-6		
		PFHBWQ4-SW2OUAT	CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1B,1C,1D FAIL TO OPEN		
61	1.33E-10	#F157-A01D-U	F157-A01D UNSUPPRESSED FIRES	0.1	45.9
		ERVC	EXTERNAL REACTOR VESSEL COOLING FAILS		
		PDS_14	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14		
		WOCHM2A-CH02A	ECW CHILLER 02A TRAIN UNAVAILABLE DUE TO T&M		
		WOCHR1A-CH01A	ECW CHILLER CH01A FAILS TO RUN FOR 24 HOURS		
62	1.33E-10	#F157-A01D-U	F157-A01D UNSUPPRESSED FIRES	0.1	46.0
		ERVC	EXTERNAL REACTOR VESSEL COOLING FAILS		
		PDS_14	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14		
		WOCHM4A-CH04A	ECW CHILLER 04A TRAIN UNAVAILABLE DUE TO T&M		
		WOCHR3A-CH03A	ECW CHILLER CH03A FAILS TO RUN FOR 24 HOURS		

Table 19.1-50 (24 of 39)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
63	1.29E-10	#F078-A05D-U	F078-A05D UNSUPPRESSED FIRES	0.1	46.0
		CDOPH-S-ALIGN	OPERATOR FAILS TO START FOR PP01,02,03 BY HAND SWITCH		
		H-SDR-POSRV-3WAY	OPERATOR FAILS TO OPERATION (POSRV & 3-WAY V/V)		
		PDS_86	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-86		
		VOHVS2A-HV33A	FAILS TO START OF MAFP ROOM A CUBICLE COOLER HV33A		
		RCOPH-S-SDSE-SL	FAILURE OF SDS VALVES EARLY PHASE OPEN (2/4)		
64	1.28E-10	#F078-AEEB-U	F078-AEEB UNSUPPRESSED FIRES	0.1	46.1
		AFTPR1A-TDP01A	FAILS TO RUN AFW TDP PP01A		
		PDS_6	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-6		
		PFHBO1A-SW01A-H2	FAILS TO OPEN OF PCB SW01A-H2 OF 4.16KV SWGR SW01A FROM UAT		
		VKHVS2A-HV14A	FAILS TO START CCW PUMP ROOM CUBICLE COOLER HV14A		

Table 19.1-50 (25 of 39)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
65	1.21E-10	#F078-A05D-U	F078-A05D UNSUPPRESSED FIRES	0.1	46.2
		AFMPM2A-MDP02A	AFW MDP PP02A UNAVAILABLE DUE TO T/M		
		CDOPH-S-ALIGN	OPERATOR FAILS TO START FOR PP01,02,03 BY HAND SWITCH		
		H-SDR-POSRV-3WAY	OPERATOR FAILS TO OPERATION (POSRV & 3-WAY V/V)		
		RCOPH-S-SDSE-SL	FAILURE OF SDS VALVES EARLY PHASE OPEN (2/4)		
		PDS_86	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-86		
66	1.20E-10	#F120-A11B-U	F120-A11B UNSUPPRESSED FIRES	0.1	46.3
		AFTPR1A-TDP01A	FAILS TO RUN AFW TDP PP01A		
		PDS_6	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-6		
		PFHBWQ2-SW2OUATAC	2/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1C FAIL TO OPEN		

Table 19.1-50 (26 of 39)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
67	1.19E-10	#F078-AAFD_F078-AGAD	MULTI-COMPARTMENT FIRE FROM F078-AAFD TO F078-AGAD	0.1	46.3
		ERVC	EXTERNAL REACTOR VESSEL COOLING FAILS		
		F-WOOPH-S-CROSSTIE-A	OPERATOR FAILS TO OPEN 1025A AND ALIGN FLOW PATH		
		H-SDR-3WAY	OPERATOR FAILS TO OPEN 3-WAY VALVE		
		WOCHM4A-CH04A	ECW CHILLER 04A TRAIN UNAVAILABLE DUE TO T&M		
		PDS_17	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-17		
68	1.16E-10	#F078-AEEB-U	F078-AEEB UNSUPPRESSED FIRES	0.1	46.4
		AFTPS1A-TDP01A	FAILS TO START AFW TDP PP01A		
		PDS_6	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-6		
		PFHBO1A-SW01A-H2	FAILS TO OPEN OF PCB SW01A-H2 OF 4.16KV SWGR SW01A FROM UAT		
		WOCHM4A-CH04A	ECW CHILLER 04A TRAIN UNAVAILABLE DUE TO T&M		

Table 19.1-50 (27 of 39)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
69	1.16E-10	#F078-AEEB-U	F078-AEEB UNSUPPRESSED FIRES	0.1	46.5
		AFTPS1A-TDP01A	FAILS TO START AFW TDP PP01A		
		PDS_6	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-6		
		PFHBO1A-SW01A-H2	FAILS TO OPEN OF PCB SW01A-H2 OF 4.16KV SWGR SW01A FROM UAT		
		WOCHM2A-CH02A	ECW CHILLER 02A TRAIN UNAVAILABLE DUE TO T&M		
70	1.13E-10	#F157-A01D-U	F157-A01D UNSUPPRESSED FIRES	0.1	46.5
		CCOPV-S-NSMV	OPERATOR FAILS TO CLOSE CC MOV 143~150 (NON-ESSENTIAL LOAD)		
		EFOPV-S-SIAS	OPERATOR FAILS TO MANUALLY INITIATE ALL CHANNELS VIA MCR FOR SIAS		
		ERVC	EXTERNAL REACTOR VESSEL COOLING FAILS		
		H-SDR-3WAY	OPERATOR FAILS TO OPEN 3-WAY VALVE		
		PDS_17	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-17		
		RPPTM-A-PT102A	LO PZR PR. CH.A IS IN BYPASS (T&M)		

Table 19.1-50 (28 of 39)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
71	1.13E-10	#F157-A01D-U	F157-A01D UNSUPPRESSED FIRES	0.1	46.6
		CCOPV-S-NSMV	OPERATOR FAILS TO CLOSE CC MOV 143~150 (NON-ESSENTIAL LOAD)		
		EFOPV-S-SIAS	OPERATOR FAILS TO MANUALLY INITIATE ALL CHANNELS VIA MCR FOR SIAS		
		ERVC	EXTERNAL REACTOR VESSEL COOLING FAILS		
		H-SDR-3WAY	OPERATOR FAILS TO OPEN 3-WAY VALVE		
		PDS_17	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-17		
		RPPTM-C-PT102C	LO PZR PR. CH.C IS IN BYPASS (T&M)		
72	1.12E-10	#F157-A01D-U	F157-A01D UNSUPPRESSED FIRES	0.1	46.7
		PDS_6	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-6		
		PFBSY1A-SW01A	BUS FAULT ON 4.16KV SWGR SW01A		
		WOCHM2A-CH02A	ECW CHILLER 02A TRAIN UNAVAILABLE DUE TO T&M		
73	1.12E-10	#F157-A01D-U	F157-A01D UNSUPPRESSED FIRES	0.1	46.7
		PDS_6	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-6		
		PFBSY1A-SW01A	BUS FAULT ON 4.16KV SWGR SW01A		
		WOCHM4A-CH04A	ECW CHILLER 04A TRAIN UNAVAILABLE DUE TO T&M		

Table 19.1-50 (29 of 39)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
74	1.09E-10	#F078-AGAC_F078-AGAD	MULTI-COMPARTMENT FIRE FROM F078-AGAC TO F078-AGAD	0.1	46.8
		AFTPR1A-TDP01A	FAILS TO RUN AFW TDP PP01A		
		AFTPR1B-TDP01B	FAILS TO RUN AFW TDP PP01B		
		H-CI-OPEN	OPERATOR FAILS TO RECOVERY FOR CIS ISOLATION		
		PDS_6	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-6		
75	1.06E-10	#F078-A52D-U	F078-A52D UNSUPPRESSED FIRES	0.1	46.9
		ERVC	EXTERNAL REACTOR VESSEL COOLING FAILS		
		PDS-FREQ-CFS	PDS FREQUENCY ADJUSTMENT FOR CFS		
		PDS_14	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14		
		WOMPM5A-PP05A	ECW PP05A TRAIN UNAVAILABLE DUE TO TEST OR MAINTENANCE		
		PR	POSRV FAILS TO RECLOSE		

Table 19.1-50 (30 of 39)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
76	1.00E-10	#F122-T01-U	F122-T01 UNSUPPRESSED FIRES	0.1	46.9
		DAMPR-A-PP02	AAC FUEL OIL FEED PUMP PP02 FAILS TO RUN		
		DGDGKQ4-DG01ABCD	CCF OF EDG 01A/01B/01C/01D FAIL TO RUN		
		H-SDR-POSRV-3WAY	OPERATOR FAILS TO OPERATION (POSRV & 3-WAY V/V)		
		SHR1-E12TD	UNRECOVERABLE SBO LEADS TO TDAFW PUMP FAILURE		
		PDS_94	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-94		
77	1.00E-10	#F078-A52D-U	F078-A52D UNSUPPRESSED FIRES	0.1	47.0
		ERVC	EXTERNAL REACTOR VESSEL COOLING FAILS		
		F-WOOPH-S-CROSSTIE-A	OPERATOR FAILS TO OPEN 1025A AND ALIGN FLOW PATH		
		PDS-FREQ-CFS	PDS FREQUENCY ADJUSTMENT FOR CFS		
		PR	POSRV FAILS TO RECLOSE		
		WOCHS4A-CH04A	ECW CHILLER CH04A FAILS TO START ON DEMAND		
		PDS_14	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14		

Table 19.1-50 (31 of 39)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
78	9.97E-11	#F122-T01-U	F122-T01 UNSUPPRESSED FIRES	0.1	47.0
		DAMPR-A-PP02	AAC FUEL OIL FEED PUMP PP02 FAILS TO RUN		
		DGDGKQ4-DG01ABCD	CCF OF EDG 01A/01B/01C/01D FAIL TO RUN		
		PDS_14	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14		
		SHR1-E12TD	UNRECOVERABLE SBO LEADS TO TDAFW PUMP FAILURE		
79	9.84E-11	#F078-A19B-U	F078-A19B UNSUPPRESSED FIRES	0.1	47.1
		AFOPH-S-ALT-LT	OPERATOR FAIL TO ALIGNE FOR SUPPLYING AN ALTERNATE SOURCE		
		ERVC	EXTERNAL REACTOR VESSEL COOLING FAILS		
		FLAG-L-FNB	FLAG FOR CONSIDERING THE FAILURE OF LONG TERM 2NDARY HEAT REMOVAL		
		PFHBO2A-SW01C-C2	FAILS TO OPEN OF PCB SW01C-C2 OF 4.16KV SWGR SW01C FROM UAT		
		RCOPH-S-SDSE-SL	FAILURE OF SDS VALVES EARLY PHASE OPEN (2/4)		
		PDS_9	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-9		

Table 19.1-50 (32 of 39)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
80	9.49E-11	#F078-AEEB-U	F078-AEEB UNSUPPRESSED FIRES	0.1	47.1
		AFTPM1A-TDP01A	AFW TDP PP01A UNAVAILABLE DUE TO T/M		
		PDS_6	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-6		
		PFHBO1A-SW01A-H2	FAILS TO OPEN OF PCB SW01A-H2 OF 4.16KV SWGR SW01A FROM UAT		
		WOCHM2A-CH02A	ECW CHILLER 02A TRAIN UNAVAILABLE DUE TO T&M		
81	9.49E-11	#F078-AEEB-U	F078-AEEB UNSUPPRESSED FIRES	0.1	47.2
		AFTPM1A-TDP01A	AFW TDP PP01A UNAVAILABLE DUE TO T/M		
		PDS_6	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-6		
		PFHBO1A-SW01A-H2	FAILS TO OPEN OF PCB SW01A-H2 OF 4.16KV SWGR SW01A FROM UAT		
		WOCHM4A-CH04A	ECW CHILLER 04A TRAIN UNAVAILABLE DUE TO T&M		
82	9.29E-11	#F157-A17C_F157-AMCR	MULTI-COMPARTMENT FIRE FROM F157-A17C TO F157-AMCR	0.1	47.3
		ASD-LRF-MCA	ALTERNATE SHUTDOWN FAILURE PROBABILITY FOR MCA LRF		

Table 19.1-50 (33 of 39)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
83	9.20E-11	#F120-A11B-U	F120-A11B UNSUPPRESSED FIRES	0.1	47.3
		AFTPR1A-TDP01A	FAILS TO RUN AFW TDP PP01A		
		PDS_6	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-6		
		PFHBO1A-SW01A-H2	FAILS TO OPEN OF PCB SW01A-H2 OF 4.16KV SWGR SW01A FROM UAT		
		WOMPM2A-PP02A	ECW PP02A TRAIN UNAVAILABLE DUE TO TEST OR MAINTENANCE		
84	9.20E-11	#F120-A11B-U	F120-A11B UNSUPPRESSED FIRES	0.1	47.4
		AFTPR1A-TDP01A	FAILS TO RUN AFW TDP PP01A		
		PDS_6	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-6		
		PFHBO1A-SW01A-H2	FAILS TO OPEN OF PCB SW01A-H2 OF 4.16KV SWGR SW01A FROM UAT		
		WOMPM5A-PP05A	ECW PP05A TRAIN UNAVAILABLE DUE TO TEST OR MAINTENANCE		

Table 19.1-50 (34 of 39)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
85	9.08E-11	#F122-T01-U	F122-T01 UNSUPPRESSED FIRES	0.1	47.4
		DAMPR-A-PP02	AAC FUEL OIL FEED PUMP PP02 FAILS TO RUN		
		H-SDR-POSRV-3WAY	OPERATOR FAILS TO OPERATION (POSRV & 3-WAY V/V)		
		PDS_94	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-94		
		WOCHWQ4-CH03A/4A/3B/4B	DEMAND CCF OF ECW CHILLERS 3A/4A/3B/4B		
		SHR1-E12TD	UNRECOVERABLE SBO LEADS TO TDAFW PUMP FAILURE		
86	9.08E-11	#F122-T01-U	F122-T01 UNSUPPRESSED FIRES	0.1	47.5
		DAMPR-A-PP02	AAC FUEL OIL FEED PUMP PP02 FAILS TO RUN		
		H-SDR-POSRV-3WAY	OPERATOR FAILS TO OPERATION (POSRV & 3-WAY V/V)		
		PDS_94	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-94		
		WOCHWQ4-CH01A/2A/1B/2B	DEMAND CCF OF ECW CHILLERS 1A/2A/1B/2B		
		SHR1-E12TD	UNRECOVERABLE SBO LEADS TO TDAFW PUMP FAILURE		

Table 19.1-50 (35 of 39)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
87	9.01E-11	#F122-T01-U	F122-T01 UNSUPPRESSED FIRES	0.1	47.5
		DAMPR-A-PP02	AAC FUEL OIL FEED PUMP PP02 FAILS TO RUN		
		PDS_14	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14		
		SHR1-E12TD	UNRECOVERABLE SBO LEADS TO TDAFW PUMP FAILURE		
		WOCHWQ4-CH01A/2A/1B/2B	DEMAND CCF OF ECW CHILLERS 1A/2A/1B/2B		
88	9.01E-11	#F122-T01-U	F122-T01 UNSUPPRESSED FIRES	0.1	47.6
		DAMPR-A-PP02	AAC FUEL OIL FEED PUMP PP02 FAILS TO RUN		
		PDS_14	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14		
		SHR1-E12TD	UNRECOVERABLE SBO LEADS TO TDAFW PUMP FAILURE		
		WOCHWQ4-CH03A/4A/3B/4B	DEMAND CCF OF ECW CHILLERS 3A/4A/3B/4B		
89	8.91E-11	#F157-A20D_F157-A21D	MULTI-COMPARTMENT FIRE FROM F157-A20D TO F157-A21D	0.1	47.6
		CDOPH-S-ALIGN	OPERATOR FAILS TO START FOR PP01,02,03 BY HAND SWITCH		
		PDS_86	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-86		
		PFHBO1A-SW01A-H2	FAILS TO OPEN OF PCB SW01A-H2 OF 4.16KV SWGR SW01A FROM UAT		

Table 19.1-50 (36 of 39)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
90	8.91E-11	#F157-A20D_F157-A16D	MULTI-COMPARTMENT FIRE FROM F157-A20D TO F157-A16D	0.1	47.7
		CDOPH-S-ALIGN	OPERATOR FAILS TO START FOR PP01,02,03 BY HAND SWITCH		
		PDS_86	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-86		
		PFHBO1A-SW01A-H2	FAILS TO OPEN OF PCB SW01A-H2 OF 4.16KV SWGR SW01A FROM UAT		
91	8.88E-11	#F120-A11B-U	F120-A11B UNSUPPRESSED FIRES	0.1	47.7
		AFTPR1A-TDP01A	FAILS TO RUN AFW TDP PP01A		
		PDS_6	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-6		
		PFHBO1A-SW01A-H2	FAILS TO OPEN OF PCB SW01A-H2 OF 4.16KV SWGR SW01A FROM UAT		
		PFHBO2A-SW01C-C2	FAILS TO OPEN OF PCB SW01C-C2 OF 4.16KV SWGR SW01C FROM UAT		
92	8.87E-11	#F157-A01D-U	F157-A01D UNSUPPRESSED FIRES	0.1	47.8
		DCBSY-A-MC01A	BUS FAULTS ON 1E 125VDC BUS MC01A		
		PDS_86	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-86		

Table 19.1-50 (37 of 39)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
93	8.72E-11	#F157-A01D-U	F157-A01D UNSUPPRESSED FIRES	0.1	47.8
		ERVC	EXTERNAL REACTOR VESSEL COOLING FAILS		
		PDS_14	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14		
		WOCHR3A-CH03A	ECW CHILLER CH03A FAILS TO RUN FOR 24 HOURS		
		WOCHS4A-CH04A	ECW CHILLER CH04A FAILS TO START ON DEMAND		
94	8.72E-11	#F157-A01D-U	F157-A01D UNSUPPRESSED FIRES	0.1	47.9
		ERVC	EXTERNAL REACTOR VESSEL COOLING FAILS		
		PDS_14	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14		
		WOCHR1A-CH01A	ECW CHILLER CH01A FAILS TO RUN FOR 24 HOURS		
		WOCHS2A-CH02A	ECW CHILLER CH02A FAILS TO START ON DEMAND		
95	8.60E-11	#F157-A25C_F157-A17C	MULTI-COMPARTMENT FIRE FROM F157-A25C TO F157-A17C	0.1	47.9
		AFTPR1B-TDP01B	FAILS TO RUN AFW TDP PP01B		
		H-SDR-POSRV-3WAY	OPERATOR FAILS TO OPERATION (POSRV & 3-WAY V/V)		
		PDS_100	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-100		
		RCOPH-S-SDSE-SL	FAILURE OF SDS VALVES EARLY PHASE OPEN (2/4)		

Table 19.1-50 (38 of 39)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
96	8.52E-11	#F078-AEEB-U	F078-AEEB UNSUPPRESSED FIRES	0.1	48.0
		PDS_6	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-6		
		PELXY-C-LX04C-P	FAILURE OF PRIMARY LOOP CONTROLLER OF 745-PE-LX04C		
		PFHBO1A-SW01A-H2	FAILS TO OPEN OF PCB SW01A-H2 OF 4.16KV SWGR SW01A FROM UAT		
97	8.52E-11	#F078-AEEB-U	F078-AEEB UNSUPPRESSED FIRES	0.1	48.0
		PDS_6	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-6		
		PELXY-C-LX02C-P	FAILURE OF PRIMARY LOOP CONTROLLER OF 745-PE-LX02C		
		PFHBO1A-SW01A-H2	FAILS TO OPEN OF PCB SW01A-H2 OF 4.16KV SWGR SW01A FROM UAT		
98	8.29E-11	#F078-AAFD_F078-AGAD	MULTI-COMPARTMENT FIRE FROM F078-AAFD TO F078-AGAD	0.0	48.1
		ERVC	EXTERNAL REACTOR VESSEL COOLING FAILS		
		H-SDR-3WAY	OPERATOR FAILS TO OPEN 3-WAY VALVE		
		PDS_17	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-17		
		WOMPM5A-PP05A	ECW PP05A TRAIN UNAVAILABLE DUE TO TEST OR MAINTENANCE		

Table 19.1-50 (39 of 39)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
99	8.28E-11	#F078-A05D-U	F078-A05D UNSUPPRESSED FIRES	0.0	48.1
		CDOPH-S-ALIGN	OPERATOR FAILS TO START FOR PP01,02,03 BY HAND SWITCH		
		H-SDR-POSRV-3WAY	OPERATOR FAILS TO OPERATION (POSRV & 3-WAY V/V)		
		PDS_86	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-86		
		VOHVM2A-HV33A	CUBICLE COOLER HV33A UNAVAILABLE DUE TO T&M		
		RCOPH-S-SDSE-SL	FAILURE OF SDS VALVES EARLY PHASE OPEN (2/4)		
100	8.24E-11	#F078-AEEB-U	F078-AEEB UNSUPPRESSED FIRES	0.0	48.2
		AFTPR1A-TDP01A	FAILS TO RUN AFW TDP PP01A		
		PDS_6	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-6		
		PFHBO1A-SW01A-H2	FAILS TO OPEN OF PCB SW01A-H2 OF 4.16KV SWGR SW01A FROM UAT		
		SXAHS-A-AH02A	ESW COOLING TOWER FAN AH02A FAILS TO START		

Table 19.1-51 (1 of 9)

Internal Fire PRA Key Basic Events by RAW (CDF)

Basic Event	Description	RAW
DCBSY-A-MC01A	BUS FAULTS ON 1E 125VDC BUS MC01A	316.53
SISPP-S-IRWST	FAILURE OF IRWST SUMP DUE TO PLUGGING	301.74
SISPP-S-CHEMICAL	DEBRIS INDUCED LOSS OF LONG TERM COOLING (DOWNSTREAM/CHEMICAL EFFECT)	300.84
WOTKB-A-TK02A	ECW AIR SEPARATOR TK02A FAILS CATASTROPHICALLY	66.32
WOTKB-A-TK04A	ECW COMPRESSION TANK TK04A FAILS CATASTROPHICALLY	66.32
WOTKB-A-TK05A	ECW AIR SEPARATOR TK05A FAILS CATASTROPHICALLY	66.32
WOTKB-A-TK01A	ECW COMPRESSION TANK TK01A FAILS CATASTROPHICALLY	66.32
CCTKB-A-TK01A	CCW SURGE TANK TK01A FAILS CATASTROPHICALLY	66.32
DCBSY-B-MC01B	BUS FAULTS ON 1E 125VDC BUS MC01B	52.06
WOTKB-B-TK05B	ECW AIR SEPARATOR TK05B FAILS CATASTROPHICALLY	46.35
CCTKB-B-TK01B	CCW SURGE TANK TK01B FAILS CATASTROPHICALLY	46.35
WOTKB-B-TK02B	ECW AIR SEPARATOR TK02B FAILS CATASTROPHICALLY	46.35
WOTKB-B-TK01B	ECW COMPRESSION TANK TK01B FAILS CATASTROPHICALLY	46.35
WOTKB-B-TK04B	ECW COMPRESSION TANK TK04B FAILS CATASTROPHICALLY	46.35
CCHEY01A-HE01A	CCW HX. HE01A FAILS WHILE OPERATING	37.34
CCHEY02A-HE02A	CCW HX. HE02A FAILS WHILE OPERATING	37.34
AXVVO-A-V1623	FAILS TO OPEN CT SYSTEM MANUAL VALVE V1623	29.54
PELXY-C-LX04C-P	FAILURE OF PRIMARY LOOP CONTROLLER OF 745-PE-LX04C	29.27

Table 19.1-51 (2 of 9)

Basic Event	Description	RAW
AXCVO-A-V1628	FAILS TO OPEN CT SYSTEM CHECK VALVE V1628	27.05
CCHEY01B-HE01B	CCW HX. HE01B FAILS WHILE OPERATING	26.67
CCHEY02B-HE02B	CCW HX. HE02B FAILS WHILE OPERATING	26.67
PR	POSRV FAILS TO RECLOSE	26.26
DCBSY-C-MC01C	BUS FAULTS ON 1E 125VDC BUS MC01C	24.39
PFGRID	GRID COLLAPSE ON TURBINE TRIP	17.02
SEAL-AFSUC	SEAL FAILURE PROBABILITY (SECONDARY HEAT REMOVAL SUCCESS)	15.21
IPINM-C-IN01C	INVERTER IN01C UNAVAIL. DUE TO T/M	7.81
SIVVT1B-V959	SI PUMP PP02B/D MINI. FLOW LINE MANUAL VALVE 959 TRANSFER CLOSED	7.67
DCBTM-C-BT01C	POWER UNAVAILABLE OF BT01C (125VDC) DUE TO MAINTENANCE	7.49
SIMVT-B-303	SI PUMP PP02B/D MINI. FLOW LINE MOV 303 FAILS TO REMAIN OPEN	7.37
SICVO-B-V101	CV 101 IN TRAIN B IRWST RETURN LINE FAILS TO OPEN	6.80
PFBSY1A-SW01A	BUS FAULT ON 4.16KV SWGR SW01A	6.54
SIMVT-A-302	SI PUMP PP02A/C MINI. FLOW LINE MOV 302 FAILS TO REMAIN OPEN	5.30
SIMVT-A-395	SI PUMP PP02A/C MINI. FLOW LINE MOV 395 FAILS TO REMAIN OPEN	5.30
DCBSY-D-MC01D	BUS FAULTS ON 1E 125VDC BUS MC01D	5.14
PALXY-D-PA06D-P	PRIMARY LOOP CONTROLLER 752-PA06D FAILS TO RUN	5.06
WOMPM5A-PP05A	ECW PP05A TRAIN UNAVAILABLE DUE TO TEST OR MAINTENANCE	5.00
ASD-CDF	ALTERNATE SHUTDOWN FAILURE PROBABILITY FOR CDF	4.93
WOMPS5A-PP05A	FAILS TO START OF ECW PUMP 05A	4.89

Table 19.1-51 (3 of 9)

Basic Event	Description	RAW
DCBTM-D-BT01D	POWER UNAVAILABLE OF BT01C (125VDC) DUE TO MAINTENANCE	4.78
VOHVS2A-HV33A	FAILS TO START OF MAFP ROOM A CUBICLE COOLER HV33A	4.78
AFMPM2A-MDP02A	AFW MDP PP02A UNAVAILABLE DUE TO T/M	4.77
PFBSY1B-SW01B	BUS FAULT ON 4.16KV SWGR SW01B	4.73
PADOY-D-PA06D03	FAILURE OF DIGITAL OUTPUT MODULE 752-PA06D BRANCH 03	4.70
PADOY-D-PA06D01	FAILURE OF DIGITAL OUTPUT MODULE PA06D BRANCH 01	4.70
PEDOY-D-LX03D01	FAILURE OF DIGITAL OUTPUT MODULE LX03D BRANCH 01	4.70
VOHVM2A-HV33A	CUBICLE COOLER HV33A UNAVAILABLE DUE TO T&M	4.70
PGBSY2A-LC01C	BUS FAULT ON 480V LC LC01C	4.61
PFBSY2A-SW01C	BUS FAULT ON 4.16KV SWGR SW01C	4.61
WOVVT5A-V1071A	ECW PP05A DISCH. LINE VV 1071A TRANSFER CLOSED	4.56
WOVVT5A-V1068A	ECW PP05A SUCTION LINE VV 1068A TRANSFER CLOSED	4.56
PGBSY1A-LC01A	BUS FAULT ON 480V LC LC01A	4.56
WOMPR5A-PP05A	FAILS TO RUN OF ECW PUMP 05A	4.55
PGXMY2A-TR01C	480V LC TRANSFORMER LC-TR01C FAULT	4.50
SICVO-A-V100	CV 100 IN TRAIN A IRWST RETURN LINE FAILS TO OPEN	4.48
AFMPS2A-MDP02A	FAILS TO START AFW MDP PP02A	4.47
PEDOY-C-LX04C01	FAILURE OF DIGITAL OUTPUT MODULE LX04C BRANCH 01	4.44
PHBSY2A-MC04C	BUS FAULT ON 480V MCC MC04C	4.36
PFHBO1A-SW01A-H2	FAILS TO OPEN OF PCB SW01A-H2 OF 4.16KV SWGR SW01A FROM UAT	4.31

Table 19.1-51 (4 of 9)

Basic Event	Description	RAW
PEAIY-C-LX04C02	FAILURE OF ANALOG INPUT MODULE LX04C BRANCH 02	4.24
PELXY-A-LX01A-P	FAILURE OF PRIMARY LOOP CONTROLLER OF 745-PE-LX01A	4.13
PFHBO2A-SW01C-C2	FAILS TO OPEN OF PCB SW01C-C2 OF 4.16KV SWGR SW01C FROM UAT	4.10
AFMPR2A-MDP02A	FAILS TO RUN AFW MDP PP02A	4.01
PELXY-C-LX02C-P	FAILURE OF PRIMARY LOOP CONTROLLER OF 745-PE-LX02C	4.00
SXFLP1A-FT01A	ESW DEBIS FILTER FT01A PLUGGED	3.95
SXFLP2A-FT02A	ESW DEBIS FILTER FT02A PLUGGED	3.95
PHBSY1A-MC01A	BUS FAULT ON 480V MCC MC01A	3.91
PELXY-A-LX06A-P	FAILURE OF PRIMARY LOOP CONTROLLER LX06A	3.85
PELXY-A-LX03A-P	FAILURE OF PRIMARY LOOP CONTROLLER OF 745-PE-LX03A	3.81
PALXY-C-PA06C-P	PRIMARY LOOP CONTROLLER 752-PA06C FAILS TO RUN	3.81
IPINM-A-IN01A	INVERTER IN01A UNAVAIL. DUE TO T/M	3.80
VOHVR2A-HV33A	FAILS TO RUN OF MAFP ROOM A CUBICLE COOLER HV33A	3.75
WOCVO5A-V1055A	ECW PP05A DISCH. LINE CV 1055A FAILS TO OPEN	3.72
AFTPR1A-TDP01A	FAILS TO RUN AFW TDP PP01A	3.71
WOCHR1A-CH01A	ECW CHILLER CH01A FAILS TO RUN FOR 24 HOURS	3.68
DCBTM-A-BT01A	POWER UNAVAILABLE OF BT01A (125VDC) DUE TO MAINTENANCE	3.67
WOCHR3A-CH03A	ECW CHILLER CH03A FAILS TO RUN FOR 24 HOURS	3.67
PGXMY1A-TR01A	480V LC TRANSFORMER LC-TR01A FAULT	3.58
IPINM-D-IN01D	INVERTER IN01D UNAVAIL. DUE TO T/M	3.53

Table 19.1-51 (5 of 9)

Basic Event	Description	RAW
IPINM-B-IN01B	INVERTER IN01B UNAVAIL. DUE TO T/M	3.52
AFVVT2A-V1011A	AFW MDP02A MINI FLOW LINE MANUAL VALVE V1011A TRANSFER CLOSED	3.50
AFVVT2A-V1001A	AFW MDP02A SUCT. MANUAL VALVE V1001A TRANSFER CLOSED	3.50
AFVVT2A-V1603	AFW MDP02A MINI FLOW LINE MANUAL VALVE V1603 TRANSFER CLOSED	3.50
AFVVT2A-V1005A	AFW MDP01A DISCH. MANUAL VALVE V1005A TRANSFER CLOSED	3.50
DCBTM-B-BT01B	POWER UNAVAILABLE OF BT01B (125VDC) DUE TO MAINTENANCE	3.49
AFTPS1A-TDP01A	FAILS TO START AFW TDP PP01A	3.42
AFTPM1A-TDP01A	AFW TDP PP01A UNAVAILABLE DUE TO T/M	3.36
PEDOY-A-LX01A04	FAILURE OF DIGITAL OUTPUT MODULE LX01A BRANCH 04	3.36
PEDOY-C-LX03C01	FAILURE OF DIGITAL OUTPUT MODULE LX03C BRANCH 01	3.34
PADOY-C-PA06C04	FAILURE OF DIGITAL OUTPUT MODULE PA06C BRANCH 04	3.32
PADOY-D-PA06C02	FAILURE OF DIGITAL OUTPUT MODULE PA06C BRANCH 02	3.32
MSAVO-B-110	FAILS TO OPEN MS AFW TDP PP01A TBN STM. SUPPLY AOV 110	3.30
ASD-CDF-MCA	ALTERNATE SHUTDOWN FAILURE PROBABILITY FOR MCA CDF	3.29
PADIY-D-PA06C02	FAILURE OF DIGITAL INPUT MODULE PA06C BRANCH 02	3.27
PADIY-C-PA06C04	FAILURE OF DIGITAL INPUT MODULE 752-PA06C BRANCH 04	3.27
PEDOY-C-LX04C02	FAILURE OF DIGITAL OUTPUT MODULE LX04C BRANCH 02	3.27
WOCHM4A-CH04A	ECW CHILLER 04A TRAIN UNAVAILABLE DUE TO T&M	3.24
SXFLP1B-FT01B	ESW DEBIS FILTER FT01B PLUGGED	3.24
WOCHS4A-CH04A	ECW CHILLER CH04A FAILS TO START ON DEMAND	3.21

Table 19.1-51 (6 of 9)

Basic Event	Description	RAW
SXFLP2B-FT02B	ESW DEBIS FILTER FT02B PLUGGED	3.17
VOHVS2B-HV33B	FAILS TO START OF MAFP ROOM B CUBICLE COOLER HV33B	3.13
AFMPM2B-MDP02B	AFW MDP PP02B UNAVAILABLE DUE TO T/M	3.12
PELXY-D-LX02D-P	FAILURE OF PRIMARY LOOP CONTROLLER OF 745-PE-LX02D	3.11
VOHVM1B-HV33B	CUBICLE COOLER HV33B UNAVAILABLE DUE TO T&M	3.07
PELXY-D-LX04D-P	FAILURE OF PRIMARY LOOP CONTROLLER OF 745-PE-LX04D	3.07
PEAIY-D-LX04D02	FAILURE OF ANALOG INPUT MODULE LX04D BRANCH 02	3.06
PELXY-B-LX02B-P	FAILURE OF PRIMARY LOOP CONTROLLER OF 745-LX02B	3.03
PGBSY1B-LC01B	BUS FAULT ON 480V LC LC01B	3.02
CSNZPA-PLUGNOZZ	CONTAINMENT SPRAY HEADER PIPE/NOZZLE PLUGGED (ECSBS)	3.00
AFMVT2A-0043	AFW ISOL. MOV V0043 TRANSFER CLOSED	2.99
CCMVO-A-392	CCW MOV 392 FOR ECW CHILLER CH04A OUTLET FAIL TO OPEN	2.98
WOCHR4A-CH04A	ECW CHILLER 04A FAILS TO RUN FOR 24 HOURS	2.96
WOCHR1B-CH01B	ECW CHILLER 01B FAILS TO RUN FOR 24 HOURS	2.95
AFMPS2B-MDP02B	FAILS TO START AFW MDP PP02B	2.91
WOCHR3B-CH03B	ECW CHILLER 03B FAILS TO RUN FOR 24 HOURS	2.84
ATAVO-C-009	FAILS TO OPEN AFW TDP PP01A TBN STM. ISOL AOV, 009	2.84
AFTPR1B-TDP01B	FAILS TO RUN AFW TDP PP01B	2.79
PELXY-C-LX03C-P	FAILURE OF PRIMARY LOOP CONTROLLERS 745-PE-LX03C	2.74
WOVVT4A-V1077A	ESSENTIAL CHILLER CH04A INLET VV 1077A TRANSFER CLOSED	2.74

Table 19.1-51 (7 of 9)

Basic Event	Description	RAW
WOVVT4A-V1078A	ESSENTIAL CHILLER CH04A OUTLET VV 1078A TRANSFER CLOSED	2.74
CCVVT-A-V1742	ECW CHILLER CH04A OUTLET MANUAL VALVE V1742 TRANSFER CLOSED	2.74
CCVVT-A-V1341	ECW CHILLER CH04A INLET MANUAL VALVE V1341 TRANSFER CLOSED	2.74
VDTTY-C-TE013C	EDG ROOM TEMPERATURE TE013C FAILS WHILE OPERATING FOR HV12A INTERLOCK SIGNAL	2.70
VDTTY-C-TE015C	EDG PUMP ROOM TEMPERATURE TE015C FAILS WHILE OPERATING FOR HV13A INTERLOCK SIGNAL	2.70
PEDOY-C-LX03C02	FAILURE OF DIGITAL OUTPUT MODULE LX03C BRANCH 02	2.69
PGXMY1B-TR01B	480V LC TRANSFORMER LC-TR01B FAULT	2.68
PEDOY-D-LX02D04	FAILURE OF DIGITAL OUTPUT MODULE 745-PE-LX02D BRANCH 04	2.67
EFGXY-A-PM3-GC1	FAILURE OF CH. A GC-1 OUTPUT GC1-PM3	2.65
PHBSY1B-MC01B	BUS FAULT ON 480V MCC MC01B	2.64
AFMPR2B-MDP02B	FAILS TO RUN AFW MDP PP02B	2.62
PHBSY2A-MC02C	BUS FAULT ON 480V MCC MC02C	2.59
AFTPS1B-TDP01B	FAILS TO START AFW TDP PP01B	2.58
AFMVC1A-0045	AFW ISOL. MOV 0045 FAILS TO CLOSE FOR CYCLING OPERATION	2.56
AFTPM1B-TDP01B	AFW TDP PP01B UNAVAILABLE DUE TO T/M	2.54
VOHVR2B-HV33B	FAILS TO RUN OF MAFP ROOM B CUBICLE COOLER HV33B	2.49
MSAVO-A-109	FAILS TO OPEN MS AFW TDP PP01B TBN STM. SUPPLY AOV 109	2.49
AFVVT2B-V1604	AFW MDP02B MINI FLOW LINE MANUAL VALVE V1604 TRANSFER CLOSED	2.39
AFVVT2B-V1001B	AFW MDP02A SUCT. MANUAL VALVE V1001B TRANSFER CLOSED	2.39

Table 19.1-51 (8 of 9)

Basic Event	Description	RAW
AFVVT2B-V1011B	AFW MDP02B MINI FLOW LINE MANUAL VALVE V1011B TRANSFER CLOSED	2.39
AFVVT2B-V1005B	AFW MDP01B DISCH. MANUAL VALVE V1005B TRANSFER CLOSED	2.39
AFCVO2A-V1012A	FAILS TO OPEN AFW MDP02A MINI FLOW CHECK VALVE V1012A	2.38
AFCVO2A-V1003A	FAILS TO OPEN AFW MDP02A DISCH. CHECK VALVE V1003A	2.38
AFCVO2A-V1007A	FAILS TO OPEN AFW MDP02A DISCH. CHECK VALVE V1017A	2.38
EFGXY-B-PM3-GC1	FAILURE OF CH. B GC-1 OUTPUT GC1-PM3	2.35
PFHBO1B-SW01B-H2	FAILS TO OPEN OF PCB SW01B-H2 OF 4.16KV SWGR SW01B FROM UAT	2.34
PEDOY-B-LX02B04	FAILURE OF DIGITAL OUTPUT MODULE LX02B BRANCH 04	2.32
PGBSY2B-LC01D	BUS FAULT ON 480V LC LC01D	2.30
PFBSY2B-SW01D	BUS FAULT ON 4.16KV SWGR SW01D	2.30
PHBSY2B-MC02D	BUS FAULT ON 480V MCC MC02D	2.30
PGXMY2B-TR01D	480V LC TRANSFORMER LC-TR01D FAULT	2.27
EFCIY-A-GC1A	FAILURE OF CH. A GC-1 CI631 COMMUNICATION CARD	2.25
ATAVO-D-010	FAILS TO OPEN AFW TDP PP01B TBN STM. ISOL AOV, 010	2.17
RCPVO-A-201	POSRV V201 FAILS TO OPEN (HARDWARE FAIL)	2.12
RCPVO-A-200	POSRV V200 FAILS TO OPEN (HARDWARE FAIL)	2.12
PADIY-D-PA06D03	FAILURE OF DIGITAL INPUT MODULE 752-PA06D BRANCH 03	2.10
PEDOY-D-LX04D02	FAILURE OF DIGITAL OUTPUT MODULE LX04D BRANCH 02	2.10
PEDIY-D-LX04D02	FAILURE OF DIGITAL INPUT MODULE LX04D BRANCH 02	2.10
AFMVT2B-0044	AFW ISOL. MOV V0044 TRANSFER CLOSED	2.10

Table 19.1-51 (9 of 9)

Basic Event	Description	RAW
DCBTY-D-BT01D	BAT. BT01D (125VDC) FAILS TO PROVIDE ADEQUATE OUTPUT	2.07
WOMPR1A-PP01A	FAILS TO RUN OF ECW PUMP 01A	2.06
DAMPR-A-PP02	AAC FUEL OIL FEED PUMP PP02 FAILS TO RUN	2.06
EFCIY-B-GC1B	FAILURE OF CH. B GC-1 CI631 COMMUNICATION CARD	2.05
WOMPR4A-PP04A	FAILS TO RUN OF ECW PUMP 04A	2.03
EFORT-A-FOR6-AFAS1A-GC1FR	FAILURE OF GC-1 CH. A FIBER OPTIC RECEIVER FOR LC	2.01
EFORT-A-FOR6-AFAS1A-GC1FT	FAILURE OF GC-1 CH. A FIBER OPTIC TRANSMITTER FOR LC	2.01

Table 19.1-52 (1 of 5)

Internal Fire PRA Key Basic Events by FV (CDF)

Basic Event	Description	FV
ASD-CDF	ALTERNATE SHUTDOWN FAILURE PROBABILITY FOR CDF	4.37E-01
SHR1-E12TD	UNRECOVERABLE SBO LEADS TO TDAFW PUMP FAILURE	1.38E-01
AFTPR1A-TDP01A	FAILS TO RUN AFW TDP PP01A	1.04E-01
PFGRID	GRID COLLAPSE ON TURBINE TRIP	8.54E-02
AFTPR1B-TDP01B	FAILS TO RUN AFW TDP PP01B	6.81E-02
DAMPR-A-PP02	AAC FUEL OIL FEED PUMP PP02 FAILS TO RUN	5.56E-02
WOCHM4A-CH04A	ECW CHILLER 04A TRAIN UNAVAILABLE DUE TO T&M	4.52E-02
WOCHS4A-CH04A	ECW CHILLER CH04A FAILS TO START ON DEMAND	2.91E-02
WOMPM5A-PP05A	ECW PP05A TRAIN UNAVAILABLE DUE TO TEST OR MAINTENANCE	2.78E-02
DADGR-S-AACTG	AAC GTG FAILS TO RUN	2.60E-02
PR	POSRV FAILS TO RECLOSE	2.32E-02
ASD-CDF-MCA	ALTERNATE SHUTDOWN FAILURE PROBABILITY FOR MCA CDF	2.31E-02
PFHBO1A-SW01A-H2	FAILS TO OPEN OF PCB SW01A-H2 OF 4.16KV SWGR SW01A FROM UAT	2.22E-02
DGDGR-B-DGB	FAILS TO RUN OF EMERGENCY DIESEL GENERATOR DG01B	2.08E-02
PFHBO2A-SW01C-C2	FAILS TO OPEN OF PCB SW01C-C2 OF 4.16KV SWGR SW01C FROM UAT	2.08E-02
SEAL-AFSUC	SEAL FAILURE PROBABILITY (SECONDARY HEAT REMOVAL SUCCESS)	1.65E-02
AFTPS1A-TDP01A	FAILS TO START AFW TDP PP01A	1.58E-02
VOHVS2A-HV33A	FAILS TO START OF MAFP ROOM A CUBICLE COOLER HV33A	1.46E-02
AFMPM2A-MDP02A	AFW MDP PP02A UNAVAILABLE DUE TO T/M	1.37E-02

Table 19.1-52 (2 of 5)

Basic Event	Description	FV
DGDGR-A-DGA	FAILS TO RUN OF EMERGENCY DIESEL GENERATOR DG01A	1.28E-02
DGDGR-D-DGD	FAILS TO RUN OF EMERGENCY DIESEL GENERATOR DG01D	1.28E-02
AFTPM1A-TDP01A	AFW TDP PP01A UNAVAILABLE DUE TO T/M	1.27E-02
DADGM-S-AAC	AAC GTG UNAVAILABLE DUE TO MAINTENANCE	1.11E-02
AFTPS1B-TDP01B	FAILS TO START AFW TDP PP01B	1.03E-02
DGDGR-C-DGC	FAILS TO RUN OF EMERGENCY DIESEL GENERATOR DG01C	1.01E-02
MSAVO-B-110	FAILS TO OPEN MS AFW TDP PP01A TBN STM. SUPPLY AOV 110	9.70E-03
DGDGM-B-DGB	DG B UNAVAILABLE DUE TO MAINTENANCE	9.21E-03
VOHVM2A-HV33A	CUBICLE COOLER HV33A UNAVAILABLE DUE TO T&M	9.20E-03
PFHBO1B-SW01B-H2	FAILS TO OPEN OF PCB SW01B-H2 OF 4.16KV SWGR SW01B FROM UAT	8.98E-03
VOHVS2B-HV33B	FAILS TO START OF MAFP ROOM B CUBICLE COOLER HV33B	8.27E-03
AFTPM1B-TDP01B	AFW TDP PP01B UNAVAILABLE DUE TO T/M	8.23E-03
AFMPM2B-MDP02B	AFW MDP PP02B UNAVAILABLE DUE TO T/M	7.74E-03
WOCHM2A-CH02A	ECW CHILLER 02A TRAIN UNAVAILABLE DUE TO T&M	6.89E-03
WOCHM2B-CH02B	ECW CHILLER 02B TRAIN UNAVAILABLE DUE TO T&M	6.70E-03
WOCHM4B-CH04B	ECW CHILLER 04B TRAIN UNAVAILABLE DUE TO T&M	6.44E-03
MSAVO-A-109	FAILS TO OPEN MS AFW TDP PP01B TBN STM. SUPPLY AOV 109	6.29E-03
DGDGM-D-DGD	DG D UNAVAILABLE DUE TO MAINTENANCE	5.93E-03
AXVVO-A-V1623	FAILS TO OPEN CT SYSTEM MANUAL VALVE V1623	5.48E-03
WOMPS5A-PP05A	FAILS TO START OF ECW PUMP 05A	5.30E-03

Table 19.1-52 (3 of 5)

Basic Event	Description	FV
VOHVM1B-HV33B	CUBICLE COOLER HV33B UNAVAILABLE DUE TO T&M	5.15E-03
NBHBC-S-SW03N-A2	FAIL TO CLOSE OF SWGR SW03N-A2 FEED BREAKER FROM AAC GTG	5.13E-03
DGDGM-A-DGA	DG 01A UNAVAILABLE DUE TO MAINTENANCE	5.08E-03
ASD-CDF	ALTERNATE SHUTDOWN FAILURE PROBABILITY FOR CDF	4.37E-01
SHR1-E12TD	UNRECOVERABLE SBO LEADS TO TDAFW PUMP FAILURE	1.38E-01
AFTPR1A-TDP01A	FAILS TO RUN AFW TDP PP01A	1.04E-01
PFGRID	GRID COLLAPSE ON TURBINE TRIP	8.54E-02
AFTPR1B-TDP01B	FAILS TO RUN AFW TDP PP01B	6.81E-02
DAMPR-A-PP02	AAC FUEL OIL FEED PUMP PP02 FAILS TO RUN	5.56E-02
WOCHM4A-CH04A	ECW CHILLER 04A TRAIN UNAVAILABLE DUE TO T&M	4.52E-02
WOCHS4A-CH04A	ECW CHILLER CH04A FAILS TO START ON DEMAND	2.91E-02
WOMPM5A-PP05A	ECW PP05A TRAIN UNAVAILABLE DUE TO TEST OR MAINTENANCE	2.78E-02
DADGR-S-AACTG	AAC GTG FAILS TO RUN	2.60E-02
PR	POSRV FAILS TO RECLOSE	2.32E-02
ASD-CDF-MCA	ALTERNATE SHUTDOWN FAILURE PROBABILITY FOR MCA CDF	2.31E-02
PFHBO1A-SW01A-H2	FAILS TO OPEN OF PCB SW01A-H2 OF 4.16KV SWGR SW01A FROM UAT	2.22E-02
DGDGR-B-DGB	FAILS TO RUN OF EMERGENCY DIESEL GENERATOR DG01B	2.08E-02
PFHBO2A-SW01C-C2	FAILS TO OPEN OF PCB SW01C-C2 OF 4.16KV SWGR SW01C FROM UAT	2.08E-02
SEAL-AFSUC	SEAL FAILURE PROBABILITY (SECONDARY HEAT REMOVAL SUCCESS)	1.65E-02
AFTPS1A-TDP01A	FAILS TO START AFW TDP PP01A	1.58E-02

Table 19.1-52 (4 of 5)

Basic Event	Description	FV
VOHVS2A-HV33A	FAILS TO START OF MAFP ROOM A CUBICLE COOLER HV33A	1.46E-02
AFMPM2A-MDP02A	AFW MDP PP02A UNAVAILABLE DUE TO T/M	1.37E-02
DGDGR-A-DGA	FAILS TO RUN OF EMERGENCY DIESEL GENERATOR DG01A	1.28E-02
DGDGR-D-DGD	FAILS TO RUN OF EMERGENCY DIESEL GENERATOR DG01D	1.28E-02
AFTPM1A-TDP01A	AFW TDP PP01A UNAVAILABLE DUE TO T/M	1.27E-02
DADGM-S-AAC	AAC GTG UNAVAILABLE DUE TO MAINTENANCE	1.11E-02
AFTPS1B-TDP01B	FAILS TO START AFW TDP PP01B	1.03E-02
DGDGR-C-DGC	FAILS TO RUN OF EMERGENCY DIESEL GENERATOR DG01C	1.01E-02
MSAVO-B-110	FAILS TO OPEN MS AFW TDP PP01A TBN STM. SUPPLY AOV 110	9.70E-03
DGDGM-B-DGB	DG B UNAVAILABLE DUE TO MAINTENANCE	9.21E-03
VOHVM2A-HV33A	CUBICLE COOLER HV33A UNAVAILABLE DUE TO T&M	9.20E-03
PFHBO1B-SW01B-H2	FAILS TO OPEN OF PCB SW01B-H2 OF 4.16KV SWGR SW01B FROM UAT	8.98E-03
VOHVS2B-HV33B	FAILS TO START OF MAFP ROOM B CUBICLE COOLER HV33B	8.27E-03
AFTPM1B-TDP01B	AFW TDP PP01B UNAVAILABLE DUE TO T/M	8.23E-03
AFMPM2B-MDP02B	AFW MDP PP02B UNAVAILABLE DUE TO T/M	7.74E-03
WOCHM2A-CH02A	ECW CHILLER 02A TRAIN UNAVAILABLE DUE TO T&M	6.89E-03
WOCHM2B-CH02B	ECW CHILLER 02B TRAIN UNAVAILABLE DUE TO T&M	6.70E-03
WOCHM4B-CH04B	ECW CHILLER 04B TRAIN UNAVAILABLE DUE TO T&M	6.44E-03
MSAVO-A-109	FAILS TO OPEN MS AFW TDP PP01B TBN STM. SUPPLY AOV 109	6.29E-03
DGDGM-D-DGD	DG D UNAVAILABLE DUE TO MAINTENANCE	5.93E-03

Table 19.1-52 (5 of 5)

Basic Event	Description	FV
AXVVO-A-V1623	FAILS TO OPEN CT SYSTEM MANUAL VALVE V1623	5.48E-03
WOMPS5A-PP05A	FAILS TO START OF ECW PUMP 05A	5.30E-03
VOHVM1B-HV33B	CUBICLE COOLER HV33B UNAVAILABLE DUE TO T&M	5.15E-03
NBHBC-S-SW03N-A2	FAIL TO CLOSE OF SWGR SW03N-A2 FEED BREAKER FROM AAC GTG	5.13E-03
DGDGM-A-DGA	DG 01A UNAVAILABLE DUE TO MAINTENANCE	5.08E-03

Table 19.1-53 (1 of 10)

Internal Fire PRA Key CCF Events by RAW (CDF)

Basic Event	Description	RAW
AFPVKQ4-TP01A/B/MP02A/B	4/4 RUNNING CCF OF AFW TDP01B, MDP02A/B DUE TO THE VOLUTE FAILURE	926.77
WOCHKQ4-CH03A/3B/4A/4B	RUNNING CCF OF ECW CHILLERS 3A/4A/3B/4B	780.55
WOCHKQ4-CH01A/1B/2A/2B	RUNNING CCF OF ECW CHILLERS 1A/2A/1B/2B	780.55
VGAHKQ4-AH01A/1B/2A/2B	4/4 RUNNING CCF OF ESW PUMP ROOM FAN AH01A/B, 02A/B	770.11
AFCVWQ4-V1007A/B/8A/B	4/4 CCF OF AFW DISCH. CHECK VALVE V1007A/B & 1008A/B	679.40
AFCVWQ4-V1003A/B/4A/B	4/4 CCF OF AFW DISCH. CHECK VALVE V1003A/B & 1004A/B	679.40
VKHVKQ4-HV13A/13B/14A/14B	4/4 CCF OF RUN FOR CCW PUMP ROOM CUBICLE COOLER HV13A, 13B, 14A, 14B	676.04
SXMPKQ4-PP01A/B/2A/B	4/4 CCF OF ESW PUMPS PP01A/2A, PP01B/2B TO RUN	618.72
PELXKO8-LX04AB03AB	8/8 CCF OF LOOP CONTROLLER LX03AB, LX04AB FOR CCW NON SAFETY LINE ISOL. VALVES	529.75
WOMPKQ4-PP01A/2A/1B/2B	RUNNING CCF OF ECW PUMPS 1A/2A/1B/2B	526.48
WOMPKQ4-PP04A/5A/4B/5B	RUNNING CCF OF ECW PUMPS 4A/5A/4B/5B	526.48
CCMPKQ4-PP01A/B/2A/B	4/4 CCF OF CCW PUMPS PP01A/1B/2A/2B (RUNNING)	526.48
AFCVWQ4-V1012A/B/4A/B	4/4 CCF OF AFW MINI FLOW CHECK VALVE V1012A/B & 1014A/B	495.14
SXAHKQ4-AH01A/02A/01B/02B	4/4 RUNNING CCF OF ESW COOLING TOWER FANS AH01A, 02A, 01B, 02B	415.91

Table 19.1-53 (2 of 10)

Basic Event	Description	RAW
CCMVXO8-143-150	8/8 CCF(DEMAND) OF MOV 143,144,145,146,147,148,149,150 IN NON SAFETY LOAD LINE	407.47
WOCHWQ4-CH03A/4A/3B/4B	DEMAND CCF OF ECW CHILLERS 3A/4A/3B/4B	352.67
WOCHWQ4-CH01A/2A/1B/2B	DEMAND CCF OF ECW CHILLERS 1A/2A/1B/2B	351.08
WOMPWQ4-PP04A/5A/4B/5B	DEMAND CCF OF ECW PUMPS 4A/5A/4B/5B	327.99
WOMPWQ4-PP01A/2A/1B/2B	DEMAND CCF OF ECW PUMPS 1A/2A/1B/2B	325.34
CCMPWQ4-PP01A/2A/1B/2B	4/4 CCF OF CCW PUMPS PP01A/1B/2A/2B (DEMAND)	325.34
SXMPWQ4-PP01A/B/2A/B	4/4 CCF OF ESW PUMPS PP01A/2A, PP01B/2B TO START	318.97
SXFLKE6-FT01AB/2AB/3AB	6/6 CCF OF ESW DEBRIS FILTER 1A/1B, 2A/B, 3A/3B IN TRAIN A/B	312.20
DGDGKQ4-DG01ABCD	CCF OF EDG 01A/01B/01C/01D FAIL TO RUN	310.78
PFHBWQ4-SW1OSAT	CCF OF PCB BETWEEN SAT & 4.16KV SW01A,1B,1C,1D FAIL TO OPEN	304.77
PFHBWQ4-SW1DG	CCF OF SW01A&1B&1C&1D FEED BREAKER FROM DG A&B FAIL TO CLOSE	295.74
VDHVWQ4-HV13ABCD	4/4 CCF OF START FOR EDG ROOM CUBICLE COOLER HV13A, 13B, 13C, 13D	295.00
VDHVWQ4-HV12ABCD	4/4 CCF OF START FOR EDG ROOM CUBICLE COOLER HV12A, 12B, 12C, 12D	295.00
SIMPWQ4-CSP1A/B/SCP1A/B	4/4 CCF OF CSP PP01A, PP01B AND SCP PP01A, PP01B TO START	292.01
PFHBWQ4-SW2OUAT	CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1B,1C,1D FAIL TO OPEN	291.81
DOMPWO8-PP012ABCD	8/8 CCF OF DIESEL FUEL OIL TRANSFER PUMP 012ABCD FAIL TO START	284.31

Table 19.1-53 (3 of 10)

Basic Event	Description	RAW
DGSQWQ4-LOADSQABCD	CCF OF LOAD SEQUNCER A, B, C, D	283.81
DGDGWQ4-DG01ABCD	CCF OF EDG 01A/01B/01C/01D FAIL TO START	281.36
DGDGWQ4-DG01ABCD-LOAD	CCF OF EDG 01A/01B/01C/01D FAIL TO LOAD AND RUN DURING 1ST 1HOUR	277.58
VGAHWQ4-AH01A/1B/2A/2B	4/4 START CCF OF ESW PUMP ROOM FAN AH01A/B, 02A/B	277.15
SXAHWQ4-AH01A/02A/01B/02B	4/4 DEMAND CCF OF ESW COOLING TOWER FANS AH01A, 02A, 01B, 02B	274.94
CCMVWQ4-191/2/181/2	4/4 CCF OF CCW MOV 191, 192, 181, 182 FOR EDG01A/B/C/D INLET	269.15
SIMPKQ4-CSP1A/B/SCP1A/B	4/4 CCF OF CSP PP01A, PP01B AND SCP PP01A , PP01B TO RUN	266.37
DOMPKO8-PP012ABCD	8/8 CCF OF DIESEL FUEL OIL TRANSFER PUMP 012ABCD FAIL TO RUN	265.41
VDHVWO8-HV12/13ABCD	8/8 CCF OF START FOR EDG ROOM CUBICLE COOLER HV12A, 12B, 12C, 12D 13A, 13B, 13C, 14D	260.58
VDHVKQ4-HV12ABCD	4/4 CCF OF RUN FOR EDG ROOM CUBICLE COOLER HV12A, 12B, 12C, 12D	248.92
VDHVKQ4-HV13ABCD	4/4 CCF OF RUN FOR EDG ROOM CUBICLE COOLER HV13A, 13B, 13C, 13D	248.92
SICVWQ4-V540/41/42/43	SI LINE C/V 543,541,542,540 CCF TO OPEN	246.13
SICVWQ4-V217/27/37/47	SI LINE C/V 247,227,237,217 CCF TO OPEN	246.13
SICVWQ4-V113/23/33/43	SI LINE C/V 113,123,133,143 CCF TO OPEN	246.13
PALXKQ4-PA06CD	4/4 CCF OF LOOP CONTROLLER PA06C, PA06D	238.98
SICVWQ4-V568/569/1001/1002	CCF TO OPEN CSP DISCH LINE 1001, 1002 AND SCP DISCH. LINE CV 568,569	231.16

Table 19.1-53 (4 of 10)

Basic Event	Description	RAW
SICVWQ4-V157/158/159/160	4/4 CCF OF CS CV 157/158 SC CV 159/160	231.16
SIHEKQ4-HE01A/B-CS&SC	4/4 CCF OF SC HE01A/B, CS HE01A/B	231.16
VDHVKO8-HV12/13ABCD	8/8 CCF OF RUN FOR EDG ROOM CUBICLE COOLER HV12A, 12B, 12C, 12D 13A, 13B, 13C, 14D	208.03
RPIAWO8-ALL	CCF ALL ANLOG INPUT MODULES OF BISTABLE	197.62
PELXKO8-LX03ABCD	8/8 CCF OF LOOP CONTROLLER LX03A/B/C/D	194.72
PELXKO8-LX05AB3CD	8/8 CCF OF LOOP CONTROLLER LX05A LX05B, LX03C ,LX03D	193.88
PELXKO8-LX06A04B03C03D	8/8 CCF OF LOOP CONTROLLER LX06A 12, LX04B 12, LX03C 12, LX03D 12	193.88
EFOTWO8-FOMCALL	CCF OF GC FIBER OPTIC TRANSMITTER	184.79
EFORWO8-FOMCALL	CCF OF GC FIBER OPTIC RECEIVER	184.79
EFGCWO8-PM12ABCD	CCF OF PM1 (PM646C) GC MODULE	181.16
RPBPWO8-BSALL	CCF ALL BISTABLE PROCESS MODULES	181.16
VGCVWQ4-Y1002A/B/11A/B	4/4 DEMAND CCF OF ESW PP ROOM DAMPER Y1002A/B, Y1011A/B	161.44
AFPVKQ3-TP01A/B/MP02A	3/4 RUNNING CCF OF AFW TDP01A/B AND MDP02A DUE TO THE VOLUTE FAILURE	150.95
VDTTKD2-TE013C/14D	CCF OF EDG ROOM TEMPERATURE TE-013C, 014D	141.75
VDTTKD2-TE015C/16D	CCF OF EDG ROOM TEMPERATURE TE-015C, 016D	141.75
DOCVWO8-V1005/7ABCD	8/8 CCF OF DIESEL FUEL OIL TRANSFER PUMP CV V1005/1007 A/B/C/D FAIL TO OPEN	140.68
PELXKQ4-LX04CD	4/4 CCF OF LOOP CONTROLLER 745-LX04C, LX04D	131.44

Table 19.1-53 (5 of 10)

Basic Event	Description	RAW
VKHVWQ4-HV11A/1B/2A/2B	4/4 CCF OF START FOR SI PUMP ROOM CUBICLE COOLER HV11A, 11B, 12A, 12B	102.74
SIMVWQ4-616/26/36/46	CCF OF 4/4 DVI LINEMOV 616,626,636,646	101.35
EFGXKO8-PA03ABCD	CCF OF GC TO LC PM646 MODULES	99.14
SXFLKE2-FT01A/B	2/6 CCF OF ESW DEBRIS FILTER 1A/1B	92.52
SXFLKE2-FT01A/2B	2/6 CCF OF ESW DEBRIS FILTER 1A/2B	92.52
SXFLKE2-FT02A/1B	2/6 CCF OF ESW DEBRIS FILTER 2A/1B	92.52
SXFLKE2-FT02A/2B	2/6 CCF OF ESW DEBRIS FILTER 2A/2B	92.52
AFPVKQ3-TP01A/B/MP02B	3/4 RUNNING CCF OF AFW TDP01A/B, MDP02B DUE TO THE VOLUTE FAILURE	81.46
AFPVKQ3-TP01A/MP02A/B	3/4 RUNNING CCF OF AFW TDP01A, MDP02A/B DUE TO THE VOLUTE FAILURE	77.70
SIMPWQ4-PP02ABCD	4/4 CCF OF START FOR SI PUMP PP02A/B/C/D	75.07
WOCHKQ3-CH01A/2A/1B	RUNNING CCF OF ECW CHILLERS 1A/2A/1B	74.00
WOCHKQ3-CH03A/4A/3B	RUNNING CCF OF ECW CHILLERS 3A/4A/3B	73.98
IPINKQ4-IN01ABCD	CCF OF 120V AC POWER SUPPLY INVERTER IN01A/B/C/D	72.23
CCCVWQ4-V1001/2/3/4	4/4 CCF OF CCW PUMP DISCH. CHECK VALVE V1001/2/3/4 TO OPEN	71.77
WOCVWQ4-V1053A/B/55A/B	CCF OF DISCH. CV 1053A/53B/55A/55B (FAIL TO OPEN)	71.77
SXCVWQ4-V1001/2/3/4	4/4 CCF OF ESW PUMP DISCH. CHECK VALVE V1001/2/3/4 TO OPEN (DEMAND)	71.77
WOCVWQ4-V1010A/B/14A/B	CCF OF DISCH. CV 1010A/10B/14A/14B (FAIL TO OPEN)	71.77

Table 19.1-53 (6 of 10)

Basic Event	Description	RAW
VKHVKQ4-HV11A/1B/2A/2B	4/4 CCF OF RUN FOR SI PUMP ROOM CUBICLE COOLER HV11A, 11B, 12A, 12B	70.95
MSRVWE6-MSSV-ALL	20/20 CCF OF MSSVS 1301~1320 ON SG 1/2	62.45
WOCHKQ2-CH01A/2A	RUNNING CCF OF ECW CHILLERS 1A/2A	61.44
WOCHKQ2-CH03A/4A	RUNNING CCF OF ECW CHILLERS 3A/4A	61.44
PELXKO8-LX04ABCD	8/8 CCF OF LOOP CONTROLLERS LX04A, LX04B, LX04C, LX04D	61.38
WOCHKQ3-CH01A/2A/2B	RUNNING CCF OF ECW CHILLERS 1A/2A/2B	61.35
WOCHKQ3-CH03A/4A/4B	RUNNING CCF OF ECW CHILLERS 3A/4A/4B	61.35
VGAHKQ3-AH01A/1B/2A	3/4 RUNNING CCF OF ESW PUMP ROOM FAN AH01A, 01B, 02A	60.12
DOLTKQ4-LS3025A/B/C/D	4/4 CCF OF DIESEL FUEL OIL DAY TANK A/B/C/D LEVEL SWITCH LS3025A/B/C/D	59.04
EFCIKO8-PA03ABCD	CCF OF GC CI MODULES	55.20
WOCHKQ3-CH03A/3B/4B	RUNNING CCF OF ECW CHILLERS 3A/3B/4B	53.17
WOCHKQ3-CH01A/1B/2B	RUNNING CCF OF ECW CHILLERS 1A/1B/2B	52.47
VGAHKQ3-AH01A/2A/2B	3/4 RUNNING CCF OF ESW PUMP ROOM FAN AH01A, 02A, 02B	50.89
VGAHKQ2-AH01A/2A	2/4 RUNNING CCF OF ESW PUMP ROOM FAN AH01A, 02A	50.14
SIMPKQ4-PP02ABCD	4/4 CCF OF RUN FOR SI PUMP PP02A/B/C/D	49.91
PFHBWQ3-SW2OUATABC	3/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1B, 1C FAIL TO OPEN	49.57
CCMVXO4-143/5/7/9	4/4 CCF(DEMAND) OF MOV 143,145,147,149 IN NON SAFETY LOAD LINE	46.75
SICVWD2-V100/101	CCF OF CV 100/101 IN TRAIN A&B IRWST RETURN LINES	45.23
WOMPKQ2-PP04A/5A	RUNNING CCF OF ECW PUMPS 4A AND 5A	44.09

Table 19.1-53 (7 of 10)

Basic Event	Description	RAW
CCMPKQ2-PP01/2A	2/4 CCF OF CCW PUMPS PP01A/2A (RUNNING)	44.09
WOMPKQ2-PP01A/2A	RUNNING CCF OF ECW PUMPS 1A AND 2A	44.09
SXMPKQ2-PP01/2A	2/4 CCF OF ESW PUMPS PP01A, PP02A (RUNNING)	44.09
VKHVKQ2-HV13A/14A	2/4 CCF OF RUN FOR CCW PUMP ROOM CUBICLE COOLER HV13A, 14A	44.08
AFPVKQ3-TP01B/MP02A/B	3/4 RUNNING CCF OF AFW TDP01B, MDP02A/B DUE TO THE VOLUTE FAILURE	43.91
PFHBWQ3-SW1OSATABC	3/4 CCF OF PCB BETWEEN SAT & 4.16KV SW01A,1B,1C FAIL TO OPEN	43.18
VGAHKQ3-AH01A/1B/2B	3/4 RUNNING CCF OF ESW PUMP ROOM FAN AH01A, 01B, 02B	43.04
WOCHKQ3-CH04A/3B/4B	RUNNING CCF OF ECW CHILLERS 4A/3B/4B	42.90
WOCHKQ2-CH01B/2B	RUNNING CCF OF ECW CHILLERS 1B/2B	42.41
WOCHKQ2-CH03B/4B	RUNNING CCF OF ECW CHILLERS 3B/4B	42.41
WOCHKQ3-CH02A/1B/2B	RUNNING CCF OF ECW CHILLERS 2A/1B/2B	42.15
DGDGKQ3-DG01ABD	CCF OF EDG 01A/01B/01D FAIL TO RUN	41.08
AFCVWQ3-V1003A/4A/B	3/4 CCF OF AFW DISCH. CHECK VALVE V1003A & 4A/B	40.11
AFCVWQ3-V1007A/8A/B	3/4 CCF OF AFW DISCH. CHECK VALVE V1007A & 8A/B	40.11
DGDGKQ3-DG01ABC	CCF OF EDG 01A/01B/01C FAIL TO RUN	40.04
RCPTKQ4-PT102ABCD	CCF OF LO PZR PRESS. TRANS. PT-102A B C & D	39.45
PELXKO8-LX02AB01CD	8/8 CCF OF LOOP CONTROLLER LX02A/B AND LX01C/D	39.05
SICVWQ4-V404/05/34/46	SI PUMP DISCHARGE C/V 404,405,434,446 CCF TO OPEN	39.05
AFPVKQ2-TP01A/MP02A	2/4 RUNNING CCF OF AFW TDP01A, MDP02A DUE TO THE VOLUTE FAILURE	38.46
RPIAWQ4-PY102ABCD	CCF OF ALL CONVERTER FOR LO PZR PR. PT-102A B C & D	38.28

Table 19.1-53 (8 of 10)

Basic Event	Description	RAW
WOCHWQ3-CH01A/2A/1B	DEMAND CCF OF ECW CHILLERS 1A/2A/1B	37.48
PFHBWQ3-SW2OUATACD	3/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1C, 1D FAIL TO OPEN	37.05
PFHBWQ3-SW2OUATABD	3/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1B, 1D FAIL TO OPEN	36.38
VGAHKQ3-AH01B/2A/2B	3/4 CCF (RUNNING) OF ESW PUMP ROOM FAN AH01B, 02A, 02B	35.28
VGAHKQ2-AH01B/2B	2/4 CCF (RUNNING) OF ESW PUMP ROOM FAN AH01B, 02B	34.53
PFHBWQ3-SW1DGABC	3/4 CCF OF SW01A&1B&1C FEED BREAKER FROM DG A&B FAIL TO CLOSE	34.39
PFHBWQ3-SW1OSATABD	3/4 CCF OF PCB BETWEEN SAT & 4.16KV SW01A,1B,1D FAIL TO OPEN	34.25
AXCVWD2-V1628/9	2/2 CCF OF CT SYSTEM CHECK VALVE V1628/1629	33.16
PELXKO8-LX01ABCD	8/8 CCF OF LOOP CONTROLLER LX01A, LX01B, LX01C, LX01D	32.13
PELXKO8-LX08A12B01C01D	8/8 CCF OF LOOP CONTROLLER LX08A 12, LX12B 12, LX01C 12, LX01D 12	32.13
DGDGKQ3-DG01BCD	CCF OF EDG 01B/01C/01D FAIL TO RUN	32.07
CCMVXO4-144/6/8/50	4/4 CCF(DEMAND) OF MOV 144,146,148,150 IN NON SAFETY LOAD LINE	30.53
VKHVKQ3-HV13A/13B/14A	3/4 CCF OF RUN FOR CCW PUMP ROOM CUBICLE COOLER HV13A, 13B, 14A	30.36
VKHVKQ3-HV13A/14A/14B	3/4 CCF OF RUN FOR CCW PUMP ROOM CUBICLE COOLER HV13A, 14A, 14B	30.29
WOCHWQ3-CH03A/4A/3B	DEMAND CCF OF ECW CHILLERS 3A/4A/3B	28.86
WOMPKQ3-PP04A/5A/4B	RUNNING CCF OF ECW PUMPS 4A/5A/4B	28.25
CCMPKQ3-PP01A/B/2A	3/4 CCF OF CCW PUMPS PP01A/1B/2A (RUNNING)	28.25
WOMPKQ3-PP01A/2A/1B	RUNNING CCF OF ECW PUMPS 1A/2A/1B	28.21
WOMPKQ3-PP01A/2A/2B	RUNNING CCF OF ECW PUMPS 1A/2A/2B	28.18

Table 19.1-53 (9 of 10)

Basic Event	Description	RAW
WOMPKQ3-PP04A/5A/5B	RUNNING CCF OF ECW PUMPS 4A/5A/5B	28.18
CCMPKQ3-PP01A/2A/B	3/4 CCF OF CCW PUMPS PP01A/2A/2B (RUNNING)	28.18
MSRVWE6-MSSV-SG1	10/10 CCF OF MSSV 1301~1310 ON SG1	28.10
WOMPKQ2-PP04B/5B	RUNNING CCF OF ECW PUMPS 4B AND 5B	27.20
CCMPKQ2-PP01/2B	2/4 CCF OF CCW PUMPS PP01B/2B (RUNNING)	27.20
WOMPKQ2-PP01B/2B	RUNNING CCF OF ECW PUMPS 1B AND 2B	27.20
SXMPKQ2-PP01/2B	2/4 CCF OF ESW PUMPS PP01B, PP02B (RUNNING)	27.20
SXMPKQ3-PP01A/B/2A	3/4 CCF OF ESW PUMPS PP01A, PP02A, PP01B (RUNNING)	25.83
SXMPKQ3-PP01A/2A/B	3/4 CCF OF ESW PUMPS PP01A, PP02A, PP02B (RUNNING)	25.76
PFHBWQ3-SW1DGABD	3/4 CCF OF SW01A&1B&1D FEED BREAKER FROM DG B FAIL TO CLOSE	25.60
PFHBWQ3-SW2OUATBCD	3/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01B,1C, 1D FAIL TO OPEN	25.57
DGDGKQ3-DG01ACD	CCF OF EDG 01A/01C/01D FAIL TO RUN	25.48
VKHVKQ2-HV13B/14B	2/4 CCF OF RUN FOR CCW PUMP ROOM CUBICLE COOLER HV13B, 14B	25.17
WOCHWQ3-CH01A/1B/2B	DEMAND CCF OF ECW CHILLERS 1A/1B/2B	24.28
WOCHWQ3-CH03A/3B/4B	DEMAND CCF OF ECW CHILLERS 3A/3B/4B	24.20
VKTTKQ4-TE211A/12B/09C/10D	CCF OF CS PUMP ROOM TEMPERATURE TE-211A, 212B, 209C, 210D	24.01
SICVWQ4-V424/26/48/51	SI LINE C/V 424,426,448,451 CCF TO OPEN	23.65
WOCHWQ3-CH03A/4A/4B	DEMAND CCF OF ECW CHILLERS 3A/4A/4B	22.18
PFHBWQ3-SW1OSATBCD	3/4 CCF OF PCB BETWEEN SAT & 4.16KV SW01B,1C,1D FAIL TO OPEN	21.99

Table 19.1-53 (10 of 10)

Basic Event	Description	RAW
AFTPKD2-TDP01A/B	2/2 CCF OF RUNNING AFW TDP PP01/A/B	21.36
VKHVKQ3-HV13B/14A/14B	3/4 CCF OF RUN FOR CCW PUMP ROOM CUBICLE COOLER HV13B, 14A, 14B	21.16
VKHVKQ3-HV13A/13B/14B	3/4 CCF OF RUN FOR CCW PUMP ROOM CUBICLE COOLER HV13A, 13B, 14B	21.16
PFHBWQ2-SW2OUATAC	2/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1C FAIL TO OPEN	20.95
WOCHWQ3-CH01A/2A/2B	DEMAND CCF OF ECW CHILLERS 1A/2A/2B	20.59
WOCHWQ3-CH04A/3B/4B	DEMAND CCF OF ECW CHILLERS 4A/3B/4B	20.30

(1) The cutoff threshold chosen for this table is based upon guidance presented in NEI 00-04 (Reference 51).

Table 19.1-54

Internal Fire PRA Key CCF Events by FV (CDF)

Basic Event	Description	FV
WOCHWQ4-CH03A/4A/3B/4B	DEMAND CCF OF ECW CHILLERS 3A/4A/3B/4B	1.54E-02
WOCHWQ4-CH01A/2A/1B/2B	DEMAND CCF OF ECW CHILLERS 1A/2A/1B/2B	1.53E-02
DGDGKQ4-DG01ABCD	CCF OF EDG 01A/01B/01C/01D FAIL TO RUN	1.50E-02
PFHBWQ4-SW1OSAT	CCF OF PCB BETWEEN SAT & 4.16KV SW01A,1B,1C,1D FAIL TO OPEN	8.24E-03
PFHBWQ4-SW2OUAT	CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1B,1C,1D FAIL TO OPEN	7.88E-03
AFTPKD2-TDP01A/B	2/2 CCF OF RUNNING AFW TDP PP01/A/B	5.54E-03

Table 19.1-55

Internal Fire PRA Key Operator Actions by RAW (CDF)

Operator Action	Description	RAW
RPOPU-S-PT102ABCD	OPERATOR ERROR: COMMON MISCALIBRATION OF LO PZR PR. CH.A/B/C/D	33.83
AFOPV-S-AFAS-TR	OPERATOR FAILS TO RECOVER AFAS	3.38
RCOPH-S-SDSE-SL	FAILURE OF SDS VALVES EARLY PHASE OPEN (2/4)	3.15
AFOPH-S-ALT-LT	OPERATOR FAIL TO ALIGNE FOR SUPPLYING AN ALTERNATE SOURCE	2.49
MSOPH-S-SGADV	OPERATOR FAILS TO OPEN ADVS	2.36
CDOPH-S-ALIGN	OPERATOR FAILS TO START FOR PP01,02,03 BY HAND SWITCH	2.21
FWOPH-S-ERY	OPERATOR FAILS TO ALINE STARTUP FEEDWATER PUMP PP07 (EARLY PHASE)	2.10

Table 19.1-56

Internal Fire PRA Key Operator Actions by FV(CDF)

Operator Action	Description	FV
RCOPH-S-SDSE-SL	FAILURE OF SDS VALVES EARLY PHASE OPEN (2/4)	6.43E-02
AFOPV-S-AFAS-TR	OPERATOR FAILS TO RECOVER AFAS	2.40E-02
RCOPH-S-SDSE-SL-MD	FAILURE OF SDS VALVES EARLY PHASE OPEN (2/4) WITH MEDIUM DEPENDENCY	2.01E-02
RCOPH-S-SDSE-SL-LD	FAILURE OF SDS VALVES EARLY PHASE OPEN (2/4) WITH LOW DEPENDENCY	1.35E-02
FWOPH-S-ERY	OPERATOR FAILS TO ALINE STARTUP FEEDWATER PUMP PP07 (EARLY PHASE)	1.11E-02
AFOPH-S-ALT-LT	OPERATOR FAIL TO ALIGNE FOR SUPPLYING AN ALTERNATE SOURCE	1.08E-02
DAOPH-S-AACTG	OPERATOR FAILS TO PROVIDE 1E 4.16KV SW01A,B,C,D	1.05E-02
CCOPV-S-NSMV	OPERATOR FAILS TO CLOSE CC MOV 143~150 (NON-ESSENTIAL LOAD)	7.68E-03
CCOPH-S-HX-ALIGN	OPERATOR FAILS TO OPEN CCW HX3A/B ISOL. V1145 /6 /ESW SUPPLYING V1027/8, 3014/5	7.52E-03
EFOPV-S-SIAS	OPERATOR FAILS TO MANUALLY INITIATE ALL CHANNELS VIA MCR FOR SIAS	6.72E-03
SIOPV-S-SIAS	OPERATOR FAILS TO RECOVERY FOR SIAS	5.04E-03

Table 19.1-57 (1 of 11)

Internal Fire PRA Key Basic Events by RAW (LRF)

EVENT	DESCRIPTION	RAW
DCBSY-A-MC01A	BUS FAULTS ON 1E 125VDC BUS MC01A	368.07
PFBSY1A-SW01A	BUS FAULT ON 4.16KV SWGR SW01A	186.84
WOTKB-A-TK01A	ECW COMPRESSION TANK TK01A FAILS CATASTROPHICALLY	134.76
WOTKB-A-TK02A	ECW AIR SEPARATOR TK02A FAILS CATASTROPHICALLY	134.76
CCTKB-A-TK01A	CCW SURGE TANK TK01A FAILS CATASTROPHICALLY	134.76
WOTKB-A-TK04A	ECW COMPRESSION TANK TK04A FAILS CATASTROPHICALLY	134.76
WOTKB-A-TK05A	ECW AIR SEPARATOR TK05A FAILS CATASTROPHICALLY	134.76
PGBSY1A-LC01A	BUS FAULT ON 480V LC LC01A	107.60
PGXMY1A-TR01A	480V LC TRANSFORMER LC-TR01A FAULT	106.73
SISPP-S-IRWST	FAILURE OF IRWST SUMP DUE TO PLUGGING	70.34
SISPP-S-CHEMICAL	DEBRIS INDUCED LOSS OF LONG TERM COOLING (DOWNSTREAM/CHEMICAL EFFECT)	70.19
CCHEY02A-HE02A	CCW HX. HE02A FAILS WHILE OPERATING	68.82
CCHEY01A-HE01A	CCW HX. HE01A FAILS WHILE OPERATING	68.82
DCBSY-B-MC01B	BUS FAULTS ON 1E 125VDC BUS MC01B	53.51
WOTKB-B-TK05B	ECW AIR SEPARATOR TK05B FAILS CATASTROPHICALLY	52.51
CCTKB-B-TK01B	CCW SURGE TANK TK01B FAILS CATASTROPHICALLY	52.51
WOTKB-B-TK01B	ECW COMPRESSION TANK TK01B FAILS CATASTROPHICALLY	52.51
WOTKB-B-TK04B	ECW COMPRESSION TANK TK04B FAILS CATASTROPHICALLY	52.51

Table 19.1-57 (2 of 11)

EVENT	DESCRIPTION	RAW
WOTKB-B-TK02B	ECW AIR SEPARATOR TK02B FAILS CATASTROPHICALLY	52.51
DCBSY-C-MC01C	BUS FAULTS ON 1E 125VDC BUS MC01C	42.46
PHBSY1A-MC03A	BUS FAULT ON 480V MCC MC03A	40.20
ASD-LRF	ALTERNATE SHUTDOWN FAILURE PROBABILITY FOR LRF	35.80
PELXY-C-LX04C-P	FAILURE OF PRIMARY LOOP CONTROLLER OF 745-PE-LX04C	28.11
CCHEY01B-HE01B	CCW HX. HE01B FAILS WHILE OPERATING	26.87
CCHEY02B-HE02B	CCW HX. HE02B FAILS WHILE OPERATING	26.87
PELXY-A-LX03A-P	FAILURE OF PRIMARY LOOP CONTROLLER OF 745-PE-LX03A	21.74
PFGRID	GRID COLLAPSE ON TURBINE TRIP	20.09
ASD-LRF-MCA	ALTERNATE SHUTDOWN FAILURE PROBABILITY FOR MCA LRF	19.58
PR	POSRV FAILS TO RECLOSE	18.14
AXVVO-A-V1623	FAILS TO OPEN CT SYSTEM MANUAL VALVE V1623	14.37
PFHBO1A-SW01A-H2	FAILS TO OPEN OF PCB SW01A-H2 OF 4.16KV SWGR SW01A FROM UAT	14.07
PELXY-C-LX02C-P	FAILURE OF PRIMARY LOOP CONTROLLER OF 745-PE-LX02C	13.92
AXCVO-A-V1628	FAILS TO OPEN CT SYSTEM CHECK VALVE V1628	13.79
PHBSY1A-MC01A	BUS FAULT ON 480V MCC MC01A	13.20
DCBSY-D-MC01D	BUS FAULTS ON 1E 125VDC BUS MC01D	12.31
DCBTM-C-BT01C	POWER UNAVAILABLE OF BT01C (125VDC) DUE TO MAINTENANCE	11.71
IPINM-C-IN01C	INVERTER IN01C UNAVAIL. DUE TO T/M	11.69
SEAL-AFSUC	SEAL FAILURE PROBABILITY (SECONDARY HEAT REMOVAL SUCCESS)	9.91

Table 19.1-57 (3 of 11)

EVENT	DESCRIPTION	RAW
PELXY-A-LX06A-P	FAILURE OF PRIMARY LOOP CONTROLLER LX06A	9.56
PELXY-A-LX01A-P	FAILURE OF PRIMARY LOOP CONTROLLER OF 745-PE-LX01A	9.01
PFBSY1B-SW01B	BUS FAULT ON 4.16KV SWGR SW01B	9.01
SXFLP2A-FT02A	ESW DEBIS FILTER FT02A PLUGGED	8.54
SXFLP1A-FT01A	ESW DEBIS FILTER FT01A PLUGGED	8.54
PALXY-D-PA06D-P	PRIMARY LOOP CONTROLLER 752-PA06D FAILS TO RUN	8.33
PEDOY-D-LX03D01	FAILURE OF DIGITAL OUTPUT MODULE LX03D BRANCH 01	8.03
PADOY-D-PA06D01	FAILURE OF DIGITAL OUTPUT MODULE PA06D BRANCH 01	7.99
PADOY-D-PA06D03	FAILURE OF DIGITAL OUTPUT MODULE 752-PA06D BRANCH 03	7.99
PEDOY-C-LX03C01	FAILURE OF DIGITAL OUTPUT MODULE LX03C BRANCH 01	7.21
DCBTM-D-BT01D	POWER UNAVAILABLE OF BT01C (125VDC) DUE TO MAINTENANCE	6.91
PALXY-C-PA06C-P	PRIMARY LOOP CONTROLLER 752-PA06C FAILS TO RUN	6.81
WOCHR3A-CH03A	ECW CHILLER CH03A FAILS TO RUN FOR 24 HOURS	6.53
WOCHR1A-CH01A	ECW CHILLER CH01A FAILS TO RUN FOR 24 HOURS	6.52
PADOY-D-PA06C02	FAILURE OF DIGITAL OUTPUT MODULE PA06C BRANCH 02	6.48
PADOY-C-PA06C04	FAILURE OF DIGITAL OUTPUT MODULE PA06C BRANCH 04	6.48
IPINM-A-IN01A	INVERTER IN01A UNAVAIL. DUE TO T/M	6.38
DCBTM-A-BT01A	POWER UNAVAILABLE OF BT01A (125VDC) DUE TO MAINTENANCE	6.29
DCBTM-B-BT01B	POWER UNAVAILABLE OF BT01B (125VDC) DUE TO MAINTENANCE	6.10
IPINM-B-IN01B	INVERTER IN01B UNAVAIL. DUE TO T/M	6.09

Table 19.1-57 (4 of 11)

EVENT	DESCRIPTION	RAW
PGBSY1B-LC01B	BUS FAULT ON 480V LC LC01B	5.75
IPINM-D-IN01D	INVERTER IN01D UNAVAIL. DUE TO T/M	5.62
PGXMY1B-TR01B	480V LC TRANSFORMER LC-TR01B FAULT	5.53
VOHVS2A-HV33A	FAILS TO START OF MAFP ROOM A CUBICLE COOLER HV33A	5.38
AFMPM2A-MDP02A	AFW MDP PP02A UNAVAILABLE DUE TO T/M	5.38
VOHVM2A-HV33A	CUBICLE COOLER HV33A UNAVAILABLE DUE TO T&M	5.37
AFMPS2A-MDP02A	FAILS TO START AFW MDP PP02A	5.35
AFMPR2A-MDP02A	FAILS TO RUN AFW MDP PP02A	5.28
VOHVR2A-HV33A	FAILS TO RUN OF MAFP ROOM A CUBICLE COOLER HV33A	5.23
AFVVT2A-V1011A	AFW MDP02A MINI FLOW LINE MANUAL VALVE V1011A TRANSFER CLOSED	5.19
AFVVT2A-V1603	AFW MDP02A MINI FLOW LINE MANUAL VALVE V1603 TRANSFER CLOSED	5.19
AFVVT2A-V1001A	AFW MDP02A SUCT. MANUAL VALVE V1001A TRANSFER CLOSED	5.19
AFVVT2A-V1005A	AFW MDP01A DISCH. MANUAL VALVE V1005A TRANSFER CLOSED	5.19
PFBSY2A-SW01C	BUS FAULT ON 4.16KV SWGR SW01C	5.15
PEDOY-A-LX01A04	FAILURE OF DIGITAL OUTPUT MODULE LX01A BRANCH 04	5.15
PGBSY2A-LC01C	BUS FAULT ON 480V LC LC01C	5.13
AFMVT2A-0043	AFW ISOL. MOV V0043 TRANSFER CLOSED	5.10
PGXMY2A-TR01C	480V LC TRANSFORMER LC-TR01C FAULT	5.01
AFCVO2A-V1003A	FAILS TO OPEN AFW MDP02A DISCH. CHECK VALVE V1003A	4.91
AFCVO2A-V1007A	FAILS TO OPEN AFW MDP02A DISCH. CHECK VALVE V1017A	4.91

Table 19.1-57 (5 of 11)

EVENT	DESCRIPTION	RAW
AFCVO2A-V1012A	FAILS TO OPEN AFW MDP02A MINI FLOW CHECK VALVE V1012A	4.91
PDS_14	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14	4.56
WOMPM5A-PP05A	ECW PP05A TRAIN UNAVAILABLE DUE TO TEST OR MAINTENANCE	4.35
AFTPR1A-TDP01A	FAILS TO RUN AFW TDP PP01A	4.30
WOMPR1A-PP01A	FAILS TO RUN OF ECW PUMP 01A	4.27
WOMPS5A-PP05A	FAILS TO START OF ECW PUMP 05A	4.24
WOMPR4A-PP04A	FAILS TO RUN OF ECW PUMP 04A	4.23
AFTPS1A-TDP01A	FAILS TO START AFW TDP PP01A	4.22
PHBSY1B-MC01B	BUS FAULT ON 480V MCC MC01B	4.22
AFTPM1A-TDP01A	AFW TDP PP01A UNAVAILABLE DUE TO T/M	4.20
AFSVI2A-0035	AFW MDP02A DISCH. MOD. VALVE 035 FAILS SPURIOUSLY CLOSED	4.20
MSAVO-B-110	FAILS TO OPEN MS AFW TDP PP01A TBN STM. SUPPLY AOV 110	4.17
PEDOY-D-LX02D04	FAILURE OF DIGITAL OUTPUT MODULE 745-PE-LX02D BRANCH 04	4.15
PEDOY-C-LX04C01	FAILURE OF DIGITAL OUTPUT MODULE LX04C BRANCH 01	4.04
WOVVT5A-V1071A	ECW PP05A DISCH. LINE VV 1071A TRANSFER CLOSED	3.99
WOVVT5A-V1068A	ECW PP05A SUCTION LINE VV 1068A TRANSFER CLOSED	3.99
PELXY-D-LX02D-P	FAILURE OF PRIMARY LOOP CONTROLLER OF 745-PE-LX02D	3.99
WOMPR5A-PP05A	FAILS TO RUN OF ECW PUMP 05A	3.98
ATAVO-C-009	FAILS TO OPEN AFW TDP PP01A TBN STM. ISOL AOV, 009	3.97
PHBSY2A-MC04C	BUS FAULT ON 480V MCC MC04C	3.97

Table 19.1-57 (6 of 11)

EVENT	DESCRIPTION	RAW
PFHBO2A-SW01C-C2	FAILS TO OPEN OF PCB SW01C-C2 OF 4.16KV SWGR SW01C FROM UAT	3.96
WOCVO5A-V1055A	ECW PP05A DISCH. LINE CV 1055A FAILS TO OPEN	3.78
AFMVC1A-0045	AFW ISOL. MOV 0045 FAILS TO CLOSE FOR CYCLING OPERATION	3.62
PELXY-B-LX11B-P	FAILURE OF PRIMARY LOOP CONTROLLER OF 745-PE-LX11B	3.57
AFVVT1A-V1002A	AFW SUCT. MANUAL VALVE V1002A TRANSFER CLOSED	3.56
AFVVT1A-V1013A	AFW TDP PP01A MINI FLOW MANUAL VALVE V1013A TRANSFER CLOSED	3.56
AFVVT1A-V1616	AFW TDP PP01A MINI FLOW MANUAL VALVE V1616 TRANSFER CLOSED	3.56
AFVVT1A-V1006A	AFW TDP01A DISCH. MANUAL VALVE V1006A TRANSFER CLOSED	3.56
MSVVT-B-V1151	MS MANUAL VALVE V1151 FOR AFW TDP01A TRANSFER CLOSED	3.56
RCPVO-A-201	POSRV V201 FAILS TO OPEN (HARDWARE FAIL)	3.55
RCPVO-A-200	POSRV V200 FAILS TO OPEN (HARDWARE FAIL)	3.55
SXFLP1B-FT01B	ESW DEBIS FILTER FT01B PLUGGED	3.54
RCMVO-A-132	MV 132 FAILS TO OPEN	3.51
RCMVO-C-133	MV 133 FAILS TO OPEN	3.51
RCMVO-C-131	MV 131 FAILS TO OPEN	3.51
RCMVO-A-130	MV 130 FAILS TO OPEN	3.51
SXFLP2B-FT02B	ESW DEBIS FILTER FT02B PLUGGED	3.48
PEDOY-B-LX11B04	FAILURE OF DIGITAL OUTPUT MODULE 745-PE-LX11B BRANCH 04	3.46
PEDOY-C-LX02C04	FAILURE OF DIGITAL OUTPUT MODULE 745-PE-LX02C BRANCH 04	3.46
PELXY-A-LX08A-P	FAILURE OF PRIMARY LOOP CONTROLLER OF 745-PE-LX08A	3.40

Table 19.1-57 (7 of 11)

EVENT	DESCRIPTION	RAW
PELXY-C-LX05C-P	FAILURE OF PRIMARY LOOP CONTROLLER OF 745-PE-LX05C	3.39
DEAVC-S-006	CTMT. ISOL. AOV DE-006 FAIL TO CLOSE	3.38
PEDOY-C-LX05C01	FAILURE OF DIGITAL OUTPUT MODULE 745-LX05C BRANCH 01	3.36
PEDOY-A-LX08A01	FAILURE OF DIGITAL OUTPUT MODULE 745-LX08A BRANCH 01	3.36
WOCHM4A-CH04A	ECW CHILLER 04A TRAIN UNAVAILABLE DUE TO T&M	3.34
WOCHS4A-CH04A	ECW CHILLER CH04A FAILS TO START ON DEMAND	3.33
AFMVT1A-0045	AFW ISOL. MOV V0045 TRANSFER CLOSED	3.32
WOCHR1B-CH01B	ECW CHILLER 01B FAILS TO RUN FOR 24 HOURS	3.31
CI-HATCH	HATCH FAILS TO ISOLATE	3.26
CIILRTLINES	LEAK RATE TEST LINES FAIL TO ISOLATE (VQ-2024, 2014, 2016)	3.26
WOCHR3B-CH03B	ECW CHILLER 03B FAILS TO RUN FOR 24 HOURS	3.26
PEDOY-C-LX04C04	FAILURE OF DIGITAL OUTPUT MODULE 745-PE-LX04C BRANCH 04	3.26
PELXY-C-LX03C-P	FAILURE OF PRIMARY LOOP CONTROLLERS 745-PE-LX03C	3.13
PEDOY-C-LX03C02	FAILURE OF DIGITAL OUTPUT MODULE LX03C BRANCH 02	3.05
CCMVO-A-392	CCW MOV 392 FOR ECW CHILLER CH04A OUTLET FAIL TO OPEN	3.04
PFHBO1B-SW01B-H2	FAILS TO OPEN OF PCB SW01B-H2 OF 4.16KV SWGR SW01B FROM UAT	3.01
WOCHR4A-CH04A	ECW CHILLER 04A FAILS TO RUN FOR 24 HOURS	3.01
SXMPR1A-PP01A	ESW PUMP PP01A FAILS TO RUN	2.99
AFCVO1A-V1004A	FAILS TO OPEN AFW TDP01A DISCH. CHECK VALVE V1004A	2.98
AFCVO1A-V1008A	FAILS TO OPEN AFW TDP01A DISCH. CHECK VALVE V1008A	2.98

Table 19.1-57 (8 of 11)

EVENT	DESCRIPTION	RAW
ATCVO-C-V1020A	FAILS TO OPEN AFW TBN SYSTEM CHECK VALVE V1020A FOR AFW TDP01A	2.98
AFCVO1A-V1014A	FAILS TO OPEN AFW TDP01A MINI FLOW CHECK VALVE V1014A	2.98
PELXY-B-LX02B-P	FAILURE OF PRIMARY LOOP CONTROLLER OF 745-LX02B	2.92
PFBSY2B-SW01D	BUS FAULT ON 4.16KV SWGR SW01D	2.78
WOVVT4A-V1078A	ESSENTIAL CHILLER CH04A OUTLET VV 1078A TRANSFER CLOSED	2.77
WOVVT4A-V1077A	ESSENTIAL CHILLER CH04A INLET VV 1077A TRANSFER CLOSED	2.77
PGBSY2B-LC01D	BUS FAULT ON 480V LC LC01D	2.76
VKHVR1A-HV13A	FAILS TO RUN CCW PUMP ROOM CUBICLE COOLER HV13A	2.74
PHBSY2A-MC02C	BUS FAULT ON 480V MCC MC02C	2.73
CCVVT-A-V1742	ECW CHILLER CH04A OUTLET MANUAL VALVE V1742 TRANSFER CLOSED	2.73
CCVVT-A-V1341	ECW CHILLER CH04A INLET MANUAL VALVE V1341 TRANSFER CLOSED	2.73
CCMPR1A-PP01A	CCW PUMP PP01A FAILS TO RUN	2.69
PGXMY2B-TR01D	480V LC TRANSFORMER LC-TR01D FAULT	2.69
PELXY-D-LX04D-P	FAILURE OF PRIMARY LOOP CONTROLLER OF 745-PE-LX04D	2.57
DAMPR-A-PP02	AAC FUEL OIL FEED PUMP PP02 FAILS TO RUN	2.50
DADGR-S-AACTG	AAC GTG FAILS TO RUN	2.48
PHBSY2B-MC02D	BUS FAULT ON 480V MCC MC02D	2.45
DADGM-S-AAC	AAC GTG UNAVAILABLE DUE TO MAINTENANCE	2.42
NPXHM-M-SAT02M	SAT TR02M UNAVAILABLE DUE TO MAINTENANCE	2.41
AFMVR1A-0045	AFW ISOL. MOV 0044 FAILS TO CONROL FOR CYCLING OPERATION	2.41

Table 19.1-57 (9 of 11)

EVENT	DESCRIPTION	RAW
PHBSY2A-MC01C	BUS FAULT ON 480V MCC MC01C	2.38
DCBTY-D-BT01D	BAT. BT01D (125VDC) FAILS TO PROVIDE ADEQUATE OUTPUT	2.37
NPBDY-S-IPB	IPB FAULT	2.36
IPINY-C-IN01C	120V AC POWER SUPPLY INVERTER IN01C FAILS WHILE OPERATING	2.35
NBHBC-S-SW03N-A2	FAIL TO CLOSE OF SWGR SW03N-A2 FEED BREAKER FROM AAC GTG	2.34
NPXOY-S-MTR	MAIN TRANSFORMER FAULT	2.32
NPXHY-N-UAT01N	UNIT AUX XFMR TR01N FAILS WHILE OPERATING	2.32
NPXHY-M-UAT01M	UNIT AUX XFMR TR01M FAILS WHILE OPERATING	2.32
DGDGR-B-DGB	FAILS TO RUN OF EMERGENCY DIESEL GENERATOR DG01B	2.26
WOMPR1B-PP01B	FAILS TO RUN OF ECW PUMP 01B	2.25
VUHVS-S-HV83	HIGH VOLUME CUBICLE COOLER HV83 FAILS TO START	2.25
VUHVS-S-HV81	FAILS TO START OF HIGH VOLUME CUBICLE COOLER HV81	2.25
PFHBC1B-SW01B-D2	FAILS TO CLOSE OF FEEDER BRK SW01B-D2 TO DG B	2.25
PFHBO1B-SW01B-A2	FAILS TO OPEN OF PCB SW01B-A2 OF 4.16KV SWGR SW01B FROM SAT	2.25
WOCHM2A-CH02A	ECW CHILLER 02A TRAIN UNAVAILABLE DUE TO T&M	2.24
WOCHS2A-CH02A	ECW CHILLER CH02A FAILS TO START ON DEMAND	2.23
PHBSY1B-MC03B	BUS FAULT ON 480V MCC MC03B	2.23
DAMPM-A-PP02	AAC FUEL OIL FEED PUMP PP02 UNAVAILABLE DUE TO MAINTENANCE	2.22
WOMPR4B-PP04B	FAILS TO RUN OF ECW PUMP 04B	2.22
DADGS-S-AACTG	AAC GTG FAILS TO START	2.21

Table 19.1-57 (10 of 11)

EVENT	DESCRIPTION	RAW
AFTPR1B-TDP01B	FAILS TO RUN AFW TDP PP01B	2.20
VUHVM-S-HV81	HIGH VOLUME CUBICLE COOLER HV81 UNAVAILABLE DUE TO MAINTENANCE	2.18
VUHVM-S-HV83	HIGH VOLUME CUBICLE COOLER HV83 UNAVAILABLE DUE TO MAINTENANCE	2.18
AFSVI1A-0037	AFW TDP01A DISCH. MOD. VALVE 037 FAILS SPURIOUSLY CLOSED	2.18
DGDGM-B-DGB	DG B UNAVAILABLE DUE TO MAINTENANCE	2.18
SXMPR1B-PP01B	ESW PUMP PP01B FAILS TO RUN	2.17
AFTPS1B-TDP01B	FAILS TO START AFW TDP PP01B	2.17
GWSVO-S-002	CTMT. ISOL. SOV GW-002 FAIL TO OPERATE	2.16
AFTPM1B-TDP01B	AFW TDP PP01B UNAVAILABLE DUE TO T/M	2.16
MSAVO-A-109	FAILS TO OPEN MS AFW TDP PP01B TBN STM. SUPPLY AOV 109	2.14
DAMPS-A-PP02	AAC FUEL OIL FEED PUMP PP02 FAILS TO START	2.12
WOMPM2A-PP02A	ECW PP02A TRAIN UNAVAILABLE DUE TO TEST OR MAINTENANCE	2.10
DGDGR-A-DGA	FAILS TO RUN OF EMERGENCY DIESEL GENERATOR DG01A	2.09
CCMPM2A-PP02A	CCW PUMP PP02A UNAVAILABLE DUE TO T/M	2.05
NPXHY-M-SAT02M	STANDBY AUX XFMR A FAILS WHILE OPERATING	2.05
ATAVO-D-010	FAILS TO OPEN AFW TDP PP01B TBN STM. ISOL AOV, 010	2.04
VKHVS2A-HV14A	FAILS TO START CCW PUMP ROOM CUBICLE COOLER HV14A	2.04
PFHBO1A-SW01A-A2	FAILS TO OPEN OF PCB SW01A-A2 OF 4.16KV SWGR SW01A FROM SAT	2.03
PFHBC1A-SW01A-E2	FAILS TO CLOSE OF FEEDER BRK SW01A-E2 TO EDG A	2.03
DGDGM-A-DGA	DG 01A UNAVAILABLE DUE TO MAINTENANCE	2.02

Table 19.1-57 (11 of 11)

EVENT	DESCRIPTION	RAW
IPBSY-C-MC01C	120V AC DIST. PANEL BUS 1-842-E-IN01C LOCAL FAULTS	2.02
VKHVM2A-HV14A	CUBICLE COOLER HV14A UNAVAILABLE DUE TO T&M	2.01
PELXY-B-LX03B-P	FAILURE OF PRIMARY LOOP CONTROLLERS 745-PE-LX03C	2.01

Table 19.1-58 (1 of 4)

Internal Fire PRA Key Basic Events by FV (LRF)

EVENT	DESCRIPTION	FV
ASD-LRF	ALTERNATE SHUTDOWN FAILURE PROBABILITY FOR LRF	3.52E-01
PDS_14	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14	2.04E-01
SHR1-E12TD	UNRECOVERABLE SBO LEADS TO TDAFW PUMP FAILURE	2.03E-01
H-SDR-POSRV-3WAY	OPERATOR FAILS TO OPERATION (POSRV & 3-WAY V/V)	1.49E-01
PDS_6	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-6	1.38E-01
AFTPR1A-TDP01A	FAILS TO RUN AFW TDP PP01A	1.26E-01
ERVC	EXTERNAL REACTOR VESSEL COOLING FAILS	1.17E-01
PFGRID	GRID COLLAPSE ON TURBINE TRIP	1.02E-01
PDS_94	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-94	9.10E-02
PFHBO1A-SW01A-H2	FAILS TO OPEN OF PCB SW01A-H2 OF 4.16KV SWGR SW01A FROM UAT	8.76E-02
PDS-FREQ-CFS	PDS FREQUENCY ADJUSTMENT FOR CFS	8.68E-02
PDS_86	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-86	7.90E-02
DAMPR-A-PP02	AAC FUEL OIL FEED PUMP PP02 FAILS TO RUN	7.86E-02
WOCHM4A-CH04A	ECW CHILLER 04A TRAIN UNAVAILABLE DUE TO T&M	4.73E-02
AFTPR1B-TDP01B	FAILS TO RUN AFW TDP PP01B	4.59E-02
DADGR-S-AACTG	AAC GTG FAILS TO RUN	3.96E-02
PDS_10	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-10	3.89E-02
DGDGR-B-DGB	FAILS TO RUN OF EMERGENCY DIESEL GENERATOR DG01B	3.37E-02

Table 19.1-58 (2 of 4)

EVENT	DESCRIPTION	FV
WOCHS4A-CH04A	ECW CHILLER CH04A FAILS TO START ON DEMAND	3.07E-02
DGDGR-A-DGA	FAILS TO RUN OF EMERGENCY DIESEL GENERATOR DG01A	2.91E-02
WOCHM2A-CH02A	ECW CHILLER 02A TRAIN UNAVAILABLE DUE TO T&M	2.51E-02
WOMPM5A-PP05A	ECW PP05A TRAIN UNAVAILABLE DUE TO TEST OR MAINTENANCE	2.33E-02
H-CI-OPEN	OPERATOR FAILS TO RECOVERY FOR CIS ISOLATION	2.26E-02
DGDGR-D-DGD	FAILS TO RUN OF EMERGENCY DIESEL GENERATOR DG01D	2.23E-02
AFTPS1A-TDP01A	FAILS TO START AFW TDP PP01A	2.11E-02
PFHBO2A-SW01C-C2	FAILS TO OPEN OF PCB SW01C-C2 OF 4.16KV SWGR SW01C FROM UAT	1.99E-02
DGDGR-C-DGC	FAILS TO RUN OF EMERGENCY DIESEL GENERATOR DG01C	1.92E-02
ASD-LRF-MCA	ALTERNATE SHUTDOWN FAILURE PROBABILITY FOR MCA LRF	1.86E-02
DADGM-S-AAC	AAC GTG UNAVAILABLE DUE TO MAINTENANCE	1.81E-02
DGDGM-B-DGB	DG B UNAVAILABLE DUE TO MAINTENANCE	1.72E-02
AFTPM1A-TDP01A	AFW TDP PP01A UNAVAILABLE DUE TO T/M	1.72E-02
VOHVS2A-HV33A	FAILS TO START OF MAFP ROOM A CUBICLE COOLER HV33A	1.70E-02
WOCHS2A-CH02A	ECW CHILLER CH02A FAILS TO START ON DEMAND	1.62E-02
AFMPM2A-MDP02A	AFW MDP PP02A UNAVAILABLE DUE TO T/M	1.60E-02
PR	POSRV FAILS TO RECLOSE	1.57E-02
PDS_90	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-90	1.50E-02
DGDGM-A-DGA	DG 01A UNAVAILABLE DUE TO MAINTENANCE	1.49E-02

Table 19.1-58 (3 of 4)

EVENT	DESCRIPTION	FV
PDS_106	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-106	1.48E-02
PDS_7	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-7	1.45E-02
PFHBO1B-SW01B-H2	FAILS TO OPEN OF PCB SW01B-H2 OF 4.16KV SWGR SW01B FROM UAT	1.35E-02
MSAVO-B-110	FAILS TO OPEN MS AFW TDP PP01A TBN STM. SUPPLY AOV 110	1.34E-02
SXMPM2A-PP02A	ESW PUMP PP02A UNAVAILABLE DUE TO T/M	1.33E-02
H-SDR-3WAY	OPERATOR FAILS TO OPEN 3-WAY VALVE	1.20E-02
PDS_17	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-17	1.20E-02
WOCHM2B-CH02B	ECW CHILLER 02B TRAIN UNAVAILABLE DUE TO T&M	1.15E-02
DGDGM-D-DGD	DG D UNAVAILABLE DUE TO MAINTENANCE	1.14E-02
WOCHM4B-CH04B	ECW CHILLER 04B TRAIN UNAVAILABLE DUE TO T&M	1.14E-02
VOHVM2A-HV33A	CUBICLE COOLER HV33A UNAVAILABLE DUE TO T&M	1.09E-02
SEAL-AFSUC	SEAL FAILURE PROBABILITY (SECONDARY HEAT REMOVAL SUCCESS)	1.04E-02
DGDGM-C-DGC	DG 01C UNAVAILABLE DUE TO MAINTENANCE	1.00E-02
RCPVO-A-201	POSRV V201 FAILS TO OPEN (HARDWARE FAIL)	9.07E-03
RCPVO-A-200	POSRV V200 FAILS TO OPEN (HARDWARE FAIL)	9.07E-03
NBHBC-S-SW03N-A2	FAIL TO CLOSE OF SWGR SW03N-A2 FEED BREAKER FROM AAC GTG	8.97E-03
RPPTM-C-PT102C	LO PZR PR. CH.C IS IN BYPASS (T&M)	8.49E-03
RPPTM-A-PT102A	LO PZR PR. CH.A IS IN BYPASS (T&M)	8.40E-03
PFHBC1B-SW01B-D2	FAILS TO CLOSE OF FEEDER BRK SW01B-D2 TO DG B	8.38E-03

Table 19.1-58 (4 of 4)

EVENT	DESCRIPTION	FV
PFHBO1B-SW01B-A2	FAILS TO OPEN OF PCB SW01B-A2 OF 4.16KV SWGR SW01B FROM SAT	8.38E-03
WOCHS1B-CH01B	ECW CHILLER CH01B FAILS TO START ON DEMAND	7.84E-03
WOMPM2A-PP02A	ECW PP02A TRAIN UNAVAILABLE DUE TO TEST OR MAINTENANCE	7.65E-03
AFTPS1B-TDP01B	FAILS TO START AFW TDP PP01B	7.61E-03
WOCHS2B-CH02B	ECW CHILLER CH02B FAILS TO START ON DEMAND	7.29E-03
WOCHS4B-CH04B	ECW CHILLER CH04B FAILS TO START ON DEMAND	7.17E-03
WOCHS1A-CH01A	ECW CHILLER CH01A FAILS TO START ON DEMAND	7.07E-03
WOCHS3A-CH03A	ECW CHILLER CH03A FAILS TO START ON DEMAND	7.07E-03
PFHBO1A-SW01A-A2	FAILS TO OPEN OF PCB SW01A-A2 OF 4.16KV SWGR SW01A FROM SAT	6.90E-03
PFHBC1A-SW01A-E2	FAILS TO CLOSE OF FEEDER BRK SW01A-E2 TO EDG A	6.90E-03
WOCHS3B-CH03B	ECW CHILLER CH03B FAILS TO START ON DEMAND	6.80E-03
PFBSY1A-SW01A	BUS FAULT ON 4.16KV SWGR SW01A	6.20E-03
AFTPM1B-TDP01B	AFW TDP PP01B UNAVAILABLE DUE TO T/M	6.20E-03
PFHBC1A-SW01A-A2	FAILS TO CLOSE OF PCB SW01A-A2 OF 4.16KV SWGR SW01A	5.81E-03
SXMPM2B-PP02B	ESW PUMP PP02B UNAVAILABLE DUE TO T/M	5.62E-03
PFHBO2B-SW01D-G2	FAILS TO OPEN OF PCB SW01D-G2 OF 4.16KV SWGR SW01D FROM UAT	5.31E-03
CCMPM2A-PP02A	CCW PUMP PP02A UNAVAILABLE DUE TO T/M	5.00E-03
VUHVS-S-HV83	HIGH VOLUME CUBICLE COOLER HV83 FAILS TO START	4.86E-03
VUHVS-S-HV81	FAILS TO START OF HIGH VOLUME CUBICLE COOLER HV81	4.86E-03
MSAVO-A-109	FAILS TO OPEN MS AFW TDP PP01B TBN STM. SUPPLY AOV 109	4.83E-03

Table 19.1-59 (1 of 11)

Internal Fire PRA Key CCF Events by RAW (LRF)

EVENT	DESCRIPTION	RAW
WOCHKQ4-CH01A/1B/2A/2B	RUNNING CCF OF ECW CHILLERS 1A/2A/1B/2B	646.69
WOCHKQ4-CH03A/3B/4A/4B	RUNNING CCF OF ECW CHILLERS 3A/4A/3B/4B	646.69
VGAHKQ4-AH01A/1B/2A/2B	4/4 RUNNING CCF OF ESW PUMP ROOM FAN AH01A/B, 02A/B	643.17
VKHVKQ4-HV13A/13B/14A/14B	4/4 CCF OF RUN FOR CCW PUMP ROOM CUBICLE COOLER HV13A, 13B, 14A, 14B	617.50
SXMPKQ4-PP01A/B/2A/B	4/4 CCF OF ESW PUMPS PP01A/2A, PP01B/2B TO RUN	602.24
PELXKO8-LX04AB03AB	8/8 CCF OF LOOP CONTROLLER LX03AB, LX04AB FOR CCW NON SAFETY LINE ISOL. VALVES	571.33
WOMPKQ4-PP04A/5A/4B/5B	RUNNING CCF OF ECW PUMPS 4A/5A/4B/5B	570.31
CCMPKQ4-PP01A/B/2A/B	4/4 CCF OF CCW PUMPS PP01A/1B/2A/2B (RUNNING)	570.31
WOMPKQ4-PP01A/2A/1B/2B	RUNNING CCF OF ECW PUMPS 1A/2A/1B/2B	570.31
SXAHKQ4-AH01A/02A/01B/02B	4/4 RUNNING CCF OF ESW COOLING TOWER FANS AH01A, 02A, 01B, 02B	534.35
CCMVXO8-143-150	8/8 CCF(DEMAND) OF MOV 143, 144, 145, 146, 147, 148, 149, 150 IN NON SAFETY LOAD LINE	524.28
AFPVKQ4-TP01A/B/MP02A/B	4/4 RUNNING CCF OF AFW TDP01B, MDP02A/B DUE TO THE VOLUTE FAILURE	476.75
AFCVWQ4-V1007A/B/8A/B	4/4 CCF OF AFW DISCH. CHECK VALVE V1007A/B & 1008A/B	436.44
AFCVWQ4-V1003A/B/4A/B	4/4 CCF OF AFW DISCH. CHECK VALVE V1003A/B & 1004A/B	436.44
AFCVWQ4-V1012A/B/4A/B	4/4 CCF OF AFW MINI FLOW CHECK VALVE V1012A/B & 1014A/B	410.98

Table 19.1-59 (2 of 11)

EVENT	DESCRIPTION	RAW
SXFLKE6-FT01AB/2AB/3AB	6/6 CCF OF ESW DEBRIS FILTER 1A/1B, 2A/B, 3A/3B IN TRAIN A/B	358.17
PFHBWQ4-SW2OUAT	CCF OF PCB BETWEEN UAT & 4.16KV SW01A, 1B, 1C, 1D FAIL TO OPEN	348.79
WOCHWQ4-CH03A/4A/3B/4B	DEMAND CCF OF ECW CHILLERS 3A/4A/3B/4B	348.36
WOCHWQ4-CH01A/2A/1B/2B	DEMAND CCF OF ECW CHILLERS 1A/2A/1B/2B	347.38
WOMPWQ4-PP04A/5A/4B/5B	DEMAND CCF OF ECW PUMPS 4A/5A/4B/5B	344.85
WOMPWQ4-PP01A/2A/1B/2B	DEMAND CCF OF ECW PUMPS 1A/2A/1B/2B	342.88
CCMPWQ4-PP01A/2A/1B/2B	4/4 CCF OF CCW PUMPS PP01A/1B/2A/2B (DEMAND)	342.81
SXMPWQ4-PP01A/B/2A/B	4/4 CCF OF ESW PUMPS PP01A/2A, PP01B/2B TO START	339.93
PELXKO8-LX03ABCD	8/8 CCF OF LOOP CONTROLLER LX03A/B/C/D	326.55
DGDGKQ4-DG01ABCD	CCF OF EDG 01A/01B/01C/01D FAIL TO RUN	303.85
PFHBWQ4-SW1OSAT	CCF OF PCB BETWEEN SAT & 4.16KV SW01A, 1B, 1C, 1D FAIL TO OPEN	302.97
PFHBWQ4-SW1DG	CCF OF SW01A&1B&1C&1D FEED BREAKER FROM DG A&B FAIL TO CLOSE	301.49
VDHVWQ4-HV12ABCD	4/4 CCF OF START FOR EDG ROOM CUBICLE COOLER HV12A, 12B, 12C, 12D	301.35
VDHVWQ4-HV13ABCD	4/4 CCF OF START FOR EDG ROOM CUBICLE COOLER HV13A, 13B, 13C, 13D	301.35
DOMPWO8-PP012ABCD	8/8 CCF OF DIESEL FUEL OIL TRANSFER PUMP 012ABCD FAIL TO START	299.75
DGSQWQ4-LOADSQABCD	CCF OF LOAD SEQUNCER A, B, C, D	299.54
DGDGWQ4-DG01ABCD	CCF OF EDG 01A/01B/01C/01D FAIL TO START	298.69
DGDGWQ4-DG01ABCD-LOAD	CCF OF EDG 01A/01B/01C/01D FAIL TO LOAD AND RUN DURING 1ST 1HOUR	297.40

Table 19.1-59 (3 of 11)

EVENT	DESCRIPTION	RAW
CCMVWQ4-191/2/181/2	4/4 CCF OF CCW MOV 191, 192, 181, 182 FOR EDG01A/B/C/D INLET	295.07
DOMPKO8-PP012ABCD	8/8 CCF OF DIESEL FUEL OIL TRANSFER PUMP 012ABCD FAIL TO RUN	294.32
VGAHWQ4-AH01A/1B/2A/2B	4/4 START CCF OF ESW PUMP ROOM FAN AH01A/B, 02A/B	293.70
SXAHWQ4-AH01A/02A/01B/02B	4/4 DEMAND CCF OF ESW COOLING TOWER FANS AH01A, 02A, 01B, 02B	292.98
VDHVWO8-HV12/13ABCD	8/8 CCF OF START FOR EDG ROOM CUBICLE COOLER HV12A, 12B, 12C, 12D 13A, 13B, 13C, 14D	291.80
VDHVKQ4-HV13ABCD	4/4 CCF OF RUN FOR EDG ROOM CUBICLE COOLER HV13A, 13B, 13C, 13D	286.65
VDHVKQ4-HV12ABCD	4/4 CCF OF RUN FOR EDG ROOM CUBICLE COOLER HV12A, 12B, 12C, 12D	286.65
PALXKQ4-PA06CD	4/4 CCF OF LOOP CONTROLLER PA06C, PA06D	281.94
WOCVWQ4-V1053A/B/55A/B	CCF OF DISCH. CV 1053A/53B/55A/55B (FAIL TO OPEN)	277.77
CCCVWQ4-V1001/2/3/4	4/4 CCF OF CCW PUMP DISCH. CHECK VALVE V1001/2/3/4 TO OPEN	276.72
WOCVWQ4-V1010A/B/14A/B	CCF OF DISCH. CV 1010A/10B/14A/14B (FAIL TO OPEN)	276.72
SXCVWQ4-V1001/2/3/4	4/4 CCF OF ESW PUMP DISCH. CHECK VALVE V1001/2/3/4 TO OPEN (DEMAND)	276.72
VDHVKO8-HV12/13ABCD	8/8 CCF OF RUN FOR EDG ROOM CUBICLE COOLER HV12A, 12B, 12C, 12D 13A, 13B, 13C, 14D	271.89
SIMPWQ4-CSP1A/B/SCP1A/B	4/4 CCF OF CSP PP01A, PP01B AND SCP PP01A, PP01B TO START	251.20
DOCVWO8-V1005/7ABCD	8/8 CCF OF DIESEL FUEL OIL TRANSFER PUMP CV V1005/1007 A/B/C/D FAIL TO OPEN	250.84
SIMPKQ4-CSP1A/B/SCP1A/B	4/4 CCF OF CSP PP01A, PP01B AND SCP PP01A, PP01B TO RUN	249.36
VGCVWQ4-Y1002A/B/11A/B	4/4 DEMAND CCF OF ESW PP ROOM DAMPER Y1002A/B, Y1011A/B	249.06

Table 19.1-59 (4 of 11)

EVENT	DESCRIPTION	RAW
PELXKO8-LX06A04B03C03D	8/8 CCF OF LOOP CONTROLLER LX06A 12, LX04B 12, LX03C 12, LX03D 12	247.87
PELXKO8-LX05AB3CD	8/8 CCF OF LOOP CONTROLLER LX05A LX05B, LX03C, LX03D	247.87
SICVWQ4-V157/158/159/160	4/4 CCF OF CS CV 157/158 SC CV 159/160	238.02
SICVWQ4-V568/569/1001/1002	CCF TO OPEN CSP DISCH LINE 1001, 1002 AND SCP DISCH. LINE CV 568,569	238.02
SIHEKQ4-HE01A/B-CS&SC	4/4 CCF OF SC HE01A/B, CS HE01A/B	237.02
IPINKQ4-IN01ABCD	CCF OF 120V AC POWER SUPPLY INVERTER IN01A/B/C/D	177.56
WOCHKQ3-CH01A/2A/1B	RUNNING CCF OF ECW CHILLERS 1A/2A/1B	174.98
WOCHKQ3-CH03A/4A/3B	RUNNING CCF OF ECW CHILLERS 3A/4A/3B	170.90
SICVWQ4-V217/27/37/47	SI LINE C/V 247,227,237,217 CCF TO OPEN	158.86
VKHVKQ3-HV13A/13B/14A	3/4 CCF OF RUN FOR CCW PUMP ROOM CUBICLE COOLER HV13A, 13B, 14A	152.45
VGAHKQ3-AH01A/1B/2A	3/4 RUNNING CCF OF ESW PUMP ROOM FAN AH01A, 01B, 02A	152.01
WOCHKQ3-CH01A/2A/2B	RUNNING CCF OF ECW CHILLERS 1A/2A/2B	151.84
WOCHKQ3-CH03A/4A/4B	RUNNING CCF OF ECW CHILLERS 3A/4A/4B	151.82
SXMPKQ3-PP01A/B/2A	3/4 CCF OF ESW PUMPS PP01A, PP02A, PP01B (RUNNING)	151.66
CCMPKQ3-PP01A/B/2A	3/4 CCF OF CCW PUMPS PP01A/1B/2A (RUNNING)	149.17
VGAHKQ3-AH01A/2A/2B	3/4 RUNNING CCF OF ESW PUMP ROOM FAN AH01A, 02A, 02B	146.59
WOMPKQ3-PP04A/5A/4B	RUNNING CCF OF ECW PUMPS 4A/5A/4B	145.87
WOMPKQ3-PP01A/2A/1B	RUNNING CCF OF ECW PUMPS 1A/2A/1B	145.22
PFHBWQ3-SW2OUATABC	3/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1B, 1C FAIL TO OPEN	142.39
VKHVKQ3-HV13A/14A/14B	3/4 CCF OF RUN FOR CCW PUMP ROOM CUBICLE COOLER HV13A, 14A, 14B	138.81

Table 19.1-59 (5 of 11)

EVENT	DESCRIPTION	RAW
CCMPKQ3-PP01A/2A/B	3/4 CCF OF CCW PUMPS PP01A/2A/2B (RUNNING)	136.03
WOMPKQ3-PP01A/2A/2B	RUNNING CCF OF ECW PUMPS 1A/2A/2B	135.73
WOMPKQ3-PP04A/5A/5B	RUNNING CCF OF ECW PUMPS 4A/5A/5B	135.70
SXMPKQ3-PP01A/2A/B	3/4 CCF OF ESW PUMPS PP01A, PP02A, PP02B (RUNNING)	135.01
WOCHKQ2-CH01A/2A	RUNNING CCF OF ECW CHILLERS 1A/2A	132.49
WOCHKQ2-CH03A/4A	RUNNING CCF OF ECW CHILLERS 3A/4A	132.49
VGAHKQ2-AH01A/2A	2/4 RUNNING CCF OF ESW PUMP ROOM FAN AH01A, 02A	129.15
CCMVXO4-143/5/7/9	4/4 CCF(DEMAND) OF MOV 143, 145, 147, 149 IN NON SAFETY LOAD LINE	127.71
WOMPKQ2-PP01A/2A	RUNNING CCF OF ECW PUMPS 1A AND 2A	127.02
WOMPKQ2-PP04A/5A	RUNNING CCF OF ECW PUMPS 4A AND 5A	127.02
CCMPKQ2-PP01/2A	2/4 CCF OF CCW PUMPS PP01A/2A (RUNNING)	127.02
SXMPKQ2-PP01/2A	2/4 CCF OF ESW PUMPS PP01A, PP02A (RUNNING)	126.94
VKHVKQ2-HV13A/14A	2/4 CCF OF RUN FOR CCW PUMP ROOM CUBICLE COOLER HV13A, 14A	126.29
PFHBWQ3-SW2OUATACD	3/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1C, 1D FAIL TO OPEN	121.11
DCBTKQ4-BT01ABCD	4/4 CCF OF FAULTS ON BATTERY BT01A/01B/01C/01D	116.37
SXAHKQ3-AH01A/02A/01B	3/4 RUNNING CCF OF ESW COOLING TOWER FANS AH01A, 02A, 01B	111.70
SXAHKQ3-AH01A/02A/02B	3/4 RUNNING CCF OF ESW COOLING TOWER FANS AH01A, 02A, 02B	111.70
SXAHKQ2-AH01A/02A	2/4 RUNNING CCF OF ESW COOLING TOWER FANS AH01A, 02A	111.06
PFHBWQ2-SW2OUATAC	2/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01A, 1C FAIL TO OPEN	96.54

Table 19.1-59 (6 of 11)

EVENT	DESCRIPTION	RAW
AFPVKQ3-TP01A/B/MP02A	3/4 RUNNING CCF OF AFW TDP01A/B AND MDP02A DUE TO THE VOLUTE FAILURE	90.03
SXFLKE2-FT02A/2B	2/6 CCF OF ESW DEBRIS FILTER 2A/2B	84.88
SXFLKE2-FT02A/1B	2/6 CCF OF ESW DEBRIS FILTER 2A/1B	84.88
SXFLKE2-FT01A/2B	2/6 CCF OF ESW DEBRIS FILTER 1A/2B	84.88
SXFLKE2-FT01A/B	2/6 CCF OF ESW DEBRIS FILTER 1A/1B	84.88
WOCHKQ3-CH03A/3B/4B	RUNNING CCF OF ECW CHILLERS 3A/3B/4B	81.80
WOCHKQ3-CH01A/1B/2B	RUNNING CCF OF ECW CHILLERS 1A/1B/2B	80.96
WOCHKQ3-CH04A/3B/4B	RUNNING CCF OF ECW CHILLERS 4A/3B/4B	68.35
WOCHKQ3-CH02A/1B/2B	RUNNING CCF OF ECW CHILLERS 2A/1B/2B	67.34
PFHBWQ3-SW2OUATABD	3/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1B, 1D FAIL TO OPEN	67.34
VGAHKQ3-AH01A/1B/2B	3/4 RUNNING CCF OF ESW PUMP ROOM FAN AH01A, 01B, 02B	66.74
AFPVKQ3-TP01A/MP02A/B	3/4 RUNNING CCF OF AFW TDP01A, MDP02A/B DUE TO THE VOLUTE FAILURE	66.30
AFCVWQ3-V1003A/4A/B	3/4 CCF OF AFW DISCH. CHECK VALVE V1003A & 4A/B	66.28
AFCVWQ3-V1007A/8A/B	3/4 CCF OF AFW DISCH. CHECK VALVE V1007A & 8A/B	66.28
PFHBWQ3-SW1OSATABC	3/4 CCF OF PCB BETWEEN SAT & 4.16KV SW01A,1B,1C FAIL TO OPEN	62.37
DCBTKQ3-BT01BCD	3/4 CCF OF FAULTS ON BATTERY BT01B/01C/01D	61.90
VGAHKQ3-AH01B/2A/2B	3/4 CCF (RUNNING) OF ESW PUMP ROOM FAN AH01B, 02A, 02B	61.76
DCBTKQ3-BT01ACD	3/4 CCF OF FAULTS ON BATTERY BT01A/01C/01D	61.14
VKHVKQ3-HV13A/13B/14B	3/4 CCF OF RUN FOR CCW PUMP ROOM CUBICLE COOLER HV13A, 13B, 14B	60.22

Table 19.1-59 (7 of 11)

EVENT	DESCRIPTION	RAW
PFHBWQ3-SW1DGABC	3/4 CCF OF SW01A&1B&1C FEED BREAKER FROM DG A&B FAIL TO CLOSE	59.80
SXMPKQ3-PP01A/B/2B	3/4 CCF OF ESW PUMPS PP01A, PP01B, PP02B (RUNNING)	59.10
WOMPKQ3-PP01A/1B/2B	RUNNING CCF OF ECW PUMPS 1A/1B/2B	58.95
WOMPKQ3-PP04A/4B/5B	RUNNING CCF OF ECW PUMPS 4A/4B/5B	58.91
CCMPKQ3-PP01A/B/2B	3/4 CCF OF CCW PUMPS PP01A/1B/2B (RUNNING)	57.71
VKHVKQ3-HV13B/14A/14B	3/4 CCF OF RUN FOR CCW PUMP ROOM CUBICLE COOLER HV13B, 14A, 14B	57.23
WOMPKQ3-PP05A/4B/5B	RUNNING CCF OF ECW PUMPS 5A/4B/5B	57.01
AFPVKQ3-TP01A/B/MP02B	3/4 RUNNING CCF OF AFW TDP01A/B, MDP02B DUE TO THE VOLUTE FAILURE	56.87
CCMPKQ3-PP01B/2A/B	3/4 CCF OF CCW PUMPS PP01B/2A/2B (RUNNING)	54.93
WOMPKQ3-PP02A/1B/2B	RUNNING CCF OF ECW PUMPS 2A/1B/2B	54.69
AFCVWQ3-V1012A/4A/B	3/4 CCF OF AFW MINI FLOW CHECK VALVE V1012A & 4A/B	54.07
SXMPKQ3-PP01B/2A/B	3/4 CCF OF ESW PUMPS PP02A, PP01B, PP02B (RUNNING)	53.89
PFHBWQ3-SW1OSATABD	3/4 CCF OF PCB BETWEEN SAT & 4.16KV SW01A,1B,1D FAIL TO OPEN	53.47
DGDGKQ3-DG01ABD	CCF OF EDG 01A/01B/01D FAIL TO RUN	53.13
DGDGKQ3-DG01ABC	CCF OF EDG 01A/01B/01C FAIL TO RUN	52.51
AFCVWQ3-V1007A/B/8A	3/4 CCF OF AFW DISCH. CHECK VALVE V1007A/B & 8A	51.56
AFCVWQ3-V1003A/B/4A	3/4 CCF OF AFW DISCH. CHECK VALVE V1003A/B & 4A	51.56
PFHBWQ3-SW1DGABD	3/4 CCF OF SW01A&1B&1D FEED BREAKER FROM DG B FAIL TO CLOSE	50.87
WOCHKQ2-CH01B/2B	RUNNING CCF OF ECW CHILLERS 1B/2B	50.74
WOCHKQ2-CH03B/4B	RUNNING CCF OF ECW CHILLERS 3B/4B	50.74

Table 19.1-59 (8 of 11)

EVENT	DESCRIPTION	RAW
VGAHKQ2-AH01B/2B	2/4 CCF (RUNNING) OF ESW PUMP ROOM FAN AH01B, 02B	48.31
CCMVXO4-144/6/8/50	4/4 CCF(DEMAND) OF MOV 144, 146, 148, 150 IN NON SAFETY LOAD LINE	47.35
WOMPKQ2-PP01B/2B	RUNNING CCF OF ECW PUMPS 1B AND 2B	46.88
CCMPKQ2-PP01/2B	2/4 CCF OF CCW PUMPS PP01B/2B (RUNNING)	46.88
WOMPKQ2-PP04B/5B	RUNNING CCF OF ECW PUMPS 4B AND 5B	46.88
SXMPKQ2-PP01/2B	2/4 CCF OF ESW PUMPS PP01B, PP02B (RUNNING)	46.84
DGSQWQ3-LOADSQABD	CCF OF LOAD SEQUNCER A, B, D	46.59
VKHVKQ2-HV13B/14B	2/4 CCF OF RUN FOR CCW PUMP ROOM CUBICLE COOLER HV13B, 14B	46.59
DGSQWQ3-LOADSQABC	CCF OF LOAD SEQUNCER A, B, C	46.18
DGDGWQ3-DG01ABD	CCF OF EDG 01A/01B/01D FAIL TO START	45.75
DGDGWQ3-DG01ABC	CCF OF EDG 01A/01B/01C FAIL TO START	45.31
WOCHWQ3-CH01A/2A/1B	DEMAND CCF OF ECW CHILLERS 1A/2A/1B	45.08
DGDGWQ3-DG01ABD-LOAD	CCF OF EDG 01A/01B/01D FAIL TO LOAD AND RUN DURING 1ST 1HOUR	43.99
DGDGWQ3-DG01ABC-LOAD	CCF OF EDG 01A/01B/01C FAIL TO LOAD AND RUN DURING 1ST 1HOUR	43.51
AFCVWQ3-V1012A/B/4A	3/4 CCF OF AFW MINI FLOW CHECK VALVE V1012A/B & 4A	41.47
DGDGKQ3-DG01BCD	CCF OF EDG 01B/01C/01D FAIL TO RUN	40.74
SXAHKQ3-AH02A/01B/02B	3/4 RUNNING CCF OF ESW COOLING TOWER FANS AH02A, 01B, 02B	38.04
SXAHKQ3-AH01A/01B/02B	3/4 RUNNING CCF OF ESW COOLING TOWER FANS AH01A, 01B, 02B	37.98
SXAHKQ2-AH01B/02B	2/4 RUNNING CCF OF ESW COOLING TOWER FANS AH01B, 02B	37.50
PFHBWQ3-SW2OUATBCD	3/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01B,1C, 1D FAIL TO OPEN	37.08

Table 19.1-59 (9 of 11)

EVENT	DESCRIPTION	RAW
AFCVWQ3-V1007B/8A/B	3/4 CCF OF AFW DISCH. CHECK VALVE V1007B & 8A/B	36.46
AFCVWQ3-V1003B/4A/B	3/4 CCF OF AFW DISCH. CHECK VALVE V1003B & 4A/B	36.46
AFPVKQ3-TP01B/MP02A/B	3/4 RUNNING CCF OF AFW TDP01B, MDP02A/B DUE TO THE VOLUTE FAILURE	36.41
DGSQWQ3-LOADSQBCD	CCF OF LOAD SEQUNCER B, C, D	35.96
WOCHWQ3-CH03A/4A/3B	DEMAND CCF OF ECW CHILLERS 3A/4A/3B	35.78
DGDGWQ3-DG01BCD	CCF OF EDG 01B/01C/01D FAIL TO START	35.37
DGDGKQ3-DG01ACD	CCF OF EDG 01A/01C/01D FAIL TO RUN	34.59
DGDGWQ3-DG01BCD-LOAD	CCF OF EDG 01B/01C/01D FAIL TO LOAD AND RUN DURING 1ST 1HOUR	34.05
CCMPWQ3-PP01A/2A/1B	3/4 CCF OF CCW PUMPS PP01A/2A/1B (DEMAND)	33.70
SXMPWQ3-PP01A/B/2A	3/4 CCF OF ESW PUMPS PP01A, PP02A, PP01B (START)	33.66
PFHBWQ3-SW1OSATBCD	3/4 CCF OF PCB BETWEEN SAT & 4.16KV SW01B,1C,1D FAIL TO OPEN	33.49
DCBTKQ2-BT01CD	2/4 CCF OF FAULTS ON BATTERY BT01C/01D	33.40
PFHBWQ3-SW1DGBCD	3/4 CCF OF SW01B&1C&1D FEED BREAKER FROM DG B FAIL TO CLOSE	31.99
MSRVWE6-MSSV-ALL	20/20 CCF OF MSSVS 1301~1320 ON SG 1/2	31.70
WOCHWQ3-CH01A/1B/2B	DEMAND CCF OF ECW CHILLERS 1A/1B/2B	31.07
WOCHWQ3-CH03A/3B/4B	DEMAND CCF OF ECW CHILLERS 3A/3B/4B	30.93
PFHBWQ3-SW1OSATACD	3/4 CCF OF PCB BETWEEN SAT & 4.16KV SW01A,1C,1D FAIL TO OPEN	30.91
DGSQWQ3-LOADSQACD	CCF OF LOAD SEQUNCER A, C, D	30.13
PFHBWQ3-SW1DGACD	3/4 CCF OF SW01A&1C&1D FEED BREAKER FROM DG B FAIL TO CLOSE	29.53
DGDGWQ3-DG01ACD	CCF OF EDG 01A/01C/01D FAIL TO START	29.53

Table 19.1-59 (10 of 11)

EVENT	DESCRIPTION	RAW
WOMPWQ3-PP01A/2A/1B	DEMAND CCF OF ECW PUMPS 1A/2A/1B	28.90
DGDGWQ3-DG01ACD-LOAD	CCF OF EDG 01A/01C/01D FAIL TO LOAD AND RUN DURING 1ST 1HOUR	28.19
WOCHWQ3-CH03A/4A/4B	DEMAND CCF OF ECW CHILLERS 3A/4A/4B	27.85
AFCVWQ3-V1012B/4A/B	3/4 CCF OF AFW MINI FLOW CHECK VALVE V1012B & 4A/B	27.30
WOCHWQ3-CH01A/2A/2B	DEMAND CCF OF ECW CHILLERS 1A/2A/2B	26.92
CCMVWQ3-192/181/2	3/4 CCF OF CCW MOV 192, 181, 182 FOR EDG01B/C/D INLET	26.71
WOCHWQ3-CH04A/3B/4B	DEMAND CCF OF ECW CHILLERS 4A/3B/4B	25.60
WOMPWQ3-PP04A/5A/4B	DEMAND CCF OF ECW PUMPS 4A/5A/4B	25.58
WOCHWQ3-CH02A/1B/2B	DEMAND CCF OF ECW CHILLERS 2A/1B/2B	24.66
IPINKQ3-IN01ACD	3/4 CCF OF 120V AC POWER SUPPLY INVERTER IN01A/C/D	24.51
AFCVWQ3-V1003A/B/4B	3/4 CCF OF AFW DISCH. CHECK VALVE V1003A/B & 4B	23.96
AFCVWQ3-V1007A/B/8B	3/4 CCF OF AFW DISCH. CHECK VALVE V1007A/B & 8B	23.96
AFPVKQ2-TP01A/MP02A	2/4 RUNNING CCF OF AFW TDP01A, MDP02A DUE TO THE VOLUTE FAILURE	23.44
AXCVWD2-V1628/9	2/2 CCF OF CT SYSTEM CHECK VALVE V1628/1629	23.11
VDTTKD2-TE013C/14D	CCF OF EDG ROOM TEMPERATURE TE-013C, 014D	22.75
VDTTKD2-TE015C/16D	CCF OF EDG ROOM TEMPERATURE TE-015C, 016D	22.75
WOMPWQ3-PP04A/5A/5B	DEMAND CCF OF ECW PUMPS 4A/5A/5B	22.45
PFHBWQ2-SW2OUATAB	2/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1B FAIL TO OPEN	21.51
PELXKQ4-LX04CD	4/4 CCF OF LOOP CONTROLLER 745-LX04C, LX04D	21.32

Table 19.1-59 (11 of 11)

EVENT	DESCRIPTION	RAW
CCMPWQ3-PP01A/2A/2B	3/4 CCF OF CCW PUMPS PP01A/2A/2B (DEMAND)	21.11
CCMVWQ3-191/2/182	3/4 CCF OF CCW MOV 191, 192, 182 FOR EDG01A/B/D INLET	21.03
CCMVWQ3-191/181/2	3/4 CCF OF CCW MOV 191, 181, 182 FOR EDG01A/C/D INLET	20.75
WOMPWQ3-PP01A/2A/2B	DEMAND CCF OF ECW PUMPS 1A/2A/2B	20.56
CCMVWQ3-191/2/181	3/4 CCF OF CCW MOV 191, 192, 181 FOR EDG01A/B/C INLET	20.44
WOMPWQ3-PP01A/1B/2B	DEMAND CCF OF ECW PUMPS 1A/1B/2B	20.19
WOMPWQ3-PP05A/4B/5B	DEMAND CCF OF ECW PUMPS 5A/4B/5B	20.08
WOMPWQ3-PP04A/4B/5B	DEMAND CCF OF ECW PUMPS 4A/4B/5B	20.06

(1) The cutoff threshold chosen for this table is based upon guidance presented in NEI 00-04 (Reference 51).

Table 19.1-60

Internal Fire PRA Key CCF Events by FV (LRF)

EVENT	DESCRIPTION	FV
WOCHWQ4-CH03A/4A/3B/4B	DEMAND CCF OF ECW CHILLERS 3A/4A/3B/4B	1.52E-02
WOCHWQ4-CH01A/2A/1B/2B	DEMAND CCF OF ECW CHILLERS 1A/2A/1B/2B	1.52E-02
DGDGKQ4-DG01ABCD	CCF OF EDG 01A/01B/01C/01D FAIL TO RUN	1.47E-02
PFHBWQ4-SW2OUAT	CCF OF PCB BETWEEN UAT & 4.16KV SW01A, 1B, 1C, 1D FAIL TO OPEN	9.43E-03
PFHBWQ4-SW1OSAT	CCF OF PCB BETWEEN SAT & 4.16KV SW01A, 1B, 1C, 1D FAIL TO OPEN	8.19E-03
PFHBWQ2-SW2OUATAC	2/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01A, 1C FAIL TO OPEN	5.75E-03

Table 19.1-61

Internal Fire PRA Key Operator Actions by RAW (LRF)

EVENT	DESCRIPTION	RAW
CCOPV-S-NSMV	OPERATOR FAILS TO CLOSE CC MOV 143~150 (NON-ESSENTIAL LOAD)	4.36
RPOPU-S-PT102ABCD	OPERATOR ERROR: COMMON MISCALIBRATION OF LO PZR PR. CH.A/B/C/D	3.42
RCOPH-S-SDSE-SL	FAILURE OF SDS VALVES EARLY PHASE OPEN (2/4)	2.61
DAOPH-S-AACTG	OPERATOR FAILS TO PROVIDE 1E 4.16KV SW01A,B,C,D	2.44
AFOPH-S-ALT-LT	OPERATOR FAIL TO ALIGNE FOR SUPPLYING AN ALTERNATE SOURCE	2.09

Table 19.1-62

Internal Fire PRA Key Operator Actions by FV (LRF)

EVENT	DESCRIPTION	FV
RCOPH-S-SDSE-SL	FAILURE OF SDS VALVES EARLY PHASE OPEN (2/4)	4.81E-02
CCOPV-S-NSMV	OPERATOR FAILS TO CLOSE CC MOV 143~150 (NON-ESSENTIAL LOAD)	2.71E-02
EFOPV-S-SIAS	OPERATOR FAILS TO MANUALLY INITIATE ALL CHANNELS VIA MCR FOR SIAS	2.46E-02
CDOPH-S-ALIGN	OPERATOR FAILS TO START FOR PP01, 02, 03 BY HAND SWITCH	2.35E-02
DAOPH-S-AACTG	OPERATOR FAILS TO PROVIDE 1E 4.16KV SW01A,B,C,D	1.75E-02
CCOPH-S-HX-ALIGN	OPERATOR FAILS TO OPEN CCW HX3A/B ISOL. V1145 /6 /ESW SUPPLYING V1027/8, 3014/5	1.15E-02
AFOPH-S-ALT-LT	OPERATOR FAIL TO ALIGNE FOR SUPPLYING AN ALTERNATE SOURCE	7.90E-03
WOOPH-S-CROSSTIE	OPERATOR FAILS TO OPEN 1025A/B, 1079A/B AND ALIGN FLOW PATH	6.59E-03

Table 19.1-63 (1 of 6)

Internal Flooding Initiating Event Summary

Initiating Event	Total IE Frequency (/yr)	Maximum EF	Adjusted IE Frequency (/yr)
IE-050A-CS-M	3.76E-08	11	3.96E-08
IE-050A-CS-X	2.02E-08	11	2.12E-08
IE-050A-SI-M	2.76E-07	11	2.91E-07
IE-050A-SI-X	6.76E-08	11	7.11E-08
IE-050B-CS-M	2.96E-08	11	3.12E-08
IE-050B-CS-X	1.58E-08	11	1.66E-08
IE-050B-SI-M	3.05E-07	11	3.21E-07
IE-050B-SI-X	3.64E-08	11	3.84E-08
IE-050C-CS-M	5.05E-07	11	5.32E-07
IE-050C-CS-X	1.12E-07	11	1.18E-07
IE-050D-CS-M	4.81E-07	11	5.06E-07
IE-050D-CS-X	1.09E-07	11	1.15E-07
IE-055C-CS-M	1.51E-07	12	1.58E-07
IE-055C-CS-X	3.28E-08	12	3.45E-08
IE-055D-CS-M	1.83E-07	12	1.92E-07
IE-055D-CS-X	3.97E-08	12	4.18E-08
IE-055-03C-FP-M	1.25E-05	5	1.32E-05
IE-055-03D-FP-M	1.06E-05	5	1.11E-05
IE-055-05C-FP-X	3.60E-05	5	3.79E-05
IE-055-14C-CS-M	1.34E-04	2	1.41E-04
IE-055-14D-CS-M	1.29E-04	2	1.36E-04
IE-055-18B-FP-X	2.14E-06	5	2.25E-06
IE-055-19A-FP-M	1.00E-04	6	1.05E-04
IE-055-19B-FP-M	3.42E-05	5	3.60E-05
IE-055-20A-FP-M	1.71E-05	5	1.80E-05
IE-055-20B-FP-M	1.75E-05	5	1.84E-05

Table 19.1-63 (2 of 6)

Initiating Event	Total IE Frequency (/yr)	Maximum EF	Adjusted IE Frequency (/yr)
IE-055-21A-CS-M	0.00E+00	0	0.00E+00
IE-055-21A-CS-X	1.33E-08	11	1.40E-08
IE-055-21A-IW-S	3.27E-05	2	3.44E-05
IE-055-21A-SI-M	1.76E-07	11	1.85E-07
IE-055-21A-SI-X	3.13E-08	11	3.30E-08
IE-055-21B-CS-M	0.00E+00	0	0.00E+00
IE-055-21B-CS-X	1.79E-08	11	1.88E-08
IE-055-21B-CV-S	9.73E-05	2	1.02E-04
IE-055-21B-IW-S	3.17E-05	2	3.34E-05
IE-055-21B-SI-M	2.05E-07	11	2.16E-07
IE-055-21B-SI-X	2.54E-08	11	2.67E-08
IE-055-22A-IW-S	0.00E+00	0	0.00E+00
IE-055-50B-FP-M	1.71E-04	5	1.80E-04
IE-078-01D-FP-M	5.52E-05	6	5.81E-05
IE-078-01D-FP-X	1.71E-04	6	1.80E-04
IE-078-02C-WO-S	1.29E-05	4	1.36E-05
IE-078-02D-WI-S	8.59E-06	4	9.04E-06
IE-078-02D-WO-S	2.08E-05	4	2.19E-05
IE-078-03C-WO-S	7.46E-05	4	7.86E-05
IE-078-03D-WI-S	8.28E-06	4	8.71E-06
IE-078-03D-WO-S	7.35E-05	4	7.73E-05
IE-78-05C-WO-S	1.53E-05	4	1.62E-05
IE-78-05D-WO-S	1.76E-05	4	1.85E-05
IE-78-07C-WD-S	3.25E-06	4	3.42E-06
IE-78-07D-WD-S	3.59E-06	4	3.78E-06
IE-078-10C-FP-M	1.04E-04	6	1.09E-04
IE-078-10C-FP-X	3.51E-04	6	3.69E-04
IE-078-15C-AF-M	1.27E-07	12	1.34E-07

Table 19.1-63 (3 of 6)

Initiating Event	Total IE Frequency (/yr)	Maximum EF	Adjusted IE Frequency (/yr)
IE-078-15C-AF-X	3.76E-07	12	3.96E-07
IE-078-15C-MS-S	1.91E-04	4	2.01E-04
IE-078-15D-AF-M	1.13E-07	12	1.19E-07
IE-078-15D-AF-X	1.98E-05	12	2.08E-05
IE-078-15D-MS-S	2.43E-04	4	2.56E-04
IE-078-19A-FP-M	8.31E-05	5	8.75E-05
IE-078-19A-FP-X	2.98E-04	5	3.14E-04
IE-078-19B-FP-M	1.34E-04	5	1.41E-04
IE-078-19B-FP-X	3.49E-04	5	3.68E-04
IE-078-19B-WM-M	1.79E-06	8	1.88E-06
IE-078-20A-AF-M	2.69E-07	12	2.83E-07
IE-078-20A-AF-X	8.19E-07	12	8.62E-07
IE-078-20B-AF-M	1.58E-06	10	1.67E-06
IE-078-20B-AF-X	1.43E-06	10	1.51E-06
IE-078-21A-SI-M	3.18E-07	11	3.35E-07
IE-078-21A-SI-X	3.13E-08	11	3.30E-08
IE-078-21B-SI-M	2.05E-07	11	2.16E-07
IE-078-21B-SI-X	2.54E-08	11	2.67E-08
IE-078-25A-WO-S	6.55E-05	4	6.90E-05
IE-078-25B-WO-S	6.77E-05	4	7.13E-05
IE-078-29B-CC-M	6.90E-07	7	7.26E-07
IE-078-29B-CC-X	1.33E-06	7	1.40E-06
IE-078-29C-CC-M	1.50E-07	11	1.58E-07
IE-078-29C-CC-X	3.92E-07	11	4.13E-07
IE-078-31A-FP-M	6.70E-05	6	7.05E-05
IE-078-31A-FP-X	2.49E-04	6	2.62E-04
IE-078-44B-FP-X	2.18E-04	6	2.30E-04
IE-078-57D-CT-M	6.54E-09	11	6.89E-09

Table 19.1-63 (4 of 6)

Initiating Event	Total IE Frequency (/yr)	Maximum EF	Adjusted IE Frequency (/yr)
IE-100-H2A-CC-M	2.39E-07	7	2.51E-07
IE-100-H2B-CC-M	1.93E-07	7	2.04E-07
IE-100-02C-DG-S	1.12E-05	4	1.17E-05
IE-100-02D-DG-S	2.38E-06	4	2.51E-06
IE-100-05C-WI-S	1.60E-05	4	1.69E-05
IE-100-05D-WI-S	2.22E-05	4	2.34E-05
IE-100-08C-WI-S	2.53E-05	4	2.67E-05
IE-100-08C-WO-S	1.14E-05	4	1.20E-05
IE-100-08D-WI-S	1.09E-05	4	1.15E-05
IE-100-08D-WO-S	5.96E-06	4	6.27E-06
IE-100-10B-FP-X	5.71E-05	5	6.01E-05
IE-100-10B-WM-M	1.81E-07	9	1.91E-07
IE-100-10B-WM-X	5.39E-07	9	5.67E-07
IE-100-11B-WD-S	2.18E-06	8	2.29E-06
IE-100-20A-FP-M	7.13E-05	6	7.50E-05
IE-100-20A-FP-X	3.35E-04	6	3.53E-04
IE-100-20A-WM-M	3.93E-07	9	4.14E-07
IE-100-22A-FP-S	6.88E-06	5	7.25E-06
IE-100-22A-FP-M	4.89E-05	5	5.15E-05
IE-100-22A-FP-X	4.24E-05	5	4.46E-05
IE-100-32B-WM-M	2.91E-06	8	3.06E-06
IE-100-37B-FP-X	9.94E-05	6	1.05E-04
IE-120-06C-CC-M	2.00E-07	6	2.11E-07
IE-120-06D-FP-M	6.42E-07	5	6.76E-07
IE-120-11A-WM-M	3.65E-07	9	3.84E-07
IE-120-11B-FP-X	1.79E-05	5	1.88E-05
IE-120-15B-WO-S	4.48E-05	4	4.71E-05
IE-137-02C-WD-M	8.70E-08	11	9.16E-08

Table 19.1-63 (5 of 6)

Initiating Event	Total IE Frequency (/yr)	Maximum EF	Adjusted IE Frequency (/yr)
IE-137-09C-FP-M	7.89E-06	6	8.30E-06
IE-137-09C-FP-X	2.56E-05	6	2.69E-05
IE-137-09D-FP-M	0.00E+00	0	0.00E+00
IE-137-09D-FP-X	0.00E+00	0	0.00E+00
IE-137-10C-WO-S	3.51E-05	4	3.70E-05
IE-137-10D-WO-S	2.83E-05	4	2.97E-05
IE-137-13B-FP-M	1.47E-05	5	1.55E-05
IE-137-13B-FP-X	0.00E+00	0	0.00E+00
IE-137-15A-WO-S	2.64E-05	4	2.77E-05
IE-137-15B-WO-S	1.23E-05	4	1.29E-05
IE-137-20A-FP-M	1.18E-05	5	1.25E-05
IE-137-23A-WO-S	3.70E-05	4	3.89E-05
IE-137-29B-FP-M	2.66E-06	6	2.80E-06
IE-137-29B-FP-X	1.22E-05	6	1.29E-05
IE-157-01D-CC-S	1.30E-06	6	1.37E-06
IE-157-01D-CC-M	1.27E-07	6	1.33E-07
IE-157-01D-WM-S	8.40E-06	5	8.84E-06
IE-157-01D-WM-M	2.32E-07	6	2.44E-07
IE-157-01D-WM-X	9.38E-07	6	9.88E-07
IE-157-01D-WO-S	4.67E-05	4	4.92E-05
IE-157-13C-FP-M	4.30E-05	4	4.53E-05
IE-157-16C-WM-M	3.03E-07	8	3.19E-07
IE-157-16D-WL-M	2.37E-07	10	2.49E-07
IE-157-19C-WO-S	2.13E-05	4	2.24E-05
IE-157-19D-WO-S	2.37E-05	4	2.49E-05
IE-157-25C-WIM-S	1.28E-05	4	1.35E-05
IE-157-P01-FP-M	1.66E-05	5	1.75E-05

Table 19.1-63 (6 of 6)

Initiating Event	Total IE Frequency (/yr)	Maximum EF	Adjusted IE Frequency (/yr)
IE-TB-MISC	1.23E-02	12	1.30E-02
IE-TB-CW-X	8.13E-05	8	8.55E-05

Table 19.1-64 (1 of 2)

Internal Flooding PRA CDF Contribution by Top Flooding Induced Initiators

#	Basic Event ID	Freq (/yr)	Contribution	DESCRIPTION
1	#IE-78-19B-FP-X	3.49E-04	20.2%	Major break of FP piping in room 078-A19B, 078-A20B, or 100-A10B. Flow greater than 690 gpm in 078-A19B or 078-A20B. Flow between 935 gpm and 1,445 gpm in 100-A10B.
2	#IE-100-20A-FP-X	3.35E-04	18.5%	Major break of FP piping in room 100-A20A, 100-A23A, 100-P06, 100-P07, 100-P08, 100-P14, 100-P19, 100-P20, 100-P21, 100-P22, 100-P23, 100-P24, 100-P25, 100-P27, 100-P28, 100-P31, 100-P33, 100-P34, 100-P35, 100-P43, 100-P45, 100-P46, 100-P47, 100-P50, 100-P51, 100-P52, 100-P53, 100-P54, 100-P55, and 100-P56. Flow greater than 2,000 gpm in 100-A20A or 100-A23A. Flow greater than 2,500 gpm in other areas.
3	#IE-78-19A-FP-X	2.98E-04	17.2%	Major break of FP piping in room 078-A19A 120-P22, 120-P25, 120-P27, and 120-P32. Flow greater than 2,000gpm in 078-A19A. Flow greater than 2,500 gpm in 120-P22, 120-P25, 120-P27, or 120-P32.
4	#IE-78-44B-FP-X	2.18E-04	13.1%	Major break of FP piping in room 078-A44B or 078 A49B with flow greater than 1,690 gpm or in 100-A30B, 100-A35B, 100-A36B, 100-A37B, 120-A29B, or 120-A31B with a flow rate between 1,690 gpm and 2,500 gpm.
5	#IE-78-19B-FP-M	1.34E-04	7.0%	Moderate break of FP piping in room 078-A19B, 078-A20B, 100-A10B, 120-A11B, or 120-A13B. Flow between 400 gpm and 690 gpm in 078-A19B or 078-A20B. Flow between 645 gpm and 935 gpm in 100-A10B. Flow between 890 gpm and 1,180 gpm in 120 -A11B or 120-A13B.
6	#IE-78-01D-FP-X	1.71E-04	5.6%	Major break of FP piping in room 078-A10D. Flow greater than 3,700gpm in 078-A10D.

Table 19.1-64 (2 of 2)

#	Basic Event ID	Freq (/year)	Contribution	DESCRIPTION
7	#IE-78-19A-FP-M	8.31E-05	4.2%	Moderate break of FP piping in room 078-A19A, 120-A11A, 120-P22, 120-P25, 120-P27, or 120-P32. Flow rate between 1,200 gpm and 2,000 gpm in 078-A19A, flow greater than 1,200 gpm in 120-A11A, or flow between 1,700 gpm and 2,500 gpm in 120-P22, 120-P25, 120-P27, and 120-P32.
8	#IE-100-10B-FP-X	5.71E-06	2.8%	Major break of FP piping in room 100-A10B. Flow greater 1,445 gpm
9	#IE-137-29B-FP-M	2.66E-06	2.0%	Moderate break of FP piping in 137-A29B. Flow between 1,690 gpm and 2,500 gpm.
10	#IE-78-10C-FP-X	8.31E-05	1.8%	Moderate break of FP piping in room 078-A19A, 120-A11A, 120-P22, 120-P25, 120-P27, and 120-P32. Flow between 1,200 gpm and 2,000gpm in 078-A19A, or 120-A11A. Flow between 1,700 gpm and 2,500 gpm in 120-P22, 120-P25, 120-P27, or 120-P32.
11	#IE-78-01D-FP-M	2.66E-06	1.7%	Moderate break of FP piping in room 137-A29B. Flow between 1,690 gpm and 2,500 gpm.
12	#IE-100-37B-FP-X	5.76E-06	1.3%	Major break of FP piping in 100-A37B is named IE-100- 37B-FP-X and represents any break in FP piping with a flow rate greater than 2,500 gpm. This event includes FP pipe breaks in 100-A30B, 100-A35B, 120-A29B, or 120-A31B with a flow rate greater than 2,500 gpm.
13	#IE-TB-MISC	1.16E-02	1.3%	Flooding event in Turbine Building with flow less than 400,000 gpm
14	#IE-120-11B-FP-X	1.79E-05	0.9%	Major break of FP piping in room 120-A11B or 120-A13B. Flow greater than 1,180 gpm.
15	#IE-78-15D-AF-X	1.98E-05	0.6%	Major break of AFW piping in room 078-A15D. Flow greater than 3,200gpm.

Table 19.1-65 (1 of 2)

Internal Flooding PRA LRF Contribution by Top Flooding Induced Initiators

Number	Basic Event ID	Frequency (per year)	Contribution to CDF	Description
1	#IE-78-19B-FP-X	3.49E-04	20.5%	Major break of FP piping in room 078-A19B, 078-A20B, or 100-A10B. Flow greater than 690 gpm in 078-A19B or 078-A20B. Flow between 935 gpm and 1,445 gpm in 100 A10B.
2	#IE-100-20A-FP-X	3.35E-04	19.4%	Major break of FP piping in room 100-A20A, 100-A23A, 100-P06, 100-P07, 100-P08, 100-P14, 100-P19, 100-P20, 100-P21, 100-P22, 100-P23, 100-P24, 100-P25, 100-P27, 100-P28, 100-P31, 100-P33, 100-P34, 100-P35, 100-P43, 100-P45, 100-P46, 100-P47, 100-P50, 100-P51, 100-P52, 100-P53, 100-P54, 100-P55, and 100-P56. Flow greater than 2,000 gpm in 100-A20A or 100-A23A. Flow greater than 2,500 gpm in other areas.
3	#IE-78-19A-FP-X	2.98E-04	17.8%	Major break of FP piping in room 078-A19A 120-P22, 120-P25, 120-P27, and 120-P32. Flow greater than 2,000gpm in 078-A19A. Flow greater than 2,500 gpm in 120-P22, 120-P25, 120-P27, or 120-P32.
4	#IE-78-44B-FP-X	2.18E-04	12.9%	Major break of FP piping in room 078-A44B or 078-A49B with flow greater than 1,690 gpm or in 100-A30B, 100-A35B, 100-A36B, 100-A37B, 120-A29B, or 120-A31B with a flow rate between 1,690 gpm and 2,500 gpm.
5	#IE-78-19B-FP-M	1.34E-04	7.2%	Moderate break of FP piping in room 078-A19B, 078-A20B, 100-A10B, 120-A11B, or 120-A13B. Flow between 400 gpm and 690 gpm in 078-A19B or 078-A20B. Flow between 645 gpm and 935 gpm in 100-A10B. Flow between 890 gpm and 1,180 gpm in 120 -A11B or 120-A13B.

Table 19.1-65 (2 of 2)

Number	Basic Event ID	Frequency (per year)	Contribution to CDF	Description
6	#IE-78-01D-FP-X	1.71E-04	4.5%	Major break of FP piping in room 078-A10D. Flow greater than 3,700gpm in 078-A10D.
7	#IE-78-19A-FP-M	8.31E-05	4.3%	Moderate break of FP piping in room 078-A19A, 120-A11A, 120-P22, 120-P25, 120-P27, or 120-P32. Flow rate between 1,200 gpm and 2,000 gpm in 078-A19A. Flow rate greater than 1,200 gpm in 120-A11A. Flow rate between 1,700 gpm and 2,500 gpm in 120-P22, 120-P25, 120-P27, or 120-P32.
8	#IE-100-10B-FP-X	5.71E-05	2.8%	Major break of FP piping in room 100-A10B. Flow greater 1,445 gpm
9	#IE-137-29B-FP-M	2.66E-06	1.8%	Moderate break of FP piping in 137-A29B. Flow rate between 1,690 gpm and 2,500 gpm
10	#IE-78-10C-FP-X	3.51E-04	1.6%	Major break of FP piping in room 078-A10C. Flow greater than 3,700gpm in 078-A10D.
11	#IE-78-01D-FP-M	5.52E-05	1.3%	Moderate break of FP piping in room 078-A01D, 078-A10D, 120-A07D, or 137-A01D. Flow greater than 2,180 gpm in 078-A01D. Flow between 2,180 gpm and 3,700 gpm in 078-A10D. Flow greater than 5,100 gpm in 120-A07D.
12	#IE-100-37B-FP-X	5.76E-06	1.2%	Major break of FP piping in 100-A37B, 100-A30B, 100-A35B, 120-A29B, or 120-A31B with a flow rate greater than 2,500 gpm.
13	#IE-TB-MISC	1.16E-02	1.1%	Flooding event in Turbine Building with flow less than 400,000 gpm
14	#IE-120-11B-FP-X	1.79E-05	0.8%	Major break of FP piping in room 120-A11B or 120-A13B. Flow greater than 1,180 gpm.

Table 19.1-66 (1 of 32)

Internal Flooding PRA Top 100 CDF Cutsets

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
1	9.46E-09	#IE-78-19B-FP-X PFHBWQ4-SW2OUAT	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 078-A19B CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1B,1C,1D FAIL TO OPEN	4.20	4.2
2	9.08E-09	#IE-100-20A-FP-X PFHBWQ4-SW2OUAT	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 100-A20A CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1B,1C,1D FAIL TO OPEN	4.1	8.3
3	8.08E-09	#IE-78-19A-FP-X PFHBWQ4-SW2OUAT	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 078-A19A CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1B,1C,1D FAIL TO OPEN	3.6	11.9
4	5.91E-09	#IE-78-19B-FP-X PFHBWQ4-SW2OUAT	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 078-A44B CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1B,1C,1D FAIL TO OPEN	2.7	14.6

Table 19.1-66 (2 of 32)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
5	5.74E-09	#IE-78-19B-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 078-A19B	2.6	17.2
		PFHBWQ3-SW2OUATAC	3/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1C,1D FAIL TO OPEN		
6	5.51E-09	#IE-100-20A-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 100-A20A	2.5	19.6
		PFHBWQ3-SW2OUATBCD	3/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01B,1C,1D FAIL TO OPEN		
7	4.90E-09	#IE-78-19A-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 078-A19A	2.2	21.8
		PFHBWQ3-SW2OUATBCD	3/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01B,1C,1D FAIL TO OPEN		
8	4.64E-09	#IE-78-01D-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 078-A01D	2.1	23.9
		PFHBWQ4-SW2OUAT	CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1B,1C,1D FAIL TO OPEN		

Table 19.1-66 (3 of 32)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
9	3.63E-09	#IE-78-19B-FP-M	THE FLOOD INITIATING EVENT FOR A MODERATE BREAK OF FP PIPING IN ROOM 078-A19B	1.6	25.5
		PFHBWQ4-SW2OUAT	CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1B,1C,1D FAIL TO OPEN		
10	3.59E-09	#IE-78-44B-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 078-A44B	1.6	27.1
		PFHBWQ3-SW2OUATACD	3/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1C,1D FAIL TO OPEN		
11	2.81E-09	#IE-78-01D-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 078-A01D	1.3	28.4
		PFHBWQ3-SW2OUATABC	3/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1B,1C FAIL TO OPEN		
12	2.25E-09	#IE-78-19A-FP-M	THE FLOOD INITIATING EVENT FOR A MODERATE BREAK OF FP PIPING IN ROOM 078-A19A	1.0	29.4
		PFHBWQ4-SW2OUAT	CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1B,1C,1D FAIL TO OPEN		

Table 19.1-66 (4 of 32)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
13	2.21E-09	#IE-78-19B-FP-M PFHBWQ3-SW2OUATACD	THE FLOOD INITIATING EVENT FOR A MODERATE BREAK OF FP PIPING IN ROOM 078-A19B 3/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1C,1D FAIL TO OPEN	1.0	30.4
14	1.55E-09	#IE-100-10B-FP-X PFHBWQ4-SW2OUAT	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 100-A10B CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1B,1C,1D FAIL TO OPEN	0.7	31.1
15	1.50E-09	#IE-78-01D-FP-M PFHBWQ4-SW2OUAT	THE FLOOD INITIATING EVENT FOR A MODERATE BREAK OF FP PIPING IN ROOM 078-A01D CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1B,1C,1D FAIL TO OPEN	0.7	31.8
16	1.37E-09	#IE-78-19A-FP-M PFHBWQ3-SW2OUATBCD	THE FLOOD INITIATING EVENT FOR A MODERATE BREAK OF FP PIPING IN ROOM 078-A19A 3/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01B,1C,1D FAIL TO OPEN	0.6	32.4

Table 19.1-66 (5 of 32)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
17	1.20E-09	#IE-78-10C-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 078-A10C	0.5	32.9
		FPOPH-1-ISO-FL	OPERATOR`S FAILURE TO ISOLATE A FP BREAK WITH LESS THAN 20 MINUTE AVAILABLE		
		PFHBWQ2-SW2OUATBD	2/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01B,1D FAIL TO OPEN		
18	1.20E-09	#IE-78-19B-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 078-A19B	0.5	33.5
		FPOPH-1-ISO-FL	OPERATOR`S FAILURE TO ISOLATE A FP BREAK WITH LESS THAN 20 MINUTE AVAILABLE		
		PFHBWQ2-SW2OUATAC	2/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1C FAIL TO OPEN		
19	1.02E-09	#IE-78-19A-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 078-A19A	0.5	33.9
		FPOPH-1-ISO-FL	OPERATOR`S FAILURE TO ISOLATE A FP BREAK WITH LESS THAN 20 MINUTE AVAILABLE		
		PFHBWQ2-SW2OUATBD	2/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01B,1D FAIL TO OPEN		

Table 19.1-66 (6 of 32)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
20	9.40E-10	#IE-100-10B-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 100-A10B	0.4	34.3
		PFHBWQ3-SW2OUATACD	3/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1C,1D FAIL TO OPEN		
21	9.08E-10	#IE-78-01D-FP-M	THE FLOOD INITIATING EVENT FOR A MODERATE BREAK OF FP PIPING IN ROOM 078-A01D	0.4	34.8
		PFHBWQ3-SW2OUATABC	3/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1B,1C FAIL TO OPEN		
22	8.83E-10	#IE-78-19B-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 078-A19B	0.4	35.1
		FPOPH-1-ISO-FL	OPERATOR`S FAILURE TO ISOLATE A FP BREAK WITH LESS THAN 20 MINUTE AVAILABLE		
		PFHBO1A-SW01A-H2	FAILS TO OPEN OF PCB SW01A-H2 OF 4.16KV SWGR SW01A FROM UAT		
		PFHBO2A-SW01C-C2	FAILS TO OPEN OF PCB SW01C-C2 OF 4.16KV SWGR SW01C FROM UAT		

Table 19.1-66 (7 of 32)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
23	7.54E-10	#IE-78-19A-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 078-A19A	0.3	35.5
		FPOPH-1-ISO-FL	OPERATOR`S FAILURE TO ISOLATE A FP BREAK WITH LESS THAN 20 MINUTE AVAILABLE		
		PFHBO1B-SW01B-H2	FAILS TO OPEN OF PCB SW01B-H2 OF 4.16KV SWGR SW01B FROM UAT		
		PFHBO2B-SW01D-G2	FAILS TO OPEN OF PCB SW01D-G2 OF 4.16KV SWGR SW01D FROM UAT		
24	5.53E-10	#IE-TB-MISC	THE FLOOD INITIATING EVENT FOR A SIGNIFICANT FLOOD IN THE TURBINE ROOM	0.2	35.7
		I-ATWS-RPMCF	FAILURE TO SCRAM DUE TO MECHANICAL FAILURES		
		MTC-ATWS	MODERATE COEFFICIENT		
25	5.37E-10	#IE-78-15D-AF-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF AF-RELATED PIPING IN ROOM 078-A15D	0.2	36.0
		PFHBWQ4-SW2OUAT	CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1B,1C,1D FAIL TO OPEN		

Table 19.1-66 (8 of 32)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
26	5.23E-10	#IE-78-19B-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 078-A19B	0.2	36.2
		DGDGR-D-DGD	FAILS TO RUN OF EMERGENCY DIESEL GENERATOR DG01D		
		PFHBWQ2-SW2OUATAC	2/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1C FAIL TO OPEN		
27	5.02E-10	#IE-100-20A-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 100-A20A	0.2	36.4
		DGDGR-C-DGC	FAILS TO RUN OF EMERGENCY DIESEL GENERATOR DG01C		
		PFHBWQ2-SW2OUATBD	2/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01B,1D FAIL TO OPEN		
28	4.85E-10	#IE-120-11B-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 120-A11B	0.2	36.7
		PFHBWQ4-SW2OUAT	CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1B,1C,1D FAIL TO OPEN		

Table 19.1-66 (9 of 32)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
29	4.47E-10	#IE-78-19A-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 078-A19A	0.2	36.9
		DGDGR-C-DGC	FAILS TO RUN OF EMERGENCY DIESEL GENERATOR DG01C		
		PFHBWQ2-SW2OUATBD	2/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01B,1D FAIL TO OPEN		
30	4.35E-10	#IE-TB-MISC	THE FLOOD INITIATING EVENT FOR A SIGNIFICANT FLOOD IN THE TURBINE ROOM	0.2	37.0
		AFPVKQ4-TP01A/B/MP02A/B	4/4 CCF OF AFW TDP01A/B, MDP02A/B DUE TO THE VOLUTE FAIL TO RUN		
		RCOPH-S-SDSE-FW	FAILURE OF SDS VALVES EARLY PHASE OPEN (1/4)		
31	4.15E-10	#IE-78-19B-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 078-A19B	0.2	37.2
		PFHBWQ2-SW2OUATAC	2/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1C FAIL TO OPEN		
		WOCHM2B-CH02B	ECW CHILLER 02B TRAIN UNAVAILABLE DUE TO T&M		

Table 19.1-66 (10 of 32)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
32	3.98E-10	#IE-100-20A-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 100-A20A	0.2	37.4
		PFHBWQ2-SW2OUATBD	2/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01B,1D FAIL TO OPEN		
		WOCHM2A-CH02A	ECW CHILLER 02A TRAIN UNAVAILABLE DUE TO T&M		
33	3.86E-10	#IE-78-19B-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 078-A19B	0.2	37.6
		DGDGR-D-DGD	FAILS TO RUN OF EMERGENCY DIESEL GENERATOR DG01D		
		PFHBO1A-SW01A-H2	FAILS TO OPEN OF PCB SW01A-H2 OF 4.16KV SWGR SW01A FROM UAT		
		PFHBO2A-SW01C-C2	FAILS TO OPEN OF PCB SW01C-C2 OF 4.16KV SWGR SW01C FROM UAT		
34	3.71E-10	#IE-100-20A-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 100-A20A	0.2	37.8
		DGDGR-C-DGC	FAILS TO RUN OF EMERGENCY DIESEL GENERATOR DG01C		
		PFHBO1B-SW01B-H2	FAILS TO OPEN OF PCB SW01B-H2 OF 4.16KV SWGR SW01B FROM UAT		
		PFHBO2B-SW01D-G2	FAILS TO OPEN OF PCB SW01D-G2 OF 4.16KV SWGR SW01D FROM UAT		

Table 19.1-66 (11 of 32)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
35	3.57E-10	#IE-78-19B-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 078-A19B	0.2	37.9
		PFHBWQ2-SW2OUATAC	2/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1C FAIL TO OPEN		
		WOOPH-B-1/2B	OPERATOR FAILS TO OPERATE ECW PUMPS PP01/2B		
36	3.54E-10	#IE-78-19A-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 078-A19A	0.2	38.1
		PFHBWQ2-SW2OUATBD	2/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01B,1D FAIL TO OPEN		
		WOCHM2A-CH02A	ECW CHILLER 02A TRAIN UNAVAILABLE DUE TO T&M		
37	3.50E-10	#IE-137-29B-FP-M	THE FLOOD INITIATING EVENT FOR A MODERATE BREAK OF FP PIPING IN ROOM 137-A29B	0.2	38.2
		PFHBO1A-SW01A-H2	FAILS TO OPEN OF PCB SW01A-H2 OF 4.16KV SWGR SW01A FROM UAT		
		WOCHM2A-CH02A	ECW CHILLER 02A TRAIN UNAVAILABLE DUE TO T&M		

Table 19.1-66 (12 of 32)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
38	3.47E-10	#IE-100-37B-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 100-A37B	0.2	38.4
		PFHBWQ2-SW2OUATAC	2/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1C FAIL TO OPEN		
39	3.43E-10	#IE-100-20A-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 100-A20A	0.2	38.5
		PFHBWQ2-SW2OUATBD	2/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01B,1D FAIL TO OPEN		
		WOOPH-A-1/2A	OPERATOR FAILS TO OPERATE ECW PUMPS PP01/2A		
40	3.30E-10	#IE-78-19A-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 078-A19A	0.1	38.7
		DGDGR-C-DGC	FAILS TO RUN OF EMERGENCY DIESEL GENERATOR DG01C		
		PFHBO1B-SW01B-H2	FAILS TO OPEN OF PCB SW01B-H2 OF 4.16KV SWGR SW01B FROM UAT		
		PFHBO2B-SW01D-G2	FAILS TO OPEN OF PCB SW01D-G2 OF 4.16KV SWGR SW01D FROM UAT		

Table 19.1-66 (13 of 32)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
41	3.27E-10	#IE-78-19B-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 078-A19B	0.1	38.8
		FPOPH-1-ISO-FL	OPERATOR`S FAILURE TO ISOLATE A FP BREAK WITH LESS THAN 20 MINUTE AVAILABLE		
		PFHBWQ3-SW2OUATABC	3/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1B,1C FAIL TO OPEN		
42	3.27E-10	#IE-78-44B-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 078-A44B	0.1	39.0
		DGDGR-D-DGD	FAILS TO RUN OF EMERGENCY DIESEL GENERATOR DG01D		
		PFHBWQ2-SW2OUATAC	2/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1C FAIL TO OPEN		
43	3.26E-10	#IE-78-15D-AF-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF AF-RELATED PIPING IN ROOM 078-A15D	0.1	39.1
		PFHBWQ3-SW2OUATABC	3/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1B,1C FAIL TO OPEN		

Table 19.1-66 (14 of 32)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
44	3.06E-10	#IE-78-19B-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 078-A19B	0.1	39.3
		PFHBO1A-SW01A-H2	FAILS TO OPEN OF PCB SW01A-H2 OF 4.16KV SWGR SW01A FROM UAT		
		PFHBO2A-SW01C-C2	FAILS TO OPEN OF PCB SW01C-C2 OF 4.16KV SWGR SW01C FROM UAT		
		WOCHM2B-CH02B	ECW CHILLER 02B TRAIN UNAVAILABLE DUE TO T&M		
45	3.05E-10	#IE-78-19A-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 078-A19A	0.1	39.4
		PFHBWQ2-SW2OUATBD	2/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01B,1D FAIL TO OPEN		
		WOOPH-A-1/2A	OPERATOR FAILS TO OPERATE ECW PUMPS PP01/2A		
46	3.02E-10	#IE-78-19B-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 078-A19B	0.1	39.5
		DGDGM-D-DGD	DG 01D UNAVAILABLE DUE TO MAINTENANCE		
		PFHBWQ2-SW2OUATAC	2/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1C FAIL TO OPEN		

Table 19.1-66 (15 of 32)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
47	2.95E-10	#IE-120-11B-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 120-A11B	0.1	39.7
		PFHBWQ3-SW2OUATACD	3/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1C,1D FAIL TO OPEN		
48	2.94E-10	#IE-100-20A-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 100-A20A	0.1	39.8
		PFHBO1B-SW01B-H2	FAILS TO OPEN OF PCB SW01B-H2 OF 4.16KV SWGR SW01B FROM UAT		
		PFHBO2B-SW01D-G2	FAILS TO OPEN OF PCB SW01D-G2 OF 4.16KV SWGR SW01D FROM UAT		
		WOCHM2A-CH02A	ECW CHILLER 02A TRAIN UNAVAILABLE DUE TO T&M		
49	2.90E-10	#IE-78-19A-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 100-A20A	0.1	39.9
		DGDGR-C-DGC	DGDGM-C-DGC		
		PFHBWQ2-SW2OUATBD	2/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01B,1D FAIL TO OPEN		

Table 19.1-66 (16 of 32)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
50	2.80E-10	#IE-78-19A-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 078-A19A	0.1	40.1
		FPOPH-1-ISO-FL	OPERATOR`S FAILURE TO ISOLATE A FP BREAK WITH LESS THAN 20 MINUTE AVAILABLE		
		PFHBWQ3-SW2OUATABD	3/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1B,1D FAIL TO OPEN		
51	2.77E-10	#IE-78-19B-FP-X	F122-T01 UNSUPPRESSED FIRES	0.1	40.2
		PFHBWQ2-SW2OUATAC	2/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1C FAIL TO OPEN		
		SXMPM2B-PP02B	ESW PUMP PP02B UNAVAILABLE DUE TO T/M		
52	2.73E-10	#IE-78-19B-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 078-A19B	0.1	40.3
		PFHBWQ2-SW2OUATAC	2/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1C FAIL TO OPEN		
		WOCHS2B-CH02B	ECW CHILLER CH02B FAILS TO START ON DEMAND		

Table 19.1-66 (17 of 32)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
53	2.66E-10	#IE-100-20A-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 100-A20A	0.1	40.4
		PFHBWQ2-SW2OUATBD	2/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01B,1D FAIL TO OPEN		
		SXMPM2A-PP02A	ESW PUMP PP02A UNAVAILABLE DUE TO T/M		
54	2.63-10	#IE-78-19B-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 078-A19B	0.1	40.5
		PFHBO1A-SW01A-H2	FAILS TO OPEN OF PCB SW01A-H2 OF 4.16KV SWGR SW01A FROM UAT		
		PFHBO2A-SW01C-C2	FAILS TO OPEN OF PCB SW01C-C2 OF 4.16KV SWGR SW01C FROM UAT		
		WOOPH-B-1/2B	OPERATOR FAILS TO OPERATE ECW PUMPS PP01/2B		
55	2.62E-10	#IE-100-20A-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 100-A20A	0.1	40.7
		PFHBWQ2-SW2OUATBD	2/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01B,1D FAIL TO OPEN		
		WOCHS2A-CH02A	ECW CHILLER CH02A FAILS TO START ON DEMAND		

Table 19.1-66 (18 of 32)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
56	2.61E-10	#IE-78-19A-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 078-A19A	0.1	40.8
		PFHBO1B-SW01B-H2	FAILS TO OPEN OF PCB SW01B-H2 OF 4.16KV SWGR SW01B FROM UAT		
		PFHBO2B-SW01D-G2	FAILS TO OPEN OF PCB SW01D-G2 OF 4.16KV SWGR SW01D FROM UAT		
		WOCHM2A-CH02A	ECW CHILLER 02A TRAIN UNAVAILABLE DUE TO T&M		
57	2.59E-10	#IE-78-44B-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 078-A44B	0.1	40.9
		PFHBWQ2-SW2OUATAC	2/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1C FAIL TO OPEN		
		WOCHM2B-CH02B	ECW CHILLER 02B TRAIN UNAVAILABLE DUE TO T&M		
58	2.58E-10	#IE-78-19A-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 078-A19A	0.1	41.0
		DGDGM-C-DGC	DG 01C UNAVAILABLE DUE TO MAINTENANCE		
		PFHBWQ2-SW2OUATBD	2/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01B,1D FAIL TO OPEN		

Table 19.1-66 (19 of 32)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
59	2.56E-10	#IE-78-01D-FP-X DGDGR-B-DGB PFHBWQ2-SW2OUATAC	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 078-A01D FAILS TO RUN OF EMERGENCY DIESEL GENERATOR DG01B 2/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1C FAIL TO OPEN	0.1	41.1
60	2.56E-10	#IE-100-37B-FP-X PFHBO1A-SW01A-H2 PFHBO2A-SW01C-C2	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 100-A37B FAILS TO OPEN OF PCB SW01A-H2 OF 4.16KV SWGR SW01A FROM UAT FAILS TO OPEN OF PCB SW01C-C2 OF 4.16KV SWGR SW01C FROM UAT	0.1	41.2
61	2.53E-10	#IE-100-20A-FP-X PFHBO1B-SW01B-H2 PFHBO2B-SW01D-G2 WOOPH-A-1/2A	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 100-A20A FAILS TO OPEN OF PCB SW01B-H2 OF 4.16KV SWGR SW01B FROM UAT FAILS TO OPEN OF PCB SW01D-G2 OF 4.16KV SWGR SW01D FROM UAT OPERATOR FAILS TO OPERATE ECW PUMPS PP01/2A	0.1	41.3

Table 19.1-66 (20 of 32)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
62	2.41E-10	#IE-78-44B-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 078-A44B	0.1	41.5
		DGDGR-D-DGD	FAILS TO RUN OF EMERGENCY DIESEL GENERATOR DG01D		
		PFHBO1A-SW01A-H2	FAILS TO OPEN OF PCB SW01A-H2 OF 4.16KV SWGR SW01A FROM UAT		
		PFHBO2A-SW01C-C2	FAILS TO OPEN OF PCB SW01C-C2 OF 4.16KV SWGR SW01C FROM UAT		
63	2.37E-10	#IE-78-19A-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 078-A19A	0.1	41.6
		PFHBWQ2-SW2OUATBD	2/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01B,1D FAIL TO OPEN		
		PFHBWQ2-SW2OUATBD	2/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01B,1D FAIL TO OPEN		
64	2.34E-10	#IE-137-29B-FP-M	THE FLOOD INITIATING EVENT FOR A MODERATE BREAK OF FP PIPING IN ROOM 137-A29B	0.1	41.7
		PFHBO1A-SW01A-H2	FAILS TO OPEN OF PCB SW01A-H2 OF 4.16KV SWGR SW01A FROM UAT		
		SXMPM2A-PP02A	ESW PUMP PP02A UNAVAILABLE DUE TO T/M		

Table 19.1-66 (21 of 32)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
65	2.33E-10	#IE-78-19A-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 078-A19A	0.1	41.8
		PFHBWQ2-SW2OUATBD	2/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01B,1D FAIL TO OPEN		
		WOCHS2A-CH02A	ECW CHILLER CH02A FAILS TO START ON DEMAND		
66	2.30E-10	#IE-137-29B-FP-M	THE FLOOD INITIATING EVENT FOR A MODERATE BREAK OF FP PIPING IN ROOM 137-A29B	0.1	41.9
		PFHBO1A-SW01A-H2	FAILS TO OPEN OF PCB SW01A-H2 OF 4.16KV SWGR SW01A FROM UAT		
		WOCHS2A-CH02A	ECW CHILLER CH02A FAILS TO START ON DEMAND		
67	2.25E-10	#IE-78-19A-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 078-A19A	0.1	42.0
		PFHBO1B-SW01B-H2	FAILS TO OPEN OF PCB SW01B-H2 OF 4.16KV SWGR SW01B FROM UAT		
		PFHBO2B-SW01D-G2	FAILS TO OPEN OF PCB SW01D-G2 OF 4.16KV SWGR SW01D FROM UAT		
		WOOPH-A-1/2A	OPERATOR FAILS TO OPERATE ECW PUMPS PP01/2A		

Table 19.1-66 (22 of 32)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
68	2.23E-10	#IE-78-19B-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 078-A19B	0.1	42.1
		DGDGM-D-DGD	DG 01D UNAVAILABLE DUE TO MAINTENANCE		
		PFHBO1A-SW01A-H2	FAILS TO OPEN OF PCB SW01A-H2 OF 4.16KV SWGR SW01A FROM UAT		
		PFHBO1A-SW01A-H2	FAILS TO OPEN OF PCB SW01A-H2 OF 4.16KV SWGR SW01A FROM UAT		
69	2.23E-10	#IE-78-44B-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 078-A44B	0.1	42.2
		PFHBWQ2-SW2OUATAC	2/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1C FAIL TO OPEN		
		WOOPH-B-1/2B	OPERATOR FAILS TO OPERATE ECW PUMPS PP01/2B		
70	2.14E-10	#IE-100-20A-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 100-A20A	0.1	42.3
		DGDGM-C-DGC	DG 01C UNAVAILABLE DUE TO MAINTENANCE		
		PFHBO1B-SW01B-H2	FAILS TO OPEN OF PCB SW01B-H2 OF 4.16KV SWGR SW01B FROM UAT		
		PFHBO2B-SW01D-G2	FAILS TO OPEN OF PCB SW01D-G2 OF 4.16KV SWGR SW01D FROM UAT		

Table 19.1-66 (23 of 32)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
71	2.05E-10	#IE-78-19B-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 078-A19B	0.1	42.4
		PFHBO1A-SW01A-H2	FAILS TO OPEN OF PCB SW01A-H2 OF 4.16KV SWGR SW01A FROM UAT		
		PFHBO2A-SW01C-C2	FAILS TO OPEN OF PCB SW01C-C2 OF 4.16KV SWGR SW01C FROM UAT		
		SXMPM2B-PP02B	ESW PUMP PP02B UNAVAILABLE DUE TO T/M		
72	2.01E-10	#IE-78-19B-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 078-A19B	0.1	42.5
		PFHBO1A-SW01A-H2	FAILS TO OPEN OF PCB SW01A-H2 OF 4.16KV SWGR SW01A FROM UAT		
		PFHBO2A-SW01C-C2	FAILS TO OPEN OF PCB SW01C-C2 OF 4.16KV SWGR SW01C FROM UAT		
		WOCHS2B-CH02B	ECW CHILLER CH02B FAILS TO START ON DEMAND		
73	2.01E-10	#IE-78-19B-FP-M	THE FLOOD INITIATING EVENT FOR A MODERATE BREAK OF FP PIPING IN ROOM 078-A19B	0.1	42.5
		DGDGR-D-DGD	FAILS TO RUN OF EMERGENCY DIESEL GENERATOR DG01D		
		PFHBWQ2-SW2OUATAC	2/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1C FAIL TO OPEN		

Table 19.1-66 (24 of 32)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
74	1.96E-10	#IE-100-20A-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 100-A20A	0.1	42.6
		PFHBO1B-SW01B-H2	FAILS TO OPEN OF PCB SW01B-H2 OF 4.16KV SWGR SW01B FROM UAT		
		PFHBO2B-SW01D-G2	FAILS TO OPEN OF PCB SW01D-G2 OF 4.16KV SWGR SW01D FROM UAT		
		SXMPM2A-PP02A	ESW PUMP PP02A UNAVAILABLE DUE TO T/M		
75	1.93E-10	#IE-100-20A-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 100-A20A	0.1	42.7
		PFHBO1B-SW01B-H2	FAILS TO OPEN OF PCB SW01B-H2 OF 4.16KV SWGR SW01B FROM UAT		
		PFHBO2B-SW01D-G2	FAILS TO OPEN OF PCB SW01D-G2 OF 4.16KV SWGR SW01D FROM UAT		
		WOCHS2A-CH02A	ECW CHILLER CH02A FAILS TO START ON DEMAND		
76	1.91E-10	#IE-78-44B-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 078-A44B	0.1	42.8
		PFHBO1A-SW01A-H2	FAILS TO OPEN OF PCB SW01A-H2 OF 4.16KV SWGR SW01A FROM UAT		
		PFHBO2A-SW01C-C2	FAILS TO OPEN OF PCB SW01C-C2 OF 4.16KV SWGR SW01C FROM UAT		
		WOCHM2B-CH02B	ECW CHILLER 02B TRAIN UNAVAILABLE DUE TO T&M		

Table 19.1-66 (25 of 32)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
77	1.91E-10	#IE-78-19A-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 078-A19A	0.1	42.9
		DGDGM-C-DGC	DG 01C UNAVAILABLE DUE TO MAINTENANCE		
		PFHBO1B-SW01B-H2	FAILS TO OPEN OF PCB SW01B-H2 OF 4.16KV SWGR SW01B FROM UAT		
		PFHBO2B-SW01D-G2	FAILS TO OPEN OF PCB SW01D-G2 OF 4.16KV SWGR SW01D FROM UAT		
78	1.89E-10	#IE-78-01D-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 078-A01D	0.1	43.0
		DGDGR-B-DGB	FAILS TO RUN OF EMERGENCY DIESEL GENERATOR DG01B		
		PFHBO1A-SW01A-H2	FAILS TO OPEN OF PCB SW01A-H2 OF 4.16KV SWGR SW01A FROM UAT		
		PFHBO2A-SW01C-C2	FAILS TO OPEN OF PCB SW01C-C2 OF 4.16KV SWGR SW01C FROM UAT		
79	1.89E-10	#IE-78-44B-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 078-A44B	0.1	43.1
		DGDGM-D-DGD	DG 01D UNAVAILABLE DUE TO MAINTENANCE		
		PFHBWQ2-SW2OUATAC	2/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1C FAIL TO OPEN		

Table 19.1-66 (26 of 32)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
80	1.75E-10	#IE-78-19A-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 078-A19A	0.1	43.1
		PFHBO1B-SW01B-H2	FAILS TO OPEN OF PCB SW01B-H2 OF 4.16KV SWGR SW01B FROM UAT		
		PFHBO2B-SW01D-G2	FAILS TO OPEN OF PCB SW01D-G2 OF 4.16KV SWGR SW01D FROM UAT		
		SXMPM2A-PP02A	ESW PUMP PP02A UNAVAILABLE DUE TO T/M		
81	1.73E-10	#IE-78-44B-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 078-A44B	0.1	43.2
		PFHBWQ2-SW2OUATAC	2/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1C FAIL TO OPEN		
		SXMPM2B-PP02B	ESW PUMP PP02B UNAVAILABLE DUE TO T/M		
82	1.72E-10	#IE-78-19A-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 078-A19A	0.1	43.3
		PFHBO1B-SW01B-H2	FAILS TO OPEN OF PCB SW01B-H2 OF 4.16KV SWGR SW01B FROM UAT		
		PFHBO2B-SW01D-G2	FAILS TO OPEN OF PCB SW01D-G2 OF 4.16KV SWGR SW01D FROM UAT		
		WOCHS2A-CH02A	ECW CHILLER CH02A FAILS TO START ON DEMAND		

Table 19.1-66 (27 of 32)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
83	1.70E-10	#IE-78-44B-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 078-A44B	0.1	43.4
		PFHBWQ2-SW2OUATAC	2/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1C FAIL TO OPEN		
		WOCHS2B-CH02B	ECW CHILLER CH02B FAILS TO START ON DEMAND		
84	1.65E-10	#IE-78-44B-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 078-A44B	0.1	43.4
		PFHBO1A-SW01A-H2	FAILS TO OPEN OF PCB SW01A-H2 OF 4.16KV SWGR SW01A FROM UAT		
		PFHBO2A-SW01C-C2	FAILS TO OPEN OF PCB SW01C-C2 OF 4.16KV SWGR SW01C FROM UAT		
		WOOPH-B-1/2B	OPERATOR FAILS TO OPERATE ECW PUMPS PP01/2B		
85	1.61E-10	#IE-137-29B-FP-M	THE FLOOD INITIATING EVENT FOR A MODERATE BREAK OF FP PIPING IN ROOM 137-A29B	0.1	43.5
		PFHBO1A-SW01A-H2	FAILS TO OPEN OF PCB SW01A-H2 OF 4.16KV SWGR SW01A FROM UAT		
		RCOPH-S-SDSE-FW	FAILURE OF SDS VALVES EARLY PHASE OPEN (1/4)		

Table 19.1-66 (28 of 32)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
86	1.60E-10	#IE-137-29B-FP-M	THE FLOOD INITIATING EVENT FOR A MODERATE BREAK OF FP PIPING IN ROOM 137-A29B	0.1	43.7
		PFHBWQ2-SW2OUATAC	2/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1C FAIL TO OPEN		
87	1.59E-10	#IE-78-19B-FP-M	THE FLOOD INITIATING EVENT FOR A MODERATE BREAK OF FP PIPING IN ROOM 078-A19B	0.1	43.7
		PFHBWQ2-SW2OUATAC	2/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1C FAIL TO OPEN		
		WOCHM2B-CH02B	ECW CHILLER 02B TRAIN UNAVAILABLE DUE TO T&M		
88	1.56E-10	#IE-100-37B-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 137-A37B	0.1	43.7
		PFHBWQ4-SW2OUAT	CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1B,1C,1D FAIL TO OPEN		
89	1.48E-10	#IE-78-19B-FP-M	THE FLOOD INITIATING EVENT FOR A MODERATE BREAK OF FP PIPING IN ROOM 078-A19B	0.1	43.8
		DGDGR-D-DGD	FAILS TO RUN OF EMERGENCY DIESEL GENERATOR DG01D		
		PFHBO1A-SW01A-H2	FAILS TO OPEN OF PCB SW01A-H2 OF 4.16KV SWGR SW01A FROM UAT		
		PFHBO2A-SW01C-C2	FAILS TO OPEN OF PCB SW01C-C2 OF 4.16KV SWGR SW01C FROM UAT		

Table 19.1-66 (29 of 32)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
90	1.48E-10	#IE-78-01D-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 078-A01D	0.1	43.9
		DGDGM-B-DGB	DG 01B UNAVAILABLE DUE TO MAINTENANCE		
		PFHBWQ2-SW2OUATAC	2/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1C FAIL TO OPEN		
91	1.45E-10	#IE-78-19B-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 078-A19B	0.1	43.9
		PFHBWQ2-SW2OUATAC	2/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1C FAIL TO OPEN		
		WOMPM2B-PP02B	ECW PP02B TRAIN UNAVAILABLE DUE TO T&M		
92	1.43E-10	#IE-78-19B-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 078-A19B	0.1	44.0
		DGDGR-D-DGD	FAILS TO RUN OF EMERGENCY DIESEL GENERATOR DG01D		
		PFHBWQ3-SW2OUATABC	3/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1B,1C FAIL TO OPEN		

Table 19.1-66 (30 of 32)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
93	1.40E-10	#IE-78-19B-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 078-A19B	0.1	44.1
		PFHBO2A-SW01C-C2	FAILS TO OPEN OF PCB SW01C-C2 OF 4.16KV SWGR SW01C FROM UAT		
		PFHBWQ2-SW2OUATAD	2/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1D FAIL TO OPEN		
94	1.40E-10	#IE-78-19B-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 078-A19B	0.1	44.1
		PFHBO2B-SW01D-G2	FAILS TO OPEN OF PCB SW01D-G2 OF 4.16KV SWGR SW01D FROM UAT		
		PFHBWQ2-SW2OUATAC	2/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1C FAIL TO OPEN		
95	1.40E-10	#IE-78-19B-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 078-A19B	0.1	44.2
		PFHBO1A-SW01A-H2	FAILS TO OPEN OF PCB SW01A-H2 OF 4.16KV SWGR SW01A FROM UAT		
		PFHBWQ2-SW2OUATCD	2/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01C,1D FAIL TO OPEN		

Table 19.1-66 (31 of 32)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
96	1.39E-10	#IE-78-44B-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 078-A44B	0.1	44.2
		DGDGM-D-DGD	DG 01D UNAVAILABLE DUE TO MAINTENANCE		
		PFHBO1A-SW01A-H2	FAILS TO OPEN OF PCB SW01A-H2 OF 4.16KV SWGR SW01A FROM UAT		
		PFHBO2A-SW01C-C2	FAILS TO OPEN OF PCB SW01C-C2 OF 4.16KV SWGR SW01C FROM UAT		
97	1.39E-10	#IE-100-37B-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 137-A37B	0.1	44.3
		AFMPM2A-MDP02A	AFW MDP PP02A UNAVAILABLE DUE TO T/M		
		PFHBO2A-SW01C-C2	FAILS TO OPEN OF PCB SW01C-C2 OF 4.16KV SWGR SW01C FROM UAT		
98	1.39E-10	#IE-100-20A-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 100-A20A	0.1	44.4
		PFHBWQ2-SW2OUATBD	2/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01B,1D FAIL TO OPEN		
		WOMPM2A-PP02A	ECW PP02A TRAIN UNAVAILABLE DUE TO T&M		

Table 19.1-66 (32 of 32)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
99	1.37E-10	#IE-100-20A-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 100-A20A	0.1	44.4
		DGDGR-C-DGC	FAILS TO RUN OF EMERGENCY DIESEL GENERATOR DG01C		
		PFHBWQ3-SW2OUATABD	3/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1B,1D FAIL TO OPEN		
100	1.37E-10	#IE-78-19B-FP-M	THE FLOOD INITIATING EVENT FOR A MODERATE BREAK OF FP PIPING IN ROOM 078-A19B	0.1	44.5
		PFHBWQ2-SW2OUATAC	2/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1C FAIL TO OPEN		
		WOOPH-B-1/2B	OPERATOR FAILS TO OPERATE ECW PUMPS PP01/2B		

Table 19.1-67 (1 of 50)

Internal Flooding PRA Top 100 LRF Cutsets

Rank	Frequency (/yr)	Cutsets		Contribution to LRF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
1	5.13E-10	#IE-78-19B-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 078-A19B	3.0	3.0
		ERVC	FAILURE OF ERVC SYSTEM		
		PDS_14	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14		
		PFHBWQ4-SW2OUAT	CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1B,1C,1D FAIL TO OPEN		
2	4.93E-10	#IE-100-20A-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 100-A20A	2.9	5.9
		ERVC	FAILURE OF ERVC SYSTEM		
		PDS_14	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14		
		PFHBWQ4-SW2OUAT	CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1B,1C,1D FAIL TO OPEN		

Table 19.1-67 (2 of 50)

Rank	Frequency (/yr)	Cutsets		Contribution to LRF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
3	4.38E-10	#IE-78-19A-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 078-A19A	2.6	8.5
		ERVC	FAILURE OF ERVC SYSTEM		
		PDS_14	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14		
		PFHBWQ4-SW2OUAT	CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1B,1C,1D FAIL TO OPEN		
4	3.21E-10	#IE-100-20A-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 100-A20A	1.9	10.4
		ERVC	FAILURE OF ERVC SYSTEM		
		PDS_14	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14		
		PFHBWQ4-SW2OUAT	CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1B,1C,1D FAIL TO OPEN		

Table 19.1-67 (3 of 50)

Rank	Frequency (/yr)	Cutsets		Contribution to LRF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
5	2.99E-10	#IE-100-20A-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 100-A20A	1.8	14.0
		ERVC	FAILURE OF ERVC SYSTEM		
		PDS_14	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14		
		PFHBWQ3-SW2OUATACD	3/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1C,1D FAIL TO OPEN		
6	2.66E-10	#IE-78-19A-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 078-A19A	1.6	15.5
		ERVC	FAILURE OF ERVC SYSTEM		
		PDS_14	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14		
		PFHBWQ3-SW2OUATACD	3/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1C,1D FAIL TO OPEN		

Table 19.1-67 (4 of 50)

Rank	Frequency (/yr)	Cutsets		Contribution to LRF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
7	2.66E-10	#IE-78-19A-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 078-A19A	1.6	15.5
		ERVC	FAILURE OF ERVC SYSTEM		
		PDS_14	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14		
		PFHBWQ3-SW2OUATACD	3/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1C,1D FAIL TO OPEN		
8	2.51E-10	#IE-78-01D-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 078-A10D	1.5	17.0
		ERVC	FAILURE OF ERVC SYSTEM		
		PDS_14	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14		
		PFHBWQ4-SW2OUAT	CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1B,1C,1D FAIL TO OPEN		

Table 19.1-67 (5 of 50)

Rank	Frequency (/yr)	Cutsets		Contribution to LRF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
9	2.46E-10	#IE-78-19B-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 078-A19B	1.4	18.5
		H-CI-OPEN	OPERATOR FAILS TO RECOVERY FOR CIS ISOLATION		
		PDS_6	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-6		
		PFHBWQ4-SW2OUAT	CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1B,1C,1D FAIL TO OPEN		
10	2.36E-10	#IE-100-20A-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 100-A20A	1.4	19.8
		H-CI-OPEN	OPERATOR FAILS TO RECOVERY FOR CIS ISOLATION		
		PDS_6	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-6		
		PFHBWQ4-SW2OUAT	CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1B,1C,1D FAIL TO OPEN		

Table 19.1-67 (6 of 50)

Rank	Frequency (/yr)	Cutsets		Contribution to LRF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
11	2.10E-10	#IE-78-19A-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 078-A19A	1.2	21.1
		H-CI-OPEN	OPERATOR FAILS TO RECOVERY FOR CIS ISOLATION		
		PDS_6	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-6		
		PFHBWQ4-SW2OUAT	CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1B,1C,1D FAIL TO OPEN		
12	1.97E-10	#IE-78-19B-FP-M	THE FLOOD INITIATING EVENT FOR A MODERATE BREAK OF FP PIPING IN ROOM 078-A19B	1.2	22.2
		H-CI-OPEN	OPERATOR FAILS TO RECOVERY FOR CIS ISOLATION		
		PDS_6	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-6		
		PFHBWQ4-SW2OUAT	CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1B,1C,1D FAIL TO OPEN		

Table 19.1-67 (7 of 50)

Rank	Frequency (/yr)	Cutsets		Contribution to LRF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
13	1.95E-10	#IE-78-44B-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 078-A44B	1.1	23.4
		ERVC	FAILURE OF ERVC SYSTEM		
		PDS_14	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14		
		PFHBWQ3-SW2OUATACD	3/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1C,1D FAIL TO OPEN		
14	1.54E-10	#IE-78-44B-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 078-A44B	0.9	24.3
		H-CI-OPEN	OPERATOR FAILS TO RECOVERY FOR CIS ISOLATION		
		PDS_6	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-6		
		PFHBWQ4-SW2OUAT	CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1B,1C,1D FAIL TO OPEN		

Table 19.1-67 (8 of 50)

Rank	Frequency (/yr)	Cutsets		Contribution to LRF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
15	1.53E-10	#IE-78-44B-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 078-A44B	0.9	25.2
		ERVC	FAILURE OF ERVC SYSTEM		
		PDS_14	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14		
		PFHBWQ3-SW2OUATABC	3/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1B,1C FAIL TO OPEN		
16	1.49E-10	#IE-78-19B-FP-X	THE FLOOD INITIATING EVENT FOR A MODERATE BREAK OF FP PIPING IN ROOM 078-A19B	0.9	26.1
		H-CI-OPEN	OPERATOR FAILS TO RECOVERY FOR CIS ISOLATION		
		PDS_6	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-6		
		PFHBWQ3-SW2OUATACD	3/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1C,1D FAIL TO OPEN		

Table 19.1-67 (9 of 50)

Rank	Frequency (/yr)	Cutsets		Contribution to LRF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
17	1.43E-10	#IE-100-20A-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 100-A20A	0.8	26.9
		H-CI-OPEN	OPERATOR FAILS TO RECOVERY FOR CIS ISOLATION		
		PDS_6	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-6		
		PFHBWQ3-SW2OUATBCD	3/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01B,1C,1D FAIL TO OPEN		
18	1.28E-10	#IE-78-19A-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 078-A19A	0.8	27.7
		H-CI-OPEN	OPERATOR FAILS TO RECOVERY FOR CIS ISOLATION		
		PDS_6	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-6		
		PFHBWQ3-SW2OUATBCD	3/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01B,1C,1D FAIL TO OPEN		

Table 19.1-67 (10 of 50)

Rank	Frequency (/yr)	Cutsets		Contribution to LRF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
19	1.22E-10	#IE-78-19A-FP-M	THE FLOOD INITIATING EVENT FOR A MODERATE BREAK OF FP PIPING IN ROOM 078-A19A	0.7	28.4
		ERVC	FAILURE OF ERVC SYSTEM		
		PDS_14	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14		
		PFHBWQ4-SW2OUAT	CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1B,1C,1D FAIL TO OPEN		
20	1.20E-10	#IE-78-19B-FP-M	THE FLOOD INITIATING EVENT FOR A MODERATE BREAK OF FP PIPING IN ROOM 078-A19B	0.7	29.1
		ERVC	FAILURE OF ERVC SYSTEM		
		PDS_14	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14		
		PFHBWQ3-SW2OUATACD	3/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1C,1D FAIL TO OPEN		

Table 19.1-67 (11 of 50)

Rank	Frequency (/yr)	Cutsets		Contribution to LRF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
21	9.45E-11	#IE-78-19B-FP-M	THE FLOOD INITIATING EVENT FOR A MODERATE BREAK OF FP PIPING IN ROOM 078-A19B	0.6	29.6
		H-CI-OPEN	OPERATOR FAILS TO RECOVERY FOR CIS ISOLATION		
		PDS_6	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-6		
		PFHBWQ4-SW2OUAT	CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1B,1C,1D FAIL TO OPEN		
22	9.33E-11	#IE-78-44B-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 078-A44B	0.5	30.2
		H-CI-OPEN	OPERATOR FAILS TO RECOVERY FOR CIS ISOLATION		
		PDS_6	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-6		
		PFHBWQ3-SW2OUATACD	3/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1C,1D FAIL TO OPEN		

Table 19.1-67 (12 of 50)

Rank	Frequency (/yr)	Cutsets		Contribution to LRF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
23	8.40E-11	#IE-100-10B-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 078-A10B	0.5	30.7
		ERVC	FAILURE OF ERVC SYSTEM		
		PDS_14	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14		
		PFHBWQ4-SW2OUAT	CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1B,1C,1D FAIL TO OPEN		
24	8.12E-11	#IE-78-01D-FP-M	THE FLOOD INITIATING EVENT FOR A MODERATE BREAK OF FP PIPING IN ROOM 078-A01D	0.5	31.2
		ERVC	FAILURE OF ERVC SYSTEM		
		PDS_14	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14		
		PFHBWQ4-SW2OUAT	CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1B,1C,1D FAIL TO OPEN		

Table 19.1-67 (13 of 50)

Rank	Frequency (/yr)	Cutsets		Contribution to LRF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
25	9.34E-11	#IE-TB-MISC	THE FLOOD INITIATING EVENT FOR A SIGNIFICANT FLOOD IN THE TURBINE ROOM	0.5	31.7
		I-ATWS-RPMCF	FAILURE TO SCRAM DUE TO MECHANICAL FAILURES		
		PDS_2	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-2		
		PI-SGTR	PRESSURE INDUECD SGTR PROBABILITY UNDER LSSB, ATWS, FWLB		
26	7.42E-11	#IE-78-19A-FP-M	THE FLOOD INITIATING EVENT FOR A MODERATE BREAK OF FP PIPING IN ROOM 078-A19A	0.4	32.2
		ERVC	FAILURE OF ERVC SYSTEM		
		PDS_14	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14		
		PFHBWQ3-SW2OUATBCD	3/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01B,1C,1D FAIL TO OPEN		

Table 19.1-67 (14 of 50)

Rank	Frequency (/yr)	Cutsets		Contribution to LRF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
27	6.53E-11	#IE-78-10C-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 078-A10C	0.4	32.5
		ERVC	FAILURE OF ERVC SYSTEM		
		FPOPH-1-ISO-FL	OPERATOR FAILS TO ISOLATE THE FP LINE BREAK		
		PDS_14	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14		
		PFHBWQ2-SW2OUATBD	2/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01B,1D FAIL TO OPEN		
28	6.49E-11	#IE-78-19B-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 078-A19B	0.4	32.9
		ERVC	FAILURE OF ERVC SYSTEM		
		FPOPH-1-ISO-FL	OPERATOR FAILS TO ISOLATE THE FP LINE BREAK		
		PDS_14	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14		
		PFHBWQ2-SW2OUATAC	2/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1C FAIL TO OPEN		

Table 19.1-67 (15 of 50)

Rank	Frequency (/yr)	Cutsets		Contribution to LRF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
29	5.86E-11	#IE-78-19A-FP-M	THE FLOOD INITIATING EVENT FOR A MODERATE BREAK OF FP PIPING IN ROOM 078-A19A	0.3	33.3
		H-CI-OPEN	OPERATOR FAILS TO RECOVERY FOR CIS ISOLATION		
		PDS_6	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-6		
		PFHBWQ4-SW2OUAT	CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1B,1C,1D FAIL TO OPEN		
30	5.73E-11	#IE-78-19B-FP-M	BASED ON THE ABOVE DISCUSSIONS, TWO SCENARIOS ARE DEFINED FOR FP BREAKS IN 078-A19B	0.3	33.6
		H-CI-OPEN	OPERATOR FAILS TO RECOVERY FOR CIS ISOLATION		
		PDS_6	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-6		
		PFHBWQ3-SW2OUATACD	3/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1C,1D FAIL TO OPEN		

Table 19.1-67 (16 of 50)

Rank	Frequency (/yr)	Cutsets		Contribution to LRF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
31	5.54E-11	#IE-78-19A-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 078-A19A	0.3	33.9
		ERVC	FAILURE OF ERVC SYSTEM		
		FPOPH-1-ISO-FL	OPERATOR FAILS TO ISOLATE THE FP LINE BREAK		
		PDS_14	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14		
		PFHBWQ2-SW2OUATBD	2/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01B,1D FAIL TO OPEN		
32	5.10E-11	#IE-100-10B-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 078-A10B	0.3	34.2
		ERVC	FAILURE OF ERVC SYSTEM		
		PDS_14	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14		
		PFHBWQ3-SW2OUATACD	3/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1C,1D FAIL TO OPEN		

Table 19.1-67 (17 of 50)

Rank	Frequency (/yr)	Cutsets		Contribution to LRF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
33	4.93E-11	#IE-78-01D-FP-M	THE FLOOD INITIATING EVENT FOR A MODERATE BREAK OF FP PIPING IN ROOM 078-A01D	0.3	34.5
		ERVC	FAILURE OF ERVC SYSTEM		
		PDS_14	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14		
		PFHBWQ3-SW2OUATABC	3/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1B,1C FAIL TO OPEN		
34	4.79E-11	#IE-78-19B-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 078-A19B	0.3	34.8
		ERVC	FAILURE OF ERVC SYSTEM		
		FPOPH-1-ISO-FL	OPERATOR FAILS TO ISOLATE THE FP LINE BREAK		
		PDS_14	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14		
		PFHBO1A-SW01A-H2	FAILS TO OPEN OF PCB SW01A-H2 OF 4.16KV SWGR SW01A FROM UAT		
		PFHBO2A-SW01C-C2	FAILS TO OPEN OF PCB SW01C-C2 OF 4.16KV SWGR SW01C FROM UAT		

Table 19.1-67 (18 of 50)

Rank	Frequency (/yr)	Cutsets		Contribution to LRF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
35	4.09E-11	#IE-78-19A-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 078-A19A	0.2	35.0
		ERVC	FAILURE OF ERVC SYSTEM		
		FPOPH-1-ISO-FL	OPERATOR FAILS TO ISOLATE THE FP LINE BREAK		
		PDS_14	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14		
		PFHBO1B-SW01B-H2	FAILS TO OPEN OF PCB SW01B-H2 OF 4.16KV SWGR SW01B FROM UAT		
		PFHBO2B-SW01D-G2	FAILS TO OPEN OF PCB SW01D-G2 OF 4.16KV SWGR SW01D FROM UAT		
36	4.03E-11	#IE-100-10B-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 078-A10B	0.2	35.3
		H-CI-OPEN	OPERATOR FAILS TO RECOVERY FOR CIS ISOLATION		
		PDS_6	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-6		
		PFHBWQ4-SW2OUAT	CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1B,1C,1D FAIL TO OPEN		

Table 19.1-67 (19 of 50)

Rank	Frequency (/yr)	Cutsets		Contribution to LRF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
37	3.56E-11	#IE-78-19A-FP-M	THE FLOOD INITIATING EVENT FOR A MODERATE BREAK OF FP PIPING IN ROOM 078-A19A	0.2	35.5
		H-CI-OPEN	OPERATOR FAILS TO RECOVERY FOR CIS ISOLATION		
		PDS_6	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-6		
		PFHBWQ3-SW2OUATBCD	3/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01B,1C,1D FAIL TO OPEN		
38	2.91E-11	#IE-78-15D-AF-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF AF-RELATED PIPING IN ROOM 078-A15D	0.2	35.7
		ERVC	FAILURE OF ERVC SYSTEM		
		PDS_14	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14		
		PFHBWQ4-SW2OUAT	CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1B,1C,1D FAIL TO OPEN		

Table 19.1-67 (20 of 50)

Rank	Frequency (/yr)	Cutsets		Contribution to LRF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
39	2.84E-11	#IE-78-19B-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 078-A19B	0.2	35.8
		DGDGR-D-DGD	FAILS TO RUN OF EMERGENCY DIESEL GENERATOR DG01D		
		ERVC	FAILURE OF ERVC SYSTEM		
		PDS_14	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14		
		PFHBWQ2-SW2OUATAC	2/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1C FAIL TO OPEN		
40	2.72E-11	#IE-100-20A-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 100-A20A	0.2	36.0
		DGDGR-C-DGC	FAILS TO RUN OF EMERGENCY DIESEL GENERATOR DG01C		
		ERVC	FAILURE OF ERVC SYSTEM		
		PDS_14	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14		
		PFHBWQ2-SW2OUATBD	2/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01B,1D FAIL TO OPEN		

Table 19.1-67 (21 of 50)

Rank	Frequency (/yr)	Cutsets		Contribution to LRF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
41	2.63E-11	#IE-120-11B-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 120-A11B	0.2	36.1
		ERVC	FAILURE OF ERVC SYSTEM		
		PDS_14	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14		
		PFHBWQ4-SW2OUAT	CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1B,1C,1D FAIL TO OPEN		
42	2.44E-11	#IE-100-10B-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 078-A10B	0.1	36.3
		H-CI-OPEN	OPERATOR FAILS TO RECOVERY FOR CIS ISOLATION		
		PDS_6	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-6		
		PFHBWQ3-SW2OUATACD	3/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1C,1D FAIL TO OPEN		

Table 19.1-67 (22 of 50)

Rank	Frequency (/yr)	Cutsets		Contribution to LRF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
43	2.42E-11	#IE-78-19A-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 078-A19A	0.1	36.4
		DGDGR-C-DGC	FAILS TO RUN OF EMERGENCY DIESEL GENERATOR DG01C		
		ERVC	FAILURE OF ERVC SYSTEM		
		PDS_14	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14		
		PFHBWQ2-SW2OUATBD	2/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01B,1D FAIL TO OPEN		
44	2.25E-11	#IE-78-19B-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 078-A19B	0.1	36.6
		ERVC	FAILURE OF ERVC SYSTEM		
		PDS_14	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14		
		PFHBWQ2-SW2OUATBD	2/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01B,1D FAIL TO OPEN		
		WOCHM2A-CH02B	ECW CHILLER 02B TRAIN UNAVAILABLE DUE TO T&M		

Table 19.1-67 (23 of 50)

Rank	Frequency (/yr)	Cutsets		Contribution to LRF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
45	2.16E-11	#IE-100-20A-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 100-A20A	0.1	36.7
		ERVC	FAILURE OF ERVC SYSTEM		
		PDS_14	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14		
		PFHBWQ2-SW2OUATBD	2/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01B,1D FAIL TO OPEN		
		WOCHM2A-CH02A	ECW CHILLER 02A TRAIN UNAVAILABLE DUE TO T&M		
46	2.09E-11	#IE-78-19B-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 078-A19B	0.1	36.8
		DGDGR-D-DGD	FAILS TO RUN OF EMERGENCY DIESEL GENERATOR DG01D		
		ERVC	FAILURE OF ERVC SYSTEM		
		PDS_14	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14		
		PFHBO1A-SW01A-H2	FAILS TO OPEN OF PCB SW01A-H2 OF 4.16KV SWGR SW01A FROM UAT		
		PFHBO2A-SW01C-C2	FAILS TO OPEN OF PCB SW01C-C2 OF 4.16KV SWGR SW01C FROM UAT		

Table 19.1-67 (24 of 50)

Rank	Frequency (/yr)	Cutsets		Contribution to LRF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
47	2.01E-11	#IE-100-20A-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 100-A20A	0.1	36.9
		DGDGR-C-DGC	FAILS TO RUN OF EMERGENCY DIESEL GENERATOR DG01C		
		ERVC	FAILURE OF ERVC SYSTEM		
		PDS_14	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14		
		PFHBO1B-SW01B-H2	FAILS TO OPEN OF PCB SW01B-H2 OF 4.16KV SWGR SW01B FROM UAT		
		PFHBO2B-SW01D-G2	FAILS TO OPEN OF PCB SW01D-G2 OF 4.16KV SWGR SW01D FROM UAT		
48	1.94E-11	#IE-78-19B-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 078-A19B	0.1	37.0
		ERVC	FAILURE OF ERVC SYSTEM		
		PDS_14	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14		
		PFHBWQ2-SW2OUATAC	2/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1C FAIL TO OPEN		
		WOOPH-B-1/2B	OPERATOR FAILS TO OPERATE ECW PUMPS PP01/2B		

Table 19.1-67 (25 of 50)

Rank	Frequency (/yr)	Cutsets		Contribution to LRF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
49	1.92E-11	#IE-78-19A-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 078-A19A	0.1	37.1
		ERVC	FAILURE OF ERVC SYSTEM		
		PDS_14	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14		
		PFHBWQ2-SW2OUATBD	2/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01B,1D FAIL TO OPEN		
		WOCHM2A-CH02A	ECW CHILLER 02A TRAIN UNAVAILABLE DUE TO T&M		
50	1.90E-11	#IE-137-29B-FP-M	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 137-A29B	0.1	37.3
		ERVC	FAILURE OF ERVC SYSTEM		
		PDS_14	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14		
		PFHBO1A-SW01A-H2	FAILS TO OPEN OF PCB SW01A-H2 OF 4.16KV SWGR SW01A FROM UAT		
		WOCHM2A-CH02A	ECW CHILLER 02A TRAIN UNAVAILABLE DUE TO T&M		

Table 19.1-67 (26 of 50)

Rank	Frequency (/yr)	Cutsets		Contribution to LRF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
51	1.88E-11	#IE-100-37B-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 100-A37B	0.1	37.4
		ERVC	FAILURE OF ERVC SYSTEM		
		PDS_14	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14		
		PFHBWQ2-SW2OUATAC	2/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1C FAIL TO OPEN		
52	1.86E-11	#IE-100-20A-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 100-A20A	0.1	37.5
		ERVC	FAILURE OF ERVC SYSTEM		
		PDS_14	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14		
		PFHBWQ2-SW2OUATBD	2/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01B,1D FAIL TO OPEN		
		WOOPH-A-1/2A	OPERATOR FAILS TO OPERATE ECW PUMPS PP01/2A		

Table 19.1-67 (27 of 50)

Rank	Frequency (/yr)	Cutsets		Contribution to LRF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
53	1.79E-11	#IE-78-19A-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 078-A19A	0.1	37.6
		DGDGR-C-DGC	FAILS TO RUN OF EMERGENCY DIESEL GENERATOR DG01C		
		ERVC	FAILURE OF ERVC SYSTEM		
		PDS_14	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14		
		PFHBO1B-SW01B-H2	FAILS TO OPEN OF PCB SW01B-H2 OF 4.16KV SWGR SW01B FROM UAT		
		PFHBO2B-SW01D-G2	FAILS TO OPEN OF PCB SW01D-G2 OF 4.16KV SWGR SW01D FROM UAT		
54	1.78E-11	#IE-78-19B-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 078-A19B	0.1	37.7
		ERVC	FAILURE OF ERVC SYSTEM		
		FPOPH-1-ISO-FL	OPERATOR FAILS TO ISOLATE THE FP LINE BREAK		
		PDS_14	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14		
		PFHBWQ3-SW2OUATABC	3/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1B,1C FAIL TO OPEN		

Table 19.1-67 (28 of 50)

Rank	Frequency (/yr)	Cutsets		Contribution to LRF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
55	1.77E-11	#IE-78-44B-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 078-A44B	0.1	37.8
		DGDGR-D-DGD	FAILS TO RUN OF EMERGENCY DIESEL GENERATOR DG01D		
		ERVC	FAILURE OF ERVC SYSTEM		
		PDS_14	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14		
		PFHBWQ2-SW2OUATAC	2/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1C FAIL TO OPEN		
56	1.77E-11	#IE-78-15D-AF-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 078-A15D	0.1	37.9
		ERVC	FAILURE OF ERVC SYSTEM		
		PDS_14	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14		
		PFHBWQ3-SW2OUATABC	3/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1B,1C FAIL TO OPEN		

Table 19.1-67 (29 of 50)

Rank	Frequency (/yr)	Cutsets		Contribution to LRF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
57	1.66E-11	#IE-78-19B-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 078-A19B	0.1	38.0
		ERVC	FAILURE OF ERVC SYSTEM		
		PDS_14	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14		
		PFHBO1A-SW01A-H2	FAILS TO OPEN OF PCB SW01A-H2 OF 4.16KV SWGR SW01A FROM UAT		
		PFHBO2A-SW01C-C2	FAILS TO OPEN OF PCB SW01C-C2 OF 4.16KV SWGR SW01C FROM UAT		
		WOCHM2B-CH02B	ECW CHILLER 02B TRAIN UNAVAILABLE DUE TO T&M		
58	1.65E-11	#IE-78-19A-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 078-A19A	0.1	38.1
		ERVC	FAILURE OF ERVC SYSTEM		
		PDS_14	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14		
		PFHBWQ2-SW2OUATBD	2/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01B,1D FAIL TO OPEN		
		WOOPH-A-1/2A	OPERATOR FAILS TO OPERATE ECW PUMPS PP01/2A		

Table 19.1-67 (30 of 50)

Rank	Frequency (/yr)	Cutsets		Contribution to LRF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
59	1.64E-11	#IE-78-19B-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 078-A19B	0.1	38.2
		DGDGM-D-DGD	DG 01D UNAVAILABLE DUE TO MAINTENANCE		
		ERVC	FAILURE OF ERVC SYSTEM		
		PDS_14	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14		
		PFHBWQ2-SW2OUATAC	2/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1C FAIL TO OPEN		
60	1.60E-11	#IE-120-11B-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 120-A11B	0.1	38.3
		ERVC	FAILURE OF ERVC SYSTEM		
		PDS_14	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14		
		PFHBWQ3-SW2OUATACD	3/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1C,1D FAIL TO OPEN		

Table 19.1-67 (31 of 50)

Rank	Frequency (/yr)	Cutsets		Contribution to LRF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
61	1.59E-11	#IE-100-20A-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 100-A20A	0.1	38.4
		ERVC	FAILURE OF ERVC SYSTEM		
		PDS_14	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14		
		PFHBO1B-SW01B-H2	FAILS TO OPEN OF PCB SW01B-H2 OF 4.16KV SWGR SW01B FROM UAT		
		PFHBO2B-SW01D-G2	FAILS TO OPEN OF PCB SW01D-G2 OF 4.16KV SWGR SW01D FROM UAT		
		WOCHM2A-CH02A	ECW CHILLER 02A TRAIN UNAVAILABLE DUE TO T&M		
62	1.57E-11	#IE-100-20A-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 100-A20A	0.1	38.5
		DGDGM-C-DGC	DG 01C UNAVAILABLE DUE TO MAINTENANCE		
		ERVC	FAILURE OF ERVC SYSTEM		
		PDS_14	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14		
		PFHBWQ2-SW2OUATBD	2/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01B,1D FAIL TO OPEN		

Table 19.1-67 (32 of 50)

Rank	Frequency (/yr)	Cutsets		Contribution to LRF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
63	1.52E-11	#IE-78-19A-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 078-A19A	0.1	38.6
		ERVC	FAILURE OF ERVC SYSTEM		
		FPOPH-1-ISO-FL	OPERATOR FAILS TO ISOLATE THE FP LINE BREAK		
		PDS_14	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14		
		PFHBWQ3-SW2OUATABD	3/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1B,1D FAIL TO OPEN		
64	1.50E-11	#IE-78-19B-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 078-A19B	0.1	38.6
		ERVC	FAILURE OF ERVC SYSTEM		
		PDS_14	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14		
		PFHBWQ2-SW2OUATAC	2/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1C FAIL TO OPEN		
		SXMPM2B-PP02B	ESW PUMP PP02B UNAVAILABLE DUE TO T/M		

Table 19.1-67 (33 of 50)

Rank	Frequency (/yr)	Cutsets		Contribution to LRF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
65	1.48E-11	#IE-78-19B-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 078-A19B	0.1	38.7
		ERVC	FAILURE OF ERVC SYSTEM		
		PDS_14	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14		
		PFHBWQ2-SW2OUATAC	2/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1C FAIL TO OPEN		
		WOCHS2B-CH02B	ECW CHILLER CH02B FAILS TO START ON DEMAND		
66	1.44E-11	#IE-100-20A-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 100-A20A	0.1	38.8
		ERVC	FAILURE OF ERVC SYSTEM		
		PDS_14	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14		
		PFHBWQ2-SW2OUATBD	2/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01B,1D FAIL TO OPEN		
		SXMPM2A-PP02A	ESW PUMP PP02A UNAVAILABLE DUE TO T/M		

Table 19.1-67 (34 of 50)

Rank	Frequency (/yr)	Cutsets		Contribution to LRF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
67	1.43E-11	#IE-78-19B-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 078-A19B	0.1	38.9
		ERVC	FAILURE OF ERVC SYSTEM		
		PDS_14	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14		
		PFHBO1A-SW01A-H2	FAILS TO OPEN OF PCB SW01A-H2 OF 4.16KV SWGR SW01A FROM UAT		
		PFHBO2A-SW01C-C2	FAILS TO OPEN OF PCB SW01C-C2 OF 4.16KV SWGR SW01C FROM UAT		
		WOOPH-B-1/2B	OPERATOR FAILS TO OPERATE ECW PUMPS PP01/2B		
68	1.42E-11	#IE-100-20A-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 100-A20A	0.1	39.0
		ERVC	FAILURE OF ERVC SYSTEM		
		PDS_14	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14		
		PFHBWQ2-SW2OUATBD	2/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01B,1D FAIL TO OPEN		
		WOCHS2A-CH02A	ECW CHILLER CH02A FAILS TO START ON DEMAND		

Table 19.1-67 (35 of 50)

Rank	Frequency (/yr)	Cutsets		Contribution to LRF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
69	1.42E-11	#IE-78-19A-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 078-A19A	0.1	39.1
		ERVC	FAILURE OF ERVC SYSTEM		
		PDS_14	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14		
		PFHBO1B-SW01B-H2	FAILS TO OPEN OF PCB SW01B-H2 OF 4.16KV SWGR SW01B FROM UAT		
		PFHBO2B-SW01D-G2	FAILS TO OPEN OF PCB SW01D-G2 OF 4.16KV SWGR SW01D FROM UAT		
		WOCHM2A-CH02A	ECW CHILLER 02A TRAIN UNAVAILABLE DUE TO T&M		
70	1.41E-11	#IE-78-19A-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 078-A19A	0.1	39.2
		ERVC	FAILURE OF ERVC SYSTEM		
		PDS_14	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14		
		PFHBWQ2-SW2OUATAC	2/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1C FAIL TO OPEN		
		WOCHM2B-CH02B	ECW CHILLER 02B TRAIN UNAVAILABLE DUE TO T&M		

Table 19.1-67 (36 of 50)

Rank	Frequency (/yr)	Cutsets		Contribution to LRF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
71	1.40E-11	#IE-78-19A-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 078-A19A	0.1	39.2
		DGDGM-C-DGC	DG 01C UNAVAILABLE DUE TO MAINTENANCE		
		ERVC	FAILURE OF ERVC SYSTEM		
		PDS_14	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14		
		PFHBWQ2-SW2OUATBD	2/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01B,1D FAIL TO OPEN		
72	1.39E-11	#IE-78-01D-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 078-A01D	0.1	39.3
		DGDGR-B-DGB	FAILS TO RUN OF EMERGENCY DIESEL GENERATOR DG01B		
		ERVC	FAILURE OF ERVC SYSTEM		
		PDS_14	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14		
		PFHBWQ2-SW2OUATAC	2/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1C FAIL TO OPEN		

Table 19.1-67 (37 of 50)

Rank	Frequency (/yr)	Cutsets		Contribution to LRF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
73	1.39E-11	#IE-100-37B-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 100-A37B	0.1	39.4
		ERVC	FAILURE OF ERVC SYSTEM		
		PDS_14	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14		
		PFHBO1A-SW01A-H2	FAILS TO OPEN OF PCB SW01A-H2 OF 4.16KV SWGR SW01A FROM UAT		
		PFHBO2A-SW01C-C2	FAILS TO OPEN OF PCB SW01C-C2 OF 4.16KV SWGR SW01C FROM UAT		
74	1.37E-11	#IE-100-20A-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 100-A20A	0.1	39.5
		ERVC	FAILURE OF ERVC SYSTEM		
		PDS_14	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14		
		PFHBO1B-SW01B-H2	FAILS TO OPEN OF PCB SW01B-H2 OF 4.16KV SWGR SW01B FROM UAT		
		PFHBO2B-SW01D-G2	FAILS TO OPEN OF PCB SW01D-G2 OF 4.16KV SWGR SW01D FROM UAT		
		WOOPH-A-1/2A	OPERATOR FAILS TO OPERATE ECW PUMPS PP01/2A		

Table 19.1-67 (38 of 50)

Rank	Frequency (/yr)	Cutsets		Contribution to LRF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
75	1.36E-11	#IE-78-19B-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 078-A19B	0.1	39.6
		DGDGR-D-DGD	FAILS TO RUN OF EMERGENCY DIESEL GENERATOR DG01D		
		H-CI-OPEN	OPERATOR FAILS TO RECOVERY FOR CIS ISOLATION		
		PDS_6	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-6		
		PFHBWQ2-SW2OUATAC	2/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1C FAIL TO OPEN		
76	1.31E-11	#IE-78-44B-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 078-A44B	0.1	39.6
		DGDGR-D-DGD	FAILS TO RUN OF EMERGENCY DIESEL GENERATOR DG01D		
		ERVC	FAILURE OF ERVC SYSTEM		
		PDS_14	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14		
		PFHBO1A-SW01A-H2	FAILS TO OPEN OF PCB SW01A-H2 OF 4.16KV SWGR SW01A FROM UAT		
		PFHBO2A-SW01C-C2	FAILS TO OPEN OF PCB SW01C-C2 OF 4.16KV SWGR SW01C FROM UAT		

Table 19.1-67 (39 of 50)

Rank	Frequency (/yr)	Cutsets		Contribution to LRF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
77	1.31E-11	#IE-100-20A-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 100-A20A	0.1	39.7
		DGDGR-C-DGC	FAILS TO RUN OF EMERGENCY DIESEL GENERATOR DG01C		
		H-CI-OPEN	OPERATOR FAILS TO RECOVERY FOR CIS ISOLATION		
		PDS_6	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-6		
		PFHBWQ2-SW2OUATBD	2/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01B,1D FAIL TO OPEN		
78	1.28E-11	#IE-78-19A-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 078-19A	0.1	39.8
		ERVC	FAILURE OF ERVC SYSTEM		
		PDS_14	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14		
		PFHBWQ2-SW2OUATBD	2/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01B,1D FAIL TO OPEN		
		SXMPM2A-PP02A	ESW PUMP PP02A UNAVAILABLE DUE TO T/M		

Table 19.1-67 (40 of 50)

Rank	Frequency (/yr)	Cutsets		Contribution to LRF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
79	1.27E-11	#IE-137-29B-FP-M	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 137-A29B	0.1	39.9
		ERVC	FAILURE OF ERVC SYSTEM		
		PDS_14	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14		
		PFHBO1A-SW01A-H2	FAILS TO OPEN OF PCB SW01A-H2 OF 4.16KV SWGR SW01A FROM UAT		
		SXMPM2A-PP02A	ESW PUMP PP02A UNAVAILABLE DUE TO T/M		
80	1.26E-11	#IE-78-19A-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 078-19A	0.1	39.9
		ERVC	FAILURE OF ERVC SYSTEM		
		PDS_14	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14		
		PFHBWQ2-SW2OUATBD	2/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01B,1D FAIL TO OPEN		
		WOCHM2A-CH02A	ECW CHILLER 02A TRAIN UNAVAILABLE DUE TO T&M		

Table 19.1-67 (41 of 50)

Rank	Frequency (/yr)	Cutsets		Contribution to LRF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
81	1.26E-11	#IE-120-11B-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 120-11B	0.1	40.0
		H-CI-OPEN	OPERATOR FAILS TO RECOVERY FOR CIS ISOLATION		
		PDS_6	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-6		
		PFHBWQ4-SW2OUAT	CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1B,1C,1D FAIL TO OPEN		
82	1.25E-11	#IE-137-29B-FP-M	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 137-A29B	0.1	40.1
		CSMPM2A-PP01A	CS PUMP 1 PP01A UNAVAILABLE DUE TO MAINTENANCE		
		PDS_7	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-7		
		PFHBO1A-SW01A-H2	FAILS TO OPEN OF PCB SW01A-H2 OF 4.16KV SWGR SW01A FROM UAT		

Table 19.1-67 (42 of 50)

Rank	Frequency (/yr)	Cutsets		Contribution to LRF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
83	1.25E-11	#IE-137-29B-FP-M	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 137-A29B	0.1	40.2
		ERVC	FAILURE OF ERVC SYSTEM		
		PDS_14	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14		
		PFHBO1A-SW01A-H2	FAILS TO OPEN OF PCB SW01A-H2 OF 4.16KV SWGR SW01A FROM UAT		
		WOCHS2A-CH02A	ECW CHILLER CH02A FAILS TO START ON DEMAND		
84	1.22E-11	#IE-78-19A-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 078-19A	0.1	40.2
		ERVC	FAILURE OF ERVC SYSTEM		
		PDS_14	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14		
		PFHBO1B-SW01B-H2	FAILS TO OPEN OF PCB SW01B-H2 OF 4.16KV SWGR SW01B FROM UAT		
		PFHBO2B-SW01D-G2	FAILS TO OPEN OF PCB SW01D-G2 OF 4.16KV SWGR SW01D FROM UAT		
		WOOPH-A-1/2A	OPERATOR FAILS TO OPERATE ECW PUMPS PP01/2A		

Table 19.1-67 (43 of 50)

Rank	Frequency (/yr)	Cutsets		Contribution to LRF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
85	1.21E-11	#IE-78-19B-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 078-19B	0.1	40.3
		DGDGM-D-DGD	DG 01D UNAVAILABLE DUE TO MAINTENANCE		
		ERVC	FAILURE OF ERVC SYSTEM		
		PDS_14	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14		
		PFHBO1A-SW01A-H2	FAILS TO OPEN OF PCB SW01A-H2 OF 4.16KV SWGR SW01A FROM UAT		
		PFHBO2A-SW01C-C2	FAILS TO OPEN OF PCB SW01C-C2 OF 4.16KV SWGR SW01C FROM UAT		
86	1.21E-11	#IE-78-44B-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 078-44B	0.1	40.4
		ERVC	FAILURE OF ERVC SYSTEM		
		PDS_14	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14		
		PFHBWQ2-SW2OUATAC	2/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1C FAIL TO OPEN		
		WOOPH-B-1/2B	OPERATOR FAILS TO OPERATE ECW PUMPS PP01/2B		

Table 19.1-67 (44 of 50)

Rank	Frequency (/yr)	Cutsets		Contribution to LRF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
87	1.16E-11	#IE-78-19A-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 078-19A	0.1	40.4
		DGDGR-C-DGC	FAILS TO RUN OF EMERGENCY DIESEL GENERATOR DG01C		
		H-CI-OPEN	OPERATOR FAILS TO RECOVERY FOR CIS ISOLATION		
		PDS_6	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-6		
		PFHBWQ2-SW2OUATBD	2/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01B,1D FAIL TO OPEN		
88	1.16E-11	#IE-100-20A-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 100-A20A	0.1	40.5
		DGDGM-C-DGC	DG 01C UNAVAILABLE DUE TO MAINTENANCE		
		ERVC	FAILURE OF ERVC SYSTEM		
		PDS_14	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14		
		PFHBO1B-SW01B-H2	FAILS TO OPEN OF PCB SW01B-H2 OF 4.16KV SWGR SW01B FROM UAT		
		PFHBO2B-SW01D-G2	FAILS TO OPEN OF PCB SW01D-G2 OF 4.16KV SWGR SW01D FROM UAT		

Table 19.1-67 (45 of 50)

Rank	Frequency (/yr)	Cutsets		Contribution to LRF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
89	1.13E-11	#IE-78-19B-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 078-19B	0.1	40.6
		GWSVO-S-002	CTMT. ISOL. SOV GW-002 FAIL TO CLOSE		
		PDS_6	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-6		
		PFHBWQ4-SW2OUAT	CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1B,1C,1D FAIL TO OPEN		
90	1.11E-11	#IE-78-19B-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 078-19B	0.1	40.6
		ERVC	FAILURE OF ERVC SYSTEM		
		PDS_14	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14		
		PFHBO1A-SW01A-H2	FAILS TO OPEN OF PCB SW01A-H2 OF 4.16KV SWGR SW01A FROM UAT		
		PFHBO2A-SW01C-C2	FAILS TO OPEN OF PCB SW01C-C2 OF 4.16KV SWGR SW01C FROM UAT		
		SXMPM2B-PP02B	ESW PUMP PP02B UNAVAILABLE DUE TO T/M		

Table 19.1-67 (46 of 50)

Rank	Frequency (/yr)	Cutsets		Contribution to LRF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
91	1.09E-11	#IE-78-19B-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 078-19B	0.1	40.7
		ERVC	FAILURE OF ERVC SYSTEM		
		PDS_14	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14		
		PFHBO1A-SW01A-H2	FAILS TO OPEN OF PCB SW01A-H2 OF 4.16KV SWGR SW01A FROM UAT		
		PFHBO2A-SW01C-C2	FAILS TO OPEN OF PCB SW01C-C2 OF 4.16KV SWGR SW01C FROM UAT		
		WOCHS2B-CH02B	ECW CHILLER CH02B FAILS TO START ON DEMAND		
92	1.09E-11	#IE-78-19B-FP-M	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 078-19B	0.1	40.8
		DGDGR-D-DGD	FAILS TO RUN OF EMERGENCY DIESEL GENERATOR DG01D		
		ERVC	FAILURE OF ERVC SYSTEM		
		PDS_14	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14		
		PFHBWQ2-SW2OUATAC	2/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1C FAIL TO OPEN		

Table 19.1-67 (47 of 50)

Rank	Frequency (/yr)	Cutsets		Contribution to LRF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
93	1.08E-11	#IE-100-20A-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 100-A20A	0.1	40.8
		GWSVO-S-002	CTMT. ISOL. SOV GW-002 FAIL TO CLOSE		
		PDS_6	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-6		
		PFHBWQ4-SW2OUAT	CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1B,1C,1D FAIL TO OPEN		
94	1.08E-11	#IE-78-19B-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 078-19B	0.1	40.9
		H-CI-OPEN	OPERATOR FAILS TO RECOVERY FOR CIS ISOLATION		
		PDS_6	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-6		
		PFHBWQ2-SW2OUATAC	2/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1C FAIL TO OPEN		
		WOCHM2B-CH02B	ECW CHILLER 02B TRAIN UNAVAILABLE DUE TO T&M		

Table 19.1-67 (48 of 50)

Rank	Frequency (/yr)	Cutsets		Contribution to LRF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
95	1.06E-11	#IE-100-20A-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 100-A20A	0.1	41.0
		ERVC	FAILURE OF ERVC SYSTEM		
		PDS_14	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14		
		PFHBO1B-SW01B-H2	FAILS TO OPEN OF PCB SW01B-H2 OF 4.16KV SWGR SW01B FROM UAT		
		PFHBO2B-SW01D-G2	FAILS TO OPEN OF PCB SW01D-G2 OF 4.16KV SWGR SW01D FROM UAT		
		SXMPM2A-PP02A	ESW PUMP PP02A UNAVAILABLE DUE TO T/M		
96	1.05E-11	#IE-100-20A-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 100-A20A	0.1	41.0
		ERVC	FAILURE OF ERVC SYSTEM		
		PDS_14	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14		
		PFHBO1B-SW01B-H2	FAILS TO OPEN OF PCB SW01B-H2 OF 4.16KV SWGR SW01B FROM UAT		
		PFHBO2B-SW01D-G2	FAILS TO OPEN OF PCB SW01D-G2 OF 4.16KV SWGR SW01D FROM UAT		
		WOCHS2A-CH02A	ECW CHILLER CH02A FAILS TO START ON DEMAND		

Table 19.1-67 (49 of 50)

Rank	Frequency (/yr)	Cutsets		Contribution to LRF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
97	1.04E-11	#IE-78-44B-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 078-44B	0.1	41.1
		ERVC	FAILURE OF ERVC SYSTEM		
		PDS_14	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14		
		PFHBO1A-SW01A-H2	FAILS TO OPEN OF PCB SW01A-H2 OF 4.16KV SWGR SW01A FROM UAT		
		PFHBO2A-SW01C-C2	FAILS TO OPEN OF PCB SW01C-C2 OF 4.16KV SWGR SW01C FROM UAT		
		WOCHM2B-CH02B	ECW CHILLER 02B TRAIN UNAVAILABLE DUE TO T&M		
98	1.04E-11	#IE-100-20A-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 100-A20A	0.1	41.1
		H-CI-OPEN	OPERATOR FAILS TO RECOVERY FOR CIS ISOLATION		
		PDS_6	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-6		
		PFHBWQ2-SW2OUATBD	2/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01B,1D FAIL TO OPEN		
		WOCHM2A-CH02A	ECW CHILLER 02A TRAIN UNAVAILABLE DUE TO T&M		

Table 19.1-67 (50 of 50)

Rank	Frequency (/yr)	Cutsets		Contribution to LRF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
99	1.03E-11	#IE-78-19A-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 078-19A	0.1	41.2
		DGDGM-C-DGC	DG 01C UNAVAILABLE DUE TO MAINTENANCE		
		ERVC	FAILURE OF ERVC SYSTEM		
		PDS_14	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14		
		PFHBO1B-SW01B-H2	FAILS TO OPEN OF PCB SW01B-H2 OF 4.16KV SWGR SW01B FROM UAT		
		PFHBO2B-SW01D-G2	FAILS TO OPEN OF PCB SW01D-G2 OF 4.16KV SWGR SW01D FROM UAT		
100	1.03E-11	#IE-78-01D-FP-X	THE FLOOD INITIATING EVENT FOR A MAJOR BREAK OF FP PIPING IN ROOM 078-01D	0.1	41.3
		DGDGR-B-DGB	FAILS TO RUN OF EMERGENCY DIESEL GENERATOR DG01B		
		ERVC	FAILURE OF ERVC SYSTEM		
		PDS_14	CONDITONAL LARGE RELEASE PROBABILITY FOR PDS-14		
		PFHBO1A-SW01A-H2	FAILS TO OPEN OF PCB SW01A-H2 OF 4.16KV SWGR SW01A FROM UAT		
		PFHBO2A-SW01C-C2	FAILS TO OPEN OF PCB SW01C-C2 OF 4.16KV SWGR SW01C FROM UAT		

Table 19.1-68 (1 of 13)

Internal Flooding PRA Key Basic Events by RAW (CDF)

Basic Event	Description	RAW
I-ATWS-RPMCF	FAILURE TO SCRAM DUE TO MECHANICAL FAILURES	1.65E+04
DCBSY-B-MC01B	BUS FAULTS ON 1E 125VDC BUS MC01B	2.58E+02
DCBSY-A-MC01A	BUS FAULTS ON 1E 125VDC BUS MC01A	2.46E+02
SXFLP-S-FT0123AB	ESW DEBIS FILTER FT01A PLUGGED	8.60E+01
SXMVR-A-MV072	LOSS OF SX DIV.II DUE TO THE MOV072 SPURIOUS OPEN (FLOW DIVERSION)	6.55E+01
SXMVR-A-MV071	LOSS OF SX DIV. I DUE TO THE MOV071 SPURIOUS CLOSURE	6.55E+01
CCHEY02A-HE02A	CCW Hx. HE02A FAILS WHILE OPERATING	5.69E+01
CCHEY01A-HE01A	CCW Hx. HE01A FAILS WHILE OPERATING	5.69E+01
SISPP-S-IRWST	FAILURE OF IRWST SUMP DUE TO PLUGGING	4.90E+01
SXMVR-B-MV073	LOSS OF SX DIV. I DUE TO THE MOV071 SPURIOUS CLOSURE	4.71E+01
SXMVR-B-MV074	LOSS OF SX DIV.II DUE TO THE MOV074 SPURIOUS OPEN (FLOW DIVERSION)	4.71E+01
CCHEY02B-HE02B	CCW Hx. HE02B FAILS WHILE OPERATING	4.33E+01
CCHEY01B-HE01B	CCW Hx. HE01B FAILS WHILE OPERATING	4.33E+01
PFHBO1A-SW01A-H2	FAILS TO OPEN OF PCB SW01A-H2 OF 4.16KV SWGR SW01A FROM UAT	2.83E+01
PFHBO1B-SW01B-H2	FAILS TO OPEN OF PCB SW01B-H2 OF 4.16KV SWGR SW01B FROM UAT	2.30E+01

Table 19.1-68 (2 of 13)

Basic Event	Description	RAW
PALXKD2-PA06CD	2/2 CCF OF LOOP CONTROLLER PA06C, PA06D	1.97E+01
PFHBO2A-SW01C-C2	FAILS TO OPEN OF PCB SW01C-C2 OF 4.16KV SWGR SW01C FROM UAT	1.10E+01
PFLOOP-TRANS	CONDITIONAL LOOP UPON TRANSIENTS	1.06E+01
NPXHM-N-SAT02N	SAT TR02N UNAVAILABLE DUE TO MAINTENANCE	9.31E+00
DCBTM-A-BT01A	CLASS 1E 125V DC BATTERY BT01A UNAVAILABLE DUE TO T&M	9.16E+00
PFBSY1A-SW01A	BUS FAULT ON 4.16KV SWGR SW01A	9.10E+00
NPXHM-M-SAT02M	SAT TR02M UNAVAILABLE DUE TO MAINTENANCE	8.83E+00
DCBTM-B-BT01B	CLASS 1E 125V DC BATTERY BT01B UNAVAILABLE DUE TO T&M	8.67E+00
PGBSY1A-LC01A	BUS FAULT ON 480V LC LC01A	8.49E+00
DCBSY-C-MC01C	BUS FAULTS ON 1E 125VDC BUS MC01C	7.80E+00
PFHBO2B-SW01D-G2	FAILS TO OPEN OF PCB SW01D-G2 OF 4.16KV SWGR SW01D FROM UAT	7.74E+00
DCBSY-D-MC01D	BUS FAULTS ON 1E 125VDC BUS MC01D	7.62E+00
PFBSY1B-SW01B	BUS FAULT ON 4.16KV SWGR SW01B	7.50E+00
PELXY-A-LX01A-P	FAILURE OF PRIMARY LOOP CONTROLLER OF 745-PE-LX01A	7.37E+00
PELXKD2-LX05AB	2/2 CCF OF LOOP CONTROLLER 745-LX05A, LX05B	7.29E+00
PGBSY1B-LC01B	BUS FAULT ON 480V LC LC01B	7.06E+00
PGXMY1A-TR01A	480V LC TRANSFORMER LC-TR01A FAULT	7.01E+00

Table 19.1-68 (3 of 13)

Basic Event	Description	RAW
IPINM-A-IN01A	CLASS 1E 120V AC INVERTER IN01A UNAVAILABLE DUE TO T&M	6.99E+00
PFBSY2A-SW01C	BUS FAULT ON 4.16KV SWGR SW01C	6.60E+00
PGBSY2A-LC01C	BUS FAULT ON 480V LC LC01C	6.60E+00
IPINM-B-IN01B	CLASS 1E 120V AC INVERTER IN01B UNAVAILABLE DUE TO T&M	6.57E+00
SXMPR1A-PP01A	ESW PUMP PP01A FAILS TO RUN	6.52E+00
VOHVKD2-HV33A/33B	2/2 CCF OF FOR CUBICLE COOLER HV33A/33B	6.43E+00
AFMPM2A-MDP02A	AFW MDP PP02A UNAVAILABLE DUE TO T/M	6.19E+00
PELXY-C-LX02C-P	FAILURE OF PRIMARY LOOP CONTROLLER OF 745-PE-LX02C	6.19E+00
PGXMY2A-TR01C	480V LC TRANSFORMER LC-TR01C FAULT	6.10E+00
VOHVM2A-HV33A	CUBICLE COOLER HV33A UNAVAILABLE DUE TO T&M	5.90E+00
VGAHR1A-AH01A	ESW PUMP ROOM I. FAN AH01A FAILS TO RUN	5.80E+00
CCMPR1A-PP01A	CCW PUMP PP01A FAILS TO RUN	5.77E+00
PGXMY1B-TR01B	480V LC TRANSFORMER LC-TR01B FAULT	5.72E+00
VOHVWD2-HV33A/33B	2/2 CCF OF START FOR CUBICLE COOLER HV33A/33B	5.59E+00
VOHVR2A-HV33A	FAILS TO RUN OF MAFP ROOM A CUBICLE COOLER HV33A	5.55E+00
SXMPR1B-PP01B	ESW PUMP PP01B FAILS TO RUN	5.48E+00
AFMPS2A-MDP02A	FAILS TO START AFW MDP PP02A	5.46E+00
VOHVS2A-HV33A	FAILS TO START OF MAFP ROOM A CUBICLE COOLER HV33A	5.39E+00

Table 19.1-68 (4 of 13)

Basic Event	Description	RAW
SXAHR-A-AH01A	ESW COOLING TOWER FAN AH01A FAILS TO RUN	5.39E+00
PELXY-D-LX02D-P	FAILURE OF PRIMARY LOOP CONTROLLER OF 745-PE-LX02D	5.36E+00
AFMPWD2-MDP02A/B	2/2 CCF OF FOR AFW MDP PP02/A/B FAIL TO START	5.26E+00
PEDOY-D-LX02D04	FAILURE OF DIGITAL OUTPUT MODULE 745-PE-LX02D BRANCH 04	5.19E+00
PGBSY1A-LC02A	BUS FAULT ON 480V LC LC02A	5.04E+00
CCMPR1B-PP01B	CCW PUMP PP01B FAILS TO RUN	4.95E+00
VGAHR1B-AH01B	ESW PUMP ROOM II. FAN AH01B FAILS TO RUN	4.94E+00
PGBSY2B-LC01D	BUS FAULT ON 480V LC LC01D	4.81E+00
PFBSY2B-SW01D	BUS FAULT ON 4.16KV SWGR SW01D	4.81E+00
PGXMY1A-TR02A	480V LC TRANSFORMER LC-TR02A FAULT	4.75E+00
SXAHR-B-AH01B	ESW COOLING TOWER FAN AH01B FAILS TO RUN	4.69E+00
PGXMY2B-TR01D	480V LC TRANSFORMER LC-TR01D FAULT	4.53E+00
PGBSY1B-LC02B	BUS FAULT ON 480V LC LC02B	4.46E+00
AFMPR2A-MDP02A	FAILS TO RUN AFW MDP PP02A	4.35E+00
RCPVO-C-201	POSRV V201 FAILS TO OPEN (HARDWARE FAIL)	4.23E+00
RCPVO-A-200	POSRV V200 FAILS TO OPEN (HARDWARE FAIL)	4.23E+00
PGXMY1B-TR02B	480V LC TRANSFORMER LC-TR02B FAULT	4.22E+00
RCPVO-B-202	POSRV V202 FAILS TO OPEN (HARDWARE FAIL)	3.84E+00
RCPVO-D-203	POSRV V203 FAILS TO OPEN (HARDWARE FAIL)	3.84E+00

Table 19.1-68 (5 of 13)

Basic Event	Description	RAW
AFMPM2B-MDP02B	AFW MDP PP02B UNAVAILABLE DUE TO T/M	3.73E+00
PHBSY1A-MC01A	BUS FAULT ON 480V MCC MC01A	3.72E+00
RCMVO-A-132	MV 132 FAILS TO OPEN	3.68E+00
RCMVO-C-133	MV 133 FAILS TO OPEN	3.68E+00
RCMVO-C-131	MV 131 FAILS TO OPEN	3.68E+00
RCMVO-A-130	MV 130 FAILS TO OPEN	3.68E+00
AFVVT2A-V1001A	AFW MDP02A SUCT. MANUAL VALVE V1001A TRANSFER CLOSED	3.59E+00
AFVVT2A-V1005A	AFW MDP01A DISCH. MANUAL VALVE V1005A TRANSFER CLOSED	3.59E+00
AFVVT2A-V1603	AFW MDP02A MINI FLOW LINE MANUAL VALVE V1603 TRANSFER CLOSED	3.59E+00
AFVVT2A-V1011A	AFW MDP02A MINI FLOW LINE MANUAL VALVE V1011A TRANSFER CLOSED	3.59E+00
PHBSY1A-MC02A	BUS FAULT ON 480V MCC MC02A	3.53E+00
VOHVM1B-HV33B	CUBICLE COOLER HV33B UNAVAILABLE DUE TO T&M	3.53E+00
WOTKB-A-TK01A	ECW COMPRESSION TANK TK01A FAILS CATASTROPHICALLY	3.52E+00
WOTKB-A-TK02A	ECW AIR SEPARATOR TK02A FAILS CATASTROPHICALLY	3.52E+00
PFHBC1A-SW01A-A2	FAILS TO CLOSE OF PCB SW01A-A2 OF 4.16KV SWGR SW01A	3.52E+00
RCMVO-D-135	MV 135 FAILS TO OPEN	3.43E+00
RCMVO-B-134	MV 134 FAILS TO OPEN	3.43E+00

Table 19.1-68 (6 of 13)

Basic Event	Description	RAW
RCMVO-B-136	MV 136 FAILS TO OPEN	3.43E+00
RCMVO-D-137	MV 137 FAILS TO OPEN	3.43E+00
WOCHM2A-CH02A	ECW CHILLER 02A TRAIN UNAVAILABLE DUE TO T&M	3.33E+00
SXMPM2A-PP02A	ESW PUMP PP02A UNAVAILABLE DUE TO T/M	3.29E+00
WOCHS2A-CH02A	ECW CHILLER CH02A FAILS TO START ON DEMAND	3.29E+00
VOHVR2B-HV33B	FAILS TO RUN OF MAFP ROOM B CUBICLE COOLER HV33B	3.28E+00
PEDOY-A-LX01A04	FAILURE OF DIGITAL OUTPUT MODULE LX01A BRANCH 04	3.25E+00
WOCHM2B-CH02B	ECW CHILLER 02B TRAIN UNAVAILABLE DUE TO T&M	3.25E+00
AFMPS2B-MDP02B	FAILS TO START AFW MDP PP02B	3.23E+00
PFHBC1B-SW01B-A2	FAILS TO CLOSE OF PCB SW01B-A2 OF 4.16KV SWGR SW01B	3.22E+00
SXMPM2B-PP02B	ESW PUMP PP02B UNAVAILABLE DUE TO T/M	3.21E+00
WOCHS2B-CH02B	ECW CHILLER CH02B FAILS TO START ON DEMAND	3.20E+00
WOMPM2A-PP02A	ECW PP02A TRAIN UNAVAILABLE DUE TO T&M	3.20E+00
VOHVS2B-HV33B	FAILS TO START OF MAFP ROOM B CUBICLE COOLER HV33B	3.18E+00
CCMPM2A-PP02A	CCW PUMP PP02A UNAVAILABLE DUE TO T/M	3.13E+00
WOMPM2B-PP02B	ECW PP02B TRAIN UNAVAILABLE DUE TO T&M	3.11E+00
PHBSY1B-MC01B	BUS FAULT ON 480V MCC MC01B	3.10E+00
PHBSY1B-MC02B	BUS FAULT ON 480V MCC MC02B	3.10E+00
CCMPM2B-PP02B	CCW PUMP PP02B UNAVAILABLE DUE TO T/M	3.05E+00
PALXY-D-PA06D-P	PRIMARY LOOP CONTROLLER 752-PA06D FAILS TO RUN	3.04E+00

Table 19.1-68 (7 of 13)

Basic Event	Description	RAW
DCBTT-A-BT01A	CLASS 1E 125V DC BATTERY BT01A FAILS BETWEEN TEST INTERVAL	3.01E+00
VGAHM2A-AH02A	ESW PUMP A FAN 605-VG-AH02A UNAVAILABLE DUE TO T&M	2.96E+00
VOHVM2A-HV32A	CUBICLE COOLER HV32A UNAVAILABLE DUE TO T&M	2.96E+00
SXAHM-A-AH02A	ESW COOLING FAN AH02A UNAVAILABLE DUE TO T&M	2.94E+00
VGAHM2B-AH02B	ESW PUMP B FAN 605-VG-AH02B UNAVAILABLE DUE TO T&M	2.86E+00
CCMPS2A-PP02A	CCW PUMP PP02A FAILS TO START	2.86E+00
VOHVM2B-HV32B	CUBICLE COOLER HV32B UNAVAILABLE DUE TO T&M	2.86E+00
SXMPS2A-PP02A	ESW PUMP PP02A FAILS TO START	2.86E+00
WOMPS2A-PP02A	FAILS TO START OF ECW PUMP 02A	2.85E+00
VKHVM2A-HV14A	CUBICLE COOLER HV14A UNAVAILABLE DUE TO T&M	2.84E+00
SXAHM-B-AH02B	ESW COOLING FAN AH02B UNAVAILABLE DUE TO T&M	2.84E+00
PADOY-D-PA06D01	FAILURE OF DIGITAL OUTPUT MODULE PA06D BRANCH 01	2.84E+00
PEDOY-D-LX03D01	FAILURE OF DIGITAL OUTPUT MODULE LX03D BRANCH 01	2.84E+00
PADOY-D-PA06D03	FAILURE OF DIGITAL OUTPUT MODULE 752-PA06D BRANCH 03	2.84E+00
DCBTT-B-BT01B	CLASS 1E 125V DC BATTERY BT01A FAILS BETWEEN TEST INTERVAL	2.83E+00
CCMPS2B-PP02B	CCW PUMP PP02B FAILS TO START	2.77E+00
WOMPS2B-PP02B	FAILS TO START OF ECW PUMP 02B	2.77E+00
SXMPS2B-PP02B	ESW PUMP PP02B FAILS TO START	2.77E+00

Table 19.1-68 (8 of 13)

Basic Event	Description	RAW
AFMVT2A-043	AFW ISOL. MOV V043 TRANSFER CLOSED	2.77E+00
CCMVO-A-131	CCW MOV 131 FOR ECW CHILLER CH02A OUTLET FAIL TO OPEN	2.75E+00
AFTPWD2-TDP01A/B	2/2 CCF OF FOR AFW TDP PP01/A/B FAIL TO START	2.71E+00
PELXKD2-LX01A02B	2/2 CCF OF LOOP CONTROLLER 745-LX01A, LX02B	2.70E+00
VKHVM2B-HV14B	CUBICLE COOLER HV14B UNAVAILABLE DUE TO T&M	2.68E+00
PALXY-C-PA06C-P	PRIMARY LOOP CONTROLLER 752-PA06C FAILS TO RUN	2.66E+00
CCMVO-B-132	CCW MOV 132 FOR ECW CHILLER CH02B OUTLET FAIL TO OPEN	2.65E+00
DCBTM-D-BT01D	CLASS 1E 125V DC BATTERY BT01D UNAVAILABLE DUE TO T&M	2.63E+00
WOCHR2A-CH02A	ECW CHILLER 02A FAILS TO RUN FOR 24 HOURS	2.63E+00
IPINM-D-IN01D	CLASS 1E 120V AC INVERTER IN01D UNAVAILABLE DUE TO T&M	2.62E+00
VGAHS2A-AH02A	FAILS TO START OF EWS PUMP ROOM I. SUPPLY FAN AH02A	2.61E+00
WOCHR1A-CH01A	ECW CHILLER CH01A FAILS TO RUN FOR 24 HOURS	2.61E+00
VOHVS2A-HV32A	FAILS TO START OF ECW ROOM CUBICLE COOLER HV32A	2.61E+00
DGDGR-D-DGD	FAILS TO RUN OF EMERGENCY DIESEL GENERATOR DG01D	2.56E+00
WOCHR2B-CH02B	ECW CHILLER 02B FAILS TO RUN FOR 24 HOURS	2.55E+00
VKHVS2A-HV14A	FAILS TO START CCW PUMP ROOM CUBICLE COOLER HV14A	2.55E+00
VOHVS2B-HV32B	FAILS TO START OF ECW ROOM B CUBICLE COOLER HV32B	2.53E+00

Table 19.1-68 (9 of 13)

Basic Event	Description	RAW
VGAHS2B-AH02B	EWS PUMP ROOM II. SUPPLY FAN AH02B FAILS TO START	2.53E+00
DGDGM-D-DGD	DG 01D UNAVAILABLE DUE TO MAINTENANCE	2.52E+00
PADOY-D-PA06C02	FAILURE OF DIGITAL OUTPUT MODULE PA06C BRANCH 02	2.51E+00
PADOY-C-PA06C04	FAILURE OF DIGITAL OUTPUT MODULE PA06C BRANCH 04	2.51E+00
PEDOY-C-LX03C01	FAILURE OF DIGITAL OUTPUT MODULE LX03C BRANCH 01	2.51E+00
DGDGKQ2-DG01BC	2/4 CCF OF EDG 01B/01C FAIL TO RUN	2.50E+00
DCBTM-C-BT01C	CLASS 1E 125V DC BATTERY BT01C UNAVAILABLE DUE TO T&M	2.49E+00
IPINM-C-IN01C	CLASS 1E 120V AC INVERTER IN01C UNAVAILABLE DUE TO T&M	2.48E+00
AFMPR2B-MDP02B	FAILS TO RUN AFW MDP PP02B	2.47E+00
IPINY-A-IN01A	120V AC POWER SUPPLY INVERTER IN01A FAILS WHILE OPERATING	2.46E+00
RCINY1C-IN01C	INVERTER FOR POSRV MOTOR OPERTAED PILOT VVs 431-V131/V133/441-V653 FAILS	2.45E+00
RCINY1A-IN01A	INVERTER FOR POSRV MOTOR OPERTAED PILOT VVs 431-V130/V132 FAILS	2.45E+00
RCPVC-A-200	POSRV V200 FAILS TO CLOSE (HARDWARE FAIL)	2.45E+00
RCPVC-C-201	POSRV V201 FAILS TO CLOSE (HARDWARE FAIL)	2.45E+00
RCPVC-D-203	POSRV V203 FAILS TO CLOSE (HARDWARE FAIL)	2.45E+00
RCPVC-B-202	POSRV V202 FAILS TO CLOSE (HARDWARE FAIL)	2.45E+00

Table 19.1-68 (10 of 13)

Basic Event	Description	RAW
NPXHY-M-UAT01M	UNIT AUX XFMR TR01M FAILS WHILE OPERATING	2.41E+00
NPXOY-S-MTR	MAIN TRANSFORMER FAULT	2.41E+00
NPXHY-N-UAT01N	UNIT AUX XFMR TR01N FAILS WHILE OPERATING	2.41E+00
NPBDY-S-IPB	IPB FAULT	2.41E+00
VKHVS2B-HV14B	FAILS TO START CCW PUMP ROOM CUBICLE COOLER HV14B	2.41E+00
DGDGR-C-DGC	FAILS TO RUN OF EMERGENCY DIESEL GENERATOR DG01C	2.40E+00
RCINY1D-IN01D	INVERTER FOR POSRV MOTOR OPERTAED PILOT VVs 431-V135/V137/441-V654 FAILS	2.40E+00
RCINY1B-IN01B	INVERTER FOR POSRV MOTOR OPERTAED PILOT VVs 431-V134/V136 FAILS	2.40E+00
VOHVR1A-HV31A	FAILS TO RUN ECW ROOM CUBICLE COOLER HV31A	2.38E+00
DGDGM-C-DGC	DG 01C UNAVAILABLE DUE TO MAINTENANCE	2.37E+00
IPINY-B-IN01B	120V AC POWER SUPPLY INVERTER IN01B FAILS WHILE OPERATING	2.37E+00
DGDGL-D-DGD	DG D FAILS TO LOAD AND RUN DURING 1ST 1HR OF OPERATION	2.35E+00
WOMPR1A-PP01A	FAILS TO RUN OF ECW PUMP 01A	2.34E+00
SIMPM2A-PP02C	SI PUMP PP02C UNAVAILABLE DUE TO T&M	2.34E+00
DGDGS-D-DGD	FAILS TO START OF EMERGENCY DIESEL GENERATOR DG01D	2.31E+00
AFTPR1A-TDP01A	FAILS TO RUN AFW TDP PP01A	2.30E+00
AFCVO2A-V1003A	FAILS TO OPEN AFW MDP02A DISCH. CHECK VALVE V1003A	2.26E+00

Table 19.1-68 (11 of 13)

Basic Event	Description	RAW
AFCVO2A-V1007A	FAILS TO OPEN AFW MDP02A DISCH. CHECK VALVE V1017A	2.26E+00
AFCVO2A-V1012A	FAILS TO OPEN AFW MDP02A MINI FLOW CHECK VALVE V1012A	2.26E+00
WOOPH-A-1/2A	OPERATOR FAILS TO OPERATE ECW PUMPS PP01/2A	2.24E+00
VDHVM-D-HV13D	CUBICLE COOLER HV13D UNAVAILABLE DUE TO T&M	2.24E+00
VDHVM-D-HV12D	CUBICLE COOLER HV12D UNAVAILABLE DUE TO T&M	2.24E+00
PELXY-C-LX05C-P	FAILURE OF PRIMARY LOOP CONTROLLER OF 745-PE-LX05C	2.22E+00
PELXY-A-LX08A-P	FAILURE OF PRIMARY LOOP CONTROLLER OF 745-PE-LX08A	2.22E+00
DGDGL-C-DGC	DG 01C FAILS TO LOAD AND RUN DURING 1ST 1HR OF OPERATION	2.22E+00
AFMVC1A-045	AFW ISOL. MOV 0045 FAILS TO CLOSE FOR CYCLING OPERATION	2.19E+00
AFMVO1A-045	AFW ISOL. MOV 045 FAILS TO OPEN FOR CYCLING OPERATION	2.19E+00
DGDGS-C-DGC	FAILS TO START OF EMERGENCY DIESEL GENERATOR DG01C	2.18E+00
CCCVC1A-V1001	CCW PP01A DISCH. CHECK VALVE V1001 FAILS TO CLOSE	2.18E+00
SXCVC1A-V1001	ESW PP01A DISCH. CHECK VALVE V1001 FAIL TO RECLOSE	2.18E+00
PELXY-B-LX09B-P	FAILURE OF PRIMARY LOOP CONTROLLER OF 745-PE-LX09B	2.17E+00
PELXY-D-LX05D-P	FAILURE OF PRIMARY LOOP CONTROLLER OF 745-PE-LX05D	2.17E+00
AFTPR1B-TDP01B	FAILS TO RUN AFW TDP PP01B	2.16E+00
NPXHY-N-SAT02N	SAT TR02N FAULT	2.15E+00

Table 19.1-68 (12 of 13)

Basic Event	Description	RAW
SIOPU2A-V254	SI PUMP PP02C MINI FLOW VV 254 NOT RESTORED AFTER T&M	2.13E+00
CCMVO-A-097	CS Hx. HE01A INLET MOV 097 FAILS TO OPEN	2.13E+00
SIMVO2A-636	SI PUMP 1 INJECTION LINE MOV 636 FAILS TO OPEN	2.13E+00
CSMVO1A-003	CS ISOL. MOV 003 IN CS TRAIN A DISCH. PATH FAILS TO OPEN	2.13E+00
VDHVM-C-HV12C	CUBICLE COOLER HV12C UNAVAILABLE DUE TO T&M	2.12E+00
VDHVM-C-HV13C	CUBICLE COOLER HV13C UNAVAILABLE DUE TO T&M	2.12E+00
SIMPS2A-PP02C	FAILS TO START SI PUMP PP02C	2.12E+00
SXCVC1B-V1002	ESW PP01B DISCH. CHECK VALVE V1002 FAIL TO RECLOSE	2.12E+00
CCCVC1B-V1002	CCW PP01B DISCH. CHECK VALVE V1002 FAILS TO CLOSE	2.12E+00
VDHVL-D-HV12D	FAILS TO RUN EDG ROOM CUBICLE COOLER HV12D FOR 1HR	2.10E+00
VDHVL-D-HV13D	FAILS TO RUN EDG ROOM CUBICLE COOLER HV13D FOR 1HR	2.10E+00
VDHVR-D-HV13D	FAILS TO RUN EDG ROOM CUBICLE COOLER HV13D	2.10E+00
VDHVR-D-HV12D	FAILS TO RUN EDG ROOM CUBICLE COOLER HV12D	2.10E+00
AFMPL2B-MDP02B	FAILS TO RUN FOR 1HR AFW MDP PP02B FOR 1HR	2.09E+00
CCMVO-D-182	CCW MOV 182 FOR EDG01D INLET FAILS TO OPEN	2.07E+00
AFTPS1A-TDP01A	FAILS TO START AFW TDP PP01A	2.07E+00
CSMPM2A-PP01A	CS PUMP 1 PP01A UNAVAILABLE DUE TO MAINTENANCE	2.05E+00
VDHVS-D-HV13D	FAILS TO START EDG ROOM CUBICLE COOLER HV13D	2.04E+00
VDHVS-D-HV12D	FAILS TO START EDG ROOM CUBICLE COOLER HV12D	2.04E+00

Table 19.1-68 (13 of 13)

Basic Event	Description	RAW
AFMVO1B-046	AFW ISOL. MOV 046 FAILS TO OPEN FOR CYCLING OPERATION	2.04E+00
AFMVC1B-046	AFW ISOL. MOV 046 FAILS TO CLOSE FOR CYCLING OPERATION	2.04E+00
VGAHR2A-AH02A	FAILS TO RUN OF ESW PUMP ROOM I. FAN AH02A	2.04E+00
VKHVR2A-HV14A	FAILS TO RUN CCW PUMP ROOM CUBICLE COOLER HV14A	2.04E+00
VOHVR2A-HV32A	FAILS TO RUN ECW ROOM CUBICLE COOLER HV32A	2.04E+00
PELXY-C-LX03C-P	FAILURE OF PRIMARY LOOP CONTROLLERS 745-PE-LX03C	2.03E+00
PELXY-C-LX01C-P	FAILURE OF PRIMARY LOOP CONTROLLER OF 745-PE-LX01C	2.02E+00
AFTPM1A-TDP01A	AFW TDP PP01A UNAVAILABLE DUE TO T/M	2.02E+00
VDHVL-C-HV13C	FAILS TO RUN EDG ROOM CUBICLE COOLER HV13C FOR 1HR	2.01E+00
VDHVL-C-HV12C	FAILS TO RUN EDG ROOM CUBICLE COOLER HV12C FOR 1HR	2.01E+00
SIVVT2A-V435	SI PUMP 3 DISCHARGE VV 435 FAILS TO REMAIN OPEN	2.00E+00
VDHVR-C-HV13C	FAILS TO RUN EDG ROOM CUBICLE COOLER HV13C	2.00E+00
VDHVR-C-HV12C	FAILS TO RUN EDG ROOM CUBICLE COOLER HV12C	2.00E+00

Table 19.1-69 (1 of 3)

Internal Flooding PRA Key Basic Events by FV (CDF)

Basic Event	Description	FV
PFHBO1A-SW01A-H2	FAILS TO OPEN OF PCB SW01A-H2 OF 4.16KV SWGR SW01A FROM UAT	1.83E-01
PFHBO1B-SW01B-H2	FAILS TO OPEN OF PCB SW01B-H2 OF 4.16KV SWGR SW01B FROM UAT	1.48E-01
AFMVC1A-045	AFW ISOL. MOV 0045 FAILS TO CLOSE FOR CYCLING OPERATION	7.33E-02
AFMVO1A-045	AFW ISOL. MOV 045 FAILS TO OPEN FOR CYCLING OPERATION	7.33E-02
PFHBO2A-SW01C-C2	FAILS TO OPEN OF PCB SW01C-C2 OF 4.16KV SWGR SW01C FROM UAT	6.72E-02
AFMVO1B-046	AFW ISOL. MOV 046 FAILS TO OPEN FOR CYCLING OPERATION	6.38E-02
AFMVC1B-046	AFW ISOL. MOV 046 FAILS TO CLOSE FOR CYCLING OPERATION	6.38E-02
AFTPR1A-TDP01A	FAILS TO RUN AFW TDP PP01A	4.75E-02
WOCHM2A-CH02A	ECW CHILLER 02A TRAIN UNAVAILABLE DUE TO T&M	4.70E-02
WOCHM2B-CH02B	ECW CHILLER 02B TRAIN UNAVAILABLE DUE TO T&M	4.53E-02
PFHBO2B-SW01D-G2	FAILS TO OPEN OF PCB SW01D-G2 OF 4.16KV SWGR SW01D FROM UAT	4.52E-02
AFTPR1B-TDP01B	FAILS TO RUN AFW TDP PP01B	4.22E-02
DGDGR-D-DGD	FAILS TO RUN OF EMERGENCY DIESEL GENERATOR DG01D	3.99E-02
DGDGR-C-DGC	FAILS TO RUN OF EMERGENCY DIESEL GENERATOR DG01C	3.59E-02
SXMPM2A-PP02A	ESW PUMP PP02A UNAVAILABLE DUE TO T/M	3.07E-02

Table 19.1-69 (2 of 3)

Basic Event	Description	FV
WOCHS2A-CH02A	ECW CHILLER CH02A FAILS TO START ON DEMAND	3.01E-02
SXMPM2B-PP02B	ESW PUMP PP02B UNAVAILABLE DUE TO T/M	2.95E-02
WOCHS2B-CH02B	ECW CHILLER CH02B FAILS TO START ON DEMAND	2.90E-02
DCBTM-A-BT01A	CLASS 1E 125V DC BATTERY BT01A UNAVAILABLE DUE TO T&M	2.31E-02
DGDGM-D-DGD	DG 01D UNAVAILABLE DUE TO MAINTENANCE	2.22E-02
DCBTM-B-BT01B	CLASS 1E 125V DC BATTERY BT01B UNAVAILABLE DUE TO T&M	2.17E-02
DGDGM-C-DGC	DG 01C UNAVAILABLE DUE TO MAINTENANCE	2.00E-02
AFMPM2A-MDP02A	AFW MDP PP02A UNAVAILABLE DUE TO T/M	1.89E-02
DGDGR-B-DGB	FAILS TO RUN OF EMERGENCY DIESEL GENERATOR DG01B	1.88E-02
PFHBC1A-SW01A-A2	FAILS TO CLOSE OF PCB SW01A-A2 OF 4.16KV SWGR SW01A	1.69E-02
IPINM-A-IN01A	CLASS 1E 120V AC INVERTER IN01A UNAVAILABLE DUE TO T&M	1.65E-02
IPINM-B-IN01B	CLASS 1E 120V AC INVERTER IN01B UNAVAILABLE DUE TO T&M	1.53E-02
WOMPM2A-PP02A	ECW PP02A TRAIN UNAVAILABLE DUE TO T&M	1.53E-02
PFHBC1B-SW01B-A2	FAILS TO CLOSE OF PCB SW01B-A2 OF 4.16KV SWGR SW01B	1.49E-02
WOMPM2B-PP02B	ECW PP02B TRAIN UNAVAILABLE DUE TO T&M	1.47E-02
NPXHM-N-SAT02N	SAT TR02N UNAVAILABLE DUE TO MAINTENANCE	1.46E-02
NPXHM-M-SAT02M	SAT TR02M UNAVAILABLE DUE TO MAINTENANCE	1.37E-02
RCPVO-C-201	POSRV V200 FAILS TO OPEN (HARDWARE FAIL)	1.15E-02
RCPVO-A-200	POSRV V201 FAILS TO OPEN (HARDWARE FAIL)	1.15E-02
DGDGR-A-DGA	FAILS TO RUN OF EMERGENCY DIESEL GENERATOR DG01A	1.09E-02

Table 19.1-69 (3 of 3)

Basic Event	Description	FV
CCMPM2A-PP02A	CCW PUMP PP02A UNAVAILABLE DUE TO T/M	1.01E-02
RCPVO-B-202	POSRV V202 FAILS TO OPEN (HARDWARE FAIL)	1.01E-02
RCPVO-D-203	POSRV V203 FAILS TO OPEN (HARDWARE FAIL)	1.01E-02
DGDGM-B-DGB	DG 01B UNAVAILABLE DUE TO MAINTENANCE	1.01E-02
AFMPM2B-MDP02B	AFW MDP PP02B UNAVAILABLE DUE TO T/M	9.95E-03
VOHVM2A-HV33A	CUBICLE COOLER HV33A UNAVAILABLE DUE TO T&M	9.80E-03
CCMPM2B-PP02B	CCW PUMP PP02B UNAVAILABLE DUE TO T/M	9.71E-03
CSMPM2A-PP01A	CS PUMP 1 PP01A UNAVAILABLE DUE TO MAINTENANCE	7.48E-03
AFTPS1A-TDP01A	FAILS TO START AFW TDP PP01A	6.95E-03
AFTPS1B-TDP01B	FAILS TO START AFW TDP PP01B	6.27E-03
CSMPM2B-PP01B	CS PUMP PP01B UNAVAILABLE DUE TO MAINTENANCE	5.75E-03
DGDGM-A-DGA	DG 01A UNAVAILABLE DUE TO MAINTENANCE	5.60E-03
AFTPM1A-TDP01A	AFW TDP PP01A UNAVAILABLE DUE TO T/M	5.47E-03
DGDGL-D-DGD	DG D FAILS TO LOAD AND RUN DURING 1ST 1HR OF OPERATION	5.12E-03
VOHVM1B-HV33B	CUBICLE COOLER HV33B UNAVAILABLE DUE TO T&M	5.06E-03
PFHBC2A-SW01C-A2	FAILS TO CLOSE OF PCB SW01C-A2 OF 4.16KV SWGR SW01C	5.00E-03

Table 19.1-70 (1 of 7)

Internal Flooding PRA Key CCF Events by RAW (CDF)

Basic Event	Description	RAW
RPRBWO8-TCBALL	CCF FAILURE OF ALL TRIP CIRCUIT BRAKER TCB	1.19E+04
RPRBWO4-TCB-AB1AC2	4/8 CCF OF TCB A-1, B-1, A-2, C-2	1.19E+04
RPRBWO4-TCB-AB1BD2	4/8 CCF OF TCB A-1, B-1, B-2 D-2	1.19E+04
RPRBWO4-TCB-CD1BD2	4/8 CCF OF TCB C-1, D-1, B-2, D-2	1.19E+04
RPRBWO4-TCB-CD1AC2	4/8 CCF OF TCB C-1, D-1, A-2 C-2	1.19E+04
PFHBWQ4-SW2OUAT	CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1B,1C,1D FAIL TO OPEN	8.00E+03
PFHBWQ3-SW2OUATACD	3/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1C,1D FAIL TO OPEN	3.65E+03
PFHBWQ3-SW2OUATBCD	3/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01B,1C,1D FAIL TO OPEN	3.29E+03
PFHBWQ3-SW2OUATABC	3/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1B,1C FAIL TO OPEN	1.95E+03
VGAHKQ4-AH01A/1B/2A/2B	4/4 RUNNING CCF OF ESW PUMP ROOM FAN AH01A/B, 02A/B	1.87E+03
SXMPKQ4-PP01A/B/2A/B	4/4 CCF OF ESW PUMPS PP01A/2A, PP01B/2B TO RUN	1.83E+03
SXAHKQ4-AH01A/02A/01B/02B	4/4 RUNNING CCF OF ESW COOLING TOWER FANS AH01A, 02A, 01B, 02B	1.80E+03
CCMPKQ4-PP01A/B/2A/B	4/4 CCF OF CCW PUMPS PP01A/1B/2A/2B (RUNNING)	1.72E+03
PFHBWQ3-SW2OUATABD	3/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1B,1D FAIL TO OPEN	9.19E+02

Table 19.1-70 (2 of 7)

Basic Event	Description	RAW
PFHBWQ2-SW2OUATAC	2/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1C FAIL TO OPEN	8.31E+02
PFHBWQ2-SW2OUATBD	2/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01B,1D FAIL TO OPEN	7.63E+02
VGAHKQ3-AH01A/2A/2B	3/4 RUNNING CCF OF ESW PUMP ROOM FAN AH01A, 02A, 02B	6.85E+02
AFPVKQ4-TP01A/B/MP02A/B	4/4 CCF OF AFW TDP01A/B, MDP02A/B DUE TO THE VOLUTE FAIL TO RUN	6.70E+02
CCMPKQ3-PP01A/2A/B	3/4 CCF OF CCW PUMPS PP01A/2A/2B (RUNNING)	6.70E+02
SXMPKQ3-PP01A/2A/B	3/4 CCF OF ESW PUMPS PP01A, PP02A, PP02B (RUNNING)	6.68E+02
SXAHKQ3-AH01A/02A/02B	3/4 RUNNING CCF OF ESW COOLING TOWER FANS AH01A, 02A, 02B	6.46E+02
AFCVWO4-V1007AB/8AB	4/8 CCF OF AF DISCH. CHECK VALVE V1007AB/8AB FAIL TO OPEN	6.40E+02
AFCVWO4-V1003AB/4AB	4/8 CCF OF AF DISCH. CHECK VALVE V1003AB/4AB FAIL TO OPEN	6.40E+02
VGAHKQ3-AH01B/2A/2B	3/4 CCF (RUNNING) OF ESW PUMP ROOM FAN AH01B, 02A, 02B	6.26E+02
CCMPKQ3-PP01B/2A/B	3/4 CCF OF CCW PUMPS PP01B/2A/2B (RUNNING)	6.15E+02
AFCVWO8-V1003AB/4AB/7AB/8AB	8/8 CCF OF AF DISCH. CHECK VALVE V1003AB/4AB/7AB/8AB FAIL TO OPEN	6.14E+02
SXMPKQ3-PP01B/2A/B	3/4 CCF OF ESW PUMPS PP02A, PP01B, PP02B (RUNNING)	6.14E+02
SXAHKQ3-AH02A/01B/02B	3/4 RUNNING CCF OF ESW COOLING TOWER FANS AH02A, 01B, 02B	5.91E+02

Table 19.1-70 (3 of 7)

Basic Event	Description	RAW
AFCVWQ4-V1012A/B/4A/B	4/4 CCF OF AFW MINI FLOW CHECK VALVE V1012A/B & 1014A/B FAIL TO OPEN	5.14E+02
VGAHKQ3-AH01A/1B/2A	3/4 RUNNING CCF OF ESW PUMP ROOM FAN AH01A, 01B, 02A	2.70E+02
CCMPKQ3-PP01A/B/2A	3/4 CCF OF CCW PUMPS PP01A/1B/2A (RUNNING)	2.50E+02
SXMPKQ3-PP01A/B/2A	3/4 CCF OF ESW PUMPS PP01A, PP02A, PP01B (RUNNING)	2.45E+02
SXAHKQ3-AH01A/02A/01B	3/4 RUNNING CCF OF ESW COOLING TOWER FANS AH01A, 02A, 01B	2.26E+02
DCBTWQ4-BT01ABCD	4/4 CCF OF 125V DC BATTERY BT01A/01B/01C/01D FAILS UPON DEMAND	1.30E+02
PFHBWQ2-SW2OUATBC	2/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01B,1C FAIL TO OPEN	1.17E+02
PFHBWQ2-SW2OUATAD	2/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1D FAIL TO OPEN	1.16E+02
WOCHKQ4-CH01A/1B/2A/2B	RUNNING CCF OF ECW CHILLERS 1A/2A/1B/2B	1.07E+02
AFPVKQ3-TP01A/B/MP02A	3/4 CCF OF AFW TDP01A/B, MDP02A DUE TO THE VOLUTE FAIL TO RUN	7.57E+01
VGAHKQ3-AH01A/1B/2B	3/4 RUNNING CCF OF ESW PUMP ROOM FAN AH01A, 01B, 02B	7.51E+01
VOHVKQ4-HV32A/32B/31A/31B	4/4 CCF OF RUN FOR CUBICLE COOLER HV32A/32B/31A/31B	7.49E+01
AFPVKQ3-TP01A/B/MP02B	3/4 CCF OF AFW TDP01A/B, MDP02B DUE TO THE VOLUTE FAIL TO RUN	7.23E+01
PFHBWQ2-SW2OUATCD	2/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01C,1D FAIL TO OPEN	6.74E+01

Table 19.1-70 (4 of 7)

Basic Event	Description	RAW
SXMPKQ2-PP01/2A	2/4 CCF OF ESW PUMPS PP01A, PP02A (RUNNING)	6.55E+01
CCMPKQ2-PP01/2A	2/4 CCF OF CCW PUMPS PP01A/2A (RUNNING)	6.55E+01
VGAHKQ2-AH01A/2A	2/4 RUNNING CCF OF ESW PUMP ROOM FAN AH01A, 02A	6.13E+01
AFPVKQ3-TP01A/MP02A/B	3/4 CCF OF AFW TDP01A, MDP02A/B DUE TO THE VOLUTE FAIL TO RUN	6.09E+01
PFHBWQ2-SW2OUATAB	2/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1B FAIL TO OPEN	5.60E+01
CCMPKQ3-PP01A/B/2B	3/4 CCF OF CCW PUMPS PP01A/1B/2B (RUNNING)	5.45E+01
SXMPKQ3-PP01A/B/2B	3/4 CCF OF ESW PUMPS PP01A, PP01B, PP02B (RUNNING)	5.45E+01
WOMPKQ4-PP01A/2A/1B/2B	RUNNING CCF OF ECW PUMPS 1A/2A/1B/2B	4.91E+01
CCMVXO8-143-150	8/8 CCF(DEMAND) OF MOV 143,144,145,146,147,148,149,150 IN NON SAFETY LOAD LINE	4.88E+01
SIMVWQ4-616/26/36/46	4/4 CCF OF DVI LINEMOV 616,626,636,646	4.88E+01
SICVWO8-DVIS	8/8 CCF OF SI LINE CHECK VALVES 123,143,217,227,237,247,541,543 TO OPEN	4.86E+01
SICVWO8-SIPUMPS	8/8 CCF OF SI PUMP DISCHARGE LINE CV 113,133,404,405,434,446,540,542 TO OPEN	4.86E+01
SICVWO4-V123/217/37/47	4/8 CCF OF SI LINE CHECK VALVES 123,217,237,247	4.86E+01
SICVWO4-V123/217/37/543	4/8 CCF OF SI LINE CHECK VALVES 123,217,237,543	4.86E+01
SICVWO4-V123/43/217/37	4/8 CCF OF SI LINE CHECK VALVES 123,143,217,237	4.86E+01
SICVWO4-V113/404/05/34	4/8 CCF OF SI PUMP DISCHARGE LINE CV 113,404,405,434	4.86E+01

Table 19.1-70 (5 of 7)

Basic Event	Description	RAW
SICVWO4-V113/33/404/05	4/8 CCF OF SI PUMP DISCHARGE LINE CV 113,133,404,405	4.86E+01
SICVWO4-V404/05/540/42	4/8 CCF OF SI PUMP DISCHARGE LINE CV 404,405,540,542	4.86E+01
SICVWO4-V113/404/05/542	4/8 CCF OF SI PUMP DISCHARGE LINE CV 113,404,405,542	4.86E+01
SICVWO4-V217/37/47/541	4/8 CCF OF SI LINE CHECK VALVES 217,237,247,541	4.86E+01
SICVWO4-V143/217/27/37	4/8 CCF OF SI LINE CHECK VALVES 143,217,227,237	4.86E+01
SICVWO4-V217/37/541/43	4/8 CCF OF SI LINE CHECK VALVES 217,237,541,543	4.86E+01
SICVWO4-V143/217/37/541	4/8 CCF OF SI LINE CHECK VALVES 143,217,237,541	4.86E+01
SICVWO4-V217/27/37/47	4/8 CCF OF SI LINE CHECK VALVES 217,227,237,247	4.86E+01
SICVWO4-V217/27/37/543	4/8 CCF OF SI LINE CHECK VALVES 217,227,237,543	4.86E+01
SICVWO4-V404/05/46/542	4/8 CCF OF SI PUMP DISCHARGE LINE CV 404,405,446,542	4.86E+01
SICVWO4-V133/404/05/46	4/8 CCF OF SI PUMP DISCHARGE LINE CV 133,404,405,446	4.86E+01
SICVWO4-V133/404/05/540	4/8 CCF OF SI PUMP DISCHARGE LINE CV 133,404,405,540	4.86E+01
SICVWO4-V404/05/34/46	4/8 CCF OF SI PUMP DISCHARGE LINE CV 404,405,434,446	4.86E+01
SICVWO4-V404/05/34/540	4/8 CCF OF SI PUMP DISCHARGE LINE CV 404,405,434,540	4.86E+01
SICVWQ4-V157/158/159/160	4/4 CCF OF CS CV 157/158 SC CV 159/160	4.86E+01
SICVWQ4-V568/569/1001/1002	CCF TO OPEN CSP DISCH LINE 1001, 1002 AND SCP DISCH. LINE CV 568,569	4.86E+01
SICVWQ4-V424/26/48/51	4/4 CCF OF SI LINE C/V 424,426,448,451 TO OPEN	4.86E+01
SICVWD2-V100/01	2/2 CCF OF CV 100/101 IN TRAIN A&B IRWST RETURN LINES	4.86E+01

Table 19.1-70 (6 of 7)

Basic Event	Description	RAW
PELXKQ4-LX8A/12B/1C/1D	4/4 CCF OF LOOP CONTROLLER LX08A 12, LX12B 12, LX01C 12, LX01D 12	4.86E+01
PELXKQ4-LX1A/1B/1C/1D	4/4 CCF OF LOOP CONTROLLER LX01A, LX01B, LX01C, LX01D	4.86E+01
SIMPKQ4-PP02ABCD	4/4 CCF OF RUN FOR SI PUMP PP02A/B/C/D	4.86E+01
SIMPZQ4-PP02ABCD	4/4 CCF OF RUN FOR SI PUMP PP02A/B/C/D FOR 1HR	4.86E+01
SIMPWQ4-PP02ABCD	4/4 CCF OF START FOR SI PUMP PP02A/B/C/D	4.86E+01
CCMPKQ2-PP01/2B	2/4 CCF OF CCW PUMPS PP01B/2B (RUNNING)	4.71E+01
SXMPKQ2-PP01/2B	2/4 CCF OF ESW PUMPS PP01B, PP02B (RUNNING)	4.60E+01
VGAHKQ2-AH01B/2B	2/4 CCF (RUNNING) OF ESW PUMP ROOM FAN AH01B, 02B	4.35E+01
AFPVKQ3-TP01B/MP02A/B	3/4 CCF OF AFW TDP01B, MDP02A/B DUE TO THE VOLUTE FAIL TO RUN	3.95E+01
DCBTWQ3-BT01BCD	3/4 CCF OF 125V DC BATTERY BT01B/01C/01D FAILS UPON DEMAND	3.88E+01
WOCHKQ3-CH01A/2A/2B	RUNNING CCF OF ECW CHILLERS 1A/2A/2B	3.79E+01
DCBTWQ3-BT01ABD	3/4 CCF OF 125V DC BATTERY BT01A/01B/01D FAILS UPON DEMAND	3.64E+01
SXAHKQ3-AH01A/01B/02B	3/4 RUNNING CCF OF ESW COOLING TOWER FANS AH01A, 01B, 02B	3.36E+01
SXMPKQ2-PP01A/2B	2/4 CCF OF ESW PUMPS PP01A, PP02B (RUNNING)	2.82E+01
SXMPKQ2-PP02A/1B	2/4 CCF OF ESW PUMPS PP02A, PP01B (RUNNING)	2.80E+01
WOCHKQ3-CH02A/1B/2B	RUNNING CCF OF ECW CHILLERS 2A/1B/2B	2.54E+01

Table 19.1-70 (7 of 7)

Basic Event	Description	RAW
DGDGKQ4-DG01ABCD	4/4 CCF OF EDG 01A/01B/01C/01D FAIL TO RUN	2.47E+01
VDHVZO8-HV12/13ABCD	8/8 CCF OF RUN FOR EDG ROOM CUBICLE COOLER HV12A, 12B, 12C, 12D 13A, 13B, 13C, 14D FOR 1HR	2.41E+01
VDHVKO8-HV12/13ABCD	8/8 CCF OF RUN FOR EDG ROOM CUBICLE COOLER HV12A, 12B, 12C, 12D 13A, 13B, 13C, 14D	2.40E+01
SXAHKQ2-AH01A/02B	2/4 RUNNING CCF OF ESW COOLING TOWER FANS AH01A, 02B	2.36E+01
CCMPKQ2-PP01A/2B	2/4 CCF OF CCW PUMPS PP01A/2B (RUNNING)	2.36E+01
VGAHKQ2-AH01A/2B	2/4 RUNNING CCF OF ESW PUMP ROOM FAN AH01A, 02B	2.36E+01
VDHVWO8-HV12/13ABCD	8/8 CCF OF START FOR EDG ROOM CUBICLE COOLER HV12A, 12B, 12C, 12D 13A, 13B, 13C, 14D	2.32E+01
SXAHKQ2-AH02A/01B	2/4 RUNNING CCF OF ESW COOLING TOWER FANS AH02A, 01B	2.24E+01
CCMPKQ2-PP01B/2A	2/4 CCF OF CCW PUMPS PP01B/2A (RUNNING)	2.24E+01
VGAHKQ2-AH01B/2A	2/4 CCF (RUNNING) OF ESW PUMP ROOM FAN AH01B, 02A	2.24E+01
DCBTWQ3-BT01ACD	3/4 CCF OF 125V DC BATTERY BT01A/01C/01D FAILS UPON DEMAND	2.18E+01
SXAHKQ2-AH01A/02A	2/4 RUNNING CCF OF ESW COOLING TOWER FANS AH01A, 02A	2.10E+01
DCBTKQ4-BT01ABCD	4/4 CCF OF 125V DC BATTERY BT01A/01B/01C/01D FAILS TO RUN	2.05E+01
DGSQWQ4-LOADSQABCD	4/4 CCF OF LOAD SEQUNCER A, B, C, D FAIL TO OPERATE	2.03E+01
DGDGWQ4-DG01ABCD	4/4 CCF OF EDG 01A/01B/01C/01D FAIL TO START	2.00E+01

(1) The cutoff threshold chosen for this table is based upon guidance presented in NEI 00-04 (Reference 51).

Table 19.1-71

Internal Flooding PRA Key CCF Events by FV (CDF)

Basic Event	Description	FV
PFHBWQ4-SW2OUAT	CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1B,1C,1D FAIL TO OPEN	2.17E-01
PFHBWQ3-SW2OUATACD	3/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1C,1D FAIL TO OPEN	6.01E-02
PFHBWQ3-SW2OUATBCD	3/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01B,1C,1D FAIL TO OPEN	5.41E-02
PFHBWQ2-SW2OUATAC	2/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1C FAIL TO OPEN	4.99E-02
PFHBWQ2-SW2OUATBD	2/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01B,1D FAIL TO OPEN	4.59E-02
PFHBWQ3-SW2OUATABC	3/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1B,1C FAIL TO OPEN	3.22E-02
PFHBWQ3-SW2OUATABD	3/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1B,1D FAIL TO OPEN	1.51E-02
PFHBWQ2-SW2OUATBC	2/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01B,1C FAIL TO OPEN	6.97E-03
PFHBWQ2-SW2OUATAD	2/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1D FAIL TO OPEN	6.91E-03

Table 19.1-72

Internal Flooding PRA Key Operator Actions by RAW (CDF)

Basic Event	Description	RAW
RCOPH-S-SDSE-FW	FAILURE OF SDS VALVES EARLY PHASE OPEN (1/4)	7.65E+00
AFOPH-S-ALT-LT	OPERATOR FAIL TO ALIGN FOR SUPPLYING AN ALTERNATE SOURCE	5.98E+00
WOOPH-B-1/2B	OPERATOR FAILS TO OPERATE ECW PUMPS PP01/2B	2.40E+00
WOOPH-A-1/2A	OPERATOR FAILS TO OPERATE ECW PUMPS PP01/2A	2.24E+00
SIOPU2A-V254	SI PUMP PP02C MINI FLOW VV 254 NOT RESTORED AFTER T&M	2.13E+00

Table 19.1-73

Internal Flooding PRA Key Operator Actions by FV (CDF)

Basic Event	Description	FV
RCOPH-S-SDSE-FW	FAILURE OF SDS VALVES EARLY PHASE OPEN (1/4)	6.11E-02
FPOPH-1-ISO-FL	OPERATOR FAILS TO ISOLATE A FIRE PROTECTION BREAK IN LESS THAN 20 MINUTES	2.54E-02
WOOPH-B-1/2B	OPERATOR FAILS TO OPERATE ECW PUMPS PP01/2B	2.42E-02
WOOPH-A-1/2A	OPERATOR FAILS TO OPERATE ECW PUMPS PP01/2A	2.15E-02

Table 19.1-74 (1 of 11)

Internal Flooding PRA Key Basic Events by RAW (LRF)

Basic Event	Description	RAW
I-ATWS-RPMCF	FAILURE TO SCRAM DUE TO MECHANICAL FAILURES	2.51E+04
DCBSY-B-MC01B	BUS FAULTS ON 1E 125VDC BUS MC01B	3.17E+02
DCBSY-A-MC01A	BUS FAULTS ON 1E 125VDC BUS MC01A	3.04E+02
SXFLP-S-FT0123AB	ESW DEBIS FILTER FT01A PLUGGED	1.14E+02
SXMVR-A-MV072	LOSS OF SX DIV.II DUE TO THE MOV072 SPURIOUS OPEN (FLOW DIVERSION)	8.58E+01
SXMVR-A-MV071	LOSS OF SX DIV. I DUE TO THE MOV071 SPURIOUS CLOSURE	8.58E+01
CCHEY01A-HE01A	CCW Hx. HE01A FAILS WHILE OPERATING	7.42E+01
CCHEY02A-HE02A	CCW Hx. HE02A FAILS WHILE OPERATING	7.42E+01
SISPP-S-IRWST	FAILURE OF IRWST SUMP DUE TO PLUGGING	6.40E+01
SXMVR-B-MV073	LOSS OF SX DIV. I DUE TO THE MOV071 SPURIOUS CLOSURE	6.16E+01
SXMVR-B-MV074	LOSS OF SX DIV.II DUE TO THE MOV074 SPURIOUS OPEN (FLOW DIVERSION)	6.16E+01
CCHEY02B-HE02B	CCW Hx. HE02B FAILS WHILE OPERATING	5.66E+01
CCHEY01B-HE01B	CCW Hx. HE01B FAILS WHILE OPERATING	5.66E+01
PFHBO1A-SW01A-H2	FAILS TO OPEN OF PCB SW01A-H2 OF 4.16KV SWGR SW01A FROM UAT	2.59E+01
PFHBO1B-SW01B-H2	FAILS TO OPEN OF PCB SW01B-H2 OF 4.16KV SWGR SW01B FROM UAT	2.15E+01
PALXKD2-PA06CD	2/2 CCF OF LOOP CONTROLLER PA06C, PA06D	1.34E+01

Table 19.1-74 (2 of 11)

Basic Event	Description	RAW
DCBTM-A-BT01A	CLASS 1E 125V DC BATTERY BT01A UNAVAILABLE DUE TO T&M	1.21E+01
DCBTM-B-BT01B	CLASS 1E 125V DC BATTERY BT01B UNAVAILABLE DUE TO T&M	1.16E+01
PFLOOP-TRANS	CONDITIONAL LOOP UPON TRANSIENTS	1.14E+01
DCBSY-C-MC01C	BUS FAULTS ON 1E 125VDC BUS MC01C	1.07E+01
DCBSY-D-MC01D	BUS FAULTS ON 1E 125VDC BUS MC01D	1.07E+01
PFHBO2A-SW01C-C2	FAILS TO OPEN OF PCB SW01C-C2 OF 4.16KV SWGR SW01C FROM UAT	1.05E+01
IPINM-A-IN01A	CLASS 1E 120V AC INVERTER IN01A UNAVAILABLE DUE TO T&M	9.29E+00
NPXHM-N-SAT02N	SAT TR02N UNAVAILABLE DUE TO MAINTENANCE	8.56E+00
IPINM-B-IN01B	CLASS 1E 120V AC INVERTER IN01B UNAVAILABLE DUE TO T&M	8.45E+00
NPXHM-M-SAT02M	SAT TR02M UNAVAILABLE DUE TO MAINTENANCE	8.22E+00
PFHBO2B-SW01D-G2	FAILS TO OPEN OF PCB SW01D-G2 OF 4.16KV SWGR SW01D FROM UAT	8.02E+00
SXMPR1A-PP01A	ESW PUMP PP01A FAILS TO RUN	7.45E+00
SXMPR1B-PP01B	ESW PUMP PP01B FAILS TO RUN	6.80E+00
GWSVO-S-002	CTMT. ISOL. SOV GW-002 FAIL TO CLOSE	6.71E+00
DEAVC-S-006	CTMT. ISOL. AOV DE-006 FAIL TO CLOSE	6.59E+00
PEDOY-D-LX02D04	FAILURE OF DIGITAL OUTPUT MODULE 745-PE-LX02D BRANCH 04	6.51E+00
VGAHR1A-AH01A	ESW PUMP ROOM I. FAN AH01A FAILS TO RUN	6.48E+00
CCMPR1A-PP01A	CCW PUMP PP01A FAILS TO RUN	6.46E+00
PFBSY1A-SW01A	BUS FAULT ON 4.16KV SWGR SW01A	6.43E+00
CCMPR1B-PP01B	CCW PUMP PP01B FAILS TO RUN	6.11E+00

Table 19.1-74 (3 of 11)

Basic Event	Description	RAW
VGAHR1B-AH01B	ESW PUMP ROOM II. FAN AH01B FAILS TO RUN	6.07E+00
PGBSY1A-LC01A	BUS FAULT ON 480V LC LC01A	6.00E+00
SXAHR-A-AH01A	ESW COOLING TOWER FAN AH01A FAILS TO RUN	5.99E+00
SXAHR-B-AH01B	ESW COOLING TOWER FAN AH01B FAILS TO RUN	5.78E+00
PGBSY1A-LC02A	BUS FAULT ON 480V LC LC02A	5.59E+00
PGBSY1B-LC02B	BUS FAULT ON 480V LC LC02B	5.49E+00
RCPVO-C-201	POSRV V201 FAILS TO OPEN (HARDWARE FAIL)	5.49E+00
RCPVO-A-200	POSRV V200 FAILS TO OPEN (HARDWARE FAIL)	5.49E+00
PELXKD2-LX05AB	2/2 CCF OF LOOP CONTROLLER 745-LX05A, LX05B	5.49E+00
PELXY-A-LX01A-P	FAILURE OF PRIMARY LOOP CONTROLLER OF 745-PE-LX01A	5.38E+00
PFBSY1B-SW01B	BUS FAULT ON 4.16KV SWGR SW01B	5.37E+00
CVAVWD2-505/6	2/2 CCF OF AV 505, 506	5.25E+00
CVAVWD2-522/3	2/2 CCF OF AV 522, 523	5.25E+00
CVAVWD2-560/1	2/2 CCF OF AV 560, 561	5.25E+00
CI-HATCH	HATCH FAILS TO ISOLATE	5.25E+00
CIILRTLINES	LEAK RATE TEST LINES FAIL TO ISOLATE (VQ-2024, 2014, 2016)	5.25E+00
PGXMY1A-TR02A	480V LC TRANSFORMER LC-TR02A FAULT	5.25E+00
PGXMY1B-TR02B	480V LC TRANSFORMER LC-TR02B FAULT	5.18E+00
PGBSY1B-LC01B	BUS FAULT ON 480V LC LC01B	5.06E+00
PFBSY2A-SW01C	BUS FAULT ON 4.16KV SWGR SW01C	4.99E+00

Table 19.1-74 (4 of 11)

Basic Event	Description	RAW
PGBSY2A-LC01C	BUS FAULT ON 480V LC LC01C	4.99E+00
PGXMY1A-TR01A	480V LC TRANSFORMER LC-TR01A FAULT	4.97E+00
RCPVO-B-202	POSRV V202 FAILS TO OPEN (HARDWARE FAIL)	4.86E+00
RCPVO-D-203	POSRV V203 FAILS TO OPEN (HARDWARE FAIL)	4.86E+00
RCMVO-C-131	MV 131 FAILS TO OPEN	4.75E+00
RCMVO-C-133	MV 133 FAILS TO OPEN	4.75E+00
RCMVO-A-130	MV 130 FAILS TO OPEN	4.75E+00
RCMVO-A-132	MV 132 FAILS TO OPEN	4.75E+00
AFMPM2A-MDP02A	AFW MDP PP02A UNAVAILABLE DUE TO T/M	4.71E+00
PGXMY2A-TR01C	480V LC TRANSFORMER LC-TR01C FAULT	4.63E+00
VOHVM2A-HV33A	CUBICLE COOLER HV33A UNAVAILABLE DUE TO T&M	4.39E+00
PELXY-D-LX02D-P	FAILURE OF PRIMARY LOOP CONTROLLER OF 745-PE-LX02D	4.32E+00
RCMVO-B-136	MV 136 FAILS TO OPEN	4.30E+00
RCMVO-B-134	MV 134 FAILS TO OPEN	4.30E+00
RCMVO-D-137	MV 137 FAILS TO OPEN	4.30E+00
RCMVO-D-135	MV 135 FAILS TO OPEN	4.30E+00
PELXY-C-LX02C-P	FAILURE OF PRIMARY LOOP CONTROLLER OF 745-PE-LX02C	4.28E+00
VOHVR2A-HV33A	FAILS TO RUN OF MAFP ROOM A CUBICLE COOLER HV33A	4.05E+00
PGXMY1B-TR01B	480V LC TRANSFORMER LC-TR01B FAULT	3.97E+00
AFMPS2A-MDP02A	FAILS TO START AFW MDP PP02A	3.96E+00

Table 19.1-74 (5 of 11)

Basic Event	Description	RAW
PFHBC1A-SW01A-A2	FAILS TO CLOSE OF PCB SW01A-A2 OF 4.16KV SWGR SW01A	3.95E+00
AFTPKD2-TDP01A/B	2/2 CCF OF FOR AFW TDP PP01/A/B FAIL TO RUN	3.90E+00
VOHVS2A-HV33A	FAILS TO START OF MAFP ROOM A CUBICLE COOLER HV33A	3.90E+00
PHBSY1A-MC01A	BUS FAULT ON 480V MCC MC01A	3.88E+00
PHBSY1A-MC02A	BUS FAULT ON 480V MCC MC02A	3.77E+00
PHBSY1B-MC02B	BUS FAULT ON 480V MCC MC02B	3.76E+00
PHBSY1B-MC01B	BUS FAULT ON 480V MCC MC01B	3.76E+00
PGBSY2B-LC01D	BUS FAULT ON 480V LC LC01D	3.72E+00
PFBSY2B-SW01D	BUS FAULT ON 4.16KV SWGR SW01D	3.72E+00
PFHBC1B-SW01B-A2	FAILS TO CLOSE OF PCB SW01B-A2 OF 4.16KV SWGR SW01B	3.66E+00
DCBTT-A-BT01A	CLASS 1E 125V DC BATTERY BT01A FAILS BETWEEN TEST INTERVAL	3.59E+00
AFTPZD2-TDP01A/B	2/2 CCF OF FOR AFW TDP PP01/A/B FAIL TO RUN FOR 1HR	3.52E+00
PGXMY2B-TR01D	480V LC TRANSFORMER LC-TR01D FAULT	3.52E+00
DCBTT-B-BT01B	CLASS 1E 125V DC BATTERY BT01A FAILS BETWEEN TEST INTERVAL	3.48E+00
CVAVC-S-505	CTMT. ISOL. AOV CV-505 FAIL TO CLOSE	3.32E+00
CVAVC-S-523	CTMT. ISOL. AOV CV-523 FAIL TO CLOSE	3.32E+00
CVAVC-S-561	CTMT. ISOL. AOV CV-561 FAIL TO CLOSE	3.32E+00
WOCHM2A-CH02A	ECW CHILLER 02A TRAIN UNAVAILABLE DUE TO T&M	3.30E+00
VOHVKD2-HV33A/33B	2/2 CCF OF FOR CUBICLE COOLER HV33A/33B	3.27E+00

Table 19.1-74 (6 of 11)

Basic Event	Description	RAW
SXMPM2A-PP02A	ESW PUMP PP02A UNAVAILABLE DUE TO T/M	3.23E+00
WOCHS2A-CH02A	ECW CHILLER CH02A FAILS TO START ON DEMAND	3.22E+00
WOCHM2B-CH02B	ECW CHILLER 02B TRAIN UNAVAILABLE DUE TO T&M	3.19E+00
IPINY-A-IN01A	120V AC POWER SUPPLY INVERTER IN01A FAILS WHILE OPERATING	3.19E+00
RCINY1A-IN01A	INVERTER FOR POSRV MOTOR OPERTAED PILOT VVs 431-V130/V132 FAILS	3.13E+00
RCINY1C-IN01C	INVERTER FOR POSRV MOTOR OPERTAED PILOT VVs 431-V131/V133/441-V653 FAILS	3.13E+00
SXMPM2B-PP02B	ESW PUMP PP02B UNAVAILABLE DUE TO T/M	3.12E+00
AFMPM2B-MDP02B	AFW MDP PP02B UNAVAILABLE DUE TO T/M	3.11E+00
WOCHS2B-CH02B	ECW CHILLER CH02B FAILS TO START ON DEMAND	3.11E+00
WOMPM2A-PP02A	ECW PP02A TRAIN UNAVAILABLE DUE TO T&M	3.09E+00
DCBTM-C-BT01C	CLASS 1E 125V DC BATTERY BT01C UNAVAILABLE DUE TO T&M	3.07E+00
IPINM-C-IN01C	CLASS 1E 120V AC INVERTER IN01C UNAVAILABLE DUE TO T&M	3.06E+00
DCBTM-D-BT01D	CLASS 1E 125V DC BATTERY BT01D UNAVAILABLE DUE TO T&M	3.06E+00
IPINM-D-IN01D	CLASS 1E 120V AC INVERTER IN01D UNAVAILABLE DUE TO T&M	3.05E+00
AFMPR2A-MDP02A	FAILS TO RUN AFW MDP PP02A	2.99E+00
CCMPM2A-PP02A	CCW PUMP PP02A UNAVAILABLE DUE TO T/M	2.98E+00
WOMPM2B-PP02B	ECW PP02B TRAIN UNAVAILABLE DUE TO T&M	2.98E+00
RCINY1B-IN01B	INVERTER FOR POSRV MOTOR OPERTAED PILOT VVs 431-V134/V136 FAILS	2.97E+00

Table 19.1-74 (7 of 11)

Basic Event	Description	RAW
RCINY1D-IN01D	INVERTER FOR POSRV MOTOR OPERTAED PILOT VVs 431-V135/V137/441-V654 FAILS	2.97E+00
IPINY-B-IN01B	120V AC POWER SUPPLY INVERTER IN01B FAILS WHILE OPERATING	2.97E+00
CCMPM2B-PP02B	CCW PUMP PP02B UNAVAILABLE DUE TO T/M	2.89E+00
SICVWD2-V100/01	2/2 CCF OF CV 100/101 IN TRAIN A&B IRWST RETURN LINES	2.88E+00
VOHVM1B-HV33B	CUBICLE COOLER HV33B UNAVAILABLE DUE TO T&M	2.87E+00
PELXY-C-LX05C-P	FAILURE OF PRIMARY LOOP CONTROLLER OF 745-PE-LX05C	2.83E+00
PELXY-A-LX08A-P	FAILURE OF PRIMARY LOOP CONTROLLER OF 745-PE-LX08A	2.83E+00
VGAHM2A-AH02A	ESW PUMP A FAN 605-VG-AH02A UNAVAILABLE DUE TO T&M	2.72E+00
VOHVM2A-HV32A	CUBICLE COOLER HV32A UNAVAILABLE DUE TO T&M	2.72E+00
SXAHM-A-AH02A	ESW COOLING FAN AH02A UNAVAILABLE DUE TO T&M	2.69E+00
PELXY-B-LX09B-P	FAILURE OF PRIMARY LOOP CONTROLLER OF 745-PE-LX09B	2.69E+00
PELXY-D-LX05D-P	FAILURE OF PRIMARY LOOP CONTROLLER OF 745-PE-LX05D	2.69E+00
AFMPL2A-MDP02A	FAILS TO RUN FOR 1HR AFW MDP PP02A	2.65E+00
VKHVM2A-HV14A	CUBICLE COOLER HV14A UNAVAILABLE DUE TO T&M	2.63E+00
VGAHM2B-AH02B	ESW PUMP B FAN 605-VG-AH02B UNAVAILABLE DUE TO T&M	2.61E+00
VOHVM2B-HV32B	CUBICLE COOLER HV32B UNAVAILABLE DUE TO T&M	2.61E+00
VOHVR2B-HV33B	FAILS TO RUN OF MAFP ROOM B CUBICLE COOLER HV33B	2.60E+00
SXAHM-B-AH02B	ESW COOLING FAN AH02B UNAVAILABLE DUE TO T&M	2.59E+00
CCMPS2A-PP02A	CCW PUMP PP02A FAILS TO START	2.57E+00

Table 19.1-74 (8 of 11)

Basic Event	Description	RAW
SXMPS2A-PP02A	ESW PUMP PP02A FAILS TO START	2.57E+00
WOMPS2A-PP02A	FAILS TO START OF ECW PUMP 02A	2.57E+00
DGDGR-D-DGD	FAILS TO RUN OF EMERGENCY DIESEL GENERATOR DG01D	2.55E+00
AFMPS2B-MDP02B	FAILS TO START AFW MDP PP02B	2.55E+00
PEDOY-C-LX05C01	FAILURE OF DIGITAL OUTPUT MODULE 745-LX05C BRANCH 01	2.50E+00
PEDOY-A-LX08A01	FAILURE OF DIGITAL OUTPUT MODULE 745-LX08A BRANCH 01	2.50E+00
VOHVS2B-HV33B	FAILS TO START OF MAFP ROOM B CUBICLE COOLER HV33B	2.48E+00
CCMPS2B-PP02B	CCW PUMP PP02B FAILS TO START	2.48E+00
WOMPS2B-PP02B	FAILS TO START OF ECW PUMP 02B	2.48E+00
SXMPS2B-PP02B	ESW PUMP PP02B FAILS TO START	2.48E+00
CCMVO-A-097	CS Hx. HE01A INLET MOV 097 FAILS TO OPEN	2.48E+00
CSMVO1A-003	CS ISOL. MOV 003 IN CS TRAIN A DISCH. PATH FAILS TO OPEN	2.48E+00
DGDGM-D-DGD	DG 01D UNAVAILABLE DUE TO MAINTENANCE	2.48E+00
VKHVM2B-HV14B	CUBICLE COOLER HV14B UNAVAILABLE DUE TO T&M	2.48E+00
AFVVT2A-V1603	AFW MDP02A MINI FLOW LINE MANUAL VALVE V1603 TRANSFER CLOSED	2.45E+00
AFVVT2A-V1001A	AFW MDP02A SUCT. MANUAL VALVE V1001A TRANSFER CLOSED	2.45E+00
AFVVT2A-V1011A	AFW MDP02A MINI FLOW LINE MANUAL VALVE V1011A TRANSFER CLOSED	2.45E+00
AFVVT2A-V1005A	AFW MDP01A DISCH. MANUAL VALVE V1005A TRANSFER CLOSED	2.45E+00
CCMVO-A-131	CCW MOV 131 FOR ECW CHILLER CH02A OUTLET FAIL TO OPEN	2.45E+00

Table 19.1-74 (9 of 11)

Basic Event	Description	RAW
DGDGR-C-DGC	FAILS TO RUN OF EMERGENCY DIESEL GENERATOR DG01C	2.44E+00
PALXY-D-PA06D-P	PRIMARY LOOP CONTROLLER 752-PA06D FAILS TO RUN	2.44E+00
CSMPM2A-PP01A	CS PUMP 1 PP01A UNAVAILABLE DUE TO MAINTENANCE	2.39E+00
PEDOY-D-LX05D01	FAILURE OF DIGITAL OUTPUT MODULE 745-LX05D BRANCH 01	2.39E+00
PEDOY-B-LX09B01	FAILURE OF DIGITAL OUTPUT MODULE 745-LX09B BRANCH 01	2.39E+00
DGDGM-C-DGC	DG 01C UNAVAILABLE DUE TO MAINTENANCE	2.37E+00
CCMVO-B-132	CCW MOV 132 FOR ECW CHILLER CH02B OUTLET FAIL TO OPEN	2.34E+00
WOCHR2A-CH02A	ECW CHILLER 02A FAILS TO RUN FOR 24 HOURS	2.32E+00
PADOY-D-PA06D01	FAILURE OF DIGITAL OUTPUT MODULE PA06D BRANCH 01	2.31E+00
PADOY-D-PA06D03	FAILURE OF DIGITAL OUTPUT MODULE 752-PA06D BRANCH 03	2.31E+00
PEDOY-D-LX03D01	FAILURE OF DIGITAL OUTPUT MODULE LX03D BRANCH 01	2.31E+00
VGAHS2A-AH02A	FAILS TO START OF EWS PUMP ROOM I. SUPPLY FAN AH02A	2.31E+00
VOHVS2A-HV32A	FAILS TO START OF ECW ROOM CUBICLE COOLER HV32A	2.31E+00
VKHVS2A-HV14A	FAILS TO START CCW PUMP ROOM CUBICLE COOLER HV14A	2.27E+00
DGDGL-D-DGD	DG D FAILS TO LOAD AND RUN DURING 1ST 1HR OF OPERATION	2.27E+00
WOCHR2B-CH02B	ECW CHILLER 02B FAILS TO RUN FOR 24 HOURS	2.25E+00
PEDOY-A-LX01A04	FAILURE OF DIGITAL OUTPUT MODULE LX01A BRANCH 04	2.25E+00
VGAHS2B-AH02B	EWS PUMP ROOM II. SUPPLY FAN AH02B FAILS TO START	2.23E+00
VOHVS2B-HV32B	FAILS TO START OF ECW ROOM B CUBICLE COOLER HV32B	2.23E+00
VKHVM1A-HV10A	CUBICLE COOLER HV10A UNAVAILABLE DUE TO T&M	2.23E+00

Table 19.1-74 (10 of 11)

Basic Event	Description	RAW
DGDGS-D-DGD	FAILS TO START OF EMERGENCY DIESEL GENERATOR DG01D	2.21E+00
WOCHR1A-CH01A	ECW CHILLER CH01A FAILS TO RUN FOR 24 HOURS	2.20E+00
RCPVC-D-203	POSRV V203 FAILS TO CLOSE (HARDWARE FAIL)	2.18E+00
RCPVC-A-200	POSRV V200 FAILS TO CLOSE (HARDWARE FAIL)	2.18E+00
RCPVC-C-201	POSRV V201 FAILS TO CLOSE (HARDWARE FAIL)	2.18E+00
RCPVC-B-202	POSRV V202 FAILS TO CLOSE (HARDWARE FAIL)	2.18E+00
PALXY-C-PA06C-P	PRIMARY LOOP CONTROLLER 752-PA06C FAILS TO RUN	2.18E+00
DGDGL-C-DGC	DG 01C FAILS TO LOAD AND RUN DURING 1ST 1HR OF OPERATION	2.17E+00
VKHVS2B-HV14B	FAILS TO START CCW PUMP ROOM CUBICLE COOLER HV14B	2.16E+00
AFTPR1A-TDP01A	FAILS TO RUN AFW TDP PP01A	2.14E+00
DGDGS-C-DGC	FAILS TO START OF EMERGENCY DIESEL GENERATOR DG01C	2.13E+00
VDHVM-D-HV12D	CUBICLE COOLER HV12D UNAVAILABLE DUE TO T&M	2.12E+00
VDHVM-D-HV13D	CUBICLE COOLER HV13D UNAVAILABLE DUE TO T&M	2.12E+00
VKHVL1A-HV10A	FAILS TO RUN CS PUMP 01A ROOM CUBICLE COOLER HV10A FOR 1HR	2.12E+00
VKHVR1A-HV10A	FAILS TO RUN CS PUMP 01A ROOM CUBICLE COOLER HV10A	2.11E+00
CSMPS2A-PP01A	CS PUMP 1 PP01A FAILS TO START	2.09E+00
PADOY-D-PA06C02	FAILURE OF DIGITAL OUTPUT MODULE PA06C BRANCH 02	2.07E+00
PEDOY-C-LX03C01	FAILURE OF DIGITAL OUTPUT MODULE LX03C BRANCH 01	2.07E+00
PADOY-C-PA06C04	FAILURE OF DIGITAL OUTPUT MODULE PA06C BRANCH 04	2.07E+00

Table 19.1-74 (11 of 11)

Basic Event	Description	RAW
AFMVC1A-045	AFW ISOL. MOV 0045 FAILS TO CLOSE FOR CYCLING OPERATION	2.07E+00
AFMVO1A-045	AFW ISOL. MOV 045 FAILS TO OPEN FOR CYCLING OPERATION	2.07E+00
VKHVS1A-HV10A	FAILS TO START CS PUMP 01A ROOM CUBICLE COOLER HV10A	2.07E+00
CSMPM2B-PP01B	CS PUMP PP01B UNAVAILABLE DUE TO MAINTENANCE	2.07E+00
VDHVM-C-HV13C	CUBICLE COOLER HV13C UNAVAILABLE DUE TO T&M	2.05E+00
VDHVM-C-HV12C	CUBICLE COOLER HV12C UNAVAILABLE DUE TO T&M	2.05E+00
AFTPR1B-TDP01B	FAILS TO RUN AFW TDP PP01B	2.03E+00
NPXOY-S-MTR	MAIN TRANSFORMER FAULT	2.02E+00
NPXHY-N-UAT01N	UNIT AUX XFMR TR01N FAILS WHILE OPERATING	2.02E+00
NPXHY-M-UAT01M	UNIT AUX XFMR TR01M FAILS WHILE OPERATING	2.02E+00
NPBDY-S-IPB	IPB FAULT	2.02E+00
AFMVT2A-043	AFW ISOL. MOV V043 TRANSFER CLOSED	2.02E+00

Table 19.1-75 (1 of 3)

Internal Flooding PRA Key Basic Events by FV (LRF)

Basic Event	Description	FV
ERVC	EXTERNAL REACTOR VESSEL COOLING FAILS	5.13E-01
PFHBO1A-SW01A-H2	FAILS TO OPEN OF PCB SW01A-H2 OF 4.16KV SWGR SW01A FROM UAT	1.67E-01
PFHBO1B-SW01B-H2	FAILS TO OPEN OF PCB SW01B-H2 OF 4.16KV SWGR SW01B FROM UAT	1.38E-01
AFMVC1A-045	AFW ISOL. MOV 0045 FAILS TO CLOSE FOR CYCLING OPERATION	6.58E-02
AFMVO1A-045	AFW ISOL. MOV 045 FAILS TO OPEN FOR CYCLING OPERATION	6.58E-02
PFHBO2A-SW01C-C2	FAILS TO OPEN OF PCB SW01C-C2 OF 4.16KV SWGR SW01C FROM UAT	6.37E-02
AFMVC1B-046	AFW ISOL. MOV 046 FAILS TO OPEN FOR CYCLING OPERATION	5.87E-02
AFMVO1B-046	AFW ISOL. MOV 046 FAILS TO CLOSE FOR CYCLING OPERATION	5.87E-02
PFHBO2B-SW01D-G2	FAILS TO OPEN OF PCB SW01D-G2 OF 4.16KV SWGR SW01D FROM UAT	4.71E-02
WOCHM2A-CH02A	ECW CHILLER 02A TRAIN UNAVAILABLE DUE TO T&M	4.63E-02
WOCHM2B-CH02B	ECW CHILLER 02B TRAIN UNAVAILABLE DUE TO T&M	4.42E-02
AFTPR1A-TDP01A	FAILS TO RUN AFW TDP PP01A	4.14E-02
DGDGR-D-DGD	FAILS TO RUN OF EMERGENCY DIESEL GENERATOR DG01D	3.96E-02
AFTPR1B-TDP01B	FAILS TO RUN AFW TDP PP01B	3.75E-02
DGDGR-C-DGC	FAILS TO RUN OF EMERGENCY DIESEL GENERATOR DG01C	3.68E-02
DCBTM-A-BT01A	CLASS 1E 125V DC BATTERY BT01A UNAVAILABLE DUE TO T&M	3.14E-02
DCBTM-B-BT01B	CLASS 1E 125V DC BATTERY BT01B UNAVAILABLE DUE TO T&M	3.00E-02
SXMPM2A-PP02A	ESW PUMP PP02A UNAVAILABLE DUE TO T/M	2.98E-02

Table 19.1-75 (2 of 3)

Basic Event	Description	FV
WOCHS2A-CH02A	ECW CHILLER CH02A FAILS TO START ON DEMAND	2.92E-02
SXMPM2B-PP02B	ESW PUMP PP02B UNAVAILABLE DUE TO T/M	2.83E-02
WOCHS2B-CH02B	ECW CHILLER CH02B FAILS TO START ON DEMAND	2.78E-02
PFLOOP-TRANS	CONDITIONAL LOOP UPON TRANSIENTS	2.51E-02
IPINM-A-IN01A	CLASS 1E 120V AC INVERTER IN01A UNAVAILABLE DUE TO T&M	2.28E-02
DGDGM-D-DGD	DG 01D UNAVAILABLE DUE TO MAINTENANCE	2.16E-02
IPINM-B-IN01B	CLASS 1E 120V AC INVERTER IN01B UNAVAILABLE DUE TO T&M	2.05E-02
DGDGM-C-DGC	DG 01C UNAVAILABLE DUE TO MAINTENANCE	2.00E-02
PFHBC1A-SW01A-A2	FAILS TO CLOSE OF PCB SW01A-A2 OF 4.16KV SWGR SW01A	1.98E-02
PFHBC1B-SW01B-A2	FAILS TO CLOSE OF PCB SW01B-A2 OF 4.16KV SWGR SW01B	1.78E-02
RCPVO-C-201	POSRV V200 FAILS TO OPEN (HARDWARE FAIL)	1.60E-02
RCPVO-A-200	POSRV V201 FAILS TO OPEN (HARDWARE FAIL)	1.60E-02
DGDGR-B-DGB	FAILS TO RUN OF EMERGENCY DIESEL GENERATOR DG01B	1.54E-02
WOMPM2A-PP02A	ECW PP02A TRAIN UNAVAILABLE DUE TO T&M	1.45E-02
WOMPM2B-PP02B	ECW PP02B TRAIN UNAVAILABLE DUE TO T&M	1.38E-02
RCPVO-B-202	POSRV V202 FAILS TO OPEN (HARDWARE FAIL)	1.37E-02
RCPVO-D-203	POSRV V203 FAILS TO OPEN (HARDWARE FAIL)	1.37E-02
AFMPM2A-MDP02A	AFW MDP PP02A UNAVAILABLE DUE TO T/M	1.35E-02
NPXHM-N-SAT02N	SAT TR02N UNAVAILABLE DUE TO MAINTENANCE	1.33E-02
NPXHM-M-SAT02M	SAT TR02M UNAVAILABLE DUE TO MAINTENANCE	1.27E-02

Table 19.1-75 (3 of 3)

Basic Event	Description	FV
CSMPM2A-PP01A	CCW PUMP PP01A UNAVAILABLE DUE TO T/M	9.89E-03
DGDGR-A-DGA	FAILS TO RUN OF EMERGENCY DIESEL GENERATOR DG01A	9.58E-03
CCMPM2A-PP02A	CCW PUMP PP02A UNAVAILABLE DUE TO T/M	9.41E-03
CCMPM2B-PP02B	CCW PUMP PP02B UNAVAILABLE DUE TO T/M	8.97E-03
DGDGM-B-DGB	DG 01B UNAVAILABLE DUE TO MAINTENANCE	8.08E-03
AFMPM2B-MDP02B	AFW MDP PP02B UNAVAILABLE DUE TO T/M	7.69E-03
CSMPM2B-PP01B	CS PUMP PP01B UNAVAILABLE DUE TO MAINTENANCE	7.57E-03
I-ATWS-RPMCF	FAILURE TO SCRAM DUE TO MECHANICAL FAILURES	7.49E-03
GWSVO-S-002	CTMT. ISOL. SOV GW-002 FAIL TO CLOSE	6.79E-03
VOHVM2A-HV33A	CUBICLE COOLER HV33A UNAVAILABLE DUE TO T&M	6.79E-03
SXFLP-S-FT0123AB	ESW DEBIS FILTER FT01A PLUGGED	6.28E-03
DCBTM-C-BT01C	CLASS 1E 125V DC BATTERY BT01C UNAVAILABLE DUE TO T&M	5.87E-03
DCBTM-D-BT01D	CLASS 1E 125V DC BATTERY BT01D UNAVAILABLE DUE TO T&M	5.82E-03
AFTPS1A-TDP01A	FAILS TO START AFW TDP PP01A	5.74E-03
IPINM-C-IN01C	CLASS 1E 120V AC INVERTER IN01C UNAVAILABLE DUE TO T&M	5.66E-03
IPINM-D-IN01D	CLASS 1E 120V AC INVERTER IN01D UNAVAILABLE DUE TO T&M	5.62E-03
DEAVC-S-006	CTMT. ISOL. AOV DE-006 FAIL TO CLOSE	5.32E-03
AFTPS1B-TDP01B	AFTPS1B-TDP01B	5.23E-03

Table 19.1-76 (1 of 6)

Internal Flooding PRA Key CCF Events by RAW (LRF)

Basic Event	Description	RAW
RPRBWO8-TCBALL	CCF FAILURE OF ALL TRIP CIRCUIT BRAKER TCB	1.88E+04
RPRBWO4-TCB-CD1AC2	4/8 CCF OF TCB C-1, D-1, A-2 C-2	1.88E+04
RPRBWO4-TCB-CD1BD2	4/8 CCF OF TCB C-1, D-1, B-2, D-2	1.88E+04
RPRBWO4-TCB-AB1AC2	4/8 CCF OF TCB A-1, B-1, A-2, C-2	1.88E+04
RPRBWO4-TCB-AB1BD2	4/8 CCF OF TCB A-1, B-1, B-2 D-2	1.88E+04
PFHBWQ4-SW2OUAT	CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1B,1C,1D FAIL TO OPEN	8.87E+03
PFHBWQ3-SW2OUATACD	3/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1C,1D FAIL TO OPEN	4.14E+03
PFHBWQ3-SW2OUATBCD	3/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01B,1C,1D FAIL TO OPEN	3.87E+03
VGAHKQ4-AH01A/1B/2A/2B	4/4 RUNNING CCF OF ESW PUMP ROOM FAN AH01A/B, 02A/B	2.45E+03
SXMPKQ4-PP01A/B/2A/B	4/4 CCF OF ESW PUMPS PP01A/2A, PP01B/2B TO RUN	2.39E+03
SXAHKQ4-AH01A/02A/01B/02B	4/4 RUNNING CCF OF ESW COOLING TOWER FANS AH01A, 02A, 01B, 02B	2.34E+03
CCMPKQ4-PP01A/B/2A/B	4/4 CCF OF CCW PUMPS PP01A/1B/2A/2B (RUNNING)	2.25E+03
PFHBWQ3-SW2OUATABC	3/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1B,1C FAIL TO OPEN	1.73E+03

Table 19.1-76 (2 of 6)

Basic Event	Description	RAW
VGAHKQ3-AH01A/2A/2B	3/4 RUNNING CCF OF ESW PUMP ROOM FAN AH01A, 02A, 02B	8.89E+02
PFHBWQ3-SW2OUATABD	3/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1B,1D FAIL TO OPEN	8.89E+02
CCMPKQ3-PP01A/2A/B	3/4 CCF OF CCW PUMPS PP01A/2A/2B (RUNNING)	8.69E+02
SXMPKQ3-PP01A/2A/B	3/4 CCF OF ESW PUMPS PP01A, PP02A, PP02B (RUNNING)	8.68E+02
PFHBWQ2-SW2OUATAC	2/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1C FAIL TO OPEN	8.44E+02
SXAHKQ3-AH01A/02A/02B	3/4 RUNNING CCF OF ESW COOLING TOWER FANS AH01A, 02A, 02B	8.40E+02
VGAHKQ3-AH01B/2A/2B	3/4 CCF (RUNNING) OF ESW PUMP ROOM FAN AH01B, 02A, 02B	8.20E+02
CCMPKQ3-PP01B/2A/B	3/4 CCF OF CCW PUMPS PP01B/2A/2B (RUNNING)	8.06E+02
SXMPKQ3-PP01B/2A/B	3/4 CCF OF ESW PUMPS PP02A, PP01B, PP02B (RUNNING)	8.04E+02
PFHBWQ2-SW2OUATBD	2/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01B,1D FAIL TO OPEN	7.77E+02
SXAHKQ3-AH02A/01B/02B	3/4 RUNNING CCF OF ESW COOLING TOWER FANS AH02A, 01B, 02B	7.75E+02
VGAHKQ3-AH01A/1B/2A	3/4 RUNNING CCF OF ESW PUMP ROOM FAN AH01A, 01B, 02A	3.54E+02
CCMPKQ3-PP01A/B/2A	3/4 CCF OF CCW PUMPS PP01A/1B/2A (RUNNING)	3.28E+02
SXMPKQ3-PP01A/B/2A	3/4 CCF OF ESW PUMPS PP01A, PP02A, PP01B (RUNNING)	3.22E+02

Table 19.1-76 (3 of 6)

Basic Event	Description	RAW
SXAHKQ3-AH01A/02A/01B	3/4 RUNNING CCF OF ESW COOLING TOWER FANS AH01A, 02A, 01B	2.97E+02
AFPVKQ4-TP01A/B/MP02A/B	4/4 CCF OF AFW TDP01A/B, MDP02A/B DUE TO THE VOLUTE FAIL TO RUN	2.48E+02
AFCVWO4-V1003AB/4AB	4/8 CCF OF AF DISCH. CHECK VALVE V1003AB/4AB FAIL TO OPEN	2.12E+02
AFCVWO4-V1007AB/8AB	4/8 CCF OF AF DISCH. CHECK VALVE V1007AB/8AB FAIL TO OPEN	2.12E+02
AFCVWO8-V1003AB/4AB/7AB/8AB	8/8 CCF OF AF DISCH. CHECK VALVE V1003AB/4AB/7AB/8AB FAIL TO OPEN	1.78E+02
DCBTWQ4-BT01ABCD	4/4 CCF OF 125V DC BATTERY BT01A/01B/01C/01D FAILS UPON DEMAND	1.59E+02
PFHBWQ2-SW2OUATBC	2/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01B,1C FAIL TO OPEN	1.08E+02
PFHBWQ2-SW2OUATAD	2/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1D FAIL TO OPEN	1.07E+02
VGAHKQ3-AH01A/1B/2B	3/4 RUNNING CCF OF ESW PUMP ROOM FAN AH01A, 01B, 02B	9.27E+01
CCMPKQ2-PP01/2A	2/4 CCF OF CCW PUMPS PP01A/2A (RUNNING)	8.58E+01
SXMPKQ2-PP01/2A	2/4 CCF OF ESW PUMPS PP01A, PP02A (RUNNING)	8.58E+01
AFCVWQ4-V1012A/B/4A/B	4/4 CCF OF AFW MINI FLOW CHECK VALVE V1012A/B & 1014A/B FAIL TO OPEN	8.30E+01
VGAHKQ2-AH01A/2A	2/4 RUNNING CCF OF ESW PUMP ROOM FAN AH01A, 02A	8.02E+01

Table 19.1-76 (4 of 6)

Basic Event	Description	RAW
PFHBWQ2-SW2OUATCD	2/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01C,1D FAIL TO OPEN	7.01E+01
CCMPKQ3-PP01A/B/2B	3/4 CCF OF CCW PUMPS PP01A/1B/2B (RUNNING)	6.57E+01
SXMPKQ3-PP01A/B/2B	3/4 CCF OF ESW PUMPS PP01A, PP01B, PP02B (RUNNING)	6.57E+01
CCMVXO8-143-150	8/8 CCF(DEMAND) OF MOV 143,144,145,146,147,148,149,150 IN NON SAFETY LOAD LINE	6.39E+01
SICVWQ4-V157/158/159/160	4/4 CCF OF CS CV 157/158 SC CV 159/160	6.36E+01
SICVWQ4-V568/569/1001/1002	CCF TO OPEN CSP DISCH LINE 1001, 1002 AND SCP DISCH. LINE CV 568,569	6.36E+01
WOCHKQ4-CH01A/1B/2A/2B	RUNNING CCF OF ECW CHILLERS 1A/2A/1B/2B	6.33E+01
CCMPKQ2-PP01/2B	2/4 CCF OF CCW PUMPS PP01B/2B (RUNNING)	6.16E+01
SXMPKQ2-PP01/2B	2/4 CCF OF ESW PUMPS PP01B, PP02B (RUNNING)	6.01E+01
VGAHKQ2-AH01B/2B	2/4 CCF (RUNNING) OF ESW PUMP ROOM FAN AH01B, 02B	5.69E+01
AFPVKQ3-TP01A/B/MP02A	3/4 CCF OF AFW TDP01A/B, MDP02A DUE TO THE VOLUTE FAIL TO RUN	5.35E+01
AFPVKQ3-TP01A/B/MP02B	3/4 CCF OF AFW TDP01A/B, MDP02B DUE TO THE VOLUTE FAIL TO RUN	5.25E+01
DCBTWQ3-BT01BCD	3/4 CCF OF 125V DC BATTERY BT01B/01C/01D FAILS UPON DEMAND	4.76E+01
DCBTWQ3-BT01ABD	3/4 CCF OF 125V DC BATTERY BT01A/01B/01D FAILS UPON DEMAND	4.45E+01

Table 19.1-76 (5 of 6)

Basic Event	Description	RAW
PFHBWQ2-SW2OUATAB	2/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1B FAIL TO OPEN	4.32E+01
VOHVKQ4-HV32A/32B/31A/31B	4/4 CCF OF RUN FOR CUBICLE COOLER HV32A/32B/31A/31B	4.03E+01
SXAHKQ3-AH01A/01B/02B	3/4 RUNNING CCF OF ESW COOLING TOWER FANS AH01A, 01B, 02B	3.81E+01
SXMPKQ2-PP02A/1B	2/4 CCF OF ESW PUMPS PP02A, PP01B (RUNNING)	3.65E+01
SXMPKQ2-PP01A/2B	2/4 CCF OF ESW PUMPS PP01A, PP02B (RUNNING)	3.29E+01
SXAHKQ2-AH02A/01B	2/4 RUNNING CCF OF ESW COOLING TOWER FANS AH02A, 01B	2.91E+01
CCMPKQ2-PP01B/2A	2/4 CCF OF CCW PUMPS PP01B/2A (RUNNING)	2.91E+01
VGAHKQ2-AH01B/2A	2/4 CCF (RUNNING) OF ESW PUMP ROOM FAN AH01B, 02A	2.91E+01
SXAHKQ2-AH01A/02A	2/4 RUNNING CCF OF ESW COOLING TOWER FANS AH01A, 02A	2.73E+01
SXAHKQ2-AH01A/02B	2/4 RUNNING CCF OF ESW COOLING TOWER FANS AH01A, 02B	2.68E+01
CCMPKQ2-PP01A/2B	2/4 CCF OF CCW PUMPS PP01A/2B (RUNNING)	2.68E+01
VGAHKQ2-AH01A/2B	2/4 RUNNING CCF OF ESW PUMP ROOM FAN AH01A, 02B	2.68E+01
DCBTWQ3-BT01ACD	3/4 CCF OF 125V DC BATTERY BT01A/01C/01D FAILS UPON DEMAND	2.67E+01
AFPVKQ3-TP01A/MP02A/B	3/4 CCF OF AFW TDP01A, MDP02A/B DUE TO THE VOLUTE FAIL TO RUN	2.58E+01
WOCHKQ3-CH01A/2A/2B	RUNNING CCF OF ECW CHILLERS 1A/2A/2B	2.49E+01

Table 19.1-76 (6 of 6)

Basic Event	Description	RAW
DCBTKQ4-BT01ABCD	4/4 CCF OF 125V DC BATTERY BT01A/01B/01C/01D FAILS TO RUN	2.47E+01
WOMPKQ4-PP01A/2A/1B/2B	RUNNING CCF OF ECW PUMPS 1A/2A/1B/2B	2.26E+01
DGDGKQ4-DG01ABCD	4/4 CCF OF EDG 01A/01B/01C/01D FAIL TO RUN	2.13E+01
VDHVZO8-HV12/13ABCD	8/8 CCF OF RUN FOR EDG ROOM CUBICLE COOLER HV12A, 12B, 12C, 12D 13A, 13B, 13C, 14D FOR 1HR	2.04E+01
VDHVKO8-HV12/13ABCD	8/8 CCF OF RUN FOR EDG ROOM CUBICLE COOLER HV12A, 12B, 12C, 12D 13A, 13B, 13C, 14D	2.04E+01

(1) The cutoff threshold chosen for this table is based upon guidance presented in NEI 00-04 (Reference 51).

Table 19.1-77

Internal Flooding PRA Key CCF Events by FV (LRF)

Basic Event	Description	FV
PFHBWQ4-SW2OUAT	CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1B,1C,1D FAIL TO OPEN	2.40E-01
PFHBWQ3-SW2OUATACD	3/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1C,1D FAIL TO OPEN	6.81E-02
PFHBWQ3-SW2OUATBCD	3/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01B,1C,1D FAIL TO OPEN	6.37E-02
PFHBWQ2-SW2OUATAC	2/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1C FAIL TO OPEN	5.07E-02
PFHBWQ2-SW2OUATBD	2/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01B,1D FAIL TO OPEN	4.67E-02
PFHBWQ3-SW2OUATABC	3/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1B,1C FAIL TO OPEN	2.85E-02
PFHBWQ3-SW2OUATABD	3/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1B,1D FAIL TO OPEN	1.46E-02
PFHBWQ2-SW2OUATBC	2/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01B,1C FAIL TO OPEN	6.46E-03
PFHBWQ2-SW2OUATAD	2/4 CCF OF PCB BETWEEN UAT & 4.16KV SW01A,1D FAIL TO OPEN	6.38E-03

Table 19.1-78

Internal Flooding PRA Key Operator Actions by RAW (LRF)

Basic Event	Description	RAW
H-CI-OPEN	OPERATOR FAILS TO RECOVERY FOR CIS ISOLATION	7.48E+00
AFOPH-S-ALT-LT	OPERATOR FAIL TO ALIGNE FOR SUPPLYING AN ALTERNATE SOURCE	4.79E+00
WOOPH-B-1/2B	OPERATOR FAILS TO OPERATE ECW PUMPS PP01/2B	2.39E+00
WOOPH-A-1/2A	OPERATOR FAILS TO OPERATE ECW PUMPS PP01/2A	2.29E+00
RCOPH-S-SDSE-FW	FAILURE OF SDS VALVES EARLY PHASE OPEN (1/4)	2.13E+00
CSOPU1A-1015	OPERATORS FAIL TO OPEN V-1015 AFTER IN-SERVICE TEST FOR CSP 01A	2.10E+00

Table 19.1-79

Internal Flooding PRA Key Operator Actions by FV (LRF)

Basic Event	Description	FV
H-CI-OPEN	OPERATOR FAILS TO RECOVERY FOR CIS ISOLATION	1.73E-01
WOOPH-B-1/2B	OPERATOR FAILS TO OPERATE ECW PUMPS PP01/2B	2.51E-02
WOOPH-A-1/2A	OPERATOR FAILS TO OPERATE ECW PUMPS PP01/2A	2.22E-02
FPOPH-1-ISO-FL	OPERATOR FAILS TO ISOLATE A FIRE PROTECTION BREAK IN LESS THAN 20 MINUTES	1.81E-02
H-SDR-POSRV-3WAY	OPERATOR FAILS TO OPERATION (POSRV & 3-WAY V/V)	1.08E-02
RCOPH-S-SDSE-FW	FAILURE OF SDS VALVES EARLY PHASE OPEN (1/4)	1.03E-02
H-SDR-3WAY	OPERATOR FAILS TO OPEN 3-WAY VALVE	6.15E-03

Table 19.1-80 (1 of 7)

Summary of External Hazard Dispositions

External Hazard	Typical Screening Criteria[(1)]	ASME Standard Remarks	APR1400 Treatment
Aircraft Impacts	N/A	Site specific, requires detailed study	COL Action Item added to address this issue on a site-specific basis.
Avalanche	3	Can be excluded for most US locations	Issue screened from consideration in Chapter 19 of the DCD based upon ASME Standard Screening Criteria. COL Action item entered to ensure the site specific susceptibility is not an outlier with respect to this item.
Biological Events	1, 5	Includes events such as detritus and zebra mussels	Issue screened from consideration in Chapter 19 of the DCD based upon ASME Standard Screening Criteria. COL Action item entered to ensure the site specific susceptibility is not an outlier.
Coastal Erosion	4, 5	Included in the effects of external flooding	Issue screened from consideration in Chapter 19 of the DCD based upon ASME Standard Screening Criteria. COL Action item entered to ensure the site specific susceptibility is not an outlier with respect to this item.
Drought	1, 5	Can often be excluded where the ultimate heat sink water level is designed for at least 30 days of operation, taking into account evaporation, drift, seepage, and other waste-loss mechanisms	Issue screened from consideration in Chapter 19 of the DCD based upon ASME Standard Screening Criteria. COL Action item entered to ensure the site specific susceptibility is not an outlier with respect to this item.

Table 19.1-80 (2 of 7)

External Hazard	Typical Screening Criteria[(1)]	ASME Standard Remarks	APR1400 Treatment
External Flooding	N/A	Site specific, requires detailed study	COL Action Item added to address this issue.
Extreme Winds and Tornadoes	N/A	Site specific, requires detailed study	COL Action Item added to address this issue.
Dam Failure	N/A	Not Mentioned in ASME Standard	Issue addressed as part of external flooding evaluation. COL action item to assess if site is susceptible to this failure mode.
Fog	1	Could increase the frequency of man-made hazard involving surface vehicles or aircraft; accident data include the effects of fog.	Issue screened from consideration in Chapter 19 of the DCD based upon ASME Standard Screening Criteria.
Forest Fire	1, 3	Fire cannot propagate to the site because the site is cleared; plant design and fire-protection provisions are adequate to mitigate the effects.	Issue screened from consideration in Chapter 19 of the DCD based upon ASME Standard Screening Criteria. COL Action item entered to ensure the site specific susceptibility is not an outlier with respect to this item.
Frost	1	Snow and ice govern	Issue screened from consideration in Chapter 19 of the DCD based upon ASME Standard Screening Criteria.
Hail	1	Other missiles govern.	Issue screened from consideration in Chapter 19 of the DCD based upon ASME Standard Screening Criteria.

Table 19.1-80 (3 of 7)

External Hazard	Typical Screening Criteria[(1)]	ASME Standard Remarks	APR1400 Treatment
High Summer Temperature	1	Can often be excluded where the ultimate heat sink temperature is designed for at least 30 days of operation, taking into account evaporation, drift, seepage, and other water-loss mechanisms. Evaluation is needed of possible loss of air cooling due to high temperatures.	Issue screened from consideration in Chapter 19 of the DCD based upon ASME Standard Screening Criteria. COL Action item entered to ensure the site specific susceptibility is not an outlier with respect to this item.
High Tide	4	Included under external flooding.	Issue screened from consideration in Chapter 19 of the DCD based upon ASME Standard Screening Criteria.
Hurricane	4	Included under external flooding; wind forces are covered under extreme winds and tornadoes.	Issue screened from consideration in Chapter 19 of the DCD based upon ASME Standard Screening Criteria.
Ice Cover	1, 4	Ice blockage of river included in flood; loss of cooling-water flow is considered in plant design.	Issue screened from consideration in Chapter 19 of the DCD based upon ASME Standard Screening Criteria.
Industrial or Military Facility	N/A	Site specific, requires detailed study	COL Action Item added to address this issue.
Internal Flooding	N/A	Site specific, requires detailed study	Issue discussed in Chapter 19 of the DCD for standard design.

Table 19.1-80 (4 of 7)

External Hazard	Typical Screening Criteria[(1)]	ASME Standard Remarks	APR1400 Treatment
Landslide	3	Can be excluded for most nuclear plant sites in the U.S.; confirm through walkdown.	Issue screened from consideration in Chapter 19 of the DCD based upon ASME Standard Screening Criteria. COL Action item entered to ensure the site specific susceptibility is not an outlier with respect to this item.
Lightning	1	Considered in plant design.	Issue screened from consideration in Chapter 19 of the DCD based upon ASME Standard Screening Criteria.
Low Lake/River Water Level	1, 5	Can often be excluded where the ultimate heat sink water level is designed for at least 30 days of operation, taking into account evaporation,	Issue screened from consideration in Chapter 19 of the DCD based upon ASME Standard Screening Criteria. COL Action item entered to ensure the site specific susceptibility is not an outlier with respect to this item.
Low Winter Temperature	1, 5	Thermal stresses and embrittlement are usually insignificant or covered by design codes and standards for plant design; generally, there is adequate warning of icing on the ultimate heat sink so that remedial action can be taken.	Issue screened from consideration in Chapter 19 of the DCD based upon ASME Standard Screening Criteria. COL Action item entered to ensure the site specific susceptibility is not an outlier with respect to this item.
Meteorite/Satellite Strikes	2	All sites have approximately the same frequency of occurrence.	Issue screened from consideration in Chapter 19 of the DCD based upon ASME Standard Screening Criteria.
Pipeline Accident	N/A	Site specific, requires detailed study	COL Action Item added to address this issue.

Table 19.1-80 (5 of 7)

External Hazard	Typical Screening Criteria(1)	ASME Standard Remarks	APR1400 Treatment
Intense Precipitation	4	Included under external and internal flooding. Roof loading and its effect on building integrity must be checked.	Issue screened from consideration in Chapter 19 of the DCD based upon ASME Standard Screening Criteria.
Release of Chemicals from Onsite Storage	N/A	Site specific, requires detailed study	COL Action Item added to address this issue.
River Diversion	1, 4	Considered in the evaluation of the ultimate heat sink; should diversion become a hazard, adequate storage is usually provided. Requires detailed site/ plant study.	COL Action Item added to address this issue.
Sandstorm	1, 4	Included under tornadoes and winds; potential blockage of air intakes with particulate matter is	COL Action Item added to address this issue.
Seiche	4	Included under external flooding	Issue screened from consideration in Chapter 19 of the DCD based upon ASME Standard Screening Criteria.
Seismic Activity	N/A	Site specific, requires detailed study	Issue discussed in Chapter 19 of the DCD for standard design.
Snow	1, 4	Plant designed for higher loading; snow melt causing river flooding is included under external flooding.	Issue screened from consideration in Chapter 19 of the DCD based upon ASME Standard Screening Criteria.
Soil Shrink / Swell	1, 5	Site-suitability evaluation and site development for the plant are designed to preclude the effects of this hazard.	Issue screened from consideration in Chapter 19 of the DCD based upon ASME Standard Screening Criteria.

Table 19.1-80 (6 of 7)

External Hazard	Typical Screening Criteria[(1)]	ASME Standard Remarks	APR1400 Treatment
Storm Surge	4	Included under external flooding.	Issue screened from consideration in Chapter 19 of the DCD based upon ASME Standard Screening Criteria.
Toxic Gas	N/A	Site specific, requires detailed study	COL Action Item added to address this issue.
Transportation Accidents	N/A	Site specific, requires detailed study	COL Action Item added to address this issue.
Tsunami	4	Included under external flooding.	Issue screened from consideration in Chapter 19 of the DCD based upon ASME Standard Screening Criteria.
Turbine-Generated Missiles	1, 2	Plant specific; requires detailed study.	For APR1400 standard plants, critical structures (e.g., the auxiliary building) will be located along or within close proximity to the longitudinal centerline of the turbine. This alignment makes the potential for a turbine-generated missile to strike critical structures or equipment negligible. In addition, the safety-related equipment is housed in structures constructed of reinforced concrete. Therefore, this event can be excluded from quantitative evaluation based on a low occurrence frequency, location of critical structures and equipment along the longitudinal centerline of the turbine, and protection of critical equipment.

Table 19.1-80 (7 of 7)

External Hazard	Typical Screening Criteria(1)	ASME Standard Remarks	APR1400 Treatment
Volcanic Activity	3	Can be excluded for most sites in the United States.	Issue screened from consideration in Chapter 19 of the DCD based upon ASME Standard Screening Criteria. COL Action item entered to ensure the site specific susceptibility is not an outlier with respect to this item.
Waves	4	Included under external flooding.	Issue screened from consideration in Chapter 19 of the DCD based upon ASME Standard Screening Criteria.

(1) (Reference 2)

Criterion 1: The event is of equal or lesser damage potential than the events for which the plant has been designed. This requires an evaluation of plant design bases in order to estimate the resistance of plant structures and systems to a particular external hazard.

Criterion 2: The event has a significantly lower mean frequency of occurrence than another event, taking into account the uncertainties in the estimates of both frequencies, and the event could not result in worse consequences than the consequences from the other event.

Criterion 3: The event cannot occur close enough to the plant to affect it. This criterion must be applied taking into account the range of magnitudes of the event for the recurrence frequencies of interest.

Criterion 4: The event is included in the definition of another event.

Criterion 5: The event is slow in developing, and it can be demonstrated that there is sufficient time to eliminate the source of the threat or to provide an adequate response.

Table 19.1-81 (1 of 2)

APR1400 Plant Operating States

Plant Operating State	Description	Technical Specifications Mode	Decay Heat
1	Reactor trip and Subcritical operation	1, 2	High
2	Cooldown with Steam Generators to 177°C (350°F)	3	High
3A	Cooldown with Shutdown Cooling System to 100°C (212°F)	4	High
3B	Cooldown with Shutdown Cooling System from 100°C (212°F) to 60°C (140°F)	5	High
4A	Reactor Coolant System drain-down (Pressurizer manway closed)	5	High
4B	Reactor Coolant System drain-down (manway open)	5	High
5	Reduced Inventory operation and nozzle dam installation	5	High
6	Fill for refueling	5	High
7	Offload	6	High
8	Defueled	Defueled	High
9	Onload	6	Low
10	Reactor Coolant System drain-down to Reduced Inventory after refueling	5	Low
11	Reduced Inventory operation with steam generator manway closure	5	Low

Table 19.1-81 (2 of 2)

Plant Operating State	Description	Technical Specifications Mode	Decay Heat
12A	Refill Reactor Coolant System (pressurizer manway open)	5	Low
12B	Refill Reactor Coolant System (pressurizer manway closed)	5	Low
13	Reactor Coolant System heat-up with Shutdown Cooling System isolation at 177°C (350°F)	4, 5	Low
14	Reactor Coolant System heat-up with steam generators	3	Low
15	Reactor startup	2,1	Low

Table 19.1-82

LPSD PRA Loss of SCS Initiators (S1, S2, SO, SL)

POS	Duration (hr)	Conversion factor	Frequency (/yr) (2)			
			S1	S2	SL	SO(3)
BASE(1)	-	-	1.40E-01	2.20E-02	2.90E-01	2.90E-03 (/demand)
POS3A	4.6	3.36E-04	4.70E-05	7.39E-06	-	-
POS3B	37.6	2.74E-03	3.84E-04	6.03E-05	-	-
POS4A	1.3	9.50E-05	1.33E-05	2.09E-06	-	-
POS4B	20.3	1.49E-03	2.08E-04	3.27E-05	-	-
POS5	16.8	1.23E-03	1.72E-04	2.71E-05	3.57E-04	1.93E-03
POS6	54.9	4.01E-03	5.62E-04	8.82E-05	-	-
POS10	85.7	6.26E-03	8.77E-04	1.38E-04	-	-
POS11	13.2	9.66E-04	1.35E-04	2.13E-05	2.80E-04	1.93E-03
POS12A	4.2	3.07E-04	4.29E-05	6.75E-06	-	-
POS13	33.5	2.44E-03	3.42E-04	5.38E-05	-	-

(1) BASE case is based on shutdown year.

(2) POS frequency = base event frequency ×conversion factor

(3) POS frequency = base event frequency (/demand) × 1 demand/outage × 1 outage/18months × 12 month/yr

Table 19.1-83

LPSD PRA General LOCA Initiators (LLOCA, MLOCA, SLOCA, SGTR)

POS	Duration (hr)	Conversion factor	Frequency (/yr)(2)			
			LLOCA	MLOCA	SLOCA	SGTR
BASE(1)	-	-	1.26E-06	4.83E-04	1.98E-03	1.96E-03
POS1	3.6	2.66E-04	3.35E-10	1.28E-07	5.26E-07	5.21E-07
POS2	32.9	2.40E-03	3.02E-09	1.16E-06	4.75E-06	4.70E-06
POS14	42.7	3.12E-03	3.93E-09	1.51E-06	6.17E-06	6.11E-06
POS15	42.4	3.10E-03	3.91E-09	1.50E-06	6.14E-06	6.08E-06

(1) BASE case is based on shutdown year.

(2) POS frequency = base event frequency × conversion factor

Table 19.1-84

LPSD PRA Shutdown-Specific LOCA Initiators (JL, RL, PL, SL1, SL2)

POS	Duration (hr)	Conv factor	Frequency (/yr)[(2)]				
			JL	RL[(3)]	PL[(4)]	SL1	SL2
BASE[(1)]	-	-	5.00E-03	4.38E-03	2.29E-04	1.60E-01	3.50E-02
POS2	32.9	2.40E-03	-	-	2.44E-03	-	-
POS3A	4.6	3.36E-04	1.68E-06	2.94E-06	-	5.38E-05	-
POS3B	37.6	2.74E-03	1.37E-05	2.40E-05	-	4.39E-04	-
POS4A	1.3	9.50E-05	4.75E-07	-	-	1.52E-05	-
POS4B	20.3	1.49E-03	7.43E-06	-	-	2.38E-04	-
POS5	16.8	1.23E-03	6.15E-06	-	-	-	2.15E-07
POS6	54.9	4.01E-03	2.01E-05	-	-	6.42E-04	-
POS10	85.7	6.26E-03	3.13E-05	-	-	1.00E-03	-
POS11	13.2	9.66E-04	4.83E-06	-	-	-	1.69E-07
POS12A	4.2	3.07E-04	1.53E-06	-	-	4.91E-05	-
POS13	33.5	2.44E-03	1.22E-05	2.14E-05	-	3.91E-04	-

(1) BASE case is based on shutdown year.

(2) POS frequency = base event frequency ×conversion factor

(3) POS frequency = base event frequency ×conversion factor × 2 (number of LTOP V/V)

(4) POS frequency = base event frequency ×conversion factor × 4 (number of LTOP V/V)
× 4 (the number of popping test / POSRV) × 1 outage / 18month × 12month/yr

Table 19.1-85 (1 of 2)

LPSD PRA LP(LOOP)/LX(SBO) Initiators

POS	Duration (hr)	Conv. Factor	O/H Component	Frequency (/yr)(2)						
				Plant-centered	Switchyard-centered	Grid-related	Weather-related	Total LP	Maintenance component (EDG)	LX(3)
BASE(1)	-	-	-	5.28E-02	6.39E-02	1.15E-02	3.67E-02	-	-	-
POS1	3.6	2.66E-04	-	1.40E-05	1.70E-05	3.06E-06	9.76E-06	4.38E-05	-	3.60E-09
POS2	32.9	2.40E-03	-	1.27E-04	1.53E-04	2.76E-05	8.81E-05	3.96E-04	-	4.76E-08
POS3A	4.6	3.36E-04	UAT	1.77E-05	2.15E-05	3.86E-06	1.23E-05	5.54E-05	EDG D	1.58E-07
POS3B	37.6	2.74E-03	UAT	1.45E-04	1.75E-04	3.15E-05	1.01E-04	4.52E-04	EDG D	1.32E-06
POS4A	1.3	9.50E-05	UAT	5.01E-06	6.07E-06	1.09E-06	3.48E-06	1.57E-05	EDG D	4.34E-08
POS4B	20.3	1.49E-03	UAT	7.84E-05	9.49E-05	1.71E-05	5.45E-05	2.45E-04	EDG D	7.10E-07
POS5	16.8	1.23E-03	UAT	6.50E-05	7.86E-05	1.42E-05	4.52E-05	2.03E-04	EDG D	5.87E-07
POS6	54.9	4.01E-03	UAT	2.12E-04	2.56E-04	4.61E-05	1.47E-04	6.61E-04	EDG D	1.93E-06
POS10	85.7	6.26E-03	SAT	3.31E-04	4.00E-04	7.20E-05	2.30E-04	1.03E-03	EDG C	3.02E-06

Table 19.1-85 (2 of 2)

POS	Duration (hr)	Conv Factor	O/H Component	Frequency (mean, /yr)(2)						
				Plant-centered	Switchyard-centered	Grid-related	Weather-related	Total LP	Maintenance component (EDG)	LX(3)
POS11	13.2	9.66E-04	-	5.10E-05	6.17E-05	1.11E-05	3.55E-05	1.59E-04	-	2.33E-07
POS12A	4.2	3.07E-04	-	1.62E-05	1.96E-05	3.53E-06	1.13E-05	5.06E-05	-	6.99E-08
POS13	33.5	2.44E-03	-	1.29E-04	1.56E-04	2.81E-05	8.97E-05	4.03E-04	-	6.07E-07
POS14	42.7	3.12E-03	-	1.65E-04	1.99E-04	3.58E-05	1.14E-04	5.14E-04	-	6.39E-08
POS15	42.4	3.10E-03	-	1.64E-04	1.98E-04	3.56E-05	1.14E-04	5.11E-04	-	6.35E-08

(1) BASE case is based on shutdown year.

(2) POS frequency = base event frequency × conversion factor

(3) POS frequency = the sum of minimal cutsets for EDG failure in LOOP initiating event at each POS.

Table 19.1-86 (1 of 2)

LPSD PRA Loss of Supporting System Initiators (LOKV, LODC, LOCCW, LOESW)

POS	Duration (hr)	Conv Factor	Frequency (mean, /yr)[2]						
			LOKV	LODCA[3]	LODCB[3]	PLOCCW[3]	TLOCCW[3]	PLOESW[3]	TLOESW[3]
BASE[1]	-	-	3.50E-02	6.98E-04	6.98E-04	6.75E-03	3.59E-04	1.86E-02	5.46E-04
POS1	3.6	2.66E-04	9.31E-06	1.86E-07	1.86E-07	1.80E-06	9.55E-08	4.96E-06	1.45E-07
POS2	32.9	2.40E-03	8.40E-05	1.68E-06	1.68E-06	1.62E-05	8.61E-07	4.47E-05	1.31E-06
POS3A	4.6	3.36E-04	1.18E-05	-	-	2.27E-06	1.21E-07	6.26E-06	1.83E-07
POS3B	37.6	2.74E-03	9.60E-05	-	-	1.85E-05	9.85E-07	5.11E-05	1.50E-06
POS4A	1.3	9.50E-05	3.32E-06	-	-	6.41E-07	3.41E-08	1.77E-06	5.18E-08
POS4B	20.3	1.49E-03	5.20E-05	-	-	1.00E-05	5.33E-07	2.77E-05	8.11E-07
POS5	16.8	1.23E-03	4.31E-05	-	-	8.31E-06	4.42E-07	2.29E-05	6.72E-07
POS6	54.9	4.01E-03	1.40E-04	-	-	2.71E-05	1.44E-06	7.48E-05	2.19E-06
POS10	85.7	6.26E-03	2.19E-04	-	-	4.23E-05	2.25E-06	1.17E-04	3.42E-06
POS11	13.2	9.66E-04	3.38E-05	-	-	6.53E-06	3.47E-07	1.80E-05	5.28E-07
POS12A	4.2	3.07E-04	1.07E-05	-	-	2.07E-06	1.10E-07	5.72E-06	1.68E-07
POS13	33.5	2.44E-03	8.56E-05	-	-	1.65E-05	8.78E-07	4.56E-05	1.33E-06

Table 19.1-86 (2 of 2)

POS	Duration (hr)	Conv Factor	Frequency (mean, /yr)(2)						
			LOKV	LODCA(3)	LODCB(3)	PLOCCW(3)	TLOCCW(3)	PLOESW(3)	TLOESW(3)
POS14	42.7	3.12E-03	1.09E-04	2.18E-06	2.18E-06	2.11E-05	1.12E-06	5.81E-05	1.70E-06
POS15	42.4	3.10E-03	1.08E-04	2.16E-06	2.16E-06	2.09E-05	1.11E-06	5.78E-05	1.69E-06

(1) BASE case is based on shutdown year.

(2) POS frequency = base event frequency × conversion factor

(3) Base event frequency = quantification via a related fault tree (except for events due to T&M.)

Table 19.1-87

LPSD PRA Transient Events Initiators (PR-A-SL, GTRN, LOFW, FWLB, LOIA, LOCV, LSSB, ATWS, RVR)

POS	Duration (hr)	Conv factor	Frequency (mean, /yr)[2]									
			PR-A-SL	GTRN	LOFW	FWLB	LOIA	LOCV	LSSB-U	LSSB-D	ATWS	RVR
BASE[1]	-	-	7.61E-04	6.54E-01	1.73E-03	1.73E-03	1.82E-02	5.55E-02	3.48E-04	7.29E-03	-	3.05E-08
POS1	3.6	2.66E-04	2.02E-07	1.74E-04	4.60E-07	4.60E-07	4.84E-06	1.48E-05	9.25E-08	1.94E-06	1.37E-09	8.11E-12
POS2	32.9	2.40E-03	1.83E-06	1.57E-03	4.15E-06	4.15E-06	4.37E-05	1.33E-04	8.35E-07	1.75E-05	-	7.32E-11
POS14	42.7	3.12E-03	2.37E-06	2.04E-03	5.39E-06	5.39E-06	5.67E-05	1.73E-04	1.08E-06	2.27E-05	-	9.51E-11
POS15	42.4	3.10E-03	2.36E-06	2.03E-03	5.36E-06	5.36E-06	5.64E-05	1.72E-04	1.08E-06	2.26E-05	1.60E-08	9.45E-11

(1) BASE case is based on shutdown year.

(2) POS frequency = base event frequency × conversion factor

Table 19.1-88 (1 of 7)

Summary of LPSD PRA Accident Sequences

POS	Sequence Description
S1 – Recoverable Loss of Shutdown Cooling	
3A	SCS recovery and secondary cooling both fail. The LTOP valve lifts and re-closes. Feed & bleed is successful but containment heat removal via IRWST cooling fails, leading to core damage.
3A, 3B, 4A, 13	SCS recovery and secondary cooling both fail. The LTOP valve lifts and re-closes. Feed & bleed fails, leading to core damage.
3A	SCS recovery and secondary cooling both fail. The LTOP valve lifts and fails open. Feed & bleed is successful but containment heat removal via IRWST cooling fails, leading to core damage.
3A, 3B, 4A, 13	SCS recovery and secondary cooling both fail. The LTOP valve lifts and fails open. Feed & bleed fails, leading to core damage.
4B, 5, 6, 10, 11, 12A	SCS recovery fails. The RCS is open to containment so that secondary cooling is unavailable. Feed fails, leading to core damage.
S2 – Unrecoverable Loss of Shutdown Cooling	
3A	Secondary cooling fails. The LTOP valve lifts and re-closes. Feed & bleed is successful but containment heat removal via IRWST cooling fails, leading to core damage.
3A, 3B, 4A, 13	Secondary cooling fails. The LTOP valve lifts and re-closes. Feed & bleed fails, leading to core damage.
3A	Secondary cooling fails. The LTOP valve lifts and fails open. Feed & bleed is successful but containment heat removal via IRWST cooling fails, leading to core damage.
3A, 3B, 4A, 13	Secondary cooling fails. The LTOP valve lifts and fails open. Feed & bleed fails, leading to core damage.
4B, 5, 6, 10, 11, 12A	SCS recovery fails. The RCS is open to containment so that secondary cooling is unavailable. Feed fails, leading to core damage.
SO – Overdrain Event	
5, 11	Primary inventory makeup is successful but SCS recovery fails. Feed fails, leading to core damage.
5, 11	Primary inventory makeup fails so that the SCS cannot be recovered. Feed fails, leading to core damage.

Table 19.1-88 (2 of 7)

POS	Sequence Description
SL – Level Control Failure During Reduced Inventory Operation	
5, 11	Primary inventory makeup is successful but SCS recovery fails. Feed fails, leading to core damage.
5, 11	Primary inventory makeup fails so that the SCS cannot be recovered. Feed fails, leading to core damage.
JL – Unrecoverable LOCA (CVCS Letdown Line)	
SL1 – SLOCA at Reduced Inventory Operation	
SL2 - SLOCA above Reduced Inventory Operation	
3A	Primary inventory makeup is successful but SCS recovery fails. Secondary cooling also fails. The LTOP valve lifts and re-closes. Feed & bleed is successful but containment heat removal via IRWST cooling fails, leading to core damage.
3A, 3B, 4A, 13	Primary inventory makeup is successful but SCS recovery fails. Secondary cooling also fails. The LTOP valve lifts and re-closes. Feed & bleed fails, leading to core damage.
3A	Primary inventory makeup is successful but SCS recovery fails. Secondary cooling also fails. The LTOP valve lifts and fails open. Feed & bleed is successful but containment heat removal via IRWST cooling fails, leading to core damage.
3A, 3B, 4A, 13	Primary inventory makeup is successful but SCS recovery fails. Secondary cooling also fails. The LTOP valve lifts and fails open. Feed & bleed fails, leading to core damage.
3A	Primary inventory makeup is successful but SCS recovery fails. Rupture isolation fails and renders the secondary system unavailable for core cooling. The LTOP valve lifts and re-closes. Feed & bleed is successful but containment heat removal via IRWST cooling fails, leading to core damage.
3A, 3B, 4A, 13	Primary inventory makeup is successful but SCS recovery fails. Rupture isolation fails and renders the secondary system unavailable for core cooling. The LTOP valve lifts and re-closes. Feed & bleed fails, leading to core damage.
3A	Primary inventory makeup is successful but SCS recovery fails. Rupture isolation fails and renders the secondary system unavailable for core cooling. The LTOP valve lifts and fails open. Feed & bleed is successful but containment heat removal via IRWST cooling fails, leading to core damage.
3A, 3B, 4A, 13	Primary inventory makeup is successful but SCS recovery fails. Rupture isolation fails and renders the secondary system unavailable for core cooling. The LTOP valve lifts and fails open. Feed & bleed fails, leading to core damage.

Table 19.1-88 (3 of 7)

POS	Sequence Description
3A	Primary inventory makeup fails so that a SCS recovery cannot be attempted. Secondary cooling also fails. The LTOP valve lifts and re-closes. Feed & bleed is successful but containment heat removal via IRWST cooling fails, leading to core damage.
3A, 3B, 4A, 13	Primary inventory makeup fails so that a SCS recovery cannot be attempted. Secondary cooling also fails. The LTOP valve lifts and re-closes. Feed & bleed fails, leading to core damage.
3A	Primary inventory makeup fails so that a SCS recovery cannot be attempted. Secondary cooling also fails. The LTOP valve lifts and fails open. Feed & bleed is successful but containment heat removal via IRWST cooling fails, leading to core damage.
3A, 3B, 4A, 13	Primary inventory makeup fails so that a SCS recovery cannot be attempted. Secondary cooling also fails. The LTOP valve lifts and fails open. Feed & bleed fails, leading to core damage.
3A	Primary inventory makeup fails so that a SCS recovery cannot be attempted. Rupture isolation fails and renders the secondary system unavailable for core cooling. The LTOP valve lifts and re-closes. Feed & bleed is successful but containment heat removal via IRWST cooling fails, leading to core damage.
3A, 3B, 4A, 13	Primary inventory makeup fails so that a SCS recovery cannot be attempted. Rupture isolation fails and renders the secondary system unavailable for core cooling. The LTOP valve lifts and re-closes. Feed & bleed fails, leading to core damage.
3A	Primary inventory makeup fails so that a SCS recovery cannot be attempted. Rupture isolation fails and renders the secondary system unavailable for core cooling. The LTOP valve lifts and fails open. Feed & bleed is successful but containment heat removal via IRWST cooling fails, leading to core damage.
3A, 3B, 4A, 13	Primary inventory makeup fails so that a SCS recovery cannot be attempted. Rupture isolation fails and renders the secondary system unavailable for core cooling. The LTOP valve lifts and fails open. Feed & bleed fails, leading to core damage.
4B, 5, 6, 10, 11, 12A	SCS recovery fails. The RCS is open to containment so that secondary cooling is unavailable. Feed & bleed fails, leading to core damage.
4B, 5, 6, 10, 11, 12A	Inventory makeup fails so that a SCS recovery cannot be attempted. The RCS is open to containment so that secondary cooling is unavailable. Feed fails, leading to core damage.

Table 19.1-88 (4 of 7)

POS	Sequence Description
PL – POSRV Fails to Reclose	
2	Safety Injection and secondary heat removal are both successful. IRWST cooling failure leads to core damage.
2	Safety Injection is successful but secondary heat removal fails. Bleed & feed are both successful. IRWST cooling failure leads to core damage.
2	Safety Injection is successful but secondary heat removal fails. Bleed is successful but feed fails, leading to core damage.
2	Safety Injection is successful but secondary heat removal fails. Bleed fails, leading to core damage.
2	Safety Injection fails but an Aggressive Secondary Cooldown is successful. SCS injection fails, leading to core damage.
2	Safety Injection and an Aggressive Secondary Cooldown both fail, leading to core damage.
RL – LTOP Safety Valve Spurious Opening	
3A	Inventory makeup is successful but the SCS recovery fails. Secondary cooling also fails. The LTOP valve lifts and re-closes. Feed & bleed is successful but containment heat removal via IRWST cooling fails, leading to core damage.
3A, 3B, 13	Inventory makeup is successful but the SCS recovery fails. Secondary cooling also fails. The LTOP valve lifts and re-closes. Feed & bleed fails, leading to core damage.
3A	Inventory makeup is successful but the SCS recovery fails. Secondary cooling also fails. The LTOP valve lifts and fails open. Feed & bleed is successful but containment heat removal via IRWST cooling fails, leading to core damage.
3A, 3B, 13	Inventory makeup is successful but the SCS recovery fails. Secondary cooling also fails. The LTOP valve lifts and fails open. Feed & bleed fails, leading to core damage.
3A	Primary inventory makeup fails so that a SCS recovery cannot be attempted. Feed & bleed is successful but containment heat removal via IRWST cooling fails, leading to core damage.
3A, 3B, 13	Primary inventory makeup fails so that a SCS recovery cannot be attempted. Feed & bleed fails, leading to core damage.

Table 19.1-88 (5 of 7)

POS	Sequence Description
	LP – Loss of Offsite Power
3 A	The EDGs energize at least one class 1E bus. SCS recovery fails. Secondary cooling fails. The LTOP valve lifts and re-closes. Feed & bleed is successful but containment heat removal via IRWST cooling fails, leading to core damage.
3 A, 3B, 4A, 13	The EDGs energize at least one class 1E bus. SCS recovery fails. Secondary cooling fails. The LTOP valve lifts and re-closes. Feed & bleed fails, leading to core damage.
3 A	The EDGs energize at least one class 1E bus. SCS recovery fails. Secondary cooling fails. The LTOP valve lifts and fails open. Feed & bleed is successful but containment heat removal via IRWST cooling fails, leading to core damage.
3 A, 3B, 4A, 13	The EDGs energize at least one class 1E bus. SCS recovery fails. Secondary cooling fails. The LTOP valve lifts and fails open. Feed & bleed fails, leading to core damage.
4B, 5, 6, 10, 11, 12A	The RCS is open to containment so that secondary cooling is unavailable. SCS recovery fails. Feed fails, leading to core damage.
	LX – Station Blackout
3 A, 3B, 4A	The AAC gas turbine generator fails. Secondary cooling is successful, but offsite power is not recovered before core damage occurs.
3 A, 3B, 4A	The AAC gas turbine generator fails. Secondary cooling fails. Offsite power is not recovered before core damage occurs.
4B, 5, 6, 10, 11, 12A, 13	The AAC gas turbine generator fails. The RCS is not intact and secondary cooling cannot be attempted; or decay heat is very low (POS 13). Offsite power is not recovered before core damage occurs.
	CC – Partial Loss of Component Cooling
3 A	SCS recovery fails. Secondary cooling fails. The LTOP valve lifts and re-closes. Feed & bleed is successful but containment heat removal via IRWST cooling fails, leading to core damage.
3 A, 3B, 4A, 13	SCS recovery fails. Secondary cooling fails. The LTOP valve lifts and re-closes. Feed & bleed fails, leading to core damage.
3 A	SCS recovery fails. Secondary cooling fails. The LTOP valve lifts and fails open. Feed & bleed is successful but containment heat removal via IRWST cooling fails, leading to core damage.
3 A, 3B, 4A, 13	SCS recovery fails. Secondary cooling fails. The LTOP valve lifts and fails open. Feed & bleed fails, leading to core damage.

Table 19.1-88 (6 of 7)

POS	Sequence Description
4B, 5, 6, 10, 11, 12A	SCS recovery fails. The RCS is not intact and secondary cooling cannot be attempted. Feed fails, leading to core damage.
TC – Total Loss of Component Cooling	
3A	This event leads directly to core damage.
3B, 4A, 13	The LTOP relief valves open and re-close. Feed and bleed fails, leading to core damage.
3B, 4A, 13	The LTOP relief valves open fail to re-close. Feed and bleed fails, leading to core damage.
4B, 5, 6, 10, 11, 12A	Feed fails, leading to core damage.
1, 2, 14, 15	These LPSD sequences are similar to their at-power counterparts.
ES – Partial Loss of Essential Service Water	
3 A	SCS recovery fails. Secondary cooling fails. The LTOP valve lifts and re-closes. Feed & bleed is successful but containment heat removal via IRWST cooling fails, leading to core damage.
3 A, 3B, 4A, 13	SCS recovery fails. Secondary cooling fails. The LTOP valve lifts and re-closes. Feed & bleed fails, leading to core damage.
3 A	SCS recovery fails. Secondary cooling fails. The LTOP valve lifts and fails open. Feed & bleed is successful but containment heat removal via IRWST cooling fails, leading to core damage.
3 A, 3B, 4A, 13	SCS recovery fails. Secondary cooling fails. The LTOP valve lifts and fails open. Feed & bleed fails, leading to core damage.
4B, 5, 6, 10, 11, 12A	SCS recovery fails. The RCS is not intact and secondary cooling cannot be attempted. Feed fails, leading to core damage.
TS – Total Loss of Essential Service Water	
3A	This event leads directly to core damage.
3B, 4A, 13	The LTOP relief valves open and re-close. Feed and bleed fails, leading to core damage.
3B, 4A, 13	The LTOP relief valves open fail to re-close. Feed and bleed fails, leading to core damage.
4B, 5, 6, 10, 11, 12A	Feed fails, leading to core damage.
1, 2, 14, 15	These LPSD sequences are similar to their at-power counterparts.

Table 19.1-88 (7 of 7)

POS	Sequence Description
KV – Loss of 4 kV Emergency Bus (SCS Power Supply)	
3 A	SCS recovery fails. Secondary cooling fails. The LTOP valve lifts and re-closes. Feed & bleed is successful but containment heat removal via IRWST cooling fails, leading to core damage.
3 A, 3B, 4A, 13	SCS recovery fails. Secondary cooling fails. The LTOP valve lifts and re-closes. Feed & bleed fails, leading to core damage.
3 A	SCS recovery fails. Secondary cooling fails. The LTOP valve lifts and fails open. Feed & bleed is successful but containment heat removal via IRWST cooling fails, leading to core damage.
3 A, 3B, 4A, 13	SCS recovery fails. Secondary cooling fails. The LTOP valve lifts and fails open. Feed & bleed fails, leading to core damage.
4B, 5, 6, 10, 11, 12A	SCS recovery fails. The RCS is not intact and secondary cooling cannot be attempted. Feed fails, leading to core damage.

Table 19.1-89 (1 of 13)

LPSD PRA Success Criteria Summary for Events Involving Loss of Operating SCS Train

POS	Equation Name	System Success Criteria	Timing Information	Comments
Top Event EA - Supply Electrical Power from EDGs				
3A 3B 4A 4B 5 6 10 11 12A 13	LPP03AEA-EDG LPP03BEA-EDG LPP04AEA-EDG LPP04BEA-EDG LPP05EA-EDG LPP06EA-EDG LPP10EA-EDG LPP11EA-EDG LPP12AEA-EDG LPP13EA-EDG	Power available from 1 of 4 Class 1E 4.16 kVAC buses.	Not Applicable. Following a LOOP, EDGs must start and load automatically to the buses of the event transfers to the SBO event tree.	Top Event EA is included only for LOOP events.

Table 19.1-89 (2 of 13)

POS	Equation Name	System Success Criteria	Timing Information	Comments
Top Event RS - Restore SCS				
3A 3B	S1P03ARS S2P03ARS LPP03ARS KVP03ARS ESP03ARS CCP03ARS S1P03BRS S2P03BRS LPP03BRS KVP03BRS ESP03BRS CCP03BRS	Cooling provided by 1 of 2 SCS trains.	SCS operating pressure limit of 31.6 kg/cm2A (450 psia) reached 4 minutes after initial SCS loss in POS3A. Timing for POS 3B is assumed to be the same as in POS3A.	Initiating events S2, KV, ES, and CC render one SCS train unavailable. The success criteria and available time for operator action in POS3B are assumed to be the same as in POS3A.
4A	S1P04ARS S2P04ARS LPP04ARS KVP04ARS ESP04ARS CCP04ARS	Cooling provided by 1 of 2 SCS trains.	SCS operating temperature limit of 177°C (350°F) is reached 7.6 hours after initial loss.	Initiating events S2, KV, ES, and CC render one SCS train unavailable.

Table 19.1-89 (3 of 13)

POS	Equation Name	System Success Criteria	Timing Information	Comments
4B	S1P04BRS S2P04BRS LPP04BRS KVP04BRS ESP04BRS CCP04BRS	Cooling provided by 1 of 2 SCS trains.	SCS operating level limit of 5.1cm (2- inches) above hot leg centerline is reached 30 minutes after initial loss.	Initiating events S2, KV, ES, and CC render one SCS train unavailable.
5	S1P05RS S2P05RS LPP05RS KVP05RS ESP05RS CCP05RS	Cooling provided by 1 of 2 SCS trains.	SCS operating level limit of 5.1cm (2- inches) above hot leg centerline is reached 6.7 minutes after initial loss.	Initiating events S2, KV, ES, and CC render one SCS train unavailable.
6	S1P06RS S2P06RS LPP06RS KVP06RS ESP06RS CCP06RS	Cooling provided by 1 of 2 SCS trains.	SCS operating level limit of 5.1cm (2- inches) above hot leg centerline is reached 52 minutes after initial loss.	Initiating events S2, KV, ES, and CC render one SCS train unavailable.
10	S1P10RS S2P10RS LPP10RS KVP10RS ESP10RS CCP10RS	Cooling provided by 1 of 2 SCS trains.	SCS operating level limit of 5.1cm (2- inches) above hot leg centerline is reached 1.6 hours after initial loss.	Initiating events S2, KV, ES, and CC render one SCS train unavailable.

Table 19.1-89 (4 of 13)

POS	Equation Name	System Success Criteria	Timing Information	Comments
11	S1P11RS S2P11RS LPP11RS KVP11RS ESP11RS CCP11RS	Cooling provided by 1 of 2 SCS trains.	SCS operating level limit of 5.1cm (2- inches) above hot leg centerline is reached 21 minutes after initial loss.	Initiating events S2, KV, ES, and CC render one SCS train unavailable.
12A	S1P12ARS S2P12ARS LPP12ARS KVP12ARS ESP12ARS CCP12ARS	Cooling provided by 1 of 2 SCS trains.	SCS operating level limit of 5.1cm (2- inches) above hot leg centerline is reached 7.6 minutes after initial loss.	Initiating events S2, KV, ES, and CC render one SCS train unavailable.
13	S1P13RS S2P13RS LPP13RS KVP13RS ESP13RS CCP13RS	Cooling provided by 1 of 2 SCS trains.	SCS operating pressure limit of 31.6 kg/cm2A (450 psia) is reached 45 minutes after initial loss.	Initiating events S2, KV, ES, and CC render one SCS train unavailable.

Table 19.1-89 (5 of 13)

POS	Equation Name	System Success Criteria	Timing Information	Comments
Top Event SG - Steam Removal Using MSADV with AFW				
3A 3B	S1P03ASG S2P03ASG LPP03ASG KVP03ASG ESP03ASG CCP03ASG S1P03BSG S2P03BSG LPP03BSG KVP03BSG ESP03BSG CCP03BSG	Heat removal from 1 of 2 steam generators: 1 of 2 motor-driven AFW pumps with 1 of 4 MSADVs	LTOP relief valve first lift occurs at 1.6 hours	Initiating events S2, KV, ES, and CC render one motor-driven AFW pump unavailable. The success criteria and available time for operator action in POS3B are assumed to be the same as in POS3A.
4A	S1P04ASG S2P04ASG LPP04ASG KVP04ASG ESP04ASG CCP04ASG	Heat removal from 1 of 2 steam generators: 1 of 2 motor-driven AFW pumps with 1 of 4 MSADVs	LTOP relief valve first lift occurs at 12.8 hours	Initiating events S2, KV, ES, and CC render one motor-driven AFW pump unavailable.

Table 19.1-89 (6 of 13)

POS	Equation Name	System Success Criteria	Timing Information	Comments
13	S1P13SG S2P13SG LPP13SG KVP13SG ESP13SG CCP13SG	Heat removal from 1 of 2 steam generators: 1 of 2 motor-driven AFW pumps with 1 of 4 MSADVs	LTOP relief valve first lift occurs at 5.9 hours	Initiating events S2, KV, ES, and CC render one motor-driven AFW pump unavailable.
Top Event LT - LTOP Relief Valve Closes				
3A 3B	S1P03ALT S2P03ALT LPP03ALT KVP03ALT ESP03ALT CCP03ALT S1P03BLT S2P03BLT LPP03BLT KVP03BLT ESP03BLT CCP03BLT	2 of 2 LTOP relief valves close	Not applicable.	Top event affects timing for feed and bleed cooling.

Table 19.1-89 (7 of 13)

POS	Equation Name	System Success Criteria	Timing Information	Comments
4A	S1P04ALT S2P04ALT LPP04ALT KVP04ALT ESP04ALT CCP04ALT	2 of 2 LTOP relief valves close	Not applicable.	Top event affects timing for feed and bleed cooling
13	S1P13LT S2P13LT LPP13LT KVP13LT ESP13LT CCP13LT	2 of 2 LTOP relief valves close	Not applicable.	Top event affects timing for feed and bleed cooling

Table 19.1-89 (8 of 13)

POS	Equation Name	System Success Criteria	Timing Information	Comments
Top Event FB - Feed and Bleed Cooling				
3A 3B	S1P03AFB1 S2P03AFB1 LPP03AFB1 KVP03AFB1 ESP03AFB1 CCP03AFB1 S1P03BFB1 S2P03BFB1 LPP03BFB1 KVP03BFB1 ESP03BFB1 CCP03BFB1	Injection with 1 of 4 SI trains Bleed with 1 of 4 POSRVs	Core damage occurs at 6 hours	Initiating event KV renders one SI pump unavailable. Initiating events ES and CC render two SI pumps unavailable. This timing is based on LTOP relief valves closing after pressure is reduced. The success criteria and available time for operator action in POS3B are assumed to be the same as in POS3A.

Table 19.1-89 (9 of 13)

POS	Equation Name	System Success Criteria	Timing Information	Comments
3A 3B	S1P03AFB2 S2P03AFB2 LPP03AFB2 KVP03AFB2 ESP03AFB2 CCP03AFB2 S1P03BFB2 S2P03BFB2 LPP03BFB2 KVP03BFB2 ESP03BFB2 CCP03BFB2	Injection with 1 of 4 SI trains	Core damage occurs at 2.7 hours	Initiating event KV renders one SI pump unavailable. Initiating events ES and CC render two SI pumps unavailable. This timing is based on one LTOP valve sticking open after first lift at 1.6 hours. The success criteria and available time for operator action in POS3B are assumed to be the same as in POS3A.
4A	S1P04AFB1 S2P04AFB1 LPP04AFB1 KVP04AFB1 ESP04AFB1 CCP04AFB1	Injection with 1 of 4 SI trains Bleed with 1 of 4 POSRVs	Core damage occurs at 13.9 hours	Initiating event KV renders one SI pump unavailable. Initiating events ES and CC render two SI pumps unavailable. This timing is based on LTOP relief valves closing after pressure is reduced.

Table 19.1-89 (10 of 13)

POS	Equation Name	System Success Criteria	Timing Information	Comments
4A	S1P04AFB2 S2P04AFB2 LPP04AFB2 KVP04AFB2 ESP04AFB2 CCP04AFB2	Injection with 1 of 4 SI trains	Core damage occurs at 13.9 hours	Initiating event KV renders one SI pump unavailable. Initiating events ES and CC render two SI pumps unavailable. This timing is based on one LTOP valve sticking open after first lift at 12.8 hours. Core damage is assumed to occur 1.1 hours after first LTOP lift at 12.8 hrs. This timing is based on the thermal-hydraulic analysis for POS3A.
4B	S1P04BFB S2P04BFB LPP04BFB KVP04BFB ESP04BFB CCP04BFB	Injection with 1 of 4 SI trains OR 1 of 2 SCS pumps injecting	Core damage occurs at 2.3 hours	Initiating event KV renders one SI pump unavailable. Initiating events ES and CC render two SI pumps unavailable.
5	S1P05FB S2P05FB LPP05FB KVP05FB ESP05FB CCP05FB	Injection with 1 of 4 SI trains OR 1 of 2 SCS pumps injecting	Core damage occurs at 2.2 hours	Initiating event KV renders one SI pump unavailable. Initiating events ES and CC render two SI pumps unavailable.

Table 19.1-89 (11 of 13)

POS	Equation Name	System Success Criteria	Timing Information	Comments
6	S1P06FB S2P06FB LPP06FB KVP06FB ESP06FB CCP06FB	Injection with 1 of 4 SI trains OR 1 of 2 SCS pumps injecting	Core damage occurs at 2.2 hours	Initiating event KV renders one SI pump unavailable. Initiating events ES and CC render two SI pumps unavailable.
10	S1P10FB S2P10FB LPP10FB KVP10FB ESP10FB CCP10FB	Injection with 1 of 4 SI trains OR 1 of 2 SCS pumps injecting	Core damage occurs at 3.6 hours	Initiating event KV renders one SI pump unavailable. Initiating events ES and CC render two SI pumps unavailable.
11	S1P11FB S2P11FB LPP11FB KVP11FB ESP11FB CCP11FB	Injection with 1 of 4 SI trains OR 1 of 2 SCS pumps injecting	Core damage occurs at 4.4 hours	Initiating event KV renders one SI pump unavailable. Initiating events ES and CC render two SI pumps unavailable.
12A	S1P12AFB S2P12AFB LPP12AFB KVP12AFB ESP12AFB CCP12AFB	Injection with 1 of 4 SI trains Bleed with 1 of 4 POSRVs	Core damage occurs at 7.4 hours	Initiating event KV renders one SI pump unavailable. Initiating events ES and CC render two SI pumps unavailable.

Table 19.1-89 (12 of 13)

POS	Equation Name	System Success Criteria	Timing Information	Comments
13	S1P13FB1 S2P13FB1 LPP13FB1 KVP13FB1 ESP13FB1 CCP13FB1	Injection with 1 of 4 SI trains Bleed with 1 of 4 POSRVs	Core damage occurs at 19.6 hours	Initiating event KV renders one SI pump unavailable. Initiating events ES and CC render two SI pumps unavailable.
13	S1P13FB2 S2P13FB2 LPP13FB2 KVP13FB2 ESP13FB2 CCP13FB2	Injection with 1 of 4 SI trains	Core damage occurs at 7.0 hours	Initiating event KV renders one SI pump unavailable. Initiating events ES and CC render two SI pumps unavailable. This timing is based on one LTOP valve sticking open after first lift at 5.9 hours. Core damage is assumed to occur 1.1 hours after first LTOP lift at 7.0 hrs. This timing is based on the thermal-hydraulic analysis for POS3A.

Table 19.1-89 (13 of 13)

POS	Equation Name	System Success Criteria	Timing Information	Comments
Top Event CH - Containment Heat Removal				
3A	S1P03ACH S2P03ACH LPP03ACH KVP03ACH ESP03ACH CCP03ACH	1 of 2 CS trains aligned for IRWST cooling.	Containment pressure is 2.2kg/cm2 (31 psig) at 24 hours. Operator action to begin IRWST cooling is assumed to be required before design pressure is exceeded.	Containment heat removal required to ensure safe, stable conditions.

Table 19.1-90 (1 of 15)

LPSD PRA Success Criteria Summary for Events Involving RCS Inventory

POS	Equation Name	System Success Criteria	Timing Information	Comments
Top Event MK - Makeup of LOCA				
3A 3B	JLP03AMK JLP03BMK	Injection with 1 of 4 SI trains	SCS operating temperature limit of 177°C (350°F) reached 1.2 hours after beginning of event.	The success criteria and available time for operator action in POS3B are assumed to be the same as in POS3A.
4A	JLP04AMK	Injection with 1 of 4 SI trains	SCS operating level limit of 5.1cm (2- inches) above hot leg centerline is reached 7.2 hours after beginning of event.	
13	JLP13MK	Injection with 1 of 4 SI trains	SCS operating temperature limit of 177°C (350°F) reached 3.6 hours after beginning of event.	
Top Event IL - Isolation of LOCA				
3A 3B	JLP03AIL1 JLP03BIL1	Not Applicable	First lift of LTOP relief valve occurs 4.8 hours after beginning of event regardless of the status of RCS makeup.	The success criteria and available time for operator action in POS3B are assumed to be the same as in POS3A.
3A 3B	JLP03AIL2 JLP03BIL2	Not Applicable	First lift of LTOP relief valve occurs 4.8 hours after beginning of event regardless of the status of RCS makeup.	The success criteria and available time for operator action in POS3B are assumed to be the same as in POS3A.

Table 19.1-90 (2 of 15)

POS	Equation Name	System Success Criteria	Timing Information	Comments
4A	JLP04AIL1	Not Applicable	Limit of RCS level lowering to top of hot leg is reached 7.2 hours after beginning of event.	Timing is based on failure of makeup node. Additional time would be available for the case where makeup is successful. Given the expansive time available, this additional time is judged to be insignificant to developing the human error probability values associated with this event.
4A	JLP04AIL2	Not Applicable	Limit of RCS level lowering to top of hot leg is reached 7.2 hours after beginning of event.	
13	JLP13IL1	Not Applicable	Limit of RCS level lowering to top of hot leg is reached 10.4 hours after beginning of event.	Timing is based on failure of makeup node. Additional time would be available for the case where makeup is successful. Given the expansive time available, this additional time is judged to be insignificant to developing the human error probability values associated with this event.
13	JLP13IL2	Not Applicable	Limit of RCS level lowering to top of hot leg is reached 10.4 hours after beginning of event.	

Table 19.1-90 (3 of 15)

POS	Equation Name	System Success Criteria	Timing Information	Comments
Top Event MI – Inventory Makeup and Isolation				
3A 3B	RLP03AMI RLP03BMI	Injection with 1 of 4 SI trains	Core damage occurs 1.4 hours after initiation of event if injection is not successful.	The success criteria and available time for operator action in POS3B are assumed to be the same as in POS3A.
13	RLP13MI	Injection with 1 of 4 SI trains	Core damage occurs 2.6 hours after initiation of event if injection is not successful.	
4B	JLP04BMI	Injection with 1 of 4 SI trains	Core damage occurs 2.3 hours after initiation of event if injection is not successful. SCS operating level limit of 5.1cm (2- inches) above hot leg centerline is reached 16 minutes after stopping injection.	
5	JLP05MI	Injection with 1 of 4 SI trains	Core damage occurs 2.2 hours after initiation of event if injection is not successful. SCS operating level limit of 5.1cm (2- inches) above hot leg centerline is reached 4.6 minutes after stopping injection.	

Table 19.1-90 (4 of 15)

POS	Equation Name	System Success Criteria	Timing Information	Comments
6	JLP06MI	Injection with 1 of 4 SI trains	Core damage occurs 2.2 hours after initiation of event if injection is not successful. SCS operating level limit of 5.1cm (2- inches) above hot leg centerline is reached 53 minutes after stopping injection.	
10	JLP10MI	Injection with 1 of 4 SI trains	Core damage occurs 3.6 hours after initiation of event if injection is not successful. SCS operating level limit of 5.1cm (2- inches) above hot leg centerline is reached 95 minutes after stopping injection.	
11	JLP11MI	Injection with 1 of 4 SI trains	Core damage occurs 4.4 hours after initiation of event if injection is not successful. SCS operating level limit of 5.1cm (2- inches) above hot leg centerline is reached 9.0 minutes after stopping injection.	

Table 19.1-90 (5 of 15)

POS	Equation Name	System Success Criteria	Timing Information	Comments
12A	JLP12AMI	Injection with 1 of 4 SI trains	Core damage occurs 7.1 hours after initiation of event if injection is not successful. SCS operating level limit of 5.1cm (2- inches) above hot leg centerline is reached 49.0 minutes after stopping injection.	
Top Event RS – Start Standby SCS				
3A 3B	JLP03ARS JLP03BRS	Cooling provided by 1 of 1 SCS trains.	SCS operating pressure limit of 177°C (350°F) reached 1.2 hours after initial LOCA with makeup success. Timing for POS 3B is assumed to be the same as in POS3A.	The success criteria and available time for operator action in POS3B are assumed to be the same as in POS3A.
3A 3B	RLP03ARS RLP03BRS	Cooling provided by 1 of 1 SCS trains.	SCS operating level limit of 5.1cm (2- inches) above hot leg centerline is reached 2.3 hours after initial lift with makeup success.	The success criteria and available time for operator action in POS3B are assumed to be the same as in POS3A.
13	RLP13RS	Cooling provided by 1 of 1 SCS trains.	SCS operating level limit of 5.1cm (2- inches) above hot leg centerline is reached 2.3 hours after initial lift with makeup success.	Based on timing for POS3A

Table 19.1-90 (6 of 15)

POS	Equation Name	System Success Criteria	Timing Information	Comments
4A	JLP04ARS	Cooling provided by 1 of 1 SCS trains.	SCS operating level limit of 5.1cm (2- inches) above hot leg centerline is reached 7.2 hours after initial LOCA with makeup success.	
4B	JLP04BRS	Cooling provided by 1 of 1 SCS trains.	SCS operating level limit of 5.1cm (2- inches) above hot leg centerline is reached 16 minutes after initial LOCA with makeup success.	
5	JLP05RS	Cooling provided by 1 of 1 SCS trains.	SCS operating level limit of 5.1cm (2- inches) above hot leg centerline is reached 4.6 minutes after initial LOCA with makeup success.	
6	JLP06RS	Cooling provided by 1 of 1 SCS trains.	SCS operating level limit of 5.1cm (2- inches) above hot leg centerline is reached 53 minutes after initial LOCA with makeup success.	
10	JLP10RS	Cooling provided by 1 of 1 SCS trains.	SCS operating level limit of 2-inches above hot leg centerline is reached 95 minutes after initial LOCA with makeup success.	
11	JLP11RS	Cooling provided by 1 of 1 SCS trains.	SCS operating level limit of 5.1cm (2- inches) above hot leg centerline is reached 9.0 minutes after initial LOCA with makeup success.	

Table 19.1-90 (7 of 15)

POS	Equation Name	System Success Criteria	Timing Information	Comments
12A	JLP12ARS	Cooling provided by 1 of 1 SCS trains.	SCS operating level limit of 5.1cm (2- inches) above hot leg centerline is reached 49 minutes after initial LOCA with makeup success.	
Top Event SG - Steam Removal Using MSADV with AFW				
3A 3B	JLP03ASG1 JLP03BSG1	Heat removal from 1 of 2 steam generators: 1 of 2 motor-driven AFW pumps with 1 of 4 MSADVs	LTOP relief valve first lift occurs at 4.8 hours with makeup success.	The success criteria and available time for operator action in POS3B are assumed to be the same as in POS3A. Timing is based on failure of makeup node. Additional time would be available for the case where makeup is successful. However, given the expansive time available, this additional time is judged to be insignificant to developing the human error probability values associated with this event.
3A 3B	JLP03ASG2 JLP03BSG2	Heat removal from 1 of 2 steam generators: 1 of 2 motor-driven AFW pumps with 1 of 4 MSADVs	LTOP relief valve first lift occurs at 4.8 hours with makeup failure.	The success criteria and available time for operator action in POS3B are assumed to be the same as in POS3A.

Table 19.1-90 (8 of 15)

POS	Equation Name	System Success Criteria	Timing Information	Comments
3A 3B	RLP03ASG RLP03BSG	Heat removal from 1 of 2 steam generators: 1 of 2 motor-driven AFW pumps with 1 of 4 MSADVs	SG operating level limit of top hot leg is reached 2.3 hours after initial lift with makeup success.	The success criteria and available time for operator action in POS3B are assumed to be the same as in POS3A.
13	RLP13SG	Heat removal from 1 of 2 steam generators: 1 of 2 motor-driven AFW pumps with 1 of 4 MSADVs	SG operating level limit of top hot leg is reached 2.3 hours after initial lift with makeup success.	Based on timing for POS3A
4A	JLP04ASG1	Heat removal from 1 of 2 steam generators: 1 of 2 motor-driven AFW pumps with 1 of 4 MSADVs	Cooling must be initiated before level decreases below the top of RCS hot leg at 7.2 hours with makeup success.	One SG is assumed to be unavailable due to outage activities. Timing is based on failure of makeup node. Additional time would be available for the case where makeup is successful. However, given the expansive time available, this additional time is judged to be insignificant to developing the human error probability values associated with this event.

Table 19.1-90 (9 of 15)

POS	Equation Name	System Success Criteria	Timing Information	Comments
4A	JLP04ASG2	Heat removal from 1 of 2 steam generators: 1 of 2 motor-driven AFW pumps with 1 of 4 MSADVs	Cooling must be initiated before level decreases below the top of RCS hot leg at 7.2 hours with makeup failure.	One SG is assumed to be unavailable due to outage activities.
13	JLP13SG1	Heat removal from 1 of 2 steam generators: 1 of 2 motor-driven AFW pumps with 1 of 4 MSADVs	Cooling must be initiated before level decreases below the top of RCS hot leg at 10.4 hours.	Timing is based on failure of makeup node. Additional time would be available for the case where makeup is successful. However, given the expansive time available, this additional time is judged to be insignificant to developing the human error probability values associated with this event.
13	JLP13SG2	Heat removal from 1 of 2 steam generators: 1 of 2 motor-driven AFW pumps with 1 of 4 MSADVs	Cooling must be initiated before level decreases below the top of RCS hot leg at 10.4 hours.	
Top Event LT - LTOP Relief Valve Closes				
3A 3B	JLP03ALT JLP03BLT	2 of 2 LTOP relief valves close	Not applicable.	Top event affects timing for feed and bleed cooling.

Table 19.1-90 (10 of 15)

POS	Equation Name	System Success Criteria	Timing Information	Comments
3A 3B	RLP03ALT RLP03BLT	1 of 1 LTOP relief valve close	Not applicable.	Valve opening on train B is definition of the initiating event. After isolation of B-train, the A-train valve is challenged.
4A	JLP04ALT	2 of 2 LTOP relief valves close	Not applicable.	Top event affects timing for feed and bleed cooling
13	JLP13LT	2 of 2 LTOP relief valves close	Not applicable.	Top event affects timing for feed and bleed cooling
13	RLP13LT	1 of 1 LTOP relief valve close	Not applicable.	Valve opening on train B is definition of the initiating event. After isolation of B-train, the A-train valve is challenged.
Top Event FB - Feed and Bleed Cooling				
3A 3B	JLP03AFB1 JLP03BFB1	Injection with 1 of 4 SI trains Bleed with 1 of 4 POSRVs	Core damage occurs at 6.0 hours if LTOP relief valve closes.	This timing is based on LTOP relief valves closing after pressure is reduced. The success criteria and available time for operator action in POS3B are assumed to be the same as in POS3A.
3A 3B	JLP03AFB2 JLP03BFB2	Injection with 1 of 4 SI trains	Core damage occurs at 5.9 hours if LTOP relief valve fails to close after lifting.	The success criteria and available time for operator action in POS3B are assumed to be the same as in POS3A.

Table 19.1-90 (11 of 15)

POS	Equation Name	System Success Criteria	Timing Information	Comments
3A 3B	RLP03AFB1 RLP03BFB1	Injection with 1 of 4 SI trains Bleed with 1 of 4 POSRVs	Core damage occurs at 7.6 hours with MI success if LTOP recloses.	The success criteria and available time for operator action in POS3B are assumed to be the same as in POS3A. Reclosing of LTOP not expected for spurious opening.
3A 3B	RLP03AFB2 RLP03BFB2	Injection with 1 of 4 SI trains	Core damage occurs at 7.2 hours with MI success.	The success criteria and available time for operator action in POS3B are assumed to be the same as in POS3A.
3A 3B	RLP03AFB3 RLP03BFB3	Injection with 1 of 4 SI trains	Core damage occurs at 1.4 hours after initial valve lift with MI failure.	The success criteria and available time for operator action in POS3B are assumed to be the same as in POS3A.
4A	JLP04AFB1	Injection with 1 of 4 SI trains Bleed with 1 of 4 POSRVs	Core damage occurs at 13.6 hours	This timing is based on LTOP relief valves closing after pressure is reduced.
4A	JLP04AFB2	Injection with 1 of 4 SI trains	Core damage occurs at 13.3 hours	This timing is based on one LTOP valve sticking open after first lift at 12.7 hours.

Table 19.1-90 (12 of 15)

POS	Equation Name	System Success Criteria	Timing Information	Comments
4B	JLP04BFB1	Injection with 1 of 4 SI trains OR 1 of 2 SCS pumps injecting	Core damage occurs at 5.3 hours	Makeup successful
4B	JLP04BFB2	Injection with 1 of 4 SI trains OR 1 of 2 SCS pumps injecting	Core damage occurs at 2.3 hours	Makeup failure
5	JLP05FB1	Injection with 1 of 4 SI trains OR 1 of 2 SCS pumps injecting	Core damage occurs at 3.7 hours	Makeup successful
5	JLP05FB2	Injection with 1 of 4 SI trains OR 1 of 2 SCS pumps injecting	Core damage occurs at 2.2 hours	Makeup failure

Table 19.1-90 (13 of 15)

POS	Equation Name	System Success Criteria	Timing Information	Comments
6	JLP06FB1	Injection with 1 of 4 SI trains OR 1 of 2 SCS pumps injecting	Core damage occurs at 3.3 hours	Makeup successful
6	JLP06FB2	Injection with 1 of 4 SI trains OR 1 of 2 SCS pumps injecting	Core damage occurs at 2.2 hours	Makeup failure
10	JLP10FB1	Injection with 1 of 4 SI trains OR 1 of 2 SCS pumps injecting	Core damage occurs at 5.4 hours	Makeup successful
10	JLP10FB2	Injection with 1 of 4 SI trains OR 1 of 2 SCS pumps injecting	Core damage occurs at 3.6 hours	Makeup failure

Table 19.1-90 (14 of 15)

POS	Equation Name	System Success Criteria	Timing Information	Comments
11	JLP11FB1	Injection with 1 of 4 SI trains OR 1 of 2 SCS pumps injecting	Core damage occurs at 7.1 hours	Makeup successful
11	JLP11FB2	Injection with 1 of 4 SI trains OR 1 of 2 SCS pumps injecting	Core damage occurs at 4.4 hours	Makeup failure
12A	JLP12AFB1	Injection with 1 of 4 SI trains Bleed with 1 of 4 POSRVs	Core damage occurs at 13.5 hours	Makeup successful
12A	JLP12AFB2	Injection with 1 of 4 SI trains Bleed with 1 of 4 POSRVs	Core damage occurs at 7.1 hours	Makeup failure
13	JLP13FB1	Injection with 1 of 4 SI trains Bleed with 1 of 4 POSRVs	Core damage occurs at 18.9 hours	Makeup successful

Table 19.1-90 (15 of 15)

POS	Equation Name	System Success Criteria	Timing Information	Comments
13	JLP13FB2	Injection with 1 of 4 SI trains	Core damage occurs at 18.9 hours	Makeup failure Timing is based on failure of makeup node. Additional time would be available for the case where makeup is successful. However, given the expansive time available, this additional time is judged to be insignificant to developing the human error probability values associated with this event.
13	RLP13FB1	Injection with 1 of 4 SI trains Bleed with 1 of 4 POSRVs	Core damage occurs at 7.6 hours with MI success if LTOP recloses.	Reclosing of LTOP not expected for spurious opening. Based on timing for POS3A
13	RLP13FB2	Injection with 1 of 4 SI trains	Core damage occurs at 6.6 hours with MI success.	Based on timing for POS3A
13	RLP13FB3	Injection with 1 of 4 SI trains	Core damage occurs at 2.6 hours after initial valve lift with MI failure.	
Top Event CH - Containment Heat Removal				
3A	JLP03ACH RLP03ACH	1 of 2 CS trains aligned for IRWST cooling.	Containment pressure is 2.2kg/cm2 (31 psig) at 24 hours. Operator action to begin IRWST cooling is assumed to be required before design pressure is exceeded.	Containment heat removal required to ensure safe, stable conditions.

Table 19.1-91 (1 of 4)

LPSD PRA Success Criteria Summary for SBO Events

POS	Equation Name	System Success Criteria	Timing Information	Comments
Top Event AAC - Supply Electrical Power from AAC				
3A 3B	LX03AAAC LX03BAAC	Supply power to 1 of 4 Class 1E 4.16 kVAC buses from AAC source.	Recover power before first lifting of LTOP relief valve at 1.6 hours	The success criteria and available time for operator action in POS3B are assumed to be the same as in POS3A.
4A	LXP04AAAC	Supply power to 1 of 4 Class 1E 4.16 kVAC buses from AAC source.	Recover power by at 8.6 hours prior to RCS level decreasing below the top of the hot leg and precluding use of secondary cooling.	
4B	LXP04BAAC	Supply power to 1 of 4 Class 1E 4.16 kVAC buses from AAC source.	Recover power before level decreased below SCS operating level limit of 5.1cm (2- inches) above hot leg center at 30 minutes.	
5	LXP05AAC	Supply power to 1 of 4 Class 1E 4.16 kVAC buses from AAC source.	SCS operating level limit of 5.1cm (2- inches) above hot leg centerline is reached 6.7 minutes after initial loss.	
6	LXP06AAC	Supply power to 1 of 4 Class 1E 4.16 kVAC buses from AAC source.	Recover power before level decreased below SCS operating level limit of 5.1cm (2- inches) above hot leg center at 52 minutes.	

Table 19.1-91 (2 of 4)

POS	Equation Name	System Success Criteria	Timing Information	Comments
10	LXP10AAC	Supply power to 1 of 4 Class 1E 4.16 kVAC buses from AAC source.	Recover power before level decreased below SCS operating level limit of 5.1cm (2- inches) above hot leg center at 95 minutes.	
11	LXP11AAC	Supply power to 1 of 4 Class 1E 4.16 kVAC buses from AAC source.	SCS operating level limit of 5.1cm (2- inches) above hot leg centerline is reached 21 minutes after initial loss.	
12A	LXP12AAAC	Supply power to 1 of 4 Class 1E 4.16 kVAC buses from AAC source.	SCS operating level limit of 5.1cm (2- inches) above hot leg centerline is reached 7.6 minutes after initial loss.	
13	LXP13AAC	Supply power to 1 of 4 Class 1E 4.16 kVAC buses from AAC source.	Recover power before exceeding SCS operating limit pressure limit of 31.6 kg/cm2A (450 psia) at 45 minutes.	
Top Event SG - Steam Removal Using MSADV without AFW				
3A 3B	LXP03A-ADV LXP03B-ADV	Heat removal from 1 of 2 steam generators using initial SG inventory and 1 of 4 MSADVs	LTO P relief valve first lift occurs at 1.6 hours.	The success criteria and available time for operator action in POS3B are assumed to be the same as in POS3A.
4A	LXP04A-ADV	Heat removal from 1 of 2 steam generators using initial SG inventory and 1 of 4 MSADVs	Cooling must be initiated before level decreases below the top of RCS hot leg at 8.5 hours	One SG is assumed to be unavailable due to outage activities.

Table 19.1-91 (3 of 4)

POS	Equation Name	System Success Criteria	Timing Information	Comments
Top Event AC - Recover Offsite Power				
3A 3B	LXP03A-AC1 LXP03B-AC1	Supply offsite power to 1 of 4 Class 1E 4.16 kVAC buses.	Core damage occurs at 9.6 hours if ADV is success	The success criteria and available time for operator action in POS3B are assumed to be the same as in POS3A.
3A 3B	LXP03A-AC2 LXP03B-AC2	Supply offsite power to 1 of 4 Class 1E 4.16 kVAC buses.	Core damage occurs at 6.0 hours if ADV heat removal fails	The success criteria and available time for operator action in POS3B are assumed to be the same as in POS3A.
4A	LXP04A-AC1	Supply offsite power to 1 of 4 Class 1E 4.16 kVAC buses.	Core damage occurs at 18.9 hours if ADV is success	
4A	LXP04A-AC2	Supply offsite power to 1 of 4 Class 1E 4.16 kVAC buses.	Core damage occurs at 13.9 hours if ADV heat removal fails	
4B	LXP04B-AC	Supply offsite power to 1 of 4 Class 1E 4.16 kVAC buses.	Core damage occurs at 2.4 hours.	
5	LXP05-AC	Supply offsite power to 1 of 4 Class 1E 4.16 kVAC buses.	Core damage occurs at 2.2 hours.	
6	LXP06-AC	Supply offsite power to 1 of 4 Class 1E 4.16 kVAC buses.	Core damage occurs at 2.2 hours.	
10	LXP10-AC	Supply offsite power to 1 of 4 Class 1E 4.16 kVAC buses.	Core damage occurs at 3.6 hours.	

Table 19.1-91 (4 of 4)

POS	Equation Name	System Success Criteria	Timing Information	Comments
11	LXP11-AC	Supply offsite power to 1 of 4 Class 1E 4.16 kVAC buses.	Core damage occurs at 4.4 hours.	
12A	LXP12A-AC	Supply offsite power to 1 of 4 Class 1E 4.16 kVAC buses.	Core damage occurs at 7.4 hours	
13	LXP13-AC	Supply offsite power to 1 of 4 Class 1E 4.16 kVAC buses.	Core damage occurs at 19.6 hours	

Table 19.1-92 (1 of 3)

LPSD PRA Success Criteria Summary for TLOCCW/TLOESW Events

POS	Equation Name	System Success Criteria	Timing Information	Comments
Top Event LT - LTOP Relief Valve Closes				
3B	TCP03BLT TSP03BLT	2 of 2 LTOP relief valves close	Not applicable.	Top event affects timing for feed and bleed cooling.
4A	TCP04ALT TSP04ALT	2 of 2 LTOP relief valves close	Not applicable.	Top event affects timing for feed and bleed cooling.
13	TCP04ALT TSP04ALT	2 of 2 LTOP relief valves close	Not applicable.	Top event affects timing for feed and bleed cooling.
Top Event FB - Feed and Bleed Cooling				
3B	TCP03BFB1 TSP03BFB1	Injection with 1 of 4 SI trains Bleed with 1 of 4 POSRVs	Core damage occurs at 6 hours	This timing is based on LTOP relief valves closing after pressure is reduced. The success criteria and available time for operator action in POS3B are assumed to be the same as in POS3A.

Table 19.1-92 (2 of 3)

POS	Equation Name	System Success Criteria	Timing Information	Comments
3B	TCP03BFB2 TSP03BFB2	Injection with 1 of 4 SI trains	Core damage occurs at 2.7 hours	This timing is based on one LTOP valve sticking open after first lift at 1.6 hours. The success criteria and available time for operator action in POS3B are assumed to be the same as in POS3A.
4A	TCP04AFB1 TSP04AFB1	Injection with 1 of 4 SI trains Bleed with 1 of 4 POSRVs	Core damage occurs at 13.9 hours	This timing is based on LTOP relief valves closing after pressure is reduced.
4A	TCP04AFB2 TSP04AFB2	Injection with 1 of 4 SI trains	Core damage occurs at 13.9 hours	This timing is based on one LTOP valve sticking open after first lift at 12.8 hours. Core damage is assumed to occur 1.1 hours after first LTOP lift at 12.8 hrs. This timing is based on the thermal-hydraulic analysis for POS3A.
4B	TCP04BFB TSP04BFB	Injection with 1 of 4 SI trains	Core damage occurs at 2.3 hours	
5	TCP05FB TSP05FB	Injection with 1 of 4 SI trains	Core damage occurs at 2.2 hours	
6	TCP06FB TSP06FB	Injection with 1 of 4 SI trains	Core damage occurs at 2.2 hours	

Table 19.1-92 (3 of 3)

POS	Equation Name	System Success Criteria	Timing Information	Comments
10	TCP10FB TSP10FB	Injection with 1 of 4 SI trains	Core damage occurs at 3.6 hours	
11	TCP11FB TSP11FB	Injection with 1 of 4 SI trains	Core damage occurs at 4.4 hours	
12A	TCP12AFB TSP12AFB	Injection with 1 of 4 SI trains	Core damage occurs at 7.4 hours	
13	TCP13FB1 TSP13FB1	Injection with 1 of 4 SI trains Bleed with 1 of 4 POSRVs	Core damage occurs at 19.6 hours	This timing is based on LTOP relief valves closing after pressure is reduced.
13	TCP13FB2 TSP13FB2	Injection with 1 of 4 SI trains	Core damage occurs at 7.0 hours	This timing is based on one LTOP valve sticking open after first lift at 5.9 hours. Core damage is assumed to occur 1.1 hours after first LTOP lift at 7.0 hrs. This timing is based on the thermal-hydraulic analysis for POS3A.

Table 19.1-93 (1 of 2)

LPSD PRA CDF Contributions for Initiating Event (all POS)

Initiating Event	CDF (/yr)	Contribution (%)
Over-Drainage during Reduced Inventory operation (SO)	1.49E-06	54.9
Loss of Offsite Power (LP) + Station Black Out (LX)	2.95E-07	10.9
Failure to maintain water level during Reduced Inventory (SL)	2.56E-07	9.4
Unrecoverable LOCA (JL)	2.17E-07	8.0
Total Loss of Emergency Service Water (TS) plus Total Loss of Component Cooling Water (TC)	1.80E-07	6.6
POSRVs fail to reclose (PL)	9.70E-08	3.6
Recoverable Loss of Shutdown Cooling System (S1)	9.63E-08	3.5
Loss of 4.16 kV AC (KV)	2.78E-08	1.0
Partial Loss of Emergency Service Water (ES)	1.93E-08	0.7
Unrecoverable Loss of Shutdown Cooling System (S2)	1.82E-08	0.7
Partial Loss of Component Cooling Water (CC)	6.96E-09	0.3
Medium Break Loss of Coolant Accident (MBLOCA)	4.89E-09	0.2
Anticipated Transient Without Scram (ATWS)	2.97E-09	0.1
LTOP's failing to reclose (RL)	2.51E-09	0.1
Small Break Loss of Coolant Accident (SBLOCA)	8.52E-10	<0.05%
Induced Small LOCA (PR-A-SL)	5.30E-10	<0.05%
Steam Generator Tube Rupture (SGTR)	3.85E-10	<0.05%
Reactor Vessel Rupture (RVR)	2.58E-10	<0.05%
General Transient (GTRN)	1.00E-10	<0.05%
Loss of Condense Vacuum (LOCV)	6.45E-11	<0.05%
Loss of Main Feedwater (LOFW)	5.90E-11	<0.05%
Main Steam Line Break downstream of MSIVs (LSSB-D)	4.06E-11	<0.05%
Main Feed Water Line Break(FWLB)	6.34E-12	<0.05%
Large Break Loss of Coolant Accident (LBLOCA)	2.55E-12	<0.05%
Main Steam Line Break upstream of MSIVs (LSSB-U)	0.00E+00	0.0%

Table 19.1-93 (2 of 2)

Initiating Event	CDF (/yr)	Contribution (%)
Loss of Instrumentation Air (LOIA)	0.00E+00	0.0%
Loss of 125V DCA (LODCA)	0.00E+00	0.0%
Loss of 125V DCB (LODCB)	0.00E+00	0.0%
SUM	2.72E-06	100.0

Table 19.1-94

LPSD PRA CDF Contributions for the Reduced Inventory POS

Initiating Event	Plant Operating State	CDF Contribution
Total Loss of Essential Service Water	3-13	52.6%
Total Loss of Component Cooling	3-13	34.6%
Over-drainage During Reduced Inventory Operation	3-13	7.2%
Failure to Maintain Water Level During Reduced Inventory Operation	3-13	1.2%
Recoverable Loss of Shutdown Cooling System	3-13	0.7%
Small LOCA at Reduced Inventory	3-13	0.7%
Loss of Offsite Power switchyard-related)	3-13	0.5%
POSRV Fails to Reclose	3-13	0.5%
Loss of Offsite Power (plant-centered)	3-13	0.4%
Loss of Offsite Power (weather-related)	3-13	0.3%
Small LOCA above Reduced Inventory	3-13	0.3%
Partial Loss of Essential Service Water	3-13	0.3%
Loss of 4 kV Bus	3-13	0.2%
Unrecoverable Loss of Shutdown Cooling System	3-13	0.1%
Partial Loss of Component Cooling	3-13	0.1%
Loss of Offsite Power (grid-related)	3-13	0.1%
Letdown Line LOCA	3-13	0.1%

Table 19.1-95

LPSD PRA CDF Contributions by Plant Operating State

POS	T/S Mode	Description	CDF(/yr)	Contribution (%)
1	1, 2	Reactor trip and subcritical state	5.3E-10	0.0
2	3	Steam Generator Cooldown to 177 °C (350 °F)	1.0E-07	3.7
3A	4	Cooldown with SCS to 100 °C (212 °F)	1.9E-07	7.1
3B	5	Cooldown with SCS to 60 °C (140 °F)	9.5E-08	3.5
4A	5	RCS Draindown (pressurizer manway closed)	1.1E-09	0.0
4B	5	RCS Draindown (manway open)	4.6E-08	1.7
5	5	Reduced Inventory Operation	1.4E-06	51
6	5	Fill for Refueling	9.7E-08	3.6
7-9	6	Refueling	-	-
10	5	RCS Draindown after Refueling	1.3E-07	4.7
11	5	Reduced Inventory Operation	6.1E-07	22
12A	5	Refill RCS (manway open)	2.3E-08	0.8
12B	5	Refill RCS (manway closed)	-	-
13	4,5	RCS Heatup with SCS Isolation at 177 °C (350 °F)	2.1E-08	0.8
14	3	RCS Heatup with Steam Generators	3.9E-09	0.1
15	2, 1	Reactor Startup	6.6E-09	0.2
Sum			2.7E-06	100

(1) The Overdrain initiating event has been binned with the reduced inventory states (POS 5 and 11.)

(2) The POSRVs are tested in POS 2 and contribute 3.5% of POS risk. No corresponding tests are performed in POS 14.

Table 19.1-96 (1 of 40)

LPSD PRA Top 100 CDF Cutsets

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
1	7.56E-07	%SO	RCS Overdraining due to SCS	27.8	27.8
		BE-RATE-OT	Conversion factor (Outage-yr → Calendar yr, 1/(18month/12month)) for Demand Failure		
		HR-FB-SOP05-01-DE	HRA Dependence for RS & FB at SO POS05		
		HR-RS-SOP05	OPERATOR FAILS TO RESTORE SCS AT SO POS05		
2	3.40E-07	%SO	RCS Overdraining due to SCS	12.5	40.3
		BE-RATE-OT	Conversion factor (Outage-yr → Calendar yr, 1/(18month/12month)) for Demand Failure		
		HR-FB-SOP11-01-DE	HRA Dependance for RS & FB at SO POS11		
		HR-RS-SOP11	OPERATOR FAILS TO RESTORE SCS AT SO POS11		

Table 19.1-96 (2 of 40)

Rank	Frequency (/yr)	Cutsets: Cutset	Cutsets: Cutset Description	Contribution to CDF (%): Cutset	Contribution to CDF (%): Cumulative
3	2.34E-07	%SO	RCS Overdraining due to SCS	8.6	48.9
		BE-RATE-OT	Conversion factor (Outage-yr → Calendar yr, 1/(18month/12month)) for Demand Failure		
		HR-FB-SOP05-02-DE	HRA Dependance for MI & FB at SO POS05		
		HR-MI-SOP05	Operator Fails To Isolate and Makeup Over-Drainage (SO) PATH at POS05		
4	1.40E-07	%SL	Failure to Maintain Water Level at Reduced Inventory	5.1	54.0
		BE-RATE-P05	Conversion factor (SD-yr → Calendar yr) for POS5 duration		
		HR-FB-SLP05-01-DE	HRA Dependance for RS & FB at SL POS05		
		HR-RS-SLP05	OPERATOR FAILS TO RESTORE SCS AT SL POS05		
5	1.24E-07	%SO	RCS Overdraining due to SCS	4.6	58.6
		BE-RATE-OT	Conversion factor (Outage-yr → Calendar yr, 1/(18month/12month)) for Demand Failure		
		HR-FB-SOP11-02-DE	HRA Dependance for MI & FB at SO POS11		
		HR-MI-SOP11	Operator Fails To Isolate and Makeup Over-Drainage (SO) PATH at POS11		

Table 19.1-96 (3 of 40)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
6	7.86E-08	%TC	Total Loss of Component Cooling Water	2.9	61.5
		BE-RATE-P03A	Conversion factor (SD-yr → Calendar yr) for POS03A duration		
7	7.86E-08	%TS	Total Loss of Essential Service Water	2.9	64.4
		BE-RATE-P03A	Conversion factor (SD-yr → Calendar yr) for POS03A duration		
8	1.39E-08	%SL1	Small LOCA at Reduced Inventory	2.8	67.2
		BE-RATE-P05	Conversion factor (SD-yr → Calendar yr) for POS5 duration		
		HR-FB-JLP05-01-DE	HRA Dependance for RS & FB at JL POS05		
		HR-RS-JLP05	OPERATOR FAILS TO RESTORE SCS AT JL POS05		
9	7.70E-08	%SL	Failure to Maintain Water Level at Reduced Inventory	1.8	69.0
		BE-RATE-P11	Conversion factor (SD-yr → Calendar yr) for POS11 duration		
		HR-FB-SLP11-01-DE	HRA Dependance for RS & FB at SL POS11		
		HR-RS-SLP11	OPERATOR FAILS TO RESTORE SCS AT SL POS11		

Table 19.1-96 (4 of 40)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
10	4.31E-08	%SL	Failure to Maintain Water Level at Reduced Inventory	1.6	70.6
		BE-RATE-P05	Conversion factor (SD-yr → Calendar yr) for POS5 duration		
		HR-FB-SLP05-02-DE	HRA Dependance for MI & FB at SL POS05		
		HR-MI-SLP05	Operator Fails To Isolate and Makeup Failing to maintain water level (SL) PATH at POS05		
11	2.98E-08	%PL	STUCK OPEN OF POSRV	1.1	71.7
		BE-RATE-OT	Conversion factor (Outage-yr → Calendar yr, 1/(18month/12month)) for Demand Failure		
		SISPP-S-IRWST	FAILURE OF IRWST SUMP DUE TO PLUGGING		
12	2.97E-08	%S1	Loss of SCS (S1)	1.1	72.8
		BE-RATE-P05	Conversion factor (SD-yr → Calendar yr) for POS5 duration		
		HR-FB-S1P05-DE	HRA Dependance for RS & FB at S1 POS05		
		HR-RS-S1P05	OPERATOR FAILS TO RESTORE SCS AT S1 POS05		

Table 19.1-96 (5 of 40)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
13	2.87E-08	%S1	Loss of SCS (S1)	1.1	73.9
		BE-RATE-P03	Conversion factor (SD-yr → Calendar yr) for POS03 duration		
		HR-FB-S1P03B-01-DE	HRA Dependance for SG & FB at S1 POS03B		
		HR-RS-S1P03B	OPERATOR FAILS TO RESTORE SCS AT S1 POS03B		
		HR-SG-S1P03B-DE	HRA Dependance for RS & SG at S1 POS03B		
14	2.72E-08	%SL1	Small LOCA at Reduced Inventory	1.0	74.9
		BE-RATE-P11	Conversion factor (SD-yr → Calendar yr) for POS11 duration		
		HR-FB-JLP11-01-DE	HRA Dependance for RS & FB at JL POS11		
		HR-RS-JLP11	OPERATOR FAILS TO RESTORE SCS AT JL POS11		

Table 19.1-96 (6 of 40)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
15	2.38E-08	%SL1	Small LOCA at Reduced Inventory	0.9	75.7
		BE-RATE-P05	Conversion factor (SD-yr → Calendar yr) for POS5 duration		
		HR-FB-JLP05-02-DE	HRA Dependance for MI & FB at JL POS05		
		HR-MI-JLP05	Operator Fails To Isolate and Makeup Unrecoverable LOCA (JL) PATH at POS05		
16	1.79E-08	%SL	Failure to Maintain Water Level at Reduced Inventory	0.7	76.4
		BE-RATE-P11	Conversion factor (SD-yr → Calendar yr) for POS11 duration		
		HR-FB-SLP11-02-DE	HRA Dependance for MI & FB at SL POS11		
		HR-MI-SLP11	Operator Fails To Isolate and Makeup Failing to maintain water level (SL) PATH at POS11		
17	1.68E-08	%SL2	Small LOCA above Reduced Inventory	0.6	77.0
		BE-RATE-P06	Conversion factor (SD-yr → Calendar yr) for POS6 duration		
		HR-FB-JLP06-02-DE	HRA Dependance for MI & FB at JL POS06		
		HR-MI-JLP06	Operator Fails To Isolate and Makeup Unrecoverable LOCA (JL) PATH at POS06		

Table 19.1-96 (7 of 40)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
18	1.41E-08	%SL2	RCS Overdraining due to SCS	0.5	77.5
		BE-RATE-P10	Conversion factor (Outage-yr → Calendar yr, 1/(18month/12month)) for Demand Failure		
		HR-FB-JLP10-02-DE	HRA Dependance for RS & FB at SO POS05		
		HR-MI-JLP10	OPERATOR FAILS TO RESTORE SCS AT SO POS05		
19	1.36E-08	%LPSW	RCS Overdraining due to SCS	0.5	78.0
		BE-RATE-P05	Conversion factor (Outage-yr → Calendar yr, 1/(18month/12month)) for Demand Failure		
		HR-FB-LPP05-DE	HRA Dependance for RS & FB at SO POS11		
		HR-RS-LPP05	OPERATOR FAILS TO RESTORE SCS AT SO POS11		
20	1.31E-08	%LPSW	RCS Overdraining due to SCS	0.5	78.5
		BE-RATE-P03B	Conversion factor (Outage-yr → Calendar yr, 1/(18month/12month)) for Demand Failure		
		HR-FB-LPP03B-01-DE	HRA Dependance for MI & FB at SO POS05		
		HR-RS-LPP03B	Operator Fails To Isolate and Makeup Over-Drainage (SO) PATH at POS05		
		HR-SG-LPP03B-DE	Failure to Maintain Water Level at Reduced Inventory		

Table 19.1-96 (8 of 40)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
21	1.22E-08	%PL	STUCK OPEN OF POSRV	0.4	79.0
		BE-RATE-OT	Conversion factor (Outage-yr → Calendar yr, 1/(18month/12month)) for Demand Failure		
		WOCHKQ4-CH03A/3B/4A/4B	RUNNING CCF OF ECW CHILLERS 3A/4A/3B/4B		
22	1.22E-08	%PL	STUCK OPEN OF POSRV	0.4	79.4
		BE-RATE-OT	Conversion factor (Outage-yr → Calendar yr, 1/(18month/12month)) for Demand Failure		
		WOCHKQ4-CH01A/1B/2A/2B	RUNNING CCF OF ECW CHILLERS 1A/2A/1B/2B		
23	1.12E-08	%LPPL	Loss of offsite power of Plant-centered for LPSD	0.4	79.8
		BE-RATE-P05	Conversion factor (SD-yr → Calendar yr) for POS5 duration		
		HR-FB-LPP05-DE	HRA Dependance for RS & FB at LP POS05		
		HR-RS-LPP05	OPERATOR FAILS TO RESTORE SCS AT LO POS05		

Table 19.1-96 (9 of 40)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
24	1.08E-08	%LPPL	Loss of offsite power of Plant-centered for LPSD	0.4	80.2
		BE-RATE-P03	Conversion factor (SD-yr → Calendar yr) for POS03 duration		
		HR-FB-LPP03B-01-DE	HRA Dependance for SG & FB at LP POS03B		
		HR-RS-LPP03B	OPERATOR FAILS TO RESTORE SCS AT LO POS03B		
		HR-SG-LPP03B-DE	HRA Dependance for RS & SG at LP POS03B		
25	1.04E-08	%SL2	Small LOCA above Reduced Inventory	0.4	80.6
		BE-RATE-P03B	Conversion factor (SD-yr → Calendar yr) for POS03B duration		
		HR-FB-JLP03B-01-DE	HRA Dependance for SG & FB at JL POS03B		
		HR-IL-JLP03B-02-DE	HRA Dependance for MK & IL at JL POS03B		
		HR-MK-JLP03B	OPERATOR FAILS TO MAKE UP INVENTORY AT JL POS03B		

Table 19.1-96 (10 of 40)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
26	1.04E-08	%S1	Loss of SCS (S1)	0.4	81.0
		BE-RATE-P10	Conversion factor (SD-yr → Calendar yr) for POS10 duration		
		HR-FB-S1P10-DE	HRA Dependance for RS & FB at S1 POS10		
		HR-RS-S1P10	OPERATOR FAILS TO RESTORE SCS AT S1 POS10		
27	9.89E-09	%SL1	Small LOCA at Reduced Inventory	0.4	81.3
		BE-RATE-P11	Conversion factor (SD-yr → Calendar yr) for POS11 duration		
		HR-FB-JLP11-02-DE	HRA Dependance for MI & FB at JL POS11		
		HR-MI-JLP11	Operator Fails To Isolate and Makeup Unrecoverable LOCA (JL) PATH at POS11		
28	9.44E-09	%SO	RCS Overdraining due to SCS	0.4	81.7
		BE-RATE-OT	Conversion factor (Outage-yr → Calendar yr, 1/(18month/12month)) for Demand Failure		
		HR-FB-SOP05-01	OPERATOR FAILS TO OPERATE F&B AT SO POS05 01		
		VKHVS2B-HV16B	FAILS TO START SC PUMP 02B ROOM CUBICLE COOLER HV16B		

Table 19.1-96 (11 of 40)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
29	9.44E-09	%SO	RCS Overdraining due to SCS	0.3	82.0
		BE-RATE-OT	Conversion factor (Outage-yr → Calendar yr, 1/(18month/12month)) for Demand Failure		
		HR-FB-SOP11-01	OPERATOR FAILS TO OPERATE F&B AT SO POS11 01		
		VKHVS2A-HV16A	FAILS TO START SC PUMP 02A ROOM CUBICLE COOLER HV16A		
30	8.93E-09	%PL	STUCK OPEN OF POSRV	0.3	82.4
		BE-RATE-OT	Conversion factor (Outage-yr → Calendar yr, 1/(18month/12month)) for Demand Failure		
		VGAHKQ4-AH01A/1B/2A/2B	4/4 RUNNING CCF OF ESW PUMP ROOM FAN AH01A/B, 02A/B		

Table 19.1-96 (12 of 40)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
31	8.93E-09	%PL BE-RATE-OT VGAHKQ4-AH01A/1B/2A/2B	STUCK OPEN OF POSRV Conversion factor (Outage-yr → Calendar yr, 1/(18month/12month)) for Demand Failure 4/4 RUNNING CCF OF ESW PUMP ROOM FAN AH01A/B, 02A/B	0.3	82.7
32	8.54E-09	%PL BE-RATE-OT VGAHKQ4-AH04A/4B/5A/5B	STUCK OPEN OF POSRV Conversion factor (Outage-yr → Calendar yr, 1/(18month/12month)) for Demand Failure 4/4 RUNNING CCF OF ESW PUMP ROOM FAN AH04A, 04B, 05A, 05B	0.3	83.0
33	7.79E-09	%LPWE BE-RATE-P05 HR-FB-LPP05-DE HR-RS-LPP05	Loss of offsite power of Weather-related for LPSD Conversion factor (SD-yr → Calendar yr) for POS5 duration HRA Dependance for RS & FB at LP POS05 OPERATOR FAILS TO RESTORE SCS AT LO POS05	0.3	83.3

Table 19.1-96 (13 of 40)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
34	7.53E-09	%LPWE	Loss of offsite power of Weather-related for LPSD	0.3	83.6
		BE-RATE-P03B	Conversion factor (SD-yr → Calendar yr) for POS03B duration		
		HR-FB-LPP03B-01-DE	HRA Dependance for SG & FB at LP POS03B		
		HR-RS-LPP03B	OPERATOR FAILS TO RESTORE SCS AT LO POS03B		
		HR-SG-LPP03B-DE	HRA Dependance for RS & SG at LP POS03B		
35	7.42E-09	%KV	Loss of Class 1E 4.16KV	0.3	83.8
		BE-RATE-P05	Conversion factor (SD-yr → Calendar yr) for POS5 duration		
		HR-FB-KVP05-DE	HRA Dependance for RS & FB at KV POS05		
		HR-RS-KVP05	OPERATOR FAILS TO RESTORE SCS AT KV POS05		

Table 19.1-96 (14 of 40)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
36	7.40E-09	%S1	Loss of SCS (S1)	0.3	84.1
		BE-RATE-P12A	Conversion factor (SD-yr → Calendar yr) for POS12A duration		
		HR-FB-S1P12A-DE	HRA Dependance for RS & FB at S1 POS12A		
		HR-RS-S1P12A	OPERATOR FAILS TO RESTORE SCS AT S1 POS12A		
37	6.67E-09	%S1	Loss of SCS (S1)	0.2	84.4
		BE-RATE-P06	Conversion factor (SD-yr → Calendar yr) for POS6 duration		
		HR-FB-S1P06-DE	HRA Dependance for RS & FB at S1 POS06		
		HR-RS-S1P06	OPERATOR FAILS TO RESTORE SCS AT S1 POS06		
38	4.74E-09	%LPSW	Loss of offsite power of Switchyard-centered for LPSD	0.2	84.5
		BE-RATE-P10	Conversion factor (SD-yr → Calendar yr) for POS10 duration		
		HR-FB-LPP10-DE	HRA Dependance for RS & FB at LP POS10		
		HR-RS-LPP10	OPERATOR FAILS TO RESTORE SCS AT LO POS10		

Table 19.1-96 (15 of 40)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
39	4.67E-09	%S2	Loss of SCS (S2)	0.2	84.7
		BE-RATE-P05	Conversion factor (SD-yr → Calendar yr) for POS5 duration		
		HR-FB-S2P05-DE	HRA Dependance for RS & FB at S2 POS05		
		HR-RS-S2P05	OPERATOR FAILS TO RESTORE SCS AT S2 POS05		
40	4.52E-09	%S2	Loss of SCS (S2)	0.2	84.9
		BE-RATE-P03B	Conversion factor (SD-yr → Calendar yr) for POS03B duration		
		HR-FB-S2P03B-01-DE	HRA Dependance for SG & FB at S2 POS03B		
		HR-RS-S2P03B	OPERATOR FAILS TO RESTORE SCS AT S2 POS03B		
		HR-SG-S2P03B-DE	HRA Dependance for RS & SG at S2 POS03B		

Table 19.1-96 (16 of 40)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
41	4.22E-09	%S1	Loss of SCS (S1)	0.2	85.0
		BE-RATE-P4B	Conversion factor (SD-yr → Calendar yr) for POS4B duration		
		HR-FB-S1P04B-DE	HRA Dependance for RS & FB at S1 POS04B		
		HR-RS-S1P04B	OPERATOR FAILS TO RESTORE SCS AT S1 POS04B		
42	3.95E-09	%ES	Loss of Essential Service Water	0.1	85.2
		BE-RATE-P05	Conversion factor (SD-yr → Calendar yr) for POS5 duration		
		HR-FB-ESP05-DE	HRA Dependance for RS & FB at ES POS05		
		HR-RS-ESP05	OPERATOR FAILS TO RESTORE SCS AT ES POS05		

Table 19.1-96 (17 of 40)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
43	3.92E-09	%LPPL	Loss of offsite power of Plant-centered for LPSD	0.1	85.3
		BE-RATE-P10	Conversion factor (SD-yr → Calendar yr) for POS10 duration		
		HR-FB-LPP10-DE	HRA Dependance for RS & FB at LP POS10		
		HR-RS-LPP10	OPERATOR FAILS TO RESTORE SCS AT LO POS10		
44	3.89E-09	%SL2	Small LOCA above Reduced Inventory	0.1	85.5
		BE-RATE-P4B	Conversion factor (SD-yr → Calendar yr) for POS4B duration		
		HR-FB-JLP04B-02-DE	HRA Dependance for MI & FB at JL POS04B		
		HR-MI-JLP04B	Operator Fails To Isolate and Makeup Unrecoverable LOCA (JL) PATH at POS04B		

Table 19.1-96 (18 of 40)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
45	3.82E-09	%ES	Loss of Essential Service Water	0.1	85.6
		BE-RATE-P03B	Conversion factor (SD-yr → Calendar yr) for POS03B duration		
		HR-FB-ESP03B-01-DE	HRA Dependance for SG & FB at ES POS03B		
		HR-RS-ESP03B	OPERATOR FAILS TO RESTORE SCS AT ES POS03B		
		HR-SG-ESP03B-DE	HRA Dependance for RS & SG at ES POS03B		
46	3.52E-09	%S1	Loss of SCS (S1)	0.1	85.7
		BE-RATE-P03A	Conversion factor (SD-yr → Calendar yr) for POS03A duration		
		HR-FB-S1P03A-01-DE	HRA Dependance for SG & FB at S1 POS03A		
		HR-RS-S1P03A	OPERATOR FAILS TO RESTORE SCS AT S1 POS03A		
		HR-SG-S1P03A-DE	HRA Dependance for RS & SG at S1 POS03A		

Table 19.1-96 (19 of 40)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
47	3.39E-09	%PL	STUCK OPEN OF POSRV	0.1	85.9
		BE-RATE-OT	Conversion factor (Outage-yr → Calendar yr, 1/(18month/12month)) for Demand Failure		
		MSOPH-S-ASC-SLOCA	OPERATOR FAILS TO PERFORM AGGRE. SEC. COOLING FOR SLOCA		
		SIMVWQ4-616/26/36/46	CCF OF 4/4 DVI LINEMOV 616,626,636,646		
48	3.38E-09	%LPSW	Loss of offsite power of Switchyard-centered for LPSD	0.1	86.0
		BE-RATE-P12A	Conversion factor (SD-yr → Calendar yr) for POS12A duration		
		HR-FB-LPP12A-DE	HRA Dependance for RS & FB at LP POS12A		
		HR-RS-LPP12A	OPERATOR FAILS TO RESTORE SCS AT LO POS12A		
49	3.38E-09	%SL2	Small LOCA above Reduced Inventory	0.1	86.1
		BE-RATE-P10	Conversion factor (SD-yr → Calendar yr) for POS10 duration		
		HR-FB-JLP10-01_DE	HRA Dependance for RS & FB at JL POS10		
		HR-RS-JLP10	OPERATOR FAILS TO RESTORE SCS AT JL POS10		

Table 19.1-96 (20 of 40)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
50	3.35E-09	%SL2	Small LOCA above Reduced Inventory	0.1	86.2
		BE-RATE-P06	Conversion factor (SD-yr → Calendar yr) for POS6 duration		
		HR-FB-JLP06-01-DE	HRA Dependance for RS & FB at JL POS06		
		HR-RS-JLP06	OPERATOR FAILS TO RESTORE SCS AT JL POS06		
51	3.04E-09	%LPSW	Loss of offsite power of Switchyard-centered for LPSD	0.1	86.3
		BE-RATE-P06	Conversion factor (SD-yr → Calendar yr) for POS6 duration		
		HR-FB-LPP06-DE	HRA Dependance for RS & FB at LP POS06		
		HR-RS-LPP06	OPERATOR FAILS TO RESTORE SCS AT LO POS06		
52	2.92E-09	%TS	Total Loss of Essential Service Water	0.1	86.4
		BE-RATE-P03B	Conversion factor (SD-yr → Calendar yr) for POS03B duration		
		HR-FB-TSP03B-01	OPERATOR FAILS TO OPERATE F&B AT TS POS03B 01		

Table 19.1-96 (21 of 40)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
53	2.92E-09	%TC	Total Loss of Component Cooling Water	0.1	86.5
		BE-RATE-P03B	Conversion factor (SD-yr → Calendar yr) for POS03B duration		
		HR-FB-TCP03B-01	OPERATOR FAILS TO OPERATE F&B AT TC POS03B 01		
54	2.79E-09	%LPPL	Loss of offsite power of Plant-centered for LPSD	0.1.	86.7
		BE-RATE-P12A	Conversion factor (SD-yr → Calendar yr) for POS12A duration		
		HR-FB-LPP12A-DE	HRA Dependance for RS & FB at LP POS12A		
		HR-RS-LPP12A	OPERATOR FAILS TO RESTORE SCS AT LO POS12A		

Table 19.1-96 (22 of 40)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
55	2.75E-09	%S1	Loss of SCS (S1)	0.1	86.8
		BE-RATE-P11	Conversion factor (SD-yr → Calendar yr) for POS11 duration		
		HR-FB-S1P11-DE	HRA Dependance for RS & FB at S1 POS11		
		HR-RS-S1P11	OPERATOR FAILS TO RESTORE SCS AT S1 POS11		
56	2.73E-09	%LPWE	Loss of offsite power of Weather-related for LPSD	0.1	86.9
		BE-RATE-P10	Conversion factor (SD-yr → Calendar yr) for POS10 duration		
		HR-FB-LPP10-DE	HRA Dependance for RS & FB at LP POS10		
		HR-RS-LPP10	OPERATOR FAILS TO RESTORE SCS AT LO POS10		

Table 19.1-96 (23 of 40)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
57	2.60E-09	%TC	Total Loss of Component Cooling Water	0.1	87.0
		BE-RATE-P13	Conversion factor (SD-yr → Calendar yr) for POS13 duration		
		HR-FB-TCP13-01	OPERATOR FAILS TO OPERATE F&B AT TC POS13 01		
58	2.60E-09	%TS	Total Loss of Essential Service Water	0.1	87.1
		BE-RATE-P13	Conversion factor (SD-yr → Calendar yr) for POS13 duration		
		HR-FB-TSP13-01	OPERATOR FAILS TO OPERATE F&B AT TS POS13 01		

Table 19.1-96 (24 of 40)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
59	2.60E-09	%KV	Loss of Class 1E 4.16KV	0.1	87.2
		BE-RATE-P10	Conversion factor (SD-yr → Calendar yr) for POS10 duration		
		HR-FB-KVP10-DE	HRA Dependance for RS & FB at KV POS10		
		HR-RS-KVP10	OPERATOR FAILS TO RESTORE SCS AT KV POS10		
60	2.55E-09	%ATWS	ANTICIPATED TRANSIENT WITHOUT SCRAM	0.1	87.3
		BE-RATE-P15	Conversion factor (SD-yr → Calendar yr) for POS15 duration		
		MTC-ATWS	MODERATE COEFFICIENT		
61	2.52E-09	%LPPL	Loss of offsite power of Plant-centered for LPSD	0.1	87.4
		BE-RATE-P06	Conversion factor (SD-yr → Calendar yr) for POS6 duration		
		HR-FB-LPP06-DE	HRA Dependance for RS & FB at LP POS06		
		HR-RS-LPP06	OPERATOR FAILS TO RESTORE SCS AT LO POS06		

Table 19.1-96 (25 of 40)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
62	2.44E-09	%LPGR	Loss of offsite power of Grid-related for LPSD	0.1	87.5
		BE-RATE-P05	Conversion factor (SD-yr → Calendar yr) for POS5 duration		
		HR-FB-LPP05-DE	HRA Dependance for RS & FB at LP POS05		
		HR-RS-LPP05	OPERATOR FAILS TO RESTORE SCS AT LO POS05		
63	2.41E-09	%JL	Unrecoverable LOCA	0.1	87.6
		BE-RATE-P06	Conversion factor (SD-yr → Calendar yr) for POS6 duration		
		HR-FB-JLP06-02-DE	HRA Dependance for MI & FB at JL POS06		
		HR-MI-JLP06	Operator Fails To Isolate and Makeup Unrecoverable LOCA (JL) PATH at POS06		

Table 19.1-96 (26 of 40)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
64	2.40E-09	%JL	Unrecoverable LOCA	0.1	87.6
		BE-RATE-P06	Conversion factor (SD-yr → Calendar yr) for POS6 duration		
		HR-FB-JLP06-02-DE	HRA Dependance for MI & FB at JL POS06		
		HR-MI-JLP06	Operator Fails To Isolate and Makeup Unrecoverable LOCA (JL) PATH at POS06		
65	2.36E-09	%LPGR	Loss of offsite power of Grid-related for LPSD	0.1	87.7
		BE-RATE-P03B	Conversion factor (SD-yr → Calendar yr) for POS03B duration		
		HR-FB-LPP03B-01-DE	HRA Dependance for SG & FB at LP POS03B		
		HR-RS-LPP03B	OPERATOR FAILS TO RESTORE SCS AT LO POS03B		
		HR-SG-LPP03B-DE	HRA Dependance for RS & SG at LP POS03B		
66	2.36E-09	%SO	RCS Overdraining due to SCS	0.1	87.8
		BE-RATE-OT	Conversion factor (Outage-yr → Calendar yr, 1/(18month/12month)) for Demand Failure		
		CCMVO-A-351	SC Hx. HE01A INLET MOV 351 FAILS TO OPEN		
		HR-FB-SOP11-01	OPERATOR FAILS TO OPERATE F&B AT SO POS11 01		

Table 19.1-96 (27 of 40)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
67	2.36E-09	%SO	RCS Overdraining due to SCS	0.1	87.9
		BE-RATE-OT	Conversion factor (Outage-yr → Calendar yr, 1/(18month/12month)) for Demand Failure		
		CCMVO-B-352	SC Hx. HE01B INLET MOV 352 FAILS TO OPEN		
		HR-FB-SOP05-01	OPERATOR FAILS TO OPERATE F&B AT SO POS05 01		
68	2.32E-09	%SO	RCS Overdraining due to SCS	0.1	88.0
		BE-RATE-OT	Conversion factor (Outage-yr → Calendar yr, 1/(18month/12month)) for Demand Failure		
		HR-FB-SOP11-01	OPERATOR FAILS TO OPERATE F&B AT SO POS11 01		
		SIMPS1A-SCPP01A	SC PUMP PP01A FAILS TO START		

Table 19.1-96 (28 of 40)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
69	2.32E-09	%SO	RCS Overdraining due to SCS	0.1	88.1
		BE-RATE-OT	Conversion factor (Outage-yr → Calendar yr, 1/(18month/12month)) for Demand Failure		
		HR-FB-SOP05-01	OPERATOR FAILS TO OPERATE F&B AT SO POS05 01		
		SIMPS1B-SCPP01B	SC PUMP 2 PP01B FAILS TO START		
70	2.25E-09	%PL	STUCK OPEN OF POSRV	0.1	88.1
		BE-RATE-OT	Conversion factor (Outage-yr → Calendar yr, 1/(18month/12month)) for Demand Failure		
		VKHVKQ4-HV13A/13B/14A/14B	4/4 CCF OF RUN FOR CCW PUMP ROOM CUBICLE COOLER HV13A, 13B, 14A, 14B		
71	2.02E-09	%JL	Unrecoverable LOCA	0.1	88.2
		BE-RATE-P10	Conversion factor (SD-yr → Calendar yr) for POS10 duration		
		HR-FB-JLP10-02-DE	HRA Dependance for MI & FB at JL POS10		
		HR-MI-JLP10	Operator Fails To Isolate and Makeup Unrecoverable LOCA (JL) PATH at POS10		

Table 19.1-96 (29 of 40)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
72	1.94E-09	%LPWE	Loss of offsite power of Weather-related for LPSD	0.1	88.3
		BE-RATE-P12A	Conversion factor (SD-yr → Calendar yr) for POS12A duration		
		HR-FB-LPP12A-DE	HRA Dependance for RS & FB at LP POS12A		
		HR-RS-LPP12A	OPERATOR FAILS TO RESTORE SCS AT LO POS12A		
73	1.93E-09	%LPSW	Loss of offsite power of Switchyard-centered for LPSD	0.1	88.4
		BE-RATE-P4B	Conversion factor (SD-yr → Calendar yr) for POS4B duration		
		HR-FB-LPP04B-DE	HRA Dependance for RS & FB at LP POS04B		
		HR-RS-LPP04B	OPERATOR FAILS TO RESTORE SCS AT LO POS04B		

Table 19.1-96 (30 of 40)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
74	1.86E-09	%TC	Total Loss of Component Cooling Water	0.1	88.4
		BE-RATE-P10	Conversion factor (SD-yr → Calendar yr) for POS10 duration		
		HR-FB-TCP10	OPERATOR FAILS TO OPERATE F&B AT TC POS10		
75	1.86E-09	%TS	Total Loss of Essential Service Water	0.1	88.5
		BE-RATE-P10	Conversion factor (SD-yr → Calendar yr) for POS10 duration		
		HR-FB-TSP10	OPERATOR FAILS TO OPERATE F&B AT TS POS10		

Table 19.1-96 (31 of 40)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
76	1.85E-09	%KV	Loss of Class 1E 4.16KV	0.1	88.6
		BE-RATE-P12A	Conversion factor (SD-yr → Calendar yr) for POS12A duration		
		HR-FB-KVP12A-DE	HRA Dependance for RS & FB at KV POS12A		
		HR-RS-KVP12A	OPERATOR FAILS TO RESTORE SCS AT KV POS12A		
77	1.75E-09	%LPWE	Loss of offsite power of Weather-related for LPSD	0.1	88.6
		BE-RATE-P06	Conversion factor (SD-yr → Calendar yr) for POS6 duration		
		HR-FB-LPP06-DE	HRA Dependance for RS & FB at LP POS06		
		HR-RS-LPP06	OPERATOR FAILS TO RESTORE SCS AT LO POS06		
78	1.74E-09	%SL	Failure to Maintain Water Level at Reduced Inventory	0.1	88.7
		BE-RATE-P05	Conversion factor (SD-yr → Calendar yr) for POS5 duration		
		HR-FB-SLP05-01	OPERATOR FAILS TO OPERATE F&B AT SL POS05 01		
		VKHVS2B-HV16B	FAILS TO START SC PUMP 02B ROOM CUBICLE COOLER HV16B		

Table 19.1-96 (32 of 40)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
79	1.67E-09	%KV	Loss of Class 1E 4.16KV	0.1	88.8
		BE-RATE-P06	Conversion factor (SD-yr → Calendar yr) for POS6 duration		
		HR-FB-KVP06-DE	HRA Dependance for RS & FB at KV POS06		
		HR-RS-KVP06	OPERATOR FAILS TO RESTORE SCS AT KV POS06		
80	1.65E-09	%PL	STUCK OPEN OF POSRV	0.1	88.8
		BE-RATE-OT	Conversion factor (Outage-yr → Calendar yr, 1/(18month/12month)) for Demand Failure		
		SIMPKQ4-CSP1A/B/SCP1A/B	4/4 CCF OF CSP PP01A, PP01B AND SCP PP01A , PP01B TO RUN		

Table 19.1-96 (33 of 40)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
81	1.63E-09	%S2	Loss of SCS (S2)	0.1	88.9
		BE-RATE-P10	Conversion factor (SD-yr → Calendar yr) for POS10 duration		
		HR-FB-S2P10-DE	HRA Dependance for RS & FB at S2 POS10		
		HR-RS-S2P10	OPERATOR FAILS TO RESTORE SCS AT S2 POS10		
82	1.61E-09	%LPSW	Loss of offsite power of Switchyard-centered for LPSD	0.1	88.9
		BE-RATE-P03A	Conversion factor (SD-yr → Calendar yr) for POS03A duration		
		HR-FB-LPP03A-01-DE	HRA Dependance for SG & FB at LP POS03A		
		HR-RS-LPP03A	OPERATOR FAILS TO RESTORE SCS AT LO POS03A		
		HR-SG-LPP03A-DE	HRA Dependance for RS & SG at LP POS03A		
83	1.59E-09	%LPPL	Loss of offsite power of Plant-centered for LPSD	0.1	89.0
		BE-RATE-P4B	Conversion factor (SD-yr → Calendar yr) for POS4B duration		
		HR-FB-LPP04B-DE	HRA Dependance for RS & FB at LP POS04B		
		HR-RS-LPP04B	OPERATOR FAILS TO RESTORE SCS AT LO POS04B		

Table 19.1-96 (34 of 40)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
84	1.49E-09	%JL	Unrecoverable LOCA	0.1	89.1
		BE-RATE-P03	Conversion factor (SD-yr → Calendar yr) for POS03 duration		
		HR-FB-JLP03B-01-DE	HRA Dependance for SG & FB at JL POS03B		
		HR-IL-JLP03B-02-DE	HRA Dependance for MK & IL at JL POS03B		
		HR-MK-JLP03B	OPERATOR FAILS TO MAKE UP INVENTORY AT JL POS03B		
85	1.43E-09	%CC	Loss of Component Cooling Water	0.1	89.1
		BE-RATE-P05	Conversion factor (SD-yr → Calendar yr) for POS5 duration		
		HR-FB-CCP05-DE	HRA Dependance for RS & FB at CC POS05		
		HR-RS-CCP05	OPERATOR FAILS TO RESTORE SCS AT CC POS05		

Table 19.1-96 (35 of 40)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
86	1.39E-09	%CC	Loss of Component Cooling Water	0.1	89.2
		BE-RATE-P03B	Conversion factor (SD-yr → Calendar yr) for POS03B duration		
		HR-FB-CCP03B-01-DE	HRA Dependance for SG & FB at CC POS03B		
		HR-RS-CCP03B	OPERATOR FAILS TO RESTORE SCS AT CC POS03B		
		HR-SG-CCP03B-DE	HRA Dependance for RS & SG at CC POS03B		
87	1.38E-09	%PL	STUCK OPEN OF POSRV	0.1	89.2
		BE-RATE-OT	Conversion factor (Outage-yr → Calendar yr, 1/(18month/12month)) for Demand Failure		
		SXMPKQ4-PP01A/B/2A/B	4/4 CCF OF ESW PUMPS PP01A/2A, PP01B/2B TO RUN		

Table 19.1-96 (36 of 40)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
88	1.38E-09	%ES	Loss of Essential Service Water	0.1	89.3
		BE-RATE-P10	Conversion factor (SD-yr → Calendar yr) for POS10 duration		
		HR-FB-ESP10-DE	HRA Dependance for RS & FB at ES POS10		
		HR-RS-ESP10	OPERATOR FAILS TO RESTORE SCS AT ES POS10		
89	1.37E-09	%SL	Failure to Maintain Water Level at Reduced Inventory	0.1	89.3
		BE-RATE-P11	Conversion factor (SD-yr → Calendar yr) for POS11 duration		
		HR-FB-SLP11-01	OPERATOR FAILS TO OPERATE F&B AT SL POS11 01		
		VKHVS2A-HV16A	FAILS TO START SC PUMP 02A ROOM CUBICLE COOLER HV16A		
90	1.33E-09	%LPPL	Loss of offsite power of Plant-centered for LPSD	0.0	89.4
		BE-RATE-P03A	Conversion factor (SD-yr → Calendar yr) for POS03A duration		
		HR-FB-LPP03A-01-DE	HRA Dependance for SG & FB at LP POS03A		
		HR-RS-LPP03A	OPERATOR FAILS TO RESTORE SCS AT LO POS03A		
		HR-SG-LPP03A-DE	HRA Dependance for RS & SG at LP POS03A		

Table 19.1-96 (37 of 40)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
91	1.28E-09	%SL2	Small LOCA above Reduced Inventory	0.0	89.4
		BE-RATE-P03A	Conversion factor (SD-yr → Calendar yr) for POS03A duration		
		HR-FB-JLP03A-01-DE	HRA Dependance for SG & FB at JL POS03A		
		HR-IL-JLP03A-02-DE	HRA Dependance for MK & IL at JL POS03A		
		HR-MK-JLP03A	OPERATOR FAILS TO MAKE UP INVENTORY AT JL POS03A		
92	1.26E-09	%PL	STUCK OPEN OF POSRV	0.0	89.5
		BE-RATE-OT	Conversion factor (Outage-yr → Calendar yr, 1/(18month/12month)) for Demand Failure		
		VGFLKD2-FT01A/01B	2/2 CCF OF ESW PUMP ROOM FILTER FT01A, 01B		
93	1.25E-09	%LPSW	Loss of offsite power of Switchyard-centered for LPSD	0.0	89.5
		BE-RATE-P11	Conversion factor (SD-yr → Calendar yr) for POS11 duration		
		HR-FB-LPP11-DE	HRA Dependance for RS & FB at LP POS11		
		HR-RS-LPP11	OPERATOR FAILS TO RESTORE SCS AT LO POS11		

Table 19.1-96 (38 of 40)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
94	1.24E-09	%SL2	Small LOCA above Reduced Inventory	0.0	89.5
		BE-RATE-P4B	Conversion factor (SD-yr → Calendar yr) for POS4B duration		
		HR-FB-JLP04B-01-DE	HRA Dependance for RS & FB at JL POS04B		
		HR-RS-JLP04B	OPERATOR FAILS TO RESTORE SCS AT JL POS04B		
95	1.19E-09	%TS	Total Loss of Essential Service Water	0.0	89.6
		BE-RATE-P06	Conversion factor (SD-yr → Calendar yr) for POS6 duration		
		HR-FB-TSP06	OPERATOR FAILS TO OPERATE F&B AT TS POS06		

Table 19.1-96 (39 of 40)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
96	1.19E-09	%TC	Total Loss of Component Cooling Water	0.0	89.6
		BE-RATE-P06	Conversion factor (SD-yr → Calendar yr) for POS6 duration		
		HR-FB-TCP06	OPERATOR FAILS TO OPERATE F&B AT TC POS06		
97	1.19E-09	%S2	Loss of SCS (S2)	0.0	89.7
		BE-RATE-P12A	Conversion factor (SD-yr → Calendar yr) for POS12A duration		
		HR-FB-S2P12A-DE	HRA Dependance for RS & FB at S2 POS12A		
		HR-RS-S2P12A	OPERATOR FAILS TO RESTORE SCS AT S2 POS12A		

Table 19.1-96 (40 of 40)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
98	1.11E-09	%KV	Loss of Class 1E 4.16KV	0.0	89.7
		BE-RATE-P03A	Conversion factor (SD-yr → Calendar yr) for POS03A duration		
		PELXY-B-LX03B-P	FAILURE OF PRIMARY LOOP CONTROLLERS 745-PE-LX03C		
99	1.11E-09	%KV	Loss of Class 1E 4.16KV	0.0	89.8
		BE-RATE-P03A	Conversion factor (SD-yr → Calendar yr) for POS03A duration		
		PELXY-B-LX02B-P	FAILURE OF PRIMARY LOOP CONTROLLER OF 745-LX02B		
100	1.11E-09	%LPWE	Loss of offsite power of Weather-related for LPSD	0.0	89.8
		BE-RATE-P4B	Conversion factor (SD-yr → Calendar yr) for POS4B duration		
		HR-FB-LPP04B-DE	HRA Dependance for RS & FB at LP POS04B		
		HR-RS-LPP04B	OPERATOR FAILS TO RESTORE SCS AT LO POS04B		

Table 19.1-97 (1 of 41)

LPSD PRA Top 100 CDF Cutsets for the Reduced Inventory Plant Operating States

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
1	7.56E-07	%SO	RCS Overdraining due to SCS	37.7	37.7
		BE-RATE-OT	Conversion factor (Outage-yr → Calendar yr, 1/(18month/12month)) for Demand Failure		
		HR-FB-SOP05-01-DE	HRA Dependance for RS & FB at SO POS05		
		HR-RS-SOP05	OPERATOR FAILS TO RESTORE SCS AT SO POS05		
2	3.40E-07	%SO	RCS Overdraining due to SCS	17.0	54.7
		BE-RATE-OT	Conversion factor (Outage-yr → Calendar yr, 1/(18month/12month)) for Demand Failure		
		HR-FB-SOP11-01-DE	HRA Dependance for RS & FB at SO POS11		
		HR-RS-SOP11	OPERATOR FAILS TO RESTORE SCS AT SO POS11		

Table 19.1-97 (2 of 41)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
3	2.34E-07	%SO	RCS Overdraining due to SCS	11.7	66.4
		BE-RATE-OT	Conversion factor (Outage-yr → Calendar yr, 1/(18month/12month)) for Demand Failure		
		HR-FB-SOP05-02-DE	HRA Dependance for MI & FB at SO POS05		
		HR-MI-SOP05	Operator Fails To Isolate and Makeup Over-Drainage (SO) PATH at POS05		
4	1.40E-07	%SL	Failure to Maintain Water Level at Reduced Inventory	7.0	73.4
		BE-RATE-P05	Conversion factor (SD-yr → Calendar yr) for POS5 duration		
		HR-FB-SLP05-01-DE	HRA Dependance for RS & FB at SL POS05		
		HR-RS-SLP05	OPERATOR FAILS TO RESTORE SCS AT SL POS05		
5	1.24E-07	%SO	RCS Overdraining due to SCS	6.1	79.5
		BE-RATE-OT	Conversion factor (Outage-yr → Calendar yr, 1/(18month/12month)) for Demand Failure		
		HR-FB-SOP11-02-DE	HRA Dependance for MI & FB at SO POS11		
		HR-MI-SOP11	Operator Fails To Isolate and Makeup Over-Drainage (SO) PATH at POS11		

Table 19.1-97 (3 of 41)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
6	7.70E-08	%SL1	OPERATOR FAILS TO RESTORE SCS AT LO POS04B	3.9	83.4
		BE-RATE-P05	Small LOCA at Reduced Inventory		
		HR-FB-JLP05-01-DE	Conversion factor (SD-yr → Calendar yr) for POS5 duration		
		HR-RS-JLP05	HRA Dependance for RS & FB at JL POS05		
7	4.93E-08	%SL	OPERATOR FAILS TO RESTORE SCS AT JL POS05	2.4	85.8
		BE-RATE-P11	Failure to Maintain Water Level at Reduced Inventory		
		HR-FB-SLP11-01-DE	Conversion factor (SD-yr → Calendar yr) for POS11 duration		
		HR-RS-SLP11	HRA Dependance for RS & FB at SL POS11		
8	4.31E-08	%SL	OPERATOR FAILS TO RESTORE SCS AT SL POS11	2.2	88.0
		BE-RATE-P05	Failure to Maintain Water Level at Reduced Inventory		
		HR-FB-SLP05-02-DE	Conversion factor (SD-yr → Calendar yr) for POS5 duration		
		HR-MI-SLP05	HRA Dependance for MI & FB at SL POS05		

Table 19.1-97 (4 of 41)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
9	2.97E-08	%S1	OPERATOR FAILS TO RESTORE SCS AT LO POS04B	1.5	89.5
		BE-RATE-P05	Small LOCA at Reduced Inventory		
		HR-FB-S1P05-DE	Conversion factor (SD-yr → Calendar yr) for POS5 duration		
		HR-RS-S1P05	HRA Dependance for RS & FB at JL POS05		
10	2.72E-08	%SL1	OPERATOR FAILS TO RESTORE SCS AT JL POS05	1.3	90.8
		BE-RATE-P11	Failure to Maintain Water Level at Reduced Inventory		
		HR-FB-JLP11-01-DE	Conversion factor (SD-yr → Calendar yr) for POS11 duration		
		HR-RS-JLP11	HRA Dependance for RS & FB at SL POS11		
11	2.38E-08	%S1	OPERATOR FAILS TO RESTORE SCS AT SL POS11	1.2	92.0
		BE-RATE-P05	Failure to Maintain Water Level at Reduced Inventory		
		HR-FB-JLP05-02-DE	Conversion factor (SD-yr → Calendar yr) for POS5 duration		
		HR-MI-JLP05	HRA Dependance for MI & FB at SL POS05		

Table 19.1-97 (5 of 41)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
12	1.79E-08	%SL	Failure to Maintain Water Level at Reduced Inventory	0.9	92.9
		BE-RATE-P11	Conversion factor (SD-yr → Calendar yr) for POS11 duration		
		HR-FB-SLP11-02-DE	HRA Dependance for MI & FB at SL POS11		
		HR-MI-SLP11	Operator Fails To Isolate and Makeup Failing to maintain water level (SL) PATH at POS11		
13	1.36E-08	%LPSW	Loss of offsite power of Switchyard-centered for LPSD	0.7	93.6
		BE-RATE-P05	Conversion factor (SD-yr → Calendar yr) for POS5 duration		
		HR-FB-LPP05-DE	HRA Dependance for RS & FB at LP POS05		
		HR-RS-LPP05	OPERATOR FAILS TO RESTORE SCS AT LO POS05		

Table 19.1-97 (6 of 41)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
14	1.12E-08	%LPPL	Loss of offsite power of Plant-centered for LPSD	0.6	94.2
		BE-RATE-P05	Conversion factor (SD-yr → Calendar yr) for POS5 duration		
		HR-FB-LPP05-DE	HRA Dependance for RS & FB at LP POS05		
		HR-RS-LPP05	OPERATOR FAILS TO RESTORE SCS AT LO POS05		
15	9.89E-09	%SL1	Small LOCA at Reduced Inventory	0.5	94.7
		BE-RATE-P11	Conversion factor (SD-yr → Calendar yr) for POS11 duration		
		HR-FB-JLP11-02-DE	HRA Dependance for MI & FB at JL POS11		
		HR-MI-JLP11	Operator Fails To Isolate and Makeup Unrecoverable LOCA (JL) PATH at POS11		
16	9.44E-09	%SO	RCS Overdraining due to SCS	0.5	95.1
		BE-RATE-OT	Conversion factor (Outage-yr → Calendar yr, 1/(18month/12month)) for Demand Failure		
		HR-FB-SOP05-01	OPERATOR FAILS TO OPERATE F&B AT SO POS05 01		
		VKHVS2B-HV16B	FAILS TO START SC PUMP 02B ROOM CUBICLE COOLER HV16B		

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
17	9.44E-09	%SO	RCS Overdraining due to SCS	0.5	95.6
		BE-RATE-OT	Conversion factor (Outage-yr → Calendar yr, 1/(18month/12month)) for Demand Failure		
		HR-FB-SOP11-01	OPERATOR FAILS TO OPERATE F&B AT SO POS11 01		
		VKHVS2A-HV16A	FAILS TO START SC PUMP 02A ROOM CUBICLE COOLER HV16A		
18	7.79E-09	%LPWE	Loss of offsite power of Weather-related for LPSD	0.4	96.0
		BE-RATE-P05	Conversion factor (SD-yr → Calendar yr) for POS5 duration		
		HR-FB-LPP05-DE	HRA Dependance for RS & FB at LP POS05		
		HR-RS-LPP05	OPERATOR FAILS TO RESTORE SCS AT LO POS05		
19	7.42E-09	%KV	Loss of Class 1E 4.16KV	0.4	96.4
		BE-RATE-P05	Conversion factor (SD-yr → Calendar yr) for POS5 duration		
		HR-FB-KVP05-DE	HRA Dependance for RS & FB at KV POS05		
		HR-RS-KVP05	OPERATOR FAILS TO RESTORE SCS AT KV POS05		

Table 19.1-97 (8 of 41)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
20	4.67E-09	%S2	Loss of SCS (S2)	0.2	96.6
		BE-RATE-P05	Conversion factor (SD-yr → Calendar yr) for POS5 duration		
		HR-FB-S2P05-DE	HRA Dependance for RS & FB at S2 POS05		
		HR-RS-S2P05	OPERATOR FAILS TO RESTORE SCS AT S2 POS05		
21	3.95E-09	%ES	Loss of Essential Service Water	0.2	96.8
		BE-RATE-P05	Conversion factor (SD-yr → Calendar yr) for POS5 duration		
		HR-FB-ESP05-DE	HRA Dependance for RS & FB at ES POS05		
22	2.75E-09	%S1	Loss of SCS (S1)	0.1	96.9
		BE-RATE-P11	Conversion factor (SD-yr → Calendar yr) for POS11 duration		
		HR-FB-S1P11-DE	HRA Dependance for RS & FB at S1 POS11		
		HR-RS-S1P11	OPERATOR FAILS TO RESTORE SCS AT S1 POS11		

Table 19.1-97 (9 of 41)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
23	2.44E-09	%LPGR	Loss of offsite power of Grid-related for LPSD	0.1	97.0
		BE-RATE-P05	Conversion factor (SD-yr → Calendar yr) for POS5 duration		
		HR-FB-LPP05-DE	HRA Dependance for RS & FB at LP POS05		
		HR-RS-LPP05	OPERATOR FAILS TO RESTORE SCS AT LO POS05		
24	2.41E-09	%JL	Unrecoverable LOCA	0.1	97.2
		BE-RATE-P05	Conversion factor (SD-yr → Calendar yr) for POS5 duration		
		HR-FB-JLP05-01-DE	HRA Dependance for RS & FB at JL POS05		
		HR-RS-JLP05	OPERATOR FAILS TO RESTORE SCS AT JL POS05		
25	2.36E-09	%SO	RCS Overdraining due to SCS	0.1	97.3
		BE-RATE-OT	Conversion factor (Outage-yr → Calendar yr, 1/(18month/12month)) for Demand Failure		
		CCMVO-B-352	SC Hx. HE01B INLET MOV 352 FAILS TO OPEN		
		HR-FB-SOP05-01	OPERATOR FAILS TO OPERATE F&B AT SO POS05 01		

Table 19.1-97 (10 of 41)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
26	2.36E-09	%SO	RCS Overdraining due to SCS	0.1	97.4
		BE-RATE-OT	Conversion factor (Outage-yr → Calendar yr, 1/(18month/12month)) for Demand Failure		
		CCMVO-A-351	SC Hx. HE01A INLET MOV 351 FAILS TO OPEN		
		HR-FB-SOP11-01	OPERATOR FAILS TO OPERATE F&B AT SO POS11 01		
27	2.32E-09	%SO	RCS Overdraining due to SCS	0.1	97.5
		BE-RATE-OT	Conversion factor (Outage-yr → Calendar yr, 1/(18month/12month)) for Demand Failure		
		HR-FB-SOP05-01	OPERATOR FAILS TO OPERATE F&B AT SO POS05 01		
		SIMPS1B-SCPP01B	SC PUMP 2 PP01B FAILS TO START		

Table 19.1-97 (11 of 41)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
28	2.32E-09	%SO	RCS Overdraining due to SCS	0.1	97.6
		BE-RATE-OT	Conversion factor (Outage-yr → Calendar yr, 1/(18month/12month)) for Demand Failure		
		HR-FB-SOP11-01	OPERATOR FAILS TO OPERATE F&B AT SO POS11 01		
		SIMPS1A-SCPP01A	SC PUMP PP01A FAILS TO START		
29	1.74E-09	%SL	Failure to Maintain Water Level at Reduced Inventory	0.1	97.7
		BE-RATE-P05	Conversion factor (SD-yr → Calendar yr) for POS5 duration		
		HR-FB-SLP05-01	OPERATOR FAILS TO OPERATE F&B AT SL POS05 01		
		VKHVS2B-HV16B	FAILS TO START SC PUMP 02B ROOM CUBICLE COOLER HV16B		
30	1.43E-09	%CC	Loss of Component Cooling Water	0.1	97.8
		BE-RATE-P05	Conversion factor (SD-yr → Calendar yr) for POS5 duration		
		HR-FB-CCP05-DE	HRA Dependance for RS & FB at CC POS05		
		HR-RS-CCP05	OPERATOR FAILS TO RESTORE SCS AT CC POS05		

Table 19.1-97 (12 of 41)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
31	1.37E-09	%SL	Failure to Maintain Water Level at Reduced Inventory	0.1	97.9
		BE-RATE-P11	Conversion factor (SD-yr → Calendar yr) for POS11 duration		
		HR-FB-SLP11-01	OPERATOR FAILS TO OPERATE F&B AT SL POS11 01		
		VKHVS2A-HV16A	FAILS TO START SC PUMP 02A ROOM CUBICLE COOLER HV16A		
32	1.25E-09	%LPSW	Loss of offsite power of Switchyard-centered for LPSD	0.1	97.9
		BE-RATE-P11	Conversion factor (SD-yr → Calendar yr) for POS11 duration		
		HR-FB-LPP11-DE	HRA Dependance for RS & FB at LP POS11		
		HR-RS-LPP11	OPERATOR FAILS TO RESTORE SCS AT LO POS11		

Table 19.1-97 (13 of 41)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
33	1.04E-09	%LPPL	Loss of offsite power of Plant-centered for LPSD	0.1	98.0
		BE-RATE-P11	Conversion factor (SD-yr → Calendar yr) for POS11 duration		
		HR-FB-LPP11-DE	HRA Dependance for RS & FB at LP POS11		
		HR-RS-LPP11	OPERATOR FAILS TO RESTORE SCS AT LO POS11		
34	9.61E-10	%SL1	Small LOCA at Reduced Inventory	0.0	98.0
		BE-RATE-P05	Conversion factor (SD-yr → Calendar yr) for POS5 duration		
		HR-FB-JLP05-01	OPERATOR FAILS TO OPERATE F&B AT JL POS05 01		
		VKHVS2B-HV16B	FAILS TO START SC PUMP 02B ROOM CUBICLE COOLER HV16B		
35	8.50E-10	%JL	Unrecoverable LOCA	0.0	98.1
		BE-RATE-P11	Conversion factor (SD-yr → Calendar yr) for POS11 duration		
		HR-FB-JLP11-01-DE	HRA Dependance for RS & FB at JL POS11		
		HR-RS-JLP11	OPERATOR FAILS TO RESTORE SCS AT JL POS11		

Table 19.1-97 (14 of 41)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
36	7.55E-10	%SL1	Small LOCA at Reduced Inventory	0.0	98.1
		BE-RATE-P11	Conversion factor (SD-yr → Calendar yr) for POS11 duration		
		HR-FB-JLP11-01	OPERATOR FAILS TO OPERATE F&B AT JL POS11 01		
		VKHVS2A-HV16A	FAILS TO START SC PUMP 02A ROOM CUBICLE COOLER HV16A		
37	7.44E-10	%JL	Unrecoverable LOCA	0.0	98.1
		BE-RATE-P05	Conversion factor (SD-yr → Calendar yr) for POS5 duration		
		HR-FB-JLP05-02-DE	HRA Dependance for MI & FB at JL POS05		
		HR-MI-JLP05	Operator Fails To Isolate and Makeup Unrecoverable LOCA (JL) PATH at POS05		
38	7.20E-10	%LPSW	Loss of offsite power of Switchyard-centered for LPSD	0.0	98.2
		BE-RATE-P11	Conversion factor (SD-yr → Calendar yr) for POS11 duration		
		HR-FB-LPP11-DE	HRA Dependance for RS & FB at LP POS11		
		HR-RS-LPP11	OPERATOR FAILS TO RESTORE SCS AT LO POS11		

Table 19.1-97 (15 of 41)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
39	6.87E-10	%KV	Loss of Class 1E 4.16KV	0.0	98.2
		BE-RATE-P11	Conversion factor (SD-yr → Calendar yr) for POS11 duration		
		HR-FB-KVP11-DE	HRA Dependance for RS & FB at KV POS11		
		HR-RS-KVP11	OPERATOR FAILS TO RESTORE SCS AT KV POS11		
40	6.87E-10	%SO	RCS Overdraining due to SCS	0.0	98.2
		BE-RATE-OT	Conversion factor (Outage-yr → Calendar yr, 1/(18month/12month)) for Demand Failure		
		HR-FB-SOP05-01	OPERATOR FAILS TO OPERATE F&B AT SO POS05 01		
		SIMPR1B-SCPP01B	SC PUMP 2 PP01B FAILS TO RUN		

Table 19.1-97 (16 of 41)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
41	6.10E-10	%SO	RCS Overdraining due to SCS	0.0	98.3
		BE-RATE-OT	Conversion factor (Outage-yr → Calendar yr, 1/(18month/12month)) for Demand Failure		
		HR-FB-SOP11-01	OPERATOR FAILS TO OPERATE F&B AT SO POS11 01		
		SIMPR1A-SCPP01A	SC PUMP PP01A FAILS TO RUN		
42	4.35E-10	%SL	Failure to Maintain Water Level at Reduced Inventory	0.0	98.3
		BE-RATE-P05	Conversion factor (SD-yr → Calendar yr) for POS5 duration		
		CCMVO-B-352	SC Hx. HE01B INLET MOV 352 FAILS TO OPEN		
		HR-FB-SLP05-01	OPERATOR FAILS TO OPERATE F&B AT SL POS05 01		

Table 19.1-97 (17 of 41)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
43	4.32E-10	%S2	Loss of SCS (S2)	0.0	98.3
		BE-RATE-P11	Conversion factor (SD-yr → Calendar yr) for POS11 duration		
		HR-FB-S2P11-DE	HRA Dependance for RS & FB at S2 POS11		
		HR-RS-S2P11	OPERATOR FAILS TO RESTORE SCS AT S2 POS11		
44	4.27E-10	%SL	Failure to Maintain Water Level at Reduced Inventory	0.0	98.3
		BE-RATE-P05	Conversion factor (SD-yr → Calendar yr) for POS5 duration		
		HR-FB-SLP05-01	OPERATOR FAILS TO OPERATE F&B AT SL POS05 01		
		SIMPS1B-SCPP01B	SC PUMP 2 PP01B FAILS TO START		

Table 19.1-97 (18 of 41)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
45	3.66E-10	%TS	Total Loss of Essential Service Water	0.0	98.3
		BE-RATE-P05	Conversion factor (SD-yr → Calendar yr) for POS5 duration		
		HR-FB-TSP05	OPERATOR FAILS TO OPERATE F&B AT TS POS05		
46	3.66E-10	%TC	Total Loss of Component Cooling Water	0.0	98.4
		BE-RATE-P05	Conversion factor (SD-yr → Calendar yr) for POS5 duration		
		HR-FB-TCP05	OPERATOR FAILS TO OPERATE F&B AT TC POS05		

Table 19.1-97 (19 of 41)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
47	3.65E-10	%ES	Loss of Essential Service Water	0.0	98.4
		BE-RATE-P11	Conversion factor (SD-yr → Calendar yr) for POS11 duration		
		HR-FB-ESP11-DE	HRA Dependance for RS & FB at ES POS11		
		HR-RS-ESP11	OPERATOR FAILS TO RESTORE SCS AT ES POS11		
48	3.64E-10	%SO	RCS Overdraining due to SCS	0.0	98.4
		BE-RATE-OT	Conversion factor (Outage-yr → Calendar yr, 1/(18month/12month)) for Demand Failure		
		SICVWQ4-V540/41/42/43	SI LINE C/V 543,541,542,540 CCF TO OPEN		
49	3.64E-10	%SO	RCS Overdraining due to SCS	0.0	98.4
		BE-RATE-OT	Conversion factor (Outage-yr → Calendar yr, 1/(18month/12month)) for Demand Failure		
		SICVWQ4-V217/27/37/47	SI LINE C/V 247,227,237,217 CCF TO OPEN		

Table 19.1-97 (20 of 41)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
50	3.64E-10	%SO BE-RATE-OT SICVWQ4-V113/23/33/43	RCS Overdraining due to SCS Conversion factor (Outage-yr → Calendar yr, 1/(18month/12month)) for Demand Failure SI LINE C/V 113,123,133,143 CCF TO OPEN	0.0	98.4
51	3.64E-10	%SO BE-RATE-OT SICVWQ4-V217/27/37/47	RCS Overdraining due to SCS Conversion factor (Outage-yr → Calendar yr, 1/(18month/12month)) for Demand Failure SI LINE C/V 247,227,237,217 CCF TO OPEN	0.0	98.5
52	3.64E-10	%SO BE-RATE-OT SICVWQ4-V540/41/42/43	RCS Overdraining due to SCS Conversion factor (Outage-yr → Calendar yr, 1/(18month/12month)) for Demand Failure SI LINE C/V 543,541,542,540 CCF TO OPEN	0.0	98.5

Table 19.1-97 (21 of 41)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
53	3.64E-10	%SO	RCS Overdraining due to SCS	0.0	98.5
		BE-RATE-OT	Conversion factor (Outage-yr → Calendar yr, 1/(18month/12month)) for Demand Failure		
		HR-FB-TCP03B-01	OPERATOR FAILS TO OPERATE F&B AT TC POS03B 01		
54	3.41E-10	%SL	Failure to Maintain Water Level at Reduced Inventory	0.0	98.5
		BE-RATE-P11	Conversion factor (SD-yr → Calendar yr) for POS11 duration		
		CCMVO-A-351	SC Hx. HE01A INLET MOV 351 FAILS TO OPEN		
		HR-FB-SLP11-01	OPERATOR FAILS TO OPERATE F&B AT SL POS11 01		

Table 19.1-97 (22 of 41)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
55	3.36E-10	%SL	Failure to Maintain Water Level at Reduced Inventory	0.0	98.5
		BE-RATE-P11	Conversion factor (SD-yr → Calendar yr) for POS11 duration		
		HR-FB-SLP11-01	OPERATOR FAILS TO OPERATE F&B AT SL POS11 01		
		SIMPS1A-SCPP01A	SC PUMP PP01A FAILS TO START		
56	3.29E-10	%SO	RCS Overdraining due to SCS	0.0	98.5
		BE-RATE-OT	Conversion factor (Outage-yr → Calendar yr, 1/(18month/12month)) for Demand Failure		
		HR-FB-SOP11-01	OPERATOR FAILS TO OPERATE F&B AT SO POS11 01		
		VKHVR2A-HV16A	FAILS TO RUN SC PUMP 02A ROOM CUBICLE COOLER HV16A		

Table 19.1-97 (23 of 41)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
57	3.29E-10	%SO	RCS Overdraining due to SCS	0.0	98.6
		BE-RATE-OT	Conversion factor (Outage-yr → Calendar yr, 1/(18month/12month)) for Demand Failure		
		HR-FB-SOP05-01	OPERATOR FAILS TO OPERATE F&B AT SO POS05 01		
		VKHVR2B-HV16B	FAILS TO RUN SC PUMP 02B ROOM CUBICLE COOLER HV16B		
58	3.09E-10	%JL	Unrecoverable LOCA	0.0	98.6
		BE-RATE-P11	Conversion factor (SD-yr → Calendar yr) for POS11 duration		
		HR-FB-JLP11-02-DE	HRA Dependance for MI & FB at JL POS11		
		HR-MI-JLP11	Operator Fails To Isolate and Makeup Unrecoverable LOCA (JL) PATH at POS11		

Table 19.1-97 (24 of 41)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
59	2.87E-10	%TS	Total Loss of Essential Service Water	0.0	98.6
		BE-RATE-P11	Conversion factor (SD-yr → Calendar yr) for POS11 duration		
		HR-FB-TSP11	OPERATOR FAILS TO OPERATE F&B AT TS POS11		
60	2.87E-10	%TC	Total Loss of Component Cooling Water	0.0	98.6
		BE-RATE-P11	Conversion factor (SD-yr → Calendar yr) for POS11 duration		
		HR-FB-TCP11	OPERATOR FAILS TO OPERATE F&B AT TC POS11		
61	2.40E-10	%SL1	Small LOCA at Reduced Inventory	0.0	98.6
		BE-RATE-P05	Conversion factor (SD-yr → Calendar yr) for POS5 duration		
		CCMVO-B-352	SC Hx. HE01B INLET MOV 352 FAILS TO OPEN		
		HR-FB-JLP05-01	OPERATOR FAILS TO OPERATE F&B AT JL POS05 01		

Table 19.1-97 (25 of 41)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
62	2.36E-10	%SL1	Small LOCA at Reduced Inventory	0.0	98.6
		BE-RATE-P05	Conversion factor (SD-yr → Calendar yr) for POS5 duration		
		HR-FB-JLP05-01	OPERATOR FAILS TO OPERATE F&B AT JL POS05 01		
		SIMPS1B-SCPP01B	SC PUMP 2 PP01B FAILS TO START		
63	2.32E-10	%SO	RCS Overdraining due to SCS	0.0	98.6
		BE-RATE-OT	Conversion factor (Outage-yr → Calendar yr, 1/(18month/12month)) for Demand Failure		
		HR-FB-SOP05-01	OPERATOR FAILS TO OPERATE F&B AT SO POS05 01		
		PELXY-B-LX02B-P	FAILURE OF PRIMARY LOOP CONTROLLER OF 745-LX02B		

Table 19.1-97 (26 of 41)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
64	2.32E-10	%SO	RCS Overdraining due to SCS	0.0	98.7
		BE-RATE-OT	Conversion factor (Outage-yr → Calendar yr, 1/(18month/12month)) for Demand Failure		
		HR-FB-SOP11-01	OPERATOR FAILS TO OPERATE F&B AT SO POS11 01		
		PELXY-A-LX01A-P	FAILURE OF PRIMARY LOOP CONTROLLER OF 745-PE-LX01A		
65	2.32E-10	%SO	RCS Overdraining due to SCS	0.0	98.7
		BE-RATE-OT	Conversion factor (Outage-yr → Calendar yr, 1/(18month/12month)) for Demand Failure		
		HR-FB-SOP11-01	OPERATOR FAILS TO OPERATE F&B AT SO POS11 01		
		PELXY-A-LX02A-P	PRIMARY LOOP CONTROLLER LX02A FAILS TO RUN		
66	2.32E-10	%SO	RCS Overdraining due to SCS	0.0	98.7
		BE-RATE-OT	Conversion factor (Outage-yr → Calendar yr, 1/(18month/12month)) for Demand Failure		
		HR-FB-SOP11-01	OPERATOR FAILS TO OPERATE F&B AT SO POS11 01		
		PELXY-A-LX04A-P	FAILURE OF PRIMARY LOOP CONTROLLER OF 745-PE-LX04A		

Table 19.1-97 (27 of 41)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
67	2.32E-10	%SO	RCS Overdraining due to SCS	0.0	98.7
		BE-RATE-OT	Conversion factor (Outage-yr → Calendar yr, 1/(18month/12month)) for Demand Failure		
		HR-FB-SOP05-01	OPERATOR FAILS TO OPERATE F&B AT SO POS05 01		
		PELXY-B-LX04B-P	FAILURE OF PRIMARY LOOP CONTROLLER OF 745-LX04B		
68	2.32E-10	%SO	RCS Overdraining due to SCS	0.0	98.7
		BE-RATE-OT	Conversion factor (Outage-yr → Calendar yr, 1/(18month/12month)) for Demand Failure		
		HR-FB-SOP05-01	OPERATOR FAILS TO OPERATE F&B AT SO POS05 01		
		PELXY-B-LX01B-P	FAILURE OF PRIMARY LOOP CONTROLLER OF 745-PE-LX01B		

Table 19.1-97 (28 of 41)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
69	2.32E-10	%SO	RCS Overdraining due to SCS	0.0	98.7
		BE-RATE-OT	Conversion factor (Outage-yr → Calendar yr, 1/(18month/12month)) for Demand Failure		
		HR-FB-SOP05-01	OPERATOR FAILS TO OPERATE F&B AT SO POS05 01		
		PELXY-B-LX03B-P	FAILURE OF PRIMARY LOOP CONTROLLERS 745-PE-LX03C		
70	2.26E-10	%LPGR	Loss of offsite power of Grid-related for LPSD	0.0	98.7
		BE-RATE-P11	Conversion factor (SD-yr → Calendar yr) for POS11 duration		
		HR-FB-LPP11-DE	HRA Dependance for RS & FB at LP POS11		
		HR-RS-LPP11	OPERATOR FAILS TO RESTORE SCS AT LO POS11		
71	2.26E-109	%SO	RCS Overdraining due to SCS	0.0	98.7
		BE-RATE-OT	Conversion factor (Outage-yr → Calendar yr, 1/(18month/12month)) for Demand Failure		
		HR-FB-SOP05-01	OPERATOR FAILS TO OPERATE F&B AT SO POS05 01		
		SIVVT2B-V107	SCS PUMP 2 SUCTION MANUAL VALVE V107 TRANSFER CLOSED		

Table 19.1-97 (29 of 41)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
72	2.25E-10	%SO	RCS Overdraining due to SCS	0.0	98.7
		BE-RATE-OT	Conversion factor (Outage-yr → Calendar yr, 1/(18month/12month)) for Demand Failure		
		CCVVT-B-V1512	SC Hx. HE01B OUTLET MANUAL VALVE V1512 TRANSFER CLOSED		
		HR-FB-SOP05-01	OPERATOR FAILS TO OPERATE F&B AT SO POS05 01		
73	2.25E-10	%SO	RCS Overdraining due to SCS	0.0	98.8
		BE-RATE-OT	Conversion factor (Outage-yr → Calendar yr, 1/(18month/12month)) for Demand Failure		
		HR-FB-SOP05-01	OPERATOR FAILS TO OPERATE F&B AT SO POS05 01		
		SIVVT2B-V579	VV V579 IN SC PUMP 2 DISCH. PATH FAILS TO REMAIN OPEN		
74	2.25E-10	%SO	RCS Overdraining due to SCS	0.0	98.8
		BE-RATE-OT	Conversion factor (Outage-yr → Calendar yr, 1/(18month/12month)) for Demand Failure		
		CCVVT-A-V1511	SC Hx. HE01A OUTLET MANUAL VALVE V1511 TRANSFER CLOSED		
		HR-FB-SOP11-01	OPERATOR FAILS TO OPERATE F&B AT SO POS11 01		

Table 19.1-97 (30 of 41)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
75	2.25E-10	%SO	RCS Overdraining due to SCS	0.0	98.8
		BE-RATE-OT	Conversion factor (Outage-yr → Calendar yr, 1/(18month/12month)) for Demand Failure		
		HR-FB-SOP11-01	OPERATOR FAILS TO OPERATE F&B AT SO POS11 01		
		SIVVT1A-V578	VV V578 IN SC PUMP1(PP02A) DISCH. PATH FAILS TO REMAIN OPEN		
76	2.25E-10	%SO	RCS Overdraining due to SCS	0.0	98.8
		BE-RATE-OT	Conversion factor (Outage-yr → Calendar yr, 1/(18month/12month)) for Demand Failure		
		HR-FB-SOP11-01	OPERATOR FAILS TO OPERATE F&B AT SO POS11 01		
		SIVVT1A-V106	VV V106 IN SC PUMP1(PP02A) SUC. LINE FAILS TO REMAIN OPEN		

Table 19.1-97 (31 of 41)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
77	2.10E-10	%KV	Loss of Class 1E 4.16KV	0.0	98.8
		BE-RATE-P05	Conversion factor (SD-yr → Calendar yr) for POS5 duration		
		HR-FB-KVP05	OPERATOR FAILS TO OPERATE F&B AT KV POS05		
		VKHVS2B-HV16B	FAILS TO START SC PUMP 02B ROOM CUBICLE COOLER HV16B		
78	2.06E-10	%LPSW	Loss of offsite power of Switchyard-centered for LPSD	0.0	98.8
		BE-RATE-P05	Conversion factor (SD-yr → Calendar yr) for POS5 duration		
		DGDGR-A-DGA	FAILS TO RUN OF EMERGENCY DIESEL GENERATOR DG01A		
		DGDGR-B-DGB	FAILS TO RUN OF EMERGENCY DIESEL GENERATOR DG01B		
		VKHVS2A-HV11A	FAILS TO START SI PUMP ROOM CUBICLE COOLER HV11A		

Table 19.1-97 (32 of 41)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
79	1.88E-10	%SL1	Small LOCA at Reduced Inventory	0.0	98.8
		BE-RATE-P11	Conversion factor (SD-yr → Calendar yr) for POS11 duration		
		CCMVO-A-351	SC Hx. HE01A INLET MOV 351 FAILS TO OPEN		
		HR-FB-JLP11-01	OPERATOR FAILS TO OPERATE F&B AT JL POS11 01		
80	1.85E-10	%SL1	Small LOCA at Reduced Inventory	0.0	98.8
		BE-RATE-P11	Conversion factor (SD-yr → Calendar yr) for POS11 duration		
		HR-FB-JLP11-01	OPERATOR FAILS TO OPERATE F&B AT JL POS11 01		
		SIMPS1A-SCPP01A	SC PUMP PP01A FAILS TO START		

Table 19.1-97 (33 of 41)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
81	1.70E-10	%LPPL	Loss of offsite power of Plant-centered for LPSD	0.0	98.8
		BE-RATE-P05	Conversion factor (SD-yr → Calendar yr) for POS5 duration		
		DGDGR-A-DGA	FAILS TO RUN OF EMERGENCY DIESEL GENERATOR DG01A		
		DGDGR-B-DGB	FAILS TO RUN OF EMERGENCY DIESEL GENERATOR DG01B		
		VKHVS2A-HV11A	FAILS TO START SI PUMP ROOM CUBICLE COOLER HV11A		
82	1.65E-10	%KV	Loss of Class 1E 4.16KV	0.0	98.8
		BE-RATE-P11	Conversion factor (SD-yr → Calendar yr) for POS11 duration		
		HR-FB-KVP11	OPERATOR FAILS TO OPERATE F&B AT KV POS11		
		VKHVS2A-HV16A	FAILS TO START SC PUMP 02A ROOM CUBICLE COOLER HV16A		

Table 19.1-97 (34 of 41)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
83	1.56E-10	%SO BE-RATE-OT HR-FB-SOP05-01 PEDOY-B-LX01B02	RCS Overdraining due to SCS Conversion factor (Outage-yr → Calendar yr, 1/(18month/12month)) for Demand Failure OPERATOR FAILS TO OPERATE F&B AT SO POS05 01 FAILURE OF DIGITAL OUTPUT MODULE LX01B BRANCH 02	0.0	98.9
84	1.56E-10	%SO BE-RATE-OT HR-FB-SOP05-01 PEDOY-B-LX04B03	RCS Overdraining due to SCS Conversion factor (Outage-yr → Calendar yr, 1/(18month/12month)) for Demand Failure OPERATOR FAILS TO OPERATE F&B AT SO POS05 01 FAILURE OF DIGITAL OUTPUT MODULE LX04B BRANCH 03	0.0	98.9
85	1.56E-10	%SO BE-RATE-OT HR-FB-SOP05-01 PEDOY-B-LX02B03	RCS Overdraining due to SCS Conversion factor (Outage-yr → Calendar yr, 1/(18month/12month)) for Demand Failure OPERATOR FAILS TO OPERATE F&B AT SO POS05 01 FAILURE OF DIGITAL OUTPUT MODULE LX02B BRANCH 03	0.0	98.9

Table 19.1-97 (35 of 41)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
86	1.56E-10	%SO	RCS Overdraining due to SCS	0.0	98.9
		BE-RATE-OT	Conversion factor (Outage-yr → Calendar yr, 1/(18month/12month)) for Demand Failure		
		HR-FB-SOP11-01	OPERATOR FAILS TO OPERATE F&B AT SO POS11 01		
		PEDOY-A-LX02A02	FAILURE OF DIGITAL OUTPUT MODULE LX02A BRANCH 02		
87	1.56E-10	%SO	RCS Overdraining due to SCS	0.0	98.9
		BE-RATE-OT	Conversion factor (Outage-yr → Calendar yr, 1/(18month/12month)) for Demand Failure		
		HR-FB-SOP11-01	OPERATOR FAILS TO OPERATE F&B AT SO POS11 01		
		PEDOY-A-LX04A02	FAILURE OF DIGITAL OUTPUT MODULE LX04A BRANCH 02		

Table 19.1-97 (36 of 41)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
88	1.56E-10	%SO	RCS Overdraining due to SCS	0.0	98.9
		BE-RATE-OT	Conversion factor (Outage-yr → Calendar yr, 1/(18month/12month)) for Demand Failure		
		HR-FB-SOP11-01	OPERATOR FAILS TO OPERATE F&B AT SO POS11 01		
		PEDOY-A-LX01A02	FAILURE OF DIGITAL OUTPUT MODULE LX01A BRANCH 02		
89	1.32E-10	%CC	Loss of Component Cooling Water	0.0	98.9
		BE-RATE-P11	Conversion factor (SD-yr → Calendar yr) for POS11 duration		
		HR-FB-CCP11-DE	HRA Dependance for RS & FB at CC POS11		
		HR-RS-CCP11	OPERATOR FAILS TO RESTORE SCS AT CC POS11		
90	1.32E-10	%S2	Loss of SCS (S2)	0.0	98.9
		BE-RATE-P05	Conversion factor (SD-yr → Calendar yr) for POS5 duration		
		HR-FB-S2P05	OPERATOR FAILS TO OPERATE F&B AT S2 POS05		
		VKHVS2B-HV16B	FAILS TO START SC PUMP 02B ROOM CUBICLE COOLER HV16B		

Table 19.1-97 (37 of 41)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
91	1.18E-10	%LPWE	Loss of offsite power of Weather-related for LPSD	0.0	98.9
		BE-RATE-P05	Conversion factor (SD-yr → Calendar yr) for POS5 duration		
		DGDGR-A-DGA	FAILS TO RUN OF EMERGENCY DIESEL GENERATOR DG01A		
		DGDGR-B-DGB	FAILS TO RUN OF EMERGENCY DIESEL GENERATOR DG01B		
		VKHVS2A-HV11A	FAILS TO START SI PUMP ROOM CUBICLE COOLER HV11A		
92	1.13E-10	%SL	Failure to Maintain Water Level at Reduced Inventory	0.0	98.9
		BE-RATE-P05	Conversion factor (SD-yr → Calendar yr) for POS5 duration		
		HR-FB-SLP05-01	OPERATOR FAILS TO OPERATE F&B AT SL POS05 01		
		SIMPR1B-SCPP01B	SC PUMP 2 PP01B FAILS TO RUN		

Table 19.1-97 (38 of 41)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
93	1.12E-10	%ES	Loss of Essential Service Water	0.0	98.9
		BE-RATE-P05	Conversion factor (SD-yr → Calendar yr) for POS5 duration		
		HR-FB-ESP05	OPERATOR FAILS TO OPERATE F&B AT ES POS05		
		VKHVS2B-HV16B	FAILS TO START SC PUMP 02B ROOM CUBICLE COOLER HV16B		
94	1.04E-10	%S2	Loss of SCS (S2)	0.0	98.9
		BE-RATE-P11	Conversion factor (SD-yr → Calendar yr) for POS11 duration		
		HR-FB-S2P11	OPERATOR FAILS TO OPERATE F&B AT S2 POS11		
		VKHVS2A-HV16A	FAILS TO START SC PUMP 02A ROOM CUBICLE COOLER HV16A		

Table 19.1-97 (39 of 41)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
95	1.03E-10	%LPSW	Loss of offsite power of Switchyard-centered for LPSD	0.0	98.9
		BE-RATE-P05	Conversion factor (SD-yr → Calendar yr) for POS5 duration		
		DGDGR-B-DGB	FAILS TO RUN OF EMERGENCY DIESEL GENERATOR DG01B		
		VDHVS-A-HV12A	FAILS TO START EDG ROOM CUBICLE COOLER HV12A		
		WOCHS2A-CH02A	ECW CHILLER CH02A FAILS TO START ON DEMAND		
96	1.03E-10	%LPSW	Loss of offsite power of Switchyard-centered for LPSD	0.0	98.9
		BE-RATE-P05	Conversion factor (SD-yr → Calendar yr) for POS5 duration		
		DGDGR-B-DGB	FAILS TO RUN OF EMERGENCY DIESEL GENERATOR DG01B		
		VDHVS-A-HV13A	FAILS TO START EDG ROOM CUBICLE COOLER HV13A		
		WOCHS2A-CH02A	ECW CHILLER CH02A FAILS TO START ON DEMAND		

Table 19.1-97 (40 of 41)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
97	9.47E-11	%LPSW	Loss of offsite power of Switchyard-centered for LPSD	0.0	98.9
		BE-RATE-P05	Conversion factor (SD-yr → Calendar yr) for POS5 duration		
		VDHVWD2-HV12B/13A	2/2 CCF OF START FOR EDG ROOM CUBICLE COOLER HV12B, 13A		
		WOCHS2A-CH02A	ECW CHILLER CH02A FAILS TO START ON DEMAND		
98	9.47E-11	%LPSW	Loss of offsite power of Switchyard-centered for LPSD	0.0	98.9
		BE-RATE-P05	Conversion factor (SD-yr → Calendar yr) for POS5 duration		
		VDHVWD2-HV13A/B	2/2 CCF OF START FOR EDG ROOM CUBICLE COOLER HV13A, 13B		
		WOCHS2A-CH02A	ECW CHILLER CH02A FAILS TO START ON DEMAND		

Table 19.1-97 (41 of 41)

Rank	Frequency (/yr)	Cutsets		Contribution to CDF (%)	
		Cutset	Cutset Description	Cutset	Cumulative
99	9.47E-11	%LPSW	Loss of offsite power of Switchyard-centered for LPSD	0.0	99.0
		BE-RATE-P05	Conversion factor (SD-yr → Calendar yr) for POS5 duration		
		VDHVWD2-HV12A/B	2/2 CCF OF START FOR EDG ROOM CUBICLE COOLER HV12A, 12B		
		WOCHS2A-CH02A	ECW CHILLER CH02A FAILS TO START ON DEMAND		
100	9.47E-11	%LPSW	Loss of offsite power of Switchyard-centered for LPSD	0.0	99.0
		BE-RATE-P05	Conversion factor (SD-yr → Calendar yr) for POS5 duration		
		VDHVWD2-HV12A/13B	2/2 CCF OF START FOR EDG ROOM CUBICLE COOLER HV12A, 13B		
		WOCHS2A-CH02A	ECW CHILLER CH02A FAILS TO START ON DEMAND		

Table 19.1-98 (1 of 2)

LPSD PRA Key Basic Events by RAW (CDF)

Event Name	Event Description	RAW
SISPP-S-IRWST	FAILURE OF IRWST SUMP DUE TO PLUGGING	911
I-ATWS-RPMCF	FAILURE TO SCRAM DUE TO MECHANICAL FAILURES	19
DCBSY-B-MC01B	BUS FAULTS ON 1E 125VDC BUS MC01B	12
SISPP-S-CHEMICAL	DEBRIS INDUCED LOSS OF LONG TERM COOLING (DOWNSTREAM/CHEMICAL EFFECT)	12
PELXY-B-LX03B-P	FAILURE OF PRIMARY LOOP CONTROLLERS 745-PE-LX03C	11
PGBSY1B-LC01B	BUS FAULT ON 480V LC LC01B	11
PHBSY1B-MC01B	BUS FAULT ON 480V MCC MC01B	11
PGXMY1B-TR01B	480V LC TRANSFORMER LC-TR01B FAULT	11
PFBSY1B-SW01B	BUS FAULT ON 4.16KV SWGR SW01B	11
PELXY-B-LX02B-P	FAILURE OF PRIMARY LOOP CONTROLLER OF 745-LX02B	11
CCTKB-B-TK01B	CCW SURGE TANK TK01B FAILS CATASTROPHICALLY	11
WOTKB-B-TK02B	ECW AIR SEPARATOR TK02B FAILS CATASTROPHICALLY	11
WOTKB-B-TK01B	ECW COMPRESSION TANK TK01B FAILS CATASTROPHICALLY	11
WOTKB-B-TK04B	ECW COMPRESSION TANK TK04B FAILS CATASTROPHICALLY	11
WOTKB-B-TK05B	ECW AIR SEPARATOR TK05B FAILS CATASTROPHICALLY	11
VGFLP1A-FT01B	ESW INTAKE STRUC. SUPPLY FAN FILTER FT01B PLUGGED	11
PELXY-B-LX01B-P	FAILURE OF PRIMARY LOOP CONTROLLER OF 745-PE-LX01B	7

Table 19.1-98 (2 of 2)

Event Name	Event Description	RAW
NPBDY-S-IPB	IPB FAULT	6
NPXHY-M-UAT01M	UNIT AUX XFMR TR01M FAILS WHILE OPERATING	6
NPXHY-N-UAT01N	UNIT AUX XFMR TR01N FAILS WHILE OPERATING	6
NPXOY-S-MTR	MAIN TRANSFORMER FAULT	6
SICVO1A-V247	SI LINE 1 CHECK VALVE V247 FAILS TO OPEN	5.2
SICVO1A-V543	SI LINE 1 CHECK VALVE V543 FAILS TO OPEN	5.2
SICVO1A-V143	SI LINE 1 CHECK VALVE V143 FAILS TO OPEN	5.2
SICVO2B-V123	SI PUMP DVI2B INJECTION LINE CV 123 FAILS TO OPEN	5.1
SICVO2B-V227	SI LINE 2 CHECK VALVE SI-227 FAILS TO OPEN	5.1
SICVO2B-V541	SI DVI INJECTION LINE 2B CHECK VALVE V541 FAILS TO OPEN	5.1

Table 19.1-99 (1 of 3)

LPSD PRA Key Basic Events by RAW (CDF) at Reduced Inventory

EVENT	DESCRIPTION	RAW
PELXY-B-LX01B-P	FAILURE OF PRIMARY LOOP CONTROLLER OF 745-PE-LX01B	3.2
SICVO2B-V227	SI LINE 2 CHECK VALVE SI-227 FAILS TO OPEN	2.8
SICVO2B-V123	SI PUMP DVI2B INJECTION LINE CV 123 FAILS TO OPEN	2.8
SICVO2B-V541	SI DVI INJECTION LINE 2B CHECK VALVE V541 FAILS TO OPEN	2.8
PELXY-B-LX03B-P	FAILURE OF PRIMARY LOOP CONTROLLERS 745-PE-LX03C	2.7
PELXY-B-LX04B-P	FAILURE OF PRIMARY LOOP CONTROLLER OF 745-LX04B	2.7
PFBSY1B-SW01B	BUS FAULT ON 4.16KV SWGR SW01B	2.7
SICVO1A-V543	SI LINE 1 CHECK VALVE V543 FAILS TO OPEN	2.7
SICVO1A-V143	SI LINE 1 CHECK VALVE V143 FAILS TO OPEN	2.7
SICVO1A-V247	SI LINE 1 CHECK VALVE V247 FAILS TO OPEN	2.7
PGBSY1B-LC01B	BUS FAULT ON 480V LC LC01B	2.7
SIMPS1B-SCPP01B	SC PUMP 2 PP01B FAILS TO START	2.7
CCMVO-B-352	SC Hx. HE01B INLET MOV 352 FAILS TO OPEN	2.7
PHBSY1B-MC01B	BUS FAULT ON 480V MCC MC01B	2.7
VKHVS2B-HV16B	FAILS TO START SC PUMP 02B ROOM CUBICLE COOLER HV16B	2.7
PGXMY1B-TR01B	480V LC TRANSFORMER LC-TR01B FAULT	2.7
SIMPR1B-SCPP01B	SC PUMP 2 PP01B FAILS TO RUN	2.7
VKHVR2B-HV16B	FAILS TO RUN SC PUMP 02B ROOM CUBICLE COOLER HV16B	2.7

Table 19.1-99 (2 of 3)

EVENT	DESCRIPTION	RAW
SIVVT2B-V107	SCS PUMP 2 SUCTION MANUAL VALVE V107 TRANSFER CLOSED	2.7
SIVVT2B-V579	VV V579 IN SC PUMP 2 DISCH. PATH FAILS TO REMAIN OPEN	2.7
CCVVT-B-V1512	SC Hx. HE01B OUTLET MANUAL VALVE V1512 TRANSFER CLOSED	2.7
PELXY-B-LX02B-P	FAILURE OF PRIMARY LOOP CONTROLLER OF 745-LX02B	2.7
PEDOY-B-LX01B02	FAILURE OF DIGITAL OUTPUT MODULE LX01B BRANCH 02	2.7
PEDOY-B-LX04B03	FAILURE OF DIGITAL OUTPUT MODULE LX04B BRANCH 03	2.7
PEDOY-B-LX02B03	FAILURE OF DIGITAL OUTPUT MODULE LX02B BRANCH 03	2.7
SICVO2B-V569	CV V569 IN SC PUMP 2 DISCH. PATH FAILS TO OPEN	2.6
DCBSY-A-MC01A	BUS FAULTS ON 1E 125VDC BUS MC01A	2.6
DCBSY-B-MC01B	BUS FAULTS ON 1E 125VDC BUS MC01B	2.6
VGFLP1A-FT01B	ESW INTAKE STRUC. SUPPLY FAN FILTER FT01B PLUGGED	2.6
CCTKB-B-TK01B	CCW SURGE TANK TK01B FAILS CATASTROPHICALLY	2.6
WOTKB-B-TK04B	ECW COMPRESSION TANK TK04B FAILS CATASTROPHICALLY	2.6
WOTKB-B-TK05B	ECW AIR SEPARATOR TK05B FAILS CATASTROPHICALLY	2.6
WOTKB-B-TK01B	ECW COMPRESSION TANK TK01B FAILS CATASTROPHICALLY	2.6
WOTKB-B-TK02B	ECW AIR SEPARATOR TK02B FAILS CATASTROPHICALLY	2.6
PGBSY1A-LC01A	BUS FAULT ON 480V LC LC01A	2.6
SIHEY1B-HE01B-SC	SC HX 2 HE01B FAILS WHILE OPERATING	2.6
PHBSY1A-MC01A	BUS FAULT ON 480V MCC MC01A	2.6
PGXMY1A-TR01A	480V LC TRANSFORMER LC-TR01A FAULT	2.6

Table 19.1-99 (3 of 3)

EVENT	DESCRIPTION	RAW
PFBSY1A-SW01A	BUS FAULT ON 4.16KV SWGR SW01A	2.6
SIMPS1A-SCPP01A	SC PUMP PP01A FAILS TO START	2.6
CCMVO-A-351	SC Hx. HE01A INLET MOV 351 FAILS TO OPEN	2.6
VKHVS2A-HV16A	FAILS TO START SC PUMP 02A ROOM CUBICLE COOLER HV16A	2.6
PELXY-A-LX04A-P	FAILURE OF PRIMARY LOOP CONTROLLER OF 745-PE-LX04A	2.6
PELXY-A-LX01A-P	FAILURE OF PRIMARY LOOP CONTROLLER OF 745-PE-LX01A	2.6
VGFLP1A-FT01A	ESW INTAKE STRUC. SUPPLY FAN FILTER FT01A PLUGGED	2.6
WOTKB-A-TK02A	ECW AIR SEPARATOR TK02A FAILS CATASTROPHICALLY	2.6
WOTKB-A-TK05A	ECW AIR SEPARATOR TK05A FAILS CATASTROPHICALLY	2.6
WOTKB-A-TK01A	ECW COMPRESSION TANK TK01A FAILS CATASTROPHICALLY	2.6
CCTKB-A-TK01A	CCW SURGE TANK TK01A FAILS CATASTROPHICALLY	2.6
WOTKB-A-TK04A	ECW COMPRESSION TANK TK04A FAILS CATASTROPHICALLY	2.6
PEDOY-A-LX04A02	FAILURE OF DIGITAL OUTPUT MODULE LX04A BRANCH 02	2.6

Table 19.1-100 (1 of 2)

LPSD PRA Key Basic Events by FV (CDF) at Reduced Inventory

EVENT	DESCRIPTION	FV
VKHVS2B-HV16B	FAILS TO START SC PUMP 02B ROOM CUBICLE COOLER HV16B	0.65%
VKHVS2A-HV16A	FAILS TO START SC PUMP 02A ROOM CUBICLE COOLER HV16A	0.61%
DGDGR-B-DGB	FAILS TO RUN OF EMERGENCY DIESEL GENERATOR DG01B	0.24%
DGDGR-A-DGA	FAILS TO RUN OF EMERGENCY DIESEL GENERATOR DG01A	0.20%
VKHVS2A-HV11A	FAILS TO START SI PUMP ROOM CUBICLE COOLER HV11A	0.17%
CCMVO-B-352	SC Hx. HE01B INLET MOV 352 FAILS TO OPEN	0.16%
SIMPS1B-SCPP01B	SC PUMP 2 PP01B FAILS TO START	0.16%
CCMVO-A-351	SC Hx. HE01A INLET MOV 351 FAILS TO OPEN	0.15%
SIMPS1A-SCPP01A	SC PUMP PP01A FAILS TO START	0.15%
WOCHS2A-CH02A	ECW CHILLER CH02A FAILS TO START ON DEMAND	0.15%
DADGR-S-AACTG	AAC GTG FAILS TO RUN	0.09%
VDHVS-A-HV12A	FAILS TO START EDG ROOM CUBICLE COOLER HV12A	0.07%
VDHVS-A-HV13A	FAILS TO START EDG ROOM CUBICLE COOLER HV13A	0.07%
PFHBO1B-SW01B-A2	FAILS TO OPEN OF PCB SW01B-A2 OF 4.16KV SWGR SW01B FROM SAT	0.05%
PFHBC1B-SW01B-D2	FAILS TO CLOSE OF FEEDER BRK SW01B-D2 TO DG B	0.05%
PFHBC1A-SW01A-E2	FAILS TO CLOSE OF FEEDER BRK SW01A-E2 TO EDG A	0.05%

Table 19.1-100 (2 of 2)

EVENT	DESCRIPTION	FV
PFHBO1A-SW01A-A2	FAILS TO OPEN OF PCB SW01A-A2 OF 4.16KV SWGR SW01A FROM SAT	0.05%
SIMPR1B-SCPP01B	SC PUMP 2 PP01B FAILS TO RUN	0.04%
SIMVO2A-636	SI PUMP 1 INJECTION LINE MOV 636 FAILS TO OPEN	0.04%
SIMPS2A-PP02C	FAILS TO START SI PUMP PP02C	0.04%

Table 19.1-101 (1 of 5)

LPSD PRA Key CCF Events by RAW (CDF)

Event	Description	RAW
SICVWQ4-V540/41/42/43	SI LINE C/V 543,541,542,540 CCF TO OPEN	4905
SICVWQ4-V113/23/33/43	SI LINE C/V 113,123,133,143 CCF TO OPEN	4905
SICVWQ4-V217/27/37/47	SI LINE C/V 247,227,237,217 CCF TO OPEN	4905
WOCHKQ4-CH03A/3B/4A/4B	RUNNING CCF OF ECW CHILLERS 3A/4A/3B/4B	980
WOCHKQ4-CH01A/1B/2A/2B	RUNNING CCF OF ECW CHILLERS 1A/2A/1B/2B	980
VGAHKQ4-AH04A/4B/5A/5B	4/4 RUNNING CCF OF ESW PUMP ROOM FAN AH04A, 04B, 05A, 05B	980
VGAHKQ4-AH01A/1B/2A/2B	4/4 RUNNING CCF OF ESW PUMP ROOM FAN AH01A/B, 02A/B	980
VKHVKQ4-HV13A/13B/14A/14B	4/4 CCF OF RUN FOR CCW PUMP ROOM CUBICLE COOLER HV13A, 13B, 14A, 14B	976
SXMPKQ4-PP01A/B/2A/B	4/4 CCF OF ESW PUMPS PP01A/2A, PP01B/2B TO RUN	973
VGFLKD2-FT01A/01B	2/2 CCF OF ESW PUMP ROOM FILTER FT01A, 01B	972
PELXKO8-LX04AB03AB	8/8 CCF OF LOOP CONTROLLER LX03AB, LX04AB FOR CCW NON SAFETY LINE ISOL. VALVES	967
CCMPKQ4-PP01A/B/2A/B	4/4 CCF OF CCW PUMPS PP01A/1B/2A/2B (RUNNING)	967
WOMPKQ4-PP01A/2A/1B/2B	RUNNING CCF OF ECW PUMPS 1A/2A/1B/2B	967
WOMPKQ4-PP04A/5A/4B/5B	RUNNING CCF OF ECW PUMPS 4A/5A/4B/5B	967
SXAHKQ4-H01A/02A/01B/02B	4/4 RUNNING CCF OF ESW COOLING TOWER FANS AH01A, 02A, 01B, 02B	962
CCMVXO8-143-150	8/8 CCF(DEMAND) OF MOV 143,144,145,146,147,148,149,150 IN NON SAFETY LOAD LINE	960

Table 19.1-101 (2 of 5)

Event	Description	RAW
SIMPWQ4-CSP1A/B/SCP1A/B	4/4 CCF OF CSP PP01A, PP01B AND SCP PP01A, PP01B TO START	908
SIMPKQ4-CSP1A/B/SCP1A/B	4/4 CCF OF CSP PP01A, PP01B AND SCP PP01A , PP01B TO RUN	907
SICVWQ4-V568/569/1001/1002	CCF TO OPEN CSP DISCH LINE 1001, 1002 AND SCP DISCH. LINE CV 568,569	903
SICVWQ4-V157/158/159/160	4/4 CCF OF CS CV 157/158 SC CV 159/160	901
SIHEKQ4-HE01A/B-CS&SC	4/4 CCF OF SC HE01A/B, CS HE01A/B	901
SICVWQ3-V227/37/47	3/4 CCF OF DVI LINE CHECK VALVES 227,237,247	435
SICVWQ3-V541/42/43	3/4 CCF OF DVI LINE CHECK VALVES 541,542,543	435
SICVWQ3-V123/33/43	SI LINE C/V 123,133,143 CCF TO OPEN	435
SICVWQ3-V113/23/43	SI LINE C/V 113,123,143 CCF TO OPEN	402
SICVWQ3-V540/41/43	3/4 CCF OF DVI LINE CHECK VALVES 540,541,543	402
SICVWQ3-V217/27/47	3/4 CCF OF DVI LINE CHECK VALVES 217,227,247	402
SIMVWQ4-616/26/36/46	CCF OF 4/4 DVI LINEMOV 616,626,636,646	164
SIMPWQ4-PP02ABCD	4/4 CCF OF START FOR SI PUMP PP02A/B/C/D	159
SICVWQ4-V404/05/34/46	SI PUMP DISCHARGE C/V 404,405,434,446 CCF TO OPEN	152
SIMPKQ4-PP02ABCD	4/4 CCF OF RUN FOR SI PUMP PP02A/B/C/D	142
SICVWQ3-V217/37/47	3/4 CCF OF DVI LINE CHECK VALVES 217,237,247	132
SICVWQ3-V113/33/43	SI LINE C/V 113,133,143 CCF TO OPEN	132
SICVWQ3-V540/42/43	3/4 CCF OF DVI LINE CHECK VALVES 540,542,543	132
SICVWQ3-V540/41/42	3/4 CCF OF DVI LINE CHECK VALVES 540,541,542	121
SICVWQ3-V113/23/33	SI LINE C/V 113,123,133 CCF TO OPEN	121

Table 19.1-101 (3 of 5)

Event	Description	RAW
SICVWQ3-V217/27/37	3/4 CCF OF DVI LINE CHECK VALVES 217,227,237	121
PELXKO8-LX03ABCD	8/8 CCF OF LOOP CONTROLLER LX03A/B/C/D	50.8
PAGXKO8-PA03ABCD	8/8 CCF OF GROUP CONTROLLER 752-PA03A,03B,03C,03D	49.7
SICVWQ2-V541/43	2/4 CCF OF DVI LINE CHECK VALVES 541,543	41.5
SICVWQ2-V227/47	2/4 CCF OF DVI LINE CHECK VALVES 227,247	41.5
SICVWQ2-V123/43	SI LINE C/V 123,143 CCF TO OPEN	41.5
IPINKQ4-IN01ABCD	CCF OF 120V AC POWER SUPPLY INVERTER IN01A/B/C/D	38.5
PELXKO8-LX08A12B01C01D	8/8 CCF OF LOOP CONTROLLER LX08A 12, LX12B 12, LX01C 12, LX01D 12	38.5
EFGXKO8-PA03ABCD	CCF OF GC TO LC PM646 MODULES	37.7
EFCIKO8-PA03ABCD	CCF OF GC CI MODULES	36.9
PELXKO8-LX01ABCD	8/8 CCF OF LOOP CONTROLLER LX01A, LX01B, LX01C, LX01D	36.9
WOCHKQ3-CH01A/1B/2B	RUNNING CCF OF ECW CHILLERS 1A/1B/2B	29.5
WOCHKQ3-CH03A/3B/4B	RUNNING CCF OF ECW CHILLERS 3A/3B/4B	29.5
WOCHKQ3-CH03A/4A/3B	RUNNING CCF OF ECW CHILLERS 3A/4A/3B	28.8
WOCHKQ3-CH01A/2A/1B	RUNNING CCF OF ECW CHILLERS 1A/2A/1B	28.8
CCMVWQ3-191/2/181	3/4 CCF OF CCW MOV 191, 192, 181 FOR EDG01A/B/C INLET	26.1
VDHVWD2-HV13A/B	2/2 CCF OF START FOR EDG ROOM CUBICLE COOLER HV13A, 13B	24.7
VDHVWD2-HV12B/13A	2/2 CCF OF START FOR EDG ROOM CUBICLE COOLER HV12B, 13A	24.7
VDHVWD2-HV12A/13B	2/2 CCF OF START FOR EDG ROOM CUBICLE COOLER HV12A, 13B	24.7
VDHVWD2-HV12A/B	2/2 CCF OF START FOR EDG ROOM CUBICLE COOLER HV12A, 12B	24.7

Table 19.1-101 (4 of 5)

Event	Description	RAW
WOCHWQ4-CH01A/2A/1B/2B	DEMAND CCF OF ECW CHILLERS 1A/2A/1B/2B	23.8
WOCHWQ4-CH03A/4A/3B/4B	DEMAND CCF OF ECW CHILLERS 3A/4A/3B/4B	23.8
VGAHWQ4-AH04A/4B/5A/5B	4/4 START CCF OF ESW PUMP ROOM FAN AH04A, 04B, 05A, 05B	23.1
WOMPWQ4-PP04A/5A/4B/5B	DEMAND CCF OF ECW PUMPS 4A/5A/4B/5B	22.7
CCMPWQ4-PP01A/2A/1B/2B	4/4 CCF OF CCW PUMPS PP01A/1B/2A/2B (DEMAND)	22.7
WOMPWQ4-PP01A/2A/1B/2B	DEMAND CCF OF ECW PUMPS 1A/2A/1B/2B	22.7
VDHVKD2-HV12B/13A	2/2 CCF OF RUN FOR EDG ROOM CUBICLE COOLER HV12B, 13A	22.6
VDHVKD2-HV13A/B	2/2 CCF OF RUN FOR EDG ROOM CUBICLE COOLER HV13A, 13B	22.6
VDHVKD2-HV12A/B	2/2 CCF OF RUN FOR EDG ROOM CUBICLE COOLER HV12A, 12B	22.6
VDHVKD2-HV12A/13B	2/2 CCF OF RUN FOR EDG ROOM CUBICLE COOLER HV12A, 13B	22.6

Table 19.1-101 (5 of 5)

Event	Description	RAW
CCMVWQ2-191/2	2/4 CCF OF CCW MOV 191, 192 FOR EDG01A/B INLET	22.1
SICVWQ2-V540/43	2/4 CCF OF DVI LINE CHECK VALVES 540,543	22.1
SICVWQ2-V540/41	2/4 CCF OF DVI LINE CHECK VALVES 540,541	22.1
SICVWQ2-V113/43	SI LINE C/V 113,143 CCF TO OPEN	22.1
SICVWQ2-V113/23	SI LINE C/V 113,123 CCF TO OPEN	22.1
SICVWQ2-V217/27	2/4 CCF OF DVI LINE CHECK VALVES 217,227	22.1
SICVWQ2-V217/47	2/4 CCF OF DVI LINE CHECK VALVES 217,247	22.1
SXMPWQ4-PP01A/B/2A/B	4/4 CCF OF ESW PUMPS PP01A/2A, PP01B/2B TO START	22.0
CCMVWQ3-191/2/182	3/4 CCF OF CCW MOV 191, 192, 182 FOR EDG01A/B/D INLET	20.6
IPINKQ2-IN01AD	2/4 CCF OF 120V AC POWER SUPPLY INVERTER IN01A/D	20.0

(1) The cutoff threshold chosen for this table is based upon guidance presented in NEI 00-04 (Reference 51).

Table 19.1-102

LPSD PRA Key CCF Events by FV (CDF)

Event	Description	FV
WOCHKQ4-CH01A/1B/2A/2B	4/4 RUNNING CCF OF ECW CHILLERS 1A/2A/1B/2B	0.49%
WOCHKQ4-CH03A/3B/4A/4B	4/4 RUNNING CCF OF ECW CHILLERS 3A/4A/3B/4B	0.49%
VGAHKQ4-AH01A/1B/2A/2B	4/4 RUNNING CCF OF ESW PUMP ROOM FAN AH01A/B, 02A/B	0.36%
VGAHKQ4-AH04A/4B/5A/5B	4/4 RUNNING CCF OF ESW PUMP ROOM FAN AH04A, 04B, 05A, 05B	0.36%
SIMPWQ4-CSP1A/B/SCP1A/B	4/4 START CCF OF CSP PP01A, PP01B AND SCP PP01A, PP01B	0.32%
VDHVWD2-HV12A/13B	2/2 START CCF FOR EDG ROOM CUBICLE COOLER HV12A, 13B	0.22%
VDHVWD2-HV12A/B	2/2 START CCF FOR EDG ROOM CUBICLE COOLER HV12A, 12B	0.22%
VDHVWD2-HV12B/13A	2/2 START CCF FOR EDG ROOM CUBICLE COOLER HV12B, 13A	0.22%
VDHVWD2-HV13A/B	2/2 START CCF FOR EDG ROOM CUBICLE COOLER HV13A, 13B	0.22%
SIMVWQ4-616/26/36/46	CCF OF 4/4 DVI LINE MOVs 616,626,636,646	0.17%

Table 19.1-103

LPSD PRA Key CCF Events by RAW (CDF) at Reduced Inventory

EVENT	Description	RAW
SICVWQ4-V113/23/33/43	SI LINE C/V 113,123,133,143 CCF TO OPEN	2848
SICVWQ4-V217/27/37/47	SI LINE C/V 247,227,237,217 CCF TO OPEN	2848
SICVWQ4-V540/41/42/43	SI LINE C/V 543,541,542,540 CCF TO OPEN	2848
SICVWQ3-V227/37/47	3/4 CCF OF DVI LINE CHECK VALVES 227,237,247	110
SICVWQ3-V123/33/43	SI LINE C/V 123,133,143 CCF TO OPEN	110
SICVWQ3-V541/42/43	3/4 CCF OF DVI LINE CHECK VALVES 541,542,543	110
SICVWQ3-V540/41/42	3/4 CCF OF DVI LINE CHECK VALVES 540,541,542	30
SICVWQ3-V113/23/33	SI LINE C/V 113,123,133 CCF TO OPEN	30
SICVWQ3-V217/27/37	3/4 CCF OF DVI LINE CHECK VALVES 217,227,237	30
SIMVWQ4-616/26/36/46	CCF OF 4/4 DVI LINEMOV 616,626,636,646	26
SICVWQ3-V540/42/43	3/4 CCF OF DVI LINE CHECK VALVES 540,542,543	25
SICVWQ3-V217/37/47	3/4 CCF OF DVI LINE CHECK VALVES 217,237,247	25
SICVWQ3-V113/33/43	SI LINE C/V 113,133,143 CCF TO OPEN	25
SIMPWQ4-PP02ABCD	4/4 CCF OF START FOR SI PUMP PP02A/B/C/D	24

(1) The cutoff threshold chosen for this table is based upon guidance presented in NEI 00-04 (Reference 51).

Table 19.1-104 (1 of 4)

LPSD PRA Key Operator Actions by RAW (CDF)

Event Name	Event Description	RAW
HR-MI-SOP05	OPERATORS FAIL TO ISOLATE AND MAKEUP FOLLOWING OVERDRAIN IN POS 05	46.2
HR-MI-SOP11	OPERATORS FAIL TO ISOLATE AND MAKEUP FOLLOWING OVERDRAIN IN POS 11	37.4
HR-RS-SOP11	OPERATORS FAIL TO RECOVER SHUTDOWN COOLING FOLLOWING OVERDRAIN IN POS 11	37.3
HR-RS-SOP05	OPERATORS FAIL TO RECOVER SHUTDOWN COOLING FOLLOWING OVERDRAIN IN POS 05	37.1
HR-RS-LPP10	OPERATORS FAIL TO RESTART SHUTDOWN COOLING FOLLOWING A LOOP IN POS 10	20.4
HR-RS-S1P10	OPERATORS FAIL TO RECOVER SHUTDOWN COOLING IN S1 POS 10	17.5
HR-RS-LPP06	OPERATORS FAIL TO RESTART SHUTDOWN COOLING FOLLOWING A LOOP IN POS 06	13.5
HR-RS-S1P06	OPERATORS FAIL TO RECOVER SHUTDOWN COOLING IN S1 POS 06	11.6
HR-MI-SLP05	OPERATORS FAIL TO ISOLATE AND MAKEUP FOLLOWING LOSS OF LEVEL IN POS 05	9.3
HR-RS-SLP05	OPERATOR FAILS TO RESTORE SCS AT SL POS05	7.7
HR-MI-SLP11	OPERATOR FAILS TO ISOLATE AND MAKEUP FAILING TO MAINTAIN WATER LEVEL (SL) PATH AT POS11	6.3

Table 19.1-104 (2 of 4)

Event Name	Event Description	RAW
HR-FB-SOP05-01	OPERATOR FAILS TO OPERATE F&B AT SO POS05 01	6.3
HR-RS-SLP11	OPERATOR FAILS TO RESTORE SCS AT SL POS11	6.3
HR-FB-SOP11-01	OPERATOR FAILS TO OPERATE F&B AT SO POS11 01	6.2
HR-FB-SOP05-01-DE	HRA DEPENDANCE FOR RS & FB AT SO POS05	6.2
HR-MI-JLP10	OPERATOR FAILS TO ISOLATE AND MAKEUP UNRECOVERABLE LOCA (JL) PATH AT POS10	5.7
HR-MI-JLP05	OPERATOR FAILS TO ISOLATE AND MAKEUP UNRECOVERABLE LOCA (JL) PATH AT POS05	5.7
HR-RS-JLP10	OPERATOR FAILS TO RESTORE SCS AT JL POS10	5.7
HR-RS-LPP04B	OPERATOR FAILS TO RESTORE SCS AT LO POS04B	5.6
HR-RS-KVP10	OPERATOR FAILS TO RESTORE SCS AT KV POS10	5.1
HR-RS-S1P04B	OPERATOR FAILS TO RESTORE SCS AT S1 POS04B	4.9
HR-RS-LPP05	OPERATOR FAILS TO RESTORE SCS AT LO POS05	4.8
HR-RS-JLP05	OPERATOR FAILS TO RESTORE SCS AT JL POS05	4.8

Table 19.1-104 (3 of 4)

Event Name	Event Description	RAW
HR-MI-JLP06	OPERATOR FAILS TO ISOLATE AND MAKEUP UNRECOVERABLE LOCA (JL) PATH AT POS06	4.7
HR-RS-S1P05	OPERATOR FAILS TO RESTORE SCS AT S1 POS05	4.2
HR-RS-JLP06	OPERATOR FAILS TO RESTORE SCS AT JL POS06	4.0
HR-RS-LPP11	OPERATOR FAILS TO RESTORE SCS AT LO POS11	4.0
HR-MI-JLP11	OPERATOR FAILS TO ISOLATE AND MAKEUP UNRECOVERABLE LOCA (JL) PATH AT POS11	4.0
HR-RS-JLP11	OPERATOR FAILS TO RESTORE SCS AT JL POS11	4.0
HR-RS-KVP06	OPERATOR FAILS TO RESTORE SCS AT KV POS06	3.6
HR-RS-S2P10	OPERATOR FAILS TO RESTORE SCS AT S2 POS10	3.6
HR-RS-S1P11	OPERATOR FAILS TO RESTORE SCS AT S1 POS11	3.5
HR-FB-SOP11-01-DE	HRA DEPENDANCE FOR RS & FB AT SO POS11	3.3

Table 19.1-104 (4 of 4)

Event Name	Event Description	RAW
HR-RS-ESP10	OPERATOR FAILS TO RESTORE SCS AT ES POS10	3.2
HR-FB-LPP10	OPERATOR FAILS TO OPERATE F&B AT LP POS10	2.9
HR-RS-S2P06	OPERATOR FAILS TO RESTORE SCS AT S2 POS06	2.7
HR-RS-ESP06	OPERATOR FAILS TO RESTORE SCS AT ES POS06	2.4
HR-MI-JLP04B	OPERATOR FAILS TO ISOLATE AND MAKEUP UNRECOVERABLE LOCA (JL) PATH AT POS04B	2.3
HR-FB-SOP05-02-DE	HRA DEPENDANCE FOR MI & FB AT SO POS05	2.2
HR-FB-LPP06	OPERATOR FAILS TO OPERATE F&B AT LP POS06	2.2
HR-RS-JLP04B	OPERATOR FAILS TO RESTORE SCS AT JL POS04B	2.1

Table 19.1-105 (1 of 4)

LPSD PRA Key Operator Actions by FV (CDF)

Event Name	Event Description	FV
HR-RS-SOP05	OPERATOR FAILS TO RESTORE SCS AT SO POS05	27.8%
HR-FB-SOP05-01-DE	HRA DEPENDANCE FOR RS & FB AT SO POS05	27.8%
HR-RS-SOP11	OPERATOR FAILS TO RESTORE SCS AT SO POS11	12.5%
HR-FB-SOP11-01-DE	HRA DEPENDANCE FOR RS & FB AT SO POS11	12.5%
HR-MI-SOP05	OPERATOR FAILS TO ISOLATE AND MAKEUP OVER-DRAINAGE (SO) PATH AT POS05	8.6%
HR-FB-SOP05-02-DE	HRA DEPENDANCE FOR MI & FB AT SO POS05	8.6%
HR-RS-SLP05	OPERATOR FAILS TO RESTORE SCS AT SL POS05	5.1%
HR-FB-SLP05-01-DE	HRA DEPENDANCE FOR RS & FB AT SL POS05	5.1%
HR-MI-SOP11	OPERATOR FAILS TO ISOLATE AND MAKEUP OVER-DRAINAGE (SO) PATH AT POS11	4.5%

Table 19.1-105 (2 of 4)

Event Name	Event Description	FV
HR-FB-SOP11-02-DE	HRA DEPENDANCE FOR MI & FB AT SO POS11	4.5%
HR-RS-JLP05	OPERATOR FAILS TO RESTORE SCS AT JL POS05	2.9%
HR-FB-JLP05-01-DE	HRA DEPENDANCE FOR RS & FB AT JL POS05	2.9%
HR-RS-SLP11	OPERATOR FAILS TO RESTORE SCS AT SL POS11	1.8%
HR-FB-SLP11-01-DE	HRA DEPENDANCE FOR RS & FB AT SL POS11	1.8%
HR-MI-SLP05	OPERATOR FAILS TO ISOLATE AND MAKEUP FAILING TO MAINTAIN WATER LEVEL (SL) PATH AT POS05	1.6%
HR-FB-SLP05-02-DE	HRA DEPENDANCE FOR MI & FB AT SL POS05	1.6%
HR-RS-LPP05	OPERATOR FAILS TO RESTORE SCS AT LO POS05	1.3%
HR-FB-LPP05-DE	HRA DEPENDANCE FOR RS & FB AT LP POS05	1.3%
HR-RS-LPP03B	OPERATOR FAILS TO RESTORE SCS AT LO POS03B	1.2%

Table 19.1-105 (3 of 4)

Event Name	Event Description	FV
HR-SG-LPP03B-DE	HRA DEPENDANCE FOR RS & SG AT LP POS03B	1.2%
HR-FB-LPP03B-01-DE	HRA DEPENDANCE FOR SG & FB AT LP POS03B	1.2%
HR-RS-S1P05	OPERATOR FAILS TO RESTORE SCS AT S1 POS05	1.1%
HR-FB-S1P05-DE	HRA DEPENDANCE FOR RS & FB AT S1 POS05	1.1%
HR-RS-S1P03B	OPERATOR FAILS TO RESTORE SCS AT S1 POS03B	1.1%
HR-SG-S1P03B-DE	HRA DEPENDANCE FOR RS & SG AT S1 POS03B	1.1%
HR-FB-S1P03B-01-DE	HRA DEPENDANCE FOR SG & FB AT S1 POS03B	1.1%
HR-RS-JLP11	OPERATOR FAILS TO RESTORE SCS AT JL POS11	1.0%
HR-FB-JLP11-01-DE	HRA DEPENDANCE FOR RS & FB AT JL POS11	1.0%
HR-MI-JLP05	OPERATOR FAILS TO ISOLATE AND MAKEUP UNRECOVERABLE LOCA (JL) PATH AT POS05	0.9%

Table 19.1-105 (4 of 4)

Event Name	Event Description	FV
HR-FB-JLP05-02-DE	HRA DEPENDANCE FOR MI & FB AT JL POS05	0.9%
HR-MI-JLP06	OPERATOR FAILS TO ISOLATE AND MAKEUP UNRECOVERABLE LOCA (JL) PATH AT POS06	0.7%
HR-FB-JLP06-02-DE	HRA DEPENDANCE FOR MI & FB AT JL POS06	0.7%
HR-FB-SOP05-01	OPERATOR FAILS TO OPERATE F&B AT SO POS05 01	0.7%
HR-MI-SLP11	OPERATOR FAILS TO ISOLATE AND MAKEUP FAILING TO MAINTAIN WATER LEVEL (SL) PATH AT POS11	0.7%
HR-FB-SLP11-02-DE	HRA DEPENDANCE FOR MI & FB AT SL POS11	0.7%
HR-FB-SOP11-01	OPERATOR FAILS TO OPERATE F&B AT SO POS11 01	0.7%
HR-MI-JLP10	OPERATOR FAILS TO ISOLATE AND MAKEUP UNRECOVERABLE LOCA (JL) PATH AT POS10	0.6%
HR-FB-JLP10-02-DE	HRA DEPENDANCE FOR MI & FB AT JL POS10	0.6%

Table 19.1-106 (1 of 2)

Shutdown LRF Screening Estimate Data

POS	T/S Mode	POS Description	CDF (/yr)	CDF (%)	CCFP	LRF (/yr)	LRF (%)	Comment
1	1, 2	Low power operation	5.33E-10	0.0%	0.1	5.3E-11	0.0%	TS 3.6 requires containment operable in Modes 1-4
2	3	Steam Generator Cooldown to 177°C (350°F)	1.00E-07	3.7%	0.1	1.0E-08	2.2%	
3A	4	Cooldown with SCS to 100 °C (212°F)	1.93E-07	7.1%	0.1	1.9E-08	4.2%	
3B	5	Cooldown with SCS to 60 °C (140°F)	9.46E-08	3.5%	1.0	9.5E-08	20.3%	Open hatch assumed
4A	5	RCS Draindown (pressurizer manway closed)	1.11E-09	0.0%	0.1	1.1E-10	0.0%	Equipment hatch closed or open with recovery credit
4B	5	RCS Draindown (manway open)	4.55E-08	1.7%	0.1	4.6E-09	1.0%	
5	5	Reduced Inventory Operation	1.40E-06	51.5%	0.1	1.4E-07	30.1%	TS 3.9.3 requires hatch closed during core alterations
6	5	Fill for Refueling	9.71E-08	3.6%	1.0	9.7E-08	20.9%	Open hatch assumed
7-9	6	Refueling	-	-	-	-	-	Not quantified for CDF
10	5	RCS Draindown after Refueling	1.28E-07	4.7%	0.1	1.3E-08	2.8%	Equipment hatch closed or open with recovery credit
11	5	Reduced Inventory Operation	6.05E-07	22.2%	0.1	6.1E-08	13.0%	TS 3.9.3 requires hatch closed during core alterations

Table 19.1-106 (2 of 2)

POS	T/S Mode	POS Description	CDF (/yr)	CDF (%)	CCFP	LRF (/yr)	LRF (%)	Comment
12A	5	Refill RCS (manway open)	2.27E-08	0.8%	1.0	2.3E-08	4.9%	Open hatch assumed
12B	5	Refill RCS (manway closed)	-	-	-	-	-	Not quantified for CDF
13	4,5	RCS Heatup with SCS Isolation at 350°F	2.12E-08	0.8%	0.1	2.1E-09	0.5%	TS 3.6 requires containment operable in Modes 1-4
14	3	RCS Heatup with Steam Generators	3.92E-09	0.1%	0.1	3.9E-10	0.1%	
15	2, 1	Reactor Startup	6.63E-09	0.2%	0.1	6.6E-10	0.1%	
			2.72E-06	100%		4.6E-07	100%	TOTALS

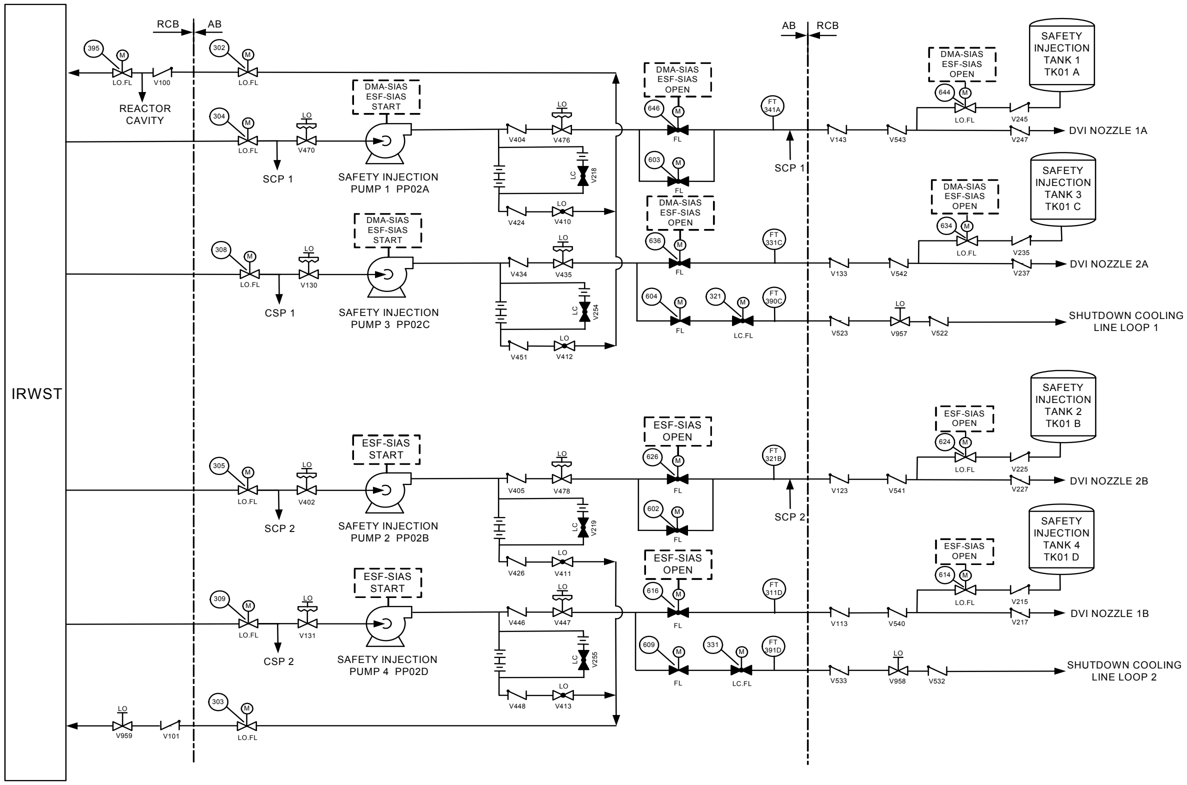

Figure 19.1-1 Simplified Diagram - Safety Injection System

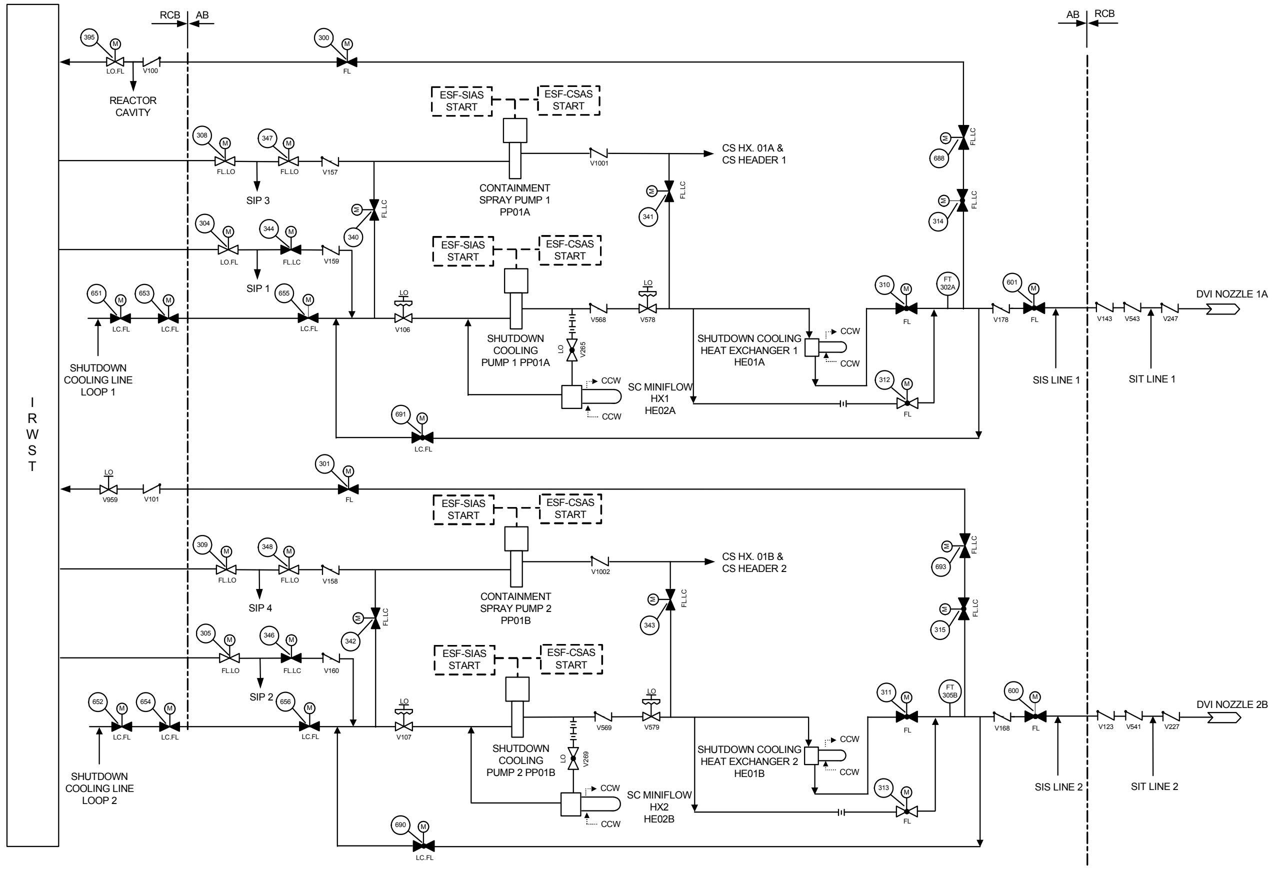

Figure 19.1-2   Simplified Diagram - Shutdown Cooling System

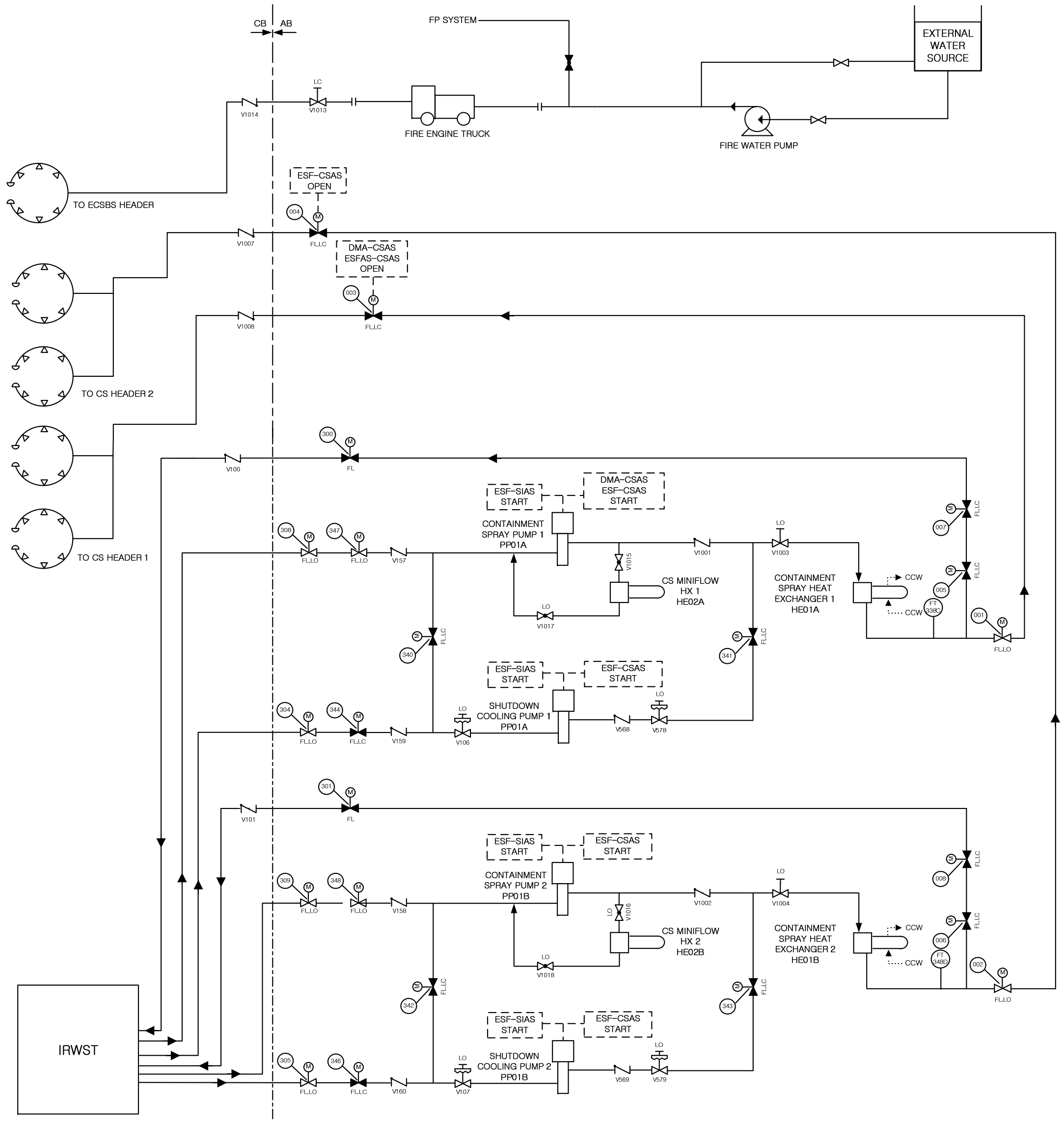

Figure 19.1-3   Simplified Diagram - Containment Spray System

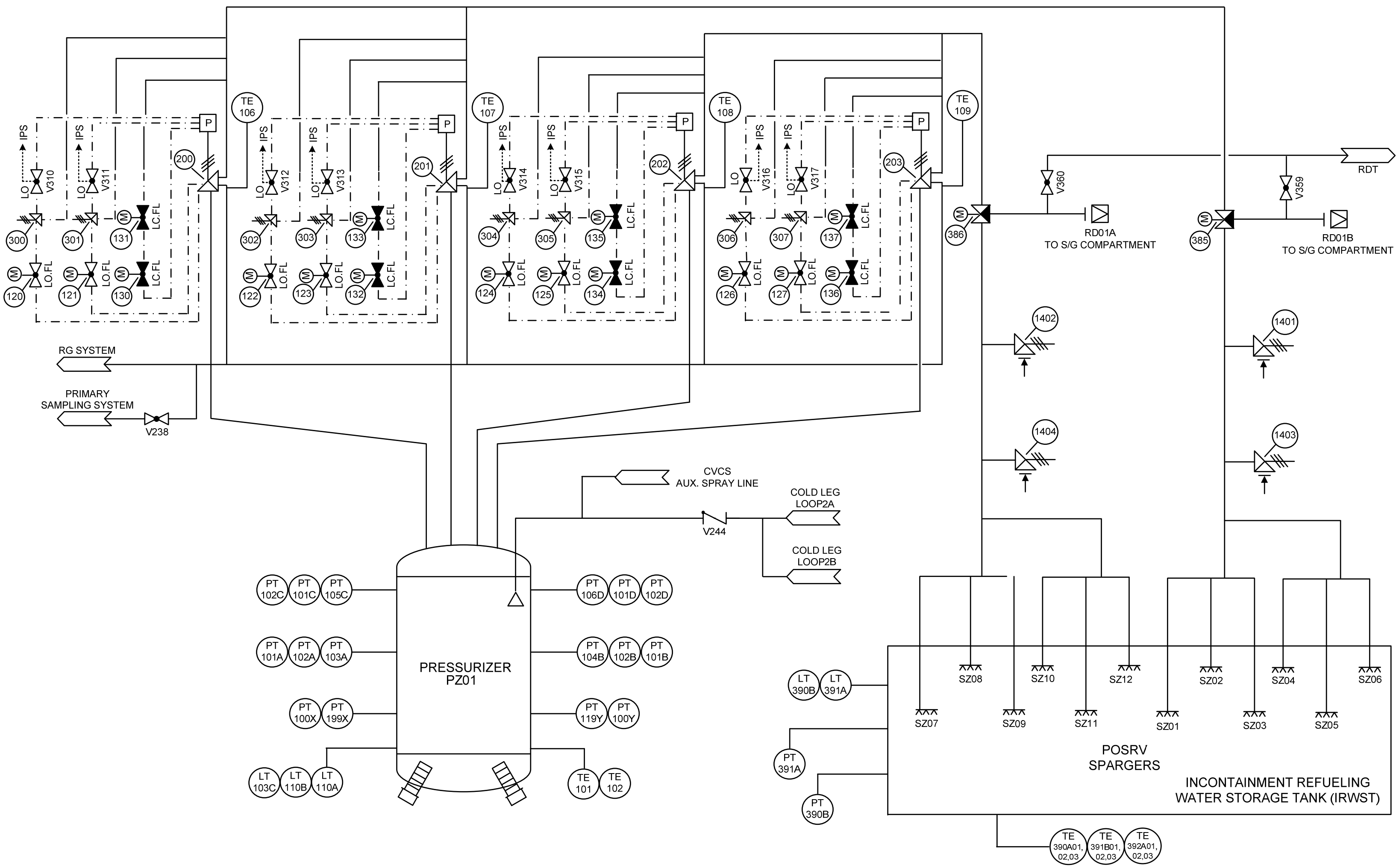

Figure 19.1-4 Simplified Diagram - POSRVs and Discharge Path to IRWST

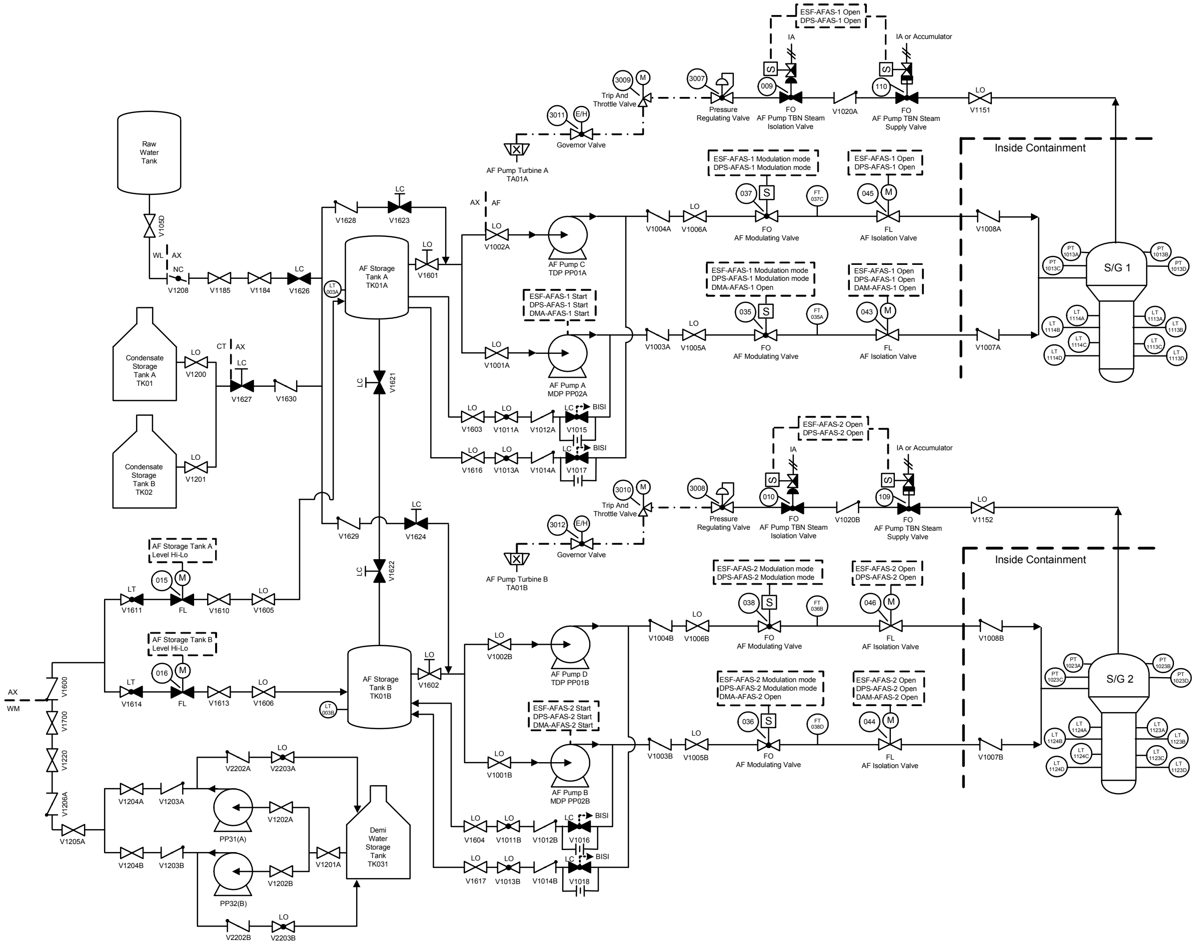

Figure 19.1-5 Simplified Diagram - Auxiliary Feedwater System

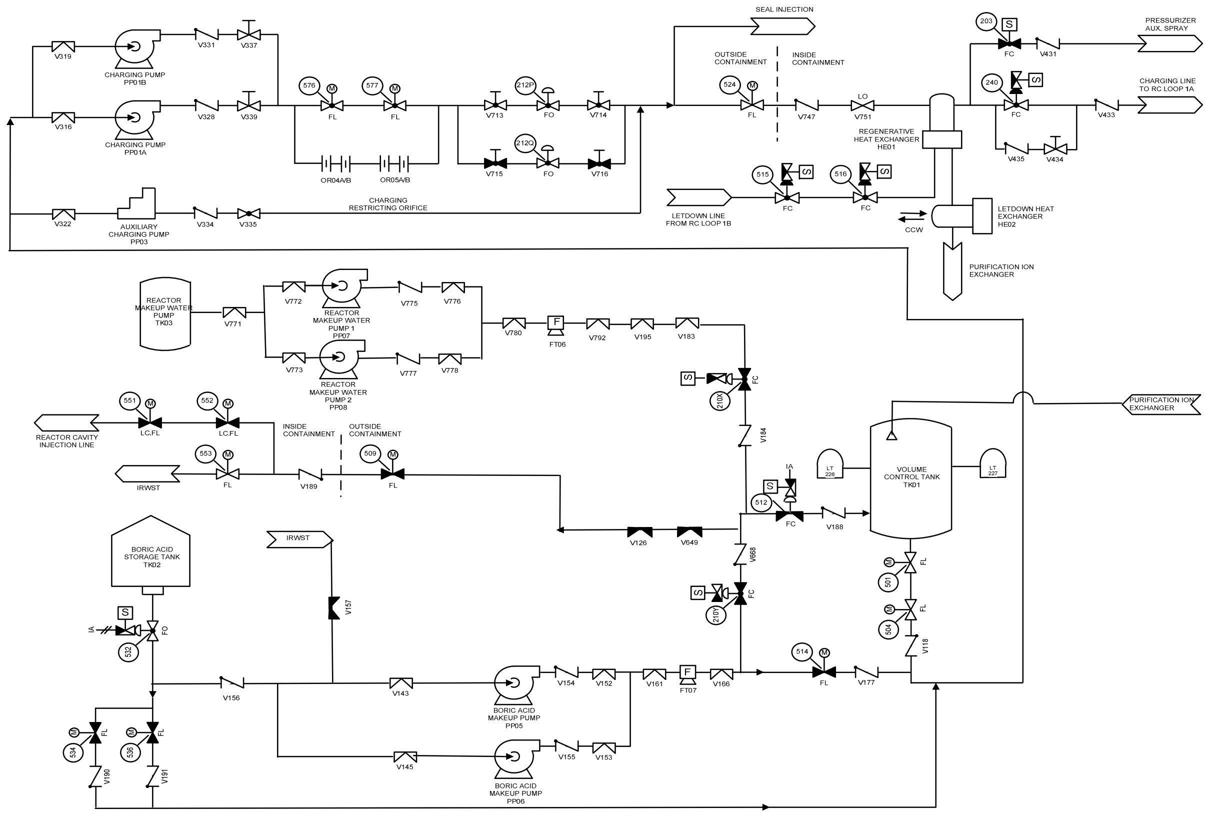

Figure 19.1-6 Simplified Diagram - Chemical and Volume Control System

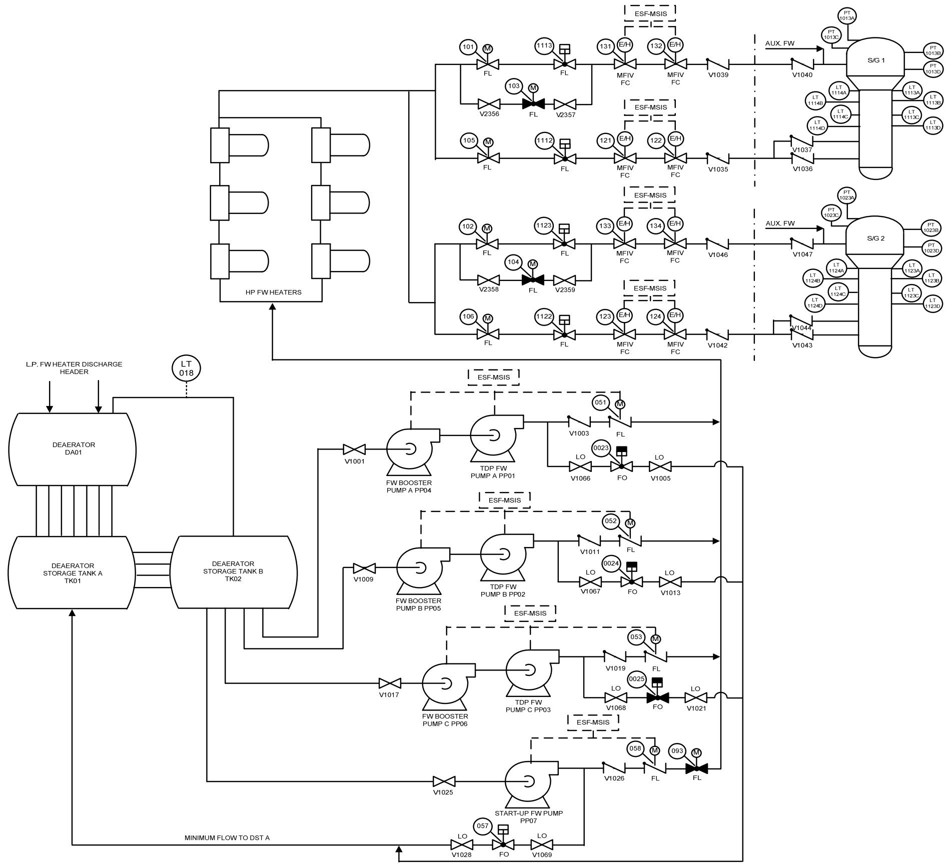

Figure 19.1-7 Simplified Diagram - Feedwater System

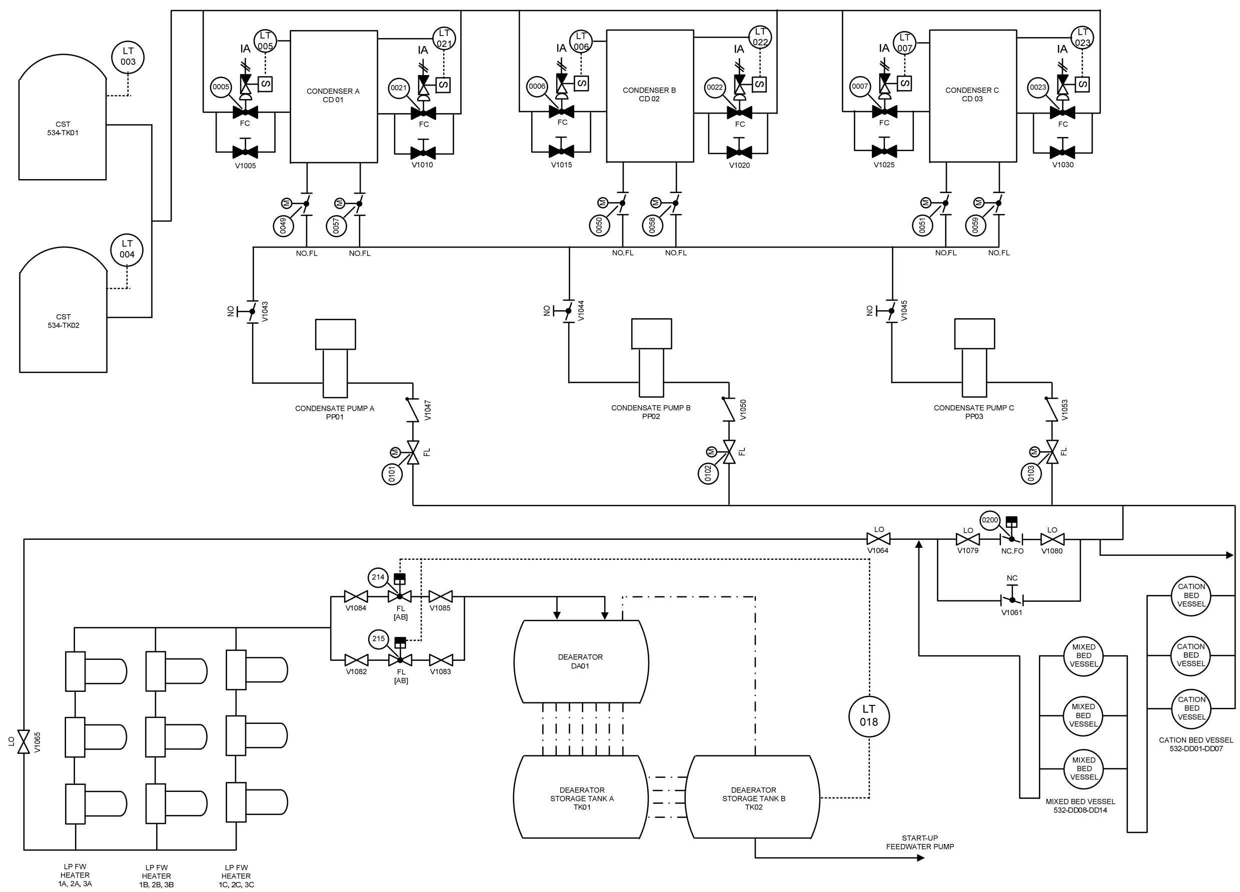

Figure 19.1-8 Simplified Diagram - Condensate System and Condensate Storage and Transfer System

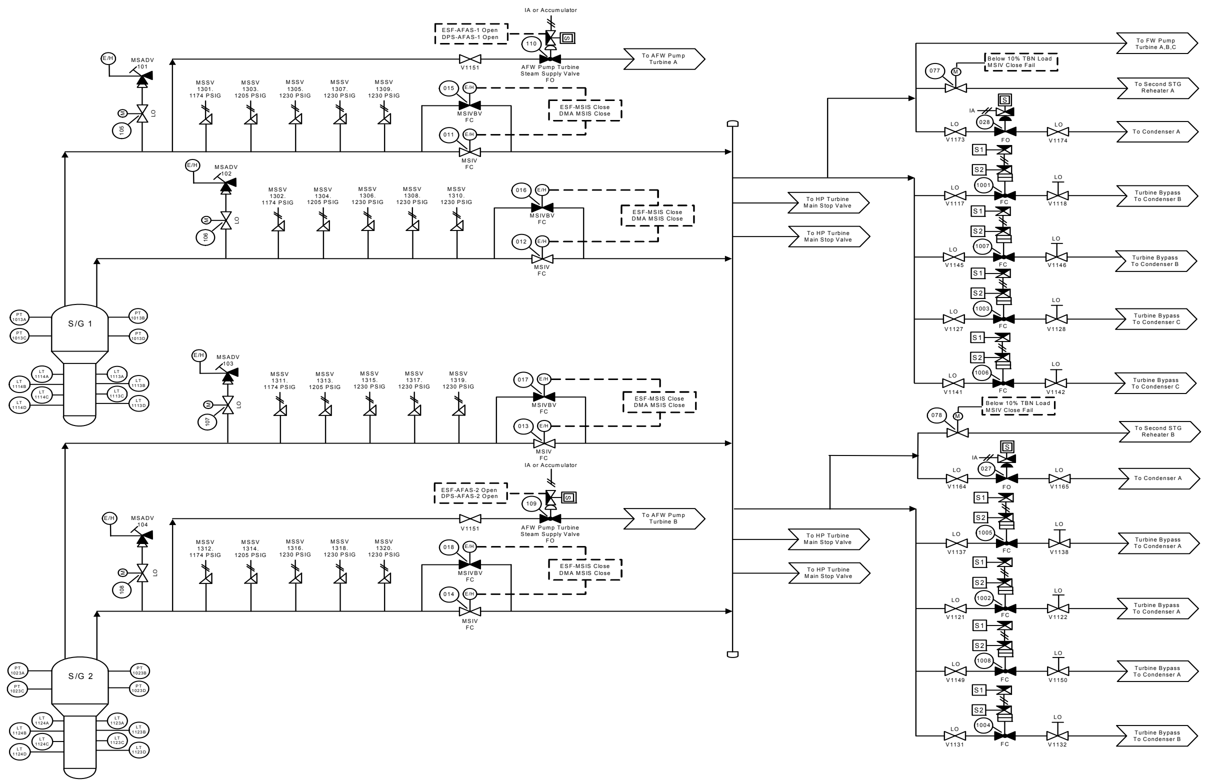

Figure 19.1-9 Simplified Diagram - Main Steam System

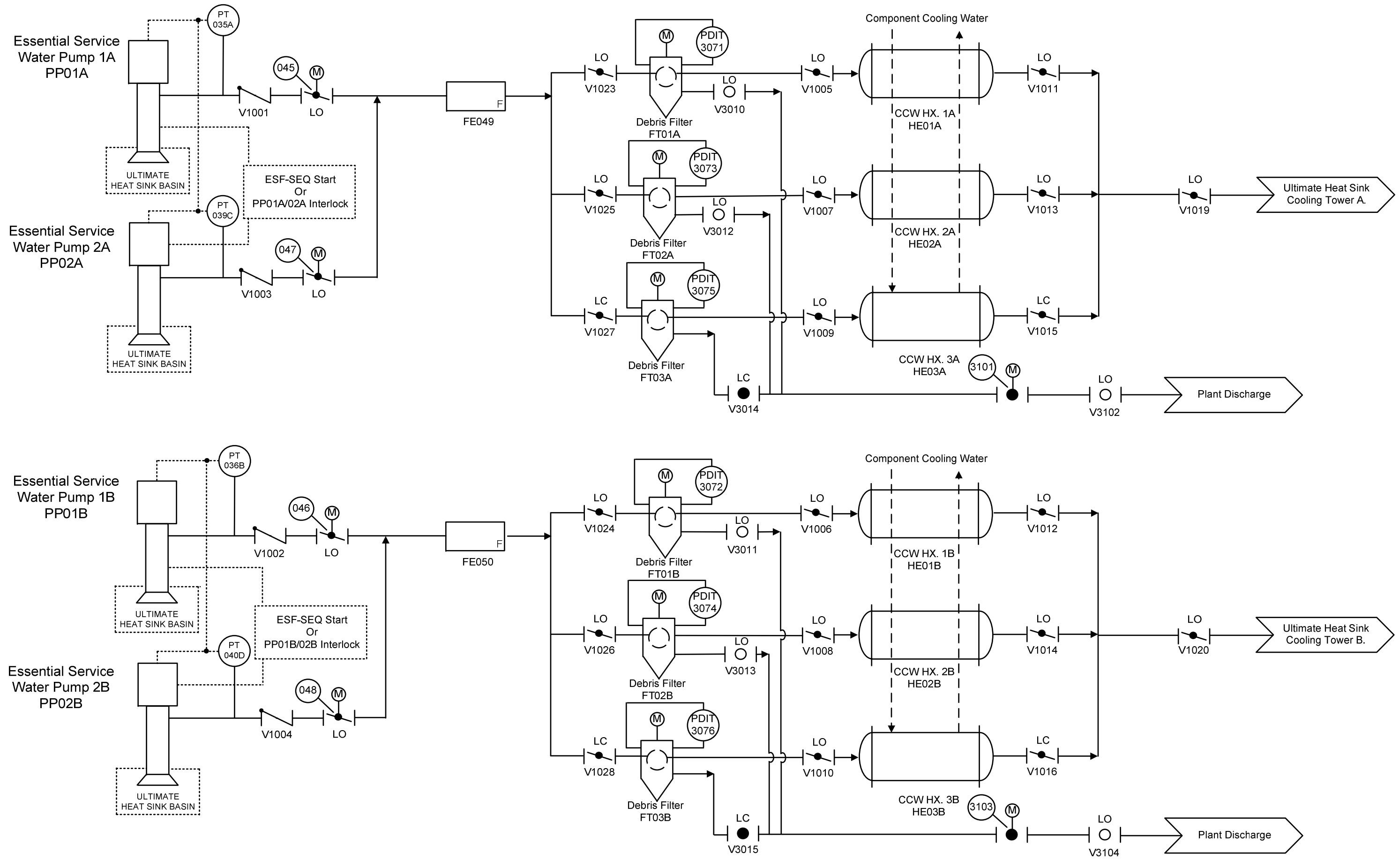

Figure 19.1-10 Simplified Diagram - Essential Service Water System

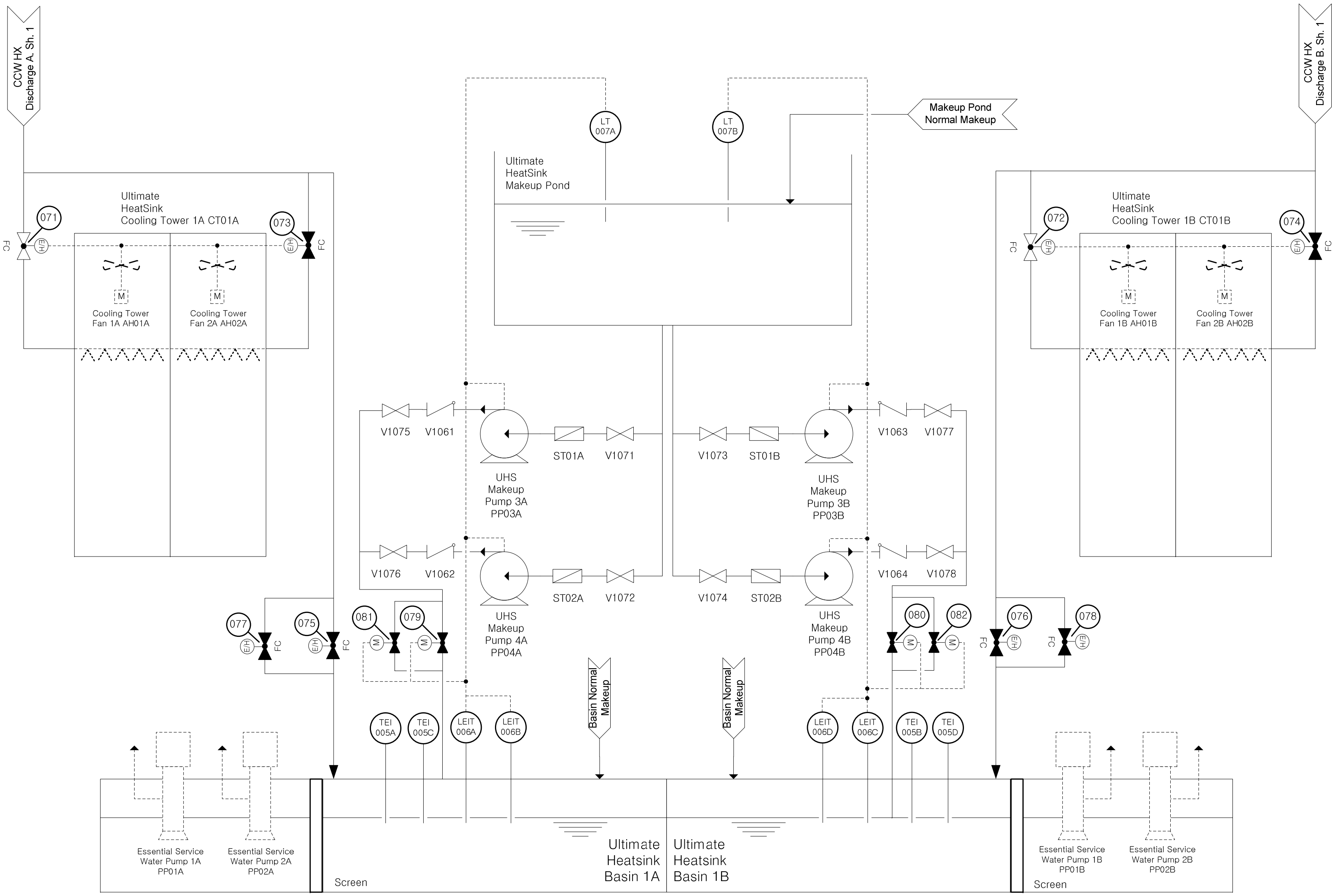

Figure 19.1-11   Simplified Diagram - Ultimate Heat Sink

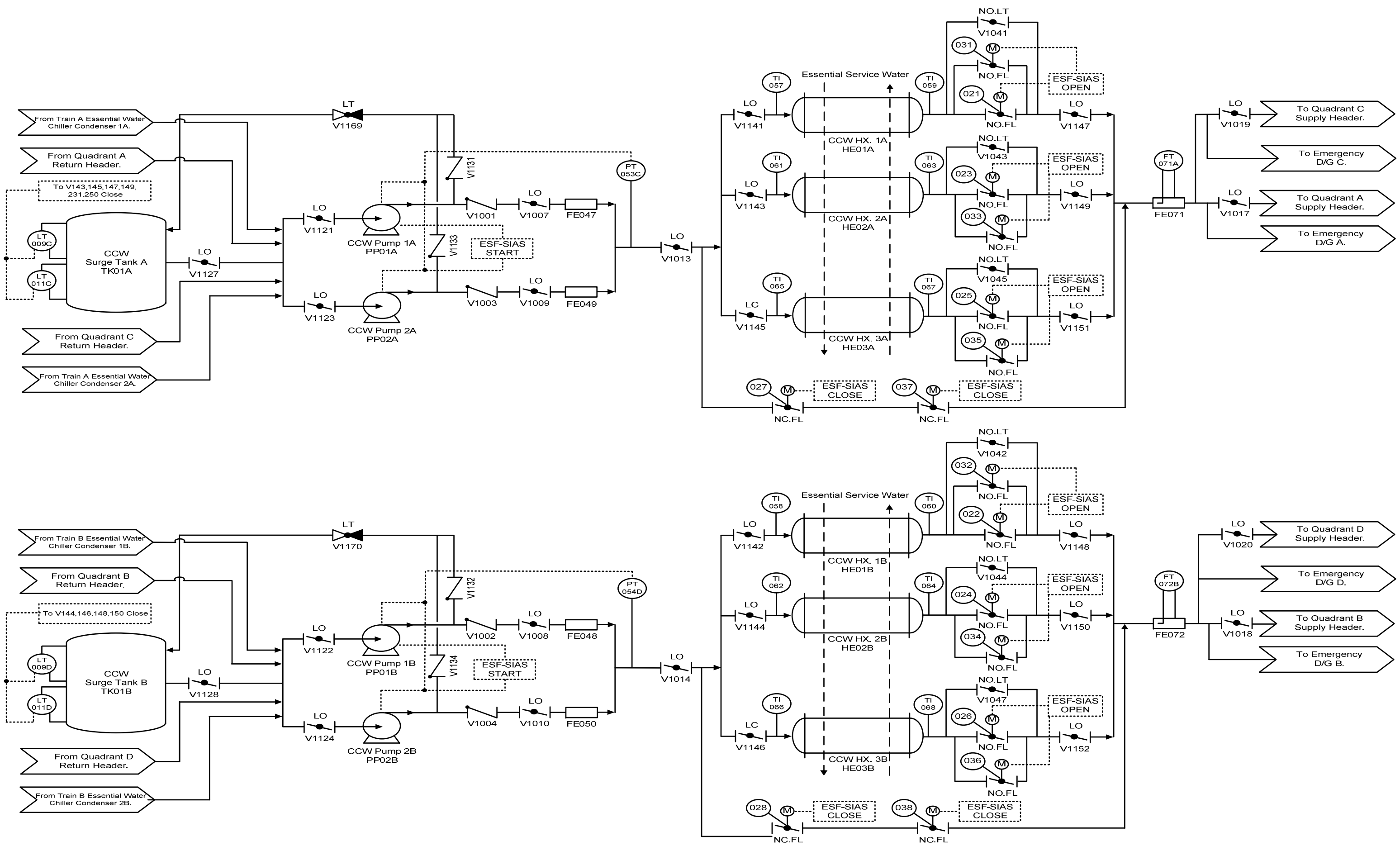

Figure 19.1-12   Simplified Diagram - Component Cooling Water System

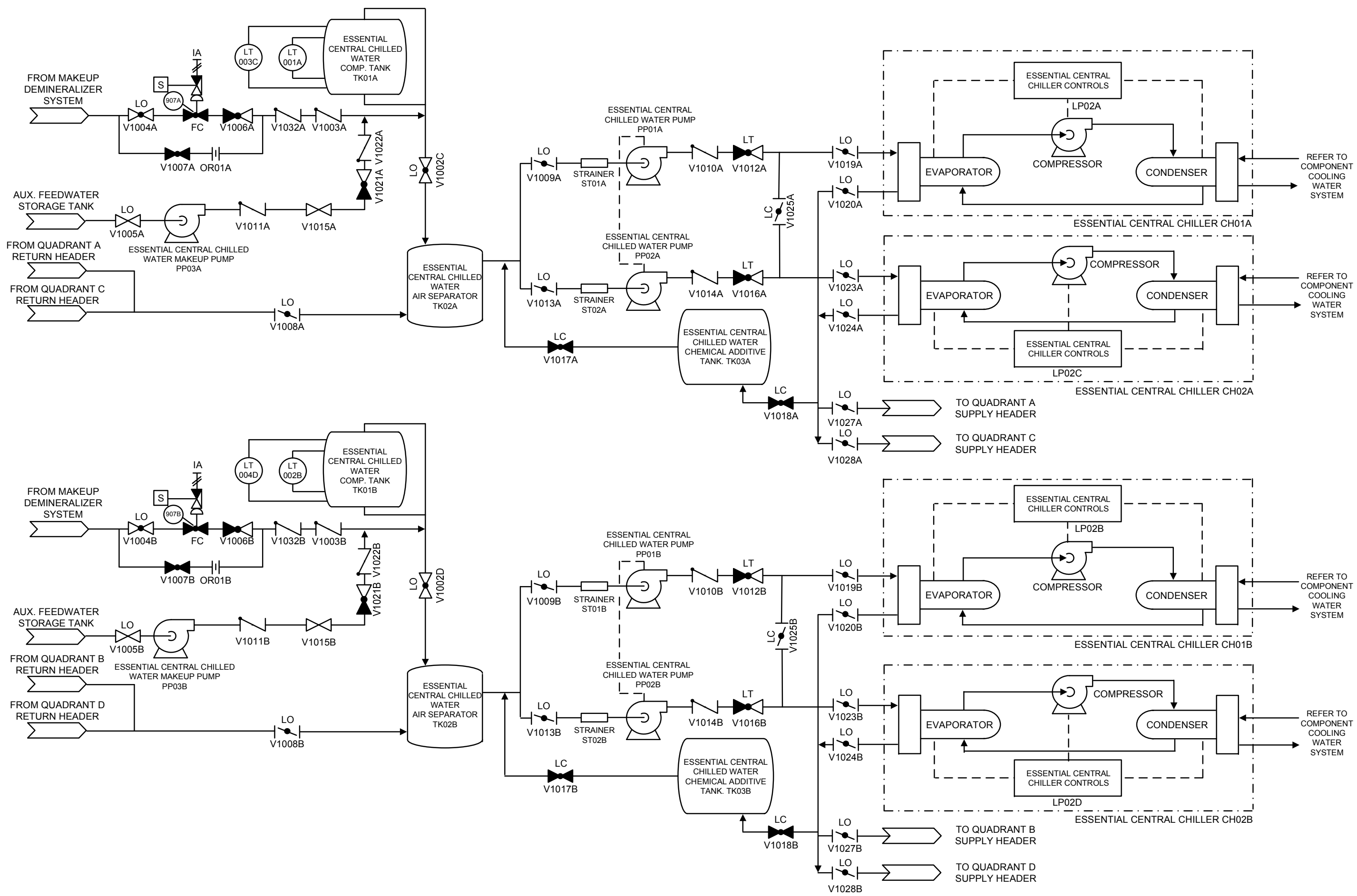

Figure 19.1-13 Simplified Diagram - Essential Chilled Water System

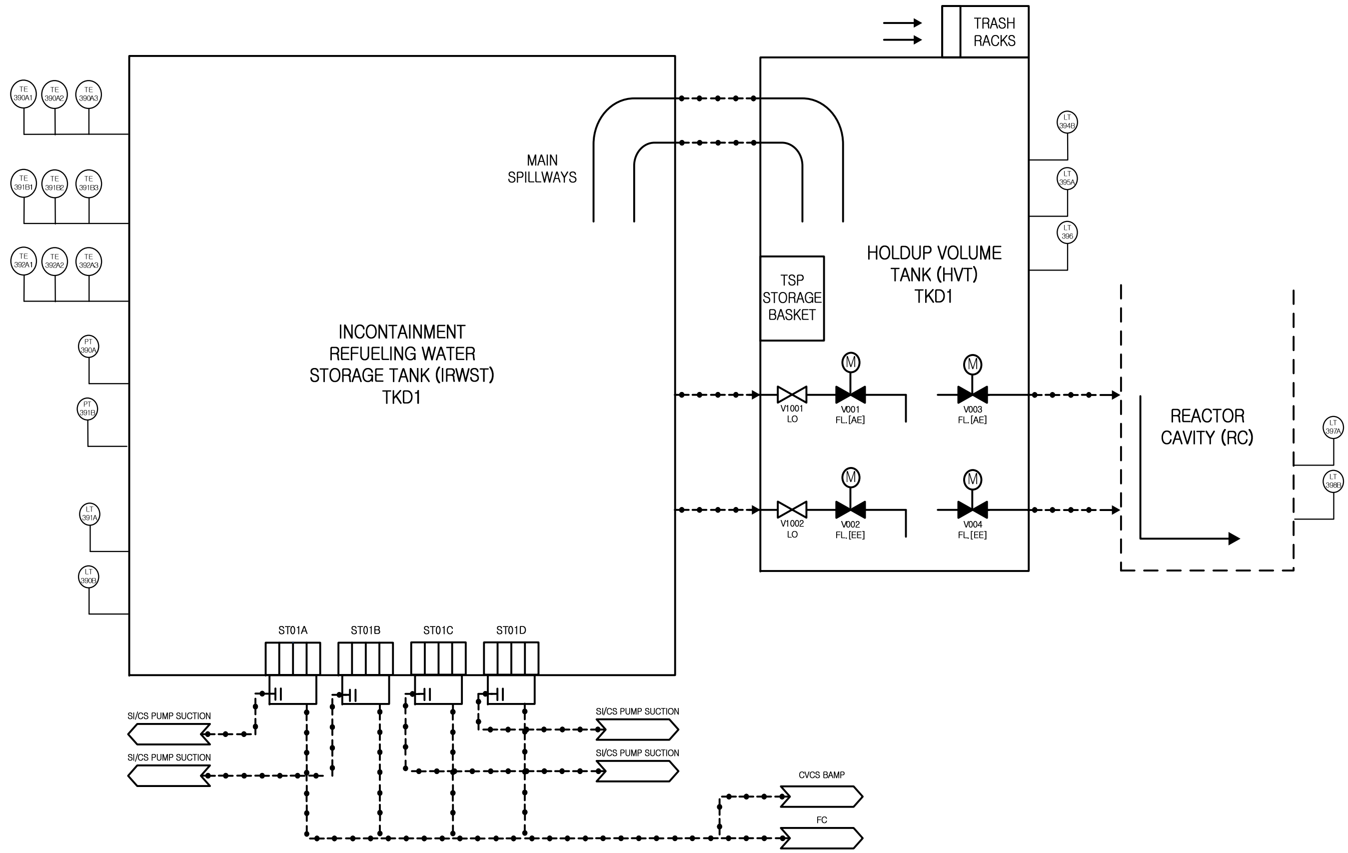

Figure 19.1-14 Simplified Diagram - IRWST, HVT and CFS

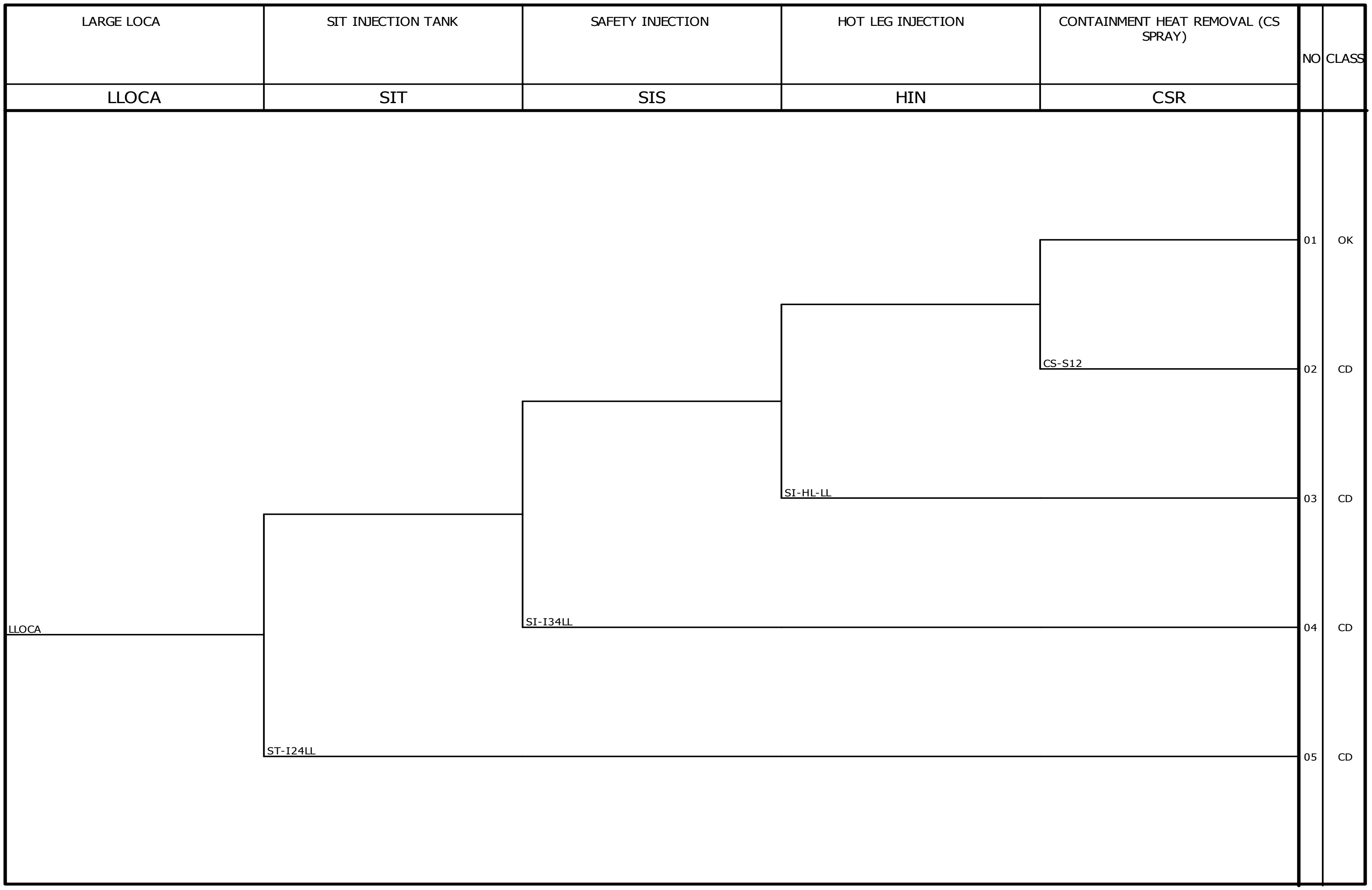

Figure 19.1-15 Level 1 Event Tree - Large LOCA (LLOCA)

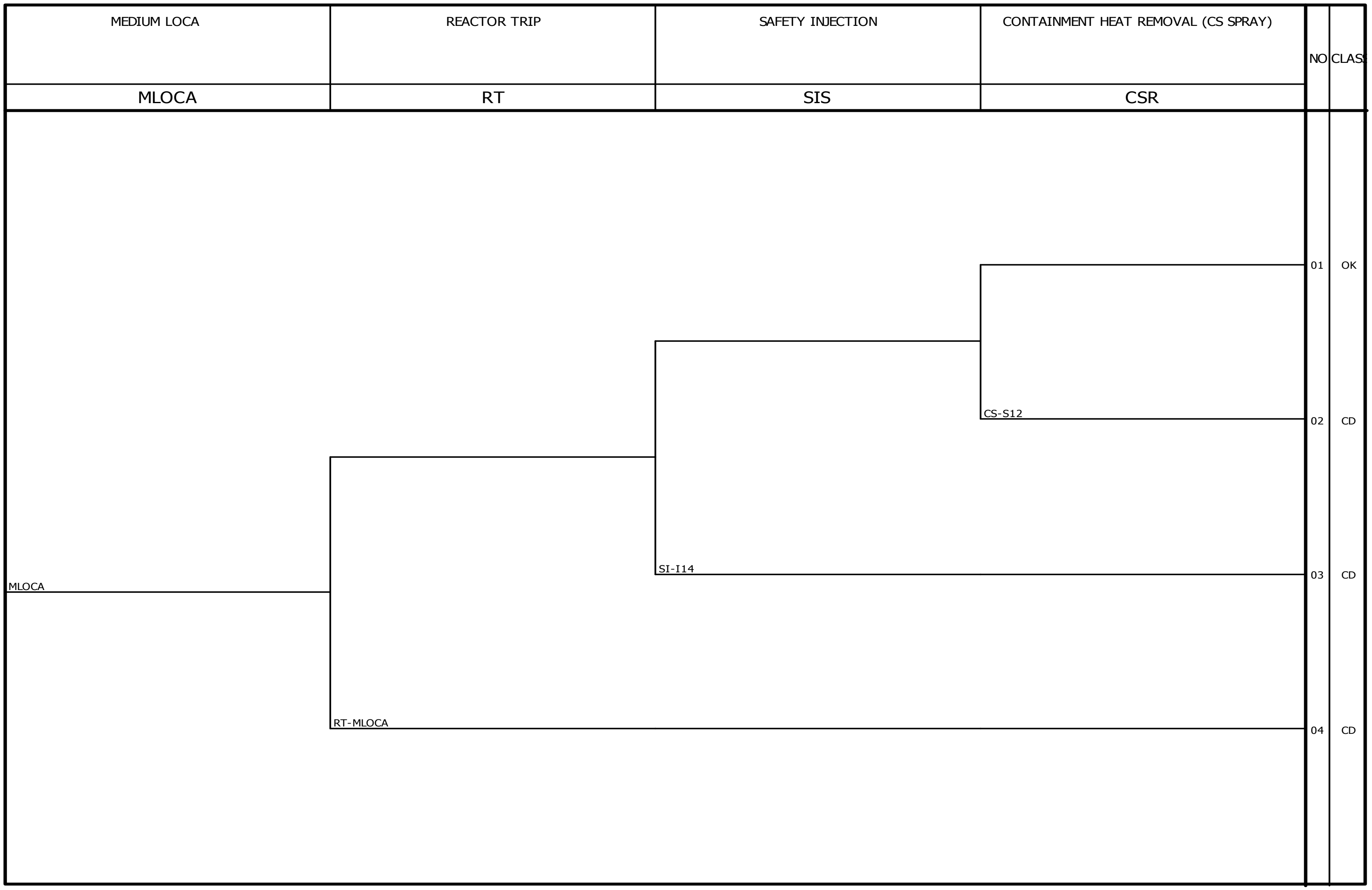

Figure 19.1-16 Level 1 Event Tree - Medium LOCA (MLOCA)

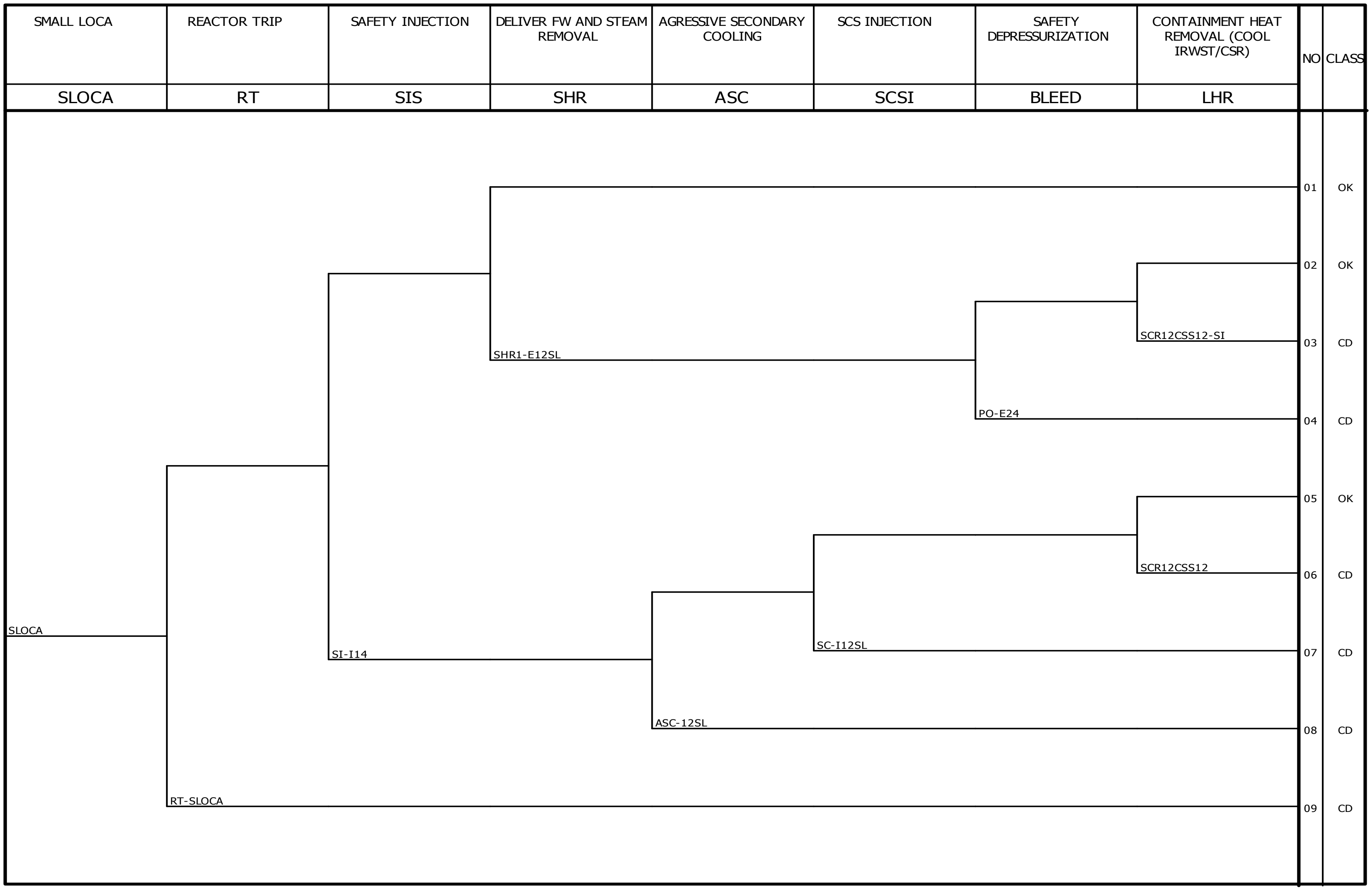

Figure 19.1-17   Level 1 Event Tree - Small LOCA (SLOCA)

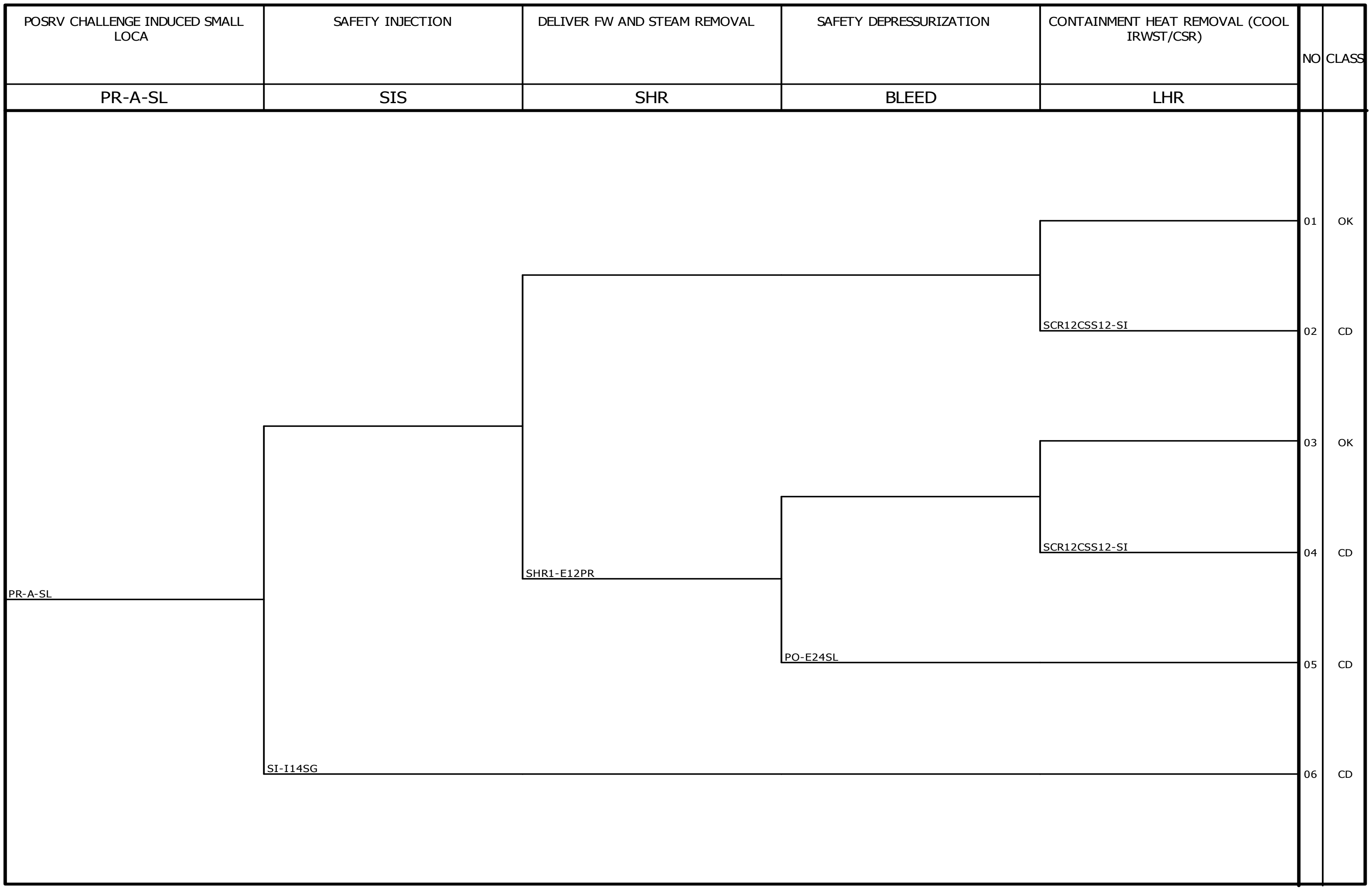

Figure 19.1-18 Level 1 Event Tree - Stuck Open POSRVs (PR-SL)

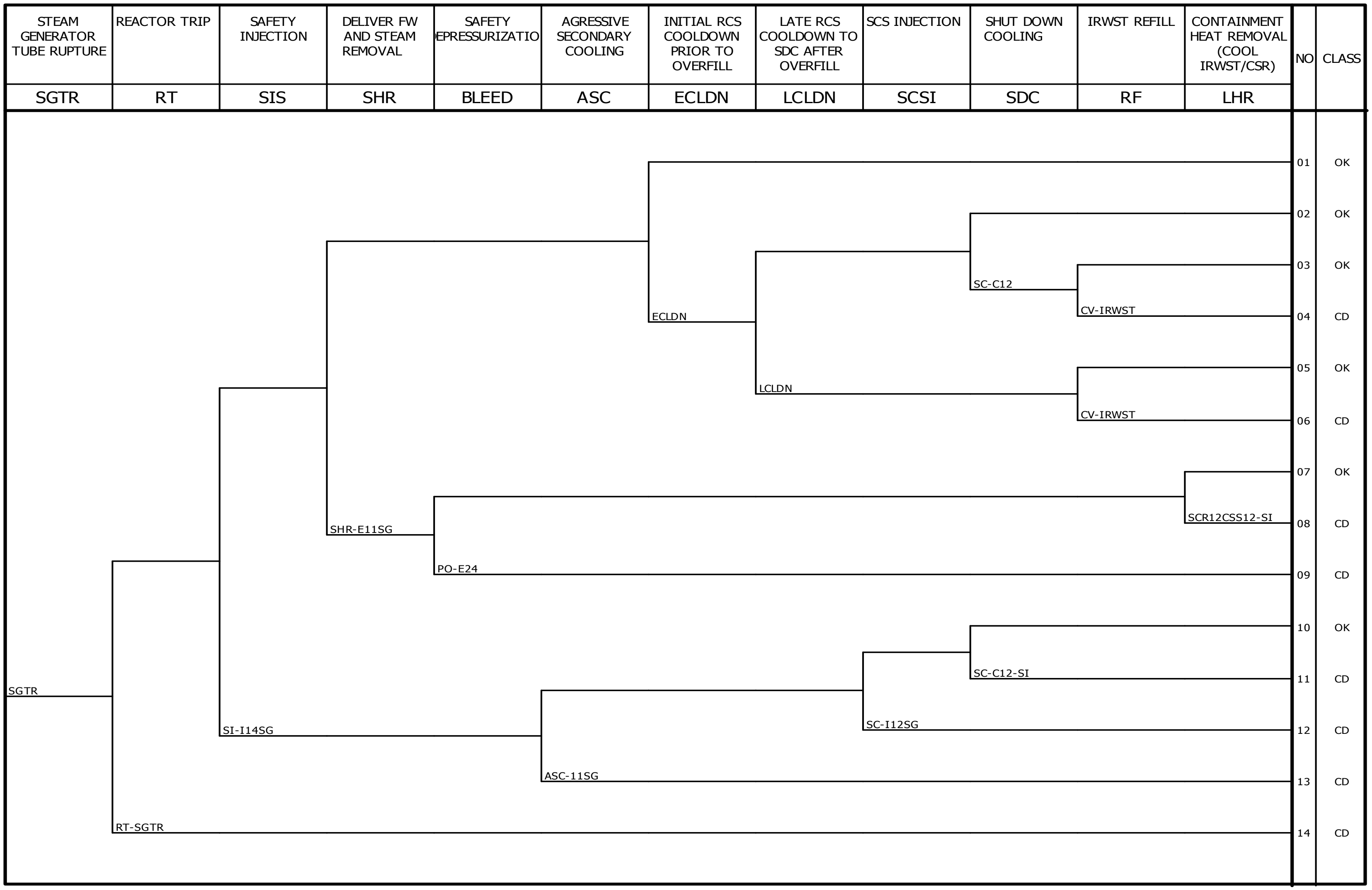

Figure 19.1-19 Level 1 Event Tree - Steam Generator Tube Rupture (SGTR)

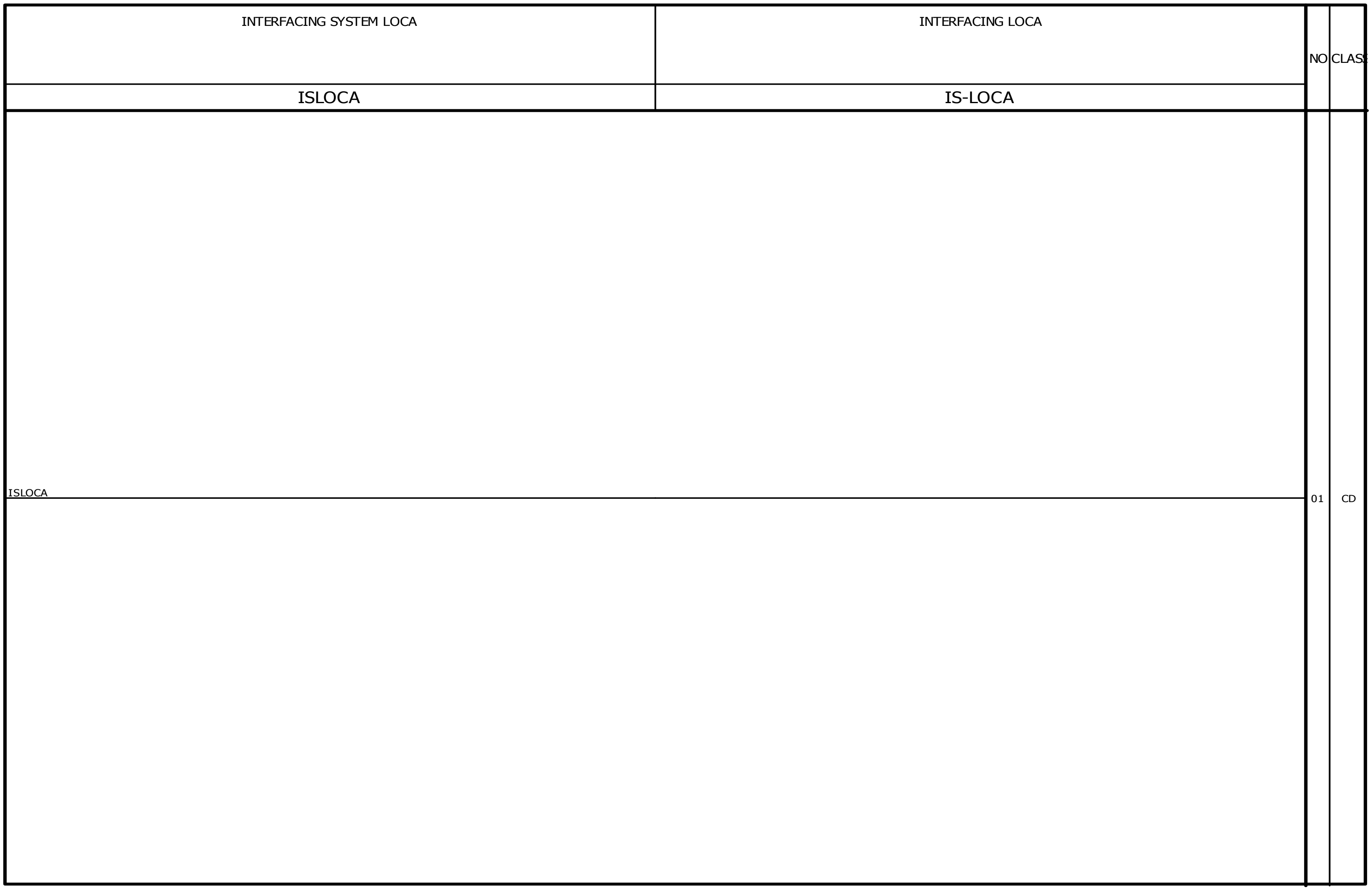

Figure 19.1-20 Level 1 Event Tree - Interfacing System LOCA (ISLOCA)

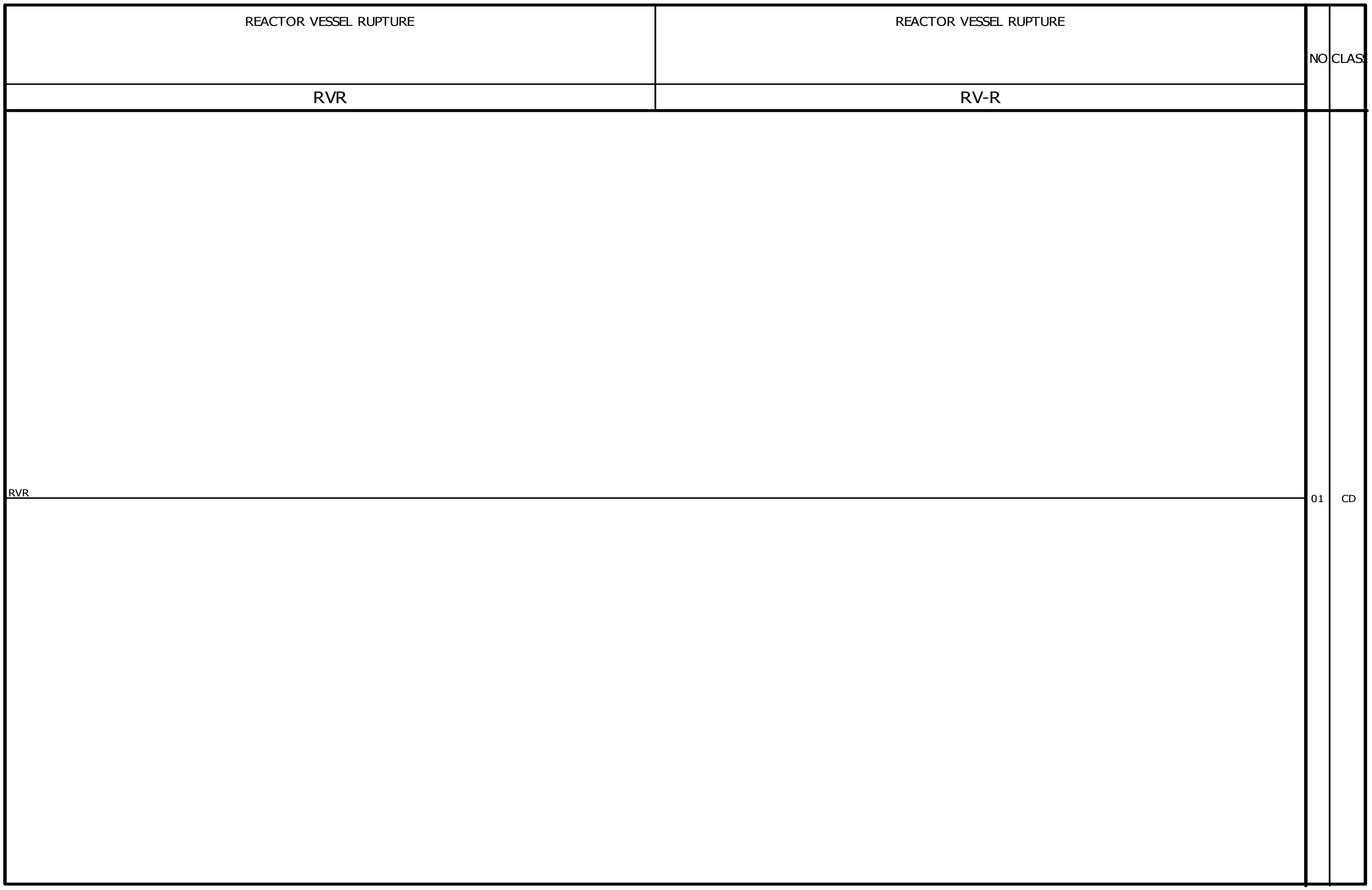

Figure 19.1-21   Level 1 Event Tree - Reactor Vessel Rupture (RVR)

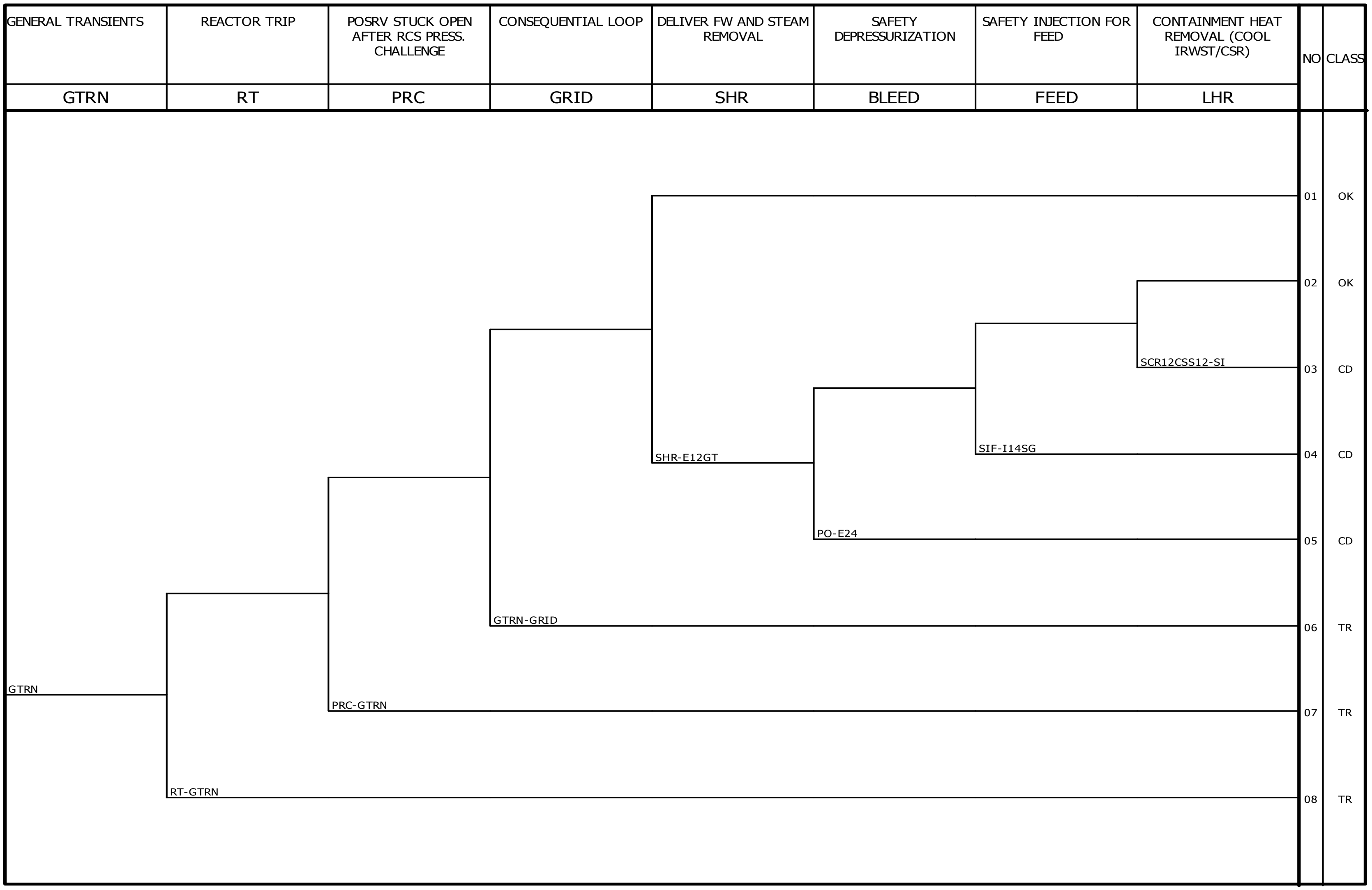

Figure 19.1-22 Level 1 Event Tree - General Transient (GTRN)

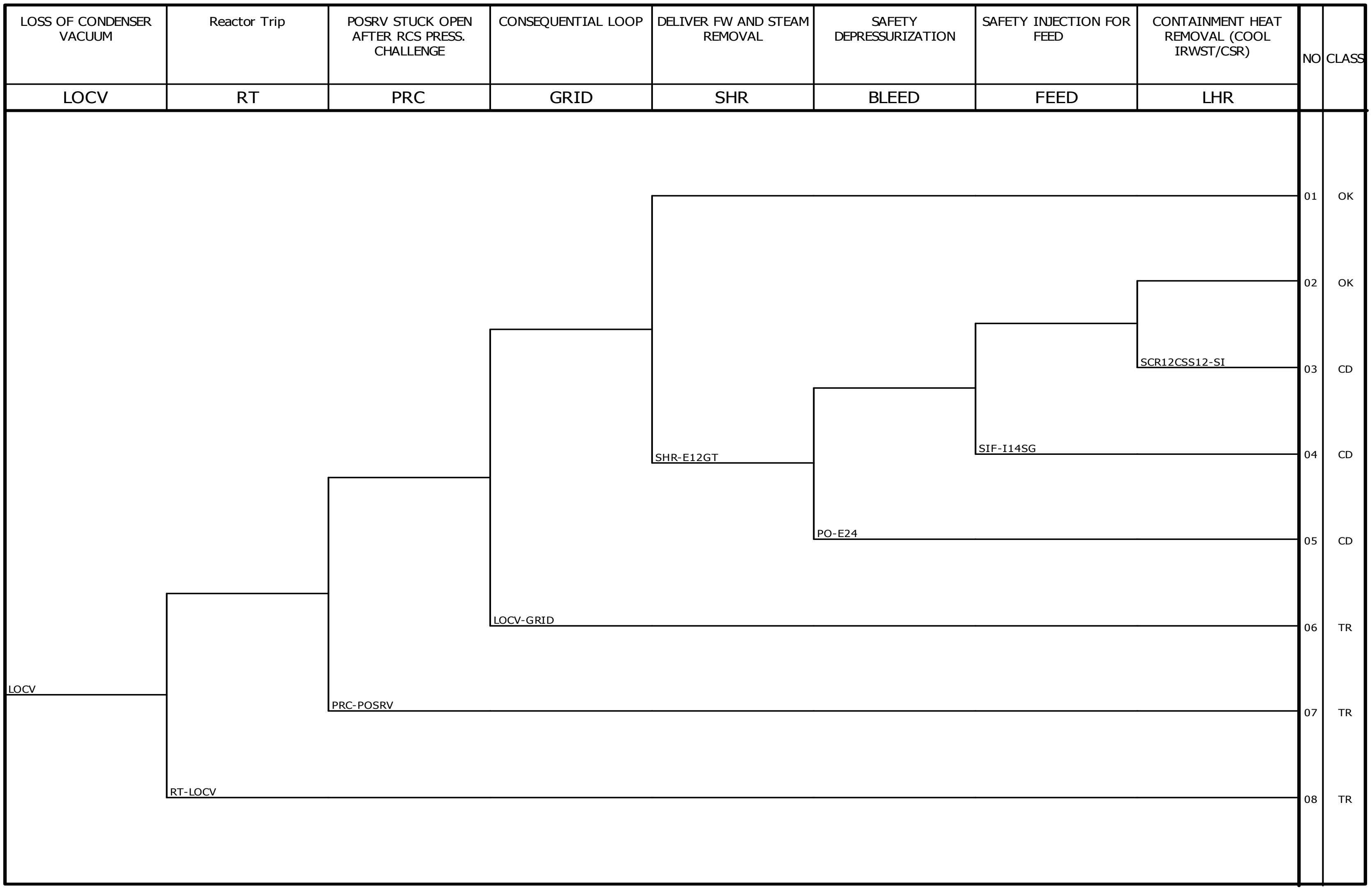

Figure 19.1-23 Level 1 Event Tree - Loss of Condenser Vacuum (LOCV)

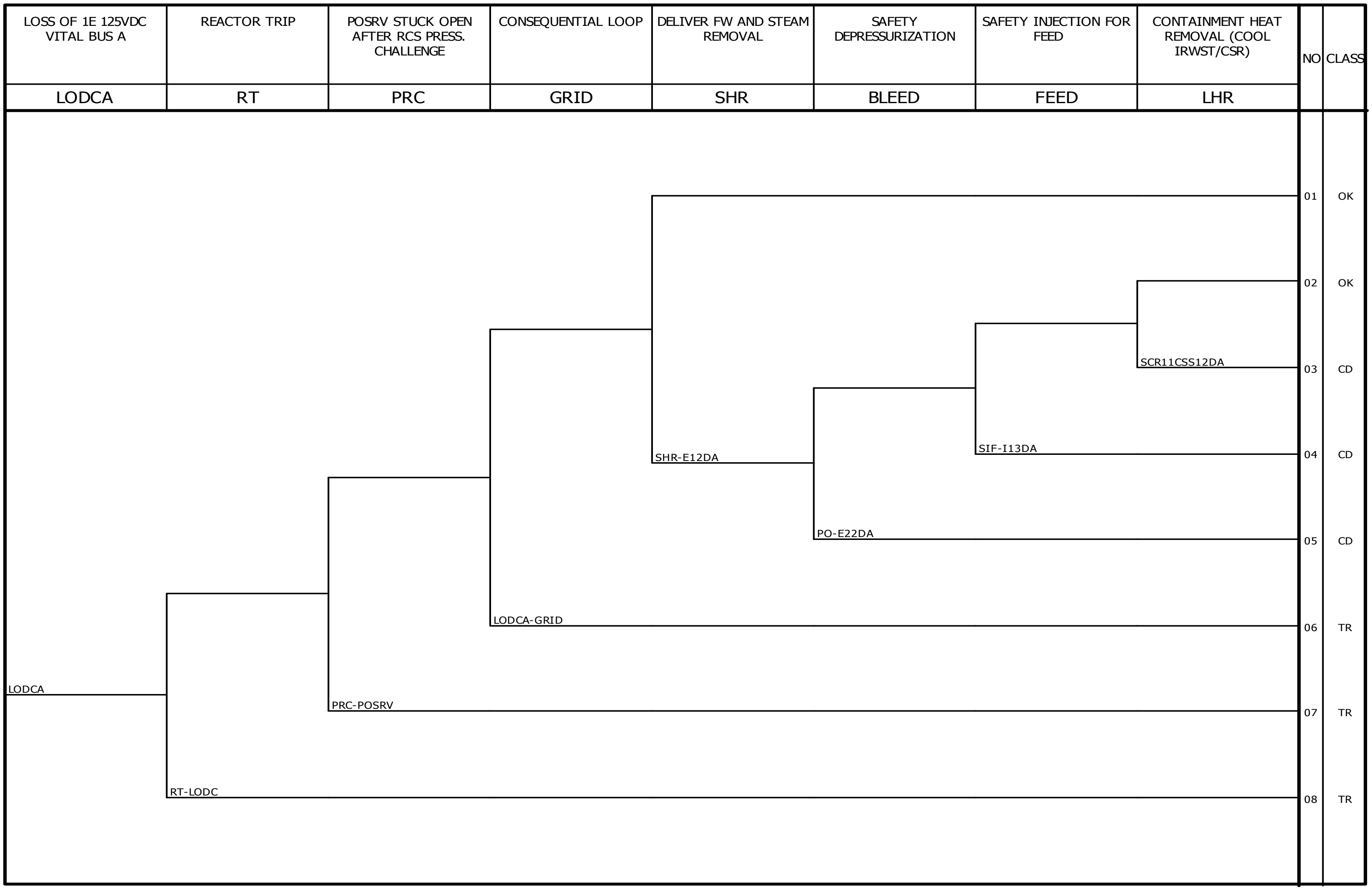

Figure 19.1-24 Level 1 Event Tree - Loss of 125V DC - Bus A (LODCA)

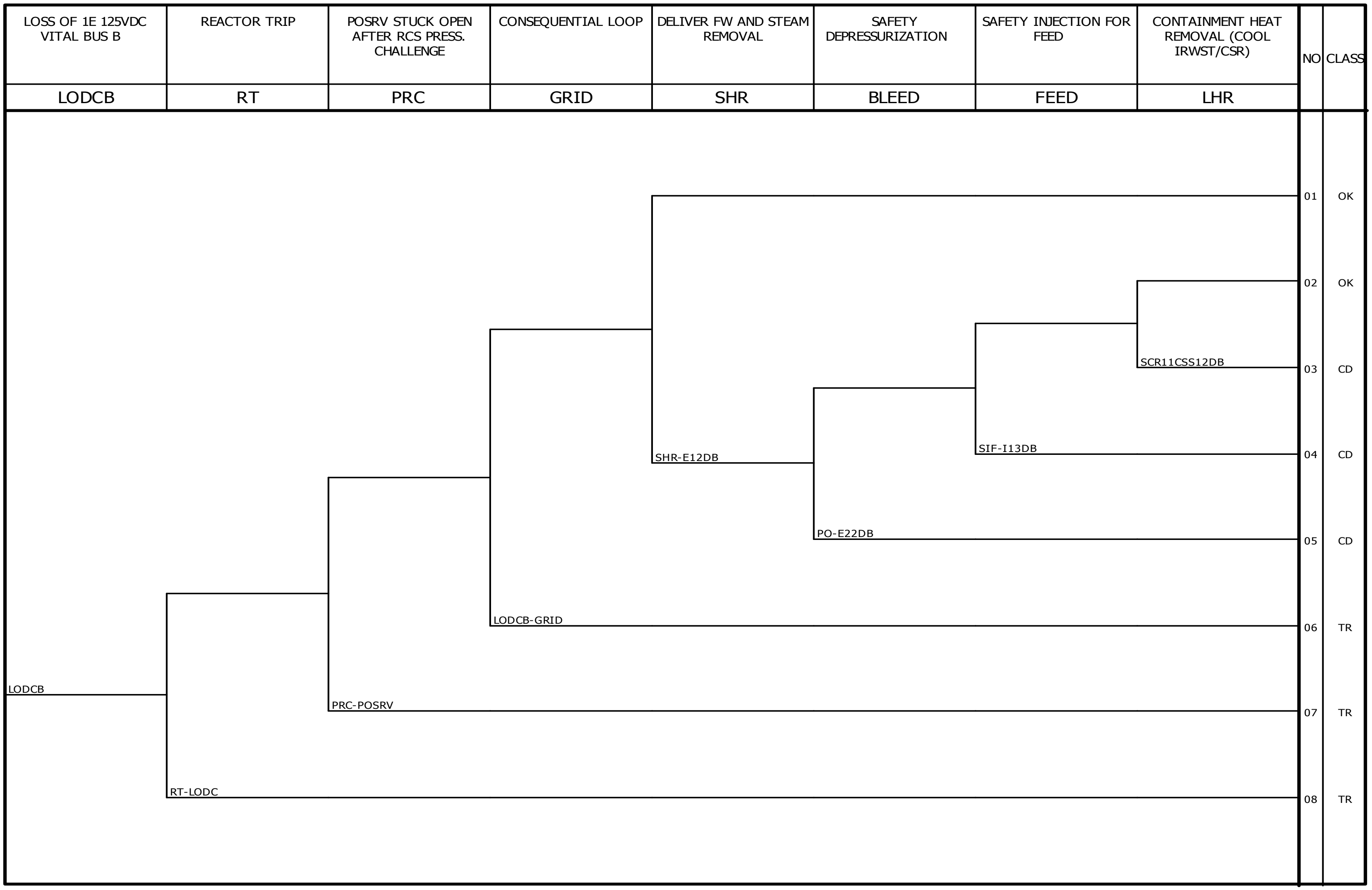

Figure 19.1-25 Level 1 Event Tree - Loss of 125V DC - Bus B (LODCB)

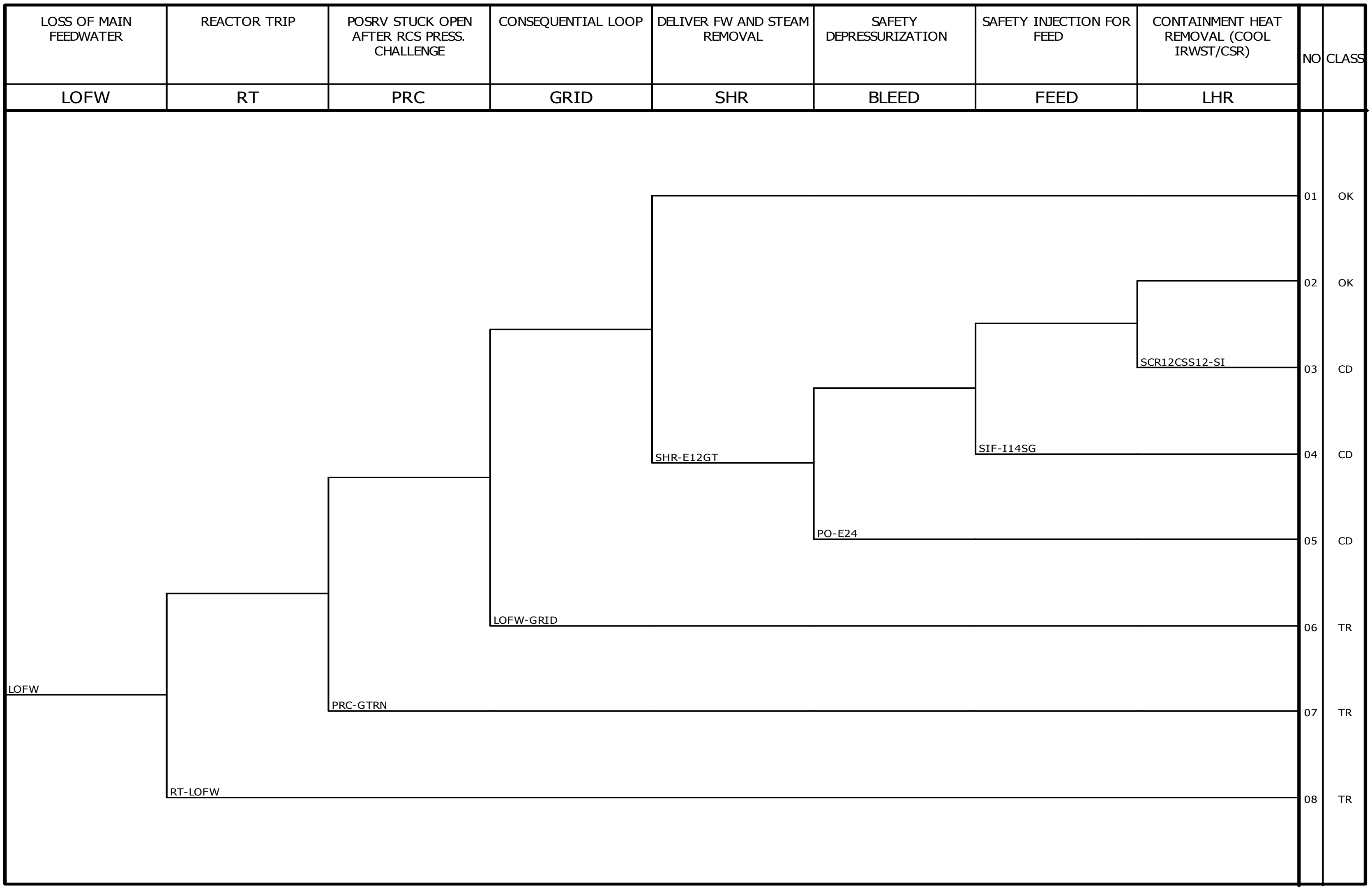

Figure 19.1-26 Level 1 Event Tree - Loss of Feedwater (LOFW)

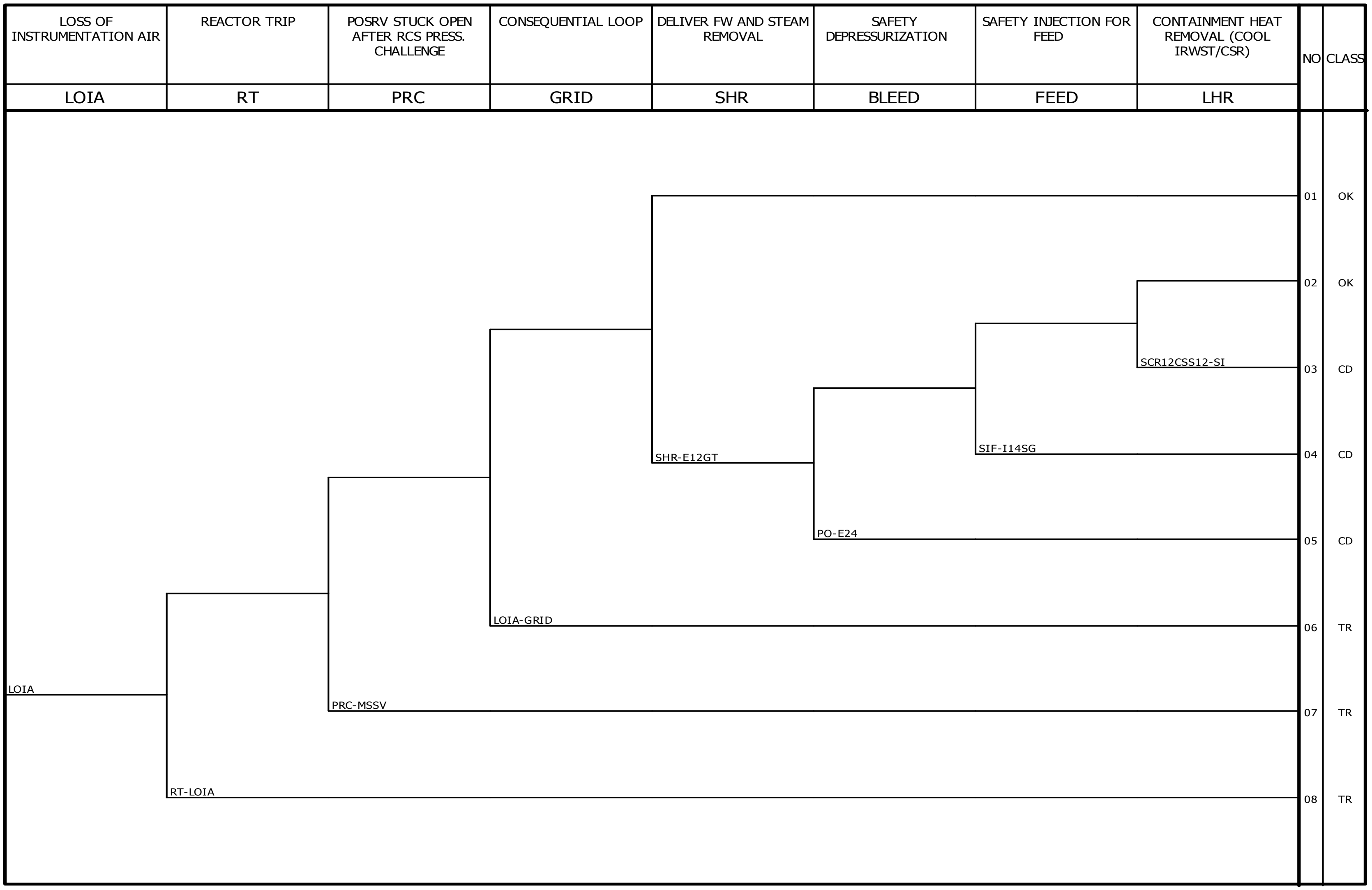

Figure 19.1-27 Level 1 Event Tree - Loss of Instrument Air (LOIA)

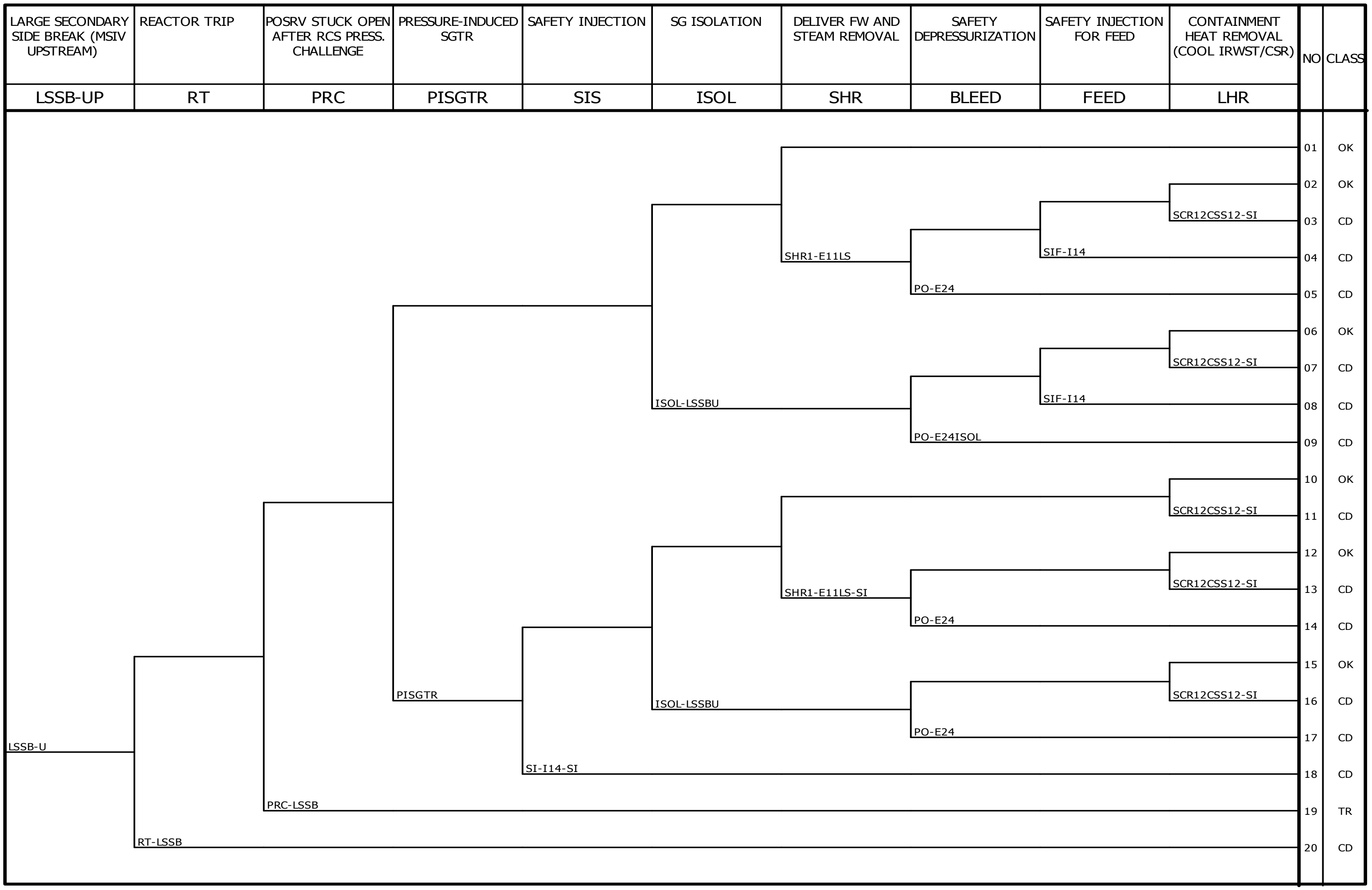

Figure 19.1-28 Level 1 Event Tree - Large Secondary Steam Line Break Upstream of MSIV (LSSB-U)

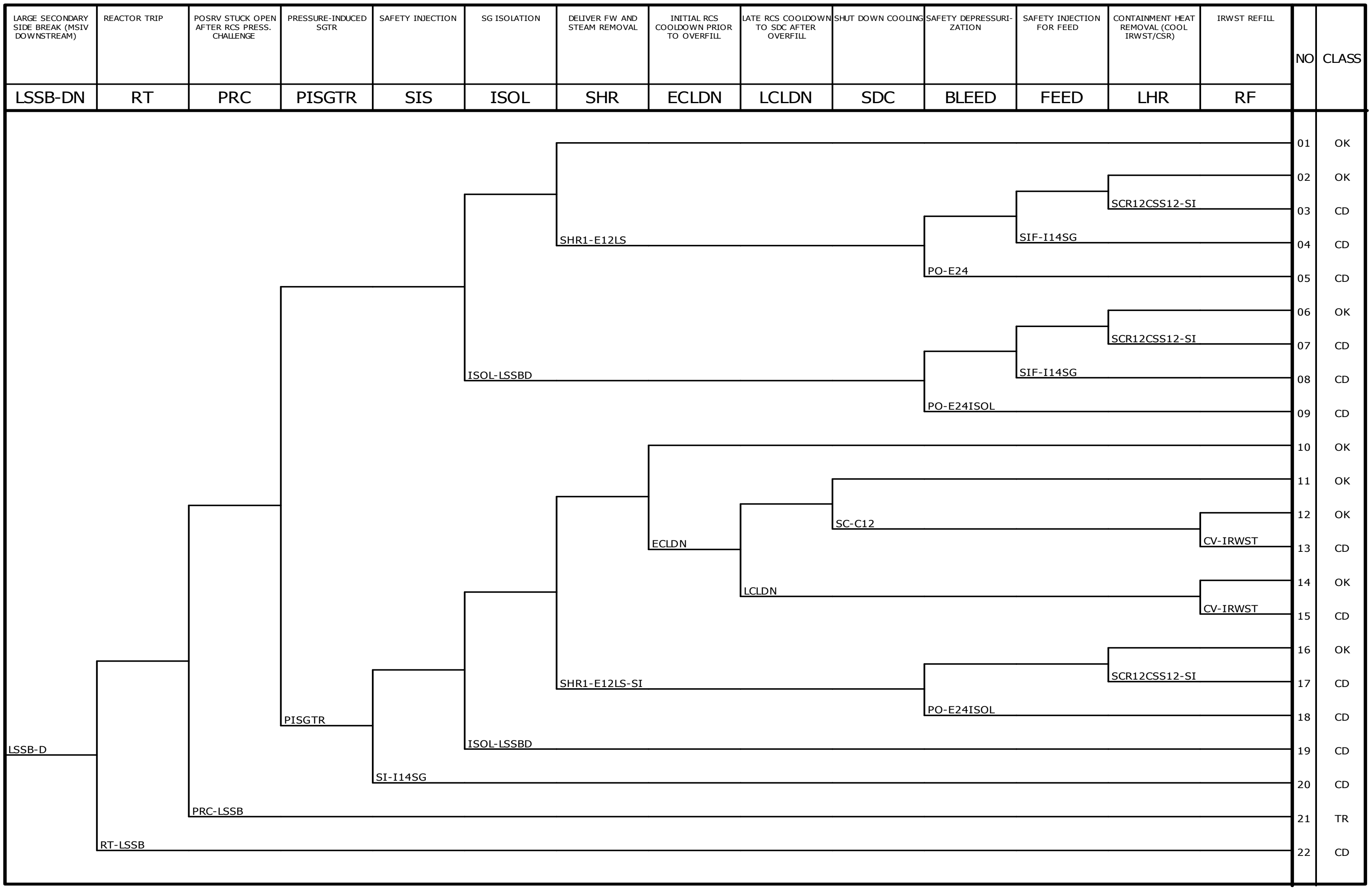

Figure 19.1-29 Level 1 Event Tree - Large Secondary Steam Line Break Downstream of MSIV (LSSB-D)

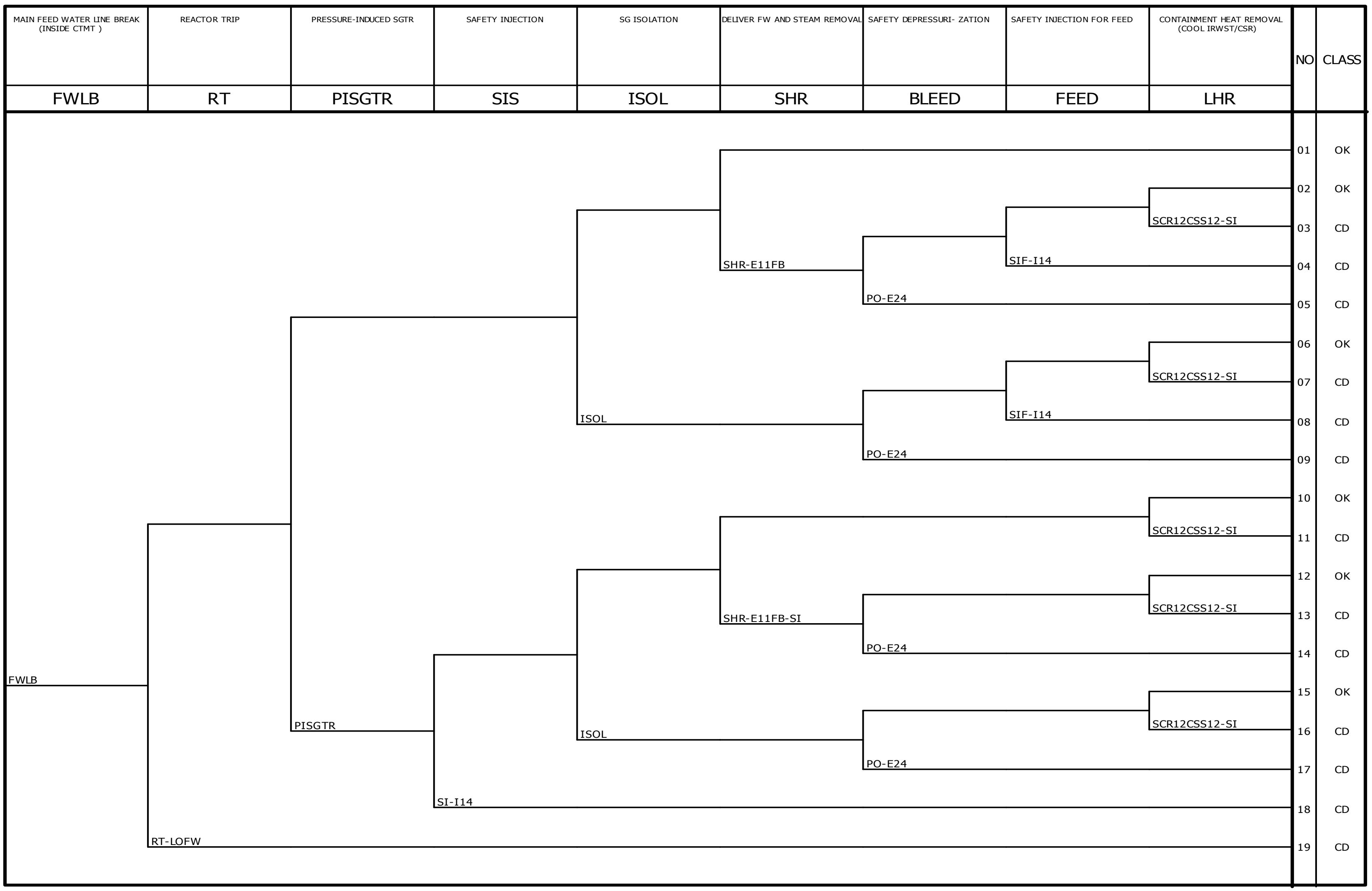

Figure 19.1-30 Level 1 Event Tree - Feedwater Line Break (FWLB)

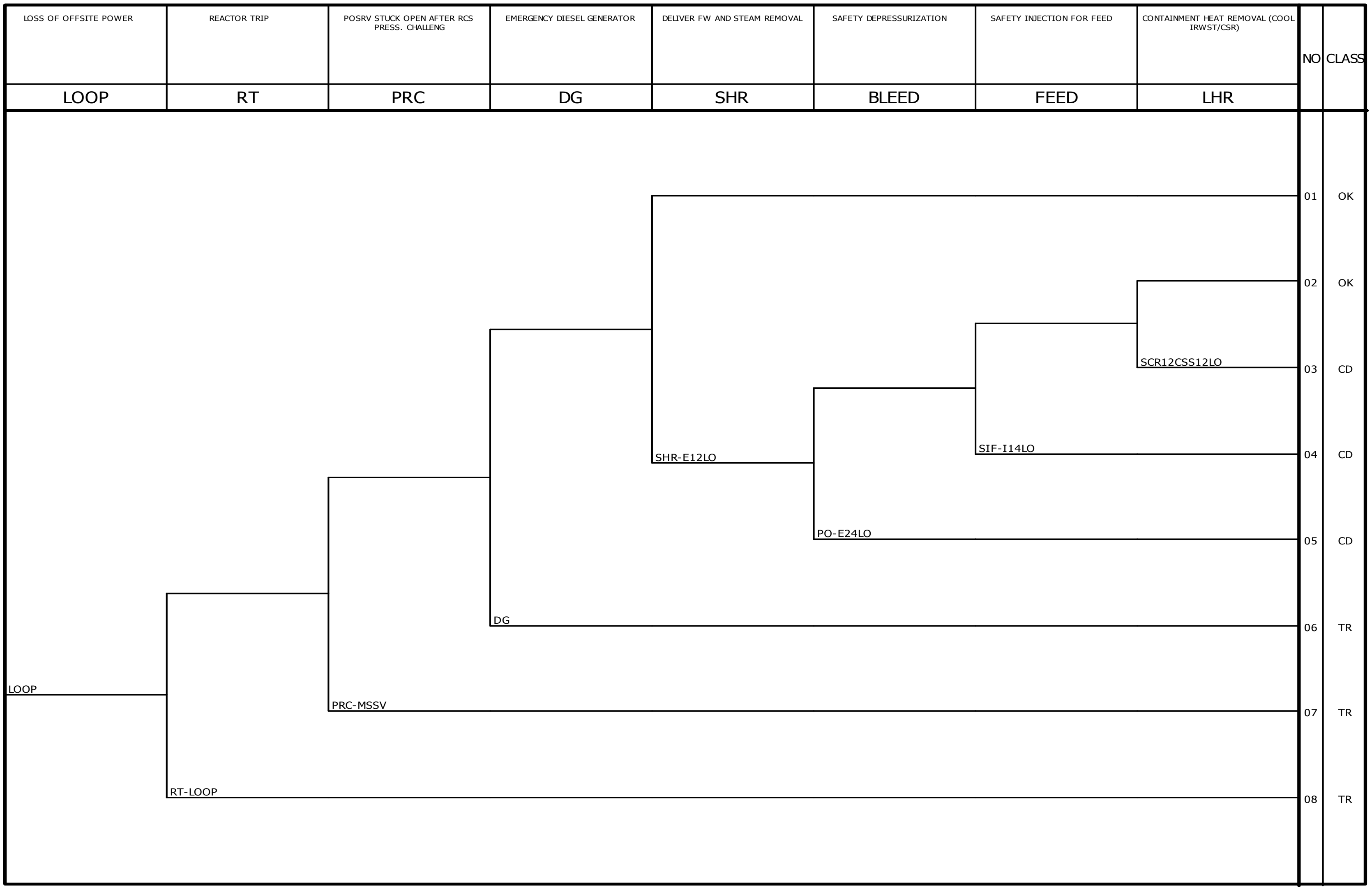

Figure 19.1-31 Level 1 Event Tree - Loss of Offsite Power (LOOP)

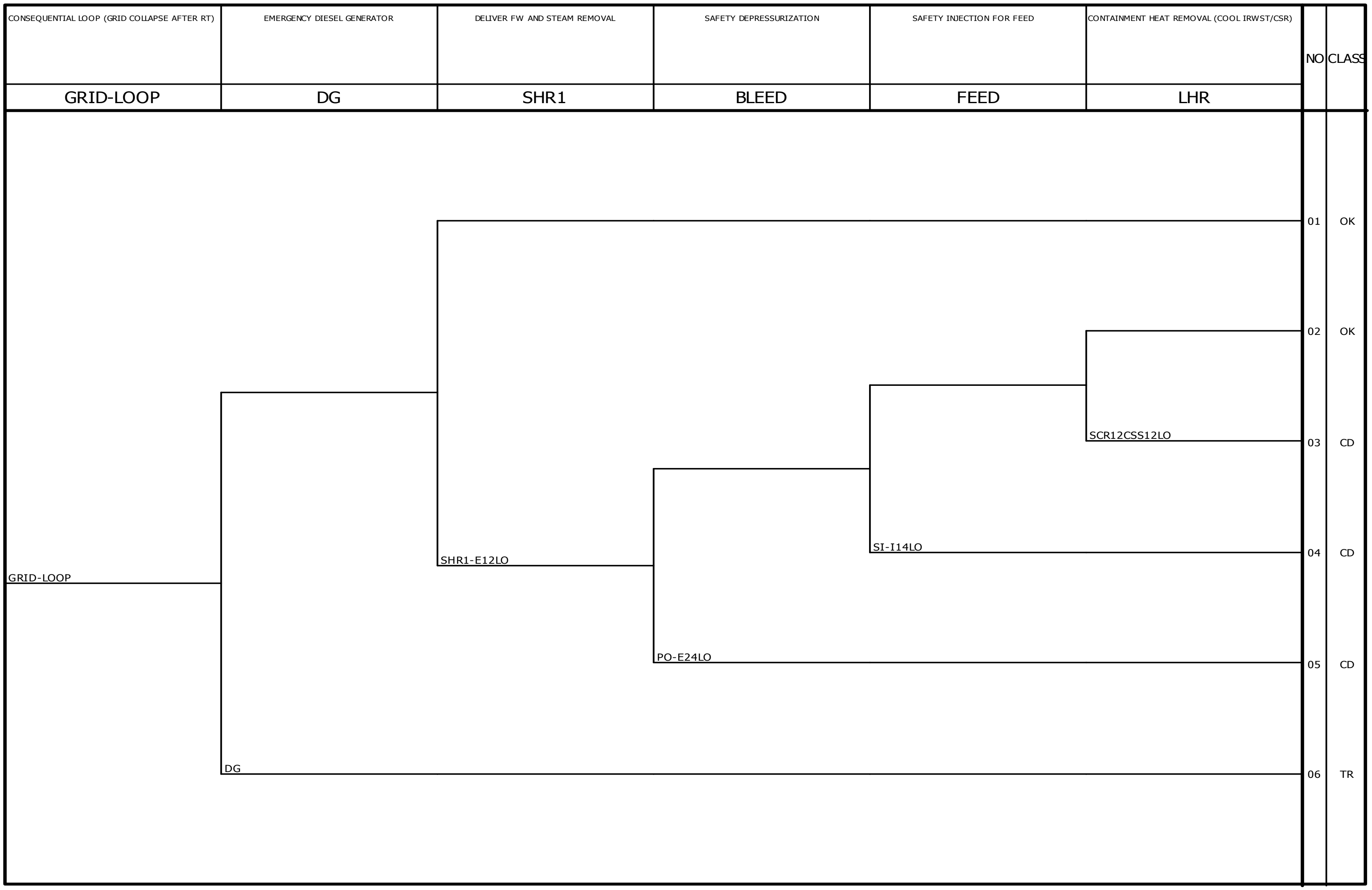

Figure 19.1-32 Level 1 Event Tree - Consequential LOOP (GRID-LOOP)

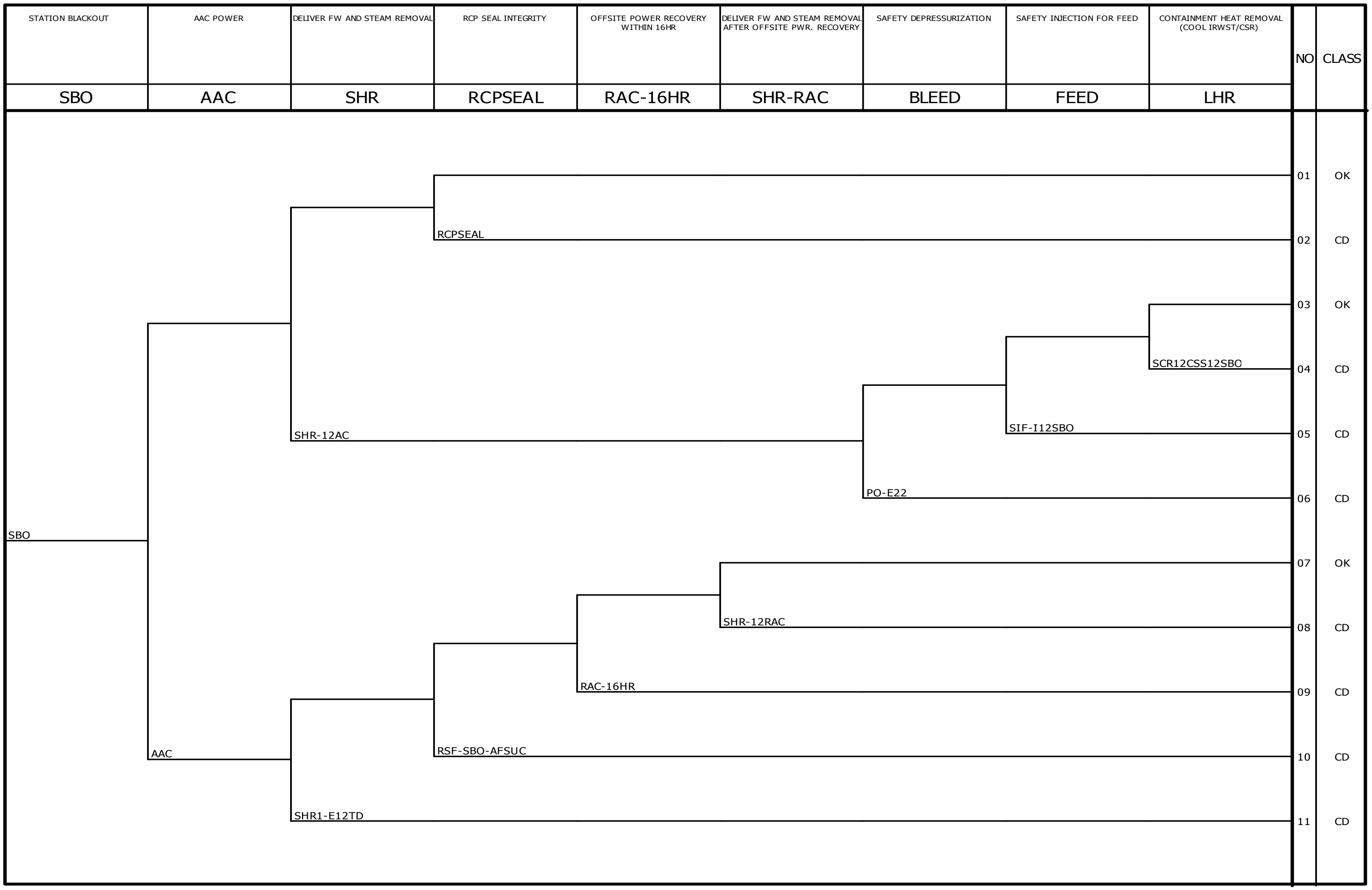

Figure 19.1-33 Level 1 Event Tree - Station Blackout (SBO)

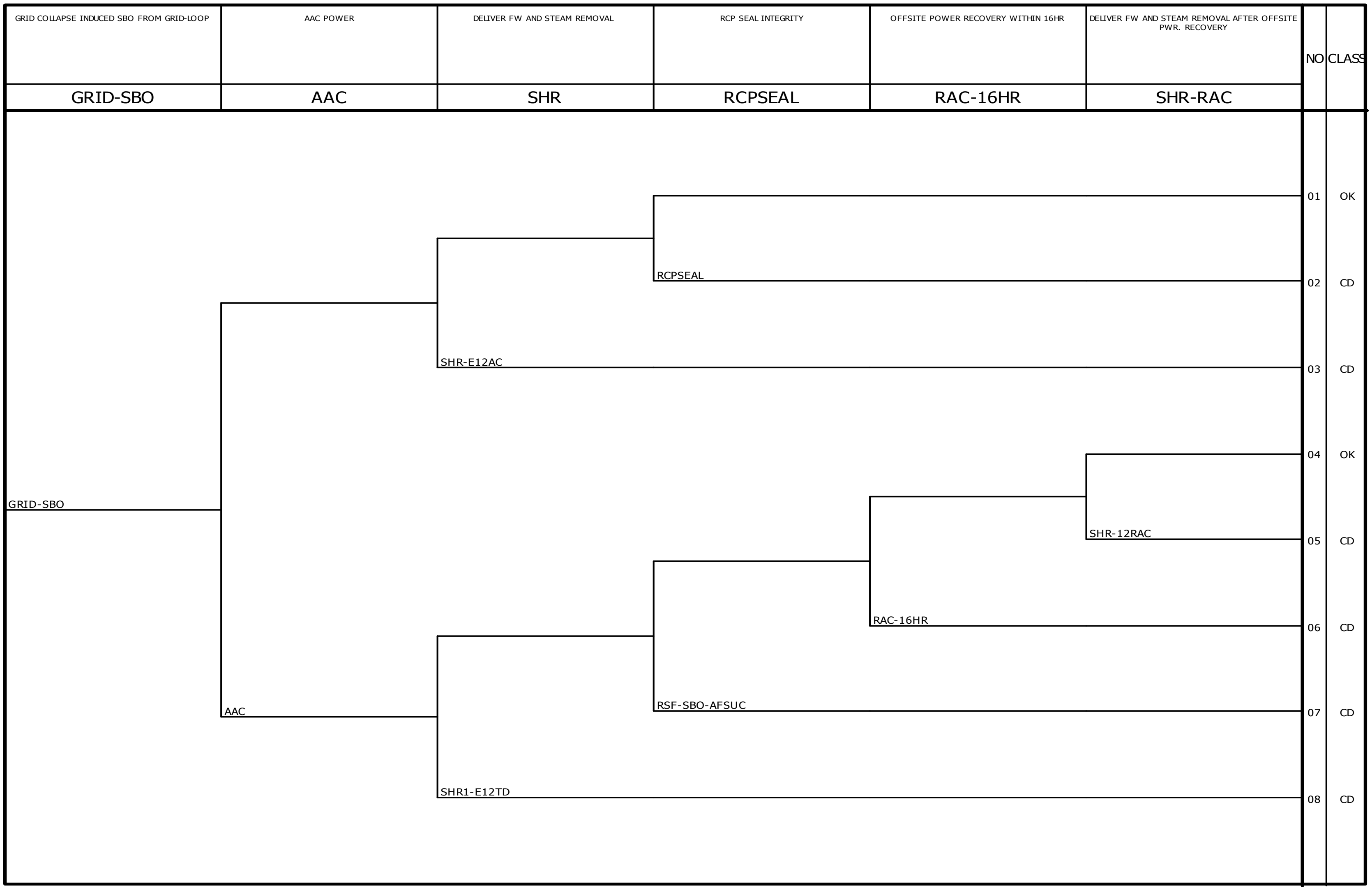

Figure 19.1-34 Level 1 Event Tree - Consequential SBO (GRID-SBO)

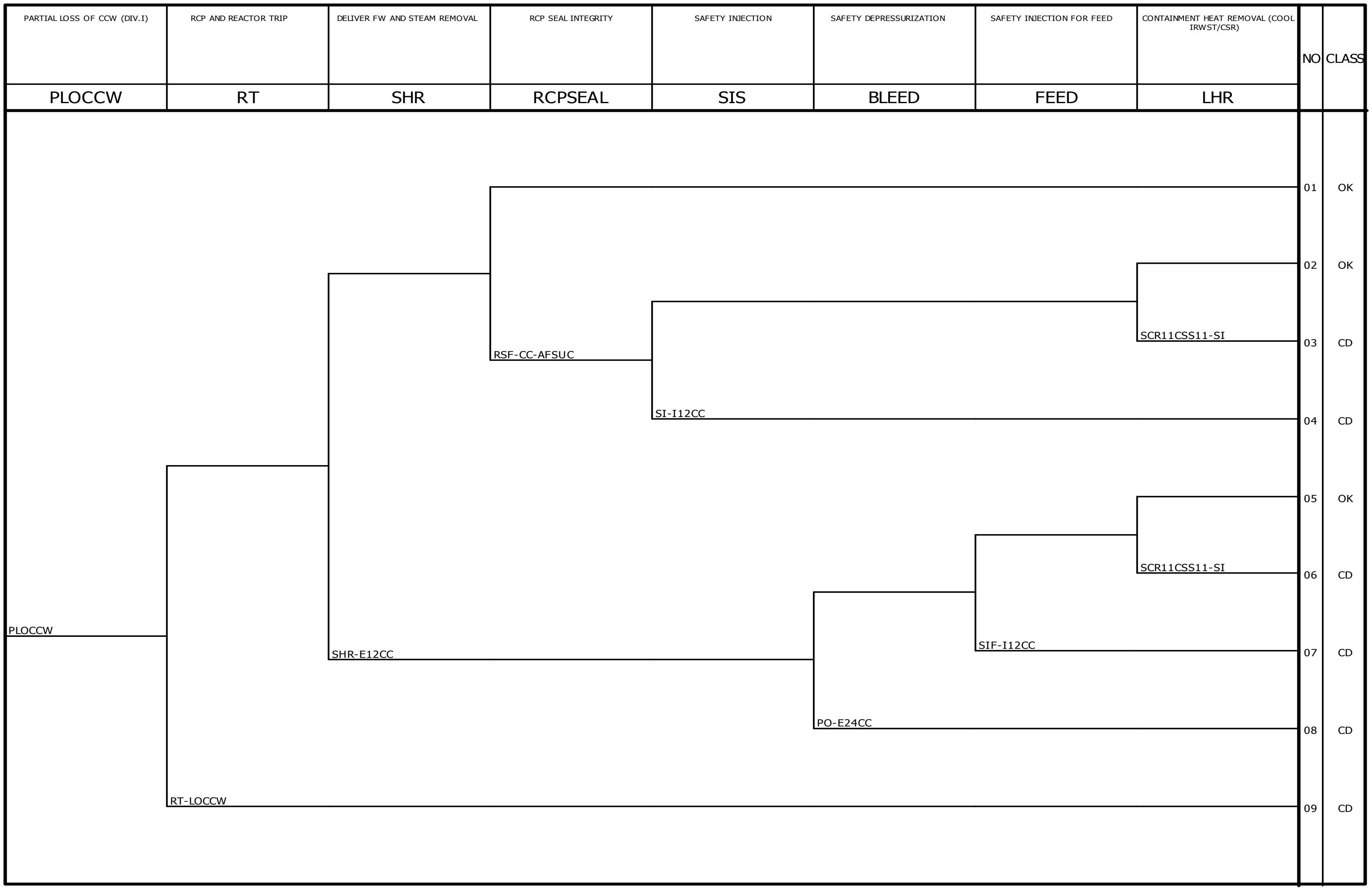

Figure 19.1-35 Level 1 Event Tree - Partial Loss of CCW (PLOCCW)

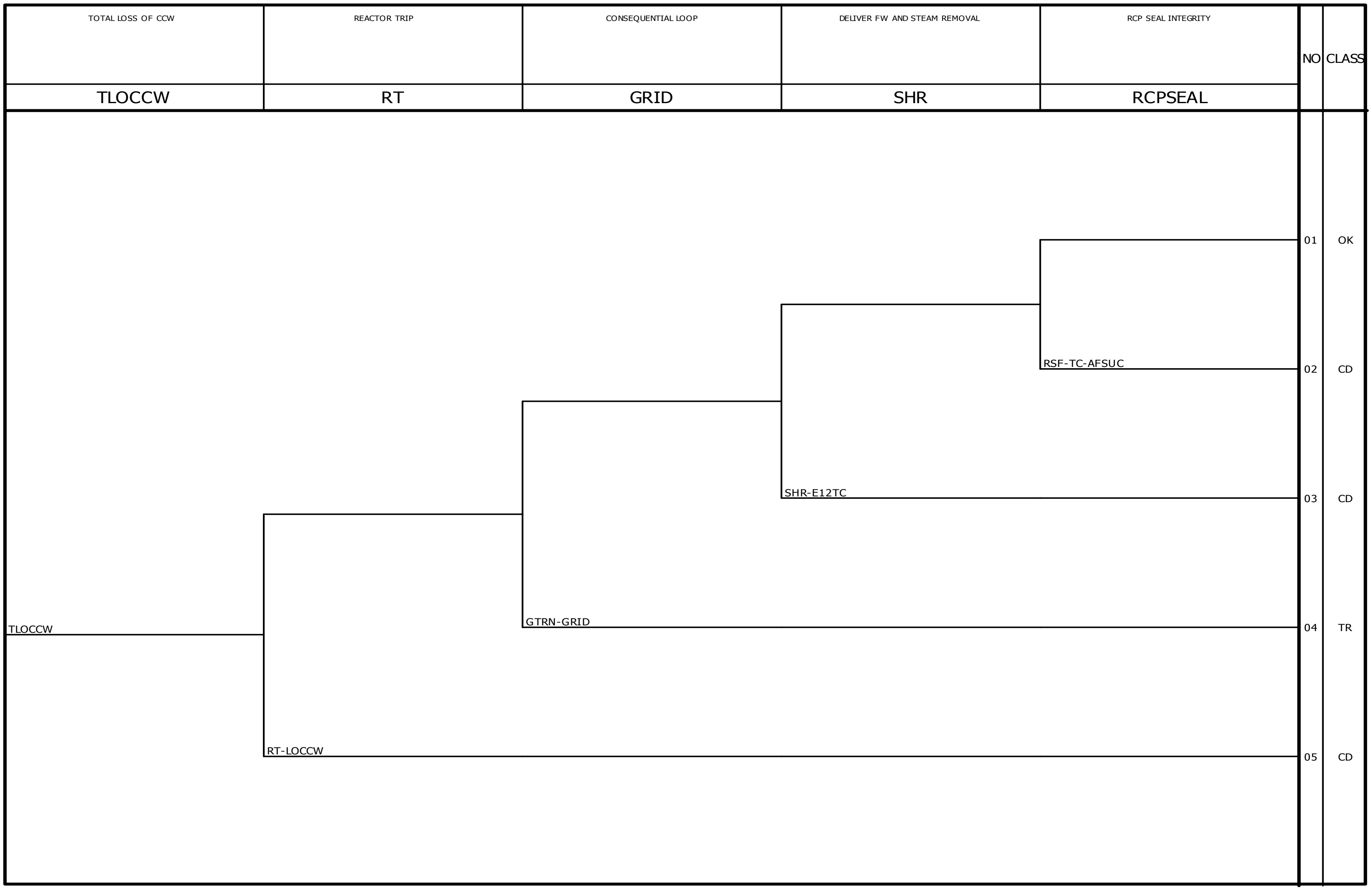

Figure 19.1-36 Level 1 Event Tree - Total Loss of CCW (TLOCCW)

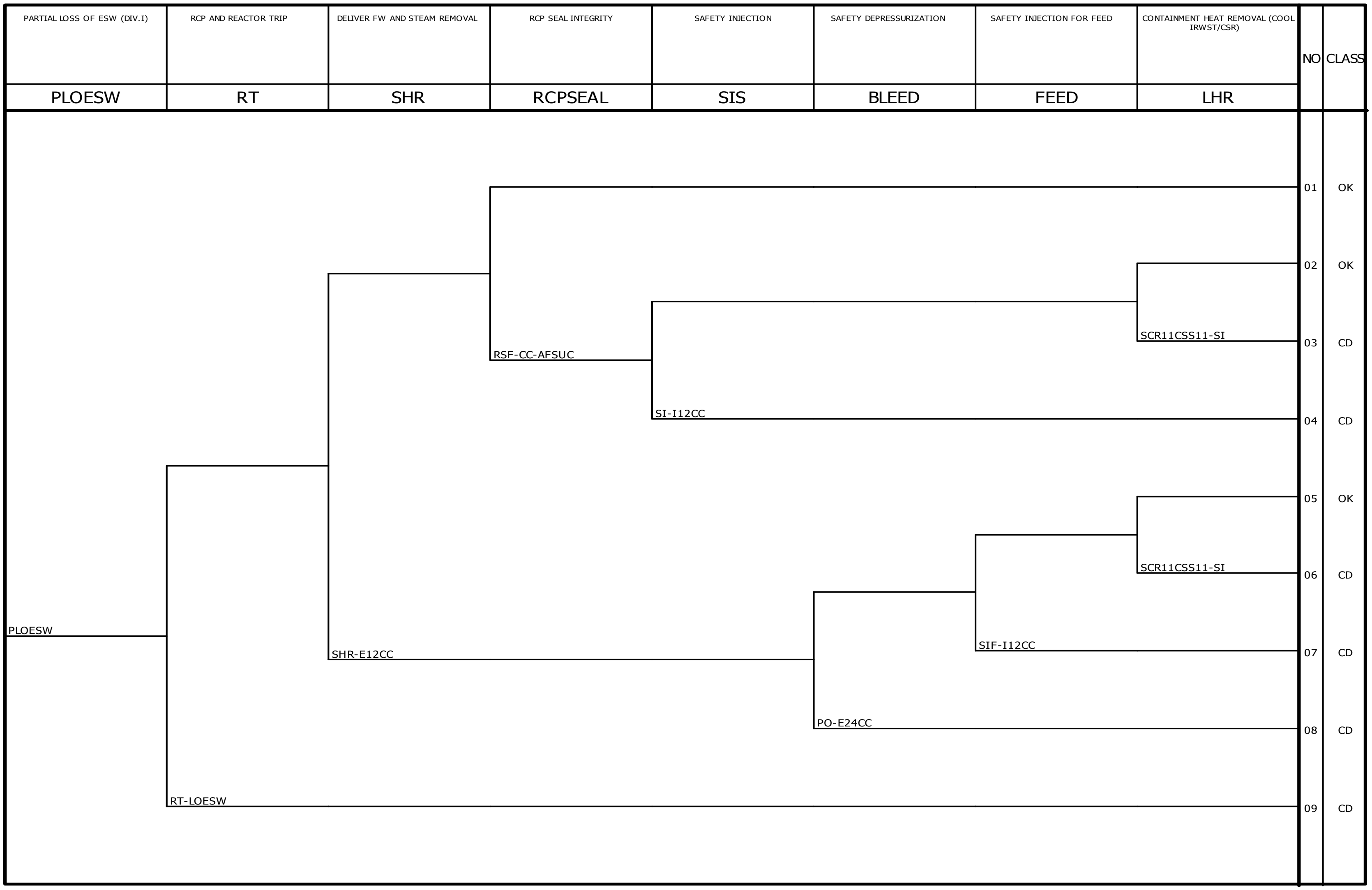

Figure 19.1-37 Level 1 Event Tree - Partial Loss of ESW (PLOESW)

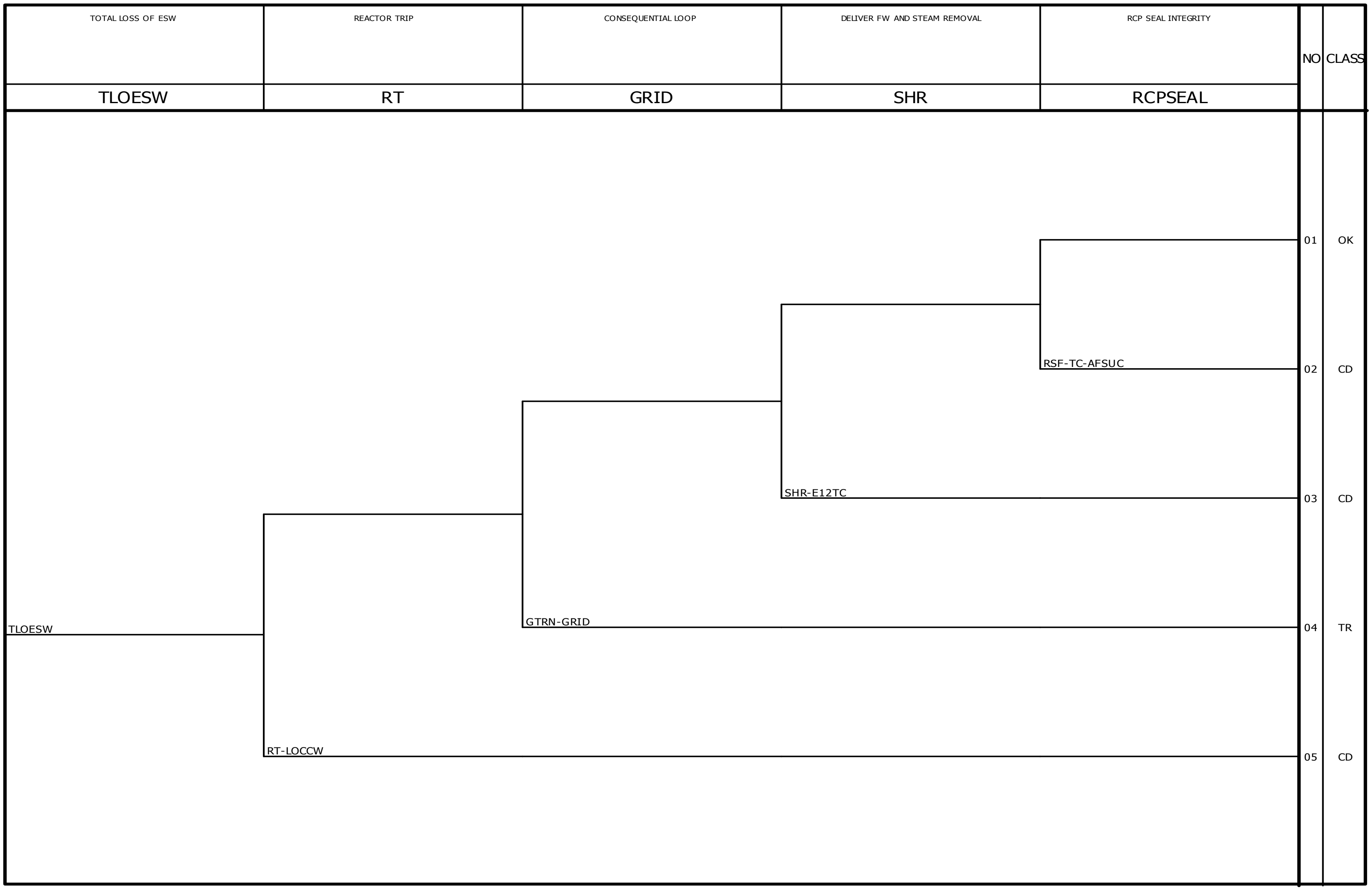

Figure 19.1-38 Level 1 Event Tree - Total Loss of ESW (TLOESW)

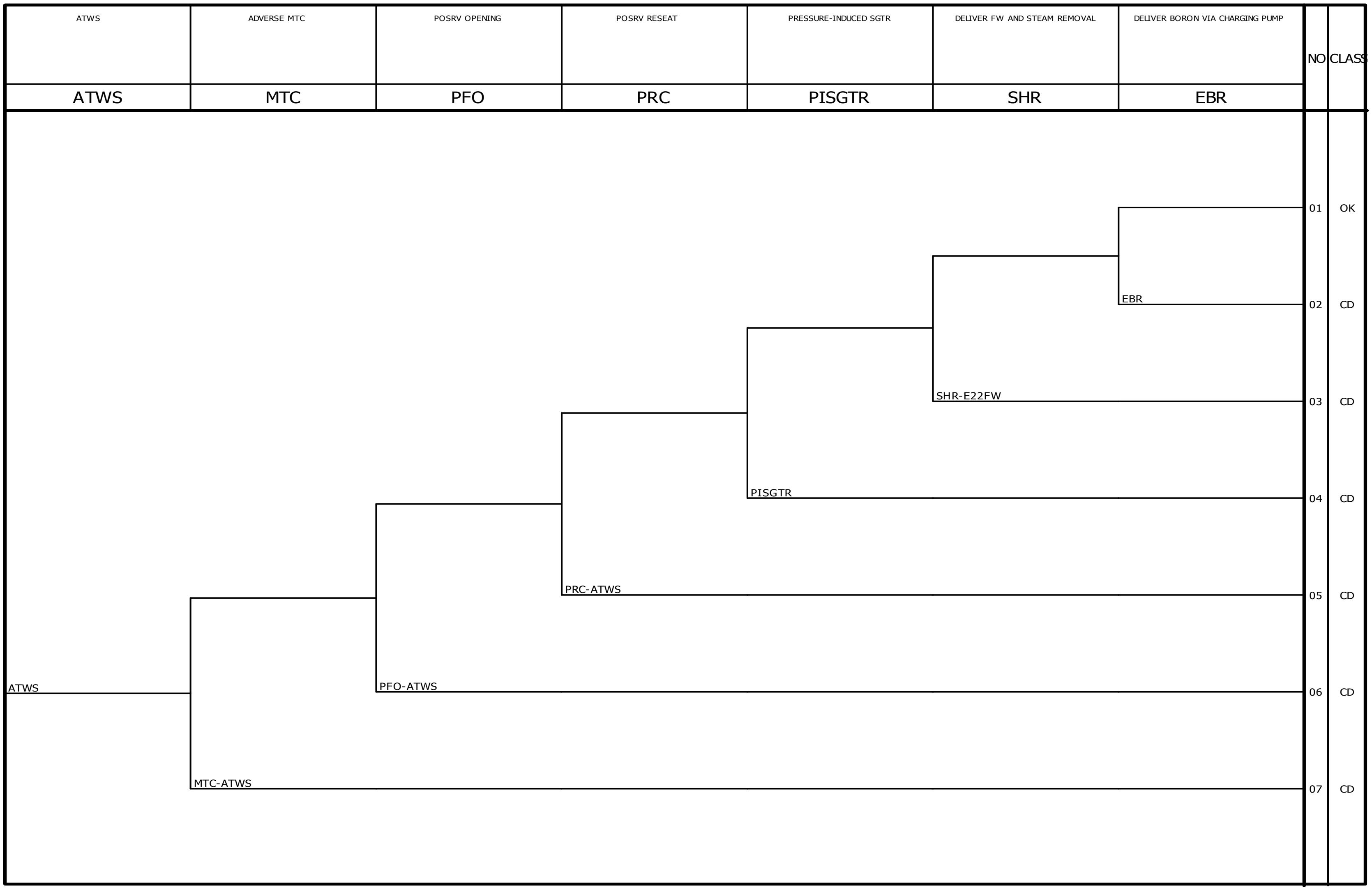

Figure 19.1-39 Level 1 Event Tree - Anticipated Transient Without Scram (ATWS)

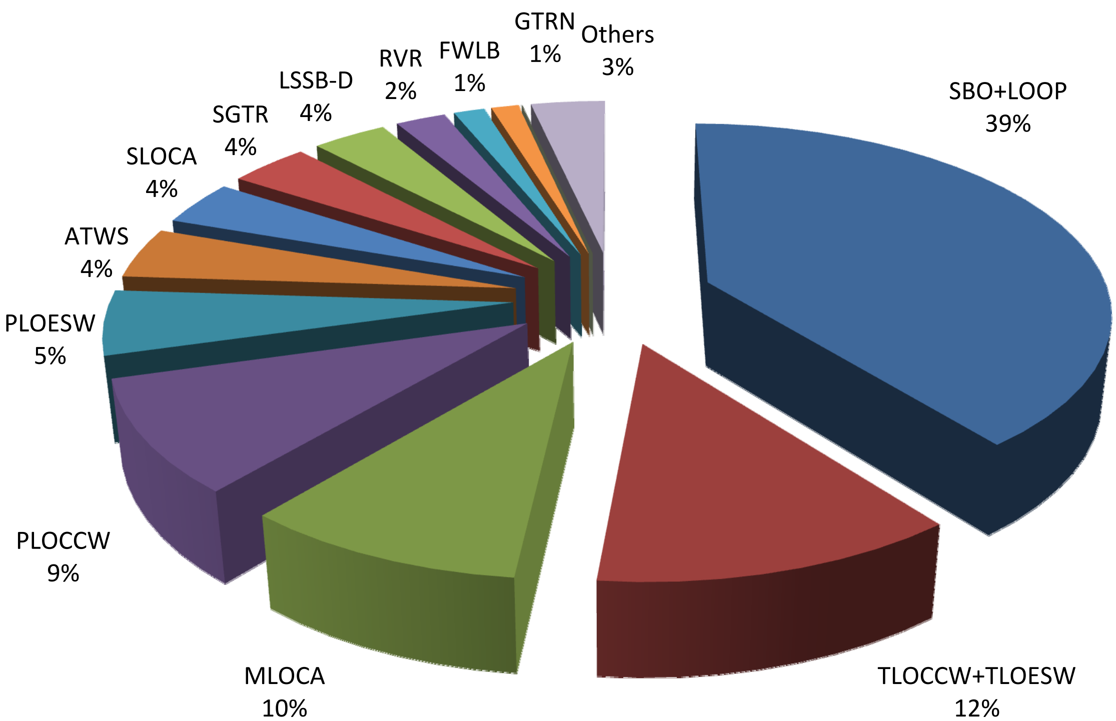

Figure 19.1-40   Initiating Events Contributions to CDF - Level 1 Internal Events

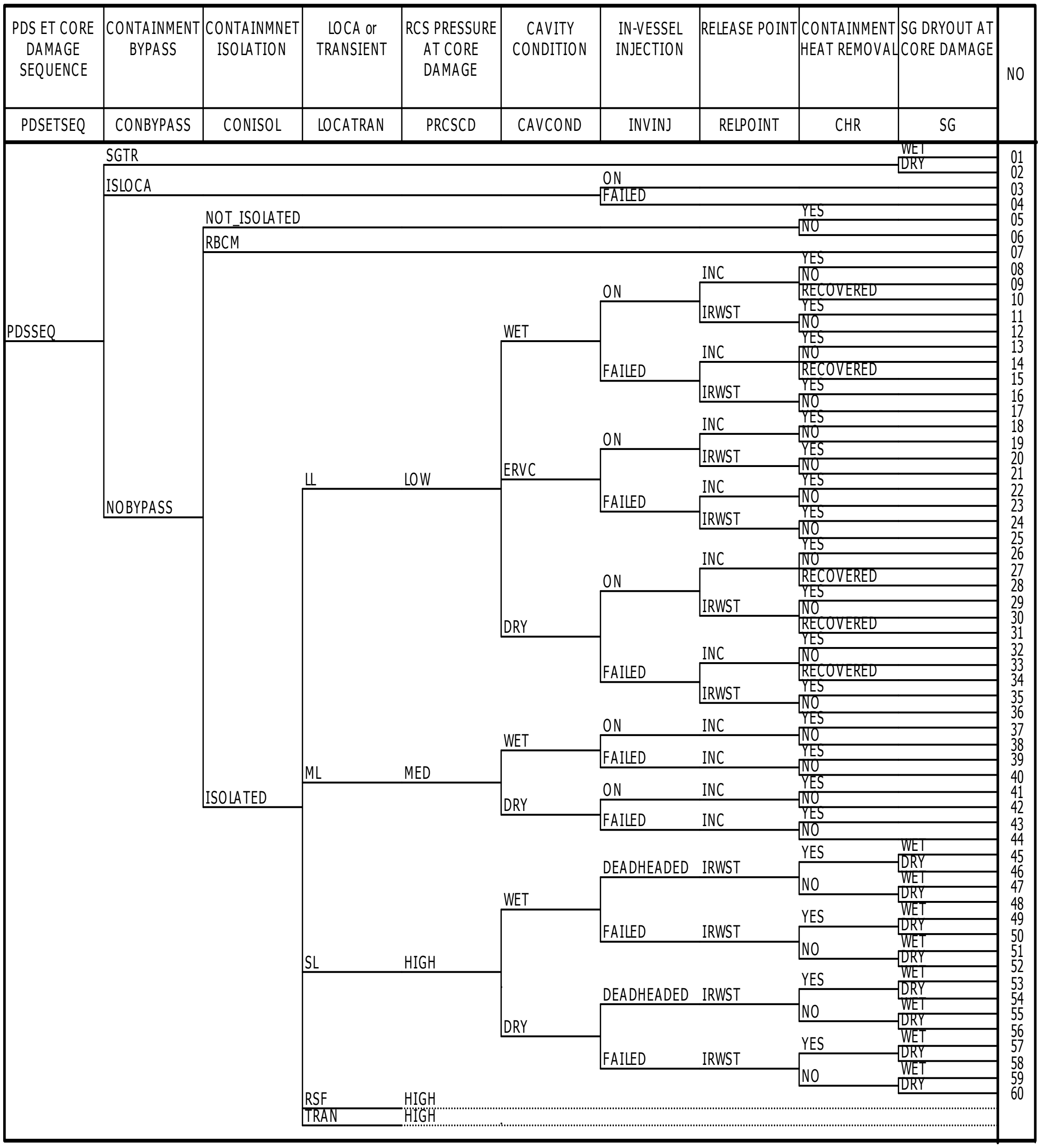

Figure 19.1-41 Plant Damage State Grouping Logic Diagram (1 of 2)

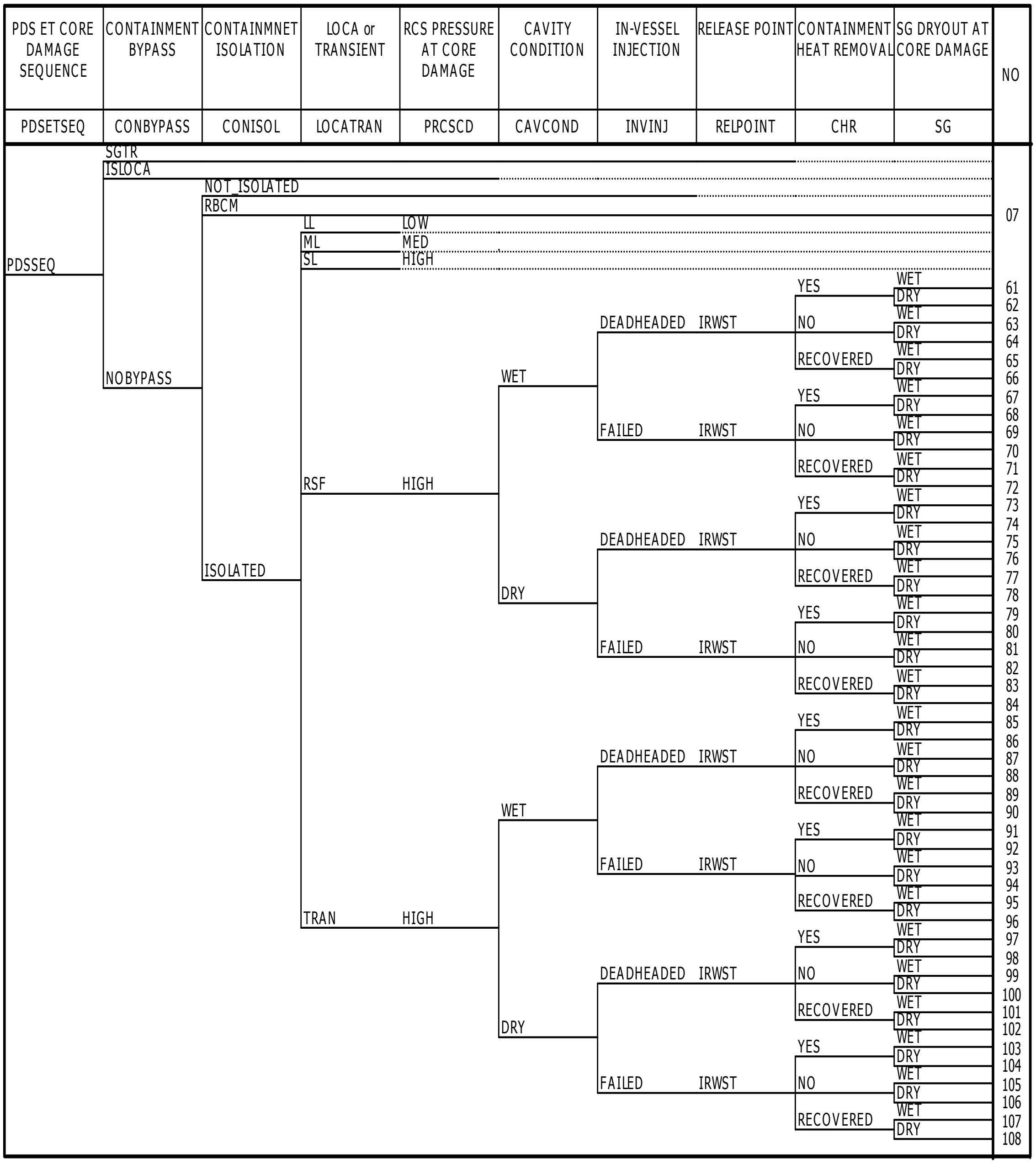

Figure 19.1-41 Plant Damage State Grouping Logic Diagram (2 of 2)

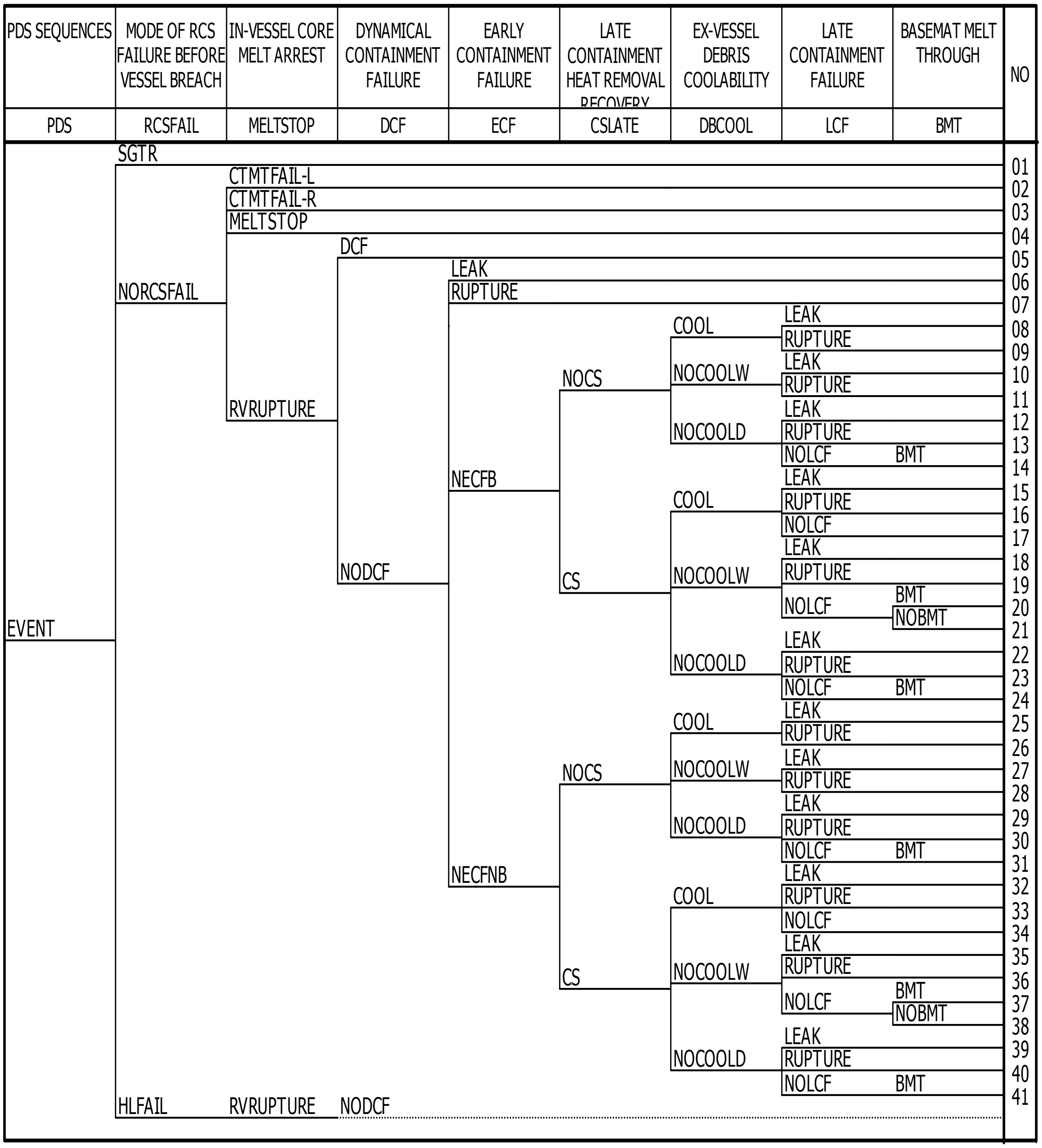

Figure 19.1-42   General Containment Event Tree (1 of 2)

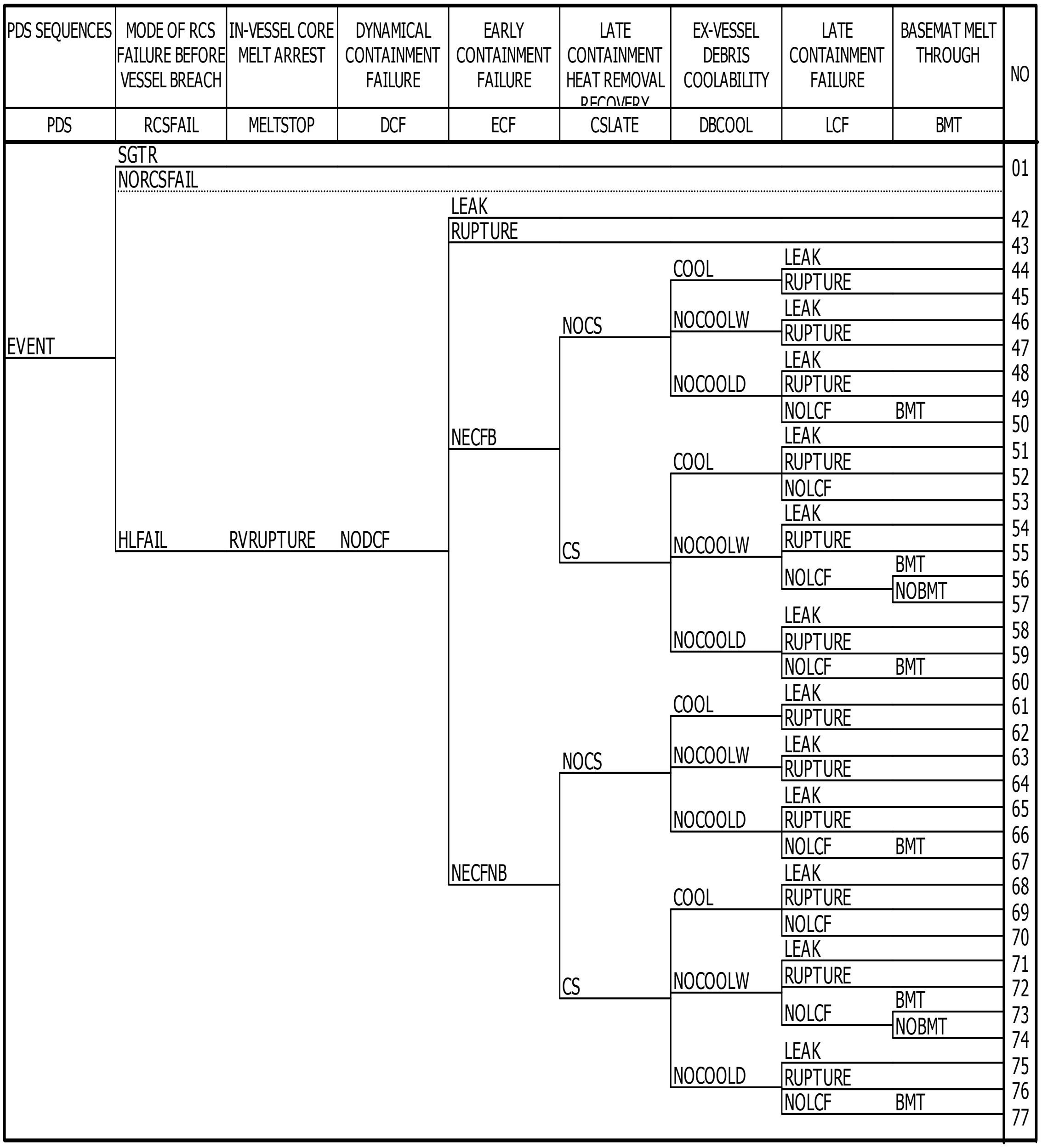

Figure 19.1-42 General Containment Event Tree (2 of 2)

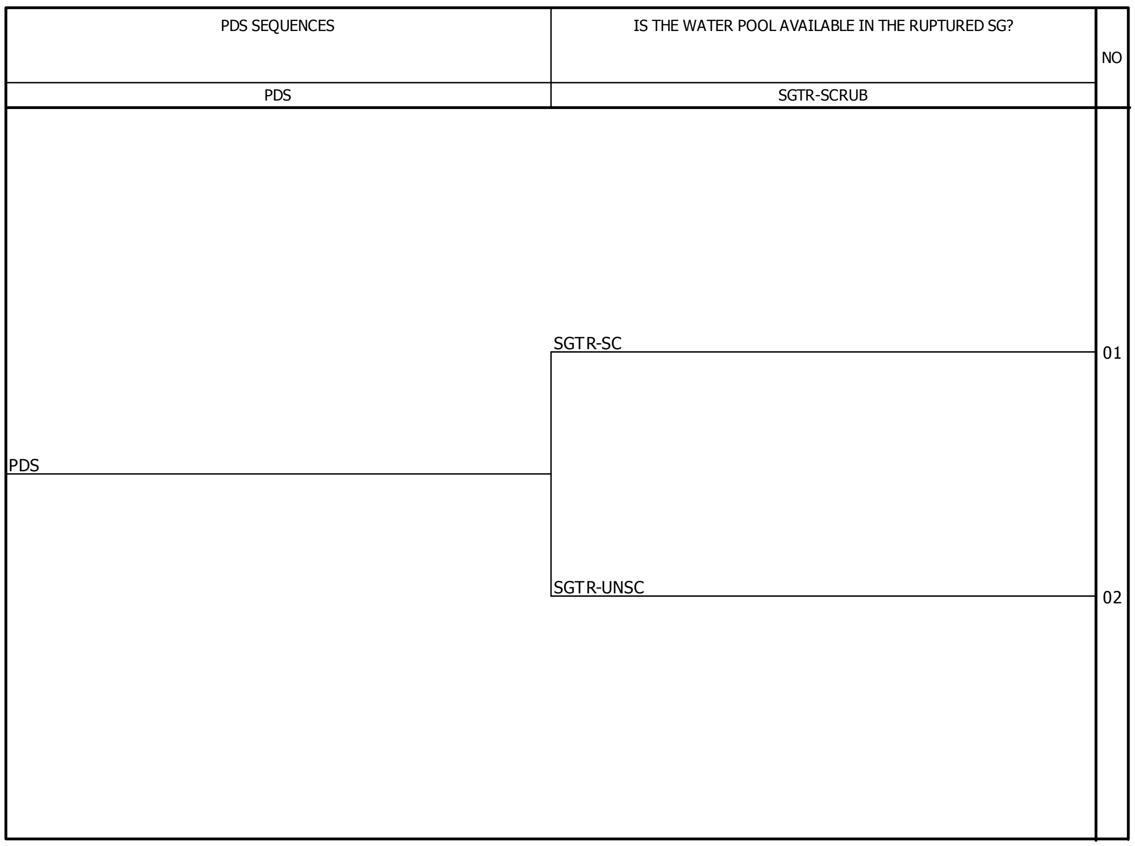

Figure 19.1-43 SGTR Containment Event Tree

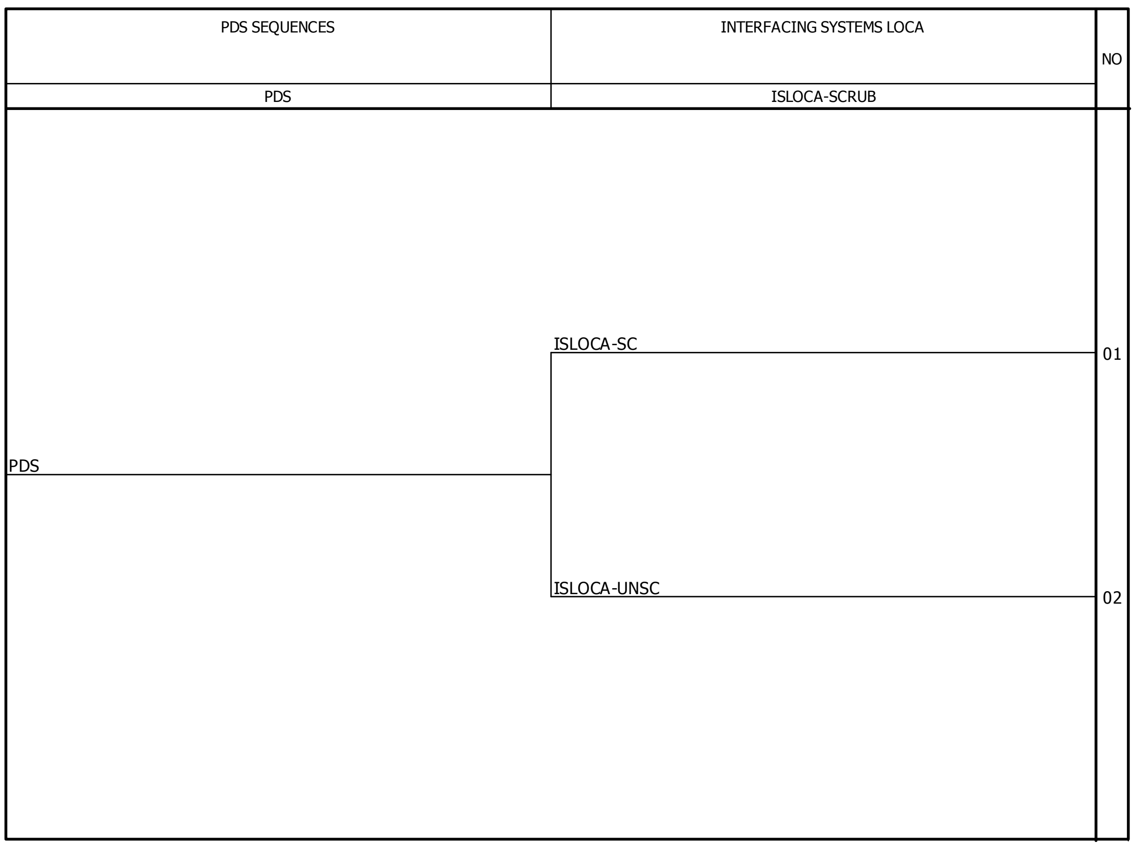

Figure 19.1-44 ISLOCA Containment Event Tree

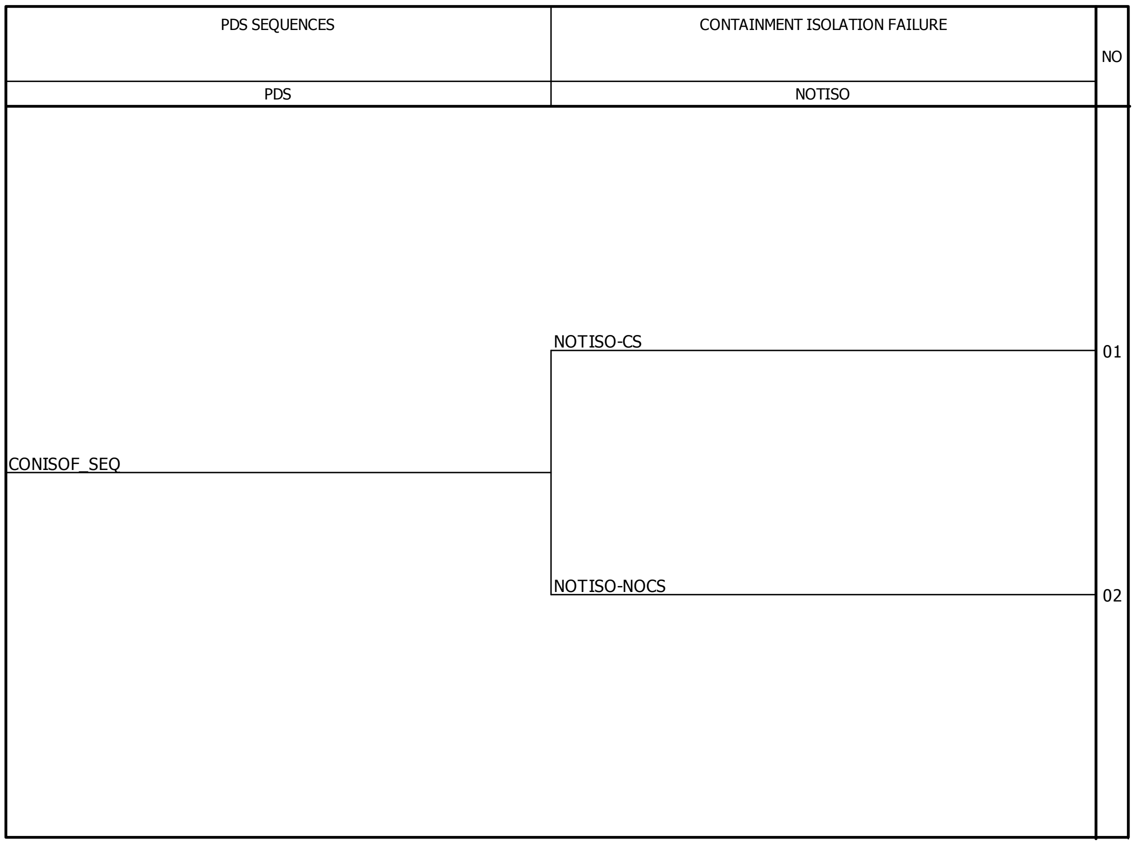

Figure 19.1-45 Containment Isolation Failure Containment Event Tree

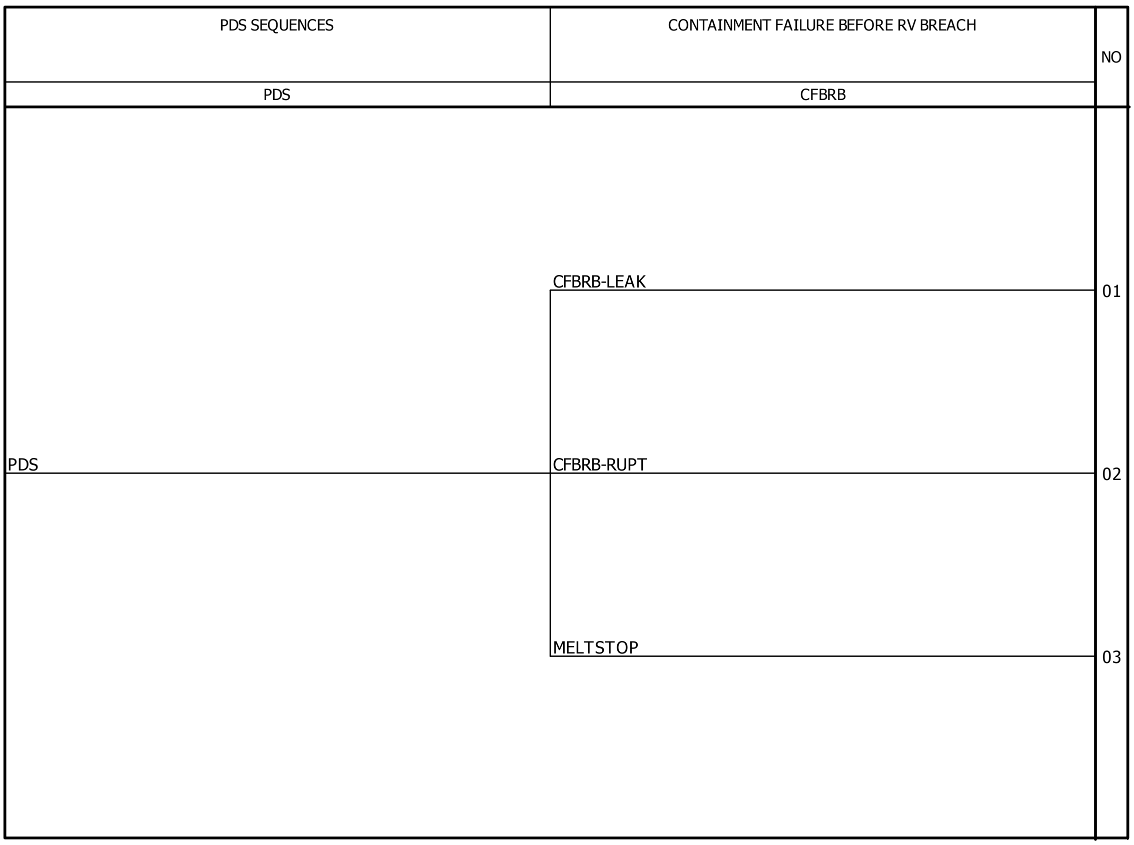

Figure 19.1-46 Containment Failure Before Vessel Breach Containment Event Tree

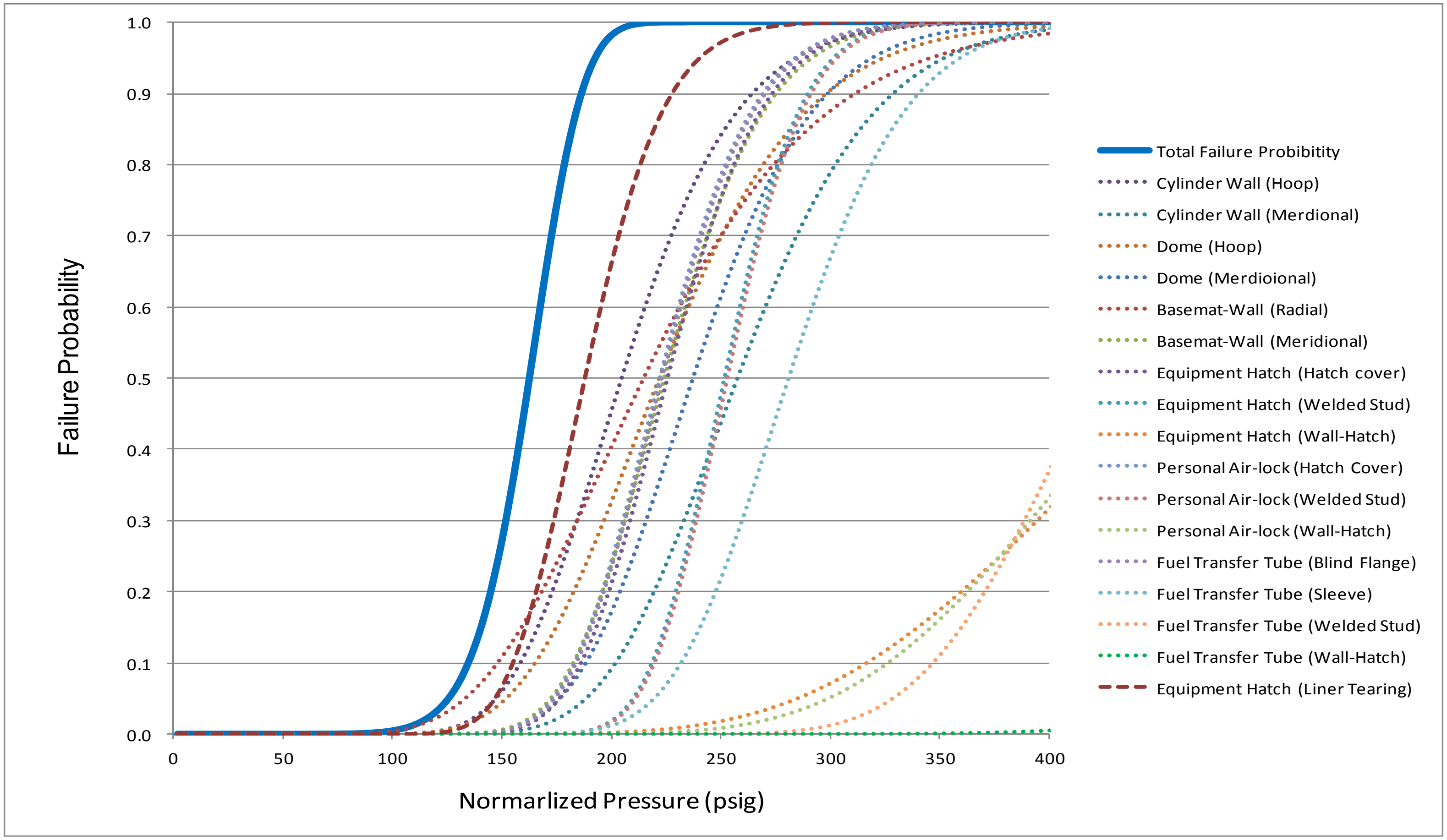

Figure 19.1-47 Total Containment Fragility Curve

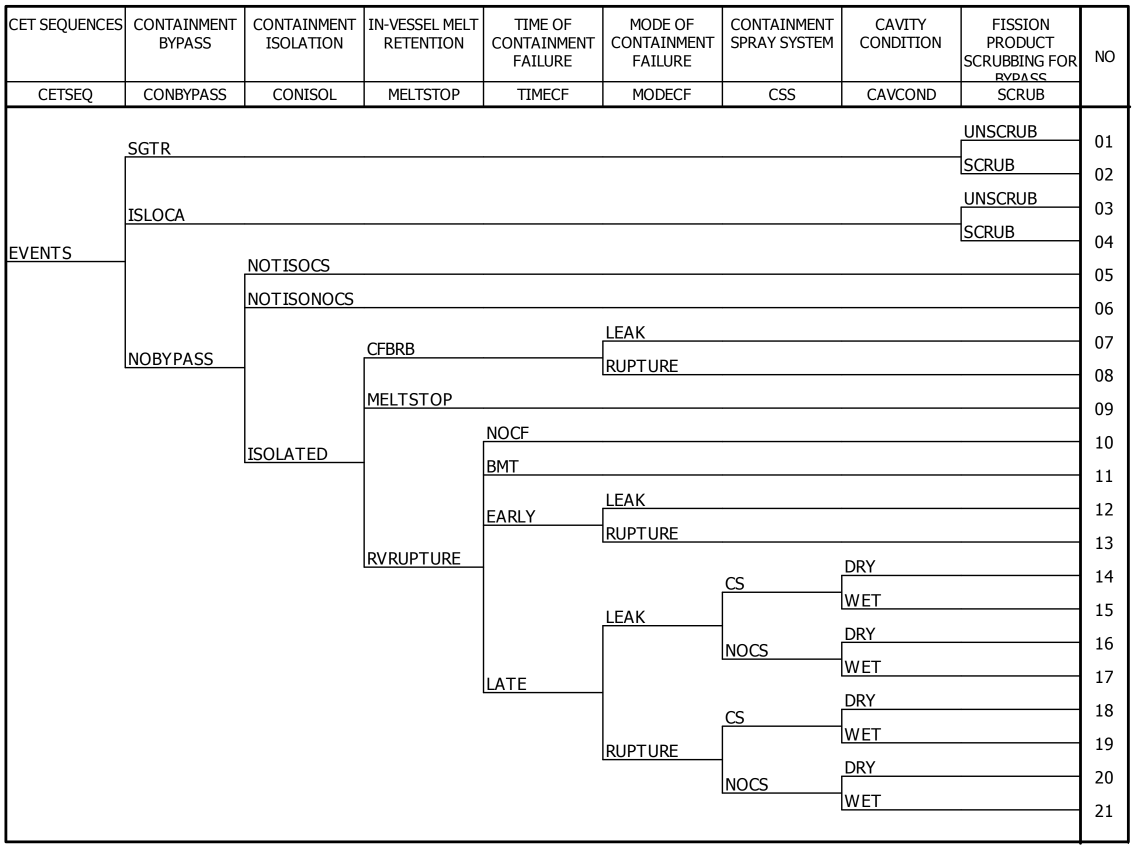

Figure 19.1-48 Source Term Binning Diagram

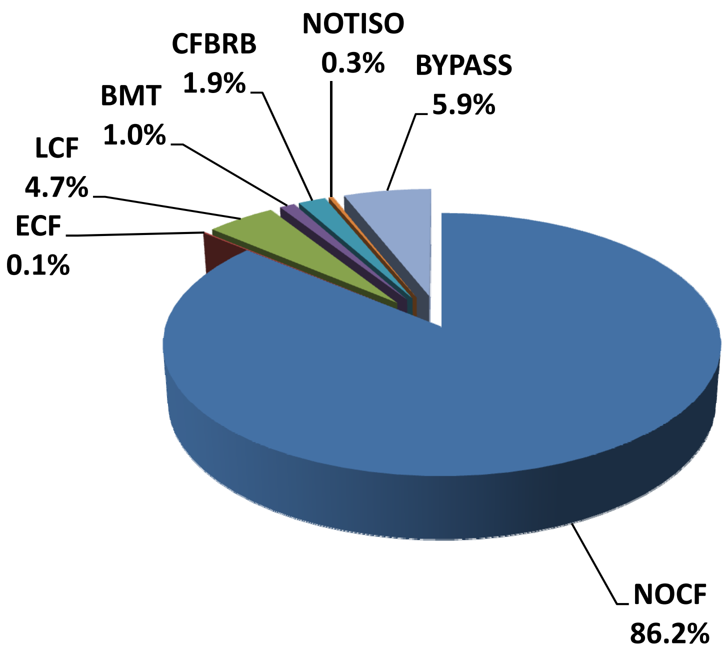

Figure 19.1-49 CET Quantification Results for Internal Events

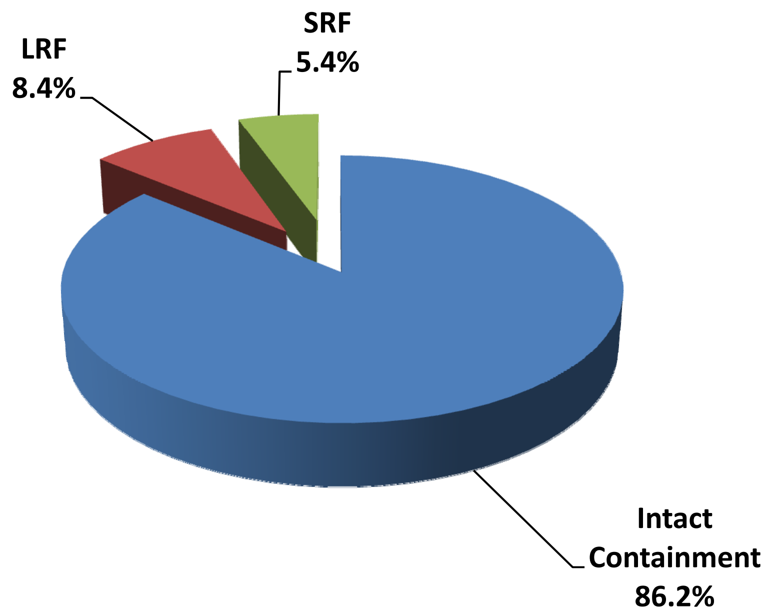

Figure 19.1-50 Level 2 PRA Results in Terms of Containment End State for Internal Events

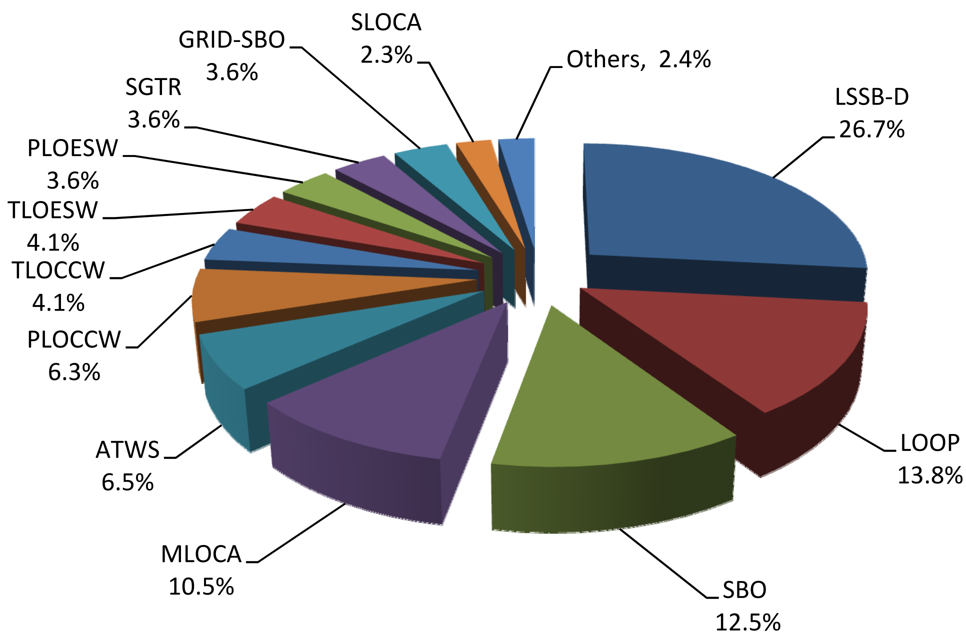

Figure 19.1-51 Internal Initiating Events Contributions to LRF

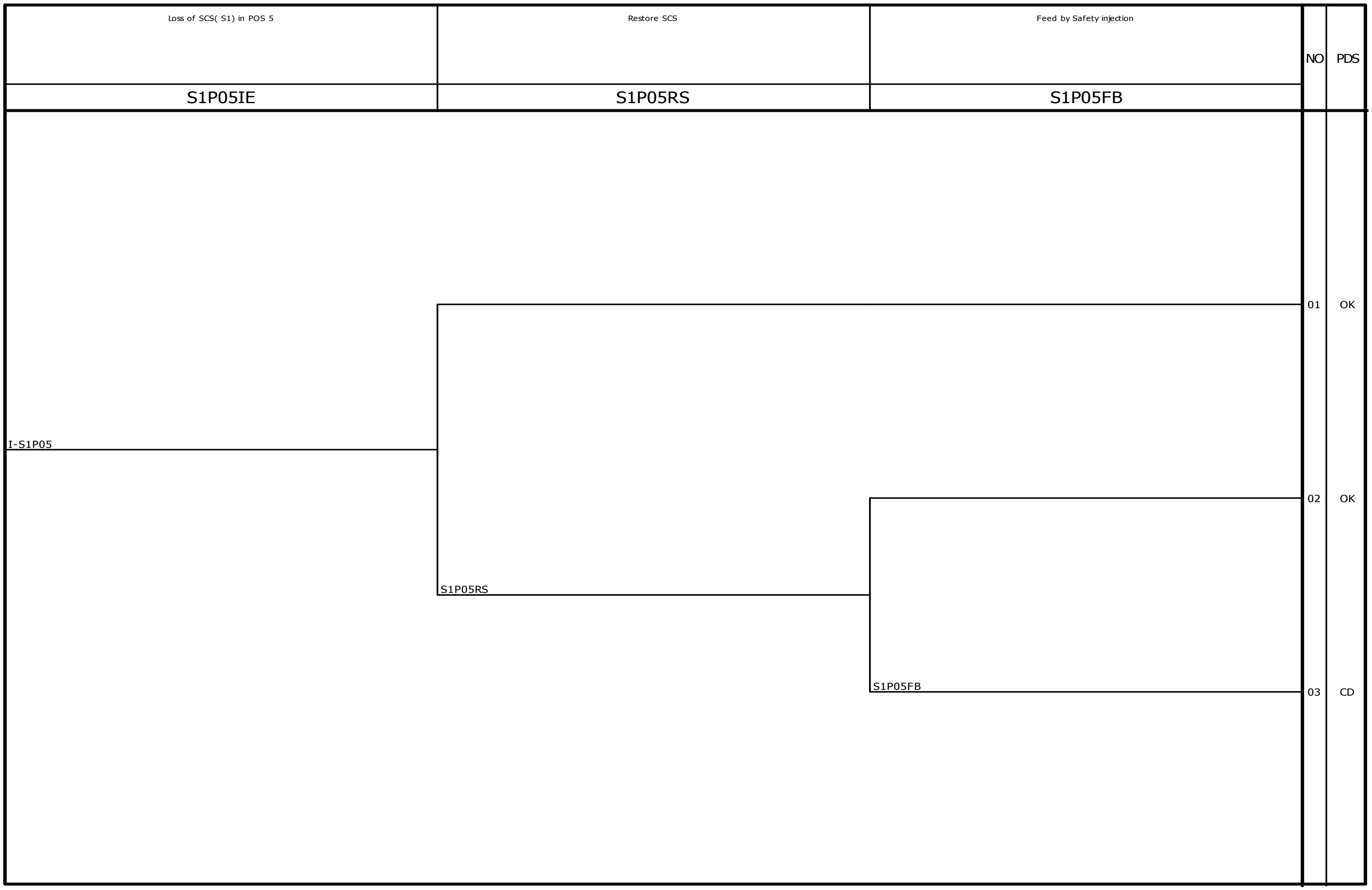

Figure 19.1-52 Recoverable Loss of Shutdown Cooling (S1) Event Tree in POS 5

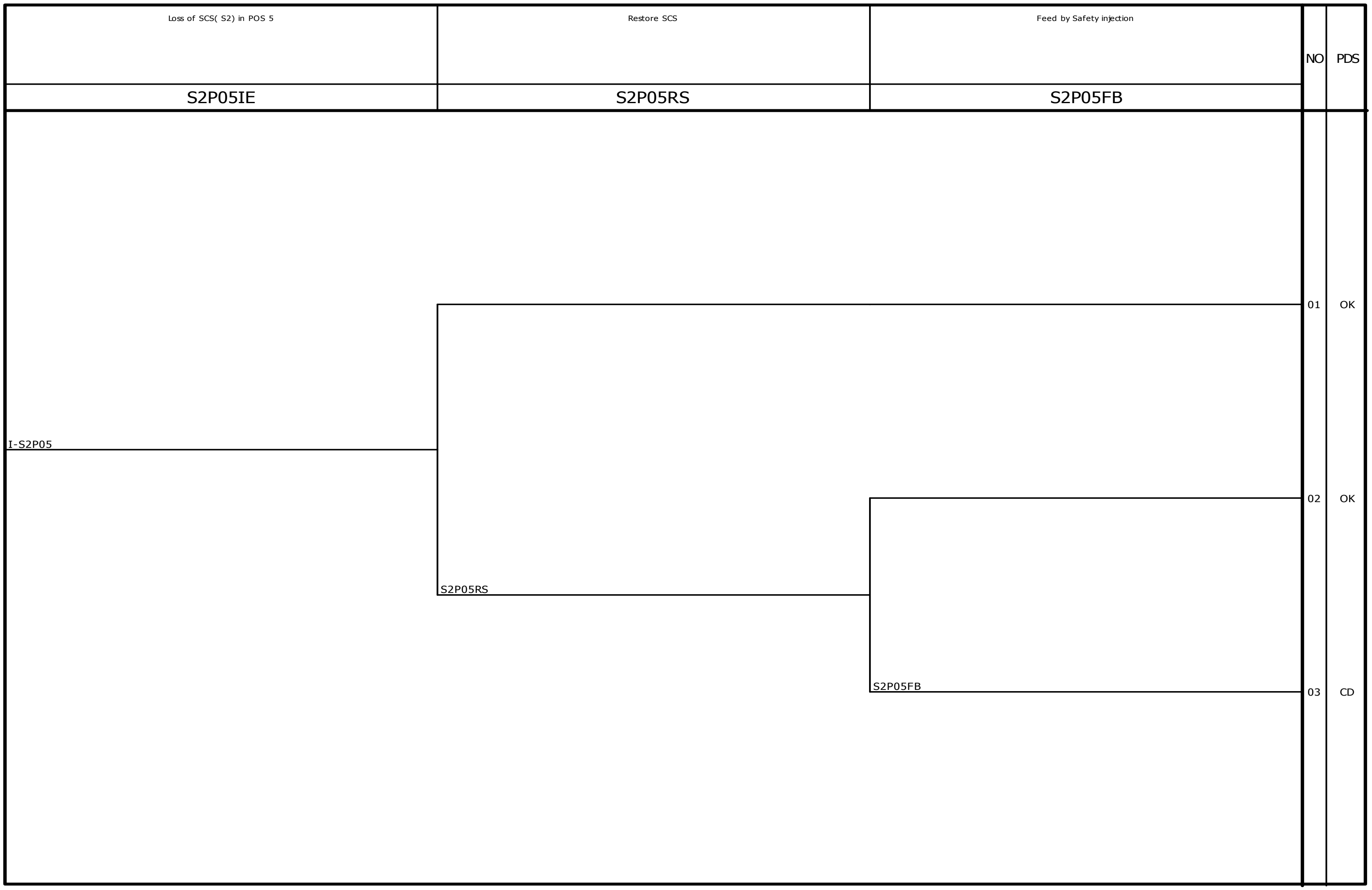

Figure 19.1-53 Unrecoverable Loss of Shutdown Cooling (S2) Event Tree in POS 5

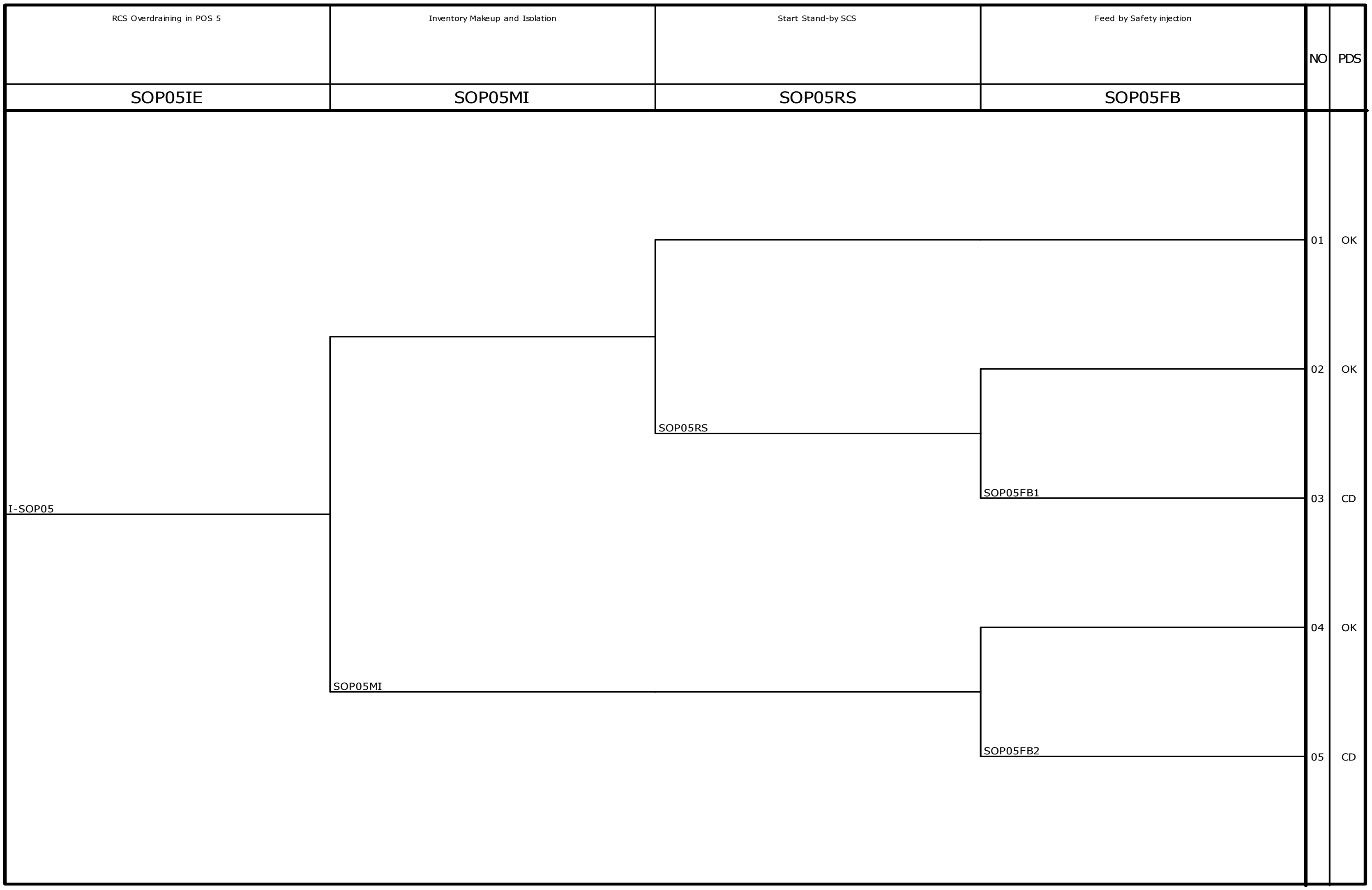

Figure 19.1-54 Over-drainage during Reduced Inventory Operation (SO) Event Tree in POS 5

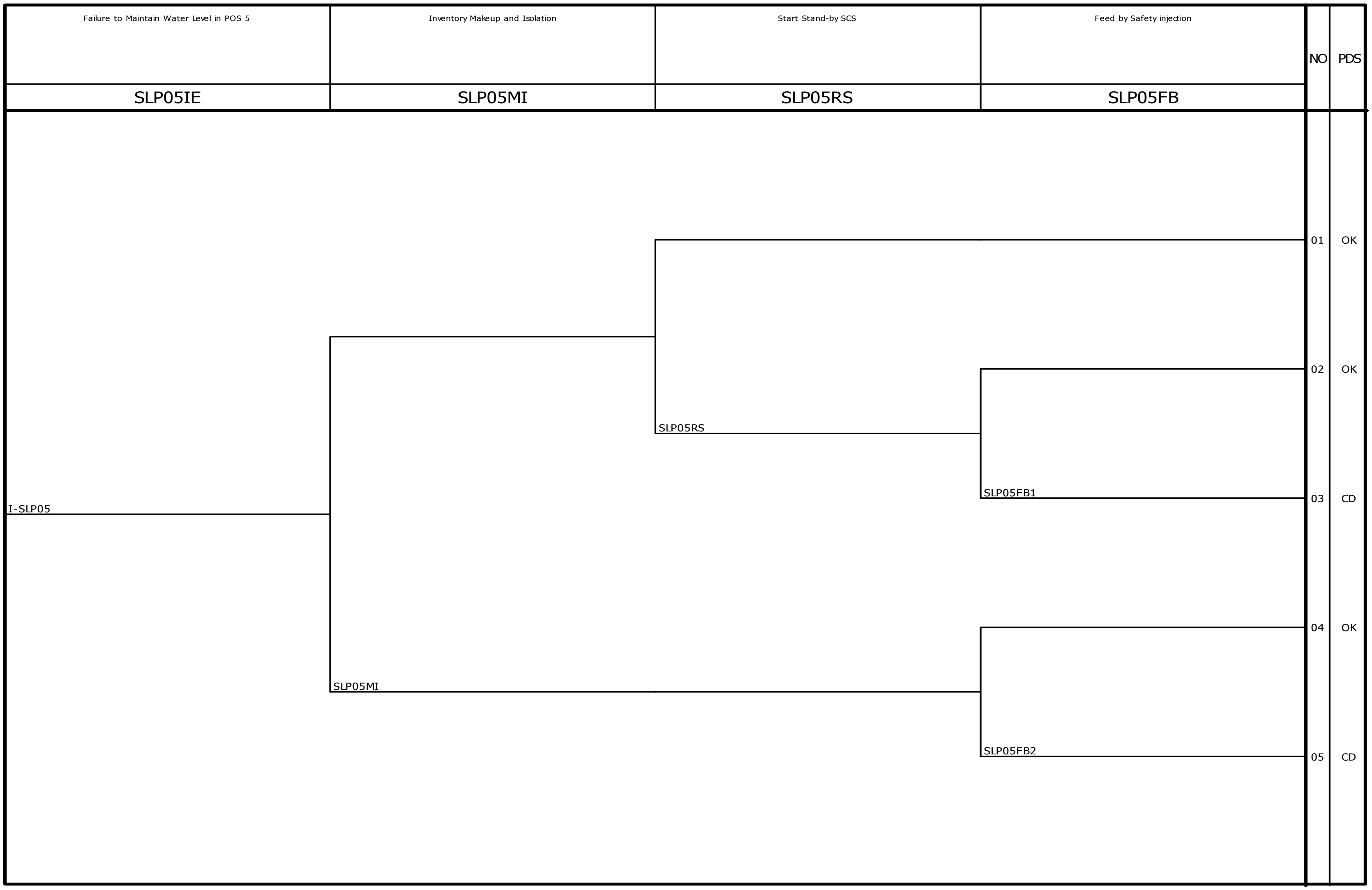

Figure 19.1-55 Failure to Maintain Water Level During Reduced Inventory Operation (SL) in POS 5

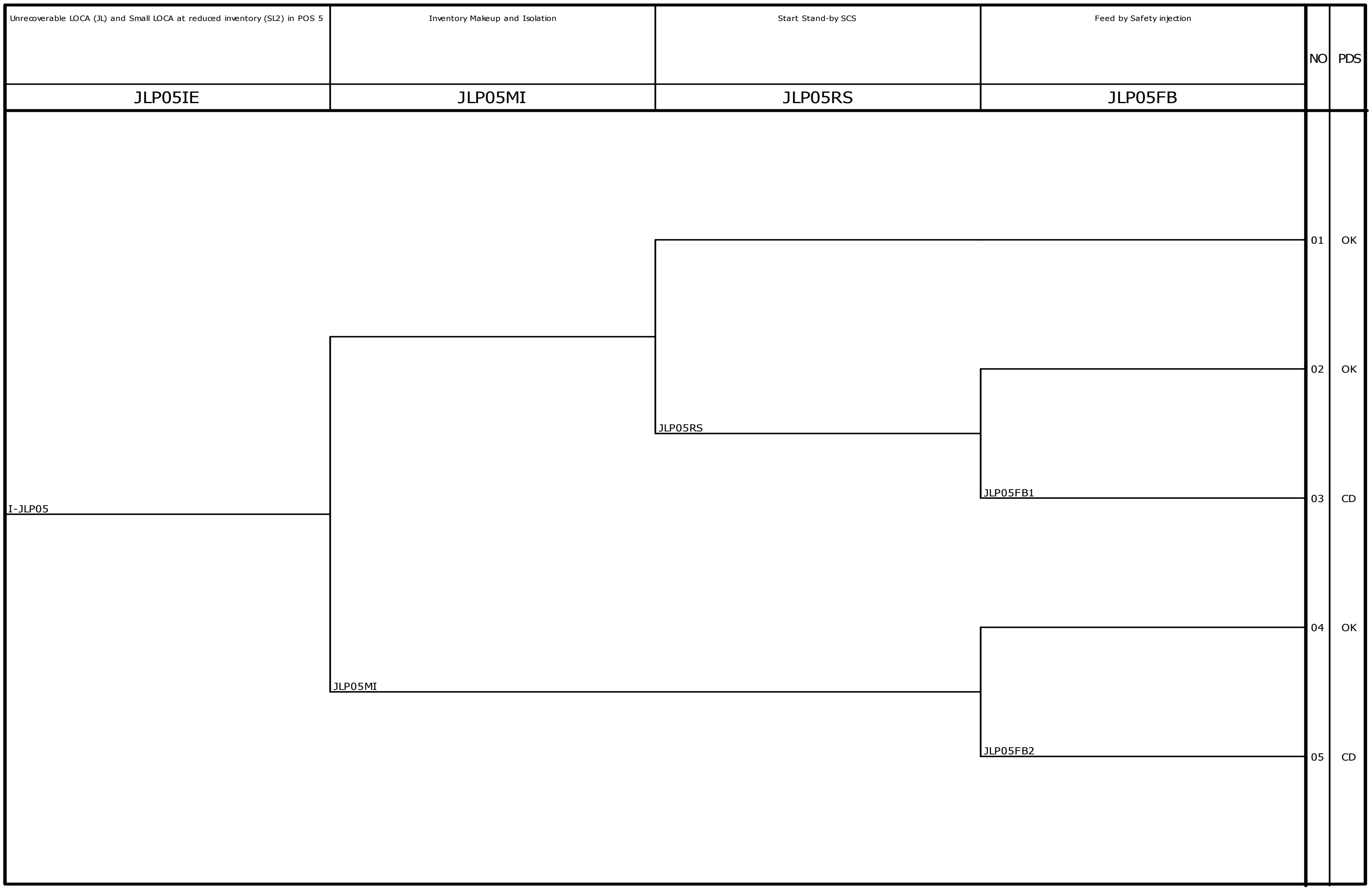

Figure 19.1-56 Unrecoverable LOCA (JL - purification line rupture) in POS 5

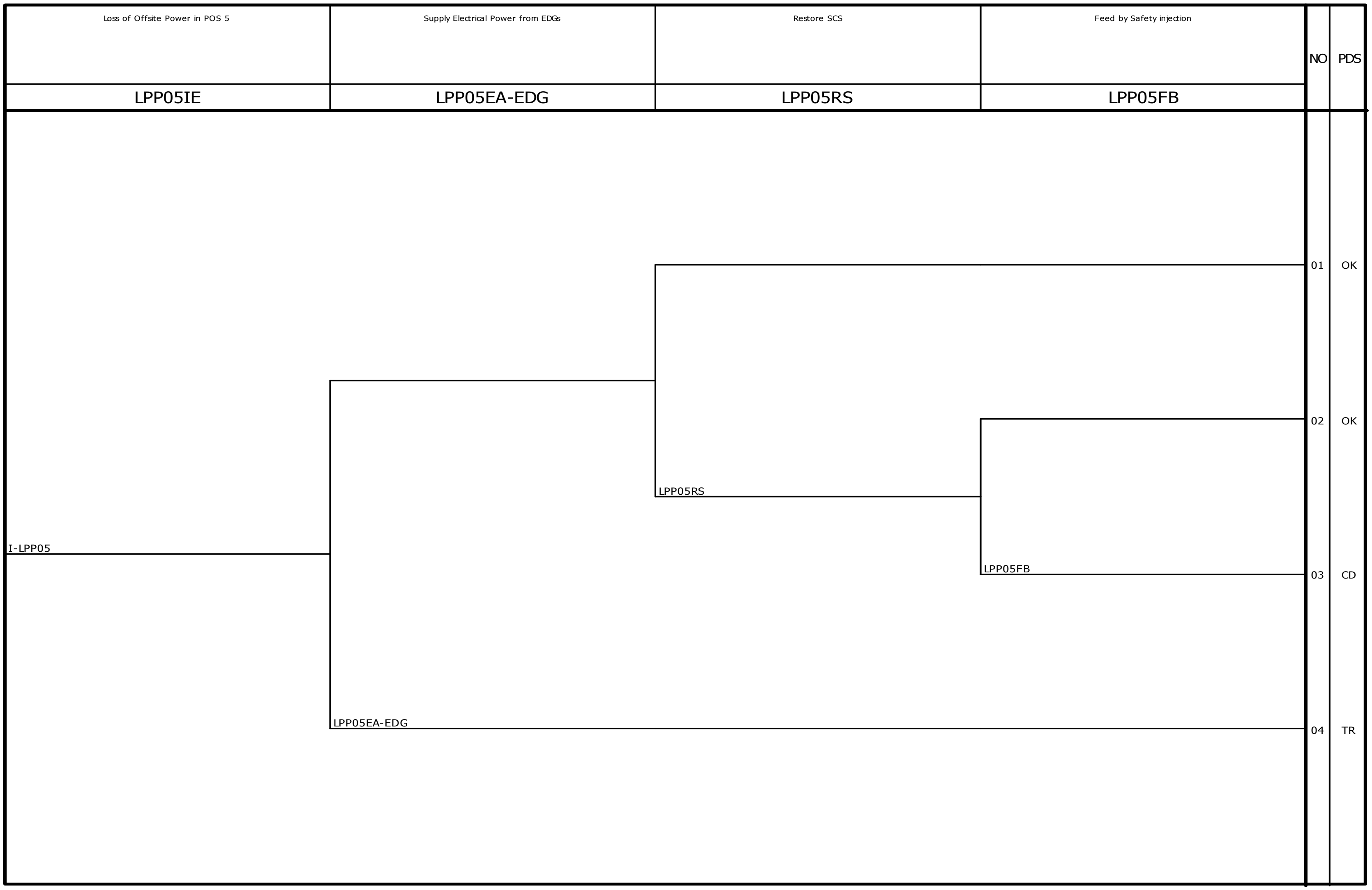

Figure 19.1-57 Loss of Offsite Power (LP) in POS 5

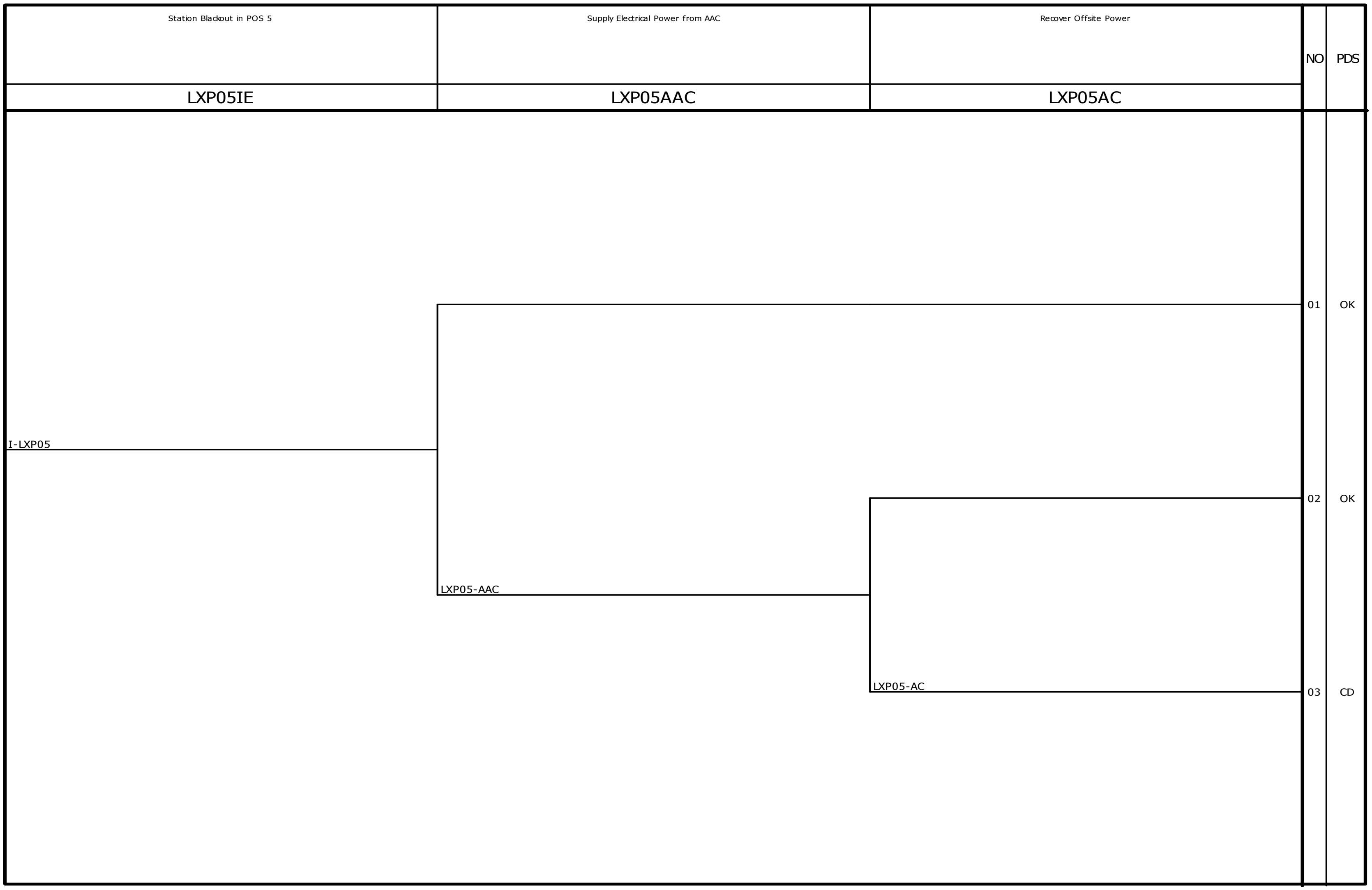

Figure 19.1-58   Station Blackout (LX) in POS 5

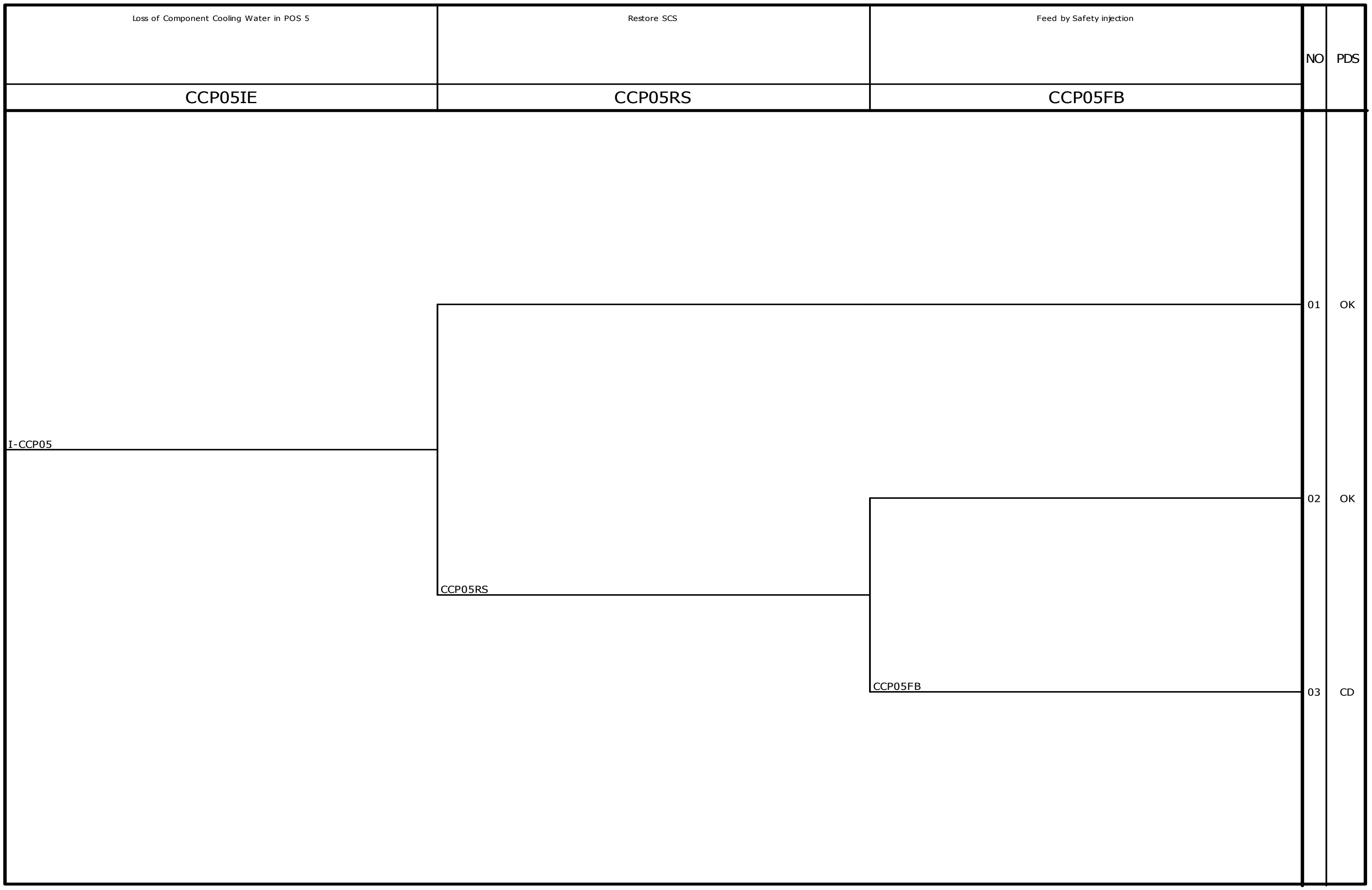

Figure 19.1-59 Partial Loss of Component Cooling (CC) in POS 5

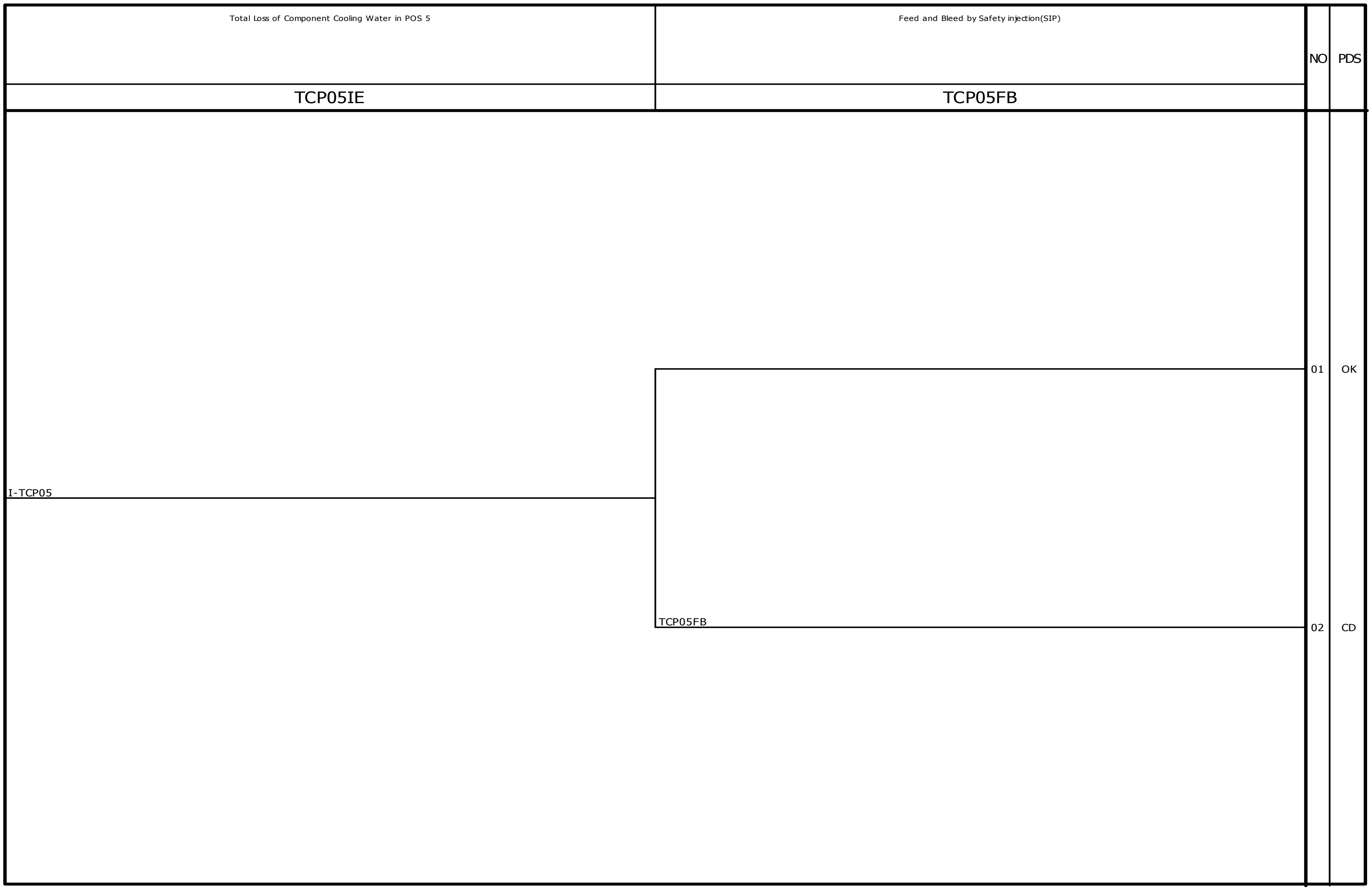

Figure 19.1-60 Partial Loss of Component Cooling (TC) in POS 5

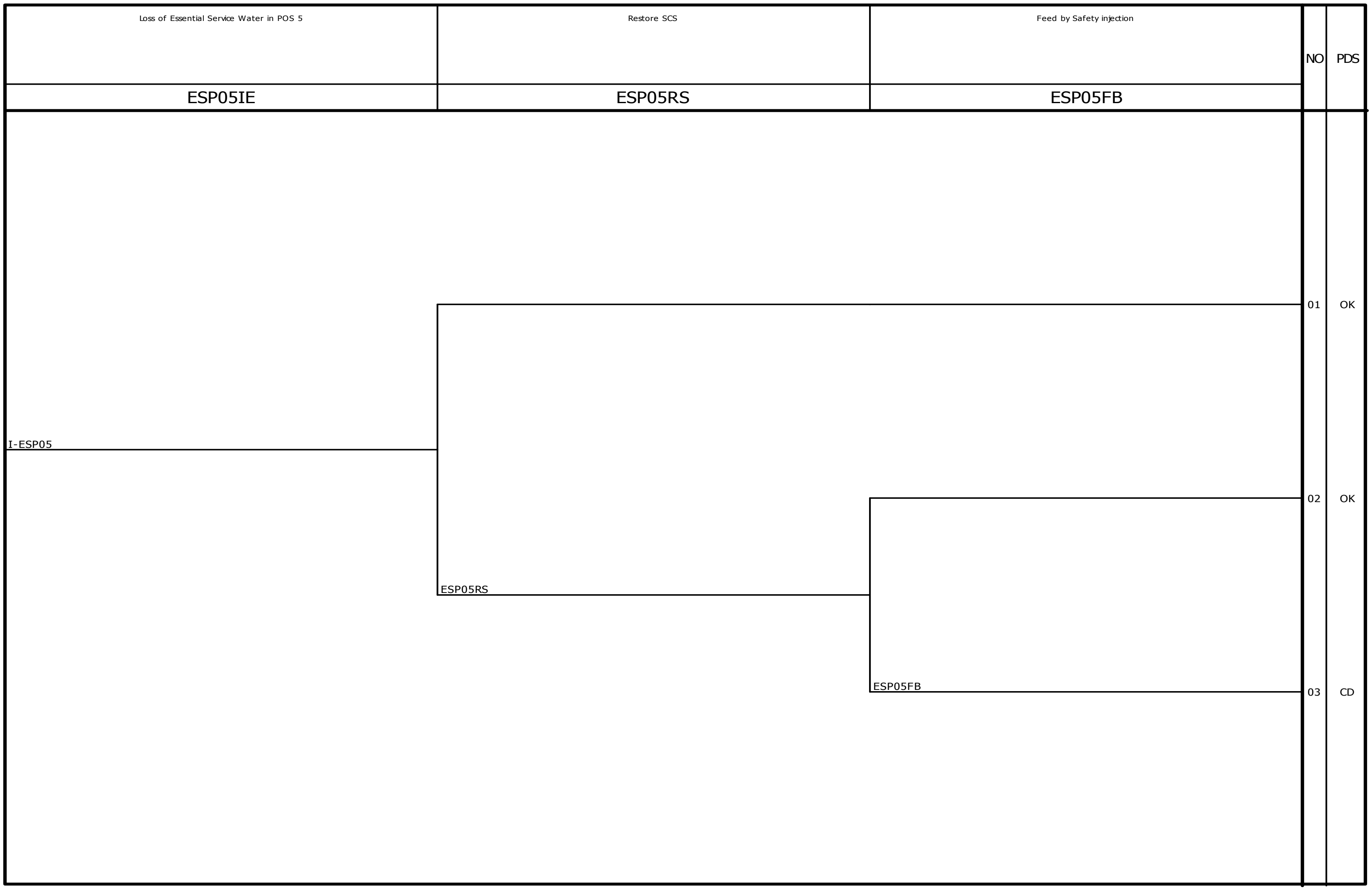

Figure 19.1-61 Partial Loss of Essential Service Water (ES) in POS 5

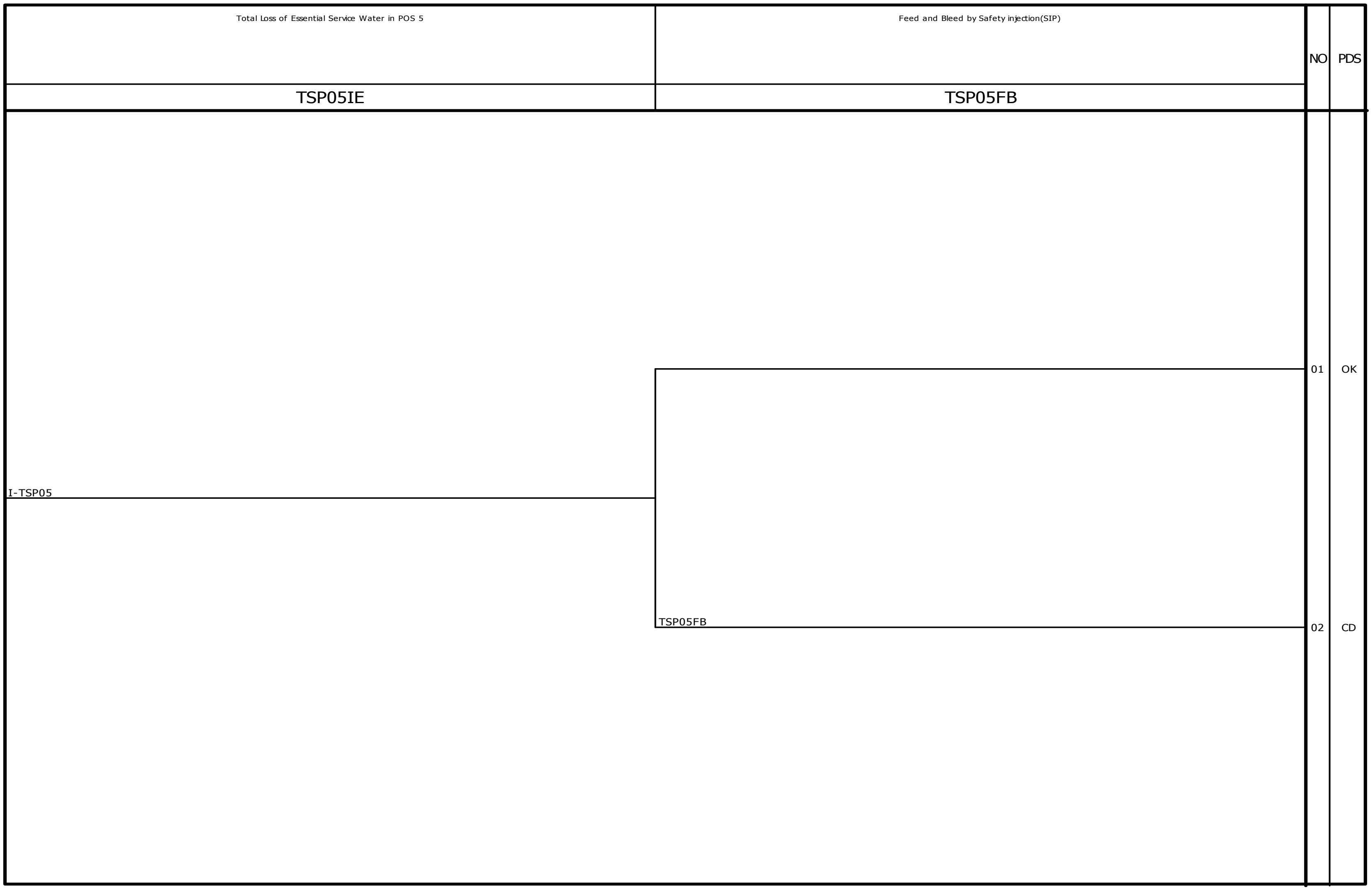

Figure 19.1-62 Total Loss of Essential Service Water (TS) in POS 5

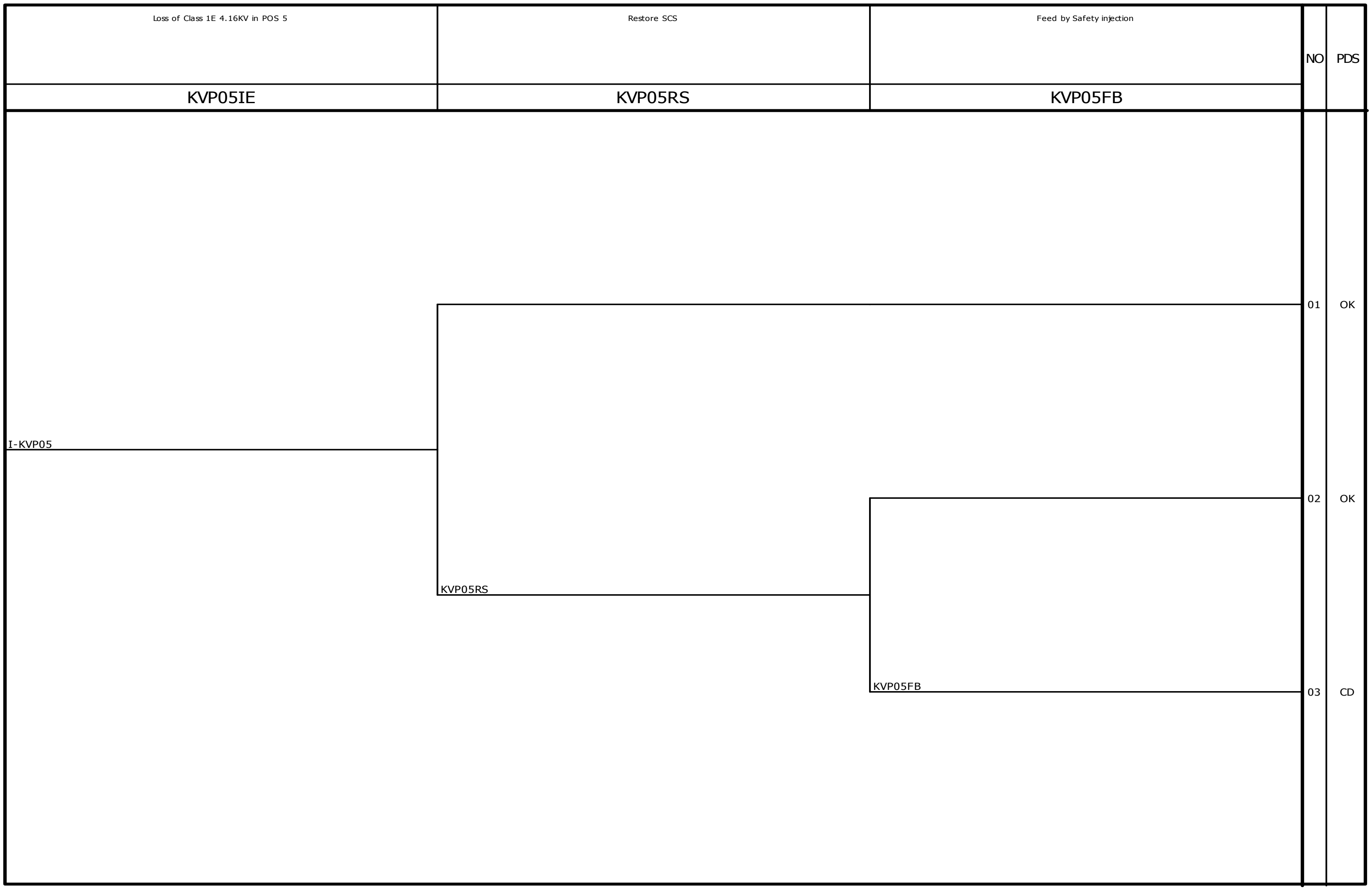

Figure 19.1-63 Loss of 4 kV Emergency Bus (KV) in POS 5

19.2 Severe Accident Evaluation

19.2.1 Introduction

This section describes the APR1400 features that are designed to prevent and mitigate severe accidents. The severe accident evaluation for the APR1400 design is consistent with the guidance in SECY-93-087 (Reference 1) as well as the corresponding Staff Requirements Memorandum (SRM), dated July 21, 1993. The reactor and containment system designs are a vital portion of the defense-in-depth philosophy. Current reactors and containments are designed to withstand a loss-of-coolant accident (LOCA) and to comply with the siting criteria of 10 CFR 100 (Reference 2), General Design Criteria (GDC) of 10 CFR 50 Appendix A (Reference 3), and the Three Mile Island (TMI)-related requirements of 10 CFR 50.34(f) (Reference 4), 10 CFR 50.44 (Reference 5), NRC RG 1.216 (Reference 6), and SECY-90-016 (Reference 7).

19.2.2 Severe Accident Prevention

The APR1400 design includes features aimed at preventing the onset of a severe accident, including the severe accident precursors identified in SECY-90-016 and SECY-93-087. These precursors include anticipated transient without scram (ATWS), mid-loop operation, station blackout (SBO) event, fire, and intersystem loss-of-coolant accident (ISLOCA). Preventive features are described below for each of these events.

19.2.2.1 Anticipated Transient without Scram

An ATWS happens when an anticipated operational occurrence (AOO) occurs but is not followed by an automatic reactor trip. Reactor trip is necessary to terminate the transient and to shut down the plant. The APR1400 design includes a digital safety system and a diverse protection system (DPS) to minimize the possibility of an ATWS.

The plant protection system (PPS) is normally available to prevent and mitigate an ATWS. The PPS includes the electrical and mechanical devices and circuitry required to perform the functions of the reactor protection system (RPS) and the engineered safety features – component control system (ESF-CCS). The RPS is the portion of the PPS that trips the reactor when required. A coincidence of two signals, due to the two-out-of-four trip logic,

is required to generate a reactor trip signal. The ESF-CCS is the portion of the PPS that activates the engineered safety feature systems (ESFSs). Additionally, the reactor trip system includes the RPS portion of the PPS, reactor trip switchgear system (RTSS), and components that perform a reactor trip after receiving a signal from the RPS (either automatically or manually).

The DPS provides a diverse backup to the PPS when the PPS is not working. The DPS initiates a reactor trip signal on high pressurizer pressure to decrease the possibility of an ATWS and provides an auxiliary feedwater actuation signal (backup to the ESF-CCS of the PPS) to mitigate an ATWS.

19.2.2.2 Mid-Loop Operation

During plant shutdowns, certain maintenance and testing activities require the controlled drain-down of the reactor coolant system (RCS) to a partially filled condition. When the reduced RCS level is within the hot leg, the risk of losing shutdown cooling is increased due to the possibility of vortex formation at the shutdown cooling suction line interface with the hot leg. If a vortex is formed in the shutdown cooling suction line, a substantial amount of air could be entrained into the shutdown cooling suction piping and degrade or interrupt the SC pump performance. If sufficient shutdown cooling is not reestablished, coolant heatup and vaporization/boiling can lead to uncovery of the reactor core.

The APR1400 design features can accommodate loss of residual heat removal during reduced reactor water inventory operations. These design features include:

a. Instrumentation for shutdown operations

   Diverse, accurate, and redundant instrumentation provides the operator with continuous system status and precise information to monitor reduced reactor water inventory operations and respond to loss of shutdown cooling events.

b. Shutdown cooling system (SCS) design

   System design features that improve SCS performance include:

1) The shutdown cooling suction lines do not contain loop seals, thereby minimizing the potential to trap gas. The suction piping layout allows self-venting of accumulated gas (or air).

2) The two redundant shutdown cooling suction lines are completely independent.

3) There are no auto-closure interlocks on the shutdown cooling suction piping valves, minimizing the potential for shutdown cooling isolation events.

c. Steam generator nozzle dam integrity

The APR1400 design addresses the regulatory concern of preventing significant pressurization in the upper plenum of the reactor vessel during core boiling scenarios. The APR1400 procedural guidance recommends a nozzle dam installation and removal sequence, which consists of the following:

1) Installation: The nozzle dams are installed in the cold legs first and in the hot legs second.

2) Removal: The nozzle dams in the hot legs are removed first and in the cold legs second.

The installation procedure requires that the pressurizer manway be opened so that a hot side vent pathway exists prior to blocking both RCS hot legs with nozzle dams.

In the APR1400 design, the ability of the RCS to withstand abnormal pressurization during reduced-inventory operations with the nozzle dams installed is limited by the design pressure of the nozzle dams. Based on overpressure tests performed on nozzle dams, the design pressure is estimated to be 3.52 kg/cm^2 (50 psia). The design pressure is sufficient to withstand an abnormal pressurization transient.

In order to provide reasonable assurance that the nozzle dam design pressure is not exceeded during reduced-inventory operations with boiling conditions in the reactor vessel, the APR1400 design requires that a mid-loop vent pathway is

opened via the pressurizer manway prior to reduced-inventory operation. When the pressurizer manway is opened to the containment atmosphere, the surge line provides sufficient venting capacity to prevent RCS pressurization and preclude subsequent nozzle dam failure. The pressurizer surge line vent pathway has sufficient capacity to prevent core uncovery due to pressurization of the hot side resulting from boiling coolant.

d. Alternate inventory additions and decay heat removal methods

If SCS is lost during Mode 5 reduced water inventory operations, containment spray (CS) pumps or the safety injection (SI) pumps are used to provide makeup. If all above methods of decay heat removal and inventory replenishment are unavailable, a charging pump or a boric acid makeup pump is used to provide makeup for Modes 5 and 6. If no method of pumped inventory addition is available, a source for gravity feed inventory addition can be used via the SI tanks.

19.2.2.3 Station Blackout

One alternate ac (AAC) source is provided to help mitigate the effects of an SBO. The AAC automatically starts and is manually aligned to provide power to a Class 1E 4.16 kV bus in case Class 1E emergency diesel generators (EDGs) fail to start and load during loss-of-offsite-power (LOOP) events. This standby unit is independent and diverse from the Class 1E EDGs. Successful startup of the AAC together with turbine-driven auxiliary feedwater pumps is sufficient to prevent core damage in station blackout events (SBOs).

19.2.2.4 Fire Protection

The systems and components required for safe shutdown are physically separated from functionally similar or redundant systems or components to maintain the ability to perform safe shutdown functions in the event of a fire. Fire protection features such as fire detection, automatic and manual fire suppression, and fixed fire barriers provide reasonable assurance that the plant does not enter an unrecoverable state as a result of a fire incident. Fire protection system is described in Subsection 9.5.1.

19.2.2.5 Intersystem Loss-of-Coolant Accident

An ISLOCA is defined as a class of events in which a break occurs outside the containment in a system connected to the RCS, leading to a loss of primary system water inventory. This is considered as a beyond-design-basis event for systems connected with the RCS. Pressurization of an interfacing system could result from the inadvertent opening of a valve or valves, failure of containment isolation, or valves that are otherwise fully open (e.g., check valves that are stuck open). The APR1400 design addresses ISLOCA challenges by including the following design features:

a. The design pressure of equipment or systems has been increased to 64.3 kg/cm^2 (900 psig) for the low-pressure systems that are connected with the RCS.

b. Equipment and instrumentation has been added to alert the operator to an ISLOCA challenge or terminate and limit the scope of an ISLOCA event.

c. Parts of systems considered unnecessary are deleted because their functions can be replaced by other existing systems.

d. The refueling water tank is located inside containment.

e. Capability is provided for leak testing pressure isolation valves.

f. Pressure isolation valve position indication and control is provided in the main control room (MCR).

g. High-pressure alarms are added to warn the operator when increasing pressure approaches the design pressure of low-pressure systems.

In the APR1400 design, the safety injection system (SIS), SCS, and chemical and volume control system (CVCS) are directly connected to the RCS and are potentially susceptible to one or more ISLOCA events (i.e., they have one or more ISLOCA pressurization pathways).

The safety injection lines are connected to the reactor vessel directly and are primary interfaces through which an ISLOCA can begin. Pressurization is postulated to move from the direct vessel injection (DVI) nozzles and out of containment through the containment isolation valves to the low-pressure sections of the system. The SIS design satisfies the ISLOCA acceptance criteria because all sections of the system and interfaces

are designed to withstand full RCS operating pressure or have a leak-test capability. In addition, the valve position indications in the control room function even when the isolation valve operators are de-energized, and high-pressure alarms sound to warn operators when pressure is approaching the design pressure. These design features protect the SIS lines and all interfacing systems from an ISLOCA challenge without adversely affecting performance or operations.

The shutdown cooling suction lines are connected to the RCS directly and are primary interfaces through which an ISLOCA event can begin. Pressurization is postulated from the hot leg and out of containment through the containment isolation valves to the low-pressure sections of the system. The shutdown cooling return lines are directly connected to the RCS directly and are primary interfaces through which an ISLOCA event can begin. Pressurization is postulated from the DVI nozzles and out of containment through the containment isolation valves to the low-pressure sections of the SCS.

This SCS line design satisfies the ISLOCA acceptance criteria because all sections of the system and interfaces are designed to withstand full RCS operating pressure, or they have leak-test capabilities, valve position indications in the control room that function even when isolation valve operators are de-energized, and high-pressure alarms to warn operators when pressure is approaching the design pressure. Deletion of the interfaces from the SCS lines eliminates the potential for an ISLOCA without adversely affecting the performance or operations of the SCS. These design features satisfy the ISLOCA acceptance criteria for the SCS line.

The containment spray system (CSS) is not connected directly to the RCS during the modes of reactor operation for which an ISLOCA challenge can occur. However, there is an indirect interface through the SCS because the CS pumps, CS heat exchangers, SC pumps, and SC heat exchangers are interchangeable respectively. All connected CS sections are designed to 64.3 kg/cm^2 (900 psig). The only low-pressure system interface with the CSS is the spent fuel pool cooling and cleanup system (SFPCCS) connection to the refueling pool. This connection provides the ability to fill the refueling pool directly rather than through the reactor vessel. A spool piece connection is available to provide a method of physical separation of the low-pressure SFPCCS from any pressurization source in the CSS.

The CVCS letdown line is directly connected to the RCS and is a primary interface through which an ISLOCA event can begin. Pressurization is postulated from the letdown nozzle,

through the regenerative and letdown heat exchangers, through the letdown orifices, and out of containment through the containment isolation and letdown control valves to the low-pressure sections of the system. The letdown line has a high-pressure alarm that is located downstream of the letdown control valves and warns the operator when the pressure is approaching the low-pressure system design pressure. When a warning is issued, the control room operator isolates the letdown line to terminate any further pressure communication downstream of the containment isolation valve.

The CVCS charging line is connected directly to the RCS and is a primary interface through which an ISLOCA event can begin. Pressurization is postulated from the charging nozzle, through the shell side of the regenerative heat exchanger, the charging control valve, and the charging pump to the low-pressure sections of the system. The charging pump suction line has a high-pressure alarm that warns the operator when the pressure is approaching the low-pressure system design pressure. When a warning is received, the control room operator isolates the charging line to terminate any further pressure communication downstream of the containment isolation valve. These design responses satisfy the ISLOCA acceptance criteria.

19.2.2.6 Other Severe Accident Preventative Features

The APR1400 design uses other features to prevent severe accidents including:

a. Feedwater can be supplied to a steam generator by a turbine-driven auxiliary feedwater pump when the motor-driven auxiliary feedwater pumps are not available. Two independent turbine-driven auxiliary feedwater pumps are available in the APR1400 design.

b. If the CS pumps are inoperable during a LOCA event, then the SC pumps can be used as a backup.

c. The CS pumps and CS heat exchangers can be used as backups for the SC pumps and SC heat exchangers to provide cooling of the IRWST during post-accident feed-and-bleed operations when the steam generators are not available to cool the RCS.

d. Cooling during a loss of all feedwater can be accomplished via feed-and-bleed operation using the SIS and the pilot-operated safety and relief valves (POSRVs).

The component cooling water system (CCWS) is composed of two separate but interconnected two-division systems. The systems are designed to automatically isolate the cross connection in an accident. One or both of these systems operate independently after isolation because their designs provide a high level of performance reliability. If the CCWS is inoperable at any time during RCP operation, the RCP seal injection function is performed by the supply of seal injection via the auxiliary charging pump.

19.2.3 Severe Accident Mitigation

If a severe accident cannot be prevented by the above design features, other APR1400 features mitigate the effects of a severe accident. Of particular importance are the containment design and the ability of mitigating equipment to survive severe accident conditions. This section describes the mitigation features in the context of various severe accident phenomena that could be encountered during severe accident progression.

19.2.3.1 Overview of the Containment Design

19.2.3.1.1 Description of the Containment

The APR1400 containment is a prestressed concrete structure composed of a right circular cylinder with a hemispherical dome and is founded on safety-related common basemat. The APR1400 containment encloses the reactor vessel, steam generators, reactor coolant loops, and portions of the auxiliary and engineered safety features systems. The containment provides reasonable assurance that leakage of radioactive material to the environment does not exceed the acceptable dose limit as defined in 10 CFR 50.34 even if a loss of coolant accident (LOCA) occurred.

The cylindrical containment shell has a constant thickness of 1.37 m (4 ft 6 in) from the top of the foundation basemat to the springline. The shell is thickened locally around the equipment hatch, two personnel airlocks, feedwater, and main steam line penetrations. The containment reinforcing consists primarily of hoop and meridional steel. Prestressing tendons are also arranged in hoop and meridional directions.

The roof of the containment is a hemispherical dome. The inside of the dome is lined with a steel liner plate to provide leak-tightness. The buttresses are extended up to 48 degrees into the dome to provide anchorage for the dome hoop tendons. The 6.0 mm (0.25 in) liner plate is attached to inside of the dome and the cylindrical wall to provide leak-tightness.

The containment provides a large free volume with its internal structures arranged in a manner to (1) protect the inner containment from missile threats, (2) promote mixing throughout the containment atmosphere, and (3) accommodate condensable and non-condensable gas releases from design basis and severe accidents. The internal structures, which are made of reinforced concrete, enclose the reactor vessel and other primary system components. The internal structures provide radiation shielding for the containment interior and missile protection for the reactor vessel and containment shell.

19.2.3.1.2 <u>Containment Pressure Limits</u>

In severe accident scenarios, the containment vessel is the last fission product barrier protecting the public from radiation release. Therefore, it is of paramount importance to provide a strong containment design to meet severe accident internal pressurization challenges.

The containment is designed in accordance with *[ASME Section III, Division 2]** (Reference 8), and for the design pressure of 4.218 kg/cm^2 (60 psig) and design basis temperature of 416.5 K (290 °F). The containment is analyzed to determine all membrane, bending, and shear stresses resulting from the specified static and dynamic design loads.

As stated in SECY 93-087, the conditional containment failure probability (CCFP) must be less than 0.1 or meet a deterministic containment performance goal that provides comparable protection so the following general criterion is met: The containment maintains its role as a reliable, leak-tight barrier by providing reasonable assurance that the containment factored load category (FLC) requirements are met for a period of approximately 24 hours following the onset of core damage, and following this 24-hour period, the containment continues to provide a barrier against the uncontrolled release of fission products. The CCFP of APR1400 containment is described in Subsection 19.1.4.2.2. The APR1400 containment meets the FLC requirement of *[ASME Section III,*

*Division 2, Subarticle CC-3720.]** The containment structural integrity evaluation is described in Subsection 3.8.1.4.12.

19.2.3.1.3 Containment Penetrations

The containment pressure boundary is made up of the containment shell and several mechanical and electrical containment penetrations. The penetrations include one equipment hatch; two personnel airlocks; containment piping penetration assemblies to provide for the passage of process, service, sampling, and instrumentation pipelines into the containment; electrical penetrations for power, control, and instrumentation; and a fuel transfer tube. All large penetrations are explicitly considered in the containment shell ultimate pressure capacity analyses. Smaller penetrations are sufficiently strong that they do not prematurely compromise the integrity of the containment shell.

19.2.3.2 Severe Accident Progression

This section provides a general description of the processes that may occur during the progression of a severe accident. Information is presented in the context of how these phenomena affect containment performance. Because of the complex processes involved, the progression of core melt scenarios can varies. Previous assessments reported in NUREG/CR-5132 (Reference 9), NUREG/CR-5597 (Reference 10), and NUREG/CR-5564 (Reference 11) provide generic insights that are also applicable to the APR1400 design.

The following subsections summarize key phenomena in the progression of severe accidents for the APR1400 design. Severe accident progression can be separated into in-vessel and ex-vessel phases. The in-vessel phase generally begins with insufficient decay heat removal and can lead to melt-through of the reactor vessel. The ex-vessel phase starts with the release of core debris from the reactor vessel into the containment, which can result in phenomena such as molten core-concrete interaction (MCCI), fuel-coolant interaction (FCI), and direct containment heating (DCH).

19.2.3.2.1 In-Vessel Melt Progression

In severe accidents that proceed to vessel failure, the in-vessel melt progression establishes the initial conditions for the thermal and mechanical loads that may ultimately threaten the

integrity of the containment when melt is ejected from the vessel. In-vessel melt progression encompasses the phenomena and processes involved in a severe core damage accident, starting with core uncovery and initial heatup, and continuing until either the degraded core stabilizes and cools within the reactor vessel stabilizes and cools, or breach of the reactor vessel occurs and molten core material is released into the containment. The phenomena and processes in the APR1400 that can occur during in-vessel melt progression include:

a. Core heatup resulting from loss of adequate cooling

b. Metal-water reaction and cladding oxidation

c. Eutectic interactions between core materials

d. Melting and relocation of cladding, structural materials, and fuel

e. Formation of blockages near the bottom of the core as relocating molten materials solidify (wet core scenario)

f. Formation of a melt pool, natural circulation heat transfer, crust formation, and crust failure (wet core scenario)

g Drainage of molten materials to the vessel lower head region (dry core scenario)

h. Formation of a melt pool, natural circulation heat transfer, and crust formation in the lower plenum

i. Reactor vessel breach from a local failure or global creep-rupture

Successful removal of decay heat prevents initiation of a severe accident. However, if decay heat removal fails, the core can heat to the point where coolant is lost and damage to the fuel and fuel cladding may occur.

When decay heat exceeds the available heat removal rate coolant, boil off can result and reduce the water level within the reactor vessel. If the coolant level within the core decreases to the point that the core is exposed then the fuel rods are only cooled by rising steam. The fuel rods begin to overheat and oxidation of the zirconium alloy cladding releases more heat and generates hydrogen from reaction with steam. As the fuel rods

continue to heat up from decay heat and reaction energy from the exothermic zirconium oxidation reaction, low melting point materials within the reactor melts first and may form eutectics.

The zirconium alloy, with a melting point near 2,033 K (3,200 °F), eventually begins to melt, breaking down the protective ZrO_2 layer, and exposing unoxidized zirconium alloy. Local melting of the fuel rods may cause changes in the core geometry and reroute the steam flow. This can lead to an increase in oxidation as more steam has access to the unoxidized zirconium alloy, or it could reduce the zirconium alloy surface available for oxidation and thereby decrease the overall reaction process.

In addition to oxidation, the potential exists for the zirconium alloy to interact with the UO_2 fuel, forming low-melting-point eutectics. Formation of eutectics may decrease the effective surface area for oxidation and the overall oxidation rate. Fuel/cladding contact, fuel liquefaction, and melt relocation can affect the oxidation behavior of zirconium alloy-based melt.

Various severe fuel damage (SFD) test programs, sponsored by the NRC, show that the oxidation of zirconium is largely controlled by the availability of steam and high rates of hydrogen generation can continue after melt formation and relocation (Reference 12). Some of these experiments indicate that most hydrogen generation occurs after onset of zirconium melting and fuel dissolution. In steam-rich experiments, oxidation took place over most of the fuel bundle length, and most of the hydrogen generation occurred early. For steam-starved experiments, oxidation was limited to local regions of the fuel bundle, and most hydrogen generation occurred after the onset of Zr/UO_2 liquefaction and relocation.

Hydrogen production and accumulation during a severe accident may challenge the containment in numerous ways, including deflagration, detonation, and pressurization. The APR1400 containment has the containment hydrogen control (HG) system to consume hydrogen as it is produced during a severe accident, thereby decreasing the potential for hydrogen combustion events that would challenge containment integrity.

The SFD tests indicated the potential for incoherent melt relocation as a result of variable temperatures within the test bundles. This is because of the different core materials present with a wide range of melting points and eutectic temperatures. Formation of

eutectics results in a non-uniform melting and relocation process. Further differences in the melt relocation process can be attributed to asymmetric bundle heating that can increase upon zirconium alloy oxidation. This process begins when one area of the fuel bundle is initially at a temperature higher than the other areas. The higher temperature zirconium alloy oxidizes at a faster rate. The exponentially increasing oxidation reaction contributes to asymmetric bundle heatup and the potential for incoherent melt relocation behavior.

As the temperature of the core increases, vaporization and release of some fission products occur. Steam or hydrogen carries these fission products throughout the primary system where they can deposit on internal components. The deposition mechanisms include condensation on the heat sinks (diffusiophoresis), gravitational settling, and thermophoresis. The fission products that are not deposited remain airborne and are released to the containment, where the dominant removal mechanisms are gravitational settling and diffusiophoresis.

Core melt progression, including relocation and fission product release, is a very complex process, which becomes increasingly difficult to predict as the scenario unfolds. The core melt could relocate into the lower reactor vessel plenum. If water is present in the lower plenum, the potential could exist for in-vessel steam explosions, wherein molten core material rapidly fragments and transfers its energy, causing rapid steam generation and possible shock waves.

The in-vessel core melt progression contains considerable uncertainty. This uncertainty relates to the following:

a. Potential for in-vessel steam explosion

b. Interaction between core debris and internal vessel structures

c. Time and mode of vessel failure

d. Composition of the core debris released at vessel failure

e. Amount of in-vessel hydrogen generation

f. In-vessel fission-product release and transport

g. Retention of fission products and other core materials in the RCS

19.2.3.2.2 Ex-Vessel Melt Progression

Upon vessel failure, the melt progression moves to the containment (ex-vessel). The following conditions affect ex-vessel severe accident progression:

a. Mode and timing of the reactor vessel failure

b. Primary system pressure at reactor vessel failure

c. Composition, amount, and character of the molten core debris expelled

d. Type of concrete used in containment construction

e. Availability of water to the reactor cavity

The initial response of the containment from ex-vessel severe accident progression depends on RCS pressure at reactor vessel failure and the existence of water within the reactor cavity. If not prevented by design features, early containment failure mechanisms and bypass usually dominate risk consequences. Early containment failure mechanisms result from energetic severe accident phenomena, such as high-pressure melt ejection (HPME) with DCH and ex-vessel steam explosions. The long-term containment pressure and temperature response from ex-vessel severe accident progression is largely a function of an interaction between molten core and concrete, known as MCCI, and the availability of mechanisms to remove heat from the containment.

At high RCS pressures, ejection of the molten core debris from the reactor vessel could occur in jet form, causing fragmentation of the debris into small particles. The potential exists for the ejected debris to be swept out of the reactor cavity and into the upper containment. Finely fragmented and dispersed core debris could rapidly heat the containment atmosphere and lead to a large pressure spike. In addition, exothermic chemical reactions of the core debris particulate with oxygen and steam could add to the pressurization. Hydrogen, preexisting in the containment or produced during DCH, could ignite, further adding to the containment pressure load. These phenomena are together referred to as HPME with DCH.

Reactor vessel failure with discharge of core debris into a wet reactor cavity (i.e. the cavity contains water) induces interactions between fuel and water (coolant) with the potential for rapid steam generation or steam explosions. Rapid steam generation involves non-explosive steam generation that pressurizes containment compartments beyond their ability to withstand or relieve the pressure; thus, the containment fails because of local overpressurization. Steam explosions involve the rapid mixing of finely fragmented core debris with surrounding water, resulting in rapid vaporization and acceleration of surrounding water, creating substantial pressure and impact loads.

The eventual contact of molten core debris with concrete in the reactor cavity leads to MCCI. This interaction decomposes the concrete and can challenge the containment by various mechanisms, including:

a. Pressurization from evolved steam and non-condensable gases, which can cause overpressure failure of containment

b. Transport of high-temperature gases and aerosols into the containment, leading to high-temperatures and possibly failure at the containment seals and penetrations

c. Containment basemat melt-through

d. Reactor support structure melt-through leading to the relocation of the reactor vessel and tearing of containment penetrations

e. Production of combustible gases such as hydrogen and carbon monoxide

Many factors affect MCCI, including the availability of water in the reactor cavity, the containment geometry, the composition and amount of core debris, the core debris superheat, and the type of concrete involved.

19.2.3.3 Severe Accident Mitigation Features

Various APR1400 design features are intended to mitigate the effects of particular severe accident phenomena, as described in the following subsections.

19.2.3.3.1 External Reactor Vessel Cooling

In-vessel retention of core debris as result of external reactor vessel cooling is a potential means to mitigate a severe accident. The goal of external cooling is retention of the molten core debris in the reactor vessel lower plenum and thus prevent vessel failure. In-vessel retention precludes the possible ex-vessel physical phenomena related to debris relocation such as steam explosions and molten core concrete interaction (MCCI).

The APR1400 is designed to allow operators to fill the reactor cavity with water and thereby submerge the reactor vessel in coolant. This can achieve ex-vessel cooling and in-vessel retention. However, in-vessel retention is not credited as a mitigation feature for the APR1400 due to uncertainty surrounding the associated phenomena along with the need for operators to take additional manual actions.

19.2.3.3.2 Hydrogen Generation and Control

19.2.3.3.2.1 Mitigation Features

During a degraded core accident, hydrogen is generated at a greater rate than that of the design basis LOCA. The containment hydrogen control system is designed to accommodate the hydrogen generation from a metal-water reaction of 100 percent of the active fuel cladding and limit the average hydrogen concentration in containment to 10 percent consistent with 10 CFR 50.34(f) and 10 CFR 50.44 (Reference 5) for a degraded core accident. These limits are imposed to preclude detonations in containment that might jeopardize containment integrity or damage essential equipment.

The HG consists of a system of passive autocatalytic recombiners (PARs) complemented by glow plug igniters installed within the containment. The PARs are capable of controlling hydrogen in all accident sequences with moderate hydrogen release rates, and are located throughout the containment. The igniters supplement PARs for accidents in which rapid hydrogen release rates are expected, and are placed near anticipated source locations to promote the combustion of hydrogen in a controlled manner. The HG design is composed of 30 PARs and 8 igniters, which are placed throughout the containment as listed in Table 19.2.3-1. The PAR and igniter locations are shown in Figure 19.2.3-1. The HG PARs are strategically distributed so that the overall average concentration

requirements are met. These locations are determined based on equipment and piping proximity as well as inspection and maintenance access. The PAR components and igniter assembly are designed to meet seismic Category I requirements.

The PARs are self-actuated and require no electric power. Therefore, no operator action is required. The igniters, which supplement PARs, are intended to control hydrogen concentration within containment once the operator confirms that an extended core uncovery is in progress. The operators use specific accident management guidance that relies on RCS and containment instrumentation, such as in-vessel level monitoring instrumentation, core-exit thermocouples, containment and RCS pressure indications, and a direct measurement of containment hydrogen concentration.

Once activated, an igniter produces either periodic small local burns or a standing diffusion flame, either of which reduces the containment hydrogen concentration below the upward flammability limit. Thus, the HG system prevents hydrogen from accumulating to the point where a destructive hydrogen detonation might occur within the containment.

19.2.3.3.2.2 Analysis Methodology

Hydrogen control analyses were performed using the Modular Accident Analysis Program (MAAP), version 4.0.8 (Reference 13), to determine hydrogen mixing, distribution, and combustion inside containment. The containment model used for hydrogen control analysis consists of 36 control volumes, 83 flow paths, and heat structures. Figure 19.2.3-2 shows the nodalization scheme of the containment model. Table 19.2.3-2 provides a description of the individual nodes. The analysis also investigated the potential for hydrogen accumulation in the containment and the response of the hydrogen mitigation system.

The accident sequences to be analyzed were selected to cover the most probable core damage sequences from outcomes of Level 1 PRA plus representative LOCA sequences. As a result, five accident sequences — large-break, medium-break, and small-break LOCA (LBLOCA, MBLOCA, and SBLOCA), SBO, and total loss of feedwater (TLOFW) — were selected as representatives.

In addition, the operations of CSS, cavity flooding system (CFS), HG, manual opening of POSRVs for rapid RCS depressurization, and alignment of the three-way valves to discharge to a steam generator (SG) compartment were considered to investigate the effects of accident management strategies for each sequence.

The guidance in 10 CFR 50.34(f) was followed to establish the total generated hydrogen. In principle, the amount generated by an equivalent to a 100 percent metal-water reaction (MWR) of the active fuel cladding was assumed to be generated due to oxidation of fuel cladding. The hydrogen generation due to ex-vessel MCCI is additionally considered in the hydrogen control analysis. This methodology results in more than 100 percent of equivalent MWR, depending on the extent of MCCI that occurs in the sequence.

Within each MAAP calculation, the potential hydrogen combustion events such as flame acceleration (FA) and deflagration-to-detonation transition (DDT) for hydrogen-steam-air mixtures are evaluated using the σ-criterion for FA and the 7λ-criterion for DDT from the Organisation for Economic Co-operation and Development (OECD) report (Reference 14).

An adiabatic isochoric complete combustion (AICC) analysis was performed to determine the peak containment pressure when combustible gases generated during the course of severe accident burn all at once. The results are summarized in Subsection 19.2.4.2.1.

19.2.3.3.2.3 Analysis Results

The MAAP computer code was used for predicting release of hydrogen at various containment compartments under severe accident scenarios. The possible hydrogen release points considered in the analysis include the hot-leg break (for LOCAs), IRWST spargers, failed reactor vessel lower head, and POSRV three-way valves. For LOCAs prior to vessel failure, hydrogen is released from the break in the hot leg into SG compartment. For non-LOCA sequences like SBO and TLOFW, hydrogen is first released to the IRWST through the pressure-lifted POSRVs. When three-way valve manual alignment is actuated, hydrogen is also released to SG compartment via the three-way valve. For high-pressure sequences including an SBO, TLOFW, and SBLOCA, an additional release point could come from hot leg failure due to creep. After vessel failure, the failed lower head provides another hydrogen release point to the cavity area.

Figures 19.2.3-3 through 19.2.3-6 show the hydrogen distribution in the containment when all severe accident mitigation features are available. Based on the results of the analysis, the APR1400 design with all of the severe accident mitigation features available is capable of maintaining a well-mixed containment atmosphere and a hydrogen concentration below 10 percent (Reference 15).

With severe accident mitigation features available, there is no potential for DDT in the containment (Reference 15). The mitigation features include HG, CFS, and manual opening of POSRVs with alignment of the three-way valves.

19.2.3.3.3 MCCI and Core Debris Coolability

After vessel failure, core debris is discharged into containment. Once there, MCCI begins, leading to erosion of the concrete in the reactor vessel cavity. This threatens the integrity of the containment pressure boundary due to the possibility of melt-through of containment liners and the concrete basemat. Concrete ablation also generates non-condensable gases such as CO_2, CO, and H_2, which can lead to containment challenges due to pressurization and hydrogen burns. In order to halt MCCI, debris superheat and decay heat are removed from the corium pool. The APR1400 design accomplishes this by providing for flooding of the reactor cavity using the CFS. This allows heat to be transferred from the corium pool into the overlying pool of water, eventually stopping MCCI. The analysis in this section shows that the CFS feature is capable of protecting against challenges to the containment integrity due to MCCI.

19.2.3.3.3.1 Mitigation Features

19.2.3.3.3.1.1 Reactor Cavity Design

The reactor cavity is configured to promote retention of, and heat removal from, the postulated core debris during a severe accident, thus serving several roles in accident mitigation. The large cavity floor area allows for spreading of the core debris, enhancing its coolability within the reactor cavity region.

The large free volume of the reactor cavity is a benefit when cavity pressurization issues are considered. Large, vented volumes are not prone to significant pressurization resulting

from vessel breach or during corium quench processes. This design characteristic is illustrated in the cavity pressurization analysis results in that the possible peak pressure in the reactor cavity during severe accidents stays well below the allowable capacity.

The reactor cavity is designed to maximize the unobstructed floor area available for the spreading of core debris. The cavity floor is free from obstructions and comprises an area available for core debris spreading such that the floor area/reactor thermal power ratio is larger than 0.02 m^2/MWt. Uniform distribution of 100 percent of the corium debris within the reactor cavity results in a relatively shallow debris bed and consequently, effective debris cooling is expected in the reactor cavity.

The containment liner plate in reactor cavity area is embedded 0.91 m (3 ft.) below from the cavity floor at the minimum.

19.2.3.3.3.1.2 Cavity Flooding System

The cavity flooding system (CFS) provides a means of flooding the reactor cavity during a severe accident to cool the core debris in the reactor cavity and to scrub fission product releases. The water delivery from the IRWST to the reactor cavity is accomplished by means of active components. The CFS is designed (in conjunction with the containment spray system) to provide an inexhaustible continuous supply of water to quench the core debris.

The components of the CFS include the IRWST, holdup volume tank (HVT), reactor cavity, connecting piping, valves, and associated power supplies. This system is used in conjunction with the containment spray system to form a closed recirculation water cooling system to provide a continuous cooling water supply to the core debris. The quenching of the corium produces steam, which is condensed by the containment spray flow. The CFS takes water from the IRWST and directs it to the reactor cavity. The water flows first into the HVT by way of the two HVT spillways and then into the reactor cavity by way of two reactor cavity spillways.

Once actuated, movement of the water from the IRWST source to the cavity occurs passively due to the natural hydraulic driving heads of the system. Actuation of the CFS results in the opening of the HVT spillway valves, allowing water from the IRWST to flood

the HVT. This flow is driven by the differences in the static heads of water between the IRWST and the HVT. Flooding of the HVT progresses until the water level in the HVT reaches the reactor cavity spillway, at which time reactor cavity flooding commences. Flooding ceases when water levels in the IRWST, HVT, and reactor cavity equalize.

The HVT and cavity spillways are located as low as possible to provide the greatest head and maximize usage of available water in the IRWST and HVT. Both spillways are equipped with remote manual motor-operated valves (MOVs).

HVT flooding valves are normally closed and located in individual flow paths connecting the IRWST to the HVT. Reactor cavity flooding valves are normally closed and located in individual flow paths connecting the HVT to the reactor cavity. The valves are opened by the MCR operator to flood the reactor cavity in the event of a severe accident. Controls are provided to allow the valves to be opened either individually or simultaneously, to initiate reactor cavity flooding.

Flooding of the reactor cavity serves the following purposes in the strategy to mitigate the consequences of a severe accident:

a. Minimize or eliminate corium-concrete attack

b. Minimize the generation of combustible gases (hydrogen and carbon monoxide) and non-condensable gases

c. Scrub fission products released due to corium-concrete interaction

d. Remove heat from the core debris

The manual operation of the CFS provides a mechanism for the operator to most efficiently use plant resources and mitigate the consequences of a severe accident. It is envisioned that the CFS is actuated once a potential core melt condition is imminent or has been diagnosed as being in progress. Typical indications of core uncovery include (1) core-exit thermocouple (CET) temperatures in excess of 922.04 K (1,200 °F), (2) reactor vessel level monitoring system (RVLMS) readings indicative of no liquid above the fuel alignment plate, and (3) significant changes in readings of self-powered neutron detectors (SPND).

It is understood that steam explosions may pose a non-negligible threat to the cavity and containment integrity. Thus, there may be an incentive to delay actuation of the CFS until vessel breach (VB) is imminent or when the reactor vessel lower head has failed. While actuation of the CFS before VB is presently deemed desirable, the consequences of delayed CFS actuation (prior to extensive concrete erosion) may also achieve similar results. Flooding of the HVT progresses until the water levels in IRWST, HVT, and reactor cavity equalize at 6.4 m (21 ft) from the reactor cavity floor (EL. 69 ft 0 in).

Thus, it is currently believed that an acceptable stable state can be achieved ex-vessel as long as the CFS has been actuated prior to VB. Although providing water to the reactor cavity may not immediately terminate the concrete erosion, having a water-filled reactor cavity initially reduces and ultimately terminates the erosion, while simultaneously providing scrubbing of fission products released in the molten core-concrete interaction process.

19.2.3.3.3.2 Analysis Methodology

The MCCI analysis for the reactor cavity is performed with MAAP using model parameters tuned based on the results of the more sophisticated debris coolability code CORQUENCH (Reference 16). CORQUENCH models a broad range of MCCI and debris coolability phenomena, including:

a. Stress-induced cracking of the upper crust and water ingression

b. Melt eruption due to debris entrainment by offgas produced from the decomposition of concrete

c. Particle bed formation due to melt eruption and jet breakup during debris relocation after vessel failure

d. Formation of stable crust bridges that prevent water contact with molten debris

Analysis of MCCI in a flooded reactor cavity and reactor cavity sump is first performed using CORQUENCH for a conservative LBLOCA sequence with early relocation of 100 percent of the core inventory into the reactor vessel cavity. The results of this analysis are then used to tune the model parameters in the MAAP. MAAP is then used to analyze the progression of MCCI in the reactor cavity for several of the most likely core damage

sequences as well as a LBLOCA sequence. Each sequence is run with a flooded reactor cavity.

Debris coolability in the sump is evaluated using CORQUENCH for a conservative LBLOCA sequence.

19.2.3.3.3.3 Analysis Result

The corium in the APR1400 reactor cavity is quenched, and the integrity of containment liners is maintained when the CFS is available, based on the analyses presented in this subsection. This is due to the ample corium spreading area in the reactor cavity, which allows for sufficient heat transfer from the corium pool into the overlying pool of water and thus prevents the ablation front from reaching the containment liner plate.

19.2.3.3.3.3.1 CORQUENCH Result for MCCI in the Reactor Cavity

For the MCCI analysis in the reactor cavity, the conservative large-break LOCA (LBLOCA) scenario is calculated by CORQUENCH. This sequence conservatively assumes early relocation of 100 percent of the core inventory into the containment and that no jet breakup occurs when the core debris relocates into the flooded reactor cavity. The depth of concrete ablation in the reactor cavity for the conservative LBLOCA scenario was predicted to be 0.27 m (0.86 ft) by CORQUENCH.

19.2.3.3.3.3.2 CORQUENCH Results for MCCI in the Reactor Cavity Sump

The limiting case for MCCI analysis is large-break LOCA with 100 percent core relocation into the reactor cavity. For the large-break LOCA scenario, corium is predicted to be quenched in the reactor cavity sump before the depth of concrete ablation reaches the buried containment liner. This sequence conservatively assumes early relocation of 100 percent of the core inventory into the containment.

19.2.3.3.3.3.3 MAAP Results for MCCI in the Reactor Cavity

The largest amount of concrete erosion in the reactor cavity is predicted to occur for the large-break LOCA scenario. This scenario models a large-break LOCA with MAAP

predicting early vessel failure and some debris retained in the reactor vessel lower plenum. Figures 19.2.3-7 through 19.2.3-11 show the ablation depth in the floor and sidewall. MAAP predicts an ablation depth of 0.24 m (0.79 ft). The final ablation depth is well short of the 0.91 m depth of the containment liner embedded in the reactor cavity. Figure 19.2.3-12 shows the containment pressure. The containment pressure remains below the 8.7 kg/cm^2 (123.7 psia) for 24 hours following the onset of core damage. The basis of pressure 8.7 kg/cm^2 (123.7 psia) is described in Subsection 19.2.4.2.1.

19.2.3.3.4 High-Pressure Melt Ejection and Direct Containment Heating

Accident initiators such as station blackout, loss of feedwater, and small-break LOCA can result in core melt and reactor vessel failure at high pressures. If the reactor vessel fails while the reactor coolant system is still pressurized, particulate core debris can be entrained from the reactor cavity by gas flows and transported directly into the upper containment atmosphere. This can result in a rapid temperature and pressure increase in containment by directly transferring the heat from the core debris into the containment gas space. This process is referred to as direct containment heating (DCH), and the core debris ejection process following reactor vessel failure at high pressure is called high-pressure melt ejection (HPME).

The DCH phenomenon is investigated by looking at three distinct areas: debris entrainment in the reactor cavity, debris de-entrainment in the lower containment compartments, and impacts of debris that reaches the upper containment compartments. Once the reactor vessel fails, core debris is discharged into the reactor cavity. As the reactor vessel depressurizes, high-velocity gas flows fragment and entrain debris from the corium pool. The fragmented debris particles can be dispersed into different areas of containment. During this transport process, a large portion of the entrained debris particles are de-entrained during sharp turns in the flow and are contained in the lower containment compartments. The fraction of core debris that is transported into the upper compartments can interact with the containment atmosphere, resulting in rapid temperature and pressure increases by rapid heat transfer. In addition, metallic constituents of the ejected material, principally zirconium and steel, can exothermically react with oxygen and steam to generate chemical energy and (in reactions with steam) hydrogen. Together with hydrogen combustion, this process can impose additional loads on the containment.

19.2.3.3.4.1 Mitigation Features

Mitigation features provided for HPME and DCH are the rapid depressurization (RD) function and reactor cavity design. The rapid depressurization function provides reasonable assurance that the reactor vessel is at low pressure when the vessel fails. The unique reactor cavity design provides reasonable assurance that even if the vessel fails at high pressure, most of the corium ejected stays in the subcompartment.

19.2.3.3.4.1.1 Rapid Depressurization Function

The RD function is a multi-purpose dedicated system designed to serve important roles in severe accident prevention and mitigation. Figure 19.2.3-13 shows some details of the RD function.

In the APR1400 design, the POSRVs are designed to allow for depressurization of the RCS below the cutoff pressure for HPME to occur. For the APR1400 design, the rapid depressurization function is initiated by operator action as part of the severe accident management strategy. When CET temperature exceeds 922.04 K (1,200 °F), the operator identifies entry into a severe accident condition and starts rapid depressurization by opening the required POSRVs.

The RD function design requirement related to severe accident mitigation is the capability to depressurize the RCS from approximately 175.8 kg/cm^2 (2,500 psia) to approximately 17.6 kg/cm^2 (250 psia) prior to reactor vessel breach. The target pressure of the RD function is determined on the basis of DOE/ID-10271 (Reference 17).

The power for each RD valve is supplied from a respective Class 1E direct current (dc) bus. The power is provided such that a bleed path can be established in case of a loss of offsite power, four emergency diesel generators (EDGs), and the AAC source. Each train of dc loads is provided with a separate and independent battery charger and a standby charger. The battery chargers are powered from the 480 V ac Class 1E power distribution systems of the same trains. A load management strategy provides reasonable assurance of dc power availability for a minimum of 4 hours for Trains A and B and 16 hours for Trains C and D following an SBO.

The RD function provides a manual means of quickly depressurizing the RCS when normal and auxiliary feedwater are unavailable to remove core decay heat through the steam generators. This function is achieved via remote manual operator control. Whenever an event, such as a TLOFW, results in a high RCS pressure with a loss of RCS liquid inventory, the POSRVs may be opened by the operator, causing a controlled depressurization of the RCS. As the RCS pressure decreases, the SI pumps start, initiating feed flow to the RCS and restoring the RCS liquid inventory. The RD function allows for both short- and long-term decay heat removal.

The RD function also serves an important role in severe accident mitigation. In the event a high-pressure meltdown scenario develops and the feed portion of feed and bleed cannot be established due to unavailability of the SI pumps, the RD function can be used to depressurize the RCS and prevent HPME following a VB.

19.2.3.3.4.1.2 Reactor Cavity Design

The reactor cavity is configured to promote retention of core debris during a severe accident. Corium retention in the core debris chamber virtually eliminates the potential for significant DCH-induced containment loadings.

When the vessel is breached under high pressure, the melt is ejected first followed by the high-speed steam and H_2 jet. The melt is entrained by the jet into small particles. The duration of the gas blowdown following melt ejection may be sufficiently long to cause complete sweep-out of the ejected melt. Therefore, it is reasonable, and conservative, to assume complete entrainment of ejected melt. Then, the mixture of steam, gas, and corium particles flow through available flow paths between the reactor cavity and the upper containment.

For flow entering the debris chamber, the lower-inertia steam/hydrogen/gas mixture negotiates right-angle turns and exit the reactor cavity while the corium particles carried by the flow impinge on walls and deposit in the subcompartment. For flow entering the in-core instrumentation (ICI) chase, the presence of the seal table prevents upward corium discharge through the instrument shaft. Even if the seal table fails due to overpressure in the reactor cavity, the flow first impinges on the wall at the end of the cavity and makes a 90-degree (upward) turn to the ICI chase where the seal table is located. It is shown that nearly all the entrained corium is captured by the impingement, and only a small amount

corium is released through the failed seal table. Therefore, the only flow path that leads directly to the upper containment without significant de-entrainment is the reactor pressure vessel (RPV) annulus. Because of the multiphase flow, the flow is choked in the reactor cavity, not in the reactor cavity access area. Thus, the fraction of the dispersed corium that enters the upper containment via the RPV annulus is given by the ratio of the area of RPV annulus, 1.96 m^2, to the total flow area, which is the sum of the area of PRV and the area of reactor cavity, 23.76 m^2, or 0.082.

19.2.3.3.4.2 Analysis Methodology

There are two parts to the methodology. The RD analysis evaluates whether the reactor vessel can be depressurized before it can fail, and the DCH analysis evaluates the containment pressure response to a HPME.

19.2.3.3.4.2.1 Rapid Depressurization Analysis

The rapid depressurization analyses were performed using MAAP code to prove the performance of the RCS depressurization. The MAAP code was used to evaluate pressure response of the reactor vessel when two POSRVs are opened following detection of core damage. The analyzed sequences for APR1400 were selected to be a representative sample of Level I PRA sequences, disabling the hot leg creep rupture model as necessary to predict a higher-pressure vessel failure.

19.2.3.3.4.2.2 DCH Analysis

NUREG/CR-6338 methodology (Reference 18) was applied for the DCH/HPME evaluation. This involves assessment of containment integrity by calculating the overall CFP based on phenomenological analysis and the uncertainties of the DCH process. If the CFP is below a certain level, containment integrity is judged to be maintained. For this purpose, the NRC developed a methodology that combines the two-cell equilibrium (TCE) model and Latin hypercube sampling (LHS) methods.

For the TCE/LHS analysis, scenarios defined in NUREG/CR-6075 (Reference 19) are selected as high-pressure sequences. For each selected scenario, initial DCH conditions such as core debris mass and its composition just after failure of the reactor vessel are

determined. The ejection characteristics of core debris are determined based upon the geometrical configuration of the containment. Probabilistic distribution functions for uncertainties in parameters such as core debris mass, degree of Zr oxidation, coherence ratio describing heat transfer between dispersed debris and gases in containment, and containment failure pressure are determined. A TCE analysis is performed by sampling inputs using 10,000 samples by LHS processing coupled with all generated data.

19.2.3.3.4.3 Analysis Result

Figure 19.2.3-14 shows the RCS pressure responses during the rapid depressurization. Operation of only two POSRVs within a half hour of the plant entering a severe accident is sufficient to decrease the RCS pressure below the DCH cutoff pressure (17.6 kg/cm^2 [250 psi]) for all sequences considered. Table 19.2.3-3 shows the summary of results for the rapid depressurization analysis about the Total Loss of Essential Service Water (TLOESW) sequence. The analysis results comply with SECY-93-087 (Reference 1).

For each of the three scenarios, no containment failure cases have resulted in 10,000 trials. Based on this outcome, the CFP in APR1400 due to DCH is estimated to be less than 0.01 percent (0.0001). This indicates that APR1400 meets the success criterion established in NUREG/CR-6338 (Reference 18) for PWR large dry containment, where DCH problem is considered resolved if CFP is less than 1 percent (0.01).

19.2.3.3.5 Fuel-Coolant Interactions

The containment integrity and function may be challenged by dynamic loads from a steam explosion resulting from FCI. For the evaluation of the risks associated with FCIs for the APR1400 design, in-vessel steam explosions (IVSEs) and ex-vessel steam explosions (EVSEs) are described and analyzed in accordance with 10 CFR 52.47(a)(23) (Reference 20).

19.2.3.3.5.1 Analysis Methodology

19.2.3.3.5.1.1 In-Vessel Steam Explosion (IVSE)

The alpha-mode failure caused by IVSE has been considered as a threat to containment integrity for many years. The FCI expert review group sponsored by the NRC concluded in NUREG-1116 (Reference 21) and NUREG-1524 (Reference 22) that probability of this failure was vanishingly small or physically unreasonable. The OECD/NEA FCI specialist meeting (Reference 23) confirmed this conclusion. Therefore, the IVSE analysis is performed to confirm the applicability of the experts' conclusions to the APR1400 design.

19.2.3.3.5.1.2 Ex-Vessel Steam Explosion (EVSE)

EVSE has been considered as one of the important threats to containment integrity for many years although no specific requirements are stated in the CFRs. Therefore, the EVSE analysis aims analytically to confirm the maintainability of containment integrity by employing a mechanistic FCI code to calculate EVSE pressure loads. The APR1400 specific analysis consists of four steps:

a. Selection of the initial and boundary conditions for the base case analysis based on MAAP analysis results

b. Evaluation of pressure loads with TEXAS-V (Reference 24) for the base case analysis

c. Assessment of uncertainties associated with the pressure load evaluation

d. Evaluation of containment structural integrity against the pressure loads

The base case of the EVSE analysis is assumed to be a case where the vessel failed at the bottom center of the RPV due to the in-core instrument guide tube ejection resulting in the ejection of oxidic core debris into a subcooled pool of water in the reactor cavity.

19.2.3.3.5.2 Analysis Result

19.2.3.3.5.2.1 In-Vessel Steam Explosion

The key physical processes that can influence in-vessel steam explosions for PWRs are (a) melt relocation into the lower plenum, (b) corium jet breakup and coarse mixing formation in the lower plenum, (c) triggering of coarse mixing, (d) energetic FCIs, and (e) pressure loads to the upper and lower vessel heads and their responses.

Both NUREG-1116 and NUREG-1524, written by the NRC-sponsored Steam Explosion Review Group, concluded that the potential for alpha-mode failure is vanishingly small or physically unreasonable. The OECD/Committee on the Safety of Nuclear Installations (CSNI) also confirmed the conclusion of NUREG-1524 and concluded that the alpha-mode failure issue was resolved from a risk perspective.

Because the APR1400 design is not significantly different from current PWRs, the NUREG-1524 conclusions are applicable to the APR1400 design, thus no mitigation features are provided to prevent or mitigate IVSE.

19.2.3.3.5.2.2 Ex-Vessel Steam Explosion

The initial and boundary conditions for EVSE are largely dependent upon the in-vessel severe accident progression, severe accident management procedure, and vessel failure modes. Thirteen severe accident sequences were chosen to cover the spectrum of key variable parameters and thus characterize the initial and boundary conditions for EVSE analysis. The key parameters considered include corium discharge rates, corium thermal conditions, cavity conditions, and related parameters.

The result of analysis using the MAAP code provided the initial conditions for the TEXAS-V code. TEXAS-V was then used to calculate the peak pressure due to EVSE. The pressure at the nearest cavity wall was then estimated by the TNT method (Reference 25).

The reactor cavity and RPV column support have to maintain structural integrity in events such as an ex-vessel steam explosion. The reactor cavity and RPV column support is

designed such that the cavity strength has an adequate capability to withstand the postulated pressure load during a severe accident.

For the assessment of reactor cavity structural integrity against the EVSE pressure loading, the concrete cracks of cavity walls and bottom slab, the stress of the RPV column support anchor bolts, reinforcement rebars, and liner plates were evaluated using LS-DYNA computer program. The results of evaluation confirm that the reactor cavity is capable of maintaining structural integrity when EVSE loads are applied.

The requirements of *[ACI 349-97]** (Reference 26) were used in determining the ultimate static pressure capacity and the dynamic pressure capacity of the reactor cavity wall (except no load factors were applied to the loads because of the highly unlikely occurrence of a severe accident and the one-time loading condition). As such, potential additional margins in reinforcing strength, concrete strength, and the material ductilities beyond those allowable by design code were not used in determining the aforementioned static and dynamic capacities of the structure. The evaluation of the cavity structural analysis indicates that the reactor cavity integrity is preserved during both static and dynamic EVSE loads.

19.2.3.3.6 Containment Bypass

Containment bypass events involve failure of the pressure boundary between the high-pressure reactor coolant system and a low-pressure auxiliary system. For PWRs, this can also occur because of the failure of the steam generator tubes, either as an initiating event or as a result of severe accident conditions.

These scenarios are important because, if core damage occurs, a direct path to the environment can exist. This can lead to an early release of fission products outside containment and public health risks. The following sections describe potential containment bypass events for the APR1400.

19.2.3.3.6.1 Steam Generator Tube Rupture

A thermally induced steam generator tube rupture (SGTR) can occur in severe accident sequences where the primary system is at high pressure during core melt. This condition

leads to creep rupture of the steam generator tubes due to the high-pressure and high-temperature conditions. The APR1400 design mitigates this possibility by operator actuation of the required POSRVs. This system is capable of reducing pressure in the reactor vessel below 17.58 kg/cm^2 (250 psia). Once primary system pressure reaches this level, there is essentially no risk of an induced tube rupture occurring.

19.2.3.3.6.2 Intersystem LOCA

Intersystem LOCA is mitigated by the instrumentation and the design pressure of systems which are directly connected to RCS. The pressure isolation valve position indication and high-pressure alarms can alert the operators to an intersystem LOCA challenge, or terminate and limit the scope of an intersystem LOCA event. The intersystem LOCA is described in detail in Subsection 19.2.2.5.

19.2.3.3.7 Equipment Survivability

According to SECY-90-016 and SECY-93-087, the equipment and instrumentation provided for severe accident mitigation do not need to be subjected to the qualification requirement of 10 CFR 50.49 (Reference 27), the quality assurance requirements of 10 CFR 50 Appendix B (Reference 28), or the redundancy/diversity requirements of 10 CFR 50 Appendix A. It is satisfactory to provide reasonable assurance that the designated equipment and instrumentation can operate in a severe accident environment over the required time span.

The equipment survivability (ES) assessment first requires identification of all essential equipment and instrumentation that are vulnerable to the harsh environmental conditions during a severe accident. Next, the harsh environmental condition expected in each location in the containment is determined. Pressure, atmospheric temperature, and radiation dose are considered. Then, the survivability of each essential piece of equipment or instrumentation is demonstrated with reasonable assurance by comparing the APR1400 severe accident environmental condition to the design basis event / severe accident testing, providing redundancy, performing thermal-lag analyses, or protecting it with thermal shields or conduits. The COL applicant is to perform and submit site-specific equipment survivability assessment in accordance with 10 CFR 50.34(f) and 10 CFR 50.44.

19.2.3.3.7.1 Identification of Required Equipment and Instrumentation for ES Assessment

During a core damage sequence, operators are confronted with multiple failures of essential safety equipment or operator errors. For operators to effectively cope with this plant condition, they are provided with equipment and instrumentation with the ultimate goal of achieving a safe stable state. This equipment and instrumentation can be grouped according to function: RCS inventory control, RCS heat removal, reactivity control, and containment integrity.

RCS inventory control is primarily provided by the SIS. If the SIS is not available and the RCS is depressurized below about 14.06 kg/cm^2 (200 psia), inventory control can be provided via realignment of SC or CS pump to operate in an injection mode.

RCS heat removal following a severe accident is accomplished by establishing auxiliary feedwater system (AFWS) flow to at least one steam generator or using the feed-and-bleed operation. Once a sufficiently low pressure is established in the RCS, long-term heat removal can be accomplished via the SC function using either SC or CS pumps, with associated heat exchangers.

Reactivity control is provided by insertion of control rods and delivering sufficiently borated water into the RCS. Reactivity control is typically achieved early in the transient via insertion of control rods.

Given the highly reliable containment isolation systems, the containment integrity of the APR1400 depends on restoration of containment heat removal function and the performance of seals in the electrical penetration assemblies (EPAs), personnel airlock (PAL), and equipment hatch. When the reactor vessel fails and the molten corium relocates into the containment, the cavity flooding system minimizes the MCCI and resulting non-condensable gas generation. The containment integrity also depends on hydrogen control and mitigation because hydrogen burns can create short but extreme temperature conditions in the containment.

The equipment and instrumentation that require ES assessment are summarized in Table 19.2.3-4.

19.2.3.3.7.2 Determination of Severe Accident Environmental Conditions

19.2.3.3.7.2.1 Bounding Temperature Environment

The bounding harsh environmental conditions are determined by simulating a broad spectrum of accident sequences including LBLOCA, MBLOCA, SBLOCA, TLOFW, and SBO, and dominant PRA sequences using the MAAP code. According to 10 CFR 50.34(f) and 10 CFR 50.44, equipment that is necessary for achieving and maintaining safe shutdown of the plant or maintaining containment integrity has to be demonstrated to be capable of performing its safety function during and after being exposed to the environmental conditions caused by the release of hydrogen generated by the equivalent of a 100 percent fuel-clad metal-water reaction, including the environmental conditions created by activation of the hydrogen control system. Appropriate MAAP inputs are used to calculate the in-vessel hydrogen generation consistent with this requirement.

The emergency containment spray backup system (ECSBS) is assumed to be actuated within 24 hours after the onset of core damage. The harsh environmental condition is removed once the spray is turned on and cools the containment atmosphere. Therefore, the essential equipment needs to be assessed for survivability only for the first 24 hours following the onset of core damage.

Similar to equipment qualification (EQ) profiles, equipment survivability (ES) profiles are constructed to characterize severe accident environmental conditions. To address the random occurrence of temperature spikes due to hydrogen burn, atmospheric temperature histories are discretized and treated as a histogram. The bins in the histogram are then reordered not by time but by decreasing order of magnitude to create a monotonically decreasing characterization of the atmospheric temperature, which has the same integrated value of temperature with respect to time. This preserves the duration and the magnitude of conditions, while minimizing the effect of uncertainty in phenomena timing. Figure 19.2.3-15 shows the temperature histories in the steam generator compartment for various scenarios. The top graph shows a random occurrence of temperature spikes due to hydrogen burn. The bottom graphs shows corresponding reordered temperature histories. A temperature of 900 K (1,160 °F) over 10 seconds envelops the temperature spikes due to hydrogen burn. Long-term atmospheric temperature after temperature spikes is enveloped by a temperature of 460 K (368 °F). The ES profile of each node is constructed to envelop the reordered temperature histograms of individual sequences. The ES curves are

used to assess survivability of individual equipment. Severe accident temperature environments can be classified as severely challenging, highly challenging, quite challenging, moderately challenging, or nominally challenging, depending on the magnitude and duration of extreme conditions. Severely challenging environments are identified by highly confined extreme conditions for a relatively long duration, such as in the reactor cavity and the IRWST. Highly challenging environments are areas close to a combustible gas source such as the steam generator compartments or the annular compartment above the IRWST. Quite challenging and moderately challenging environments are areas where combustible gas may accumulate such as the containment dome. Nominally challenging environments are compartments where the containment atmosphere can be considered well-mixed and is inerted by a high steam concentration. The equipment survivability curves constructed for each of the five types of environments are shown in Figures 19.2.3-16 through 19.2.3-20. The bounding temperature profile expected in each containment node during a severe accident is summarized in Table 19.2.3-5.

19.2.3.3.7.2.2 Bounding Pressure Environment

Based on the MAAP results, the bounding containment pressure expected during a severe accident is 7.75 kg/cm^2 (110 psia).

19.2.3.3.7.2.3 Bounding Radiation Environment

MAAP4-DOSE (Reference 29) is used to determine the bounding radiation dose during a severe accident. MAAP4-DOSE is a radiation dose calculation code that reads input from MAAP output. The maximum radiation dose that equipment in the containment is expected to receive during a severe accident is 4.4×10^5 Gy, predicted in the steam generator compartment for the LOFW sequence.

19.2.3.3.7.3 Analysis Methodology

ES is assessed by comparing reliable EQ information such as equipment suppliers' documents, research results, and experimental data with severe accident environmental conditions at the locations where the equipment is installed.

For the comparison with equipment supplier documents, related documents are reviewed and the location of equipment is identified. The assessment of survivability is performed by comparing the equipment data to the ES profile and the accident conditions to which the equipment is exposed. If the equipment data cannot support survivability under the specified severe accident environmental conditions, survivability is confirmed by consulting the equipment vendors.

Major research and experiments for equipment survivability related to qualification of electrical cables, instruments, data transmitters, valves, etc., were performed by Sandia National Laboratories, EPRI, and the Hydrogen Control Owner's Group (HCOG). Some examples are the Nevada Test Site (NTS) experiments (Reference 30), Central Receiver Test Facility (CRTF) experiments (Reference 31), Severe Combined Environment Test Chamber (SCETCh) experiments (Reference 32), and HCOG 1/4-scale experiments (Reference 33). The assessment methodology for equipment survivability compares research results and experimental data with predicted severe accident environmental conditions.

Thermal lag analysis may be used for equipment survivability assessments using analytical methods (Reference 34). A "thermal lag" analysis is one that accounts for the time that it takes for the temperature of the critical component to rise when exposed to a rise in the ambient gas temperature. Although the local atmospheric condition could rise to an extreme temperature momentarily due to hydrogen combustion, the temperature at the surface of the equipment may be much lower than that in the gas space. Hence, the equipment survivability can be assessed using simplified thermal lag analysis methods based on the temperature difference between the containment atmosphere and equipment surface or inside equipment.

19.2.3.3.7.4 Analysis Results

19.2.3.3.7.4.1 Hydrogen Igniters

Eight hydrogen igniters are distributed near hydrogen release points throughout the containment: reactor cavity access area, regenerative heat exchanger room, steam generator compartments, and pressurizer compartment. Of these, the harshest environment is expected in the steam generator compartment. The hydrogen igniters are protected with

fire wrap, allowing them to survive a severe accident environment and perform their intended function.

19.2.3.3.7.4.2 Passive Autocatalytic Recombiners

The PARs are made of Pt or Pd catalysis in a stainless steel casing. There are no organic material components susceptible to thermal degradation. Therefore, they are expected to survive the harsh environment of a severe accident and perform their intended functions of hydrogen removal.

19.2.3.3.7.4.3 Cavity Flooding System Motor-Operated Valves

The CFS consists of two spillways between IRWST and HVT, two spillways between HVT and reactor cavity, and related valves. Four MOVs are installed in the HVT. The goal of CFS is pre-flooding the reactor cavity prior to vessel failure to enhance core debris cooling in the reactor cavity floor. Hence, the MOVs need to operate only prior to vessel failure under a relatively mild environment that is bounded by the DBA EQ temperature profile. Therefore, the CFS MOVs are expected to perform their intended function of opening valves for cavity flooding.

19.2.3.3.7.4.4 Post-Accident Sampling System (PASS)

PASS is designed to collect and deliver representative samples of liquids and gases in various process systems to sample stations for chemical and radiological analysis. The RCS hot-leg sample isolation MOVs and their position transmitters are located in the steam generator compartment. The containment air sample isolation MOVs and their position transmitters are located in the annular compartment and steam generator compartment. MOVs were included in the hydrogen burn experiments (Reference 35) and survived many transients.

19.2.3.3.7.4.5 Containment Hydrogen Monitoring System

The containment and IRWST hydrogen monitoring system contains hydrogen monitor inlet valves, hydrogen analyzers, and piping. It samples the containment atmosphere and measures the hydrogen concentration employing sensing devices outside containment.

The hydrogen analyzers and discharge valve are not subject to the harsh environment of the severe accident because they are located outside containment. However, the inlet valves are subjected to the harsh environment located in the dome, the annular compartment, and the IRWST. If the device fails during a severe accident, the primary sampling system can be used to determine containment hydrogen concentrations since relatively uniform concentration is expected throughout the containment.

19.2.3.3.7.4.6 Containment Atmospheric Temperature Sensors

13 temperature sensors are distributed throughout the containment: dome, steam generator compartments, pressurizer room, annular compartment above the operating deck, annular compartment below the operating deck, and reactor cavity.

Although the harsh environmental conditions expected during a severe accident are more severe than the EQ data provided by the equipment vendor in some locations, there are enough temperature sensors distributed throughout the containment to provide redundancy.

19.2.3.3.7.4.7 Containment Radiation Monitoring System

Two RMSs are located in the south side of the upper operating area. The thermally limiting components in the RMS are PEEK insulators in the chamber and cable connectors. Based on the percentage retention of elongation at break after aging test data for PEEK material, the RMS is determined to have a qualified life of 50 hours at 583 K (590 °F). The test temperature is higher than the long-term severe accident environmental temperature of 460 K (368 °F) (see Subsection 19.2.3.3.7.2). Short-term temperature transients due to hydrogen burn would not affect the insulators because of thermal lag. Therefore, the PEEK insulators in RMS are expected to maintain their integrity during severe accidents.

19.2.3.3.7.4.8 Equipment Hatch and Personnel Airlock

The equipment hatch and PALs are located in the annular compartment, two at the operating deck and one above the IRWST.

Thermally limiting components in the equipment hatch and PAL are EPDM O-rings, compression seals, and gaskets. In the Sandia/CBI Personnel Airlock Testing (Reference 36), an actual full-scale airlock assembly was subjected to environmental conditions corresponding to severe accident events. In particular, Test 2C consisted of three thermal and pressure cycles. In the second cycle, air temperature was raised to 700 K (800 °F), and the pressure was increased to 21.09 kg/cm^2 (300 psig). There was no measurable leakage of the inner door seal. In the tests, it was determined that the temperature at which the material deteriorates is approximately 600 K (620 °F). Indeed, the peak temperature recorded on the door surface when the seal failed during the third cycle was 633 K (680 °F). The Test 2C results demonstrated that the EPDM seal material survives the ambient temperature over 24 hours. Hence, the seal and gaskets in the equipment hatch and PALs are expected to maintain their integrity during severe accidents.

19.2.3.3.7.4.9 Electrical Penetration Assembly (EPA)

The EPAs are installed on the containment pressure boundary and are sealed with double O-rings. The EPAs are located in the annular compartment at various elevations above the operating deck. The thermally limiting components in EPAs are Viton O-rings, polysulfone module conductor sealant, and polyimide film conductor insulation. A Conax EPA was tested under severe accident conditions by Sandia National Laboratories (Reference 37). The EPA was a lower voltage penetration assembly with a typical cable mix for power, control, and instrumentation functions. The EPA was first irradiated and then thermally aged. Then, the EPA was exposed to steam at 9.49 kg/cm^2 (135 psia) and 644 K (700 °F) for 8 days. The temperature in the test chamber reached the maximum value, 644 K (700 °F), about 45 minutes into the test. Temperature in the junction box reached the steady-state temperature of about 561 K (550 °F) about four hours into the test. Temperature on the header plate reached the steady-state temperature of about 444 K (340 °F) about four hours into the test. The leak integrity of the Conax EPA was maintained during the entire 10-day period of the severe accident test. The test condition exceeds the long-term severe accident condition. Hence, the seal in the EPA is expected to maintain its integrity during severe accidents.

19.2.3.3.7.4.10 Mechanical Penetrations

Mechanical penetrations include the MS and FW flow penetrations and hot/cold process piping. These penetrations have no organic material and are designed to maintain their sealing function under severe accident environmental conditions.

19.2.3.3.7.4.11 Rapid Depressurization Function

The POSRVs and three-way valves in the pressurizer compartment are manually operated to rapidly depressurize the RCS following onset of core damage. The goal of the system is depressurization of the RCS from 175.8 kg/cm^2 (2,500 psia) to 17.6 kg/cm^2 (250 psia) prior to vessel failure, thereby preventing HPME. The essential components of the system that need to be assessed for harsh environment include:

a. POSRVs and actuation circuitry

b. POSRV position transmitters and indicators

c. POSRV discharge branch line isolation valves and position transmitters, and indicators

d. MOVs for three-way valves

The system is not needed during a LOCA because the break depressurizes the RCS. Therefore, the essential components are not subject to the harsh environment of design basis accidents. Also, prior to actuation of the RD function, the essential components are not subject to the harsh environment of hydrogen burning nor of containment heatup by relocated corium. Hence, the RD function equipment is expected to survive and perform its intended function during severe accidents.

19.2.3.3.7.4.12 Reactor Vessel Level Monitoring System

The RVLMS consists of two probes with heated and unheated junction thermocouples. The heated junction thermocouple (HJTC) probes measure the inventory above the fuel alignment plate. The temperature difference between the heated and unheated junction thermocouple pairs is a direct indication of the presence of liquid inventory. The RVLMS provides useful information as the core uncovers and provides confirmation of core

recovery. Individual unheated junction thermocouples may also trend the progression of core degradation by monitoring the reactor vessel upper plenum gas temperature.

The HJTC probes use heated and unheated junction type K thermocouples. Unlike the core-exit thermocouple, the RVLMS thermocouple string is top mounted and it does not pass through the core. These thermocouples are calibrated to operate at very high temperature, in accordance with the RVLMS design requirements. Hence, these instruments are expected to function far into core degradation.

Core-Exit Thermocouples (CETs) and Resistance Temperature Detectors (RTDs)

The CETs and RTDs used to monitor RCS inventory are expected to survive well past design basis conditions and they provide useful information until their temperature limits are exceeded.

Pressurizer Pressure Sensors and Steam Generator Level Monitors

RCS pressure monitoring is necessary to trend RCS depressurization following operator action taken to either establish feed-and-bleed operation or confirm sufficiently low pressure to enter SC operation. In the event the operator has to depressurize the RCS via the steam generator, the water level in the steam generator is monitored to provide reasonable assurance of the presence of steam generator secondary side inventory.

All pressure-transmitting devices are located outside the secondary shield wall. A small, long tube connects the RCS to the high-pressure side of the pressure transmitter. The sensor tap of these pressure-transmitting devices is typically filled with stagnant fluid. The substantial length of the tube provides sufficient heat loss and thermal capacity to maintain the fluid temperature closer to the ambient. Therefore, the in-vessel temperature does not influence the operation of these pressure-transmitting devices.

19.2.3.3.7.4.13 Equipment Located Outside Containment

The active components of the following equipment required for severe accident mitigation and monitoring are located outside containment. They are not subjected to the harsh environment of a severe accident.

a. SIS

b. AFWS

c. CSS

d. ECSBS

e. SCS

f. Containment hydrogen monitors

g. Containment pressure sensor

h. IRWST water level sensors

The check valve at the ECSBS spray headers is located inside containment, but it contains no organic materials that are susceptible to thermal degradation.

19.2.3.3.7.4.14 Radiation Dose ES Results

The EQ report for safety-related equipment contains radiation test data. All safety-related equipment was tested under at least five times the bounding radiation dose in the containment during severe accidents as shown in Table 19.2.3-6.

For most equipment and instrumentation, it is concluded there is reasonable assurance that instrumentation and equipment required to mitigate a severe accident and achieve a safe stable state perform their function as intended under severe accident environmental conditions.

19.2.3.3.8 Other Severe Accident Mitigation Features

According to 10 CFR 50.34(f)(3)(iv), a design is required to "provide one or more dedicated containment penetrations, equivalent in size to a single 3-foot diameter opening, in order not to preclude future installation of systems to prevent containment failure, such as a filtered vented containment system." The APR1400 design meets this requirement by providing a dedicated containment penetration to allow for installation of a filtered vent system.

19.2.4 Containment Performance Capability

The containment pressurization analysis is performed to confirm containment performance. Furthermore, analyses of thermo-hydraulic response of the containment building are carried out to provide basic understanding of the transient plant responses for different severe accident sequences.

19.2.4.1 Containment Performance Goal

According to the requirements for containment performance for the APR1400 design, the containment is designed so that the CCFP is below 0.1 or the containment meets the FLC requirement of ASME Section III, Division 2, Subarticle CC-3720 for approximately 24 hours after the onset of core damage (Reference 1). In order to comply with this requirement, deterministic analysis is performed to confirm that the latter portion of the requirement is met by evaluating the containment loads.

19.2.4.2 Containment Performance Analysis

The containment pressurization scenarios considered in this analysis include overpressurization by steam and non-condensable gases. In order to reflect these phenomena, MAAP analyses are performed for the severe accident scenarios.

19.2.4.2.1 Combustible Gas Control inside Containment

NRC RG 1.216 (Reference 6) describes the requirements for providing reasonable assurance that new reactor designs are capable of coping with combustible gases generated during the course of a severe accident. According to Regulatory Position 2, the containment should be evaluated for the pressure arising from the fuel cladding-water reaction, hydrogen burning, and post-accident inerting (if applicable). Additionally, the containment failure criterion for concrete containments should meet the factored load category requirements of *[ASME Section III, Division 2, Subarticle CC-3720]** (Reference 8).

In order to evaluate the ability of the containment to cope with combustible gases generated during the course of a severe accident, an adiabatic isochoric complete combustion (AICC)

analysis was performed. This analysis assumed the generation of hydrogen equivalent to the complete reaction of 100 percent of the active fuel cladding with steam. Also, the hydrogen mitigation features are assumed to be unavailable. The hydrogen was then assumed to be burned completely with no heat transfer to heat sinks in the containment with initial containment atmospheric pressure at the highest value possible that would still allow for hydrogen to burn. The maximum pressure load on the containment structure is evaluated to be 7.0 kg/cm^2 (99.8 psia) under the AICC condition. Considering the safety margin of APR1400 containment, for the FLC, the pressure resulting from 100 percent metal water reaction of fuel cladding and resulting from uncontrolled hydrogen burning is determined as 8.7 kg/cm^2 (123.7 psia).

19.2.4.2.2 Containment Pressurization Results

Figure 19.2.3-21 shows the containment pressure response for a large-break LOCA that results in the highest containment pressure at 24 hours following the onset of core damage. For this scenario, the containment pressure does not reach 8.7 kg/cm^2 (123.7 psia) for 24 hours after the onset of core damage.

19.2.4.2.3 Emergency Containment Spray Backup System Performance

For a provision against a beyond-design-basis accident where either two SC pumps and two CS pumps or the IRWST is unavailable, the ECSBS is provided as an alternative to the CSS.

The ECSBS is designed to protect the containment integrity against overpressure and prevent the uncontrollable release of radioactive materials into the environment. The emergency containment spray flow path is from external water sources (the reactor makeup water tank, demineralized water storage tank, fresh water tank, or the raw water tank), through the fire protection system line via the diesel-driven fire pump, to the ECSBS line emergency connection located at ground level near the auxiliary building.

The ECSBS flow rate provides sufficient heat removal to prevent containment pressure from exceeding 8.7 kg/cm^2 (123.7 psia). In order to evaluate the performance of ECSBS, analysis is performed using the MAAP code.

Sequences are analyzed assuming that ECSBS operation began 24 hours after the onset of core damage. Figure 19.2.3-21 shows the containment pressure response following the ECSBS actuation. The result shows that ECSBS is capable of controlling containment pressure and reducing atmospheric temperature for a period of 48 hours. The maximum pressure and temperature following the initial 24-hour period are enveloped by the maximum pressure and temperature during the initial 24-hour period. This prevents the uncontrolled release of fission products into the environment.

19.2.5 Accident Management

Accident management (AM) encompasses those actions taken during the course of an accident by the plant operating and technical staff to (1) prevent core damage, (2) terminate the progress of core damage if it begins and retain the core within the reactor vessel, (3) maintain containment integrity as long as possible, and (4) minimize offsite releases. In effect, AM extends the defense-in-depth principle to plant operating staff by extending the operating procedures well beyond the plant design basis into severe fuel damage conditions, and by making full use of existing plant equipment and operator skills and creativity to terminate severe accidents and limit offsite releases.

The overall responsibility for AM, including development, implementation, and maintenance of the accident management plan, lies with the nuclear utility, because the utility bears ultimate responsibility for the safety of the plant and for establishing and maintaining an emergency response organization capable of effectively responding to potential accident situations. However, the development and implementation of accident management involves both the reactor designer and the plant owner/operator.

The COL applicant is to develop and submit an accident management plan. The plan provides a commitment to perform a systematic evaluation of plant functions during potential severe accidents and to implement the necessary enhancements within the detailed plant design and organization, including severe accident management guidelines and training. The plan addresses (1) accident management strategies and implementing procedures, (2) training in severe accidents, (3) guidance and computational tools for technical support, (4) instrumentation, and (5) decision making responsibilities.

The following sections provide a framework that discusses the APR1400 design features that are to be considered by the COL applicant when developing a plant-specific accident management plan.

19.2.5.1 Severe Accident Management Framework

19.2.5.1.1 Prevent Core Damage

19.2.5.1.1.1 During Operations at Power

A key accident management goal is prevention of core damage by maintaining coolant level in the reactor core. During operations at power, this can involve operation of secondary cooling, core cooling, containment cooling, as well as isolation of any paths for inventory loss to the outside of containment.

In LOCA scenarios where safety injection is unavailable, the SC or CS pumps are able to be aligned to provide injection to the reactor vessel. These systems remove decay heat and prevent core damage from occurring.

In non-LOCA scenarios, auxiliary feedwater pumps can be used to establish secondary side cooling. The APR1400 design is equipped with two motor-driven and two turbine-driven auxiliary feedwater pumps that are each capable of removing decay heat. If secondary cooling cannot be established, the operators can depressurize the RCS using the POSRVs. Once depressurized, once-through cooling of the core can be established using SI and SC or CS pumps.

In scenarios where secondary cooling cannot be established and containment sprays are not available to remove heat from the containment, SC pumps and heat exchangers can be aligned to discharge to the containment spray header in order to depressurize containment and cool the IRWST water. This allows for IRWST inventory to be continuously circulated through the core to maintain core cooling.

In scenarios where an SGTR has occurred, primary system inventory loss can be terminated by isolation of main steam isolation valves (MSIVs) or turbine bypass valves. If isolation of the ruptured steam generator cannot be established, then operators can terminate

inventory loss by depressurizing the primary system using the intact steam generator or RD function.

In LOOP scenarios, the APR1400 design prevents core damage by operation of emergency diesel generators to provide power. If the emergency diesel generators are unavailable, an alternate AC source is available to provide backup power.

19.2.5.1.1.2 During Low-Power Shutdown Operations

During LPSD operations, core damage is prevented by operation of the SI, recovery of water level using the charging pumps, secondary side cooling, and SCS isolation if the water level is insufficient.

If inventory loss is identified during LPSD operations, operators can manually isolate the failed SCS train to terminate the loss of inventory.

If RCS water level decreases too far, it can reach a level that is insufficient for SC pump suction. If this occurs, SC pumps are isolated to prevent damage to the pumps. In this situation, the charging pumps can be used to increase RCS water level and allow resumed operation of the SCS.

In LPSD scenarios where the RCS is fully filled with water, secondary cooling can be used to induce natural circulation in the coolant loops to remove decay heat from the core.

The SIS is isolated during LPSD operations; however, at least two trains are kept in standby so that SI can be available to provide core cooling if necessary; when needed, the SIS is manually activated by the operators.

19.2.5.1.2 Retain the Core within the Reactor Vessel

19.2.5.1.2.1 During Operations at Power

The onset of core damage is identified when core-exit temperature reaches 922.04 K (1,200 °F). The primary way to terminate the progress of core damage is inject water into the reactor vessel. This can be achieved by operation of the SI, SC, or CS pumps. Once

core relocation to the lower plenum occurs, another option available to prevent accident progression is ex-vessel cooling.

If the SI pumps can be recovered prior to reactor vessel melt-through, injection may be capable of cooling the core and preventing failure of the reactor vessel. If the SI pumps cannot be recovered, the RCS can be depressurized using the POSRVs to allow injection using the SC or CS pumps. Successful cooling of the core depends on the configuration of core (i.e., whether it is intact, melted, relocated).

Once the core has relocated to the lower plenum, ex-vessel cooling can be established by the operators. This entails using the SC pumps to pump water from the IRWST into the reactor cavity to submerge the reactor vessel lower head in water. This action has the potential to remove decay heat through the lower head wall and prevent vessel failure.

19.2.5.1.2.2 During Low-Power Shutdown Operations

During LPSD operations, the accident management options for terminating the progress of core damage and preventing vessel failure are the same as during operations at power.

19.2.5.1.3 Maintain Containment Integrity

19.2.5.1.3.1 During Operations at Power

In order to maintain containment integrity during an accident, containment isolation provides reasonable assurance that decay heat is removed from containment. In addition, steps are taken to prevent a containment bypass event due to an induced steam generator tube rupture.

Containment isolation usually occurs before core damage. However, once core damage has been detected, it is required that operators reconfirm containment isolation to prevent radiological releases to the environment.

Once core damage has been detected, the reactor cavity is flooded using the CFS. Operation of the CFS allows for removal of decay heat from the molten corium and

prevents challenges to containment integrity due to liner melt-through and flammable/non-condensable gas generation during MCCI.

After vessel failure occurs, decay heat is removed from the containment vessel using either the SCS or CSS. If the SCS and CSS are unavailable, ECSBS can be actuated to decrease containment pressure to prevent containment failure due to overpressure.

Operation of hydrogen igniters after core damage allows hydrogen concentration in containment to be maintained at the lower flammability limit. This mitigates the potential for containment failure due to detonation of hydrogen.

Actuation of the POSRVs to depressurize the RCS after core damage is detected helps mitigate the threat of early containment failure due to HPME and DCH. It also minimizes the risk of a containment bypass event due to induced steam generator tube rupture. In addition, actuation of the three-way valves prevents detonable concentrations of hydrogen from accumulating in regions surrounding the IRWST.

Another key step that mitigates the potential for containment bypass due to induced SGTR is providing reasonable assurance that the secondary side of the steam generators is always filled with water. This mitigates the potential for thermally induced tube rupture. FW and AFW systems can be used to perform this function.

Deflagration-to-detonation transition (DDT) in a hydrogen-filled IRWST headspace is prevented because of high steam mole fraction in the headspace. POSRV steam discharge to IRWST preceding the hydrogen discharge raises the pool temperature and the vapor pressure. Any recovery action for IRWST pool cooling includes consideration of the unintended consequence of reducing the steam mole fraction in the hydrogen-filled IRWST headspace, thereby creating a condition conducive to DDT.

19.2.5.1.3.2 During Low-Power Shutdown Operations

During LPSD operations, it is likely that the containment is not isolated at the onset of the accident. Because of this, the primary action to maintain containment integrity during LPSD operations is the isolation of containment. Once containment has been isolated, the

options for decay heat removal and maintenance of containment integrity are the same as those during normal operations at power.

19.2.5.1.4 Minimize Offsite Release

19.2.5.1.4.1 During Operations at Power

The key action that can be taken to minimize offsite release during an accident is the operation of containment sprays to remove fission products from the containment gas space by using either the CS or SC pumps. If neither of these two systems is available, ECSBS can be used to serve the same function.

19.2.5.1.4.2 During Low-Power Shutdown Operations

During LPSD operations, the most important action to minimize offsite release is the isolation of containment. Once this is achieved, methods for minimizing offsite release are the same as for normal operations at power.

19.2.6 Consideration of Potential Design Improvements under 10 CFR 50.34(f)

This section provides information related to the potential design improvements as required under 10 CFR 50.34(f)(1)(I) which states that:

> *Perform a plant/site specific probabilistic risk assessment, the aim of which is to seek such improvements in the reliability of core and containment heat removal systems as are significant and practical and do not impact excessively on the plant.*

19.2.6.1 Introduction

The information in this section is based on the evaluation of severe accident mitigation design alternatives (SAMDA) for the APR1400 design, which is performed to address the potential costs and potential benefits of severe accident mitigation design alternatives. The APR1400 SAMDA document has been developed in accordance with applicable regulatory requirements as follows:

The National Environmental Policy Act (NEPA), Section 102.(C)(iii) requires, in part, that:

> *...all agencies of the Federal Government shall ... (C) include in every recommendation or report on proposals for legislation and other major Federal actions significantly affecting the quality of the human environment, a detailed statement by the responsible official on ... (iii) alternatives to the proposed action.*

10 CFR 52.47(b)(2) requires the submittal of an environmental report as required by 10 CFR 51.55. 10 CFR 51.55 requires each applicant for a standard design certification to submit with its application a separate document entitled, "Applicant's Environmental Report—Standard Design Certification." The environmental report must address the costs and benefits of severe accident mitigation design alternatives, and the bases for not incorporating severe accident mitigation design alternatives in the design to be certified.

The complete Severe Accident Mitigation Design Alternatives (SAMDA) analysis is reported in the Environmental Report - Standard Design Certification (Reference 38). The report documents the calculation of the monetary value of unmitigated base risk then evaluates the maximum risk reduction that could be expected from implementing a risk reduction strategy. Consideration of SAMDAs includes identifying a broad range of potential alternatives, and then determining whether implementation of those alternatives is feasible or would be beneficial on a cost-risk reduction basis. This report also documents the identification, screening, and evaluation of SAMDAs for the APR1400 reactor design certification. The report summary is described in this section.

19.2.6.2 Estimate of Risk for Design

The initial step to determine base risk is the development and quantification of an at-power, internal events Level 1 and Level 2 probabilistic risk assessment (PRA). The results of PRA provide overall risk measured by core damage frequency (CDF) and the characteristics of any expected radionuclide release following a severe accident, see Section 19.1.

The APR1400 PRA also quantified internal fire, internal flooding, and low-power and shutdown (LPSD) events. Risk from other external events, for example, high winds, seismic events, etc., was determined to be negligible. Total CDF from the at-power internal events PRA is 1.3×10^{-6} per year and is calculated as the sum of the 21 source term

categories (STCs) calculated from the Level 2 PRA model. Total CDF from internal flooding events is 4.0×10^{-7} per year. Fire-induced accident sequences had a calculated CDF of 1.9×10^{-6} per year. LPSD accident sequences had a calculated CDF of 2.7×10^{-6} per year. The total CDF from events other than full-power internal events is estimated to be 5.0×10^{-6} per year. Total CDF, therefore, is 6.3×10^{-6} per year and the ratio of total CDF to internal events CDF is 4.85. This factor can be used in later calculations to adjust benefits that are calculated using only the internal events STCs.

The next step in determining base risk is the identification of the characteristics of any expected radionuclide release following a severe accident, and to quantify the expected frequency of release. The APR1400 Level 2 PRA model characterizes releases into 21 STCs. Each of the STCs is distinguished by the magnitude of fission products released, the timing of the fission product release, and the pathway for the release.

For each STC, representative releases are determined. The Level 2 PRA analyzes representative sequences from each STC and develops timing and release characteristic information for representative fission product groups. This information is then used to approximate the radiological release plumes used in the Level 3 analysis.

Offsite consequences are calculated from the Level 3 PRA analysis. For each STC, the Level 3 PRA provides values for the conditional offsite dose and conditional offsite property damage that would result given that a fission product release with the plume characteristics used to represent the source term occurred. The total expected dose consequence is obtained by multiplying the conditional offsite dose by the expected frequency for each STC, then summing the expected doses for all STCs. Similarly, the total expected property damage is obtained by multiplying the conditional property damage value by the expected frequency for each STC, then summing the expected property damage values for all STCs.

19.2.6.3 Identification of Potential Design Improvements

The list of severe accident mitigation alternative (SAMA) items evaluated for the APR1400 design is based on the generic industry SAMAs that are identified in Table 14 of NEI 05-01 (Reference 39). There are 153 items to be considered. The list of potential SAMDAs was developed from a generic list of sources related to many plant designs, and an initial

screening is performed to identify the subset of potential SAMDAs that warranted a detailed evaluation.

Potential SAMDAs to be examined in detail are identified by exception. That is, a screening process is used to remove potential SAMDAs from consideration. Any potential SAMDAs not screened undergoes a more detailed evaluation.

As described in NEI 05-01, items can be screened for several reasons. First, items were screened that were not applicable to the APR1400 design. For example, some items are associated with specific equipment that is not present in the APR1400 design. A total of 64 potential SAMDAs were screened as not applicable. Next, items were identified that were effectively implemented in the APR1400 design. A total of 64 potential SAMDAs were identified as effectively implemented in the APR1400 design.

Other SAMDA items were screened because they would not be feasible to implement. An item would not be feasible if the cost to implement the SAMDA clearly would exceed the maximum benefit possible. NEI 05-01 allows items to be screened if they would be of low benefit. An item is of low benefit if it is from a non-risk-significant system and a change in reliability would have negligible impact on the risk profile. A total of 25 potential SAMDAs were screened as not feasible.

Overall, all generic industry items delineated in NEI 05-01 have been screened from further consideration.

19.2.6.4 Risk Reduction Potential of Design Improvements

Because all SAMDA items identified in Table 14 of NEI 05-01 have been screened, there is no risk reduction potential of design improvement items.

19.2.6.5 Cost Impacts of Candidate Design Improvements

The unmitigated risk monetary value is calculated using the methodology given in NEI 05-01 for the performance of cost-benefit analyses. The value of unmitigated risk can be used to represent the maximum benefit that could be achieved if all risk was eliminated for

at-power events. The methodology of the Producer Price Index (Reference 40) determines the present worth net value of public risk according to the following formula:

$$NPV = (APE + AOC + AOE + AOSC) - COE$$

Where:

NPV = present value of current risk ($),

APE = present value of averted public exposure ($),

AOC = present value of averted offsite property damage costs ($),

AOE = present value of averted occupational exposure ($),

AOSC = present value of averted onsite costs ($)

COE = cost of any enhancement implemented to reduce risk ($).

NPV = ($14,209 + $19,571 + $652 + $140,611) – $0 = $140,611

This value can be viewed as the maximum risk benefit attainable if all core damage scenarios from internal events are eliminated over the 60-years licensing period.

The conversion factor used for assigning a monetary value to on-site and off-site exposures was $2,000/person-rem averted, which is consistent with the NRC's regulatory analysis guidelines presented in NEI 05-01.

The occupational exposure associated with severe accidents was assumed at 23,300 person-rem/accident. This value includes a short-term component of 3,300 person-rem/accident and a long-term component of 20,000 person-rem/accident. These estimates are consistent with the "best estimate" values presented in Subsection 5.7.3 of NUREG/BR-0184 (Reference 41). In calculating base risk, the accident-related onsite exposures were calculated using the best estimate exposure components applied over the on-site cleanup period. For onsite cleanup, the accident-related on-site exposures were calculated over a 10-year cleanup period. Costs associated with immediate dose, long-term dose and total dose are calculated below for internal events, internal flooding events, fires, and LPSD events.

Since the models for events other than internal events were not explicitly quantified, the total benefit is adjusted upward using the factor shown in Subsection 19.2.6.2 to account for the potential benefit that could be achieved if the other events were explicitly considered in the quantification. Therefore, the maximum available benefit used is:

$$NPV = (\$140{,}611) \times 4.85 = \$848{,}959$$

NEI 05-01 recommends using a 7 percent discount rate for cost-benefit analyses and suggests that a 3 percent discount rate should be used for sensitivity analyses on the maximum benefit and the unscreened SAMDAs to indicate the sensitivity of the results to the choice of discount rate. The NPV value for a 3 percent discount rate is calculated to be ($196,693 × 4.85) = $953,961.

The parameters that influence the cost-benefit analyses of the SAMDA evaluations were examined to determine if a change in value for one of the parameters would change the conclusions of the evaluation. Equations for each of the four types of averted costs each contain a term for the real discount rate and evaluation period. Therefore, a change in either of those terms would have a direct impact on the averted costs calculated.

Using maximum benefit calculated for the three percent discount rate above, the SAMDA items were reviewed and screened again. No changes to the screening results were identified using the higher maximum benefit value.

19.2.6.6 Cost-Benefit Comparison

Because all SAMDA items have been screened, no detailed benefit evaluation is performed.

19.2.6.7 Conclusions

The analyses described in the previous sections analyzed conceptual alternatives for mitigating severe accident impacts in the APR1400 design. Preliminary screening eliminated all SAMDA candidates from further consideration, based on inapplicability to the APR1400 design, the design features that have already been incorporated into the APR1400 design, inapplicability to a design certification analysis, or extremely high cost of the alternatives considered.

19.2.7 Combined License Information

COL 19.2(1) The COL applicant is to perform and submit site-specific equipment survivability assessment in accordance with 10 CFR 50.34(f) and 10 CFR 50.44.

COL 19.2(2) The COL applicant is to develop and submit an accident management plan.

19.2.8 References

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Table 19.2.3-1

Hydrogen Control System Design Status

Security-Related Information – Withheld Under 10 CFR 2.390

Table 19.2.3-2 (1 of 2)

Containment Node Description

Security-Related Information – Withheld Under 10 CFR 2.390

Table 19.2.3-2 (2 of 2)

Security-Related Information – Withheld Under 10 CFR 2.390

Table 19.2.3-3

Summary of Results for Rapid Depressurization Analysis

Security-Related Information – Withheld Under 10 CFR 2.390

Table 19.2.3-4

Systems and Equipment/Instrumentation Required
for Equipment Survivability Assessments

Security-Related Information – Withheld Under 10 CFR 2.390

Table 19.2.3-5

Summary of Temperature Envelopes for Equipment Survivability Assessment

Security-Related Information – Withheld Under 10 CFR 2.390

Table 19.2.3-6

Test Radiation Dose Level

Security-Related Information – Withheld Under 10 CFR 2.390

Security-Related Information – Withheld Under 10 CFR 2.390

Figure 19.2.3-1 Location of PARs and Igniters for APR1400 Containment (1 of 9)

Security-Related Information – Withheld Under 10 CFR 2.390

Figure 19.2.3-1 Location of PARs and Igniters for APR1400 Containment (2 of 9)

Security-Related Information – Withheld Under 10 CFR 2.390

Figure 19.2.3-1 Location of PARs and Igniters for APR1400 Containment (3 of 9)

Security-Related Information – Withheld Under 10 CFR 2.390

Figure 19.2.3-1   Location of PARs and Igniters for APR1400 Containment (4 of 9)

Security-Related Information – Withheld Under 10 CFR 2.390

Figure 19.2.3-1 Location of PARs and Igniters for APR1400 Containment (5 of 9)

Security-Related Information – Withheld Under 10 CFR 2.390

Figure 19.2.3-1 Location of PARs and Igniters for APR1400 Containment (6 of 9)

Security-Related Information – Withheld Under 10 CFR 2.390

Figure 19.2.3-1 Location of PARs and Igniters for APR1400 Containment (7 of 9)

Security-Related Information – Withheld Under 10 CFR 2.390

Figure 19.2.3-1 Location of PARs and Igniters for APR1400 Containment (8 of 9)

Security-Related Information – Withheld Under 10 CFR 2.390

Figure 19.2.3-1 Location of PARs and Igniters for APR1400 Containment (9 of 9)

Security-Related Information – Withheld Under 10 CFR 2.390

Figure 19.2.3-2 MAAP model for APR1400 Containment (1 of 2)

Security-Related Information – Withheld Under 10 CFR 2.390

Figure 19.2.3-2   MAAP model for APR1400 Containment (2 of 2)

Security-Related Information – Withheld Under 10 CFR 2.390

Figure 19.2.3-3 Mole Fraction of Hydrogen in the Dome Region for LBLOCA

Security-Related Information – Withheld Under 10 CFR 2.390

Figure 19.2.3-4 Mole Fraction of Hydrogen in the Dome Region for SBLOCA

Security-Related Information – Withheld Under 10 CFR 2.390

Figure 19.2.3-5 Mole Fraction of Hydrogen in the Dome Region for SBO with three-way valve

Security-Related Information – Withheld Under 10 CFR 2.390

Figure 19.2.3-6 Mole Fraction of Hydrogen in the Dome Region for LOFW with three-way valve

Security-Related Information – Withheld Under 10 CFR 2.390

Figure 19.2.3-7 Ablation Depth in Floor and Sidewall for the PRA Sequence of Loss of Essential Service Water

Security-Related Information – Withheld Under 10 CFR 2.390

Figure 19.2.3-8 Ablation Depth in Floor and Sidewall for the PRA Sequence of Medium Break LOCA

Security-Related Information – Withheld Under 10 CFR 2.390

Figure 19.2.3-9 Ablation Depth in Floor and Sidewall for the PRA Sequence of Loss of Offsite Power

Security-Related Information – Withheld Under 10 CFR 2.390

Figure 19.2.3-10 Ablation Depth in Floor and Sidewall for the PRA Sequence of Loss of AC Power with Short Battery Life

Security-Related Information – Withheld Under 10 CFR 2.390

Figure 19.2.3-11 Ablation Depth in Floor and Sidewall for the PRA Sequence of Large Break LOCA

Security-Related Information – Withheld Under 10 CFR 2.390

Figure 19.2.3-12 Containment Pressure for Different FCHF's

Security-Related Information – Withheld Under 10 CFR 2.390

Figure 19.2.3-13 Rapid Depressurization Function with 3-Way Valve

Security-Related Information – Withheld Under 10 CFR 2.390

Figure 19.2.3-14 Primary System Pressure Responses for TLOESW Sequence when 0, 2, or 4 POSRVs are Manually Opened after Entering Severe Accident Conditions

Security-Related Information – Withheld Under 10 CFR 2.390

Figure 19.2.3-15 Gas Temperatures and Corresponding Rearranged Temperatures in Node 7, S/G Compartment #2 at El. 136.5'

Security-Related Information – Withheld Under 10 CFR 2.390

Figure 19.2.3-16 ES Curve for Nominally Challenging Environments

Security-Related Information – Withheld Under 10 CFR 2.390

Figure 19.2.3-17 ES Curve for Moderately Challenging Environments

Security-Related Information – Withheld Under 10 CFR 2.390

Figure 19.2.3-18 ES Curve for Quite Challenging Environments

Security-Related Information – Withheld Under 10 CFR 2.390

Figure 19.2.3-19 ES Curve for Highly Challenging Environments

Security-Related Information – Withheld Under 10 CFR 2.390

Figure 19.2.3-20 ES Curve for Severely Challenging Environments

Security-Related Information – Withheld Under 10 CFR 2.390

Figure 19.2.3-21 Containment Pressure for Large Break LOCA with ECSBS Actuated 24 hours after the onset of core damage

19.3 [Reserved]

19.4 Loss of Large Area

19.4.1 Introduction and Background

The NRC has issued 10 CFR 50.54(hh)(2) (Reference 1) that requires licensees to develop guidance and strategies for addressing the Loss Of Large Areas (LOLAs) of the plant due to explosions or fires from a beyond design basis event through the use of readily available resources and by identifying potential practicable areas for the use of beyond-readily-available resources. These strategies would address licensee response to events that are beyond the design basis of the facility.

This section identifies the APR1400 strategies that are implemented in the event that a large area of the facility is lost due to explosions or fire. Initiating events classified as LOLAs are beyond the design basis for existing and proposed new nuclear power plants. Existing nuclear power plants have evaluated these beyond design basis events and implemented changes and operational programs to assist in coping with LOLA events.

The operational and programmatic elements of responding to LOLA events are to be addressed by the COL applicant prior to fuel load.

19.4.2 Scope of the evaluation

The APR1400 plans to approach the LOLA event evaluations in a phased approach similar to the existing plants. Phase 1 LOLA event evaluations focus on the operational aspects of responding to explosions or fire including items such as prearranging for the involvement of outside organizations, planning and preparation activities (e.g., pre-positioning equipment, personnel, and materials to be used for mitigating the event), and developing procedures and training for the event.

Phase 2 LOLA event evaluations focus on issues associated with mitigating an event involving the spent fuel pool (SFP). They include issues such as fuel configuration within the pool and focus on alternative sources of water that could be provided to the SFP for cooling, heat removal, and inventory makeup.

Phase 3 LOLA event evaluations focus on methods to provide sources of alternative cooling water to critical systems as well as mitigating the impact of a radiological release. In addition, they focus on alternative methods to operate critical systems or components in a manner to assist with the mitigation of the event.

19.4.3 Conclusion

Preliminary evaluation on the LOLA mitigative strategies of the APR1400 has been performed using the industry developed guidance in NEI 06-12 (Reference 2). Final LOLA evaluation is to be performed after safeguards information clearance is obtained, and this section is to be revised adequately reflecting final evaluation results.

19.4.4 References

1. 10 CFR 50.54, "Conditions of Licenses," U.S Nuclear Regulation Commission.

2. NEI 06-12, "B.5.b Phase 2&3 submittal Guideline," Revision 3, Nuclear Energy Institute, July, 2009.

19.5 Aircraft Impact Assessment

19.5.1 Introduction and Background

The design of the APR1400 takes into account the potential effects of the impact of a large commercial aircraft. In accordance with 10 CFR 50.150(a) (Reference 1), a design specific assessment is performed using realistic analysis to demonstrate that, in the event the APR1400 is struck by a large commercial aircraft, design features and functional capabilities exist to provide reasonable assurance that the reactor core remains cooled and spent fuel pool (SFP) integrity is maintained.

The assessment is to demonstrate the inherent robustness of the APR1400 design with regard to a potential large aircraft impact. Specific assumptions used in the APR1400 aircraft impact assessment are based on NRC requirements and guidance provided by the NRC and the Nuclear Energy Institute (NEI). The methodology for assessing effects on aircraft impact is described in NEI 07-13 (Reference 2), which is endorsed by RG 1.217 (Reference 3). These guidelines are followed with no exceptions taken.

This section describes the design features and functional capabilities of the APR1400 identified in the detailed assessment to provide reasonable assurance that the reactor core remains cooled and SFP integrity is maintained. These identified design features are designated as “key” design features.

19.5.2 Scope of the Assessment

The evaluation of plant damage caused by the impact of a large commercial aircraft is a complex problem involving phenomena associated with structural damage resulting from the initial impact, shock-induced vibration, and the effects of an aviation fuel-fed fire. The analysis assesses the following effects of a large commercial aircraft impact on the APR1400;

a. Damage resulting from the impact of the aircraft fuselage and wing structure,

b. Shock-induced vibration on structures, systems, and components (SSC),

c. Perforation or penetration of hardened aircraft components, such as engine rotors and landing gear, and

d. The extent of damage from fires fed by aviation fuel.

The analysis assesses the above effects of a large commercial aircraft impact at multiple locations where a large commercial aircraft could potentially strike critical APR1400 structures.

19.5.3 Assessment Methodology

Methods described in NEI 07-13 are followed to assess the effects on the:

a. Structural integrity of the reactor containment building (RCB) and SFP

b. Physical, fire and vibration effects of the aircraft impact on SSCs in the auxiliary building to provide reasonable assurance of continued core cooling capability

19.5.4 Conclusions

Preliminary assessment on the effect of a large commercial aircraft impact has been performed. In accordance with 10 CFR 50.150(a), preliminary structural assessment for the integrity of RCB and SFP has been performed using conservative analysis, and preliminary heat removal assessments have been performed for the potential aircraft impacts on the auxiliary building.

Final aircraft impact assessment is to be performed after safeguard information clearance is obtained. This section is to be revised reflecting the final assessment results.

19.5.5 References

1. 10 CFR 50.150, "Aircraft Impact Assessment," July 2009.

2. NEI 07-13, "Methodology for Performing Aircraft Impact Assessments for New Plant Designs," Revision 8P, April 2011.

3. NRC RG 1.217, "Guidance for the Assessment of Beyond-Design-Basis Aircraft Impacts," U.S. Nuclear Regulatory Commission, August 2011.