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Evaluation of Potential Severe Accidents During Low Power and Shutdown Operations at Grand Gulf, Unit 1

Analysis of Core Damage Frequency from Internal Events for Plant Operational State 5 During a Refueling Outage

Internal Events Appendices I and J

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Abstract

This report provides supporting documentation for various tasks associated with the performance of the probabilistic risk assessment for Plant Operational State 5 (approximately Cold Shutdown as defined by Grand Gulf Technical Specifications) during a refueling outage at Grand Gulf, Unit 1 as documented in Volume 2, Part 1 of NUREG/CR-6143. The report contains the following appendices:

I - Fault Trees

J - Miscellaneous Topics

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Acronyms

ADHR	Auxiliary Decay Heat Removal
ADS	Automatic Depressurization System
ATWS	Anticipated Transient Without Scram
BNL	Brookhaven National Laboratory
BWR	Boiling Water Reactor
CCW	Component Cooling Water
CDS	Condensate
CI	Containment Isolation
CRD	Control Rod Drive
CRWST	Condensate and Refueling Water Storage Transfer System
CS	Containment Spray
CST	Condensate Storage Tank
CV	Check Valves
CVS	Containment Venting System
DBA	Design Basis Accident
DG	Diesel Generator
ECCS	Emergency Core Cooling Systems
EHC	Electro-Hydraulic Controller
EHV	Emergency Ventilation System
ENSDC	Enhanced Shutdown Cooling
EPS	Emergency Power System
FCV	Flow Control Valve
FDW	Feed Water System
FW	Fire Water
HCU	Hydraulic Control Unit
HPCS	High Pressure Core Spray
IAS	Instrument Air System
IRRAS	Integrated Reliability and Risk Analysis System
LCO	Limiting Condition of Operation
LOCA	Loss of Coolant Accident
LPCI	Low Pressure Coolant Injection
LPCS	Low Pressure Core Spray
MSIV	Main Steam Isolation Valve
MSL	Mean Sea Level
MSR	Moisture Separator Reheater
NPSHA	Net Positive Suction Head Available
NPSHR	Net Positive Suction Head Required
NRC	Nuclear Regulatory Commission
OC	Operating Condition
POS	Plant Operating State
PRA	Probabilistic Risk Assessment
PSW	Plant Service Water
PWR	Pressurized Water Reactor
RCIC	Reactor Core Isolation Cooling
RES	Research (Office of NRC)
RFPT	Reactor Feedwater Pump Turbine
RHR	Residual Heat removal
RPV	Reactor Pressure Vessel
RRS	Reactor Recirculation System
RWCU	Reactor Water Cleanup System
SDC	Shutdown Cooling System(s)
SGTS	Standby Gas Treatment System

Acronyms (Continued)

SL	Safety Limit
SLC	Standby Liquid Control
SP	Suppression Pool
SPC	Suppression Pool Cooling
SPMU	Suppression Pool Makeup
SPMU	Suppression Pool Makeup
SR	Surveillance Requirement
SRV	Safety Relief Valve
SSWXT	Standby Service Water Crosstie
TBCW	Turbine Building Cooling Water
TBV	Turbine Bypass Valve(s)
UFSAR	Updated Final Safety Analysis Report

Foreword

(NUREG/CR-6143 and 6144) Low Power and Shutdown Probabilistic Risk Assessment Program

Traditionally, probabilistic risk assessments (PRA) of severe accidents in nuclear power plants have considered initiating events potentially occurring only during full power operation. Some previous screening analyses that were performed for other modes of operation suggested that risks during those modes were small relative to full power operation. However, more recent studies and operational experience have implied that accidents during low power and shutdown could be significant contributors to risk.

During 1989, the Nuclear Regulatory Commission (NRC) initiated an extensive program to carefully examine the potential risks during low power and shutdown operations. The program includes two parallel projects performed by Brookhaven National Laboratory (BNL) and Sandia National Laboratories (SNL), with the seismic analysis performed by Future Resources Associates. Two plants, Surry (pressurized water reactor) and Grand Gulf (boiling water reactor), were selected as the plants to be studied.

The objectives of the program are to assess the risks of severe accidents due to internal events, internal fires, internal floods, and seismic events initiated during plant operational states other than full power operation and to compare the estimated core damage frequencies, important accident sequences and other qualitative and quantitative results with those accidents initiated during full power operation as assessed in NUREG-1150. The scope of the program includes that of a level-3 PRA.

The results of the program are documented in two reports, NUREG/CR-6143 and 6144. The reports are organized as follows:

For Grand Gulf:

NUREG/CR-6143 - Evaluation of Potential Severe Accidents During Low Power and Shutdown Operations at Grand Gulf, Unit 1

- Volume 1: Summary of Results
- Volume 2: Analysis of Core Damage Frequency from Internal Events for Plant Operational State 5 During a Refueling Outage
 - Part 1: Main Report
 - Part 1A: Sections 1 - 9
 - Part 1B: Section 10
 - Part 1C: Sections 11 - 14
 - Part 2: Internal Events Appendices A to H
 - Part 3: Internal Events Appendices I and J
 - Part 4: Internal Events Appendices K to M
- Volume 3: Analysis of Core Damage Frequency from Internal Fire Events for Plant Operational State 5 During a Refueling Outage
- Volume 4: Analysis of Core Damage Frequency from Internal Flooding Events for Plant Operational State 5 During a Refueling Outage
- Volume 5: Analysis of Core Damage Frequency from Seismic Events for Plant Operational State 5 During a Refueling Outage
- Volume 6: Evaluation of Severe Accident Risks for Plant Operational State 5 During a Refueling Outage
 - Part 1: Main Report
 - Part 2: Supporting MELCOR Calculations

Foreword (Continued)

For Surry:

NUREG/CR-6144 - Evaluation of Potential Severe Accidents During Low Power and Shutdown Operations at Surry Unit-1

- Volume 1: Summary of Results
- Volume 2: Analysis of Core Damage Frequency from Internal Events During Mid-loop Operations
 - Part 1: Main Report
 - Part 1A: Chapters 1 - 6
 - Part 1B: Chapters 7 - 12
 - Part 2: Internal Events Appendices A to D
 - Part 3: Internal Events Appendix E
 - Part 3A: Sections E.1 - E.8
 - Part 3B: Sections E.9 - E.16
 - Part 4: Internal Events Appendices F to H
 - Part 5: Internal Events Appendix I
- Volume 3: Analysis of Core Damage Frequency from Internal Fires During Mid-loop Operations
 - Part 1: Main Report
 - Part 2: Appendices
- Volume 4: Analysis of Core Damage Frequency from Internal Floods During Mid-loop Operations
- Volume 5: Analysis of Core Damage Frequency from Seismic Events During Mid-loop Operations
- Volume 6: Evaluation of Severe Accident Risks During Mid-loop Operations
 - Part 1: Main Report
 - Part 2: Appendices

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Appendix I Fault Trees

This appendix provides the fault trees used in the detailed analysis of POS 5.

The fault trees are in alphanumeric order.

BALANCE OF PLANT AC ELECTRICAL SYSTEM (BOP) (11B12)

Figure I.1 11B12 Tree

BALANCE OF PLANT AC ELECTRICAL SYSTEM (BOP) (11B13)

Figure L.2 11B13 Tree

BALANCE OF PLANT AC ELECTRICAL SYSTEM (BOP) (11B51).

Figure I.3 11B51 Tree

BALANCE OF PLANT AC ELECTRICAL SYSTEM (BOP) (11BD3)

Figure I.4 11BD3 Tree

BALANCE OF PLANT AC ELECTRICAL SYSTEM (BOP) (11BD5)

Figure I.5 11BD5 Tree

BALANCE OF PLANT AC ELECTRICAL SYSTEM (BOP) (11HD)

Figure L6 11HD Tree

BALANCE OF PLANT AC ELECTRICAL SYSTEM (BOP) (12B22)

Figure I.7 12B22 Tree

BALANCE OF PLANT AC ELECTRICAL SYSTEM (BOP) (12B51)

Figure I.8 12B51 Tree

BALANCE OF PLANT AC ELECTRICAL SYSTEM (BOP) (12BE2)

Figure I.9 12BE2 Tree

BALANCE OF PLANT AC ELECTRICAL SYSTEM (BOP) (12HE)

Figure L.10 12HE Tree

BALANCE OF PLANT AC ELECTRICAL SYSTEM (BOP) (13AD)

Figure L.11 13AD Tree

BALANCE OF PLANT AC ELECTRICAL SYSTEM (BOP) (13B11)

Figure I.12 13B11 Tree

BALANCE OF PLANT AC ELECTRICAL SYSTEM (BOP) (13B22)

Figure I.13 13B22 Tree

BALANCE OF PLANT AC ELECTRICAL SYSTEM (BOP) (14AE)

Figure I.14 14AE Tree

BALANCE OF PLANT AC ELECTRICAL SYSTEM (BOP) (14B11)

Figure I.15 14B11 Tree

BALANCE OF PLANT AC ELECTRICAL SYSTEM (BOP) (14B12)

Figure I.16 14B12 Tree

BALANCE OF PLANT ELECTRICAL AC SYSTEM (BOP) (14B22)

Figure I.17 14B22 Tree

BALANCE OF PLANT AC ELECTRICAL SYSTEM (BOP) (14BE1)

Figure I.18 14BE1 Tree

EMERGENCY AC ELECTRICAL SYSTEM (ACP-I) (15B11)

Figure I.19 15B11 Tree

EMERGENCY AC ELECTRICAL SYSTEM (ACP-I) (15B21)

Figure 1.20 15B21 Tree

EMERGENCY AC ELECTRICAL SYSTEM (ACP-I)
(15B31)

Figure I.21 15B31 Tree

EMERGENCY AC ELECTRICAL SYSTEM (ACP-I) (15B41)

Figure I.22 15B41 Tree

EMERGENCY AC ELECTRICAL SYSTEM (ACP-I) (15B42)

Figure I.23 15B42 Tree

EMERGENCY AC ELECTRICAL SYSTEM (ACP-II) (15B51)

Figure I.24 15B51 Tree

EMERGENCY AC ELECTRICAL SYSTEM (ACP-II) (16B11)

Figure I.25 16B11 Tree

EMERGENCY AC ELECTRICAL SYSTEM (ACP-II) (16B31)

Figure I.26 16B31 Tree

EMERGENCY AC ELECTRICAL SYSTEM (ACP-II) (16B41)

Figure I.27 16B41 Tree

EMEERGENCY AC ELECTRICAL SYSTEM (ACP-II) (16B42)

Figure I.28 16B42 Tree

MOV ELECTRICAL POWER FAILURE

Figure I.29 16B51 Tree

LOSS OF POWER FROM MCC 17B01

Figure I.30 17B01 Tree

LOSS OF POWER AT MCC 17B11

Figure I.31 17B11 Tree

BALANCE OF PLANT AC ELECTRICAL SYSTEM (BOP) (18AG)

Figure I.32 18AG Tree

FAILURE OF 1 SRV OUT OF 20 TO OPEN IN RELEIF MODE

Figure I.33 ISALL Tree

SAFETY RELIEF VALVE (SRV) (1SRV)

Figure I.34 1SRV Tree

SAFETY RELIEF VALVE (SRV) (1SRV1)

Figure I.35 1SRV1 Tree

SAFETY RELIEF VALVE (SRV) (1SRVA)

Figure I.36 1SRVA Tree

SAFETY RELIEF VALVE (SRV) (1SRVB)

Figure L37 1SRVB Tree

SAFETY RELIEF VALVE (SRV) (1SRVH)

Figure L.38 1SRVH Tree

SAFETY RELIEF VALVE (SRV) (1SRVS)

Figure I.39 1SRVS Tree

SAFETY RELIEF VALVE (SRV) (ISRVS8)

Figure I.40 ISRVS8 Tree

SAFETY RELIEF VALVE (SRV) (1SRVX)

Figure L.41 1SRVX Tree

SAFETY RELIEF VALVE (SRV) (1SRVHA)

Figure I.42 1SRVHA Tree

BALANCE OF PLANT AC ELECTRICAL SYSTEM (BOP) (28AG)

Figure I.43 28AG Tree

LOW PRESSURE COOLANT INJECTION SYSTEM (LCI) (2LPCI)

Figure I.44 2L PCI Tree

FAILURE OF 2 OUT OF 20 SRVs TO OPEN IN RELIEF MODE

Figure I.45 2SALL Tree

SAFETY RELIEF VALVE (SRV) (2SRV)

Figure I.46 2SRV Tree

SAFETY RELIEF VALVE (SRV) (2SRV1)

Figure I.47 2SRV1 Tree

SAFETY RELIEF VALVE (SRV) (2SRVA)

Figure I.48 2SRVA Tree

SAFETY RELIEF VALVE (SRV) (2SRVB)

Figure I.49 2SRVB Tree

SAFETY RELIEF VALVE (SRV) (2SRVX)

Figure I.50 2SRVX Tree

EMERGENCY AC ELECTRICAL SYSTEM (ACP-I) (AC 15AA-F)

Figure I.51 AC15AA-F Tree

EMERGENCY AC ELECTRICAL SYSTEM (ACP-II) (AC16AB-F)

Figure I.52 AC16AB-F Tree

Figure I.53 AC17AC-F Tree

EMERGENCY AC ELECTRICAL SYSTEM (ACP-I) (ACDG11-F)

Figure I.54 ACDG11-F Tree

EMERGENCY AC ELECTRICAL SYSTEM (ACP-II) (ACDG12-F)

Figure I.55 ACDG12-F Tree

EMERGENCY AC ELECTRICAL SYSTEM (ACP-III) (ACDG13-F)

Figure I.56 ACDG13-F Tree

FAILURE OF MSIVs TO AUTO-CLOSE ON LEVEL 1

Figure I.57 ACMSV Tree

LOSS OF POWER TO EMERGENCY AC DIVISION 1

Figure I.58 ACP-I Tree

LOSS OF POWER TO EMERGENCY AC DIVISION II

Figure I.59 ACP-II Tree

EMERGENCY AC ELECTRICAL SYSTEM (ACP-III) (ACP-III)

Figure I.60 ACP-III Tree

LOSS OF POWER TO 4160V AC BUS 15AA

Figure I.61 ACP2 Tree

EMERGENCY AC ELECTRICAL SYSTEM (ACP-I) (ACP3)

Figure I.62 ACP3 Tree

Figure I.63 ACP5 Tree

EMERGENCY AC ELECTRICAL SYSTEM (ACP-III) (ACP9)

Figure I.64 ACP9 Tree

ALTERNATE DECAY HEAT REMOVAL SYSTEM (ADHRS) (ADHIS)

Figure I.65 ADHIS Tree

ALTERNATE DECAY HEAT REMOVAL SYSTEM (ADHRS) (ADHR1)

Figure I.66 ADHR1 Tree

ALTERNATE DECAY HEAT REMOVAL SYSTEM (ADHRS) (ADHR2)

Figure I.67 ADHR2 Tree

ALTERNATE DECAY HEAT REMOVAL SYSTEM (ADHRS) (ADHR7)

Figure I.68 ADHR7 Tree

Figure I.69 ADHRR Tree

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ALTERNATE DECAY HEAT REMOVAL SYSTEM (ADHRS) (ADMP5AF)

Figure I.71 ADMP5AF Tree

ALTERNATE DECAY HEAT REMOVAL SYSTEM (ADHRS) (ADMP5B-F)

Figure I.72 ADMP5B-F Tree

ALTERNATE DECAY HEAT REMOVAL SYSTEM (ADHRS) (ADMP5BF)

Figure I.73ADMP5BF Tree

ALTERNATE DECAY HEAT REMOVAL SYSTEM (ADHRS) (ADMV424F)

Figure I.74 ADMV424F Tree

EMERGENCY SAFEGUARDS ACTUATION (ESF) (ADN091AF)

Figure I.75 ADN091AF Tree

EMERGENCY SAFEGUARDS ACTUATION (ESF) (ADN091BF)

Figure I.76 ADN091BF Tree

EMERGENCY SAFEGUARDS ACTUATION (ESF) (ADN091EF)

Figure I.77 ADN091EF Tree

EMERGENCY SAFEGUARDS ACTUATION (ESF) (ADN091FF)

Figure I.78 ADN091FF Tree

EMERGENCY SAFEGUARDS ACTUATION (ESF) (ADN095AF)

Figure L.79ADN095AF Tree

EMERGENCY SAFEGUARDS ACTUATION (ESF) (ADN095BF)

Figure I.80 ADN095BF Tree

EMERGENCY SAFEGUARDS ACTUATION (ESF) (ADN694A)

Figure I.81 ADN694A Tree

EMERGENCY SAFEGUARDS ACTUATION (ESF) (ADN694AF)

Figure I.82 ADN694AF Tree

EMERGENCY SAFEGUARDS ACTUATION (ESF) (ADN694B)

Figure I.83 ADN694B Tree

EMERGENCY SAFEGUARDS ACTUATION (ESF) (ADN694BF)

Figure I.84 ADN694BF Tree

EMERGENCY SAFEGUARDS ACTUATION (ESF) (ADN694E)

Figure I.85 ADN694E Tree

EMERGENCY SAFEGUARDS ACTUATION (ESF) (ADN694EF)

Figure I.86 ADN694EF Tree

EMERGENCY SAFEGUARDS ACTUATION (ESF) (ADN694F)

Figure I.87 ADN694F Tree

ALTERNATE DECAY HEAT REMOVAL SYSTEM (ADHRS) (ADR-10)

Figure I.89 ADR-10 Tree

ALTERNATE DECAY HEAT REMOVAL SYSTEM (ADHRS) (ADR-16)

Figure I.90 ADR-16 Tree

Figure I.91 ADR-3 Tree

Figure I.92 ADR-4 Tree

Figure I.93 ADR-5 Tree

ALTERNATE DECAY HEAT REMOVAL SYSTEM (ADHRS) (ADR-F)

Figure 1.94 ADR-F Tree

ALTERNATE DECAY HEAT REMOVAL SYSTEM (ADHRS) (ADR-FAN)

Figure I.95 ADR-FAN Tree

Figure I.96 ADR-FS Tree

ALTERNATE DECAY HEAT REMOVAL SYSTEM (ADHRS) (ADR-G)

Figure I.97 ADR-G Tree

ALTERNATE DECAY HEAT REMOVAL SYSTEM (ADHRS) (ADR-H)

Figure I.99 ADR-H Tree

ALTERNATE DECAY HEAT REMOVAL SYSTEM (ADHRS) (ADR-HTX)

Figure I.100 ADR-HTX Tree

ALTERNATE DECAY HEAT REMOVAL SYSTEM (ADHRS) (ADR-HTX2)

Figure I.101 ADR-HTX2 Tree

ALTERNATE DECAY HEAT REMOVAL SYSTEM (ADHRS) (ADR-HX3A)

Figure I.102 ADR-HX3A Tree

ALTERNATE DECAY HEAT REMOVAL SYSTE (ADHRS) (ADR-HX3B)

Figure I.103 ADR-HX3B Tree

ALTERNATE DECAY HEAT REMOVAL SYSTEM (ADHRS) (ADR-I)

Figure I.104 ADR-I Tree

ALTERNATE DECAY HEAT REMOVAL SYSTEM (ADHRS) (ADR-J)

Figure I.105 ADR-J Tree

ALTERNATE DECAY HEAT REMOVAL SYSTEM (ADHRS) (ADR-K)

Figure I.106 ADR-K Tree

ALTERNATE DECAY HEAT REMOVAL SYSTEM (ADHRS) (ADR-PMP1)

Figure I.107 ADR-PMP1 Tree

ALTERNATE DECAY HEAT REMOVAL SYSTEM (ADHRS) (ADR-PSWA)

Figure I.108 ADR-PSWA Tree

ALTERNATE DECAY HEAT REMOVAL SYSTEM (ADHRS) (ADR-PSWB)

Figure L.109 ADR-PSWB Tree

ALTERNATE DECAY HEAT REMOVAL SYSTEM (ADHRS) (ADR-PUMP)

Figure I.110 ADR-PUMP Tree

ALTERNATE DECAY HEAT REMOVAL SYSTEM (ADHRS) (ADRAB1)

Figure I.111 ADRAB1. Tree

ALTERNATE DECAY HEAT REMOVAL SYSTEM (ADHRS) (ADRF1)

Figure I.112 ADRF1 Tree

ALTERNATE DECAY HEAT REMOVAL SYSTEM (ADHRS) (ADRG1)

Figure I.113 ADRG1 Tree

ALTERNATE DECAY HEAT REMOVAL SYSTEM (ADHRS) (ADRI)

Figure I.114 ADRI Tree

ALTERNATE DECAY HEAT REMOVAL SYSTEM (ADHRS) (ADRPAB)

Figure I.115 ADRPAB Tree

ALTERNATE DECAY HEAT REMOVAL SYSTEM (ADHRS) (ADV424-F)

Figure I.116 ADV424-F Tree

COMPONENT COOLING WATER SYSTEM (CCW) (CCMDPA-F)

Figure L.117 CCMDPA-F Tree

COMPONENT COOLING WATER SYSTEM (CCW) (CCMDPB-F)

Figure I.118 CCMDPB-F Tree

COMPONENT COOLING WATER SYSTEM (CCW) (CCMDPC-F)

Figure L.119 CCMDPC-F Tree

COMPONENT COOLING WATER SYSTEM (CCW) (CCMP 1A-F)

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COMPONENT COOLING WATER SYSTEM (CCW) (CCMP1C-F)

Figure I.121 CCMP1C-F Tree

COMPONENT COOLING WATER SYSTEM (CCW) (CCMV42-F)

Figure L122 CCMV42 - F Tree

COMPONENT COOLING WATER SYSTEM (CCW) (CCMV54-F)

Figure I.123 CCMV54-F Tree

COMPONENT COOLING WATER SYSTEM (CCW) (CCMV67-F)

Figure I.124 CCMV67-F Tree

COMPONENT COOLING WATER SYSTEM (CCW) (CCW)

Figure I.125 CCW Tree

COMPONENT COOLING WATER SYSTEM (CCW)
(CCW-50)

Figure I.126 CCW-50 Tree

COMPONENT COOLING WATER SYSTEM (CCW) (CCW-RRS)

Figure I.127 CCW-RRS Tree

COMPONENT COOLING WATER SYSTEM (CCW) (CCW-RWCU)

Figure I.128 CCW-RWCU Tree

COMPONENT COOLING WATER SYSTEM (CCW) (CCW1)

Figure I.129 CCW1 Tree

COMPONENT COOLING WATER SYSTEM (CCW) (CCW11)

Figure I.130 CCW11 Tree

COMPONENT COOLING WATER SYSTEM (CCW) (CCW15)

Figure I.131 CCW15 Tree

COMPONENT COOLING WATER SYSTEM (CCW) (CCW2)

Figure I.132 CCW2 Tree

COMPONENT COOLING WATER SYSTEM (CCW) (CCW2-A)

Figure I.133 CCW2-A Tree

COMPONENT COOLING WATER SYSTEM (CCW) (CCW4)

Figure I.134 CCW4 Tree

COMPONENT COOLING WATER SYSTEM (CCW)
(CCW4A)

Figure I.135 CCW4A Tree

CONDENSATE SYSTEM (CDS) (CDAV2)

Figure I.136 CDAV2 Tree

Figure I.137 CDS Tree

CONDENSATE SYSTEM (CDS) (CDS)

Figure I.138 CDS 2 Tree

CONDENSATE SYSTEM (CDS) (CDSAV504)

Figure I.139 CDSAV504 Tree

CONDENSATE SYSTEM (CDS) (CDSAV513)

Figure I.140 CDSAV513 Tree

(CONDENSATE SYSTEM (CDS) (CDSMDP-F)

Figure I.141 CDSMDP-F

CONDENSATE SYSTEM (CDS) (CDSMV1F)

Figure I.142 CDSMV1F Tree

NUCLEAR BOILER SYSTEM (NBS) (CHECK)

Figure I.143 CHECK Tree

STATUS OF PRIMARY CONTAINMENT IN POS 5 - 7

Figure I.144 CINTG Tree

COMMON MODE FAILURE OF LPCI MOV 4A/B/C ON DEMAND

Figure I.145 CM-LC14 Tree

COMMON MODE FAILURE OF LCI MOV 6A/B ON DEMAND

Figure I.146 CM-LCI 6 Tree

COMMON MODE FAILURE OF SDC MOV MV8 AND
MV9 ON DEMAND

Figure I.147 CM-LCI89

STANDBY SERVICE WATER SYSTEM (SSW) (CM-SSWPMP)

Figure L.148 CM-SWPMP Tree

COMPONENT COOLING WATER SYSTEM (CCW) (CMV105-F)

Figure I.149 CV105-F Tree

COMPONENT COOLING WATER SYSTEM (CCW) (CMV205-F)

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Figure I.151 CMV28A-F Tree

Figure I.152 CMV28AOF Tree

CONTAINMENT SPRAY SYSTEM (CSS) (CMV28B-F)

Figure I.153 CMV28B-F Tree

COMPONENT COOLING WATER SYSTEM (CCW) (CMV66-F)

Figure I.154 CMV66-F Tree

Figure I.155 CNDAV Tree

CONDENSATE SYSTEM (CDS) (CNDHS)

Figure I.156 CNDHS Tree

CONTROL ROD DRIVE SYSTEM (CRD) (CRD)

Figure I.157 CRD Tree

CONTROL ROD DRIVE SYSTEM (CRD) (CRD-4A)

Figure I.158 CRD-4A Tree

CONTROL ROD DRIVE SYSTEM (CRD) (CRD-4P)

Figure I.159 CRD-4P Tree

Figure I.160 CRD-6A Tree

CONTROL ROD DRIVE SYSTEM (CRD) (CRD-6P)

Figure I.161 CRD-6P Tree

CONTROL ROD DRIVE SYSTEM (CRD) (CRD-7A)

Figure I.162 CRD-7A Tree

CONTROL ROD DRIVE SYSTEM (CRD) (CRD1)

Figure L163 CRD1 Tree

Figure I.164 CRDDWP-F

CONTROL ROD DRIVE SYSTEM (CRD) (CRDPMP-F)

Figure I.165 CRPMP-F Tree

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CONTAINMENT SPRAY SYSTEM (CSS) (CS)

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CONTAINMENT SPRAY SYSTEM (CSS) (CSS-11)

Figure I.167 CSS-11 Tree

CONTAINMENT SPRAY SYSTEM (CSS) (CSS-12)

CONTAINMENT SPRAY SYSTEM (CSS) (CSS-14)

Figure I.169 CSS-14 Tree

CONTAINMENT SPRAY SYSTEM (CSS) (CSS-15)

Figure I.170 CSS-15 Tree

CONTAINMENT SPRAY SYSTEM (CSS) (CSS-3A)

Figure I.171 CSS-3A Tree

CONTAINMENT SPRAY SYSTEM (CSS) (CSS-3B)

Figure I.172 CSS-3B Tree

CONTAINMENT SPRAY SYSTEM (CSS) (CSS-3C)

Figure I.173 CSS-3C Tree

CONTAINMENT SPRAY SYSTEM (CSS) (CSS10)

Figure I.174 CSS10 Tree

CONTAINMENT SPRAY SYSTEM (CSS) (CSS14)

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CONTAINMENT SPRAY SYSTEM (CSS) (CSS3)

Figure I-182 CSS3 Tree

CONTAINMENT SPRAY SYSTEM (CSS) (CSS4A)

Figure I-183 CSS4A Tree

CONTAINMENT SPRAY SYSTEM (CSS) (CSS5)

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Figure I-186 CSS61A Tree

CONTAINMENT SPRAY SYSTEM (CSS) (CSS66)

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EMERGENCY DC ELECTRICAL SYSTEM (DCP) (DC11DA-F)

Figure I.192 DC11DA-F Tree

EMERGENCY DC ELECTRICAL SYSTEM (DCP) (DC11DB-F)

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EMERGENCY DC ELECTRICAL SYSTEM (DCP) (DC11DC-F)

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EMERGENCY DC ELECTRICAL SYSTEM (DCP) (DCB1A3-F)

Figure I.195 DCB1A3-F Tree

EMERGENCY DC ELECTRICAL SYSTEM (DCP) (DCB1B3-F)

Figure I.196 DCB1B3-F Tree

EMERGENCY DC ELECTRICAL SYSTEM (DCP) (DCB1C3-F)

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EMERGENCY DC ELECTRICAL SYSTEM (DCP) (DCH1A4-F)

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EMERGENCY DC ELECTRICAL SYSTEM (DCP) (DCH1A5-F)

Figure L.199 DCH1A5-F Tree

EMERGENCY DC ELECTRICAL SYSTEM (DCP) (DCH1B4-F)

Figure I.200 DCH1B4-F Tree

Figure I.201 DCH1B5-F Tree

EMERGENCY DC ELECTRICAL SYSTEM (DCP) (DCH1C4-F)

Figure L.202 DCH1C4-F Tree

EMERGENCY DC ELECTRICAL SYSTEM (DCP) (DCH1C5-F)

Figure I.203 DCH1C5-F Tree

EMERGENCY DC ELECTRICAL SYSTEM (DCP) (DCP-A)

Figure I.204 DCP-A Tree

EMERGENCY DC ELECTRICAL SYSTEM (DCP) (DCP-ASRV)

Figure I.205 DCP-ASRV Tree

EMERGENCY DC ELECTRICAL SYSTEM (DCP) (DCP-AX)

Figure I.206 DCP-AX Tree

EMERGENCY DC ELECTRICAL SYSTEM (DCP) (DCP-B)

EMERGENCY DC ELECTRICAL SYSTEM (DCP) (DCP-BSRV)

Figure I.208 DCP-BSRV Tree

EMERGENCY DC ELECTRICAL SYSTEM (DCP) (DCP-BX)

Figure I.209 DCP-BX Tree

EMERGENCY DC ELECTRICAL SYSTEM (DCP) (DCP-C)

Figure I.210 DCP-C Tree

EMERGENCY DC ELECTRICAL SYSTEM (DCP) (DCP-CX)

Figure I.211 DCP-CX Tree

EMERGENCY DC ELECTRICAL SYSTEM (DCP) (DCP10)

Figure I.212 DCP10 Tree

EMERGENCY DC ELECTRICAL SYSTEM (DCP) (DCP14)

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EMERGENCY DC ELECTRICAL SYSTEM (DCP) (DCP4)

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EMERGENCY AC ELECTRICAL SYSTEM (ACP-III) (DG77C02F)

Figure L215 DG77C02F Tree

EMERGENCY AC ELECTRICAL SYSTEM (ACP-I) (DG77C1AF)

Figure I.216 DG77C1AF Tree

EMERGENCY AC ELECTRICAL SYSTEM (ACP-II) (DG77C1BF)

Figure I.217 DG77C1BF Tree

CROSS-TIE DIESEL C TO DIVISION II (XTIE) (XTIE2)

Figure I.218 DGL1611F Tree

EMERGENCY AC ELECTRICAL SYSTEM (ACP-III) (DGL1701F)

Figure I.219 DGL1701F Tree

CROSS-TIE DIESEL C TO DIVISION II (XTIE) (DGL1702F)

Figure I.220 DGL1702F Tree

CROSS-TIE DIESEL C TO DIVISION II (XTIE) (DGL1704F)

Figure I.221 DGL1704F Tree

CROSS-TIE DIESEL C TO DIVISION II (XTIE) (DGL1903F)

Figure I.222 DGL1903F Tree

CROSS-TIE DIESEL C TO DIVISION II (XTIE) (DGL1904F)

Figure I.223 DGL1904F Tree

EMERGENCY VENTILATION SYSTEM (EHV) - DG
ROOM 13 (DGMVC02F)

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EMERGENCY VENTILATION SYSTEM (EHV) — DG ROOM 11 (DGMVC1AF)

Figure I.225 DGMVC1AF Tree

EMERGENCY VENTILATION SYSTEM (EHV) - DG ROOM 12 (DGMVC1BF)

Figure I.226 DGMVC1BF Tree

FAILURE OF ONSITE AC POWER DIVISION 3

Figure I.227 DIV3 Tree

FAILURE OF ONSITE AC POWER DIV 1 & 2

Figure I.228 DV1-2 Tree

EMERGENCY VENTILATION SYSTEM (EHV) – DG ROOM 11 (EHV-DG11)

Figure L.229 EHV-DG11 Tree

Fault Trees

EMERGENCY VENTILATION SYSTEM (EHV) - DG ROOM 13 (EHV-DG13)

Figure L231 EHV-DG13 Tree

EMERGENCY VENTILATION SYSTEM (EHV) – HPCS ROOM (EHVHPCS)

Figure I.232 EHVHPCS Tree

EMERGENCY VENTILATION SYSTEM (EHV) — LPCI ROOM A (EHLPCIA)

Figure I.233 EHLPCIA Tree

EMERGENCY VENTILATION SYSTEM (EHV) — LPCI ROOM B (EHVPCIB)

Figure I.234 EHVPCIB Tree

EMERGENCY VENTILATION SYSTEM (EHV) –
LPCI ROOM C (EHLPCIC)

Figure I.235 EHVLPCIC Tree

EMERGENCY VENTILATION SYSTEM (EHV) – LPCS ROOM (EHVLPCS)

Figure I.236 EHV-LPCS Tree

EMERGENCY VENTILATION SYSTEM (EHV) – RCIC ROOM (EHVRCIC)

Figure I.237 EHVRCIC Tree

SHUTDOWN COOLING SYSTEM (SDC) (ENSDC)

Figure I.238 ENSDC Tree

EMERGENCY SAFEGUARDS ACTUATION (ESF) (ESN035AF)

Figure I.239 ESN035AF Tree

EMERGENCY SAFEGUARDS ACTUATION (ESF) (ESN054CF)

Figure I.240 ESN054CF Tree

EMERGENCY SAFEGUARDS ACTUATION (ESF)
(ESN054GF)

Figure I.241 ESN054GF Tree

EMERGENCY SAFEGUARDS ACTUATION (ESF) (ESN063CF)

Figure I.242 ESN063CF Tree

EMERGENCY SAFEGUARDS ACTUATION (ESF) (ESN677CF)

Figure I.243 ESN677CF Tree

EMERGENCY SAFEGUARDS ACTUATION (ESF) (ESN677GF)

Figure I.244 ESN677GF Tree

EMERGENCY SAFEGUARDS ACTUATION (ESF) (ESN677LF)

Figure I.245 ESN677LF Tree

EMERGENCY SAFEGUARDS ACTUATION (ESF) (ESN677RF)

Figure I.246 ESN677RF Tree

Figure I.247 ESN694BF Tree

EMERGENCY SAFEGUARDS ACTUATION (ESF) (ESN694FF)

Figure I.248 ESN694FF Tree

REACTOR RECIRCULATION SYSTEM (RRS) (FCIRC)

Figure I.249 FCIRC Tree

FIRE WATER SYSTEM (FW) (FW)

Figure I.250 FW Tree

Figure 1.251 FW4 Tree

FIRE WATER SYSTEM (FW) (FW7)

Figure I.252 FW7 Tree

FIRE WATER SYSTEM (FW) (FW8)

Figure I.253 FW8 Tree

Figure I.254 FW9 Tree

FIRE WATER SYSTEM (FW) (FWDDPA-F)

Figure I.255 FWDDPA-F Tree

FIRE WATER SYSTEM (FW) (FWDDPB-F)

Figure I.256 FWDDPB-F Tree

FIRE WATER SYSTEM (FW) (FWLVL)

Figure I.257 FWLVL Tree

FIRE WATER SYSTEM (FW) (FWMAN)

Figure I.258 FWMAN Tree

FIRE WATER SYSTEM (FW) (FWMDP-F)

Figure L.259 FWMDP-F Tree

FIRE WATER SYSTEM (FW) (FWSPS236)

Figure I.260 FWSPS236 Tree

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FAILURE OF THE HYDROGEN IGNITERS

Figure I.261 H2 Tree

HIGH PRESSURE CORE SPRAY SYSTEM (HPCS) (HCS10)

Figure I.262 HCS10 Tree

HIGH PRESSURE CORE SPRAY SYSTEM (HPCS) (HCS17)

Figure I.263 HCS17 Tree

FAILURE OF AUTO AND MANUAL ACTUATION OF SP SUCTION MOV

Figure I.264 HCS18 Tree

HIGH PRESSURE CORE SPRAY SYSTEM (HPCS) (HCS2)

Figure I.265 HCS2 Tree

HIGH PRESSURE CORE SPRAY SYSTEM (HPCS) (HCS4)

Figure I.266 HCS4 Tree

HIGH PRESSURE CORE SPRAY SYSTEM (HPCS) (HMDP1-F)

Figure I.268 HMDP1-F Tree

HIGH PRESSURE CORE SPRAY SYSTEM (HPCS) (HP51B1CF)

Figure I.269 HP51B1CF Tree

HPCS FAILS TO QUTO-ISOLATE AT LEVEL 8

Figure L.270 HPCAO Tree

HIGH PRESSURE CORE SPRAY SYSTEM (HPCS) (HPCS)

Figure L.271 HPCS Tree

HIGH PRESSURE CORE SPRAY SYSTEM (HPCS) (HPCSA)

Figure I.272 HPCSA Tree

HIGH PRESSURE CORE SPRAY SYSTEM (HPCS) (HPCSA-1)

Figure I.273 HPCSA-1 Tree

HIGH PRESSURE CORE SPRAY SYSTEM (HPCS) (HPMV1-F)

Figure I.274 HPMV1-F Tree

HIGH PRESSURE CORE SPRAY SYSTEM (HPCS) (HPMV10-F)

Figure I.275 HPMV10-F Tree

HIGH PRESSURE CORE SPRAY SYSTEM (HPCS) (HPMV11-F)

Figure I.276 HPMV11-F Tree

HIGH PRESSURE CORE SPRAY SYSTEM (HPCS) (HPMV12-F)

Figure L277 HPMV12-F Tree

HIGH PRESSURE CORE SPRAY SYSTEM (HPCS) (HPMV15-F)

Figure I.278 HPMV15-F Tree

HIGH PRESSURE CORE SPRAY SYSTEM (HPCS) (HPMV23-F)

Figure I.279 HPMV23-F Tree

HIGH PRESSURE CORE SPRAY SYSTEM (HPCS) (HPMV4-F)

Figure I.280 HPMV4-F Tree

HIGH PRESSURE CORE SPRAY SYSTEM (HPCS) (HPMV4OF) --

Figure I.281 HPMV4OF Tree

INSTRUMENT AIR SYSTEM (IAS) (IAS)

Figure L.282 IAS Tree

INSTRUMENT AIR SYSTEM (IAS) (IAS-1)

Figure I.283 IAS-1 Tree

INSTRUMENT AIR SYSTEM (IAS) (IAS10)

Figure I.284 IAS10 Tree

INSTRUMENT AIR SYSTEM (IAS) (IAS11)

Figure L.285 IAS11 Tree

INSTRUMENT AIR SYSTEM (IAS) (IAS13)

Figure I.286 IAS13 Tree

INSTRUMENT AIR SYSTEM (IAS) (IAS16)

Figure I.287 IAS16 Tree

INSTRUMENT AIR SYSTEM (IAS) (IAS17)

Figure I.288 IAS17 Tree

INSTRUMENT AIR SYSTEM (IAS) (IAS2)

Figure I.289 IAS2 Tree

INSTRUMENT AIR SYSTEM (IAS) (IAS20)

Figure I.290 IAS20 Tree

INSTRUMENT AIR SYSTEM (IAS) (IAS5)

Figure I.291 IAS5 Tree

LOSS OF AIR PRESSURE FROM NORMALLY OPERATING COMPRESSOR

Figure I.292 IAS6 Tree

INSTRUMENT AIR SYSTEM (IAS) (IAS7)

Figure I.293 IAS7 Tree

INSTRUMENT AIR SYSTEM (IAS) (IASC001B).

Figure L294 IASC001B Tree

INSTRUMENT AIR SYSTEM (IAS) (IASCOO1N)

Figure I.295 IASCOO1N Tree

INITIAL STATUS OF MAIN STEAM ISOLATION VALVES

Figure L296 ISMSV Tree

OPERATOR FAILS TO ISOLATE SDC VALVE MV8
AND/OR MV9

Figure L297 ISO89 Tree

FRACTION OF TIME ON RHR/SDC IN POS 5

Figure I.298 ISSDC Tree

INITIAL STATUS OF THE SUPPRESSION POOL IN POS- 5H

Figure I.299 ISSP Tree

FAILURE OF OP. TO ISOLATE S3 LEAK

Figure I.300 ISSSL Tree

INITIAL STATUS OF REACTOR RECIRCULATION SYSTEM

Figure I.301 ISTRC Tree

FAILURE TO CONTROL LEVEL WITH LOW
PRESSURE SYSTEM TO PREVENT

Figure I.302 LC-LP Tree

FAILURE TO CONTROL LEVEL WITH HPCS TO PREVENT OVERPRESSURIZA

Figure I.303 LCHPC Tree

LOW PRESSURE COOLANT INJECTION SYSTEM (LPCI) (LCI-34)

Figure I.304 LCI-34 Tree

LOW PRESSURE CORE SPRAY SYSTEM (LPCI) (LCI-39)

Figure I.305 LCI-39 Tree

LOW PRESSURE COOLANT INJECTION SYSTEM (LPCI) (LCI-39C)

Figure I.306 LCI-39C Tree

LOW PRESSURE COOLANT INJECTION SYSTEM (LPCI) (LCI42)

Figure I.307 LCI42 Tree

LOW PRESSURE COOLANT INJECTION SYSTEM (LPCI) (LCI-43)

Figure L366 LCI-43 Tree

LOW PRESSURE COOLANT INJECTION SYSTEM (LPCI) (LCI-46)

Figure I.309 LCI-46 Tree

Figure I.310 LCI-47 Tree

LOW PRESSURE COOLANT INJECTION SYSTEM (LPCI) (LCI-50)

Figure L311 LCI-50 Tree

LOW PRESSURE COOLANT INJECTION SYSTEM (LPCI) (LCI-51)

Figure I.312 LCI-51 Tree

LOW PRESSURE COOLANT INJECTION SYSTEM (LPCI) (LCI-53)

Figure L313 LCI-53 Tree

LOW PRESSURE COOLANT INJECTION SYSTEM (LCPI) (LCI-55)

Figure I.314 LCI-55 Tree

Figure I.315 LCI-6 Tree

LOW PRESSURE COOLANT INJECTION SYSTEM (LPCI) (LCI-8)

Figure I.316 LCI8 Tree

LOW PRESSURE COOLANT INJECTION SYSTEM (LPCI) (LCI10)

Figure I.317 LCI10 Tree

LOW PRESSURE COOLANT INJECTION SYSTEM (LPCI) (LCI11)

Figure I.318 LCI11 Tree

LPCI TRAIN A ACTUATION FAILS

Figure I.319 LC112A Tree

Figure I.320 LCI13 Tree

LOW PRESSURE COOLANT INJECTION SYSTEM (LPCI) (LCI16)

Figure I.321 LCI16 Tree

LOW PRESSURE COOLANT INJECTION SYSTEM (LPCI) (LCI16ADS)

Figure I.322 LCI16ADS Tree

LOW PRESSURE COOLANT INJECTION SYSTEM (LPCI) (LCI19)

Figure I.323 LCI19 Tree

FAIL OF WATER TO INJ. INTO REACTOR THROUGH INJ. LINE PS-117

Figure L324 LCI2 Tree

LOW PRESSURE COOLANT INJECTION SYSTEM (LPCI) (LCI20)

Figure I.325 LCI20 Tree

LOW PRESSURE COOLANT INJECTION SYSTEM (LPCI) -- (LCI23)

Figure I.326 LCI23 Tree

Figure I.327 LCI23ADS Tree

LOW PRESSURE COOLANT INJECTION SYSTEM (LPCI) (LCI24)

Figure I.328 LCI24 Tree

LOW PRESSURE COOLANT INJECTION SYSTEM (LPCI) (LCI27)

Figure I.329 LCI27 Tree

FLOW THROUGH PS-104 HTX TRAIN FAILS BECAUSE OF HARDWARE

Figure I.330 LCI27A Tree

FLOW THROUGH PS-104 HTX TRAIN FAILS BECAUSE OF MAINTENANCE

Figure I.331 LCI27B Tree

LOW PRESSURE COOLANT INJECTION SYSTEM (LPCI) (LCI28)

Figure I.332 LCI28 Tree

LOW PRESSURE COOLANT INJECTION SYSTEM (LPCI) (LCI2A)

Figure I.333 LCI2A Tree

LOW PRESSURE COOLANT INJECTION SYSTEM (LPCI) (LCI2B)

Figure I.334 LCI2B Tree

LOW PRESSURE COOLANT INJECTION SYSTEM (LPCI) (LCI30)

Figure I.335 LCI30 Tree

LOW PRESSURE COOLANT INJECTION SYSTEM (LPCI) (LCI30ADS)

Figure I.336 LCI30ADS Tree

LOW PRESSURE COOLANT INJECTION SYSTEM (LPCI) (LCI32)

Figure I.337 LCI32 Tree

LOW PRESSURE COOLANT INJECTION SYSTEM (LPCI) LCI33

Figure L.338 LCI33 Tree

LOW PRESSURE COOLANT INJECTION SYSTEM (LPCI) (LCI33A)

Figure L339 LCI33A Tree

LOW PRESSURE COOLANT INJECTION SYSTEM (LPCI) (LCI33B)

Figure I.340 LCI33B Tree

Figure I.341 LCI33C Tree

LOW PRESSURE COOLANT INJECTION SYSTEM (LPCI) (LCI34)

Figure I.342 LCI34 Tree

LOW PRESSURE COOLANT INJECTION SYSTEM (LPCI) (LCI36)

Figure I.343 LCI36 Tree

LOW PRESSURE COOLANT INJECTION SYSTEM (LPCI) (LCI39)

Figure I.344 LCI39 Tree

LOW PRESSURE COOLANT INJECTION SYSTEM (LPCI) (LCI42)

Figure I.345 LCI42 Tree

LOW PRESSURE COOLANT INJECTION SYSTEM (LPCI) (LCI43)

Figure I.346 LCI43 Tree

FLOW DIVERTED THROUGH PS-11B

Figure I.347 LC143A Tree

LOW PRESSURE COOLANT INJECTION SYSTEM (LPCI) (LCI46)

Figure I.348 LCI46 Tree

LOW PRESSURE COOLANT INJECTION SYSTEM (LPCI) (LCI47)

Figure I.349 LCI47 Tree

LOW PRESSURE COOLANT INJECTION SYSTEM (LPC) (LCI47ADS)

Figure I.350 LCI47ADS Tree

LOW PRESSURE COOLANT INJECTION SYSTEM (LPCI) (LCI50)

Figure I.351 LCI50 Tree

LOW PRESSURE COOLANT INJECTION SYSTEM (LPCI) (LCI51)

Figure I.352 LCI51 Tree

LOW PRESSURE COOLANT INJECTION SYSTEM (LPCI) (LCI53)

Figure I.353 LCI53 Tree

LOW PRESSURE COOLANT INJECTION SYSTEM (LPCI) (LCI56)

Figure 1.354 LC156 Tree

LOW PRESSURE COOLANT INJECTION SYSTEM (LPCI) (LCI56-B)

Figure I.355 LCI56-B Tree

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LOW PRESSURE COOLANT INJECTION SYSTEM (LPCI) (LCI6)

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LOW PRESSURE COOLANT INJECTION SYSTEM (LPCI) (LCI60)

Figure I.357 LCI60 Tree

LOW PRESSURE COOLANT INJECTION SYSTEM (LPCI) (LCI83)

Figure 1.358 LCI83 Tree

LOW PRESSURE COOLANT INJECTION SYSTEM (LPCI) (LCI84)

Figure I.359 LCI84 Tree

LOW PRESSURE COOLANT INJECTION SYSTEM (LPCI) (LCI88)

Figure I.360 LCI88 Tree

FAILURE TO CONTROL MAKEUP GIVEN LETDOWN IS ISOLATED

Figure I.361 LCMK Tree

Figure I.362 LCMV5-F Tree

LOW PRESSURE CORE SPRAY SYSTEM (LPCS) (LCS12)

Figure I.363 LCS12 Tree

LOW PRESSURE CORE SPRAY SYSTEM (LPCS) (LCS13ADS)

Figure I.364 LCS13ADS Tree

LOW PRESSURE CORE SPRAY SYSTEM (LPCS) (LCS17)

Figure I.365 LCS17 Tree

LOW PRESSURE CORE SPRAY SYSTEM (LPCS) (LCS18)

Figure I.366 LCS18 Tree

LOW PRESSURE CORE SPRAY SYSTEM (LPCS) (LCS20)

Figure I.367 LCS20 Tree

LOW -PRESSURE CORE SPRAY SYSTEM (LPCS) (LCS5A)

Figure I.368 LCS5A Tree

LOW PRESSURE CORE SPRAY (LPCS) (LCS8)

Figure I.369 LCS8 Tree

LOW PRESSURE COOLANT INJECTION SYSTEM (LPCI) (LIMDP-F)

Figure I.370 LIMDP-F Tree

LOW PRESSURE COOLANT INJECTION SYSTEM (LPCI) (LIMDP2-F)

Figure I.371 LIMDP2-F Tree

SHUTDOWN COOLING SYSTEM (SDC) (LIMDP2F)

Figure I.372 LIMDP2F Tree

LOW PRESSURE COOLANT INJECTION SYSTEM (LPCI) (LIMP2A-F)

Figure L373 LIMP2A-F Tree

FAILURE OF MOV MV64B DUE TO FIRE/RANDOM EVENTS (CC)

Figure I.374 LIMV64B-F Tree

FAILURE OF MOV MV64B DUE TO FIRE/RANDOM EVENTS (CC)

Figure I.375 LIMV64BF Tree

SHUTDOWN COOLING SYSTEM (SDC) (LIMV6B-F)

Figure I.377 LIMV6B-F Tree

Figure I.378 LIMV8-F Tree

SHUTDOWN COOLING SYSTEM (SDC) (LIMV80F)

Figure I.379 LIMV80F Tree

SHUTDOWN COOLING SYSTEM (SDC) (LIMV9-F)

Figure I.380 LIMV9-F Tree

SHUTDOWN COOLING SYSTEM (SDC) (LIMV90F)

Figure I.381 LIMV90F Tree

LOW PRESSURE COOLANT INJECTION SYSTEM (LPCI) (LMV28AOF)

Figure I.383 LMV28AOF Tree

Figure I.384 LMV28BOF Tree

LOW PRESSURE COOLANT INJECTION SYSTEM
(LPCI) (LMV42A-F)

Figure I.385 LMV42A-F Tree

Figure I.387 LMV42B-F Tree

SHUTDOWN COOLING SYSTEM (SDC) (LMV42BOF)

Figure I.388 LMV42BOF Tree

Figure I.389 LMV42C-F Tree

Figure I.390 LMV48ACF Tree

Fault Trees

Figure I.391 LMV48AOF Tree

LOW PRESSURE COOLANT INJECTION SYSTEM (LPCI) (LMV48B-F)

Figure I.392 LMV48B-F Tree

LOW PRESSURE COOLANT INJECTION SYSTEM (LPCI) (LMV48BCF)

Figure I.393 LMV48BCF Tree

SHUTDOWN COOLING SYSTEM (SDC) (LMV48BOF)

Figure I.394 LMV48BOF Tree

FAILURE OF MOV MV4A DUE TO FIRE RANDOM EVENTS (00)

Figure I.395 LMV4A-F Tree

FAILURE OF MOV MV4B DUE TO FIRE/RANDOM EVENTS (OO)

Figure I.396 LMV4B-F Tree

FAILURE OF MOV MV4C DUE TO FIRE/RANDOM EVENTS (00)

Figure I.397 LMV4C-F Tree

LOW PRESSURE COOLANT INJECTION SYSTEM (LPCI) (LMV53B-F)

Figure I.398 LMV53B-F Tree

FAILURE OF MOV MV64A DUE TO FIRE RANDOM EVENTS (CO)

Figure I.399 LMV64A-F Tree

FAILURE OF MOV MV64A DUE TO FIRE RANDOM EVENTS (00)

Figure I.400 LMV64AOF Tree

SHUTDOWN COOLING SYSTEM (SDC) (LMV64B-F)

Figure I.401 LMV64B-F Tree

SHUTDOWN COOLING SYSTEM (SDC) (LMV64BOF)

Figure I.402 LMV64BOF Tree

FAILURE OF MOV MV64C DUE TO FIRE/RANDOM EVENTS (CC)

Figure L.403 LMOV64C-F Tree

LOW PRESSURE COOLANT INJECTION SYSTEM (LPCI) (LMV64COF)

Figure L-404 LMV64COF Tree

LOW PRESSURE COOLANT INJECTION SYSTEM (LPCI) (LMV66B--F)

Figure I.405 LMV66B-F Tree

SHUTDOWN COOLING SYSTEM (SDC) (LMV6BF)

Figure I.406 LMV6BF Tree

SHUTDOWN COOLING SYSTEM (SDC) (LMV8-F)

Figure I.407 LMV8-F Tree

Figure I.408 LMV8F Tree

SHUTDOWN COOLING SYSTEM (SDC) (LMV9-F)

Figure I.409 LMV9-F Tree

SHUTDOWN COOLING SYSTEM (SDC) (LMV9F)

Figure I.410 LMV9F Tree

EMERGENCY VENTILATION SYSTEM (EHV) LPCS ROOM (LP51B2AF)

Figure I.411 LP51B2AF Tree

EMERGENCY VENTILATION SYSTEM (EHV) LPCI ROOM A (LP51B3AF)

Figure I.412 LP51B3AF Tree

FAILURE OF LPCI ROOM COOLER 51B4B DUE TO FIRE/RANDOM EVENTS

Figure I.413 LP51B4B Tree

EMERGENCY VENTILATION SYSTEM (EHV) LPCI ROOM B (LP51B4BF)

Figure I.414 LP51B4BF Tree

EMERGENCY VENTILATION SYSTEM (EHV) LPCI ROOM C (LP51B5BF)

Figure I.415 LP51B5BF Tree

LOW PRESSURE COOLANT INJECTION SYSTEM (LPCI) (LPCI)

Figure I.416 LPCI Tree

LOW PRESSURE COOLANT INJECTION SYSTEM (LPCI) (LPCIA)

Figure L417 LPCIA Tree

LOW PRESSURE CORE SPRAY SYSTEM (LPCS) (LPCS)

Figure I.418 LPCS Tree

LOW PRESSURE CORE SPRAY SYSTEM (LPCS) (LPCS2)

Figure I.419 LPCS2 Tree

Figure I.420 LPMP1-F Tree

LOW PRESSURE COOLANT INJECTION SYSTEM (LPCI) (LPMV242F)

Figure I.421 LPMV242F Tree

LOW PRESSURE COOLANT INJECTION SYSTEM (LPCI) (LPMV27AF)

Figure I.422 LPMV27AF Tree

LOW PRESSURE COOLANT INJECTION SYSTEM (LPCI) (LPMV27BF)

Figure I.423 LPMV27BF Tree

LOW PRESSURE COOLANT INJECTION SYSTEM (LPCI) (LPMV28AF)

Figure I.424 LPMV28AF Tree

SHUTDOWN COOLING SYSTEM (SDC) (LPMV28BF)

Figure I.425 LPMV28BF Tree

LOW PRESSURE COOLANT INJECTION SYSTEM (LPCI) (LPMV3A-F)

Figure I.426 LPMV3A-F Tree

LOW PRESSURE COOLANT INJECTION SYSTEM (LPCI) (LPMV3ACF)

Figure I.427 LPMV3ACF Tree

LOW PRESSURE COOLANT INJECTION SYSTEM (LPCI) (LPMV3B-F)

Figure I.428 LPMV3B-F Tree

LOW PRESSURE COOLANT INJECTION SYSTEM (LPCI) (LPMV3BCF)

Figure I.429 LPMV3BCF Tree

STANDBY SERVICE WATER CROSS-TIE (SSW-XTIE) (LPMV3BOF)

Figure I.430 LPMV3BOF Tree

LOW PRESSURE COOLANT INJECTION SYSTEM (LPCI) (LPMV42CF)

Figure I.431 LPMV42CF Tree

SUPPRESSION POOL COOLING SYSTEM (SPC) (LPMV47AF)

Figure I.432 LPMV47AF Tree

LOW PRESSURE COOLANT INJECTION SYSTEM (LPCI) (LPMV47BF)

Figure I.433 LPMV47BF Tree

Figure L.434 LPMV48AF Tree

Figure I.435 LPMV48BF Tree

LOW PRESSURE COOLANT INJECTION SYSTEM (LPCI) (LPMV4A-F)

Figure I.436 LPMV4A-F Tree

SHUTDOWN COOLING SYSTEM (SDC) (LPMV4AOF)

Figure I.437 LPMV4AOF Tree

SHUTDOWN COOLING SYSTEM (SDC) (LPMV4B-F)

Figure I.438 LPMV4B-F Tree

LOW PRESSURE COOLANT INJECTION SYSTEM (LPCI) (LPMV4BCF)

Figure I.439 LPMV4BCF Tree

LOW PRESSURE COOLANT INJECTION SYSTEM (LPCI) (LPMV4C-F)

Figure I.440 LPMV4C-F Tree

LOW PRESSURE COOLANT INJECTION SYSTEM (LPCI) (LPMV4CCF)

Figure I.441 LPMV4CCF Tree

LOW PRESSURE COOLANT INJECTION SYSTEM (LPCI) (LPMV64AF)

Figure I.442 LPMV64AF Tree

Figure I.443 LPMV64B-F Tree

LOW PRESSURE COOLANT INJECTION SYSTEM (LPCI) (LPMV64BF)

Figure I.444 LPMV64BF Tree

LOW PRESSURE COOLANT INJECTION SYSTEM (LPCI) (LPMV64CF)

Figure I.445 LPMV64CF Tree

ALTERNATE DECAY HEAT REMOVAL SYSTEM (ADHRS) (LPMV66AF)

Figure I.446 LPMV66AF Tree

ALTERNATE DECAY HEAT REMOVAL SYSTEM
(ADHRS) (LPMV66BF)

Figure I.447 LPMV66BF Tree

LOW PRESSURE COOLANT INJECTION SYSTEM (LPCI) (LPMV6B-F)

Figure I.448 LPMV6B-F Tree

LOW PRESSURE CORE SPRAY SYSTEM (LPCS) (LSMV1-F)

Figure I.449 LSMV1-F Tree

LOW PRESSURE CORE SPRAY SYSTEM (LPCS) (LSMV11-F)

Figure I.459 LSMV11-F Tree

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LOW PRESSURE CORE SPRAY SYSTEM (LPCS) (LSMV11FF)

Figure I.451 LSMV11FF Tree

FAILURE TO MANUALLY INSERT RODS

Figure I.452 MANRI Tree

NUCLEAR BOILER SYSTEM (NBS) (MSIVO)

Figure I.454 MSIVO Tree

NUCLEAR BOILER SYSTEM (NBS) (MSIVS)

Figure I.455 MSIVS Tree

OPERATOR DECIDES OPEN AT LEAST ONE SRV

Figure I.456 OP1SV Tree

FAILURE TO OPEN CONTAINMENT LONG TERM

Figure I.457 OPCMT Tree

OPERATOR FAILS TO CLOSE OPEN SRV

Figure I.458 OPCSV Tree

OPERATOR FAILS TO DEPRESSURIZE IN HYDRO
BY ISOLATING CRD

Figure I.459 OPDEP Tree

RECOGNITION OF LOSS OF DHR

Figure I.460 OPDHR Tree

Figure I.461 OPDHR-1 Tree

Figure I.462 OPDHR-2 Tree

Figure I.463 OPDHR-3 Tree

Figure I.464 OPDSV Tree

OPERATOR ACTION TO INITIATE ECCS WATER SOLID OPERATION

Figure I.465 OPECS Tree

OPERATOR FAILS TO RECOGNIZE NEED TO FLOOD VESSEL/CONTAINMENT

Figure I.466 OPFLD Tree

OPERATOR FAILS TO INJECT INTO VESSEL AND FLOOD CONTAINMENT

Figure I.467 OPFLL Tree

OPERATOR DECIDES TO USE HPCS FOR ECCS WATER SOLID OPERATION

Figure I.468 OPHIS Tree

FAILURE TO CONTROL INADVERTENT HPCS ACTUATION

Figure L469 OPHCP Tree

OPERATOR FAILS TO CLOSE OPEN CONTAINMENT

Figure I.470 OPFCT Tree

OPERATOR FAILS TO ISOLATE SDC FROM OVERPRESSURIZATION

Figure I.471 OPIS Tree

OPERATOR FAILS TO ISOLATE ADHRS FOR WATER SOLID ECCS

Figure I.472 OPISA Tree

FAILURE TO ISOLATE LARGE DIVERSION AND LETDOWN

Figure L.473 OPL1L Tree

FAILURE OF THE RHR SDC SUCTION VALVE MV8 OR MV9 TO CLOSE

Figure L474 OPL11L-1 Tree

FAILURE OF THE RWCU ISOLATION VALVE MV1 OR MV4 TO CLOSE

Figure I.475 OPL1L-2 Tree

FAILURE TO ISOLATE SMALL DIVERSION BEFORE LEVEL DROPS 2 FT

Figure I.476 OPL1S Tree

FAILURE TO ISOLATE LARGE DIVERSION AFTER LEVEL DROPS 2 FT

Figure I.477 OPL2L Tree

FAILURE TO ISOLATE LETDOWN AND INCREASE MAKEUP FOR S2 IE'S

Figure I.478 OPDM Tree

OPERATOR FAILS TO USE ECCS FOR REFILL TO CONTROL LEVEL

Figure I.479 OPLEC Tree

OPERATOR FAILS TO INITIATE CLOSURE OF
OPEN MSIVs

Figure I.480 OPLMS Tree

OPERATOR FAILS TO INITIATING STEAMING THE CORE

Figure I.481 OPLST Tree

OPERATOR DECIDES TO ISOLATE THE MAIN STEAM LINES

Figure I.482 OPMSV Tree

OP. DECIDES TO DEPRESS. DURING HYDRO
FOLLOWING LOSS OF FCIRC

Figure I.483 OPNCF Tree

OPERATOR FAILS TO OPEN MSIVs TO PREVENT OVERPRESSURIZATION

Figure L484 OPOMS Tree

FAILURE TO RECOGNIZE LOSS OF SDC

Figure L.485 OPSDC Tree

FAILURE TO CONTROL INADVERTENT LOW PRESSURE ACTUATION

Figure I.486 OPSLP Tree

OPERATOR FAILS TO STOP FLOODING THROUGH OPEN MS LINES

Figure I.487 OPSOF Tree

OPERATOR FAILS TO INITIATE SPMU

Figure I.488 OPSM Tree

FAILURE TO CLOSE OPEN SRV

Figure I.489 OPSRV Tree

FAILURE TO RECOGNIZE LOSS OF SSW

Figure I.490 OPSSW Tree

OPERATOR FAILS TO INITIATE STEAMING OF CORE AT HI PRESSURE

Figure I.491 OPSTH Tree

OPERATOR FAILS TO INITIATE STEAMING OF
CORE AT HI PRESS.

Figure I.492 OPSTL Tree

OPERATOR FAILS TO INITIATE STEAMING OF
CORE AT LO PRESSURE

Figure I.493 OPSTM Tree

OPERATOR FAILS TO INITIATE STEAMING OF CORE AT LO PRESSURE

Figure I.494 OPSTM-1 Tree

OPERATOR FAILS TO VENT CONTAINMENT

Figure I.495 OPVNT Tree

FAILURE OF ONE SRV TO CLOSE

Figure I.496 P1 Tree

FAILURE OF TO CLOSE TWO SRV's

Figure I.497 P2 Tree

Figure L.498 PCS Tree

POWER CONVERSION SYSTEM (PCS) (PCS-E)

Figure I.499 PCS-E Tree

POWER CONVERSION SYSTEM (PCS) (PCS-L)

Figure I.500 PCS-L Tree

FRACTION OF TIME SPENT IN POS 5 PLANT OPERATIONAL STATE 5

Figure I.501 POSS Tree

PLANT SERVICE WATER SYSTEM (PSW) (PSW-101)

Figure I.502 PSW-101 Tree

PLANT SERVICE WATER SYSTEM (PSW) (PSW-110)

Figure I.503 PSW-110

PLANT SERVICE WATER SYSTEM (PSW) (PSW-111)

Figure I.504 PSW-111

PLANT SERVICE WATER SYSTEM (PSW) (PSW-112)

Figure I.505 PSW-112

PLANT SERVICE WATER SYSTEM (PSW) (PSW-901)

Figure I.506 PSW-901 Tree

PLANT SERVICE WATER SYSTEM (PSW) (PSW-903)

Figure I.507 PSW-903 Tree

PLANT SERVICE WATER SYSTEM (PSW) (PSW1)

Figure I.508 PSW1 Tree

PLANT SERVICE WATER SYSTEM (PSW) (PSW14CCW)

Figure I.509 PSW14CCW Tree

PLANT SERVICE WATER SYSTEM (PSW) (PSW2)

Figure I.510 PSW2 Tree

PLANT SERVICE WATER SYSTEM (PSW) (PSW2-CCW)

Figure I.511 PSW2-CCW Tree

PLANT SERVICE WATER SYSTEM (PSW) (PSW6-CCW)

Figure I.512 PSW6-CCW Tree

PLANT SERVICE WATER SYSTEM (PSW) (PSW7-CCW)

Figure I.513 PSW7-CCW Tree

PLANT SERVICE WATER SYSTEM (PSW) (PSW8-CCW)

Figure I.514 PSW8-CCW Tree

FAILURE TO RESTORE ISOLATED ADHRS

Figure I.515 RESAD Tree

FAILURE TO RESTORE ISOLATED SDC TRAIN B

Figure I.516 RESB Tree

FAILURE TO RESTORE ISOLATED COMMON SUCTION LINE

Figure L.517 RESCS Tree

OPERATOR FAILS TO RECOGNIZE NEED TO UNISOLATE RWCU (HYDRO)

Figure L518 RESRW Tree

HIGH PRESSURE PROTECTION FOR MV8 FAILS

Figure I.519 RHIPA Tree

FAILURE OF LEVEL 3 ISOLATION OF SDC

Figure I.520 RHRIL Tree

FAILURE OF HIGH PRESSURE PROTECTION FOR SDC

Figure I.521 RHRIP Tree

HIGH PRESSURE PROTECTION FOR MV8 FAILS

Figure I.522 RHRMV8HP Tree

LEVEL 3 ISOLATION OF MV8 FAILS

Figure I.523 RHRMV81V Tree

HIGH PRESSURE PROTECTION FOR MW9 FAILS

Figure I.524 RHRM9HP Tree

LEVEL 3 ISOLATION OF MV9 FAILS

Figure I.525 RHRMV9LV Tree

Figure I.526 RQ23 Tree

SUBSEQUENT LOSS OF OFFSITE POWER

Figure I.527 RLOSP Tree

RESTORATION OF MAKEUP IN THE LONG TERM

Figure I.528 RM-LT Tree

REACTOR WATER CLEANUP SYSTEM (RWCU) (RMV107-F)

Figure I.529 RMV107-F Tree

REACTOR PROTECTION SYSTEM (RPS) (RPS-A)

Figure I.530 RPS-A Tree

REACTOR PROTECTION SYSTEM (RPS) (RPS-B)

Figure I.531 RPS-B Tree

Figure I.532 RRMDPA-1 Tree

Figure I.533 RRMDPA-F Tree

REACTOR RECIRCULATION SYSTEM (RRS) (RRMV23AF)

Figure I.535 RRMV23AF Tree

REACTOR RECIRCULATION SYSTEM (RRS) (RRMV23BF)

Figure I.536 RRMV23BF Tree

REACOTR RECIRCULATION SYSTEM (RRS) (RRMV67AF)

Figure I.537 RRMV67AF Tree

TRAIN A SUCTION VALVE MV23A FAILS TO OPEN ON DEMAND

Figure I.539 RRS-3 Tree

TRAIN A PUMP FAILS TO START AND RUN

Figure I.540 RRS-4 Tree

TRAIN B PUMP FAILS TO CONTINUE TO RUN

Figure I.541 RRS-8 Tree

REACTOR RECIRCULATION SYSTEM (RRS) (RRV23BOF)

Figure I.542 RRV23BOF Tree

REACTOR RECIRCULATION SYSTEM (RRS) (RRV67BOF)

Figure I.543 RRV67BOF Tree

REACTOR WATER CLEANUP SYSTEM (RWCU) (RWC-RH22)

Figure I.544 RWC-RH22 Tree

REACTOR WATER CLEANUP SYSTEM (RWCU) (RWC-RH23)

Figure I.545 RWC-RH23 Tree

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REACTOR WATER CLEANUP SYSTEM (RWCU) (RWC-RH24)

Figure I.546 RWC-RH24 Tree

REACTOR WATER CLEANUP SYSTEM (RWCU) (RWC-RH33)

Figure I.547 RWC-RH33 Tree

REACTOR WATER CLEANUP SYSTEM (RWCU) (RWC-RH34)

Figure I.548 RWC-RH34 Tree

REACTOR WATER CLEANUP SYSTEM (RWCU) (RWCRH22C)

Figure I.549 RWCRH22C Tree

REACTOR WATER CLEANUP SYSTEM (RWCU) (RWCRH22L)

Figure I.550 RWCRH22L Tree

REACTOR WATER CLEANUP SYSTEM (RWCU) (RWCRH23C)

Figure I.551 RWCRH23C Tree

REACTOR WATER CLEANUP SYSTEM (RWCU) (RWCRH23L)

Figure I.552 RWCRH231 Tree

REACTOR WATER CLEANUP SYSTEM (RWCU) (RWCU)

Figure I.553 RWCU Tree

REACTOR WATER CLEANUP SYSTEM (RWCU) (RWCU-3)

Figure I.554 RWCU-3 Tree

REACTOR WATER CLEANUP SYSTEM (RWCU) (RWCU-9)

Figure I-555 RWCU-9 Tree

REACTOR WATER CLEANUP SYSTEM (RWCU) (RWCUC)

Figure I.556 RWCUC Tree

REACTOR WATER CLEANUP SYSTEM (RWCUC) (RWCUC-4)

Figure I.557 RWCUC-4 Tree

REACTOR WATER CLEANUP SYSTEM (RWCUC) (RWCUC-5)

Figure I.558 RWCUC-5 Tree

REACTOR WATER CLEANUP SYSTEM (RWCU) (RWCUC-6)

Figure I.559 RWCUC-6 Tree

REACTOR WATER CLEANUP SYSTEM (RWCUC) (RWCUC-9)

Figure I.560 RWCUC-9 Tree

REACTOR WATER CLEANUP SYSTEM (RWCU) (RWCUS)

Figure I.561 RWCUS Tree

REACTOR WATER CLEANUP SYSTEM (RWCUS) (RWCUS-11)

Figure I.562 RWCUS-11 Tree

NO FLOW TO RETURN HEADER

Figure I.563 RWCUS-2 Tree

REACTOR WATER CLEANUP SYSTEM (RWCU) (RWCUS-4)

Figure I.564 RWCUS-4 Tree

REACTOR WATER CLEANUP SYSTEM (RWCU)
(RWCUS-5)

Figure I.565 RWCUS-5 Tree

REACTOR WATER CLEANUP SYSTEM (RWCU) (RWCUS-6)

Figure I.566 RWCUS-6 Tree

REACTOR WATER CLEANUP SYSTEM (RWCU) (RWCUS-9)

Figure I.567 RWCUS-9 Tree

REACTOR WATER CLEANUP SYSTEM (RWCU) (RWLS)

Figure I.568 RWLS Tree

REACTOR WATER CLEANUP SYSTEM (RWCU) (RWLS-1)

Figure I.569 RWLS-1 Tree

Fault Trees

REACTOR WATER CLEANUP SYSTEM (RWCU)
(RWLS-13)

Figure I.571 RWLS-13 Tree

REACTOR WATER CLEANUP SYSTEM (RWCU) (RWLS-8)

Figure I.572 RWLS-8 Tree

REACTOR WATER CLEANUP SYSTEM (RWCU) (RWLS-9)

Figure I.573 RWLS-9 Tree

Figure I.574 RWMPLA-F Tree

REACTOR WATER CLEANUP SYSTEM (RWCU) (RWMP1AF)

Figure I.575 RWMP1AF Tree

REACTOR WATER CLEANUP SYSTEM (RWCU) (RWMP 1B-F)

Figure I.576 RWMP1B-F Tree

REACTOR WATER CLEANUP SYSTEM (RWCU) (RWMP1BF)

Figure L577 RWMP1BF Tree

REACTOR WATER CLEANUP SYSTEM (RWCU) (RWMV1-F)

Figure I.578 RWMV1-F Tree

REACTOR WATER CLEANUP SYSTEM (RWCU) (RWMV100)

Figure L579 RWMV100 Tree

REACTOR WATER CLEANUP SYSTEM (RWCU) (RWMV 100F)

Figure I.580RWMV100F Tree

REACTOR WATER CLEANUP SYSTEM (RWCU) (RWMV102)

Figure I.581 RWMV102 Tree

REACTOR WATER CLEANUP SYSTEM (RWCU) (RWMV102F)

Figure I.582 RWMV102F Tree

REACTOR WATER CLEANUP SYSTEM (RWCU) (RWMV106)

Figure I.583 RWMV106 Tree

REACTOR WATER CLEANUP SYSTEM (RWCU) (RWMV106F)

Figure L584 RWMV106F Tree

REACTOR WATER CLEANUP SYSTEM (RWCU) (RWMV107F)

Figure I.585 RWMV107F Tree

REACTOR WATER CLEANUP SYSTEM (RWCU) (RWMV1B-F)

Figure I.586 RWMV1B-F Tree

REACTOR WATER CLEANUP SYSTEM (RWCU) (RWMV1F)

Figure I.587 RWMV1F Tree

REACTOR WATER CLEANUP SYSTEM (RWCU) (RWMV254)

Figure I.588 RWMV254 Tree

REACTOR WATER CLEANUP SYSTEM (RWCU) (RWMV254F)

Figure I.589 RWMV254F Tree

REACTOR WATER CLEANUP SYSTEM (RWCU) (RWMV255)

Figure I.590 RWMV255 Tree

REACTOR WATER CLEANUP SYSTEM (RWCU)
(RWMV255F)

Figure L.591 RWMV255F Tree

REACTOR WATER CLEANUP SYSTEM (RWCU) (RWMV256)

Figure I.592 RWMV256 Tree

REACTOR WATER CLEANUP SYSTEM (RWCU) (RWMV256F)

Figure I.593 RWMV256F Tree

REACTOR WATER CLEANUP SYSTEM (RWCS) (RWMV28BF)

Figure I.594 RWMV28BF Tree

REACTOR WATER CLEANUP SYSTEM (RWCU) (RWMV280F)

Figure 1.595 S RWMV280F Tree

REACTOR WATER CLEANUP SYSTEM (RWCU) (RWMV310F)

Figure I.596 RWMV310F Tree

REACTOR WATER CLEANUP SYSTEM (RWMV) (RWMV34AF)

Figure L.597 RWMV34AF Tree

REACTOR WATER CLEANUP SYSTEM (RWCU) (RWMV340F)

Figure I.598 RWMV340F Tree

REACTOR WATER CLEANUP SYSTEM (RWCU) (RWMV35-F)

Figure I.599 RWMV35-F Tree

REACTOR WATER CLEANUP SYSTEM (RWCU) (RWMV350F)

Figure I.600RWMV350F Tree

REACTOR WATER CLEANUP SYSTEM (RWCU) (RWMV-4)

Figure I.601 RWMV4-F Tree

REACTOR WATER CLEANUP SYSTEM (RWCU) (RWMV44F)

Figure I.602 RWMV44F Tree

REACTOR WATER CLEANUP SYSTEM (RWCU) (RWMV440F)

Figure I.603 RWMV440F Tree

REACTOR WATER CLEANUP SYSTEM (RWCU) (RWMV4A-F)

Figure I.604 RWMV4A-F Tree

REACTOR WATER CLEANUP SYSTEM (RWCU) (RWMV54AF)

Figure I.605 RWMV54AF Tree

REACTOR WATER CLEANUP SYSTEM (RWCU) (RWV254-F)

Figure I.606 RWV254-F Tree

REACTOR WATER CLEANUP SYSTEM (RWCU)
(RWV2550F)

Figure I.607 RWV2550F Tree

REACTOR WATER CLEANUP SYSTEM (RWCU)
(RWV256OF)

Figure I.608 RWV256OF Tree

SAFETY RELIEF VALVE (SRV) (SAFE)

Figure I.609 SAFE Tree

SAFETY RELIEF VALVE (SRV) (SAFE)

Figure I.610 SAFEC Tree

FAILURE OF SA COMPRESSOR C001A DUE TO
FRIE/RANDOM EVENTS

Figure I.611 SASC001A Tree

Figure I.612 SASC001B Tree

RPS FAILS

Figure I.613 SCRAM Tree

SHUTDOWN COOLING SYSTEM (SDC) (SDC)

Figure I.614 SDC Tree

SHUTDOWN COOLING SYSTEM (SDC) (SDC-10)

Figure I.615 SDC-10 Tree

SHUTDOWN COOLING SYSTEM (SDC) (SDC-G30)

Figure I.616 SDC-G30 Tree

SHUTDOWN COOLING SYSTEM (SDC) (SDC10)

Figure I.617 SDC10 Tree

SHUTDOWN COOLING SYSTEM (SDC) (SDC13)

Figure I.618 SDC13 Tree

SHUTDOWN COOLING SYSTEM (SDC) (SDC14)

Figure I.619 SDC14 Tree

SHUTDOWN COOLING SYSTEM (SDC) (SDC14F)

Figure I.620 SDC14F Tree

SHUTDOWN COOLING SYSTEM (SDC) (SDC15)

Figure I.621 SDC15 Tree

SHUTDOWN COOLING SYSTEM (SDC) (SDC19)

Figure I.622 SDC19 Tree

SHUTDOWN COOLING SYSTEM (SDC) (SDC20)

Figure I.623 SDC20 Tree

SHUTDOWN COOLING SYSTEM (SDC) (SDC23)

Figure I.624 SDC Tree

SHUTDOWN COOLING SYSTEM (SDC) (SDC25)

Figure I.625 SDC25 Tree

SHUTDWON COOLING SYSTEM (SDC) (SDC26)

Figure I.626 SDC26 Tree

Figure I.627 SDC29 Tree

SHUTDOWN COOLING SYSTEM (SDC) (SDC3)

Figure I.628 SDC3 Tree

SHUTDOWN COOLING SYSTEM (SDC) (SDC30F1)

Figure I.630 SDC30F1 Tree

SHUTDOWN COOLING SYSTEM (SDC) (SDC30F2)

Figure I.631 SDC30F2 Tree

SHUTDOWN COOLING SYSTEM (SDC) (SDC30G)

Figure L.632 SDC30G Tree

Figure I.633 SDC30GD Tree

SHUTDOWN COOLING SYSTEM (SDC) (SDC31)

Figure I.634 SDC31 Tree

SHUTDOWN COOLING SYSTEM (SDC) (SDC4)

Figure I.635SDC4 Tree

SHUTDOWN COOLING SYSTEM (SDC) (SDC4G)

Figure I.636 SDC4G Tree

SHUTDOWN COOLING SYSTEM (SDC) (SDC7)

Figure I.637 SDC7 Tree

SHUTDOWN COOLING SYSTEM (SDC) (SDC9)

Figure I.638 SDC9 Tree

Figure I.639 SDCA Tree

SHUTDOWN COOLING SYSTEM (SDC) (SDCB)

Figure I.640 SDCB Tree

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SHUTDOWN COOLING SYSTEM (SDC) (SDCB3)

Figure I.641 SDCB3 Tree

Figure I.642 SDCBS Tree

SHUTDOWN COOLING SYSTEM (SDC) (SDCB6)

Figure I.643 SDCB6 Tree

SHUTDOWN COOLING SYSTEM (SDC) (SDCBBR)

Figure L.644 SDCBBR Tree

SHUTDOWN COOLING SYSTEM (SDC) (SDCB)

Figure I.645 SDCBS Tree

SHUTDOW COOLING SYSTEM (SDC) (SDCIL)

Figure I.646 SDCIL Tree

FAILURE OF OPERATOR TO INITIATE SDC OR ADHRS

Figure I.647 SDCUI Tree

SHUTDOWN COOLING SYSTEM (SDC) (SDV53A-F)

Figure L.648 SDV53A-F Tree

SHUTDOWN COOLING SYSTEM (SDC) (SDV53A0F)

Figure I.649 SDV53A0F Tree

SHUTDOWN COOLING SYSTEM (SDC) (SDV53B-F)

Figure I.650 SDV53B-F Tree

SHUTDOWN COOLING SYSTEM (SDC) (SDV53BCF)

Figure I.651 SDV53BCF Tree

Figure I.652 SDV53BOF Tree

LOSS OF REACTOR RECIRCULATION PUMP SEAL COOLING

Figure I.653 SEAL Tree

SUPPRESSION POOL MAKEUP SYSTEM (SPMU) (SMM603AF)

Figure I.654 SMM603AF Tree

SUPPRESSION POOL MAKEUP SYSTEM (SPMU) (SMM603BF)

Figure I.655 SMM603BF Tree

Figure I.656 SMMV1A-F Tree

SUPPRESSION POOL MAKEUP SYSTEM (SPMU) (SMMV1B-F)

Figure I.657 SMMV1B-F Tree

SUPPRESSION POOL MAKEUP SYSTEM (SPMU) (SMMV2A-F)

Figure I.658 SMMV2A-F Tree

SUPPRESSION POOL MAKEUP SYSTEM (SPMU) (SMMV2B-F)

Figure I.659 SMMV2B-F Tree

SUPPRESSION POOL MAKEUP SYSTEM (SPMU) (SMN3A-F)

Figure I.660 SMN3A-F Tree

SUPPRESSION POOL MAKEUP SYSTEM (SPMU)
(SMN3B-F)

Figure L.661 SMN3B-F Tree

SUPPRESSION POOL MAKEUP SYSTEM (SPMU) (SMN3C-F)

Figure I.662 SMN3C-F Tree

SUPPRESSION POOL MAKEUP SYSTEM (SPMU) (SMN3D-F)

Figure L663 SMN3D-F Tree

SUPPRESSION POOL MAKEUP SYSTEM (SPMU) (SMV24AOF)

Figure I.664 SMV24AOF Tree

SUPPRESSION POOL MAKEUP SYSTEM (SPMU) (SMV24BCF)

Figure I.665 SMV24BCF Tree

SUPPRESSION POOL COOLING SYSTEM (SPC) (SPC)

Figure I.666 SPC Tree

SUPPRESSION POOL COOLING SYSTEM (SPC) (SPC-24)

Figure I.667 SPC24 Tree

SUPPRESSION POOL COOLING SYSTEM (SPC) (SPC-30)

Figure I.668 SPC30 Tree

SUPPRESSION POOL COOLING SYSTEM (SPC) (SPC-35)

Figure I.669 SPC35 Tree

SUPPRESSION POOL COOLING SYSTEM (SPC) (SPC3)

Figure I.670 SPC-3A Tree

SUPPRESSION POOL COOLING SYSTEM (SPC) (SPC-3B)

Figure I.671 SPC-3B Tree

SUPPRESSION POOL COOLING SYSTEM (SPC) (SPC-3C)

Figure L.672 SPC-3C Tree

SUPPRESSION POOL COOLING SYSTEM (SPC) (SPC13)

Figure I.673 SPC13 Tree

SUPPRESSION POOL COOLING SYSTEM (SPC)

Figure L674 SPC16 Tree

SUPPRESSION POOL COOLING SYSTEM (SPC) (SPC2)

Figure L.675 SPC 2 Tree

SUPPRESSION POOL COOLING SYSTEM (SPC) (SPC20)

Figure L676 SPC20 Tree

Figure I.677 SPC24 Tree

SUPPRESSION POOL COOLING SYSTEM (SPC) (SPC24A)

Figure I.678 SPC24A Tree

SUPPRESSION POOL COOLING SYSTEM (SPC) (SPC29)

Figure I.679 SPC29 Tree

TRAIN B FAILS TO PROVIDE COOLING THROUGH PS-144 OR PS-72B

Figure L680 SPC3 Tree

SUPPRESSION POOL COOLING SYSTEM (SPC)

Figure I.681 SPC30 Tree

SUPPRESSION POOL COOLING SYSTEM (SPC) (SPC31)

Figure I.682 SPC 31 Tree

SUPPRESSION POOL COOLING SYSTEM (SPC) (SPC35)

Figure I.683 SPC35 Tree

SUPPRESSION POOL COOLING SYSTEM (SPC)

Figure I.684 SPC4 Tree

SUPPRESSION POOL COOLING SYSTEM (SPC)
(SPC41)

Figure I.685 SPC41 Tree

SUPPRESSION POOL COOLING SYSTEM (SPC) (SPC42)

Figure 1.686 SPC42 Tree

SUPPRESSION POOL COOLING SYSTEM (SPC) (SPC46)

Figure I.687 SPC46 Tree

SUPPRESSION POOL COOLING SYSTEM (SPC) (SPCA)

Figure I.689 SPCA Tree

OPERATOR FAILS TO RE-ALIGN FOR POS 1-3

Figure L690SPCALI13 Tree

OPERATOR FAILS TO RE-ALIGN FOR POS 1-7

Figure I.691 SPCALI17 Tree

OPERATOR FAILS TO RE-ALIGN FOR POS 4-7

Figure I.692 SPCALI47 Tree

SUPPRESSION POOL MAKEUP SYSTEM (SPMU) (SPM12)

Figure I.693 SPM12 Tree

SUPPRESSION POOL MAKEUP SYSTEM (SPMU) (SPM14)

Figure I.694 SPM14 Tree

SUPPRESSION POOL MAKEUP SYSTEM (SPMU) (SPM3)

Figure 1.695 SPM3 Tree

SUPPRESSION POOL MAKEUP SYSTEM (SPMU) (SPM5)

Figure I.696 SPM5 Tree

SUPPRESSION POOL MAKEUP SYSTEM (SPMU) (SPM9)

Figure I.698 SPM9 Tree

CONDENSATE AND REFUELING WATER STARAGE AND TRANSFER SYSTEM

Figure I.699 SPMKP Tree

FAILURE OF SUPPRESSION POOL MAKEUP — TRAIN A VALVES

Figure I.701 SPMU-2 Tree

SUPPRESSION POOL MAKEUP SYSTEM (SPMU) (SPMU1)

Figure I.702 SPMU1 Tree

SUPPRESSION POOL MAKEUP SYSTEM (SPMU)
(SPMU2)

Figure I.703 SPMU2 Tree

OPERATOR FAILS TO LOCALLY OPEN SPMU DUMP VALVES

Figure I.704 SPMUN Tree

SUPPRESSION POOL MAKEUP SYSTEM (SPMU) (SPMV24AF)

Figure I.705 SPMV24AF Tree

SUPPRESSION POOL MAKEUP SYSTEM (SPMU) (SPMV24BF)

Figure I.706 SPMV24BF Tree

SP WATER LEVEL IS EITHER AT LWL OR 12'8"

Figure I.707 SPWL V Tree

STANDBY SERVICE WATER SYSTEM (SSW) (SSMP2C-F)

Figure I.708 SSMP2C-F Tree

STANDBY SERVICE WATER SYSTEM (SSW)
(SSMV11-F)

Figure I.709 SSMV11-F Tree

STANDBY SERVICE WATER SYSTEM (SSW) (SSMV14AF)

Figure I.710 SSMV14AF Tree

STANDBY SERVICE WATER SYSTEM (SSW) (SSMV14B)

Figure I.711 SSMV14B Tree

STANDBY SERVICE WATER SYSTEM (SSW) (SSMV14BF)

Figure I.712 SSMV14BF Tree

STANDBY SERVICE WATER SYSTEM (SSW) (SSMV154F)

Figure I.713 SSMV154F Tree

STANDBY SERVICE WATER SYSTEM (SSW) (SSMV18AF)

Figure I.714 SSMV18AF Tree

STANDBY SERVICE WATER SYSTEM (SSW) (SSMV18BF)

Figure I.715 SSMV18BF Tree

STANDBY SERVICE WATER SYSTEM (SSW) (SSMV1A-F)

Figure I.716 SSMV1A-F Tree

STANDBY SERVICE WATER SYSTEM (SSW) (SSMV1B)

Figure I.717 SSMV1B Tree

STANDBY SERVICE WATER SYSTEM (SSW) (SSMV1B-F)

Figure I.718 SSMV1B-F Tree

STANDBY SERVICE WATER SYSTEM (SSW) (SSMV5A-F)

Figure I.719 SSMV5A-F Tree

STANDBY SERVICE WATER SYSTEM (SSW) (SSMV5B)

Figure I.720 SSMV5B Tree

STANDBY SERVICE WATER SYSTEM (SSW) (SSMV5B-F)

Figure I.721 SSMV5B-F Tree

STANDBY SERVICE WATER SYSTEM (SSW) (SSMV68AF)

Figure I.722 SSMV68AF Tree

Figure I.723 SSMV68B Tree

STANDBY SERVICE WATER SYSTEM (SSW) (SSMV68BF)

Figure I.724 SSMV68BF Tree

STANDBY SERVICE WATER SYSTEM (SSW) (SSMV94-F)

Figure I.725 SSMV94-F Tree

Figure I.726 SSMV96-F Tree

INSTRUMENT AIR SYSTEM (IAS) (SSV155AF)

Figure I.727 SSV155AF Tree

INSTRUMENT AIR SYSTEM (IAS) (SSV155BF)

Figure I.728 SSV155BF Tree

STANDBY SERVICE WATER SYSTEM (SSW) (SSW-ACE6)

Figure I.729 SSW-ACE6 Tree

STANDBY SERVICE WATER SYSTEM (SSW) (SSW--BCE5)

Figure I.730 SSW-BCE5 Tree

FAILURE OF TRAIN A ISOLATION VALVE TO SUPPLY SSW LOADS

Figure I.731 SSW-DGA4 Tree

NO WATER TO TRAIN B PS-173 FROM SSW COMMON ELEMENTS

Figure I.732 SSW-DGB3 Tree

FAILURE OF TRAIN B MDP1B SUPPORT SYSTEMS

Figure I.733 SSW-DCB8 Tree

STANDBY SERVICE WATER SYSTEM (SSW) (SSW-PC)

Figure I.734 SSW-PC Tree

STANDBY SERVICE WATER SYSTEM (SSW) (SSW3-CCW)

Figure I.735 SSW3-CCW Tree

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STANDBY SERVICE WATER SYSTEM (SSW) (SSWACE1)

Figure I.736 SSWACE1 Tree

STANDBY SERVICE WATER SYSTEM (SSW) (SSWB)

Figure I.737 SSWB Tree

STANDBY SERVICE WATER SYSTEM (SSW) (SSWB-HX)

Figure I.738 SSWB-HX Tree

STANDBY SERVICE WATER SYSTEM (SSW) (SSWB-RC)

Figure I.739 SSWB-RC Tree

FAILURE OF SSW TRAIN B COMMON ELEMENTS

Figure I.740 SSWBCE1 Tree

STANDBY SERVICE WATER SYSTEM (SSW) (SSWCCE)

Figure I.741 SSWCCE Tree

SSW TRAIN A FAILS TO PROVIDE DGA COOLING

Figure I.742 SSWDG11 Tree

SSW TRAIN B FAILS TO PROVIDE DGB COOLING

Figure I.743 SSWDG12 Tree

STANDBY SERVICE WATER SYSTEM (SSW) (SSWDG13)

Figure L.744 SSWDG13 Tree

STANDBY SERVICE WATER SYSTEM (SSW) (SSWHCSR)

Figure I.745 SSWHCSR Tree

STANDBY SERVICE WATER SYSTEM (SSW) (SSWHPCS1)

Figure I.746 SSWHPCS1 Tree

STANDBY SERVICE WATER SYSTEM (SSW) (SSWLCIPA)

Figure I.747 SSWLCIPA Tree

SSW TRAIN B FAILS TO PROVIDE RHR B PUMP COOLING

Figure I.748SSWLCIPB Tree

STANDBY SERVICE WATER SYSTEM (SSW) (SSWLCIPC)

Figure I.749 SSWLCIPC Tree

STANDBY SERVICE WATER SYSTEM (SSW) (SSWLCSRM)

Figure I.750 SSWLCSRM Tree

Figure I.751 SSWLPCRA Tree

SSW TRAIN B FAILS TO PROVIDE RHR B ROOM COOLING

Figure I.752 SSWLPCRB Tree

STANDBY SERVICE WATER SYSTEM (SSW) (SSWLPCRC)

Figure I.753 SSWLPCRC Tree

SSW TRAIN A FAILS TO PROVIDE RHR A HTX COOLING

Figure I.755 SSWRHRXA Tree

Figure I.757 SSWX2 Tree

STANDBY SERVICE WATER SYSTEM (SSW) (SSWXT)

Figure I.758 SSWXT Tree

STANDBY SERVICE WATER SYSTEM (SSW) (SW-PS169)

Figure I.759 SW-PS169 Tree

STANDBY SERVICE WATER SYSTEM (SSW) (SWLVL)

Figure I.760 SWLVL Tree

STANDBY SERVICE WATER SYSTEM (SSW) (SWMP1B)

Figure I.761 SWMP1B Tree

STANDBY SERVICE WATER SYSTEM (SSW) (SWMP1B-F)

Figure I.762 SWMP1B-F Tree

WATER TO INJECTION LINE PS-114 IS DIVERTED THROUGH PS-113

Figure L.763 SXT4 Tree

STANDBY SERVICE WATER SYSTEM CROSS-TIE (SSW-XTIE) (SXT6)

Figure I.764 SXT6 Tree

STANDBY SERVICE WATER SYSTEM CROSS-TIE (SSW-XTIE) (SXT7)

Figure I.765 SXT7 Tree

CROSS-TIE TRAIN C TO TRAIN A (ACP) (XTIE-C-A)

Figure I.767 XTIE-C-A Tree

CROSS-TIE DIESEL C TO DIVISION I (ACP) (XTIE1)

Figure I.768 XTIE1 Tree

CROSS-TIE DIESEL C TO DIVISION II (ACP) (XTIE2)

Figure I.769 XTIE2 Tree

CROSS-TIE DIESEL C TO DIVISION B (ACP) (XTIEB)

Figure I.770 XTIEB Tree

Appendix J. Miscellaneous Topics

This section of the report provides a summary discussion of a number of topics considered in performing the analysis. It is included in this report to document how the model addressed these topics.

J.1 Major Dependencies in Event Trees

The event trees of Section 6 were constructed considering major system dependencies. By considering major dependencies in the construction of event tree sequences, numerous illogical sequences were eliminated without requiring fault tree linking. Lower level dependencies were considered by fault tree linking.

For water systems, the major dependencies are given in Table J.1.1. For instrument air, the major dependencies are given in Table J.1.2. For 1E AC train B, the major dependencies are given in Table J.1.3. For 1E DC train B, the major dependencies are given in Table J.1.4.

J.2 T5B and T5C Initiating Events

This section discusses the effects of two initiating events, Loss of TBCW (T5B) and Loss of PSW (T5C), for all seven POSs.

As indicated in Table J.1.1, loss of TBCW causes loss of the following systems:

- (1) Feedwater/Condensate
- (2) Main Turbine and Generator
- (3) Instrument Air (auto backup cooling from SSW only if offsite power lost).

Loss of feedwater/condensate and loss of turbine/generator affects POSs 1, 2, and 3. Loss of IA affects all seven POSs.

To model T5B for POSs 1, 2, and 3, the T2 event tree was used with the addition of loss of IA. To model T5B for POSs 4, 5, 6, and 7, the TIA event tree was used. (Note: SSW is an automatic backup to TBCW for IA if offsite power is lost, and the assumption that loss of TBCW causes loss of IA is conservative for conditions after offsite power is lost.)

As indicated in table J.1.1, Loss of PSW causes loss of the following systems:

- (1) TBCW
- (2) CCW (auto backup cooling from SSW only if offsite power lost).

Loss of TBCW causes loss of IA, as previously discussed. Loss of CCW causes loss of RWCU, as indicated in Table J.1.1. Since loss of IA also causes loss of RWCU, initiating event T5C has the same effect as loss of TIA, and the same event tree structure was used for both events.

J.3 Non-1E Buses as Initiating Events

Failure of non-1E buses as initiating events were not quantified. Such failures were screened from the analysis because they have essentially the same effect as other events of much higher frequency which were considered as initiating events.

This section summarizes the process used to screen out non-1E buses as initiating events.

The electrical supply network at Grand Gulf has redundant buses upstream of the balance of plant transformers, and has redundant balance of plant transformers. Thus, we focused on non-1E buses downstream of the balance of plant transformers. In particular, the following buses were examined:

11HD, 12HE, 13AD, 14AE, and 18AG.

The major loads were identified from Grand Gulf information and are tabulated in Table J.3.1.

The effect of losing one of these non-1E buses is tabulated in Table J.3.2. For loss of any given bus, the effect is no worse than loss of instrument air, since as explained in the preceding Section J.1, loss of instrument air causes loss of: CDS, CRD, RWCU, FW, and Vent (also, the MSIVs drift closed). The frequency assigned to Loss of Instrument Air (TIA) is 0.18 per year (Table 4.1.1 in Section 4), and a typical frequency for loss of an AC bus is on the order of 2×10^{-3} per year (Section 4). Therefore, loss of an AC bus can be screened out as an initiating event for Grand Gulf.

We have not investigated in detail the effect of losing a non-1E DC bus. The DC buses provide control power for switchgear on associated AC buses (for example, DC power for opening, closing and tripping AC metal clad

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Table J.1.1 Systems Requiring Water

PSW Loads	SSW Loads	CCW Loads	TBCW Loads
CCW Heat Exchangers	CCW Heat Exchangers ^b	Recirc Pumps	IA Compressors and Aftercoolers
TBCW Heat Exchangers	IA Compressors and Aftercoolers ^b	RWCU Pumps and Non-Regenerative Heat Exchangers	Feedwater/Condensate Pumps
ADHRS Heat Exchangers	RHR Trains A, B, and C	FPCCU Heat Exchangers	Turbine Oil
FW Storage Tank Makeup	LPCS	CRD Pump Coolers	Generator Cooling
ESF Switchgear Room Coolers ^d	LPCI Trains A, B, and C		
Control Room Coolers ^d	HPCS ^d		
SSW Cooling Tower Makeup	FPCCU Heat Exchangers ^d		
	ESF Switchgear Room Coolers ^{a,c}		
	Control Room Coolers ^{a,c}		

- * Not required (pages 4.6-18, 4.6-79, and 4.6-88 of [Drouin et al., 1989])
- ^b Auto backup for PSW or TBCW only if reactor trip with loss of offsite power
- ^c Backup for PSW
- ^d Backup for CCW
- ^e SSW Train C is dedicated to HPCS

Table J.1.2 Systems Requiring Instrument Air

System/Equipment
CRD Flow Control Valves, F.C. ^a (pages 4.6-18 and 4.6-21 of [Drouin et al., 1989])
ADS, Accumulators can Stroke Twice (page 4.6-31 of [Drouin et al., 1989])
CDS, Feedwater Startup Valve, F.C. (Page 4.6-35 of [Drouin et al., 1989] and Figure 10.4-13 P&ID #M-1054 of [SERI, 1992])
CDS, Min. flow Control Valve, F.C.
Firewater Supply Valves, F. C. (pages 4.6-53 and B-194 of [Drouin et al., 1989])
MSIVs, F. C. (Table 9.3.2 sheet 3 of 9 of [SERI, 1992]) (Grand Gulf says drift closed)
Containment Ventilation Dampers, F. C. (page 4.6-69 of [Drouin et al., 1989])
RWCU, AOVs FO33, F234, F235 letdown to Condenser, F. C. (Figure 5.4-21 P&ID #M-1079-13 of [SERI, 1992])
PSW Requires IA, except for FW makeup (information from Grand Gulf)

- * Valves actually fail as is., but normal throttled position provides insufficient flow for use of CRD as required in event trees; effect is same as if valves fail closed.

Table J.1.3 Major Loads Off 1E 4160 V Bus #16AB¹

Load
RHR Pump B
LPCI Pump C
SSW Pump B
Battery Chargers for 1E 125 V DC Bus #11DB ^a
CRD Pump B
FPCCU Pump B
CCW Pump B
One IA Compressor
Containment Vent
SSWXT
Auxiliary Building and Containment Isolation Logic (loss causes loss of IA)

¹ From [Drouin et al., 1989] and [SERI, 1992]

^a Batteries last 11 hours with load shedding (page 4.6-75 of [Drouin et al., 1989])

Table J.1.4 Major Loads Off 1E 125 V DC Bus #11DB¹

Load
Switchgear Control for 4160 V AC Bus #16AB (e.g., circuit breakers control power)
RCIC (half of actuation logic is train B) ^a
ADS (half of control power is train B) ^a
Auxiliary Building and Containment Isolation Logic (loss causes loss of IA)

¹ From (Section 8.3-2 and Figures 8.3-6, 8.3-7, 8.3-8, and 8.3-10 of [SERI, 1992]) and [Drouin et al., 1989]

^a RCIC and ADS can still function without DC B power.

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Table J.3.1 Major Loads off Non-1E AC Buses

Bus and Voltage	Major Loads
11D, 6.9 KV	Recirc Pump A
	Circ Water Pump A
	RWCU Pump A
	CCW Pump A
12HE, 6.9 KV	Recirc Pump B
	Circ Water Pump B
	RWCU Pump B
	CCW Pump C
14AE, 4.16 KV	Condensate Pumps B and C
	Condensate Booster Pump C
	TBCW Pumps B and C
	Service Air Compressor B
	Recirc Pump B Low Frequency Motor Generator Set
13AD, 4.16 KV	Condensate Pump A
	Condensate Booster Pumps A and B
	TBCW Pump A
	Service Air Compressor A
	Recirc Pump A Low Frequency Motor Generator Set
18 AG, 4.16 KV	Four Radial Well Pumps
	PSW Pumps A, B, C, and D

Table J.3.2 Effects of Loss of a Non-1E Bus

Bus Lost	Effects on POSs 1, 2, and 3	Effects on POSs 4, 5, 6, and 7
11D	Degrade Recirc, Degrade Circ Water, Degrade CCW, Degrade RWCU	Degrade CCW, Degrade RWCU
12E	Degrade Recirc, Degrade Circ Water, Degrade CCW, Degrade RWCU	Degrade CCW, Degrade RWCU
14AE	Degrade CDS, Degrade TBCW, Degrade IA	Degrade CDS, Degrade TBCW, Degrade IA, Degrade Recirc
13AD	Degrade CDS, Degrade TBCW, Degrade IA	Degrade CDS, Degrade TBCW, Degrade IA, Degrade Recirc
18AG	Degrade PSW	Degrade PSW

circuit breakers), as well as providing power to other DC loads. We have assumed that loss of a non-1E DC bus can be screened out in a similar fashion as loss of a non-1E AC bus was screened out.

J.4 Steaming into the Auxiliary Building

J.4.1 Steaming Out Open Equipment Hatch and Personnel Portals

The event tree models for POS 5 include the possibility that if containment is open and the core is steamed, the environment in the auxiliary building can result in conditions (temperature, moisture, etc.) that increase the likelihood of component failures. This section documents the results of an engineering evaluation of this concern.

Assuming POS 5 is entered at 7 hours after shutdown with decay heat at 0.9% of full power, the total energy release was calculated to be following.

Δ Time, hr (Final time - 7 hrs)	Energy, Btu
0.8	1e+08
1.7	2e+08
2.6	3e+08
3.6	4e+08

For steaming at 15 psia, the enthalpy of phase change h_{fg} is 970 Btu/lbm and the specific volume of steam v_g is 26.83 cu ft/lbm. The maximum rate of steam generation is 1.2e5 lbm/hr. Steam releases are as follows (neglecting heat and mass transfer):

Δ Time, hr (Final time - 7 hrs)	Steam Produced, cu ft, Saturated at 15 psia
0.8	2.8e+06
1.7	5.6e+06
2.6	8.4e+06
3.6	1.1e+07

The total volume of the containment, shield building, and auxiliary building is on the order of 5E6 cu ft, and each train of the SGTS can purge 4000 cfm [SERI, 1992]. Thus, it requires hours for steam to globally affect

components in the auxiliary building, even if normal auxiliary building ventilation is not available.

For the accident sequences where equipment failures due to steaming are of concern, offsite power is lost and the components in the following systems are important:

LPCI B
CRD B
SSWXT (with SSW B)
FW.

The SSW B and FW pumps are not located in the auxiliary building. Furthermore, FW can be supplied by a diesel driven pump which does not require electrical power from 1E train B. LPCI pump B is in the auxiliary building, located in the RHR B pump room, area 1A105 at the 93 foot level. Room cooling is provided by a dedicated cooler which does not require offsite power. CRD pump B is in the auxiliary building, located in the miscellaneous equipment area 1A117 at the 93 foot level.

The systems of concern, except for FW, require electrical power from 1E train B. The emergency diesel generator B power source is located in a room in the diesel generator building at the 158 foot level. The diesel generator building can be accessed from the auxiliary building through a door, and the room containing diesel generator B can be accessed through an inner door [SERI, 1992]. The diesel generator diesel room is cooled by once through ventilation of outside air, using intake/exhaust dampers and fans which do not require offsite power. The components of concern are supplied by 1E 4160 V ac bus 16AB off DG B which is located in the division 2 switchgear area of the control building at the 111 foot level [SERI, 1992]. The control building can be accessed from the auxiliary building through doors. The switchgear area has room cooling provided by a dedicated cooler which does not require offsite power.

Based on information from Grand Gulf, electrical supply, switchgear, and control components for providing power to the components in the systems of concern can be identified and located. The search was conducted in two ways.

- (1) The load list for bus 16AB was reviewed, and major electrical components of specific concern for LPCI B, SSWXT, and CRD were identified,

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- (2) All major electrical components located on or above the 166 foot level in the auxiliary building were identified.

Major Electrical components of specific concern are as follows: LCC 16BB1, MCC 16B11, LCC 16BB3, MCC 16B31, LCC 16BB4, LCC 16BB5, and MCC 16B51. Locations of these electrical components are given in Table J.4.1.

All major electrical components in the auxiliary building at or above the 166 foot elevation are as follows:

Electrical Component	Associated with 1E Train B ?
LCC 12BE5	No
LCC 13BD3	No
MCC 11B13	No
MCC 12B52	No
MCC 15B21	No
MCC 16B41	Yes

Based on this identification and location of major components, the following can be concluded:

- (1) All major components are located in rooms/buildings separated from the general open areas of the auxiliary building except for the CRD pumps, which are located in the general area at the 93 foot elevation.
- (2) All major components in separate rooms/buildings have room coolers which do not require offsite power.
- (3) All major components in the auxiliary building are located at or below the 166 foot elevation. Only one component is at the 166 foot elevation, MCC 16B41, all the rest are at or below the 139 foot elevation.

The effect of steam on electrical equipment depends on the location of the equipment relative to the source of steam. The three major sources of steaming into the auxiliary building are as follows:

Equipment Hatch at the 172 foot elevation
 Personnel Hatch at the 212 foot elevation
 Personnel Hatch at the 120 foot elevation.

Table J.4.1 Electrical Component Locations

Electrical Component	Location in Auxiliary Building or in Connected Building
LCC 16BB1	Div 2 Switchgear Room 1A221, 119 foot ^{a,b}
MCC 16B11	Div 2 Switchgear Room 1A221, 119 foot ^{a,b}
LCC 16BB2	Div 2 Switchgear Room 1A308, 139 foot ^{a,b}
MCC 16B21	Electrical Penetration Room 1A320, 139 foot ^{a,b}
LCC 16BB3	Div 2 Switchgear Room 1A221, 119 foot ^{a,b}
MCC 16B31	Div 2 Switchgear Room 1A207, 119 foot ^{a,b}
LCC 16BB4	Div 2 Switchgear Room 1A308, 139 foot ^{a,b}
MCC 16B41	Electrical Penetration Room 1A407, 166 foot ^{a,b}
MCC 16B42	Div 2 Switchgear Room 1A207, 119 foot ^{a,b}
(LCC 16BB5)	NOT IN AUX BLDG: IN SSW PUMPHOUSE
(MCC 16B51)	NOT IN AUX BLDG: IN SSW PUMPHOUSE
LCC 16BB5	Control Bldg Room OC215, 111 Foot ^{a,b}
MCC 16B61	Control Bldg Room OC215, 111 Foot ^{a,b}

- ^a Separated from the auxiliary building general area, but with access to the general area through personnel access door(s).
^b Room cooling provided; offsite power not required.

For accident sequences in which the suppression pool is available as a heat sink but no suppression pool cooling is available, steaming was not predicted to start until about 5 hours into the transient. For accident sequences in which the suppression pool is not available, steaming will occur at about 5 minutes into the transient. As indicated previously in this section, the steaming rate is sufficiently slow that hours are required before the auxiliary building is globally affected. Both of the personnel hatches can

be closed before the effects of steaming on equipment are of concern. The major concern is steaming out the open equipment hatch at the 172 foot elevation. The equipment hatch at the 172 foot elevation is open to the general area of the auxiliary building at the 166 foot elevation. The electrical penetration room 1A407 which contains MCC 16B41 is at this elevation. Figures from [SERI, 1992] show a room cooler in this room.

Temperature Concerns

MELCOR calculations for POS 6 (with decay heat about 1/2 of that in POS 5) indicate that even with the auxiliary building compartmentalized (small building model), temperatures in the lower portions of the auxiliary building (lower two floors) do not exceed 110 F for at least 20 hours. For POS 5, it is not expected that temperatures will exceed 110 F on any floor below the 166 foot level in the auxiliary building for at least 10 hours, if steaming is from the equipment hatch. Thus, there is ample time for operator action to open doors in the auxiliary building to lower steam temperatures. For example, door # 1A401 can be opened to vent the 166 foot level.

The only major component that is not located in the lower portions of the auxiliary building is MCC 16B41. However, as previously discussed, this MCC is located in electrical penetration room 1A407 which can be isolated (from the general area of the auxiliary building at the 166 foot elevation) by closing door # 1A403. Also, this room has a room cooler [SERI, 1992]. In summary, the room containing MCC 16B41 can be isolated and kept cool, and the 166 foot elevation can be vented by opening a door. Sufficient time to accomplish these actions is available due to the low rate of steaming in POS 5.

In NUREG 4550, expert judgement was used for the issue of equipment qualification (EQ) in the auxiliary building [Wheeler et al., 1989]. In the final aggregate results, no failures below 225 F were presented in the summary curves, because the focus of the study was for accidents at full power in which high temperatures can occur. Equipment qualification temperatures for the LaSalle BWR were given in this reference as follows:

Electric motors, failure to start: 310 F
 Electric motors, failure to run: 310 F
 Switchgear, failure to operate: 350 F
 Switchgear, spurious operation: 200 F
 Electric Terminals, short: 200 F.

Two important aspects related to equipment qualification are as follows.

- (1) For conditions above nominal but lower than qualification, significant degradation in the reliability of components can occur, and
- (2) The qualification temperatures provided in NUREG 4550 are specific to LaSalle, and qualification ratings can vary significantly among plants.

Experts B and C also indicated that failure rates can increase significantly at elevated temperature/steam conditions, even if the temperature is below qualification [Wheeler et al., 1989]. However, with a temperature of -90 F from qualification (200-110) expert B estimated a failure probability of only on the order of 1E-3 over a 10 hour exposure time (Figure C.3-3 of [Wheeler et al., 1989]). Furthermore, this expert indicated that no increase in failure probability over nominal is expected if the temperature is 100 F or lower.

It is expected that temperatures in the auxiliary building at the locations of major components of concern can be maintained at or below about 100 F, for the following reasons:

- (1) Action to vent the auxiliary building can be taken by opening door(s).
- (2) Only one major component of concern is located at the elevation at or above the equipment hatch. However, this component is located in a room which can be isolated from the steam, and can be cooled by a room cooler that does not require offsite power.
- (3) All major components of concern, except for the one just discussed, are located in the lower portions of the auxiliary building. All of these components, except for the CRD pumps, are in rooms which can be isolated, and which have room coolers that do not require offsite power.
- (4) The CRD pumps are located in the bottom of the auxiliary building at the 93 foot elevation, where temperatures will not be high before actions to vent the building can be taken.

In conclusion, temperature-related failures of the major equipment should not occur.

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Flooding Concerns

The concern addressed in this section is that due to steaming, not flooding. However, creation of condensate does lead to buildup water on the floor. Based on the steaming data presented in the first part of this Appendix, if all steam is condensed, the rate of water creation is only 250 gpm.

Grand Gulf performed a flooding study [GG Flood]. This study indicates that 250 gpm is not of concern for flooding out equipment in the subject systems.

Based on the slow rate of condensate buildup, and information in the flooding study, flooding due to the slow build up of water from steam condensation is not of concern.

Local Effects

If equipment is located directly in the path of steam as it flows into the auxiliary building, the effects on the equipment can be greater than those due to 'global' temperature and flooding as previously discussed. Such 'local' effects include increased condensation and dripping of water onto critical locations such as terminal connections.

As indicated by the previous discussion, no major components of concern are located near the equipment hatch. Therefore, local effects should not be of concern.

Conclusions and Recommendations

For the major components of concern, it is concluded that the effects of steaming into the auxiliary building (through the open equipment hatch) should not result in significantly increased failure rates.

It is not possible to locate every component of concern without a detailed evaluation and a plant walkdown. For example, only major equipment was addressed in this study, since we do not know the exact location of every junction box and cable. It is possible that a piece of minor electrical equipment necessary for operation of an important system is located where it could fail, but that piece may not fail all of the systems of concern.

One possible approach to estimating the effect of steaming into the auxiliary building is to increase the failure probability for each piece of equipment located in the auxiliary building that serves LPCI B, SSWXT, CRD, and FW, by a factor of 10 and evaluate the impact.

Another possible approach would be to assume that the likelihood that all the subject systems are lost due to common-cause steaming is equal to $1E-3$ (based on the information from expert B provided earlier).

If, in fact, it can be shown that no equipment is more susceptible to steam than the major equipment previously discussed, and if operator actions can be counted on with high confidence, then steaming should have no effect.

In the detailed analysis of POS 5, we considered the effect of steaming into the auxiliary building by assigning a value of $1E-3$ to the event EQSTM in the event trees. In effect, this assumes that steaming into the auxiliary building has a probability of $1E-3$ of failing all core cooling equipment.

A detailed walkdown of Grand Gulf is required to further resolve this issue.

J.4.2 Steaming Out Open MSIVs or Broken Feedwater Line

The event trees consider steaming out the open MSIVs. In this scenario, the steam passes through the open MSIVs, through the main steam tunnel at the 140 foot level in the auxiliary building, and into the turbine building [SERI, 1992]. No steam is released into the auxiliary building. Thus, steaming into the auxiliary building is not of concern.

The event trees consider steaming the core through an unisolated, broken feedwater line outside containment. The location of the break is downstream of the two check valves in the broken feedwater line. Therefore, the break is either in the main steam tunnel in the auxiliary building, or in the turbine building. If the break is in the main steam tunnel, the steam is released to the atmosphere from a blowout shaft [SERI, 1992], and this prevents steam flooding of the rest of the auxiliary building. No equipment necessary for core cooling for the scenario of concern is located in the main steam tunnel. Steam released into the turbine building is not of concern.

J.5 Special Considerations in the Event Tree Structures

Section 6 and Appendix H of this report discuss the event trees used to analyze POS 5.

As indicated in Section 6.1, the event trees that address mitigation for transient initiating events considered a

hierarchy of core cooling options. In certain cases, the detailed development of specific event trees deviated from this hierarchy. Significant deviations and the reasons for them are discussed in this section.

J.5.1 EC Trees

The EC set of trees (EC, ECP, ECX, ECPN) model containment support for use of ECCS in a water solid mode if shutdown cooling is lost. These trees are used if ECCS is successful in the short term, and they consider long term loss of ECCS due to loss of suppression pool inventory. If suppression pool inventory is lost, these trees transfer to the S set of trees (S, SP, SX, SNP), which model steaming the core at low pressure.

The EC trees do not transfer to the F set of trees, which consider flooding the core, rather they transfer to the S set of trees. This non-transfer to the F trees is a departure from the core cooling hierarchy, which indicates that flooding would be attempted before steaming. Flooding is not considered in these scenarios for the following reasons:

- (1) ECCS is successful in the short term. ECCS is lost due to boil off of suppression pool inventory, and there is time for operator action to restore inventory. It is likely that operators would focus on restoring support for a running system (ECCS) rather than focus on instituting a new method of core cooling (flooding). (It should be noted that in the E set of trees, which consider early loss of ECCS, the flooding option is considered.)
- (2) Hardware required for flooding is a subset of hardware that can be used for steaming. As indicated in the structure of the F and S trees, if flooding can be accomplished with either SSWXT or FW, then steaming can be accomplished with either SWLVL or FWLVL. Thus, aside from operator action considerations on whether to flood or steam, steaming is easier to accomplish than flooding.

By not considering flooding in the EC trees, the model is conservative. We did not include flooding because we cannot be certain that this option would be attempted for sequences in which ECCS is lost only over the long term.

J.5.2 S Trees

The S set of trees (S, SP, SX, SNP) model steaming the core at low pressure. In these trees, we did not consider the use of ECCS (except for HPCS in the SNP tree).

For the S, SP, and SX trees, ECCS was not considered as a source of water for steaming for the following reasons:

- (1) Before the steaming option is considered, the ECCS water solid option is considered. Therefore, ECCS in a water solid mode has failed prior to transferring into the S trees. Some of the failures, such as loss of all ECCS pumps, preclude the use of ECCS for steaming. Other failures, such as operator failure to attempt ECCS water solid operation do not preclude the use of ECCS for steaming. We have conservatively assumed that if the operator fails to consider using ECCS for water solid operation, then the operator will not try and use ECCS for steaming.
- (2) If ECCS is included in the S trees, then suppression pool inventory must be considered, requiring inclusion of the EC trees. However, to avoid logic loops, all transfers from the EC trees to the S trees must be eliminated. Therefore, the inclusion of ECCS in the steaming trees involves the creation of special EC trees, which further complicates an already large model.

For all sequences that transfer to the SNP tree, offsite power and electrical power from 1E trains 1 and 2 are lost. The only sources available for injection are HPCS, and FW in manual operation. We included HPCS in the SNP tree as an option for steaming since so little equipment is available in these sequences. For successful steaming with HPCS, adequate suppression pool inventory must be maintained as modeled in the ECNPL tree. The ECNPL tree is identical to the ECPN tree, except that transfers to SNP are not permitted to avoid logic loops.

J.5.3 P Trees

The P set of trees (P, PP, PX, PISOL, PISLP, and PISLX) model steaming the core at rated pressure.

These trees do not consider the use of HPCS as a source

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of makeup water. If ECCS was previously lost in the E trees as a result of failure of ECCS hardware, then ECCS is not available for use in the P trees. If ECCS was lost due to operator failure to use ECCS, it is assumed that the operator will not attempt to use ECCS for steaming.

If ECCS was lost due to failure of an SRV to operate in the relief mode, ECCS cannot be used and low pressure maintained. However, if the system is allowed to pressurize and an SRV opens in the safety mode, then steaming at the safety setpoint with makeup from HPCS is possible. The P trees do not consider this option, based on the same rationale provided for reason (2) in Section J.5.2.

These trees assume that if seal cooling for the recirc pumps is not provided (at rated temperature, about 545 F), then core damage results. This is a conservative assumption, since if makeup is sufficient to match steaming and compensate for loss out failed seal(s), adequate level in the core region can be maintained. This assumption also results in no consideration of steaming at power in transfers from the SNP tree, since without offsite power and without 1E trains 1 and 2, seal cooling (at rated temperature) cannot be maintained. (For low temperature conditions, 200 F, we have assumed seal cooling can be provided by controlled leakage of a few gpm of cold vessel water out the recirc pump(s) shaft.)

J.5.4 Train A Out for Maintenance

As discussed in Section 3 of this report, in the analysis of POS 5, we assumed that train A is unavailable due to maintenance. However, the event trees completely consider train A equipment, except for the one case that is the subject of this section. The actual analysis was conducted by setting all train A systems and components to 'failed' in the event trees.

The reason that train A systems were included in the event tree models, is so that the sensitivity of core damage to variations in maintenance practices can be performed without requiring extensive modifications to the event trees. This was an objective of our study, as discussed in objective 3 of Section 1.1 of this report.

Only one modification to the event trees for POS 5 is necessary to allow for complete consideration of train A equipment. The event XTIEB considers cross tie of the diesel generator for train 3 (C) only to the train 2 (B) distribution network. No consideration for cross tie to the train 1 (A) network is modeled. This model for cross tie was used to simplify the structure of the event trees. To completely model train A systems and components, consideration for cross tie to train 1 (A) should be added to the event trees.

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