

**Risk Assessment for Indian Point Unit 2  
A Hypothetical Case  
Loss of Safeguards Electrical Bus 6A  
Coincident with a Steam Generator Tube Rupture**

**Background:**

**February 15, 2000 - Steam Generator Tube Rupture**

The Indian Point Unit 2 facility experienced a steam generator tube rupture (SGTR) on February 14, 2000 when a flaw in the U-bend of tube R2C5 in steam generator 24 failed. This flaw had not been detected during the last nondestructive examination of steam generator tubes because of programmatic problems. During the recovery process following the SGTR, there were no failures in equipment or operator actions that were needed to mitigate the consequences of the event.

The conditional core damage probability (CCDP) associated with this event was calculated by ConEd using their risk model as  $7.7E-05$ . This is comparable to the CCDP of  $3.3E-04$  calculated using the NRC's Rev. 2-QA Standardized Plant Analysis Risk Model (SPAR) for Indian Point Unit 2. Additional analysis was performed by NRR to quantify the increase in core damage frequency (CDF) and large early release frequency (LERF) that resulted from operation with the flawed steam generator tubes<sup>1</sup>. An incremental increase in CDF was calculated as  $1.0E-04$  per reactor year for the second year of operation. In accordance with the guidance from MC0609, Appendix H, the LERF frequency equals the CDF for a SGTR, therefore the LERF frequency for this condition is also  $1.0E-04$ <sup>2</sup>. Risk was dominated by the probability of human error in identifying and isolating the faulted steam generator and depressurizing the reactor coolant system to below the steam generator safety valve pressure.

**August 31, 1999 - Reactor Trip and Loss of Safeguards Electrical Power**

The Indian Point Unit 2 facility also experienced a reactor trip prior to the SGTR on August 31, 1999. This trip was complicated by the loss of the 6A 480 volt ac safeguards electrical bus and the subsequent loss of the 24 battery. The loss of the 6A bus resulted in the loss of some emergency core cooling equipment including: one of the two motor driven auxiliary feedwater (AFW) trains, one of three high pressure injection trains, one of two high pressure recirculation trains, one of two residual heat removal trains and loss of power to one of the two normally closed PORV block valves.

The CCDP associated with this event was calculated as  $2.0E-04$  by the NRR Operations support team (OST). Risk was dominated by the failure probabilities of the one remaining motor driven AFW pump, the turbine driven AFW pump and the probability for non-recovery of main feedwater. Had auxiliary feedwater failed, core damage could normally be prevented through use of primary bleed and feed. The success for reactor coolant system bleed and feed requires flow through both power operated relief valves (PORVs). However, flow through one of the

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<sup>1</sup>Subsequent examination determined that other tubes had not been detected during the examination performed prior to the SGTR event.

<sup>2</sup>Reference: memorandum Barrett to Blough, dated May 4, 2000

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PORVs was prevented because its normally closed block valve receives power from electrical bus 6A.

The CDF calculated using the NRC's Rev. 2-QA Standardized Plant Analysis Risk Model (SPAR) for Indian Point Unit 2 was somewhat less than that calculated by the OST. The Rev 2-QA SPAR<sup>3</sup> model calculated a CCDP for this event of 4.9E-05. The difference being that the SPAR model uses industry average basic event equipment failure data where the OST used data from the IP-2 individual plant evaluation (IPE) without including credit for equipment recovery.

**Risk Analysis of Concurrent Events:**

This analysis constructed a hypothetical event, a SGTR, for which the recovery was complicated by failures in the electrical distribution system similar to those experienced during the August 31 event. Risk would increase because of the loss of safety related equipment and also because of the additional challenges to the operators. The August 31 event proved difficult for the ConEd organization to analyze and react to in a timely manner.

The August 31<sup>st</sup> event was initiated following a normal reactor trip that was complicated by actuation of safeguards bus undervoltage protective devices. A switchyard transformer tap changer was in its manual mode for an extended period. The event would have been a routine reactor trip had the tap changer been in automatic mode. Following the loss of self generation, safeguards 480 volt ac bus voltage sagged because of plant distribution system impedence. Protective instrumentation started all three emergency diesel generators (EDGs). When the diesel generators were ready to load, their output breakers were closed onto the three safeguards electrical buses. However, the generator output breaker to bus 6A tripped open on overload. Subsequent investigation found issues with the overcurrent trip device calibration process, including the type of equipment used for this activity. Although the process deficiencies may have resulted in a common cause failure of all three EDG output breakers, only one of the breakers' overcurrent trip point was set low enough to cause an overcurrent trip. The above referenced risk analysis for this event did not include recovery of the EDG, recovery of offsite power or activation of the station blackout cross-connection from Unit 1. Recovery was not considered because it is a complex process and the licensee's organization performed poorly during follow-up to the event as evidenced by their allowing a station battery to discharge to the point of cell reversal.

In reviewing the circumstances of these two events, it is clear that the causes for the August 31<sup>st</sup> event may not have revealed themselves until the SGTR event had there not been the earlier reactor trip. If that were the case, the SGTR recovery would have become complicated by the

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<sup>3</sup> The IP-2 Rev 2-QA SPAR model was corrected to reflect the normally CLOSED position of the PORV block valves and was revised to credit operator recovery of the RHR suction path MOVs for shutdown cooling. The SPAR model human error recovery process was used to calculate the HRA for this recovery action as 2.0E-03 after consultation with RI operator licensing personnel.

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loss of power to important emergency safeguards equipment. A SGTR is a significant challenge to operators who would then have to cope with additional degraded plant equipment.

A risk assessment was performed of this hypothetical event, this assessment imposed the bus 6A electrical failures on to the SGTR event analysis. The CCDP was calculated using the NRC's Rev. 2-QA SPAR as 3.8E-04. The probability for core damage was dominated by the failure to identify and isolate the faulted steam generator and the failure to depressurize the RCS. This assessment did not calculate new human error probabilities for actions needed to recover from a SGTR. The loss of the 6A 480 volt electrical bus is expected to increase these failure probabilities because it complicates the recovery and causes additional stress to the operators. A copy of this analysis is Attachment 1.

**Effect of Concurrent Events on Human Reliability Analysis**

Additional stress may have affected the Indian Point Unit 2 plant operators performance if bus 6A had failed during the SGTR. This increase stress level was accounted for in an additional risk analysis that used recalculated human error probabilities for four of the five operator tasks associated with the SGTR top events:

- RCS-SG      Depressurize RCS to below SG RV setpoint
- DEP-REC     Operator depressurizes the RCS after SG RV lift
- SGISOL      Ruptured SG isolated
- THROTTLE   Throttle HPI to reduce pressure
- RCS-DEP     Depressurize RCS to RHR entry

The human error values for these five tasks were originally derived for the Rev. 2-QA SPAR models from sources such as the Surry facility NUREG 1150 study<sup>4</sup>, plant IPE's and the NRC Daily Events Manual. These values were recalculated using the Rev. 3i SPAR Model Human Error Worksheets. For each case, the "Stress" shaping factor associated with task diagnosis or action was set to "Extreme". The following summarizes these changes:

| Event Name       | Task Description   | Original Value                | Re-Calculated Value |
|------------------|--|-------------------------------|---------------------|
| HPI-XHE-XM-THRTL | Operator fails to throttle HPI flow to reduce RCS pressure | 1.0E-02<br>Surry 1150         | 5.0E-03             |
| MSS-XHE-XM-ERROR | Operator fails to isolate faulted steam generator          | 1.0E-03<br>San Onfre IPE      | 5.0E-03             |
| PCS-XHE-XM-RCOOL | Operator fails to initiate RCS cooldown below SDC          | 1.0E-03<br>Daly Events Manual | no change           |

<sup>4</sup>Analysis of Core Damage frequency: Surry Unit 1, Internal Events, NUREG/CR-4550

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| Event Name      | Task Description  | Original Value       | Re-Calculated Value |
|-----------------|---|----------------------|---------------------|
| RCS-XHE-DIAG    | Operator fails to diagnose SGTR and start procedures              | 6.8E-03<br>Sury 1150 | 2.1E-02             |
| RCS-XHE-RECOVER | Operator fails to depressurize RCS below SG SRV given SG RV opens | 3.5E-03<br>Sury 1150 | 5.0E-03             |
| RCS-XHE-XM-SG   | Operator fails to initiate RCS depressurization                   | 2.1E-02<br>Sury 1150 | 5.0E-03             |

The CCDP for a SGTR with a loss of the 6A 480 volt electrical bus and re-calculated human error failure probabilities is 4.6E-04. A copy of this risk assessment is Attachment 2. Again, the probability for core damage was dominated by the failure to identify and isolate the faulted steam generator and the failure to depressurize the RCS. The table below lists the human error tasks and the contribution to the CDF from cut sets that the tasks are included.

| Event Name       | Task Description  | Contribution to CDF |       |
|------------------|---|---------------------|-------|
| RCS-XHE-RECOVER  | Operator fails to depressurize RCS below SG SRV given SG RV opens | 1.6E-04             | 33.6% |
| RCS-XHE-DIAG     | Operator fails to diagnose SGTR and start procedures              | 1.1E-04             | 23.8% |
| MSS-XHE-XM-ERROR | Operator fails to isolate faulted steam generator                 | 7.8E-05             | 16.9% |
| RCS-XHE-XM-SG    | Operator fails to initiate RCS depressurization                   | 2.6E-05             | 5.7%  |
| HPI-XHE-XM-THRTL | Operator fails to throttle HPI flow to reduce RCS pressure        | 2.6E-05             | 5.7%  |
| PCS-XHE-XM-RCOOL | Operator fails to initiate RCS cooldown below SDC                 | 1.5E-05             | 3.4%  |

**Completed by:  
Tom Shedlosky**

**Reviewed by:  
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INITIATING EVENT ASSESSMENT

Fam : IPT2\_2QA  
 User :  
 Ev ID: SGTR W/BUS 6A OOS  
 Desc : Initiating Event Assessment

Code Ver : 6:68  
 Model Ver : 1998/04/14  
 Init Event: IE-SGTR  
 Total CCDP: 3.8E-004

| BASIC EVENT CHANGES |                              |           |           |      |
|---------------------|------------------------------|-----------|-----------|------|
| Event Name          | Description                  | Base Prob | Curr Prob | Type |
| ACP-BAC-LP-6A       | DIVISION 6A AC POWER 480V BU | 9.0E-005  | 1.0E+000  | TRUE |
| IE-LOOP             | LOSS OF OFFSITE POWER INITIA | 3.1E-005  | +0.0E+000 |      |
| IE-SGTR             | STEAM GENERATOR TUBE RUPTURE | 1.6E-006  | 1.0E+000  |      |
| IE-SLOCA            | SMALL LOCA INITIATING EVENT  | 2.3E-006  | +0.0E+000 |      |
| IE-TRANS            | TRANSIENT INITIATING EVENT   | 2.7E-004  | +0.0E+000 |      |

SEQUENCE PROBABILITIES

Truncation : Cummulative : 100.0% Individual : 1.0%

| Event Tree Name | Sequence Name | CCDP     | %Cont |
|-----------------|---------------|----------|-------|
| SGTR            | 11            | 1.3E-004 | 34.2  |
| SGTR            | 03            | 1.2E-004 | 31.6  |
| SGTR            | 43            | 5.7E-005 | 15.0  |
| SGTR            | 04            | 4.4E-005 | 11.6  |
| SGTR            | 05            | 1.0E-005 | 2.6   |
| SGTR            | 44            | 5.5E-006 | 1.5   |
| SGTR            | 08            | 4.6E-006 | 1.2   |

SEQUENCE LOGIC

| Event Tree | Sequence Name | Logic   |
|------------|---------------|---|
| SGTR       | 11            | /RT /AFW-SGTR<br>/HPI RCS-SG<br>DEP-REC                         |
| SGTR       | 03            | /RT /AFW-SGTR<br>/HPI /RCS-SG<br>/SG-DEP SGISOL<br>/RCS-DEP RHR |
| SGTR       | 43            | /RT AFW-SGTR<br>MFW-NT F&B                                      |
| SGTR       | 04            | /RT /AFW-SGTR<br>/HPI /RCS-SG<br>/SG-DEP SGISOL                 |

| RCS-DEP |    |   |  |
|---------|----|---|--|
| SGTR    | 05 | /RT<br>/HPI<br>SG-DEP                     | /AFW-SGTR<br>/RCS-SG                       |
| SGTR    | 44 | RT  |  |
| SGTR    | 08 | /RT<br>/HPI<br>/DEP-REC<br>SGISOL1<br>RHR | /AFW-SGTR<br>RCS-SG<br>/SG-DEP<br>/RCS-DEP |

| Fault Tree Name | Description   |
|-----------------|---|
| AFW-SGTR        | NO OR INSUFFICIENT AFW FLOW DURING SGTR               |
| DEP-REC         | OPERATOR FAILS TO DEPRESSURIZE RCS GIVEN SG ADV OR SR |
| F&B             | FAILURE TO PROVIDE FEED AND BLEED COOLING             |
| HPI             | NO OR INSUFFICIENT FLOW FROM THE HPI SYSTEM           |
| MFW-NT          | FAILURE OF THE MAIN FEEDWATER SYSTEM DURING NON-TRANS |
| RCS-DEP         | FAILURE TO COOLDOWN RCS TO < RHR PRESSURE             |
| RCS-SG          | OPERATOR FAILS TO LOWER RCS PRESSURE TO < SG RV SETP  |
| RHR             | NO OR INSUFFICIENT FLOW FROM THE RHR SYSTEM           |
| RT              | REACTOR FAILS TO TRIP DURING TRANSIENT                |
| SG-DEP          | HARDWARE FAILS TO LOWER RCS PRESSURE TO < SG RV SETPO |
| SGISOL          | FAILURE TO ISOLATE RUPTURED SG BEFORE RWST DEPLETION  |
| SGISOL1         | FAILURE TO DEPRESSURIZE RCS TO ISOLATE SG             |

SEQUENCE CUT SETS

Truncation: Cumulative: 100.0% Individual: 1.0%

Event Tree: SGTR  
 Sequence: 11

CCDP: 1.3E-004

| CCDP     | % Cut Set | Cut Set Events                  |
|----------|-----------|---------------------------------|
| 7.4E-005 | 55.6      | RCS-XHE-RECOVER<br>SGTR-11-NREC |
| 3.5E-005 | 26.5      | RCS-XHE-RECOVER<br>SGTR-11-NREC |
| 2.4E-005 | 18.0      | RCS-XHE-RECOVER<br>SGTR-11-NREC |

Event Tree: SGTR  
 Sequence: 03

CCDP: 1.2E-004

| CCDP     | % Cut Set | Cut Set Events                   |                  |
|----------|-----------|----------------------------------|------------------|
| 3.8E-005 | 31.7      | RHR-MDP-FC-2B<br>SGTR-03-NREC    | MSS-VCF-HW-ISOL  |
| 3.0E-005 | 25.0      | RHR-MOV-OO-RWST<br>SGTR-03-NREC  | MSS-VCF-HW-ISOL  |
| 2.0E-005 | 16.7      | MSS-VCF-HW-ISOL<br>SGTR-03-NREC  | RHR-XHE-SUCTION  |
| 1.0E-005 | 8.3       | RHR-XHE-XM<br>SGTR-03-NREC       | MSS-VCF-HW-ISOL  |
| 5.6E-006 | 4.7       | RHR-MDP-CF-ALL<br>SGTR-03-NREC   | MSS-VCF-HW-ISOL  |
| 3.8E-006 | 3.2       | RHR-MDP-FC-2B<br>SGTR-03-NREC    | MSS-XHE-XM-ERROR |
| 3.0E-006 | 2.5       | RHR-MOV-OO-RWST<br>SGTR-03-NREC  | MSS-XHE-XM-ERROR |
| 2.6E-006 | 2.2       | RHR-MOV-CF-DIS<br>SGTR-03-NREC   | MSS-VCF-HW-ISOL  |
| 2.0E-006 | 1.7       | MSS-XHE-XM-ERROR<br>SGTR-03-NREC | RHR-XHE-SUCTION  |
| 1.4E-006 | 1.2       | RHR-MOV-OC-VLV<br>SGTR-03-NREC   | MSS-VCF-HW-ISOL  |

Event Tree: SGTR  
 Sequence: 43

CCDP: 5.7E-005

| CCDP     | % Cut Set | Cut Set Events                |                  |
|----------|-----------|-------------------------------|------------------|
| 2.8E-005 | 49.0      | AFW-MDP-FC-21<br>SGTR-43-NREC | AFW-TDP-FC-22    |
| 1.2E-005 | 21.3      | AFW-PMP-CF-ALL                | SGTR-43-NREC     |
| 7.9E-006 | 13.8      | AFW-TDP-FC-22<br>SGTR-43-NREC | AFW-AOV-CC-MSG21 |
| 4.0E-006 | 7.0       | AFW-AOV-CF-SGS                | SGTR-43-NREC     |
| 1.5E-006 | 2.6       | AFW-MDP-CF-AB<br>SGTR-43-NREC | AFW-TDP-FC-22    |
| 7.2E-007 | 1.3       | AFW-TDP-FC-22<br>SGTR-43-NREC | AFW-CKV-CC-SG21  |
| 6.5E-007 | 1.1       | AFW-TDP-FC-22<br>SGTR-43-NREC | ACP-BAC-LP-2-3A  |
| 5.9E-007 | 1.0       | AFW-CKV-CF-SUCT               | SGTR-43-NREC     |
| 5.9E-007 | 1.0       | AFW-CKV-CF-SGS-S              | SGTR-43-NREC     |
| 5.9E-007 | 1.0       | AFW-CKV-CF-PMPS               | SGTR-43-NREC     |

Event Tree: SGTR  
 Sequence: 04

CCDP: 4.4E-005

| CCDP     | % Cut Set | Cut Set Events                   |                  |
|----------|-----------|----------------------------------|------------------|
| 3.0E-005 | 68.2      | PCS-VCF-HW<br>SGTR-04-NREC       | MSS-VCF-HW-ISOL  |
| 1.0E-005 | 22.7      | PCS-XHE-XM-RCOOL<br>SGTR-04-NREC | MSS-VCF-HW-ISOL  |
| 3.0E-006 | 6.8       | PCS-VCF-HW<br>SGTR-04-NREC       | MSS-XHE-XM-ERROR |
| 1.0E-006 | 2.3       | PCS-XHE-XM-RCOOL<br>SGTR-04-NREC | MSS-XHE-XM-ERROR |

Event Tree: SGTR  
 Sequence: 05

CCDP: 1.0E-005

| CCDP     | % Cut Set | Cut Set Events |              |
|----------|-----------|----------------|--------------|
| 1.0E-005 | 100.0     | PCS-PSF-HW     | SGTR-05-NREC |

Event Tree: SGTR  
 Sequence: 44

CCDP: 5.5E-006

| CCDP     | % Cut Set | Cut Set Events                   |                 |
|----------|-----------|----------------------------------|-----------------|
| 4.3E-006 | 77.8      | RPS-XHE-XM-SCRAM<br>SGTR-44-NREC | RPS-VCF-FO-ELEC |
| 1.1E-006 | 20.6      | RPS-BKR-FC-FTO<br>SGTR-44-NREC   | RPS-XHE-ERROR   |
| 8.9E-008 | 1.6       | RPS-VCF-FO-MECH                  | SGTR-44-NREC    |

Event Tree: SGTR  
 Sequence: 08

CCDP: 4.6E-006

| CCDP     | % Cut Set | Cut Set Events                     |                                  |
|----------|-----------|------------------------------------|----------------------------------|
| 8.0E-007 | 17.4      | RHR-MDP-FC-2B<br>MSS-VCF-HW-ISOL   | RCS-XHE-XM-SG<br>SGTR-08-NREC    |
| 6.3E-007 | 13.7      | RHR-MOV-OO-RWST<br>MSS-VCF-HW-ISOL | RCS-XHE-XM-SG<br>SGTR-08-NREC    |
| 4.2E-007 | 9.2       | RCS-XHE-XM-SG<br>RHR-XHE-SUCTION   | MSS-VCF-HW-ISOL<br>SGTR-08-NREC  |
| 3.8E-007 | 8.3       | RHR-MDP-FC-2B<br>MSS-VCF-HW-ISOL   | HPI-XHE-XM-THRTL<br>SGTR-08-NREC |
| 3.0E-007 | 6.5       | RHR-MOV-OO-RWST<br>MSS-VCF-HW-ISOL | HPI-XHE-XM-THRTL<br>SGTR-08-NREC |
| 2.6E-007 | 5.6       | RHR-MDP-FC-2B<br>MSS-VCF-HW-ISOL   | RCS-XHE-DIAG<br>SGTR-08-NREC     |
| 2.1E-007 | 4.6       | RCS-XHE-XM-SG<br>MSS-VCF-HW-ISOL   | RHR-XHE-XM<br>SGTR-08-NREC       |

|          |     |                                     |                                  |
|----------|-----|-------------------------------------|----------------------------------|
| 2.0E-007 | 4.5 | RHR-MOV-OO-RWST<br>MSS-VCF-HW-ISOL  | RCS-XHE-DIAG<br>SGTR-08-NREC     |
| 2.0E-007 | 4.4 | HPI-XHE-XM-THRTL<br>RHR-XHE-SUCTION | MSS-VCF-HW-ISOL<br>SGTR-08-NREC  |
| 1.4E-007 | 3.0 | RCS-XHE-DIAG<br>RHR-XHE-SUCTION     | MSS-VCF-HW-ISOL<br>SGTR-08-NREC  |
| 1.2E-007 | 2.6 | RHR-MDP-CF-ALL<br>MSS-VCF-HW-ISOL   | RCS-XHE-XM-SG<br>SGTR-08-NREC    |
| 1.0E-007 | 2.2 | HPI-XHE-XM-THRTL<br>MSS-VCF-HW-ISOL | RHR-XHE-XM<br>SGTR-08-NREC       |
| 8.0E-008 | 1.7 | RHR-MDP-FC-2B<br>MSS-XHE-XM-ERROR   | RCS-XHE-XM-SG<br>SGTR-08-NREC    |
| 6.8E-008 | 1.5 | RCS-XHE-DIAG<br>MSS-VCF-HW-ISOL     | RHR-XHE-XM<br>SGTR-08-NREC       |
| 6.3E-008 | 1.4 | RHR-MOV-OO-RWST<br>MSS-XHE-XM-ERROR | RCS-XHE-XM-SG<br>SGTR-08-NREC    |
| 5.6E-008 | 1.2 | RHR-MDP-CF-ALL<br>MSS-VCF-HW-ISOL   | HPI-XHE-XM-THRTL<br>SGTR-08-NREC |
| 5.5E-008 | 1.2 | RCS-XHE-XM-SG<br>MSS-VCF-HW-ISOL    | RHR-MOV-CF-DIS<br>SGTR-08-NREC   |

BASIC EVENTS (Cut Sets Only)

| Event Name       | Description                                   | Curr Prob |
|------------------|---|-----------|
| ACP-BAC-LP-2-3A  | DIVISION 2A/3A AC POWER 480V BUS FAILS        | 9.0E-005  |
| AFW-AOV-CC-MSG21 | SG-21 FLOW CONTROL VALVE 406A FAILS           | 1.1E-003  |
| AFW-AOV-CF-SGS   | CCF OF STEAM GENERATOR INLET AOVs (FCVS)      | 1.9E-005  |
| AFW-CKV-CC-SG21  | STEAM GENERATOR 21 INLET CHECK VALVE FAILS    | 1.0E-004  |
| AFW-CKV-CF-PMPS  | CCF OF AFW PUMP DISCHARGE CHECK VALVES        | 2.7E-006  |
| AFW-CKV-CF-SGS-S | CCF OF SG INLET CHECK VALVES - SGTR           | 2.7E-006  |
| AFW-CKV-CF-SUCT  | CCF OF AFW PUMP SUCTION CHECK VALVES          | 2.7E-006  |
| AFW-MDP-CF-AB    | COMMON CAUSE FAILURE OF MOTOR DRIVEN PUMPS    | 2.1E-004  |
| AFW-MDP-FC-21    | AFW MOTOR DRIVEN PUMP 21 FAILS                | 3.9E-003  |
| AFW-PMP-CF-ALL   | COMMON CAUSE FAILURE OF AFW PUMPS             | 5.6E-005  |
| AFW-TDP-FC-22    | AFW TURBINE DRIVEN PUMP 22 FAILS              | 3.3E-002  |
| HPI-XHE-XM-THRTL | OPERATOR FAILS TO THROTTLE HPI TO REDUCE PRES | 1.0E-002  |
| MSS-VCF-HW-ISOL  | RUPTURED STEAM GENERATOR ISOLATION FAILURES   | 1.0E-002  |
| MSS-XHE-XM-ERROR | OPERATOR FAILS TO ISOLATE FAULTED STEAM GENER | 1.0E-003  |
| PCS-PSF-HW       | HARDWARE FAILURES CAUSING FAILURE TO DEPRESSU | 1.0E-005  |
| PCS-VCF-HW       | TEVS/COND/CIR FAILURES                        | 3.0E-003  |
| PCS-XHE-XM-RCOOL | OPERATOR FAILS TO INITIATE RCS COOLDOWN BELOW | 1.0E-003  |
| RCS-XHE-DIAG     | OPERATOR FAILS TO DIAGNOSE SGTR TO START PROC | 6.8E-003  |
| RCS-XHE-RECOVER  | OPERATOR FAILS TO DEPRESSURIZE RCS BELOW SG S | 3.5E-003  |
| RCS-XHE-XM-SG    | OPERATOR FAILS TO INITIATE RCS DEPRESSURIZATI | 2.1E-002  |
| RHR-MDP-CF-ALL   | RHR PUMP COMMON CAUSE FAILURES                | 5.6E-004  |
| RHR-MDP-FC-2B    | RHR TRAIN B FAILS                             | 3.8E-003  |
| RHR-MOV-CF-DIS   | COMMON CAUSE FAILURE OF RHR DISCHARGE MOVs    | 2.6E-004  |
| RHR-MOV-OC-VLV   | RHR DISCHARGE VALVE FAILS                     | 1.4E-004  |
| RHR-MOV-OO-RWST  | RHR/RWST ISOLATION MOV FAILS                  | 3.0E-003  |
| RHR-XHE-SUCTION  | OPERATOR FAILS TO RECOVER RHR SUCTION PATH    | 2.0E-003  |

| Event Name       | Description                                 | Curr Prob |
|------------------|---|-----------|
| RHR-XHE-XM       | OPERATOR FAILS TO INITIATE RHR SYSTEM       | 1.0E-003  |
| RPS-BKR-FC-FTO   | RPS BREAKERS FAIL TO OPEN                   | 5.7E-006  |
| RPS-VCF-FO-ELEC  | CONTROL ROD DRIVES REMAIN ENERGIZED         | 4.3E-004  |
| RPS-VCF-FO-MECH  | CONTROL ROD ASSEMBLIES FAIL TO INSERT       | 8.9E-008  |
| RPS-XHE-ERROR    | OPERATOR FAILS TO DE-ENERGIZE MG SETS       | 2.0E-001  |
| RPS-XHE-XM-SCRAM | OPERATOR FAILS TO MANUALLY TRIP THE REACTOR | 1.0E-002  |
| SGTR-03-NREC     | SGTR SEQUENCE 03 NONRECOVERY PROBABILITY    | 1.0E+000  |
| SGTR-04-NREC     | SGTR SEQUENCE 04 NONRECOVERY PROBABILITY    | 1.0E+000  |
| SGTR-05-NREC     | SGTR SEQUENCE 05 NONRECOVERY PROBABILITY    | 1.0E+000  |
| SGTR-08-NREC     | SGTR SEQUENCE 08 NONRECOVERY PROBABILITY    | 1.0E+000  |
| SGTR-11-NREC     | SGTR SEQUENCE 11 NONRECOVERY PROBABILITY    | 1.0E+000  |
| SGTR-43-NREC     | SGTR SEQUENCE 43 NONRECOVERY PROBABILITY    | 2.2E-001  |
| SGTR-44-NREC     | SGTR SEQUENCE 44 NONRECOVERY PROBABILITY    | 1.0E+000  |

INITIATING EVENT ASSESSMENT

Fam : IPT2\_2QA  
 User :  
 Ev ID: SGTR W/BUS 6A OOS  
 Desc : Initiating Event Assessment

Code Ver : 6:68  
 Model Ver : 1998/04/14  
 Init Event: IE-SGTR  
 Total CCDP: 4.6E-004

| BASIC EVENT CHANGES |                              |           |           |      |
|---------------------|------------------------------|-----------|-----------|------|
| Event Name          | Description                  | Base Prob | Curr Prob | Type |
| ACP-BAC-LP-6A       | DIVISION 6A AC POWER 480V BU | 9.0E-005  | 1.0E+000  | TRUE |
| HPI-XHE-XM-THRTL    | OPERATOR FAILS TO THROTTLE H | 1.0E-002  | 5.0E-003  |      |
| IE-LOOP             | LOSS OF OFFSITE POWER INITIA | 3.1E-005  | +0.0E+000 |      |
| IE-SGTR             | STEAM GENERATOR TUBE RUPTURE | 1.6E-006  | 1.0E+000  |      |
| IE-SLOCA            | SMALL LOCA INITIATING EVENT  | 2.3E-006  | +0.0E+000 |      |
| IE-TRANS            | TRANSIENT INITIATING EVENT   | 2.7E-004  | +0.0E+000 |      |
| MSS-XHE-XM-ERROR    | OPERATOR FAILS TO ISOLATE FA | 1.0E-003  | 5.0E-003  |      |
| RCS-XHE-DIAG        | OPERATOR FAILS TO DIAGNOSE S | 6.8E-003  | 2.1E-002  |      |
| RCS-XHE-RECOVER     | OPERATOR FAILS TO DEPRESSURI | 3.5E-003  | 5.0E-003  |      |
| RCS-XHE-XM-SG       | OPERATOR FAILS TO INITIATE R | 2.1E-002  | 5.0E-003  |      |

SEQUENCE PROBABILITIES

Truncation : Cumulative : 100.0% Individual : 0.0%

| Event Tree Name | Sequence Name | CCDP     | %Cont |
|-----------------|---------------|----------|-------|
| SGTR            | 03            | 1.6E-004 | 34.8  |
| SGTR            | 11            | 1.6E-004 | 34.8  |
| SGTR            | 04            | 6.0E-005 | 13.0  |
| SGTR            | 43            | 5.7E-005 | 12.4  |
| SGTR            | 05            | 1.0E-005 | 2.2   |
| SGTR            | 44            | 5.5E-006 | 1.2   |
| SGTR            | 08            | 5.1E-006 | 1.1   |
| SGTR            | 13            | 3.4E-006 | 0.7   |
| SGTR            | 09            | 1.9E-006 | 0.4   |
| SGTR            | 10            | 3.1E-007 | 0.1   |
| SGTR            | 16            | 8.8E-008 | 0.0   |
| SGTR            | 18            | 2.9E-008 | 0.0   |
| SGTR            | 14            | 2.2E-009 | 0.0   |
| SGTR            | 17            | 5.8E-011 | 0.0   |

SEQUENCE LOGIC

| Event Tree | Sequence Name | Logic  |
|------------|---------------|--|
| SGTR       | 03            | /RT<br>/HPI<br>/SG-DEP<br>/AFW-SGTR<br>/RCS-SG<br>SGISOL |

|      |    | /RCS-DEP                                  | RHR  |
|------|----|---|--|
| SGTR | 11 | /RT<br>/HPI<br>DEP-REC                    | /AFW-SGTR<br>RCS-SG                        |
| SGTR | 04 | /RT<br>/HPI<br>/SG-DEP<br>RCS-DEP         | /AFW-SGTR<br>/RCS-SG<br>SGISOL             |
| SGTR | 43 | /RT<br>MFW-NT                             | AFW-SGTR<br>F&B                            |
| SGTR | 05 | /RT<br>/HPI<br>SG-DEP                     | /AFW-SGTR<br>/RCS-SG                       |
| SGTR | 44 | RT  |  |
| SGTR | 08 | /RT<br>/HPI<br>/DEP-REC<br>SGISOL1<br>RHR | /AFW-SGTR<br>RCS-SG<br>/SG-DEP<br>/RCS-DEP |
| SGTR | 13 | /RT<br>HPI<br>/SG-DEP                     | /AFW-SGTR<br>/RCS-SG1<br>SGISOL            |
| SGTR | 09 | /RT<br>/HPI<br>/DEP-REC<br>SGISOL1        | /AFW-SGTR<br>RCS-SG<br>/SG-DEP<br>RCS-DEP  |
| SGTR | 10 | /RT<br>/HPI<br>/DEP-REC                   | /AFW-SGTR<br>RCS-SG<br>SG-DEP              |
| SGTR | 16 | /RT<br>HPI<br>/DEP-REC<br>SGISOL1         | /AFW-SGTR<br>RCS-SG1<br>/SG-DEP            |
| SGTR | 18 | /RT<br>HPI<br>DEP-REC                     | /AFW-SGTR<br>RCS-SG1                       |
| SGTR | 14 | /RT<br>HPI<br>SG-DEP                      | /AFW-SGTR<br>/RCS-SG1                      |

|      |    |          |           |
|------|----|----------|-----------|
| SGTR | 17 | /RT      | /AFW-SGTR |
|      |    | HPI      | RCS-SG1   |
|      |    | /DEP-REC | SG-DEP    |

| Fault Tree Name | Description   |
|-----------------|---|
| AFW-SGTR        | NO OR INSUFFICIENT AFW FLOW DURING SGTR               |
| DEP-REC         | OPERATOR FAILS TO DEPRESSURIZE RCS GIVEN SG ADV OR SR |
| F&B             | FAILURE TO PROVIDE FEED AND BLEED COOLING             |
| HPI             | NO OR INSUFFICIENT FLOW FROM THE HPI SYSTEM           |
| MFW-NT          | FAILURE OF THE MAIN FEEDWATER SYSTEM DURING NON-TRANS |
| RCS-DEP         | FAILURE TO COOLDOWN RCS TO < RHR PRESSURE             |
| RCS-SG          | OPERATOR FAILS TO LOWER RCS PRESSURE TO < SG RV SETP  |
| RCS-SG1         | OPERATOR FAILS TO LOWER RCS PRESSURE TO < SG RV SETPO |
| RHR             | NO OR INSUFFICIENT FLOW FROM THE RHR SYSTEM           |
| RT              | REACTOR FAILS TO TRIP DURING TRANSIENT                |
| SG-DEP          | HARDWARE FAILS TO LOWER RCS PRESSURE TO < SG RV SETPO |
| SGISOL          | FAILURE TO ISOLATE RUPTURED SG BEFORE RWST DEPLETION  |
| SGISOL1         | FAILURE TO DEPRESSURIZE RCS TO ISOLATE SG             |

SEQUENCE CUT SETS

Truncation: Cumulative: 100.0% Individual: 1.0%

Event Tree: SGTR  
 Sequence: 03

CCDP: 1.6E-004

| CCDP     | % Cut Set | Cut Set Events                   |
|----------|-----------|----------------------------------|
| 3.8E-005 | 23.3      | RHR-MDP-FC-2B<br>SGTR-03-NREC    |
| 3.0E-005 | 18.4      | RHR-MOV-OO-RWST<br>SGTR-03-NREC  |
| 2.0E-005 | 12.2      | MSS-VCF-HW-ISOL<br>SGTR-03-NREC  |
| 1.9E-005 | 11.6      | RHR-MDP-FC-2B<br>SGTR-03-NREC    |
| 1.5E-005 | 9.2       | RHR-MOV-OO-RWST<br>SGTR-03-NREC  |
| 1.0E-005 | 6.1       | MSS-XHE-XM-ERROR<br>SGTR-03-NREC |
| 1.0E-005 | 6.1       | RHR-XHE-XM<br>SGTR-03-NREC       |
| 5.6E-006 | 3.4       | RHR-MDP-CF-ALL<br>SGTR-03-NREC   |
| 5.0E-006 | 3.1       | RHR-XHE-XM<br>SGTR-03-NREC       |
| 2.8E-006 | 1.7       | RHR-MDP-CF-ALL<br>SGTR-03-NREC   |
|          |           | MSS-VCF-HW-ISOL                  |
|          |           | MSS-VCF-HW-ISOL                  |
|          |           | RHR-XHE-SUCTION                  |
|          |           | MSS-XHE-XM-ERROR                 |
|          |           | MSS-XHE-XM-ERROR                 |
|          |           | RHR-XHE-SUCTION                  |
|          |           | MSS-VCF-HW-ISOL                  |
|          |           | MSS-VCF-HW-ISOL                  |
|          |           | MSS-XHE-XM-ERROR                 |
|          |           | MSS-XHE-XM-ERROR                 |



Event Tree: SGTR  
 Sequence: 05

CCDP: 1.0E-005

| CCDP     | % Cut Set | Cut Set Events |              |
|----------|-----------|----------------|--------------|
| 1.0E-005 | 100.0     | PCS-PSF-HW     | SGTR-05-NREC |

Event Tree: SGTR  
 Sequence: 44

CCDP: 5.5E-006

| CCDP     | % Cut Set | Cut Set Events                   |                 |
|----------|-----------|----------------------------------|-----------------|
| 4.3E-006 | 77.8      | RPS-XHE-XM-SCRAM<br>SGTR-44-NREC | RPS-VCF-FO-ELEC |
| 1.1E-006 | 20.6      | RPS-BKR-FC-FTO<br>SGTR-44-NREC   | RPS-XHE-ERROR   |
| 8.9E-008 | 1.6       | RPS-VCF-FO-MECH                  | SGTR-44-NREC    |

Event Tree: SGTR  
 Sequence: 08

CCDP: 5.1E-006

| CCDP     | % Cut Set | Cut Set Events                      |                                  |
|----------|-----------|-------------------------------------|----------------------------------|
| 8.0E-007 | 15.6      | RHR-MDP-FC-2B<br>MSS-VCF-HW-ISOL    | RCS-XHE-DIAG<br>SGTR-08-NREC     |
| 6.3E-007 | 12.3      | RHR-MOV-OO-RWST<br>MSS-VCF-HW-ISOL  | RCS-XHE-DIAG<br>SGTR-08-NREC     |
| 4.2E-007 | 8.2       | RCS-XHE-DIAG<br>RHR-XHE-SUCTION     | MSS-VCF-HW-ISOL<br>SGTR-08-NREC  |
| 4.0E-007 | 7.8       | RHR-MDP-FC-2B<br>MSS-XHE-XM-ERROR   | RCS-XHE-DIAG<br>SGTR-08-NREC     |
| 3.2E-007 | 6.2       | RHR-MOV-OO-RWST<br>MSS-XHE-XM-ERROR | RCS-XHE-DIAG<br>SGTR-08-NREC     |
| 2.1E-007 | 4.1       | RCS-XHE-DIAG<br>MSS-VCF-HW-ISOL     | RHR-XHE-XM<br>SGTR-08-NREC       |
| 2.1E-007 | 4.1       | RCS-XHE-DIAG<br>RHR-XHE-SUCTION     | MSS-XHE-XM-ERROR<br>SGTR-08-NREC |
| 1.9E-007 | 3.7       | RHR-MDP-FC-2B<br>MSS-VCF-HW-ISOL    | HPI-XHE-XM-THRTL<br>SGTR-08-NREC |
| 1.9E-007 | 3.7       | RHR-MDP-FC-2B<br>MSS-VCF-HW-ISOL    | RCS-XHE-XM-SG<br>SGTR-08-NREC    |
| 1.5E-007 | 2.9       | RHR-MOV-OO-RWST<br>MSS-VCF-HW-ISOL  | HPI-XHE-XM-THRTL<br>SGTR-08-NREC |
| 1.5E-007 | 2.9       | RHR-MOV-OO-RWST<br>MSS-VCF-HW-ISOL  | RCS-XHE-XM-SG<br>SGTR-08-NREC    |
| 1.2E-007 | 2.3       | RHR-MDP-FC-ALL<br>MSS-VCF-HW-ISOL   | RCS-XHE-DIAG<br>SGTR-08-NREC     |
| 1.1E-007 | 2.1       | RCS-XHE-DIAG<br>MSS-XHE-XM-ERROR    | RHR-XHE-XM<br>SGTR-08-NREC       |
| 1.0E-007 | 2.0       | HPI-XHE-XM-THRTL<br>RHR-XHE-SUCTION | MSS-VCF-HW-ISOL<br>SGTR-08-NREC  |

|          |     |                                     |                                  |
|----------|-----|-------------------------------------|----------------------------------|
| 1.0E-007 | 2.0 | RCS-XHE-XM-SG<br>RHR-XHE-SUCTION    | MSS-VCF-HW-ISOL<br>SGTR-08-NREC  |
| 9.5E-008 | 1.9 | RHR-MDP-FC-2B<br>MSS-XHE-XM-ERROR   | HPI-XHE-XM-THRTL<br>SGTR-08-NREC |
| 9.5E-008 | 1.9 | RHR-MDP-FC-2B<br>MSS-XHE-XM-ERROR   | RCS-XHE-XM-SG<br>SGTR-08-NREC    |
| 7.5E-008 | 1.5 | RHR-MOV-OO-RWST<br>MSS-XHE-XM-ERROR | HPI-XHE-XM-THRTL<br>SGTR-08-NREC |
| 7.5E-008 | 1.5 | RHR-MOV-OO-RWST<br>MSS-XHE-XM-ERROR | RCS-XHE-XM-SG<br>SGTR-08-NREC    |
| 5.9E-008 | 1.2 | RHR-MDP-CF-ALL<br>MSS-XHE-XM-ERROR  | RCS-XHE-DIAG<br>SGTR-08-NREC     |
| 5.5E-008 | 1.1 | RCS-XHE-DIAG<br>MSS-VCF-HW-ISOL     | RHR-MOV-CF-DIS<br>SGTR-08-NREC   |

Event Tree: SGTR  
 Sequence: 13

CCDP: 3.4E-006

| CCDP     | % Cut Set | Cut Set Events                    |                               |
|----------|-----------|-----------------------------------|-------------------------------|
| 1.2E-006 | 35.1      | HPI-MOV-OC-SUCT<br>SGTR-13-NREC   | MSS-VCF-HW-ISOL               |
| 7.6E-007 | 22.8      | HPI-MDP-CF-ALL<br>SGTR-13-NREC    | MSS-VCF-HW-ISOL               |
| 5.9E-007 | 17.5      | HPI-MOV-OC-SUCT<br>SGTR-13-NREC   | MSS-XHE-XM-ERROR              |
| 3.8E-007 | 11.4      | HPI-MDP-CF-ALL<br>SGTR-13-NREC    | MSS-XHE-XM-ERROR              |
| 1.2E-007 | 3.7       | HPI-MDP-FC-2A<br>MSS-VCF-HW-ISOL  | HPI-MDP-FC-2B<br>SGTR-13-NREC |
| 9.2E-008 | 2.8       | MSS-VCF-HW-ISOL<br>SGTR-13-NREC   | HPI-CKV-CF-CLINJ              |
| 6.2E-008 | 1.9       | HPI-MDP-FC-2A<br>MSS-XHE-XM-ERROR | HPI-MDP-FC-2B<br>SGTR-13-NREC |
| 4.6E-008 | 1.4       | MSS-XHE-XM-ERROR<br>SGTR-13-NREC  | HPI-CKV-CF-CLINJ              |

Event Tree: SGTR  
 Sequence: 09

CCDP: 1.9E-006

| CCDP     | % Cut Set | Cut Set Events                      |                                  |
|----------|-----------|-------------------------------------|----------------------------------|
| 6.3E-007 | 33.6      | PCS-VCF-HW<br>MSS-VCF-HW-ISOL       | RCS-XHE-DIAG<br>SGTR-09-NREC     |
| 3.2E-007 | 16.8      | PCS-VCF-HW<br>MSS-XHE-XM-ERROR      | RCS-XHE-DIAG<br>SGTR-09-NREC     |
| 2.1E-007 | 11.2      | PCS-XHE-XM-RCOOL<br>MSS-VCF-HW-ISOL | RCS-XHE-DIAG<br>SGTR-09-NREC     |
| 1.5E-007 | 8.0       | PCS-VCF-HW<br>MSS-VCF-HW-ISOL       | RCS-XHE-XM-SG<br>SGTR-09-NREC    |
| 1.5E-007 | 8.0       | PCS-VCF-HW<br>MSS-VCF-HW-ISOL       | HPI-XHE-XM-THRTL<br>SGTR-09-NREC |

|          |     |                                      |                                  |
|----------|-----|--------------------------------------|----------------------------------|
| 1.1E-007 | 5.6 | PCS-XHE-XM-RCOOL<br>MSS-XHE-XM-ERROR | RCS-XHE-DIAG<br>SGTR-09-NREC     |
| 7.5E-008 | 4.0 | PCS-VCF-HW<br>MSS-XHE-XM-ERROR       | HPI-XHE-XM-THRTL<br>SGTR-09-NREC |
| 7.5E-008 | 4.0 | PCS-VCF-HW<br>MSS-XHE-XM-ERROR       | RCS-XHE-XM-SG<br>SGTR-09-NREC    |
| 5.0E-008 | 2.7 | PCS-XHE-XM-RCOOL<br>MSS-VCF-HW-ISOL  | RCS-XHE-XM-SG<br>SGTR-09-NREC    |
| 5.0E-008 | 2.7 | PCS-XHE-XM-RCOOL<br>MSS-VCF-HW-ISOL  | HPI-XHE-XM-THRTL<br>SGTR-09-NREC |
| 2.5E-008 | 1.3 | PCS-XHE-XM-RCOOL<br>MSS-XHE-XM-ERROR | HPI-XHE-XM-THRTL<br>SGTR-09-NREC |
| 2.5E-008 | 1.3 | PCS-XHE-XM-RCOOL<br>MSS-XHE-XM-ERROR | RCS-XHE-XM-SG<br>SGTR-09-NREC    |

Event Tree: SGTR  
 Sequence: 10

CCDP: 3.1E-007

| CCDP     | % Cut Set | Cut Set Events                   |            |
|----------|-----------|----------------------------------|------------|
| 2.1E-007 | 67.7      | RCS-XHE-DIAG<br>SGTR-10-NREC     | PCS-PSF-HW |
| 5.0E-008 | 16.1      | RCS-XHE-XM-SG<br>SGTR-10-NREC    | PCS-PSF-HW |
| 5.0E-008 | 16.1      | HPI-XHE-XM-THRTL<br>SGTR-10-NREC | PCS-PSF-HW |

Event Tree: SGTR  
 Sequence: 16

CCDP: 8.8E-008

| CCDP     | % Cut Set | Cut Set Events                                |                                  |
|----------|-----------|---|----------------------------------|
| 2.5E-008 | 28.1      | HPI-MOV-OC-SUCT<br>MSS-VCF-HW-ISOL            | RCS-XHE-DIAG<br>SGTR-16-NREC     |
| 1.6E-008 | 18.3      | HPI-MDP-CF-ALL<br>MSS-VCF-HW-ISOL             | RCS-XHE-DIAG<br>SGTR-16-NREC     |
| 1.2E-008 | 14.1      | HPI-MOV-OC-SUCT<br>MSS-XHE-XM-ERROR           | RCS-XHE-DIAG<br>SGTR-16-NREC     |
| 8.0E-009 | 9.1       | HPI-MDP-CF-ALL<br>MSS-XHE-XM-ERROR            | RCS-XHE-DIAG<br>SGTR-16-NREC     |
| 5.9E-009 | 6.7       | HPI-MOV-OC-SUCT<br>MSS-VCF-HW-ISOL            | RCS-XHE-XM-SG<br>SGTR-16-NREC    |
| 3.8E-009 | 4.4       | HPI-MDP-CF-ALL<br>MSS-VCF-HW-ISOL             | RCS-XHE-XM-SG<br>SGTR-16-NREC    |
| 2.9E-009 | 3.3       | HPI-MOV-OC-SUCT<br>MSS-XHE-XM-ERROR           | RCS-XHE-XM-SG<br>SGTR-16-NREC    |
| 2.6E-009 | 3.0       | HPI-MDP-FC-2A<br>RCS-XHE-DIAG<br>SGTR-16-NREC | HPI-MDP-FC-2B<br>MSS-VCF-HW-ISOL |
| 1.9E-009 | 2.2       | RCS-XHE-DIAG<br>HPI-CKV-CF-CLINJ              | MSS-VCF-HW-ISOL<br>SGTR-16-NREC  |
| 1.9E-009 | 2.2       | HPI-MDP-CF-ALL                                | RCS-XHE-XM-SG                    |

|          |     |   |   |
|----------|-----|---|---|
| 1.3E-009 | 1.5 | MSS-XHE-XM-ERROR<br>HPI-MDP-FC-2A<br>RCS-XHE-DIAG<br>SGTR-16-NREC | SGTR-16-NREC<br>HPI-MDP-FC-2B<br>MSS-XHE-XM-ERROR |
| 9.7E-010 | 1.1 | RCS-XHE-DIAG<br>HPI-CKV-CF-CLINJ                                  | MSS-XHE-XM-ERROR<br>SGTR-16-NREC                  |

Event Tree: SGTR  
 Sequence: 18

CCDP: 2.9E-008

| CCDP     | % Cut Set | Cut Set Events                                   |                                 |
|----------|-----------|--|---------------------------------|
| -----    | -----     | -----  | -----                           |
| 1.2E-008 | 42.5      | RCS-XHE-RECOVER<br>RCS-XHE-DIAG                  | HPI-MOV-OC-SUCT<br>SGTR-18-NREC |
| 8.0E-009 | 27.6      | RCS-XHE-RECOVER<br>RCS-XHE-DIAG                  | HPI-MDP-CF-ALL<br>SGTR-18-NREC  |
| 2.9E-009 | 10.1      | RCS-XHE-RECOVER<br>RCS-XHE-XM-SG                 | HPI-MOV-OC-SUCT<br>SGTR-18-NREC |
| 1.9E-009 | 6.6       | RCS-XHE-RECOVER<br>RCS-XHE-XM-SG                 | HPI-MDP-CF-ALL<br>SGTR-18-NREC  |
| 1.3E-009 | 4.5       | RCS-XHE-RECOVER<br>HPI-MDP-FC-2B<br>SGTR-18-NREC | HPI-MDP-FC-2A<br>RCS-XHE-DIAG   |
| 9.7E-010 | 3.3       | RCS-XHE-RECOVER<br>HPI-CKV-CF-CLINJ              | RCS-XHE-DIAG<br>SGTR-18-NREC    |
| 3.1E-010 | 1.1       | RCS-XHE-RECOVER<br>HPI-MDP-FC-2B<br>SGTR-18-NREC | HPI-MDP-FC-2A<br>RCS-XHE-XM-SG  |

Event Tree: SGTR  
 Sequence: 14

CCDP: 2.2E-009

| CCDP     | % Cut Set | Cut Set Events                  |                               |
|----------|-----------|---------------------------------|-------------------------------|
| -----    | -----     | -----                           | -----                         |
| 1.2E-009 | 52.6      | HPI-MOV-OC-SUCT<br>SGTR-14-NREC | PCS-PSF-HW                    |
| 7.6E-010 | 34.2      | HPI-MDP-CF-ALL<br>SGTR-14-NREC  | PCS-PSF-HW                    |
| 1.2E-010 | 5.6       | HPI-MDP-FC-2A<br>PCS-PSF-HW     | HPI-MDP-FC-2B<br>SGTR-14-NREC |
| 9.2E-011 | 4.1       | PCS-PSF-HW<br>SGTR-14-NREC      | HPI-CKV-CF-CLINJ              |
| 2.3E-011 | 1.0       | HPI-TNK-VF-RWST<br>SGTR-14-NREC | PCS-PSF-HW                    |
| 2.3E-011 | 1.0       | PCS-PSF-HW<br>SGTR-14-NREC      | HPI-CKV-CF-PMPS               |

Event Tree: SGTR  
 Sequence: 17

CCDP: 5.8E-011

| CCDP  | % Cut Set | Cut Set Events |       |
|-------|-----------|----------------|-------|
| ----- | -----     | -----          | ----- |

|          |      |  |                               |
|----------|------|--|-------------------------------|
| 2.5E-011 | 42.5 | HPI-MOV-OC-SUCT<br>PCS-PSF-HW                  | RCS-XHE-DIAG<br>SGTR-17-NREC  |
| 1.6E-011 | 27.6 | HPI-MDP-CF-ALL<br>PCS-PSF-HW                   | RCS-XHE-DIAG<br>SGTR-17-NREC  |
| 5.9E-012 | 10.1 | HPI-MOV-OC-SUCT<br>PCS-PSF-HW                  | RCS-XHE-XM-SG<br>SGTR-17-NREC |
| 3.8E-012 | 6.6  | HPI-MDP-CF-ALL<br>PCS-PSF-HW                   | RCS-XHE-XM-SG<br>SGTR-17-NREC |
| 2.6E-012 | 4.5  | HPI-MDP-FC-2A<br>RCS-XHE-DIAG<br>SGTR-17-NREC  | HPI-MDP-FC-2B<br>PCS-PSF-HW   |
| 1.9E-012 | 3.3  | RCS-XHE-DIAG<br>HPI-CKV-CF-CLINJ               | PCS-PSF-HW<br>SGTR-17-NREC    |
| 6.2E-013 | 1.1  | HPI-MDP-FC-2A<br>RCS-XHE-XM-SG<br>SGTR-17-NREC | HPI-MDP-FC-2B<br>PCS-PSF-HW   |

BASIC EVENTS (Cut Sets Only)

| Event Name       | Description                                   | Curr Prob |
|------------------|---|-----------|
| ACP-BAC-LP-2-3A  | DIVISION 2A/3A AC POWER 480V BUS FAILS        | 9.0E-005  |
| AFW-AOV-CC-MSG21 | SG-21 FLOW CONTROL VALVE 406A FAILS           | 1.1E-003  |
| AFW-AOV-CF-SGS   | CCF OF STEAM GENERATOR INLET AOVs (FCVS)      | 1.9E-005  |
| AFW-CKV-CC-SG21  | STEAM GENERATOR 21 INLET CHECK VALVE FAILS    | 1.0E-004  |
| AFW-CKV-CF-PMPS  | CCF OF AFW PUMP DISCHARGE CHECK VALVES        | 2.7E-006  |
| AFW-CKV-CF-SGS-S | CCF OF SG INLET CHECK VALVES - SGTR           | 2.7E-006  |
| AFW-CKV-CF-SUCT  | CCF OF AFW PUMP SUCTION CHECK VALVES          | 2.7E-006  |
| AFW-MDP-CF-AB    | COMMON CAUSE FAILURE OF MOTOR DRIVEN PUMPS    | 2.1E-004  |
| AFW-MDP-FC-21    | AFW MOTOR DRIVEN PUMP 21 FAILS                | 3.9E-003  |
| AFW-PMP-CF-ALL   | COMMON CAUSE FAILURE OF AFW PUMPS             | 5.6E-005  |
| AFW-TDP-FC-22    | AFW TURBINE DRIVEN PUMP 22 FAILS              | 3.3E-002  |
| HPI-CKV-CF-CLINJ | CCF OF COLD LEG INLET CHECK VALVES            | 1.1E-005  |
| HPI-CKV-CF-PMPS  | CCF OF HPI PUMP DISCHARGE CHECK VALVES        | 2.7E-006  |
| HPI-MDP-CF-ALL   | HPI PUMP COMMON CAUSE FAILURES                | 9.1E-005  |
| HPI-MDP-FC-2A    | HPI TRAIN A FAILS                             | 3.9E-003  |
| HPI-MDP-FC-2B    | HPI TRAIN B FAILS                             | 3.8E-003  |
| HPI-MOV-OC-SUCT  | HPI SUCTION VALVES FAIL                       | 1.4E-004  |
| HPI-TNK-VF-RWST  | RWST NOT AVAILABLE                            | 2.7E-006  |
| HPI-XHE-XM-THRTL | OPERATOR FAILS TO THROTTLE HPI TO REDUCE PRES | 5.0E-003  |
| MSS-VCF-HW-ISOL  | RUPTURED STEAM GENERATOR ISOLATION FAILURES   | 1.0E-002  |
| MSS-XHE-XM-ERROR | OPERATOR FAILS TO ISOLATE FAULTED STEAM GENER | 5.0E-003  |
| PCS-PSF-HW       | HARDWARE FAILURES CAUSING FAILURE TO DEPRESSU | 1.0E-005  |
| PCS-VCF-HW       | TBVS/COND/CIR FAILURES                        | 3.0E-003  |
| PCS-XHE-XM-RCOOL | OPERATOR FAILS TO INITIATE RCS COOLDOWN BELOW | 1.0E-003  |
| RCS-XHE-DIAG     | OPERATOR FAILS TO DIAGNOSE SGTR TO START PROC | 2.1E-002  |
| RCS-XHE-RECOVER  | OPERATOR FAILS TO DEPRESSURIZE RCS BELOW SG S | 5.0E-003  |
| RCS-XHE-XM-SG    | OPERATOR FAILS TO INITIATE RCS DEPRESSURIZATI | 5.0E-003  |
| RHR-MDP-CF-ALL   | RHR PUMP COMMON CAUSE FAILURES                | 5.6E-004  |
| RHR-MDP-FC-2B    | RHR TRAIN B FAILS                             | 3.8E-003  |
| RHR-MOV-CF-DIS   | COMMON CAUSE FAILURE OF RHR DISCHARGE MOVs    | 2.6E-004  |

| Event Name       | Description                                 | Curr Prob |
|------------------|---|-----------|
| RHR-MOV-OO-RWST  | RHR/RWST ISOLATION MOV FAILS                | 3.0E-003  |
| RHR-XHE-SUCTION  | OPERATOR FAILS TO RECOVER RHR SUCTION PATH  | 2.0E-003  |
| RHR-XHE-XM       | OPERATOR FAILS TO INITIATE RHR SYSTEM       | 1.0E-003  |
| RPS-BKR-FC-FTO   | RPS BREAKERS FAIL TO OPEN                   | 5.7E-006  |
| RPS-VCF-FO-ELEC  | CONTROL ROD DRIVES REMAIN ENERGIZED         | 4.3E-004  |
| RPS-VCF-FO-MECH  | CONTROL ROD ASSEMBLIES FAIL TO INSERT       | 8.9E-008  |
| RPS-XHE-ERROR    | OPERATOR FAILS TO DE-ENERGIZE MG SETS       | 2.0E-001  |
| RPS-XHE-XM-SCRAM | OPERATOR FAILS TO MANUALLY TRIP THE REACTOR | 1.0E-002  |
| SGTR-03-NREC     | SGTR SEQUENCE 03 NONRECOVERY PROBABILITY    | 1.0E+000  |
| SGTR-04-NREC     | SGTR SEQUENCE 04 NONRECOVERY PROBABILITY    | 1.0E+000  |
| SGTR-05-NREC     | SGTR SEQUENCE 05 NONRECOVERY PROBABILITY    | 1.0E+000  |
| SGTR-08-NREC     | SGTR SEQUENCE 08 NONRECOVERY PROBABILITY    | 1.0E+000  |
| SGTR-09-NREC     | SGTR SEQUENCE 09 NONRECOVERY PROBABILITY    | 1.0E+000  |
| SGTR-10-NREC     | SGTR SEQUENCE 10 NONRECOVERY PROBABILITY    | 1.0E+000  |
| SGTR-11-NREC     | SGTR SEQUENCE 11 NONRECOVERY PROBABILITY    | 1.0E+000  |
| SGTR-13-NREC     | SGTR SEQUENCE 13 NONRECOVERY PROBABILITY    | 8.4E-001  |
| SGTR-14-NREC     | SGTR SEQUENCE 14 NONRECOVERY PROBABILITY    | 8.4E-001  |
| SGTR-16-NREC     | SGTR SEQUENCE 16 NONRECOVERY PROBABILITY    | 8.4E-001  |
| SGTR-17-NREC     | SGTR SEQUENCE 17 NONRECOVERY PROBABILITY    | 8.4E-001  |
| SGTR-18-NREC     | SGTR SEQUENCE 18 NONRECOVERY PROBABILITY    | 8.4E-001  |
| SGTR-43-NREC     | SGTR SEQUENCE 43 NONRECOVERY PROBABILITY    | 2.2E-001  |
| SGTR-44-NREC     | SGTR SEQUENCE 44 NONRECOVERY PROBABILITY    | 1.0E+000  |