RISK-INFORMED INSPECTION NOTEBOOK FOR

GENERIC PWR PLANT
(Revision 2.1)

PWR, TWO-LOOP PLANT WITH LARGE DRY CONTAINMENT

Date Issued: June 2007

Prepared by

U. S. Nuclear Regulatory Commission
Office of Nuclear Reactor Regulation
Division of Risk Assessment

NOTICE

This notebook was developed for the NRC to support the risk-informed inspection program. The "Reactor Oversight Process Improvement," SECY-99-007A [1] and NRC Inspection Manual Chapter 0308, Reactor Oversight Process (ROP) Basis Document [2] discuss the activities involved in these inspections. The user of this notebook is assumed to be an inspector or risk analyst with an extensive understanding of plant-specific design features and operation. Therefore, the notebook is not a stand-alone document, and may not be suitable for use by non-specialists. It will be periodically updated with new or replacement pages incorporating additional information on this plant. All recommendations for improvement of this document should be forwarded to the Chief, PRA Operational Support and Maintenance Branch, NRR, with a copy to the Chief, Reactor Inspection Branch, NRR.

U. S. Nuclear Regulatory Commission
One White Flint North
11555 Rockville Pike
Rockville, MD 20852-2738

ABSTRACT

This notebook contains summary information to support the Significance Determination Process (SDP) in risk-informed inspections for a Generic PWR plant.

The information includes the following: Categories of Initiating Events Table, Initiators and System Dependency Table, SDP Worksheets, SDP Event Trees, and a comparison of the notebook results with that obtained using the plant-specific probabilistic risk assessment (PRA). This information is used by the NRC's inspectors to identify the significance of their findings, i.e., in screening risk-significant findings, consistent with Phase 2 screening in SECY-99-007A [1]. The Categories of Initiating Event Table is used to determine the likelihood for the applicable initiating events. The SDP worksheets are used to assess the remaining mitigation capability rating for the applicable initiating event likelihood in identifying the significance of the inspector's findings. The Initiators and System Dependency Table and the SDP Event Trees (the simplified event trees developed in preparing the SDP worksheets) provide additional information supporting the use of SDP worksheets. The comparison with the plant-specific PRA provides insights on differences in assessment of risk significance of inspection findings using the notebook and the plant's PRA.

The information contained herein is based on the licensee's Individual Plant Examination (IPE) submittal, the updated PRA, system information obtained from the licensee during site visits as part of the review of earlier versions of this notebook, and subsequent interactions. Approaches used to maintain consistency within the SDP, i.e, consistent modeling considerations and applicable assumptions, specifically within similar plant types, resulted in sacrificing some plant-specific modeling approaches and details. The approaches used are documented in the Technical Basis Document for At-Power Significance Determination Process (SDP) Notebooks [3]. Plant-specific comments and insights are also considered. Specific changes made addressing plant-specific features and insights are summarized. A benchmarking of the notebook was conducted comparing and analyzing the risk significance of the inspection findings obtained using this notebook and the plant-specific PRA. Following benchmarking, the notebook is updated considering licensee's updated PRA, and any changes in plant design and operational practices. A table is provided comparing the order of magnitude results, i.e., the colors for an inspection finding, using the notebook and the plant PRA. Conservative and non-conservative results by the notebook, compared to the plant PRA, are noted in the table with a brief discussion of the reasons for the differences.

CONTENTS

Page

Notice ii

Abstract iii

1. Information Supporting Significance Determination Process (SDP) 1
   1.1 Initiating Event Likelihood 5
   1.2 Initiators and System Dependency 8
   1.3 SDP Worksheets 16
   1.4 SDP Event Trees 47

2. Benchmarking of Risk Significance of Inspection Findings Using the Notebook 58

3. Resolution of Plant-Specific Comments 65

References 69

TABLES

Page

1 Categories of Initiating Events for a Generic PWR Plant 6
2 Initiators and System Dependency for a Generic PWR Plant 9
3.1 SDP Worksheet — Transients with PCS Available (Reactor Trip) (TRANS) 17
3.2 SDP Worksheet — Transients with Loss of PCS (TPCS) 18
3.3 SDP Worksheet — Small LOCA (SLOCA) 19
3.4 SDP Worksheet — Stuck-Open Relief Valve (SORV) 21
3.5 SDP Worksheet — Medium LOCA (MLOCA) 23
3.6 SDP Worksheet — Large LOCA (LLOCA) 25
3.7 SDP Worksheet — Loss of Offsite Power (LOOP) 27
3.8 SDP Worksheet — Steam Generator Tube Rupture (SGTR) 30
3.9 SDP Worksheet — Anticipated Transients Without Scram (ATWS) 32
3.10 SDP Worksheet — Main Steam Line Break (MSLB) 34
3.11 SDP Worksheet — Loss of Plant Cooling Water (PW) (LOPW) 36
3.12 SDP Worksheet — Loss of Turbine Cooling Water (LTCW) 37
3.13 SDP Worksheet — Loss of 125 V-DC Channel A (LDCA) 38
3.14 SDP Worksheet — Loss of 125 V-DC Channel B (LDCB) 40
3.15 SDP Worksheet — Loss of Instrumental Air (LOIA) 41
3.16 SDP Worksheet — Loss of Nuclear Cooling Water (NCW) (LONCW) 42
3.17 SDP Worksheet — Loss of Emergency AC Bus A (LACA) 43
3.18 SDP Worksheet — Loss of Emergency AC Bus B (LACB) 44
3.19 SDP Worksheet — Interfacing Systems LOCA (ISLOCA) 45
4 Benchmarking Table [***Plant-Specific Information Removed***] Against Rev. 2 SDP Notebook 60

FIGURES

Page

SDP Event Tree — Transients with PCS Available (Reactor Trip) (TRANS) 48
SDP Event Tree — Transients with Loss of PCS (TPCS) 49
SDP Event Tree — Small LOCA (SLOCA) 50
SDP Event Tree — Stuck-Open Relief Valve (SORV) 51
SDP Event Tree — Medium LOCA (MLOCA) 52
SDP Event Tree — Large LOCA (LLOCA) 53
SDP Event Tree — Loss of Offsite Power (LOOP) 54
SDP Event Tree — Steam Generator Tube Rupture (SGTR) 55
SDP Event Tree — Anticipated Transients Without Scram (ATWS) 56
SDP Event Tree — Main Steam Line Break (MSLB) 57

1. INFORMATION SUPPORTING SIGNIFICANCE DETERMINATION PROCESS (SDP)

SECY-99-007A [1] and NRC Inspection Manual 0308 [2] describe the process for making a Phase 2 evaluation. The first step is to identify the pertinent core damage and large early release scenarios that require further evaluation consistent with the specifics of the inspection findings. To aid in this process, this notebook provides the following information:

1. Estimated Likelihood for Initiating Event Categories
2. Initiators and System Dependency Table
3. Significance Determination Process (SDP) Worksheets
4. SDP Event Trees
5. Selected cases of comparison of colors to be obtained for inspection findings using the notebook and the plant PRA.

Table 1, Categories of Initiating Events, is used to obtain an estimated likelihood for the applicable initiating events for the plant for different exposure time under degraded conditions. Initiating events are grouped in frequency bins covering one order-of-magnitude apart. The Table includes the initiating events that should be considered for the plant and for which SDP worksheets are provided. The following initiating events are categorized by industry-average frequency: transients (Reactor Trip) (TRANS); transients without power conversion system (TPCS); large, medium, and small loss of coolant accidents (LLOCA, MLOCA, and SLOCA); stuck-open relief valve (SORV), if applicable; steam generator tube rupture (SGTR); main steam line break (MSLB), anticipated transients without scram (ATWS), and interfacing system LOCA (ISLOCA). The frequency of the remaining initiating events vary significantly from plant to plant, and accordingly, they are categorized by plant-specific frequency obtained from the licensee. They include loss of offsite power (LOOP) and special initiators caused by loss of support systems. Table 1 may also include an initiator with an acronym LEAC standing for LOOP with loss of one Emergency AC bus. This initiator is added to capture those sequences that are not included in the simplified LOOP worksheet. An initiating event is categorized into a row if the estimated frequency falls within the frequency range defined for the row. In some situations, where the frequency of the initiating event is near the upper end of the range, it may be assigned to the next row with higher frequency range based on the benchmarking conducted at the plant. In such cases, a note is given at the bottom of Table 1.

Table 2, The Initiators and System Dependency Table, shows the major dependencies between frontline and support systems, and identifies their involvement in different types of initiators. This table identifies the most risk-significant systems; it is not an exhaustive compilation of the dependency matrix, as known in Probabilistic Risk Assessments (PRAs). Notes are provided to explain any specific design characteristics and considerations that may be needed in defining system/component failures based on the dependency defined. Systems/components for which the Phase 2 assessment using this notebook is expected to result in non-conservative or conservative estimates are also noted in the notes. For pressurized water reactors (PWRs), the support systems/success criteria for Reactor Coolant Pump (RCP) seals are explicitly denoted to assure that the inspection findings on them are properly accounted for. This table is also used to identify the SDP worksheets to be evaluated, corresponding to inspection findings on systems and components.

To evaluate the impact of an inspection finding on the core damage and large early release scenarios, SDP worksheets are provided (Table 3). The SDP worksheets contain two parts. The first part identifies the functions, the systems, or combinations thereof that have mitigating functions, the number of trains in each system, and the number of trains required (success criteria) for the initiator. It also characterizes the mitigation capability in terms of the available hardware (e.g., 1 train, 1 multi-train system) and the operator action involved. The second part of the SDP worksheet contains the core damage accident sequences associated with each initiator; these sequences are based on SDP event trees. In the parenthesis next to each sequence, the corresponding event tree branch number(s) representing the sequence is given. Multiple branch numbers indicate that the different accident sequences identified by the event tree have been merged into one through Boolean reduction.

The accident sequences included are used to obtain the change in core damage frequency (CDF) and large early release frequency (LERF) contributions for assessing the risk significance of inspection findings. The LERF contribution or value is determined from the CDF value or contribution modified by a factor. This factor or modifier is provided in the LERF column. A value in the LERF column indicates that the sequence should be considered for evaluating the LERF significance. A zero in the LERF column indicates that the sequence does not need to be considered for LERF evaluation. In other words, it signifies that the core damage sequence will not result in a large early release. The LERF significance is determined considering the modifiers defined for the applicable accident sequences.

Below each of the terms of the sequences, the applicable ratings or credits for the base case defined in this notebook is noted. For the initiating event, an estimated likelihood corresponding to a degraded condition existing for more than 30 days is used. For the safety function base case, credits are given for full mitigation capability. The result for the sequence is obtained by summing the likelihood for the initiating event and the credits for the mitigation functions. The overall result signifies a base case value for the sequences and is provided to help the user determine the results for specific inspection findings.

SDP worksheets are developed for each initiating event, including the “Special Initiators” that typically are caused by complete or partial loss of support systems. A special initiator typically leads to a reactor scram and degrades some mitigation capabilities (e.g., Loss of CCW in PWRs). Some differences are noted among the plant PRAs in the criteria for including special initiators. For the SDP notebook, a set of criteria was defined to include special initiators to maintain consistency across the plants. The criteria and approach for defining special initiators are discussed in the Technical Basis Document [3]. SDP worksheets are not developed for special initiators that directly lead to a core damage (the inspection of these initiators are assessed differently; see SECY-99-007A [1]). If these initiators are significant contributors for the plant, they are noted in Table 2.

From the above considerations, the special initiators applicable for this plant are defined and worksheets are developed for each. Section 1.3 lists the initiating events including the plant-specific special initiators addressed in this notebook.

SDP worksheet for ISLOCA is different from other worksheets discussed above. This worksheet identifies potential paths for high and low pressure interface, but does not identify the mitigation capabilities. The inspection finding that could degrade integrity of any of these paths should be evaluated in consultation with the Regional Senior Reactor Analyst (SRA).

Following the SDP worksheets, the SDP event trees corresponding to each of the worksheets are presented. The SDP event trees are simplified event trees developed to define the accident sequences identified in the SDP worksheets. For special initiators whose event tree closely corresponds to another event tree (typically, the Transient (Reactor trip) or Transients w/o PCS event tree) with one or more functions eliminated or degraded, a separate event tree may not be drawn. When a separate event tree is not developed, reference to the applicable worksheet/event tree is provided in the note.

The following items were considered in establishing the SDP event trees and the core damage and large early release sequences in the SDP worksheets.

1. Event trees and sequences were developed considering the major accident sequences identified by the plant-specific IPEs/PRAs and the modeling approach and assumptions discussed in the Technical Basis Document [3]. The special initiators modeled for a plant is based on a review of the special initiators included in the plant IPE/PRA and the information provided by the licensee. For modeling the response to an initiating event, major deviations in one plant from similar plants may be noted at the end of the worksheet.

2. The event trees and the sequences were designed to capture core damage scenarios and their contribution to LERF. Event tree sequences are merged, using Boolean logic, absorbing non-minimal sequences.

3. The simplified event trees focus on classes of initiators, as defined above. In so doing, many separate event trees in the IPEs/PRAs often are represented by a single tree. For example, some IPEs/PRAs define four classes of LOCAs rather than the three classes considered here. The sizes of LOCAs for which high-pressure injection is not required are sometimes divided into two classes, the only difference between them being the need for reactor scram in the smaller break size. There may be some consolidation of transient event trees besides defining the special initiators following the criteria defined above.

4. Major actions by the operator during accident scenarios are credited using three categories of Human Error Probabilities (HEPs). They are termed operator action=1 (representing an error probability of 5E-2 to 0.5), operator action=2 (error probability of 5E-3 to 5E-2), and operator action=3 (error probability of 5E-4 to 5E-3). A human action is assigned to a category bin, based on a generic grouping of similar actions among a class of plants. This approach resulted in designation of some actions to a higher bin, even though the IPE/PRA HEP value may have been indicative of a lower category. In such cases, it is noted at the end of the worksheet. On

the other hand, if the IPE/PRA HEP value suggests a higher category than that generically assumed, the HEP is assigned to a bin consistent with the IPE/PRA value in recognition of potential plant-specific design; a note is also given in these situations. A special case for operator action with credit of 4 is defined for hot leg/cold leg switchover in medium and large LOCAs. Additional discussion on assigning credits for operator actions can be obtained in the Technical Basis Document [3].

Table 4 is provided comparing the color to be obtained for an inspection finding using the notebook with that to be obtained based on evaluation using the detailed plant-specific PRA. Selected components from the systems identified as part of Table 2, the Initiators and System Dependency Table, and operator actions modeled in the worksheets are evaluated in this table. As can be noted, there are differences in the color for specific inspection findings obtained using the plant-specific notebook vs plant-specific PRA. The lower and higher risk estimates by the notebook are identified. The reasons for these differences can be one or more of the following: differences in modeling and assumptions between the notebook and the plant-specific PRA, differences in plant-specific data vs the generic credit used in the notebook, and conservatism used in evaluating the colors using the notebook.

The following sections include Categories for Initiating Events Table, Initiators and Dependency Table, SDP worksheets, the SDP event trees, and the Benchmarking table comparing the results of the notebook with that of the plant-specific PRA.

1.1 INITIATING EVENT LIKELIHOOD

Table 1 lists the applicable initiating events for this plant and their estimated likelihood corresponding to the exposure time under degraded conditions. The initiating events are grouped into rows based on their frequency. As mentioned earlier, loss of offsite power and special initiators are assigned to rows using the plant-specific frequency obtained from individual licensees. For other initiating events, industry-average values are used, as per SECY-99-007A [1]. The plant-specific initiating event frequency for the special initiators is noted as a note in the worksheet for the special initiator in Section 1.3. A special initiator event is assigned to a row in Table 1 if its frequency falls within the range of the frequency defined for that row. In some cases, when the frequency is close to the upper range it may be placed in the next row with higher frequency; then, a note is provided.

Table 1 Categories of Initiating Events for Generic PWR Plant

Row	Approximate Frequency	Event Type	Initiating Event Likelihood (IEL)		
I	> 1 per 1-10 yr	Transients With PCS Available (Reactor Trip) (TRANS), Transients With Loss of PCS (TPCS)	**1**	**2**	**3**
II	1 per 10-10^2 yr	Loss of Offsite Power (LOOP), Loss of Nuclear Cooling Water (NCW) (LONCW) [1], Loss of Turbine Cooling Water (LTCW) [2]	**2**	**3**	**4**
III	1 per 10^2 - 10^3 yr	Steam Generator Tube Rupture (SGTR) [3], Small LOCA (SLOCA) [7], Main Steam Line Break (MSLB), Loss of Plant Cooling Water (PW) (LOPW) [4], Loss of 125 V-DC Channel A (LDCA) [5], Loss of 125 V-DC Channel B (LDCB) [5], Loss of Instrument Air (LOIA), Loss of Emergency AC Bus A (LACA) [6], Loss of Emergency AC Bus B (LACB) [6]	**3**	**4**	**5**
IV	1 per 10^3 - 10^4 yr	Medium LOCA (MLOCA) [7], Stuck-Open Relief Valve (SORV)	**4**	**5**	**6**
V	1 per 10^4 - 10^5 yr	Large LOCA (LLOCA) [7]	**5**	**6**	**7**
VI	less than 1 per 10^5 yr	Anticipated Transients Without Scram (ATWS) [8], Interfacing Systems LOCA (ISLOCA)	**6**	**7**	**8**
			> 30 days	**3-30 days**	**< 3 days**
			Exposure Time for Degraded Condition		

Notes:

1. Loss of Nuclear Cooling Water initiating frequency is x.xxE-3/reactor-year. It is assigned to Row II since (1) its value is at the high end of Row III, (2) the CDF contribution is more appropriately captured by the SDP notebook, and (3) the PRA sequences are more appropriately accounted for by the SDP notebook.

2. Loss of Turbine Cooling Water initiating event frequency is x.xxE-3/reactor-year. It is assigned to Row II since (1) its value is at the high end of Row III, (2) the CDF contribution is more appropriately captured by the SDP notebook, and 3) the PRA sequences are more appropriately accounted for by the SDP notebook.

3. The SGTR frequency is xE-3/reactor-year, a factor of 6 higher than it is assumed here based on its assignment in Row III.

4. Loss of Plant Cooling Water initiating frequency is x.xE-4/reactor-year. It is assigned to Row III since (1) its value is at the high end of Row IV, (2) the CDF contribution is more appropriately captured by the SDP notebook, and (3) the PRA sequences are more appropriately accounted for by the SDP notebook.

5. Loss of one 125 V-DC Channel (LDCA or LDC B) initiating event frequency is x.xE-4/reactor-year. Both LDCA and LDCB are assigned to Row III since (1) the value is at the high end of Row IV, (2) the CDF contribution is more appropriately captured by the SDP notebook, and (3) the PRA sequences are more appropriately accounted for by the SDP notebook.

6. Loss of Emergency AC Bus (A or B) initiating event frequency is x.xE-3/reactor-year (based on the evaluation of the fault tree used to model the initiating event in the plant PRA).

7. SLOCA, MLOCA, and LLOCA frequencies in the plant PRA are respectively x.xE-4, x.xE-5, and x5E-6/reactor-year. The LOCA frequencies in this plant were different from the generic values in NUREG/CR-5750.

8. The SDP worksheet for ATWS core damage sequences assumes that the ATWS is not recoverable by manual actuation of the reactor trip function. Thus, the ATWS frequency to be used by this worksheet must represent the ATWS condition that can only be mitigated by the systems shown in the worksheet (e.g., boration). Any inspection finding that represents a loss of capability for manual reactor trip for a postulated ATWS scenario should be evaluated by a risk analyst to consider the probability of a successful manual trip.

1.2 INITIATORS AND SYSTEM DEPENDENCY

Table 2 lists the systems included in the SDP worksheets, the major components in the systems, and the support system dependencies. The appropriate initiating event scenarios corresponding to each affected system are noted in the last column.

Table 2 Initiators and System Dependency for Generic PWR Plant [1]

Affected Systems	Major Components	Support Systems	Initiating Event Scenarios
Alternate Feedwater [2]	Three Condensate Pumps	Non-class 1E 4.16 kV, Turbine Cooling Water (TC), IA [3], Non-Class 1E 120 V-AC	TRANS, SGTR, MSLB, LDCA, LDCB, LONCW, LACA, LACB
Atmospheric Dump System (ADS)	Per SG: Two Atmospheric Dump Valves (ADVs) [4], one per main steam line. There are two steam lines per SG.	120 V-AC, 125 V-DC, IA (each valve has backup N_2)	All except TPCS, MLOCA, LLOCA, LOOP, LOPW, LTCW, LOIA
Auxiliary Feedwater (AFW)	One TDP (train A) , MOVs	125 V-DC, ESFAS. No room cooling is required. [5]	All except MLOCA, LLOCA, and LDCA
	One (essential) MDP (train B), MOVs	4.16 kV AC, 125 V-DC, ESFAS, EC (for HVAC) [6], IA [3], WC (for normal HVAC) [6]	All except MLOCA, LLOCA, LDCB, and LACB
	One (non-essential) MDP (train X), AOVs, SOVs	4.16 kV AC, 125 V-DC, IA [3]. No room cooling required. [5]	All except MLOCA, LLOCA, ATWS, and LACA
Chemical Volume Control System (CVCS) and Charging and Auxiliary Pressurizer Spray System (APSS)	Three positive displacement charging pumps [7]	480 V-AC, 125 V-DC, ESFAS (auto-start following LOP). No room cooling is required. [8]	LOOP, ATWS
	Two boric acid makeup pumps	Non-Class 1E 480 V-AC (supported by Class 1E 4.16 kV AC), 125 V-DC	SGTR, ATWS
	Two Auxiliary Pressurizer Spray valves	125 V-DC	SGTR
Class 1E 4.16 kV AC Power System (PB)	Two buses	125 V-DC (for breakers). No room cooling is required. [5]	All

Table 2 (Continued)

Affected Systems	Major Components	Support Systems	Initiating Event Scenarios
Class 1E Standby Generating System (PE)	Two dedicated EDGs [9]	ESFAS, 125 V-DC, DG room cooling, Essential Spray Pond, Diesel Fuel oil system (DF)	LOOP
Class 1E 480 V-AC Power Switchgear System (PG)	Two load groups, each with three load center unit substations	4.16 kV AC, 125 V-DC	All
Class 1E 125 V-DC Power System (PK)	Two load groups, each with four channels. Each channel consists of a battery [11], a DC Control Center, and one charger. Two swing chargers [10] for four channels. Batteries last for at least 2 hours after loss of charging.	4.16 kV AC, ESFAS, HJ	All
Class 1E Instrument (120 V) AC Power System (PN)	Four channels [12]	125 V-DC, HJ	SLOCA, SORV, MLOCA, LLOCA, LOOP, ATWS, SGTR, MSLB
Containment Spray System (CS)	Two MDPs and two spray headers	4.16 kV AC, 480 V-AC, 125 V-DC, ESFAS, EC (for HVAC)	SLOCA, SORV, MLOCA, LLOCA
DG Room Cooling	Each DG train has two fans [13]	480 V-AC (no cooling water is required)	LOOP
Engineered Safety Features Actuation System (ESFAS)	Sensors, logic, and actuation circuits	120 V-AC, 125 V-DC	SLOCA, SORV, MLOCA, LLOCA, LOOP, SGTR, ATWS, MSLB

Table 2 (Continued)

Affected Systems	Major Components	Support Systems	Initiating Event Scenarios
ESF Switchgear “DC Equipment” Room HVAC (HJ)	Normal air-handling units (AHUs) [14]	Non-Class 1E 480 V-AC, Class 1E 125 V-DC, Non-Class 1E 125 V-DC, WC, IA (for temperature control valves on each AHU served by WC), ESFAS	Refer to note 14.
	Essential air-cooling units (ACUs) [14]	480 V-AC, EC, ESFAS	
Essential Chilled Water (EC) [15]	Two MDPs, chillers and room ACUs	ESFAS, 4.16 kV AC, 125 V-DC, EW	All except LDCB and LACB
Essential Cooling Water (EW) [15]	Two MDPs, Two Heat Exchangers, Surge tank	ESFAS, 4.16 kV AC, 125 V-DC, SP, EC (for HVAC)	All except LDCB and LACB
Essential Spray Pond (SP) [15]	Two MDPs, Spray Pond Structure	4.16 kV AC, 125 V-DC, ESFAS,	All except LDCB and LACB
Gas Turbine Generators (GT)	Two Gas Turbine Generators	Non-Class 1E 125 V-DC	LOOP
High Pressure Safety Injection (HPSI)	Two MDPs (shutoff head approx. 1900 psig), MOVs	4.16 kV AC, 480 V-AC, 125 V-DC, ESFAS. EC (for HVAC) [16]	SLOCA, SORV, MLOCA, LLOCA, LOOP, SGTR, MSLB
High Pressure Safety Recirculation (HPR)	Two MDPs, Containment Sump MOVs	4.16 kV AC, 480 V-AC, 125 V-DC, ESFAS, EC (for HVAC) [16]	SLOCA, SORV, MLOCA, LLOCA
Instrument Air (IA)	Three air compressors and two dryers	Non-class 1E 480 V-AC, non-class 1E 125 V-DC, TC	LOIA
Low Pressure Safety Injection (LPSI)	Two MDPs, MOVs	4.16 kV AC, 480 V-AC, 125 V-DC, ESFAS. EC (for HVAC) [16]	SLOCA, SORV, LLOCA, SGTR

Table 2 (Continued)

Affected Systems	Major Components	Support Systems	Initiating Event Scenarios
Low Pressure Safety Recirculation (LPR)	Two MDPs, Containment Sump MOVs	4.16 kV AC, 480 V-AC, 125 V-DC, ESFAS, EC (for HVAC) [16]	SLOCA, SORV, LLOCA
Main Steam Isolation Valves (MSIVs)	One MSIV per steam line. There are two steam lines per SG.	125 V-DC (to remain open)	SGTR, MSLB
Main Steam Safety Valves (MSSVs) [17]	Ten Main Steam Safety Valves (MSSVs) per SG	None	Refer to note 17.
Normal Chilled Water (WC)	Three 50%-capacity chillers and one 10%-capacity chiller	4.16 kV AC, Non-class 1E 4.16 kV AC, Non-class 1E 480 V-AC, 125 V-DC, Non-class 1E 125 V-DC, NC	LDCA, LDCB
Normal Pressurizer Spray	Two air-operated valves in parallel	IA, non-class instrument AC (for reactor control system)	SGTR
Nuclear Cooling Water (NC)	Two pumps in parallel with heat exchangers	Non-class 1E 4.16 kV, PW	LONCW
Plant Cooling Water (PW)	Two parallel pumps (one operating and one in standby). Not split.	Non-class 1E 4.16 kV	TRANS, SGTR, MSLB, LOPW, LTCW, LDCA, LDCB, LONCW
Pressurizer Vent Valves	Two vent paths (five Solenoid-Operated Valves [SOVs]) [18]	125 V-DC	SGTR
Reactor Coolant Pump (RCP) [19]	Byron Jackson type seals	1/3 charging pumps, Nuclear Cooling Water (NC)	SLOCA
Safety Injection Tanks (SITs) [20]	Four tanks (each connected to a cold leg), Isolation Check Valves, MOVs (normally opened)	None	SLOCA, SORV, MLOCA, LLOCA, SGTR

Table 2 (Continued)

Affected Systems	Major Components	Support Systems	Initiating Event Scenarios
(Primary) Safety Relief Valves (SRVs)	Four SRVs	None	ATWS, SORV (for failing to open)
Shutdown Cooling (SDC)	Two SDC heat exchangers	EW	SLOCA, SORV, MLOCA, LLOCA, SGTR
Turbine Bypass Valves (TBVs)	Eight TBVs	Non-Class 1E 125 V-DC, Non-Class 1E 120 V-AC, IA (N_2 backup not credited), Circulating Water (CW) (to maintain condenser vacuum)	SLOCA, SORV, SGTR, MSLB
Turbine Cooling Water (TC)	Two pumps in parallel with heat exchangers	Non-class 1E 4.16 kV, PW	TRANS, SGTR, MSLB, LDCA, LDCB, LTCW

Notes:

1. Plant internal initiator CDF = x.xxE-5/reactor-year, excluding internal flooding and ISLOCA. The CDF including external initiator contributions is x.xxE-5/reactor-year. The corresponding LERF contributions for internal initiators and internal plus external initiators are x.xxE-6/reactor-year and x.xxE-6/reactor-year. respectively.

2. Operator actions from the Control Room are required to align and initiate the Alternate Feedwater system.

3. Instrument air is used to control FW regulation valves and feedwater isolation valves. High pressure N_2 accumulators are used to provide backup to these valves. N_2 is from the Service Gas system (GA).

4. ADV requires manual operation.

5. HVAC Analysis performed as part of the plant PRA analysis shows that no room cooling is required for the 24 hour mission time.

6. Normal cooling to the essential AFW pump room is provided by the auxiliary building Normal Air Handling Units (AHUs). Cooling water to the normal AHUs is provided by the normal chilled water system (WC). Normal HVAC to the AFW pump room is tripped upon receipt of the ESFAS signal (Safety Injection Actuation Signal [SIAS] or Containment Spray Actuation Signal [CSAS]). For abnormal operation, Train A and Train B AF pump rooms' essential cooling are provided by their respective essential Air Cooling Units (ACUs). The essential chiller water system supplies cooling water to the essential ACUs. Each ACU includes a fan which circulates room air across the cooling coils. EC has to be manually started. In the

Table 2 (Continued)

PRA, with the loss of room cooling, AF pump is assumed to operate with high likelihood of failure, i.e., failure of the pump is not assumed based on analysis performed.

7. The normal charging valves require instrument air (IA) and fail closed on a loss of IA which isolates the normal charging line. Charging to the RCS is still available through spring-loaded check valve which bypasses the normal charging valve.

8. Loss of HVAC to the charging pump does not fail the charging system. Each pump room, however, is supplied by the Auxiliary Building normal ventilation system. Additionally, each pump room has its own room cooling unit which is in operation when the associated charging pump is in operation.

9. Diesel day tank capacity is for 6 hours. Each diesel generator includes a fuel oil day tank and a fuel transfer pump. For long term operation, the diesel fuel oil system is required to maintain fuel supply in the day tank from the train-related underground fuel oil storage tank. There is a capability to crosstie a fuel transfer pump to the other diesel's day tank. However, it is not credited in the plant's PRA.

10. There are two swing chargers; one swing charger for Channels A and C and another for Channels B and D. Swing chargers are auto-aligned.

11. Battery depletion time without charging is estimated to be 2 hours. Battery chargers cannot carry the SI loads. The depletion time for the Switchyard station battery used for offsite power recovery and starting GTG is 3 hours.

12. Loss of Channel A or B impacts the SG ADVs and EC flow permissive instrumentation. Loss of Channel C or D does not affect any mitigating equipment.

13. Both the fans are needed for successful DG room cooling.

14. During normal operation, two normally running AHUs provide the "normal" HVAC. One of two is needed. It is a non-split system. Inspection findings associated with an AHU are Green.

    In case of a Safety Injection Actuation Signal (SIAS) or LOOP, the ESF switchgear area will be isolated from the normal AHUs through closure of the HVAC dampers. The normal AHUs are either tripped off or shed upon loss of power. The area is then served by one or both essential HVAC systems. The Division 1 main switchgear room, the Channels A and C DC equipment room, and Class battery rooms are cooled by Division 1 essential HVAC. Similarly, Division 2 main switchgear room, Channels B and D DC equipment rooms, and Class battery rooms are cooled by Division 2 essential HVAC. Each Division contains two essential ACUs. One of two essential ACUs is required. Essential HVAC is thus a split-train system.

    Operator action is needed to unisolate "normal" HVAC including normal chilled water (WC) when essential HVAC fails after a SIAS or LOOP signal has been received. Operators can also provide temporary backup cooling to the DC equipment room by opening doors and setting up portable fans. These actions are modeled in the plant PRA.

Table 2 (Continued)

15. The Essential Chilled Water System (EC) supplies chilled water to the essential HVAC systems for cooling of safety related equipment rooms during emergency situations. The EC system requires the Essential Cooling Water System (EW) for cooling and the EW system in turn depends on the Essential Spray Ponds (SP). The EW system removes heat from the essential chillers and the shutdown cooling heat exchangers and rejects heat to the essential spray ponds through the EW heat exchangers. The SP system removes heat from the EW system and the DG cooling heat exchangers during normal shutdown and emergency conditions. The essential spray ponds are the “ultimate heat sink”. Each of these systems consists of two redundant trains and they are split-train systems.

16. Loss of HPSI and LPSI room HVAC will result in actuation of an alarm in the Control Room when the room temperature reaches 105 degree F. The plant PRA models operator action to provide backup cooling in case of loss of room cooling. The backup cooling is provided by opening doors and setting up portable fans.

17. Typically 1 of 20 MSSVs is required for success. Because of the significant redundancies available, findings associated with MSSVs are Green.

18. Failure of either DC power train will not fail the pressurizer vent system due to the redundant line being connected to the opposite electrical train. Due to the size of the vent lines, pressure reduction is extremely limited and slow. There are two vent paths in the following configuration: two parallel paths connected in series. The first path has two SOVs in series and one SOV in the parallel path. The second path has one SOV in each parallel path. <u>NOTE: These SOVs are not large enough to support primary “feed and bleed” as many other PWRs are capable of performing.</u>

19. The RCPs at the Generic PWR Plant are similar in design and performance to Byron Jackson (BJ) pumps. The RCP seal packages at the Generic PWR Plant have been replaced with a new type of seal which limits maximum leakage after loss of cooling to about 17 gpm per pump.

20. The Nitrogen system is not required for operation of the SIT but may be required if the SIT pressure decreases during normal operation.

1.3 SDP WORKSHEETS

This section presents the SDP worksheets to be used in the Phase 2 evaluation of the inspection findings for the Generic PWR Plant. The SDP worksheets are presented for the following initiating event categories:

1. Transients with PCS Available (Reactor Trip) (TRANS)
2. Transients with Loss of PCS (TPCS)
3. Small LOCA (SLOCA)
4. Stuck-Open Relief Valve (SORV)
5. Medium LOCA (MLOCA)
6. Large LOCA (LLOCA)
7. Loss of Offsite Power (LOOP)
8. Steam Generator Tube Rupture (SGTR)
9. Anticipated Transients Without Scram (ATWS)
10. Main Steam Line Break (MSLB)
11. Loss of Plant Cooling Water (PW) (LOPW)
12. Loss of Turbine Cooling Water (LTCW)
13. Loss of 125 V-DC Channel A (LDCA)
14. Loss of 125 V-DC Channel B (LDCB)
15. Loss of Instrument Air (LOIA)
16. Loss of Nuclear Cooling Water (NCW) (LONCW)
17. Loss of Emergency AC Bus A (LACA)
18. Loss of Emergency AC Bus B (LACB)
19. Interfacing Systems LOCA (ISLOCA)

Table 3.1 SDP Worksheet for Generic PWR Plant — Transients With PCS Available (Reactor Trip) (TRANS)

Safety Functions Needed:	Full Creditable Mitigation Capability for Each Safety Function:
Auxiliary Feedwater (AFW)	[1/1 essential AFW MDP B or 1/1 non-essential AFW MDP X [(1)]] (1 multi-train system) or 1/1 AFW TDP A (1 ASD train)]
Power Conversion System/Alternate Feedwater (PCS)	Operator reduces secondary pressure to below 500 psia and uses 1/3 condensate MDPs (operator action = 2) [(2)] with 1/8 TBVs or 1/4 ADVs

Circle Affected Functions		IEL	Remaining Mitigation Capability Rating for Each Affected Sequence	Recovery Credit	Results	LERF Factor
1 TRANS - AFW - PCS (3) **1 + 4 + 2**	**7**					**0**

Identify any operator recovery actions that are credited to directly restore the degraded equipment or initiating event:

If operator actions are required to credit placing mitigation equipment in service or for recovery actions, such credit should be given only if the following criteria are met: 1) sufficient time is available to implement these actions, 2) environmental conditions allow access where needed, 3) procedures exist, 4) training is conducted on the existing procedures under conditions similar to the scenario assumed, and 5) any equipment needed to complete these actions is available and ready for use.

Notes:

1. An operator action is required to use Train "X" of AFW to provide feedwater to at least one SG following a main steam isolation signal (MSIS). The plant's PRA assigns a human error probability (HEP) of 3.2E-3.

2. The plant's PRA assesses a HEP of 4E-2.

Table 3.2 SDP Worksheet for Generic PWR Plant — Transients With Loss of PCS (TPCS)

Safety Functions Needed:	**Full Creditable Mitigation Capability for Each Safety Function:**
Auxiliary Feedwater (AFW)	[1/1 essential AFW MDP B or 1/1 non-essential AFW MDP X [(1)]] (1 multi-train system) or 1/1 AFW TDP A (1 ASD train)]

Circle Affected Functions		**IEL**	**Remaining Mitigation Capability Rating for Each Affected Sequence**	**Recovery Credit**	**Results**	**LERF Factor**
1 TPCS - AFW (2) **1 + 4**	**5**					**0**

Identify any operator recovery actions that are credited to directly restore the degraded equipment or initiating event:

If operator actions are required to credit placing mitigation equipment in service or for recovery actions, such credit should be given only if the following criteria are met: 1) sufficient time is available to implement these actions, 2) environmental conditions allow access where needed, 3) procedures exist, 4) training is conducted on the existing procedures under conditions similar to the scenario assumed, and 5) any equipment needed to complete these actions is available and ready for use.

Note:

1. An operator action is required to use Train "X" of AFW to provide feedwater to at least one SG following a main steam isolation signal (MSIS). The plant's PRA assesses a human error probability of 3.2E-3.

Table 3.3 SDP Worksheet for Generic PWR Plant — Small LOCA (< 2") (SLOCA) [1, 2]

Safety Functions Needed:	**Full Creditable Mitigation Capability for Each Safety Function:**
High Pressure Safety Injection (HPSI)	1/2 HPSI trains through three injection lines (1 multi-train system)
Auxiliary Feedwater (AFW)	[1/1 essential AFW MDP B or 1/1 non-essential AFW MDP Train X [3]] (1 multi-train system) or 1/1 AFW TDP A (1 ASD train)]
RCS Depressurization (RCSDEP)	Operator depressurizes RCS using 1/8 TBVs or 1/4 ADVs (operator action = 2) [4]
Rapid RCS Depressurization (RDEP) [5]	Rapid cooldown and depressurization (using 2/4 ADVs or 1/8 TBVs) with 4/4 SITs followed by 1/2 LPSI MDPs (operator action = 1) [6]
Low Pressure Safety Recirculation (LPR)	1/2 LPSI MDPs taking suction from the containment sump (operator action = 3) [7]
High Pressure Safety Recirculation (HPR)	1/2 HPSI trains taking suction from the containment sump (1 multi-train system)
Containment Heat Removal (CHR) [2]	1/2 CS MDPs for containment spray with associated SDC heat exchanger (1 multi-train system) [8]

Circle Affected Functions		**IEL**	**Remaining Mitigation Capability Rating for Each Affected Sequence**	**Recovery Credit**	**Results**	**LERF Factor**
1 SLOCA - RCSDEP - CHR (4) **3 + 2 + 3**	**8**					**0**
2 SLOCA - LPR (2, 8) **3 + 3**	**6**					**0**
3 SLOCA - RCSDEP- HPR (5) **3 + 2 + 3**	**8**					**0**
4 SLOCA - AFW (6, 10) **3 + 4**	**7**					**0**
5 SLOCA - HPSI - RDEP (9) **3 + 3 + 1**	**7**					**0**

Identify any operator recovery actions that are credited to directly restore the degraded equipment or initiating event:

If operator actions are required to credit placing mitigation equipment in service or for recovery actions, such credit should be given only if the following criteria are met: 1) sufficient time is available to implement these actions, 2) environmental conditions allow access where needed, 3) procedures exist, 4) training is conducted on the existing procedures under conditions similar to the scenario assumed, and 5) any equipment needed to complete these actions is available and ready for use.

Notes:

1. In modeling SLOCA here, it is assumed that recirculation from the sump will be needed following injection. No credit is given for directly entering the shutdown cooling mode following successful HPSI and AFW. The licensee's PRA assumes such a success path, i.e., successful shutdown cooling following successful HPSI and AFW will lead to successful termination of the accident. Also, following failure of HPR, a rapid depressurization and cooldown followed by low pressure injection and recirculation can be attempted. This notebook models LPR following successful depressurization and HPR when depressurization is not successful.

2. In situations where RCS is successfully depressurized, it is assumed that CHR is not needed. This is based on plant-specific analyses conducted as part of the PRA.

3. An operator action is required to use Train "Train X" of AFW to provide feedwater to at least one SG following a main steam isolation signal (MSIS). The plant's PRA assesses a human error probability (HEP) of 3.2E-3.

4. The plant's PRA assesses a HEP of 6E-3. An operator action credit of 2 is assigned.

5. The failure of HPSI/HPR requires aggressive cooldown/depressurization within 15 minutes in order to utilize LPSI and/or LPR. AFW has to be provided to both SGs.

6. The plant's PRA assesses a HEP of 2.7E-1.

7. This function requires an operator action to re-start at least one LPSI train (the Recirculation Actuation Signal shuts down LPSI). The associated HEP is 1.3E-3.

8. As noted in note 2 above, when RCS is successfully depressurized, it is assumed that CHR is not required.

Table 3.4 SDP Worksheet for Generic PWR Plant — Stuck-Open Relief Valve (SORV) [1, 2]

<u>Safety Functions Needed</u>:	<u>Full Creditable Mitigation Capability for Each Safety Function</u>:
High Pressure Safety Injection (HPSI)	1/2 HPSI trains through three injection lines (1 multi-train system)
Auxiliary Feedwater (AFW)	[1/1 essential AFW MDP B or 1/1 non-essential AFW MDP Train X [3]] (1 multi-train system) or 1/1 AFW TDP A (1 ASD train)]
High Pressure Safety Recirculation (HPR)	1/2 HPSI trains taking suction from the containment sump (1 multi-train system)
Rapid RCS Depressurization (RDEP) [5]	Rapid cooldown and depressurization (using 2/4 ADVs or 1/8 TBVs) with 4/4 SITs followed by 1/2 LPSI MDPs (operator action = 1) [6]
Low Pressure Safety Recirculation (LPR)	1/2 LPSI MDPs taking suction from the containment sump (operator action = 3) [7]
RCS Depressurization (RCSDEP)	Operator depressurizes RCS using 1/8 TBVs or 1/4 ADVs (operator action = 2) [4]
Containment Heat Removal (CHR) [2]	1/2 CS MDPs for containment spray with associated SDC heat exchanger (1 multi-train system) [8]

<u>Circle Affected Functions</u>		**<u>IEL</u>**	**<u>Remaining Mitigation Capability Rating for Each Affected Sequence</u>**	**<u>Recovery Credit</u>**	**<u>Results</u>**	**<u>LERF Factor</u>**
1 SORV - RCSDEP - CHR (4) **4 + 2 + 3**	**9**					**0**
2 SORV - LPR (2, 8) **4 + 3**	**7**					**0**
3 SORV - RCSDEP - HPR (5) **4 + 2 + 3**	**9**					**0**
4 SORV - AFW (6, 10) **4 + 4**	**8**					**0**
5 SORV - HPSI - RDEP (9) **4 + 3 + 1**	**8**					**0**

Identify any operator recovery actions that are credited to directly restore the degraded equipment or initiating event:

If operator actions are required to credit placing mitigation equipment in service or for recovery actions, such credit should be given only if the following criteria are met: 1) sufficient time is available to implement these actions, 2) environmental conditions allow access where needed, 3) procedures exist, 4) training is conducted on the existing procedures under conditions similar to the scenario assumed, and 5) any equipment needed to complete these actions is available and ready for use.

<u>**Notes**</u>**:**

1. This worksheet models SORV that may occur in different transients. In the plant PRA, SORV contributions are important in LOOP and in loss of emergency AC buses. The plant response is similar to a SLOCA.

2. In situations where RCS is successfully depressurized, it is assumed that CHR is not needed. This is based on plant-specific analyses conducted as part of the PRA.

3. An operator action is required to use Train "Train X" of AFW to provide feedwater to at least one SG following a main steam isolation signal (MSIS). The plant's PRA assesses a human error probability (HEP) of 3.2E-3.

4. The plant's PRA assesses a HEP of 6E-3. An operator action credit of 2 is assigned.

5. The failure of HPSI/HPR requires aggressive cooldown/depressurization within 15 minutes in order to utilize LPSI and/or LPR. AFW has to be provided to both SGs.

6. The plant's PRA assesses a HEP of 2.7E-1.

7. This function requires an operator action to re-start at least one LPSI train (the Recirculation Actuation Signal shuts down LPSI). The associated HEP is 1.3E-3.

8. As noted in note 2 above, when RCS is successfully depressurized, it is assumed that CHR is not required.

Table 3.5 SDP Worksheet for Generic PWR Plant — Medium LOCA (>2" and <6") (MLOCA)

Safety Functions Needed:	**Full Creditable Mitigation Capability for Each Safety Function:**
Safety Injection Tank Injection (SITS)	2/3 remaining SITs [1] into 2 intact RCS legs (1 multi-train system)
High Pressure Safety Injection (HPSI)	1/2 HPSI MDP trains [2] (1 multi-train system)
High Pressure Safety Recirculation (HPR)	1/2 HPSI MDP trains taking suction from the containment sump (1 multi-train system)
Containment Heat Removal (CHR)	1/2 CS MDPs for containment spray with associated SDC heat exchanger [3] (1 multi-train system)
Hot Leg Injection (HLI)	1/2 HPSI MDPs into a hot leg (operator action = 3) [4]

Circle Affected Functions		**IEL**	**Remaining Mitigation Capability Rating for Each Affected Sequence**	**Recovery Credit**	**Results**	**LERF Factor**
1 MLOCA - HLI (2) **4 + 3**	**7**					**0**
2 MLOCA - CHR (3) **4 + 3**	**7**					**0**
3 MLOCA - HPR (4) **4 + 3**	**7**					**0**
4 MLOCA - HPSI (5) **4 + 3**	**7**					**0**
5 MLOCA - SITS (6) **4 + 3**	**7**					**0**

Identify any operator recovery actions that are credited to directly restore the degraded equipment or initiating event:

If operator actions are required to credit placing mitigation equipment in service or for recovery actions, such credit should be given only if the following criteria are met: 1) sufficient time is available to implement these actions, 2) environmental conditions allow access where needed, 3) procedures exist, 4) training is conducted on the existing procedures under conditions similar to the scenario assumed, and 5) any equipment needed to complete these actions is available and ready for use.

Notes:

1. Inventory from one SIT is assumed to be lost through the break, reducing the available SITs to three.

2. Two injection points, one from each pump, are assumed unavailable due to the pipe break location. At least one HPSI train injects water via at least three of the six unaffected HPSI injection lines.

3. Crosstie abilities between the A train SDC heat exchanger and the B train SDC heat exchanger are not credited by the licensee in its current PRA model.

4. The operator must realign valves from the control room for hot leg injection. The plant's PRA assesses a human error probability of 2.0E-3.

Table 3.6 SDP Worksheet for Generic PWR Plant — Large LOCA (>6") (LLOCA)

Safety Functions Needed:	**Full Creditable Mitigation Capability for Each Safety Function:**
Safety Injection Tank Injection (SITS)	2/3 remaining SITs (1 multi-train system)[1]
Low Pressure Safety Injection (LPSI)	1/2 LPSI trains (1 multi-train system)
High Pressure Safety Recirculation (HPR)	1/2 HPSI trains taking suction from the containment sump (1 multi-train system)
Low Pressure Recirculation (LPR)	1/2 LPSI MDPs taking suction from the containment sump (operator action = 3)[2]
Containment Heat Removal (CHR)	1/2 CS MDPs for containment spray with associated SDC heat exchanger[3] (1 multi-train system)
Hot Leg Injection (HLI)	1/2 HPSI MDPs into a hot leg (operator action = 3)[4]

Circle Affected Functions		**IEL**	**Remaining Mitigation Capability Rating for Each Affected Sequence**	**Recovery Credit**	**Results**	**LERF Factor**
1 LLOCA - HLI (2, 5) **5 + 3**	**8**					**0**
2 LLOCA - CHR (3,6) **5 + 3**	**8**					**0**
3 LLOCA - HPR - LPR (7) **5 + 3 + 3**	**11**					**0**
4 LLOCA - LPSI (8) **5 + 3**	**8**					**0**
5 LLOCA - SITS (9) **5 + 3**	**8**					**0**

Identify any operator recovery actions that are credited to directly restore the degraded equipment or initiating event:

If operator actions are required to credit placing mitigation equipment in service or for recovery actions, such credit should be given only if the following criteria are met: 1) sufficient time is available to implement these actions, 2) environmental conditions allow access where needed, 3) procedures exist, 4) training is conducted on the existing procedures under conditions similar to the scenario assumed, and 5) any equipment needed to complete these actions is available and ready for use.

Notes:

1. It is assumed that inventory of one SIT is lost through the break, thereby reducing available SITs from 4 to 3.

2. This function requires an operator action to re-start at least one LPSI train (RAS shuts down LPSI).

3. Crosstie abilities between the A train SDC heat exchanger and the B train SDC heat exchanger are not credited by the licensee in its current PRA model.

4. The operator must realign valves from the control room for hot leg injection. The plant’s PRA assesses a human error probability of 2.0E-3.

Table 3.7 SDP Worksheet for Generic PWR Plant — Loss of Offsite Power (LOOP) [1]

Safety Functions Needed:	**Full Creditable Mitigation Capability for Each Safety Function:**
Emergency AC Power (EAC)	1/2 EDGs (1 multi-train system) [2]
RCP Seal LOCA (SEAL)	Probability that RCP seal LOCA does not occur (credit = 3) [1]
Secondary Cooling using TDAFW (TDAFW)	1/1 TDAFW A train (1 ASD train)
Recovery of AC Power in 1 Hour (REC1)	Restoring a source of AC within 1 hour (operator action = 1) [3] or 1/2 Gas Turbine Generators (operator action = 1) [2]
Recovery of AC Power in 3 Hours (REC3)	Restoring a source of AC within 3 hours (operator action = 2) [4] or 1/2 Gas Turbine Generators (operator action = 1) [2]
Motor-Driven Auxiliary Feedwater (MDAFW) [6]	[1/1 essential AFW MDP B or 1/1 non-essential AFW MDP Train X [5]] (1 multi-train system)
Auxiliary Feedwater (AFW)	[1/1 essential AFW MDP B or 1/1 non-essential AFW MDP Train X [5]] (1 multi-train system) or 1/1 AFW TDP A (1 ASD train)]
High Pressure Safety Injection (HPSI)	1/2 HPSI trains in injection mode (1 multi-train system) or 2/3 charging pumps [7] (1 multi-train system)

Circle Affected Functions		**IEL**	**Remaining Mitigation Capability Rating for Each Affected Sequence**	**Recovery Credit**	**Results**	**LERF Factor**
1 LOOP - AFW (1, 5, 12) **2 + 4**	**6**					**0**
2 LOOP - EAC - REC3 (3) **2 + 3 + 3**	**8**					**0**
3 LOOP - EAC - TDAFW - REC1 (6, 13) **2 + 3 + 1 + 2**	**8**					**0**
4 LOOP - EAC - SEAL - HPSI (8, 11) **2 + 3 + 3 + 6** (AC recovered)	**14**					**0**
5 LOOP - EAC - SEAL - REC1 (9) **2 + 3 + 3 + 2**	**10**					**0**

Identify any operator recovery actions that are credited to directly restore the degraded equipment or initiating event: If operator actions are required to credit placing mitigation equipment in service or for recovery actions, such credit should be given only if the following criteria are met: 1) sufficient time is available to implement these actions, 2) environmental conditions allow access where needed, 3) procedures exist, 4) training is conducted on the existing procedures under conditions similar to the scenario assumed, and 5) any equipment needed to complete these actions is available and ready for use.

Notes:

1. In a LOOP with successful operation of EDGs, the plant response is similar to TPCS since the condensate pumps are not available for Alternate Feedwater. With the loss of all station power (station blackout), the RCPs trip and RCP seal injection and cooling water will be lost. The RCP seals are made similar to Byron Jackson pumps. The RCP seal package at the Generic PWR Plant has been replaced with a new type of seal which limits maximum leakage after loss of cooling to about 17 gpm per pump. The plant does model any RCP seal leakage. Here it is assumed that the likelihood of seal failure is approximately 1E-3; credit for SEAL is 3. This notebook also models that the inventory loss following seal failure is limited and is within the capacity of two of the charging pumps. Also, for this loss, high pressure recirculation and containment heat removal are not needed.

2. The human error probability (HEP) for starting the GTGs is 0.16. Since the Gas Turbine generators will take approximately 1 hour to align, they are credited as part of REC1 and REC3.

3. In a SBO scenario with failure of the TDP of AFW, the steam generators boil dry at approximately 30 minutes, and core uncovery occurs within 30 minutes of SG dryout. It is assumed that AFW flow can be provided to the SGs after SG dryout without a significant adverse impact. This is consistent with the assumption in the plant's PRA. Given absence of early phase AFW (TDAFW), power must be restored within 1 hour to avoid steam generator dryout and core uncovery. The plant's PRA assesses a HEP of 0.18 for restoring power within an hour.

4. The emergency batteries would deplete after 2 hours at The Generic PWR Plant in SBO scenarios. Once battery depletes, it is assumed that control to the turbine-driven AFW pump throttle valve and other system valves will be lost. In addition, primary coolant losses due to excessive pump seal leakage do not lead to core uncovery prior to 3 hours. Also, station batteries deplete at 3 hours. Recovering AC power within 2 hours is assigned a probability of 1.6E-2. An operator action credit of 2 is assigned.

5. An operator action is required to use Train "Train X" of AFW to provide feedwater to at least one SG following a main steam isolation signal (MSIS). The plant's PRA assesses a HEP = 3.2E-3.

6. MDAFW pumps are credited following recovery of offsite power within 1 hour where TDAFW has failed. However, sequences involving MDAFW are absorbed in another sequence.

7. Charging pumps are credited since as mentioned earlier they are sufficient to provide the inventory loss for the seal leakage assumed.

Table 3.8 SDP Worksheet for Generic PWR Plant — Steam Generator Tube Rupture (SGTR) (1)

Safety Functions Needed:	**Full Creditable Mitigation Capability for Each Safety Function:**
High Pressure Safety Injection (HPSI)	1/2 HPSI trains through one injection line (1 multi-train system)
Auxiliary Feedwater (AFW)	[1/1 essential AFW MDP B or 1/1 non-essential AFW MDP Train X (2)] (1 multi-train system) or 1/1 AFW TDP A (1 ASD train)]
Power Conversion System/Alternate Feedwater (PCS)	Operator reduces secondary pressure to below 500 psia (1/4 ADVs or 1/8 TBVs) and uses 1/3 condensate MDPs (operator action = 1) (3)
SG Isolation (ISO)	Operator isolates the damaged SG by closing 2/2 MSIVs, MFIVs and ADVs (operator action = 2)
Equalization (EQ)	Operator carries out equalization (depressurizes RCS to less than setpoint of relief valve of SGs) using (1/2 auxiliary spray valves or 1/2 pressurizer vent paths or normal spray) (operator action = 2)
Rapid RCS Depressurization (RDEP)	Rapid depressurization using (2/4 ADVs [one per SG] or 2/8 TBVs) and 4/4 SITs with 1/2 LPSI trains (operator action = 2) (4)
Shutdown Cooling (SDC)	Operator depressurizes using 1/2 pressurizer vent paths with (1/8 TBVs or 1/2 ADVs) and uses 1/2 LPSI trains with associated SDC heat exchanger (operator action = 2)
Refill Refueling Water Storage Tank (RWT)	Operator refills RWT from Spent Fuel Pool using 1/2 Boric Acid Makeup Pumps (operator action = 3) (5)

Circle Affected Functions		**IEL**	**Remaining Mitigation Capability Rating for Each Affected Sequence**	**Recovery Credit**	**Results**	**LERF Factor**
1 SGTR - EQ - RWT (3) **3 + 2 + 3**	**8**					**1.0**
2 SGTR - ISO - SDC - RWT (6) **3 + 2 + 2 + 3**	**10**					**1.0**
3 SGTR - AFW - SDC - RWT (9) **3 + 4 + 2 + 3**	**12**					**1.0**
4 SGTR - AFW - PCS (10) **3 + 4 + 1**	**8**					**1.0**
5 SGTR - HPSI - SDC (12) **3 + 3 + 2**	**8**					**1.0**

6 SGTR - HPSI - RDEP (13) **3 + 3 + 2**	**8**					**1.0**
7 SGTR - HPSI - AFW (14) **3 + 3 + 4**	**10**					**1.0**

Identify any operator recovery actions that are credited to directly restore the degraded equipment or initiating event:

If operator actions are required to credit placing mitigation equipment in service or for recovery actions, such credit should be given only if the following criteria are met: 1) sufficient time is available to implement these actions, 2) environmental conditions allow access where needed, 3) procedures exist, 4) training is conducted on the existing procedures under conditions similar to the scenario assumed, and 5) any equipment needed to complete these actions is available and ready for use.

Notes:

1. The SDP notebook's event tree and worksheet are based on the licensee's updated event tree reflecting new EOPs. Credit is not given to PCS after the failure of both HPSI and AFW because the operator would have to carry out actions to use PCS under time and stress constraints. Also, following successful HPSI and use of alternate feedwater (with failure of AFW), it is assumed that operators will attempt late depressurization and entry into the shutdown cooling mode.

2. An operator action is required to use Train "Train X" of AFW to provide feedwater to at least one SG following a main steam isolation signal (MSIS). The plant's PRA assesses a human error probability (HEP) = 3.2E-3.

3. The plant's PRA assesses a HEP = 1.2E-1.

4. The HEP for depressurization for SDC is 5.5E-3. An operator action credit of 2 is assigned.

5. The plant's PRA only credits the Spent Fuel Pool as a makeup source for RWT refill since it is the easiest and fastest means of replenishment. The plant's PRA assesses a HEP = 2.5E-3. It should also be noted that RWT refill will be needed approximately 30 hours after the initiation of the event.

Table 3.9 SDP Worksheet for Generic PWR Plant — Anticipated Transients Without Scram (ATWS)

Safety Functions Needed:	**Full Creditable Mitigation Capability for Each Safety Function:**
Turbine Trip (TTP)	Turbine trips using CEDMCS (1) (1 multi-train system)
Emergency Boration (EMBO)	1/3 charging pumps inject borated water to vessel using (1/1 RWT valve or 1/2 boric acid pumps) (operator action = 2) (2)
Auxiliary Feedwater (AFW)	1/1 AFW MDP B (1 train) or 1/1 TDAFW pump A (1 ASD train) (3) with 1/4 ADVs or 1/20 MSSVs
Primary Relief (SRV)	4/4 SRVs open to protect against early overpressurization (1 train)

Circle Affected Functions		**IEL**	**Remaining Mitigation Capability Rating for Each Affected Sequence**	**Recovery Credit**	**Results**	**LERF Factor**
1 ATWS - SRV (2) **6 + 2**	**8**					**0**
2 ATWS - AFW (3) **6 + 3**	**9**					**0**
3 ATWS - EMBO (4) **6 + 2**	**8**					**0**
4 ATWS - TTP (5) **6 + 3**	**9**					**0**

Identify any operator recovery actions that are credited to directly restore the degraded equipment or initiating event:

If operator actions are required to credit placing mitigation equipment in service or for recovery actions, such credit should be given only if the following criteria are met: 1) sufficient time is available to implement these actions, 2) environmental conditions allow access where needed, 3) procedures exist, 4) training is conducted on the existing procedures under conditions similar to the scenario assumed, and 5) any equipment needed to complete these actions is available and ready for use.

Notes:

1. Undervoltage coils in the Control Element Drive Mechanism Control System (CEDMCS) trip the turbine. CEDMCS is a subset of the Electro-Hydraulic Control (EHC) system. Operator can trip the turbine within 10 minutes if the CEDMCS fails to trip the turbine.

2. The plant's PRA assesses a human error probability of 1.0E-2.

3. The AFW train "Train X" is not credited because it requires manual action which is not directed in the ATWS procedure.

Table 3.10 SDP Worksheet for Generic PWR Plant — Main Steam Line Break (MSLB) (1)

Safety Functions Needed:	Full Creditable Mitigation Capability for Each Safety Function:
MSIV Closure (MSIV)	2 /2 MSIVs for one of the SG close and MFIVs close (1 multi-train system) (2)
High Pressure Safety Injection (HPSI)	1/2 HPSI trains (1 multi-train system)
Auxiliary Feedwater (AFW)	[1/1 essential AFW MDP B or 1/1 non-essential AFW MDP Train X (3)] (1 multi-train system) or 1/1 AFW TDP A (1 ASD train)]
Power Conversion System/Alternate Feedwater (PCS)	Operator reduces secondary pressure to below 500 psia (1/4 ADVs or 1/8 TBVs) and uses 1/3 condensate MDPs (operator action = 1) (4)

Circle Affected Functions		IEL	Remaining Mitigation Capability Rating for Each Affected Sequence	Recovery Credit	Results	LERF Factor
1 MSLB - AFW - PCS (3) **3 + 4 + 1**	**8**					**0**
2 MSLB - HPSI - AFW (5) **3 + 3 + 4**	**10**					**0**
3 MSLB - MSIV - PCS (7) **3 + 3 + 1**	**7**					**0**
4 MSLB - MSIV - HPSI (8) **3 + 3 + 3**	**9**					**0**

Identify any operator recovery actions that are credited to directly restore the degraded equipment or initiating event:

If operator actions are required to credit placing mitigation equipment in service or for recovery actions, such credit should be given only if the following criteria are met: 1) sufficient time is available to implement these actions, 2) environmental conditions allow access where needed, 3) procedures exist, 4) training is conducted on the existing procedures under conditions similar to the scenario assumed, and 5) any equipment needed to complete these actions is available and ready for use.

Notes:

1. [Note removed]

2. Depressurization of the Steam Generators following steam line break results in actuation of the Main Steam Isolation Signal (MSIS). This closes the MSIVs, isolating the affected and the unaffected steam generators and closes the main feedwater isolation valves (MFIVs), terminating main feedwater flow to both steam generators. Here, failure to close the MSIVs of at least one of the SGs along with the failure to isolate the feedwater flow to the affected SG is assumed to affect AFW success because of the loss of inventory from the CST. In such a scenario, AFW is not credited.

3. An operator action is required to use Train “Train X” of AFW to provide feedwater to at least one SG following a MSIS. The plant PRA assesses a human error probability (HEP) = 3.2E-3.

4. The plant’s PRA assesses a HEP = 0.3. No credit is given for using the alternate feedwater when HPSI fails.

Table 3.11 SDP Worksheet for Generic PWR Plant — Loss of Plant Cooling Water (PW) (LOPW) [1, 3]

Safety Functions Needed:	**Full Creditable Mitigation Capability for Each Safety Function:**
Auxiliary Feedwater (AFW)	[1/1 essential AFW MDP B or 1/1 non-essential AFW MDP Train X [42]](1 multi-train system) or 1/1 AFW TDP A (1 ASD train)]

Circle Affected Functions		**IEL**	**Remaining Mitigation Capability Rating for Each Affected Sequence**	**Recovery Credit**	**Results**	**LERF Factor**
1 LOPW - AFW (2) **3 + 4**	**7**					**0**

Notes:

1. An extended loss of Plant Cooling Water (PW) causes the following: loss of cooling to turbine cooling water (TC), nuclear cooling water (NC), and condenser air removal pumps. The operator is expected to carry out the following actions: manual turbine trip (per procedure), possible RCP trip due to loss of NC heat sink, manual FW pump trip, manual circulating water pump trip, manual condensate pump trip, and manual instrument air compressor trip. Eventual loss of condenser vacuum and loss of normal HVAC is expected. Since the condenser vacuum is lost, PCS is not credited. The frequency of loss of Plant Cooling Water = 9.7E-4/reactor-year.

2. An operator action is required to use Train "Train X" of AFW to provide feedwater to at least one SG following a main steam isolation signal (MSIS). The plant's PRA assesses a human error probability = 3.2E-3.

3. The transient is similar to TPCS. No separate event tree is provided. Please refer to the TPCS tree.

Table 3.12 SDP Worksheet for Generic PWR Plant — Loss of Turbine Cooling Water (LTCW) (1, 3)

Safety Functions Needed: **Auxiliary Feedwater (AFW)**		**Full Creditable Mitigation Capability for Each Safety Function:** [1/1 essential AFW MDP B or 1/1 non-essential AFW MDP Train X (2)] (1 multi-train system) or 1/1 AFW TDP A (1 ASD train)]				
Circle Affected Functions		**IEL**	**Remaining Mitigation Capability Rating for Each Affected Sequence**	**Recovery Credit**	**Results**	**LERF Factor**
1 LTCW - AFW (2) **2 + 4**	**6**					**0**

Notes:

1. Loss of Turbine Cooling Water will result in loss of cooling water to the Main Turbine lube oil, main generator stator and hydrogen coolers, FW pump lube oil, instrument air compressors, and circulating water pumps. It does not immediately render MFW lost; condensate pumps can run for 2.5 hours. In the modeling here, the condensate pumps are not credited. The initiating event frequency is 8.92E-3/reactor-year.

2. An operator action is required to use Train "Train X" of AFW to provide feedwater to at least one SG following a main steam isolation signal (MSIS). The plant's PRA assesses a human error probability = 3.2E-3.

3. The transient is similar to TPCS. No separate event tree is provided. Please refer to the TPCS tree.

Table 3.13 SDP Worksheet for Generic PWR Plant — Loss of 125 V-DC Channel A (LDCA) [(1)]

Safety Functions Needed:	Full Creditable Mitigation Capability for Each Safety Function:
Auxiliary Feedwater (AFW)	[1/1 essential AFW MDP B or 1/1 non-essential AFW MDP Train X (operator action = 1)[(2)]] (1 multi-train system)
Power Conversion System/Alternate Feedwater (PCS)	Operator reduces secondary pressure to below 500 psia (1/2 ADVs or 1/8 TBVs) and uses 1/3 condensate MDPs (operator action = 1) [(3)]

Circle Affected Functions		IEL	Remaining Mitigation Capability Rating for Each Affected Sequence	Recovery Credit	Results	LERF Factor
1 LDCA - AFW - PCS (3) **3 + 3 + 1**	**7**					**0**

Identify any operator recovery actions that are credited to directly restore the degraded equipment or initiating event:

If operator actions are required to credit placing mitigation equipment in service or for recovery actions, such credit should be given only if the following criteria are met: 1) sufficient time is available to implement these actions, 2) environmental conditions allow access where needed, 3) procedures exist, 4) training is conducted on the existing procedures under conditions similar to the scenario assumed, and 5) any equipment needed to complete these actions is available and ready for use.

Notes:

1. Loss of channel A of DC has the following impact on the plant: one ADV on each SG fails closed, all of the train A ESF pumps fail to start due to loss of DC control power, DG A will not start or run, the normal pressurizer spray valves fail closed (instrument air is isolated to containment), the non-essential (start-up) AFW Train X pump loses primary DC control power (operators are directed to manually transfer its control power to its backup source, Channel C), normal and train A essential control room HVAC are unavailable, and normal and train A essential DC equipment room HVAC are unavailable. The TDP of AFW (train A) can be manually operated, but is not credited here because of the high human error probability (HEP). Loss of channel A has a frequency of x.xE-4/reactor-year. The event tree for loss of channel A of DC is the same as that of the TRANS event tree.

2. Per procedure, operators are directed to manually transfer Train X pump control power to its backup source upon loss of channel A of DC power. The plant's PRA assesses a HEP of 7.5E-2. An operator action credit of 1 is assigned.

3. The plant's PRA assesses a HEP of 4E-2. In addition, there a likelihood of MSIS generated (6E-2). A credit of 1 is assigned.

Table 3.14 SDP Worksheet for Generic PWR Plant — Loss of 125 V-DC Channel B (LDCB) (1)

Safety Functions Needed:	Full Creditable Mitigation Capability for Each Safety Function:
Auxiliary Feedwater (AFW)	1/1 non-essential AFW MDP Train X (1 train) (2) or 1/1 AFW TDP A (1 ASD train)
Power Conversion System/Alternate Feedwater (PCS)	Operator reduces secondary pressure to below 500 psia (1/2 ADVs or 1/8 TBVs) and uses 1/3 condensate MDP (operator action = 1) (3)

Circle Affected Functions		IEL	Remaining Mitigation Capability Rating for Each Affected Sequence	Recovery Credit	Results	LERF Factor
1 LDCB - AFW - PCS (3) **3 + 3 + 1**	**7**					**0**

Identify any operator recovery actions that are credited to directly restore the degraded equipment or initiating event:

If operator actions are required to credit placing mitigation equipment in service or for recovery actions, such credit should be given only if the following criteria are met: 1) sufficient time is available to implement these actions, 2) environmental conditions allow access where needed, 3) procedures exist, 4) training is conducted on the existing procedures under conditions similar to the scenario assumed, and 5) any equipment needed to complete these actions is available and ready for use.

Notes:

1. Loss of channel B of DC has the following impact on the plant: one ADV on each SG fails closed, all of the train B ESF pumps fail to start due to loss of DC control power, DG B will not start or run, normal and train B essential control room HVAC are unavailable, and normal and train B essential ESF switchgear room HVAC are unavailable. The plant's PRA assumes that the train B of AFW is lost. The loss of channel B has a frequency of x.xE-4/reactor-year. The event tree for loss of channel B of DC is the same as that for the TRANS tree.

2. Operators use Train "Train X" of AFW to at least one SG following a main steam isolation signal (MSIS). The plant's PRA assesses a human error probability (HEP) of 3.2E-3.

3. The plant's PRA assesses a HEP of 4E-2. In addition, there is a likelihood of MSIS generated (6E-2). A credit of 1 is assigned.

Table 3.15 SDP Worksheet for Generic PWR Plant — Loss of Instrument Air (LOIA)

Safety Functions Needed:	**Full Creditable Mitigation Capability for Each Safety Function:**
Auxiliary Feedwater (AFW)	[1/1 essential AFW MDP B (1 train) or 1/1 non-essential AFW MDP Train X using N_2 backup [1, 2]] (1 multi-train system) or 1/1 AFW TDP A (1 ASD train)

Circle Affected Functions		**IEL**	**Remaining Mitigation Capability Rating for Each Affected Sequence**	**Recovery Credit**	**Results**	**LERF Factor**
1 LOIA - AFW (2) **3 + 4**	**7**					**0**

Identify any operator recovery actions that are credited to directly restore the degraded equipment or initiating event:

If operator actions are required to credit placing mitigation equipment in service or for recovery actions, such credit should be given only if the following criteria are met: 1) sufficient time is available to implement these actions, 2) environmental conditions allow access where needed, 3) procedures exist, 4) training is conducted on the existing procedures under conditions similar to the scenario assumed, and 5) any equipment needed to complete these actions is available and ready for use.

Notes:

1. The loss of instrument air results in the following: TBVs fail to operate, condensate pump shaft seal water isolation valves fail closed failing the pump, letdown isolation valves close, and normal plant ventilation isolates due to damper failing closed. Instrument air to feedwater regulating valves fail, but they have high pressure nitrogen backup and ADVs fail, but they also have nitrogen backup. The operator is expected to manually trip the reactor per procedure. The initiating event frequency of LOIA is x.xxE-3/reactor-year. The event tree is similar to that for the TPCS tree.

2. An operator action is required to use Train “Train X” of AFW to provide feedwater to at least one SG. Backup nitrogen is credited for allowing continued operation of the pump. The assessed human error probability is 3.2E-3.

Table 3.16 SDP Worksheet for Generic PWR Plant — Loss of Nuclear Cooling Water (NCW) (LONCW) (1)

Safety Functions Needed:	Full Creditable Mitigation Capability for Each Safety Function:
Auxiliary Feedwater (AFW)	1/1 essential AFW MDP B (1 train) or 1/1 non-essential AFW MDP Train X (operator action = 1) (2) or 1/1 AFW TDP (1 ASD train)
Power Conversion System/Alternate Feedwater (PCS)	Operator reduces secondary pressure to below 500 psia (1/4 ADVs or 1/8 TBVs) and uses 1/3 condensate MDPs (operator action = 2) (3)

Circle Affected Functions		IEL	Remaining Mitigation Capability Rating for Each Affected Sequence	Recovery Credit	Results	LERF Factor
1 LONCW - PCS - AFW (3) **2 + 2 + 4**	8					0

Identify any operator recovery actions that are credited to directly restore the degraded equipment or initiating event:

If operator actions are required to credit placing mitigation equipment in service or for recovery actions, such credit should be given only if the following criteria are met: 1) sufficient time is available to implement these actions, 2) environmental conditions allow access where needed, 3) procedures exist, 4) training is conducted on the existing procedures under conditions similar to the scenario assumed, and 5) any equipment needed to complete these actions is available and ready for use.

Notes:

1. The loss of nuclear cooling water causes a loss of cooling to the RCP shaft seals, containment air, normal chillers, and the spent fuel pool. Operators can use the essential cooling water (EW) to provide cooling to the RCP seals. The initiating event frequency for nuclear cooling water is x.xxE-3/reactor-year. No separate event tree is provided. Please refer to the TRANS tree.

2. An operator action is required to use Train "Train X" of AFW to provide feedwater to at least one SG following a main steam isolation signal (MSIS). The plant's PRA assesses a human error probability (HEP) = 3.2E-3.

3. The plant's PRA assesses a HEP of 4E-2.

Table 3.17 SDP Worksheet for Generic PWR Plant — Loss of Emergency AC Bus A (LACA) (1)

Safety Functions Needed:	**Full Creditable Mitigation Capability for Each Safety Function:**
Auxiliary Feedwater (AFW)	1/1 essential AFW MDP B (1 train) or 1/1 AFW TDP A (1 ASD train)
Power Conversion System/Alternate Feedwater (PCS)	Operator reduces secondary pressure to below 500 psia (1/ 4 ADVs or 1/8 TBVs) and uses 1/3 condensate MDPs (operator action = 2) (2)

Circle Affected Functions		**IEL**	**Remaining Mitigation Capability Rating for Each Affected Sequence**	**Recovery Credit**	**Results**	**LERF Factor**
1 LACA - PCS - AFW (3) **3 + 2 + 3**	**8**					**0**

Identify any operator recovery actions that are credited to directly restore the degraded equipment or initiating event:

If operator actions are required to credit placing mitigation equipment in service or for recovery actions, such credit should be given only if the following criteria are met: 1) sufficient time is available to implement these actions, 2) environmental conditions allow access where needed, 3) procedures exist, 4) training is conducted on the existing procedures under conditions similar to the scenario assumed, and 5) any equipment needed to complete these actions is available and ready for use.

Notes:

1. The loss of emergency AC bus A results is loss of the train X AFW pump along with of 1 train of the safety systems. TDAFW pump will require local manual control. Swing charger does not auto-align on loss of the bus. The human error probability (HEP) for local manual control is 0.135. The initiating event frequency is x.xE-3/reactor-year. No separate event tree is provided. Please refer to the TRANS tree.

2. The plant's PRA assesses a HEP of 4E-2.

Table 3.18 SDP Worksheet for Generic PWR Plant — Loss of Emergency AC Bus B (LACB) [(1)]

Safety Functions Needed:	**Full Creditable Mitigation Capability for Each Safety Function:**
Auxiliary Feedwater (AFW)	1/1 non-essential AFW MDP Train X (operator action = 2) [(2)] or 1/1 AFW TDP (1 ASD train)
Power Conversion System/Alternate Feedwater (PCS)	Operator reduces secondary pressure to below 500 psia (1/4 ADVs or 1/8 TBVs) and uses 1/3 condensate MDPs (operator action = 2) [(3)]

Circle Affected Functions		**IEL**	**Remaining Mitigation Capability Rating for Each Affected Sequence**	**Recovery Credit**	**Results**	**LERF Factor**
1 LACB - PCS - AFW (3) **3 + 2 + 3**	**8**					**0**

Identify any operator recovery actions that are credited to directly restore the degraded equipment or initiating event:

If operator actions are required to credit placing mitigation equipment in service or for recovery actions, such credit should be given only if the following criteria are met: 1) sufficient time is available to implement these actions, 2) environmental conditions allow access where needed, 3) procedures exist, 4) training is conducted on the existing procedures under conditions similar to the scenario assumed, and 5) any equipment needed to complete these actions is available and ready for use.

Notes:

1. The loss of emergency AC bus B results in loss of the B AFW pump along with loss of 1 train of the safety systems. The initiating event frequency is x.xE-3/reactor-year. No separate event tree is provided. Please refer to the TRANS tree.

2. An operator action is required to use Train "Train X" of AFW to provide feedwater to at least one SG following a main steam isolation signal (MSIS). The plant's PRA assesses a human error probability (HEP) = 3.2E-3.

3. The plant's PRA assesses a HEP of 4E-2.

Table 3.19 SDP Worksheet for Generic PWR Plant — Interfacing Systems LOCA (ISLOCA) (1)

Initiating Pathways:	**Mitigation Capability: Ensure Component Operability for Each Pathway**
RCS Cold-Leg to the High Pressure Safety Injection (HPSI) System	Three check valves and one normally-closed MOV.
RCS Cold-Leg to the Low Pressure Safety Injection (LPSI) System	Three check valves and one normally-closed MOV.
RCS Hot-Leg to Shutdown Cooling Suction Line	Two normally-closed MOVs in a SDC suction line and failure of LTOP relief valve.
RCS to Letdown Line	Two air-operated, fail-closed containment isolation valves).
RCS to Nuclear Cooling Water System	Tube to shell leak in the High Pressure Seal Cooler (2).

List Affected Pathways	**Recovery Credit**	**Remaining Mitigation Capability Rating for Each Affected Pathway**	**Color**

Identify any operator recovery actions that are credited to directly restore the degraded equipment or initiating event:

If operator actions are required to credit placing mitigation equipment in service or for recovery actions, such credit should be given only if the following criteria are met: 1) sufficient time is available to implement these actions, 2) environmental conditions allow access where needed, 3) procedures exist, 4) training is conducted on the existing procedures under conditions similar to the scenario assumed, and 5) any equipment needed to complete these actions is available and ready for use.

Notes:

1. This worksheet is different from the other worksheets in that ISLOCA is typically an unmitigated initiating event in most PRAs. Therefore, the right side of the worksheet contains paths which may lead to an ISLOCA rather than mitigating systems to address an event in progress. As such, it is not intended to be referenced by the last column of Table 2, Initiators and System Dependency Table.

2. The Nuclear Cooling Water (NC) system interfaces with the RCS via the Letdown Heat Exchanger and the RCP high pressure cooler and high pressure seal cooler (HPSC). A tube to shell leak in any of these heat exchangers would result in high pressure RCS coolant entering the low pressure NC system. The plant's PRA considers that the only RCS/NC interface that has significant ISLOCA potential is in the RCP/HPSC.

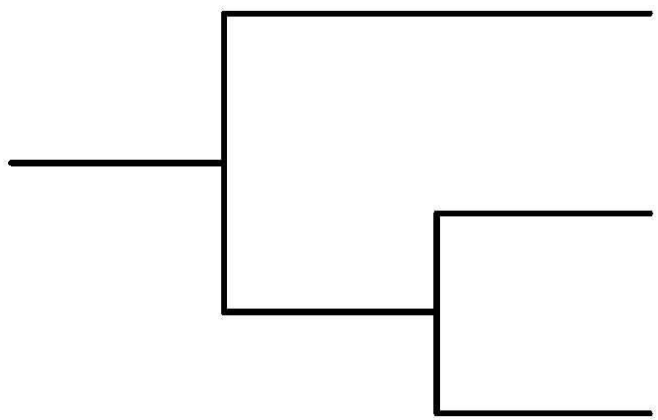
1.4 SDP EVENT TREES

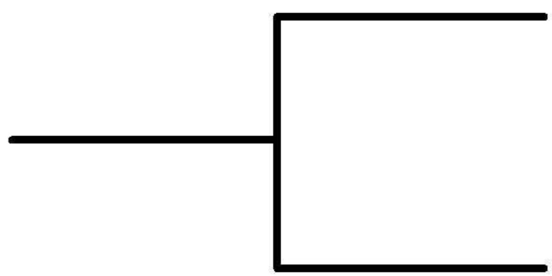
This section provides the simplified event trees called SDP event trees used to define the accident sequences identified in the SDP worksheets in the previous section. The event tree headings are defined in the corresponding SDP worksheets.

The following event trees are included:

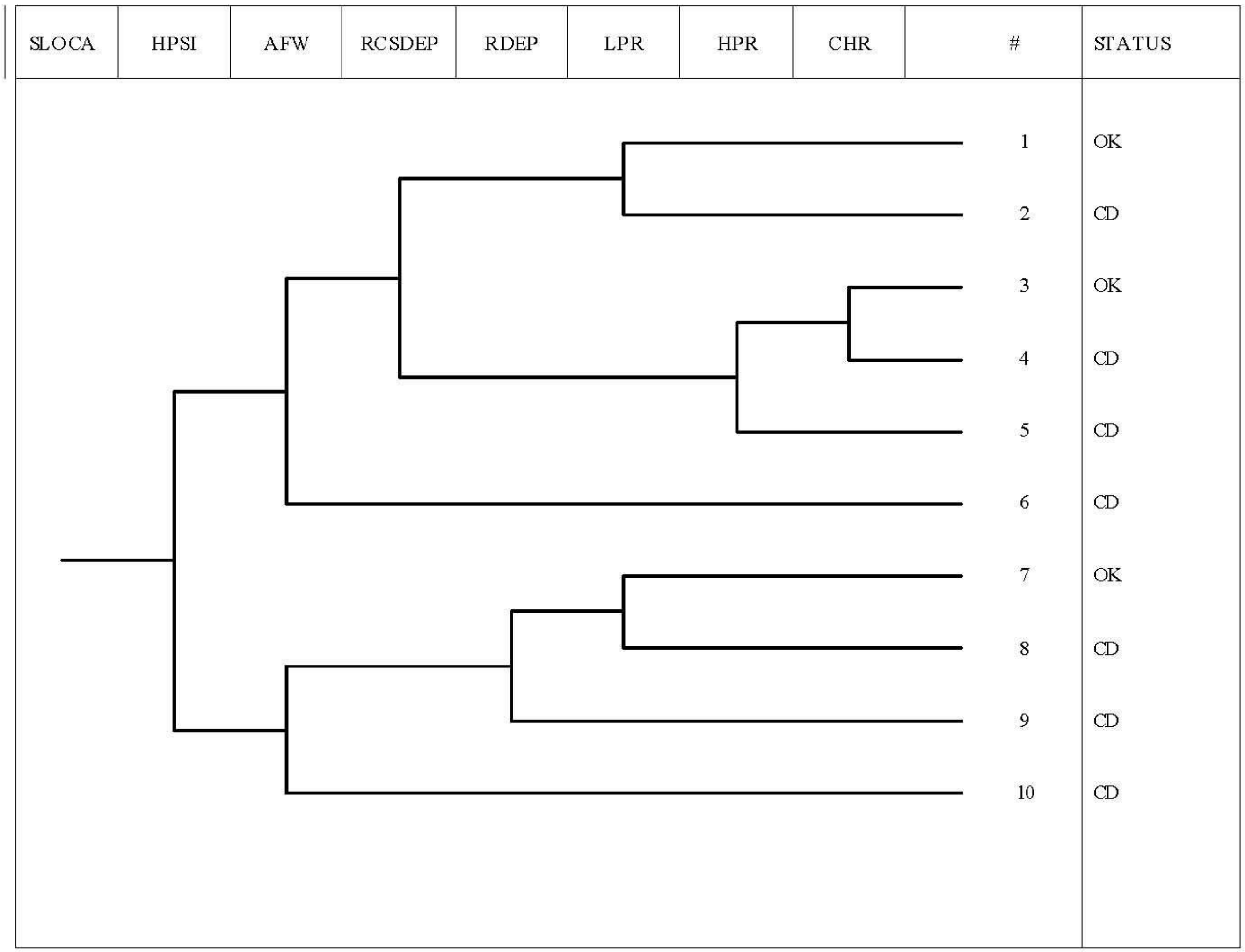
1. Transients With PCS Available (Reactor Trip) (TRANS)
2. Transients With Loss of PCS (TPCS)
3. Small LOCA (SLOCA)
4. Stuck-Open Relief Valve (SORV)
5. Medium LOCA (MLOCA)
6. Large LOCA (LLOCA)
7. Loss of Offsite Power (LOOP)
8. Steam Generator Tube Rupture (SGTR)
9. Anticipated Transients Without Scram (ATWS)
10. Main Steam Line Break (MSLB)

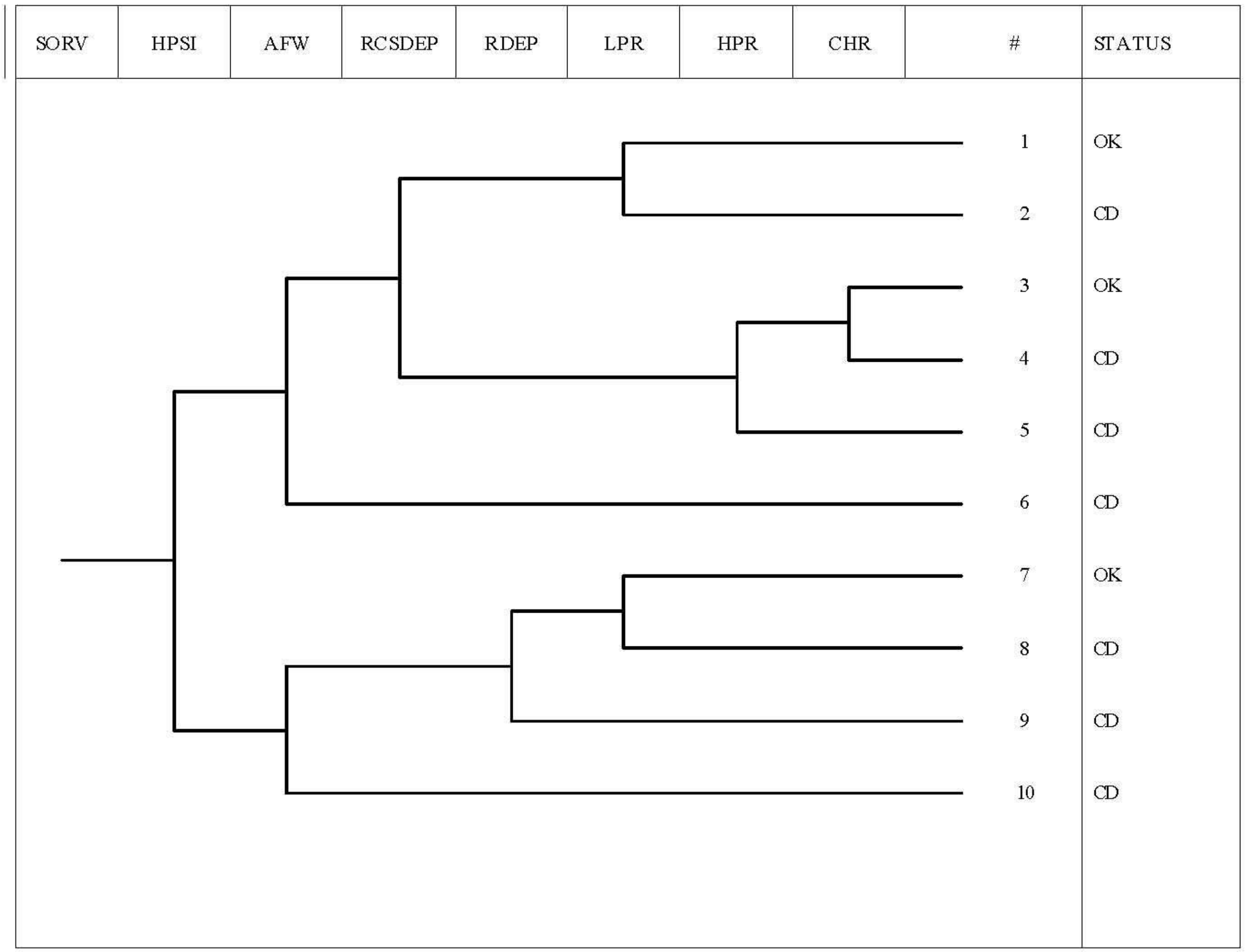
TRANS	AFW	PCS	#	STATUS
			1	OK
			2	OK
			3	CD

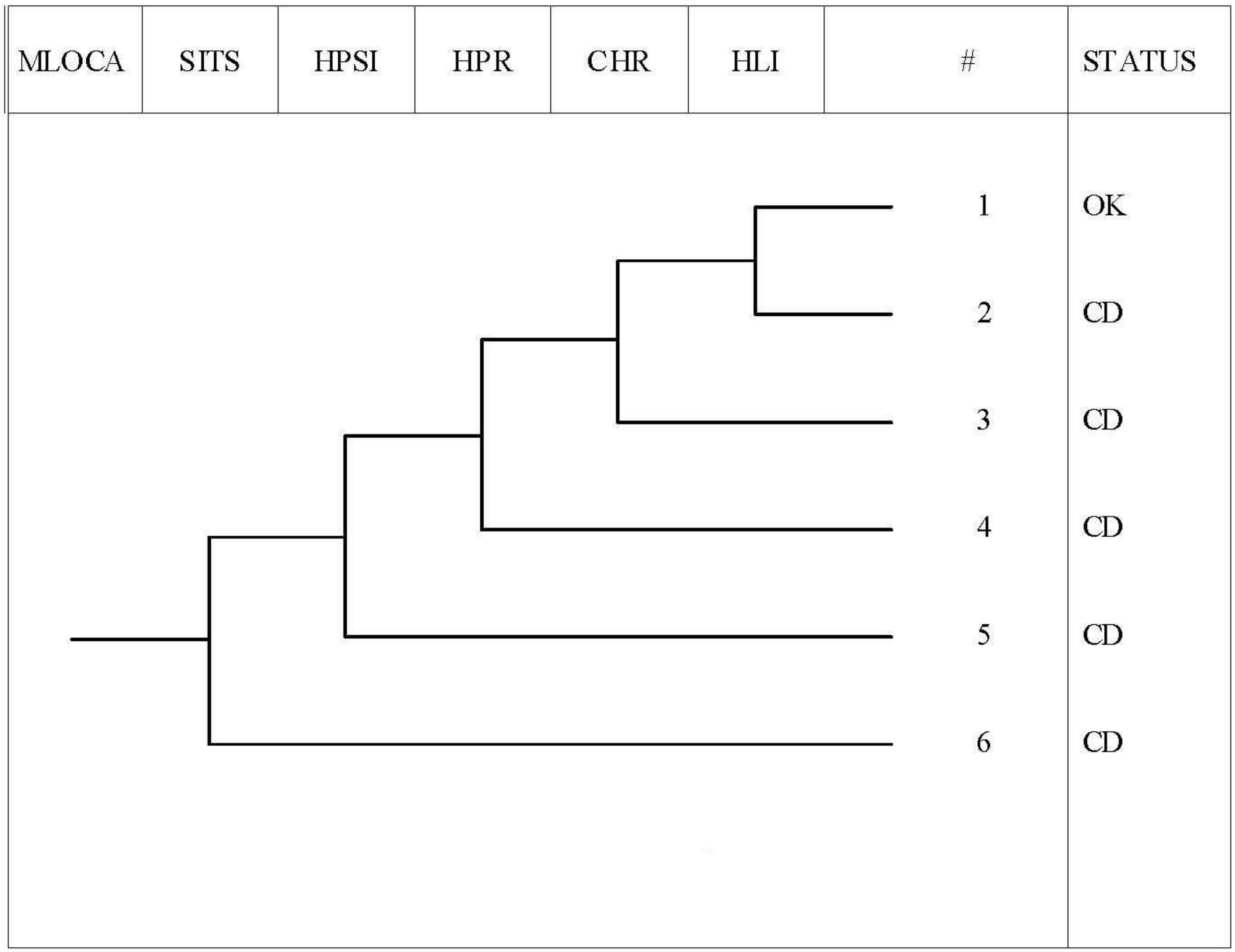




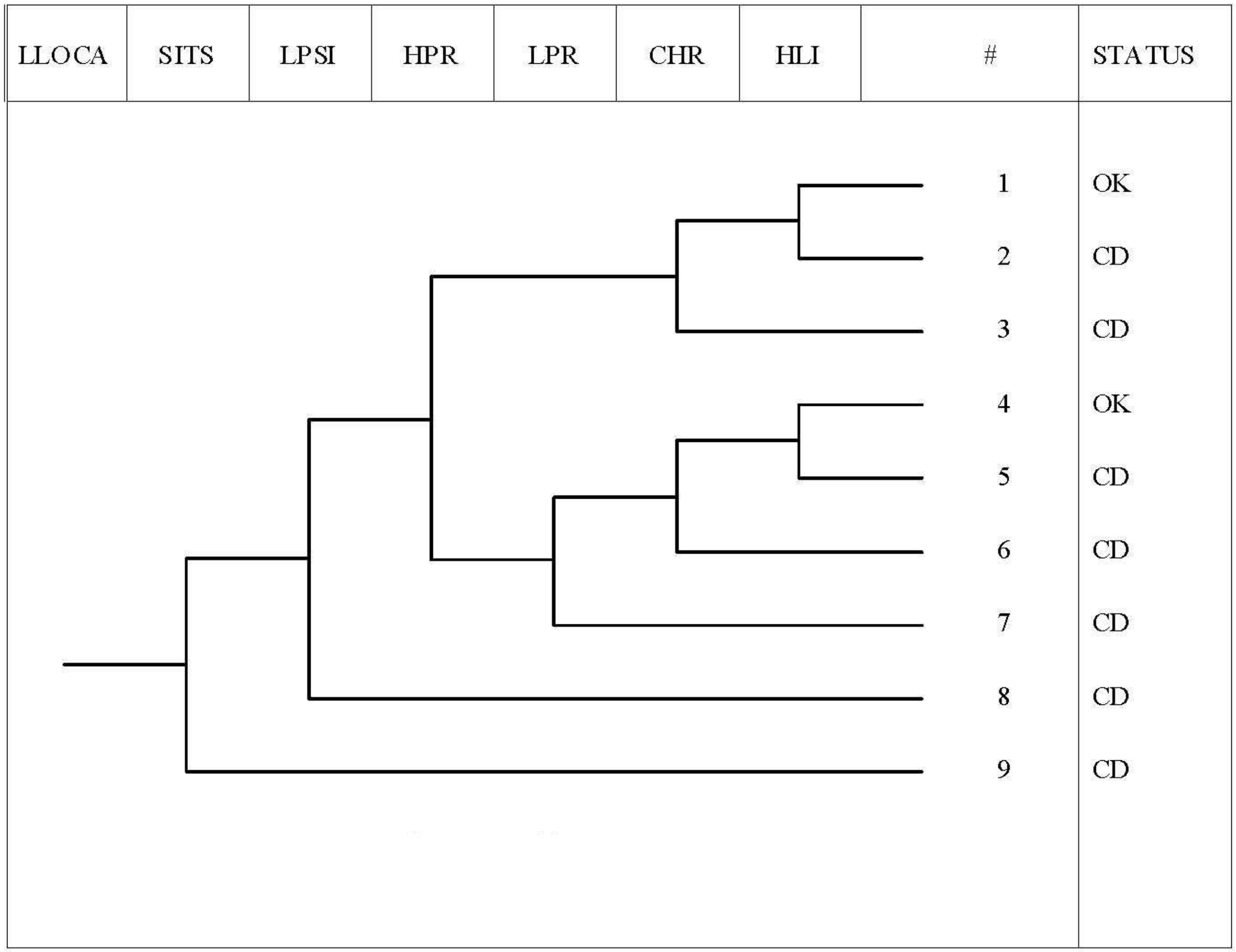
TPCS	AFW	#	STATUS
		1	OK
		2	CD

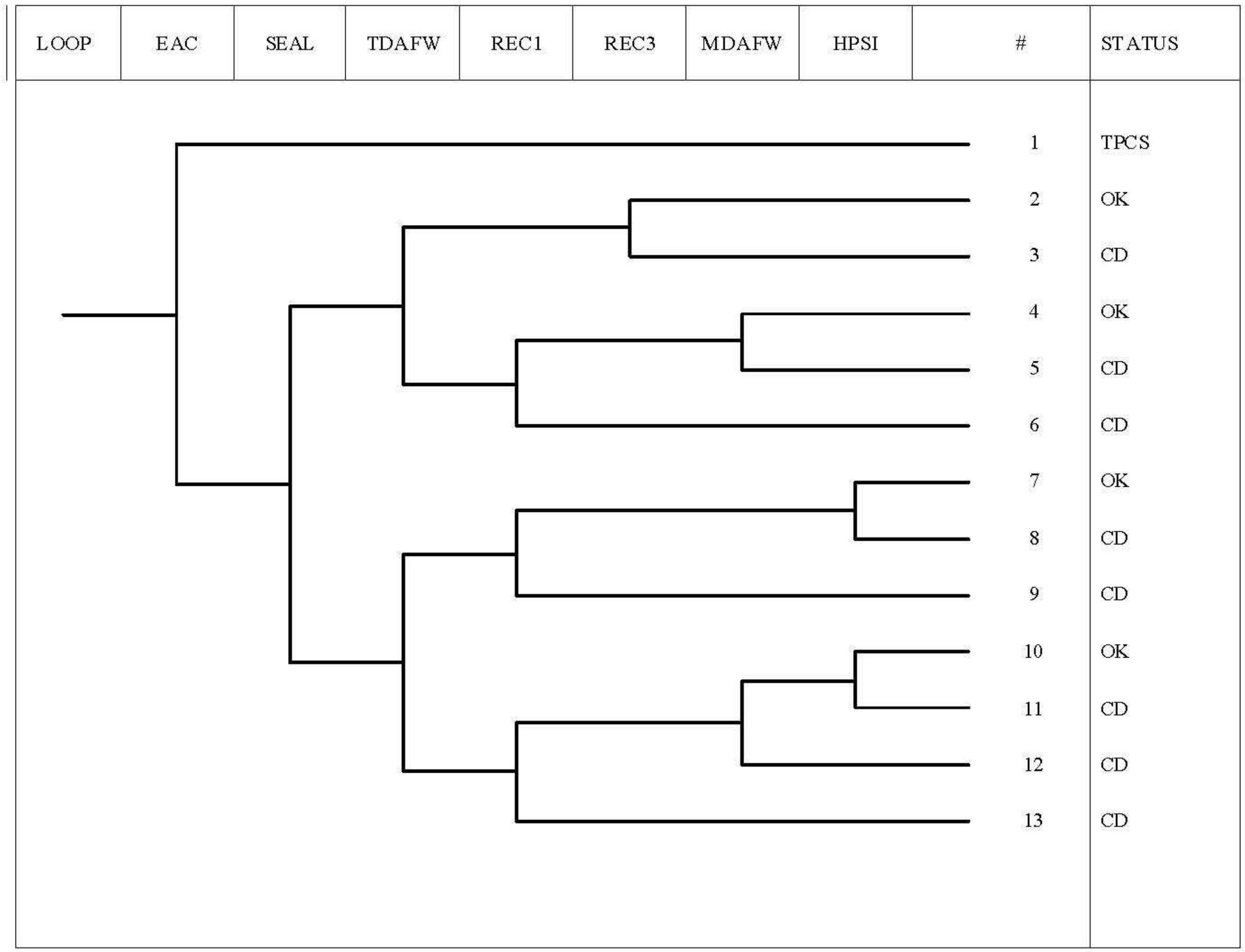

SLOCA
HPSI
AFW
RCSDEP
RDEP
LPR
HPR
CHR
#
STATUS
1 OK
2 CD
3 OK
4 CD
5 CD
6 CD
7 OK
8 CD
9 CD
10 CD

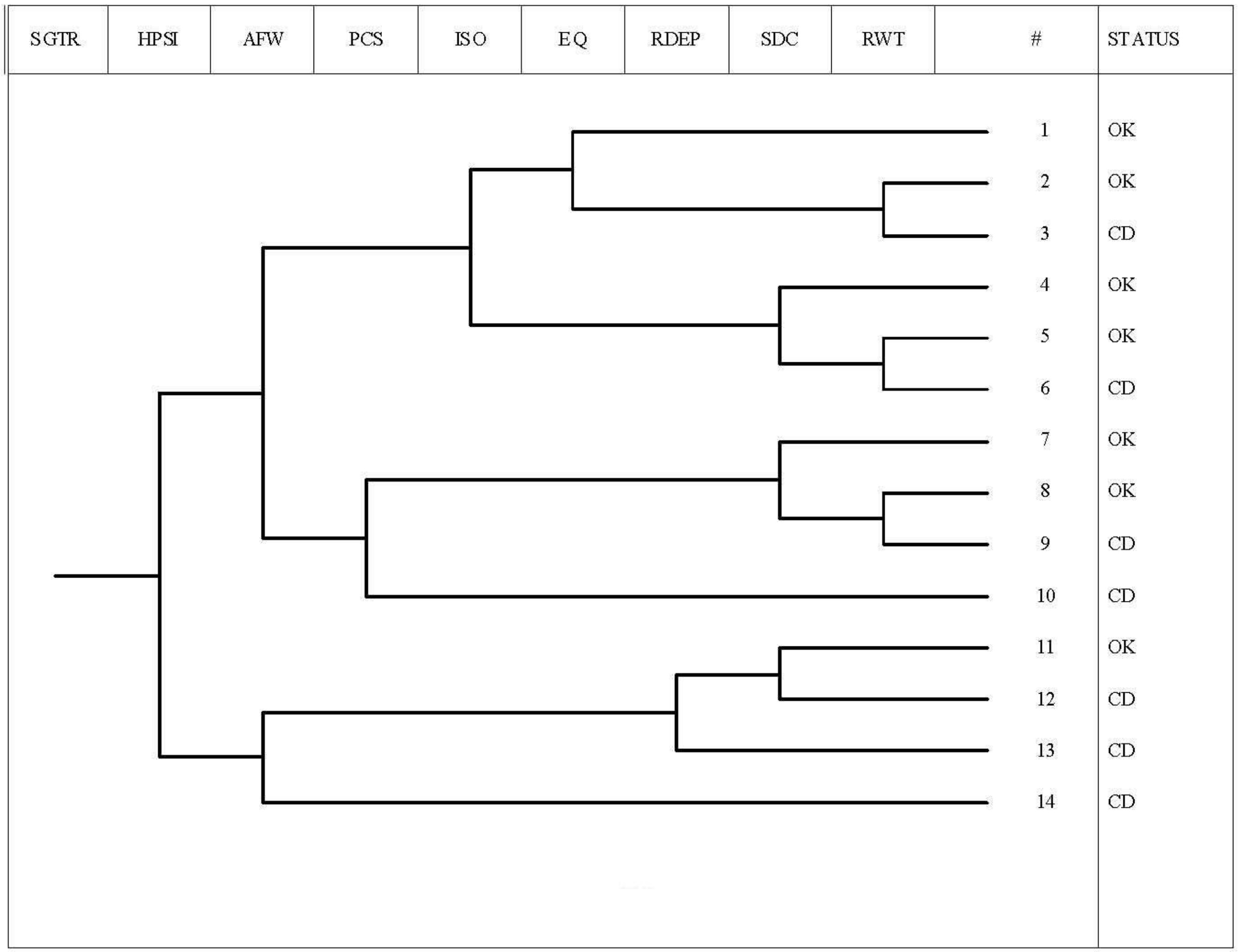

SORV
HPSI
AFW
RCSDEP
RDEP
LPR
HPR
CHR
#
STATUS
1
OK
2
CD
3
OK
4
CD
5
CD
6
CD
7
OK
8
CD
9
CD
10
CD

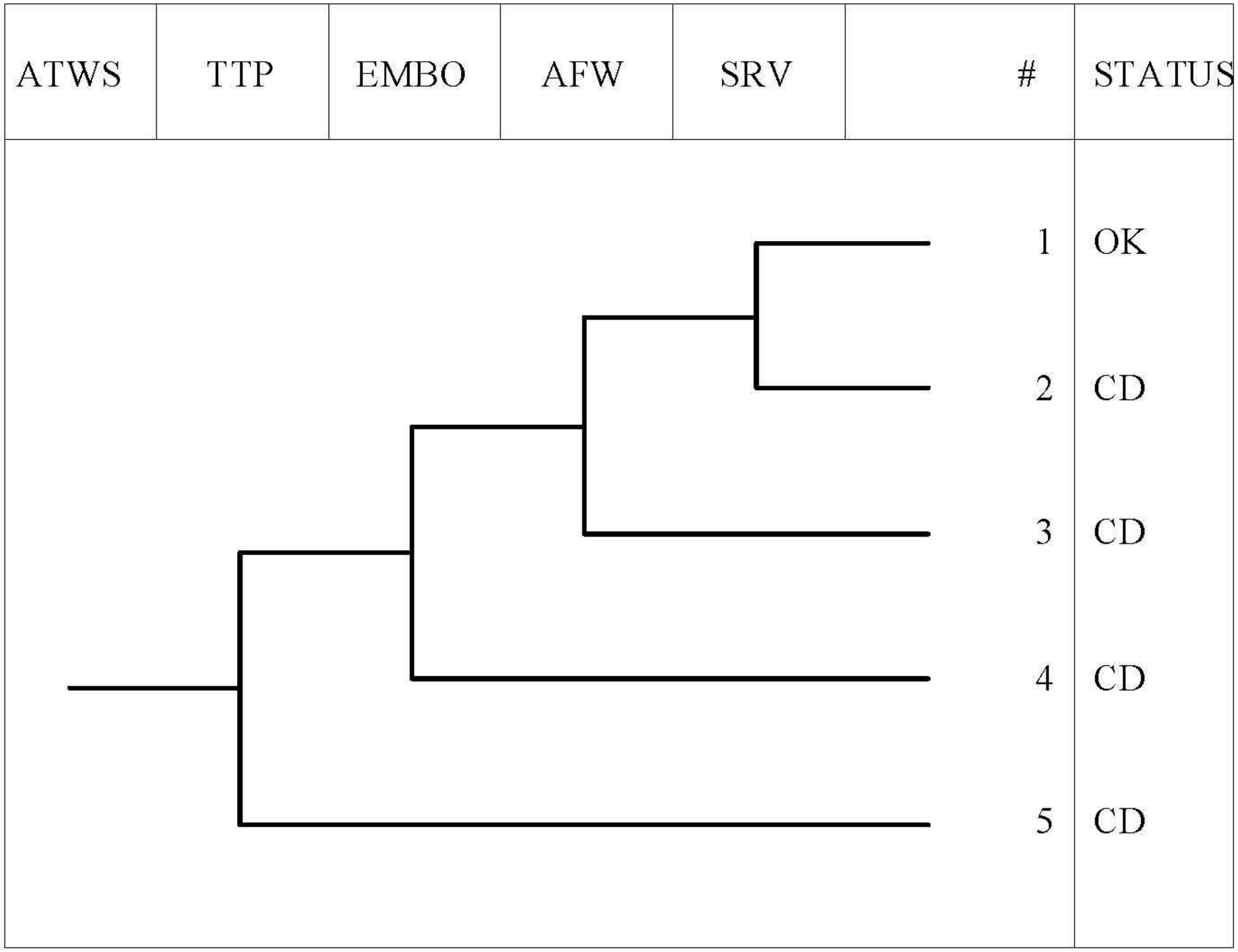


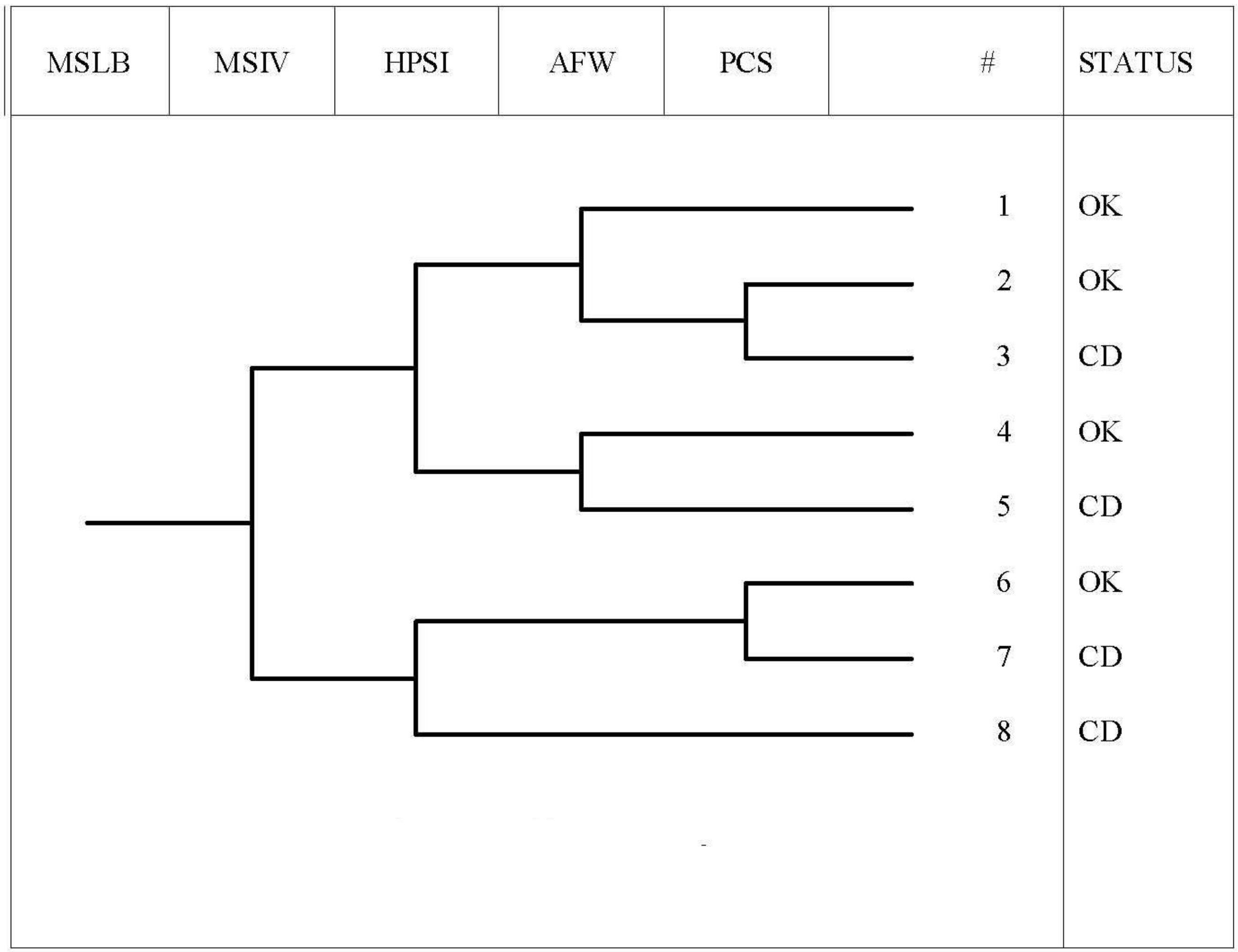
MLOCA
SITS
HPSI
HPR
CHR
HLI
#
STATUS
1
OK
2
CD
3
CD
4
CD
5
CD
6
CD


LLOCA
SITS
LPSI
HPR
LPR
CHR
HLI
#
STATUS
1 OK
2 CD
3 CD
4 OK
5 CD
6 CD
7 CD
8 CD
9 CD


LOOP
EAC
SEAL
TDAFW
REC1
REC3
MDAFW
HPSI
#
STATUS
1 TPCS
2 OK
3 CD
4 OK
5 CD
6 CD
7 OK
8 CD
9 CD
10 OK
11 CD
12 CD
13 CD


SGTR
HPSI
AFW
PCS
ISO
EQ
RDEP
SDC
RWT
#
STATUS
1 OK
2 OK
3 CD
4 OK
5 OK
6 CD
7 OK
8 OK
9 CD
10 CD
11 OK
12 CD
13 CD
14 CD


ATWS
TTP
EMBO
AFW
SRV
#
STATUS
1
OK
2
CD
3
CD
4
CD
5
CD


MSLB
MSIV
HPSI
AFW
PCS
#
STATUS
1 OK
2 OK
3 CD
4 OK
5 CD
6 OK
7 CD
8 CD

2. BENCHMARKING OF RISK SIGNIFICANCE OF INSPECTION FINDINGS USING THE NOTEBOOK

A benchmarking of the notebook was conducted by assessing the risk significance of an inspection finding to be obtained using the notebook and comparing the result to that obtained based on an evaluation using the detailed plant-specific PRA. Components identified in Table 2 of this document and operator actions modeled in the worksheets (Table 3 of this document) were considered for benchmarking. An inspection finding postulating that the component remains out of service for one year, i.e., a period greater than 30 days, or the operator will fail to carry out the required action was considered for the benchmarking. The color of the inspection finding noted in Table 4 will change based on the actual finding and its impact, and the exposure time of the degraded condition.

Table 4 summarizes the benchmarking results. The table provides a list of components, judged out-of-service based on an inspection finding, and failed operator actions. Risk significance or colors for these items are evaluated and compared. The third column of the table denotes the basic event in the plant-specific PRA for the item, i.e., the basic event which is used to calculate the risk achievement worth (RAW) for the component or the failed operator action. The RAW, in terms of a ratio, is presented in the next column. The color represented by the plant PRA is based on the RAW thresholds presented at the top of the table. The RAW thresholds are calculated using the base case CDF and the delta CDF representing the color, i.e., delta CDF of 1E-6 for White (W), delta CDF of 1E-5 for Yellow (Y), and delta CDF of 1E-4 for Red (R). A value below the White threshold signifies a Green (G) finding. A value above the defined threshold for a particular color signifies that color. The Red findings are further delineated in terms of the severity of the impact. When the delta CDF impact is greater than 1E-4, but less than 1E-3, it is termed Red (4) or red (R). Similarly, Red (3) represents a delta CDF impact in the range of 1E-3 and 1E-2, and Red (2) represents a delta CDF impact between 1E-2 and 1E-1. The fifth column defines the color based on the RAW value of the plant PRA. The RAW values are obtained from the importance measure calculations using the plant PRA. In select cases, separate computer runs are made to obtain the specific RAW value. The sixth column gives the color of the inspection finding obtained using the notebook. Assessment of color of an inspection finding based on the notebook follows the Usage Rules and is conducted using an EXCEL spreadsheet program. The color of the inspection finding, based on CDF contributions, is presented. In some cases, consideration of LERF contributors may signify a higher color. Such cases are noted with an asterisk (*). For those plants where integrated models were available for both internal and external events, consideration of external event contributors could elevate the importance of the component. These cases are identified by double asterisks (**) and specific characteristics are defined in the note. The last column provides any applicable comments, specifically noting the comparison of results between the notebook and the plant PRA.

Differences in the results between the notebook and the plant PRA are noted in terms of higher and lower risk estimates by the notebook. When the color obtained using the notebook represents a higher risk significance than the plant PRA, then it is noted as a higher risk estimate. Conversely, when the color obtained using the notebook represents a lower risk significance, then it is noted as a lower risk estimate. The order of magnitude difference is also noted. The notebook is designed to be a screening tool and is expected to provide a slightly conservative result. An higher risk estimate by one order of magnitude is not unlikely considering the conservatism in modeling assumptions, assignment of generic mitigation credit, and the rules for estimation. Reasons for an higher risk estimate by two or more orders of magnitude and any lower risk estimates are briefly discussed. The comments column and notes are used to explain these differences and to provide any additional useful information relating to the color evaluated by the notebook and the plant PRA.

Table 4 Benchmarking Table for Generic PWR Plant;
Licensee's PRA Against Rev. 2 SDP Notebook Internal Event CDF
Excluding Flood Contribution = x.xxE-5/reactor-year
RAW Thresholds: White = x.xx; Yellow = x.xx; Red (4) =x.xx; Red (3) = xx.xx; Red (2) = xxx.xx

No.	Components Out of Service or Failed Operator Actions	Basic Event Names	PRA RAW Values	PRA Colors	Colors by Rev. 2 SDP Notebook	Comments
1	TD AFW train (train A)			Red (4)	Red (4)	Match
2	MD AFW Essential train (train B)			Red (4)	Red (4)	Match
3	MD AFW non-essential train (train X)			Red (4)	Red (4)	Match
4	One Condensate pump (Alternate feedwater)			White	White	Match
5	One ADV			Green	Yellow	Over by 2 orders (7)
6	One Charging pump			Green	Green	Match
7	One Boric Acid Makeup pump			Green	Green * (8)	Match
8	One Auxiliary Pressurizer Spray valve			Green	Green	Match
9	One CS train			White	White	Match
10	ESFAS train A			Yellow	Red (4)	Over by 1 order
11	ESFAS train B			Red (4)	Red (4)	Match
12	One HPSI pump			White	Yellow	Over by 1 order

No.	Components Out of Service or Failed Operator Actions	Basic Event Names	PRA RAW Values	PRA Colors	Colors by Rev. 2 SDP Notebook	Comments
13	Containment sump MOV UV-675			White	Yellow	Over by 1 order
14	One LPSI pump			Green	Yellow	Over by 2 orders (1)
15	One MSIV			White	White	Match
16	One Normal pressurizer spray			Green	Green	Match
17	One Pressurizer vent valve			Green	Green	Match
18	One SIT			Green	Yellow	Over by 2 orders (2)
19	One SRV (FTO)			White	White	Match
20	One SRV (FTC)			White	White	Match
21	One SDC HX			White	White	Match
22	One TBV			Green	White	Over by 1 order
23	One MSSV			Green	Green	Match
24	One Air Handling Unit (Train B DC Eq Rm Ess ACU)			Green	Green	Match
25	Damper in DC Equipment Room (fails normal AHU and 1 train of ACU)			Yellow	Red (4)	Over by 1 order
26	One Essential Chiller (EC) train B			Yellow	Red (4)	Over by 1 order

No.	Components Out of Service or Failed Operator Actions	Basic Event Names	PRA RAW Values	PRA Colors	Colors by Rev. 2 SDP Notebook	Comments
27	One Essential Cooling Water (EW) train B			Yellow	Red (4)	Over by 1 order
28	One Spray pond (SP) train B			Yellow	Red (4)	Over by 1 order
29	One IA compressor			Green	White	Over by 1 order
30	One Nuclear Cooling Water (NC) pump			Green	White	Over by 1 order
31	One Plant Cooling Water (PW) pump (standby)			Green	Yellow	Over by 2 orders [4]
32	One Turbine Cooling Water (TC) train			White	Red (4)	Over by 2 orders [4]
33	One 4.16 kV AC bus			Red (3)	Red (3)	Match
34	One EDG			Yellow	Yellow	Match
35	Battery A			Red (4)	Red (3)	Over by 1 order
36	Battery B			Red (3)	Red (3)	Match
37	Battery Charger A			White	Red (4)	Over by 2 orders [6]
38	One 120 V-AC instrument channel			White	Yellow	Over by 1 order
39	One DG room cooling fan			Yellow	Yellow	Match
40	One Gas Turbine generator			Green	Green	Match
	Operator Actions					

No.	Components Out of Service or Failed Operator Actions	Basic Event Names	PRA RAW Values	PRA Colors	Colors by Rev. 2 SDP Notebook	Comments
41	Failure to use Alt. Feedwater (PCS)			Yellow	Red (4)	Over by 1 order
42	Failure to align non-essential AFW MDP			Red (4)	Red (4)	Match
43	RCS Dep in SLOCA			Green	White	Over by 1 order
44	Operator fails to restart LPSI in LPSR			Green	Green	Match
45	Operator fails to initiate HLI for MLOCA and LLOCA			Yellow	Red (4)	Over by 1 order
46	SG isolation and pressure equalization in SGTR			Green	White *	Over by 1 order
47	Operator fails to makeup RWT in SGTR			Yellow	Yellow *	Match
48	Initiate SDC in SGTR			Green	Green	Match
49	Use GTG			White	Green	Under by 1 order (5)
50	Operator fails to initiate emergency boration			White	White	Match

Notes:

1. In SLOCA scenarios, the assumption in the SDP notebook is that recirculation will be needed. Operators can depressurize and conduct low pressure recirculation. On failure to depressurize, operators will conduct high pressure recirculation. In the plant PRA, in SLOCA, following successful HPSI and AFW, it is modeled that recirculation is not necessary and operators can initiate shutdown cooling to terminate the accident. This difference in assumption makes LPSI pumps more significant in the notebook evaluation.

2. The MLOCA and LLOCA frequencies are higher in the notebook compared to the plant PRA and, also, in the notebook it is assumed that depressurization in a SGTR requires all 4 SITs. In the SDP notebook, success criteria for RCS depressurization in SGTR is assumed to be the same as that for SLOCA. In the plant PRA, for SGTR, all 4 SITs are not assumed required for SGTR. This difference has led to the difference in risk significance assessed between the notebook and the plant PRA.

3. The RAW for a single TBV was not available. However, the RAW for the common-cause failure of the TBVs was green. Given that the RAW for failing all the TBVs is green, it is assumed that the RAW for failure of a single TBV is green.

4. In the plant PRA, the loss of one pump increases the IE frequency by one order of magnitude, whereas in the SDP evaluation it is increased by two orders. Also, the mitigation credit, which primarily consists of the AFW system, differs by about an order of magnitude. These two differences result in two orders of magnitude difference between the notebook and the plant PRA.

5. This lower risk estimate resulted from the rounding error in the SDP evaluation process. The LOOP frequency is a factor of 3 higher than the assumed value (a Row II placement of LOOP implies a frequency of 1E-2/reactor-year) and the Unavailability of both EDGs failing is a factor of 5 higher. (The unavailability is approximately 5E-3 whereas in the notebook it is considered 1E-3 based on the categorization of 1 multi-train system.) The differences led to the lower risk estimate by the notebook.

6. The battery charger is of higher risk significance in the SDP evaluation primarily due to differences in assumptions in the notebook evaluation compared to the assumptions involved in the plant PRA evaluation. In the notebook evaluation, the failure is assumed to last for a year. Such failures are alarmed in the control room and are immediately detected. Because of the availability of the spare charger, the impact is low in the plant PRA. In the notebook, the base credit is counted for all applicable sequences and, by the counting rule, leads to a higher risk significance.

7. Multiple redundancies exist in case of an ADV failure. Typically, success criteria involve 1 of 4 ADVs or 1 of 8 TBVs. The impact of the loss of an ADV is negligible. However, in the order of magnitude evalution conducted in the SDP evaluations, the impact is evaluated nominally, resulting in a higher risk significance.

8. The ‘*’ after the color by this SDP notebook indicates that the item in the target list has the potential for higher risk significance due to LERF considerations.

3. RESOLUTION OF PLANT-SPECIFIC COMMENTS

Licensee comments and information on plant-specific PRA updates (obtained during initial benchmarking) were incorporated in the Rev. 1 notebook. Post issuance of the Rev. 1 notebook, the licensee submitted additional comments and information on the latest PRA updates which are incorporated in this Rev. 2 notebook. The following sections document the changes made to the Rev. 2 and Rev. 1 notebooks, respectively.

Summary of Changes Addressed in Preparing the Rev. 2 Notebook

The Revision 2 SDP notebook was generated based on the Rev. 1 SDP notebook and the Technical Basis Document [3] which provides a standard format and content based on a set of instructions and generic assumptions. In addition to these standard changes, the following modifications were incorporated into the Rev. 2 SDP notebook based on the information received from the licensee:

[Specific changes removed]

Summary of Changes Addressed in Preparing the Rev. 1 Notebook

The following changes were made based on the licensee's inputs during benchmarking and evaluations conducted during benchmarking:

[Specific changes removed]

REFERENCES

1. SECY-99-007A, Recommendations for Reactor Oversight Process Improvements (Follow-up to SECY-99-007), U.S. Nuclear Regulatory Commission, March 22, 1999.

2. NRC Inspection Manual Chapter 0308, Reactor Oversight Process (ROP) Basis Document, U.S. Nuclear Regulatory Commission, Issue date February 21, 2003.

3. Technical Basis Document for At-Power Significance Determination Process (SDP) Notebooks, M. A. Azarm, P. K. Samanta, G. Martinez-Guridi, and J. Higgins, Brookhaven National Laboratory, BNL-72341-2004, May 2004.

4. [Reference removed]

5. [Reference removed]

6. [Reference removed]

7. [Reference removed]