

May 10, 2001

Mr. Ted C. Feigenbaum
Executive Vice President and
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North Atlantic Energy Service Corporation
c/o Mr. James M. Peschel
P.O. Box 300
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SUBJECT: SITE-SPECIFIC WORKSHEETS FOR USE IN THE NUCLEAR REGULATORY
COMMISSION'S SIGNIFICANCE DETERMINATION PROCESS
(TAC NO. MA6544)

Dear Mr. Feigenbaum:

Enclosed please find the Risk-Informed Inspection Notebook which incorporates the updated Significance Determination Process (SDP) Phase 2 Worksheets that inspectors will be using to characterize and risk-inform inspection findings. This document is one of the key implementation tools of the reactor safety SDP in the reactor oversight process and is also publically available through the Nuclear Regulatory Commission (NRC) external website at <http://www.nrc.gov/NRC/IM/index.html>.

The 1999 Pilot Plant review effort clearly indicated that significant site-specific design and risk information was not captured in the Phase 2 Worksheets forwarded to you last spring. Subsequently, a site visit was conducted by the NRC to verify and update plant equipment configuration data and to collect site-specific risk information from your staff. The enclosed document reflects the results of this visit.

The enclosed Phase 2 Worksheets have incorporated much of the information we obtained during our site visits. The staff encourages further licensee comments where it is identified that the worksheets give inaccurately low significance determinations. Any comments should be forwarded to the Chief, Probabilistic Safety Assessment Branch, Office of Nuclear Reactor Regulation. We will continue to assess SDP accuracy and update the document based on continuing experience.

While the enclosed Phase 2 Worksheets have been verified by our staff to include the site-specific data, we will continue to assess its accuracy throughout implementation and update the document based on comments by our inspectors and your staff.

T. Feigenbaum

- 2 -

We will coordinate our efforts through your licensing or risk organizations as appropriate. If you have any questions, please contact me at 301-415-1484.

Sincerely,

/RA/

Victor Nerses, Senior Project Manager, Section 2
Project Directorate I
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

Docket No. 50-443

Enclosure: As stated

cc w/encl: See next page

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- 2 -

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**RISK-INFORMED INSPECTION NOTEBOOK FOR
SEABROOK STATION**

PWR, WESTINGHOUSE, FOUR-LOOP PLANT WITH LARGE DRY CONTAINMENT

Prepared by

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NOTICE

This notebook was developed for the NRC's inspection teams to support risk-informed inspections. The activities involved in these inspections are discussed in "Reactor Oversight Process Improvement," SECY-99-007A, March 1999. The user of this notebook is assumed to be an inspector 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. This notebook 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, Probabilistic Safety Assessment Branch, NRR, with a copy to the Chief, Inspection Program Branch, NRR.

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ABSTRACT

This notebook contains summary information to support the Significance Determination Process (SDP) in risk-informed inspections for the Seabrook Station.

The information includes the following: Categories of Initiating Events Table, Initiators and System Dependency Table, SDP Worksheets, and SDP Event Trees. 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. The Categories of Initiating Event Table is used to determine the likelihood rating for the applicable initiating events. The SDP worksheets are used to assess the remaining mitigation capability rating for the applicable initiating event likelihood ratings 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 information contained herein is based on the licensee's Individual Plant Examination (IPE) submittal, the updated Probabilistic Risk Assessment (PRA), and system information obtained from the licensee during site visits as part of the review of earlier versions of this notebook. Approaches used to maintain consistency within the SDP, specifically within similar plant types, resulted in sacrificing some plant-specific modeling approaches and details. Such generic considerations, along with changes made in response to plant-specific comments, are summarized.

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1. INFORMATION SUPPORTING SIGNIFICANCE DETERMINATION PROCESS (SDP)

SECY-99-007A (NRC, March 1999) describes the process for making a Phase 2 evaluation of the inspection findings. The first step in this is to identify the pertinent core damage 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 Rating for Initiating Event Categories
2. Initiators and System Dependency Table
3. Significance Determination Process (SDP) Worksheets
4. SDP Event Trees.

Table 1, Categories of Initiating Events, is used to estimate the likelihood rating for different initiating events for a given degraded condition and the associated exposure time at the plant. This Table follows the format of Table 1 in SECY-99-007A. Initiating events are grouped in frequency bins that are 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); inadvertent or stuck open relief valve (IORV or SORV); 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.

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 nor comprehensive compilation of the dependency matrix, as known in Probabilistic Risk Assessments (PRAs). 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 used to identify the SDP worksheets to be evaluated, corresponding to the inspection's findings on systems and components.

To evaluate the impact of the inspection's findings on the core-damage scenarios, SDP worksheets are provided. There are two sets of SDP worksheets; one for those initiators that can be mitigated by redundant trains of safety systems, and the other for those initiators that cannot be mitigated; however, their occurrence is prevented by several levels of redundant barriers.

The first set of SDP worksheets contain two parts. The first 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 SDP worksheets are developed for each of the initiating event categories, including the "Special Initiators", the exception being those which directly lead to a core damage (the inspections of these initiators are assessed differently; see SECY-99-007A). The special initiators are those that are caused by complete or partial loss of support systems. A special initiator typically leads to a reactor scram and degrades some frontline or support systems (e.g., Loss of CCW in PWRs).

In considering the special initiators, we defined a set of criteria for including them to maintain some consistency across the plants. These conditions are as follows:

1. The special initiator should degrade at least one of the mitigating safety functions thereby changing its mitigation capability in the worksheet. For example, when a safety function with two redundant trains, classified as a multi-train system, degrades to a one-train system, it is classified as 1 Train, due to the loss of one of the trains as a result of the special initiator.
2. The special initiators which degrade the mitigation capability of the systems/functions associated with the initiator from comparable transient sequences by two and higher orders of magnitude must be considered.

From the above considerations, the following classes of initiators are considered in this notebook:

1. Transients with power conversion system (PCS) available, called Transients (Reactor trip) (TRANS),
2. Transients without PCS available, called Transients w/o PCS (TPCS),
3. Small Loss of Coolant Accident (SLOCA),
4. Stuck-open Power Operated Relief Valve (SORV),
5. Medium LOCA (MLOCA),
6. Large LOCA (LLOCA),
7. Steam Generator Tube Rupture (SGTR),
8. Anticipated Transients Without Scram (ATWS), and
9. Main Steam Line Break (MSLB).

Examples of special initiators included in the notebook are as follows:

1. Loss of Offsite Power (LOOP),
2. LOOP with failure of 1 Emergency AC bus or associated EDG (LEAC),
3. Loss of 1 DC Bus (LDC),
4. Loss of component cooling water (LCCW),
5. Loss of instrument air (LIA),

6. Loss of service water (LSW).

The worksheet for the LOOP includes LOOP with emergency AC power (EAC) available and LOOP without EAC, i.e., Station Blackout (SBO). LOOP with partial availability of EAC, i.e., LOOP with loss of a bus of EAC, is covered in a separate worksheet to avoid making the LOOP worksheet too large. In some plants, LOOP with failure of 1 EAC bus is a large contributor to the plant's core damage frequency (CDF).

The second set of SDP worksheets addresses those initiators that cannot be mitigated, i.e., can directly lead to core-damage. It currently includes the Interfacing System LOCA (ISLOCA) initiator. ISLOCAs are those initiators that could result in a loss of RCS inventory outside the containment, sometimes referred to as a "V" sequence. In PWRs, this event effectively bypasses the capability to utilize the containment sump recirculation once the RWST has emptied. Also, through bypassing the containment, the radiological consequences may be significant. In PWRs, this typically includes loss of RCS inventory through high- and low-pressure interfaces, such as RHR connections, RCP thermal barrier heat-exchanger, high-pressure injection piping if the design pressure (pump head) is much lower than RCS pressure, and, potentially, through excess letdown heat exchanger. RCS inventory loss through ISLOCA could vary significantly depending on the size of the leak path; some may be recoverable with minimal impact. The SDP worksheet for ISLOCA, therefore, identifies the major consequential leak paths, and the barriers that should fail, allowing the initiator to occur.

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.

The following items were considered in establishing the SDP event trees and the core-damage sequences in the SDP worksheets:

1. Event trees and sequences were developed such that the worksheet contains all the major accident sequences identified by the plant-specific IPEs/PRA. 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.
2. The event trees and sequences for each plant take into account the IPE/PRA models and event trees for all similar plants. For modeling the response to an initiating event, any major deviations in one plant from similar plants may be noted at the end of the worksheet.
3. The event trees and the sequences were designed to capture core-damage scenarios, without including containment-failure probabilities and consequences. Therefore, branches of event trees that are developed only for the purpose of a Level II PRA analysis are not considered. The resulting sequences are merged, using Boolean logic.
4. The simplified event trees focus on classes of initiators, as defined above. In so doing, many separate event trees in the IPEs/PRA often are represented by a single tree. For example, some IPEs/PRA

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.

5. Major actions by the operator during accident scenarios are credited using four 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), operator action=3 (error probability of 5E-4 to 5E-3), and operator action=4 (error probability of 5E-5 to 5E-4). An 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. Operator's actions belonging to category 4, i.e., operator action=4, may only be noted at the bottom of worksheet because, in those cases, equipment failures may have the dominating influence in determining the significance of the findings.

The four sections that follow include Categories for Initiating Events Table, Initiators and Dependency Table, SDP worksheets, and the SDP event trees for the Seabrook Station.

1.1 INITIATING EVENT LIKELIHOOD RATINGS

Table 1 presents the applicable initiating events for this plant and their estimated likelihood ratings corresponding to the exposure time for degraded conditions. The initiating events are grouped into rows based on their frequency. As mentioned earlier, loss of offsite power (LOOP) 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.

Table 1 Categories of Initiating Events for Seabrook Station

Row	Approximate Frequency	Example Event Type	Estimated Likelihood Rating		
			A	B	C
I	> 1 per 1-10 yr	Loss of Power Conversion System (TPCS)	A	B	C
II	1 per 10-10 ² yr	Loss of offsite power (LOOP)	B	C	D
III	1 per 10 ² - 10 ³ yr	Small LOCA including RCP seal failures (SLOCA), SGTR, Stuck open PORV/SRV (SORV), MSLB (outside containment), Loss of one train of CCW (LOCC), Loss of 125 VDC Vital Bus A (LDCA), Loss of 125 VDC Vital Bus B (LDCB), Loss of Class 1E 4.16 kV AC Bus A (E5) (LACA), Loss of Class 1E 4.16 kV AC Bus B (E6) (LACB)	C	D	E
IV	1 per 10 ³ - 10 ⁴ yr	Medium LOCA (MLOCA), LOOP and Loss of Class 1E 4.16 kV AC Bus A (E5) (LOAA), LOOP and Loss of Class 1E 4.16 kV AC Bus B (E6) (LOAB)	D	E	F
V	1 per 10 ⁴ - 10 ⁵ yr	Large LOCA (LLOCA)	E	F	G
VI	less than 1 per 10 ⁵ yr	ATWS ¹ , ISLOCA	F	G	H
			> 30 days	3-30 days	< 3 days
			Exposure Time for Degraded Condition		

Note:

- The SDP worksheets for ATWS core damage sequences assume that the ATWS is not recoverable by manual actuation of the reactor trip function. Thus, the ATWS frequency to be used by these worksheets must represent the ATWS condition that can only be mitigated by the systems shown in the worksheet (e.g., boration).

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 systems' involvements in different initiating events are noted in the last column.

Table 2 Initiators and System Dependency for Seabrook Station

Affected Systems	Major Components	Support Systems	Initiating Event
AC Power System	AC Power: Two load groups, each with a Class 1E bus	Vital 125 VDC, Switchgear ventilation, Emergency power sequencer ¹	LACA, LACB
	120 VAC vital instrument power	AC Power, Vital 125 VDC	All
	Two diesel generators (one per load group)	Vital 125 VDC, SW, Diesel generator building ventilation, Fuel oil transfer pump	LOOP, LOAA, LOAB
DC Power System	Vital 125 VDC: two essential buses (11A and 11B), battery chargers and batteries. Batteries' rating is 4 hours.	AC Power (without AC, battery capacity is 4 hrs.)	LDCA, LDCB
Emergency Air Handling (EAH) ²	Containment Enclosure Cooling System: 2 trains, each with supply and return fans and a cooler unit	AC Power, CC, IA	All
Emergency Core Cooling System	SI system: Two SI pumps	AC Power, Vital 125 VDC, ESFAS, CC, EAH	All except LLOCA, ATWS
	Four accumulators ³		LLOCA
	CVCS: Two CVCS centrifugal charging pumps	AC Power, Vital 125 VDC, ESFAS, CC, EAH	All except LLOCA
	RHR: Two RHR pumps and two heat exchangers	AC Power, Vital 125 VDC, ESFAS, CC, EAH	All except ATWS
Emergency Feedwater (EFW) System	One MDP	AC Power, Vital 125 VDC, ESFAS, AMSAC, EPAH	TPCS, SLOCA, SORV, MLOCA, LOOP, SGTR, ATWS, MSLB, LOCC, LACB, LOAB

Table 2 (continued)

Affected Systems	Major Components	Support Systems	Initiating Event
	One TDP	Vital 125 VDC, IA ⁴ , MS, ESFAS, AMSAC, EPAH	All except LLOCA, MSLB, LDCB
	One start-up feed pump (SUFP) ⁵	Non-Vital AC Power (bus 4), Vital 125 VDC, Turbine Building Ventilation System	TPCS, SLOCA, SORV, MLOCA, SGTR, ATWS, MSLB, LOCC, LDCB, LACA
Emergency Pump House Air Handling (EPAH)	2 trains of ventilation (1 / 2 required for success), fans and dampers	Not found in IPE	All except LLOCA, LDCB
Engineered Safety Features Actuation System (ESFAS)	Two trains of relays, Solid State Protection System (SSPS) ⁶	120 VAC vital instrument power	All
Instrument Air (IA)	3 100% capacity compressors	AC Power, Vital 125 VDC, Secondary Closed Cooling (SCC)	All
Main Steam (MS)	4 Atmospheric Relief Valves (ARVs)	120 VAC vital instrument power, Vital 125 VDC, IA ⁴	All except LLOCA
	4 Main Steam Isolation Valves (MSIVs)	Vital 125 VDC, ESFAS	MSLB
	12 steam dump valves (SDVs) to condenser	120 VAC vital instrument power, Condenser vacuum, Circulating water, IA	All except LLOCA
Primary Component Cooling Water (CC)	Two trains, each with two full-capacity pumps and one heat exchanger	AC Power, Vital 125 VDC, SW, ESFAS	LOCC
Reactor Coolant Pressure Relief System (RCPRS)	Two PORVs and associated block valves	PORVs: Vital 125 VDC Block valves: Vital 4.16 kV	All except MLOCA, LLOCA, SGTR

Affected Systems	Major Components	Support Systems	Initiating Event
	Three safety valves	None	ATWS
Reactor Coolant Pumps (RCP)	Seals	1 / 2 centrifugal charging pumps to seal injection or 1 / 2 CC trains to thermal barrier heat exchanger	SLOCA
Service Water System (SWS)	Two trains, each with three pumps (2 ocean and 1 tower pump in each train)	AC Power, Service Water (isolation of secondary loads), cooling tower ventilation, ESFAS	All

Notes:

1. Unavailability of the emergency power sequencer can be recovered manually.
2. EAH supports ECCS room coolers.
3. Accumulators usually do not require support systems for their operation.
4. Valves have high pressure gas bottle back-up. Back-up capacities as shown below:
 EFW turbine driven pump steam supply valves: 4 cycles in 10 hours
 Atmospheric steam dump valves: 10 cycles in 10 hours
 Primary Component Cooling temperature control valves: 10 cycles in 6 hours
 Primary Component Cooling heat exchanger bypass valves: 10 cycles in 6 hours
5. The IPE (page E-96) states that EFW start-up feed pump is used only for the loss of main feedwater initiating event. The licensee subsequently provided comments indicating that the EFW start-up feed pump will auto start on main feedwater trip, and that an operator action is required for other initiating events.
6. When the SSPS has determined that unsatisfactory conditions exist, signals are sent to the ESFAS.
7. Plant total CDF = 3.6 E-5/yr. (total internal and external events of "1999 PRA" model). CDF of internal events= 1.7 E-5/yr.

1.3 SDP WORKSHEETS

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

1. Transients with Loss of Main Feedwater (TPCS)
2. Small LOCA (SLOCA)
3. Stuck-open PORV (SORV)
4. Medium LOCA (MLOCA)
5. Large LOCA (LLOCA)
6. Loss of Offsite Power (LOOP)
7. Steam Generator Tube Rupture (SGTR)
8. Anticipated Transients Without Scram (ATWS)
9. Main Steam Line Break Outside Containment (MSLB)
10. Loss of One Train of CCW (LOCC)
11. Loss of 125 VDC Vital Bus A (LDCA)
12. Loss of 125 VDC Vital Bus B (LDCB)
13. Loss of Class 1E 4.16 kV AC Bus A (E5) (LACA)
14. Loss of Class 1E 4.16 kV AC Bus B (E6) (LACB)
15. LOOP and Loss of Class 1E 4.16 kV AC Bus A (E5) (LOAA)
16. LOOP and Loss of Class 1E 4.16 kV AC Bus B (E6) (LOAB)
17. Interfacing System LOCA (ISLOCA)

Table 3.1 SDP Worksheet for Seabrook Station — Transients with Loss of Main Feedwater⁽¹⁾ (TPCS)

Estimated Frequency (Table 1 Row) _____ Exposure Time _____ Table 1 Result (circle): A B C D E F G H			
Safety Functions Needed: Secondary Heat Removal (EFW) Early Inventory Pressure Injection (EIHP) Primary Heat Removal, Feed/Bleed (FB) High Pressure Recirculation (HPR)		Full Creditable Mitigation Capability for Each Safety Function: 1/1 MDEFW pump (1 train) or 1/1 SUFP (1 train) or 1/1 TDEFW pump (1 ASD train) with 2/4 ARVs or 6/12 SDVs 1/2 charging pumps (1 multi-train system) or 1/2 SI pumps ⁽²⁾ (1 multi-train system) 1/2 PORVs and block valve open (with 1/2 charging pumps) or 2/2 PORVs and block valves open (with 1/2 SI pumps) for Feed/Bleed (operator action = 2) (1/2 charging pumps or 1/2 SI pumps) with (1/2 RHR pumps with 1/2 heat exchangers) and with operator action for switchover (operator action = 2) ⁽³⁾	
<u>Circle Affected Functions</u>	<u>Recovery of Failed Train</u>	<u>Remaining Mitigation Capability Rating for Each Affected Sequence</u>	<u>Sequence Color</u>
1 TPCS - EFW - HPR (3)			
2 TPCS - EFW - FB (4)			
3 TPCS - EFW - EIHP (5)			
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. Main feedwater is always lost due to a feedwater isolation on low Tave and a reactor trip. Thus, this worksheet covers both Transients (Reactor Trip) and Transients with loss of PCS.
2. Since both PORVs are needed to depressurize the RCS for using the SI pumps, these pumps cannot be credited for feed and bleed unless both PORVs are available.
3. High pressure recirculation requires operator to simply shut the suction from the RWST. The initiation logic will set up the system and open the sump suction valves automatically. According to licensee's comments, operator switchover to recirculation has a human error probability (HEP) = $2.66E-2$. An operator action credit of 2 is assigned.

Table 3.2 SDP Worksheet for Seabrook Station — Small LOCA (SLOCA)

Estimated Frequency (Table 1 Row) _____ Exposure Time _____ Table 1 Result (circle): A B C D E F G H			
Safety Functions Needed: Secondary Heat Removal (EFW) Early Inventory, High Pressure Injection (EIHP) Primary Heat Removal, Feed/Bleed (FB) RCS Cooldown / Depressurization (RCSDEP) Low Pressure Injection (LPI) High Pressure Recirculation (HPR) Low Pressure Recirculation (LPR)		Full Creditable Mitigation Capability for Each Safety Function: 1/1 MDEFW pump (1 train) or 1/1 SUFP (operator action = 2) ⁽¹⁾ or 1/1 TDEFW pump (1 ASD train) with 2/4 ARVs or 6/12 SDVs 1/2 charging pumps (1 multi-train system) or 1/2 SI pumps ⁽²⁾ (1 multi-train system) 1/2 PORVs and block valve open (with 1/2 charging pumps) or 2/2 PORVs and block valves open (with 1/2 SI pumps) for Feed/Bleed (operator action = 2) Operator depressurizes RCS using either the steam dump or atmospheric dump valves ⁽³⁾ (operator action = 2) 1/2 RHR pump trains (1 multi-train system) (1/2 charging pumps or 1/2 SI pumps) with (1/2 RHR pumps with 1/2 heat exchangers) and with operator action for switchover (operator action = 2) ⁽⁴⁾ 1/2 RHR pumps with 1/2 heat exchangers and with operator action for switchover (operator action = 3)	
<u>Circle Affected Functions</u>	<u>Recovery of Failed Train</u>	<u>Remaining Mitigation Capability Rating for Each Affected Sequence</u>	<u>Sequence Color</u>
1 SLOCA - LPR (2, 6)			
2 SLOCA - RCSDEP - HPR (4)			
3 SLOCA - EIHP - LPI (7)			
4 SLOCA - EIHP - RCSDEP (8)			

5 SLOCA - EFW - HPR (10)			
6 SLOCA - EFW - FB (11)			
7 SLOCA - EFW - EIHP (12)			
Identify any operator recovery actions that are credited to directly restore the degraded equipment or initiating event:			
<p>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.</p>			

Notes:

1. This action is represented in the "PSA - 1999 Update, Section 5.0, Table 5-3, Sheet 5" by the split fraction OSF2, HEP = 8.3E-3.
2. Since both PORVs are needed to depressurize the RCS for using the SI pumps, these pumps cannot be credited for feed and bleed unless both PORVs are available.
3. The specific success criteria for the valves used in the safety function RCSDEP was not found in the IPE.
4. High pressure recirculation requires operator to simply shut the suction from the RWST. The initiation logic will set up the system and open the sump suction valves automatically. According to licensee's comments, operator switchover to recirculation has a human error probability (HEP) = 2.66E-2. An operator action credit of 2 is assigned.

Table 3.3 SDP Worksheet for Seabrook Station — Stuck Open PORV (SORV)⁽¹⁾

Estimated Frequency (Table 1 Row) _____ Exposure Time _____ Table 1 Result (circle): A B C D E F G H			
Safety Functions Needed:		Full Creditable Mitigation Capability for Each Safety Function:	
Isolation of Small LOCA (BLK)	The closure of the block valve associated with stuck open PORV (operator action = 3)		
Secondary Heat Removal (EFW)	1/1 MDEFW pump (1 train) or 1/1 SUFP (operator action = 2) ⁽²⁾ or 1/1 TDEFW pump (1 ASD train) with 2 / 4 ARVs or 6 / 12 SDVs		
Early Inventory, High Pressure Injection (EIHP)	1/2 charging pumps (1 multi-train system) or 1/2 SI pumps ⁽³⁾ (1 multi-train system)		
Primary Heat Removal, Feed/Bleed (FB)	Stuck open PORV (with 1/2 charging pumps) or 1/1 PORV and block valve open (with 1/2 SI pumps) for Feed/Bleed ⁽⁴⁾ (operator action = 2)		
RCS Cooldown / Depressurization (RCSDEP)	Operator depressurizes RCS using either the steam dump or atmospheric dump valves ⁽⁵⁾ (operator action = 2)		
Low Pressure Injection (LPI)	1/2 RHR pump trains (1 multi-train system)		
High Pressure Recirculation (HPR)	(1/2 charging pumps or 1/2 SI pumps) with (1/2 RHR pumps with 1/2 heat exchangers) and with operator action for switchover (operator action = 2) ⁽⁶⁾		
Low Pressure Recirculation (LPR)	1/2 RHR pumps with 1/2 heat exchangers and with operator action for switchover (operator action = 3)		
<u>Circle Affected Functions</u>	<u>Recovery of Failed Train</u>	<u>Remaining Mitigation Capability Rating for Each Affected Sequence</u>	<u>Sequence Color</u>
1 SORV - BLK - LPR (2, 6)			
2 SORV - BLK - RCSDEP - HPR (4)			
3 SORV - BLK - EIHP - LPI (7)			
4 SORV - BLK - EIHP - RCSDEP (8)			

5 SORV - BLK - EFW - HPR (10)			
6 SORV - BLK - EFW - FB (11)			
7 SORV - BLK - EFW - EIHP (12)			
Identify any operator recovery actions that are credited to directly restore the degraded equipment or initiating event:			
<p>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.</p>			

Notes:

1. The sequences of the SDP SORV worksheet are the same as those of the SDP small LOCA worksheet with the addition of the failure of the safety function "Isolation of Small LOCA (BLK)" after the initiating event, SORV.
2. This action is represented in the "PSA - 1999 Update, Section 5.0, Table 5-3, Sheet 5" by the split fraction OSF2, HEP = 8.3E-3.
3. Since both PORVs are needed to depressurize the RCS for using the SI pumps, these pumps cannot be credited for feed and bleed unless the remaining PORV is available.
4. By definition, the initiating event causes one PORV open. For using 1 / 2 charging pumps, no additional PORV is required to open. For using 1 / 2 SI pumps, the operator can open the other PORV and block valve.
5. The specific success criteria for the valves used in the safety function RCSDEP was not found in the IPE.

6. High pressure recirculation requires operator to simply shut the suction from the RWST. The initiation logic will set up the system and open the sump suction valves automatically. According to licensee's comments, operator switchover to recirculation has a human error probability (HEP) = $2.66E-2$. An operator action credit of 2 is assigned.

Table 3.4 SDP Worksheet for Seabrook Station — Medium LOCA (MLOCA)

Estimated Frequency (Table 1 Row) _____ Exposure Time _____ Table 1 Result (circle): A B C D E F G H			
Safety Functions Needed:		Full Creditable Mitigation Capability for Each Safety Function:	
Early Inventory, High Pressure Injection (EIHP)		1/2 charging pumps (1 multi-train system) or 1/2 SI pumps (1 multi-train system)	
Secondary Heat Removal (EFW)		1/1 MDEFW pump (1 train) or 1/1 SUFP (operator action = 2) ⁽¹⁾ or 1/1 TDEFW pump (1 ASD train) with 2/4 ARVs or 6/12 SDVs	
RCS Cooldown / Depressurization (RCSDEP)		Operator depressurizes RCS using steam generators (either the steam dump or atmospheric dump valves) ⁽²⁾ (operator action = 1) ⁽³⁾	
Low Pressure Injection (LPI)		1/2 RHR pump trains (1 multi-train system)	
High Pressure Recirculation (HPR)		(1/2 charging pumps or 1/2 SI pumps) with (1/2 RHR pumps with 1/2 heat exchangers) and with operator action for switchover (operator action = 2) ⁽⁴⁾	
Low Pressure Recirculation (LPR)		1/2 RHR pumps with 1/2 heat exchangers and with operator action for switchover (operator action = 3)	
<u>Circle Affected Functions</u>	<u>Recovery of Failed Train</u>	<u>Remaining Mitigation Capability Rating for Each Affected Sequence</u>	<u>Sequence Color</u>
1 MLOCA - HPR (2)			
2 MLOCA - EIHP - LPR (4)			
3 MLOCA - EIHP - LPI (5)			
4 MLOCA - EIHP - RCSDEP (6)			

5 MLOCA - EIHP - EFW (7)			
<p>Identify any operator recovery actions that are credited to directly restore the degraded equipment or initiating event:</p> <p>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.</p>			

Notes:

1. No similar action was found in the "PSA - 1999 Update, Section 5.0, Table 5-3". We assume that the split fraction OSF2, HEP = $8.3E-3$, is applicable.
2. We do not know what are the specific valves used to depressurize the RCS, and the number of valves required to successfully carry out this operation.
3. The licensee considers that these are actions are under extremely high stress and assesses a human error probability = $5.1E-2$.
4. High pressure recirculation requires operator to simply shut the suction from the RWST. The initiation logic will set up the system and open the sump suction valves automatically. According to licensee's comments, operator switchover to recirculation has a human error probability (HEP) = $2.66E-2$. An operator action credit of 2 is assigned.

Table 3.5 SDP Worksheet for Seabrook Station — Large LOCA (LLOCA)

Estimated Frequency (Table 1 Row) _____ Exposure Time _____ Table 1 Result (circle): A B C D E F G H			
Safety Functions Needed: Early Inventory, Accumulators (EIAC) Early Inventory, LP Injection (EILP) Low Pressure Recirculation (LPR)		Full Creditable Mitigation Capability for Each Safety Function: 3/3 remaining accumulators (1 train) 1/2 RHR pump trains (1 multi-train system) 1/2 RHR trains with 1/2 heat exchangers and with operator switchover from injection to recirculation (operator action = 2) ⁽¹⁾	
<u>Circle Affected Functions</u>	<u>Recovery of Failed Train</u>	<u>Remaining Mitigation Capability Rating for Each Affected Sequence</u>	<u>Sequence Color</u>
1 LLOCA - LPR (2)			
2 LLOCA - EILP (3)			
3 LLOCA - EIAC (4)			
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. According to licensee's comments, operator switchover to recirculation has a human error probability (HEP) = 2.66E-2. Thus, an operator action credit of 2 is assigned.

Table 3.6 SDP Worksheet for Seabrook Station — Loss of Offsite Power (LOOP)

Estimated Frequency (Table 1 Row) _____ Exposure Time _____ Table 1 Result (circle): A B C D E F G H			
Safety Functions Needed: Emergency AC Power (EAC) Turbine-driven EFW pump (TDEFW) Secondary Heat Removal (EFW) Recovery of AC Power in < 2 hrs (REC2) Recovery of AC Power in < 5 hrs (REC5) Early Inventory, High Pressure Injection (EIHP) Primary Heat Removal, Feed/Bleed (FB) High Pressure Recirculation (HPR)		Full Creditable Mitigation Capability for Each Safety Function: 1/2 Emergency Diesel Generators (1 multi-train system) ⁽¹⁾ 1/1 TDEFW pump (1 ASD train) with 2/4 ARVs or 6/12 SDVs 1/1 MDEFW pump (1 train) ⁽²⁾ or 1/1 TDEFW pump (1 ASD train) with 2/4 ARVs or 6/12 SDVs SBO procedures implemented (operator action = 1) SBO procedures implemented (operator action = 2) ⁽³⁾ 1/2 charging pumps (1 multi-train system) or 1/2 SI pumps (1 multi-train system) 1/2 PORVs and block valve open (with 1/2 charging pumps) or 2/2 PORVs and block valves open (with 1/2 SI pumps) for Feed/Bleed (operator action = 2) (1/2 charging pumps or 1/2 SI pumps) with (1/2 RHR pumps with 1/2 heat exchangers) and with operator action for switchover (operator action = 2) ⁽⁴⁾	
<u>Circle Affected Functions</u>	<u>Recovery of Failed Train</u>	<u>Remaining Mitigation Capability Rating for Each Affected Sequence</u>	<u>Sequence Color</u>
1 LOOP - EFW - HPR (3)			
2 LOOP - EFW - FB (4)			
3 LOOP - EFW - EIHP (5)			
4 LOOP - EAC - HPR (7, 11) (AC recovered)			

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5 LOOP - EAC - EIHP (8, 13) (AC recovered)			
6 LOOP - EAC - REC5 (9)			
7 LOOP - EAC - TDEFW - FB (12) (AC recovered)			
8 LOOP - EAC - TDEFW - REC2 (14)			
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.			

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Notes:

1. Split fraction E7C2, Total loss of two diesel generators, is $2.15\text{E-}3$ (Table 3.1-1).
2. Start SUFP given LOOP is represented in the "PSA - 1999 Update, Section 5.0, Table 5-3, Sheet 4" by the split fraction OSF3, HEP = $5.8\text{E-}1$. Since the HEP is larger than 0.5, we did not give credit to this action in the worksheet.
3. In an SBO situation, an RCP seal LOCA may occur, with subsequent core damage at about 5 hours. The probability of failure to recover off-site power in 5 hours was not found in the IPE; we used the generic mitigating credit = 2.

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4. High pressure recirculation requires operator to simply shut the suction from the RWST. The initiation logic will set up the system and open the sump suction valves automatically. According to licensee's comments, operator switchover to recirculation has a human error probability (HEP) = 2.66E-2. An operator action credit of 2 is assigned.

Table 3.7 SDP Worksheet for Seabrook Station — Steam Generator Tube Rupture (SGTR)

Estimated Frequency (Table 1 Row) _____ Exposure Time _____ Table 1 Result (circle): A B C D E F G H			
Safety Functions Needed: Secondary Heat Removal (EFW) Early Inventory, High Pressure Injection (EIHP) Primary Heat Removal, Feed/Bleed (FB) Pressure Equalization (EQ) Isolate Ruptured SG (ISOL) RCS Cooldown / Depressurization (RCSDEP) Low Pressure Injection (LPI) Operator Stabilizes Plant (OSP) High Pressure Recirculation (HPR)		Full Creditable Mitigation Capability for Each Safety Function: 1/1 MDEFW pump (1 train) or 1/1 SUFP (operator action = 2) ⁽¹⁾ or 1/1 TDEFW pump (1 ASD train) with 2/4 ARVs or 6/12 SDVs 1/2 charging pumps (1 multi-train system) or 1/2 SI pumps ⁽²⁾ (1 multi-train system) 1/2 PORVs and block valve open (with 1/2 charging pumps) or 2/2 PORVs and block valves open (with 1/2 SI pumps) for Feed/Bleed (operator action = 2) Operator depressurizes RCS using SGs to less than setpoint of relief valves of SG (operator action = 1) ⁽³⁾ Operator isolates the ruptured SG (operator action = 2) Operator rapidly depressurizes and cools down the RCS and initiates low pressure injection (operator action = 1) ⁽⁴⁾ 1/2 RHR pump trains (1 multi-train system) Operator stabilizes plant (operator action = 4) ⁽⁵⁾ (1/2 charging pumps or 1/2 SI pumps) with (1/2 RHR pumps with 1/2 heat exchangers) and with operator action for switchover (operator action = 2) ⁽⁶⁾	
<u>Circle Affected Functions</u>	<u>Recovery of Failed Train</u>	<u>Remaining Mitigation Capability Rating for Each Affected Sequence</u>	<u>Sequence Color</u>
1 SGTR - EQ - OSP (3, 9, 16)			
2 SGTR - EQ - ISOL (4, 12, 17)			

3 SGTR - EIHP - LPI (6, 10)			
4 SGTR - EIHP - RCSDEP (7, 11)			
5 SGTR - EFW - HPR (14)			
6 SGTR - EFW - FB (18)			
7 SGTR - EFW - EIHP (19)			

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 action is represented in the "PSA - 1999 Update, Section 5.0, Table 5-3, Sheet 7" by the split fraction OSF2, HEP = $8.3E-3$.
2. Since both PORVs are needed to depressurize the RCS for using the SI pumps, these pumps cannot be credited for feed and bleed unless both PORVs are available.

3. Operator depressurizes RCS (to control break flow) is represented in the "PSA - 1999 Update, Section 5.0, Table 5-3, Sheet 7" by the basic event HH.CNTRSGTR.FA, HEP = 5.0E-2.
4. Operator depressurizes RCS is represented in the "PSA - 1999 Update, Section 5.0, Table 5-3, Sheet 8" by "Depressurize the RCS, given EFW success and failure of HP injection" (split fraction OD3, HEP = 9.0E-2).
5. The licensee models this operator action as event OQ3 with a human error probability = 1E-4. The licensee provided the following additional information: "In fact, analysis has shown that with a single double-ended tube rupture, a successful supply of auxiliary feedwater, and uncontrolled safety injection flow with a stuck-open steam generator safety valve, the RWST will not be emptied until about 24 hours have elapsed. At that time, the RCS would be fully cooled down and depressurized and effectively on a standpipe head filled to and vented at the stuck-open safety valve. Therefore, a stable condition could be maintained by instituting closed loop RHR cooling or continuing to cool the steam generators. With no additional cooling, several hours would be required before the RCS heated up and boiled off exposing the core to overheating. The point of all this is that if makeup water and cooling are available, there are long time windows for successful operator intervention before serious core damage occurs."
6. High pressure recirculation requires operator to simply shut the suction from the RWST. The initiation logic will set up the system and open the sump suction valves automatically. According to licensee's comments, operator switchover to recirculation has a human error probability (HEP) = 2.66E-2. An operator action credit of 2 is assigned.

Table 3.8 SDP Worksheet for Seabrook Station — Anticipated Transients Without Scram (ATWS)

Estimated Frequency (Table 1 Row) _____ Exposure Time _____ Table 1 Result (circle): A B C D E F G H			
Safety Functions Needed:⁽¹⁾ Turbine trip (TTP) Secondary Heat Removal (EFW) ⁽²⁾ Primary Relief (SRV) Emergency Boration (EMEBOR)		Full Creditable Mitigation Capability for Each Safety Function: AMSAC trips the turbine and starts EFW (1 train) 1/1 MDEFW pump (1 train) or 1/1 SUFP (operator action = 1) ⁽³⁾ or 1 / 1 TDEFW pump (1 ASD train) with 2/4 ARVs or 6/12 SDVs 3/3 safety valves with 2/2 PORVs open (1 train) Operator conducts emergency boration using 1/2 centrifugal charging pumps (operator action = 2)	
<u>Circle Affected Functions</u>	<u>Recovery of Failed Train</u>	<u>Remaining Mitigation Capability Rating for Each Affected Sequence</u>	<u>Sequence Color</u>
1 ATWS - EMEBOR (2)			
2 ATWS - SRV (3)			
3 ATWS - EFW (4)			
4 ATWS - TTP (5)			

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 assumes that main feedwater is not available.
2. The IPE's success criteria of EFW for ATWS (page E-96) is the same as for other initiating events (except Transients with Loss of Main Feedwater), that is, 1/1 MDEFW pump (1 train) or 1/1 SUFP (operator action = 2) or 1/1 TDEFW pump (1 ASD train), but feeding 4/4 steam generators. We assume that the success criteria for steam relief is also the same, namely, 2/4 ARVs or 6/12 SDVs.
3. Due to the timing and stress involved in this scenario, we consider that the credit for this action is 1.

Table 3.9 SDP Worksheet for Seabrook Station — Main Steam Line Break (MSLB)

Estimated frequency (Table 1 row) _____ Exposure time _____ Table 1 result (circle): A B C D E F G H			
Safety Functions Needed:		Full Creditable Mitigation Capability for each Safety Function:	
MSIV closure (MSIV)		3/4 MSIV close (1 train)	
Secondary Heat Removal (EFW)⁽¹⁾		1/1 MDEFW pump (1 train) or 1/1 SUFP (operator action = 3) ⁽²⁾ with 2/4 ARVs or 6/12 SDVs	
Operator controls EFW (OPEFW)		Operator controls EFW to prevent overcooling (operator action = 1) ⁽³⁾	
Early Inventory, High Pressure Injection (EIHP)		1/2 charging pumps (1 multi-train system) or 1/2 SI pumps ⁽⁴⁾ (1 multi-train system)	
Operator controls HPI (OPHPI)		Operator controls HPI flow to prevent overpressurization (operator action = 2) ⁽⁵⁾	
RCS Cooldown / Depressurization (RCSDEP)		Operator depressurizes RCS using either the steam dump or atmospheric dump valves (operator action = 2)	
RHR Cooldown (RHR)		1/2 RHR pumps with 1/2 heat exchangers (1 multi-train system)	
Primary Heat Removal, Feed/Bleed (FB)		1/2 PORVs and block valve open (with 1/2 charging pumps) or 2/2 PORVs and block valves open (with 1/2 SI pumps) for Feed/Bleed (operator action = 2)	
High Pressure Recirculation (HPR)		(1/2 charging pumps or 1/2 SI pumps) with (1/2 RHR pumps with 1/2 heat exchangers) and with operator action for switchover (operator action = 2) ⁽⁶⁾	
<u>Circle Affected Functions</u>	<u>Recovery of Failed Train</u>	<u>Remaining Mitigation Capability Rating for Each Affected Sequence</u>	<u>Sequence Color</u>
1 MSLB - MSIV - EIHP - RHR (4)			
2 MSLB - MSIV - EIHP - RCSDEP (5)			
3 MSLB - MSIV - OPEFW - RHR (7)			
4 MSLB - MSIV - OPEFW - OPHPI (8)			

5 MSLB - MSIV - OPEFW - EIHP (9)			
6 MSLB - MSIV - EFW - HPR (11)			
7 MSLB - MSIV - EFW - FB (12)			
8 MSLB - MSIV - EFW - EIHP (13)			
Identify any operator recovery actions that are credited to directly restore the degraded equipment or initiating event:			
<p>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.</p>			

Notes:

1. In the SDP event trees we do not give credit to the TD pump of EFW, even though the IPE does give credit.
2. This action is represented in the "PSA - 1999 Update, Section 5.0, Table 5-3, sheet 4" by the split fraction OSF1, HEP = 1.0E-3.
3. The human error probability (HEP) assessed in the IPE (page 130) for operator failing to control EFW to prevent overcooling is 6.2E-2 (split fraction OM1).
4. Since both PORVs are needed to depressurize the RCS for using the SI pumps, these pumps cannot be credited for feed and bleed unless both PORVs are available.
5. The human error probability (HEP) assessed in the IPE (page 131) for operator failing to control HPI flow to prevent overpressurization is 2.3E-2 (split fraction OP1).

6. High pressure recirculation requires operator to simply shut the suction from the RWST. The initiation logic will set up the system and open the sump suction valves automatically. According to licensee's comments, operator switchover to recirculation has a human error probability (HEP) = $2.66E-2$. An operator action credit of 2 is assigned.

Table 3.10 SDP Worksheet for Seabrook Station — Loss of One Train of CCW (LOCC)

Estimated Frequency (Table 1 Row) _____ Exposure Time _____ Table 1 Result (circle): A B C D E F G H			
Safety Functions Needed: Redundant Train of CCW (LRCC) Secondary Heat Removal (EFW) Early Inventory Pressure Injection (EIHP) Primary Heat Removal, Feed/Bleed (FB) High Pressure Recirculation (HPR)		Full Creditable Mitigation Capability for Each Safety Function: 1/1 CC train (1 train) ⁽¹⁾ 1/1 MDEFW pump (1 train) or 1/1 SUIFP (operator action = 2) or 1/1 TDEFW pump (1 ASD train) with 2/4 ARVs or 6/12 SDVs 1/1 charging pump or 1/1 SI pump ⁽²⁾ (1 multi-train system) 1/2 PORVs and block valve open (with 1/1 charging pump) or 2/2 PORVs and block valves open (with 1/1 SI pump) for Feed/Bleed (operator action = 2) (1/1 charging pump or 1/1 SI pump) with (1/1 RHR pump with 1/1 heat exchanger) and with operator action for switchover (operator action = 2) ⁽³⁾	
<u>Circle Affected Functions</u>	<u>Recovery of Failed Train</u>	<u>Remaining Mitigation Capability Rating for Each Affected Sequence</u>	<u>Sequence Color</u>
1 LOCC - EFW - HPR (3)			
2 LOCC - EFW - FB (4)			
3 LOCC - EFW - EIHP (5)			
4 LOCC - LRCC (6)			

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 frequency of loss of one train of CC is $4.52E-3$ / year, and hence, the frequency of loss of any one train of CC is $9.04E-3$ / year. The charging, SI, and RHR pumps are cooled by CC, and we assume that following a loss of one train of CC (but not the other) there is a transient with the unavailability of one of the charging, SI, and RHR pumps. On the other hand, complete loss of Primary Component Cooling (CC) Water results in failure of CVCS and SI pumps. RHR also fails in the sump recirculation mode. RCP seal cooling is normally provided by charging pump seal injection and backed up by the Thermal Barrier Cooling System. Both seal cooling methods depend on the CC, and hence, a total loss of CC guarantees an RCP seal LOCA. The IPE does not credit the recovery of CC failures. Core damage occurs due to the RCP seal LOCA with no makeup.
2. Since both PORVs are needed to depressurize the RCS for using the SI pump, this pump cannot be credited for feed and bleed unless both PORVs are available.
3. High pressure recirculation requires operator to simply shut the suction from the RWST. The initiation logic will set up the system and open the sump suction valves automatically. According to licensee's comments, operator switchover to recirculation has a human error probability (HEP) = $2.66E-2$. An operator action credit of 2 is assigned.

Table 3.11 SDP Worksheet for Seabrook Station — Loss of 125 VDC Vital Bus A (LDCA)⁽¹⁾

Estimated Frequency (Table 1 Row) _____ Exposure Time _____ Table 1 Result (circle): A B C D E F G H			
Safety Functions Needed: Secondary Heat Removal (EFW) Early Inventory Pressure Injection (EIHP) Primary Heat Removal, Feed/Bleed (FB) High Pressure Recirculation (HPR)		Full Creditable Mitigation Capability for Each Safety Function: 1/1 MDEFW pump (1 train) or 1/1 TDEFW pump (1 ASD train) with 2/4 ARVs or 6/12 SDVs 1/1 charging pumps ⁽²⁾ (1 train) 1/1 PORV and block valve open for Feed/Bleed (operator action = 2) (1/1 charging pump or 1/1 SI pump) with (1/1 RHR pump with 1/1 heat exchanger) and with operator action for switchover (operator action = 2) ⁽³⁾	
<u>Circle Affected Functions</u>	<u>Recovery of Failed Train</u>	<u>Remaining Mitigation Capability Rating for Each Affected Sequence</u>	<u>Sequence Color</u>
1 LDCA - EFW - HPR (3)			
2 LDCA - EFW - FB (4)			
3 LDCA - EFW - EIHP (5)			
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 frequency of loss of train A DC bus = $4.29E-3$ / year. The structure of the event tree is the same as that of Transients with Loss of Main Feedwater. We assume that the loss of one DC bus causes the unavailability of one redundant train of mitigating equipment. Since the PORVs remain closed during normal plant operation, and DC power is required to open them, we concluded that, given the loss of one bus of DC, one PORV will be unavailable, and this SDP sheet was developed under this condition. The IPE states (page E-91) that the PORVs may be manually opened for "feed and bleed" cooling or in those instances where an auto open signal failed to actuate the PORVs. No credit was given in this SDP sheet to this manual opening.
2. Since both PORVs are needed to depressurize the RCS for using the SI pump, but one PORV is unavailable, this pump cannot be credited for feed and bleed.
3. High pressure recirculation requires operator to simply shut the suction from the RWST. The initiation logic will set up the system and open the sump suction valves automatically. According to licensee's comments, operator switchover to recirculation has a human error probability (HEP) = $2.66E-2$. An operator action credit of 2 is assigned.

Table 3.12 SDP Worksheet for Seabrook Station — Loss of 125 VDC Vital Bus B (LDCB)⁽¹⁾

Estimated Frequency (Table 1 Row) _____ Exposure Time _____ Table 1 Result (circle): A B C D E F G H			
Safety Functions Needed: Secondary Heat Removal (EFW) Early Inventory Pressure Injection (EIHP) Primary Heat Removal, Feed/Bleed (FB) High Pressure Recirculation (HPR)		Full Creditable Mitigation Capability for Each Safety Function: 1/1 SUFP (operator action = 2) ⁽²⁾ or 1/1 TDEFW pump (1 ASD train) with 2/4 ARVs or 6/12 SDVs 1/1 charging pumps ⁽³⁾ (1 train) 1/1 PORV and block valve open for Feed/Bleed (operator action = 2) (1/1 charging pump or 1/1 SI pump) with (1/1 RHR pump with 1/1 heat exchanger) and with operator action for switchover (operator action = 2) ⁽⁴⁾	
<u>Circle Affected Functions</u>	<u>Recovery of Failed Train</u>	<u>Remaining Mitigation Capability Rating for Each Affected Sequence</u>	<u>Sequence Color</u>
1 LDCB - EFW - HPR (3)			
2 LDCB - EFW - FB (4)			
3 LDCB - EFW - EIHP (5)			
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 frequency of loss of train B DC bus = $4.29E-3$ / year. The structure of the event tree is the same as that of Transients with Loss of Main Feedwater. We assume that the loss of one DC bus causes the unavailability of one redundant train of mitigating equipment. Since the PORVs remain closed during normal plant operation, and DC power is required to open them, we concluded that, given the loss of one bus of DC, one PORV will be unavailable, and this SDP sheet was developed under this condition. The IPE states (page E-91) that the PORVs may be manually opened for "feed and bleed" cooling or in those instances where an auto open signal failed to actuate the PORVs. No credit was given in this SDP sheet to this manual opening.
2. This action is represented in the "PSA - 1999 Update, Section 5.0, Table 5-3, sheet 4" by the split fraction OSF1, HEP = $1.0E-3$. However, given the loss of redundancy of EFW equipment and resulting stress, we assume that the credit for this operator action should be no less than 2.
3. Since both PORVs are needed to depressurize the RCS for using the SI pump, but one PORV is unavailable, this pump cannot be credited for feed and bleed.
4. High pressure recirculation requires operator to simply shut the suction from the RWST. The initiation logic will set up the system and open the sump suction valves automatically. According to licensee's comments, operator switchover to recirculation has a human error probability (HEP) = $2.66E-2$. An operator action credit of 2 is assigned.

Table 3.13 SDP Worksheet for Seabrook Station — Loss of Class 1E 4.16 kV AC Bus A (E5) (LACA)⁽¹⁾

Estimated Frequency (Table 1 Row) _____ Exposure Time _____ Table 1 Result (circle): A B C D E F G H			
Safety Functions Needed: Secondary Heat Removal (EFW) Early Inventory Pressure Injection (EIHP) Primary Heat Removal, Feed/Bleed (FB) High Pressure Recirculation (HPR)		Full Creditable Mitigation Capability for Each Safety Function: 1/1 SUFP (operator action = 2) or 1/1 TDEFW pump (1 ASD train) with 2/4 ARVs or 6/12 SDVs 1/1 charging pump (1 train) or 1/1 SI pump (1 train) 1/2 PORVs open (with 1/1 charging pump) or 2/2 PORVs open (with 1/1 SI pump) for Feed/Bleed (operator action = 2) (1/1 charging pump or 1/1 SI pump) with (1/1 RHR pump with 1/1 heat exchanger) and with operator action for switchover (operator action = 2) ⁽²⁾	
<u>Circle Affected Functions</u>	<u>Recovery of Failed Train</u>	<u>Remaining Mitigation Capability Rating for Each Affected Sequence</u>	<u>Sequence Color</u>
1 LACA - EFW - HPR (3)			
2 LACA - EFW - FB (4)			
3 LACA - EFW - EIHP (5)			

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 frequency of the loss of the Class 1E 4.16 kV AC bus A is $4.28E-3$ / year. For this SDP worksheet we assume that, given the loss of one AC bus, one train of redundant equipment will be unavailable. We also assumed that a block valve will fail open upon loss of AC power. The structure of the event tree is the same as that of Transients with Loss of Main Feedwater.
2. High pressure recirculation requires operator to simply shut the suction from the RWST. The initiation logic will set up the system and open the sump suction valves automatically. According to licensee's comments, operator switchover to recirculation has a human error probability (HEP) = $2.66E-2$. An operator action credit of 2 is assigned.

Table 3.14 SDP Worksheet for Seabrook Station — Loss of Class 1E 4.16 kV AC Bus B (E6) (LACB)⁽¹⁾

Estimated Frequency (Table 1 Row) _____ Exposure Time _____ Table 1 Result (circle): A B C D E F G H			
Safety Functions Needed: Secondary Heat Removal (EFW) Early Inventory Pressure Injection (EIHP) Primary Heat Removal, Feed/Bleed (FB) High Pressure Recirculation (HPR)		Full Creditable Mitigation Capability for Each Safety Function: 1/1 MDEFW pump (1 train) or 1/1 SUFP (operator action = 2) or 1/1 TDEFW pump (1 ASD train) with 2/4 ARVs or 6/12 SDVs 1/1 charging pump (1 train) or 1/1 SI pump (1 train) 1/2 PORVs open (with 1/1 charging pump) or 2/2 PORVs open (with 1/1 SI pump) for Feed/Bleed (operator action = 2) (1/1 charging pump or 1/1 SI pump) with (1/1 RHR pump with 1/1 heat exchanger) and with operator action for switchover (operator action = 2) ⁽²⁾	
<u>Circle Affected Functions</u>	<u>Recovery of Failed Train</u>	<u>Remaining Mitigation Capability Rating for Each Affected Sequence</u>	<u>Sequence Color</u>
1 LACB - EFW - HPR (3)			
2 LACB - EFW - FB (4)			
3 LACB - EFW - EIHP (5)			

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 frequency of the loss of the Class 1E 4.16 kV AC bus B is $4.28E-3$ / year. For this SDP worksheet we assume that, given the loss of one AC bus, one train of redundant equipment will be unavailable. We also assumed that a block valve will fail open upon loss of AC power. The structure of the event tree is the same as that of Transients with Loss of Main Feedwater.
2. High pressure recirculation requires operator to simply shut the suction from the RWST. The initiation logic will set up the system and open the sump suction valves automatically. According to licensee's comments, operator switchover to recirculation has a human error probability (HEP) = $2.66E-2$. An operator action credit of 2 is assigned.

Table 3.15 SDP Worksheet for Seabrook Station — LOOP and Loss of Class 1E 4.16 kV AC Bus A (E5) (LOAA)⁽¹⁾

Estimated Frequency (Table 1 Row) _____ Exposure Time _____ Table 1 Result (circle): A B C D E F G H			
<u>Safety Functions Needed:</u> PORV recloses (SORV) Secondary Heat Removal (EFW) Early Inventory, High Pressure Injection (EIHP) Primary Heat Removal, Feed/Bleed (FB) RCS Cooldown / Depressurization (RCSDEP) Low Pressure Recirculation (LPR) High Pressure Recirculation (HPR)		<u>Full Creditable Mitigation Capability for Each Safety Function:</u> 2/2 Pressurizer PORVs reclose after opening during transient (1 train) 1/1 TDEFW train (1 ASD train) with 2/4 ARVs or 6/12 SDVs 1/1 charging pump or 1/1 SI pump (1 multi-train system) (1 PORV is already open with 1/1 charging pump) or (1/1 remaining PORV and block valve open with 1/1 SI pump) for Feed/Bleed (operator action = 2) Operator depressurizes RCS using either the steam dump or atmospheric dump valves (operator action = 2) 1/1 RHR pump (1 train) (1/1 charging pump or 1/1 SI pump) with (1/1 RHR pump with 1/1 heat exchanger) and with operator action for switchover (operator action = 2) ⁽²⁾	
<u>Circle Affected Functions</u>	<u>Recovery of Failed Train</u>	<u>Remaining Mitigation Capability Rating for Each Affected Sequence</u>	<u>Sequence Color</u>
1 LOAA - SORV - LPR (3, 7)			
2 LOAA - SORV - RCSDEP - HPR (5)			
3 LOAA - SORV - EIHP - RCSDEP (8)			
4 LOAA - SORV - EFW - HPR (10)			

5 LOAA - SORV - EFW - FB (11)			
6 LOAA - SORV - EFW - EIHP (12)			
<p>Identify any operator recovery actions that are credited to directly restore the degraded equipment or initiating event:</p> <p>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.</p>			

Notes:

1. For this SDP worksheet we assume that, given the loss of one AC bus, one train of redundant equipment will be unavailable. We did not find in the IPE what is the position of a block valve when it loses AC power. We assume for this SDP sheet that a block valve will fail open when it loses AC power, and hence, if its associated PORV fails to close, a non-isolable small LOCA occurs. The event tree for this initiating event is identified by the initiating event LOAC.
2. High pressure recirculation requires operator to simply shut the suction from the RWST. The initiation logic will set up the system and open the sump suction valves automatically. According to licensee's comments, operator switchover to recirculation has a human error probability (HEP) = 2.66E-2. An operator action credit of 2 is assigned.

Table 3.16 SDP Worksheet for Seabrook Station — LOOP and Loss of Class 1E 4.16 kV AC Bus B (E6) (LOAB)⁽¹⁾

Estimated Frequency (Table 1 Row) _____ Exposure Time _____ Table 1 Result (circle): A B C D E F G H			
<u>Safety Functions Needed:</u> PORV recloses (SORV) Secondary Heat Removal (EFW) Early Inventory, High Pressure Injection (EIHP) Primary Heat Removal, Feed/Bleed (FB) RCS Cooldown / Depressurization (RCSDEP) Low Pressure Recirculation (LPR) High Pressure Recirculation (HPR)		<u>Full Creditable Mitigation Capability for Each Safety Function:</u> 2/2 Pressurizer PORVs reclose after opening during transient (1 train) 1/1 MDEFW train (1 train) or 1/1 SUFP (operator action = 1) ⁽²⁾ or 1/1 TDEFW train (1 ASD train) with 2/4 ARVs or 6/12 SDVs 1/1 charging pump or 1/1 SI pump (1 multi-train system) (1 PORV is already open with 1/1 charging pump) or (1/1 remaining PORV and block valve open with 1/1 SI pump) for Feed/Bleed (operator action = 2) Operator depressurizes RCS using either the steam dump or atmospheric dump valves (operator action = 2) 1/1 RHR pump (1 train) (1/1 charging pump or 1/1 SI pump) with (1/1 RHR pump with 1/1 heat exchanger) and with operator action for switchover (operator action = 2) ⁽³⁾	
<u>Circle Affected Functions</u>	<u>Recovery of Failed Train</u>	<u>Remaining Mitigation Capability Rating for Each Affected Sequence</u>	<u>Sequence Color</u>
1 LOAB - SORV - LPR (3, 7)			
2 LOAB - SORV - RCSDEP - HPR (5)			
3 LOAB - SORV - EIHP - RCSDEP (8)			

4 LOAB - SORV - EFW - HPR (10)			
5 LOAB - SORV - EFW - FB (11)			
6 LOAB - SORV - EFW - EIHP (12)			
Identify any operator recovery actions that are credited to directly restore the degraded equipment or initiating event:			
<p>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.</p>			

Notes:

1. For this SDP worksheet we assume that, given the loss of one AC bus, one train of redundant equipment will be unavailable. We did not find in the IPE what is the position of a block valve when it loses AC power. We assume for this SDP sheet that a block valve will fail open when it loses AC power, and hence, if its associated PORV fails to close, a non-isolable small LOCA occurs. The event tree for this initiating event is identified by the initiating event LOAC.
2. The SUFP is normally supplied from 4.160 kV Bus 4. The operators can provide power to the SUFP from emergency Bus E5. Start SUFP given LOOP is represented in the "PSA - 1999 Update, Section 5.0, Table 5-3, Sheet 4" by the split fraction OSF3, HEP = 5.8E-1. Since the Loss of One Class 1E 4.16 kV AC Bus can be considered to be less severe than a LOOP, we assumed that the credit for this operator action is 1.
3. High pressure recirculation requires operator to simply shut the suction from the RWST. The initiation logic will set up the system and open the sump suction valves automatically. According to licensee's comments, operator switchover to recirculation has a human error probability (HEP) = 2.66E-2. An operator action credit of 2 is assigned.

Table 3.17 SDP Worksheet for Seabrook Station — Interfacing System LOCA (ISLOCA)⁽¹⁾

Estimated Frequency (Table 1 Row) _____ Exposure Time _____ Table 1 Result (circle): A B C D E F G H			
Initiating Pathways: RHR Injection Line RHR Suction Line RCP Thermal Barrier Cooler ⁽³⁾		Mitigation Capability: Ensure Component Operability for Each Pathway: Two isolation series check valves ⁽²⁾ Two isolation series motor-operated valves ⁽²⁾	
<u>Circle Affected Functions</u>	<u>Recovery of Failed Train</u>	<u>Remaining Mitigation Capability Rating for Each Affected Pathway</u>	<u>Sequence Color</u>
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 description of the specific valves was not found in the IPE.
3. The IPE did not judge this path to be potentially significant. We included it to be consistent with other plants of similar design.

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. An event tree for the stuck-open PORV is not included since it is similar to the small LOCA event tree. The event tree headings are defined in the corresponding SDP worksheets.

The following event trees are included:

1. Transients with Loss of Main Feedwater (TPCS)
2. Small LOCA (SLOCA)
3. Medium LOCA (MLOCA)
4. Large LOCA (LLOCA)
5. Loss of Offsite Power (LOOP)
6. Steam Generator Tube Rupture (SGTR)
7. Anticipated Transients Without Scram (ATWS)
8. Main Steam Line Break (MSLB)
9. Loss of One Train of CCW (LOCC)
10. LOOP and Loss of One Class 1E 4.16 kV AC Bus (LOAC)

TPCS	EFW	EIHP	FB	HPR	#	STATUS
					1	OK
					2	OK
					3	CD
					4	CD
					5	CD

Plant name abbrev.: SBRK

SLOCA	EFW	EIHP	FB	RCSDEP	LPI	HPR	LPR	#	STATUS
								1	OK
								2	CD
								3	OK
								4	CD
								5	OK
								6	CD
								7	CD
								8	CD
								9	OK
								10	CD
								11	CD
								12	CD

Plant name abbrev.: SBRK

M LOCA	EIHP	EFW	RCSDEP	LPI	H PR	LPR	#	STATUS
							1	OK
							2	CD
							3	OK
							4	CD
							5	CD
							6	CD
							7	CD

Plant name abbrev.: SBRK

LLOCA	EIAC	EILP	LPR	#	STATUS
				1	OK
				2	CD
				3	CD
				4	CD

Plant name abbrev.: SBRK

LOOP	EAC	TDEFW	EFW	REC2	REC5	EIHP	FB	HPR	#	STATUS
									1	OK
									2	OK
									3	CD
									4	CD
									5	CD
									6	OK
									7	CD
									8	CD
									9	CD
									10	OK
									11	CD
									12	CD
									13	CD
									14	CD

Plant name abbrev.: SBRK

SGTR	EFW	EIHP	FB	EQ	ISOL	RCSDEP	LPI	OSP	HPR	#	STATUS
										1	OK
										2	OK
										3	CD
										4	CD
										5	OK
										6	CD
										7	CD
										8	OK
										9	CD
										10	CD
										11	CD
										12	CD
										13	OK
										14	CD
										15	OK
										16	CD
										17	CD
										18	CD
										19	CD

Plant name abbrev.: SBRK

ATWS	TTP	EFW	SRV	EMEBOR	#	STATUS
					1	OK
					2	CD
					3	CD
					4	CD
					5	CD

Plant name abbrev.: SBRK

MSLB	MSIV	EFW	OPEFW	EIHP	OPH PI	RCSDEP	RHR	FB	HPR	#	STATUS
										1	OK
										2	OK
										3	OK
										4	CD
										5	CD
										6	OK
										7	CD
										8	CD
										9	CD
										10	OK
										11	CD
										12	CD
										13	CD

Plant name abbrev.: SBRK

LOCC	LRCC	EFW	EIHP	FB	HPR	#	STATUS
						1	OK
						2	OK
						3	CD
						4	CD
						5	CD
						6	CD

Plant name abbrev.: SBRK

LOAC	SORV	EFW	EIHP	FB	RCSDEP	LPR	HPR	#	STATUS
								1	OK
								2	OK
								3	CD
								4	OK
								5	CD
								6	OK
								7	CD
								8	CD
								9	OK
								10	CD
								11	CD
								12	CD

Plant name abbrev.: SBRK

2. RESOLUTION AND DISPOSITION OF COMMENTS

This section is composed of two subsections. Subsection 2.1 summarizes the generic assumptions that were used for developing the SDP worksheets for the PWR plants. These guidelines were based on the plant-specific comments provided by the licensee on the draft SDP worksheets and further examination of the applicability of those comments to similar plants. These assumptions which are used as guidelines for developing the SDP worksheets help the reader better understand the worksheets' scope and limitations. The generic guidelines and assumptions for PWRs are given here. Subsection 2.2 documents the plant-specific comments received on the draft version of the material included in this notebook and their resolution.

2.1 GENERIC GUIDELINES AND ASSUMPTIONS (PWRs)

The following generic guidelines and assumptions were used in developing the SDP worksheets for PWRs. These guidelines and assumptions were derived from a review of the licensee's comments, the resolutions of those comments, and the applicability to similar plants.

1. Assignment of plant-specific IEs into frequency rows:

Transient (Reactor trip) (TRANS), transients without PCS (TPCS), small, medium, and large LOCA (SLOCA, MLOCA, LLOCA), inadvertent or stuck-open PORV/SRV (SORV), main steam and feedwater line break (MSLB), anticipated transients without scram (ATWS), and interfacing system LOCAs (ISLOCA) are assigned into rows based on a consideration of the industry-average frequency. Plant-specific frequencies are considered for loss of offsite power (LOOP) and special initiators, and are assigned to the appropriate rows in Table 1.

2. Stuck open PORV/SRV as an IE in PWRs:

This event typically is not modeled in PRAs/IPEs as an initiating event. The failure of the PORVs/SRVs to re-close after opening is typically modeled within the transient event trees subsequent to the initiators. In addition, the intermittent failure or excessive leakage through PORVs as an initiator, albeit with much lower frequency, needed to be considered. To account for such failures and to keep the transient worksheets simple in the SDP, a separate worksheet for the SORV initiator was set up to explicitly model the contribution from such failures. This SDP worksheet, and the associated event tree, is similar to that of SLOCA. The frequency of PORV to re-close depends on the status of pressurizer. If the pressurizer is solid, then the frequency would be higher than the case in which the pressurizer level is maintained. Typically, this depends on early availability of secondary heat removal. However, the frequency for the SORV initiator is generically estimated for all PWR plants in Table 1.

3. Inclusion of special initiators:

The special initiators included in the worksheets are those applicable to this plant. A separate worksheet is included for each of them. The applicable special initiators are primarily based on the plant-specific IPEs/PRAs. In other words, the special initiators included are those modeled in the IPEs/PRAs unless shown to be negligible contributors. In some cases, a particular special initiator may be added for a plant even if it is not included in the IPE/PRA, if it is included in other plants of similar design, and is considered applicable for the plant. However, no attempt is made at this time to have a consistent set of special initiators across similarly designed plants. Except for the interfacing system LOCA (ISLOCA), if the occurrence of the special initiator results in a core damage, i.e., no mitigation capability exists for the initiating event, then a separate worksheet is not developed. For such cases, the inspection's focus is on the initiating event and the risk implication of the finding can be directly assessed. For ISLOCA, a separate worksheet is included noting the pathways that can lead to it.

4. Inclusion of systems under the support system column of the Initiators and System Dependency Table:

This Table shows the support systems for the support- and frontline systems. The intent is to include only the support systems, and not the systems supporting that support system, i.e., those systems whose failure will result in failure of the system being supported. Partial dependency, e.g., a backup system, is not included. If they are, this should be so noted. Sometimes, some subsystems on which inspection findings may be noted were included as a support system, e.g., the EDG fuel oil transfer pump as a support system for EDGs.

5. Coverage of system/components and functions included in the SDP worksheets:

The Initiators and System Dependency Table includes systems and components which are included in the SDP worksheets and those which can affect the performance of these systems and components. One-to-one matching of the event tree headings/functions to that included in the Table was not considered necessary.

6. Crediting of non-safety related equipment:

SDP worksheets credit or include safety-related equipment and also, non-safety related equipment, as used, in defining the accident sequences leading to core damage. In defining the success criteria for the functions needed, the components included are those covered under the Technical Specifications (TS) and the Maintenance Rule (MR). Credits for other components may have been removed in the SDP worksheets.

7. No credit for certain plant-specific mitigation capability:

The significance determination process (SDP) screens inspection findings for Phase 3 evaluations. Some conservative assumptions are made which result in not crediting some plant-specific features. Such assumptions are usually based on comparisons with plants of similar design, and they help to maintain consistency across the SDP worksheets for similar plant designs.

8. Crediting system trains with high unavailability:

Some system component/trains may have unavailability higher than $1E-2$, but they are treated similarly to other trains with lower unavailability in the range of $1E-2$. In this screening, this approach is considered adequate to keep the process simple. An exception is made for steam-driven components which are designated as Automatic Steam Driven (ASD) train with a credit of $1E-1$.

9. Treating passive components (of high reliability) the same as active components:

Passive components, namely accumulators, are credited similarly to active components, even though they exhibit higher reliability. Considering the potential for common-cause failures, the reliability of a passive system is not expected to differ by more than an order of magnitude from active systems. Pipe failures

were excluded, except as part of initiating events where the appropriate frequency is used. Accordingly, a separate designation for passive components was not considered necessary.

10. Crediting accumulators:

SDP worksheets assume the loss of the accumulator unit associated with the failed leg in LOCA scenarios. Accordingly, in defining the mitigation capability for the accumulators, the worksheets refer to the remaining accumulators. For example, in a plant with 4 accumulators with a success criteria of 1 out of 4, for large LOCA the mitigation capability is defined as 1/3 remaining accumulators (1 multi-train system), assuming the loss of the accumulator in the failed leg. For a plant with a success criteria of 2 out of 4 accumulators, the mitigation capability is defined as 2/3 remaining accumulators (1 multi-train system).

The inspection findings are then assessed as follows (using the example of the plant with 4 accumulators and success criteria of 2 out of 4):

4 Acc. Available	Credit=3
3 Acc. Available (1 Acc. is considered unavailable, based on inspection findings)	Credit=2
< 3 Acc. Available (2 or more Acc. are considered unavailable, Based on inspection findings)	Credit=0

11. Crediting operator actions

The operator's actions modeled in the worksheets are categorized as follows: operator action=1 representing an error probability of 5E-2 to 0.5; operator action=2 representing an error probability of 5E-3 to 5E-2; operator action=3 representing an error probability of 5E-4 to 5E-3; and operator action=4 representing an error probability of 5E-5 to 5E-4. Actions with error probability > 0.5 are not credited. Thus, operator actions are associated with credits of 1, 2, 3, or 4. Since there is large variability in similar actions among different plants, a survey of the error probability across plants of similar design was used to categorize different operator actions. From this survey, similar actions across plants of similar design are assigned the same credit. If a plant uses a lower credit or recommends a lower credit for a particular action compared to our assessment of similar action based on plant survey, then the lower credit is assigned. An operator's action with a credit of 4, i.e., operator action=4, is noted at the bottom of the worksheet; the corresponding hardware failure, e.g., 1 multi-train system, is defined in the mitigating function.

12. Difference between plant-specific values and SDP designated credits for operator actions:

As noted, operator actions are assigned to a particular category based on a review of similar actions for plants with similar design. This results in some differences between plant-specific values and credit for the action in the worksheet. The plant-specific values are usually noted at the bottom of the worksheet.

13. Dependency among multiple operator actions:

IPEs or PRAs, in general, account for dependencies among the multiple operator actions that may be applicable. In the SDP screening approach, if multiple actions are involved in one function, then the credit for the function is designated as one operator action to the extent possible, considering the dependency involved.

14. Crediting the standby high-pressure pump:

The high-pressure injection system in some plants consists of three pumps with two of them auto-aligned and the third spare pump requiring manual action. The mitigating capability then is defined as : 1/2 HPI trains or use of a spare pump (1 multi-train system). Also, a footnote is added to reflect that the use of a spare pump could be given a credit of 1 (i.e., 1E-1) as a recovery action.

15. Emergency AC Power:

The full mitigating capability for emergency AC could include dedicated Emergency Diesel Generators (EDG), Swing EDG, SBO EDG, and finally, nearby fossil-power plants. The following guidelines are used in the SDP modeling of the Emergency AC power capability:

- a) Describe the success criteria and the mitigation capability of dedicated EDGs.
- b) Assign a mitigating capability of "operator action=1" for a swing EDG. The SDP worksheet assumes that the swing EDG is aligned to the other unit at the time of the LOOP (in a sense a dual unit LOOP is assumed). The operator, therefore, should trip, transfer, re-start, and load the swing EDG.
- c) Assign a mitigating capability of "operator action=1" for an SBO EDG similar to the swing EDG. Note, some of the PWRs do not take credit for an SBO EDG for non-fire initiators. In these cases, credit is not given.
- d) Do not credit the nearby power station as a backup to EDGs. The offsite power source from such a station could also be affected by the underlying cause for the LOOP. As an example, overhead cables connecting the station to the nuclear power plant also could have been damaged due to the bad weather which caused the LOOP. This level of detail should be left for a Phase 3 analysis.

16. Treatment of HPR and LPR:

The operation of both the HPR and LPR rely on the operation of the RHR pumps and the associated heat exchangers. Therefore, failure of LPR could imply failure of both HPR and LPR. A sequence which contains failure of both HPR and LPR as independent events will significantly underestimate the CDF contribution. To properly model this configuration within the SDP worksheets, the following procedure is used. Consider the successful depressurization and use of LPR as the preferred path. HPR is credited

when depressurization has failed. In this manner, a sequence containing both HPR and LPR failures together is not generated.

17. SGTR event tree:

Event trees for SGTR vary from plant to plant depending on the size of primary-to-secondary leak, SG relief capacity, and the rate of rapid depressurization. However, there are several common functional steps that are addressed in the SDP worksheet: early isolation of the affected SG, initiation of primary cool-down and depressurization, and prevention of the SG overfill. These actions also include failure to maintain the secondary pressure below that of Main Steam safety valves which could occur either due to the failure of the relief valves to open or the operator's failure to follow the procedure. Failure to perform this task (sometimes referred to as early isolation and equalization) is assumed to cause continuous leakage of primary outside the containment. The success of this step implies the need for high-pressure makeup for a short period, followed by depressurization and cooldown for RHR entry (note, relief valves are assumed to re-close when primary pressure falls below that of the secondary). If the early makeup is not available or the operator fails to perform early isolation and equalization, rapid depressurization to RHR entry is usually assumed. This would typically require some kind of intermediate- or low-pressure makeup. Finally, depending on the size of the Refueling Water Storage Tank (RWST), sometimes it would be necessary to establish makeup to the RWST to allow sufficient time to enter the RHR mode.

18. ATWS scenarios:

The ATWS SDP worksheet assumes that these scenarios are not recoverable by operator actions, such as a manual trip. The failure of the scram system, therefore, is not recoverable, neither by the actuation of a back-up system nor through the actuation of manual scram. The initiator frequency, therefore, should only account for non-recoverable scrams, such as mechanical failure of the scram rods.

19. Recovery of losses of offsite power:

Recovery of losses of offsite power is assigned an operator-action category even though it is usually dominated by a recovery of offsite AC, independent of plant activities. Furthermore, the probability of recovery of offsite power in "X" hours (for example 4 hours) given it is not recovered earlier (for example, in the 1st hour) would be different from recovery in 4 hours with no condition. The SDP worksheet uses a simplified approach for treating recovery of AC by denoting it as an operator action=1 or 2 depending upon the HEP used in the IPE/PRA. A footnote highlighting the actual value used in the IPE/PRA is provided, when available.

20. RCP seal LOCA in a SBO:

The RCP seal LOCA in a SBO scenario is included in the LOOP worksheet. RCP seal LOCA resulting from loss of support functions is considered only if the loss of support function is a special initiator. The dependencies of RCP seal cooling are identified in Table 2.

21. RCP Seal LOCA for Westinghouse Plants during SBO Scenarios:

The modeling of the RCP seal failures upon loss of cooling and injection as occurs during SBO scenarios has been the subject of many studies (e.g., BNL Technical report W6211-08/99 and NUREG/CR-4906P). These studies are quite complex and assign probabilities of seal failure as a function of time (duration of SBO) and the associated leak rates. The leak rates, in turn, will determine what would be the safe period for recovery of the AC source and the use of SI pumps before core uncover and damage. On the contrary, the SDP worksheets simplify the analysis of the RCP seal LOCA during the SBO scenarios using the following two assumptions: (1) The probability of catastrophic RCP seal failure is assumed to be 1 if the SBO lasts beyond two hours, and (2) Given a catastrophic seal LOCA, the available time prior to core damage for recovery of offsite power and establishing injection is about two hours. Therefore, in almost all cases, to prevent a core damage, a source of AC should be recovered within 4 hours in SBO scenarios.

22. Tripping the RCP on loss of CCW:

Upon loss of CCW, the motor cooling will be lost. The operation of RCPs without motor cooling could result in overheating and failure of bearings. Bearing failure, in turn, could cause the shaft to vibrate and thereby result in the potential for seal failure if the RCP is not tripped. In Westinghouse plants, the operator is instructed to trip the RCPs early in the scenario (from 2 to 10 minutes after detecting the loss of cooling). Failure to perform this action is conservatively assumed to result in seal failure and, potentially in a LOCA. This failure mechanism (occurrence of seal LOCA) due to failure to trip the RCPs upon loss of cooling is not considered likely in some plants, whereas it has been modeled explicitly in other plants. To ensure consistency, the trip of the RCP pumps are modeled in the SDP worksheets, and the operator failure to do this is assumed to result in a LOCA. In many cases, the failure to trip RCP following a loss of CCW results in core damage.

23. Hot leg/Cold leg switchover:

The hot leg to cold leg switchover during ECCS recirculation is typically done to avoid boron precipitation. This is typically part of the procedure for PWRs during medium and large LOCA scenarios. Some IPEs/PRAAs do not consider the failure of this action as relevant to core damage. For plants needing the hot /cold switchover, it usually can only be accomplished with SI pumps and the ECCS recirculation also uses the SI pumps.

2.2 RESOLUTION OF PLANT-SPECIFIC COMMENTS

The licensee has provided useful comments on the draft worksheets. The licensee's comments were reviewed and incorporated into the SDP worksheets to the extent possible within the framework, scope, and limitations of the SDP worksheets. The licensee's comments were limited to the original SDP sheets, so we did not receive comments on special initiators and ISLOCA. The licensee's comment and feed back have significantly contributed to the improvement of this document.

1. No specific discussion of the loss of one DC bus was found in the IPE (Notes 2 and 9 of Table 3.2-2 of the IPE discuss the failure of DC power coincident with loss of offsite power). We modeled this event as described in the corresponding worksheet.
2. A complete loss of the Service Water System (SWS), that is, loss of one train, and then the other, has an initiating event frequency of $1.3E-6$ / year. Hence, the total frequency of the loss of both trains is about $2.6E-6$ / year. It appears that this frequency is multiplied by a recovery factor to obtain the total CDF contribution of about $2.6E-7$ / year. Total failure of SWS causes total failure of CC, which, in turn, causes core damage due to an RCP seal LOCA with no makeup; please see the discussion under Loss of One Train of CCW (LOCC).
3. Loss of instrument air is not consider a special initiator at Seabrook. The pneumatic systems are, in general, designed to fail safe. PRA important pneumatic modulating valves have high pressure gas bottle back-up. Back-up capacities as shown below:
EFW turbine driven pump steam supply valves: 4 cycles in 10 hours
Atmospheric steam dump valves: 10 cycles in 10 hours
Primary Component Cooling temperature control valves: 10 cycles in 6 hours
Primary Component Cooling heat exchanger bypass valves: 10 cycles in 6 hours
4. Loss of Ventilation is not modeled in the IPE. The IPE (page E-65) states that failure of the EAH (ventilation) System to operate for 24 hours is conservatively assumed to cause long-term failure of the charging, SI, RHR, and CBS pumps.
5. Licensee's comments on Table 2 (previously, Table 1) Initiators and System Dependency, reflecting the up-to-date plant-specific system interactions, clarification notes, and plant specific acronyms were incorporated. The licensee suggested some changes to the format of the Table, but they were not incorporated to preserve consistency with other plants' SDP documents.
6. Licensee's comments reflecting the current understanding of success criteria were incorporated in the SDP sheets.

7. The licensee suggested that the EFW MDPs have a success criteria of “2 diverse trains”. Consistent with the mitigation capability used for the SDP, they were assigned as 1 multi-train system.
8. In several cases (mainly for HPR), the licensee suggested that the support systems should be included in the SDP worksheets. This was not implemented because the support systems are included in Table 2, Initiators and System Dependency.
9. The licensee suggested that an event tree should be provided for the Stuck Open PORV (SORV) event. The event tree is the same as the one for small LOCA with the addition of the heading “Isolation of Small LOCA (BLK)”, after the initiating event, SORV. A related footnote is included in the SORV worksheet.
10. The licensee suggested to remove the branch in the ATWS event tree that leads to core damage when turbine trip fails. However, the SDP worksheets make the generic assumption that turbine trip failure results in peak RCS pressure exceeding the ASME Level C service criteria and core melt.
11. The licensee removed the MSLB event tree from its PRA model. We kept the SDP’s tree and worksheet to be consistent with the SDP models of other plants. The operator actions related to this event are not contained in the licensee’s “PSA - 1999 Update, Section 5.0, Human Action Analysis.” The HEP values from the IPE were used in the SDP’s worksheet.

REFERENCES

1. NRC SECY-99-007A, Recommendations for Reactor Oversight Process Improvements (Follow-up to SECY-99-007), March 22, 1999.
2. New Hampshire Yankee, "Seabrook Station Individual Plant Examination Report," March 1991.
3. Seabrook Station Probabilistic Safety Study - 1999 Update, Section 5.0, Human Action Analysis", 12/1/97.