

January 10, 2001

Mr. James Scarola, Vice President
Shearon Harris Nuclear Power Plant
Carolina Power & Light Company
Post Office Box 165, Mail Code: Zone 1
New Hill, North Carolina 27562-0165

SUBJECT: SITE-SPECIFIC WORKSHEETS FOR USE IN THE NUCLEAR REGULATORY
COMMISSION'S SIGNIFICANCE DETERMINATION PROCESS
(TAC NO. MA6544)

Dear Mr. Scarola:

Enclosed please find the Risk-Informed Inspection Notebook that 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. This document is publicly available through the NRC ADAMS system.

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 obtained during the 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, NRR. We will continue to assess SDP accuracy and update the document based on continuing experience.

If you have any questions, please contact me at 301-415-1373.

Sincerely,

/RA/

Richard J. Laufer, Project Manager, Section 2
Project Directorate II
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

Docket No. 50-400

Enclosure: As stated

cc w/encl: See next page

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RISK-INFORMED INSPECTION NOTEBOOK FOR SHEARON HARRIS NUCLEAR POWER PLANT

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

Prepared by

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**U. S. Nuclear Regulatory Commission
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Division of Systems Analysis and Regulatory Effectiveness**

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 Harris Nuclear Power Plant .

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 Shearon Harris Nuclear Power Plant.

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 Shearon Harris Nuclear Power Plant

Row	Approximate Frequency	Example Event Type	Estimated Likelihood Rating		
			A	B	C
I	> 1 per 1-10 yr	Reactor Trip (TRANS), Loss of Power Conversion System (TPCS), Loss of Instrument Air (LOIA)	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	SGTR, Stuck open PORV/SRV (SORV), Small LOCA including RCP seal failures (SLOCA), MSLB/FLB (outside containment), Loss of CCW (LCCW), Loss of DC bus A (LDCA), Loss of DC bus B (LDCB), LOOP with loss of one division of emergency AC (LEAC)	C	D	E
IV	1 per 10 ³ - 10 ⁴ yr	Medium LOCA (MLOCA)	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 (mechanical only), ISLOCA	F	G	H
			> 30 days	3-30 days	< 3 days
			Exposure Time for Degraded Condition		

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 Shearon Harris ⁽¹⁾

Affected Systems	Major Components	Support Systems	Initiating Event Scenarios
CSIP	Charging/SI Pumps	ESW, CSIP HVAC, AC Power distribution (6.9 kV), 125 VDC	All except Large LOCA
LHSI	RHR/LPSI Pumps	CCW trains, AC power distribution (6.9 kV), 125 VDC	All except ATWS
AFW	MDP	ESW (backup to CST) AC power, DC Power Instrument Power, UPS channel II and III	All except Medium and Large LOCAs
	TDP	DC power, Train B	
SG	PORVs A/B	125V AC ⁽³⁾ (Not Uninterrupted Power, lost in SBO)	All except Medium and Large LOCAs
	PORV C	UPS Channel III (battery backed inverter)	
RCS	3 PORVs A, B, and C	Two from vital 125 VDC and one from non-vital DC, Instrument Air	All except Medium and Large LOCAs
	Block Valve A	480V AC (Train A)	
	Block Valve B,C	480V AC (Train B)	
Containment Fan Coolers	Fans	ESW, 480V AC, and 120 VAC	Not Applicable for Core Damage
Containment Spray System	Pumps	480V AC (emergency buses 1A2-SA, 1A-SA, 1B2-SB, 1B-SB)	Not Applicable for Core Damage
CCW	Pumps	ESW, 6.9 kV (Bus 1A-SA, and 1B-SB), 125 VDC	LCCW

Table 2 (Continued)

Affected Systems	Major Components	Support Systems	Initiating Event Scenarios
NSW (Could Perform ESW function when no SI)	Pumps	Non-safety AC Power ⁽²⁾	Transients, TPCS, LDCA, and LDCB
ESW	Pumps	6.9 kV (Bus 1A, 1B), UPS Channel III, 125 VDC	All
EDG		125V DC, ESW, HVAC	LOOP, LEAC
Instrument Air (IA)	Rotary Air Compressor (RAC), valves, filters, and dryers	Non-Emergency 480V AC bus 1E3, NSW	LOIA
CSIP HVAC		ESW, AC Power	All except Medium and Large LOCA
ESFAS	Channels	UPS Channel	All
AC Power System	Non-safety distribution	Non-vital 125V DC	All
	Offsite AC circuit	Non-vital 125V DC	All
	Distribution Train A/B	vital 125V DC, DC PowerA/B	LOOP, Transient, LOCAs, SGTR, ATWS
DC Power System		AC Distribution (Without AC, battery capacity is 2 hrs.)	LDCA, LDCB
RCP	Seals	1 / 2 CSIPs to seal injection or 1 / 2 CCW Trains (3 pumps) to thermal barrier Heat Exchanger	SLOCA

Notes:

- The information contained in this table is based on the original plant IPE dated August 20, 1993 and additional licensee's comments provided during the site visit that took place on 2/9/2000. The updated plant core damage frequency from internal events is 5.0E-5.

Table 2 (Continued)

2. The NSW system could provide the cooling loads for ESW system during normal operation and when there is no SI signal.
3. The PORV could be manually operated as necessary.

1.3 SDP WORKSHEETS

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

1. Transients (Reactor Trip) (TRANS)
2. Transients with Loss of PCS (TPCS)
3. Small LOCA (SLOCA)
4. Stuck-open PORV (SORV)
5. Medium LOCA (MLOCA)
6. Large LOCA (LLOCA)
7. Loss of Off-site Power (LOOP)
8. Steam Generator Tube Rupture (SGTR)
9. Anticipated Transients Without Scram (ATWS)
10. Main Steam/Feed Water Line Break (MSLB/FLB)
11. Loss of Component Cooling Water (LCCW)
12. Loss of DC Bus A (DP-1A-SA) (LDCA)
13. Loss of DC Bus B (DP-1B-SB) (LDCB)
14. Loss of Instrument Air (LOIA)
15. LOOP with Loss of 1 Division of AC (LEAC)
16. Interfacing System LOCA (ISLOCA)

Table 3.1 SDP Worksheet for Shearon Harris — Transients (Reactor Trip) (TRANS)

Estimated Frequency (Table 1 Row) _____ Exposure Time _____ Table 1 Result (circle): A B C D E F G H			
Safety Functions Needed: Power Conversion System (PCS) Secondary Heat Removal (AFW) 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 Feedwater trains with 1/2 condensate trains (operator action = 2) 1/2 MDAFW trains (1 multi-train system) or 1 TDAFW train (1 ASD train) with 1/3 SG-PORVs 1/2 CSIPs or use of spare pump (1 multi-train system) ⁽¹⁾ 1/3 PORVs or 1/3 SRVs open for Feed/Bleed (operator action = 2) ⁽²⁾ 1/2 CSIPs with 1/2 RHR pumps and with operator action for switchover (operator action = 3) ⁽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 TRANS - PCS - AFW - HPR (4)			
2 TRANS - PCS - AFW - FB (5)			
3 TRANS - PCS - AFW - EIHP (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 IPE (page 3-77) states that the spare pump can be connected to the B train within a few minutes. However, connection to the A train will require up to eight hours to complete. Designation A&B is arbitrary and is used to differentiate between the two trains. The credit for this system follows the generic guideline number 13 of Section 2.1 of this report.
2. The HEP value for F&B in the IPE is 1.85E-3, however, the generic HEP credit of 2 (1E-2) for this action is given based on the average HEP values in similar plants.
3. The IPE HEP value for the recirculation switchover is 2.0E-3 consistent with similar plants; hence, a credit of 3 is given.

Table 3.2 SDP Worksheet for Shearon Harris — Transients with Loss of PCS (TPCS)⁽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 (AFW) 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 MDAFW trains (1 multi-train system) or 1 TDAFW train (1 ASD train) with 1/3 SG-PORVs 1/2 CSIPs or use of spare pump (1 multi-train system) ⁽²⁾ 1/3 PORVs or 1/3 SRVs open for Feed/Bleed (operator action=3) 1/2 CSIPs with 1/2 RHR pumps 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 TPCS - AFW - HPR (4)			
2 TPCS - AFW - FB (5)			
3 TPCS - AFW - EIHP (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. Transient Event Tree is used for this SDP worksheet.
2. The IPE (page 3-77) states that the spare pump can be connected to the B train within a few minutes. However, connection to the A train will require up to eight hours to complete. Designation A&B is arbitrary and is used to differentiate between the two trains. The credit for this system follows the generic guideline number 13 of Section 2.1 of this report.

Table 3.3 SDP Worksheet for Shearon Harris — 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: Early Inventory, HP Injection (EIHP) Secondary Heat Removal (AFW) RCS Cooldown/ Depressurization (RCSDEP) ⁽²⁾ Primary Bleed (F&B) Low Pressure Injection (LPI) High Pressure Recirculation (HPR) Low Pressure Recirculation (LPR)		Full Creditable Mitigation Capability for Each Safety Function: 1/2 CSIPs or use of spare pump (1 multi-train system) ⁽¹⁾ 1/2 MDAFW trains (1 multi-train system) or 1 TDAFW train (1 ASD train) Operator depressurizes RCS using 1/3 SG PORVs (operator action = 2) 1/3 SRVs or 1/3 PORVs open for Feed/Bleed (operator action = 2) 1/2 RHR trains (1 multi-train system) 1/2 CSIPs with 1/2 RHR trains and with operator action for switchover (operator action = 3) 1/2 RHR pumps; operator action to establish CCW cooling to RHR heat exchangers (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, 9)			
2 SLOCA - RCSDEP - HPR (4)			
3 SLOCA - AFW - HPR (6)			
4 SLOCA - AFW - F&B (7)			

Table 3.4 SDP Worksheet for Shearon Harris — 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: Closure of the Associated Block Valve (BLK) Early Inventory, HP Injection (EIHP) Secondary Heat Removal (AFW) RCS Cooldown/Depressurization (RCSDEP) Primary Bleed (F&B) Low Pressure Injection (LPI) High Pressure Recirculation (HPR) Low Pressure Recirculation (LPR)		Full Creditable Mitigation Capability for Each Safety Function: Operator closes the associated block valve (operator action = 3) ⁽¹⁾ 1/2 CSIPs or use of spare pump (1 multi-train system) ⁽²⁾ 1/2 MDAFW trains (1 multi-train system) or 1 TDAFW train (1 ASD train) Operator depressurizes RCS using 1/3 SG PORVs (operator action = 2) 1/3 SRVs or 1/3 PORVs open for Feed/Bleed (operator action = 2) 1/2 RHR pumps (1 multi-train system) 1/2 CSIPs with 1/2 RHR pumps and with operator action for switchover (operator action = 3) 1/2 RHR pumps ; operator action to establish CCW cooling to RHR heat exchangers (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 (2,9)			
2 SORV - BLK - RCSDEP - HPR (4)			
3 SORV - BLK - AFW - HPR (6)			
4 SORV - BLK - AFW - F&B (7)			

Table 3.5 SDP Worksheet for Shearon Harris — 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: Early Inventory, HP Injection (EIHP) Low Pressure Recirculation (LPR)		Full Creditable Mitigation Capability for Each Safety Function: 1/2 CSIPs or use of spare pump (1 multi-train system) 1/2 RHR pump trains, operator aligning CCW to RHR heat exchanger (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 - LPR (2)			
2 MLOCA - EIHP (3)			
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.			

Table 3.6 SDP Worksheet for Shearon Harris — 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, LP Injection (EILP) Low Pressure Recirculation (LPR)		Full Creditable Mitigation Capability for Each Safety Function: 1/2 RHR pump trains (1 multi-train system) 1/2 RHR trains; Operator aligns CCW to RHR Heat Exchanger (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 LLOCA - LPR (2)			
3 LLOCA - EILP (3)			
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.			

Table 3.7 SDP Worksheet for Shearon Harris — Loss of Offsite Power (LOOP)

Estimated Frequency (Table 1 Row) _____ Exposure Time _____ Table 1 Result (circle): A B C D E F G H			
<u>Safety Functions Needed:</u> Emergency AC Power (EAC) Turbine-driven AFW Pump (TDAFW) Secondary Heat Removal (AFW) Recovery of AC Power in < 2 hrs (REC2) Recovery of AC Power in < 5 hrs (REC5) Early Inventory, HP Injection (EIHP) Primary Heat Removal (FB) High Pressure Recirculation (HPR)		<u>Full Creditable Mitigation Capability for Each Safety Function:</u> 1/2 Emergency Diesel Generators (1 multi-train system) 1/1 TDP trains of AFW (1 ASD train) with 1/1 SG-PORVs ⁽¹⁾ 1/2 MDAFW trains (1 multi-train system) or 1 TDAFW train (1 ASD train) ⁽¹⁾ plus 1/3 SG-PORVs SBO procedures implemented (operator action = 1) ⁽²⁾ SBO procedures implemented (operator action = 2) ^(3, 4) 1/2 CSIPs or use of spare pump (1 multi-train system) ⁽⁵⁾ Operator uses RCS pressurizer 1/3 SRV or 1/3 PORVs (operator action = 2) 1/2 CSIPs with 1/2 RHR pumps, requires 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 LOOP - AFW - HPR (3)			
2 LOOP - AFW - FB (4)			
3 LOOP - AFW - EIHP (5)			
4 LOOP - EAC - HPR (7, 11) (AC recovered)			
5 LOOP - EAC - EIHP (8, 13) (AC recovered)			

require up to eight hours to complete. Designation A&B is arbitrary and is used to differentiate between the two trains.

Table 3.8 SDP Worksheet for Shearon Harris — 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 (SHR) Early Inventory, HP Injection (EIHP) Pressure Equalization (EQ) Feed-and-Bleed (FB) High Pressure Recirculation (HPR) Long-Term RCS Makeup Source (LTMS)		Full Creditable Mitigation Capability for Each Safety Function: 1/2 MDPs of AFW (1 multi-train system) or 1/1 TDP of AFW (1 ASD Train) 1/2 CSIPs or use of spare pump (1 multi-train system) ⁽¹⁾ Operator isolates the ruptured SG and depressurizes RCS using SG PORVs (2/2) or RCS pressurizer PORV (1/3) to less than setpoint of relief valves of SG (operator action = 2) ⁽²⁾ Operator uses RCS pressurizer 1/3 SRV or 1/3 PORVs (operator action = 2) 1/2 RHR pump trains with 1/2 CSIPs and with operator switchover to recirculation (operator action = 3) Operator refills RWST or aligns other sources to safety injection system (operator action = 2) ⁽³⁾	
Circle Affected Functions	Recovery of Failed Train	Remaining Mitigation Capability Rating for Each Affected Sequence	Sequence Color
1 SGTR - EQ - LTMS (3)			
2 SGTR - EIHP - EQ (5)			
3 SGTR - SHR - HPR - LTMS (8)			
4 SGTR - SHR - FB (9)			
5 SGTR - SHR - EQ (10)			

6 SGTR - SHR - EIHP (11)			
<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. The IPE (page 3-77) states that the spare pump can be connected to the B train within a few minutes. However, connection to the A train will require up to eight hours to complete. Designation A&B is arbitrary and is used to differentiate between the two trains.
2. Operator isolates the ruptured SG and depressurizes RCS may be represented in the IPE (page 3-228) by the human action "Operator fails to locally operate any SG PORV" (OPER-27, human error probability = 9.5E-3).
3. The HEP value for this action in the IPE is 5.2E-3 (OPER-30). A HEP credit of 2 consistent with generic data was given.

Table 3.9 SDP Worksheet for Shearon Harris — 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) Emergency Boration (HPI) Secondary Heat Removal (AFW) Primary Relief (SRV)		Full Creditable Mitigation Capability for Each Safety Function: Operator trips the turbine (operator action = 2) Operator conducts emergency boration using 1/2 CSIP pump trains (operator action = 2) ⁽²⁾ 2/2 MDPs AFW (1 train) or 1/1 TDP of AFW (1 ASD train) 3/3 SRVs with 2/3 PORVs open (1 train)	
<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 - SRV (2)			
2 ATWS - AFW (3)			
3 ATWS - HPI (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 does not apply to those initiators for which the operation of main feedwater provides sufficient time for emergency boration.
2. The operator action associated with initiation of emergency boration in the updated IPE is OPER-36 with a value of 1.5E-3. A HEP credit of 2 is given based on the generic SDP-HEP values.

Table 3.10 SDP Worksheet for Shearon Harris — Main Steam/Feed Water Line Break (MSLB/FLB)

Estimated Frequency (Table 1 Row) _____ Exposure Time _____ Table 1 Result (circle): A B C D E F G H			
Safety Functions Needed: Power Conversion System (PCS) Isolation of the Secondary Break (ISO) Secondary Heat Removal (AFW) 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 Feedwater trains with 1/2 condensate trains (operator action = 2) Closure of the MSIV for MSLB or Feed Water Isolation valve for FLB (1 train) 1/2 MDAFW trains (1 multi-train system) or 1 TDAFW train (1 ASD train) with 1/3 SG-PORVs 1/2 CSIPs or use of spare pump (1 multi-train system) ⁽¹⁾ 1/3 PORVs or 1/3 SRVs open for Feed/Bleed (operator action = 2) 1/2 CSIPs with 1/2 RHR pumps 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 MSLB/FLB - PCS - AFW - HPR (4)			
2 MSLB/FLB - PCS - AFW - FB (5)			
3 MSLB/FLB - PCS - AFW - EIHP (6)			
4 MSLB/FLB - ISO - AFW - PCS ⁽²⁾ (9)			

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 IPE (page 3-77) states that the spare pump can be connected manually. The credit for this system follows the generic guideline number 13 of Section 2.1 of this report.
2. FB is not credited when secondary break is not isolated. This is consistent with the updated minimal cut sets received from the licensee during the site visit.

Table 3.11 SDP Worksheet for Shearon Harris — Loss of Component Cooling Water⁽¹⁾ (LCCW)

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 (AFW) RCP Trip (RCPT) Early Inventory, High Pressure Injection (EIHP) Early Inventory, Low Pressure Injection (LPI) RCS Cooldown and Depressurization (RCSDEP)		Full Creditable Mitigation Capability for Each Safety Function: 1/2 MDAFW trains (1 multi-train system) or 1 TDAFW train (1 ASD train) ⁽²⁾ Trip the RCP on loss of CCW to avoid bearing failure (operator action = 3) ⁽³⁾ 1/2 CSIPs or use of spare pump (1 multi-train system) ⁽⁴⁾ 1/2 RHR pump trains (1 multi-train system) Operator depressurizes RCS using 1/3 SG PORVs and secondary heat removal (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 LCCW - AFW (2, 5, 9)			
2 LCCW - RCPT - RCSDEP (4)			
3 LCCW - EIHP - LPI (7)			
4 LCCW - EIHP - RCSDEP ⁽⁵⁾ (8) (Would result in RCP seal LOCA)			

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 CCW is estimated to be 4.4 E-3 in the plant IPE. Reactor trip will occur since CCW provides cooling to RCP motors. If the charging flow to RCP seals is not available or the operator does not trip the RCP, the seal LOCA will occur in loss of CCW transients. Occurrence of Seal LOCA in the original SDP was considered to lead directly to core damage since no recirculation would be available. However, this assumption was considered too conservative per the site visit and was relaxed (see note 5).
2. The value assessed by the IPE (Table 3-26, page 3-214, and Table 3-27, page 3-216) for the failure of the TDP of AFW is 1.8E-1 (assuming a mission time of 24 hours). For the SDP calculation, a value of 1E-1 can be used.
3. The credit for operator action is based on generic data for trip of RCPs on loss of CCW.
4. The IPE (page 3-77) states that the spare pump can be connected to the B train within a few minutes, and this recovery action can be credited (operator action). However, connection to the A train will require up to eight hours to complete, and in most cases the injection is needed before this time; hence, such recovery action cannot be credited in the models when only train A is available.
5. In those scenarios where RCP seal LOCA occurs due to loss of CCW and no seal injection, the operator depressurizes the primary and uses the LPI. The current licensee's IPE assumes that the operator could depressurize and cool down as long as the secondary heat removal and LPI are available. The operator may not need to go to the recirculation phase within 24 hours due to reduced leakage (i.e., the 24 hour mission time considered by the PRA).

Table 3.12 SDP Worksheet for Shearon Harris — Loss of DC Bus A (DP-1A-SA)⁽¹⁾ (LDCA)

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 (AFW) Early Inventory, High Pressure Injection (EIHP) Primary Heat Removal, Feed/Bleed (FB) High Pressure Recirculation (HPR)		Full Creditable Mitigation Capability for Each Safety Function: 1/1 MDAFW trains (1 multi-train system) or 1 TDAFW train (1 ASD train) ⁽²⁾ with 1/3 SG-PORVs 1/1 CSIPs or use of spare pump (1 train system) 1/3 SRVs or 2/2 PORVs (operator action = 2) ⁽³⁾ 1/1 CSIPs with 1/1 RHR pumps and with operator action for switchover, operator action = 3, but limited by hard ware failure (1 train system)	
<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 - AFW - HPR (4)			
2 LDCA - AFW - FB (5)			
3 LDCA - AFW - EIHP (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 division DC is estimated to be $1.7 \text{ E-}3$ in the plant IPE. Reactor trip will occur due to feedwater isolation. Upon loss of a division of DC, all safety train associated with that bus is assumed not to be available. The transient event tree with loss of PCS (TPCS) was used for this initiator with .
2. The value assessed by the IPE (Table 3-26, page 3-214, and Table 3-27, page 3-216) for the failure of the TDP of AFW is $1.8\text{E-}1$ (assuming a mission time of 24 hours). For the SDP calculation, a value of $1\text{E-}1$ can be used.
3. One PORV is fed from non-vital DC and the other PORV is fed from the B division of vital DC.

Table 3.13 SDP Worksheet for Shearon Harris — Loss of DC Bus B (DP-1B-SB)⁽¹⁾ (LDCB)

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 (AFW) Early Inventory, High Pressure Injection (EIHP) Primary Heat Removal, Feed/Bleed (FB) High Pressure Recirculation (HPR)		Full Creditable Mitigation Capability for Each Safety Function: 1/1 MDAFW trains (1 train system) 1/1 CSIPs (1 train system) ⁽²⁾ 1/3 SRVs or 2/2 PORVs (operator action = 2) ⁽³⁾ 1/1 CSIPs with 1/1 RHR pumps and with operator action for switchover; operator action = 3, but limited by hardware failure (1 train system)	
Circle Affected Functions	Recovery of Failed Train	Remaining Mitigation Capability Rating for Each Affected Sequence	Sequence Color
1 LDCB - AFW - HPR (4)			
2 LDCB - AFW - FB (5)			
3 LDCB - AFW - EIHP (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 division DC is estimated to be 1.7 E-3 in the plant IPE. Reactor trip will occur due to feedwater isolation. Upon loss of a division of DC, all safety trains associated with that bus is assumed not to be available. Loss of division B of DC would affect two trains of the AFW system (the TDAFW would also lose control power). The transient event tree with loss of PCS (TPCS) was used for this initiator. No Credit could be given to the spare CSIP pump.
2. The IPE (page 3-77) states that the spare pump can be connected to the B train within a few minutes, but connection to the A train will require up to eight hours to complete. In case of failure of Bus B resulting in failure of CSIP B, the use of spare CSIP is not credited.
3. One PORV is fed from non-vital DC whereas the other PORV not affected by the initiator is fed from division A of vital DC.

Table 3.14 SDP Worksheet for Shearon Harris — Loss of Instrument Air ⁽¹⁾ (LOIA)

Estimated Frequency (Table 1 Row) _____ Exposure Time _____ Table 1 Result (circle): A B C D E F G H			
Safety Functions Needed: Recovery of MFW and PCS (PCSL) Secondary Heat Removal (AFW) Early Inventory, High Pressure Injection (EIHP) Primary Heat Removal, Feed/Bleed (FB) High Pressure Recirculation (HPR)		Full Creditable Mitigation Capability for Each Safety Function: Local manual action of the valves to align and recover PCS (operator action = 1) ⁽²⁾ 1/2 MDAFW trains (1 multi-train system) or 1 TDAFW train (1 ASD train) plus 1/3 SG-PORV or the safeties 1/2 CSIPs or use of spare pump (1 multi-train system) ⁽³⁾ 1/3 PORV or 1/3 SRVs open for Feed/Bleed (operator action = 2) 1/2 CSIPs with 1/2 RHR pumps 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 LOIA - AFW - PCSL - HPR (4)			
2 LOIA - AFW - PCSL - FB (5)			
3 LOIA - AFW - PCSL - EIHP (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 instrument air is estimated to be 0.13 per reactor year. It would cause a trip due to loss of MFW and MSIV closures. Pressurizer PORV may not be available if nitrogen is inadequate; however, they are credited here. Pressurizer auxiliary spray will also fail. Since the high head pumps have a shut off head of 2700 psi, feed and bleed could be performed either by PORVs or SRVs. The PCS/MFW/MSIVs could be operated locally without any instrument air; however, the actions are considered to be operator actions with credit of one. The transient event tree is used for this worksheet.
2. The recovery of PCS by local alignment of the valves prior to SG dryout is considered a demanding action and a credit of one is generically assigned.
3. The IPE (page 3-77) states that the spare pump can be connected to the B train within a few minutes. However, connection to the A train will require up to eight hours to complete. Designation A&B is arbitrary and is used to differentiate between the two trains. The credit for this system follows the generic guideline number 13 of Section 2.1 of this report.

Table 3.15 SDP Worksheet for Shearon Harris — LOOP with Loss of 1 Division of AC ⁽¹⁾ (LEAC)

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 (AFW) Failure of the PORV to Re-close (SORV) RCS Cooldown/Depressurization (RCSDEP) Early Inventory, High Pressure Injection (EIHP) Low Pressure Injection (LPI) Primary Heat Removal, Feed/Bleed (FB) Low Pressure Recirculation (LPR) High Pressure Recirculation (HPR)				Full Creditable Mitigation Capability for Each Safety Function: 1/1 MDAFW trains (1 train system) or 1 TDAFW train (1 ASD train) ⁽²⁾ 3/3 PORVs to re-close (1 train system) Operator depressurizes RCS using 1/3 SG PORVs (operator action = 2) 1/1 CSIPs (1 train system) ⁽³⁾ 1/1 RHR pumps (1 train system) 1/3 PORVs or 1/3 SRVs open for Feed/Bleed (operator action = 2) 1/1 RHR trains ; operator action to establish CCW cooling to RHR heat exchangers; operator action = 3, but limited by hardware failure (1 train system) 1/1 CSIPs with 1/1 RHR pumps and with operator action for switchover, operator action = 3, but limited by hardware failure (1 train system)							
<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 LEAC - AFW - HPR (3,15)											
2 LEAC - AFW - FB (4)											
3 LEAC - AFW - EIHP (5,16)											
4 LEAC - SORV - LPR (7,11)											

Table 3.16 SDP Worksheet for Shearon Harris Nuclear Power Plant — 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 Hot Leg Suction LHSI Cold Leg Injection LHSI Hot Leg Injection		Mitigation Capability: Ensure Component Operability for Each Pathway: 2 normally closed MOVs per train ((1RH-1 & 1RH-2) or (1RH-39 & 1RH-40) and RWST protected by a check valve. Break size of 12 to 14 inches and may not be an ISLOCA (leak inside containment) One shared check valve, one non-shared check valve per train, and an open MOV that can be closed, if needed (operator action). One shared check valve, one non-shared check valve per train, and a closed MOV	
<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. Information is provided based on the docketed IPE. Other sources of ISLOCA are not included due to very low likelihood of occurrence.

1.4 SDP EVENT TREES

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

The following event trees are included:

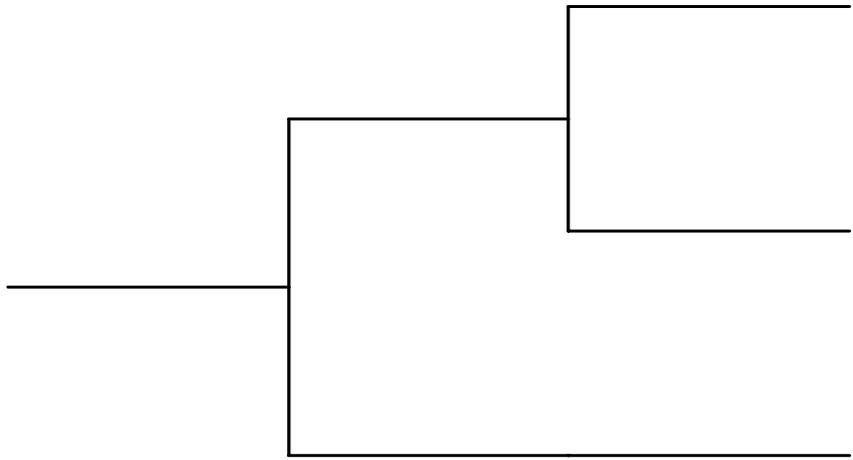
1. Transients (Reactor Trip) (TRANS)
2. Small LOCA (SLOCA)
3. Medium LOCA (MLOCA)
4. Large LOCA (LLOCA)
5. Loss of Offsite Power (LOOP)
6. Steam Generator Tube Rupture (SGTR)
7. Anticipated Transients Without Scram (ATWS)
8. Main Steam/Feed Water Line Break (MSLB/FLB)
9. Loss of Component Cooling Water (LCCW)
10. LOOP with Loss of 1 Division of AC (LEAC)

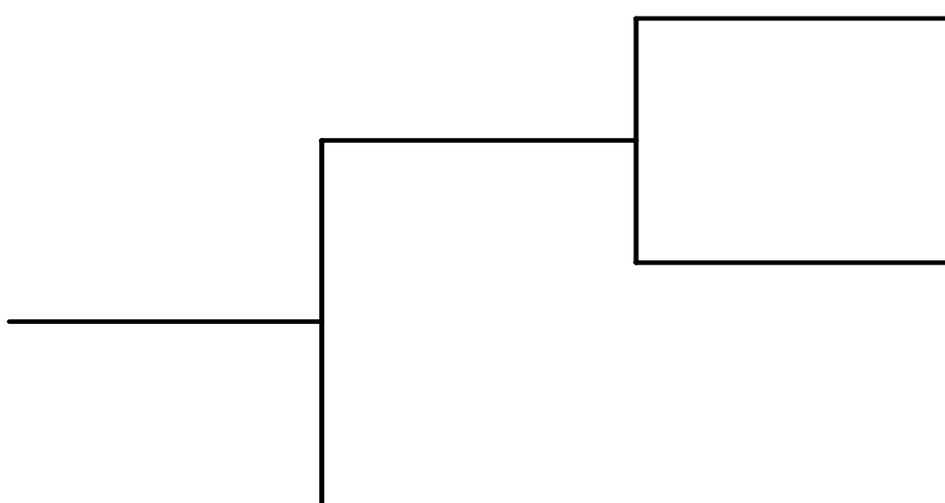
TRANS	PCS	AFW	EIHP	FB	HPR	#	STATUS
						1	OK
						2	OK
						3	OK
						4	CD
						5	CD
						6	CD

Plant Name Abbrev.: HARR

SLOCA	EIHP	AFW	RCSDEP	F&B	LPI	HPR	LPR	#	STATUS
								1	OK
								2	CD
								3	OK
								4	CD
								5	OK
								6	CD
								7	CD
								8	OK
								9	CD
								10	CD
								11	CD
								12	CD

Plant name abbrev.: HARR

MLOCA	EIHP	LPR	#	STATUS
 <p data-bbox="762 1247 1402 1292">Plant name abbrev.: HARR</p>				1 OK
				2 CD
				3 CD

LLOCA	EILP	LPR	#	STATUS
			1	OK
			2	CD
			3	CD

Plant Name Abbrev.: HARR

LOOP	EAC	TDAFW	AFW	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.: HARR

SGTR	SHR	EIHP	EQ	FB	HPR	L.TMS	#	STATUS
							1	TRANS
							2	OK
							3	CD
							4	TRANS
							5	CD
							6	OK
							7	OK
							8	CD
							9	CD
							10	CD
							11	CD

Plant name abbrev.: HARR

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

Plant Name Abbrev.: HARR

MSLB/FLB	ISO	AFW	PCS	EIHP	FB	HPR	#	STATUS
							1	OK
							2	OK
							3	OK
							4	CD
							5	CD
							6	CD
							7	OK
							8	OK
							9	CD

Plant Name Abbrev.: HARR

LCCW	EIHP	RCPT	AFW	RCSDEP	LPI	#	STATUS
						1	OK
						2	CD
						3	OK
						4	CD
						5	CD
						6	OK
						7	CD
						8	CD
						9	CD

Plant Name Abbrev.: HARR

LEAC	SOR V	AFW	EIHP	RCSDEP	FB	LPI	HPR	LPR	#	STATUS
									1	OK
									2	OK
									3	CD
									4	CD
									5	CD
									6	OK
									7	CD
									8	OK
									9	CD
									10	OK
									11	CD
									12	CD
									13	CD
									14	OK
									15	CD
									16	CD

Plant Name Abbrev.: HARR

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:

- 0.01 Describe the success criteria and the mitigation capability of dedicated EDGs.
- 0.02 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.
- 0.03 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.
- 0.04 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/PRA's 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

BNL and the NRC met with Shearon Harris personnel on February 9, 2000. Shearon Harris was a pilot plant; therefore, licensee comments on the draft worksheets were received previously and were incorporated prior to site visit. The Licensee provided useful comments on the updated worksheets. The special initiators, plant response, and the initiator impacts were discussed. Other items included as a part of NRC review process were also discussed. Number of questions were raised and written responses were received from the licensee subsequent to the meeting. The licensee responses were reviewed and incorporated into the SDP worksheet to the extent possible within the framework, scope, and limitations of the SDP worksheets. The licensee's comment and feedback have significantly contributed to the improvement of this document.

1. Licensee's comments on the Initiator and System Dependency Tables reflecting the up-to-date plant-specific system interactions, clarification notes, and plant specific acronyms were all incorporated.
2. Licensee's comments reflecting the current understanding of success criteria were all incorporated in the SDP worksheets.
3. The information provided by the licensee on the impacts of special initiators on the plants systems and components were all incorporated in developing the SDP worksheets for the special initiators and the associated Event Trees. Footnotes are added under the worksheet for each special initiator to reflect the discussion that took place during the site visit.
4. Licensee performed a series of importance and sensitivity calculations for the purpose of benchmarking of the SDP worksheets. The outputs from these runs were provided to BNL/NRC staff. Generally, the updated worksheets provided consistent results with the exception of the cases where the scenario involved dependent operator actions. The SDP worksheets are not modified to account for these discrepancies since this level of detail is beyond the current SDP process.

REFERENCES

1. NRC SECY-99-007A, Recommendations for Reactor Oversight Process Improvements (Follow-up to SECY-99-007), March 22, 1999.
2. Carolina Power and Light Company, "Shearon Harris Nuclear Power Plant Individual Plant Examination Submittal Final Report," August 31, 1993.