PWR DRAFT
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RISK-INFORMED INSPECTION TEMPLATE FOR A PWR DURING SHUTDOWN

U. S. Nuclear Regulatory Commission
Office of Nuclear Reactor Regulation

POINT OF CONTACT FOR ASSISTANCE/COMMENTS
Marie Pohida NRR/DSSA/SPSB
301-415-1846

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1.0 ENTRY CONDITIONS AND APPLICABILITY

As directed in the SRM to SECY 97-168, the staff is inspecting and monitoring licensee performance at shutdown to ensure that the licensees are maintaining a mitigation capability (equipment, instrumentation, policies, procedures, and training) consistent with the staff's estimate of industry shutdown risk presented to the Commission in SECY 97-168 (the proposed shutdown rule). In the Reactor Oversight Process (ROP), the significance of such inspection findings is assessed, using a Risk Informed process, called the Significance Determination Process (SDP). The shutdown SDP consists of two phases: Phase 1, Definition and Initial Screening of Findings and, Phase 3, Risk Significance Finalization and Justification. IMC 0609 Appendix G, Shutdown Operations Significance Determination Process is used to conduct the phase 1 screening analysis. This template is used to perform phase 3 analyses for certain PWR shutdown findings discussed below.

1.1 Entry Conditions

1.1.1 SDP-related Inspection Finding

This SDP provides a simplified risk-informed framework to estimate the increase in core damage frequency during shutdown operations due to conditions which contribute unintended risk increases caused by deficient licensee performance. Conditions which do NOT represent deficient licensee performance, as determined by the staff, are considered part of the acceptable plant normal operating risk, and are NOT candidates for SDP evaluation. The entry conditions for the shutdown SDP described in this document are degraded plant equipment, functions, or processes affecting initiating event frequency, mitigation system availability/reliability, or RCS barrier integrity that result from deficient licensee performance.

Concurrent performance deficiencies should be assessed collectively if they resulted from a closely-tied common cause. If causes are independent, each performance deficiency should be assigned a color individually. See IMC 0609, Appendix A for more detailed guidance.

Each issue should first be screened by using IMC 0612 (formerly 0610*), Appendix B to determine whether or not the issue is a minor issue. If the issue screens as minor this SDP should not be entered.

1.1.2 MD 8.3 Entry

This tool is used when a performance deficiency is identified as needing quantitative assessment from the phase 1 shutdown SDP screening tool (IMC 0609 Appendix G).

1.2 Applicability

The process in this SDP is designed to provide Senior Reactor Analysts a simple scrutable probabilistic risk framework for use in identifying potentially risk-significant shutdown issues within the initiating events, mitigation systems, and barriers cornerstones. The results from this SDP tool are intended to facilitate communication on the basis of risk significance between the NRC and licensees.

2.0 LIMITS AND PRECAUTIONS

2.1 Limits

The template is a simplified tool that generates an order-of-magnitude assessment of the risk significance of inspection findings during shutdown.

2.2 Precautions

2.2.1 The analyst should consider each evaluated Core Damage sequence using the event trees to ensure that the scenario makes sense for the deficiency. The variability of plant configurations at shutdown and timing issues may result in performance deficiencies which do not directly map on the event trees. See Headquarters for assistance if needed. Before using Worksheets, SRAs should review attached event trees to ensure that Worksheet entries are consistent with the sequence logic in the event trees.

2.2.2 The analyst must understand: (1) the differences between precursor and condition findings, (2) the definitions of the plant operational states, and (3) the definitions of the shutdown initiating events. These definitions can be found in Chapter 6.4, Procedure for Significance Determination.

2.2.2 The SDP is constructed for a Westinghouse 4-loop PWR. This template can be used for other PWR types acknowledging that different systems may be used to maintain the safety functions listed in the worksheets.

2.2.3 The availability of standby RCS injection along with operator error drives shutdown risk. As long as standby injection is available, in most cases, standby injection buys time for other operator recovery actions such as: leak path termination and RHR recovery. If there are factors that could render the standby RCS injection unavailable such as: gas intrusion or support system unavailability, then these factors (assumptions) become risk significant and should be assessed carefully.

2.2.4 Some findings are not covered by these templates and go directly to Headquarters for Phase 3 analysis. Examples of such findings are as follows:

- Potential over-pressurization of low -pressure piping and deficiencies associated with maintaining low temperature over pressure protection.

- Use of Nozzle Dams without an adequate RCS vent path that would prevent the RCS from re-pressurizing above 25 psig following an extended loss of RHR (25 psi represents an approximate differential pressure capability for the nozzle dams)

- Findings that increase the likelihood of having a boron dilution event such as the source range monitors being inoperable or the RWST having boron concentrations lower than Technical Specifications prescribed values.

- Findings that involve containment closure deficiencies

3.0 ABBREVIATIONS AND DEFINITIONS

3.1 Abbreviations

CETs	Core Exit Thermocouples
CD	Core Damage
High Decay Heat	Decay heat of early time window
Low Decay Heat	Decay heat of late time window
CCW	Component Cooling Water
DHR	Decay Heat Removal
ECCS	Emergency Core Cooling System
INDIC.	Indication
IMC	Inspection Manual Chapter
LOI	Loss of Reactor Inventory Initiating Event
LER	Licensee Event Report
LOOP	Loss of Offsite Power
LORHR	Loss of RHR Initiating Event
OP.	Operator
POS	Plant Operational State
PRA	Probabilistic Risk Assessment
RCS	Reactor Coolant System
RHR	Residual Heat Removal
ROP	Reactor Oversight Process
SDP	Significance Determination Process
SG	Steam Generator
SG PORV	Steam Generator Power Operated Relief Valve
SRW	Site Raw Water
SSW	Standby Service Water
TBB	Time to Boiling
TW	Time Window
TW-E	Early Time Window, before refueling operation
TW-L	Late Time Window, after refueling operation

3.2 Definitions

Phases of a Significance Determination

Phase 1 -Characterization and Initial Screening of Findings: Precise characterization of the finding and an initial screening of very low-significance findings for disposition by the licensee's corrective action program.

Phase 3 - Risk Significance Finalization and Justification: Quantitative assessment of the risk significance of a shutdown finding as directed from the Phase 1 shutdown SDP analysis (IMC 0609 Appendix G).

Types of Shutdown Performance Deficiencies

Precursor Finding - Inspection findings that have the potential to cause a loss of the operating train of RHR.

Condition findings - Inspection findings that only involve a degradation of the licensee's mitigation capability.

Shutdown Initiating Events

Loss of RHR (LORHR) - Includes losses of RHR resulting from failures of the RHR system (such as RHR pump failure) or failures of the RHR support systems other than offsite power.

Loss of Offsite Power (LOOP) - Includes losses of offsite power which cause a loss of RHR.

Loss of Reactor Inventory (LOI) - Includes losses of RCS inventory that lead to a loss of RHR due to loss of RHR pump suction.

Loss of Level Control (LOLC) - This initiating event category includes: (1) the operator overdrains the RCS to reach midloop conditions such that RHR is lost, and (2) the operator fails to maintain level control while in midloop such that the RHR function is lost.

Plant Operational States (POSs)

POS 1 - This POS starts when the RHR system is put into service. The RCS is closed such that a steam generator could be used for decay heat removal, if the secondary side of a steam generator is filled. The RCS may have a bubble in the pressurizer. This POS ends when the RCS is vented such that the steam generators cannot sustain core heat removal. This POS typically includes Mode 4 (hot shutdown) and portions of Mode 5 (cold shutdown).

POS 2 - This POS starts when the RCS is vented such that: (1) the steam generators cannot sustain core heat removal and (2) a sufficient vent path exists for feed and bleed. This POS includes portions of Mode 5 (cold shutdown) and Mode 6 (refueling). Reduced inventory operations and midloop operations with a vented RCS are subsets of this POS. Note: performance deficiencies occurring during a vacuum refill of the RCS require use of the POS 1 event trees.

POS 3 - This POS represents the shutdown condition with the refueling cavity filled to 23 feet above the vessel flange and the spent fuel storage pool gates are removed. A very large amount of coolant inventory is available. This POS occurs during Mode 6.

Time Windows

Early Time Window (TW-E)- This time widow represents the time before POS 3 is entered. The decay heat is relatively high. The reactor is either in POS 1 or 2.

Late Time Window (TW-L)- This time window represents the time after POS group 3. The decay heat is relatively low. The reactor is either in POS 1, 2, or 3.

Other Key Shutdown Definitions

Available - A piece of equipment is considered available if it can be put into service quickly enough to meet its function need and all necessary supporting systems are functional (such as AC power, cooling water, and DC control power)

Gravity Feed - Gravity feeding to the RCS may be credited if Gravity Feed is expected to be available AFTER RCS boiling initiates. To credit Gravity Feed, the analyst needs to consider the following factors that can negate the elevation head provided by the RWST or other sources of RCS inventory: (1) pressure drops in the surge line, (2) entrained water accumulating in the pressurizer, (3) RCS vent paths that are restricted (to control loose parts or control off gassing)

RCS Vented - RCS vented with such that(1) SG heat removal cannot be sustained, and (2) the vent path is large enough to support feed and bleed. Examples of vent paths include: open pressurizer manways, safety relief valve removal, or vessel head removal.

Reduced Inventory Operations - Reduced inventory operation exists whenever the reactor vessel water level is lower than 3 feet below the reactor vessel flange.

RWST Depletion - RWST level reaches the level that requires makeup or recirculation to continue injection to RCS

Shutdown Operations - Shutdown Operation exists during hot shutdown, cold shutdown, and refueling when more than one fuel assembly is in the reactor vessel and the decay heat removal system is in operation.

4.0 PROCEDURE FOR SIGNIFICANCE DETERMINATION

Step 4.1 Initiating Event Characterization

Detailed guidance for initiating event characterization can be found in Sections 6.2 through 6.5 of the Basis Document.

Step 4.1.1 Determine if the finding is a precursor to an initiating event (a loss of the RHR function) or a condition finding. Note: Precursor findings have the potential to cause a loss of the operating train of RHR or actually caused the loss of the RHR function. Condition findings only involve a degradation of the licensee's capability to mitigate an event if an event were to occur. The SDP is significantly different for these two different types of findings.

Step 4.1.2 Go to Step 4.1.2.1 for Precursor Findings or Step 4.1.2.2 for Condition Findings.

Step 4.1.2.1 *Precursor Findings* - Determine the IEL rating. Evaluate the following in order, one will apply:

- IF a finding increases the likelihood of a loss of level control (LOLC) or actually caused a LOLC, THEN LOLC is the applicable initiating event. Use Table 1 to determine the IEL. Go to Step 4.1.2.1.1.

- IF a finding increases the likelihood of a loss of offsite power (LOOP) or actually caused a LOOP, THEN LOOP is the applicable initiating event. Use Table 2 to determine the IEL. Go to Step 4.1.2.1.1.

- IF a finding increases the likelihood of a loss of reactor inventory (LOI) or actually caused a LOI, THEN LOI is the applicable initiating event. Use Table 3 to determine the IEL. Go to Step 4.1.2.1.1.

- IF a finding increases the likelihood of a loss of the operating train of RHR (LORHR) or actually caused a LORHR (except for LOOP and LOI), THEN LORHR is the applicable initiating event. Use Table 4 to determine the IEL. Go to Step 4.1.2.1.1.

- IF a finding involves the RHR support systems (except for LOOP and LOI), THEN LORHR is the applicable initiating event. Use Table 4 to determine the IEL. Go to Step 4.1.2.1.1.

Step 4.1.2.1.1 Determine the POS and TW in which the precursor occurred. Figure 3 defines the POSs used in the SDP. Go to Step 4.2.

Step 4.1.2.2 *Condition Findings* - Select the applicable initiating events (LOLC, LORHR, LOOP and/or LOI) by identifying the equipment or safety functions affected and determine the initiating event scenarios that must be evaluated (i.e., the affected function plays some role in mitigating the initiating event scenario). Tables provided in the plant-specific full power SDP notebooks provide useful information, as do the SDP worksheets in this document.

Step 4.1.2.2.1 Determine the exposure times for the degraded condition in the mitigating system. A separate exposure time must be determined for each POS for findings that span one or more POS. Using Table 5, determine an IEL for each applicable initiating event in each applicable POS. Go to Step 4.3.

Step 4.2 Evaluation of Mitigation Capability for Precursor Findings

Use the SDP Worksheet that contains the POS and initiating event that were determined to be applicable in Step 4.1. **EXCEPTIONS**: (1) For LOI precursors where the leak path would naturally terminate at the bottom of the hotleg **without** operator intervention, the use the LOLC worksheets and event trees. (2) For LOOP findings in POS, if failure of the cavity seal could occur following LOOP or SBO, then use the LOOP POS 2 worksheets. If the cavity seal stays intact, then the finding is screened green.

Detailed guidance for initiating event characterization can be found in Sections 6.6 of the Basis Document. Underlined phrases are Worksheet column headings.

Step 4.2.1 Enter the time to boiling, the time to core uncovery, and the time to core damage in the first line of the Worksheet and the IEL in each row of the lower section of the worksheet. Table 9 can be used to estimate time to core damage from hot leg midplane conditions. Below the safety function section of the Worksheet is a listing of core damage sequences associated with the initiating event being evaluated. Evaluate all sequences for the applicable initiating event in the applicable POS.

Step 4.2.2 Determine the remaining creditable mitigation capability for each safety function assuming the occurrence of the initiating event, and using the reported status of plant equipment and the times to boiling and core damage. The various Safety Functions Needed to mitigate the specific initiating event are listed in the first column of the SDP Worksheet. The creditable plant-specific capability that is potentially available to satisfy the safety function is described in the second column, entitled Success Criteria and Important Instrumentation. Use the Event Tree associated with the Worksheet to help understand the successes and failures associated with each accident sequence.

Step 4.2.2.1 Determine the Equipment Credit based on the remaining equipment capability for each affected safety function. Use guidance in Tables 7 and 8, and notes in the Worksheet to enter the Equipment Credit in the third column of the Worksheet. Document key assumptions.

Step 4.2.2.2 Determine the Operator Credit based on the time and complexity of operator actions to use the available equipment to achieve each safety function. Take into account the availability of instrumentation, alarms, time and procedures for the operator. Table 6 provides general guidance for operator credits and the Worksheets contain sequence specific guidance. Document key assumptions.

Step 4.2.2.3 Determine the Credit for Function for each Safety Function Needed. Select the lower of Equipment Credit and Operator Credit, and enter the value in this column.

Step 4.2.3 Working in the lower section of the Worksheet, determine the risk increase for the Finding. Use the Event Tree associated with the Worksheet to help understand the successes and failures associated with each accident sequence.

Step 4.2.3.1 Enter the Mitigation Credit in the form of an additive equation of Credit for Functions from the upper section of the worksheet for each Core Damage Sequence. For example, take the Core Damage Sequence is LOLC - SG - BLEED - RHR-S. If the Credit for Function for SG is 0 (meaning steam generators are not available), for BLEED is 4 and for RHR-S is 2, enter 0+4+2 into the Mitigation Credit column.

Step 4.2.3.2 Recovery credit IS NOT used for precursor findings since recovery is already factored into the availability of the safety functions. Therefore, the recovery credit should be left blank.

Step 4.2.3.3 Sum these credit values (IEL + Mitigation Credit + Recovery) for each sequence and enter the value in the Result column. Go to Step 4.4.

Step 4.3 Evaluation of Mitigation Capability for Condition Findings

Use the SDP Worksheet(s) that contain the POSs and initiating events that were determined to be applicable in Step 4.2. Detailed guidance for initiating event characterization can be found in Sections 6.6 of the Basis Document. Perform the following steps on the Worksheet for each applicable POS and initiating event.

Step 4.3.1 Enter the time to boiling, the time to core uncovery, and the time to core damage in the first line of the Worksheet. Table 9 can be used to help estimate time to core uncovery and core damage from hot leg midplane conditions with a vented RCS. Often, time to boiling is tracked and monitored by the licensee.

Step 4.3.2 Determine which Core Damage Sequences are affected by the finding. Circle the affected safety function(s) in the Core Damage Sequences in the lower area of the Worksheet. Write the IEL in each row of the lower section of the worksheet that corresponds to an affected sequence.

Step 4.3.2 Determine the remaining creditable mitigation capability for safety functions assuming the occurrence of the initiating event, and using the reported status of plant equipment and the times to boiling and core damage. The various Safety Functions Needed to mitigate the specific initiating event are listed in the first column of the SDP Worksheet. This step only needs to be done for safety functions that appear in affected sequences, as identified in Step 4.3.1. The creditable plant-specific capability that is potentially available to satisfy the safety function is described in the second column, entitled Success Criteria and Important Instrumentation. Pay particular attention to the safety functions affected by the finding. Use the Event Tree associated with the Worksheet to help understand the successes and failures associated with each accident sequence.

> **Step 4.3.2.1** Determine the Equipment Credit based on the remaining equipment capability for each affected safety function. Use guidance in Tables 7 and 8, and notes in the Worksheet to enter the Equipment Credit in the third column of the Worksheet. Document key assumptions.
>
> **Step 4.3.2.2** Determine the Operator Credit based on the time and complexity of operator actions to use the available equipment to achieve each safety function. Table 6 provides general guidance for operator credits and the Worksheets contain sequence specific guidance. Document key assumptions.
>
> **Step 4.3.2.3** Determine the Credit for Function for each Safety Function Needed. Select the lower of Equipment Credit and Operator Credit, and enter the value in this column.

Step 4.3.3 Working in the lower section of the Worksheet, determine the risk increase for the Finding. Use the Event Tree associated with the Worksheet to help understand the successes and failures associated with each accident sequence.

> **Step 4.3.3.1** Enter the Mitigation Credit in the form of an additive equation of Credit for Functions from the upper section of the worksheet for each Core Damage Sequence. For example, take the Core Damage Sequence is LOLC - SG - BLEED - RHR-S. If the Credit for Function for SG is 0 (meaning steam

generators are not available), for BLEED is 4 and for RHR-S is 2, enter 0+4+2 into the Mitigation Credit column.

Step 4.3.3.2 Enter the Recovery credit and document the value in the box provided at the bottom of the Worksheet. For phase 2 analyses, the recovery credit is not used.

Step 4.3.3.3 Sum these credit values (IEL + Mitigation Credit + Recovery) for each affected sequence and enter the value in the Result column.

Step 4.3.3.4 Go to the next applicable Worksheet and begin at Step 4.3.1 or, if all Worksheets are completed, continue to Step 4.4.

Step 4.4 Estimating the Risk Significance of Inspection Findings

The risk significance of an inspection finding is determined in the same manner as for at-power findings. Use IMC 0609, Appendix A, Step 2.4 - "Estimating the Risk Significance of Inspection Findings" to determine the risk significance of a finding.

5.0 FIGURES, TABLES, WORKSHEETS AND EVENT TREES

5.1 Figures

5.2 Tables

5.3 Worksheets and Event Trees

Figure 1 Determination of Applicable POSs and Time Windows - PWRs

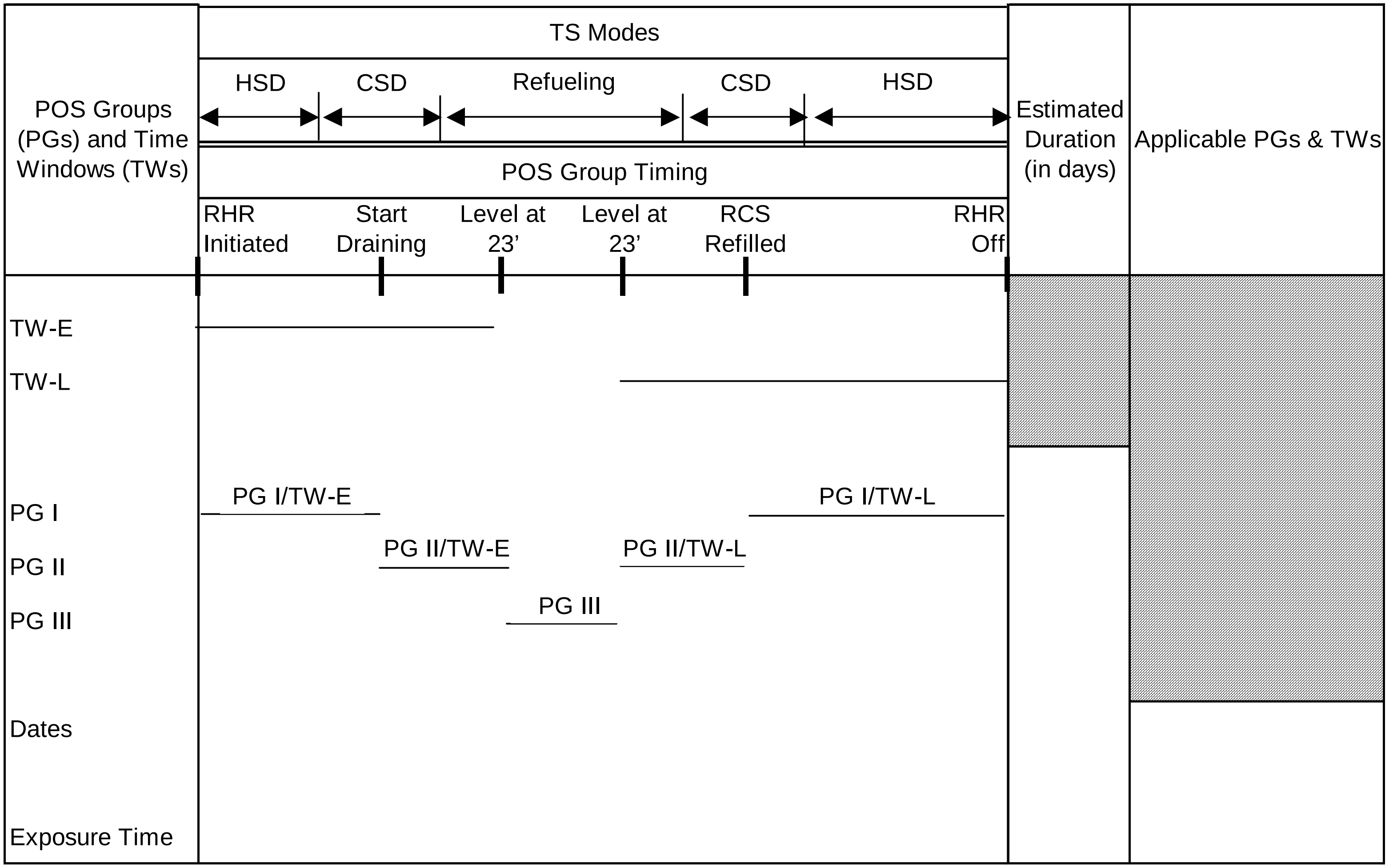

Table 1 - Initiating Event Likelihood (IELs) For LOLC Precursors

Time to RHR loss due to loss of RHR function due to loss of NPSH or vortexing assuming no successful operator action	Was RCS Level Indic.. Reasonable Reflection of RCS level ? AND Is DHR flow indic. & DHR motor current available	Can Action to Recover RHR be identified within ½ time to RHR loss? Eg. Decrease RHR pump flow rate or increase RCS level	Can Action to Recover RHR be performed within ½ time to RHR loss?	Estimated IEL
LOLC occurred OR X<10 min.	N/A	N/A	N/A	0
10<x< 30 min.	YES	YES	YES	1
10<x< 30min.	NO	N/A	N/A	0
10<X <30min.	YES	NO	N/A	0
10<x< 30 min.	YES	YES	NO	0
30<x< 60 min.	YES	YES	YES	2
30<x< 60min.	NO	N/A	N/A	0
30<X <60min.	YES	NO	N/A	0
30<X<60 min.	YES	YES	NO	0
1HR<X<4HR	YES	YES	YES	3
1HR<X<4HR	NO	Yes	Yes	1
1HR<X<4HR	YES	NO	N/A	0
1HR<X<4HR	YES	Yes	NO	0
X>4HR	YES	YES	YES	3
X>4HR	NO	Yes	Yes	1
X> 4HR	YES	NO	N/A	0
X> 4 HR	YES	Yes	NO	0

Table 2 - Initiating Event Likelihoods (IELs) for LOOP Precursors

Type of LOOP precursor	Estimated Initiator Rating
Actual LOOP occurred	0
Work Activities have the potential to affect existing power supplies (example: crane operating close to a Reserve Auxiliary Transformer supplying power to RHR without adequate controls on its movement)	1

Table 3 - Initiating Event Likelihood (IELs) For LOI Precursors

Time to RHR loss due to loss of RHR pump suction Given no successful operator action (X = time to loss of RHR pump suction)	Was RCS Level Indic.. Reasonable Reflection of RCS level ? AND Is DHR flow indic. & DHR motor current available (LOLC events only)	Can leak path be readily identified within ½ time to loss of RHR	Can drain path be isolated by at least one functional valve such that a train of RHR can be re-started (e.g. not RHR suction valves)	Estimated IEL
LOI occurred X<10 min.	N/A	N/A	N/A	0
10<x< 30 min.	YES	YES	YES	1
10<x< 30min.	NO	N/A	N/A	0
10<X <30min.	YES	NO	N/A	0
10<x< 30 min.	YES	YES	NO	0
30<x< 60 min.	YES	YES	YES	2
30<x< 60min.	NO	N/A	N/A	0
30<X <60min.	YES	NO	N/A	0
30<X<60 min.	YES	YES	NO	0
1HR<X<4HR	YES	YES	YES	3
1HR<X<4HR	NO	YES	YES	1
1HR<X<4HR	YES	NO	N/A	0
1HR<X<4HR	YES	YES	NO	0
X>4HR	YES	YES	YES	3
X>4HR	NO	YES	YES	1
X> 4HR	YES	NO	N/A	0
X> 4 HR	YES	YES	NO	0

TABLE 4 - INITIATING EVENT LIKELIHOODS (IELs) FOR LORHR PRECURSORS

Findings affecting loss of the operating train of RHR and RHR supports system including CCW, SRW, AC, DC

Time to RHR loss given no successful operator action	Trouble Alarms Present for Finding AND Core Exit Thermocouples (CETs) Ex. DHR high temp. DHR low flow Support System Trouble Alarms Ex. CCW low flow	Can Action to Recover RHR be identified within ½ time to RHR loss? Eg. RHR recovery procedures, Support System Recovery procedures,	Can Action to Recover RHR be performed within ½ time to RHR loss?	Estimated IEL
LORHR occurred OR< 10 minutes	N/A	N/A	N/A	0
10<X<30 min.	Yes	Yes	Yes	1
10<X< 30 min.	No	N/A	N/A	0
10 <X< 30min.	Yes	No	N/A	0
10<X< 30 min.	Yes	Yes	NO	0
30<X< 60min.	Yes	Yes	Yes	2
30<X< 60min.	No	N/A	N/A	0
30<X< 60min.	Yes	No	N/A	0
30>X < 60min.	Yes	Yes	NO	0
1hr< X<4 hr.	Yes	Yes	Yes	3
1hr <X< 4 hr.	No	Yes	Yes	1
1 hr <X<4 hr.	Yes	No	N/A	0
1hr <X < 4 hr.	Yes	Yes	No	0
X > 4 hr	Yes	Yes	Yes	3
X > 4 hr	No	Yes	Yes	1
X> 4 hr	Yes	No	N/A	0
X> 4 hr	Yes	Yes	NO	0

Table 5 - Initiating Event Likelihoods (IELs) for Condition Findings - PWRs

Row	Approximate Conditional Frequency	Example Event Type	IEL		
I	> 1 per 1-10 yr	Loss of offsite power (LOOP), Loss of RHR (LORHR)	**1**	**2**	**3**
II	1 per 10-10^{2} yr	Loss of Inventory (LOI)	**2**	**3**	**4**
III	1 per 10-10^{2} yr	Loss of Level Control (LOLC)[1]	**2**	**2**	**2**
			> 30 days	**3-30 days**	**< 3 days**
			Exposure Time for Degraded Condition		

LOLC is only applicable to POS group II.
LORHR and LOI are not applicable to POS group III.

[1] Loss of level control failure is dominated by likelihood of overdraining to reach midloop conditions (this is a demand failure)

Table 6 - Adjustment to Credits for Operator Actions

To Use:

Take operator action from work sheet and adjust credits using rows 1, 2, and 3.

ROW	Factors Affecting Operator Action Credit	Impact of Inspection Findings on the Factors	Adjustment to Operator Action Credit
1	TIME TO COMPLETE OPERATOR ACTION	Half of the assumed available time in the worksheet	Reduce credit by 1
		Same as that assumed available time in the worksheets	No change in credit
		Twice as that assumed in the worksheet	Increase credit by 1
2	COMPLEXITY OF ACTION Additional complicating factors (list not exhaustive) Poor Environment (example steam, hi rad.) Equipment Not Staged Procedures ambiguous, not available or incorrect for HEP .	Additional complicating factors	Reduce credit by 1 or by 2 (depending on severity)
		No Additional Complexities	No change
3	AVAILABILITY OF INSTRUMENTATION	Unavailable or Providing Erroneous Indication.	Reduce credit by 2
		Same as worksheet	No change

Table 7 - Mitigation Capability Credits for Installed Equipment

Type of Remaining Capability	**Remaining Capability Rating**
Recovery of Failed Train Operator action to recover failed equipment that is capable of being recovered after an initiating event occurs. Action may take place either in the control room or outside the control room and is assumed to have a failure probability of approximately 0.1 when credited as "Remaining Mitigation Capability." Credit should be given only if the following criteria are satisfied: (1) sufficient time is available; (2) environmental conditions allow access, where needed; (3) procedures exist; (4) training is conducted on the existing procedures under similar conditions; and (5) any equipment needed to perform these actions is available and ready for use.	1
1 Automatic Steam-Driven (ASD) Train A collection of associated equipment that includes a single turbine-driven component to provide 100% of a specified safety function. The probability of such a train being unavailable due to failure, test, or maintenance is assumed to be approximately 0.1 when credited as "Remaining Mitigation Capability."	1
1 Train A collection of associated equipment (e.g., pumps, valves, breakers, etc.) that together can provide 100% of a specified safety function. The probability of this equipment being unavailable due to failure, test, or maintenance is approximately 1E-2 when credited as "Remaining Mitigation Capability."	2
1 Multi-Train System A system comprised of two or more trains (as defined above) that are considered susceptible to common cause failure modes. The probability of this equipment being unavailable due to failure, test, or maintenance is approximately 1E-3 when credited as "Remaining Mitigation Capability," regardless of how many trains comprise the system.	3
2 Diverse Trains A system comprised of two trains (as defined above) that are not considered to be susceptible to common cause failure modes. The probability of this equipment being unavailable due to failure, test, or maintenance is approximately 1E-4 when credited as "Remaining Mitigation Capability."	4 (=2+2)

TABLE 8 - CREDIT FOR TEMPORARY EQUIPMENT

Mitigation Capability	**Credits**
Equipment available during power operation and available during shutdown operation	Use credit similar to at-power SDP; manual alignment and actuation may be needed limiting the credit to the credit for operator action
Temporary Equipment (e.g. skid mounted diesel) that is available during shutdown; equipment and tools needed are staged for quick hookup	Use credit of 1

TABLE 9 - Definitions and Characterizations of Time Windows from the Surry Shutdown PRA (NUREG/CR-6144 Table 5.4-20) assuming a vented RCS (RCS temperature initially 140F)

	Window 1	Window 2	Window 3	Window 4
Definitions	< 75 hrs	75 hrs < X <240 hrs	240 hrs <X < 32 days	32 days < X
Decay Heat	13MW (2 days)	10 MW (5 days)	7 MW (12 days)	5 MW (32 days)
TBB (from midloop)	15 min.	20 min.	27 min.	37 min.
Time to Core Uncovery	120 min.	157 min.	209 min.	273 min.
Time to Core Damage	219 min.	297 min.	411 min.	557min.

Worksheet 1. SDP for a Westinghouse 4-Loop Plant — Loss Level Control in POS 1 (LOLC - POS 1)

FILL IN: TIME TO BOILING _________ TIME TO CORE UNCOVERY __________ TIME TO CORE DAMAGE __________
(NOTE: losses of inventory shorten time to core uncovery and core damage)

Safety Functions Needed:	**Success Criteria and Important Instrumentation:**	**Equip. Credit**	**Operator Credit**	**Credit for Function**
SG Cooling (SG)	Operator maintains SG cooling by: (1) maintaining adequate level for 24 hours and (2) venting steam from SGs, and (3) keeping RCS closed. Operator needs SG level and pressure indication.		Credit = 3 if supported by procedures and analyses	
RCS Injection And Bleed Before Core Damage **(FEED& BLEED)**	Operator initiates RCS injection before CD requires: 1standby ECCS train or injection train capable of keeping core covered Operator needs RCS level indic. and CETs. AND Operator opens a RCS vent path (ex PORV) for RCS pressure control.,		Credit = 4, CD assumed >3 hrs w/o injection	
RHR Recovery Before RWST Depletion (RHR-R)	Operator vents RHR pumps and restarts RHR before RWST depletion Operator needs RHR inlet/outlet temp indic. and RHR flow indic. w/low alarm		Credit = 3 time until RWST depletion assumed > 10 hrs	
Borated Water Makeup (RWSTMU)	Operator initiates RWST makeup before RWST depletion and core damage. Operator needs RWST level indic		Credit = 1 if needed <16 hours Credit =2 if needed > 16 hours	

Circle Affected Functions	**IEL**	**Mitigation Credit**	**Recovery**	**Result**
LOLC - SG - RHR-R - RWSTMU (4)				
LOLC - SG - FEED&BLEED (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: Failure to recover RHR before RWST depletion is assumed to fail recirculation from the sump since the RHR pumps are also used to perform the recirculation function. Recovery of RHR does not guarantee available recirculation since the sump may be unavailable due to trash..

Worksheet 2. SDP for a Westinghouse 4-Loop Plant — Loss Level Control in POS 2 (LOLC - POS 2)

FILL IN: TIME TO BOILING _________ TIME TO CORE UNCOVERY _______ TIME TO CORE DAMAGE ________
(NOTE: losses of inventory shorten time to core uncovery and core damage)

Safety Functions Needed:	**Success Criteria and Important Instrumentation:**	**Equip. Credit**	**Operator Credit**	**Credit for Function**
RCS injection before Core Damage (FEED)	Operator initiates RCS injection before CD requires: 1standby ECCS train or injection train capable of keeping core covered Operator needs RCS level indication and CETs ,		Credit = 5, CD assumed >3 hrs w/o injection	
RHR Recovery Before RWST depletion (RHR-R)	Operator vents RHR pumps, and restarts RHR before RWST depletion. Operator needs RHR inlet/outlet temp indic. and RHR flow indic. w/low alarm	N/A	Credit = 3 time to RWST depletion >10hrs	
Borated Water Makeup (RWSTMU)	Operator initiates RWST makeup before RWST depletion and core damage. Operator needs RWST level indic		Credit = 1 if needed <16 hours Credit = 2 if needed > 16 hours	

Circle Affected Functions	**IEL**	**Mitigation Credit**	**Recovery**	**Result**
LOI - RHR-R-RWSTMU (3)				
LOI -FEED (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.

Notes: Failure to recover RHR before RWST depletion is assumed to fail recirculation from the sump since the RHR pumps are also used to perform the recirculation function. Recovery of RHR does not guarantee available recirculation since the sump may be unavailable due to trash..

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Worksheet 3. SDP for a Westinghouse 4-Loop Plant — Loss of Offsite Power in POS 1 (LOOP - POS 1)

FILL IN: TIME TO BOILING _________ TIME TO CORE UNCOVERY __________ TIME TO CORE DAMAGE __________
(NOTE: losses of inventory shorten time to core uncovery and core damage)

Safety Functions Needed:	**Success Criteria and Important Instrumentation:**	**Equip. Credit**	**Operator Credit**	**Credit for Function**
Emergency AC starts and loads (EAC)	One EDG or alternate AC source [2]	N/A		
SG Cooling (SGSBO)	Operator maintains SG cooling by: (1) maintaining adequate level for 24 hours and (2) venting steam from SGs, and (3) keeping RCS closed. Operator needs SG level and SG pressure indication.		Credit = 3 if supported by procedures and analyses	
Operator recovers offsite power before CD (RLOOP3)	Recovery of offsite power before core damage given SGSBO failed	Credit = 1 (assumes CD = 3 hours)	N/A	

Circle Affected Functions	**IEL**	**Mitigation Credit**	**Recovery**	**Results**
LOOP-EAC-SGSBO-RLOOP3 (3)				

[2] If time to CD minus time to actuate AC source > 1 hr then equipment limited, else credit for alternate source = 0

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

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

Worksheet 4. SDP for a Westinghouse 4-Loop Plant — Loss of Offsite Power in POS 2 (LOOP - POS 2)

FILL IN: TIME TO BOILING _________ TIME TO CORE UNCOVERY __________ TIME TO CORE DAMAGE _________

Safety Functions Needed:	**Success Criteria and Important Instrumentation:**	**Equip. Credit**	**Operator Credit**	**Credit for Function**
Emergency AC starts and loads (EAC)	One EDG or alternate AC source [1]	N/A		
Gravity Feed (GRAVITY) before CD	Operator initiates Gravity Feed assuming SBO before core damage. Requires an available flow path, procedures, and supporting analyses. Gravity feeding to the RCS may be credited if Gravity Feed is expected to be available AFTER RCS boiling initiates. To credit Gravity Feed, the analyst needs to consider the following factors that can negate the elevation head provided by the RWST or other sources of RCS inventory: (1) pressure drops in the surge line (2) entrained water accumulating in the pressurizer (3) RCS vent paths that are restricted (to control loose parts or control off gassing) .		Credit = 2	
Operator recovers offsite power before CD (RLOOP4)	Recovery of offsite power before core damage given unsuccessful gravity feed (CD assumed at 4 hours)	Credit = 1	N/A	

[1] If time to CD minus time to actuate AC source > 1 hr then equipment limited, else credit for alternate source = 0

Operator recovers offsite power before CD (RLOOP18)	Recovery of offsite power before core damage given successful gravity feed (CD assumed at 18 hours)	Credit = 2	N/A	

Circle Affected Functions	**IEL**	**Remaining Mitigation Capability Rating for Each Affected Sequence**	**Recovery**	**Result**
LOOP-EAC-RLOOP18 (3)				
LOOP-EAC-GRAVITY-RLOOP4 (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.

Worksheet 5. SDP for a Westinghouse 4-Loop Plant — Loss of Inventory in POS I (LOI - POS I)

FILL IN: TIME TO BOILING _________ TIME TO CORE UNCOVERY _________ TIME TO CORE DAMAGE __________ **(NOTE: losses of inventory shorten time to core uncovery and core damage)**				
Safety Functions Needed:	**Success Criteria and Important Instrumentation:**	**Equip. Credit**	**Operator Credit**	**Credit for Function**
RCS injection (FEED)	Operator initiates RCS injection before CD requires: 1standby ECCS train or injection train capable of keeping core covered Operator needs RCS level indic and CETs,		Credit = 4, CD assumed >3 hrs w/o injection	
Leak Path Terminated before RWST depletion (LEAK-STOP)	Operator isolates leak before RWST depletion, requires: one available valve such that RHR can be restarted (not RHR isolation valves) Operator needs RCS level indic.		Credit = 3 (assumed >10 hrs to depletion)	
Leak Path Terminated before core uncovery given no FEED (LEAK-STOP2)	Operator isolates leak before core uncovery, requires: one available valve such that RHR can be restarted (not RHR isolation valves), Operator needs RCS level indic.		Credit = 2 (assumes leak path identified within 30 min. and core uncovery > 1hr)	
SG Cooling (SG)	Operator maintains SG cooling by: (1) maintaining adequate level for 24 hours, (2) venting steam from SGS, and (3) keeping the RCS closed. Operator needs SG level and SG pressure indic.		Credit = 3, if supported by procedures and analyses	
RCS Vent path for Feed and Bleed (BLEED)	Operator opens a PORV or vent path large enough to remove decay heat		Credit = 3	

RHR recovery before RWST depletion (RHR-R)	Operator vents RHR pumps and restarts RHR before RWST depletion. Operator needs RHR inlet/outlet temp indic. and RHR flow indic. w/low alarm	N/A	Credit = 3 time until RWST depletion > 10 hrs	
Borated Water Makeup before CD(RWSTMU)	Operator initiates RWST makeup before RWST depletion and core damage. Operator needs RWST level indication.		Credit = 1 if needed < 16 hours Credit = 2 if needed >16 hours	

Circle Affected Functions	**IEL**	**Mitigation Credit**	**Recovery**	**Result**
LOI - SG - RHR-R - RWSTMU (4)				
LOI-SG-BLEED (5)				
LOI- LEAKSTOP-RWSTMU (7)				
LOI - FEED - SG - (9)				
LOI - FEED - LEAKSTOP2 (10)				

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: Failure to recover RHR before RWST depletion is assumed to fail recirculation from the sump since the RHR pumps are also used to perform the recirculation function. Recovery of RHR does not guarantee available recirculation since the sump may be unavailable due to trash..

Worksheet 6. SDP for a Westinghouse 4-Loop Plant — Loss of Inventory in POS 2 (LOI - POS 2)

FILL IN: TIME TO BOILING _________ TIME TO CORE UNCOVERY __________ TIME TO CORE DAMAGE __________ (NOTE: losses of inventory shorten time to core uncovery and core damage)				
Safety Functions Needed:	**Success Criteria and Important Instrumentation:**	**Equip. Credit**	**Operator Credit**	**Credit for Function**
RCS injection before CD (FEED)	**Operator initiates RCS injection before CD requires: 1standby ECCS train or injection train capable of keeping core covered** **Operator needs RCS level indication and CETs.**		**Credit = 5, CD assumed >3 hrs w/o injection**	
Leak Path Terminated before RWST depletion (LEAK-STOP)[2]	**Operator isolates leak before RWST depletion, requires: one available valve such that RHR can be restarted (not RHR isolation valves)** **Operator needs RCS level indication.**		**Credit = 3 (assumed >10 hrs to depletion)**	
RHR recovery before RWST depletion (RHR-R)	**Operator vents RHR pumps and restarts RHR before RWST depletion.** **Operator needs RHR inlet/outlet temp indic. and RHR flow indic. w/low alarm**	**N/A**	**Credit = 3 time to RWST depletion >10hrs**	
Borated Water Makeup before CD(RWSTMU)	**Operator initiates RWST makeup before RWST depletion and core damage.** **Operator needs RWST level indication.**		**Credit = 1 if needed < 16 hours** **Credit =2 if needed > 16 hours**	

[2]If leak path is back to the RWST , then use operator credit = 5 to account that RWST will not deplete but will heat up without cooling.

Circle Affected Functions	IEL	Mitigation Credit	Recovery	Result
LOI - RHR-R-RWSTMU (3)				
LOI- LEAK-ST-RWSTMU (5)				
LOI -FEED (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: Failure to recover RHR before RWST depletion is assumed to fail recirculation from the sump since the RHR pumps are also used to perform the recirculation function. Recovery of RHR does not guarantee available recirculation since the sump may be unavailable due to trash..

Worksheet 7. SDP for a Westinghouse 4-Loop Plant — Loss of Inventory in POS 3 (LOI - POS 3)

FILL IN: TIME TO BOILING _________ TIME TO CORE UNCOVERY __________ TIME TO CORE DAMAGE _________
(NOTE: losses of inventory shorten time to core uncovery and core damage)

Safety Functions Needed:	**Success Criteria and Important Instrumentation:**	**Equip. Credit**	**Operator Credit**	**Credit for Function**
RCS injection before CD (FEED)	**Operator initiates RCS injection before CD requires: 1 standby ECCS train or injection train capable of keeping core covered, a source of borated water** **Operator needs RCS level indic. and CETs,**		**Credit = 5, CD assumed >3 hrs w/o injection**	
Leak terminated before RCS injection cannot be sustained and CD occurs (LEAK-STOP)	**Operator isolates drain path using at least one functional valve such that RHR can be restarted.**		**Credit = 3 time to CD assumed > 4 hours**	
RHR recovery before RCS injection cannot be sustained and CD results (RHR-R)	**Operator vents RHR pumps and restarts RHR system.** **Operator needs RHR inlet/outlet temp and RHR flow indic. w/low alarm.**		**Credit = 3 time to CD assumed > 4 hours**	

Circle Affected Functions	**IEL**	**Mitigation Credit**	**Recovery**	**Sequence Color**
LOI - RHR-R- (2)				
LOI - LEAK-STOP (3)				
LOI -FEED (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.

Worksheet 8. SDP for a Westinghouse 4-Loop Plant — Loss of RHR in POS I (LORHR - POS I)

FILL IN: TIME TO BOILING _________ TIME TO CORE UNCOVERY ___________ TIME TO CORE DAMAGE ___________
(NOTE: losses of inventory shorten time to core uncovery and core damage)

Safety Functions Needed:	Success Criteria and Important Instrumentation:	Equip. Credit[1]	Operator Credit[2]	Credit for Function
RHR recovery before RCS boiling (RHR-S)	**Operator Recovers RHR system before RCS boiling.** **Operator needs RHR inlet/outlet temp indic. and RHR flow indic. w/low alarm** **AND IF APPLICABLE[3]** **Operator recovers failed RHR support systems before RCS boiling (SEE FOOT NOTE 3)**		**Credit = 0 if TBB <10 minutes** **IF** **RHR recovery action can be identified within ½ TBB** **AND** **RHR recovery action can be performed within ½ TBB.** **AND** **Trouble alarms are available.** **THEN** **CREDIT = 1 if 10 min. < TBB < 30 min.** **CREDIT = 2 if 30 min. <TBB < 1hour** **ELSE, Credit = 0**	

[1]If performance deficiency is being transferred from LOOP tree, analyst must consider if the front line systems and necessary support systems are supported from successful EAC.

[2]For the safety function RHR-S, when being transferred from LOOP tree, if TBB < 10 minutes and re-start of RHR requires operator action outside the control room, then operator credit = 0. Otherwise, operator credit = 1.

[3]If this worksheet is being used to assess a RHR support system deficiency that could cause a loss of the operating train of RHR, then the equipment credit and operator credit is determined by the operator's ability to recover the support system before RCS boiling.

SG Cooling (SG)	**Operator maintains SG cooling by: (1) maintaining adequate level for 24 hours, (2) venting steam from SGS, and (3) keeping the RCS closed. Operator needs SG level and pressure indic.**		**Credit = 3, if supported by procedures and analyses**	
RCS Injection AND Bleed Before Core Damage (FEED&BLEED)	**Operator initiates RCS injection before CD requires: 1standby ECCS train or injection train capable of keeping core covered** **Operator needs RCS level indic and CETs,** **AND** **Operator also opens a RCS vent path (ex PORV) to control RCS pressure**		**Credit = 4, CD assumed >3 hrs w/o injection**	
RHR recovery before RWST depletion (RHR-R)	**Operator vents RHR pumps and restarts RHR before RWST depletion.** **Operator needs RHR inlet/outlet temp indic. and RHR flow indic. w/low alarm**		**Credit = 3 time until RWST depletion > 10 hrs.**	
Borated Water Makeup before CD(RWSTMU)	**Operator initiates RWST makeup before RWST depletion and core damage.** **Operator needs RWST level indication.**		**Credit = 1 if needed < 16 hours** **Credit =2 if needed > 16 hours**	

Circle Affected Functions	**IEL**	**Mitigation Credit**	**Recovery**	**Result**

LORHR - RHR-S - SG - RHR-R-RWSTMU (5)				
LORHR - RHR-S - SG - FEED&BLEED (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: Failure to recover RHR before RWST depletion is assumed to fail recirculation from the sump since the RHR pumps are also used to perform the recirculation function. Recovery of RHR does not guarantee available recirculation since the sump may be unavailable due to trash..

Worksheet 9. SDP for a Westinghouse 4-Loop Plant — Loss of RHR in POS 2 (LORHR - POS 2)

FILL IN: TIME TO BOILING _________ TIME TO CORE UNCOVERY _________ TIME TO CORE DAMAGE _____________ (NOTE: losses of inventory shorten time to core uncovery and core damage)				
Safety Functions Needed:	**Success Criteria and Important Instrumentation:**	**Equip. Credit [1]**	**Operator Credit[2]**	**Credit for Function**
RHR recovery before RCS boiling (RHR-S)	Operator Recovers RHR system before RCS boiling. Operator needs RHR inlet/outlet temp indic. and RHR flow indic. w/low alarm AND IF APPLICABLE[3] Operator recovers failed RHR support systems before RCS boiling (SEE FOOT NOTE 3)	N/A	Credit = 0 if TBB <10 minutes IF RHR recovery action can be identified within ½ TBB AND RHR recovery action can be performed within ½ TBB. AND Trouble alarms are available. THEN CREDIT = 1 if 10 min. < TBB < 30 min. CREDIT = 2 if 30 min. <TBB < 1hour ELSE, Credit = 0	

[1]If performance deficiency is being transferred from LOOP tree, analyst must consider if the front line systems and necessary support systems are supported from successful EAC.

[2]For the safety function, RHR-S, when being transferred from LOOP tree, if TBB < 10 minute and re-start of RHR requires operator action outside the control room, then operator credit = 0. Otherwise, operator credit = 1.

[3]If this worksheet is being used to assess a RHR support system deficiency that could cause a loss of the operating train of RHR, then the equipment credit and operator credit is determined by the operator's ability to recover the support system before RCS boiling.

RCS injection before CD	**Operator initiates RCS injection before CD requires: 1standby ECCS train or injection train capable of keeping core covered, RCS level indic., CETs,**		**Credit = 5, CD assumed >3 hrs w/o injection**	
RHR recovery before RWST depletion (RHR-R)	**Operator fills RCS, vents RHR pumps, and restarts RHR before RWST depletion, requires: CET w/hi alarm, RHR inlet/outlet temp indic., RHR flow indic. w/low alarm**	**N/A**	**Credit = 3 time to RWST depletion >10hrs**	
Borated Water Makeup before CD(RWSTMU)	**Operator initiates RWST makeup before RWST depletion with boric acid transfer pumps and primary grade water, RWST level indic**		**Credit = 1 if needed < 16 hours** **Credit = 2 if needed > 16 hours**	

Circle Affected Functions	**IEL**	**Mitigation Credit**	**Recovery**	**Result**
LORHR - RHR-S - RHR-R - RWSTMU (4)				
LORHR - RHR-S - FEED (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: Failure to recover RHR before RWST depletion is assumed to fail recirculation from the sump since the RHR pumps are also used to perform the recirculation function. Recovery of RHR does not guarantee available recirculation since the sump may be unavailable due to trash..

6.0 BASIS DOCUMENT

6.0.1 Abstract

This report provides a template for assessing the risk significance of the inspection findings for a Westinghouse Four Loop (PWR) plant during shutdown conditions. This template is intended for use in the Significance Determination Process (SDP) for shutdown operations under the US NRC's Risk-Informed Reactor Oversight Process. It supplements the at-power SDP by considering shutdown conditions when the residual heat removal (RHR) system is the normal means of removing decay heat. In considering the plant's characteristics at shutdown, we define plant operational state (POS) and time windows (TWs) (considering the elapsed time from shutdown), similar to probabilistic risk assessments (PRAs) for shutdown. Because an order-of-magnitude impact on risk is assessed in the SDP for determining a color (to represent the risk significance) for the inspection findings, shutdown characteristics are defined in terms of fewer POS groups and time windows than they are in a shutdown PRA. Additional assumptions also are made to allow inspectors to quickly assess the inspection findings. The approach used is similar to that used for an at-power SDP so that the assessment process remains comparable and inspection findings are treated similarly. In addition, the way in which the at-power and shutdown findings are determined remains conceptually similar, facilitating their use by the inspectors.

This template is a generic Westinghouse 4-loop template and accordingly, plant-specific characteristics or differences are not included. Plant-specific features and outage-specific information will be collected by the analyst who then can use this template to evaluate the findings of the inspection. Guidance is given on using the template. It covers the adjustment of the initiating event ratings for inspection findings which increase the likelihood of initiating event occurring, adjustment of credit for the operator's actions considering the changes in the time available and the limitations in the available instrumentations, and also, adjustment of mitigation credit considering the temporary equipment that may be used as part of the contingency measures implemented.

6.0.2 OVERVIEW OF THE SHUTDOWN SDP PROCESS

As directed in the SRM to SECY 97-168, the staff is inspecting and monitoring licensee performance at shutdown to ensure that the licensees are maintaining an adequate mitigation capability (equipment, instrumentation, policies, procedures, and training). In the Reactor Oversight Process (ROP), the significance of such inspection findings is assessed, using a Risk Informed process, called the Significance Determination Process (SDP). The shutdown SDP consists of two phases: Phase 1, Definition and Initial Screening of Findings and Phase 3, Risk Significance Finalization and Justification. IMC 0609 Appendix G, Shutdown Operations Significance Determination Process, has guidance for conducting a significance determination for the inspection findings during a shutdown.

Templates have been developed for conducting Phase 3 assessments in the SDP for shutdown operations. The templates supplement the at-power notebooks for addressing the inspection findings identified during a plant shutdown. They use a similar conceptual approach to that of at-power Phase 2 SDP and assume that the analyst is familiar with the ideas used in the at-power notebooks. This report is the template for a Pressurized Water Reactor (PWR) plant, developed considering a Westinghouse 4-loop design. A companion template also was made for a Boiling Water Reactor (BWR) plant, considering a General Electric BWR/4- Mark 1 design.

6.1 ENTRY CONDITIONS AND APPLICABILITY

6.1.1 Entry Condition and Definition of Inspection Findings

Inspection Manual Chapter (IMC) 0612 specifies the evaluation process that is used to determine if an inspection observation should be subjected to the SDP process. The shutdown SDP provides a graded risk-informed process to estimate the increase in core damage frequency during shutdown operations from conditions which contribute to unintended increases in risk caused by a licensee's deficient performance. Conditions which do NOT represent such a deficiency, as determined by the staff, are considered part of the acceptable normal shutdown risk, and are NOT candidates for SDP evaluation. Hence, the entry conditions for the Reactor Safety SDP described in this template include any degraded equipment, functions, or processes affecting the frequency of initiating events, the availability/ reliability of mitigation systems, or the integrity of the RCS barrier arising from deficiencies in the licensee's performance.

6.1.2 Phase 1 - Definition and Initial Screening of the Findings

In Phase 1, the Shutdown Screening tool presented in IMC 0609 Appendix G is used to characterize shutdown findings and determine if the finding should be screened out, or further evaluated in a Phase 3 analysis. The impact of the finding on the ability of a licensee to maintain the five key shutdown safety functions (decay heat removal, inventory control, power availability, reactivity control and containment) is evaluated. These safety functions impact the initiating events cornerstone, the mitigating systems cornerstone, and the barrier integrity cornerstone. Findings with low-significance are forwarded to the licensee's corrective action program..

Special Findings Not Covered by this Template

Some findings are not covered by these templates and go directly to Headquarters for Phase 3 analysis. Examples of such findings are as follows:

- Potential over-pressurization of low -pressure piping and deficiencies associated with maintaining low temperature over pressure protection.

- Use of Nozzle Dams without an adequate RCS vent path that would prevent the RCS from re-pressurizing above 25 psig following an extended loss of RHR (25 psi represents an approximate differential pressure capability for the nozzle dams).

- Findings that increase the likelihood of having a boron dilution event such as the source range monitors being inoperable or the RWST having boron concentrations lower than Technical Specifications prescribed values.

- Findings that involve containment closure deficiencies

A Phase 3 assessment conducts an order-of-magnitude evaluation of the risk significance of the inspection findings denoted by the colors (Green, White, Yellow, and Red).

6.1.4 Phase 3 Refined Risk Assessment

A Phase 3 assessment conducts an order-of-magnitude evaluation of the risk significance of the inspection findings denoted by the colors (Green, White, Yellow, and Red). It is anticipated that the SRAs would perform the Phase 3 analyses with assistance from staff at headquarters.

6.2 SCOPE AND LIMITATIONS OF THE CURRENT TEMPLATE

The template is a simplified tool that generates an order-of-magnitude assessment of the risk significance of the inspection findings during a shutdown. This template is developed for a PWR plant, considering the features of a Westinghouse 4-loop plant. The template is a generic one and was developed based on maintaining key safety functions such as the ability to: provide RCS injection; recover RHR if has been interrupted; and maintain containment closure. This generic tool could not include plant specific mitigating features because they vary between licensees and outages. Therefore, the analyst has to consider the licensee's outage-specific mitigation capability. For example, due to relative elevation differences between the RWST and the pressurizer, a PWR may not have the ability to gravity feed following RCS boiling.

Developing a simple, easy-to-use process for assessing the risk significance of inspection findings during a shutdown required many assumptions and approximations. During a shutdown, the plant's configuration changes as time progresses; there are differences in the availability of equipment and in the time spent in different configurations from one shutdown to another. Our intent in making the assumptions is to capture the changes and discriminate different findings within an order of magnitude.

We used information from shutdown risk assessments and past shutdown events (including past Phase 3 shutdown SDP evaluations) to make assumptions and approximations, especially in the assessment of human error. Since every interruption of RHR requires a successful operator response to prevent core damage, operator error is a key contributor to shutdown risk. Operator error appears in almost every top event/mitigation path in the shutdown event trees. To simplify the shutdown event trees, the event trees treat each operator error in each of the top events independently. In reality, the operator error events can be dependent; they share a cognitive error that is based on the operators failure to understand the plant conditions and required actions. This cognitive error is the failure of the operator to diagnose that a loss of shutdown cooling has taken place and action is needed to prevent core damage. The cognitive element was not explicitly treated in the event trees. The operator error included in the event trees is failure for the operator to execute each top event in the core damage scenario.

When the operator has: (1) RCS level indication that is reflective of plant conditions and (2) RCS temperature indication that is reflective of core exit conditions, the failure of the operator to acknowledge that a shutdown event occurred and action is required before core damage is not perceived as a dominant contributor to shutdown risk. This error probability is also reduced during shutdown since (1) the RCS may be open and RCS boiling would be observed well before core damage, and (2) the licensee has many personnel performing maintenance and testing around the plant and may be observing adverse conditions such as inventory losses.

If a finding is identified and the inspector concludes that RCS level instrumentation was not available or key trouble alarms were not available or bypassed, then a set of tables was developed to allow the inspector to scale up each operator error probability in the event trees. In this situation, the execution failure probability for each mitigation path would be increased to account for the reduced ability for the operator to diagnose a loss of RHR.

Since the template was developed based on maintaining key shutdown safety functions, this template does not provide any information on frontline system dependencies. We ask the user to refer to the system-dependency table provided in the at-power Notebooks. However, the inspector has to consider additional dependencies for additional systems/functions not needed at full power (e.g., AC power for containment closure). The inspector also has to consider whether a support system is needed for the frontline system at shutdown. For example, CCW may not be required for high pressure injection pump bearing and motor cooling if the pump is pumping cool water (< 120F).

6.3 DEFINITIONS

Additional definitions are provided in IMC 0612-03, "Power Reactor Inspection Reports."

6.4 PROCEDURE FOR SIGNIFICANCE DETERMINATION

6.4.1 Initiating Event Characterization

Determining Whether the Finding is a Precursor to a loss of RHR or a Condition Finding

Once a finding has been identified by the inspector as requiring Phase 3 analysis, the inspector must determine whether the finding represents a precursor to a loss of RHR or the finding represents a condition finding. These two findings are evaluated differently in the SDP process.

Precursors to a loss of RHR include inspection findings that have the potential to cause a loss of the operating train of RHR. These findings increase the likelihood of an initiating event, i.e., they are precursors to the initiating event or they define a condition which makes the initiating event more likely. Examples of such findings include:

- Losses of inventory that are terminated before midloop conditions are reached and before RHR pump suction could be lost.   This type of finding increases the likelihood of a loss of the RHR function due to a loss of inventory.

- Switchyard activities that increase the likelihood of a loss of offsite power, such as a crane operating too close to a reserve auxiliary transformer. This type of finding increases the likelihood of a loss of offsite power event which would result in a loss of the RHR function.

- Level instrumentation that does not reflect plant conditions and the licensee plans to initiate RCS draining. This type of finding increases the likelihood of a loss of inventory event which would result in a loss of the RHR function.

- Performance deficiencies associated with the RHR support systems, (such as a loss of inventory from the CCW system) increase the likelihood of a loss of the operating train of RHR which would result in a loss of the RHR function.

Condition findings include findings that ONLY involve a degradation of the licensee's mitigation capability. For example, during POS 1 and POS 2, the licensee planned to have two EDG's available, but both were found to have coolant in the cylinders. Clearly, a loss of offsite power initiating event is no more likely, but the plant's ability to successfully mitigate a loss of offsite power initiating event is reduced.

Initiating Event Descriptions

An initiating event at shutdown is defined as an event that causes a loss or interruption of the decay heat removal function.   This template considers the four internal initiators known to dominate the internal-event shutdown risk based on the Surry Shutdown PRA (NUREG/CR 6144).

The following are the initiating events considered, with their applicability to the POS groups.

Loss of RHR (LORHR) -

This initiating event category includes losses of RHR resulting from failures of the RHR system (such as RHR pump failure) or failures of the RHR support systems such as loss of CCW, loss of SRW, loss of vital AC, and loss of DC power. (Loss of offsite power is treated as a separate category.) This category also includes interruptions of RHR caused by spurious ESFAS signals such as RHR suction valve closure. This initiating event category is considered for POS 1 and POS 2 . This category is not considered applicable to POS 3, since the time to core uncovery is assumed to be greater than 24 hours.

Loss of Offsite Power (LOOP) -

This initiating event category covers losses of offsite power at shutdown which cause an interruption in DHR. This initiator category is considered for all POSs. For POS 3, the possibility that a LOOP or SBO could a loss of air to the cavity seal is considered by using the POS 2 LOOP worksheets.

Loss of Reactor Inventory (LOI) -

This initiating event category includes losses of RCS inventory that lead to a loss of RHR due to loss of RHR pump suction. Many of these flow diversions are caused from improper alignment of valves. This initiator category is considered for all POSs.

Loss of Level Control (LOLC) -

This initiating event category includes: (1) the operator overdrains the RCS to reach midloop conditions such that the RHR function is lost, and (2) the operator fails to maintain level control while in midloop such that the RHR function is lost. This initiator is considered for midloop operations only.

Other initiators that merit consideration include those events that challenge low-temperature over pressure protection (LTOP), and findings that increase the likelihood of a reactivity transient. In Surry Shutdown PRA (NUREG/CR 6144), these two initiators were found to make a smaller contribution to the core damage frequency than the four initiators discussed above. For some inspection findings, their contribution may become significant. Therefore, they will go directly to Headquarters for Phase 3 analysis.

Guidance for Assessing Precursor and Condition Findings

The tables in Chapters 5 are based on estimates of initiating event frequencies from the best available data. Initiating-event frequencies were estimated by searching LERs from 1992 to 1998. They represent the frequencies conditional on the plant being in a shutdown. Accordingly, the same tables can be used with any combination of POSs and time windows. The estimated duration of the degraded condition in such a combination is used to determine the likelihood rating. The likelihood ratings of the applicable categories of initiating events are employed in evaluating the core-damage sequences in the worksheets of the applicable combinations of POSs and time windows.

For precursor findings, findings involving an actual loss of RHR, or findings that involve level instrumentation that is not representative of plant conditions, use Tables 1, 2, 3 or 4 for estimating the initiator rating. Then, use the guidance in this Chapter for filling in the worksheets.

For condition findings, use Table 5 for estimating the initiating event rating. The ratings correspond to the duration of exposure to the degraded conditions identified by the inspector. Then, use the guidance in this Chapter for filling in the worksheets.

Definitions of the POSs and Time Windows

The risk significance of an inspection finding depends on the associated shutdown condition. A unique aspect in assessing the risk significance of a finding during a shutdown is the consideration of the plant's changing configuration and level of decay heat. During development of a shutdown PRA, the plant's changing configuration and decay heat level are taken into account by dividing the shutdown into plant operational states (POSs) and time windows (TWs). The plant's response to the initiating events and success criteria for mitigation functions are considered to remain unchanged during a given POS. From one time window to another, the decay heat can be substantially different, such that the time available for the operator's actions is different, and the credit given for them may vary.

PWR POSs and Time Windows for Phase 3 Assessment

For this template, Figure 1 defines the POSs and time windows for a PWR plant. It also shows the relationship between the POSs and the modes defined in the Technical Specifications (TSs). We now describe the POSs and Time Windows (TWs).

POS 1- This POS starts when the RHR system is put into service. The RCS is closed such that the steam generators could be used for decay heat removal, if the secondary side of a steam generator is filled. The RCS may have a bubble in the pressurizer. This POS ends when the RCS is vented such that the steam generators cannot sustain core head removal. This POS typically includes Mode 4 (hot shutdown) and portions of Mode 5 (cold shutdown).

POS 2- This POS starts when the RCS is vented such that: (1) the steam generators cannot sustain core heat removal and (2) a sufficient vent path exists for feed and bleed. This POS includes portions of Mode 5 (cold shutdown) and Mode 6 (refueling). Reduced inventory conditions and midloop operations with a vented RCS are subsets of this POS. Note: performance deficiencies occurring during a vacuum refill of the RCS require use of the POS 1 event trees.

POS 3- This POS represents the shutdown condition with the refueling cavity filled to 23' above the vessel flange. A very large amount of coolant inventory is available. This POS occurs during Mode 6.

Early Time Window (TW-E)-

This time widow represents the time before POS 3 is entered. The decay heat is relatively high. The reactor is either in POS 1 or 2.

Late Time Window (TW-L)-

This time window represents the time after POS group 3. The decay heat is relatively low. The reactor is either in POS 1, 2, or 3

The above definitions of the POSs and Time Windows can be used to address different types of plant shutdowns, i.e., refueling outage, planned maintenance outage, and an unplanned outage. Depending on the type of outage and its duration, the POSs and TWs can be identified from the above list. For example, all POSs and both TWs will apply to a refueling outage. Only POS 1 and the early Time Window (TW-E) may apply to an unplanned outage.

NOTE: The operator credits in the SDP worksheets are given for Time Window 1. The same worksheets can be used for Time Window 2 except the credits for operator response may need to be changed to account for the longer operator's response time. Detailed instructions are given in Chapter 6.0 of this template

Selecting Applicable Tables For Precursor Findings

This section provides guidance for estimating the initiating event likelihood (IEL) for precursor findings. This chapter consists of tables that the analyst uses to estimate the initiator rating depending on the type of precursor that occurred.

- For findings that increase the likelihood of a loss of a level control (LOLC) or actually caused a LOLC, go to Table 1.

- For findings that increase the likelihood of a loss of offsite power (LOOP) or actually caused a LOOP, go to Table 2.

- For findings that increase the likelihood of a loss of reactor inventory (LOI) or actually caused a LOI , go to Table 3.

- For findings that increase the likelihood of a loss of the operating train of RHR (LORHR) or actually caused a LORHR for reasons other than LOLC, LOOP or LOI, go to Table 4. Findings involving RHR support systems also use Table 4.

Condition Findings

For condition findings, the analyst must obtain an initiating event likelihood for EACH POS that the condition finding occurred in. Table 5 is used in the same manner as the full power notebooks.   Then, the analyst enters the initiating event likelihood in the shutdown worksheets in the same manner as the full power worksheets.

6.4.2 Evaluation of Mitigation Capability

The SDP worksheets for shutdown are used in the same manner as the full power worksheets using the following guidance.

- ❑ The success criterion of a safety function specifies what is needed, not what might be available.   Therefore, the inspector should use the outage plan determine what equipment to credit for each safety function.

- ❑ A frontline system is considered available if all support systems that are necessary to support the function of the frontline system are available (such as AC power, SRW cooling, instrument air, etc.). If manual action is required, there must be enough time to: (1) recognize that manual action is needed and (2) execute the manual action after recognizing that manual action is needed.   To credit system availability, these two tasks should be able to be completed reliably within ½ the time that the equipment must actuate.

- ❑ If the performance deficiency involves a support system, the analyst must consider the impact of potential loss of the system for each safety function specified in the worksheets.

- ❑ A piece of equipment is considered available if all support systems that are necessary to support the piece of equipment is available. If manual action is required, there must be enough time to: (1) recognize that manual action is needed and (2) execute the manual action after recognizing that manual action is needed.   To credit system availability, these two tasks should be able to be completed reliably within ½ the time that the equipment must actuate.

- ❑ For losses of inventory in POS 1 and POSs 2 that would eventually terminate at the bottom of the hotleg WITHOUT operator intervention, use the LOLC worksheets but use the appropriate IEL for LOI.

- ❑ Installed equipment is credited similar to the full power worksheets.   Use Table 7 for guidance.

- ❑ Temporary equipment can be credited. Use Table 8 for guidance.

- ❑ Operator action drives shutdown risk.   Almost every function in the worksheets (almost every top event in the event trees) has an operator action.   Often the operator credit defines the credit given to the mitigating function (operator limited). Nominal operator credits are specified in the worksheets based on: (1) the time available to perform the action, and (2) the assumed available instrumentation.

THE ANALYST MUST ADJUST EACH OPERATOR CREDIT IN THE WORKSHEETS IF USING TABLE 6 IF:

✓ If the time available to perform the action is too short or too long by greater than a factor of 2 (e.g., the finding occurs in Time Window 2).

OR

✓ The assumed instrumentation specified in the worksheet is not available/not reflective of plant conditions.

OR

✓ There are significant, finding specific, negative performance shaping factors for the operator action. Examples include (not limited to) : (1) RHR venting cannot be accomplished easily because the scaffolding needed to access the vents is not staged, (2), the ability to vent the RHR pipes is limited due to high points in the RHR suction piping, (3) the operator needs to enter an area that has high steam or radiation levels , or (4) the operator needs special equipment to open a valve that is not staged.

❏ The inspector should jot down any unique assumptions that significantly influence the credit given to the mitigating function at the bottom of the worksheet. These assumptions are critical to performing the Phase 3 analysis and these assumptions are critical to understanding plant specific risk of the finding. For example, if CCW is not needed to support high pressure injection and if the ECCS pump is pumping water cooling than 120F, that assumption should be written down at the bottom of the worksheet.

❏ This template does not provide any information on system dependency or alignment during shutdown. We refer the user to the system-dependency table of at-power plant-specific SDP notebook. However, the inspector has to consider additional dependencies for additional systems/functions not needed at full power (e.g., AC power for containment closure). The inspector also has to consider whether the support system is needed for the frontline system at shutdown. For example, for some licensees, CCW may not be required for high pressure injection pump bearing and motor cooling if the pump is pumping cool water (< 120F).

❏ Representative Times to Boiling and Core Damage based on Decay Level from midloop conditions can be found in Table 9.

- Time to RWST depletion can be estimated by using gpm of water needed to make up for boiloff.

- Finally, the availability of standby RCS injection along with operator error drives shutdown risk. As long as standby injection is available, in most cases, standby injection buys time for other operator recovery actions such as: leak path termination and RHR recovery. If there are factors that could render the standby RCS injection unavailable such as: gas intrusion, system unavailability, etc, then these factors (assumptions) become risk significant and should be assessed carefully.