APPENDIX G
ATTACHMENT 3

PHASE 2 SIGNIFICANCE DETERMINATION PROCESS TEMPLATE FOR BWR DURING SHUTDOWN

TABLE OF CONTENTS

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 inspection findings is assessed using a Risk Informed process, called the Significance Determination Process (SDP). The Shutdown SDP consists of: Phase 1, Definition and Initial Screening of Findings; Phase 2, Initial Risk Significance Approximation and Basis; and Phase 3, Risk Significance Finalization and Justification. Inspection Manual Chapter (IMC) 0609 Appendix G, Shutdown Operations Significance Determination Process is used to conduct the phase 1 screening analysis by inspectors. This template is used for performing phase 2 analyses by SRAs for certain BWR shutdown performance deficiencies 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 performance deficiencies that are identified as requiring quantitative assessment from the Phase 1 Screening Tool.

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.

1.1.2 Management D 8.3 Entry

Procedures are given in Chapter 4 for using this template to perform quantitative assessment of shutdown event to satisfy Management Directive 8.3.

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 operation.

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. Contact risk analyst in NRR/SPSB for assistance if needed.

2.2.2 The analyst must understand: (1) the differences between precursor and condition findings, (2) the definitions of the plant operational states (POSs), and (3) the definitions of the shutdown initiating events.

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 Findings that involve freeze seals that are installed in systems connected to the RCS where failure could lead to a loss of inventory are not covered by these worksheets and go directly to Headquarters for Phase 3 analysis.

2.2.5 Findings that involve containment closure are assessed using IMC 0609 Appendix H.

3.0 ABBREVIATIONS AND DEFINITIONS

3.1 Abbreviations

CD	Core Damage
CCW	Component Cooling Water
DHR	Decay Heat Removal
ECCS	Emergency Core Cooling System
IEL	Initiating Event Likelihood
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
SRW	Site Raw Water
SSW	Standby Service Water
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 2 - Initial Risk Significance Approximation and Basis: Initial approximation of the risk significance of the finding and development of the basis for this determination for those findings that are not screened out in Phase 1 screening.

Phase 3 - Risk Significance Finalization and Justification: Review and as-needed refinement of the risk significance estimation results from Phase 2, or development of any risk analysis outside of this guidance, by an NRC risk analyst (any departure from the

guidance provided in this document or IMC 609 Appendix G for Phase 1 or Phase 2 constitutes a Phase 3 analysis and must be performed by an NRC risk analyst).

Types of Shutdown Performance Deficiencies

Precursor Finding - Inspection findings that: (1) have the potential to cause a loss of the operating train of RHR, (2) increase the likelihood that the operating RHR train could be lost, or (3) result in a shutdown event - cause a loss/interruption of the operating train of RHR.

Condition findings - Inspection findings that only involve a degradation of the licensee's capability to mitigate an event if an event were to occur. Findings only affecting the standby train of RHR are condition findings.

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 the DHR function. LOOP events are not assessed in POS 3.

Loss of Reactor Inventory (LOI) - Includes losses of RCS inventory that lead to a loss of the DHR function due to isolation of RHR on Level 3 or loss of RHR due to loss of RHR pump suction.

Plant Operational States (POSs)

POS 1 - This POS starts when the RHR system is put into service. The vessel head is on and the RCS is closed such that an extended loss of the DHR function without operator intervention could result in a RCS re-pressurization above the shutoff head for the RHR pumps.

POS 2 - This POS represents the shutdown condition when (1) the vessel head is removed and reactor pressure vessel water level is less than the minimum level required for movement of irradiated fuel assemblies within the reactor pressure vessel as defined by Technical Specifications OR (2) a sufficient RCS vent path exists for decay heat removal.

POS 3 - This POS represents the shutdown condition when the reactor pressure vessel water level is equal or greater than the minimum level required for movement of irradiated fuel assemblies within the reactor pressure vessel as define by Technical Specifications. This POS occurs during Mode 5.

Time Windows

Early Time Window (TW-E) - This time window 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 or 2.

Other Key Shutdown Definitions

Available - A piece of equipment is considered available if: (1) it can be put into service within half the time that is needed for the equipment to perform its function, (2) procedures or standing orders exist for using the equipment to meet its intended function, (3) all necessary supporting systems (such as AC power, cooling water, and DC control power) can be put into service within half the time that is needed for the equipment to perform its function, and (4) operators have been trained for using the equipment for the given situation.

Core Damage - Core damage corresponds to a peak clad temperature above 1300 degrees Fahrenheit. Above 1340 degrees Fahrenheit, phenomena such as clad oxidation and ballooning affect core behavior. This definition is consistent with the definition of the onset of core damage used in NUREG/CR 6144 Vol.2, Part 1A, "Evaluation of Potential Severe Accidents During Low Power and Shutdown Operations at Surry, Unit 1, Analysis of Core Damage Frequency from Internal Events During Mid-Loop Operations."

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 Transition from Phase 1 SDP

Step 4.1.1 Use the information gathered in the Phase 1 process to identify the set of equipment that the licensee planned to achieve the following safety functions: Standby RCS injection and RCS pressure control, if applicable.

Caution: Equipment is considered available if: (1) it can be put into service within half the time that is needed for the equipment to perform its function, (2) procedures or standing orders exist for using the equipment to meet its intended function, (3) all necessary supporting systems (such as AC power, cooling water, and DC control power) can be put into service within half the time that is needed for the equipment to perform its function, and (4) operators have been trained for using the equipment for the given situation.

Caution: 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 allows 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.

Step 4.2 Determine if the finding is a precursor to an initiating event (a loss of the DHR function) or a condition finding.

NOTE: Precursor findings: (1) have the potential to cause a loss of the operating train of RHR, or (2) increase the likelihood that the operating RHR train could be lost, or (3) result in a shutdown event - cause a loss/interruption of the operating train of RHR. Condition findings only involve a degradation of the licensee's capability to mitigate an event if an event were to occur. Findings only affecting the standby train of RHR are condition findings. The templates treats precursor and condition findings differently.

Go To Step 4.3 for Precursor Findings

OR

Go To Step 4.4 for Condition Findings

NOTE: If this tool is being used to assess a shutdown event under Management Directive 8.3, Go to Step 4.5.

Step 4.3 Procedure for Assessing SDP Precursor Findings

Step 4.3.1 Identify each TW and POS where the finding could have occurred.

Step 4.3.2 Determine the IEL. The IEL is the conditional likelihood of having a loss of the RHR function given the occurrence of the performance deficiency.

- 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 1 to determine the IEL. Go to Step 4.3.3.

- 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 2 to determine the IEL. Go to Step 4.3.3.

- 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 3 to determine the IEL. Go to Step 4.3.3.

- IF a finding involves the RHR support systems (except for LOOP and LOI), THEN LORHR is the applicable initiating event. Use Table 3 to determine the IEL. Go to Step 4.3.3.

Step 4.3.3 Use the SDP Worksheet that contains the POSs and initiating events that were determined to be applicable in Step 4.3.2.

Step 4.3.4 Enter the time to RCS boiling and an approximate time to core uncovery/core damage in the first line of the Worksheet.

Step 4.3.5 Label the IEL in each row of the lower section of the worksheet.

Step 4.3.6 Determine Credit for each top event function.

A. Verify that the licensee has the instrumentation referenced for the top event function.

NOTE: If the licensee does not have the referenced instrumentation available or the referenced instrumentation is not reflective of RCS conditions, then the default operator credit MUST by decreased by 2.

B. To obtain the Equipment Credit, credit each available system that is (1) capable of maintaining the top event function and (2) is not impacted by the finding. Use the Event Tree associated with the Worksheet to help understand the successes and failures associated with each accident sequence. Use guidance in Tables 6 and 7 to determine equipment credits. Document key assumptions.

C. To obtain the Operator Credit, Use the default operator credit unless any of the following four conditions are applicable:

1. If the referenced instrumentation is missing or misleading, then decrease the operator credit by two.
2. The default time is incorrect and is significantly reduced. If the diagnoses time is less than 20 minutes, OR the time required to perform the action is approximately the time available, then decrease the operator credit by one.
3. If the action is complicated by missing equipment, unaccessible equipment, steam or high radiation, or loop seals for pump venting, then decrease the operator credit by two.
4. If the procedures are incomplete for the shutdown configuration, then the operator credit is decreased by one.

NOTE: If the default operator credit is changed and results in a negative operator credit, then the operator credit is zero.

D. Determine the Credit for Function for each Top Event Function needed. Select the lower of Equipment Credit and Operator Credit, and enter the value in this column.

Step 4.3.7 Quantification of Core Damage Scenarios

Quantify each accident scenario by adding the credits for IEL + Mitigation Credit. Enter the sum in the Result column.

NOTE: For phase 2 analyses, the recovery credit is not used.

Step 4.3.8 Identifying the Frequency of Finding Occurrence. Select Between Condition A or B.

A. If the performance deficiency occurred during an outage (forced outage, refueling outage, etc.), the color of the finding is determined similar to the process using the guidance in IMC 0609 Appendix A. The resulting ICCDP associated with the performance deficiency is interpreted as the addition to the licensee's total CDF contribution

over the previous year (previous 12 months). Therefore the resulting ICCDP becomes the increase in delta CDF.

B. If the deficiency needs a random event to reveal the deficiency (e.g. at Palisades, the digging of a sign revealed underground protective cabling common to both offsite power sources outside the protected area), then the frequency of the random event (1/32 calender years of operation) is multiplied by:

The Frequency that the licensee enters an outage (1 outage per 18 months) * (12 months/ calender year) *(Number of Days of POS 1 operation/ outage) * (1 calender year/365 days) *(CCDP of POS 1 operation)

Added to:

The Frequency that the licensee enters an outage (1 outage per 18 months) * (12 months/ calender year) *(Number of Days of POS 2 operation/ outage) * (1 calender year/365 days) *(CCDP of POS 2 operation)

Step 4.4 Process for Assessing SDP Condition Findings

NOTE: Only the core damage scenarios impacted by the finding are quantified.

Step 4.4.1 Select the applicable initiating events (LOOP. LORHR, 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).

Step 4.4.2 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.

Step 4.4.3 Use the SDP Worksheet(s) that contain the POSs and initiating events that were determined to be applicable in Step 4.4.2. Perform the following steps on the Worksheet for each applicable POS and initiating event.

Step 4.4.4 Enter the time to RCS boiling and an approximate time to core uncovery/core damage in the first line of the Worksheet.

Step 4.4.5 Label the IEL in each row of the lower section of the worksheet.

Step 4.4.6 Determine Revised Credit for each top event function Impacted by the Finding.

A. Verify that the licensee has the instrumentation referenced for the top event function.

NOTE: If the licensee does not have the referenced instrumentation available or the referenced instrumentation is not reflective of RCS conditions, then the default operator credit must be decreased by two.

B. To obtain the Equipment Credit, credit each available system that is: (1) capable of maintaining the top event function and (2) is not impacted by the finding. Use the Event Tree associated with the Worksheet to help understand the successes and failures associated with each accident sequence. Use guidance in Tables 5 and 6 to determine equipment credits. Document key assumptions.

NOTE: Each top event has a equipment credit and an operator credit, only the equipment credit change or the operator credit change is propagated through the worksheets. See the following example:

Example: If the licensee has a finding that changes the MINJ equipment credit from 5 to 3, then the revised credit for the MINJ&SRV becomes 3, regardless of the SRV credit or the operator credit.

C. To obtain the revised Operator Credit, use the following guidance:

1. If the referenced instrumentation is missing or misleading, then decrease the operator credit by two.
2. The default time is incorrect and is significantly reduced. If the diagnoses time is less than 20 minutes, OR the time required to perform the action is approximately the time available, then decrease the operator credit by one.
3. If the action is complicated by missing equipment, unaccessible equipment, steam or high radiation, or loop seals for pump venting, then decrease the operator credit by two.
4. If the procedures are incomplete for the shutdown configuration, then the operator credit is decreased by one.

NOTE: If the default operator credit is changed and results in a negative operator credit, then the operator credit is zero.

Example: If the licensee has a finding that changes the operator credit from a 5 to a 3 due to a loss of instrumentation, then the revised credit for the MINJ&SRV becomes 3, regardless of the equipment MINJ&SRV equipment credit.

D. Determine the Credit for Function for each Top Event Function needed. Select the lower of Equipment Credit and Operator Credit, and enter the value in this column.

Step 4.4.7 Quantification of Core Damage Scenarios

Quantify each accident scenario that is impacted by the finding adding the credits for IEL + Mitigation Credit. Enter the sum in the Result column.

Note, For phase 2 analyses, the recovery credit is not used.

Step 4.4.8 Go to the next applicable Worksheet and begin at Step 4.4.1 or, if all Worksheets are completed, continue to Step 4.4.9.

Step 4.4.9 Estimating the Risk Significance of the Inspection Finding

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.

Step 4.5 Process for Assessing Events Under MD 8.3

Step 4.5.1 Identify the TW and POS where the shutdown event occurred.

Step 4.5.2 Identify the appropriate shutdown initiating event.

Use an IEL = 1.0 if the event caused a loss of interruption of the RHR function.

OR

Determine the IEL. Evaluate each question in order. Only one of the following will apply:

- C 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 1 to determine the IEL. Go to Step 4.5.3.

- C 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 2 to determine the IEL. Go to Step 4.5.3.

- C 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 3 to determine the IEL. Go to Step 4.5.3.

- C IF a finding involves the RHR support systems (except for LOOP and LOI), THEN LORHR is the applicable initiating event. Use Table 3 to determine the IEL. Go to Step 4.5.3.

Step 4.5.3 Use the SDP Worksheet that contains the POS and initiating event that were determined to be applicable in Step 4.5.1.

Step 4.5.4 Enter the time to RCS boiling and an approximate time to core uncovery/core damage in the first line of the Worksheet.

Step 4.5.5 Label the IEL in each row of the lower section of the worksheet.

Step 4.5.6 Determine the revised Credit for each top event function impacted by the finding for the as found condition during the event.

A. Verify the licensee has the instrumentation referenced for the top event function.

NOTE: If the licensee does not have the referenced instrumentation available or the referenced instrumentation is not reflective of RCS conditions, then the default operator credit MUST be reduced by two.

B. To obtain the Equipment Credit, credit each available system that is (1) capable of maintaining the top event function and (2) is not impacted by the finding. Use the Event Tree associated with the Worksheet to help understand the successes and failures associated with each accident sequence. Use guidance in Tables 7 and 8 to determine equipment credits. Document key assumptions.

C. To obtain the Operator Credit, use the default operator credit unless any of the following four conditions are applicable:

1. If the referenced instrumentation is missing or misleading, then decrease the operator credit by two.
2. The default time is incorrect and is significantly reduced. If the diagnoses time is less than 20 minutes, OR the time required to perform the action is approximately the time available, then decrease the operator credit by one.
3. If the action is complicated by missing equipment, unaccessible equipment, steam or high radiation, or loop seals for pump venting, then decrease the operator credit by two.
4. If the procedures are incomplete for the shutdown configuration, then the operator credit is decreased by one.

NOTE: If the default operator credit is changed and results in a negative operator credit, then the operator credit is zero.

D. Determine the Credit for Function for each Top Event Function needed. Select the lower of Equipment Credit and Operator Credit, and enter the value in this column.

Step 4.5.7 Quantification of Core Damage Scenarios

Quantify each accident scenario by adding the credits for IEL + Mitigation Credit. Enter the sum in the Result column.

NOTE: For phase 2 analyses, the recovery credit is not used.

Step 4.5.8 Go to the next applicable Worksheet and begin at Step 4.5.1, or if all Worksheets are completed, continue to Step 4.5.9.

Step 4.5.9 Estimating the Risk Significance of the Inspection Finding

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 POS Groups and Time Windows - BWRs

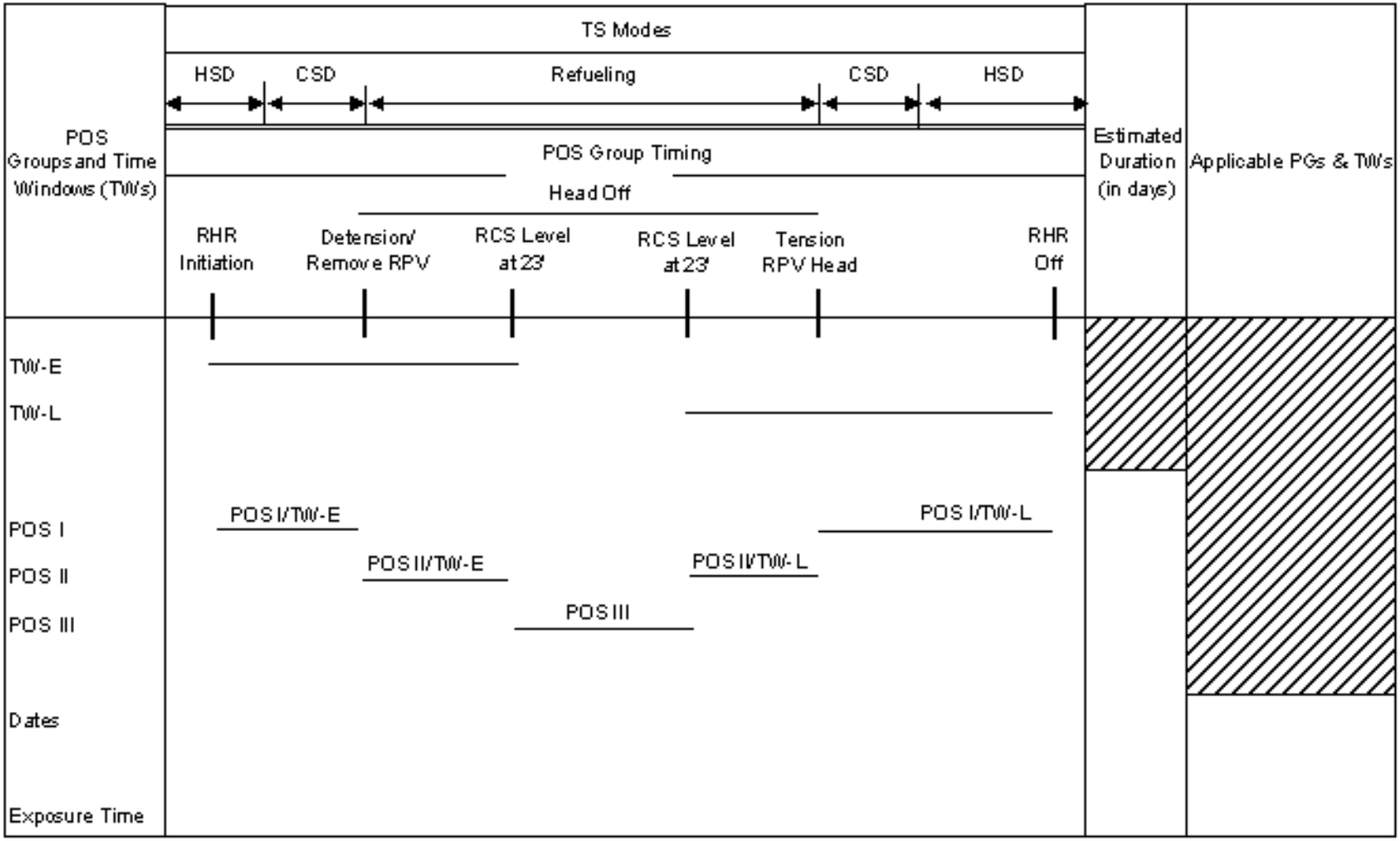


Table 1 - Initiating Event Likelihoods (IELs) for LOOP Precursors

Type of LOOP precursor	Initiating Event Likelihood (IEL)
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 2 - Initiating Event Likelihoods (IELs) for LOI Precursors

Time to RHR loss due to isolation of RHR on level 3 given no operator action	Is RCS Level Indication a reasonable reflection of RCS level	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
loss of RHR occurred or X<20 min.	N/A	N/A	N/A	0
20<X<40 min.	YES	YES	YES	1
20<X<40 min.	NO	N/A	N/A	0
20<X<40 min.	YES	NO	N/A	0
20<X<40 min.	YES	YES	NO	0
40<X<60 min.	YES	YES	YES	2
40<X<60 min.	NO	YES	YES	0
40<X<60 min.	YES	NO	N/A	0
40<X<60 min.	YES	YES	NO	0
1<X<2 hours	YES	YES	YES	3
1<X<2 hours	NO	YES	YES	1
1<X<2 hours	YES	NO	N/A	0
1<X<2 hours	YES	YES	NO	0
X>2 hours	YES	YES	YES	4
X>2 hours	NO	YES	YES	1
X>2 hours	YES	NO	N/A	0
X>2 hours	YES	YES	NO	0

Table 3 - Initiating Event Likelihoods (IELs) for LORHR Precursors

Note: For findings affecting Loss of the Operating Train of RHR and RHR Supports System Including SSW, AC and DC components

Time to RHR loss given no successful operator action	**Trouble Alarms Present for Finding** **Ex.** **DHR high temp.** **DHR low flow** **Support System Trouble Alarms** **Ex. SSW 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**
Loss of RHR occurred OR < 20 minutes	N/A	N/A	N/A	0
20<X<40 min.	YES	YES	YES	1
20<X<40 min.	NO	N/A	N/A	0
20 <X<40min.	Yes	NO	N/A	0
20<X<40 min.	YES	YES	NO	0
40<X<60min.	YES	YES	YES	2
40<X<60min.	NO	N/A	N/A	0
40<X<60min.	YES	NO	N/A	0
40>X<60min	YES	YES	NO	0
1<X<2 hours	YES	YES	YES	3
1<X<2 hours	NO	YES	YES	1
1<X<2 hours	YES	NO	N/A	0
1<X<2 hours	YES	YES	NO	0
X>2 hour	YES	YES	YES	4
X>2 hour	NO	YES	YES	1
X>2 hour	YES	NO	N/A	0
X> 2 hour	YES	YES	NO	0

Table 4 - Initiating Event Likelihoods (IELs) for Condition Findings - BWRs

Row	Approximate Conditional Frequency	Example Event Type	Estimated IEL[(1)]		
0	> 1 per yr	Loss of a Operating Train of RHR (LORHR)	**0**	**1**	**2**
I	1 per 1-10 yr	Loss of offsite power (LOOP)	**1**	**2**	**3**
II	1 per 10-10^2 yr	Loss of Inventory (LOI)	**2**	**3**	**4**
			> 30 days	**3-30 days**	**< 3 days**
			Exposure Time for Degraded Condition		

1. The likelihood ratings are presented in terms of 0, 1, 2, etc. A rating of 0 is comparable to a frequency of 1 per year, a rating of 1 is comparable to a frequency of 1E-1 per year, and similarly, a rating of 2 is comparable to a frequency of 1E-2 per year.

Table 5 - 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 6 - Credits 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 generator) that is available during shutdown; equipment and tools needed are staged for quick hookup	Use credit of 1

Worksheet 1. SDP Worksheet for a BWR Plant - Loss of Inventory in POS 1 (Head on)

FILL IN: TIME TO BOILING _____ TIME TO CORE DAMAGE _____
(NOTE: losses of inventory shorten time to core damage)

Safety Functions Needed:	Success Criteria and Important Instrumentation:	Equip. Credit	Operator Credit	Credit for Function
Isolation of the loss (ISOL)	Downcomer losses: Auto isolation of RHR on Low Vessel Level W/low level alarm ---------- ---------- Losses from lower plenum	Credit = 3 ---------- Unisolable leak (lower plenum) - 0	N/A ---------- ---------- Credit = 0	
Early Automatic ECCS (AECCS)	1 low pressure ECCS pump train in automatic		N/A	
Manual Low Pressure Injection - Leak isolated (MINJ)	Reconfigure RHR to ECCS injection, or LPCS, or a condensate pump or another low pressure non-ECCS pump capable of keeping the core covered Operator needs Vessel level indic. W/low level alarms		Credit = 4 (Assumes time to RHR shutoff head > 1hr).	
Manual Low Pressure Injection - Leak not isolated (MINJX)	Reconfigure RHR to ECCS injection or other high flow rate source essentially equivalent in capability to ECCS injection. Operator needs Vessel level indication w/low level alarms		Credit = 4 (Assumed time to CD >2hours w/o leak path isolation)	

DHR Recovery before RCS pressure control needed. Leak Isolated. (RHRREC)	Operator restarts RHR before RCS pressure control needed. OR Operator initiates an alternate, diverse, DHR path such as CRD and RWCU before RCS pressure control is needed.		Credit = 4 (Time to RHR shutoff head >1 hr.)	
RCS Pressure Control **(SRV)**	Operator opens A RCS vent path (e.g. SRV) to control RCS pressure. Operator needs RCS pressure indication.		Credit = 2	
Manual High Pressure Injection at Pressure (MINJY)	Operator injects following isolation of RHR on high pressure or SRVs lifting. using high pressure pumps such as Control Rod Drive pumps or HPCI.		Credit = 1	
Containment Venting (CV)	Operator opens available vent paths. Additionally, long term make-up water must be provided to the injection source.		Credit = 3	

Core Damage Sequences (Circle Affected Functions)	**IEL**	**Mitigation Credit**	**Recovery**	**Result**
LOI - RHRREC- CV (3)				
LOI - RHRREC - SRV (4)				
LOI - MINJ - CV (6)				
LOI - MINJ - MINJY(7)				
LOI - ISOL - CV (9)				
LOI - ISOL - SRV (10)				
LOI - ISOL - AECCS - CV (12)				

LOI - ISOL - AECCS - SRV (13)				
LOI-ISOL-AECCS-MINJX (14)				

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

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

Notes:

1. Different non-ECCS sources may apply for different plants. Examples include: firewater and high pressure service water.
2. Failure of ECCS and alternate injection sources is assumed to fail the ability of the operator to recover RHR and is assumed to fail suppression pool cooling and makeup.
3. Failure to isolate the leak reduces the ability to recover RHR.
4. Non-ECCS systems are not assumed to be able to keep core covered if leak path is not isolated.
5. If a leak is isolated by the operator, it is assumed that ECCS will not automatically be activated.
6. Actions to steam the core at high or low pressure to prevent core damage are treated as recovery actions.

Worksheet 2 SDP Worksheet for a BWR Plant — Loss of Inventory in POS 2 (Head Off or RCS vented)

FILL IN: **TIME TO BOILING** _____ **TIME TO CORE DAMAGE** _____ **(NOTE: losses of inventory shorten time to core damage)**				
Safety Functions Needed:	**Success Criteria and Important Instrumentation:**	**Equip. Credit**	**Operator Credit**	**Credit for Function**
Isolation of the loss (ISOL)	**Downcomer losses: Auto isolation of RHR on Low Vessel Level W/low level alarm** **----------** **Losses from lower plenum**	**Credit = 3** **----------** **Unisolable leak (lower plenum) - 0**	**N/A** **----------** **Credit = 0**	
Early Automatic ECCS (AECCS)	**1 low pressure ECCS pump train in automatic**		**N/A**	
Manual RCS Injection by operator - Leak isolated (MINJ)	**Reconfigure RHR to ECCS injection, or manual CRD, or HPCS, or LPCS, or LPCI, or condensate pump or CRD or other non-ECCS before Core Damage** **Operator needs Vessel level indic. W/low level alarms**		**Credit = 4** **(Time to CD > 3 hrs. w/o injection)**	
Manual RCS Injection - - Leak not isolated (MINJX)	**Reconfigure RHR to ECCS injection or other high flow rate source essentially equivalent in capability to ECCS injection before core damage.** **Operator needs Vessel level indic. W/ low level alarms**		**Credit = 4** **(Time to CD > 3 hrs w/o injection.)**	

DHR Recovery before Long Term Cooling needed Leak Isolated. (RHRREC)	**Operator restarts RHR before Long Term Cooling needed OR Operator initiates an alternate, diverse DHR path such as CRD and RWCU before Long Term Cooling is needed.**		**Credit = 4**	
Long Term Cooling (LCOOL)	**Operator maintains long term inventory source**		**Credit = 4**	

Core Damage Sequences (Circle Affected Functions)	**IEL**	**Mitigation Credit**	**Recovery**	**Result**
LOI-RHRREC-LCOOL (3)				
LOI-AECCS-RHRREC-LCOOL (6)				
LOI-AECCS-MINJ (7)				
LOI -ISOL-LCOOL (9)				
LOI - ISOL-AECCS - LCOOL (11)				
LOI-ISOL-AECCS-MINJX (12)				

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. **Different non-ECCS sources may apply for different plants. Examples include: firewater and high pressure service water.**
2. **Failure of ECCS and alternate injection sources is assumed to fail the ability of the operator to recover RHR**
3. **Failure to isolate the leak reduces the ability to recover RHR.**
4. **Non-ECCS systems are not assumed to be able to keep core covered if leak path is not isolated.**
5. **If a leak is isolated by the operator, it is assumed that ECCS will not automatically be activated.**

Worksheet 3. SDP Worksheet for a BWR Plant - Loss of Inventory in POS 3 (Cavity Flooded)

FILL IN: **TIME TO BOILING** _____ **TIME TO CORE DAMAGE** _____
(NOTE: losses of inventory shorten time to core damage)

Safety Functions Needed:	Success Criteria and Important Instrumentation:	Equip. Credit	Operator Credit	Credit for Function
Isolation of the loss (ISOL)	Downcomer losses: Auto isolation of RHR on Low Vessel Level W/low level alarm ---------- ---------- Losses from lower plenum	Credit = 3 ---------- Unisolable leak (lower plenum) - 0	N/A ---------- ---------- Credit = 0	
Manual RCS Injection - Leak isolated (MINJ)	Reconfigure RHR to ECCS injection, or manual CRD, or HPCS, or LPCS, or LPCI, or condensate pump or CRD or other non-ECCS before Core Damage Operator needs Vessel level indic. W/low level alarms		Credit = 4 (Time to CD > 3 hrs. w/o injection)	
Manual RCS Injection - Leak not isolated (MINJX)	Reconfigure RHR to ECCS injection or other high flow rate source essentially equivalent in capability to ECCS injection before Core Damage Operator needs Vessel level indic. W/ low level alarms		Credit = 4 (Time to CD > 3 hrs. w/o injection.)	

DHR Recovery before Long Term Cooling needed. (RHRREC)	**Operator restarts RHR before Long Term Cooling is needed. OR Operator initiates an alternate, diverse DHR path such as CRD and RWCU before Long Term Cooling is needed.**		**Credit = 4**	
Long Term Cooling	**Operator maintains long term inventory source**		**Credit = 4**	

Core Damage Sequences (Circle Affected Functions)	**IEL**	**Mitigation Credit**	**Recovery**	**Result**
LOI-RHRREC-LCOOL (3)				
LOI - MINJ (4)				
LOI-ISOL-LCOOL (6)				
LOI-ISOL-MINJX (7)				

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. **Different non-ECCS sources may apply for different plants. Examples include: firewater and high pressure service water.**
2. **Failure to isolate the leak reduces the ability to recover RHR.**
3. **Non-ECCS systems are not assumed to be able to keep core covered if leak path is not isolated.**

Worksheet 4. SDP Worksheet for a BWR Plant - Loss of Operating Train of RHR (LORHR) in POS 1 (Head On)

FILL IN: TIME TO BOILING _____ TIME TO CORE DAMAGE _____

Safety Functions Needed:	Success Criteria and Important Instrumentation:	Equip. Credit [1]	Operator Credit	Credit for Function
DHR Recovery (RHRREC) before RHR shutoff head reached	**Operator restores a train of RHR or Alternate DHR path before RHR shutoff head (Tshut) is reached** **Operator needs RHR inlet/outlet temp indic. and RHR flow indic. with low flow alarm** **OR IF APPLICABLE[2]** **Operator recovers failed RHR support systems before RHR shutoff head (Tshut) is reached .**		**Credit = 0 if Tshut <20 min** **If recovery action can be identified within ½ time to Tshut AND recovery action can be performed within ½ Tshut , then:** **Credit = 1, if 20<Tshut <40min.** **Credit = 2, if 40min<Tshut <1 hr** **Credit = 3, if Tshut > 1 hr.**	

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

Manual Low Pressure Injection & RCS Pressure Control (MINJ&SRV)	**Operator uses a LPCS pump, a condensate pump or another low pressure pump capable of keeping the core covered, in addition to the RHR pumps which are assumed to be failed. Operator needs RCS pressure indication and RCS level indication with low level alarm AND Operator opens a RCS vent a path to control RCS pressure (e.g SRV).**		**Credit = 2**	
Manual High Pressure Injection at Pressure (MINJY)	**Following isolation of RHR on high pressure, operator injects using high pressure pumps such as Control Rod Drive pumps or HPCI and steaming out the SRVs at their safety setpoint.**		**Credit = 1**	
Containment Venting (CV)	**Operator vents containment and provides long term inventory for injection system**		**Credit = 3**	

Core Damage Sequences (Circle Affected Functions)	**IEL**	**Mitigation Credit**	**Recovery**	**Result**
LORHR - RHRREC - CV (3)				
LORHR - RHRREC - MINJ&SRV- CV (5)				
LORHR-RHRREC-MINJ&SRV-MINJY(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. **Failure to recover RHR before RHR shutoff head is reached is assumed to fail short term injection using LPCI.**
2. **Actions to prevent core damage by steaming the core at high or low pressure are treated as recovery actions.**

Worksheet 5. SDP Worksheet for a BWR Plant — Loss of Operating Train of RHR in POS 2 (Head Off or RCS Vented)

FILL IN: TIME TO BOILING _____ TIME TO CORE DAMAGE _____

Safety Functions Needed:	Success Criteria and Important Instrumentation:	Equip. Credit [3]	Operator Credit	Credit for Function
DHR Recovery (RHRREC) before RCS Level 3 reached and RHR automatically isolates	**Operator restores a train of RHR or Alternate DHR path before RCS Level 3 (Tisol) reached** **Operator needs RHR inlet/outlet temp indic. and RHR flow indic. with low flow alarm** **OR IF APPLICABLE[4]** **Operator recovers failed RHR support systems before RCS Level 3 (Tisol) is reached .**		**Credit = 0 if Tisol <20 min** **If recovery action can be identified within ½ time to Tisol AND recovery action can be performed within ½ Tisol , then:** **Credit = 1, if 20<Tisol <40min.** **Credit = 2, if 40min<Tisol <1 hr** **Credit = 3, if Tisol > 1 hr.**	
Early Automatic ECCS (AECCS)	**1 low pressure ECCS pump train in automatic in addition to the RHR pumps which are assumed to be failed.**		**N/A**	

[3]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.

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

Manual RCS Injection before CD (MINJ)	**Operator actuates LPCS pump, or another high pressure or low pressure pump capable of keeping core covered, in addition to the RHR pumps which are assumed to be failed** **Operator needs Vessel level indic. with low level alarms**		**Credit = 2**	
Long Term Cooling (LCOOL)	**Operator maintains long term inventory source**		**Credit = 4**	

Core Damage Sequences	IEL	Mitigation Credit	Recovery	Result
LORHR-RHRREC-LCOOL (3)				
LORHR -RHREC-AECCS-LCOOL (5)				
LORHR-RHRREC-AECCS-MINJ (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.

Worksheet 6. SDP Worksheet for a BWR Plant - Loss of Offsite Power in POS 1 (Head On)

FILL IN: **TIME TO BOILING** _____ **TIME TO CORE DAMAGE** _____

Safety Functions Needed:	Success Criteria and Important Instrumentation:	Equip. Credit	Operator Credit	Credit for Function
Emergency AC before RHR pump shutoff head reached (EAC)	1 EDG or 1 alternate on-side AC power source[5]		Credit = 3 (assumed 2 hrs to shutoff head)	
AC-Independent injection and RCS Pressure Control (ACI&SRV)	Operator actuates 1 AC independent pump (.e.g Firewater) Operator needs RCS pressure indication and RCS level indication with low level alarm AND Operator opens a RCS vent path to control RCS pressure (e.g. SRV)		Credit =3 (Time to CD w/o injection > 3hrs)	
Recovery of LOOP in 8 hours (RLOOP8)	Offsite power recovered before core damage with no RCS makeup (assumed 8 hours)	Credit = 1		
Recovery of LOOP in 20 hours (RLOOP20)	Offsite power recovered after battery depletion but before core damage (12 hours to depletion + 8 hours to core damage)	Credit = 2		

Core Damage Sequences (Circle Affected Functions)	IEL	Mitigation Credit	Recovery	Result

[5]Alternate AC source can be credited if can be tied in to 4KV buses at least 1hour before RHR pump shutoff head reached.

LOOP-EAC-RLOOP20 (3)				
LOOP-EAC-ACI&SRV-RLOOP8 (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. **Different non-ECCS sources may apply for different plants. Examples include: firewater and high pressure service water.**
2. **In sequence 1, LOOP followed by successful start of a EDG or EAC source, analyze the Loss of RHR sequences. The IEL for the Loss of RHR analysis should the LOOP IEL. The analysis must take into account the complexities of recovering RHR with specific deficiencies of the electrical system.**

Worksheet 7. SDP Worksheet for a BWR Plant - Loss of Offsite Power in POS 2 (Head Off or RCS Vented)

FILL IN: TIME TO BOILING _____ TIME TO CORE DAMAGE _____
(NOTE: losses of inventory shorten time to core damage)

Safety Functions Needed:	Success Criteria and Important Instrumentation:	Equip. Credit	Operator Credit	Credit for Function
Emergency AC (EAC)	1 EDG or 1 alternate on-side AC power source[6]		Credit = 3	
AC-Independent injection before core damage (EAC-AIC)	Operator actuates 1 AC independent pump (e.g. fire water) Operator needs Vessel level indication w/low level alarms		Credit =3 (Time to CD w/o injection > 3hrs)	
Recovery of LOOP in 8 hours (RLOOP8)	Offsite power recovered before core damage with no RCS makeup (assumed 8 hours)	Credit = 1		
Recovery of LOOP in 20 hours (RLOOP20)	Offsite power recovered after battery depletion but before core damage (12 hours to depletion + 8 hours to core damage)	Credit = 2		

Core Damage Sequences (Circle Affected Functions)	IEL	Mitigation Credit	Recovery	Result
LOOP - EAC- RLOOP20 (3)				
LOOP - EAC-ACI - RLOOP8 (5)				

[6]Alternate AC source can be credited if can be tied in to 4KV buses at least 1hour before RHR pump shutoff head reached.

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. **Different non-ECCS sources may apply for different plants. Examples include: firewater and high pressure service water.**
2. **In sequence 1, LOOP followed by successful start of a EDG or EAC source, analyze the Loss of RHR sequences. The IEL for the Loss of RHR analysis should the LOOP IEL. The analysis must take into account the complexities of recovering RHR with specific deficiencies of the electrical system.**

Figure 2 - Event Tree for Loss of Inventory - BWR POS-1

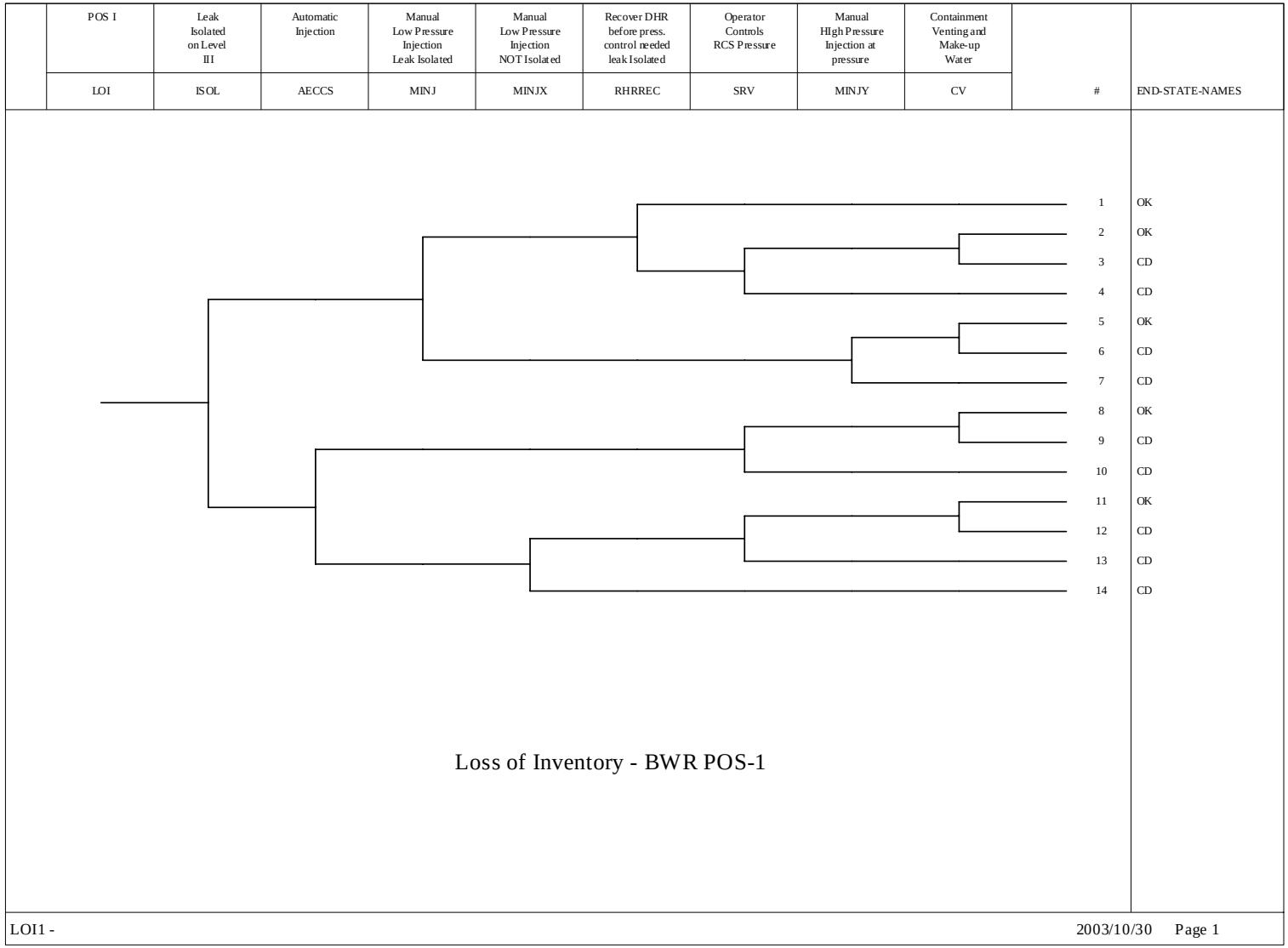


Figure 3 - Event Tree for Loss Of Inventory - BWR POS - 2

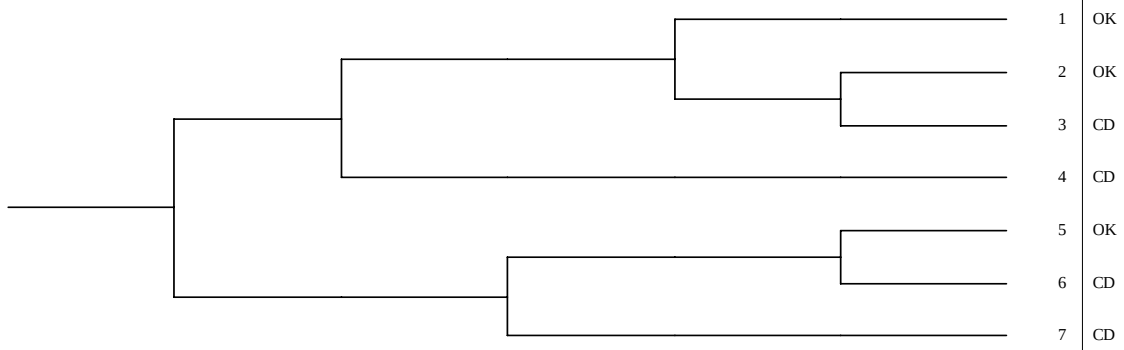
POS 2	Leak Isolated	Automatic Injection	Manual Injection (any source) Leak Isolated	Manual Injection Leak NOT Isolated	Recovery of DHR - Leak Isolated	Long Term Makeup		
LOI	ISOL	AECCS	MINJ	MINJX	RHRREC	LCOOL	#	END-STATE-NAMES
							1	OK
							2	OK
							3	CD
							4	OK
							5	OK
							6	CD
							7	CD
							8	OK
							9	CD
							10	OK
							11	CD
							12	CD

Loss of Inventory - BWR POS-2

LOI2 - 2004/12/28 Page 2

Figure 4 - Event Tree for Loss of Inventory - BWR POS-3

POS 3	Leak Isolated	Manual Injection (any source) Leak Isolated	Manual Injection Leak NOT Isolated	Recovery of DHR - Leak Isolated	Long Term Makeup		
LOI	ISOL	MINJ	MINJX	RHRREC	LCOOL	#	END-STATE-NAMES

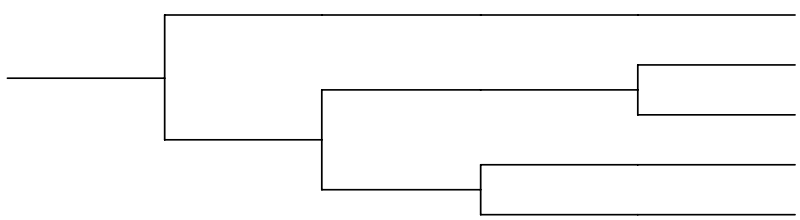


Loss of Inventory - BWR POS-3

LOI3 - 2003/10/30 Page 3

Figure 5 - Event Tree for Loss of Offsite Power - BWR POS-1

	POS-1	Emergency AC	AC-Indep. Injection & Pressure Control	Recover AC in 8 hours	Recover AC in 20 hours before Battery Depletes and CD		
	LOOP	EAC	ACI&SRV	RLOOP8	RLOOP20	#	END-STATE-NAMES
						1	LORHR
						2	OK
						3	CD
						4	OK
						5	CD

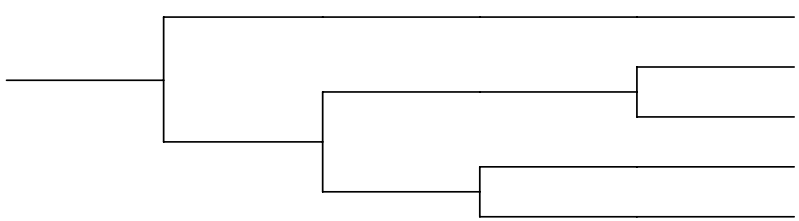


Loss of Offsite Power - BWR POS-1

LOOP1 - 2003/10/30 Page 4

Figure 6 - Event Tree for Loss of Offsite Power - BWR POS-2

	POS-2	Emergency AC	AC-Indep. Injection	Recover AC in 8 hours	Recover AC in 20 hours before Battery Depletes and CD		
	LOOP	EAC	ACI	RLOOP8	RLOOP20	#	END-STATE-NAMES
						1	LORHR
						2	OK
						3	CD
						4	OK
						5	CD

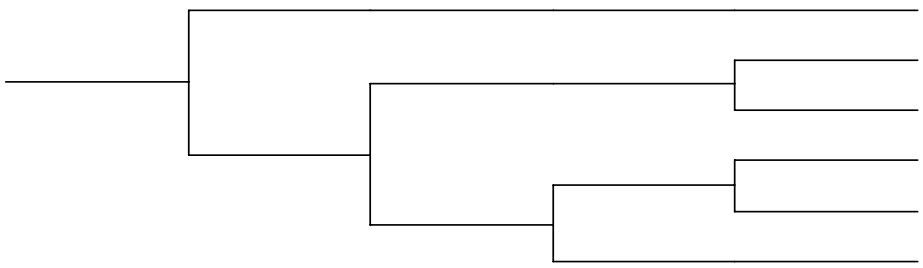


Loss of Offsite Power - BWR POS-2

LOOP2 - 2003/10/30 Page 5

Figure 7 - Event Tree for Loss of RHR - BWR POS-1

POS 1	DHR Recovery before RHR shutoff head reached	Manual Injection and RCS Pressure Control	Manual High Pressure Injection at Pressure	Containment Venting and Make-up Water		
LORHR	RHRREC	MINJ&SRV	MINJY	CV	#	END-STATE-NAMES
					1	OK
					2	OK
					3	CD
					4	OK
					5	CD
					6	CD



Loss of RHR - BWR POS-1

LORHR1 - 2003/10/30 Page 6

Figure 8 - Event Tree for Loss of RHR - BWR POS - 2