SDP Handouts 110106 /
bwrsdpans.pdf

SDP PHASE 1 SCREENING WORKSHEET FOR INITIATING EVENTS, MITIGATION SYSTEMS, AND BARRIERS CORNERSTONES

Reference/Title (LER #, Inspection Report #, etc):

Performance Deficiency (concise statement clearly stating deficient licensee performance):
Inoperable High Pressure Coolant Injection System (HPCI) due to failure to restore discharge valve after corrective maintenance.

Factual Description of Condition (statement of facts known about the condition that resulted from the performance deficiency, without hypothetical failures included): While performing a complete system walkdown of the HPCI system in accordance with Inspection Procedure 71111.04, "Equipment Alignment," an inspector identified that a normally open, motor operated, injection valve in the discharge flow path was closed. The valve position for this valve indicated open in the control room. This valve was also not in the flow path during quarterly surveillance testing of the system. It was subsequently determined that the valve had been out of position since maintenance was last performed on the system ten months prior. The inspectors determined that the criteria for crediting operator recovery of the HPCI system were satisfied and that credit for recovery of the system was appropriate.

System(s)/Train(s) Degraded by Condition:

High Pressure Coolant Injection (HPCI) system

Licensing Basis Function of System(s)/Train(s):

Provide core cooling/decay heat removal, ECCS

Other Safety Function of System(s)/Train(s):

Backup to RCIC system

Maintenance Rule Category (check one):

__X__ risk-significant   ______non risk-significant

Time condition existed or is assumed to have existed:
10 months

C23

CORNERSTONES AND FUNCTIONS DEGRADED AS A RESULT OF DEFICIENCY (✔) Check the appropriate boxes		
INITIATING EVENTS CORNERSTONE	**MITIGATION SYSTEMS CORNERSTONE**	**BARRIERS CORNERSTONE**
☐ Primary System LOCA initiator contributor - (e.g., RCS leakage from pressurizer heater sleeves, RPV piping penetrations, CRDM nozzles, PORVs, SRVs, ISLOCA issues, etc.) ☐ Transient initiator contributor (e.g., reactor/turbine trip, loss of offsite power, loss of service water, main steam/feedwater piping degradations, etc.) ☐ Fire initiator contributor (e.g., transient loadings and combustibles, hotwork) ☐ Internal/external flooding initiator contributor	☒ Core Decay Heat Removal Degraded ☒ Short Term Heat Removal Degraded ☒ Primary (e.g., Safety Inj, [main feedwater, HPCI, and RCIC - BWR only]) _X_ High Pressure ____ Low Pressure ☐ Secondary - PWR only (e.g. AFW, main feedwater, ADVs) ☐ Long Term Heat Removal Degraded (e.g., ECCS sump recirculation, suppression pool) ☐ Reactivity Control Degraded ☐ Seismic/Fire/Flood/Severe Weather Protection Degraded	☐ RCS Boundary as a mitigator following plant upset (e.g., pressurized thermal shock). Note: all other RCS boundary issues, such as leaks, will be considered under the Initiating Events Cornerstone. ☐ Containment Barrier Degraded ☐ Reactor Containment Degraded ___ Actual Breach or Bypass ___ Heat Removal, Hydrogen or Pressure Control Degraded ☐ Control Room, Aux Bldg/Reactor Bldg, or Spent Fuel Bldg Barrier Degraded ☐ Fuel Cladding Barrier Degraded

SDP PHASE 1 SCREENING WORKSHEET FOR IE, MS, and B CORNERSTONES
Check the appropriate boxes ✔

IF the finding is assumed to degrade:

1. fire protection defense-in-depth strategies involving: detection, suppression (equipment for both manual and automatic), barriers, fire prevention and administrative controls, and post fire safe shutdown systems, **THEN STOP. Go to** IMC 0609, Appendix F. Issues related to performance of the fire brigade are not included in Appendix F and require NRC management review.

2. steam generator tube integrity, **THEN STOP. Go to** IMC 0609, Appendix J.

3. the safety of an operating reactor, **THEN IDENTIFY** the degraded cornerstone(s):

   - ☐ Initiating Event
   - ☒ Mitigation Systems
   - ☐ RCS Barrier (e.g., PTS issues)
   - ☐ Fuel Barrier
   - ☐ Containment Barriers

IF TWO OR MORE of the above cornerstones are degraded ➛ **THEN STOP. Go to Phase 2.**

IF ONLY ONE of the above cornerstones is degraded, **THEN CONTINUE** in the appropriate column on page 4 of 5 of this worksheet.

NOTE: When assessing the significance of a finding affecting multiple cornerstones, the finding should be assigned to the cornerstone that best reflects the dominant risk of the finding.

Initiating Events Cornerstone	Mitigation Systems Cornerstone	RCS Barrier or Fuel Barrier	Containment Barriers Cornerstone
LOCA Initiators 1. Assuming worst case degradation, would the finding result in exceeding the Tech Spec limit for identified RCS leakage or could the finding have likely affected other mitigation systems resulting in a total loss of their safety function. ☐ **If YES →Stop. Go to Phase 2.** ☐ If NO, screen as Green. Transient Initiators 1. Does the finding contribute to both the likelihood of a reactor trip AND the likelihood that mitigation equipment or functions will not be available? ☐ **If YES→Stop. Go to Phase 2.** ☐ If NO, screen as Green. External Event Initiators 1. Does the finding increase the likelihood of a fire or internal/external flood? ☐ **If YES →** Use the IPEEE or other existing plant-specific analyses to identify core damage scenarios of concern and factors that increase the frequency. Provide this input for **Phase 3** analysis. ☐ If NO, screen as Green.	1. Is the finding a design or qualification deficiency confirmed not to result in loss of operability per "Part 9900, Technical Guidance, Operability Determination Process for Operability and Functional Assessment." 2. ☐ **If YES, screen as Green.** ☒ If NO, continue. 2. Does the finding represent a loss of system safety function? ☒ **If YES →Stop. Go to Phase 2.** ☐ If NO, continue. 3. Does the finding represent actual loss of safety function of a single Train, for > its Tech Spec Allowed Outage Time? ☐ **If YES → Stop. Go to Phase 2.** ☐ If NO, continue. 4. Does the finding represent an actual loss of safety function of one or more non-Tech Spec Trains of equipment designated as risk-significant per 10CFR50.65, for >24 hrs? ☐ **If YES → Stop. Go to Phase 2.** ☐ If NO, continue. 5. Does the finding screen as potentially risk significant due to a seismic, flooding, or severe weather initiating event, using the criteria on page 5 of this Worksheet? ☐ **If YES →** Use the IPEEE or other existing plant-specific analyses to identify core damage scenarios of concern and provide this input for **Phase 3** analysis. ☐ If NO, screen as Green.	1. RCS Barrier (e.g.,pressurized thermal shock issues) Stop. Go to Phase 3. 2. Fuel Barrier Screen as Green.	1. Does the finding only represent a degradation of the radiological barrier function provided for the control room, or auxiliary building, or spent fuel pool, or SBGT system (BWR)? ☐ **If YES →** screen as Green. ☐ If NO, continue. 2. Does the finding represent a degradation of the barrier function of the control room against smoke or a toxic atmosphere? ☐ **If YES → Stop. Go to Phase 3.** ☐ If NO, continue. 3. Does the finding represent an actual open pathway in the physical integrity of reactor containment, or involve an actual reduction in defense-in-depth for the atmospheric pressure control or hydrogen control functions of the reactor containment? ☐ **If YES → Stop. Go to Appendix H of IMC 0609.** ☐ If NO, screen as Green.

SDP PHASE 1 SCREENING WORKSHEET FOR IE, MS, and B CORNERSTONES

Seismic, Flooding, and Severe Weather Screening Criteria

1. Does the finding involve the loss or degradation of equipment or function specifically designed to mitigate a seismic, flooding, or severe weather initiating event (e.g., seismic snubbers, flooding barriers, tornado doors)?

   - ☐ **If YES** ➛ continue to question 2
   - ☐ If NO ➛ skip to question 3

2. If the equipment or safety function is assumed to be completely failed or unavailable, are ANY of the following three statements TRUE? The loss of this equipment or function by itself, during the external initiating event it was intended to mitigate

   a) would cause a plant trip or any of the Initiating Events used by Phase 2 for the plant in question;

   b) would degrade **two or more** Trains of a multi-train safety system or function;

   c) would degrade one or more Trains of a system that supports a safety system or function.

   - ☐ **If YES** ➛the finding is potentially risk significant due to external initiating event core damage sequences - return to page 4 of this Worksheet
   - ☐ If NO, screen as Green

3. Does the finding involve the total loss of any safety function, identified by the licensee through a PRA, IPEEE, or similar analysis, that contributes to external event initiated core damage accident sequences (i.e., initiated by a seismic, flooding, or severe weather event)?

   - ☐ **If YES** ➛the finding is potentially risk significant due to external initiating event core damage sequences - return to page 4 of this Worksheet
   - ☐ If NO, screen as Green

Result of Phase 1 screening process:

☐ **Screen as Green** ☒ **Go to Phase 2** ☐ **Go to Phase 3**

Important Assumptions: Credit Given for Operator Recovery

Performed by: ______________________ Date: ____________

Table 1 - Categories of Initiating Events for Generic BWR Nuclear Power Plant

Row	Approximate Frequency	Example Event Type	Initiating Event Likelihood (IEL)		
I	> 1 per 1-10 yr	Transient (Reactor Trip) (TRAN), Loss of Power Conversion System (Loss of condenser, Closure of MSIVs, Loss of feedwater) (TPCS)	1	2	3
II	1 per $10\text{-}10^{2}$ yr	Loss of offsite power (LOOP), Inadvertent or stuck open SRVs (IORV), Loss of Instrument Air (LOIA)	2	3	4
III	1 per 10^{2} - 10^{3} yr	Loss of Service Water (LOSW), Loss of an AC Bus (LOAC)	3	4	5
IV	1 per 10^{3} - 10^{4} yr	Small LOCA (RCS rupture) (SLOCA), Medium LOCA (RCS rupture) (MLOCA)	4	5	6
V	1 per 10^{4} - 10^{5} yr	Large LOCA (RCS rupture) (LLOCA), ATWS	5	6	7
VI	less than 1 per 10^{5} yr	ISLOCA, Vessel rupture	6	7	8
			> 30 days	3-30 days	< 3 days
			Exposure Time for Degraded Condition		

Note:

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

Table 2 Initiators and System Dependency for Generic BWR Nuclear Power Plant

Affected System		Major Components	Support Systems	Initiating Event Scenarios
Code	Name			
ADS	Reactor Vessel Pressure Control and Automatic Depressurization System	5 relief Valves (ADS) & 8 safety valves	IA/nitrogen, 125 V-DC	All except LLOCA
PCS	Power Conversion System	3 reactor feed pumps, 4 condensate pumps,4 condensate booster pumps	4160 V-AC, 125 V-DC, TBCCW, IA (1)	TRAN, IORV, SLOCA, ATWS
RHR	Residual Heat Removal	2 Loops, each with 2 RHR pumps & 1 RHR HX, MOVs	4160 V-AC, 125 V-DC, 480V AC, RHRSW, Pump Room HVAC	All
SBCS	Standby Coolant Supply System	2 Valves	Non-emergency ESF AC Buses, SW	LLOCA, MLOCA
AC	AC Power (non-EDG)	4160V AC, 480V AC	125V DC	All
DC	DC Power	125V DC (2 batteries & 4 battery charger), 250V DC (2 batteries & 3 battery charger) (shared between two units)	480V AC	All
EDGs	Emergency Diesel Generators	1 dedicated EDG, 1 shared EDG, & 1 SBO DG	125 V-DC, DGCW, EDG HVAC	LOOP
RHRSW	RHR Service Water	2 Loops, 2 pump-motor set per loop	HVAC, 4160 V-AC, 480 V-AC, 125 V-DC	All

Affected System		Major Components	Support Systems	Initiating Event Scenarios
DGCW	Diesel generator Cooling Water	Pumps	480 V-AC	LOOP
SW	Service water	5 pumps in Unit 1/ 2 Crib house; shared system supplying a common header	4160 V-AC, 125 V-DC, IA	LOSW
TBCCW	Turbine Building Closed Cooling Water System	2 pumps, 2 HXs, an expansion tank	SW, IA, 4160 V-AC	TRAN, TPCS, SLOCA, IORV, LOOP, ATWS
HPCI	High Pressure Coolant Injection	1 TDP, MOV	125 V-DC, 250 V-DC, Room HVAC	All except LLOCA, LOSW
LPCS	Low Pressure Core Spray	2 Trains or Loops; 1 LPCS pump per train	4160 V-AC, 480 V-AC, 125 V-DC, SW, Pump Room HVAC	All except LOSW
RCIC	Reactor Core Isolation Cooling	1 TDP, MOV	125 V-DC, Room HVAC	All except LLOCA, MLOCA, LOSW, ATWS
FPS	Fire Protection System	2 diesel fire pumps, MOV	120V AC, SW, 24V Nickel-cadmium batteries	LOSW, LOIA
CRD	Control Rod Drive Hydraulic System	2 MDP, MOV	Non-emergency ESF AC Buses, TBCCW	TRAN, TPCS, SLOCA, IORV, LOOP, ATWS
IA	Instrument Air	2 compressors for each unit plus a shared compressor supplying both units	SW, 480V AC	LOIA
SLC	Standby Liquid Control	2 MDP, 2 explosive valves	480 V-AC, 125 V-DC	ATWS
Room HVAC			DGCW	All
APCV	Augmented Primary Containment Vent	Valves, Dampers	Essential Service Bus, IA backed up by accumulators for each valve operator	All

Notes:

1. IA supplies all AOVs in the FW&C system. Regulating valves fail as is on loss of IA or control signals. RFP regulating valves fail open on loss of IA and the makeup and emergency makeup valves fail closed.

2. The internal event CDF is estimated as 4.6E-6/yr (PSA Model 99A).

Table 3.1 SDP Worksheet for Generic BWR — Transients (Reactor Trip) (TRAN)

Safety Functions Needed:	**Full Creditable Mitigation Capability for Each Safety Function:**
Power Conversion System (PCS)	1/3 Feedpumps and 1/4 condensate/condensate booster pumps (operator action = 3)
High Pressure Injection (HPI)	HPCI (1 ASD train) or RCIC (1 ASD train)
Depressurization (DEP)	1/5 ADS valves (RVs) manually opened (operator action = 2)
Low Pressure Injection (LPI)	1/4 RHR pumps in 1/2 trains in LPCI Mode (1 multi-train system) or 1/2 LPCS trains (1 multi-train system)
Containment Heat Removal (CHR)	1/4 RHR pumps in 1/2 trains with heat exchangers and 1/4 RHRSW pumps in SPC (1 multi-train system)
Containment Venting (CV)	Venting through 8" drywell or wetwell APCV (operator action = 2)
Late Inventory Makeup (LI)	2/2 CRD pumps (operator action = 2)

Circle Affected Functions		**IEL**	**Remaining Mitigation Capability Rating for Each Affected Sequence**	**Recovery Credit**	**Results**
1 TRAN - PCS - CHR - CV (5, 9) **1 + 3 + 3 + 2**	**9**				
2 TRAN - PCS -CHR - LI (4, 8) **1 + 3 + 3 + 2**	**9**				
3 TRAN - PCS - HPI - DEP (11) **1 + 3 + 2 + 2**	**8**	**1**	**(PCS = 3) + (HPI = 1, 1 for RCIC) + (DEP = 2), Total = 6**	**1**	**8**
4 TRAN - PCS - HPI - LPI (10) **1 + 3 + 2 + 6**	**12**	**1**	**(PCS = 3) + (HPI = 1, 1 for RCIC) + (LPI = 6), Total = 10**	**1**	**12**

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

Credit given for operator recovery of injection valve.

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 available and ready for use.

Notes:

1. A credit of 3 for operator action to use feed pumps is assigned based on data from other BWR plants.
2. The HEP for DEP is 7E-04. A credit of 2 is assigned based on a survey of similar BWR plants.
3. The HEP for failure to initiate SPC is 2.0E-04. This function is defined as a multi-train system, because the hardware failure dominates.
4. The HEP for initiating containment venting is 3.2E-03. A credit of 2 is assigned based on a survey of similar BWR plants.

Table 3.2 SDP Worksheet for Generic BWR — Transients without PCS (TPCS)

Safety Functions Needed:	Full Creditable Mitigation Capability for Each Safety Function:
High Pressure Injection (HPI)	HPCI (1 ASD train) or RCIC (1 ASD train)
Depressurization (DEP)	1/5 ADS valves (RVs) manually opened (operator action = 2)
Low Pressure Injection (LPI)	1/4 RHR pumps in 1/2 trains in LPCI Mode (1 multi-train system) or 1/2 LPCS trains (1 multi-train system)
Containment Heat Removal (CHR)	1/4 RHR pumps in 1/2 trains with heat exchangers and 1/4 RHRSW pumps in SPC (1 multi-train system)
Containment Venting (CV)	Venting through 8" drywell or wetwell APCV (operator action = 2)
Late Inventory Makeup (LI)	2/2 CRD pumps (operator action = 2)

Circle Affected Functions		IEL	Remaining Mitigation Capability Rating for Each Affected Sequence	Recovery Credit	Results
1 TPCS - CHR - CV (4, 8) **1 + 3 + 2**	**6**				
2 TPCS - CHR - LI (3, 7) **1 + 3 + 2**	**6**				
3 TPCS - HPI - DEP (10) **1 + 2 + 2**	**5**	**1**	**(HPI = 1, 1 for RCIC) + (DEP = 2), Total = 3**	**1**	**5**
4 TPCS - HPI - LPI (9) **1 + 2 + 6**	**9**	**1**	**(HPI = 1, 1 for RCIC) + (LPI = 6), Total = 7**	**1**	**9**

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

Credit given for operator recovery of injection valve.

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 available and ready for use.

Notes:

1. The HEP for DEP is 7E-04. A credit of 2 is assigned based on a survey of similar BWR plants.

2. The HEP for failure to initiate SPC is 2.0E-04. This function is defined as a multi-train system, because the hardware failure dominates.

3. The HEP for initiating containment venting is 3.2E-03. A credit of 2 is assigned based on a survey of similar BWR plants.

Table 3.4 SDP Worksheet for Generic BWR — Loss of Instrument Air (LOIA)[1,2]

Safety Functions Needed:	**Full Creditable Mitigation Capability for Each Safety Function:**
High Pressure Injection (HPI)	HPCI (1 ASD train) or RCIC (1 ASD train)
Depressurization (DEP)	1/5 ADS valves (RVs) manually opened (operator action = 2)
Low Pressure Injection (LPI)	1/4 RHR pumps in 1/2 trains in LPCI Mode (1 multi-train system) or 1/2 LPCS trains (1 multi-train system)
Containment Heat Removal (CHR)	1/4 RHR pumps in 1/2 trains with heat exchangers and 1/4 RHRSW pumps in SPC (1 multi-train system)
Containment Venting (CV)	Venting through 8" drywell or wetwell APCV (operator action = 2)

Circle Affected Functions		**IEL**	**Remaining Mitigation Capability Rating for Each Affected Sequence**	**Recovery Credit**	**Results**
1 LOIA - CHR (2,4) **2 + 3**	**5**				
2 LOIA - HPI - LPI (5) **2 + 2 + 6**	**10**	**2**	**(HPI = 1, 1 for RCIC) + (LPI = 6), Total = 7**	**1**	**10**
3 LOIA - HPI - DEP (6) **2 + 2 + 2**	**6**	**2**	**(HPI = 1, 1 for RCIC) + (DEP = 2), Total = 3**	**1**	**6**

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

Credit given for operator recovery of injection valve.

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 available and ready for use.

Notes:

1. Loss of instrument air (LOIA) results in closure of the MSIV and loss of control of the feedwater regulating valves. This is similar to transients without the PCS. In addition, at Generic BWR Nuclear Power Plant, the HPCI and RCIC steamline drain valves require IA, but they reposition for HPCI/RCIC initiation on loss of IA. The valves in the APCV system are all air-operated supplied from IA, but accumulators on each valve is assumed to allow actuations on LOIA. CRD is assumed to be lost due to loss of TBCCW as the cooling source. With HPCI/RCIC injection, failure of SPC leads to core damage since CRD is not available as a late injection source.

2. LOIA initiating frequency is estimated as 1.75E-2.

Table 3.5 SDP Worksheet for Generic BWR — Loss of an AC Bus (LOAC)

Safety Functions Needed:	Full Creditable Mitigation Capability for Each Safety Function:
High Pressure Injection (HPI)	HPCI (1 ASD train) or RCIC (1 ASD train)
Depressurization (DEP)	1/5 ADS valves (RVs) manually opened (operator action = 2)
Low Pressure Injection (LPI)	1/2 RHR pumps in 1/1 train in LPCI Mode (1 train) or 1/1 LPCS train (1 train)
Containment Heat Removal (CHR)	1/2 RHR pumps in 1/1 train with heat exchangers and 1/2 RHRSW pumps in 1/1 train in SPC (1 train)
Containment Venting (CV)	Venting through 8" drywell or wetwell APCV (operator action = 2)
Late Inventory Makeup (LI)	1/2 condensate (operator action = 2)

Circle Affected Functions		IEL	Remaining Mitigation Capability Rating for Each Affected Sequence	Recovery Credit	Results
1 LOAC - CHR - CV (4,8) **3 + 2 + 2**	**7**				
2 LOAC - CHR - LI (3,7) **3 + 2 + 2**	**7**				
3 LOAC - HPI - DEP (10) **3 + 2 + 2**	**7**	**3**	**(HPI = 1, 1 for RCIC) + (DEP = 2), Total = 3**	**1**	**7**
4 LOAC - HPI - LPI (9) **3 + 2 + 4**	**9**	**3**	**(HPI = 1, 1 for RCIC) + (LPI = 4), Total = 5**	**1**	**9**

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

Credit given for operator recovery of injection valve.

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 available and ready for use.

Notes:

1. Loss of an AC Bus (Bus 13, 14, 18, 19) results in loss of one loop RHR and one loop of CS systems. The IE frequency for each of Bus 13 and 18 is 1.2E-3. The IE frequency for other buses is estimated at 1.2E-4.

2. No separate event tree is provided. Please refer to the TPCS tree.

Table 3.6 SDP Worksheet for Generic BWR — Small LOCA (SLOCA)

Safety Functions Needed:	Full Creditable Mitigation Capability for Each Safety Function:
Early Containment Control (EC)	Passive operation of SP, 7/8 vacuum breakers remain closed and 1/8 open, when needed (1 multi-train system)
Power Conversion System (PCS)	1/3 Feedwater pumps and 1/4 condensate/ condensate booster pumps (operator action = 3)
High Pressure Injection (HPI)	HPCI (1 ASD train) or RCIC (1 ASD train)
Depressurization (DEP)	1/5 ADS valves manually opened (operator action = 2)
Low Pressure Injection (LPI)	1/4 RHR pumps in 1/2 trains in LPCI Mode (1 multi-train system) or 1/2 LPCS trains (1 multi-train system)
Containment Heat Removal (CHR)	1/4 RHR pumps in 1/2 trains with heat exchangers and 1/4 RHRSW pumps in SPC (1 multi-train system)
Containment Venting (CV)	Venting through 8" drywell or wetwell APCV (operator action = 2)
Late Inventory Makeup (LI)	1/4 Condensate or 2/2 CRD pumps (operator action = 2)

Circle Affected Functions:		IEL	Remaining Mitigation Capability Rating for Each Affected Sequence	Recovery Credit	Results
1 SLOCA - PCS - CHR- CV (5,9) **4 + 3 + 3 + 2**	**12**				
2 SLOCA - PCS - CHR - LI (4, 8) **4 + 3 + 3 + 2**	**12**				
3 SLOCA - PCS - HPI - LPI (10) **4 + 3 + 2 + 6**	**15**	**4**	**(PCS = 3) + (HPI = 1, 1 for RCIC) + (LPI = 6), Total = 10**	**1**	**15**
4 SLOCA - PCS - HPI - DEP (11) **4 + 3 + 2 + 2**	**11**	**4**	**(PCS = 3) + (HPI = 1, 1 for RCIC) + (DEP = 2), Total = 6**	**1**	**11**
5 SLOCA - EC (12) **4 + 3**	**7**				

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

Credit given for operator recovery of injection valve.

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 available and ready for use.

Notes:

1. A credit of 3 for operator action to use feed pumps is assigned based on data from other BWR plants.
2. The HEP for DEP is 7E-04. A credit of 2 is assigned based on a survey of similar BWR plants.
3. The HEP for failure to initiate SPC is 2.0E-04. This function is defined as a multi-train system, because the hardware failure dominates.
4. The HEP for initiating containment venting is 3.2E-03. A credit of 2 is assigned based on a survey of similar BWR plants.

Table 3.7 SDP Worksheet for Generic BWR — Inadvertent Opening of Relief Valve (IORV)

Safety Functions Needed:	Full Creditable Mitigation Capability for Each Safety Function:
Power Conversion System (PCS)	1/3 Feedwater pumps and 1/4 condensate / condensate booster pumps (operator action = 3)
High Pressure Injection (HPI)	HPCI (1 ASD train) or RCIC (1 ASD train)
Control Rod Drive (CRD)	Operator initiates 2/2 CRD pumps (operator action = 2)
Low Pressure Injection (LPI)	1/4 RHR pumps in 1/2 trains in LPCI Mode (1 multi-train system) or 1/2 LPCS trains (1 multi-train system)
Containment Heat Removal (CHR)	1/4 RHR pumps in 1/2 trains with heat exchangers and 1/4 RHRSW pumps in 1/2 trains in SPC (1 multi-train system)
Containment Venting (CV)	Venting through 8" drywell or wetwell APCV (operator action = 2)

Circle Affected Functions:		IEL	Remaining Mitigation Capability Rating for Each Affected Sequence	Recovery Credit	Results
1 IORV - PCS - CHR - CV (4) **2 + 3 + 3 + 2**	**10**				
2 IORV - PCS - CRD - CHR (6) **2 + 3 + 2 + 3**	**10**				
3 IORV - PCS - CRD - LPI (7) **2 + 3 + 2 + 6**	**13**				
4 IORV - PCS - HPI - CHR (9) **2 + 3 + 2 + 3**	**10**	**2**	**(PCS = 3) + (HPI = 1, 1 for RCIC) + (CHR = 3), Total = 7**	**1**	**10**
5 IORV - PCS - HPI - LPI (10) **2 + 3 + 2 + 6**	**13**	**2**	**(PCS = 3) + (HPI = 1, 1 for RCIC) + (LPI = 6), Total = 10**	**1**	**13**

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

Credit given for operator recovery of injection valve.

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 available and ready for use.

Notes:

1. One relief valve can relieve about 558,000 lbm/hr at 1135 psig. It will result in depressurization of the reactor vessel pressure due to the initiating event. Accordingly, depressurization is not a safety function in this worksheet. IORV frequency in the PRA is 3.3E-2.
2. The HEP for DEP is 7E-04. A credit of 2 is assigned based on a survey of similar BWR plants.
3. The HEP for failure to initiate SPC is 2.0E-04. This function is defined as a multi-train system, because the hardware failure dominates.
4. The HEP for initiating containment venting is 3.2E-03. A credit of 2 is assigned based on a survey of similar BWR plants.

Table 3.8 SDP Worksheet for Generic BWR — Medium LOCA (MLOCA)

Safety Functions Needed:	**Full Creditable Mitigation Capability for Each Safety Function:**
Early Inventory (EI)	HPCI (1 ASD train)
Early Containment Control (EC)	Passive operation of SP, 7/8 vacuum breakers remain closed and 1/8 open, when needed (1 multi-train system)
Depressurization (DEP)	Operator opens 1/ 5 ADS valves (operator action = 2)
Low Pressure Injection (LPI)	1/4 RHR pumps in 1/2 trains in LPCI mode (1 multi-train system) or 1/2 LPCS trains (1 multi-train system)
Containment Heat Removal (CHR)	1/4 RHR pumps with heat exchangers and 1/4 RHRSW pumps in 1/2 trains in SPC mode (1 multi-train system)
Containment Venting (CV)	Venting through 8" drywell or wetwell APCV (operator action = 2)
Late Inventory (LI)	Operator action to add water using SBCS and feedwater system (operator action = 2)

Circle Affected Sequences:		**IEL**	**Remaining Mitigation Capability Rating for Each Affected Sequence**	**Recovery Credit**	**Results**
1 MLOCA - CHR - LI (3, 8) **4 + 3 + 2**	**9**				
2 MLOCA - CHR - CV (4, 9) **4 + 3 + 2**	**9**				
3 MLOCA - LPI (5, 10) **4 + 6**	**10**				
4 MLOCA - EI - DEP (11) **4 + 1 + 2**	**7**	**4**	**(EI = 0) + (DEP = 2), Total = 2**	**1**	**7**
5 MLOCA - EC (12) **4 + 3**	**7**				

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

Credit given for operator recovery of injection valve.

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 available and ready for use.

Notes:

1. Operator action to initiate standby coolant supply (SBCS) is assigned a credit of 2. PRA assigns a failure probability of 1.6 E-2.

2. Containment venting (CV) is assigned a credit of 2, based on survey of other BWR plant. PRA assigns a failure probability of 3.2E-3.

Table 3.10 SDP Worksheet for Generic BWR — Loss of Offsite Power (LOOP)

Safety Functions Needed:	Full Creditable Mitigation Capability for each Safety Function:
Emergency Power (EAC)	1/1 EDGs (1train) or 1/1 SBO or cross-tie DG (operator action = 1)
Recovery of LOOP in 45 min (RLOOP 45 M)	Recovery of LOOP (operator action = 1)
Recovery of LOOP in 4 hrs (RLOOP 4 HR)	Recovery of LOOP in 4 hrs (operator action = 1)
High Pressure Injection (HPI)	HPCI (1 ASD train) or RCIC (1 ASD train)
Depressurization (DEP)	1/5 ADS valves manually opened (operator action = 2)
Low Pressure Injection (LPI)	1/4 RHR trains in 1/2 trains in LPCI Mode (1 multi-train system) or 1/2 LPCS trains (1 multi-train system)
Containment Heat Removal (CHR)	1/4 RHR pumps with heat exchangers and 1/4 RHRSW pumps in 1/2 trains in SPC (1 multi-train system)
Containment Venting (CV)	Venting through 8" drywell or wetwell APCV (operator action = 2)
Late Inventory (LI)	2/2 CRD pumps (operator action = 2)

Circle Affected Functions:		IEL	Remaining Mitigation Capability Rating for Each Affected Sequence	Recovery Credit	Results
1 LOOP - EAC - HPI - RLOOP 45 M (25) 2 + 3 + 2 + 1	8	2	**(EAC = 3) + (HPI = 1, 1 for RCIC) + RLOOP45M = 1), Total = 5**	1	8
2 LOOP - EAC - RLOOP 4 HR (26) 2 + 3 + 1	6				
3 LOOP - HPI - DEP (10, 20) 2 + 2 + 2	6	2	**(HPI = 1, 1 for RCIC) + (DEP = 2), Total = 3**	1	6
4 LOOP - HPI - LPI (9, 19) 2 + 2 + 6	10	2	**(HPI = 1, 1 for RCIC) + (LPI = 6), Total = 7**	1	10
5 LOOP - CHR - CV (4, 8, 14, 18, 24) 2 + 3 + 2	7				

6 LOOP - CHR - LI (3, 7, 13, 17, 23) **2 + 3 + 2**	**7**				
Identify any operator recovery actions that are credited to directly restore the degraded equipment or initiating event: **Credit given for operator recovery of injection valve.** 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 available and ready for use.					

Notes:

1. A dual unit LOOP is assumed. Each unit has a dedicated EDG. It is conservatively assumed that the shared diesel is aligned to the other unit. A operator action credit of 1 is assigned for use of the shared or SBO diesel.

2. PRA defines battery depletion at 4 hrs.

3. In sequences 3 and 4, either EAC or recovery of LOOP in 45 mins is successful. Failure to recover offsite power in 45 mins is assigned an operator action credit of 1.

4. In sequences 5 and 6, either EAC or recovery of LOOP in 4 hrs is successful. In PRA, failure to recover offsite power in 4 hrs in estimated at 1.6E-01. An operator action credit of 1 is assigned.

Table 3.11 SDP Worksheet for Generic BWR — Anticipated Transients without Scram (ATWS)

Safety Functions Needed:	Full Creditable Mitigation Capability for Each Safety Function:
Over Pressure Protection (OVERP)	11/13 RVs/SRVs (1 multi-train system)
Reactivity Control (SLC)	1/2 SLC train (operator action = 2)
Recirculation Pump Trip (RPT)	Manual or automatic trip of recirculation pumps (1 multi-train system)
High Pressure Injection (HPI)	HPCI (1 ASD train) or 1/3 Feedwater pumps (1 multi-train system)
Depressurization (DEP)	1/5 ADS valves manually opened (operator action = 2)
Low Pressure Injection (LPI)	1/4 RHR pumps in 1/2 trains in LPCI mode (1 multi-train system) or 1/2 LPCS train (1 multi-train system)
Inhibit ADS and LVI Control (INH)	Operator inhibits ADS and controls RPV level (operator action = 2)
Containment Heat Removal (CHR)	1/4 RHR pumps with heat exchangers and 1/4 RHRSW pump in 1/2 trains in SPC (1 multi-train system)
Containment Venting (CV)	containment venting through 8" drywell or wetwell APCV (operator action = 2)
Late Inventory (LI)	2/2 CRD pumps (operator action=2)

Circle Affected Functions:		IEL	Remaining Mitigation Capability Rating for Each Affected Sequence	Recovery Credit	Results
1 ATWS - OVERP (14) **5 + 3**	**8**				
2 ATWS - SLC (11) **5 + 2**	**7**				
3 ATWS - RPT (13) **5 + 3**	**8**				
4 ATWS - HPI - DEP (10) **5 + 4 + 2**	**11**	5	**(HPI = 3, 3 for Feedwater pumps) + (DEP = 2), Total = 5**	**1**	**11**
5 ATWS - HPI - LPI (9) **5 + 4 + 6**	**15**	5	**(HPI = 3, 3 for Feedwater pumps) + (LPI = 6), Total = 9**	**1**	**15**

6 ATWS - INH (12) **5 + 2**	**7**				
7 ATWS - CHR - CV (4,8) **5 + 3 + 2**	**10**				
8 ATWS - CHR - LI (3, 7) **5 + 3 + 2**	**10**				

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

Credit given for operator recovery of injection valve.

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 available and ready for use.

Notes:

1. The standby liquid control system (SLC) is manually operated. PRA assigns a human error probability of 4.7 E-2. A credit of 2 is assigned.

2. Operator failure to inhibit ADS is estimated at 1.4E-02. An operator action credit of 2 is assigned.

Table 4 - Remaining Mitigation Capability Credit

Type of Remaining Mitigation Capability	Remaining Mitigation Capability Credit $X = -\log_{10}(\text{failure prob})$
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 describing the appropriate operator actions 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)
Operator Action Credit Major actions performed by operators during accident scenarios (e.g., primary heat removal using bleed and feed, etc.). These actions are credited using three categories of human error probabilities (HEPs). These categories are Operator Action = 1 which represents a failure probability between 5E-2 and 0.5, Operator Action = 2 which represents a failure probability between 5E-3 and 5E-2, and Operator Action = 3 which represents a failure probability between 5E-4 and 5E-3.	1, 2, or 3

Table 5 - Counting Rule Worksheet

Step	Instructions	
(1)	Enter the number of sequences with a risk significance equal to 9.	(1) 2
(2)	Divide the result of Step (1) by 3 and round down.	(2) 0
(3)	Enter the number of sequences with a risk significance equal to 8.	(3) 2
(4)	Add the result of Step (3) to the result of Step (2).	(4) 2
(5)	Divide the result of Step (4) by 3 and round down.	(5) 0
(6)	Enter the number of sequences with a risk significance equal to 7.	(6) 2
(7)	Add the result of Step (6) to the result of Step (5).	(7) 2
(8)	Divide the result of Step (7) by 3 and round down.	(8) 0
(9)	Enter the number of sequences with a risk significance equal to 6.	(9) 2
(10)	Add the result of Step (9) to the result of Step (8).	(10) 2
(11)	Divide the result of Step (10) by 3 and round down.	(11) 0
(12)	Enter the number of sequences with a risk significance equal to 5.	(12) 1
(13)	Add the result of Step (12) to the result of Step (11).	(13) 1
(14)	Divide the result of Step (13) by 3 and round down.	(14) 0
(15)	Enter the number of sequences with a risk significance equal to 4.	(15) 0
(16)	Add the result of Step (15) to the result of Step (14).	(16) 0

- If the result of Step 16 is greater than zero, then the risk significance of the inspection finding is of high safety significance (RED).
- If the result of Step 13 is greater than zero, then the risk significance of the inspection finding is at least of substantial safety significance (YELLOW).
- If the result of Step 10 is greater than zero, then the risk significance of the inspection finding is at least of low to moderate safety significance (WHITE).
- If the result of Steps 10, 13, and 16 are zero, then the risk significance of the inspection finding is of very low safety significance (GREEN).

Phase 2 Result: ☐ **GREEN** ☐ **WHITE** ☐ **YELLOW** ☐ **RED**