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MFN 08-844, Supplement 1

Docket No. 52-010

December 17, 2008

U.S. Nuclear Regulatory Commission
11555 Rockville Pike
Document Control Desk
Rockville, MD 20852

Subject: **Response to Portion of NRC Request for Additional Information Letter No. 256 Related to ESBWR Design Certification Application – Instrumentation & Control Systems - RAI Number 7.1-131**

Enclosures 1 and 2 contain the GE Hitachi Nuclear Energy (GEH) response to RAI Number 7.1-131 from the U.S. Nuclear Regulatory Commission (NRC) Request for Additional Information (RAI) sent by NRC letter dated September 16, 2008.

If you have any questions or require additional information, please contact me.

Sincerely,

Richard E. Kingston

Richard E. Kingston
Vice President, ESBWR Licensing

D068
NRO

Reference:

1. MFN 08-714, Letter from U.S. Nuclear Regulatory Commission to Robert E. Brown, *Request For Additional Information Letter No. 256 Related To ESBWR Design Certification Application*, dated September 16, 2008

Enclosures:

1. Response to Portion of NRC Request for Additional Information Letter No. 256 Related to ESBWR Design Certification Application - Instrumentation & Control Systems - RAI Number 7.1-131

2. Response to Portion of NRC Request for Additional Information Letter No. 256 Related to ESBWR Design Certification Application - DCD and Licensing Topical Report Markups for RAI Number 7.1-131

cc:

AE Cubbage	USNRC (with enclosures)
RE Brown	GEH/Wilmington (with enclosures)
DH Hinds	GEH/Wilmington (with enclosures)
eDRF Section:	0000-0094-3263 (RAI 7.1-131)

MFN 08-844, Supplement 1

Enclosure 1

Response to Portion of NRC Request for Additional Information Letter No. 256 Related to ESBWR Design Certification Application

Instrumentation & Control Systems

RAI Number 7.1-131

NRC RAI 7.1-131

Ensure that the events and accidents evaluated in the D3 analysis is consistent with DCD Tier 2 Chapter 15

NEDO-33251 is now inconsistent with DCD Tier Revision 5 Chapter 15. DCD Tier 2 Revision 4, Chapter 15 and NEDO-33251, Appendices A and B, identify that there are no reactor and power distribution anomalies. However, DCD Tier 2, Revision 5, Chapter 15 identifies two reactor and power distribution anomalies, "Control Rod Withdrawal Error During Startup," and "Control Rod Withdrawal Error During Power Operation." Revise NEDO-33251 to ensure that the events and accidents evaluated in the diversity and defense-in-depth (D3) analysis is consistent with DCD Tier 2 Chapter 15.

GEH Response

GEH concurs that the evaluation of design basis events (including accidents) documented in Appendices A (ESBWR Instrumentation & Control Defense-in-Depth and Diversity (D3) Evaluation of Chapter 15 Events Assuming Common Mode Failure of a Digital Protection System) and B (Summary Table of DCD Chapter 15 Events Evaluated for D3) of Licensing Topical Report (LTR) NEDO-33251, ESBWR I&C Diversity and Defense-In-Depth Report, Revision 1, is inconsistent with the update of the Safety Analyses incorporated into Revision 5 of DCD Tier 2, Chapter 15. GEH will update the evaluation of chapter 15 events as part of Revision 2 to NEDO-33251. The updated evaluation addresses the changes to the Safety Analyses documented in Revision 5 of DCD Tier 2, including evaluations of the "Control Rod Withdrawal Error During Startup" and "Control Rod Withdrawal Error During Power Operation" events.

In Revision 2 of NEDO-33251, GEH intends to delete Appendix B, since this appendix is redundant to Appendix A and does not provide additional value.

DCD/LTR Impact

The evaluation of DCD Tier 2 Chapter 15 events documented in Appendix A of GEH Licensing Topical Report NEDO-33251 will be updated as part of Revision 2, per the attached.

DCD Tier 2, Chapters 1 and 7, will be updated in Revision 6 to reflect the revision to NEDO-33251 per the attached.

MFN 08-844, Supplement 1

Enclosure 2

Response to Portion of NRC Request for Additional Information Letter No. 256 Related to ESBWR Design Certification Application

DCD and Licensing Topical Report Markups for RAI Number 7.1-131

Table 1.6-1
Referenced GE / GEH Reports

Report No.	Title	Section No.
NEDC-33238P NEDO-33238	Global Nuclear Fuel, "GE14 Pressure Drop Characteristics", NEDC-33238P, Class III (Proprietary), and NEDO-33238, Class I (Non-proprietary), December 2005.	4.4
NEDC-33239P NEDO-33239	Global Nuclear Fuel, "GE14 for ESBWR Nuclear Design Report," NEDC-33239-P, Class III (Proprietary) and NEDO-33239, Class I (Non-proprietary), Revision 2, April 2007.	4.3, 4.4, 4D, 15.0, 15.2, 15.3, 15.5, Chapter 16 B3.1.1
NEDC-33240P NEDO-33240	Global Nuclear Fuel, "GE14E Fuel Assembly Mechanical Design Report," NEDC-33240P, Class III (Proprietary), and NEDO-33240, Class I (Non-proprietary), January 2006.	4.2
NEDC-33242P NEDO-33242	Global Nuclear Fuel, "GE14 for ESBWR Fuel Rod Thermal-Mechanical Design Report," NEDC-33242P, Class III (Proprietary), and NEDO-33242, Class I (Non-proprietary), Revision 1, February 2007.	4.2
NEDC-33243P	Global Nuclear Fuel, "ESBWR Marathon Control Rod Nuclear Design Report," NEDC-33243P, Class III (Proprietary), Revision 1, October 2007.	4.2, Chapter 16 B3.1.3
NEDC-33244P	Global Nuclear Fuel, "ESBWR Marathon Control Rod Mechanical Design Report," NEDC-33244P, Class III (Proprietary), Revision 1, November 2007.	4.2
NEDE-33245P NEDO-33245	GE Energy – Nuclear, "ESBWR I&C Software Quality Assurance Plan," NEDO-33245P, Class III (Proprietary), and NEDO-33245, Class I (Non-proprietary), Revision 2, July 2007.	7.1, 7.2, 7.3, 7.8, 17.1
NEDO-33251	GE Energy – Nuclear, ESBWR I&C Defense-In-Depth and Diversity Report, NEDO-33251, Class I (Non-proprietary), Revision 2~~1, August 2007~~.	7.1, 7.8

Inspections, tests, analyses, and acceptance criteria (ITAAC) associated with the cyber-security program plan are provided in Tier 1 together with the SDP.

7.1.7 COL Information

None

7.1.8 References

7.1-1 (Deleted)

7.1-2 (Deleted)

7.1-3 (Deleted)

7.1-4 GE-Hitachi Nuclear Energy Licensing Topical Report (LTR) entitled, "ESBWR I&C Defense-In-Depth and Diversity Report." NEDO-33251, Class I (Non-proprietary), Revision ~~1~~2~~, August 2007~~.

7.1-5 (Deleted)

7.1-6 (Deleted)

7.1-7 (Deleted)

7.1-8 GE Energy, "ESBWR Cyber Security Program Plan," NEDO-33295, Class I (Non-Proprietary); and "ESBWR Cyber Security Program Plan," NEDE-33295-P, Class III (Proprietary).

7.1-9 GE-Hitachi Nuclear Energy, "GEH ABWR/ESBWR Setpoint Methodology," NEDO-33304, Class I (Non-proprietary); and "GEH ABWR/ESBWR Setpoint Methodology," NEDE-33304P, Class III (Proprietary), Revision 0, October 2007.

7.1-10 GE Hitachi~~Energy~~ Nuclear Energy, "ESBWR ~~-I&C~~ Software Quality Assurance ~~Plan~~Program Manual," NEDO-33245, Class I (Non-proprietary); and "ESBWR ~~-I&C~~ Software Quality Assurance ~~Plan~~Program Manual," NEDE-33245P, Class III (Proprietary), Revision ~~2~~3, July ~~2007~~2008.

7.1-11 GE Nuclear Energy, "General Electric Instrument Setpoint Methodology," NEDO-31336, Class I (Non-proprietary); and "General Electric Instrument Setpoint Methodology," NEDC-31336P-A, Class III (Proprietary), September 1996.

7.1-12 GE Hitachi~~Energy~~ Nuclear Energy, "ESBWR ~~-I&C~~ Software Management ~~Plan~~Program Manual," NEDO-33226, Class I (Non-proprietary); and "ESBWR ~~-I&C~~ Software Management ~~Plan~~Program Manual," NEDE-33226P, Class III (Proprietary), Revision 3~~2~~, ~~July~~ June 200~~7~~8.

7.1-13 ~~7.1-13~~ (Deleted)~~*GE Energy Nuclear, "ESBWR Man-Machine Interface System and Human Factors Engineering Implementation Plan," Revision 3, NEDO-33217.*~~

- Conformance: Reference 7.8-1 details the echelons of defense used in the design that conforms to BTP HICB-19. This document also discusses the basis for selection of the DPS functions used as backups for the RPS and SSLC/ESF. A failure modes and effects analysis based on the Guidance in NUREG/CR-6303 (Reference 7.8-2) is performed to ensure the radiation guidelines from 10 CFR 100 are not exceeded in the event of a common mode failure of the RPS or SSLC/ESF software platform during the design basis events discussed in the Safety Analyses.

BTP HICB-21, Guidance on Digital System Real-Time Performance:

- Conformance: The safety-related ATWS mitigation logic conforms to the guidance in HICB-21. This BTP is not applicable to the nonsafety-related DPS.

7.8.4 Testing and Inspection Requirements

Periodic testing to verify proper operation of the ATWS/SLC logic is performed. Periodic testing to verify proper operation of the DPS logic is also performed.

7.8.5 Instrumentation and Control Requirements

The ATWS/SLC uses logic that is diverse from the RPS. Logic and controls for ATWS/SLC are located in divisional RTIF cabinets. Operating status is available to the operator in the MCR. Division of sensors bypass capability is provided for the ATWS/SLC logic. Communication with external interfaces is through isolation devices. Provisions are made to allow testing of the ATWS/SLC logic and maintenance of the ATWS/SLC equipment.

The DPS uses triple redundant microprocessor-based automatic actuation logic that is diverse from the RPS and SSLC/ESF automatic actuation logic.

The information available to the operator from the diverse I&C systems is described in Subsection 7.8.1.3.

7.8.6 COL Information

None

7.8.7 References

7.8-1 GE-Hitachi Nuclear Energy, "ESBWR I&C Defense-In-Depth and Diversity Report", NEDO-33251, Class I (Non-proprietary), Revision 2~~1, August 2007~~.

7.8-2 NUREG/CR-6303, "Method for Performing Diversity and Defense-in-Depth Analyses of Reactor Protection Systems, December 1994

7.8-3 GE Hitachi Nuclear Energy, "ESBWR ~~I&C~~ Software Quality Assurance ~~Plan~~ Program Manual (SQAPM)," NEDO-33245, Class I (Non-proprietary); and "ESBWR ~~I&C~~ Software Quality Assurance ~~Plan~~ Program Manual (SQAPM)," NEDE-33245P, Class III (Proprietary), Revision ~~2~~3, July ~~2007~~2008.

~~Reference 1,~~ Chapter 15 Event Analysis

15.2 Analysis of Anticipated Operational Occurrences

15.2.1 Decrease in Core Coolant Temperature (Event Category)

15.2.1.1 Loss of Feedwater Heating (AOO)

Systems / functions required (DCD Table 15.1-5: System Event Matrix): SCRRI/SRI
Automatic Trip (from DCD Table 15.1-6): None
Event Diagram: 15.1-2
Event Analysis: Non-limiting event. No reactor SCRAM is assumed for this event (which results in a slow power increase ~~occurs~~). SCRRI/SRI which is initiated by DPS and ATLM separately is available to mitigate the event. Bypass valves are assumed to remain functional. No barrier breaches occur. No radiological consequences associated with this event.
Conclusion: No radiological consequences and no significant pressure challenge are associated with this event.

15.2.2 Increase in Reactor Pressure

15.2.2.1 Closure of One Turbine Control Valve (AOO)

Systems / functions required (DCD Table 15.1-5: System Event Matrix): None
Automatic Trip (from DCD Table 15.1-6): None
Event Diagram: 15.1-3
Event Analysis: Event bounded by load reject. SB&PC failure escalates event to infrequent event, but is not credible. SB&PC uses a triple modular redundant (TMR) controller and a discussion on the likelihood of its failure is presented in Section 15.2.4.2 of Reference 6-3. SB&PC acts to open remaining TCVs and some TBVs to maintain reactor pressure. ~~and p~~ The plant stabilizes at a new steady state. No barrier breaches occur and this event results in neutron flux within acceptable limits. This event does not result in fuel failure. Overpressure protection is available but not challenged.
Conclusion: No radiological consequences and no significant pressure challenge are associated with this event.

15.2.2.2 Generator Load Rejection With- Turbine ~~System~~Bypass (AOO)

Systems / functions required (DCD Table 15.1-5: System Event Matrix): TBV Initiation – TCV Fast Closure; SCRRI/SRI
Automatic Trip (from DCD Table 15.1-6): None
Event Diagram: 15.1-4
Event Analysis: Event bounded by load rejection with a single failure in the Turbine Bypass. SB&PC ~~acts to open remaining TCVs and some~~produces a fast opening of the TBVs and plant stabilizes at new steady state with a slight pressure increase. SCRRI/SRI assumed to function. Neutron flux may reach reactor SCRAM setpoint (but CCF~~CMF failure~~ precludes trip). There is a possibility of SCRAM on high

reactor pressure from DPS. However, SB&PC acts to mitigate event. This event does not result in fuel failure.
No barrier breaches occur.
Conclusion: No radiological consequences are associated with this event. This Eevent results in a slight pressure increase within the control range of the SB&PC. Overpressure protection is available from the ICS and SRVs.

15.2.2.3 Generator Load Rejection With Aa Single Failure Iin Tthe Turbine Bypass System (AOO)

Systems / functions required (DCD Table 15.1-5: System Event Matrix): ICS initiation – MSIV position ICS initiation – RPV High Dome Pressure (10 sec delay); ICS initiation and MSIV closure – RPV Low Water Level (L2 + 30 sec delay); MSIV closure – Low Turbine Inlet/Main Steamline Pressure; TBV Initiation – TCV Fast Closure; Automatic Trip (from DCD Table 15.1-6): TCV Fast Closure (with insufficient bypass available)
Event Diagram: 15.1-5
Event Analysis: Only 50% of the BPVs are assumed to be available; pressurization is less severe than MSIV closure event and the event does not challenge SCRAM setpoints. This Eevent is bounded by MSIV closure event. Peak neutron flux and average simulated thermal power may increase but the event does not result in fuel failure.
Conclusion: No radiological consequences and no significant pressure challenge are associated with this event. Overpressure protection is available from the ICS and SRVs.

15.2.2.4 Turbine Trip With Turbine Bypass (AOO)

Systems / functions required (DCD Table 15.1-5: System Event Matrix): TBV Initiation – TSV Closure; SCRRI/SRI
Automatic Trip (from DCD Table 15.1-6): None
Event Diagram: 15.1-6
Event Analysis: This event is Bbounded by Turbine trip with a Single Failure in the Turbine Bypass system. This event is similar to the generator load rejection with turbine bypass event. The Ppressure increase is mitigated by SB&PC, which in turn limits the thermal power increase.
Conclusion: No radiological consequences and no significant pressure challenge are associated with this event. Overpressure protection is available from the ICS and SRVs.

15.2.2.5 Turbine Trip With Aa Single Failure Iin Tthe Turbine Bypass System (AOO)

Systems / functions required (DCD Table 15.1-5: System Event Matrix): ICS initiation– MSIV Position; ICS – RPV High Dome Pressure (10 sec delay); ICS initiation and MSIV closure – RPV Low Water Level (L2 + 30 sec delay); MSIV closure – Low Turbine Inlet/Main Steamline Pressure; TBV Initiation –TSV Closure; Automatic Trip (from DCD Table 15.1-6): TSV Closure (with insufficient bypass available)
Event Diagram: 15.1-7

Event Analysis: This ~~E~~event is bounded by the MSIV closure event. This event is similar to the generator load rejection with a single failure in the turbine bypass system event. In this event the single failure assumed results in the worst-case scenario of 50% of the bypass valves failing. A realistic failure is failure of one bypass valve to open (a TMR controller failure discussion is provided in Section 15.2.4.2 of Reference 6-3). The pressurization resulting from this event is less severe than all MSIV closure event. The credited RPS flux SCRAM is assumed to fail. SCRRI/SRI is available to reduce power to avoid fuel failure.
Conclusion: No radiological consequences are associated with this event. Overpressure protection is available from the ICS and SRVs.

15.2.2.6 Closure of One Main Steamline Isolation Valve (AOO)

Systems / functions required (DCD Table 15.1-5: System Event Matrix): ICS initiation – MSIV position; MSIV Closure – High Steamline Flow
Automatic Trip (from DCD Table 15.1-6): MSIV Position
Event Diagram: 15.1-8
Event Analysis: This ~~E~~event is bounded by closure of all MSIVs.
Conclusion: No radiological consequences are associated with this event. Overpressure protection is available from the ICS and SRVs.

15.2.2.7 Closure of All Main Steamline Isolation Valves (AOO)

Systems / functions required (DCD Table 15.1-5: System Event Matrix): ICS initiation – MSIV position
Automatic Trip (from DCD Table 15.1-6): MSIV Position
Event Diagram: 15.1-9
Event Analysis: ~~In worst-case analysis, MSIV position trip (which is the primary trip) is not credited, and high neutron flux trip is credited. Safety valves function to protect the reactor coolant pressure boundary (RCPB).~~ In this event, assume RPS (i.e., the RTIF platform including LD&IS – MSIV logic) does not function. The DPS MSIV position trip and ICS initiation occurs to mitigate the event. Additionally, ~~T~~the DPS high reactor pressure trip is reached within seconds and serves to limit the pressure transient. ~~Some fuel failure may occur.~~ Pressure transient is bounded by the ATWS scenario. High neutron flux and~~,~~ vessel pressure ~~and suppression pool temperature~~ are anticipated for this event.
Conclusion: No radiological consequences are associated with this event. DPS MSIV position SCRAM occurs. ICS is initiated on MSIV position to limit the pressure increase, and results in no radiological consequences. ~~Some fuel failure may occur if the DPS high pressure SCRAM is credited vice the MSIV position.~~ ~~[Worst case, dose less than D3 acceptance criteria (i.e., with 10% of 10 CFR 100 guidelines.]~~ Pressure response is bounded by ATWS analysis (discussed in DCD Section 15.5.4). Implementation of an MSIV closure trip in DPS provides margin. ICS operation prevents a challenge to the SRVs.

15.2.2.8 Loss of Condenser Vacuum (AOO)

Systems / functions required (DCD Table 15.1-5: System Event Matrix): ICS initiation – MSIV position; ~~TBV Closure – Low Low Condenser Vacuum;~~ TSV Closure – Low Condenser Vacuum; MSIV Closure – Low Condenser Vacuum

Automatic Trip (from DCD Table 15.1-6): Low Condenser Vacuum
Event Diagram: 15.1-10
Event Analysis: If RPS CMFCCF is assumed, vessel pressurization and peak cladding temperature may approach MSIV closure event which is bounding. Overpressure protection is available (with peak pressure controlled by the SRVs). AssumeAn RPS CMFCCF asis the worst case for this event. With an RPS CMFCCF, it may be possible that ATWS/SLC may fail to function due to unavailability of the NMS neutron flux permissive (same platform for RPS and NMS), but this function is not required for event mitigation. DPS MSIV closure and high reactor pressure tripSCRAMs -(and ARI) functions to provide negative reactivity insertion within seconds. DPS initiates ICS on high reactor pressure to avoid challenging the SRVs. The DPS MSIV closure and high reactor pressure SCRAMstrip and ICS initiationalso attenuates the pressure transient. As an additional layer of defense, manual initiation of ATWS mitigation is available to provide initiation of ARI, and FMCRD Run-inSLC injection and feedwater runback. Manual scram SCRAM from RPS or DPS is available to mitigate this event. (ATWS/SLC sensor indication and DPS sensor indication are available for operators to assess and determine an ATWS event has occurred and manual initiation action is required.)
Conclusion: No radiological consequences are associated with this event. Overpressure protection is available fromfrom the ICS and SRVs.

15.2.2.9 Loss of Shutdown Cooling Function of RWCU/SDC System (AOO)

Systems / functions required (DCD Table 15.1-5: System Event Matrix): ICS initiation – RPV High Dome Pressure (10 sec delay); ICS initiation – RPV Low Water Level (L2 + 30 sec delay); GDCS
Automatic Trip (from DCD Table 15.1-6): None
Event Diagram: 15.1-11
Event Analysis: Not a significant event or limiting event. Operating systems function to mitigate this event. (One train of SDC still assumed to function. In the unlikely event that both RWCU/SDC trains are lost, ICS is initiated by the DPS as a backup to SSLC/ESF. Fuel and Auxiliary Pools Cooling System (FAPCS) is available to provide alternate shutdown cooling in the event ICS is unavailable during Refueling mode. GDCS (initiation via the DPS) provides an additional layer of protection if RPV level approaches Level 1.)
Conclusion: No radiological consequences are associated with this event and this event does not challenge the RCPB.

15.2.3 ReactivityReactor and Power Distribution Anomalies (Event Category)

(No events identified for ESBWR)

15.2.3.1 Control Rod Withdrawal Error During Startup

Systems / functions required (DCD Table 15.1-5: System Event Matrix): None
Automatic Trip (from DCD Table 15.1-6): No automatic trip credited. Rod Block – SRNM Period, RWM, ATLM Parameter Exceeded, or MRBM Parameter Exceeded
Event Diagram: 15.1-24a
Event Analysis: The Control Rod Withdrawal Error During Startup with Failure of Control Rod Block event, which is discussed in 15.3.8, bounds this event.

Conclusion: No radiological consequences are associated with this event and this event does not challenge the RCPB.

15.2.3.2 Control Rod Withdrawal Error During Power Operation

Systems / functions required (DCD Table 15.1-5: System Event Matrix): None
Automatic Trip (from DCD Table 15.1-6): No automatic trip credited. Rod Block – SRNM Period, RWM, ATLM Parameter Exceeded, or MRBM Parameter Exceeded
Event Diagram: 15.1-25b
Event Analysis: The Control Rod Withdrawal Error During Power Operation with ATLM Failure event, which is discussed in 15.3.9, bounds this event.
Conclusion: No radiological consequences are associated with this event and this event does not challenge the RCPB.

15.2.4 Increase in Reactor Coolant Inventory (Event Category)

15.2.4.1 Inadvertent Isolation Condenser Initiation (AOO)

Systems / functions required (DCD Table 15.1-5: System Event Matrix): FWCS (Level Controller)~~None~~
Automatic Trip (from DCD Table 15.1-6): None
Event Diagram: 15.1-12
Event Analysis: This event is potentially limiting for OLMCPR; however no significant effect is experienced and~~Not a significant or limiting event,~~ plant control systems (i.e., water level control and SB&PC) respond to mitigate this event.
Conclusion: No radiological consequences are associated with this event. Startup of the isolation condenser causes a slight pressure decrease; therefore the event~~which~~ does not challenge the RCPB.

15.2.4.2 Runout of One Feedwater Pump (AOO)

Systems / functions required (DCD Table 15.1-5: System Event Matrix): ~~None~~FWCS (Level Controller)
Automatic Trip (from DCD Table 15.1-6): None
Event Diagram: 15.1-13
Event Analysis: The Feedwater ~~c~~Control ~~s~~System acts to reduce flow from other pumps to maintain desired water level. ~~No~~Neither RPS nor SSLC/ESF~~protection systems~~ is~~are~~ credited. With failure of RPS, DPS is available to produce a high water level L8 reactor ~~trip~~SCRAM as a worst-case scenario. This is ~~N~~not a significant or limiting event.
Conclusion: No radiological consequences are associated with this event and this event does not result in an RCPB challenge.

15.2.5 Decrease in Reactor Coolant Inventory (Event Category)

15.2.5.1 Opening of One Turbine Control or Bypass Valve (AOO)

Systems / functions required (DCD Table 15.1-5: System Event Matrix): None
Automatic Trip (from DCD Table 15.1-6): None
Event Diagram: 15.1-14

Event Analysis: SB&PC mitigates event by modulating of other TCVs and/or TBVs to stabilize the transient. No protection systems are credited.
Conclusion: No radiological consequences are associated with this event and no RCPB challenge is associated with this event.

15.2.5.2 Loss of Non-eEmergency AC Power to Station Auxiliaries (AOO)

Systems / functions required (DCD Table 15.1-5: System Event Matrix): TBV Closure – Low Low Condenser Vacuum; ICS initiation – Loss of Power Generation BussBus (Loss of Feedwater Flow); and MSIV closure – RPV Low Water Level (L2 + 30 sec delay); TBV Initiation – TCV Fast Closure; TCV Fast Closure – Load rejection; MSIV Closure – Low Condenser Vacuum;
Automatic Trip (from DCD Table 15.1-6): Loss of Power on Power Generation BussesBuses - Loss of Feedwater Flow
Event Diagram: 15.1-15
Event Analysis: This event is Ssimilar to the loss of all feedwater flow event. Level approaches L3 very quickly due to loss of power to the feedwater pump motors. Condenser vacuum is lost due to circulating water pump trips. Brief operation of bypass valves is assumed until vacuum decays. IfAssume RPS fails to process tripSCRAM signals,.
DPS (L3) SCRAM is availableused to quickly provide negative reactivity insertion quickly. SCRRI/SRI is also available for power reduction prior to the DPS SCRAM. DPS can initiate ICS on a delayed L2 signal to maintain level. HP CRD flow to the RPV is available for level recovery after diesel generator start (i.e., within 145 seconds).
Conclusion: No radiological consequences are associated with this event and no RCPB challenge is associated with this event.

15.2.5.3 Loss of All Feedwater Flow (AOO)

Systems / functions required (DCD Table 15.1-5: System Event Matrix): ICS initiation –Loss of Power Generation BussBus (Loss of Feedwater Flow); MSIV closure – RPV Low Water Level (L2 + 30 sec delay)
Automatic Trip (from DCD Table 15.1-6): Loss of Power on Power Generation BussesBuses- Loss of Feedwater Flow
Event Diagram: 15.1-16
Event Analysis: (This Eevent is similar to loss of power generation bus, which trips power to all feedwater pump motors.) If CMFCCF of RPS assumed, DPS provides trip SCRAM at L3. It is possible that the loss of all feedwater flow resulted from the trip of the feedwater pumps on high RPV level. In this case, DPS provides a tripSCRAM at L8, with a resultant level decrease. DPS also starts ICS on delayed L2 signal. HP/CRD pumps also start on a delayed L2 signal to provide level recovery. Not a limiting event.
Conclusion: No radiological consequences are associated with this event and no RCPB challenge is associated with this event.

15.2.6 AOO Analysis Summary

Conclusions are provided within each event evaluation. (Event Category)

15.2.7 COL Information (Event Category) - Not Applicable

15.3 Analysis of Infrequent Events

15.3.1 Loss of Feedwater Heating With Failure of SCRRI and SRI (Infrequent Event)

Systems / functions required (DCD Table 15.1-5: System Event Matrix): NoneHigh Radiation MCR EFU Initiation
Automatic Trip (from DCD Table 15.1-6): None (APRM High Simulated Thermal Power-not credited)
Event Diagram: 15.1-17
Event Analysis: ATLM and DPS independently initiate SCRRI/SRI on a loss of feedwater heating event. APRM High simulated thermal power SCRAM available for this event, but not credited. Failure of both SCRRI/SRI and RPS simultaneously is of extremely low probability, especially when combined with the failure of the feedwater temperature controller. (In the unlikely scenario of both SCRRI/SRI failure and RPS CMFCCF, a percentage of fuel may fail.)
Conclusion: Worst case, dose is within 10% of 10 CFR 100 guidelines. The ESBWR is designed such that no single operator error or equipment failure shall cause a loss of more than 55.6 °C (100 °F) feedwater heating. Analysis conservatively assumes a loss of 55.6°C FW heating, while 39°C is realistic. The Aassumption of 1000 rods entering transition boiling and subsequently failinged is conservative. Using realistic assumptions, acceptance criteria is met, without crediting DPS action.

15.3.2 Feedwater Controller Failure – Maximum Flow Demand (Infrequent Event)

Systems / functions required (DCD Table 15.1-5: System Event Matrix): ICS initiation – MSIV Position; ICS initiation – RPV High Dome Pressure (10 sec delay); ICS initiation- and MSIV closure – RPV Low Water Level (L2 + 30 sec delay); TBV Initiation – TSV Closure; TSV Closure – RPV high water Level (L8); -MSIV Closure – Low Turbine Inlet/Main Steamline Pressure
Automatic Trip (from DCD Table 15.1-6): RPV High Water Level (L8)
Event Diagram: 15.1-18
Event Analysis: Assume RPS failure for this event, DPS provides SCRAM on L8 to mitigate this event. FW runback occurs. As a backup, DPS trips the feedwater pumps at L9. SB&PC is available to control pressure.
Conclusion: No radiological consequences associated with this event. SB&PC controller failure mode not assumed credible, using realistic assumptions. DPS initiated SCRAM on L8 occurs early enough to limit neutron flux peak and fuel thermal transient so that no fuel damage occurs. This event does not challenge RCPB pressure and temperature limits.

15.3.3 Pressure Regulator Failure Opening of All Turbine Control and Bypass Valves (Infrequent Event)

Systems / functions required (DCD Table 15.1-5: System Event Matrix): ICS initiation – MSIV Position; MSIV Closure – Low Turbine Inlet Pressure; CRD Makeup Water – RPV Low Water Level (L2)
Automatic Trip (from DCD Table 15.1-6): MSIV Position
Event Diagram: 15.1-19
Event Analysis: Using realistic assumptions, a complete failure of the SB&PC is not assumed credible. SB&PC should function to mitigate this event. Failure of RPS requires DPS MSIV closure SCRAM and/or L3 SCRAM to mitigate the event.
If SSLC/ESF CMFCCF assumed, RPS SCRAMs on MSIV closure from low turbine inlet pressure. Diverse ICS initiation occurs on decreasing level (delayed L2). If level drops to L1, diverse ESF (ECCS) initiation occurs.
Conclusion: No radiological consequences are associated with this event and no RCPB challenge associated with this event.

15.3.4 Pressure Regulator Failure – Closure of All Turbine Control and Bypass Valves (Infrequent Event)

Systems / functions required (DCD Table 15.1-5: System Event Matrix): ICS initiation – MSIV Position; ICS initiation – RPV High Dome Pressure (10 sec delay); ICS initiation and MSIV Closure - RPV Low Water Level (L2 + 30 Sec delay); MSIV closure – Low Turbine Inlet/Main Steamline Pressure
Automatic Trip (from DCD Table 15.1-6): APRM High Neutron Flux
Event Diagram: 15.1-20
Event Analysis: Using realistic assumptions, a complete failure of the SB&PC is not assumed as a credible event. Therefore, Rreactor power and pressure should be controlled by SB&PC. This Eevent is bounded by closure of all MSIVs for over pressure (an analysis of this event is provided in DCD Section 15.5.4). RCPB: Reactor pressure is maintained below ASME Service Level C limit (<120% of design pressure). AssumeIn the event of an unlikely SB&PC failure, a turbine trip is generated with a -failure of RPS to SCRAMSCRAM as the worst case scenario.
DPS SCRAMs on high pressure and initiates ICS to limit the pressure transient. Overpressure protection is available from ICS and SRVs.
Conclusion: No radiological consequences are associated with this event. With failure of the RPS flux SCRAM fuel failure is more likely to occur. The Ddose within acceptance criteria criterion (10% of 10 CFR 100 guidelines) is not challenged. Overpressure protection is available from ICS and SRVs to protect the RCPB.

15.3.5 Generator Load Rejection with Total Turbine Bypass Failure (Infrequent Event)

Systems / functions required (DCD Table 15.1-5: System Event Matrix): ICS initiation – MSIV Position; ICS initiation – RPV High Dome Pressure (10 sec delay); ICS initiation and MSIV Closure - RPV Low Water Level (L2 + 30 Sec delay); TCV Fast closure – Load Rejection; MSIV closure – Low Turbine Inlet/Main Steamline Pressure; High Radiation MCR EFU Initiation
Automatic Trip (from DCD Table 15.1-6): TCV Fast Closure (with insufficient bypass available)

Event Diagram: 15.1-21
Event Analysis: Using realistic assumptions, a complete failure of the SB&PC not assumed. Bounded by closure of all MSIV event for overpressure. If RPS CMFCCF failure assumed, DPS provides high-pressure tripSCRAM. ICS and HP-CRD are still available to stabilize the plant. If SSLC/ESF CMFCCF assumed, RPS scram occurs on TCV fast closure with insufficient bypass capacity and RPS high neutron flux SCRAM signal and high RPV pressure SCRAMs are still available as backups.
Conclusion: Although not likely to occur if realistic assumptions are applied, Tthere is a fuel failure analysis in DCD 15.3.1.5 for this event which is bounding. With failure of the TCV/flux SCRAM fuel failure would be more severe.
Overpressure protection still available. Radiological consequences are bounded by the analytical assumption of 1000 rods entering transition boiling and subsequently failinged rods, with off-site dose below the acceptance criterion (i.e., less than 10% of 10 CFR 100 guidelines). Overpressure protection is available from the ICS and SRVs.

15.3.6 Turbine Trip with Total Turbine Bypass Failure (Infrequent Event)

Systems / functions required (DCD Table 15.1-5: System Event Matrix): ICS initiation – MSIV Position; ICS initiation – RPV High Dome Pressure (10 sec delay); ICS initiation and MSIV Closure - RPV Low Water Level (L2 + 30 Sec delay); MSIV closure – Low Turbine Inlet/Main Steamline Pressure; High Radiation MCR EFU Initiation
Automatic Trip (from DCD Table 15.1-6): TSV Closure (with insufficient bypass available)
Event Diagram: 15.1-22
Event Analysis:
Using realistic assumptions, a complete failure of the SB&PC is not assumed. If RPS CMFCCF assumed, DPS provides high-pressure trip and can initiate ICS on high RPV pressure. If SSLC/ESF CMFCCF failure is assumed, RPS available for high-pressure SCRAM, high neutron flux SCRAM and TSV closure with insufficient bypass SCRAMs.
Conclusion: There is a fuel failure analysis in DCD 15.3.1.5 for this event. With failure of the TCVTSV closure and/ flux SCRAMs, fuel failure is more severe. This event is assumed to be bounded by the load rejection with no bypass. Radiological consequences are bounded by the analytical assumption of 1000 failed rods entering transition boiling and subsequently failing, with off-site dose below the acceptance criterion (i.e., less than 10% of 10 CFR 100 guidelines).
Overpressure protection availableprotection is available from the ICS and SRVs to protect RCPB.

15.3.7 Control Rod Withdrawal Error During Refueling (Infrequent Event)

Systems / functions required (DCD Table 15.1-5: System Event Matrix): None
Automatic Trip (from DCD Table 15.1-6): NoneNo automatic trip credited. Rod Block – SRNM Period, RWM, ATLM Parameter Exceeded, or MRBM Parameter Exceeded
Event Diagram: 15.1-23

Event Analysis: Core is designed to meet shutdown requirements and remain subcritical with one control rod pair or one rod of maximum worth withdrawn. Event is a low probability event that is mitigated by RC&IS interlocks that prevent additional withdrawals.~~Not a credible event.~~
Conclusion: Not analyzed based on core design and RC&IS interlocks.

15.3.8 Control Rod Withdrawal Error During Startup with Failure of Control Rod Block (Infrequent Event)

Systems / functions required (DCD Table 15.1-5: System Event Matrix): None
Trip/Protection (from DCD Table 15.1-6): SRNM Period~~; Rod Block – SRNM Period or ATLM Parameter Exceeded~~
Event Diagram: 15.1-24
Event Analysis: Tightly controlled evolution with monitoring and feedback. Although withdrawal error postulated, recovery from error crediting operator action to manually SCRAM the reactor and place the plant in a safe condition is assumed. Operability verified just prior to the event. Any aberrant indication requires the operator to stop and verify information and place the plant in a safe condition, before significant reactivity excursion occurs. Either APRM or SRNM assumed to fail but not both.
Conclusion: No radiological consequences are associated with this event. No RCPB challenge associated with this event.

15.3.9 Control Rod Withdrawal Error During Power Operations with ATLM Failure (Infrequent Event)

Systems / functions required (DCD Table 15.1-5: System Event Matrix): ~~None~~High Radiation MCR EFU Initiation
Automatic Trip (from DCD Table 15.1-6): No automatic trip credited. Rod Block – SRNM Period, RWM, ~~or~~ ATLM Parameter Exceeded, or MRBM Parameter Exceeded
Event Diagram: 15.1-25
Event Analysis: Simultaneous failure of RC&IS and RPS/NMS is extremely low. ~~Event not analyzed.~~ If a failure of both ATLM channels occurs which does not inhibit rod movement as designed, MRBM ~~stops~~prevents control rod withdrawal from continuing. The radiological analysis performed in DCD 15.3.1.5 which conservatively assumes 1000 ~~failed~~ rods enter transition boiling and subsequently fail, bounds this event.
Conclusion: Radiological consequences associated with this event if conservative assumptions are used are still below the acceptance criterion (i.e., less than 10% of 10 CFR 100 guidelines). No RCPB challenge associated with this event. ~~Event not analyzed.~~

15.3.10 Fuel Assembly Loading Error, Mis-located Bundle (Infrequent Event)

Systems / functions required (DCD Table 15.1-5: System Event Matrix): None
Automatic Trip (from DCD Table 15.1-6): None
Event Diagram: 15.1-26

Event Analysis: Tightly controlled evolution with procedural steps for error checking. DPS not required.
Conclusion: No safety systems are credited in mitigating this event. The existing DCD Chapter 15 analysis applies.~~No radiological consequences associated with this event.~~

15.3.11 Fuel Assembly Loading error, Mis-oriented Bundle (Infrequent Event)

Systems / functions required (DCD Table 15.1-5: System Event Matrix): None
Automatic Trip (from DCD Table 15.1-6): None
Event Diagram: 15.1-27
Event Analysis: Tightly controlled evolution with procedural steps for error checking. DPS not required.
Conclusion: No safety systems are credited in mitigating this event. The existing DCD Chapter 15 analysis applies.~~No radiological consequences associated with this event.~~

15.3.12 Inadvertent SDC Function Operation (Infrequent Event)

Systems / functions required (DCD Table 15.1-5: System Event Matrix): None
Automatic Trip (from DCD Table 15.1-6): APRM High Neutron Flux
Event Diagram: 15.1-28
Event Analysis: If RPS ~~CMF~~CCF assumed, SB&PC is available to mitigate this event. This event is characterized by a slow power rise. Operator action can be credited for tightly controlled startup/shutdown scenario where the largest effects are manifested.
Conclusion: No radiological consequences are associated with this event. No RCPB challenge is associated with this event.

15.3.13 Inadvertent Opening of a Safety/Relief Valve (Infrequent Event)

Systems / functions required (DCD Table 15.1-5: System Event Matrix): None
Automatic Trip (from DCD Table 15.1-6): High Suppression Pool Temperature
Event Diagram: 15.1-29
Event Analysis: SB&PC available to stabilize pressure prior to occurrence of SCRAM, after which time the pressure will decrease. If RPS ~~CMF~~CCF assumed, DPS available to SCRAM on high suppression pool temperature. FAPCS provides suppression pool cooling.
Conclusion: This event should not result in a release. Therefore no radiological consequences are associated with this event.

15.3.14 Inadvertent Opening of a Depressurization ~~P~~Valve (Infrequent Event)

Systems / functions required (DCD Table 15.1-5: System Event Matrix): SRV – Power Actuated Mode (ADS); DPV – Actuation; GDCS; Passive Containment Cooling System (PCCS).
Automatic Trip (from DCD Table 15.1-6): High Drywell Pressure
Event Diagram: 15.1-30
Event Analysis: SB&PC is available to stabilize pressure prior to occurrence of SCRAM after which time the pressure decreases. If RPS ~~CMF~~CCF assumed, DPS is available to SCRAM on high drywell pressure. PCCS is available to limit

containment pressure. Transient controlled by SB&PC and high drywell pressure trip. Diverse ESF is available and may be required if conditions degrade
Conclusion: No fuel damage anticipated for this event, only coolant activity is a concern. Worst-case dose is within 10% of 10 CFR 100 guidelines Radiation monitoring and isolation can be credited.

15.3.15 Stuck Open Safety/Relief Valve (Infrequent Event)

Systems / functions required (DCD Table 15.1-5: System Event Matrix): SRV – Power Actuated Mode (ADS); DPV – Actuation; ICS initiation – MSIV Position; MSIV Closure – Low Turbine Inlet /Main Steamline Pressure; GDCS; PCCS
Automatic Trip (from DCD Table 15.1-6): None
Event Diagram: 15.1-31
Event Analysis: If RPS ~~CMF~~CCF assumed DPS SCRAMs on high suppression pool temperature. FAPCS provides suppression pool cooling.
~~IF~~If SSLC/ESF ~~CMF~~CCF assumed, RPS provides SCRAM on high suppression pool temperature.
Conclusion: No fuel failure occurs in this event, only coolant activity is a concern. Worst-case dose within 10% of 10 CFR 100 guidelines. Radiation monitoring and isolation can be credited.

15.3.16 Liquid Containing Tank Failure (Infrequent Event) ~~[COL Applicant Scope]~~

Systems / functions required (DCD Table 15.1-5: System Event Matrix): ~~None~~High Radiation MCR EFU Initiation
Automatic Trip (from DCD Table 15.1-6): None
Event Diagram: 15.1-32
Event Analysis: All normally operating systems assumed available to mitigate this event. This event does not involve the RPV or containment and requires no actions from RPS. ~~or DPS.~~A 5 rem onsite dose is assumed which could potentially impact control room habitability. Area and process radiation monitors are assumed to function to annunciate any potential release. If SSLC/ESF fails to automatically isolate the control room and start the EFUs, manual actuation of the EFUs is assumed to be available.
Conclusion: ~~No adverse consequences assumed.~~This event results in potential adverse consequences to the main control room operators, if there is a failure to maintain control room habitability, due to a failure of SSLC/ESF logic processors. SSLC/ESF capability to manually provide control room habitability is assumed due to the diversity between the VDU controls and the automatic logic.

15.3.17 COL Information - Not Applicable

15.4 Analysis of Accidents (Event Category)

15.4.1 Fuel Handling Accident (Accident)

Systems / functions required (DCD Table 15.1-5: System Event Matrix): None
Automatic Trip (from DCD Table 15.1-6): None
Event Diagram: 15.1-33
Event Analysis: Tightly controlled evolution; ventilation systems assumed available to mitigate this event. Credit taken for Radiation ~~m~~Monitoring ~~s~~System. This event

does not involve the RPV or containment and requires no actions from RPS, SSLC/ESF, or DPS.
Conclusion: Worst case dose within 10 CFR 100 guidelines.

15.4.2 Loss-of-Coolant AccidentOCA Inside Containment (Containment Analysis) (Accident)

Systems / functions required (DCD Table 15.1-5: System Event Matrix): SRV – Power Actuated Mode (ADS); DPV – Actuation; ICS initiation – MSIV position; ICS initiation – RPV High Dome Pressure (10 sec delay); ICS initiation and MSIV Closure– RPV Low Water Level (L2 + 30 sec delay); ICS initiation and MSIV Closure– RPV Low Water Level (L1); ICS initiation – Loss of Power Generation BussBus (Loss of Feedwater Flow); Feedwater Isolation Signals; SLC System - DPV Open; GDCS; GDCS Equalizing Lines; PCCS; High Radiation MCR recirculation EFU Initiation; PCCS
Automatic Trip (from DCD Table 15.1-6): RPV Low Water Level (L3); Loss of Power Generation Bus- Loss of Feedwater Flow; High Drywell Pressure
Event Diagram: 15.1-34
Event Analysis: If RPS CMFCCF assumed, DPS provides SCRAM on low water level (L3) or high drywell pressure. LD&IS (MSIV) isolation failure assumed because of the same platform as RPS and DPS provides MSIV isolation (on low steamline pressure or high steamline flow or low RPV level) to limit consequences. SSLC/ESF initiation occurs to mitigate the event. Non-MSIV LD&IS isolation occurs. If SSLC/ESF CMFCCF is assumed, diverse ESF initiation (at L1) is required to mitigate the event. In the event of a feedwater line break inside containment, the DPS is also capable of isolating the feedwater lines on high differential pressure between the feedwater lines coincident with high drywell pressure.
Conclusion: The Wworst-case dose may challengedoes not exceed 10 CFR 100 guidelines. Diverse ECCS initiation available to mitigate the event. Diverse containment or feedwater system isolation may be required to mitigate the event, either of which is provided by the DPS.

15.4.3 Loss-of-Coolant Accident ECCSOCA Inside Containment (Performance Analysis) (Accident)

Systems / functions required (DCD Table 15.1-5: System Event Matrix): SRV – Power Actuated Mode (ADS); DPV – Actuation; ICS initiation – MSIV Position; ICS initiation – RPV High Dome Pressure (10 sec delay); ICS initiation and MSIV Closure– RPV Low Water Level (L2 + 30 sec delay); ICS initiation and MSIV Closure– RPV Low Water Level (L1); ICS initiation – Loss of Power Generation BussBus (Loss of Feedwater Flow); Feedwater Isolation Signals; SLC System - DPV Open;; GDCS; GDCS Equalizing Lines; High Radiation MCR recirculation EFU Initiation; PCCS
Automatic Trip (from DCD Table 15.1-6): RPV Low Water Level (L3); Loss of Power Generation Bus-Loss of Feedwater Flow; High Drywell Pressure
Event Diagram: 15.1-34
Event Analysis: Refer to 15.4.2
Conclusion: Refer to 15.4.2

15.4.4 ~~LOCA~~ Loss-of-Coolant Accident Inside Containment ~~(Radiological Analysis)~~ (Accident)

Systems / functions required (DCD Table 15.1-5: System Event Matrix): SRV – Power Actuated Mode (ADS); DPV – Actuation; ICS initiation – MSIV Position; ICS initiation – RPV High Dome Pressure (10 sec delay); ICS initiation and MSIV Closure– RPV Low Water Level (L2 + 30 sec delay); ICS initiation and MSIV Closure– RPV Low Water Level (L1); ICS initiation – Loss of Power Generation ~~Buss~~Bus (Loss of Feedwater Flow); Feedwater Isolation Signals; SLC System - DPV Open; GDCS; GDCS Equalizing Lines; High Radiation MCR ~~recirculation~~EFU Initiation; PCCS
Automatic Trip (from DCD Table 15.1-6): RPV Low Water Level (L3); Loss of Power Generation Bus-Loss of Feedwater Flow; High Drywell Pressure
Event Diagram: 15.1-34
Event Analysis: Refer to 15.4.2
Conclusion: Refer 15.4.2

15.4.5 Main Steamline Break Accident Outside Containment (Accident)

Systems / functions required (DCD Table 15.1-5: System Event Matrix): SRV – Power Actuated Mode (ADS); DPV – Actuation; ICS initiation – MSIV Position; ICS initiation – RPV High Dome Pressure (10 sec delay); ICS initiation and MSIV Closure– RPV Low Water Level (L2 + 30 sec delay); ICS initiation and MSIV Closure– RPV Low Water Level (L1); ICS initiation – Loss of Power Generation ~~Buss~~Bus (Loss of Feedwater Flow); MSIV Closure – Low Turbine Inlet/Main Steamline Pressure; MSIV Closure – High Steamline Flow; SLC System - DPV Open; ~~SLC System – RPV Low Water Level L2 – APRM not Downscale;~~ GDCS; GDCS Equalizing Lines; High Radiation MCR EFU Initiation
Automatic Trip (from DCD Table 15.1-6): RPV Low Water Level (L3); MSIV Position; Loss of Power Generation Bus-Loss of Feedwater Flow
Event Diagram: 15.1-35
Event Analysis: If RPS ~~CMF~~CCF is assumed, DPS provides SCRAM on low water level (L3). LD&IS (MSIV) isolation failure is assumed because of the same platform as RPS and DPS isolates the MSIVs (on low steamline pressure or high steamline flow or low RPV level) to limit consequences. SSLC/ESF initiation occurs. ~~Diverse ESF may be required for MSIV isolation (L1) (on low turbine inlet pressure or low flow) to isolate any radiation release quickly.~~ If SSLC/ESF ~~CMF~~CCF assumed, diverse ESF initiation (at L1) is required to mitigate the event.
Conclusion: Worst-case dose ~~may challenge~~does not exceed 10 CFR 100 guidelines. Diverse ECCS initiation and diverse MSIV isolation~~available to~~ mitigate the event. ~~Diverse containment/MSIV isolation may be required to mitigate the event.~~

15.4.6 Control Rod Drop Accident (Accident)

Systems / functions required (DCD Table 15.1-5: System Event Matrix): No systems credited. ~~None~~
Automatic Trip (from DCD Table 15.1-6): ~~None~~Rod Block – SRNM Period, RWM, ATLM Parameter Exceeded, or MRBM Parameter Exceeded
Event Diagram: 15.1-36
Event Analysis: No clad failures are predicted and no automatic trip or ESF is credited~~Not a credible event~~.

Conclusion: This event does not result in any fuel failures or any radiological consequences, and does not challenge the RCPBNot analyzed.

15.4.7 Feedwater Line Break Outside Containment (Accident)

Systems / functions required (DCD Table 15.1-5: System Event Matrix): SRV – Power Actuated Mode (ADS); DPV – Actuation; ICS initiation – MSIV Position; ICS initiation– and MSIV Closure– RPV Low Water Level (L2 + 30 sec delay); ICS initiation and MSIV Closure– RPV Low Water Level (L1); ICS initiation – RPV High Dome Pressure (10 sec delay); ICS initiation – Loss of Power Generation BussBus (Loss of Feedwater Flow); SLC System - DPV Open; GDCS; GDCS Equalizing Lines; High Radiation MCR EFU Initiation; PCCS
Automatic Trip (from DCD Table 15.1-6): RPV Low Water Level (L3); MSIV Position; Loss of Power Generation Bus-Loss of Feedwater Flow
Event Diagram: 15.1-37
Event Analysis: If RPS CMFCCF is assumed, DPS provides SCRAM on low water level (L3). SSLC/ESF initiation occurs. If SSLC/ESF CMFCCF assumed, diverse ESF initiation (at L1) is required to mitigate the event.
Conclusion: No fuel failure is assumed for this event. Worst-case dose does not challenge 10 CFR 100 guidelines.

15.4.8 Failure of Small Line Carrying Primary Coolant Outside Containment (Accident)

Systems / functions required (DCD Table 15.1-5: System Event Matrix): SRV – Power Actuated Mode (ADS); DPV – Actuation; ICS initiation – MSIV Position; ICS initiation and MSIV Closure– RPV Low Water Level (L2 + 30 sec delay); ICS initiation and MSIV Closure– RPV Low Water Level (L1); ICS initiation – RPV High Dome Pressure (10 sec delay); ICS initiation – Loss of Power Generation BussBus (Loss of Feedwater Flow); SLC System - DPV Open; GDCS; GDCS Equalizing Lines; High Radiation MCR EFU Initiation; PCCS
Automatic Trip (from DCD Table 15.1-6): RPV Low Water Level (L3); MSIV Position; Loss of Power Generation Bus-Loss of Feedwater Flow
Event Diagram: 15.1-38
Event Analysis: Leak detection by aberrant indication (radiation, temperature, humidity or noise) alerts operator to perform an orderly shutdown. If RPS CMFCCF assumed, manual reactor SCRAM is still available. DPS provides manual backup SCRAM. Manually controlled orderly shutdown is performed to depressurize the reactor if leak is not isolable. Manual containment isolation and diverse ESF are available. CR habitability not impacted adversely.
Conclusion: This line break is bounded by larger breaks. Using realistic assumptions, excess flow check valves limit the release of coolant. Dose is within 10 CFR 100 guidelines.

15.4.9 RWCU/SDC System Line Failure Outside Containment (Accident)

Systems / functions required (DCD Table 15.1-5: System Event Matrix): SRV – Power Actuated Mode (ADS); DPV – Actuation; ICS initiation – MSIV Position; ICS initiation and MSIV Closure– RPV Low Water Level (L2 + 30 sec delay); ICS initiation and MSIV Closure– RPV Low Water Level (L1); ICS initiation – RPV High Dome Pressure (10 sec delay); ICS initiation – Loss of Power Generation

~~Buss~~Bus (Loss of Feedwater Flow); SLC System - DPV Open; GDCS; GDCS Equalizing Lines; High Radiation MCR EFU Initiation; PCCS
Automatic Trip (from DCD Table 15.1-6): RPV Low Water Level (L3); MSIV Position; Loss of Power Generation Bus-Loss of Feedwater Flow
Event Diagram: 15.1-39
Event Analysis: If RPS ~~CMF~~CCF assumed, DPS available to SCRAM on L3. If level continues to drop, ESF initiation occurs at L1, and differential flow sensors are available to isolate the RWCU/SDC line. If SSLC/ESF CCF is assumed which results in failure of LD&IS to provide isolation signal, ~~D~~diverse ESF is available. Diverse initiation occurs at L1. Diverse ~~D~~differential flow sensors are available to~~may~~ isolate the RWCU/SDC line.~~ to terminate event.~~ ~~CMF failure of LD&IS extends the duration of the event until leak is identified and isolated. Manual remote isolation is available to the operator. High radiation Main Control Room Recirculation actuation signal alerts the operator to a possible line break. Additional mitigation measure may be required if dose consequences are unacceptable. [If time permits (radiation release is not excessive for ~30 minutes), consider differential flow indication to DPS for remote manual operator isolation, or diverse automatic isolation of break.]~~

Conclusion: ~~Worst case~~Worst-case dose may challenge 10 CFR 100 guidelines with ~~CMF~~CCF~~ failure~~ of LD&IS. Diverse RWCU/SDC isolation and diverse ECCS are provided~~ may be required~~ to mitigate. If exposure does not challenge 10 CFR 100 guidelines, no additional DPS scope is required.

15.4.10 Spent Fuel Cask Drop Accident (Accident)

Systems / functions required (DCD Table 15.1-5: System Event Matrix): None
Automatic Trip (from DCD Table 15.1-6): None
Event Diagram: 15.1-40
Event Analysis: Controlled evolution. Normal operating systems are assumed to be available. This event does not involve the RPV or containment and requires no actions from RPS, SSLC/ESF, ~~and~~or DPS.
Conclusion: No adverse consequences.

15.4.11 (COL Information) - Not Applicable

15.5 Special Event Evaluations (Event Category)

The events in this section are beyond design basis events per DCD 15.0.1.2 and are not included in this evaluation.

~~APPENDIX B – Summary Table of DCD Chapter 15 Accidents Evaluated for D3~~

~~Assume the worst case scenario is a CMFCCF of a digital protection platform; no cross platform CMFCCFs are assumed. Therefore, the analysis assumes that RPS/RTIF and LD&IS-MSIV isolation or SSLC/ESF platform fails.~~

~~Sect~~	~~Description~~	~~Event Class~~	~~Diverse I&C system~~	~~Comments~~
~~15.2.1 Decrease in Core Coolant Temperature (Event Category)~~				
~~15.2.1.1~~	~~Loss of Feedwater Heating~~	~~AOO~~	~~No SCRAM assumed~~	~~Diverse Protection System (DPS) has no action. Worst case failure is failure of RC&IS/SCRRI. No radiological consequences associated with this event.~~
~~15.2.2 Increase in Reactor Pressure (Event Category)~~				
~~15.2.2.1~~	~~Closure of One Turbine Control Valve~~	~~AOO~~	~~No significant pressure increase assumed. No Diverse Protection System (DPS) challenge~~	~~Bounded by load reject. Common mode failure of any protection system presents no challenge. Since the closure of one TCV will automatically result in the opening of a sufficient number of Turbine Bypass Valves (TBVs) to offset the loss in~~

~~Sect~~	~~Description~~	~~Event Class~~	~~Diverse I&C system~~	~~Comments~~
				~~steam flow to the turbine, nothing happens other than a reduction of generator output and an alarm. DPS has no action. No radiological consequences associated with this event.~~
~~15.2.2.2~~	~~Generator Load rejection With Turbine Bypass~~	~~AOO~~	~~No challenge to SCRAM setpoints.~~	~~DPS has no action. Event bounded by load rejection with turbine bypass system failure.~~
~~15.2.2.3~~	~~Generator Load Rejection With a Single Failure in the Turbine Bypass System~~	~~AOO~~	~~No DPS SCRAM assumed.~~	~~A 50% reduction in bypass capacity is conservatively assumed. It is possible this results in reaching a RPS SCRAM (flux) SCRAM setpoint (but no DPS SCRAM). There should not be a pressure increase to the DPS SCRAM setpoint, so no DPS action. This should look like a turbine trip with good level and pressure control. Event bounded by MSIV closure event.~~

Sect	Description	Event Class	Diverse I&C system	Comments
15.2.2.4	Turbine Trip With Turbine Bypass	AOO	Bypass capability not affected. No challenge to DPS.	Event bounded by turbine trip with a single failure in the turbine bypass system.
15.2.2.5	Turbine Trip With a Single Failure in the Turbine Bypass System	AOO	No significant pressure increase. No challenge to DPS.	A 50% reduction in bypass capacity is conservatively assumed. Event bounded by MSIV closure event.
15.2.2.6	Closure of One Main Steamline Isolation Valve (MSIV)	AOO	High reactor pressure SCRAM	DPS will SCRAM at approximately the same pressure as RPS. Event bounded by MSIV closure event.
15.2.2.7	Closure of All Main Steamline Isolation Valves	AOO	High reactor pressure SCRAM.	DPS SCRAMs on MSIV closure or SCRAMs on resulting reactor pressure – effect is an MSIV closure with a slightly delayed SCRAM. ATWS event bounds this event. Some fuel failure may occur if DPS is credited. Worst case dose less than 2.5 REM.

Sect	Description	Event Class	Diverse I&C system	Comments
15.2.2.8	Loss of Condenser Vacuum	AOO	High reactor pressure SCRAM	This event is essentially a turbine trip without bypass or a Main Steam Isolation Valve (MSIV) closure – DPS SCRAMs on pressure if RPS does not SCRAM on vacuum.
15.2.2.9	Loss of Shutdown Cooling Function of RWCU/SDC	AOO	No DPS action.	1 train still assumed to function. No challenge to DPS
15.2.3 Reactor and Power Distribution Anomalies (Event Category)				
	(No events identified for ESBWR)			
15.2.4 Increase in Reactor Coolant Inventory (Event Category)				
15.2.4.1	Inadvertent Isolation Condenser Initiation	AOO	No significant impact.	No DPS action. No challenge to DPS.
15.2.4.2	Runout of One Feedwater Pump	AOO	No SCRAM occurs. DPS L8 SCRAM is worst case.	A feedwater (FW) pump run out results in a slowdown of the other FW pump speeds and therefore there is no level change (failure of the TMR feedwater controller (FWC) is incredible). Either DPS has no action or (like RPS) worst case requires DPS SCRAM at level L8.

~~Sect~~	~~Description~~	~~Event Class~~	~~Diverse I&C system~~	~~Comments~~
~~15.2.5 Decrease in Reactor Coolant Inventory (Event Category)~~				
~~15.2.5.1~~	~~Opening of One Turbine Control or Bypass Valve~~	~~AOO~~	~~No SCRAM assumed.~~	~~Non-event since SB&PC will automatically reduce other control valve positions. If level does get to L3, then DPS will SCRAM~~
~~15.2.5.2~~	~~Loss of Non-Emergency AC Power to Station Auxiliaries~~	~~AOO~~	~~L3 SCRAM. DPS is still available (battery power) high reactor pressure SCRAM worst case.~~	~~RPS normally SCRAMs on loss of power to plant 13.8 kV busses – DPS does not. However if RPS fails to SCRAM, then DPS SCRAMs on L3.~~
~~15.2.5.3~~	~~Loss of All Feedwater Flow~~	~~AOO~~	~~L3 SCRAM~~	~~DPS SCRAMs on L3~~
~~15.2.6 AOO Analysis of Infrequent Events Summary (Event Category)~~				
~~15.2.7 COL Information~~				
	~~Not Applicable~~			
~~15.3 Analysis of Infrequent Events (Event Category)~~				
~~15.3.1~~	~~Loss of Feedwater Heating With Failure of Selected Control Rod Run-In~~	~~Infrequent Event~~	~~SCRAM not credited.~~ ~~NOo DPS SCRAM~~	~~Failure of both SCRRI and RPS unlikely, If both fail, percentage of fuel may fail. Doses within 10% of 10 CFR 100 guidelines (2.5 REM).~~

Sect	Description	Event Class	Diverse I&C system	Comments
~~15.3.2~~	~~Feedwater Controller Failure – Maximum Demand~~	~~Infrequent Event~~	~~L8 SCRAM~~	~~Incredible event but DPS SCRAMs on L8~~
~~15.3.3~~	~~Pressure Regulator Failure – Opening of All Turbine Control and Bypass Valves~~	~~Infrequent Event~~	~~L3 SCRAM~~	~~Level swells initially but delayed SCRAM on low level from DPS (L3).~~
~~15.3.4~~	~~Pressure Regulator Failure – Closure of All Turbine Control and Bypass Valves~~	~~Infrequent Event~~	~~High reactor pressure SCRAM~~	~~Incredible event but DPS SCRAMs on high pressure~~
~~15.3.5~~	~~Generator Load Rejection With Total Turbine Bypass Failure~~	~~Infrequent Event~~	~~High reactor pressure SCRAM~~	~~Incredible event but DPS SCRAMs on high pressure~~
~~15.3.6~~	~~Turbine Trip With Total Turbine Bypass Failure~~	~~Infrequent Event~~	~~High reactor pressure SCRAM~~	~~Incredible event but DPS SCRAMs on high pressure~~
~~15.3.7~~	~~Control Rod Withdrawal Error During Refueling~~	~~Infrequent Event~~	~~No Diverse I&C required~~	~~No DPS action~~
~~15.3.8~~	~~Control Rod Withdrawal Error During Startup~~	~~Infrequent Event~~	~~No Diverse I&C required~~	~~No DPS action~~
~~15.3.9~~	~~Control Rod Withdrawal Error During Power Operation~~	~~Infrequent Event~~	~~No Diverse I&C required:~~	~~No DPS action~~
~~15.3.10~~	~~Fuel Assembly Loading Error, Mislocated Bundle~~	~~Infrequent Event~~	~~No Diverse I&C required~~	~~No DPS action~~
~~15.3.11~~	~~Fuel Assembly Loading Error, Misoriented Bundle~~	~~Infrequent Event~~	~~No Diverse I&C required~~	~~No DPS action~~

Sect	Description	Event Class	Diverse I&C system	Comments
15.3.12	Inadvertent SDC Function Operation	Infrequent Event	No significant impact.	SB&PC available to mitigate. Slow moving event most likely terminated by operator (for tightly controlled startup scenario).
15.3.13	Inadvertent Opening of a Safety-Relief Valve	Infrequent Event	High suppression pool temperature SCRAM	DPS also SCRAMs on high suppression pool temperature
15.3.14	Inadvertent Opening of a Depressurization Valve	Infrequent Event	High drywell pressure SCRAM	DPS also SCRAMs on high drywell pressure
15.3.15	Stuck Open Safety-Relief Valve	Infrequent Event	Suppression pool temperature SCRAM	DPS also SCRAMs on high suppression pool temperature
15.3.16	Liquid Containing Tank Failure (COL applicant scope)	Infrequent Event	No diverse I&C required	No DPS action
15.3.17	COL Information	-	-	Not Applicable
15.4 Analysis of Accidents (Event Category)				
15.4.1	Fuel Handling Accident	Accident	No diverse I&C required	No DPS action

Sect	Description	Event_Class	Diverse I&C system	Comments
15.4.2	Loss-of-Coolant Accident (Containment Analysis)	Accident	L3 SCRAM/Hi drywell pressure SCRAM Diverse ESF/ECCS actuation	DPS SCRAMs on reactor level, drywell pressure and initiate (ECCS) Automatic Depressurization System (ADS)/Gravity Driven Cooling System (GDCS), SLC System, etc. Worst case dose may challenge 10 CFR 100 guidelines. Need confirmatory analysis. Diverse containment isolation may be required.
15.4.3	Loss-of-Coolant Accident Performance Analysis	Accident	L3 SCRAM Diverse ESF/ECCS actuation	Refer to 15.4.2.
15.4.4	Loss-of-Coolant Accident Inside Containment Radiological Analysis	Accident	L3 SCRAM Diverse ESF/ECCS actuation	Refer to 15.4.2.
15.4.5	Main Steamline Break Accident Outside Containment	Accident	L3 SCRAM Diverse ESF/ECCS actuation	DPS SCRAMs on low level (L3). Diverse containment/MSIV closure may be required to limit radiological consequences. Release may challenge 10 CFR 100 guidelines. Confirmatory analysis required. MSIV closure

Sect	Description	Event_Class	Diverse I&C system	Comments
				on flow may be required.
15.4.6	Control Rod Drop Accident	Accident	No diverse I&C required	No DPS action
15.4.7	Feedwater Line Break Outside Containment	Accident	L3 SCRAM Diverse ESF/ECCS actuation	DPS SCRAMs on low RPV water level. Worst case dose does not challenge 10 CFR 100 guidelines.
15.4.8	Failure of Small Line Carrying Primary Coolant Outside Containment	Accident	L3 SCRAM Diverse ESF/ECCS actuation	No DPS action unless level reaches L3. If level reaches (L1), DPS operates diverse ECCS. Containment line break bounded by larger breaks. Manual containment isolation available. Aberrant indication (radiation) available to alert the operator. Excess flow check valves should limit release of coolant. Dose within 10 CFR 100 guidelines.

Sect	Description	Event_Class	Diverse I&C system	Comments
15.4.9	RWCU/SDC System Line Failure Outside Containment	Accident	L3 SCRAM Diverse ESF/ECCS actuation Possible operator action required.	No DPS action unless level reaches L3. If level reaches L1, the DPS actuates the diverse ESF. May require operator action to remotely isolate or locally isolate based on conditions. Worst case dose may challenge 10 CFR 100 guidelines. (Possible inclusion of differential flow sensor for DPS leak isolation function)
15.4.10	Spent Fuel Cask Drop Accident	Accident	No diverse I&C required	No DPS action
15.4.11	COL Information			Not Applicable
Category 15.5 Special Event Evaluations (Event Category) Events not evaluated.				