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Subject: **Response to Portion of NRC Request for Additional Information Letter No. 100 Related to ESBWR Design Certification Application - Safety Analyses – RAI Numbers 15.3-26, 15.3-29 and 15.3-33**

The purpose of this letter is to submit the GE Hitachi Nuclear Energy (GEH) response to the U.S. Nuclear Regulatory Commission (NRC) Request for Additional Information (RAI) sent by NRC letter dated May 30, 2007. GEH responses to RAI Numbers 15.3-26, 15.3-29 and 15.3-33 are addressed in Enclosure 1. Enclosure 2 contains the associated DCD change markups.

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

Sincerely,

James C. Kinsey

James C. Kinsey
Vice President, ESBWR Licensing

DO68
NRO

Reference:

1. MFN 07-327, Letter from U.S. Nuclear Regulatory Commission to James C. Kinsey, GEH, *Request For Additional Information Letter No.100 Related To ESBWR Design Certification Application*, dated May 30, 2007

Enclosures:

1. Response to Portion of NRC Request for Additional Information Letter No. 100 Related to ESBWR Design Certification Application – Safety Analyses – RAI Numbers 15.3-26, 15.3-29 and 15.3-33
2. MFN 07-582 DCD Markups

cc:	AE Cubbage	USNRC (with enclosure)
	GB Stramback	GEH/San Jose (with enclosure)
	RE Brown	GEH/Wilmington (with enclosure)
	eDRF	0000-0074-6050R1

Enclosure 1

MFN 07-582

Response to Portion of NRC Request for Additional Information Letter No. 100 Related to ESBWR Design Certification Application

Safety Analyses

RAI Numbers 15.3-26, 15.3-29, 15.3-33

NRC RAI 15.3-26:

Since only the limiting events will be analyzed during the COL licensing phase, analyses of all Infrequent Events are required for design certification. DCD Tier 2 Table 15.3-1 needs to be revised to show the results of all the Infrequent Events. Events described in Sections 15.3.7 to 12 and 15.3.14 needs to be analyzed.

GEH Response:

Table 15.3-1 incorrectly implies that the results of all Infrequent Events are included in the table. The table only includes the results of TRACG calculations. However, all Infrequent Events are evaluated in DCD Tier 2. An additional table (Table 15.3-1b) will be added to show results of the remaining events.

DCD Impact:

DCD Tier 2, Table 15.3-1 and Section 15.3 will be included in DCD, Revision 5 as noted on the attached markup.

NRC RAI 15.3-29:

In DCD Tier 2, Rev 3, Section 15.3.3.1, Pressure Regulator Failure-Opening of All Turbine

Control and Bypass Valves, it is stated that "-----the event is considered as a limiting fault." The staff does not agree with this characterization of the event. This event is an Infrequent category event as referred in other parts of the DCD and should be characterized as an Infrequent Event not as limiting fault. Revision of the DCD is required.

GEH Response:

GEH agrees and the requested change will be made in DCD Tier 2, Revision 5.

DCD Impact:

DCD Tier 2, Section 15.3.3.1 will be included in DCD Tier 2, Revision 5 as noted on the attached markup.

NRC RAI 15.3-33:

Control Rod Withdrawal Error During Power Operation, DCD 15.3.9.4 states: "An evaluation of the barrier performance is not made for this event, because there is no postulated set of circumstances for which this event could occur."

The current version of the SRP requires that RWE be analyzed as an AOO. The additional system in the ESBWR is supposed to prevent RWE but the estimated frequency is considerably smaller than 1.0E-02, it is finite and accounts for ATLM failure. Other transients, an example being 15.3.6 with an estimated frequency in the same order of magnitude as this one were analyzed, and therefore the staff believes that the RWE transient should be analyzed. Provide your analysis of this event.

GEH Response:

A Rod Withdrawal Error (RWE) during power operations is categorized as an Infrequent Event (IE) based on the unlikely event that the Automated Thermal Limit Monitor (ALTM) fails in conjunction with either operator error or failure of the redundant PAS control logic (see DCD, Tier 2, Section 15A.3.13). However, the RWE event described in Subsection 15.3.9 of the DCD assumes that the ATLM functions properly. This event (with functioning ATLM) is more likely to occur and can be classified as an Anticipated Operational Occurrence (AOO). Regardless, the event is benign because the withdrawal of rods is stopped prior to any operating thermal limits being reached, and no additional analysis is required.

For the IE case (includes failure of the dual channel ATLM subsystem), a new RWE during power operations will be included in Section 15.3, the Analysis of Infrequent Events section, to correspond with the RWE-during-power-operations case described in DCD, Section 15A. As part of the Neutron Monitoring System, ESBWR has the Multi-Channel Rod Block Monitor (MRBM) subsystem. In the unlikely event that a RWE occurs and the ATLM fails, the MRBM provides control rod blocks to the Rod Control and Information System (RC&IS) to prevent core thermal limit violations.

The DCD will be revised to include two sets of RWE-during-power-operations: one for the AOO and the other for an IE that includes ATLM failure.

DCD Impact:

DCD Tier 2, Sections 15.0, 15.1, 15.2, and 15.3 changes will be included in DCD Tier 2, Revision 5, as noted on the attached markups. Sections 15.2 and 15.3 show the new or revised events, and Sections 15.0 and 15.1 shows the updated figures and tables that refer to these events.

Enclosure 2

MFN 07-582

DCD Markups

Table 15.0-2

ESBWR Abnormal Event Classifications

Abnormal Event	Event Classification	Relevant SRP(s)
Loss of Feedwater Heating	AOO	15.1.1 - 4
Closure of One Turbine Control Valve	AOO	15.2.1 – 5
Generator Load Rejection with Turbine Bypass	AOO	15.2.1 – 5
Generator Load Rejection with a Single Failure in the Turbine Bypass System	AOO*	15.2.1 – 5
Turbine Trip with Turbine Bypass	AOO	15.2.1 – 5
Turbine Trip with a Single Failure in the Turbine Bypass System	AOO*	15.2.1 – 5
Closure of One Main Steamline Isolation Valve	AOO	15.2.1 – 5
Closure of All Main Steamline Isolation Valves	AOO	15.2.1 – 5
Loss of Condenser Vacuum	AOO	15.2.1 – 5
Loss of Shutdown Cooling Function of RWCU/SDC	AOO	15.2.1 – 5
Control Rod Withdrawal Error During Power Operation	AOO	15.4-2
Inadvertent Isolation Condenser Initiation	AOO	15.1.1 – 4
Runout of One Feedwater Pump	AOO	15.1.1 – 4
Opening of One Turbine Control or Bypass Valve	AOO	15.1.1 – 4
Loss of Unit Auxiliary Transformer **	AOO	15.2.6
Loss of Grid Connection **	AOO	15.2.6
Loss of All Feedwater Flow	AOO	15.2.7
Loss of Feedwater Heating With Failure of Selected Control Rod Run-In	Infrequent Event	15.1.1 – 4
Feedwater Controller Failure – Maximum Demand	Infrequent Event	15.1.1 – 4
Pressure Regulator Failure - Opening of All Turbine Control and Bypass Valves	Infrequent Event	15.1.1 – 4
Pressure Regulator Failure – Closure of All Turbine Control and Bypass Valves	Infrequent Event	15.1.1 – 4
Generator Load Rejection with Total Turbine Bypass Failure	Infrequent Event	15.2.1-5
Turbine Trip with Total Turbine Bypass Failure	Infrequent Event	15.2.1-5

Table 15.0-2

ESBWR Abnormal Event Classifications

Abnormal Event	Event Classification	Relevant SRP(s)
Control Rod Withdrawal Error During Refueling	Infrequent Event	15.4.1
Control Rod Withdrawal Error During Startup	Infrequent Event	15.4.1
Control Rod Withdrawal Error During Power Operation with ATLM Failure	Infrequent Event	15.4.2
Fuel Assembly Loading Error, Mislocated Bundle	Infrequent Event	15.4.7
Fuel Assembly Loading Error, Misoriented Bundle	Infrequent Event	15.4.7
Inadvertent SDC Function Operation	Infrequent Event	15.4.9
Inadvertent Opening of a Safety Relief Valve	Infrequent Event	15.6.1
Inadvertent Opening of a Depressurization Valve	Infrequent Event	15.6.1, 15.6.5
Stuck Open Safety Relief Valve	Infrequent Event	15.6.1
Liquid-Containing Tank Failure	Infrequent Event	15.7.3
Fuel Handling Accident	Accident	15.7.4
LOCA Inside Containment	Accident	15.6.5 & 5a
Main Steamline Break Outside Containment	Accident	15.6.4
Control Rod Drop Accident	See Subsection 15.4.6	
Feedwater Line Break Outside Containment	Accident	15.3.5
Failure of Small Line Carrying Primary Coolant Outside Containment	Accident	15.6.2
RWCU/SDC System Line Failure Outside Containment	Accident	15.6.4, 15.6.5
Spent Fuel Cask Drop Accident	Accident	15.7.5
MSIV Closure With Flux Scram (Overpressure Protection)	Special Event	5.2.2
Shutdown Without Control Rods (i.e., SLC system shutdown capability)	Special Event	9.3.5
Shutdown from Outside Main Control Room	Special Event	7.5
Anticipated Transients Without Scram	Special Event	15.8
Station Blackout	Special Event	8.2 (and RG 1.155)
Safe Shutdown Fire	Special Event	9.5.1
Waste Gas System Leak or Failure	Special Event	11.3

* An AOO in combination with an additional SACF or SOE, as discussed in SRP 15.1 and SRP 15.2.

** Both covered by the Loss of Non-Emergency AC Power to Station Auxiliaries event.

Table 15.0-7

ESBWR Event Classifications and Radiological Acceptance Criteria

Event*	Accident Class**		Radiological Acceptance Criteria***					
	Infrequent Event	Accident	10 CFR 20, App. B, Table 2, Column 2	10 CFR 20.1301	GDC 19, 5 rem TEDE	2.5 rem TEDE	6.3 rem TEDE	25 rem TEDE
Loss of Feedwater Heating With Failure of Selected Control Rod Run-In	X				+	X		
Inadvertent SDC Function Operation	X				+	X		
Control Rod Withdrawal Error During Refueling	X				+	X		
Control Rod Withdrawal Error During Startup	X				+	X		
Control Rod Withdrawal Error During Power Operation with ATLM Failure	X				+	X		
Inadvertent Opening of a Depressurization Valve	X				+	X		
Inadvertent Opening of a Safety Relief Valve	X				+	X		
Stuck Open Safety Relief Valve	X				+	X		
Feedwater Controller Failure – Maximum Demand	X				+	X		
Pressure Regulator Failure - Opening of All Turbine Control and Bypass Valves	X				+	X		
Pressure Regulator Failure – Closure of All Turbine Control and Bypass Valves	X				+	X		
Generator Load Rejection with Total Turbine Bypass Failure	X				+	X		

Table 15.0-8

ESBWR Safety Analysis Codes

Safety Analysis	Analysis Code
Stability Evaluation (Chapter 4)	TRACG04[1]
Reactor Building Compartment Pressurization Analysis (Chapter 6)	CONTAIN 2.0
Loss of Feedwater Heating	TRACG04[1]
Closure of One Turbine Control Valve	TRACG04[1]
Generator Load Rejection with Turbine Bypass	TRACG04[1]
Generator Load Rejection with a Single Failure in the Turbine Bypass System	TRACG04[1]
Turbine Trip with Turbine Bypass	TRACG04[1]
Turbine Trip with a Single Failure in the Turbine Bypass System	TRACG04[1]
Closure of One Main Steamline Isolation Valve	TRACG04[1]
Closure of All Main Steamline Isolation Valves	TRACG04[1]
Loss of Condenser Vacuum	TRACG04[1]
Loss of Shutdown Cooling Function of RWCU/SDC	N/A
Control Rod Withdrawal Error During Power Operation	N/A
Inadvertent Isolation Condenser Initiation	TRACG04[1]
Runout of One Feedwater Pump	TRACG04[1]
Opening of One Turbine Control or Bypass Valve	TRACG04[1]
Loss of Non-Emergency AC Power to Station Auxiliaries	TRACG04[1]
Loss of All Feedwater Flow	TRACG04[1]
Loss of Feedwater Heating With Failure of Selected Control Rod Run-In	TRACG04[1] / RADTRAD 3.03
Feedwater Controller Failure – Maximum Demand	TRACG04[1]
Pressure Regulator Failure - Opening of All Turbine Control and Bypass Valves	TRACG04[1]
Pressure Regulator Failure – Closure of All Turbine Control and Bypass Valves	TRACG04[1]
Generator Load Rejection with Total Turbine Bypass Failure	TRACG04[1]
Turbine Trip with Total Turbine Bypass Failure	TRACG04[1]
Control Rod Withdrawal Error During Refueling	N/A
Control Rod Withdrawal Error During Startup	PANAC11
Control Rod Withdrawal Error During Power Operation with ATLM Failure	N/A

Table 15.1-3

ESBWR Events Associated With Operating Modes

Abnormal Event	Applicable Operating Mode(s)
Loss of Feedwater Heating	1 & 2
Closure of One Turbine Control Valve	1 & 2
Generator Load Rejection with Turbine Bypass	1 & 2
Generator Load Rejection with a Single Failure in the Turbine Bypass System	1 & 2
Turbine Trip with Turbine Bypass	1 & 2
Turbine Trip with a Single Failure in the Turbine Bypass System	1 & 2
Closure of One Main Steamline Isolation Valve	1 - 4
Closure of All Main Steamline Isolation Valves	1 - 4
Loss of Condenser Vacuum	1 - 4
Loss of Shutdown Cooling Function of RWCU/SDC System	2 - 6 & 6S
Control Rod Withdrawal Error During Power Operation	1 & 2
Inadvertent Isolation Condenser Initiation	1 - 6 & 6S
Runout of One Feedwater Pump	1 & 2
Opening of One Turbine Control or Bypass Valve	1 - 4
Loss of Non-Emergency AC Power to Station Auxiliaries	1 - 6 & 6S
Loss of All Feedwater Flow	1 & 2
Loss of Feedwater Heating With Failure of Selected Control Rod Run-In	1 & 2
Feedwater Controller Failure – Maximum Demand	1 & 2
Pressure Regulator Failure Opening of All Turbine Control and Bypass Valves	1 - 4
Pressure Regulator Failure – Closure of All Turbine Control and Bypass Valves	1 & 2
Generator Load Rejection with Total Turbine Bypass Failure	1 & 2
Turbine Trip with Total Turbine Bypass Failure	1 & 2
Control Rod Withdrawal Error During Refueling	6
Control Rod Withdrawal Error During Startup	2 - 5 & 6S

Table 15.1-3

ESBWR Events Associated With Operating Modes

Abnormal Event	Applicable Operating Mode(s)
Control Rod Withdrawal Error During Power Operation with ATLM Failure	1 & 2
Fuel Assembly Loading Error, Mislocated Bundle	1 - 6 & 6S
Fuel Assembly Loading Error, Misoriented Bundle	1 - 6 & 6S
Inadvertent SDC Function Operation	1 - 5
Inadvertent Opening of a Safety Relief Valve	1 - 6 & 6S
Inadvertent Opening of a Depressurization Valve	1 - 6 & 6S
Stuck Open Safety Relief Valve	1 - 6 & 6S
Liquid-Containing Tank Failure	1 - 6 & 6S
Fuel Handling Accident	1 - 6 & 6S
LOCA Inside Containment	1 - 6 & 6S
Main Steamline Break Outside Containment	1 - 5
Control Rod Drop Accident	1 - 6 & 6S
Feedwater Line Break Outside Containment	1 - 6 & 6S
Failure of Small Line Carrying Primary Coolant Outside Containment	1 - 6 & 6S
RWCU/SDC System Line Failure Outside Containment	1 - 6 & 6S
Spent Fuel Cask Drop Accident	1 - 6 & 6S
MSIV Closure With Flux Scram (Overpressure Protection)	1 & 2
Shutdown Without Control Rods (i.e., SLCS shutdown capability)	1 & 2 & 6S
Shutdown from Outside Main Control Room	1 & 2 & 6S
Anticipated Transients Without Scram	1 & 2
Station Blackout	1 & 2
Safe Shutdown Fire	1 & 2
Waste Gas System Leak or Failure	1 & 2

Table 15.1-5

NSOA System Event Matrix

	SRV – Safety Relief Mode	SRV – Power Actuated Mode (ADS)	DPV Actuation	ICS – MSIV Position	ICS – RPV High Dome Pressure (10-second delay)	ICS – RPV Low Water Level (L2 30-sec delay)	ICS – RPV Low Water Level (L1)	TBV Closure – Low-low condenser vacuum	ICS – Los of Power Generation Bus (Loss of Feedwater Flow)	TBV Initiation – TSV Closure	TBV Initiation – TCV Fast Closure	TSV Closure – RPV High Water Level (L8)	TSV Closure – Low Condenser Vacuum	TCV Fast Closure – Load Rejection	MSIV Closure – RPV Low Water Level (L2 w/30 sec)	MSIV Closure – RPV Low Water Level (L1)	MSIV Closure – Low Turbine Inlet/Main Streamline Pressure	MSIV Closure – Low Main Condenser Vacuum	MSIV Closure – High Steamline Flow	FW Pump Runback – L8	CRD Makeup Water – RPV Low Water Level (L2)	RWCU/SDC Operation	ATWS – Feedwater Flow Runback	ATWS – ADS Inhibition	SLCS – RPV Dome High Pressure - APRM not downscale	SLCS – DPV Open	SLCS – RPV Low Water Level (L2) - APRM not downscale	FAPCS – High Suppression Pool Temperature	SCRRI/SRI	GDCS	GDCS Equilizing Lines	High Radiation MCR Recirculation	Passive Containment Cooling PCCS
Loss of Feedwater Heating																													X				
Closure of One Turbine Control Valve																																	
Generator Load Rejection with Bypass											X																		X				
Generator Load Rejection with a Single Failure in the Turbine Bypass System				X	X	X					X				X		X																
Turbine Trip with Bypass										X																			X				
Turbine Trip with a Single Failure in the Turbine Bypass System				X	X	X				X					X		X																
Closure of One Main Steamline Isolation Valve				X															X														
Closure of All Main Steamline Isolation Valves				X																													

Table 15.1-5

NSOA System Event Matrix

	SRV – Safety Relief Mode	SRV – Power Actuated Mode (ADS)	DPV Actuation	ICS – MSIV Position	ICS – RPV High Dome Pressure (10-second delay)	ICS – RPV Low Water Level (L2 30-sec delay)	ICS – RPV Low Water Level (L1)	TBV Closure – Low-low condenser vacuum	ICS – Los of Power Generation Bus (Loss of Feedwater Flow)	TBV Initiation – TSV Closure	TBV Initiation – TCV Fast Closure	TSV Closure – RPV High Water Level (L8)	TSV Closure – Low Condenser Vacuum	TCV Fast Closure – Load Rejection	MSIV Closure – RPV Low Water Level (L2 w/30 sec)	MSIV Closure – RPV Low Water Level (L1)	MSIV Closure – Low Turbine Inlet/Main Steamline Pressure	MSIV Closure – Low Main Condenser Vacuum	MSIV Closure - High Steamline Flow	FW Pump Runback – L8	CRD Makeup Water – RPV Low Water Level (L2)	RWCU/SDC Operation	ATWS – Feedwater Flow Runback	ATWS – ADS Inhibition	SLCS – RPV Dome High Pressure - APRM not downscale	SLCS – DPV Open	SLCS – RPV Low Water Level (L2) - APRM not downscale	FAPCS – High Suppression Pool Temperature	SCRRI/SRI	GDCS	GDCS Equilizing Lines	High Radiation MCR Recirculation	Passive Containment Cooling PCCS
Loss of Condenser Vacuum				X				X					X					X															
Loss of Shutdown Cooling Function of RWCU/SDC System					X	X																								X			
<u>Control Rod Withdrawal Error During Power Operation</u>																																	
Inadvertent Isolation Condenser Initiation																																	
Runout of One Feedwater Pump																																	
Opening of One Turbine Control or Bypass Valve																																	
Loss of Non-Emergency AC Power to Station Auxiliaries								X	X		X			X	X			X															
Loss of All Feedwater Flow									X						X																		

Table 15.1-5

NSOA System Event Matrix

	SRV – Safety Relief Mode	SRV – Power Actuated Mode (ADS)	DPV Actuation	ICS – MSIV Position	ICS – RPV High Dome Pressure (10-second delay)	ICS – RPV Low Water Level (L2 30-sec delay)	ICS – RPV Low Water Level (L1)	TBV Closure – Low-low condenser vacuum	ICS – Los of Power Generation Bus (Loss of Feedwater Flow)	TBV Initiation – TSV Closure	TBV Initiation – TCV Fast Closure	TSV Closure – RPV High Water Level (L8)	TSV Closure – Low Condenser Vacuum	TCV Fast Closure – Load Rejection	MSIV Closure – RPV Low Water Level (L2 w/30 sec)	MSIV Closure – RPV Low Water Level (L1)	MSIV Closure – Low Turbine Inlet/Main Steamline Pressure	MSIV Closure – Low Main Condenser Vacuum	MSIV Closure - High Steamline Flow	FW Pump Runback - L8	CRD Makeup Water – RPV Low Water Level (L2)	RWCU/SDC Operation	ATWS – Feedwater Flow Runback	ATWS – ADS Inhibition	SLCS – RPV Dome High Pressure - APRM not downscale	SLCS – DPV Open	SLCS – RPV Low Water Level (L2) - APRM not downscale	FAPCS – High Suppression Pool Temperature	SCRRI/SRI	GDCS	GDCS Equilizing Lines	High Radiation MCR Recirculation	Passive Containment Cooling PCCS
Loss of Feedwater Heating With Failure of SCRRI																																	
Feedwater Controller Failure – Maximum Demand				X	X	X				X		X			X		X																
Pressure Regulator Failure Opening of All Turbine Control and Bypass Valves				X													X																
Pressure Regulator Failure – Closure of All Turbine Control and Bypass Valves				X	X	X									X		X																
Generator Load Rejection with Total Turbine Bypass Failure				X	X	X								X	X		X																
Turbine Trip with Total Turbine Bypass Failure				X	X	X									X		X																

Table 15.1-5

NSOA System Event Matrix

	SRV - Safety Relief Mode	SRV - Power Actuated Mode (ADS)	DPV Actuation	ICS - MSIV Position	ICS - RPV High Dome Pressure (10-second delay)	ICS - RPV Low Water Level (L2 30-sec delay)	ICS - RPV Low Water Level (L1)	TBV Closure - Low-low condenser vacuum	ICS - Los of Power Generation Bus (Loss of Feedwater Flow)	TBV Initiation - TSV Closure	TBV Initiation - TCV Fast Closure	TSV Closure - RPV High Water Level (L8)	TSV Closure - Low Condenser Vacuum	TCV Fast Closure - Load Rejection	MSIV Closure - RPV Low Water Level (L2 w/30 sec)	MSIV Closure - RPV Low Water Level (L1)	MSIV Closure - Low Turbine Inlet/Main Steamline Pressure	MSIV Closure - Low Main Condenser Vacuum	MSIV Closure - High Steamline Flow	FW Pump Runback - L8	CRD Makeup Water - RPV Low Water Level (L2)	RWCU/SDC Operation	ATWS - Feedwater Flow Runback	ATWS - ADS Inhibition	SLCS - RPV Dome High Pressure - APRM not downscale	SLCS - DPV Open	SLCS - RPV Low Water Level (L2) - APRM not downscale	FAPCS - High Suppression Pool Temperature	SCRRI/SRI	GDCS	GDCS Equilizing Lines	High Radiation MCR Recirculation	Passive Containment Cooling PCCS
Control Rod Withdrawal Error During Refueling																																	
Control Rod Withdrawal Error During Startup																																	
Control Rod Withdrawal Error During Power Operation with ATLM Failure																																	
Fuel Assembly Loading Error, Mislocated Bundle																																	
Fuel Assembly Loading Error, Misoriented Bundle																																	
Inadvertent SDC Function Operation																																	
Inadvertent Opening of a Safety Relief Valve																																	
Inadvertent Opening of a DPV		X	X																											X			X

Table 15.1-5

NSOA System Event Matrix

	SRV – Safety Relief Mode	SRV – Power Actuated Mode (ADS)	DPV Actuation	ICS – MSIV Position	ICS – RPV High Dome Pressure (10-second delay)	ICS – RPV Low Water Level (L2 30-sec delay)	ICS – RPV Low Water Level (L1)	TBV Closure – Low-low condenser vacuum	ICS – Los of Power Generation Bus (Loss of Feedwater Flow)	TBV Initiation – TSV Closure	TBV Initiation – TCV Fast Closure	TSV Closure – RPV High Water Level (L8)	TSV Closure – Low Condenser Vacuum	TCV Fast Closure – Load Rejection	MSIV Closure - RPV Low Water Level (L2 w/30 sec)	MSIV Closure - RPV Low Water Level (L1)	MSIV Closure - Low Turbine Inlet/Main Steamline Pressure	MSIV Closure - Low Main Condenser Vacuum	MSIV Closure - High Steamline Flow	FW Pump Runback – L8	CRD Makeup Water – RPV Low Water Level (L2)	RWCU/SDC Operation	ATWS – Feedwater Flow Runback	ATWS – ADS Inhibition	SLCS – RPV Dome High Pressure - APRM not downscale	SLCS - DPV Open	SLCS - RPV Low Water Level (L2) - APRM not downscale	FAPCS - High Suppression Pool Temperature	SCRRI/SRI	GDCS	GDCS Equilizing Lines	High Radiation MCR Recirculation	Passive Containment Cooling PCCS
Stuck Open Safety Relief Valve		X	X	X													X													X			X
Liquid-Containing Tank Failure																																	
Fuel Handling Accident																																	
LOCA Inside Containment		X	X	X	X	X	X		X						X	X										X				X	X	X	X
Main Steamline Break Outside Containment		X	X	X	X	X	X		X						X	X	X		X							X				X	X		
Control Rod Drop Accident																																	
Feedwater Line Break Outside Containment		X	X	X	X	X	X		X						X	X										X				X	X		X
Failure of Small Line Carrying Primary Coolant Outside Containment		X	X	X	X	X	X		X						X	X										X				X	X		X
RWCU/SDC System Line Failure Outside Containment		X	X	X	X	X	X		X						X	X										X				X	X		X
Spent Fuel Cask Drop Accident																																	

Table 15.1-5

NSOA System Event Matrix

	SRV – Safety Relief Mode	SRV – Power Actuated Mode (ADS)	DPV Actuation	ICS – MSIV Position	ICS – RPV High Dome Pressure (10-second delay)	ICS – RPV Low Water Level (L2 30-sec delay)	ICS – RPV Low Water Level (L1)	TBV Closure – Low-low condenser vacuum	ICS – Los of Power Generation Bus (Loss of Feedwater Flow)	TBV Initiation – TSV Closure	TBV Initiation – TCV Fast Closure	TSV Closure – RPV High Water Level (L8)	TSV Closure – Low Condenser Vacuum	TCV Fast Closure – Load Rejection	MSIV Closure – RPV Low Water Level (L2 w/30 sec)	MSIV Closure – RPV Low Water Level (L1)	MSIV Closure – Low Turbine Inlet/Main Steamline Pressure	MSIV Closure – Low Main Condenser Vacuum	MSIV Closure - High Steamline Flow	FW Pump Runback – L8	CRD Makeup Water – RPV Low Water Level (L2)	RWCU/SDC Operation	ATWS – Feedwater Flow Runback	ATWS – ADS Inhibition	SLCS – RPV Dome High Pressure - APRM not downscale	SLCS – DPV Open	SLCS – RPV Low Water Level (L2) - APRM not downscale	FAPCS - High Suppression Pool Temperature	SCRRI/SRI	GDCS	GDCS Equilizing Lines	High Radiation MCR Recirculation	Passive Containment Cooling PCCS
MSIV Closure With Flux Scram (Overpressure Protection)	X																																
Shutdown Without Control Rods (i.e., SLCS shutdown capability)																																	
Shutdown from Outside Main Control Room				X		X	X								X	X																	
Anticipated Transients Without Scram	X			X	X	X	X														X		X	X	X		X	X					
Station Blackout		X	X						X						X	X														X	X		X
Safe Shutdown Fire				X		X									X						X												
Waste Gas System Leak or Failure																																	

Table 15.1-6

NSOA Automatic Instrument Trip/Event Matrix

	Scram – APRM High Neutron Flux	Scram – APRM High Simulated Thermal Power	Scram – RPV Low Water Level (L3)	Scram – RPV High Water Level (L8)	Scram – Loss of Power on Four Power Generation Buses	Scram – MSIV Position	Scram – High Suppression Pool Temperature	Scram – TSV Closure (with insufficient bypass available)	Scram – TCV Fast Closure (with insufficient bypass available)	Scram – Low Condenser Vacuum	Scram – (Loss of Power Generation Bus) – Loss of Feedwater Flow	Scram – SRNM Period	Scram – High Drywell Pressure	Rod Block – SRNM Period or ALTM Parameter Exceeded or MRBM Parameter Exceeded
Loss of Feedwater Heating														
Closure of One Turbine Control Valve														
Generator Load Rejection with Bypass														
Generator Load Rejection with a Single Failure in the Turbine Bypass System									X					
Turbine Trip with Bypass														
Turbine Trip with a Single Failure in the Turbine Bypass System								X						
Closure of One Main Steamline Isolation Valve						X								

Table 15.1-6

NSOA Automatic Instrument Trip/Event Matrix

	Scram – APRM High Neutron Flux	Scram – APRM High Simulated Thermal Power	Scram – RPV Low Water Level (L3)	Scram – RPV High Water Level (L8)	Scram – Loss of Power on Four Power Generation Busses	Scram – MSIV Position	Scram – High Suppression Pool Temperature	Scram – TSV Closure (with insufficient bypass available)	Scram – TCV Fast Closure (with insufficient bypass available)	Scram – Low Condenser Vacuum	Scram – (Loss of Power Generation Bus) – Loss of Feedwater Flow	Scram – SRNM Period	Scram – High Drywell Pressure	Rod Block – SRNM Period or ALTM Parameter Exceeded or MRBM Parameter Exceeded
Closure of All Main Steamline Isolation Valves						X								
Loss of Condenser Vacuum										X				
Loss of Shutdown Cooling Function of RWCU/SDC System														
Control Rod Withdrawal Error During Power Operation														X
Inadvertent Isolation Condenser Initiation														
Runout of One Feedwater Pump														
Opening of One Turbine Control or Bypass Valve														

Table 15.1-6

NSOA Automatic Instrument Trip/Event Matrix

	Scram – APRM High Neutron Flux	Scram – APRM High Simulated Thermal Power	Scram – RPV Low Water Level (L3)	Scram – RPV High Water Level (L8)	Scram – Loss of Power on Four Power Generation Buses	Scram – MSIV Position	Scram – High Suppression Pool Temperature	Scram – TSV Closure (with insufficient bypass available)	Scram – TCV Fast Closure (with insufficient bypass available)	Scram – Low Condenser Vacuum	Scram – (Loss of Power Generation Bus) – Loss of Feedwater Flow	Scram – SRNM Period	Scram – High Drywell Pressure	Rod Block – SRNM Period or ALTM Parameter Exceeded or MRBM Parameter Exceeded
Loss of Non-Emergency AC Power to Station Auxiliaries											X			
Loss of All Feedwater Flow											X			
Loss of Feedwater Heating With Failure of SCRRI		No credit												
Feedwater Controller Failure – Maximum Demand				X										
Pressure Regulator Failure Opening of All Turbine Control and Bypass Valves						X								

Table 15.1-6

NSOA Automatic Instrument Trip/Event Matrix

	Scram – APRM High Neutron Flux	Scram – APRM High Simulated Thermal Power	Scram – RPV Low Water Level (L3)	Scram – RPV High Water Level (L8)	Scram – Loss of Power on Four Power Generation Buses	Scram – MSIV Position	Scram – High Suppression Pool Temperature	Scram – TSV Closure (with insufficient bypass available)	Scram – TCV Fast Closure (with insufficient bypass available)	Scram – Low Condenser Vacuum	Scram – (Loss of Power Generation Bus) – Loss of Feedwater Flow	Scram – SRNM Period	Scram – High Drywell Pressure	Rod Block – SRNM Period or ALTM Parameter Exceeded or MRBM Parameter Exceeded
Pressure Regulator Failure – Closure of All Turbine Control and Bypass Valves	X													
Generator Load Rejection with Total Turbine Bypass Failure									X					
Turbine Trip with Total Turbine Bypass Failure								X						
Control Rod Withdrawal Error During Refueling														
Control Rod Withdrawal Error During Startup												X		X
Control Rod Withdrawal Error During Power Operation with ATLM Failure														X

Table 15.1-7

ESBWR NSOA Events

NSOA Event	Subsection Describing Event	Relevant Event Diagram
Loss of Feedwater Heating	15.2.1.1	15.1-2
Closure of One Turbine Control Valve	15.2.2.1	15.1-3
Generator Load Rejection with Turbine Bypass	15.2.2.2	15.1-4
Generator Load Rejection with a Single Failure in the Turbine Bypass System	15.2.2.3	15.1-5
Turbine Trip with Turbine Bypass	15.2.2.4	15.1-6
Turbine Trip with a Single Failure in the Turbine Bypass System	15.2.2.5	15.1-7
Closure of One Main Steamline Isolation Valve	15.2.2.6	15.1-8
Closure of All Main Steamline Isolation Valves	15.2.2.7	15.1-9
Loss of Condenser Vacuum	15.2.2.8	15.1-10
Loss of Shutdown Cooling Function of RWCU/SDC System	15.2.2.9	15.1-11
Control Rod Withdrawal Error During Power Operation	15.2.3.1	15.1-12
Inadvertent Isolation Condenser Initiation	15.2.4.1	15.1-~~12~~13
Runout of One Feedwater Pump	15.2.4.2	15.1-~~13~~14
Opening of One Turbine Control or Bypass Valve	15.2.5.1	15.1-~~14~~15
Loss of Non-Emergency AC Power to Station Auxiliaries	15.2.5.2	15.1-~~15~~16
Loss of All Feedwater Flow	15.2.5.3	15.1-~~16~~17
Loss of Feedwater Heating With Failure of Selected Control Rod Run-In	15.3.1	15.1-~~17~~18
Feedwater Controller Failure – Maximum Demand	15.3.2	15.1-~~18~~19
Pressure Regulator Failure Opening of All Turbine Control and Bypass Valves	15.3.3	15.1-~~19~~20
Pressure Regulator Failure – Closure of All Turbine Control and Bypass Valves	15.3.4	15.1-~~20~~21
Generator Load Rejection with Total Turbine Bypass Failure	15.3.5	15.1-~~21~~22
Turbine Trip with Total Turbine Bypass Failure	15.3.6	15.1-~~22~~23
Control Rod Withdrawal Error During Refueling	15.3.7	15.1-~~23~~24

Table 15.1-7

ESBWR NSOA Events

NSOA Event	Subsection Describing Event	Relevant Event Diagram
Control Rod Withdrawal Error During Startup	15.3.8	15.1-~~24~~25
Control Rod Withdrawal Error During Power Operation with ATLM Failure	15.3.9	15.1-~~25~~26
Fuel Assembly Loading Error, Mislocated Bundle	15.3.10	15.1-~~26~~27
Fuel Assembly Loading Error, Misoriented Bundle	15.3.11	15.1-~~27~~28
Inadvertent SDC Function Operation	15.3.12	15.1-~~28~~29
Inadvertent Opening of a Safety Relief Valve	15.3.13	15.1-~~29~~30
Inadvertent Opening of a Depressurization Valve	15.3.14	15.1-~~30~~31
Stuck Open Safety Relief Valve	15.3.15	15.1-~~31~~32
Liquid-Containing Tank Failure	15.3.16	15.1-~~32~~33
Fuel Handling Accident	15.4.1	15.1-~~33~~34
LOCA Inside Containment	15.4.2, 15.4.3, 15.4.4	15.1-~~34~~35
Main Steamline Break Outside Containment	15.4.5	15.1-~~35~~36
Control Rod Drop Accident	15.4.6	15.1-~~36~~37
Feedwater Line Break Outside Containment	15.4.7	15.1-~~37~~38
Failure of Small Line Carrying Primary Coolant Outside Containment	15.4.8	15.1-~~38~~39
RWCU/SDC System Line Failure Outside Containment	15.4.9	15.1-~~39~~40
Spent Fuel Cask Drop Accident	15.4.10	15.1-~~40~~41
MSIV Closure with Flux Scram (Overpressure Protection)	15.5.1	15.1-~~41~~42
Shutdown Without Control Rods (i.e., SLCS shutdown capability)	15.5.2	15.1-~~42~~43
Shutdown from Outside Main Control Room	15.5.3	15.1-~~43~~44
Anticipated Transients Without Scram	15.5.4	15.1-~~44~~45
Station Blackout	15.5.5	15.1-~~45~~46
Safe Shutdown Fire	15.5.6	15.1-~~46~~47
Waste Gas System Leak or Failure	15.5.7	15.1-~~47~~48

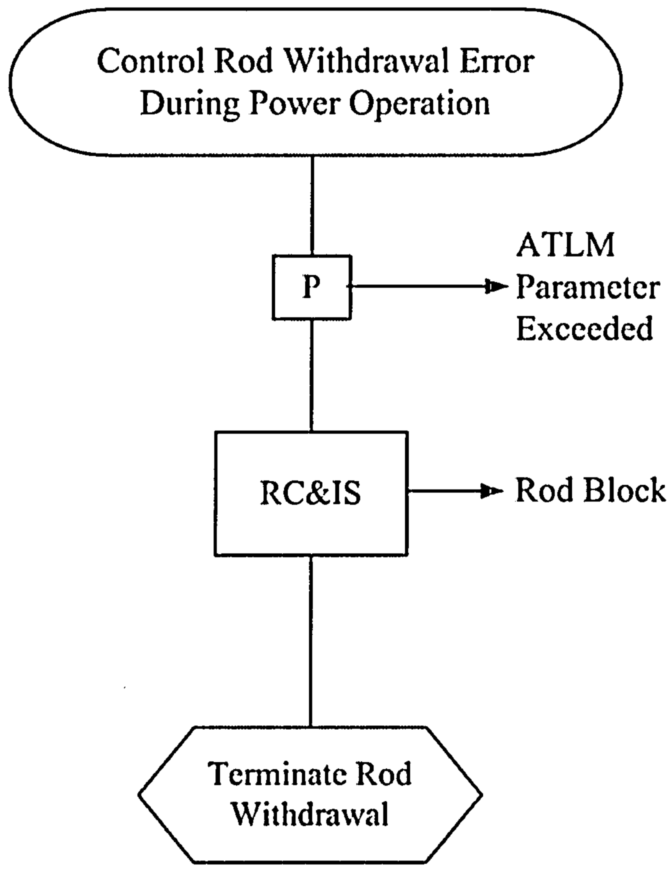

Figure 15.1-12. Event Diagram – Control Rod Withdrawal Error During Power Operation

Figure 15.1-~~12~~13. Event Diagram – Inadvertent Isolation Condenser Initiation

Figure 15.1-~~13~~14. Event Diagram – Runout of One Feedwater Pump

Figure 15.1-~~14~~15. Event Diagram – Opening of One Turbine Control or Bypass Valve

Figure 15.1-~~15~~16. Event Diagram – Loss of Non-Emergency AC Power to Station Auxiliaries

Figure 15.1-~~16~~17. Event Diagram – Loss of All Feedwater Flow

Figure 15.1-~~17~~18. Event Diagram – Loss of Feedwater Heating With Failure of Selected Control Rod Run-In

Figure 15.1-~~18~~19. Event Diagram – Feedwater Controller Failure – Maximum Demand

Figure 15.1-~~19~~20. Event Diagram – Pressure Regulator Failure – Opening of All Turbine Control and Bypass Valves

Figure 15.1-~~20~~21. Event Diagram – Pressure Regulator Failure – Closure of All Turbine Control and Bypass Valves

Figure 15.1-~~21~~22. Event Diagram – Generator Load Rejection with Total Bypass Failure

Figure 15.1-~~22~~23. Event Diagram – Turbine Trip with Total Bypass Failure

Figure 15.1-~~23~~24. Event Diagram – Control Rod Withdrawal Error During Refueling

Figure 15.1-~~24~~25. Event Diagram – Control Rod Withdrawal Error During Startup

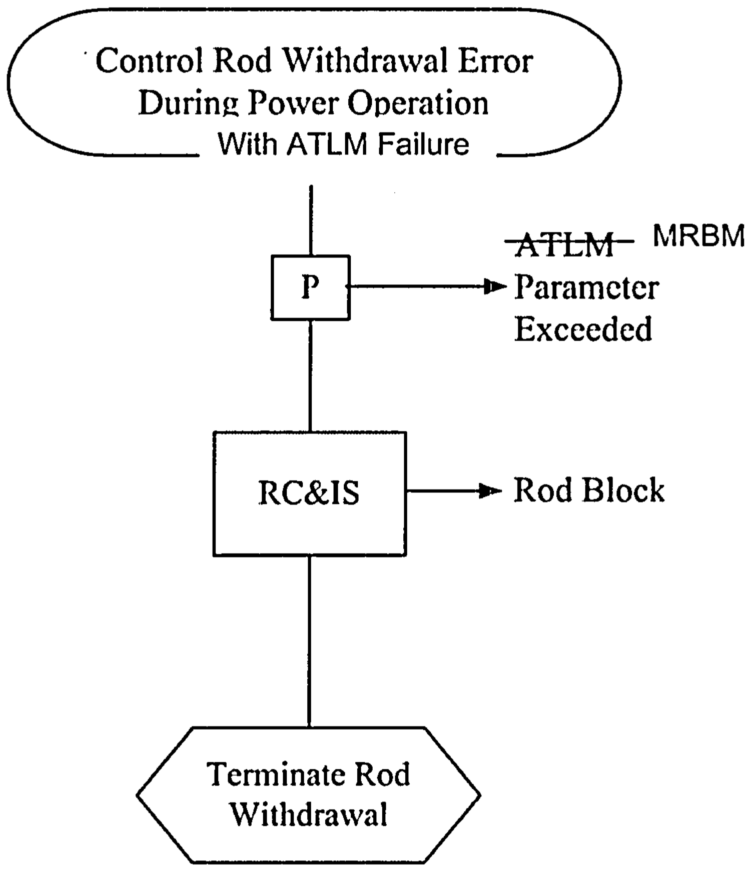

Figure 15.1-~~25~~26. Event Diagram – Control Rod Withdrawal Error During Power Operation with ATLM Failure

Figure 15.1-~~26~~27. Event Diagram – Fuel Assembly Loading Error – Mislocated Bundle

Figure 15.1-~~27~~28. Event Diagram – Fuel Assembly Loading Error – Misoriented Bundle

Figure 15.1-~~28~~29. Event Diagram – Inadvertent SDC Function Operation

Figure 15.1-~~29~~30. Event Diagram – Inadvertent Opening of a Safety Relief Valve

Figure 15.1-~~30~~31. Event Diagram – Inadvertent Opening of a Depressurization Valve

Figure 15.1-~~31~~32. Event Diagram – Stuck Open Safety Relief Valve

Figure 15.1-~~32~~33. Event Diagram – Liquid-Containing Tank Failure

Figure 15.1-~~33~~34. Event Diagram – Fuel Handling Accident

Figure 15.1-~~34a~~35a. Event Diagram – Loss-of-Coolant Accident Inside Containment

Figure 15.1-~~34b~~35b. Event Diagram – Loss-of-Coolant Accident Inside Containment

Figure 15.1-~~35a~~36a. Event Diagram – Main Steamline Break Outside Containment

Figure 15.1-~~35b~~36b. Event Diagram – Main Steamline Break Outside Containment

Figure 15.1-~~36~~37. Event Diagram – Control Rod Drop Accident

Figure 15.1-~~37a~~38a. Event Diagram – Feedwater Line Break Outside Containment

Figure 15.1-~~37b~~38b. Event Diagram – Feedwater Line Break Outside Containment

Figure 15.1-~~38a~~39a. Event Diagram – Failure of Small Line Carrying Primary Coolant Outside Containment

Figure 15.1-~~38b~~39b. Event Diagram – Failure of Small Line Carrying Primary Coolant Outside Containment

Figure 15.1-~~39a~~40a. Event Diagram – RWCU/SDC System Line Failure Outside Containment

Figure 15.1-~~39b~~40b. Event Diagram – RWCU/SDC System Line Failure Outside Containment

Figure 15.1-~~40~~41. Event Diagram – Spent Fuel Cask Drop Accident

Figure 15.1-~~41~~42. Event Diagram – MSIV Closure With Flux Scram (Overpressure Protection)

Figure 15.1-~~42~~43. Event Diagram – Shutdown Without Control Rods (Standby Liquid Control System Capability)

Figure 15.1-~~43~~44. Event Diagram – Shutdown from Outside Main Control Room

Figure 15.1-~~44a~~45a. Event Diagram – Anticipated Transients Without Scram

Figure 15.1-~~44b~~45b. Event Diagram – Anticipated Transients Without Scram

Figure 15.1-~~45a~~46a. Event Diagram – Station Blackout

Figure 15.1-~~45b~~46b. Event Diagram – Station Blackout

Figure 15.1-~~46~~47. Event Diagram – Safe Shutdown Fire

Figure 15.1-~~47~~48. Event Diagram – Waste Gas System Leak or Failure

~~15.3.9~~ *15.2.3.1 Control Rod Withdrawal Error During Power Operation*

~~15.3.9.1~~ 15.2.3.1.1 Identification of Causes

In ESBWR, the Automated Thermal Limit Monitor (ATLM) subsystem performs the associated rod block monitoring function. The ATLM is a dual channel subsystem of the RC&IS. Each ATLM channel has two independent thermal limit monitoring functions. One function monitors the Minimum Critical Power Ratio (MCPR) limit and protects the operating limit MCPR, another function monitors the Maximum Linear Heat Generation Rate (MLHGR) limit and protects the operating limit of the MLHGR. The rod block algorithm and setpoint of the ATLM are based on actual on-line core thermal limit information. If any operating limit protection setpoint limit is reached, such as due to control rod withdrawal, control rod withdrawal permissive is removed. Detailed description of the ATLM subsystem is presented in Chapter 7.

The causes of a potential control rod withdrawal error are either a procedural error by the operator in which a single control rod or a gang of control rods is withdrawn continuously, or a malfunction of the automated rod withdrawal sequence control logic during automated operation in which a gang of control rods is withdrawn continuously. In either case, the operating thermal limits rod block function blocks any further rod withdrawal when the operating thermal limit is reached. That is, the withdrawal of rods is stopped before the operating thermal limit is reached. Because there is no operating limit violation due to the preventive function of the ATLM, there is no continuous rod withdrawal error transient event.

~~The frequency of this event is evaluated in Subsection 15A.3.13.~~

~~15.3.9.2~~ 15.2.3.1.2 Sequence of Events and System Operation

A single control rod or a gang of control rods is withdrawn continuously due to an operator error or a malfunction of the automated rod withdrawal sequence control logic~~,~~. The ATLM operating thermal limit protection function of either the MCPR or MLHGR protection algorithms stops further control rod withdrawal when either operating limit is reached. As there are no operating limit violations, there is no basis for occurrence of the continuous control rod withdrawal error event in the power range.

No operator action is required to preclude this event, because the plant design as described above prevents its occurrence.

~~15.3.9.3~~ 15.2.3.1.3 Core and System Performance

The performance of the ATLM subsystem of the RC&IS prevents the control rod withdrawal error event from occurring. The core and system performance are not affected by such an operator error or control logic malfunction. ~~There is no need to analyze this event.~~

~~15.3.9.4~~ 15.2.3.1.4 Barrier Performance

The ATLM prevents pressure operating limits from being reached and fuel rods from entering transition boiling. ~~An evaluation of the barrier performance is not made for this~~

event, because there is no postulated set of circumstances for which this event could occur.

15.3.9.5 15.2.3.1.5 **Radiological Consequences**

Because this event does not result in any fuel failures or any release of primary coolant to the environment, there is no radiological consequence associated with this event. An evaluation of the radiological consequences is not required for this event, because no radioactive material is released from the fuel.

15.3 ANALYSIS OF INFREQUENT EVENTS

Appendix 15A provides a determination of event frequency to categorize AOOs as defined in 10 CFR 50 Appendix A, or Infrequent Events. Section 15.0 describes the licensing basis for this categorization.

The input parameters, initial conditions, and assumptions in Tables 15.2-1, 2 and 3 are applied in the TRACG calculations, based on the equilibrium core in Reference 15.3-4, for the Infrequent Events addressed in Subsections 15.3.1 through 15.3.6 and Subsections 15.3.13 and 15.3.15. The summary of the Infrequent Events analyses is given in Tables 15.3-1a and 15.3-1b.

The results of the system response analyses for the initial core design documented in Reference 15.3-5 are provided in Reference 15.3-6. System response analyses bounding operation in the feedwater temperature operating domain is documented in Reference 15.3-7.

15.3.1 Loss Of Feedwater Heating With Failure of Selected Control Rod Run-In

15.3.1.1 Identification of Causes

The loss of a feedwater (FW) heater can occur in at least two ways:

- Steam extraction line to heater is closed; or
- FW is bypassed around heater.

The first case produces a gradual FW cooling. In the second case, the FW bypasses the heater and no FW heating occurs. In either case, the reactor vessel receives colder FW. The maximum number of FW heaters that can be tripped or bypassed by a single event represents the most severe event for analysis considerations.

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) FW heating.

This event conservatively assumes the loss of FW heating as shown on Table 15.2-1, causing an increase in core inlet subcooling and core power due to the negative void reactivity coefficient. However, the power increase is slow.

The Feedwater Control System (FWCS) logic is provided in Subsection 7.7.3, and includes logic provided to mitigate the effects of a loss of FW heating capability. The FWCS is constantly monitoring the actual FW temperature and comparing it with a reference temperature. When a loss of FW heating is detected [i.e., when the difference between the actual and reference temperatures exceeds a ΔT setpoint], the FWCS sends an alarm to the operator and sends a signal to the Rod Control and Information System (RC&IS) to initiate the Selected Control Rods Run-In and Select Rod Insertion (SCRRI/SRI) function to automatically reduce the reactor power and avoid a scram. However, for this event, SCRRI/SRI is assumed to fail and reactor scram on high simulated thermal power is not credited due to uncertainties. Therefore a new steady state is reached.

The frequency of this event is evaluated in Subsection 15A.3.6.

15.3.2.3.2 Results

The simulated runout of all FW pumps is shown in Figure 15.3-2. The high water level turbine trip and FW pump runback are initiated early in the event as shown in Table 15.3-3. Scram occurs and limits the neutron flux peak and fuel thermal transient so that no fuel damage occurs. The Turbine Bypass System (TBS) opens to limit peak pressure in the steamline near the SRVs and the peak pressure at the bottom of the vessel. The peak pressure in the bottom of the vessel remains below the ASME code upset limit. Peak steam line pressure near the SRVs remains below the setpoint of the SRVs.

The water level gradually drops, and can reach the Low Level reference point (Level 2), activating the IC system for long-term level control and the HP_CRD system to permit a slow recovery to the desired level.

This event is reanalyzed for each specific initial core configuration.

15.3.2.4 Barrier Performance

As previously noted, the effect of this event does not result in any temperature or pressure transient in excess of the criteria for which the pressure vessel or containment are designed. Therefore, these barriers maintain their integrity and function as designed. In this event, there are no fuel rods that enter transition boiling.

15.3.2.5 Radiological Consequences

Because this event does not result in any fuel failures or any release of primary coolant to the environment, there is no radiological consequence associated with this event.

15.3.3 Pressure Regulator Failure – Opening of All Turbine Control and Bypass Valves

15.3.3.1 Identification of Causes

The ESBWR Steam Bypass and Pressure Control (SB&PC) system uses a triplicated digital control system. The SB&PC system controls the turbine control valves and turbine bypass valves to maintain reactor pressure. As presented in Subsection 15.2.4.2, no credible single failure in the control system results in a maximum demand to all actuators for all turbine control valves and bypass valves. A voter or actuator failure may result in an inadvertent opening of one turbine control valve or one turbine bypass valve. In this case, the SB&PC system senses the pressure change and commands the remaining control valves to close, and thereby automatically mitigates the transient and maintains reactor power and pressure.

As presented in Subsection 15.2.4.2, multiple failures might cause the SB&PC system to erroneously issue a maximum demand to all turbine control valves and bypass valves. Should this occur, all turbine control valves and bypass valves could be fully opened. However, the probability of this event is extremely low, and thus, the event is considered as an infrequent event~~ limiting fault~~. The frequency of this event is evaluated in Subsection 15A.3.1.

15.3.8.4 Barrier Performance

An evaluation of the barrier performance is not made for this event, because there is no fuel damage in this event and only with mild change in gross core characteristics.

15.3.8.4.1 Radiological Consequences

An evaluation of the radiological consequences is not required for this event, because no radioactive material is released from the fuel.

15.3.8.4.2 COL Action Item (Deleted)

15.3.9 Control Rod Withdrawal Error During Power Operation with ATLM Failure

15.3.9.1 Identification of Causes

In ESBWR, the Automated Thermal Limit Monitor (ATLM) subsystem performs the associated rod block monitoring function. The ATLM is a dual channel subsystem of the RC&IS. Each ATLM channel has two independent thermal limit monitoring functions. One function monitors the Minimum Critical Power Ratio (MCPR) limit and protects the operating limit MCPR, another function monitors the Maximum Linear Heat Generation Rate (MLHGR) limit and protects the operating limit of the MLHGR. The rod block algorithm and setpoint of the ATLM are based on actual on-line core thermal limit information. If any operating limit protection setpoint limit is reached, such as due to control rod withdrawal, control rod withdrawal permissive is removed. Detailed description of the ATLM subsystem is presented in Chapter 7.

The causes of a potential control rod withdrawal error are either a procedural error by the operator in which a single control rod or a gang of control rods is withdrawn continuously, or a malfunction of the automated rod withdrawal sequence control logic during automated operation in which a gang of control rods is withdrawn continuously.

If the thermal limit monitoring function of either of the two ATLM channels is operable, when the potential control rod withdrawal error event occurs, the control rod withdrawal permissive is removed (i.e. a rod withdrawal block is initiated) when the potential violation of thermal limits is detected and further rod withdrawal is stopped automatically. Each ATLM channel also has continuous self-diagnostics monitoring that detects if the ATLM channel has failed. If ATLM channel failure (of an unbypassed ATLM channel) is detected, this also initiates a rod withdrawal block condition for that channel. It is possible to bypass the one failed ATLM channel, but when an ATLM channel is bypassed, automatic rod movement is not possible (i.e. both ATLM channels must be operable and not bypassed to allow automatic rod movements). Operator initiated rod withdrawals would still be possible with a failed ATLM channel in the bypass condition, but the other operable ATLM channel would still monitor for protection of thermal limits and initiate the rod withdrawal block if needed. If one ATLM channel is bypassed and the failure of the other ATLM channel is detected, the rod withdrawal block is activated and even manual rod withdrawals are prevented in this situation. Therefore, a credible single failure cannot result in loss of the combined ATLM channels functionality to prevent thermal limit violations. However, for conservative analytical purposes, multiple failures of the ATLM channels are assumed such that neither ATLM channel prevents the continued withdrawal of the selected control rod gang or selected individual control rod during this potential control rod withdrawal error event during power range operation.

In either case, the operating thermal limits rod block function blocks any further rod withdrawal when the operating thermal limit is reached. That is, the withdrawal of rods is stopped before the operating thermal limit is reached. Because there is no operating thermal limit violation due to the preventive function of the ATLMMRBM, there is no further continual rod withdrawal error transient event.

The frequency of this event is evaluated in Subsection 15A.3.13.

15.3.9.2 Sequence of Events and System Operation

A single control rod or a gang of control rods is withdrawn continuously due to an operator error or a malfunction of the automated rod withdrawal sequence control logic,. For conservatism, it is assumed neither ATLM channel stops the continued withdrawal of rods to prevent violation of the operating thermal limits, and rods continue to be withdrawn. However, the dual-channel Multi-channel Rod Block Monitor (MRBM) subsystem of the Neuutron Monitoring System (NMS) The ATLM operating thermal limit protection function of either the MCPR or MLHGR protection algorithms stops further control rod withdrawal to protect the fuel. when either operating limit is reached. As there are no operating limit violations, there is no basis for occurrence of the continuous control rod withdrawal error event in the power range.

No operator action is required to preclude this event, because the plant design as described above prevents its occurrence.

15.3.9.3 Core and System Performance

The performance of the MRBMATLM subsystem of the Neutron Monitoring SystemRC&IS prevents the control rod withdrawal error event from continuingoccurring. The MRBM limits the neutron flux peak and assures no fuel damage.The core and system performance are not affected by such an operator error or control logic malfunction. There is no need to analyze this event.

15.3.9.4 Barrier Performance

The MRBM rod block limits the neutron flux peak and fuel thermal transient so that no fuel damage occursAn evaluation of the barrier performance is not made for this event, because there is no postulated set of circumstances for which this event could occur.

15.3.9.5 Radiological Consequences

Because this event does not result in any fuel failures or any release of primary coolant to the environment, there is no radiological consequence associated with this event.

An evaluation of the radiological consequences is not required for this event, because no radioactive material is released from the fuel.

Table 15.3-1a

Results Summary of Infrequent Events (1) (2)

Sub-section I.D.	Description	Max. Neutron Flux, % NBR	Max. Dome Pressure, MPaG (psig)	Max. Vessel Bottom Pressure, MPaG (psig)	Max. Steamline Pressure, MPaG (psig)	Max. Core Average Surface Heat Flux, % of Initial	ΔCPR/ ICPR	Maximum Calculated TEDE
15.3.1	Loss of Feedwater Heating with SCRRI failure	122	7.13 (1034)	7.27 (1054)	7.09 (1028)	121	0.11	(Note 4)
15.3.2	FWCF – Maximum Demand	117.	7.29 (1057)	7.43 (1078)	7.25 (1052)	109	0.04	--
15.3.3	Pressure Regulator Failure – Opening of all TCVs and BPVs	100	7.08 (1027)	7.21 (1046)	7.04 (1021)	100	0.00	--
15.3.4	Pressure Regulator Failure – Closing of all TCVs and BPVs	137.	8.06 (1169)	8.19 (1188)	8.06 (1169)	104	0.05	(Note 4)
15.3.5	Load Rejection with total bypass failure	339	8.14 (1181)	8.27 (1199)	8.15 (1182)	108	0.11	(Note 4)
15.3.6	Turbine Trip with total bypass failure	295	8.13 (1179)	8.26 (1198)	8.13 (1179)	108	0.11	(Note 4)
15.3.13	Inadvertent SRV open	101	7.08 (1027)	7.21 (1046)	6.99 (1014)	101	<0.01	--
15.3.15	Stuck open SRV (3)	100.0	7.08 (1027)	7.21 (1046)	7.04 (1021)	100.0	<0.1	--

(1) The input parameters and initial conditions used to perform the analysis in this table are located in Table 15.2-1.

(2) This table summarizes the events calculated with the TRACG code. Table 15.3-1b contains the summary of the remaining Infrequent Events.

(3) The initiating event can produce some over power, but the Stuck SRV open should not produce any appreciable overpower or MCPR reduction.

(4) The 1000 fuel-rod failure case bounds this event. Results are shown in Table 15.3-16.

Table 15.3-1b

Results Summary of Infrequent Events

Sub-section I.D.	Description	Summary	Maximum Calculated TEDE
15.3.7	Control RWE During Refueling	Reactor remains subcritical; no fuel damage, no radioactive material is released.	--
15.3.8	Control RWE During Startup	Peak fuel enthalpy is 146.5 J/g, less than the criterion of 711 J/g; no fuel damage; no radioactive material is released.	--
15.3.9	Control RWE During Power Operations with ATLM Failure	No fuel damage, no radioactive material is released	--
15.3.10	Fuel Assembly Loading Error, Mislocated Bundle	Fuel bundle could potentially operate above thermal mechanical limits; however, this event is bounded by the radiological analysis and meteorological criteria in Reference 15.3.3	Note (1)
15.3.11	Fuel Assembly Loading Error, Misoriented Bundle	Fuel bundle could potentially operate above thermal mechanical limits; however, this event is bounded by the radiological analysis and meteorological criteria in Reference 15.3.3	Note (1)
15.3.12	Inadvertent SDC Function Operation	No fuel damage; no radioactive material is released.	--
15.3.14	Inadvertent Opening of a Depressurization Valve	No fuel damage; no radioactive material is released outside of containment.	--
15.3.16	Liquid Containing Tank Failure	Any potential airborne doses and effluent concentration limits outside of the Radwaste building are all within specified limits as shown in Table 15.3-19.	Note (2)

(1) Bounding results are documented in Reference 15.3.3.

(2) Results are shown in Table 15.3-19.