Table 19.1-81—U.S. EPR Risk-Significant Equipment based on FV Importance - Level 2 Internal Fires

System	Component ID	Description	FV	RAW
ELEC	31/32BRA	ELEC, 480V MCC	0.038	217.0
SCWS	30QKA10GH001	SCWS, Chiller Unit Train 1	0.030	28.6
ESWS	30PED10AN002	UHS, Cooling Tower Cooling Fan Train 1	0.023	2.8
ELEC	30XKA20	ELEC, Emergency Diesel Generator, Train 2	0.022	1.5
ESWS	30PED20/30AN002	UHS, Cooling Tower Cooling Fan, Trains 2 and 3	0.018	2.1
CCWS	30KAA12AA005	CCWS, LHSI HTX Cooling MOV Train 1	0.017	2.6
SCWS	30QKA40GH001	SCWS, Train 4 Chiller Unit	0.016	15.2
ELEC	30XKA10	ELEC, Emergency Diesel Generator, Train 3	0.015	1.3
CCWS	30KAA22/32AA005	CCWS, LHSI HTX 20 Cooling MOV Trains 2 and 3	0.014	2.0
MSS	30LBA13/23/33/43	MSS, MSRIV Train	0.014	1.1
HVAC	30SAC01/31AN001	SAC, Normal Air Supply/Exhaust Fan Train 1	0.012	25.7
ELEC	30XKA30	ELEC, Emergency Diesel Generator Train 3	0.012	1.1
EFWS	30LAS11AP001	EFWS, Motor Driven Pump Train	0.011	1.3
ESWS	30PEB20/30AP001	ESWS, Motor Driven Pump Trains 2 and 3	0.010	2.6
ESWS	30PED40AN002	UHS, Cooling Tower Cooling Fan Train 4	0.009	1.0
MSS	30LBA10/20AA002	MSS, Main Steam Isolation Valve Trains 1 and 2	0.009	5.6
CCWS	30KAA42AA005	CCWS, LHSI HTX 40 Cooling MOV	0.008	1.0
HVAC	30SAC34/04AN001	SAC, Normal Air Supply/Exhaust Fan Train 4	0.008	15.0
ELEC	30XKA40	ELEC, Emergency Diesel Generator Train 4	0.007	1.0
SCWS	30QKA20/30GH001	SCWS, Chiller Unit Trains 2 and 3	0.006	8.9
SIS/ RHRS	30JNG13/23/ 33AA005	LHSI, First SIS Isolation Check Valve to CL1, 2 and 3	0.006	1.8
SIS/ RHRS	30JND10/30AP001	MHSI, MHSI Motor Driven Pump Trains 1 and 3	0.006	1.2
OCWS	30QNA21/24AN001	OCWS, Chiller Unit Trains 1 and 4	0.006	9.3
MSS	30LBA30AA002	MSS, Train 3 Main Steam Isolation Valve	0.005	2.5
ELEC	30XKA50	ELEC, SBO Diesel Generator	0.005	1.1

Table 19.1-82—U.S. EPR Risk-Significant Equipment based on RAW Importance - Level 2 Internal Fires
Sheet 1 of 2

Rank	System	Component ID	Description	RAW	FV
1	ELEC	31BRA/32BRA	ELEC, 480V MCC	217.0	0.038
2	ELEC	31BDA/BDB/BDC	ELEC, 6.9kV SWGR	204.0	0.005
3	ELEC	30BRW32BUW33/ 30BRW10BUW11	ELEC, 24V DC I&C Power Rack	195.0	0.005
4	ELEC	31/32BMB	ELEC, 480V Load Center	195.0	0.005
5	ELEC	32BDA/BDB	ELEC, 6.9kV SWGR	195.0	0.005
6	SCWS	30QKA10GH001	SCWS, Chiller Unit Train	28.6	0.025
7	HVAC	30SAC01/31AN001	SAC, Normal Air Supply/ Exhaust Fan, Train 1	25.7	0.011
8	CCWS	30KAB10AA192	CCWS, CCWS CH Safety Valve	15.6	0.001
9	SCWS	30QKA40GH001	SCWS, Chiller Unit Train 4	15.2	0.016
10	HVAC	30SAC04/34AN001	SAC, Normal Air Supply/ Exhaust Fan, Train 4	15.0	0.008
11	OCWS	30QNA21/24AN001	OCWS, Chiller Unit, Trains 1 and 4	9.3	0.006
12	SCWS	30QKA20/30GH001	SCWS, Chiller Unit, Trains 2 and 3	8.9	0.006
13	HVAC	30SAC02/32AN001	SAC, Normal Air Supply/ Exhaust Fan, Train 2	8.7	0.005
14	SIS/RHRS	30JNA10AA101	RHR, LHSI Train 1 HTX Bypass MOV	7.9	0.000
15	HVAC	30SAC03AN001/ 30SAC33AN001	SAC, Normal Air Supply/ Exhaust Fan, Train 3	7.2	0.004
16	ELEC	33/34BMB	ELEC, 480V Load Center	7.1	0.000
17	ELEC	34BDA/BDB 33BDB/34BDC	ELEC, 6.9kV SWGR	7.1	0.000
18	ELEC	33/34BMT02	ELEC, 6.9kV-480V Transformer	7.1	0.000
19	ELEC	30BRW52BUW53/ 30BRW70BUW71	ELEC, 24V DC I&C Power Rack	6.7	0.000
20	ELEC	35/36BBA	ELEC, 13.8kV SWGR	6.3	0.000
21	ELEC	35/36BFE	ELEC, 480V Load Center	6.3	0.000
22	ELEC	35/36BBG	ELEC, 6.9kV SWGR	5.6	0.000
23	SIS/RHRS	30JNA20AA101	RHR, LHSI Train 2 HTX Bypass MOV	5.6	0.000

Table 19.1-82—U.S. EPR Risk-Significant Equipment based on RAW Importance - Level 2 Internal Fires
Sheet 2 of 2

Rank	System	Component ID	Description	RAW	FV
24	MSS	30LBA10/20AA002	MSS, Main Steam Isolation Valve Train 1 and 2	5.6	0.009
25	ESWS	30PEB10AP001	ESWS, Motor Driven Pump Train 1	4.5	0.000
26	CCWS	30KAA10AP001	CCWS, Motor Driven Pump Train 1	4.0	0.000
27	ELEC	33BDA	ELEC, 6.9kV SWGR 33BDA	3.8	0.000
28	HVAC	30SAC05/35AN001	SAC, Maintenance Division Air Supply/Exhaust Fan	3.0	0.001
29	ELEC	31BTD01_BAT	ELEC, 250V 1E 2-hr Battery	2.9	0.001
30	ESWS	30PED10AN001/2	UHS, Cooling Tower Cooling Fan Train 1	2.8	0.023
31	ESWS	30PEB20AP001	ESWS, Motor Driven Pump Train 2	2.6	0.010
32	MSS	30LBA30AA002	MSS, Main Steam Isolation Valve, Train 3	2.5	0.005
33	CVCS	30KBA31AP001	CVCS, HP Motor Driven Charging Pump	2.1	0.000
34	SIS/RHRS	30JNG10AP001	LHSI, LHSI Motor Driven Pump	2.1	0.002
35	RCS	30JEB10/20/30/40AA010/020	RCP Seal, RCP Isolation MOV Train	2.1	0.004

Table 19.1-83—U.S. EPR Risk-Significant Human Actions based on FV Importance-Level 2 Internal Fires

Rank	ID	Description	Nominal Value	FV	RAW
1	OPF-SAC-2H	Operator Fails to Recover Room Cooling Locally	1.3E-02	0.352	27.8
2	OPE-RHR-4H	Operator Fails to Initiate RHR Within 4 Hours	1.0E-03	0.139	138.1
3	OPE-MCR-RSS-90M	Operator Fails to Transfer to the RSS in 90 Mins Given A MCR Fire	7.0E-05	0.118	1686.0
4	OPF-RCP-10M	Operator Fails to Trip RCPs on a Loss of Seal Injection	6.0E-02	0.077	2.2
5	OPF-XTDIV-NSC	Operator Fails to Xtie Division 1 to Division 2 or Division 4 to Division 3 During Non-SBO Conditions	5.0E-01	0.060	1.1
6	OPF-RCP-30M	Operator Fails to Trip RCPs on a Loss of Bearing Cooling	4.0E-02	0.053	2.3
7	OPF-XTIE BC	Operator Fails to Align Backup Battery Charger to BUC Bus	1.0E+00	0.039	1.0
8	OPE-FB-40M	Operator Fails to Initiate Feed & Bleed for SLOCA	1.3E-01	0.036	1.2
9	OPF-XTLDSBO-NSC	Operator Fails to Connect and Load SBO DGs to Div 1 or 4 During Non-SBO Conditions	1.0E-01	0.014	1.1
10	OPF-EBS-30M	Operator Fails to Manually Actuate EBS (SLB & ATWS)	2.2E-02	0.012	1.5
11	OPE-FCD-40M	Operator Fails to Initiate Fast Cooldown for SLOCA	1.3E-01	0.010	1.1

Table 19.1-84—U.S. EPR Risk-Significant Human Actions based on RAW Importance-Level 2 Internal Fires

Rank	ID	Description	Nominal Value	RAW	FV
1	OPE-MCR-RSS-90M	Operator Fails to Transfer to the RSS in 90 Mins Given A MCR Fire	7.0E-05	1686.0	0.118
2	OPE-RHR-4H	Operator Fails to Initiate RHR Within 4 Hours	1.0E-03	138.1	0.139
3	OPF-SAC-2H	Operator Fails to Recover Room Cooling Locally	1.3E-02	27.8	0.352
4	OPE-FB-90M	Operator Fails to Initiate Feed & Bleed for Transient	5.0E-04	2.9	0.001
5	OPF-RCP-30M	Operator Fails to Trip RCPs on a Loss of Bearing Cooling	4.0E-02	2.3	0.053
6	OPF-RCP-10M	Operator Fails to Trip RCPs on a Loss of Seal Injection	6.0E-02	2.2	0.077

Table 19.1-85—U.S. EPR Risk-Significant Common Cause Events based on RAW Importance - Level 2 Internal Fires

Rank	System	ID	Description	Nominal Value	RAW
1	HVAC	SAC01/31AN001EFR_D-ALL	CCF to Run Normal Air Exhaust Fans	1.3E-06	767.0
2	SCWS	QKA10AP107EFR_D-ALL	CCF of SCWS Pumps to Run	6.4E-07	671.0
3	SIS/RHRS	JNG13AA005CFO_D-ALL	CCF to Open LHSI/MHSI Common Injection Check Valves	4.5E-06	419.0
4	CCWS	KAA12AA005EFO_D-ALL	CCF to Open CCWS to LHSI HTX Cooling MOV	2.2E-05	339.0
5	ESWS	PED10AN002EFS_D-ALL	CCF to Start/Run Standby Cooling Tower Fans	1.9E-05	339.0
6	ESWS	PED10AN001EFR_D-ALL	CCF to Run Normally Running Cooling Tower Fans	2.7E-06	331.0
7	SIS/RHRS	JNG10AP001EFS_D-ALL	CCF of LHSI Pumps to Start	1.9E-06	319.0
8	MSS	LBA13AA001PFO_D-ALL	CCF to Open Main Steam Relief Isolation Train	3.7E-05	280.0
9	IRWST	JNK10AT001SPG_P-ALL	CCF of IRWST Sump Strainers - Plugged	5.7E-07	265.0
10	SCWS	QKA10GH001_FR_B-ALL	CCF of the Air Cooled SCWS Chiller Units to Run	2.2E-05	262.0
11	EFWS	LAS11AP001EFS_D-ALL	CCF of EFWS Pumps to Start/Run	1.1E-05	163.0
12	SIS/RHRS	JNA10AA003EFO_D-ALL	CCF to Open LHSI Pump Suction from RCS MOVs	1.1E-05	137.0
13	ELEC	BTD01_BAT__ST_D-ALL	CCF of Safety-related Batteries on Demand	2.9E-07	69.1
14	MSS	LBA10AA002PFC_D-ALL	CCF to Close Main Steam Isolation Valves	1.2E-05	59.8
15	ELEC	XKA10_____DFR_D-ALL	CCF of EDGs to Run/Start	1.0E-04	42.5
16	SIS/RHRS	JND10AP001EFR_D-ALL	CCF of MHSI Pumps to Run/Start	3.8E-05	37.3
17	SCWS	QKA20GH001_FR_B-ALL	CCF of the CCWS Cooled SCWS Chiller Units to Run	2.2E-05	33.4
18	ESWS	PEB20AP001EFS_B-ALL	CCF of ESWS Pumps 2 and 3 to Start (Standby)	9.9E-05	21.2

Table 19.1-86—U.S. EPR Risk-Significant I&C Common Cause Events based on RAW Importance - Level 2 Internal Fires

ID	Description	Nominal Value	RAW
CL-TXS-OSCCF	SW CCF of TXS operating system or multiple diversity groups	1.0E-07	19,100.0
SAS CCF-ALL	CCF of SAS Divisions	5.0E-07	290.0
PAS	Process Automation System (PAS) Fails (Estimate)	1.0E-03	185.0
CL-PS-A-SWCCF	SW CCF of Protection System diversity group A	5.0E-06	153.0
CL-PS-B-SWCCF	SW CCF of Protection System diversity group B	5.0E-06	80.5
PZR PRES CCF-ALL	CCF of pressurizer (RCS) pressure sensors	8.4E-07	36.8

Table 19.1-87—Plant Operating States (POS)
Sheet 1 of 2

POS	Description	RCS Conditions				Transition Boundaries
		T (F)	P(psia)	Integrity	Level	
A	Power Operation	Nominal	Nominal	Closed	Normal	Reactor is Critical (all rods are not in)
B	Hot Standby	Nominal to 248	Nominal to 460	Closed	Normal	From 0% power (all rods in) until RHR operation (<248°F and 460 psia)
CA_{d1}	RHR: RCS Normal Level with 2 RHR and SG (shutting down)	248 to 212	460 to 380	Closed	Normal	From start of RHR operation until 4 RHR in operation
CA_{d2}	RHR: RCS Solid with 4 RHR and SG (shutting down)	212 to 131	380	Closed	PZR 90% to Solid	From 4 RHR operation till all RCPs stopped at 131°F (Secondary cooling with SG stopped earlier)
CA_{d3}	RHR: RCS Solid 4 RHR (shutting down)	131	380 to Atm	Closed	PZR Solid	From 131°F (no RCPs running) until start of drain down
CB_d	RHR: Mid-loop w/ RPV head on (shutting down)	131	Atm	Vent	Mid-loop	From start of drain down until RPV head off
D_d	RHR: Mid-loop w/ RPV head off (shutting down)	131	Atm	RPV head off	Mid-loop	From RPV head off until cavity is flooded
E	Cavity Flooded (fuel off load)	131	Atm	RPV head off	Cavity	From cavity is flooded until fuel in SFP with gates/transfer tube closed
F	Core Off-load					Fuel is in SFP with gates/ transfer tube closed
E	Cavity Flooded (fuel load)	131	Atm	RPV head off	Cavity	From opening of transfer tube/gates until start of draining the cavity
D_u	RHR: Mid-loop w/ RPV head off (starting up after refueling)	131	Atm	RPV head off	Mid-loop	From start of cavity draining until RPV head on
CB_u	RHR: Mid-loop w/ RPV head on (starting up after refueling)	131	Atm	Vent	Mid-loop	From RPV head on till level in the pressurizer

Table 19.1-87—Plant Operating States (POS)
Sheet 2 of 2

POS	Description	RCS Conditions				Transition Boundaries
		T (F)	P(psia)	Integrity	Level	
CA_u	RHR: RCS Normal Level (starting up after refueling)	131 to 248	Atm to 460	Closed	Normal	From level in the pressurizer until RHR is secured
B	Startup	248 to Nominal	460 to Nominal	Closed	Normal	From RHR secured until criticality
A	Power Operation	Nominal	Nominal	Closed	Normal	Reactor is Critical

Table 19.1-88—LPSD Initiating Event List

Initiating Event		Basis
Loss of RHR		
IE RHR CAd	Loss of 4 running RHR trains	Fault Tree Analysis
IE RHR CBd	Loss of 3 running/1 Stand-by RHR trains	
IE RHR Dd	Loss of 3 running/1 Stand-by RHR trains	
IE RHR Du	Loss of 2 running/2 Stand-by RHR trains	
IE RHR CBu	Loss of 2 running/2 Stand-by RHR trains	
IE RHR CAu	Loss of 2 running/2 Stand-by RHR trains	
Loss of Inventory		
IE LOCA CAd	Flow diversions and leaks in POS CAd	Generic SLOCA Frequency, Flow Diversion Analysis, Fault Tree Analysis
IE LOCA CBd	Flow diversions and leaks in POS CBd	
IE LOCA Dd	Flow diversions and leaks in POS Dd	
IE LOCA E	Flow diversions and leaks in POS E	
IE LOCA Du	Flow diversions and leaks in POS Du	
IE LOCA CBu	Flow diversions and leaks in POS CBu	
IE LOCA CAu	Flow diversions and leaks in POS CAu	
IE ULD CBd	Uncontrolled Level drop during POS CBd	Fault Tree Analysis
IE ULD Dd	Uncontrolled Level drop during POS Dd	
IE ULD Du	Uncontrolled Level drop during POS Du	
IE ULD CBu	Uncontrolled Level drop during POS CBu	
IE RHR ISLOCA CAd	RHR LOCA Outside Containment in POS CAd	Pipe Break Frequency and Operator Recovery
IE RHR ISLOCA CBd	RHR LOCA Outside Containment in POS CBd	
IE RHR ISLOCA Dd	RHR LOCA Outside Containment in POS Dd	
IE RHR ISLOCA E	RHR LOCA Outside Containment in POS E	
IE RHR ISLOCA Du	RHR LOCA Outside Containment in POS Du	
IE RHR ISLOCA CBu	RHR LOCA Outside Containment in POS CBu	
IE RHR ISLOCA CAu	RHR LOCA Outside Containment in POS CAu	

Table 19.1-89—System Availability During Shutdown
Sheet 1 of 2

POS	Description	LHSI/RHR Availability				Secondary Cooling Availability		SIS		SAHR	Hatch	Comment
		Trains Avail	RHR Run	RHR Stdby	LHSI Stdby	SG with MSRT	EFW	Signal	MHSI			
CA_d	RHR Heat Removal with Level in PZR (shutting down)	4	4	0	0	2	2 (Trains 1 and 2 w/ P13)	Low delta Psat	4	1	Closed	MSRT set at 148 psia
CB_d	RHR Heat Removal at mid-LOOP with RPV Head On (shutting down)	4	3	0	1 (Train 1 or 4)	2	2 (Trains 1 and 2 w/ P13)	Low Loop Level	4	1	Closed	MSRT set at 148 psia
D_d	RHR Heat Removal at mid-LOOP with RPV Head Off (shutting down)	4	3	0	1 (Train 1 or 4)	NA	NA	Low Loop Level	4	NA	Closed	
E	Reactor Cavity Flooded (fuel off load)	3	2 (Train 2 & 3)	0	1 (Train 4)	NA	NA	Low Loop Level	3	NA	Open	
F	Core Off-load	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
E	Reactor Cavity Flooded (fuel load)	3	2 (Train 1 & 2)	0	1 (Train 4)	NA	NA	Low Loop Level	3	NA	Open	
D_u	RHR Heat Removal at mid-LOOP with RPV Head OFF (starting up after refueling)	4	2 (Train 1 & 2)	1 (Train 3)	1 (Train 4)	NA	NA	Low Loop Level	4	NA	Closed	

Table 19.1-89—System Availability During Shutdown
Sheet 2 of 2

POS	Description	LHSI/RHR Availability				Secondary Cooling Availability		SIS		SAHR	Hatch	Comment
		Trains Avail	RHR Run	RHR Stdby	LHSI Stdby	SG with MSRT	EFW	Signal	MHSI			
CB_u	RHR: Mid-loop w/ RPV head on (starting up after refueling)	4	2 (Train 1 & 2)	1 (Train 3)	1 (Train 4)	2	2	Low Loop Level	4	1	Closed	MSRT set at 148 psia
CA_u	RHR: RCS Normal Level (starting up after refueling)	4	2 (Train 1 & 2)	1 (Train 3)	1 (Train 4)	2 to 4	2 to 4	Low delta Psat	4	1	Closed	MSRT set at 148 psia

Table 19.1-90—U.S. EPR Significant Initiating Events Contributions - Level 1 Shutdown

Initiating Event ID	Initiating Event Description	IE Frequency (1/yr)	CDF (1/yr)	Contribution (SD Total)
SD ULD CBD D	SD Uncontrolled Level Drop in State CBd (Demand)	1.4E-02	8.1E-09	14.0%
SD ULD DU D	SD Uncontrolled Level Drop in State Du (Demand)	1.4E-02	7.9E-09	13.5%
SD LOCA CBD	SD LOCA in State CBd	1.1E-03	7.7E-09	13.3%
SD RHR CBD	SD Loss of RHR in State CBd	1.7E-06	7.3E-09	12.6%
SD RHR CBU	SD Loss of RHR in State CBu	1.3E-06	5.5E-09	9.4%
SD RHR CAD	SD Loss of RHR in State Cad	1.2E-06	5.4E-09	9.3%
SD LOCA CBU	SD LOCA in State CBu	5.7E-04	3.8E-09	6.6%
SD RHR CAU	SD Loss of RHR in State CAu	8.3E-07	3.7E-09	6.4%
SD LOCA DU	SD LOCA in State Du	5.7E-04	3.1E-09	5.3%
SD LOCA DD	SD LOCA in State Dd	2.5E-04	1.4E-09	2.3%
SD RHR DU	SD Loss of RHR in State Du	1.3E-06	1.2E-09	2.1%
SD RHR ISLOCA E	SD RHR ISLOCA in State E	7.9E-10	7.9E-10	1.4%
Total SD CDF:			5.8E-08	

Table 19.1-91—U.S. EPR Shutdown State (POS) Contributions - Level 1 Shutdown

Shutdown State (POS)	POS Description	Estimated POS Duration (days)	CDF (1/yr)	CDF (1/day)	Contribution to Total
CAD	RHR Heat Removal with Level in PZR -- Shutting Down	1.5	6.1E-09	4.1E-09	10.6%
CBD	RHR Heat Removal at mid-LOOP with RPV Head On -- Shutting Down	2	2.3E-08	1.2E-08	40.0%
DD	RHR Heat Removal at mid-LOOP with RPV Head Off -- Shutting Down	0.5	1.9E-09	3.9E-09	3.3%
E	Reactor Cavity Flooded	10	9.9E-10	9.9E-11	1.7%
DU	RHR Heat Removal at mid-LOOP with RPV Head Off -- Starting Up	1.5	1.2E-08	8.1E-09	21.1%
CBU	RHR Heat Removal at mid-LOOP with RPV Head On -- Starting Up	1.5	9.4E-09	6.2E-09	16.2%
CAU	RHR Heat Removal with Level in PZR -- Starting Up	1	4.0E-09	4.0E-09	7.0%
TOTAL SD CDF:		18 (+ POS F)	5.8E-08	3.8E-08	

Table 19.1-92—U.S. EPR Important Cutset Groups - Level 1 Shutdown
Sheet 1 of 13

Group No	Cutset Numbers	Group Frequencies	Contribution to CDF (%)		Sequence Type and a Representative Cutset		Sequence Description
			Group	Cumulative	Event Identifier	Event Description	
0	**Uncontrolled Level Drop Sequences**						
1	1, 4, 10, 17, 39, 41, 100	3.39E-09 – 6.34E-11	12.0	12.0	**SD ULD D-3: ISOLSD, OP ISOLSD**		
					IE SD ULD DU D	Initiator - Uncontrolled Level Drop in Shutdown State Du (Demand)	Shutdown State DU: An uncontrolled level drop IE is caused by CC failure of CVCS LP reducing station MOVs to close, this also fails a second chance to isolate, the mitigating systems are available, but a long term operator failure to isolate, leads to a slow RCS drain outside containment.
					KBA14AA004E FC_B-ALL	CCF to Close CVCS Low Pressure Reducing Station MOVs	
					OPE-ISOCSLPRS	Operator Fails to Isolate the CVCS Low Pressure Reducing Station	
2	2, 5, 9, 18, 38, 40	3.39E-09 – 1.84E-10	11.9	23.9	**SD ULD CB-3: SISOLSD, OP ISOLSD**		
					IE SD ULD CBD D	Initiator - Uncontrolled Level Drop in Shutdown State CBd (Demand)	Shutdown State CBD: An uncontrolled level drop IE is caused by CC failure of CVCS LP reducing station MOVs to close, this also fails a second chance to isolate, the mitigating systems are available, but a long term operator failure to isolate, leads to a slow RCS drain outside containment
					KBA14AA004E FC_B-ALL	CCF to Close CVCS Low Pressure Reducing Station MOVs	
					OPE-ISOCSLPRS	Operator Fails to Isolate the CVCS Low Pressure Reducing Station	

Table 19.1-92—U.S. EPR Important Cutset Groups - Level 1 Shutdown
Sheet 2 of 13

Group No	Cutset Numbers	Group Frequencies	Contribution to CDF (%) Group	Contribution to CDF (%) Cumulative	Sequence Type and a Representative Cutset: Event Identifier	Sequence Type and a Representative Cutset: Event Description	Sequence Description
3	30, 49	2.276E-10 – 1.54E-10	0.7	24.6	**SD ULD D-6: ISOLSD, MHSISD, LHSISD**		
					IE SD ULD DU D	Initiator - Uncontrolled Level Drop in Shutdown State Du (Demand)	Shutdown State DU: An uncontrolled level drop IE is caused by CC Failure of CVCS LP reducing station MOVs to close, this also fails a second chance to isolate, the injection systems MHSI and LHSI fail because of a CC failure of the common injection check valves.
					KBA14AA004E FC_B-ALL	CCF to Close CVCS Low Pressure Reducing Station MOVs	
					JNG13AA005C FO_D-ALL	CCF to Open LHSI/ MHSI Common Injection Check Valves (SIS First Isolation Valves)	
4	31, 50	2.76E-10 – 1.54E-10	0.7	25.3	**SD ULD CB-39: ISOLSD, MHSISD, LHSISD**		
					IE SD ULD CBD D	Initiator - Uncontrolled Level Drop in Shutdown State CBd (Demand)	Shutdown State CBD: An uncontrolled level drop IE is caused by CC failure of CVCS LP reducing station MOVs to close, this also fails a second chance to isolate, the injection systems MHSI and LHSI fail because of a CC failure of the common injection check valves
					KBA14AA004E FC_B-ALL	CCF to Close CVCS Low Pressure Reducing Station MOVs	
					JNG13AA005C FO_D-ALL	CCF to Open LHSI/ MHSI Common Injection Check Valves (SIS First Isolation Valves)	

Table 19.1-92—U.S. EPR Important Cutset Groups - Level 1 Shutdown
Sheet 3 of 13

Group No	Cutset Numbers	Group Frequencies	Contribution to CDF (%) Group	Contribution to CDF (%) Cumulative	Sequence Type and a Representative Cutset: Event Identifier	Sequence Type and a Representative Cutset: Event Description	Sequence Description
5	3, 6, 7, 8, 29, 33, 34, 35, 42, 43, 51, 52, 57, 58, 66, 70, 95	2.46E-09 – 7.11E-11	16.5	41.8	**SD RHR C-15: EFWSD, MHSISD, LHSISD, SAHRSD**		
					IE SD RHR CBD	Initiator - RHR in Power State CBd	Shutdown State CBD: A loss of RHR IE is caused by a LOOP during the CBD state and a CC failure of all EDGs; failure of SBODG Division 1 disables all EFW (only SG1 & 2 are assumed to be available in the CBD state); a loss of CCW (not supplied from SBODGs) disables MHSI and RHR heat exchangers; a loss of Division 1 disables SAHR This sequence also occurs in shutdown states CAU, CAD, & CBU
					SD LOOP24+REC	Loss Of Offsite Power During Shutdown and Failure of Recovery Within 1 Hour	
					XKA10_____D FR_D-ALL	CCF of EDGs to Run	
					XKA50_____D FR	ELEC, SBO Diesel Generator XKA50, Fails to Run	

Table 19.1-92—U.S. EPR Important Cutset Groups - Level 1 Shutdown
Sheet 4 of 13

Group No	Cutset Numbers	Group Frequencies	Contribution to CDF (%)		Sequence Type and a Representative Cutset		
			Group	Cumulative	Event Identifier	Event Description	Sequence Description
6	32, 36, 37, 55	2.62E-10 – 1.31E-10	1.4	43.2	**SD RHR C-15: EFWSD, MHSISD, LHSISD, SAHRSD**		
					IE SD RHR CBD	Initiator - RHR in Power State CBd	Shutdown State CBD: A loss of RHR IE is caused by a LOOP during the CBD state and a CC failure of all EDGs; operator failure to x-tie divisions disables all MSRTs and EFW; a loss of CCW (not supplied from SBODGs) disables MHSI and RHR heat exchangers; a loss of UHS4 disables SAHR This sequence also occurs in shutdown states CAU, CAD, & CBU
					SD LOOP24+REC	Loss Of Offsite Power During Shutdown and Failure of Recovery Within 1 Hour	
					XKA10_____D FR_D-ALL	CCF of EDGs to Run	
					OPF-XTDIVSBO-2H	Operator Fails to Xtie Division 1 to Division 2 or Division 4 to Division 3 During SBO Conditions	
					SA-ESWS UHS4 SBO	Failure of SA-ESWS/ UHS4 in SBO Conditions	

Table 19.1-92—U.S. EPR Important Cutset Groups - Level 1 Shutdown
Sheet 5 of 13

Group No	Cutset Numbers	Group Frequencies	Contribution to CDF (%) Group	Contribution to CDF (%) Cumulative	Sequence Type and a Representative Cutset: Event Identifier	Event Description	Sequence Description
7	54, 62, 63, 94	1.43E-10 – 7.14E-11	0.7	43.9	**SD RHR C-15: EFWSD, MHSISD, LHSISD, SAHRSD**		
					IE SD RHR CBD	Initiator - RHR in Power State CBd	Shutdown State CBD: A loss of RHR IE is caused by a LOOP during the CBD state and a CC failure of all EDGs; operator failure to x-tie divisions disables all MSRTs and EFW; a loss of CCW (not supplied from SBODGs) disables MHSI and RHR heat exchangers; a loss of SBO DG4 disables SAHR This sequence also occurs in shutdown states CAU, CAD, & CBU
					SD LOOP24+REC	Loss Of Offsite Power During Shutdown and Failure of Recovery Within 1 Hour	
					XKA10_____D FR_D-ALL	CCF of EDGs to Run	
					OPF-XTDIVSBO-2H	Operator Fails to Xtie Division 1 to Division 2 or Division 4 to Division 3 During SBO Conditions	
					XKA80_____D FR	ELEC, SBO Diesel Generator XKA80, Fails to Run	

Table 19.1-92—U.S. EPR Important Cutset Groups - Level 1 Shutdown
Sheet 6 of 13

Group No	Cutset Numbers	Group Frequencies	Contribution to CDF (%) Group	Contribution to CDF (%) Cumulative	Sequence Type and a Representative Cutset: Event Identifier	Sequence Type and a Representative Cutset: Event Description	Sequence Description
8	56, 67, 69, 99	1.29E-10 – 6.44E-11	0.7	44.6	**SD RHR C-15: EFWSD, MHSISD, LHSISD, SAHRSD**		
					IE SD RHR CBD	Initiator - RHR in Power State CBd	**Shutdown State CBD:** ● A loss of RHR IE is caused by a LOOP during the CBD state and a CC failure of all batteries (disabling all EDGs and possibility to connect SBODGs). Result is a total station blackout. ● This sequence also occurs in shutdown states CAU, CAD, & CBU
					SD LOOP24+REC	Loss Of Offsite Power During Shutdown and Failure of Recovery Within 1 Hour	
					BTD01_BAT__ST_D-ALL	CCF of Safety-related Batteries on Demand	

Table 19.1-92—U.S. EPR Important Cutset Groups - Level 1 Shutdown
Sheet 7 of 13

Group No	Cutset Numbers	Group Frequencies	Contribution to CDF (%) Group	Contribution to CDF (%) Cumulative	Sequence Type and a Representative Cutset: Event Identifier	Sequence Type and a Representative Cutset: Event Description	Sequence Description
9	64, 83, 84	1.01E-10 – 7.60E-11	0.4	45.0	**SD RHR C-12: EFWSD, LHSISD, SAHRSD**		
					IE SD RHR CBD	Initiator - RHR in Power State CBd	**Shutdown State CBD:** • A loss of RHR IE is caused by a LOOP during the CBD state, a CC failure of 3 EDGs and failure of air chiller cooling to LHSI/RHR pump1; operator failure to crosstie divisions disables all MSRTs and EFW; LHSI/RHR heat exchangers are lost; a loss of Division 4 (ESW80-crosstie was not credited for non-SBO conditions) disables SAHR • This sequence also occurs in shutdown states CAU, CAD, & CBU
					SD LOOP24+REC	Loss Of Offsite Power During Shutdown and Failure of Recovery Within 1 Hour	
					XKA10_____DFR_D-234	CCF of EDGs to Run	
					QKA10GH001_FS	SCWS, Train 1 Chiller Unit QKA10GH001, Fails to Start on Demand	
					OPF-XTDIV-NSC	Operator Fails to Xtie Division 1 to Division 2 or Division 4 to Division 3 During Non-SBO Conditions	

Table 19.1-92—U.S. EPR Important Cutset Groups - Level 1 Shutdown
Sheet 8 of 13

Group No	Cutset Numbers	Group Frequencies	Contribution to CDF (%) Group	Contribution to CDF (%) Cumulative	Sequence Type and a Representative Cutset: Event Identifier	Sequence Type and a Representative Cutset: Event Description	Sequence Description
10	65	1.00E-10	0.2	45.2	**SD RHR D-3: MHSISD, LHSISD**		
					IE SD RHR DU	Initiator - RHR in Power State Du	**Shutdown State DU:** • A loss of RHR IE is caused by a LOOP during the DU state, a CC failure of all EDGs.Failure of both SBODGs. The result is a total station blackout.
					SD LOOP24+REC	Loss Of Offsite Power During Shutdown and Failure of Recovery Within 1 Hour	
					XKA10_____D FR_D-ALL	CCF of EDGs to Run	
					XKA50_____D FR	ELEC, SBO Diesel Generator XKA50, Fails to Run	
					XKA80_____D FR	ELEC, SBO Diesel Generator XKA80, Fails to Run	

Table 19.1-92—U.S. EPR Important Cutset Groups - Level 1 Shutdown
Sheet 9 of 13

Group No	Cutset Numbers	Group Frequencies	Contribution to CDF (%) Group	Contribution to CDF (%) Cumulative	Sequence Type and a Representative Cutset: Event Identifier	Sequence Type and a Representative Cutset: Event Description	Sequence Description
11	68	9.67E-11	0.2	45.4	**SD RHR D-3: MHSISD, LHSISD**		
					IE SD RHR DU	Initiator - RHR in Power State Du	**Shutdown State DU:** ● A loss of RHR IE is caused by a LOOP during the DU state and a CC failure of all batteries (disabling all EDGs and the possibility to connect SBODGs). The result is a total station blackout.
					SD LOOP24+REC	Loss Of Offsite Power During Shutdown and Failure of Recovery Within 1 Hour	
					BTD01_BAT__ST_D-ALL	CCF of Safety-related Batteries on Demand	

Table 19.1-92—U.S. EPR Important Cutset Groups - Level 1 Shutdown
Sheet 10 of 13

Group No	Cutset Numbers	Group Frequencies	Contribution to CDF (%) Group	Contribution to CDF (%) Cumulative	Sequence Type and a Representative Cutset: Event Identifier	Event Description	Sequence Description
12	81, 82	8.00E-11	0.3	45.7	**SD RHR C-16: EFWSD, PBLSD**		
					IE SD RHR CBD	Initiator - RHR in Power State CBd	**Shutdown State CBD:** • A loss of RHR IE is caused by a CC failure of SAC air supply fans during the CBD state and two operator failures to recover HVAC, disabling all divisions. Result is a total station blackout. • This sequence also includes shutdown state CBU.
					SAC01AN001EFR_D-ALL	CCF to Run Normal Air Supply Fans	
					OPF-SAC-1H	Operator Fails to Start Maintenance HVAC Trains after Failure of Normal SAC Safety Train	
					OPD-SAC2H/SAC1H	Dependency (MED) Between OAs for Starting HVAC Maintenance Trains Recovering Room Cooling Locally	

Table 19.1-92—U.S. EPR Important Cutset Groups - Level 1 Shutdown
Sheet 11 of 13

Group No	Cutset Numbers	Group Frequencies	Contribution to CDF (%) Group	Contribution to CDF (%) Cumulative	Sequence Type and a Representative Cutset: Event Identifier	Event Description	Sequence Description
13	11, 12, 13, 14, 15, 16, 19, 20, 24, 25, 59, 60, 61, 71, 72, 73, 74, 75, 76, 79, 80, 85, 86, 87, 88, 89, 90, 91, 92, 93	6.45E-10 – 7.52E-11	12.9	58.6	**SD LOCA C-30: MHSISD, LHSISD**		
					IE SD LOCA CBD	Initiator - LOCA During Shutdown State CBd	**Shutdown State CBD:** • A LOCA IE is caused by a premature opening of an RHR/LHSI safety valve and an operator failure to isolate flow diversion; MHSI/LHSI injection fails due to a CC failure of common cold leg injection check valves.
					JNG10AA192SPO	LHSI, LHSI/RHR Train 10 Overpressure Protection Safety Valve JNG10AA192, Premature Opening	
					OPF-ISORHRFD-CB	Operator Fails to Isolate RHR Flow Diversion (LOCA) in State CB	
					JNG13AA005CFO_D-ALL	CCF to Open LHSI/ MHSI Common Injection Check Valves (SIS First Isolation Valves)	

Table 19.1-92—U.S. EPR Important Cutset Groups - Level 1 Shutdown
Sheet 12 of 13

Group No	Cutset Numbers	Group Frequencies	Contribution to CDF (%) Group	Contribution to CDF (%) Cumulative	Sequence Type and a Representative Cutset: Event Identifier	Sequence Type and a Representative Cutset: Event Description	Sequence Description
14	21, 22, 23, 26, 44, 45, 46, 47, 48, 53, 77, 78	4.84E-10 – 8.06E-11	5.3	63.9	**SD LOCA DE-3: MHSISD, LHSISD**		
					IE SD LOCA DU	Initiator - LOCA During Shutdown State Du	**Shutdown State DU:** • A LOCA IE is caused by a premature opening of a RHR/LHSI safety valve and an operator failure to isolate flow diversion; MHSI/LHSI injection fails due to a CC failure of common cold leg injection check valves.
					JNA10AA191S PO	RHR, LHSI Train 1 Safety Valve JNA10AA191, Premature Opening	
					OPF-ISORHRFD-CB	Operator Fails to Isolate RHR Flow Diversion (LOCA) in State CB	
					JNG13AA005C FO_D-ALL	CCF to Open LHSI/ MHSI Common Injection Check Valves (SIS First Isolation Valves)	

Table 19.1-92—U.S. EPR Important Cutset Groups - Level 1 Shutdown
Sheet 13 of 13

Group No	Cutset Numbers	Group Frequencies	Contribution to CDF (%) Group	Contribution to CDF (%) Cumulative	Sequence Type and a Representative Cutset: Event Identifier	Sequence Type and a Representative Cutset: Event Description	Sequence Description
15	27, 28, 96, 97, 98	3.43E-10 – 6.86E-11	1.6	65.5	**SD RHR ISLOCA E-02/CBD-2: RHR ISLOCA SD**		
					IE SD RHR ISLOCA E	RHR ISLOCA During Shutdown State E	**Shutdown State E:** ● A ISLOCA IE is caused by a pipe break in one RHR train, a failure of PAS disables automatic isolation and operator failure to isolate leads to unisolated LOCA outside containment. ● This sequence also occurs in shutdown state CBD.
					RHR TR1 PIPE BRK	Pipe Break in RHR Train 1	
					PAS	Process Automation System (PAS) Fails (Estimate)	
					OPF-ISORHRBRK	Operator Fails to Isolate RHR Pipe Break	

Table 19.1-93—U.S. EPR Risk-Significant Equipment based on FV Importance - Level 1 Shutdown

Rank	System	Component ID	Description	FV	RAW
1	ELEC	30XKA10/20/30/40	ELEC, Emergency Diesel Generator Train	0.291	1.8
2	SIS/RHRS	30JNG13/23/33/43AA005	LHSI, First SIS CL Isolation Check Valve Train	0.244	3.2
3	CVCS	30KBA14AA004/106	CVCS, Low Pressure Reducing Station Isolation MOV Train	0.239	IE-NA[1]
4	ELEC	30XKA50/80	ELEC, SBO Diesel Generator Train	0.226	4.6
5	SIS/RHRS	30JNA10/20/30AA191 30JNG10/20/30AA192	RHR, LHSI Safety Valve Train	0.042	IE-NA[1]
6	SIS/RHRS	30JND10/20/30/40AP001	MHSI, Motor Driven Pump Train	0.041	1.6
7	IRWST	30JNK10AT001/002 30JNK11AT001/002	IRWST, SIS Sump Strainer to MHSI/LHSI Pumps	0.029	1.2
8	IRWST	30JNK11AT003	IRWST, SAHR Sump Strainer	0.028	2.3
9	SCWS	30QKA10/40GH001	SCWS, Chiller Unit Train	0.019	4.4
10	ELEC	31/32/33/34BTD01_BAT	ELEC, 250V 1E 2-hr Battery Train	0.018	10.2
11	CCWS	30KAA10/20/30/40AP001	CCWS, Motor Driven Pump Train	0.012	3.7
12	SIS/RHRS	30JNG10/20AA001	LHSI, LHSI Pump Suction from IRWST MOV Train	0.011	IE-NA[1]
13	SAHRS	30JMQ42AA001	SAHR, Recirculation Line MOV	0.011	3.8
14	EFWS	30LAS11AP001	EFWS, Motor Driven Pump	0.011	1.7
15	HVAC	30SAC01/02/03/04AN001 30SAC31/32/33/34AN001	SAC, Normal Air Supply/Exhaust Fan	0.010	1.6

1. NOTE: IE-NA denotes a component whose failure also leads to an initiating event, hence, the calculated RAW value is not valid; it is produced due to software limitations.

Table 19.1-94—U.S. EPR Risk-Significant Equipment based on RAW Importance - Level 1 Shutdown

Rank	System	Component ID	Description	RAW	FV
1	ELEC	31/34BMB 34BMC/ 31/34BMD	ELEC, 480V Load Center	50.6	0.001
2	ELEC	31BBH/34BDA 31/34BDB 31/34BDC 31/ 33/34BDD	ELEC, 6.9kV SWGR	50.6	0.001
3	ELEC	31BNB01/02/03 34BNB02/03	ELEC, 480V MCC	42.8	0.001
4	ELEC	31/34BTD01_BAT	ELEC, 250V 1E 2-hr Battery	10.2	0.018
5	ELEC	31/34BUC	ELEC, 250V DC Bus	10.0	0.000
6	ELEC	31/32BUD	ELEC, Non 1E 250V DC Distribution Panel	5.7	0.000
7	SIS/RHRS	30JNG13/23/33AA005	LHSI, CL First SIS Isolation Check Valve	4.6	0.236
8	ELEC	30XKA50	ELEC, SBO Diesel Generator	4.6	0.226
9	ELEC	31BTB01_BAT	ELEC, 250V Non 1E 12-hr Battery	4.6	0.002
10	SCWS	30QKA10/40GH001	SCWS, Chiller Unit	4.4	0.019
11	ELEC	31BRV31BUV/ 30BRW10BUW11/ 30BRX10BUX11/30BRX70BUX71	ELEC, 24V DC I&C Power Rack	4.2	0.000
12	SIS/RHRS	30JNG10/30AP001	LHSI, Motor Driven Pump Train	3.7	0.008
13	SAHRS	30JMQ40AP001	SAHR, Motor Driven Pump	3.6	0.002

Table 19.1-95—U.S. EPR Risk-Significant Human Actions at Shutdown based on FV Importance - Level 1 Shutdown

Rank	Basic Event	Description	Nom Value	FV	RAW
1	OPE-ISOCSLPRS	Operator Fails to Isolate the CVCS Low Pressure Reducing Station	5.5E-05	0.249	4,531.0
2	OPF-ISORHRFD-CB	Operator Fails to Isolate RHR Flow Diversion (LOCA) in State CB	1.0E+00	0.185	1.0
3	OPF-ULD	Operator Fails to Stop Draindown at Mid-Loop	1.0E-02	0.107	IE-NA[1]
4	OPF-ISORHRFD-D	Operator Fails to Isolate RHR Flow Diversion (LOCA) in State D	1.0E+00	0.072	1.0
5	OPF-XTDIVSBO-2H	Operator Fails to Xtie Division 1 to Division 2 or Division 4 to Division 3 During SBO Conditions	5.8E-02	0.036	1.6
6	OPF-XTDIV-NSC	Operator Fails to Xtie Division 1 to Division 2 or Division 4 to Division 3 During Non-SBO Conditions	5.0E-01	0.030	1.0
7	OPF-ISORHRBRK	Operator Fails to Isolate RHR Pipe Break	1.1E-01	0.025	1.2
8	OPD-SAC2H/SAC1H	Dependency (MED) Between OAs for Starting HVAC Maintenance Trains Recovering Room Cooling Locally	1.5E-01	0.019	1.1
9	OPF-SAC-1H	Operator Fails to Start Maintenance HVAC Trains After Failure of Normal SAC Safety Train	2.0E-04	0.019	96.6
10	OPF-SAC-2H	Operator Fails to Recover Room Cooling Locally	1.3E-02	0.018	2.4
11	OPF-XTLDSBO-NSC	Operator Fails to Connect and Load SBODGs to Div 1 or 4 During Non-SBO Conditions	1.0E-01	0.011	1.1
12	OPF-ISOIRWSTFD-CB	Operator Fails to Isolate RHR Suction to IRWST (Valve JNGX0AA001) in CB	1.0E+00	0.011	1.0
13	OPF-ISOIRWSTFD-CA	Operator Fails to Isolate RHR Suction to IRWST (Valve JNGX0AA001) in CA	1.0E+00	0.010	1.0

1. NOTE: IE-NA denotes a component whose failure also leads to an initiating event, hence, the calculated RAW value is not valid; it is produced due to software limitations.

Table 19.1-96—U.S. EPR Risk-Significant Human Actions based on RAW Importance - Level 1 Shutdown

Rank	Basic Event	Description	Nom Value	RAW	FV
1	OPE-ISOCSLPRS	Operator Fails to Isolate the CVCS Low Pressure Reducing Station	5.5E-05	4,531.0	0.249
2	OPF-SAC-1H	Operator Fails to Start Maintenance HVAC Trains After Failure of Normal SAC Safety Train	2.0E-04	96.6	0.019
3	OPF-LHSIRHR-DU	Operator Fails to Start LHSI Pump in DU, given a loss of RHR	2.0E-04	7.4	0.001
4	OPF-XTLDSBO-2H	Operator Fails to Connect and Load SBO DGs to Div 1 and 4	7.0E-04	5.6	0.003
5	OPF-SAHR/ IRWST-4H	Operator Fails to Initiate IRWST Cooling with SAHR	4.0E-04	3.6	0.001
6	OPF-LHSIRHR-DD	Operator Fails to Start LHSI Pump in DD, given a loss of RHR	2.0E-04	3.1	0.000
7	OPE-RHRLO-CBD	Operator Fails to Start RHR in CBd (LOCA Initiator)	1.1E-03	2.7	0.002
8	OPF-SAC-2H	Operator Fails to Recover Room Cooling Locally	1.3E-02	2.4	0.018

Table 19.1-97—U.S. EPR Risk-Significant Common Cause Events based on RAW Importance - Level 1 Shutdown

Rank	System	ID	Description	RAW
1	SIS/RHRS	JNG13AA005CFO_D-ALL	CCF to Open LHSI/MHSI Common Injection Check Valves (SIS First Isolation Valves)	50,890.0
2	IRWST	JNK10AT001SPG_P-ALL	CCF of IRWST Sump Strainers - Plugged	50,250.0
3	ELEC	BTD01_BAT__ST_D-ALL	CCF of Safety-related Batteries on Demand	30,590.0
4	HVAC	SAC01/31AN001EFR_D-ALL	CCF to Run Normal Air Exhaust/Supply Fans	5,100.0
5	SCWS	QKA10AP107EFR_D-ALL	CCF of SCWS Pumps to Run	5,078.0
6	ESWS	PEB10AP001EFS_D-ALL	CCF of the ESWS Pumps to Start	1,977.0
7	ELEC	XKA10_____DFR_D-ALL	CCF of EDGs to Run/Start	1,933.0
8	SIS/RHRS	JND10AP001EFR_D-ALL	CCF of MHSI Pumps to Run/Start	751.6
9	SIS/RHRS	JNG10AP001EFS_D-ALL	CCF of LHSI Pumps to Start	525.0
10	SCWS	QKA10AP107EFS_D-ALL	CCF of SCWS Pumps to Start	401.0
11	HVAC	SAC01/31AN001EFS_D-ALL	CCF to Start Normal Air Supply/Exhaust Fans	398.0
12	SIS/RHRS	JNG10AA006CFO_D-ALL	CCF to Open LHSI Check Valves (SIS Second Isolation Valves)	287.2
13	CCWS	KAA10AP001EFS_D-ALL	CCF of the CCWS Pumps to Start	52.4

Table 19.1-98—U.S. EPR Risk-Significant Common Cause I&C Events based on RAW Importance - Level 1 Shutdown

Rank	ID	Description	Nominal Value	RAW
1	CL-TXS-OSCCF	SW CCF of TXS operating system or multiple diversity groups	1.0E-07	8,059.0
2	SAS CCF-ALL	CCF of SAS Divisions	5.0E-07	5,673.0
3	CL-PS-B-SWCCF	SW CCF of Protection System diversity group B	5.0E-06	617.3
4	HL LVL CCF-ALL	CCF of hot leg loop level	1.3E-06	552.6
5	APU3 CCF NS-ALL	CCF of APU-3 Protection System Computer Processors (Non-Self-Monitored)	3.3E-07	368.7
6	ALU-B CCF NS-ALL	CCF of ALU-B Protection System Computer Processors (Non-Self-Monitored)	3.3E-07	368.7
7	APU3 CCF SM-ALL	CCF of APU-3 Protection System Computer Processors (Self-Monitored)	9.0E-08	290.8
8	ALU-B CCF SM-ALL	CCF of ALU-B Protection System Computer Processors (Self-Monitored)	9.0E-08	290.8
9	PAS	Process Automation System (PAS) Fails	1.0E-03	54.6
10	HL TEMP CCF-ALL	CCF of hotleg WR temperature sensors	4.3E-06	53.6
11	HL PRES CCF-ALL	CCF of hotleg WR pressure sensors	6.7E-07	42.5
12	CL WRTEMP CCF-ALL	CCF of cold leg WR temp sensors	4.3E-06	29.5

Table 19.1-99—U.S. EPR Risk-Significant PRA Parameters - Level 1 Shutdown

ID	Description	Nominal Value	FV	RAW
PRA Modeling Parameters				
JEF-PSRV-FRC	PZR, Pressurizer Safety Relief Valve Fails to Reclose or to Reseat	3.0E-03	0.003	2.0
RHR TR1 PIPE BRK	Pipe Break in RHR Train 1	3.1E-07	0.012	39,520.0
RHR TR2 PIPE BRK	Pipe Break in RHR Train 2	3.1E-07	0.012	39,490.0
RHR TR3 PIPE BRK	Pipe Break in RHR Train 3	3.1E-07	0.003	8,767.0
RHR TR4 PIPE BRK	Pipe Break in RHR Train 4	3.1E-07	0.001	3,296.0
SA-ESWS UHS4 SBO	Failure of SA-ESWS/UHS4 in SBO Conditions	1.0E-01	0.031	1.3
SIG P14 PERM	Failure of P-14 Permissive - MSRT Set Point to 145 psia	1.0E-04	0.000	5.3
Offsite Power Related Events				
SD LOOP24+REC	Loss Of Offsite Power During Shutdown and Failure of Recovery Within 1 Hour	2.2E-04	0.373	1,695.0

Table 19.1-100—U.S. EPR LEVEL 1 Internal Events Sensitivity Studies - Level 1 Shutdown

Sensitivity Case Group	Case #	Sensitivity Case Description	SC CDF (1/yr)	Delta CDF (%)
0	0	Base Case (Shutdown CDF)	5.8E-08	0%
1	**Common Cause Assumption**			
	1a	Common cause events not considered	1.1E-08	-81%
	1b	EDGs & SBODGs in the same CC group	2.4E-07	307%
2	**Assumptions on Electrical Dependencies**			
	2a	UHS 4 assumed unavailable during SBO Conditions (no credit for SBO x-tie for dedicated ESW)	7.4E-08	28%
	2b	The same credit given to the operators to X-tie two divisions in SBO (HEP=7.0E-02) & non-SBO conditions (HEP=0.5)	5.6E-08	-3%
3	**Assumptions on HVAC Recoveries**			
	3a	Room heat-up was not considered	5.6E-08	-4%
	3b	Operator recovery of HVAC not credited	1.4E-07	148%
	3c	Circular logic adjustment: Failure of HVAC 1 disables HVAC 2 (HVAC4 disables HVAC 3)	7.7E-08	34%
4	**Sensitivity to HEPs Values**			
	4a	All HEPs Set to 5% Value	3.4E-08	-40%
	4b	All HEPs Set to 95% Value	1.8E-07	217%
5	**UHS Requirement in Shutdown**			
	5	UHS Fans not required	5.8E-08	0%
6		**Assumptions on Preventive Maintenance**		
	6	Train 3 in preventive maintenance during shutdown states CBU and DU	8.5E-08	48%

Table 19.1-101—Level 2 Low Power Shutdown Plant Operating States Release Categories

Release Category	RC Freq for State C	RC % of LRF in State C	RC Freq for State D	RC % of LRF in State D	RC Freq for State E	RC % of LRF in State E
RC 201	2.9E-11	2.39%	3.2E-14	0.02%	0.0E+00	0.00%
RC 202	6.3E-15	0.00%	2.0E-17	0.00%	0.0E+00	0.00%
RC 203	1.2E-14	0.00%	0.0E+00	0.00%	0.0E+00	0.00%
RC 204	4.9E-12	0.41%	0.0E+00	0.00%	0.0E+00	0.00%
RC 205	1.1E-11	0.96%	0.0E+00	0.00%	9.9E-10	100.00%
RC 301	1.1E-13	0.01%	0.0E+00	0.00%	0.0E+00	0.00%
RC 302	2.1E-13	0.02%	3.9E-14	0.02%	0.0E+00	0.00%
RC 303	3.1E-10	26.07%	0.0E+00	0.00%	0.0E+00	0.00%
RC 304	1.6E-10	13.48%	0.0E+00	0.00%	0.0E+00	0.00%
RC 702	0.0E+00	0.00%	0.0E+00	0.00%	0.0E+00	0.00%
RC 802	6.7E-10	56.65%	1.8E-10	99.96%	0.0E+00	0.00%

Table 19.1-102—U.S. EPR Design Features Contributing to Low Risk
Sheet 1 of 7

No	U.S. EPR Design Feature Description	Disposition
1	**High level of redundancy and independence for safety systems** The U.S. EPR design incorporates four trains of most safety systems, and provides for significant separation:	
	• Four trains of the safety injection systems (LHSI, MHSI, and accumulators).	Tier 1, Section 2.2.3; Tier 2, Section 6.3
	• Four trains of emergency feedwater (EFW), supplying four steam generators. Each train has an EFW water storage tank for its suction source.	Tier 1, Section 2.2.4; Tier 2, Section 10.4.9.2.1
	• Four safety trains of support systems (cooling trains, building HVAC, and electric power).	Cooling Trains: Tier 2, Section 9.2.2; Tier 2, Section 9.2.1.2 HVAC: Tier 1, Section 2.6.6; Tier 2, Section 9.4.5 Electrical power: Tier 1, Section 2.5.1; Tier 2, Section 8.1.2
2	**Physical separation of safety systems** In addition to being highly redundant, the four trains of safety systems are physically separated by being located in different safeguard buildings. This significantly reduces the potential for core-damage accidents due to internal flooding, internal fires, or external events for which spatial considerations are important.	Tier 1, Section 2.1.1; Tier 2, Section 3.8.4; Tier 2, Section 6.3.2.6
3	**In-containment refueling water storage tank (IRWST)** The design of the IRWST eliminates some failure modes that have been important for current-generation plants: • Use of the IRWST eliminates the need to change system alignment by switching suction sources for safety injection following a LOCA. The failure to accomplish this switchover has been an important contributor to failure of long term safety injection for many current-generation PWRs. • Eliminating the need for switchover also obviates the need to isolate the suction path used during the injection phase. For some current-generation PWRs, failure to isolate this path has been assessed to result in inadequate NPSH for the safety injection paths, and may create a release path after the recirculation path is opened. • The reactor containment building affords the IRWST better protection against some types of external events than is the case for equivalent tanks at current-generation plants.	Tier 1, Section 2.2.2; Tier 2, Section 6.3.2.2.2

Table 19.1-102—U.S. EPR Design Features Contributing to Low Risk
Sheet 2 of 7

No	U.S. EPR Design Feature Description	Disposition
4	**High level of redundancy and independence for onsite power supply system** The U.S. EPR design includes both emergency diesel-generators (EDGs) and station blackout diesel generators that serve as an alternate AC source. These onsite power sources have the following features:	
	• There are four EDGs, one supporting each safety division. This provides substantial redundancy to maintain the function of safety systems following a loss of offsite power.	Tier 1, Section 2.5.4; Tier 2, Section 8.3.1.1.5
	• There are two backup SBO diesel-generators for AAC. The SBO diesel-generators are diverse from the EDGs in design, cooling, actuation and control, fuel oil supply and operating environment. This affords significant defense against potential common-cause failures that might affect all of the diesel generators.	Tier 1, Section 2.5.3; Tier 2, Section 8.4.1
	• The SBO diesel-generators can be aligned to back up two divisions of the safety loads if the EDGs are unavailable, and can be used to support systems provided to mitigate severe-accident conditions.	Tier 1, Section 2.5.3; Tier 2, Section 8.4.1
5	**Reliability of normal AC power supplies** Among the provisions incorporated into the design of the U.S. EPR to provide for improved reliability of the normal supply of AC power, reducing the demand for emergency power from the diesel-generators, are the following:	
	• The design includes the capability to withstand a full load rejection without tripping the reactor. In the event of a load rejection, the reactor and turbine would automatically run back to a power level sufficient to allow the main generator to continue to supply the plant auxiliary loads. This design would reduce the potential for reactor trip and challenge to onsite emergency power systems for grid-centered loss of power events.	Tier 2, Section 8.3.1.1
	• During normal operation, two auxiliary transformers supply power directly from the switchyard to all four safety-related switchgear divisions. An additional three transformers supply the non-safety-related switchgear. Since the main generator does not normally supply auxiliary loads in this configuration, a reactor trip does not create a demand for fast transfer to an offsite power source. Moreover, there are redundant feeds for each switchgear (safety-related and non-safety-related), so that loss of an individual auxiliary transformer will not affect the continued supply of offsite power to plant loads.	Tier 1, Section 2.5.5; Tier 2, Section 8.2.1.1; COLA Item 8.1-1; COLA Item 8.2-1; COLA Item 8.2-3

Table 19.1-102—U.S. EPR Design Features Contributing to Low Risk
Sheet 3 of 7

No	U.S. EPR Design Feature Description	Disposition
6	**Provisions to limit the impact of sequences involving failure to scram** The extra borating system (EBS) provides manual injection capability of highly borated water into the reactor pressure vessel (RPV) in the event that the reactor shutdown system does not function properly. EBS is a two-train system which further reduces the potential contribution of accidents involving a failure to scram	Tier 1, Section 2.2.7; Tier 2, Section 2 6.8
7	**Reduced potential for a small LOCA due to failure of reactor coolant pump (RCP) seals** The potential for RCS leakage or small LOCA (SLOCA) due to failure of reactor coolant pump (RCP) shaft seals has been an important risk contributor for many PWRs. The U.S. EPR design includes a stand still seal for each RCP. The stand still seal is a pneumatic, “metal-to-metal” seal that serves as a back-up seal, and is independent of the normal shaft seal. The stand still seal system reduces the risk of a LOCA event as a result of postulated RCP seal degradation.	Tier 2, Section 5.4.1.2.1
8	**Reduced potential for release pathway following a steam generator tube rupture (SGTR)** Among the features of the MHSI system is the provision for a shutoff head below the setpoints for the main steam safety valves (MSSV). In the event of an SGTR, the lower MHSI shutoff head limits the pressure differential that forces reactor coolant through the broken tube. The lower MHSI pressure will not challenge the associated MSSV to open (with possible failure to re-close). This reduces the potential for a release pathway from the RCS through the MSSV.	Tier 2, Table 6.3-3; Tier 2, Table 10.3-2; Tier 2, Section 15.6.3.1.1
9	**A state-of-the-art digital instrumentation and control (I&C) system**	
	The U.S. EPR uses state-of-the-art digital systems for I&C functions. The reliability of these systems enhances the automatic initiation of functions important to maintaining core cooling, including the following: • Reactor shutdown, • Emergency feedwater, and • Safety injection	Tier 1, Section 2.4.1; Tier 2, Section 7.1.1.4.1
	The man-machine interface implemented through a fully computerized control room also optimizes the information available to the operators.	Tier 2, Section 7.1.1.1

Table 19.1-102—U.S. EPR Design Features Contributing to Low Risk
Sheet 4 of 7

No	U.S. EPR Design Feature Description	Disposition
	Because of the level of redundancy of such systems, concerns regarding the potential for common-cause failures must be addressed. A number of important measures have been taken to limit the potential for CCFs for the digital I&C systems of the U.S. EPR, including the following: • The Protection System employs subsystems called diversity groups to accomplish essential actuations. These subsystems are functionally diverse and independent. The diversity results from the use of different application programs and different parameter/sensor inputs. No information is shared between diversity groups via network connections. • The outputs of the protective system (PS) are connected to diverse reactor trip devices. • The ESF functions are also divided between the diverse subsystems to obtain maximum functional diversity. In addition to the functional diversity provided by the subsystems within the PS and the diversity of the reactor trip devices, there is additional defense-in-depth provided in the I&C architecture. This includes the following:	Tier 2, Section 7.1.1.4.1
	• Trip reduction features of the RCSL and PAS systems, which provide control, surveillance, and limitation functions to reduce reactor trips and PS challenges. Among these features is the automatic power reduction that is not credited in the PRA.	Tier 2, Section 7.1.1.4.5; Tier 2, Section 7.1.1.4.6
	• Backup trip and actuation functions are performed by the non-safety-related I&C system (i.e., the PAS).	Tier 2, Section 7.4.1.1
	The potential for software CCFs is minimized by such measures as the following: • High quality software design tools. • A deterministic operating system. • Built in monitoring and testing. • Built in functional diversity.	Tier 2, Section 7.1.1.1; Tier 2, Section 7.1.1.2
10	**Diversity of some elements of HVAC** Diversity is incorporated into the design of the safety chilled water system through the use of air cooling for the refrigeration units in Divisions 1 and 4, and CCW cooling for the refrigeration units of Divisions 2 and 3.	Tier 2, Section 9.2.8.2.2

Table 19.1-102—U.S. EPR Design Features Contributing to Low Risk
Sheet 5 of 7

No	U.S. EPR Design Feature Description	Disposition
11	**A large, robust containment** The U.S. EPR has a containment that can withstand a variety of challenges, including the following:	
	• The containment has a free volume of about 2.8 x 10^6 ft^3, and a design pressure of 62 psig. This volume and relatively high design pressure provide significant capacity to accommodate the loadings due to a LOCA, a main steam-line break inside containment, or severe-accident phenomena.	Tier 2, Section 6.2.1.1.2; Tire 2, Section 6.2.1.5.3
	• The containment is also designed to maintain its integrity when challenged by external forces, including the impact from aircraft and the loadings from seismic events.	Tier 1, Section 2.1.1; Tier 2, Section 6.2.1.1.1
12	**Primary depressurization system (PDS)**	
	The U.S. EPR is equipped with a PDS that goes well beyond the capabilities for depressurization in current-generation PWRs to address the potential for accidents that might progress with the RCS at high pressure. This system is comprised of two trains with four depressurization valves, independent of three pressurizer safety valves, that can provide the following benefits:	Tier 2, Section 19.2.3.3.4
	• The SADVs can be used to provide a bleed path independent of the PSVs to support feed-and-bleed cooling in the event of a total loss of feedwater to the steam generators. This feature of the system further reduces the potential for occurrence of a core-damage accident.	Tier 2, Section 19.2.2.6
	• In the event of a severe accident, the primary purpose of the SADVs is to prevent the progression from taking place with the RCS at high pressure. Depressurization of the RCS limits the potential for induced failures of the RCS due to the generation of high-temperature gases. This is of particular interest because it further reduces the potential for induced failure of tubes in the steam generators; such failure could create the possibility of a path for radionuclide release that would bypass the containment boundary.	Tier 2, Section 19.1.4.2.1.2
	• Depressurization of the RCS also limits the dispersion of core debris to the containment atmosphere, essentially eliminating the possibility of direct containment heating.	Tier 2, Section 19.2.3.3.4
13	**Provisions to control combustible gases** The containment is equipped with passive autocatalytic recombiners. These recombiners prevent the buildup of hydrogen concentration so as to limit the size of any hydrogen deflagration and prevent hydrogen detonation	Tier 1, Section 2.3.1; Tier 2, Section 6.2.5.2.1

**Table 19.1-102—U.S. EPR Design Features Contributing to Low Risk
Sheet 6 of 7**

No	U.S. EPR Design Feature Description	Disposition
14	**Core-melt retention system** A passive device allows water from the IRWST to flood the corium spreading area to remove heat from below the core debris via the cooling water channels. This design limits the potential for core-concrete interactions that could cause pressurization of the containment via the generation of non-condensable gases.	Tier 2, Section 19.2.3.3.3.1
15	**Severe-accident heat removal system** The severe accident heat removal system (SAHRS) provides a means for removing heat from containment following a severe accident. Feature of the SAHRS that play an important role in the Level 2 PRA include the following: • The system supports passive cooling of the molten core debris. • The system includes a containment spray mode that enhances scrubbing of fission products from the containment atmosphere. • The system provides for active recirculation of cooling water for the molten core debris. • Active elements of the SAHRS rely on the SBO diesel generators, providing a degree of diversity and independence from the safety systems involved in core cooling. In addition to containment heat removal credited in Level 2, the SAHRS is also credited in some Level 1 sequences for cooling IRWST if the heat removal function of LHSI fails. The demands/ challenges to the SAHRS are relatively low in frequency due to the four train reliability of LHSI heat removal and overall low CDF. The SAHRS is a single train, which has a dedicated CCW and ESW cooling capability. The system is manually initiated.	Tier 1, Section 2.3.3; Tier 2, Section 19.2.3.3.3.2
16	**Main steam relief trains for reliable heat removal** Each main steam line is equipped with a MSRT. To provide for both reliable operation and limited potential for spurious operation, each MSRT is equipped with four solenoid valves.	Tier 2, Section 10.3.2.2
17	**The remote shutdown workstation is in a fire and flood area separate from the main control room.** Although a main control room fire may defeat manual actuation of equipment from the main control room, it will not affect the automatic functioning of safe shutdown equipment via the PS or manual operation from the remote shutdown station. Sufficient instrumentation and control is provided at the remote shutdown station to bring the plant to safe shutdown conditions in case the control room must be evacuated. There are no differences between the main control room and remote shutdown workstation controls and monitoring that would be expected to affect safety system redundancy and reliability.	Tier 2, Section 3.4.3.4; Tier 2, Section 9.5.1.2.1

Table 19.1-102—U.S. EPR Design Features Contributing to Low Risk
Sheet 7 of 7

No	U.S. EPR Design Feature Description	Disposition
18	**MCR & RSS ventilation systems** The main control room has its own ventilation system, and is pressurized. This prevents smoke, hot gases, or fire suppressants originating in areas outside the control room from entering the control room via the ventilation system. The ventilation system for the remote shutdown workstation is independent of the ventilation system for the main control room.	Tier 2, Section 6.4.2.4; Tier 2, Section 9.4.1.3
19	**Seismic margins analysis** The plant level HCLPF is ≥ 1.67 SSE, where the SSE is defined by the Certified Design Response Spectra (CSDRS), and there are no spatial seismic interaction issues. Differences between the as-built plant and the design used as the basis for the U.S. EPR FSAR seismic margins analysis will be reviewed.	COL Item 19.1-6; COL Item 19.1-9
20	**Instrumentation through RPV top head** The U.S. EPR location of the RPV instrumentation which is through RPV top head not lower head, reduces likelihood of LOCA during maintenance	Tier 2, Section 5.3.3.1.1

Table 19.1-103—U.S. EPR Level 1 Top Initiating Event Contributions to the Total CDF at Power

IE Rank	IE ID	CDF	CDF	Cumulative CDF
1	LOOP - General	9.6E-08	17.4%	17.4%
2	FIRE-SAB14-AC	7.9E-08	14.3%	31.7%
3	SLOCA	5.1E-08	9.2%	40.9%
4	FIRE-MS-VR	3.4E-08	6.2%	47.1%
5	FLD-ANN ALL	3.2E-08	5.8%	52.9%
6	LOOP - SBO	3.1E-08	5.7%	58.6%
7	GT	2.7E-08	4.9%	63.5%
8	FIRE-MCR	2.5E-08	4.6%	68.1%
9	FIRE-SWGR	2.2E-08	3.9%	72.0%
10	FLD-SAB14 FB	2.1E-08	3.8%	75.8%
11	All SLBs	1.9E-08	3.4%	79.2%
12	LOCCWS (ESWS/UHS)	1.7E-08	3.1%	82.3%
13	LOOP - Seal LOCA	1.7E-08	3.0%	85.3%
14	FIRE-SAB-MECH	1.6E-08	2.9%	88.2%
15	SGTR	1.3E-08	2.3%	90.5%
16	ATWS	1.0E-08	1.8%	92.4%
17	FLD-EFW	7.2E-09	1.3%	93.7%
18	LBOP	6.2E-09	1.1%	94.8%
19	LOMFW	5.8E-09	1.0%	95.8%
	TOTAL CDF:	5.3E-07		

Table 19.1-104—U.S. EPR Level 1 Total Events Sensitivity Studies
Sheet 1 of 3

Sensitivity Case Group	Case #	Sensitivity Case Description	SC CDF (1/yr)	Delta CDF (%)
0	0	Base Case (Total CDF)	5.3E-07	0%
1		**Common Cause Assumption**		
	1a	Common cause events not considered	3.7E-07	-31%
	1b	EDGs & SBODGs in the same CC group	1.4E-06	159%
	1c	CC for I&C Software - recovery not credited	5.4E-07	2%
2		**LOOP Assumptions**		
	2a	No Credit was given for LOOP recoveries (DG MT also set back to 24 hours)	1.1E-06	100%
	2b	DG Mission Time set to 24 hours	6.5E-07	24%
	2c	SBO DG Mission Time set to 18 hours	5.2E-07	-1%
	2d	Consequential LOOP events were not considered	4.6E-07	-13%
	2e	All Consequential LOOP values set to 5.3E-03 (value for LOCA)	1.1E-06	100%
3		**Assumptions on Electrical Dependencies**		
	3a	MSRT Realignment to One Power Train per Train	4.4E-07	-16%
	3b	For CVCS seal injection, assume that a switchover from the VCT to the IRWST is always required (Div1 & Div4 required)	1.1E-06	102%
	3c	UHS 4 assumed unavailable during SBO Conditions (no credit for SBO x-tie for dedicated ESW)	5.4E-07	2%
	3d	The same credit given to the operators to X-tie two divisions in SBO (HEP=7E-2) & non-SBO conditions (HEP=0.5)	5.0E-07	-5%
4		**Assumptions on HVAC Recoveries**		
	4a	Room heat-up was not considered	3.7E-07	-30%
	4b	Operator recovery of HVAC not credited	1.3E-05	2426%

Table 19.1-104—U.S. EPR Level 1 Total Events Sensitivity Studies
Sheet 2 of 3

Sensitivity Case Group	Case #	Sensitivity Case Description	SC CDF (1/yr)	Delta CDF (%)
	4c	Circular logic adjustment: Failure of HVAC 1 disables HVAC 2 (HVAC4 disables HVAC 3)	5.4E-07	2%
5		**Sensitivity to HEPs Values**		
	5a	All HEPs Set to 5% Value	2.2E-07	-59%
	5b	All HEPs Set to 95% Value	1.6E-06	203%
6		**Assumptions on Probabilities of an RCP LOCA**		
	6a	RCP Seal LOCA Probability - 1.0	1.1E-06	102%
	6b	RCP Seal LOCA Probability - 0.5	7.3E-07	38%
	6c	RCP Seal LOCA Probability - 0.1	4.6E-07	-12%
7		**Assumptions on Long Term Cooling Mission Time**		
	7a	SAHR Mission Time set to 36 hours	5.3E-07	0%
	7b	SAHR Mission Time set to 72 hours	5.3E-07	0%
8		**Preventive Maintenance Assumptions**		
	8a	Train 3 assumed to be in PM for all year	1.3E-06	140%
	8b	W/o Preventive Maintenance	3.1E-07	-41%
9		**Isolation of EFW Tank Leak**		
	9	EFW Isolation not possible	5.3E-07	1%
10		**Location of CCW Switchover Valves**		
	10	Flood in SAB14 doesn't disable CCWS SO	5.1E-07	-3%
11		**Physical Separation of Non-safety Cables**		
	11	Fire in CSR kills Safety Train 4 and all Non-Safety Divisions	8.3E-07	58%
12		**Simultaneous Hot Shorts not Considered**		

Table 19.1-104—U.S. EPR Level 1 Total Events Sensitivity Studies
Sheet 3 of 3

Sensitivity Case Group	Case #	Sensitivity Case Description	SC CDF (1/yr)	Delta CDF (%)
	12	Simultaneous hot shorts not considered, therefore no inadvertent valve openings for PZR cubicle or MFW/MS valve room fire	4.9E-07	-7%
13	**Assumptions on MS isolation, given a Fire in MFW/MS Valve Room**			
	13a	MSIV3 & MSIV4 isolation not credited for a fire in MFW/MS valve room	1.1E-06	114%
	13b	MSIV3 and MSIV4 assumed not to be separated by a fire barrier, for a fire in MFW/MS Valve Room	5.0E-07	-6%
14		**Combination of Different Cases**		
	14	Combination of Cases 1b, 2b, 2e, 3a, 3b, 5b, 6a	7.5E-06	1318%

Table 19.1-105—U.S. EPR Release Category Contributions to Total LRF from at Power Internal Events, Fire and Flooding
Sheet 1 of 2

Release Category	Description	Mean	Contribution to LRF	Conditional Containment Failure Probability
RC201	Containment fails before vessel breach due to isolation failure, melt retained in vessel	5.0E-10	1.9%	0.001
RC202	Containment fails before vessel breach due to isolation failure, melt released from vessel, with MCCI, melt not flooded ex vessel, with containment sprays	4.0E-14	0.0%	0.000
RC203	Containment fails before vessel breach due to isolation failure, melt released from vessel, with MCCI, melt not flooded ex vessel, without containment sprays	8.5E-13	0.0%	0.000
RC204	Containment fails before vessel breach due to isolation failure, melt released from vessel, without MCCI, melt flooded ex vessel with containment sprays	2.4E-11	0.1%	0.000
RC205	Containment failures before vessel breach due to isolation failure, melt released from vessel, without MCCI, melt flooded ex vessel without containment sprays	4.1E-10	1.5%	0.001
RC301	Containment fails before vessel breach due to containment rupture, with MCCI, melt not flooded ex vessel, with containment sprays	1.6E-12	0.0%	0.000
RC302	Containment fails before vessel breach due to containment rupture, with MCCI, melt not flooded ex vessel, without containment sprays	1.5E-11	0.1%	0.000
RC303	Containment fails before vessel breach due to containment rupture, without MCCI, melt flooded ex vessel, with containment sprays	2.3E-09	8.7%	0.004
RC304	Containment fails before vessel breach due to containment rupture, without MCCI, melt flooded ex vessel, without containment sprays	1.8E-08	66.5%	0.033

Table 19.1-105—U.S. EPR Release Category Contributions to Total LRF from at Power Internal Events, Fire and Flooding
Sheet 2 of 2

Release Category	Description	Mean	Contribution to LRF	Conditional Containment Failure Probability
RC702	Steam Generator Tube Rupture without Fission Product Scrubbing	5.4E-09	20.3%	0.010
RC801	Interfacing System LOCA with Fission Product Scrubbing		0.0%	0.000
RC802	Interfacing System LOCA without Fission Product Scrubbing but building credited	2.6E-10	1.0%	0.001
	Total LRF:	**2.7E-08**	**100.0%**	**0.050**

Table 19.1-106—Seismic Fragilities of Safety-Related Structures

Building/ Structure	Designation/ Location	Failure Mode	Am (g)	βR	βU	HCLPF (g)
Reactor Bldg & Annulus (I)	0UJA, 0UJB	Shear failure of containment wall	8.9	0.25	0.41	3.0
Contain-ment Internal Structure (I)	0UJA	Shear failure of internal structure walls	6.4	0.25	0.42	2.1
Safeguards Bldgs (I)	1UJH and 4UJH; 1UJK and 4UJK; 1UJE and 4UJE	Shear failure of concrete shear wall	4.9	0.26	0.41	1.6
Safeguards Bldgs (I)	UJH/UJK 2+3; UJE 2+3	Shear failure of concrete shear wall	5.8	0.26	0.42	1.9
Fuel Bldg (I)	0UFA	Shear failure of concrete shear wall	5.8	0.26	0.42	1.9
Diesel Bldgs (I)	1UBP through 4UBP	Shear failure of concrete shear wall	5.6	0.26	0.41	1.8
Nuclear Auxiliary Bldg (II)	0UKA	--	--	--	--	1.30

Table 19.1-107—Seismic Fragilities of Mechanical and Electrical Equipment

Equipment Category	Am (g) spectral accel.	β_R	β_U	HCLPF g
Battery	7.0	0.25	0.37	2.5
Cable Tray	7.9	0.34	0.43	2.2
Charger	4.3	0.26	0.39	1.5
Chiller	5.2	0.30	0.35	1.8
Compressor	5.2	0.20	0.40	1.9
Converter	4.3	0.26	0.39	1.5
Engine Generator	--	--	--	1.3
Fan	5.2	0.20	0.40	1.9
Filter	5.2	0.30	0.35	1.8
Instrumentation Rack	--	--	--	1.3
Inverter	4.3	0.26	0.39	1.5
MCC	4.3	0.26	0.39	1.5
Offsite power	0.8	0.40	0.38	0.2
Piping	7.9	0.34	0.43	2.2
Pump	5.2	0.20	0.40	1.9
Switchgear	4.3	0.26	0.39	1.5
Tank	5.2	0.30	0.35	1.8
Transformer	6.2	0.25	0.37	2.2
Valve	7.9	0.34	0.43	2.2

Table 19.1-108—U.S. EPR PRA Based Insights
Sheet 1 of 5

No	U.S. EPR PRA Based Insight	Disposition
1	**Significance of AC power to the core-damage results** Despite the provisions made for the reliable supply of offsite and onsite AC power, the risk results indicate that losses of offsite power are among the dominant contributors to the frequency of core damage. Since the U.S. EPR employs active safety systems that derive their motive power from AC sources, this is to be expected. The CDF remains low because of the level of redundancy and diversity incorporated into the AC systems.	Tier 2, Section 19.1.4.1.2.2
2	**Modest contribution of SLOCA** Small LOCAs are less significant than are losses of offsite power. This is large part due to the four-train redundancy of the safety injection systems. The contribution from SLOCAs is, however, still important on a relative basis, because of the potential for common-cause failures of the systems needed to prevent core damage (e.g., common injection check valves, MHSI and actuation systems).	Tier 2, Section 19.1.4.1.2.2
3	**Potential cross-train impact of loss of HVAC** Because of the normal configuration with two trains of CCW in operation, a loss of HVAC for the building in which one CCW operating train is located can have consequences that affect HVAC for the building in which the standby CCW train is located. For example, as the systems are modeled in the PRA, a failure of HVAC with failure to recover cooling for SB 1 has a potential to result in the following effects: ● A complete loss of the AC and DC buses in Division 1. ● Loss of operating CCW pump Division 1 and failure of CCW common header switchover. ● Loss of CCW flow for thermal-barrier and motor cooling of RCPs 1 and 2. ● Loss of charging pump 1. ● Loss of cooling to the safety chillers Division 2 and loss of HVAC in SB 2.	Tier 2, Section 9.2.2.2.1; Tier 2, Section 9.4.5; Tier 2, Section 9.4.6; Tier 2, Section 19.1.4.1.1.3
4	**Sensitivity to human reliability** The Level 1 internal events CDF is sensitive to probabilities for human failure events. The U.S. EPR employs active safety systems, and in unlikely sequences of multiple trains failures, operators are credited to initiate recovery actions (e.g., loss of HVAC recovery, feed and bleed, recovery in SBO conditions, or fast cooldown function). The HRA is performed under assumptions that the operating procedures and guidelines will be well written and complete. This applies to operator training as well.	Tier 1, Section 3.04; Tier 2, Section 18.6

Table 19.1-108—U.S. EPR PRA Based Insights
Sheet 2 of 5

No	U.S. EPR PRA Based Insight	Disposition
5	**EDGs and SBO DGs are assigned to different common-cause groups.** This PRA modeling assumption will be confirmed by assuring diversity between EDGs and SBO DGs (multiple diversities that could be accomplished be selecting different model, control power, heating, ventilation and air conditioning (HVAC), engine cooling, fuel systems, and location.	Tier 2, Section 8.4.1
6	**High I&C system reliability** The fault-tolerant design of the TXS platform contributes to high I&C system reliability. Inherent in the modeling of the fault tolerant design is the “coverage” of the self-monitoring features, which determines for a given module the percentage of failure modes that are assumed to be repaired quickly (24 hours) versus the non-self-monitored failure modes that are detected by periodic surveillance tests.	Tier 2, Section 7.1.2.6.26; Tier 2, Section 7.1.2.6.16; Tier 2, Section 7.1.2.6.21; Tier 2, Table 1.8-2, Item 19.1-9
7	**The AV42 priority module is not susceptible to CCF** Software CCF is not a concern for the AV42 priority module because the safety-related functions contain neither software nor an operating system. The AV42 uses a programmable logic device; the functions on the module are implemented in solid state logic gate arrays and are non-user programmable. The AV42 is 100% testable before installation. The device also undergoes rigorous physical testing and qualification (environmental, electrical, seismic, radiation, electromagnetic interference, and radio frequency interference). The AV42 module is designed with features to ensure independence between the safety-related and non-safety-related circuits.	Tier 2, Section 7.1.1.2.1
8	**Risk of losing all instrumentation is negligible** The human machine interface (HMI) design includes both SICS and PICS systems for operator monitoring and controls. Consequently the risk of losing all instrumentation is negligible relative to the human error probability.	Tier 2, Section 7.1.1.3.1; Tier 2, Section 7.1.1.3.2
9	**Floods caused by a break in a system with very large flooding potential (ESWS or DWS) are assumed to be contained below ground level of the affected buildings (SB or FB).** Bases for this assumption are following: 1. Those systems are automatically isolated if the building sump detects a large flooding event 2. Expansive time is needed to flood a building up to ground level, so operator isolation is likely to succeed if automatic isolation failed.	Tier 1, Section 2.1.1; Tier 2, Section 3.4.3.1; Tier 2, Section 3.4.3.3; Tier 2, Section 3.4.3.4; Tier 2, Section 3.4.3.5

Table 19.1-108—U.S. EPR PRA Based Insights
Sheet 3 of 5

No	U.S. EPR PRA Based Insight	Disposition
10	**Isolation of EFW tank leaks or pipe breaks is assumed possible for any break location.** Pipe breaks in the EFWS are treated as flooding events with the potential to drain all four EFW tanks. It is assumed that the operators would have the ability to manually isolate an EFW pipe break occurring in any of the four SB with isolation valves in another unaffected SB and to initiate DWS makeup to the tanks of the intact EFW trains. The severity of a flooding event from an EFW tank leak will be reduced as a result of the design change identified in Section 19.1.2.4, which maintains the EFW suction header isolation valves closed. Manual isolation of an EFW tank leak or pipe break will not be necessary.	Tier 2, Section 3.4.3.4; Tier 2, Section 10.4.9.2.1
11	**Flooding event would not affect the electrical and I&C rooms of a safeguard building.** Flood paths are provided in the safeguard buildings, such that water from a break anywhere in the building would be stored in the lower elevation of the building. In particular, a flooding event would not affect the electrical and I&C rooms of a safeguard building. All electrical / I&C equipment is located above the maximum postulated flood level.	Tier 1, Section 2.1.1; Tier 2, Section 3.4.3.4
12	**Cable separation in the MCR Cable Spreading Area** Due to divisional separation measures in the MCR Cable Spreading Area, a fire in the cable spreading area is assumed to disable only one electrical safety division. Non-safety division cables are also assumed to be separated from the safety divisions.	Tier 2, Section 9.5.1.2.1
13	**Shutdown management guidelines** The shutdown guidelines as described in the Shutdown Management Guidelines, NUMARC 91-06, should be considered when developing the plant specific operations procedures.	Tier 2, Section 13.5.2; COLA Item 13.1-1; COLA Item 13.4-1; COLA Item 13.5-1
14	**The low probability that the IRWST suction strainers are plugged during shutdown.** The IRWST design (e.g., large, separation between suction lines, debris retaining capability) and plant procedures (e.g., foreign material control) are expected to ensure that this probability is low.	Tier 2, Section 6.3.2.2.2; COLA Item 6.3-1
15	**Closing containment hatches and penetrations** The ability to close containment hatches and penetrations during Modes 5 & 6 prior to steaming to containment is important. It is assumed that procedures and training will be developed that encompass this item.	Tier 2, Section 13.5.2; COLA Item 13.1-1; COLA Item 13.4-1; COLA Item 13.5-1
16	**Low pressure reducing station auto isolation** In shutdown operation, low pressure reducing station auto isolation on low loop level is important to prevent possible RCS flow diversion through CVCS.	Tier 2, Section 9.3.4.2.2

Table 19.1-108—U.S. EPR PRA Based Insights
Sheet 4 of 5

No	U.S. EPR PRA Based Insight	Disposition
17	**Automatic level control at mid-loop** Automatic level control at mid-loop is important to reduces likelihood of RHR pumps cavitations.	Tier 2, Section 5.4.7.2.1
18	**In-containment refueling water storage tank/SD** As stated in the Insight #3, the design of the IRWST eliminates some failure modes that have been important for current-generation plants: in shutdown operation IRWST inside containment reduces impacts of RHR flow diversions which lead to LOCAs inside containment not outside.	Tier 2, Section 6.3.2.2.2
19	**RHR auto isolation on safeguards building sump level** In shutdown operation, RHR auto isolation and pump shutoff on a high safeguards building sump level, divisionally based, is an important protection from RHR LOCAs outside containment.	Tier 2, Section 5.4.7.2.1
20	**Automatic MHSI actuation** In shutdown operation, automatic MHSI actuation on a low RCS (hot leg) loop level or on a low dPsat (for cold shutdown) is important to mitigate losses of RHR, LOCAs and flow diversions.	Tier 2, Section 5.4.7.2
21	**Sensitivity to human reliability in shutdown** Similarly to the Insight # 20, the shutdown CDF is sensitive to probabilities for human failure events. Important human actions in shutdown are operator isolations of various flow diversions; operator actions to control draindown in midloop and operator manual actuations of RHR/LHSI pumps. It is assumed that instrumentation to support above actions will be available (e.g. loop level and sump level indications and alarms) and that the written procedures covering the above actions will be implemented, and maintained.	Tier 2, Section 18.6
22	**An alternate decay heat removal path** An alternate decay heat removal path in shutdown, can be established by operator action to manually open PSV valves or primary depressurization valves and to initiate MHSI/LHSI injection.	Tier 2, Section 5.2.2
23	**Physical separation of safety systems/SD** As stated in the Insight #2, complete physical separation of the U.S. EPR safety systems, significantly reduces the potential for core-damage accidents due to internal or external hazards in shutdown. It is assumed that this separation also makes it possible to implement controls during maintenance in shutdown to protect operating trains. It is also expected that the written procedures will be developed to cover Fire Protection Program implementation.	Tier 2, Section 5.4.7.2; Tier 2, Section 9.5.1.6

Table 19.1-108—U.S. EPR PRA Based Insights
Sheet 5 of 5

No	U.S. EPR PRA Based Insight	Disposition
24	**Seal Loca contribution to fire and flooding CDF** RCP seal LOCAs are identified as important contributors to both the internal fire and the internal flooding CDF. The design change to thermal barrier cooling, identified in Section 19.1.2.4, exhibits a prospective reduction in seal LOCA contribution to fire and flooding CDF.	Tier 2, Section 19.1.5.2.2.8 Tier 2, Section 19.1.5.3.2.8

Table 19.1-109—U.S. EPR PRA General Assumptions
Sheet 1 of 16

No.	Category[1]	PRA General Assumptions[2]
1	Model	Because of the circular logic problem, failures of electrical supplies to the HVAC/CCW/ESW trains used in the electrical system fault trees are not considered. Because of that, some interdependencies between different HVAC divisions may not be completely captured in the PRA model.
2	IE	Initiating event frequencies are based on a full year at power and were not adjusted for time spent at shutdown. For the current estimated shutdown duration, an adjustment factor would be 0.95. This assumption will be evaluated when plant–specific shutdown information is available.
3	IE	Trains 1 and 4 are assumed to be running for CCW/ESW pumps. This assumption on the running CCW trains results in an inclusion of the HVAC dependency between two safety divisions, and presents a higher risk configuration. Trains 1 and 4 are assumed to be operating for 8760 hr/year in order to calculate the LOCCW/ESW initiating event frequencies. The all year mission time is also used for the system common cause events.
4	IE	In the U.S. EPR PRA, LOCAs are assumed to occur on RCS loop 4. For medium and large break LOCAs, any injection flow (MHSI, LHSI, or accumulators) into cold leg 4 is assumed to pass out the break and not to reach the reactor vessel and core. In addition, due to the effects of steam entrainment during large break LOCAs, flow into the vessel from LHSI injection into cold leg 1 is also assumed to be unavailable.
5	IE	Very small leaks are not considered in the LOCA analysis since the response to this event would be similar to that of a transient and are within the makeup capability of the CVCS.
6	IE	In modeling SLOCA events, if the MHSI system fails, it is assumed that operators would initiate a fast cooldown. However, if a partial cooldown function fails (therefore failing MHSI), it is assumed that operators will initiate feed and bleed. These modeling assumptions and timing of these sequences will be analyzed in more detail after operating procedures are available.
7	IE	Spurious operation of MHSI and LHSI (a spurious SIS signal) are screened out as initiating events because the pump's shutoff head is lower than the reactor coolant system (RCS) normal operating pressure and spurious operation is not likely to cause an initiating event.
8	IE	One or few MSIVs closure was not considered as an initiating event; it was assumed that the operators can open the MSIV bypass valves from the control room to support secondary cooling. Closure of all MSIVs is included in the loss of main condenser initiating event.

Table 19.1-109—U.S. EPR PRA General Assumptions
Sheet 2 of 16

No.	Category[1]	PRA General Assumptions[2]
9	IE	Initiating events due to a loss of HVAC to the SWGR rooms or the main control room (MCR) are not explicitly modeled. These events are assumed to have similar effects as for the loss of single division initiator, or fires in the SWGR rooms, or the MCR. Even for a complete loss of HVAC event, it is not expected that the loss of HVAC event would result in plant trip. There is a chance that the CCW pump in the building is initially running, but this pump likely has low dependence on HVAC considering the relatively low heat load in the building during normal operation and compensatory actions that could be taken. Even if the CCW pump failed due to loss of HVAC, it is unlikely that a plant trip would be required, as the standby CCW pump or common header supply MOV serving the same CCW common header would have to fail to require reactor trip.
10	IE	Human errors during maintenance are not considered as possible initiators. Human maintenance actions will be evaluated for possible initiators after the maintenance procedures and insights from maintenance practice are available.
11	IE	The MFW system is assumed to require the main condenser and main steam bypass for success. The capability of MFW to provide SG makeup with only the demineralized water system has not been confirmed, thus the PRA model conservatively neglects this possibility.
12	IE	Recovery of offsite power is considered for transient events in two hours and for RCP seal LOCA events in one hour. Possible recovery for other times is partially credited through modifying the EDG running mission time, which was reduced to 12 hours. SBO DGs mission time was not modified.
13	IE	The full load rejection capability feature is assumed to have a failure probability of 0.32. If the full load rejection capability successfully performs its intended function, the U.S. EPR design can withstand a grid-induced loss of offsite power without requiring a reactor trip. The plant will isolate itself from the grid, and continue at power with only the “house” load supplied by the main generator.
14	IE	Conservative simplifying assumptions are made when modeling ATWS events; possibility to relieve RCS pressure is not credited for any events which lead to a loss of FW (e.g., a loss of MFW or a loss of condenser). Exceptions are LOOP events, when the RCP are tripped instantly.
15	CC	Common mode failure of the water cooled-chillers and the air-cooled chillers is not modeled. It was judged that the air-cooled and water-cooled chillers are functionally diverse.
16	CC	Intersystem common cause failure is only considered between the six IRWST sump strainers associated with SIS and SAHRS. For these six components, common cause factors from a group of four components are used. Using this data has the effect of overestimating the probability of a common cause failure of all six sump strainers by a factor of three.

Table 19.1-109—U.S. EPR PRA General Assumptions
Sheet 3 of 16

No.	Category[1]	PRA General Assumptions[2]
17	CC	The I&C of the U.S. EPR has not been designed to the point where a formal software reliability analysis is feasible. Therefore, the MGL common cause parameters assigned to I&C components are a rough approximation and are expected to be conservative.
18	CC	The most important common cause event based on RAW importance is the CCF of the safety-related batteries on demand because, in the case of a LOOP event, this event is assumed to lead directly to core damage.
19	PM	Maintenance unavailability in the PRA model is assumed to be a combination of preventive and corrective maintenance. The unavailability time due to preventive maintenance is assumed to be seven days per year. Preventive maintenance is only considered for systems where it is assumed that scheduled maintenance will normally be performed "at power". The unavailability time due to corrective maintenance is assumed to be three days for the running systems, and nine days for the standby systems.
20	PM	Maintenance unavailability is assumed on a divisional basis; only one division is allowed to have one (or several) of its systems unavailable for maintenance at any given time. In addition: • One EFW train cannot be in maintenance when SSS/EDWS is in maintenance. • One SBO DG and one EDG cannot be out for maintenance at the same time.
21	PM	Maintenance assumptions are not included for operating electrical and I&C equipment. The basis for this assumption is discussed below: • Each Class 1E DC bus has two separate battery chargers and only one of them is credited in the PRA analysis which allows for one battery charger to be unavailable for maintenance. • It is assumed that maintenance unavailability of the battery and the UPS inverter will be small relative to the other failure modes that are included in the model, since preventive maintenance is assumed to be performed during shutdown modes and corrective maintenance is assumed to be negligible. • The maintenance unavailability of a Class 1E AC or DC bus is also assumed to be negligible, given that preliminary design information suggests an eight hour AOT for Class 1E buses and a two hour AOT for the Class 1E dc buses.
22	HRA	The HRA is performed under the assumption that the operating procedures and emergency guidelines will be well written and complete and that the operators will be well trained. Conservative HRA methods are used because the detailed design for the human machine interface (HMI) and corresponding emergency operating guidelines are not completed.

Table 19.1-109—U.S. EPR PRA General Assumptions
Sheet 4 of 16

No.	Category[1]	PRA General Assumptions[2]
23	HRA	For the experience and training performance shaping factors (PSF), the specific qualifications of the operators are not known at this time and the base PSF reflects nominal conditions based on insufficient information. For certain operator actions, however, a PSF reflecting a higher than nominal level of training and experience was applied. This factor (0.5 x the nominal value) was applied, for example, to failure to initiate feed-and-bleed cooling or to initiate cooldown of the RCS because these are actions that are assumed to receive extensive attention in operator training and to be practiced many times on the simulator.
24	HRA	The deciding factor in the HRA is the time available for the diagnosis and action, measured from initiation of the event or a subsequent cue, until core damage is unavoidable (as determined by the MAAP analysis). The timing elements are analyzed in a cue-response time framework. However, the specific cues, their timing, and the decision criteria are preliminary at this time; therefore the cues discussed in the models are based on engineering judgment from the available MAAP runs and conceptual understanding of the emergency operating guidelines.
25	HRA	Dependencies between pre-initiator human errors are not considered in the PRA model due to lack of test and maintenance procedures. Instead, a zero dependency is assumed for maintenance or tests on redundant trains. It was assessed that maintenance or test actions, especially at power, could not be performed on redundant equipment concurrently and are likely to be separated in time.
26	HRA	In the ASEP method, it is proposed that a complete dependency should be assumed between the functional testing and the independent verification. In this application, this assumption was considered to be overly conservative, given that the functional testing and verification are likely to be performed in different time steps, with different crews (two different tasks). Instead, the ASEP method was modified and a medium dependency was considered between these two recovery actions.
27	HRA	Most components in the electrical system (inverters, buses and transformers required to operate post accident) are continuously operating and are continuously monitored. It is assumed that pre-startup checklists confirm appropriate equipment configuration prior to startup. The operation of the batteries is also frequently monitored, and the float charge verifies electrical continuity. Therefore, there are no pre-accident human errors included in the electrical fault trees to represent an inappropriate initial operating condition or alignment for these components.

Table 19.1-109—U.S. EPR PRA General Assumptions
Sheet 5 of 16

No.	Category[1]	PRA General Assumptions[2]
28	HRA	Different operator actions human error probabilities (HEPs) are estimated for the SBO conditions (LOOP and all EDGs not available) versus non-SBO conditions (LOOP and at least one EDG available). It was assumed that operators will have more clear direction about the crosstie of buses and equipment in clear SBO conditions when no emergency power is available (i.e., versus the partially powered situation). The PRA also assumes that in SBO conditions operators will perform actions as required to allow LHSI and SAHRS to function. This assumption will be evaluated when the operating procedures and guidelines are available.
29	HRA	Because of the limited amount of information available at this time, a simplified HRA approach is used for LPSD operator actions. A spreadsheet is created that provides generic HEPs for operator actions assigned to the five categories of PSF for time (inadequate, barely adequate, nominal, extra, and expansive) for both diagnosis and action. The other PSFs are assumed to be nominal. However, the spreadsheet allows the PSFs for stress, complexity, and experience/training to be adjusted by the user as needed. The spreadsheet is based on the methodology and formulae of the SPAR-H methodology as implemented by the EPRI HRA calculator.
30	HRA	The MCR design including human factors engineering (HFE) and the human system interface (HSI) information was unavailable input into the DC PRA. The HFE and HSI will become much more specific as the design progresses. PSFs that were unable to be assigned specifically, such as those for ergonomics will need to be assessed and existing PSFs may need to change when more information becomes available.
31	SYS	CVCS is not credited for an RCS injection function. CVCS is only credited for RCP seal injection. It is assumed that the CVCS supply from the volume control tank will be available for a majority of the events where CVCS is credited for RCP seal injection with an estimated failure probability of 0.1. This assumption will be evaluated when plant–specific information is available.

Table 19.1-109—U.S. EPR PRA General Assumptions
Sheet 6 of 16

No.	Category[1]	PRA General Assumptions[2]
32	SYS	If both means of thermal barrier cooling are lost (CVCS seal injection and CCW thermal barrier cooling), the applicable seal LOCA assumptions are summarized below: ● If the RCPs are not tripped within 10 minutes (either automatically or manually), a seal LOCA is assumed. ● If seal leak-off valves fail open on any of the four RCPs, the probability of a seal LOCA is estimated to be 0.2. ● If Standstill Seal System fails to engage the probability of a seal LOCA is estimated to be 0.2. ● The probability that the standstill seal fails to engage was estimated as 1E-03 per demand (this is a newly developed system for which historical failure data is not available). ● Additionally, If the RCP motor and thrust bearing cooling is lost and the RCPs are not tripped within 30 minutes (either automatically or manually), a seal LOCA is assumed.
33	SYS	The PRA conservatively assumes that a loss of ventilation (SAC) to the electrical and I&C rooms in the Safeguards Building results in the complete loss of function of the electrical and I&C equipment in the affected building, after about two hours. Recovery actions are credited. The above assumption is conservative because generally it is judged unlikely that an electrical bus would fail due to loss of HVAC. However, important electrical supplies such as the inverters and battery chargers could fail, and instrumentation and control cabinets may fail, effectively rendering the electrical buses incapable of performing their intended function. It is judged likely that when the final building heat loads are known, including size of the area, location of sensitive equipment, qualification of equipment, heat up rates, time to failure if applicable, recovery actions etc., this modeling can be relaxed.
34	SYS	The HVAC model makes conservative assumptions regarding the equipment required to provide adequate cooling. ● Both the supply fan and the recirculation\exhaust fan are assumed to be required. However, in reality either fan may be sufficient to maintain an environment conducive to equipment survival. ● Availability of chilled water to the SAC is assumed to be required. However, for most, or even all, of the year, availability of chilled water to the SAC system may not be required for equipment survivability; those areas requiring ventilation may only need fresh air with exhaust.

Table 19.1-109—U.S. EPR PRA General Assumptions
Sheet 7 of 16

No.	Category[1]	PRA General Assumptions[2]
35	SYS	The following location dependency on the ventilation is considered negligible: ● Emergency Diesel Generator Buildings. ● Service Water Pump Buildings. ● SIS pump rooms. ● Fuel Building. ● Main Steam & Feedwater Valve Compartments. ● Circulating Water Building. ● Turbine Building. ● Conventional Island Electrical Building.
36	SYS	The EFWS pump rooms are judged to require SAC room cooling (local unit coolers) although this may be conservative because the SAC system provides air movement through the room. These SAC unit coolers are included in the EFWS model. The SAC coolers require chilled water (QK) which is included in the model.
37	SYS	It was judged that loss of MCR ventilation (SAB) is a negligible contributor to plant risk. There are four 50% ventilation trains powered by the 4 emergency power supplies, and only trains 2 and 3 are dependent on essential service water and containment cooling water. Also, the operators can open the doors to obtain partial cooling from SAC. In the unlikely case that the heat up causes unacceptable temperatures in the MCR the operators can evacuate to the remote shutdown room.
38	SYS	The capacity of the safety UHS basins will provide adequate NPSH to the ESWS/UHS pumps for 72 hours; no makeup to the basin is required for or assumed in the PRA. There will be no failure modes based on the failure of makeup to the basin of any cooling tower.
39	SYS	An estimate of the heat removal capability of a single cooling tower fan shows that a UHS train one pump and one fan will supply sufficient cooling for all of the system's heat loads except for RHR heat exchanger cooling. In those sequences where RHR heat exchanger cooling is required, the model requires that one pump and both cooling tower fans are running.

Table 19.1-109—U.S. EPR PRA General Assumptions
Sheet 8 of 16

No.	Category[1]	PRA General Assumptions[2]
40	SYS	A 100% volume per day leakage rate was used to determine the size of the containment failure above which the release for a containment isolation failure was considered "large." The results from MAAP runs performed for the Level 2 source term analysis were examined, and this resulted in the determination that: ● Leakage from a 1" diameter or smaller break could be neglected, as the flow rated observed were less than 10% of the threshold value for "large" releases. ● Leakage from a single 2" diameter break would fall below the criteria for "large" release. ● Leakage from two or more 2" lines, as well as any single line greater than 2" in diameter should be considered as a "large" release.
41	SYS	The PRA model models passive flooding valves as having two failure modes. For IRWST cooling, these valves are modeled as undeveloped basic events, "Failure to Remain Closed" with an assumed failure rate of 1.00E-04. For basemat flooding in either the active or the passive mode, these valves are modeled as basic events, "Failure to Open and Remain Open" with an assumed failure rate of 1.00E-02.
42	I&C	Reactor trip fault trees specific to every initiating event are not developed. Instead, representative reactor trips are modeled with a typical set of challenged parameters. This assumption is based on the protection system (PS) being designed so that each postulated initiating event will challenge at least two different measured parameters for reactor trip that are implemented in the two PS subsystems..
43	I&C	The I&C design has measures to preclude spurious operation. The frequency of initiating events caused by spurious I&C actions is not modeled explicitly and is subsumed in the reactor trip and other applicable initiating events. This is a reasonable assumption because the frequency of spurious operation of the digital I&C is expected to be improved relative to the historical initiating event data base.
44	I&C	The signal conditioning for the PS (signal modifiers, multipliers, etc.) assumes typical arrangements because design details were unavailable.
45	I&C	The PICS and the SICS are assumed not to be vulnerable to common cause failures based on the diversity of the PICS and the SICS I&C platforms (described in Section 7.1).
46	I&C	The system PAS contains controls for non-safety systems and diverse backups for reactor trip and ESFAS actuations. The diverse ESFAS actuations (automatic and/or manual) are not included in the PRA model at this time because design details were unavailable. The PRA contains simplified models of the diverse reactor trip and, where needed, the non-safety control functions.

Table 19.1-109—U.S. EPR PRA General Assumptions
Sheet 9 of 16

No.	Category[1]	PRA General Assumptions[2]
47	I&C	The system SAS contains controls for post-accident safety systems. The SAS model in the PRA is simplified because design details were unavailable.
48	I&C	The normal plant control systems (PAS and RCSL) have features to reduce the frequency and consequence of plant transients that may challenge the safety systems. This is accomplished both by the way that the control functions are distributed within the I&C system divisions and by the limitation I&C functions. In as much as the PRA uses historic operating experience for the initiating event frequencies, the impact of these features is not evaluated in the PRA.
49	I&C	Instrument calibration errors are not evaluated for the design certification PRA. Instrumentation calibration errors will be analyzed in more detail after maintenance procedures and insights from maintenance practices are available.
50	LPSD	RCS level and volume are treated conservatively during the RCS level transitions in outages. For example, whenever the reactor cavity is not flooded and RCS level is not in the pressurizer, mid-loop operation is assumed. The following further summarizes this conservatism: ● Whenever the pressurizer is being drained, this time is applied to mid-loop. ● Whenever the reactor cavity is being drained after refueling, this time is applied to mid-loop. ● When level is near the flange during RPV head removal and installation, this time is applied to mid-loop. ● When level is increased from mid-loop to fill the cavity or pressurizer, this time is applied to midloop.
51	LPSD	The shutdown POS durations and schedule in the LPSD PRA are based on the following assumptions: ● 18-month refueling cycle. ● 94% plant availability. ● Normal refueling outage of 14 days. ● Forced outage rate of 5 days/year. The LPSD PRA model assumes that the RCS status as well as decay heat are constant during the time within the POS. The analysis considers an early entry time after shutdown for the start of a POS and then decay heat is not reduced during the POS. This is conservative during a shutdown to cold conditions (e.g., unplanned maintenance) when decay heat levels would be much lower over time than that assumed in POS CA or POS CB.

Table 19.1-109—U.S. EPR PRA General Assumptions
Sheet 10 of 16

No.	Category[1]	PRA General Assumptions[2]
52	LPSD	Possible transient LOCA events through RPV and PZR vent are not considered. The PRZ vent is normally open during shutdown. The RPV vent is open during mid-loop and during plant startup after refueling. Given RCS temperatures and pressures, a loss of inventory in the form of steam was evaluated after a loss of RHR cooling. The pressurizer vent contains a flow restrictor, which significantly limits the flow well below the makeup capacity of the CVCS system. The RPV vent is a one-inch line, and it would take a large amount of time to uncover the core by venting steam through this line. The risk from this event is not considered significant because the operators have more than enough time to isolate the vent or to provide makeup to the RCS.
53	LPSD	Loss of decay heat removal initiators while the plant is in POS E are neglected because the time to boil and then boil-off to top of fuel is very long when the cavity is flooded.
54	LPSD	Risk from the pressurizer solid state was not considered. Inadvertent start of a reactor coolant pump or a MHSI pump could cause an overpressure event when the pressurizer is solid. The PSVs and RHR relief valves would protect the system from overpressure and the exposure time is small. To address the risk of such an event, the low frequency of occurrence must be combined with the low probability of pressure relief failure and the probability that over pressure actually fails the pressure boundary and causes a core damage event. Thus, overfill events that could lead to a low temperature overpressure event have been considered not likely and have not been identified as initiating events that could significantly contribute to risk.
55	LPSD	IRWST cooling is assumed not to be required when the RPV head is off. Makeup to the RPV for boil-off is required when heat removal is lost. It would take more than 3 days to boil-off the IRWST if it is assumed that the steam is not condensed in the containment and returned to the IRWST.
56	LPSD	Preventive maintenance unavailabilities used in the full power PRA are not applicable during LPSD. At this stage, system/functions are conservatively assumed to either be available or unavailable, as defined below: ● Maintenance on the SG systems is assumed to be performed on two SGs that are assumed not available in states CAD and CBD. ● Maintenance on all other trains is assumed to occur in state E. One division is assumed out for maintenance during that state. ● PSVs maintenance is assumed to be performed after the RPV head is removed. ● Because of maintenance unavailability assumptions, the charging system is not credited, even though it is likely to be available in states CAD and CBD.

Table 19.1-109—U.S. EPR PRA General Assumptions
Sheet 11 of 16

No.	Category[1]	PRA General Assumptions[2]
57	LPSD	The equipment hatch is considered open in shutdown POS Ca, Cb, E and closed in D. The possibility to close hatch is credited (except in POS E). The initial actions are performed inside the containment, therefore the habitability of the containment (local temperature) is considered to be the limiting criterion in determining the time available to close the hatch. The closing action is assumed to take 20 minutes if power is available, or 90 minutes (and 6 operators) if the power is not available. All containment isolation valves are considered to have equal or higher probabilities of being open compared to the full power. No containment isolation line is assumed to be closed during entire shutdown duration.
58	LPSD	In the shutdown PRA it was assumed that the control of transient combustibles and limitation of the maintenance activities would apply to the operating RHR train and supporting systems. Because of the physical separation between operating and standby trains, the impact of the possible degradation in the fire and flood barriers during shutdown is assumed to be not significant. Based on these judgments, the risk from fire and flood events during at-power operation is assumed to envelop the risk during shutdown.
59	Flood	Because of incomplete information on equipment and piping locations, it is assumed that a flood in any building will fail all equipment in the building.
60	Flood	U.S. EPR plant systems that transport fluid (water) through any area are considered potential flood sources. The maximum released volume is the full inventory contained in the system. If automatic make-up from another source exists, the inventory of the second source is also considered.
61	Flood	Pipe failure data is characterized by pipe diameter and system category. A pipe failure rate is defined for each pipe system category and is assumed to be constant over time. No distinction was made between running systems and standby systems.
62	Flood	It is assumed that a component listed as “affected” could fail as soon as the water reaches its lowest electrical part. The height of water needed to fail components depends on the room considered. However, it is assumed that this height will always be higher than one foot (1’). Therefore, systems that are not capable of generating a flood level of more than 1’ at the lowest elevation of their flood area are screened out of this analysis.
63	Flood	It is assumed that a flood in SB 1 or SB 4 would propagate to the fuel building, and vice versa. The door that separates those buildings is supposed to withstand a three-foot water column; it is conservatively assumed that any flood will cause it to fail.

Table 19.1-109—U.S. EPR PRA General Assumptions
Sheet 12 of 16

No.	Category[1]	PRA General Assumptions[2]
64	Flood	Floods caused by a break in a system with very large flooding potential (ESWS or DWS) are assumed to be contained below ground level of the affected buildings (SB or FB). This assumption is based on the ability to automatically isolate those systems upon high sump level. Moreover, the amount of time needed to flood a building up to ground level is lengthy which supports detection and isolation by the operator if automatic isolation failed. This manual isolation is credited because an alarm exists in the Control Room, and the operation can be performed with high reliability.
65	Flood	A flood in an SB is assumed to affect the CCW switchover valves. This is a conservative assumption, since those valves are located exactly at ground level, while all flooding events considered are contained below ground level. Failure of either Train 1 or 4 of CCW requires a switchover to be performed in order to ensure continuous supply to the CCW common header. This assumption results in asymmetrical results for SAB1/4 versus SAB2/3.
66	Flood	Pipe breaks in the EFWS are treated as flooding events with the potential to drain all four EFW tanks. It is assumed that the operators would have the ability to manually isolate an EFW pipe break occurring in any of the four SB with isolation valves located in the unaffected SBs, and to initiate DWS makeup to the tanks of the intact EFW trains. The severity of a flooding event from an EFW tank leak or pipe break will be reduced as a result of the design change identified in Section 19.1.2.4, which maintains the EFW suction header isolation valves closed. Manual isolation of an EFW tank leak or pipe break will not be necessary.
67	Flood	If a flood in the annulus from a fire water distribution system (FWDS) pipe break is left unisolated, water level will reach the level of the doors before it reaches the level of the electrical penetration. The doors are not designed to withstand water pressure applied from the Annulus side, therefore, their opening is considered. If both doors fail to open, water will reach the electrical penetrations level. All instrumentation to the core is affected, leading to a possible loss of control and/or spurious signals. It is difficult to assess the consequences, but they could be severe and, conservatively, core damage was assumed. The probability that the connection boxes of the electrical penetrations that run through the annulus will fail if submerged is estimated to be 0.5. This number represents the limited state of knowledge regarding the design of those penetrations. This assumption has a very high importance, because the failure of the penetrations is assumed to lead directly to core damage.

Table 19.1-109—U.S. EPR PRA General Assumptions
Sheet 13 of 16

No.	Category[1]	PRA General Assumptions[2]
68	Flood	Since detailed design for the Turbine Building has not been generated, an attempt was made to perform flooding evaluation by applying conservative assumptions in cases where information was not available. It is assumed that all equipment required for secondary heat removal (e.g., MFW/SSS pumps) will be located on the lowest elevations of the Turbine Building and will fail as the result of flooding. As far as the flooding potential is concerned, the circulating water system connected to the conventional UHS is consider to be the bounding system, and it is assumed that it has the potential to flood the TB above ground level. Should that occur, and should communication exist between the TB and the SWGR building, it is assumed that this communication would be protected by a water-resistant door so that water would preferably flow outside. Therefore, the spreading of the TB flood to another building is not considered.
69	Fire	Based on the spatial separation of safety trains in the U.S. EPR, a conservative internal fire analysis has been performed implying that the fires are analyzed for an entire fire area (FA) (i.e., a location separated by three-hour fire barriers), that the worst PRA scenario resulting from the failure of all SSC in the FA is modeled, and that the total area fire ignition frequency is applied to that scenario. Propagation between fire areas is not considered. When two FAs are essentially identical and a fire in one or the other would have the same effect on the plant operation, only one of the symmetrical PFAs is modeled; the ignition frequency and risk of each area is assumed to be equal.
70	Fire	Transient fires are not specifically considered in the analysis. It is assumed that they are enveloped in the used generic fire frequencies. For the FAs where component specific frequencies are used (transformer yard, MS/MFW valve room and containment), it was assumed that a transient contribution would be minimal.
71	Fire	If no detailed information about fire detection and suppression is available for a fire area, no suppression is credited. The exceptions are: 1. It is assumed that automatic fire suppression will be installed in the Turbine Building in the vicinity of the Turbine Generator oil and Hydrogen inventories which represent major combustible loads. A factor of 0.1 is used as a suppression failure probability 2. To account for the fact that the MCR is permanently manned, making visual detection and manual suppression more likely to succeed, a factor of 0.1 is used as a manual suppression failure probability.
72	Fire	A fire in any AC or DC switchgear room is assumed to disable all divisions. Even if the fire is localized, detection is likely to shut down the room ventilation. The temperature resulting from the fire and loss of ventilation is likely to exceed the equipment qualification limit.

Table 19.1-109—U.S. EPR PRA General Assumptions
Sheet 14 of 16

No.	Category[1]	PRA General Assumptions[2]
73	Fire	The U.S. EPR RCPs will be fitted with an oil-collection system designed to prevent RCP oil leakage from reaching any ignition source. Because of this improved design, it is assumed that fire ignition due to RCP oil leakage reaching an ignition source does not occur.
74	Fire	A fire in the MCR is assumed to disable the entirety of the MCR if it is not suppressed. This will happen if a fire affects either the functional capability of the MCR (destroying cables or workstations) or if it degrades the habitability to an extent where operators have to evacuate the control room. A corresponding operator action is associated with the entire process, including the decision to evacuate the MCR and the action of switching controls. It is assumed that once the operators resume control of the plant from the RSS, the status of the plant will be similar as that following a Loss of Balance of Plants (LBOP) since the fire in the MCR could result in a loss of control of secondary side balance of plant systems. Failure of the operators to transfer to the RSS is assumed to lead directly to core damage. The RSS is assumed to be available in all POS where fuel is loaded to the core.
75	Fire	For the CSR and MCR, the generic room fire ignition frequency is modified by using the 0.5 correction factor to account for the fact that most of the cables routed through the CSR and MCR will be fiber optic cables that are not susceptible to ignition under any condition.
76	Fire	The consequences of the spurious opening of an MSRIV are dependent on the position of the MSIV, with higher consequences corresponding to an open MSIV. The MSIVs are designed to fail closed in the case that their associated SOVs are de-energized. However, hot shorts may still cause one or more MSIVs to remain open. It is conservatively assumed that if there is a fire in the valve room that causes a spurious opening of an MSRIV, it could affect MSIV on the same location, even though there is approximately 14 feet of spatial separation between the MSRIV and MSIV. Based on engineering judgment, it is assumed that a fire affecting an MSRIV would cause its associated MSIV to fail open with a probability of 0.5 and independently cause the other MSIV in the same Valve Room to fail open with a probability of 0.1. Since this modeling was finalized, fire barriers were added in each of the two main steam/main feedwater valve rooms to separate Division 1 from Division 2 and Division 3 from Division 4. This separation would prevent any fire impact on the second MSIV.
77	Fire	Detailed designs for the Turbine Building and the Switchgear Building were not available at the time of the fire risk evaluation. Therefore, it was conservatively assumed that both the TB and SWGR building are one contiguous fire area. Given that the type of communications that will exist between the Switchgear Building and the TB is not known, it was consider reasonable to assume that electrical penetrations and doors, if any, will have a fire rating of three hours.

Table 19.1-109—U.S. EPR PRA General Assumptions
Sheet 15 of 16

No.	Category[1]	PRA General Assumptions[2]
78	Fire	The entire Transformer Yard is considered a single fire area and is physically separated from other plant structures. Separation will be assured by non-rated exterior barriers and distance. These factors will prevent a fire in the Transformer Yard from propagating to other plant structures. In the fire risk evaluation, it is also assumed that fire protection features will be designed to prevent fire propagation between transformers.
79	Seismic	When equipment is not seismically qualified by analysis or testing or anchorage design is not complete, the seismic analysis is based on the seismic design criteria and qualification methods normally followed in the nuclear industry.
80	Seismic	Seismic-induced LOOP, LOCA and ATWS events are assumed to dominate all potential initiating events. Equipment and structures that are not seismically qualified are not credited in the model. The key assumptions regarding system availability and operator response are given below: ● Seismic-induced LOOP is assumed not to be recoverable. ● Station Blackout (SBO) Diesels are assumed to fail as a result of a SSE. ● All systems that depend on normal AC power such as main feedwater, main condenser, Startup and Shutdown System (SSS) pump, and their support systems are assumed to fail as a result of a SSE. ● Operator actions in response to seismic events are not credited. ● RCP seal injection with CVCS is assumed to be lost due to a seismic event. ● CVCS makeup to the Reactor Pressure Vessel (RPV) and auxiliary pressurizer spray are assumed to fail as a result of a SSE. ● Dedicated Relief Valves (DRV) are assumed to fail as a result of a SSE. ● Severe Accident Heat Removal (SAHR) is assumed to fail as a result of a SSE.
81	Seismic	The PRA-based seismic margin assessment assumes that equipment will be installed as designed and that there are no potential spatial interaction concerns in the as-built configuration (e.g., adjacent cabinets are bolted together, collapse of non-seismically designed equipment or masonry wall onto safety-related equipment is precluded, and no likelihood of seismically-induced fire or flood impacting safety-related equipment).

Table 19.1-109—U.S. EPR PRA General Assumptions
Sheet 16 of 16

No.	Category[1]	PRA General Assumptions[2]
82	LPSD	Nozzle dams are not required during a plant shutdown, but may be used infrequently during mid-cycle maintenance, when full core off-load is not desirable. Appropriate RCS operating conditions will be considered in the specification of nozzle dams to provide reasonable assurance that nozzle dams will not fail. Plant procedures that cover reduced inventory operation will govern the installation of nozzle dams and the establishment of adequate venting to prevent pressurization of the RPV upper plenum due to a postulated loss of decay heat removal. Nozzle dams are the only U.S. EPR related temporary reactor coolant system boundary as specified by NUREG-1449 and NUREG-1512. Freeze seals are not expected to be used; they will not be part of the maintenance procedures for the U.S. EPR.
83	LPSD	The efficiency of the Passive Autocatalytic Recombiners (PAR) during shutdown is assumed to be nominal. Maintenance unavailability, if any, is assumed to be limited to a small fraction of the PARs and would not affect the overall efficiency of the system.

Notes:

1.

Category	Description
Model	Modeling Assumption
IE	Initiating Event
CC	Common Cause
PM	Preventive Maintenance
HRA	Human Reliability Analysis
SYS	System Modeling
I&C	Instrumentation and Controls
LPSD	Low Power/ Shutdown Modeling
Flood	Flood Analysis
Fire	Fire Analysis
Seismic	Seismic Analysis

2. The PRA assumptions will be reevaluated as part of the PRA maintenance and update process. The PRA maintenance and upgrade process is described in Section 19.1.2.4. COL item 19.1-9 listed in Table 1.8-2—U.S. EPR Combined License Information Items is provided to confirm that assumptions used in the PRA remain valid for the as-to-be-operated plant.

Next File