REVISED RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

APR1400 Design Certification

Korea Electric Power Corporation / Korea Hydro & Nuclear Power Co., LTD

Docket No. 52-046

RAI No.:	**433-8363**
SRP Section:	**SRP 19**
Application Section:	**19.1**
Date of RAI Issue:	**03/08/2016**

Question No. 19-75

10 CFR 52.47(a)(27) states that a design certification (DC) application must contain an FSAR that includes a description of the design-specific PRA and its results. SECY 93-087 approves an alternative approach to seismic PRA for the DC application and interim staff guidance (ISG) 20 provide guidance on the methods acceptable to the staff to demonstrate acceptably low seismic risk for a DC. As per the guidance in DC/COL-ISG-020, Section 5.1.2, two methods, namely the separation of variables (EPRI Report TR-103959) and conservative deterministic failure margin (CDFM; EPRI Report NP-6041) are acceptable to the staff for determining seismic fragility.

a. Design Control Document (DCD) Section 19.1.5.1, Table 19.1-43 provides specific fragilities (i.e., high confidence in low probabilities of failure (HCLPFs)) for the Containment Building Exterior Walls, Containment Building Interior Structure, and the Auxiliary Building. The table indicates that these specific seismic fragilities were derived by analysis. The staff requests the applicant to describe the methodology used for developing these specific seismic fragilities, and to include pertinent references for the methodology and any generic data or assumptions (e.g., failure modes, capacity and response factors, and associated uncertainties) used to develop HCLPF capacities for the Containment Building Exterior Walls, Containment Building Interior Structures, and Auxiliary Building.

b. DCD Section 19.1.5.1.1.2 states, “The seismic fragilities (mean failure probabilities) for the component groups are calculated based on values of AM, βR, βU for these components at an HCLPF value of 0.5g and a relative acceleration of 1.0g”. Clarify what is meant by a relative acceleration of 1.0g with regards to the seismic fragility.

Response – (Rev. 2)

a. Table 19.1-43 for DCD 19.1.1.5.1 is revised as shown in Attachment 1.

The detailed HCLPF calculations including Reactor Containment Building (Exterior wall), Containment Internal structure and Auxiliary Building are included in the calculation for seismic fragility analysis (9-035-N392-304, Rev.2).

b. The paragraph of DCD Section 19.1.5.1.1.2, “The seismic fragilities (mean failure probabilities) for the component groups are calculated based on values of A_M, β_R, β_U for these components at an HCLPF value of 0.5g and a relative acceleration of 1.0g” is deleted and revised as shown in Attachment 2.

Impact on DCD

Table 19.1.43 is revised as shown in Attachment 1 and the DCD Section 19.1.5.1.1.2 is revised as shown in Attachment 2.

Impact on PRA

There is no impact on the PRA.

Impact on Technical Specifications

There is no impact on the Technical Specifications.

Impact on Technical/Topical/Environmental Reports

There is no impact on any Technical, Topical, or Environmental Report.

Replace with "A" B

Table 19.1-43 (1 of 10)

Seismic Fragility Analysis Results Summary

Component	Location	Freq (Hz)	Failure mode	Am	Br	Bu	HCLPF(1) (g)	Mean Failure Prob	Qualification Method	Remark
Reactor Pressure Vessel	Containment El. 69'-156'	11.28	Support	>1.5	-	-	S/O	-	Analysis	
Reactor Vessel Internal	Containment El. 69'-156'	11.28	Core Support Barrel	>1.5	-	-	S/O	-	Analysis	
Steam Generator	Containment El. 114'-136'06"	11.28	Upper Support	>1.5	-	-	S/O	-	Analysis	
Pressurizer	Containment El. 114'-156'	11.28	Shear Lug	>1.5	-	-	S/O	-	Analysis	
Reactor Coolant Pumps	Containment El. 114'-136'06"	11.28	Upper Support	>1.5	-	-	S/O	-	Analysis	
Reactor Coolant System Piping	Containment	-	Generic	>1.5	-	-	S/O	-	Generic DB	
Regenerative Heat Exchanger	Containment El. 114'	>33	Foundation bolt	>1.5	-	-	S/O	-	Analysis	
Charging Pumps	A/B El. 55'	-	Nozzle MB	>1.5	-	-	S/O	-	Analysis	
Letdown Heat Exchanger	Containment El. 100'	>33	Base Plate	>1.5	-	-	S/O	-	Analysis	
Auxiliary Charging Pump	A/B El. 55'	>33	Concrete Coning	>1.5	-	-	S/O	-	Analysis	

Replace with "A"
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Table 19.1-43 (2 of 10)

Component	Location	Freq (Hz)	Failure mode	Am	Br	Bu	HCLPF(1) (g)	Mean Failure Prob	Qualification Method	Remark
Safety Injection Tanks	Containment El. 136' 06"	11.86	Concrete Coning	1.79	0.42	0.36	0.50	1.46E-01	Analysis	
Shutdown Cooling Pumps	A/B El. 50'	>33	Concrete Coning	>1.5	-	-	S/O	-	Analysis	
Shutdown Cooling Heat Exchanger	A/B El. 50'	>33	Concrete Coning	>1.5*	-	-	S/O	-	Analysis	
SC Pump Miniflow Heat Exchanger	A/B El. 50'	>33	Saddle Plate	>1.5	-	-	S/O	-	Analysis	
Safety Injection Pump	A/B El. 50'	>33	Concrete Coning	>1.5	-	-	S/O	-	Analysis	
Containment Spray Pump	A/B El. 50'	>33	Concrete Coning	>1.5	-	-	S/O	-	Analysis	
CS Miniflow Hx	A/B El. 50'	7.1	Support	>1.5	-	-	S/O	-	Analysis	
Containment Spray Heat Exchanger	A/B El. 55'	7.43	Concrete Coning	>1.5	-	-	S/O	-	Analysis	
Main Steam Isolation Valves	A/B El. 137' 06"	-	Generic	>1.5	-	-	S/O	-	Generic DB	
Main Steam Atmospheric Valves(ADV)	A/B El. 137'06"	-	Generic	>1.5	-	-	S/O	-	Generic DB	
Main Steam Safety Valves	A/B El. 137'06"	-	Generic	>1.5	-	-	S/O	-	Generic DB	

Replace with "A"

B

Table 19.1-43 (3 of 10)

Component	Location	Freq (Hz)	Failure mode	Am	Br	Bu	HCLPF[(1)] (g)	Mean Failure Prob	Qualification Method	Remark
AFW Pump-Motor Driven	A/B El. 78'	>33	Base Plate	>1.5	-	-	S/O	-	Test/ Analysis	
AFW Pump-Turbine Driven	A/B El. 78'	24.5	Foundation Bolt	>1.5	-	-	S/O	-	Analysis	
Emergency Diesel Generators	EDG[(2)] El. 100' A/B El. 100'	3	Fixation Bolt	1.82	0.42	0.37	0.50	1.42E-01	Analysis	
Emergency Diesel Fuel Oil transfer pump	EDG El. 65' A/B El. 63'	>33	Base Plate	>1.5	-	-	S/O	-	Test/ Analysis	
Starting Air Tank	A/B El. 100'	>33	Skirt Support	>1.5	-	-	S/O	-	Analysis	
Diesel Fuel Oil Day Tank	EDG El. 121' A/B El. 120'	>33	Saddle Support	>1.5	-	-	S/O	-	Analysis	
Diesel Fuel Oil Storage Tank	EDG El. 63' A/B El. 65'	4.1	Concrete Coning	>1.5	-	-	S/O	-	Analysis	
Silencer	A/B El. 100'	0.58	Head Plate	>1.5	-	-	S/O	-	Analysis	
Air Intake Filter	A/B El. 109'	11.6	Body	>1.5	-	-	S/O	-	Analysis	
Lube Oil Water Hx	A/B El. 100'	5.84	Concrete Coning	>1.5	-	-	S/O	-	Analysis	
Motor Driven Fuel Oil Feed Pump	EDG El. 100' A/B El. 100'	>33	Pump Pad	>1.5	-	-	S/O	-	Analysis	
Essential Service Water Pump	ESW building El. 69'	18	Discharge Head Rib	>1.	-	-	S/O	-	Analysis	

Replace with "A" B

Table 19.1-43 (4 of 10)

Component	Location	Freq (Hz)	Failure mode	Am	Br	Bu	HCLPF[(1)] (g)	Mean Failure Prob	Qualification Method	Remark
CCW Heat Exchangers	CCW HX Building El. 100'	10.97	Head Plate	>1.5	-	-	S/O	-	Analysis	
CCW Pump	A/B El. 55'	>33	Pump Mt Bolt	>1.5	-	-	S/O	-	Analysis	
CCW Surge Tank	A/B El. 172'	>33	Concrete Coning	>1.5	-	-	S/O	-	Analysis	
Essential Chilled Water Pumps	A/B El. 78'	>33	Pump Mt Bolt	>1.5	-	-	S/O	-	Analysis	
Essential Chillers	A/B El. 78'	>33	Functional	>1.5	-	-	S/O	-	Test	
		>33	Concrete Coning	>1.5	-	-	S/O		Analysis	
ECW Compression Tank	A/B El. 172'	26.1	Vessel Shell	>1.5	-	-	S/O	-	Analysis	
ECW Air Separator	A/B El. 78'	>33	Structure	>1.5	-	-	S/O	-	Analysis	
Essential Chilled Water System Control Panel	A/B El. 78'	15.12	Functional	>1.5	-	-	S/O	-	Test	
			Structural	>1.5	-	-	S/O			
AFWP Room Cubicle Cooler-MD	A/B El. 78'	8.67	Functional	>1.5	-	-	S/O	-	Test	
			Foundation Bolt	>1.5	-	-	S/O		Analysis	
CCWP Room Cubicle Cooler	A/B El. 55'	11.53	Functional	>1.5	-	-	S/O	-	Test	
			Drain Pipe	>1.5	-	-	S/O		Analysis	

Replace with "A"
B

Table 19.1-43 (5 of 10)

Component	Location	Freq (Hz)	Failure mode	Am	Br	Bu	HCLPF(1) (g)	Mean Failure Prob	Qualification Method	Remark
SI Room Cubicle Cooler	A/B El. 50' A/B El. 55'	11.53	Functional	>1.5	-	-	S/O	-	Test	
			Drain Pipe	>1.5	-	-	S/O		Analysis	
SC Pump & Mini-flow HX Room Cubicle Cooler	A/B El. 50' A/B El. 55'	8.67	Functional	>1.5	-	-	S/O	-	Test	
			Fan/Motor Frame	>1.5	-	-	S/O		Analysis	
Mech. Pen. Room Cubicle Cooler	A/B El. 100' A/B El. 120'	8.67	Functional	>1.5	-	-	S/O	-	Test	
			Fan/Motor Frame	>1.5	-	-	S/O		Analysis	
CS Pump Room Cubicle Cooler	A/B El. 50' A/B El. 55'	8.67	Functional	>1.5	-	-	S/O	-	Test	
			Fan/Motor Frame	>1.5	-	-	S/O		Analysis	
Aux Charging Pump Room Cubicle Cooler	A/B El. 55'	11.53	Functional	>1.5	-	-	S/O	-	Test	
			Outlet End Skin	>1.5	-	-	S/O		Analysis	
Charging Pump Room Cubicle Cooler	A/B El. 55'	11.53	Functional	>1.5	-	-	S/O	-	Test	
			Outlet End Skin	>1.5	-	-	S/O		Analysis	
Elect. Pen. Room Area Cubicle Cooler	A/B El. 120' A/B El. 137' 6"	8.67	Functional	>1.5	-	-	S/O	-	Test	
			Fan/Motor Frame	>1.5	-	-	S/O		Analysis	

Replace with "A"

B

Table 19.1-43 (6 of 10)

Component	Location	Freq (Hz)	Failure mode	Am	Br	Bu	HCLPF(1) (g)	Mean Failure Prob	Qualification Method	Remark
Essential Chiller & Pump Cubicle Cooler	A/B El. 78'	8.67	Functional	>1.5	-	-	S/O	-	Test	
			Fan/Motor Frame	>1.5	-	-	S/O		Analysis	
CCW HX Room Supply Fans	CCW HX Building El. 100'	17	Functional	>1.5	-	-	S/O	-	Test	
	El. 126'		Structural	>1.5	-	-	S/O		Analysis	
ESW Pump Room Supply Fan	ESW building El. 90'	>33	Functional	>1.5	-	-	S/O	-	Test	
			Structural	>1.5	-	-	S/O		Analysis	
EDG Room Emergency Exhaust Fan	EDG El. 100' A/B El. 172'	32	Functional	>1.5	-	-	S/O	-	Test	
			Structural	>1.5	-	-	S/O		Analysis	
Control Room Emergency Makeup ACU	A/B El. 172'	10.13	Functional	>1.5	-	-	S/O	-	Test	
			Housing	>1.5	-	-	S/O		Analysis	
ESF-CCS GC Cabinet	A/B El. 156'	11.9	Functional	1.01	0.25	0.38	0.35		Test	There are no relays to affect the function of the panel.
			Structure	1.5	0.25	0.42	0.50	2.03E-01		
ESF-CCS LC Cabinet	A/B El. 156'	12.14	Functional	1.01	0.25	0.38	0.35	-	Test	The structural failure is related to the parts and accessory which are listed in table below.
			Structural	1.5	0.25	0.42	0.50	2.03E-01		
	A/B El. 137'6"	12.14	Functional	1.2	0.25	0.38	0.42	-		
			Structural	>1.5	-	-	S/O			

Replace with "A" B

Table 19.1-43 (7 of 10)

Component	Location	Freq (Hz)	Failure mode	Am	Br	Bu	HCLPF[(1)] (g)	Mean Failure Prob	Qualification Method	Remark
Plant Protection System Cabinet	A/B El. 156'	12.1	Functional	1.01	0.25	0.38	0.35	-	Test	There are no relays to affect the function of the panel. The structural failure is related to the parts and accessory which are listed in table below.
			Structural	1.5	0.25	0.42	0.50	2.03E-01		
Reactor Trip Switchgear	A/B El. 137'6"	-	Functional	>1.5	-	-	S/O	-	Test	There are no relays to affect the function of the panel
			Structural	>1.5	-	-	S/O			
MCR Operator Consoles	A/B El. 156'	>33	Functional	1.13	0.36	0.44	0.3	-	Test	There are no relays to affect the function of the panel
			Structural	>1.5	-	-	S/O			
MCR Safety Consoles	A/B El. 156'	>33	Functional	-	-	-	-	-	Test	There are no relays to affect the function of the panel
			Structural	>1.5	-	-	S/O			
125V DC Battery Chargers	A/B El. 78'	13.94	Functional	1.12	0.21	0.36	0.44	-	Test	There are no relays to affect the function of the panel
			Structural	>1.5	-	-	S/O			
SI Inverter	A/B El. 78'	14.07	Functional	1.36	0.21	0.43	0.48	-	Test	There are no relays to affect the function of the pane
			Structural	>1.5	-	-	S/O			
20V AC Inverter(VBPSS)	A/B El. 78'	9	Functional	1.11	0.21	0.33	0.46	-	Test	There are no relays to affect the function of the panel
			Structural	>1.5	-	-	S/O			

Replace with "A" B

Table 19.1-43 (8 of 10)

Component	Location	Freq (Hz)	Failure mode	Am	Br	Bu	HCLPF[1] (g)	Mean Failure Prob	Qualification Method	Remark
Regulating Transformer	A/B El. 78'	9.49	Functional	1.27	0.21	0.41	0.46	-	Test	There are no relays to affect the function of the panel
			Structural	>1.5	-	-	S/O			
125V DC Control Center	A/B El. 78'	6.4	Functional	>1.5	-	-	S/O	-	Test	Relay is the solid state which is inherently rugged
			Structural	>1.5	-	-	S/O			
4.16kV MCSG	A/B El. 78'	6.23	Functional	1.62	0.32	0.4	0.50	1.73E-01	Test	Lockout Relay which can be recoverable by operator
			Structural	>1.5	-	-	S/O			
480V Load Center	A/B El. 78'	7.7	Functional	>1.5	-	-	S/O	-	Test	Relay is the solid state which is inherently rugged
			Structural	>1.5	-	-	S/O			
480V MCC (Aux. EL.137'06")	A/B El. 137'06"	14.32	Functional	>1.5	-	-	S/O	-	Test	Relay is the solid state which is inherently rugged
			Structural	>1.5	-	-	S/O			
480V MCC (Aux. EL.120')	A/B El. 120'	14.32	Functional	>1.5	-	-	S/O	-	Test	Relay is the solid state which is inherently rugged
			Structural	>1.5	-	-	S/O			
480V MCC (Aux. EL.100')	A/B El. 100'	14.32	Functional	>1.5	-	-	S/O	-	Test	Relay is the solid state which is inherently rugged
			Structural	>1.5	-	-	S/O			
480V MCC (Aux. EL.78')	A/B El. 78'	14.32	Functional	>1.5	-	-	S/O	-	Test	Relay is the solid state which is inherently rugged
			Structural	>1.5	-	-	S/O			
480V MCC(ESW IS EL.100')	ESW building El. 90'	14.32	Functional	>1.5	-	-	S/O	-	Test	Relay is the solid state which is inherently rugged
			Structural	>1.5	-	-	S/O			

Replace with "A"
B

Table 19.1-43 (9 of 10)

Component	Location	Freq (Hz)	Failure mode	Am	Br	Bu	HCLPF[1] (g)	Mean Failure Prob	Qualification Method	Remark
Batteries & Racks	A/B El. 78' A/B El. 100'	25.9	Functional	>1.5	-	-	S/O	-	Test	-
			Structural	>1.5	-	-	S/O			
BOP Piping & Supports	various	-	Generic	>1.5	-	-	S/O	-	-	-
HVAC Ducting & Dampers	various	-	Generic	>1.5	-	-	S/O	-	-	-
Cable Trays & Supports	various	-	Generic	>1.5	-	-	S/O	-	-	-
Motor Operated Valves	various	-	Generic	>1.5	-	-	S/O	-	-	-
Air Operated Valves	various	-	Generic	>1.5	-	-	S/O	-	-	-
Off-Site Power	various	-	Generic	1.7	0.3	0.45	0.50	1.63E-01	-	-
Electrical Conduit	various	-	Generic	>1.5	-	-	S/O	-	-	-
Relief and Check Valves	various	-	Generic	>1.5	-	-	S/O	-	-	-
Resistance Temperature Detectors	various	-	Generic	>1.5	-	-	S/O	-	-	-
Pressure Transmitters	various	-	Generic	>1.5	-	-	S/O	-	-	-

Replace with "A" B

Table 19.1-43 (10 of 10)

Component	Location	Freq (Hz)	Failure mode	Am	Br	Bu	HCLPF(1) (g)	Mean Failure Prob	Qualification Method	Remark
Containment Building Exterior Walls	-	-	-	1.418	0.153	0.308	0.66	1.55E-01	Analysis	-
Containment Building Internal Structure	-	-	-	2.616	0.153	0.427	1.01	1.70E-02	Analysis	-
Auxiliary Building	-	-	-	1.492	0.154	0.327	0.67	1.34E-01	Analysis	-
Emergency Diesel Generator (EDG) Building	-	-	-	1.492	0.154	0.327	0.67	-	Assumption(3)	-

(1) S/O: Screened Out

(2) EDG: EDG Building

(3) Assumed EDG Building fragilities are greater than the associated EDG equipment contained in the building.

Replace with "B"

A (1/6)

Table 19.1-43 (1 of 6)

Seismic Fragility Analysis Results Summary

Component	Location	Failure mode	HCLPF	Remark
Buildings				
Reactor Contain Building		Tangential shear failure near the base	0.94g	(1)
Reactor Containment Internal		Tangential shear failure of secondary shield wall near the base	1.09g	(1)
Auxiliary Building		Shear failure of shear wall at the basemat	0.51g	(1)
Emergeny Diesel Generator Building		Shear failure of shear wall at the basemat	0.87g	(1)
Diesel Fuel Oil Tank Building		Shear failure of shear wall at the basemat	0.73g	(1)
Stability of NI Structure		Sliding toward the turbine building	0.52g	(1)
ESWIS			0.5g	(2)
CCW Hx Building			0.5g	(2)
RCS Components				
Reactor Pressure Vessel	Containment El. 69'~156'	Column Support	0.92g	(1)
Reactor Vessel Internal	Containment El. 69'~156'	Core Support Barrel lower flange	0.51g	(1)
CEDM	Containment El. 69'~156'	Binding of control extension shaft	0.64	(1)
Reactor Coolant Pumps	Containment El. 114'~136'06"	Upper horizontal column support	1.31g	(1)
Steam Generator	Containment El. 114'~136'06"	Anchorage failure of snubber lever support assembly	0.60g	(1)
Pressurizer	Containment El. 114'~156'	Skit support	0.63g	(1)
Steam Generator's Nozzle	Containment El. 114'~136'06"	Steam generator economizer nozzle	0.54g	(1)
Pressurizer's nozzle	Containment El. 114'~156'	Pressurizer spray nozzle	0.51g	(1)
RCS Piping	Containment	Large loss of coolant at aurge line nozzle	0.55g	(1)

Replace with "B"

A (2/6)

Table 19.1-43 (2 of 6)

Component	Location	Failure mode	HCLPF	Remark
BOP Components				
Regenerative Heat Exchanger	Containment El. 114'		0.5g	(2)
Charging Pumps	A/B El. 55'		0.5g	(2)
Letdown Heat Exchanger	Containment El. 100'		0.5g	(2)
Auxiliary Charging Pump	A/B El. 55'		0.5g	(2)
Safety Injection Tanks	Containment El. 136’ 06”		0.5g	(2)
Shutdown Cooling Pumps	A/B El. 50'		0.5g	(2)
Shutdown Cooling Heat Exchanger	A/B El. 50'		0.5g	(2)
SC Pump Miniflow Heat Exchanger	A/B El. 50'		0.5g	(2)
Safety Injection Pump	A/B El. 50'		0.5g	(2)
Containment Spray Pump	A/B El. 50'		0.5g	(2)
CS Miniflow Hx	A/B El. 50'		0.5g	(2)
Containment Spray Heat Exchanger	A/B El. 55'		0.5g	(2)
Main Steam Isolation Valves	A/B El. 137' 06"		0.5g	(2)
Main Steam Atmospheric Valves(ADV)	A/B El. 137'06"		0.5g	(2)
Main Steam Safety Valves	A/B El. 137'06"		0.5g	(2)
AFW Pump-Motor Driven	A/B El. 78'		0.5g	(2)
AFW Pump-Turbine Driven	A/B El. 78'		0.5g	(2)
Emergency Diesel Generators	EDG* El. 100' A/B El. 100'		0.5g	(2)

Replace with "B"

A (3/6)

Table 19.1-43 (3 of 6)

Component	Location	Failure mode	HCLPF	Remark
Emergency Diesel Fuel Oil transfer pump	EDG El. 65' A/B El. 63'		0.5g	(2)
Starting Air Tank	A/B El. 100'		0.5g	(2)
Diesel Fuel Oil Day Tank	EDG El. 121' A/B El. 120'		0.5g	(2)
Diesel Fuel Oil Storage Tank	EDG El. 63' A/B El. 65'		0.5g	(2)
Silencer	A/B El. 100'		0.5g	(2)
Air Intake Filter	A/B El. 109'		0.5g	(2)
Lube Oil Water Hx	A/B El. 100'		0.5g	(2)
Motor Driven Fuel Oil Feed Pump	EDG El. 100' A/B El. 100'		0.5g	(2)
Essential Service Water Pump	ESW building El. 69'		0.5g	(2)
CCW Heat Exchangers	CCW HX Building El. 100'		0.5g	(2)
CCW Pump	A/B El. 55'		0.5g	(2)
CCW Surge Tank	A/B El. 172'		0.5g	(2)
Essential Chilled Water Pumps	A/B El. 78'		0.5g	(2)
Essential Chillers	A/B El. 78'		0.5g	(2)
ECW Compression Tank	A/B El. 172'		0.5g	(2)
ECW Air Separator	A/B El. 78'		0.5g	(2)
Essential Chilled Water System Control Panel	A/B El. 78'		0.5g	(2)
AFWP Room Cubicle Cooler-MD	A/B El. 78'		0.5g	(2)
CCWP Room Cubicle Cooler	A/B El. 55'		0.5g	(2)
SI Room Cubicle Cooler	A/B El. 50' A/B El. 55'		0.5g	(2)

A (4/6)

Table 19.1-43 (4 of 6)

Component	Location	Failure mode	HCLPF	Remark
SC Pump & Mini-flow HX Room Cubicle Cooler	A/B El. 50' A/B El. 55'		0.5g	(2)
Mech. Pen. Room Cubicle Cooler	A/B El. 100' A/B El. 120'		0.5g	(2)
CS Pump Room Cubicle Cooler	A/B El. 50' A/B El. 55'		0.5g	(2)
Aux Charging Pump Room Cubicle Cooler	A/B El. 55'		0.5g	(2)
Charging Pump Room Cubicle Cooler	A/B El. 55'		0.5g	(2)
Elect. Pen. Room Area Cubicle Cooler	A/B El. 120' A/B El. 137' 6"		0.5g	(2)
Essential Chiller & Pump Cubicle Cooler	A/B El. 78'		0.5g	(2)
CCW HX Room Supply Fans	CCW HX Building El. 100' El. 126'		0.5g	(2)
ESW Pump Room Supply Fan	ESW building El. 90'		0.5g	(2)
EDG Room Emergency Exhaust Fan	EDG El. 100' A/B El. 172'		0.5g	(2)
Control Room Emergency Makeup ACU	A/B El. 172'		0.5g	(2)
ESF-CCS GC Cabinet	A/B El. 156'		0.5g	(2)
ESF-CCS LC Cabinet	A/B El. 156'		0.5g	(2)
	A/B El. 137'6"		0.5g	(2)

Replace with "B"

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Table 19.1-43 (5 of 6)

Component	Location	Failure mode	HCLPF	Remark
Plant Protection System Cabinet	A/B El. 156'		0.5g	(2)
Reactor Trip Switchgear	A/B El. 137'6"		0.5g	(2)
MCR Operator Consoles	A/B El. 156'		0.5g	(2)
MCR Safety Consoles	A/B El. 156'		0.5g	(2)
125V DC Battery Chargers	A/B El. 78'		0.5g	(2)
SI Inverter	A/B El. 78'		0.5g	(2)
20V AC Inverter(VBPSS)	A/B El. 78'		0.5g	(2)
Regulating Transformer	A/B El. 78'		0.5g	(2)
125V DC Control Center	A/B El. 78'		0.5g	(2)
4.16kV MCSG	A/B El. 78'		0.5g	(2)
480V Load Center	A/B El. 78'		0.5g	(2)
480V MCC (Aux. EL.137'06")	A/B El. 137'06"		0.5g	(2)
480V MCC (Aux. EL.120')	A/B El. 120'		0.5g	(2)
480V MCC (Aux. EL.100')	A/B El. 100'		0.5g	(2)
480V MCC (Aux. EL.78')	A/B El. 78'		0.5g	(2)
480V MCC(ESW IS EL.100')	ESW building El. 90'		0.5g	(2)
Batteries & Racks	A/B El. 78' A/B El. 100'		0.5g	(2)
BOP Piping & Supports	various		0.5g	(2)

Replace with "B"

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A (6/6)

Table 19.1-43 (6 of 6)

Component	Location	Failure mode	HCLPF	Remark
HVAC Ducting & Dampers	various		0.5g	(2)
Cable Trays & Supports	various		0.5g	(2)
Motor Operated Valves	various		0.5g	(2)
Air Operated Valves	various		0.5g	(2)
Off-Site Power	various		0.09g	(3)
Electrical Conduit	various		0.5g	(2)
Relief and Check Valves	various		0.5g	(2)
Resistance Temperature Detectors	various		0.5g	(2)
Pressure Transmitters	various		0.5g	(2)

(1) HCLPF based on conservative deterministic fragility margin approach.

(2) The component is assigned to COL item and 0.5g HCLPF value is assumed.

(3) HCLPF based on generic value from Risk Assessment of Operational Events Handbook, volume 2 – External Events, 2008 R.1

EDG* EDG Building

B(1/6)

Table 19.1-43 (1 of 6)

Seismic Fragility Analysis Results Summary

Component	Location	Failure mode	HCLPF
Buildings			
Reactor Contain Building		Tangential shear failure near the base	0.94g
Reactor Containment Internal		Tangential shear failure of secondary shield wall near the base	1.09g
Auxiliary Building		Shear failure of shear wall at the basemat	0.51g
Emergeny Diesel Generator Building		Shear failure of shear wall at the basemat	0.87g
Diesel Fuel Oil Tank Building		Shear failure of shear wall at the basemat	0.73g
Stability of NI Structure		Sliding toward the turbine building	0.52g
ESWIS			(2)
CCW Hx Building			(2)
RCS Components			
Reactor Pressure Vessel	Containment El. 69'~156'	Column Support	0.92g
Reactor Vessel Internal	Containment El. 69'~156'	Core Support Barrel lower flange	0.51g
CEDM	Containment El. 69'~156'	Binding of control extension shaft	0.64
Reactor Coolant Pumps	Containment El. 114'~136'06"	Upper horizontal column support	1.31g
Steam Generator	Containment El. 114'~136'06"	Anchorage failure of snubber lever support assembly	0.60g
Pressurizer	Containment El. 114'~156'	Skit support	0.63g
Steam Generator's Nozzle	Containment El. 114'~136'06"	Steam generator economizer nozzle	0.54g
Pressurizer's nozzle	Containment El. 114'~156'	Pressurizer spray nozzle	0.51g
RCS Piping	Containment	Large loss of coolant at aurge line nozzle	0.55g

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Table 19.1-43 (2 of 6)

Component	Location	Failure mode	HCLPF
BOP Components (mechanical, electrical and I&C components)			
Regenerative Heat Exchanger	Containment El. 114'		(2)
Charging Pumps	A/B El. 55'		(2)
Letdown Heat Exchanger	Containment El. 100'		(2)
Auxiliary Charging Pump	A/B El. 55'		(2)
Safety Injection Tanks	Containment El. 136’ 06”		(2)
Shutdown Cooling Pumps	A/B El. 50'		(2)
Shutdown Cooling Heat Exchanger	A/B El. 50'		(2)
SC Pump Miniflow Heat Exchanger	A/B El. 50'		(2)
Safety Injection Pump	A/B El. 50'		(2)
Containment Spray Pump	A/B El. 50'		(2)
CS Miniflow Hx	A/B El. 50'		(2)
Containment Spray Heat Exchanger	A/B El. 55'		(2)
Main Steam Isolation Valves	A/B El. 137' 06"		(2)
Main Steam Atmospheric Valves(ADV)	A/B El. 137'06"		(2)
Main Steam Safety Valves	A/B El. 137'06"		(2)
AFW Pump-Motor Driven	A/B El. 78'		(2)
AFW Pump-Turbine Driven	A/B El. 78'		(2)
Emergency Diesel Generators	EDG* El. 100' A/B El. 100'		(2)

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Table 19.1-43 (3 of 6)

Component	Location	Failure mode	HCLPF
Emergency Diesel Fuel Oil transfer pump	EDG El. 65' A/B El. 63'		(2)
Starting Air Tank	A/B El. 100'		(2)
Diesel Fuel Oil Day Tank	EDG El. 121' A/B El. 120'		(2)
Diesel Fuel Oil Storage Tank	EDG El. 63' A/B El. 65'		(2)
Silencer	A/B El. 100'		(2)
Air Intake Filter	A/B El. 109'		(2)
Lube Oil Water Hx	A/B El. 100'		(2)
Motor Driven Fuel Oil Feed Pump	EDG El. 100' A/B El. 100'		(2)
Essential Service Water Pump	ESW building El. 69'		(2)
CCW Heat Exchangers	CCW HX Building El. 100'		(2)
CCW Pump	A/B El. 55'		(2)
CCW Surge Tank	A/B El. 172'		(2)
Essential Chilled Water Pumps	A/B El. 78'		(2)
Essential Chillers	A/B El. 78'		(2)
ECW Compression Tank	A/B El. 172'		(2)
ECW Air Separator	A/B El. 78'		(2)
Essential Chilled Water System Control Panel	A/B El. 78'		(2)
AFWP Room Cubicle Cooler-MD	A/B El. 78'		(2)
CCWP Room Cubicle Cooler	A/B El. 55'		(2)
SI Room Cubicle Cooler	A/B El. 50' A/B El. 55'		(2)

B(4/6)

Table 19.1-43 (4 of 6)

Component	Location	Failure mode	HCLPF
SC Pump & Mini-flow HX Room Cubicle Cooler	A/B El. 50' A/B El. 55'		(2)
Mech. Pen. Room Cubicle Cooler	A/B El. 100' A/B El. 120'		(2)
CS Pump Room Cubicle Cooler	A/B El. 50' A/B El. 55'		(2)
Aux Charging Pump Room Cubicle Cooler	A/B El. 55'		(2)
Charging Pump Room Cubicle Cooler	A/B El. 55'		(2)
Elect. Pen. Room Area Cubicle Cooler	A/B El. 120' A/B El. 137' 6"		(2)
Essential Chiller & Pump Cubicle Cooler	A/B El. 78'		(2)
CCW HX Room Supply Fans	CCW HX Building El. 100' El. 126'		(2)
ESW Pump Room Supply Fan	ESW building El. 90'		(2)
EDG Room Emergency Exhaust Fan	EDG El. 100' A/B El. 172'		(2)
Control Room Emergency Makeup ACU	A/B El. 172'		(2)
ESF-CCS GC Cabinet	A/B El. 156'		(2)
ESF-CCS LC Cabinet	A/B El. 156'		(2)
	A/B El. 137'6"		(2)

B(5/6)

Table 19.1-43 (5 of 6)

Component	Location	Failure mode	HCLPF
Plant Protection System Cabinet	A/B El. 156'		(2)
Reactor Trip Switchgear	A/B El. 137'6"		(2)
MCR Operator Consoles	A/B El. 156'		(2)
MCR Safety Consoles	A/B El. 156'		(2)
125V DC Battery Chargers	A/B El. 78'		(2)
SI Inverter	A/B El. 78'		(2)
20V AC Inverter(VBPSS)	A/B El. 78'		(2)
Regulating Transformer	A/B El. 78'		(2)
125V DC Control Center	A/B El. 78'		(2)
4.16kV MCSG	A/B El. 78'		(2)
480V Load Center	A/B El. 78'		(2)
480V MCC (Aux. EL.137'06")	A/B El. 137'06"		(2)
480V MCC (Aux. EL.120')	A/B El. 120'		(2)
480V MCC (Aux. EL.100')	A/B El. 100'		(2)
480V MCC (Aux. EL.78')	A/B El. 78'		(2)
480V MCC(ESW IS EL.100')	ESW building El. 90'		(2)
Batteries & Racks	A/B El. 78' A/B El. 100'		(2)
BOP Piping & Supports	various		(2)

B(6/6)

Table 19.1-43 (6 of 6)

Component	Location	Failure mode	HCLPF
HVAC Ducting & Dampers	various		(2)
Cable Trays & Supports	various		(2)
Motor Operated Valves	various		(2)
Air Operated Valves	various		(2)
Off-Site Power	various		0.09g(1)
Electrical Conduit	various		(2)
Relief and Check Valves	various		(2)
Resistance Temperature Detectors	various		(2)
Pressure Transmitters	various		(2)

(1) HCLPF based on generic value from Risk Assessment of Operational Events Handbook, volume 2 – External Events, R.1.01, January 2008, USNRC.

(2) The component is assigned to COL item (COL 19.1(17)) and HCLPF value is assumed to be equal to or exceed 1.67 times CSDRS.

EDG* : EDG Building

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10) Check valves

11) Instrumentation such as resistance temperature detectors, pressure transmitters, etc.

12) Electrical components/relays/circuit breakers (not specifically analyzed in Table 19.1-42)

b. Since a formal evaluation of the EDG building has not been completed, it is assumed that the building fragility is greater than that of the diesel generators and associated equipment contained in the building.

19.1.5.1.1.2 Seismic Fragility Analysis

~~Seismic fragilities are calculated for component groups developed from the SEL. For the SMA, component fragility values from the reference plants are assumed to apply. The exception to the use of fragility information from the reference plants is when a component has a HCLPF of less than 0.5g. In such cases, it is assumed that the APR1400 design will be modified to increase the capacity of components to at least a 0.5g HCLPF.~~

~~A fragility evaluation is performed to obtain the seismic margin of components and structures that could have an effect on safe shutdown of the plant following a seismic event. In this evaluation, the seismic margin values of components and structures modeled in the accident sequences are obtained. The seismic margin is expressed in terms of HCLPF values.~~

~~$HCLPF = A_m \times \exp(-1.65 \times (\beta_R + \beta_U))$~~

~~or~~

~~$HCLPF = A_m \times \exp(-2.33 \times \beta_C)$~~

~~The equation for mean failure probability is:~~

~~$= \text{Normal distribution of} \left[\frac{(\ln 1.0g) - (\ln A_m)}{\sqrt{(\beta_R^2 + \beta_U^2)}} \right]$~~

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~~A_m: median capacity~~

~~β_R: logarithmic standard deviation representing the randomness~~

~~β_U: logarithmic standard deviation representing the uncertainty~~

~~β_C: composite logarithmic standard deviation~~

~~The median capacities and HCLPFs are expressed in terms of the peak ground acceleration (PGA). An earthquake of 0.5g PGA is defined as the RLE for the APR1400.~~

~~The seismic fragilities (mean failure probabilities) for the component groups are calculated based on values of A_M, β_R, β_U for these components at an HCLPF value of 0.5g and a relative acceleration of 1.0g.~~

New text is added as shown A

The major assumptions for the SMA model are as follows:

a. It is assumed that the seismic event would result in a LOOP, since offsite power equipment is not seismic Category I.

b. No credit is taken for non-safety-related systems, and they are assumed in the model to have failed or to be non-functional due to the seismic event.

c. In the SMA system fault trees, the operator actions in the random failure cutsets from the internal events PRA are assumed to apply, and the HEPs are reevaluated considering the seismic events.

d. As a conservative assumption, if one component fails due to the seismic event, other components of the same type in the system will also fail.

e. Failure of the reactor trip signal is not modeled since the breakers for motor generator sets would be de-energized following a LOOP due to a seismic event, thereby causing the release of control rods into the core even if the reactor trip function fails.

f. Failure of buildings that are not seismic Category I (e.g., turbine building and compound building) does not impact SSCs designed to be seismic Category I. Seismic spatial interactions ~~between SSCs designed to be seismic Category I and~~ between seismic Category I equipment and non-seismically qualified equipment

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~~any other buildings~~ will be avoided by proper equipment layout and design. The following seismic Category I buildings and structures are identified as buildings and structures that involve safety-related SSCs to prevent core damage.

1) Reactor containment building

2) Reactor containment internal

~~2)~~ 3) Auxiliary building

~~3)~~ 4) ~~CCW heat exchanger building~~ ~~/Diesel fuel oil tank building~~ Emergency diesel generator building/Diesel fuel oil tank building

~~4)~~ 5) ~~ESW building~~ CCW heat exchanger building

~~5)~~ 6) ~~Emergency diesel generator building~~ ESW building

g. Relay chatter does not occur or does not affect safety functions during and after the seismic event.

19.1.5.1.2 Results from the Seismic Risk Evaluation

19.1.5.1.2.1 Seismic Equipment List

The plant has a number of systems that are available for safe shutdown after a seismic event. In selecting the systems, the following potential seismic initiating event scenarios were considered:

a. Loss of offsite power (LOOP)

b. Small break LOCA

c. Large break LOCA

d. Loss of all I&C

e. Direct to core damage scenarios such as building collapse

f. Steam generator tube rupture (SGTR)

g. Anticipated transient without scram (ATWS)

h. Station blackout (SBO)

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A

The objective of this evaluation is to demonstrate that the APR1400 SSCs have HCLPF capacities equal to or exceeding a target value of 1.67 times the Certified Seismic Design Response Spectra (CSDRS).

Since the site-specific and plant-specific information is not available during the APR1400 DC application, the seismic fragilities should be based on the standard plant design-specific information. It is not practical to perform a seismic probabilistic risk assessment (PRA) at the DC stage due to lack of site-specific seismic hazard information. As such, SECY-93-087 proposed the PRA-based seismic margin analysis (SMA) method and DC/COL ISG-020 provides detailed guidance that should be followed to demonstrate plant safety.

According to DC/COL-ISG-020, two methods are acceptable for determining seismic fragility of the structures, systems, and components (SSCs) to demonstrate a seismic margin over the design-specific CSDRS. They are the Conservative Deterministic Failure Margin (CDFM) method and the Separation of Variables (SOV) method. The CDFM method requires code allowable as capacity and design analysis demand while the SOV method requires determination of medians and variabilities associated with capacities, equipment response, and structural response. The CDFM method is selected for this evaluation for the APR1400 Design Certification application.