Response to

Request for Additional Information No. 3, Revision 0

4/16/2008
U. S. EPR Standard Design Certification
AREVA NP Inc.
Docket No. 52-020
SRP Section: 19 - Probabilistic Risk Assessment and Severe Accident Evaluation Application Section: 19 SPLA Branch

Question 19-47:

The NRC staff is requesting the applicant to provide the information listed below in order to complete its MELCOR input deck, to carry out the confirmatory assessment of AREVA's Level 2 PRA results, and severe accident evaluation reported in Chapter 19 of the U.S. EPR FSAR:

1) Containment elevation and overhead drawings, if available, would be helpful for understanding the containment layout, especially in the reactor pit region and the containment spreading compartment/area (Note that the information shown in the figures in Section 3B of EPR-FSAR are not considered sufficient). These should be provided in order to supplement, but not substitute for, the detailed requests for data listed below.

2) Please provide the following core and reactor pressure vessel data:

   - Elevation of the bottom of the cylindrical portion of the reactor vessel wall, with respect to the inside bottom of the reactor pressure vessel (RPV).
   - Total length of the control rod guide tubes.
   - Outer diameter of the control rod guide assembly in the upper plenum region of the reactor vessel.
   - Outer diameter of the normal columns in the upper plenum region of the reactor vessel.
   - Outer diameter of the Level Measurement Probe (LMP) columns in the upper plenum region of the reactor vessel.
   - Outer diameter of the instrument lance in the upper dome of the reactor vessel
   - Mass of the control poison inside the control rods.
   - Loss coefficient or the pressure drop along the fuel rods in the core region, as well as for the lower support plate.
   - Loss coefficient or the pressure drop at the inlet of the heavy reflectors.
   - Loss coefficient or the pressure drop at the exit of the heavy reflectors.
   - Loss coefficient or the pressure drop for the upper support plate.
   - Loss coefficient or the pressure drop for the upper core plate.

3) Please provide the following reactor coolant system and steam generators data:

   - The elevation of the centerline of the hot leg at the reactor pressure vessel nozzles, with respect to the inside bottom of the RPV lower head.
   - Loss coefficient or pressure drop along the cross-over leg (i.e., the leg from the steam generator outlet plenum to the reactor coolant pump).
   - Elevation of the bottom of the pressurizer quench tank with respect to the bottom of the reactor vessel.
   - Height of the pressurizer quench tank.
   - Opening and closing pressures of the steam generator safety valves.

- Opening and closing pressures of the steam generator relief valve.
- Mass of separators per steam generator.
- Surface area of steam generator separators per steam generator.
- Mass and surface area of dryers per steam generator.
- Outer diameter of steam generator dryers.
- Total free volume in the shield building.
- Thermo-physical properties (i.e., density, thermal conductivity and specific heat as functions of temperature) of the Inconel 690 alloy used to fabricate the steam generator tubes.

4) Please provide the following containment data:

- Density, ablation temperature, liquidus temperature of the sacrificial material in the reactor pit.
- Density, ablation temperature, liquidus temperature of the sacrificial material covering the spreading area.
- Thermo-physical properties of the protective layer in the containment spreading area, including its density, thermal conductivity, and specific heat as functions of temperature.
- Dimensions of the reactor pit (with drawings, if available).
- Dimensions of the spreading area (with drawings that show the dimensions, if available), including the following:
  - Surface area of the sidewalls.
  - Thickness of the sacrificial floor.
  - Total heat transfer area of the bottom and sidewalls (separately) of the sacrificial region facing the coolant in the channel.
  - Hydraulic equivalent diameter, length, and the channel gap for the coolant channel underneath and on the side of the spreading floor.
  - Diameter (or hydraulic area) and length of the pipe section connecting the IRWST to the spreading floor).

5) Table 6.2.1-5 of EPR FSAR tabulates the thicknesses and surface areas of the various heat sinks in the containment; however, the data for the height and bottom and top elevations are not provided. Please provide the height and the bottom and the top elevations of each heat sink listed in Table 6.2.1-5 with respect to the ground level. The following data sources have been utilized to prepare the preliminary MELCOR 1.8.6 input deck for the U.S. EPR confirmatory assessment:

- U.S. EPR Final Safety Analysis Report (FSAR) (AREVA NP Inc., 2007).
- The U.S. EPR MAAP4 input deck (AREVA NP Inc., 2007).
- Database – Parameter.doc (AREVA NP Inc., 2007).

In the course of preparing the MELCOR input deck, the missing design data requested above were identified. Depending on the nature and completeness of the data that will be made available to NRC by AREVA, pursuant to these requests and in the progression of the MELCOR deck development, additional requests for data may be made at a later date. Note that some data are requested here due to their unavailability in the EPR FSAR and other initially supplied sources, while other requests for clarification are present because of apparent inconsistencies that need to be resolved among the various data sources.

Response to Question 19-47.1:

The following requested figures are provided as enclosures.

- Figure 19-47-1 through 19-47-12 (containment elevation and overhead drawings).
- Figure 19-47-13 (reactor pit region).
- Figure 19-47-14 and 19-47-15 (spreading compartment/area).

Response to Question 19-47.2:

Values for the requested core and reactor pressure vessel (RPV) data are listed in Table 19-47-1.

Table 19-47-1—Core and Reactor Pressure Vessel

Description	Value	Comment
Elevation of the bottom of the cylindrical portion of the reactor vessel wall, with respect to the inside bottom of the RPV	[ ]	
Total length of the control rod guide tubes	[ ]	
Outer diameter of the control rod guide assembly in the upper plenum region of the reactor vessel	[ ]	
Outer diameter of the normal columns in the upper plenum region of the reactor vessel	[ ]	
Outer diameter of the LMP columns in the upper plenum region of the reactor vessel	[ ]	
Outer diameter of the instrument lance in the upper dome of the reactor vessel	[ ]	
Mass of the control poison inside the control rods	[ ]	

Description	Value	Comment
Pressure drop along the fuel rods in the core region	[ ]	Flow rate of 4x28,330 m^3/hr
Pressure drop for the lower support plate	[ ]	Flow rate of 4x28,330 m^3/hr
Pressure drop at the inlet of the heavy reflectors	[ ]	Flow rate of 4x28,330 m^3/hr
Pressure drop at the exit of the heavy reflectors	[ ]	Flow rate of 4x28,330 m^3/hr
Pressure drop for the upper support plate	[ ]	Flow rate of 51038 lb/s (564.8F) vessel inlet flow
Pressure drop for the upper core plate	[ ]	Flow rate of 4x28,330 m^3/hr

Response to Question 19-47.3:

Values for the requested reactor coolant system and steam generators data are listed in Table 19-47-2.

Table 19-47-2—Reactor Coolant System and Steam Generator

Description	Value	Comment
The elevation of the centerline of the hot leg at the RPV nozzles, with respect to the inside bottom of the RPV lower head	[ ]	
Loss coefficient along the cross-over leg (i.e., the leg from the steam generator outlet plenum to the reactor coolant pump)	[ ]	From the SG nozzle to the RCP flange based on [ ]
Elevation of the bottom of the pressurizer quench tank with respect to the bottom of the reactor vessel	[ ]	Elevation difference between quench tank compartment floor and bottom of reactor vessel.
Height of the pressurizer quench tank	[ ]	The value listed is approximate. The PRT shall be designed to have a footprint commensurate with the expected containment building design.
Opening pressures of the steam generator safety valves	1460 psig (Valve 1) 1490 psig (Valve 2)	
Closing pressures of the steam generator safety valves	1372.4 psig (Valve 1) 1400.6 psig (Valve 2)	

Description	Value	Comment
Opening and closing pressures of the steam generator relief valve	Opens and closes on delta pressure of 1291 psi	
Mass of separators per steam generator	[ ] per SG	Material 304L SS inner diameter = [ ] Wall thickness = [ ] Height = [ ] Separators are double walled 53 Separators per SG
Surface area of steam generator separators per steam generator	[ ] m^2 per SG	Inner diameter = [ ] m, Height = [ ]m, 53 Separators per SG
Mass of dryers per steam generator	[ ] kg	Assuming the dryer is a hollow cylinder with thickness of [ ] mm Material SA-516 Grade 60 Height = [ ]m
Surface area of dryers per steam generator	[ ] m^2 per SG	Assuming a hollow cylinder, Height= [ ] m
Outer diameter of steam generator dryers	[ ] m	
Total free volume in the Shield Building	[ ] m^3	Estimated total free volume
Thermo-physical properties (i.e., density, thermal conductivity and specific heat as functions of temperature) of the Inconel 690 alloy used to fabricate the steam generator tubes	Public Record	See Tables TE-4, TCD, & NF-2 of the ASME Boiler Pressure Vessel Code 2007, Section II Materials Part D Properties (Metric)

Response to Question 19-47.4:

Values for the requested data are listed in Table 19-47-3.

Table 19-47-3—Containment Data

Description	Value	Comment
Density of the sacrificial material in the reactor pit	[ ] kg/m^3	FeSi/PZ15/8 concrete
Ablation temperature of the sacrificial material in the reactor pit	[ ]C	FeSi/PZ15/8 concrete
Liquidus temperature of the sacrificial material in the reactor pit	[ ]C	FeSi/PZ15/8 concrete
Density of the sacrificial material covering the spreading area	[ ] kg/m^3	Siliceous concrete
Ablation temperature of the sacrificial material covering the spreading area	[ ] C	Siliceous concrete
Liquidus temperature of the sacrificial material covering the spreading area	[ ]C	Siliceous concrete
Density of the protective layer in the containment spreading area	[ ] kg/m^3	ZrO^2
Thermal conductivity of the protective layer in the containment spreading area	[ ] W/m-°C	ZrO^2
Specific heat of the protective layer in the containment spreading area	[ ] J/kg-°C	ZrO^2
Melting temperature of the protective layer in the containment spreading area	[ ] K	ZrO^2
Latent heat of melting of the protective layer in the containment spreading area	[ ] J/kg	ZrO^2
Dimensions of the reactor pit (with drawings, if available)	See Figure 19-47-13	
Dimensions of the spreading area (with drawings that show the dimensions, if available)	See Figures 19-47-14 and 19-47-15	
Surface area of the spreading area sidewalls	[ ] m^2	
Thickness of the spreading area sacrificial floor	[ ] m	
Total heat transfer area of the spreading area bottom and sidewalls (separately) of the sacrificial region facing the coolant in the channel	Floor = [ ] m^2, Sidewalls = [ ] m^2	Total sidewall surface area calculated from the perimeter of the spreading room [ ] and the height of the cooling structures [ ] taken from Figures 19-47-14 and 19-47-15

Description	Value	Comment
Hydraulic equivalent diameter for the coolant channel underneath and on the side of the spreading floor	[ ] mm	
Length for the coolant channel underneath and on the side of the spreading floor	Main cooling channel = [ ] m Average side wall = [ ] m Average floor = [ ]m	Floor cooling channels are perpendicular to the Main cooling channel
Channel gap for the coolant channel underneath and on the side of the spreading floor	[ ] m	
Diameter of the pipe section connecting the IRWST to the spreading floor	7.001 in	Inner diameter
Length of the pipe section connecting the IRWST to the spreading floor	56.5 in	

Response to Question 19-47.5:

Tables 19-47-4 and 19-47-5 give the elevation and heights of the heat sinks. Note, the tables are numbered differently than in the FSAR.

Table 19-47-4—Lumped Heat Structure Breakdown

LHS No.	HS ID	From Room	To Room	Orientation	Material	Length (m)	Height (m)	Area (m2)	Thickness (m)
1	52	UJA07-016	UJA07-021	Wall	Steel	[			
1	620	UJA07-016	UJA07-016	Wall	Steel				
1	621	UJA07-016	UJA07-016	Wall	Steel				
1	742	UJA07-016	UJA07-016	Wall	Steel				
1	743	UJA07-016	UJA07-016	Wall	Steel				
2	185	UJA11-016	UJA11-024	Wall	Steel				
2	631	UJA11-016	UJA11-016	Wall	Steel				
2	632	UJA11-	UJA11-	Wall	Steel				]

LHS No.	HS ID	From Room	To Room	Orientation	Material	Length (m)	Height (m)	Area (m2)	Thickness (m)
		016	016						
2	753	UJA11-016	UJA11-016	Wall	Steel				
2	754	UJA11-016	UJA11-016	Wall	Steel				
3	552	UJA29-016	UJANNULUS	Spherical	Steel				
3	700	UJA29-016	UJA29-016	Wall	Steel				
3	701	UJA29-016	UJA29-016	Wall	Steel				
3	822	UJA29-016	UJA29-016	Wall	Steel				
3	823	UJA29-016	UJA29-016	Wall	Steel				
4	612	UJA04-006	UJA04-006	Wall	Steel				
4	734	UJA04-006	UJA04-006	Wall	Steel				
5	613	UJA04-005	UJA04-005	Wall	Steel				
5	735	UJA04-005	UJA04-005	Wall	Steel				
6	614	UJA04-003	UJA04-003	Wall	Steel				
6	615	UJA04-003	UJA04-003	Wall	Steel				
6	736	UJA04-003	UJA04-003	Wall	Steel				
6	737	UJA04-003	UJA04-003	Wall	Steel				
7	616	UJA07-019	UJA07-019	Wall	Steel				
7	738	UJA07-019	UJA07-019	Wall	Steel				
8	617	UJA07-013	UJA07-013	Wall	Steel				

LHS No.	HS ID	From Room	To Room	Orientation	Material	Length (m)	Height (m)	Area (m2)	Thickness (m)
8	624	UJA07-013	UJA07-013	Wall	Steel				
8	739	UJA07-013	UJA07-013	Wall	Steel				
8	746	UJA07-013	UJA07-013	Wall	Steel				
9	618	UJA07-015	UJA07-015	Wall	Steel				
9	619	UJA07-015	UJA07-015	Wall	Steel				
9	740	UJA07-015	UJA07-015	Wall	Steel				
9	741	UJA07-015	UJA07-015	Wall	Steel				
10	622	UJA07-014	UJA07-014	Wall	Steel				
10	623	UJA07-014	UJA07-014	Wall	Steel				
10	744	UJA07-014	UJA07-014	Wall	Steel				
10	745	UJA07-014	UJA07-014	Wall	Steel				
11	625	UJA15-006	UJA15-006	Wall	Steel				
11	747	UJA15-006	UJA15-006	Wall	Steel				
12	626	UJA15-009	UJA15-009	Wall	Steel				
12	748	UJA15-009	UJA15-009	Wall	Steel				
13	627	UJA15-002	UJA15-002	Wall	Steel				
13	749	UJA15-002	UJA15-002	Wall	Steel				
14	628	UJA15-005	UJA15-005	Wall	Steel				

LHS No.	HS ID	From Room	To Room	Orientation	Material	Length (m)	Height (m)	Area (m2)	Thickness (m)
14	750	UJA15-005	UJA15-005	Wall	Steel				
15	629	UJA11-020	UJA11-020	Wall	Steel				
15	636	UJA11-020	UJA11-020	Wall	Steel				
15	751	UJA11-020	UJA11-020	Wall	Steel				
15	758	UJA11-020	UJA11-020	Wall	Steel				
16	630	UJA11-015	UJA11-015	Wall	Steel				
16	752	UJA11-015	UJA11-015	Wall	Steel				
17	633	UJA11-013	UJA11-013	Wall	Steel				
17	634	UJA11-013	UJA11-013	Wall	Steel				
17	755	UJA11-013	UJA11-013	Wall	Steel				
17	756	UJA11-013	UJA11-013	Wall	Steel				
18	635	UJA11-014	UJA11-014	Wall	Steel				
18	757	UJA11-014	UJA11-014	Wall	Steel				
19	637	UJA15-007	UJA15-007	Wall	Steel				
19	759	UJA15-007	UJA15-007	Wall	Steel				
20	638	UJA15-008	UJA15-008	Wall	Steel				
20	760	UJA15-008	UJA15-008	Wall	Steel				
21	639	UJA15-003	UJA15-003	Wall	Steel				

LHS No.	HS ID	From Room	To Room	Orientation	Material	Length (m)	Height (m)	Area (m2)	Thickness (m)
21	761	UJA15-003	UJA15-003	Wall	Steel				
22	640	UJA15-004	UJA15-004	Wall	Steel				
22	762	UJA15-004	UJA15-004	Wall	Steel				
23	641	UJA15-018	UJA15-018	Wall	Steel				
23	763	UJA15-018	UJA15-018	Wall	Steel				
24	642	UJA15-019	UJA15-019	Wall	Steel				
24	764	UJA15-019	UJA15-019	Wall	Steel				
25	643	UJA18-006	UJA18-006	Wall	Steel				
25	663	UJA18-006	UJA18-006	Wall	Steel				
25	765	UJA18-006	UJA18-006	Wall	Steel				
25	785	UJA18-006	UJA18-006	Wall	Steel				
26	644	UJA18-009	UJA18-009	Wall	Steel				
26	664	UJA18-009	UJA18-009	Wall	Steel				
26	766	UJA18-009	UJA18-009	Wall	Steel				
26	786	UJA18-009	UJA18-009	Wall	Steel				
27	645	UJA18-002	UJA18-002	Wall	Steel				
27	665	UJA18-002	UJA18-002	Wall	Steel				
27	767	UJA18-002	UJA18-002	Wall	Steel				

LHS No.	HS ID	From Room	To Room	Orientation	Material	Length (m)	Height (m)	Area (m2)	Thickness (m)
27	787	UJA18-002	UJA18-002	Wall	Steel				
28	646	UJA18-005	UJA18-005	Wall	Steel				
28	666	UJA18-005	UJA18-005	Wall	Steel				
28	768	UJA18-005	UJA18-005	Wall	Steel				
28	788	UJA18-005	UJA18-005	Wall	Steel				
29	647	UJA15-015	UJA15-015	Wall	Steel				
29	648	UJA15-015	UJA15-015	Wall	Steel				
29	769	UJA15-015	UJA15-015	Wall	Steel				
29	770	UJA15-015	UJA15-015	Wall	Steel				
30	649	UJA15-016	UJA15-016	Wall	Steel				
30	650	UJA15-016	UJA15-016	Wall	Steel				
30	771	UJA15-016	UJA15-016	Wall	Steel				
30	772	UJA15-016	UJA15-016	Wall	Steel				
31	651	UJA15-013	UJA15-013	Wall	Steel				
31	652	UJA15-013	UJA15-013	Wall	Steel				
31	773	UJA15-013	UJA15-013	Wall	Steel				
31	774	UJA15-013	UJA15-013	Wall	Steel				
32	653	UJA15-014	UJA15-014	Wall	Steel				

LHS No.	HS ID	From Room	To Room	Orientation	Material	Length (m)	Height (m)	Area (m2)	Thickness (m)
32	654	UJA15-014	UJA15-014	Wall	Steel				
32	775	UJA15-014	UJA15-014	Wall	Steel				
32	776	UJA15-014	UJA15-014	Wall	Steel				
33	655	UJA18-015	UJA18-015	Wall	Steel				
33	667	UJA18-015	UJA18-015	Wall	Steel				
33	668	UJA18-015	UJA18-015	Wall	Steel				
33	777	UJA18-015	UJA18-015	Wall	Steel				
33	789	UJA18-015	UJA18-015	Wall	Steel				
33	790	UJA18-015	UJA18-015	Wall	Steel				
34	656	UJA18-016	UJA18-016	Wall	Steel				
34	669	UJA18-016	UJA18-016	Wall	Steel				
34	670	UJA18-016	UJA18-016	Wall	Steel				
34	778	UJA18-016	UJA18-016	Wall	Steel				
34	791	UJA18-016	UJA18-016	Wall	Steel				
34	792	UJA18-016	UJA18-016	Wall	Steel				
35	657	UJA18-013	UJA18-013	Wall	Steel				
35	671	UJA18-013	UJA18-013	Wall	Steel				
35	672	UJA18-013	UJA18-013	Wall	Steel				

LHS No.	HS ID	From Room	To Room	Orientation	Material	Length (m)	Height (m)	Area (m2)	Thickness (m)
35	779	UJA18-013	UJA18-013	Wall	Steel				
35	793	UJA18-013	UJA18-013	Wall	Steel				
35	794	UJA18-013	UJA18-013	Wall	Steel				
36	658	UJA18-014	UJA18-014	Wall	Steel				
36	673	UJA18-014	UJA18-014	Wall	Steel				
36	674	UJA18-014	UJA18-014	Wall	Steel				
36	780	UJA18-014	UJA18-014	Wall	Steel				
36	795	UJA18-014	UJA18-014	Wall	Steel				
36	796	UJA18-014	UJA18-014	Wall	Steel				
37	659	UJA18-007	UJA18-007	Wall	Steel				
37	781	UJA18-007	UJA18-007	Wall	Steel				
38	660	UJA18-008	UJA18-008	Wall	Steel				
38	782	UJA18-008	UJA18-008	Wall	Steel				
39	661	UJA18-003	UJA18-003	Wall	Steel				
39	783	UJA18-003	UJA18-003	Wall	Steel				
40	662	UJA18-004	UJA18-004	Wall	Steel				
40	784	UJA18-004	UJA18-004	Wall	Steel				
41	675	UJA23-006	UJA23-006	Wall	Steel				

LHS No.	HS ID	From Room	To Room	Orientation	Material	Length (m)	Height (m)	Area (m2)	Thickness (m)
41	797	UJA23-006	UJA23-006	Wall	Steel				
42	676	UJA23-007	UJA23-007	Wall	Steel				
42	798	UJA23-007	UJA23-007	Wall	Steel				
43	677	UJA23-008	UJA23-008	Wall	Steel				
43	799	UJA23-008	UJA23-008	Wall	Steel				
44	678	UJA23-009	UJA23-009	Wall	Steel				
44	800	UJA23-009	UJA23-009	Wall	Steel				
45	679	UJA23-002	UJA23-002	Wall	Steel				
45	801	UJA23-002	UJA23-002	Wall	Steel				
46	680	UJA23-003	UJA23-003	Wall	Steel				
46	802	UJA23-003	UJA23-003	Wall	Steel				
47	681	UJA23-004	UJA23-004	Wall	Steel				
47	803	UJA23-004	UJA23-004	Wall	Steel				
48	682	UJA23-005	UJA23-005	Wall	Steel				
48	804	UJA23-005	UJA23-005	Wall	Steel				
49	683	UJA23-019	UJA23-019	Wall	Steel				
49	805	UJA23-019	UJA23-019	Wall	Steel				
50	684	UJA23-015	UJA23-015	Wall	Steel				

LHS No.	HS ID	From Room	To Room	Orientation	Material	Length (m)	Height (m)	Area (m2)	Thickness (m)
50	685	UJA23-015	UJA23-015	Wall	Steel				
50	806	UJA23-015	UJA23-015	Wall	Steel				
50	807	UJA23-015	UJA23-015	Wall	Steel				
51	686	UJA23-016	UJA23-016	Wall	Steel				
51	687	UJA23-016	UJA23-016	Wall	Steel				
51	808	UJA23-016	UJA23-016	Wall	Steel				
51	809	UJA23-016	UJA23-016	Wall	Steel				
52	688	UJA23-013	UJA23-013	Wall	Steel				
52	689	UJA23-013	UJA23-013	Wall	Steel				
52	810	UJA23-013	UJA23-013	Wall	Steel				
52	811	UJA23-013	UJA23-013	Wall	Steel				
53	690	UJA23-014	UJA23-014	Wall	Steel				
53	691	UJA23-014	UJA23-014	Wall	Steel				
53	812	UJA23-014	UJA23-014	Wall	Steel				
53	813	UJA23-014	UJA23-014	Wall	Steel				
54	692	UJA29-006	UJA29-006	Wall	Steel				
54	814	UJA29-006	UJA29-006	Wall	Steel				
55	693	UJA29-007	UJA29-007	Wall	Steel				

LHS No.	HS ID	From Room	To Room	Orientation	Material	Length (m)	Height (m)	Area (m2)	Thickness (m)
55	815	UJA29-007	UJA29-007	Wall	Steel				
56	694	UJA29-008	UJA29-008	Wall	Steel				
56	816	UJA29-008	UJA29-008	Wall	Steel				
57	695	UJA29-003	UJA29-003	Wall	Steel				
57	817	UJA29-003	UJA29-003	Wall	Steel				
58	696	UJA29-004	UJA29-004	Wall	Steel				
58	818	UJA29-004	UJA29-004	Wall	Steel				
59	697	UJA29-005	UJA29-005	Wall	Steel				
59	819	UJA29-005	UJA29-005	Wall	Steel				
60	698	UJA29-015	UJA29-015	Wall	Steel				
60	699	UJA29-015	UJA29-015	Wall	Steel				
60	820	UJA29-015	UJA29-015	Wall	Steel				
60	821	UJA29-015	UJA29-015	Wall	Steel				
61	702	UJA29-014	UJA29-014	Wall	Steel				
61	824	UJA29-014	UJA29-014	Wall	Steel				
62	703	UJA29-023	UJA29-023	Wall	Steel				
62	825	UJA29-023	UJA29-023	Wall	Steel				
63	704	UJA34-014	UJA34-014	Wall	Steel				

LHS No.	HS ID	From Room	To Room	Orientation	Material	Length (m)	Height (m)	Area (m2)	Thickness (m)
63	705	UJA34-014	UJA34-014	Wall	Steel				
63	826	UJA34-014	UJA34-014	Wall	Steel				
63	827	UJA34-014	UJA34-014	Wall	Steel				
64	706	UJA34-006	UJA34-006	Wall	Steel				
64	828	UJA34-006	UJA34-006	Wall	Steel				
65	707	UJA34-007	UJA34-007	Wall	Steel				
65	712	UJA34-007	UJA34-007	Wall	Steel				
65	829	UJA34-007	UJA34-007	Wall	Steel				
65	834	UJA34-007	UJA34-007	Wall	Steel				
66	708	UJA34-008	UJA34-008	Wall	Steel				
66	713	UJA34-008	UJA34-008	Wall	Steel				
66	830	UJA34-008	UJA34-008	Wall	Steel				
66	835	UJA34-008	UJA34-008	Wall	Steel				
67	709	UJA34-003	UJA34-003	Wall	Steel				
67	714	UJA34-003	UJA34-003	Wall	Steel				
67	831	UJA34-003	UJA34-003	Wall	Steel				
67	836	UJA34-003	UJA34-003	Wall	Steel				
68	710	UJA34-004	UJA34-004	Wall	Steel				

LHS No.	HS ID	From Room	To Room	Orientation	Material	Length (m)	Height (m)	Area (m2)	Thickness (m)
68	715	UJA34-004	UJA34-004	Wall	Steel				
68	832	UJA34-004	UJA34-004	Wall	Steel				
68	837	UJA34-004	UJA34-004	Wall	Steel				
69	711	UJA34-005	UJA34-005	Wall	Steel				
69	833	UJA34-005	UJA34-005	Wall	Steel				
70	716	UJA40-001	UJA40-001	Wall	Steel				
70	717	UJA40-001	UJA40-001	Wall	Steel				
70	722	UJA40-001	UJA40-001	Wall	Steel				
70	723	UJA40-001	UJA40-001	Wall	Steel				
70	724	UJA40-001	UJA40-001	Wall	Steel				
70	725	UJA40-001	UJA40-001	Wall	Steel				
70	726	UJA40-001	UJA40-001	Wall	Steel				
70	727	UJA40-001	UJA40-001	Wall	Steel				
70	728	UJA40-001	UJA40-001	Wall	Steel				
70	729	UJA40-001	UJA40-001	Wall	Steel				
70	730	UJA40-001	UJA40-001	Wall	Steel				
70	731	UJA40-001	UJA40-001	Wall	Steel				
70	732	UJA40-001	UJA40-001	Wall	Steel				

LHS No.	HS ID	From Room	To Room	Orientation	Material	Length (m)	Height (m)	Area (m2)	Thickness (m)
70	733	UJA40-001	UJA40-001	Wall	Steel				
70	838	UJA40-001	UJA40-001	Wall	Steel				
70	839	UJA40-001	UJA40-001	Wall	Steel				
70	844	UJA40-001	UJA40-001	Wall	Steel				
70	845	UJA40-001	UJA40-001	Wall	Steel				
70	846	UJA40-001	UJA40-001	Wall	Steel				
70	847	UJA40-001	UJA40-001	Wall	Steel				
70	848	UJA40-001	UJA40-001	Wall	Steel				
70	849	UJA40-001	UJA40-001	Wall	Steel				
70	850	UJA40-001	UJA40-001	Wall	Steel				
70	851	UJA40-001	UJA40-001	Wall	Steel				
70	852	UJA40-001	UJA40-001	Wall	Steel				
70	853	UJA40-001	UJA40-001	Wall	Steel				
70	854	UJA40-001	UJA40-001	Wall	Steel				
70	855	UJA40-001	UJA40-001	Wall	Steel				
71	718	UJA34-104	UJA34-104	Wall	Steel				
71	719	UJA34-104	UJA34-104	Wall	Steel				
71	840	UJA34-104	UJA34-104	Wall	Steel				

LHS No.	HS ID	From Room	To Room	Orientation	Material	Length (m)	Height (m)	Area (m2)	Thickness (m)
71	841	UJA34-104	UJA34-104	Wall	Steel				
72	720	UJA34-108	UJA34-108	Wall	Steel				
72	721	UJA34-108	UJA34-108	Wall	Steel				
72	842	UJA34-108	UJA34-108	Wall	Steel				
72	843	UJA34-108	UJA34-108	Wall	Steel				

Table 19-47-5—Lumped Heat Structure Spatial Properties

Lumped HS -i	Node Containing HS(i)	Total Mass (kg)	Surface Area (m^2)	Elevation of Bottom Surface (m)
1	26			
2	18			
3	21			
4	13			
5	13			
6	2			
7	14			
8	22			
9	16			
10	15			
11	4			
12	4			
13	3			
14	4			
15	22			
16	18			
17	17			
18	17			
19	4			
20	4			
21	3			
22	4			
23	11			
24	11			
25	6			
26	6			
27	5			
28	6			

Lumped HS -i	Node Containing HS(i)	Total Mass (kg)	Surface Area (m^2)	Elevation of Bottom Surface (m)
29	18			
30	18			
31	17			
32	17			
33	18			
34	18			
35	17			
36	17			
37	6			
38	6			
39	5			
40	6			
41	6			
42	6			
43	6			
44	6			
45	5			
46	5			
47	6			
48	6			
49	12			
50	18			
51	18			
52	17			
53	17			
54	10			
55	10			
56	10			
57	7			
58	7			

Lumped HS -i	Node Containing HS(i)	Total Mass (kg)	Surface Area (m^2)	Elevation of Bottom Surface (m)
59	7			
60	20			
61	19			
62	23			
63	19			
64	10			
65	10			
66	10			
67	7			
68	7			
69	7			
70	21			
71	21			
72	21			

FSAR Impact:

The FSAR will not be changed as a result of this question.

Question 19-48:

Section 19.1.4.2.2.4 discusses initiating event contributions to the large release frequency (LRF). According to Table 19.1-27, the most significant initiator from the LRF standpoint is a main steam line break inside containment, followed by steam generator tube rupture, loss of offsite power, and induced steam generator tube rupture. The large release frequencies of these four initiators sum to a total of 2.0E-09/year, more than 90% of the total LRF for the plant (2.2E-09/year).

1) Considering that a main steam line break inside containment has never occurred, please explain how the initiating event frequency of 1.0E-03/year was determined?

    a. Were any of the methods in the paper by Williams and Thorne, "The Estimation of Failure Rates for Low Probability Events" Reference [1] used?

    b. If so, which equations were used?

    c. If not, what was the basis for selecting the value?

2) There have only been a few tube ruptures in the industry to date. What was the basis for selecting the initiating event frequencies for a steam generator tube rupture and induced steam generator tube rupture?

    a. Was Reference [1] used? If so, how?

    b. Was tube failure from wear at anti-vibration bars considered?

    c. Was tube failure from foreign object wear above the tube sheet considered?

    d. Was stress corrosion cracking considered? (Note that the EPR steam generator tubes will be made from Alloy 690 and will be thermally treated.)

    e. How were the tube failure rates from these mechanisms estimated?

3) Why are the LRF values so much lower than the initiating event frequencies (six orders of magnitude for the MSLB inside containment and SGTR initiators, and three orders of magnitude for the ISTGR initiator)?

4) Was the possibility of induced steam generator tube failure from MSLB (inside or outside containment) considered? If so, how were the frequencies determined?

Reference 1: M. M. R. Williams and M. C. Thorne, "The Estimation of Failure Rates for Low Probability Events," Progress in Nuclear Energy Vol. 31, No. 4, pp 373-446, 1997.

Response to Question 19-48.1a:

Reference [1] was not used to estimate the steam line break inside containment (SLBI) initiating event (IE) frequency.

Response to Question 19-48.1b:

Not Applicable.

Response to Question 19-48.1c:

The frequency used for the initiator SLBI is obtained from NUREG/CR-5750, "Rates of Initiating Events at U.S. Nuclear Power Plants," Table 3-1. The initiating event frequency is based on U.S. operating experience from 1987 to 1995.

Response to Question 19-48.2a:

Reference [1] was not used to estimate the steam generator tube rupture (SGTR) and induced steam generator tube rupture (ISGTR) IE frequencies.

Response to Question 19-48.2b, c, and d:

The specific failure mechanisms mentioned in questions 19-48.2b, 19-48.2c and 19-48.2d are treated differently for the SGTR IE frequency determination and the induced SGTR IE frequency calculation.

An SGTR initiating event frequency of 3.54E-03/year is obtained from NUREG/CR-6928, "Industry-Average Performance for Components and Initiating Events at U.S. Commercial Nuclear Power Plants," Table 8-1, which includes SGTR data from 1991 to 2002. The impact of specific failure mechanisms was not explicitly considered.

To estimate the ISGTR IE frequency, the methodology of NUREG/CR-6365, "Steam Generator Tube Failures," was modified for the U.S. EPR by taking into account the use of Alloy 690 in SG tubes. The likelihood of the specific failure mechanisms was evaluated in the following way:

a. Wear at anti-vibration bars was not considered a credible tube failure mechanism due to the proposed configuration of anti-vibration bars and tube support plates.

b. Tube failure from foreign object wear was still considered a credible failure mechanism.

c. Stress corrosion cracking was not considered a credible failure mechanism due to the use of Alloy 690.

Response to Question 19-48.2e:

Failure rates associated with each failure mechanism are not specifically estimated. An improvement factor in the conditional probability of induced SGTR is calculated. This factor accounts for the proportion of events due to credible failure mechanisms. After removing all events that are not considered credible for the U.S. EPR from the SGTR data pool, it is found that about 20% of SGTR events remain (due to foreign object wear). Therefore, the conditional probability of an induced SGTR from NUREG/CR-6365 is reduced by a factor of 5.

Response to Question 19-48.3:

The LRF values for the SGTR and ISGTR are lower than the initiating event frequency due to the conditional core damage probability (CCDP) and conditional large release probability (CLRP) associated with these initiators. For each initiator, LRF = IE Frequency x CCDP x CLRP.

Conditional Core Damage Probability

The CCDPs for the SGTR initiating event and ISGTR initiating event are different as summarized below:

- IE SGTR: CCDP = 3.6E-6, it is a single IE, isolable.
- IE ISGTR: CCDP = 1.4E-3, it is a combined IE (MSL & SGTR), assumed not to be isolable (isolation is considered in the IE frequency, See SG3 below).

Conditional Large Release Probability

Given an SGTR/ISGTR initiating event resulting in core damage, large release does not automatically occur. Depending on the core damage end state (CDES), the CLRP can be smaller than 1. All SGTR CDES are assumed to lead to a containment bypass. Isolation of feedwater to the faulted SG is considered to lead to an unscrubbed release. Releases with fission product scrubbing are non-LRF sequences.

There are four CDESs that capture all of the core damage sequences with SGTR:

- **SG**: the faulted SG is isolated, and a high primary pressure core melt is assumed to lead to CLRP =1.
- **SG1**: the faulted SG is isolated, and primary depressurization has occurred. Large release is assumed if low head safety injection is not available, or if the core is retained in vessel but the containment fails to isolate. These instances lead to a CLRP < 1.
- **SG2**: the faulted SG is not isolated and feedwater is available. The sequence is treated as a scrubbed release and a non-LRF sequence with CLRP=0.
- **SG3:** the faulted SG is not isolated and feedwater is not available. This sequence leads to a release category included in LRF with CLRP=1.

Based on the preceding, the overall CLRP for SGTR events is smaller than 1 and provides the second reduction factor between the IE Frequency and the LRF.

Response to Question 19-48.4:

Induced steam generator tube failure from MSLB (or from other types of secondary side breaks) is considered as a specific initiating event in the PRA. The ISGTR IE frequency is derived by applying the methodology from NUREG/CR-6365, “Steam Generator Tube Failures,” modified for the U.S. EPR. The frequency is derived considering the following:

- IEs that can induce tube ruptures (triggering events) are identified.

- The basic induced SGTR conditional probability from NUREG/CR-6365 is modified as explained in the response to question 19-48.2e.

- For each triggering event a conditional tube rupture probability is derived, using the NUREG/CR-6365 formula based on the pressure differential (ΔP). The maximum ΔP for each triggering event is obtained from U.S. EPR safety analyses.

- Triggering event probabilities are calculated, so that only triggering events where an induced tube rupture results in an unisolable containment bypass are retained.

Table 19-48-1 summarizes the preceding contributions and shows the details of the ISGTR frequency (1.20E-06/year) calculation:

Table 19-48-1—Determination of the ISGTR Initiating Event Frequency

EVENT	EVENT Frequency [1/yr]	SGTR Conditional Probability (total)	Possible Isolation Failure Probability	Frequency of Induced SGTR [1/yr]
Inadvertent opening of MSSV [MSSV]	1.0E-03	7.0E-04	1	7.0E-07
MSLB upstream of MSIV [outside containment]	1.25E-04	3.7E-03	1	4.6E-07
MSLB downstream of MSIV [MSLBO]	2.1E-03	3.7E-03	5.0E-03	3.8E-08
MFWLB outside containment [MFLBO]	3.4E-03	5.4E-03	1.4E-05	2.6E-10
Total				1.2E-06

FSAR Impact:

The FSAR will not be changed as a result of this question.