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.: **520-8693**

SRP Section: **06.02.02 - Containment Heat Removal Systems**

Application Section:

Date of RAI Issue: **09/13/2016**

Question No. 06.02.02-43

In RAI 391-8462, Question 06.02.02-35, the staff requested information about the source of the temperature profiles used in the chemical effects analysis, including the treatment of submerged vs. unsubmerged aluminum and the LOCADM calculation for deposition of chemical precipitates on the fuel. The response, dated August 10, 2016 (ML16223A976), described the source of the temperature profiles as DCD Figure 6.2.1-4 extended to 30 days. The response did not identify how the profiles in Figure 6.2.1-4 were extended. Since those profiles end at 10^6 seconds (approximately 11.6 days), the extended profile has a significant effect on the amount of chemical precipitate calculated for 30 days. Although the response includes a temperature column in the proposed revision to Table 3.8-5 of the APR1400 GSI-191 technical report (APR1400-E-N-NR-14001-NP, Rev. 0, "Design Features to Address GSI-191"), it does not provide the 30-day pool and containment temperature profiles used in the chemical precipitate calculations. The staff requests the following information:

a) description of how the sump and containment temperature profiles in FSAR Figure 6.2.1-4 were extended from 10^6 seconds to 30 days,

b) a description of how the extension of the temperature profiles was documented, and

c) the 30-day sump and containment temperature profiles used in the chemical precipitate calculations.

Response – (Rev. 1)

a) During the decay heat phase of a LOCA, which is referred to as the long-term period from the End-of-the Post-Reflood (EOPR) to the end of the transient, the containment pressure and temperature are gradually decreased with a reduction of steaming of the core coolant caused by a decrease in decay heat. In this phase, the IRWST water is continually cooled by heat removal of the containment spray heat exchanger (CSHX) as

well. For this phase, the containment and sump temperatures are calculated using the containment analysis model which was developed using the GOTHIC computer code.

The GOTHIC containment model was revised to resolve several issues raised from the response to RAI 296-8342 Question 06.02.01.01.A-3, which was discussed in public teleconferences dated at July 7, 2016, August 9, 2016, and September 2, 2016.

The containment and sump temperature profiles, which were produced from the limiting LOCA that yields the maximum containment pressure, had been used for calculating the chemical effect until the DCD Rev. 1. However, The LOCA containment analysis that yields the highest sump temperature has some differences in the containment initial conditions from that applied to the containment model described in DCD Section 6.2.1 that maximizes the containment pressure. Thus, the containment responses to a LOCA were recalculated with the initial conditions that maximizes the sump temperature and its results has been finally chosen for the chemical effect analysis.

The description of the containment model that yields the highest sump temperature is presented in the Appendix B, Section B.4 of Technical report, APR1400-Z-A-NR-14007-P, “Mass and Energy Release Methodologies for LOCA and MSLB”, Rev. 2. From the comparison of all LOCA analyses, the scenario that yields highest sump temperature is estimated to the case “Double-ended discharge leg slot break with Max. SI flow”.

Figure 1 below illustrates the temperature profiles of the containment and sump extended up to 30 days of the accident.

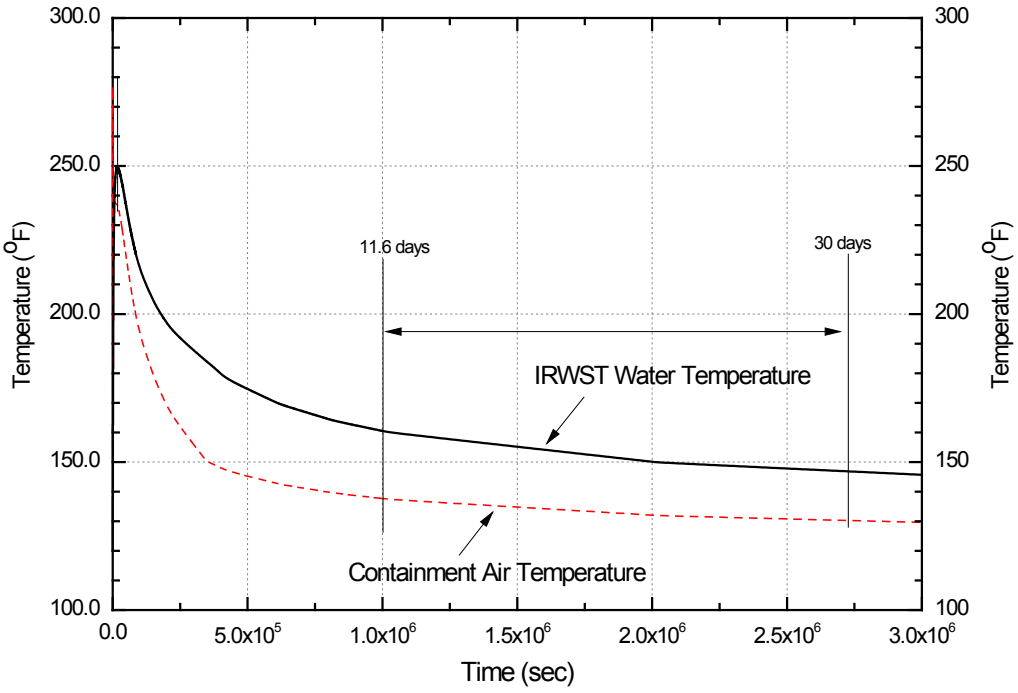

Figure 1

In Figure 2 below, it illustrates the containment pressure and sump temperature responses to the LOCA up to 10^7 seconds (116 days) with logarithmic scaling for the X-axis.

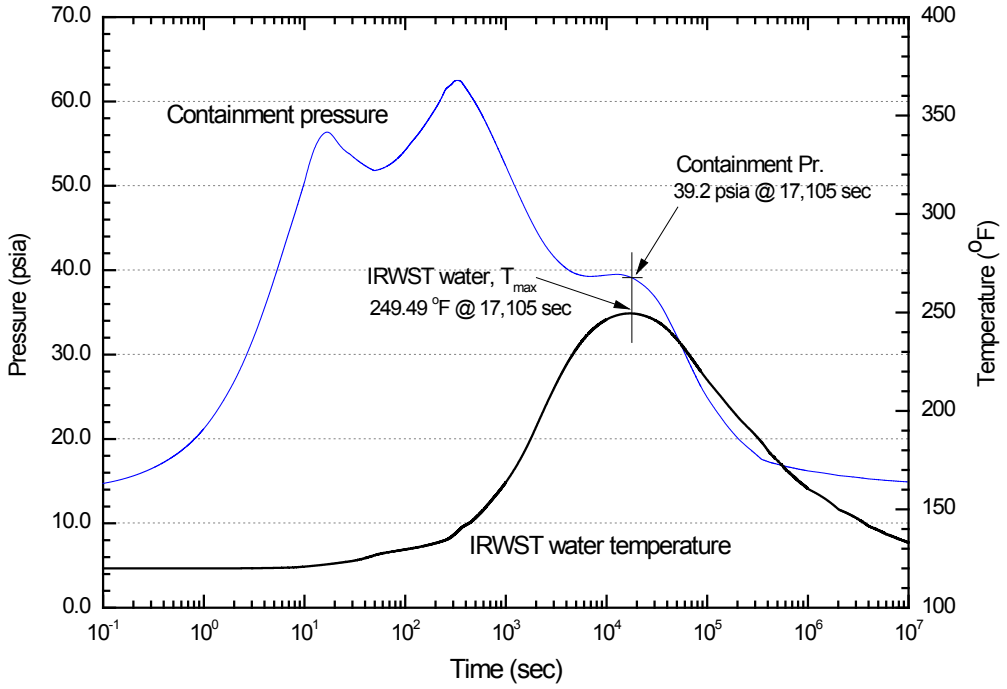

Figure 2

b) A description of the GOTHIC containment model and how the containment and sump temperatures are calculated during the decay heat phase is provided in detail in the Appendix A of Technical Report, APR1400-Z-A-NR-14007-P, Rev. 2.

c) Based on the revised 30 day containment and sump temperature profiles, the chemical effect analysis has been re-performed and incorporated in Technical Report, APR1400-E-N-NR-14001-P/NP, Rev. 3. Technical Report, Subsections 3.8.2 and 6 have been revised to incorporate the changed assumption of temperature profiles for chemical effect analysis and its reference. Subsection 4.3.2, Tables 3.8-4, 3.8-5, and 4.3-2 have been revised to incorporate the changed IRWST average temperature profiles and calculation results of chemical effects analysis.

Revised chemical effects analysis results do not affect the strainer design and associated testing results, based on the existing test results, as described in the response to RAI 391-8462 Question 06.02.02-35.

The revised temperature profiles for the chemical effect analysis are provided below.

Time (sec)	min	hr	days	Sump pH	Sump Temp. (°F)	Sump Mixed 1=Yes	Steam or Spray pH	Containment Temp. (°F)
10.00001	0	0.00	0	10	120.883	0	10	260.0398
150.0307	2.5	0.04	0	10	131.2436	0	10	268.7843
250.0307	4.2	0.07	0	10	134.3058	0	10	274.9165
350.0307	6	0.10	0	10	139.8727	0	10	276.2973
550.0502	9	0.15	0	10	147.7199	0	10	271.4709
800.0352	13	0.22	0	10	157.3256	0	10	265.6382
1,201.40	20	0.33	0	10	169.8575	0	10	258.1261
1,806.10	30	0.50	0	10	186.8405	0	10	250.27
2,701.97	45	0.75	0	10	206.4409	0	10	243.7442
4,008.25	67	1.11	0	10	223.5439	0	10	239.4057
5,807.90	97	1.61	0	10	235.8982	0	10	237.5173
8,000.68	133	2.22	0	10	243.1143	0	10	237.3219
12,001.01	200	3.33	0	10	248.1351	0	10	237.6717
14,402.60	240	4.00	0	8.5	249.1753	0	8.5	237.5392
17,104.52	285	4.75	0	8.5	249.4851	0	8.5	236.9539
27,012.74	450	7.50	0	8.5	247.2806	0	8.5	233.076
39,022.98	650	10.84	0	8.5	242.0837	0	8.5	226.2202
55,037.62	917	15.29	1	8.5	233.7735	0	8.5	216.1138
80,064.75	1334	22.24	1	8.5	222.4623	0	8.5	202.2903
120,004.10	2000	33.33	1	8.5	210.7919	0	8.5	187.6952
180,013.40	3000	50.00	2	8.5	199.8533	0	8.5	173.0438
250,030.10	4167	69.45	3	8.5	191.9353	0	8.5	161.9907
380,062.30	6334	105.57	4	8.5	181.5331	0	8.5	148.9329
550,079.20	9168	152.80	6	8.5	172.5131	0	8.5	144.0736
800,114.40	13335	222.25	9	8.5	164.513	0	8.5	139.8202
1,200,004.00	20000	333.33	14	8.5	158.2274	0	8.5	136.4261
1,390,009.00	23167	386.11	16	8.5	156.2835	0	8.5	135.3757
1,560,011.00	26000	433.34	18	8.5	154.5565	0	8.5	134.4452
1,730,014.00	28834	480.56	20	8.5	152.8324	0	8.5	133.5195
1,900,015.00	31667	527.78	22	8.5	151.1141	0	8.5	132.5977
2,070,017.00	34500	575.00	24	8.5	149.6763	0	8.5	131.8159
2,240,020.00	37334	622.23	26	8.5	148.9302	0	8.5	131.3985
2,410,022.00	40167	669.45	28	8.5	148.1989	0	8.5	130.9946
2,580,023.00	43000	716.67	30	8.5	147.4718	0	8.5	130.5956

Impact on DCD

DCD Tier 2, Table 6.8-3 will be revised to incorporate the updated chemical precipitates quantities, as indicated in Attachment.

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

Technical Report, APR1400-E-N-NR-14001-P/NP, Subsections 3.8.2, 4.3.2, and 6, and Tables 3.8-4, 3.8-5, and 4.3-2 have been revised, as indicated in Rev.3.

Table 6.8-3

Design Basis Debris

Debris Type		Debris Amount
Reflective Metal Insulation (RMI)		3.44 / 121.5 (m^3/ft^3)
Qualified Epoxy Coating		132.2 / 291.4 (kg/lbm)
Latent Debris	Particulate	83.9 / 185 (kg/lbm)
	Fibers	6.8 / 15 (kg/lbm)
Miscellaneous		Note
Chemical	Aluminum Oxy-hydroxide	180.6 / 398.2 (kg/lbm)
	Sodium Aluminum Silicate	4.3 / 9.5 (kg/lbm)
	Calcium Phosphate	0.7 / 1.5 (kg/lbm)

Note:

To deal with the quantity of miscellaneous debris, a 9.29 m^2 (100 ft^2) penalty of sacrificial strainer surface area per sump is applied.

153.6/338.7 (kg/lbm)
4.36/9.60 (kg/lbm)
0.71/1.56 (kg/lbm)