PRA Issue List Regarding APR-1400, DCD Tier 2, SECTION 19.2

Issue # PRA-223 (AI 19-246)

APR1400-E-P-NR-14003-P, Severe Accident Analysis Report, Rev. 0, Table 4-3 melt conditions at vessel failure for penetrations for different sequences. The total melt mass listed in the table for sequences TLOES W003, SLOCA 007, SLOCA are 199, 131, and 196 ton, respectively. However, the staff calculated the total from the melt mass of different constituents listed in the table as 192.5, 126.8, and 189.3 ton, respectively, which are about 3% less than the total melt mass listed in the table.

Similarly, the total melt mass listed in Table 4-4 for the same sequences are 199.5, 132, and 196 ton, respectively. The staff calculated the total from the melt mass of different constituents listed in the table as 192.9, 128.1, and 189.8 ton, respectively, which are also about 3% less than the total melt mass listed in the table.

Response

The constituents listed in Table 4-3 and Table 4-4 represents major ones of corium in the lower plenum at vessel failure. Therefore a little difference such as 3% of total mass and the calculated mass from the constituents in the tables corresponds to the mass of minor constituents including B_4C, Sn, Mn, etc.

The properties shown in the Table 4-3 and 4-4 are employed to establish the initial conditions of the ex-vessel steam explosion analyses by using TEXAS-V code. As described in section 4.2.1 of APR1400-E-P-NR-14003-P, Rev. 0, Appendix D, it was introduced that the 100% oxidic melt of binary mixture (UO_2/ZrO_2) as corium jet material for the TEXAS-V code. Thus these small mass of around 3 % has no impact on the evaluated ex-vessel steam explosion loads. However, for the completeness of the tables, Table 4-3 and Table 4-4 also will be revised accordingly (See attachment 1).

Impact on DCD
There is no impact on the DCD.

Impact on PRA
There is no impact on the PRA model.

Impact on Technical Specifications
There is no impact on the Technical Specifications.

Impact on Technical/Topical/Environmental Reports
Table 4-3 and Table 4-4 of APR1400-E-P-NR-14003-P (Rev.0) will be revised as shown in Attachment 1.

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Attachment 1- APR1400-E-P-NR-14003-P Markup for Question PRA-223

[Table 4-3, page D-67]

Table 4-3 Melt Conditions at Vessel Failure with Penetrations (IOXIDHT=0) [Reference 32]

	Sequences											
	TLOES W003	MLOCA 003	LOOP 004	SBO 002	SBO 005	SLOCA 008	SLOCA 007	SBO 006	SGTR 010	LLOCA	MLOCA	SLOCA
Conditions at vessel failure												
RCS pressure (bar)	1.466	1.224	2.53	2.47	2.63	1.70	2.23	2.99	2.27	2.28	2.217	3.59
Cavity Pres. (bar)	1.233	1.225	2.00	2.24	2.07	1.70	1.98	2.48	2.02	2.28	2.211	3.11
Total Corium Mass in LP (ton)	199	152.1	156	145	130	160	131	189	128	133.9	145.2	196
Ave. Corium Temp. (K)	2,662	2,615	2,624	2,591	2,659	2,456	2,601	2,640	2,599	2,624	2,628	2,641
Corium Solidus Temp. (K)	2,150	2,196	2,188	2,185	2,223	2,189	2,214	2,162	2,217	2,219	2,197	2,170
Corium Liquidus Temp. (k)	2,591	2,531	2,538	2,541	2,594	2,560	2,582	2,580	2,581	2,558	2,522	2,564
Steel Layer Temp. (K)	2,275	2,380	2,391	2,325	2,387	2,241	2,314	2,247	2,334	2,426	2,412	2,008
Corium Oxide Temp. (K)	2,762	2,681	2,693	2,687	2,726	2,706	2,718	2,697	2,716	2,702	2,691	2,720
Initial Vel. (m/s)	6.13	4.95	6.13	5.4	5.75	5.39	5.14	6.4	5.08	4.63	4.88	6.47
Corium composition and mass (ton) in lower plenum at vessel failure												
UO2	117.8	90.25	91.42	83.73	81.91	95.46	80.28	113	78.49	83.8	82.7	118
Zr	13.39	20.12	19.38	16.87	11.17	16.35	11.85	14.25	11.56	14.35	19.89	17.6
ZrO2	21.96	9.44	11.03	12.58	10.88	13.75	11.93	18.47	11.3	8.57	11.28	16.27
Cr	6.76	4.84	5.03	4.78	3.83	5.16	4.07	6.41	4.02	4.1	4.91	6.54
Cr2O3	0.32	0.06	0.0931	0.056	0.0023	0.0662	0.0123	0.219	0.013	0.012	0.026	0.209
Fe	27.78	19.9	20.67	19.64	15.76	21.23	16.75	26.4	16.52	16.87	20.18	27
FeO	1.3	0.24	0.383	0.23	0.0095	0.272	0.0506	0.858	0.0533	0.048	0.1	0.714
Ni	3.0	2.15	2.24	2.12	1.70	2.30	1.81	2.86	1.79	1.82	2.18	2.94
NiO	0.14	0.026	0.0414	0.0249	0.0010	0.0294	0.00547	0.0851	0.00576	0.005	0.011	0.051
Etc	**6.55**	**5.074**	**5.713**	**4.969**	**4.737**	**5.382**	**4.242**	**6.448**	**4.248**	**4.325**	**3.923**	**6.676**

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[Table 4-3, page D-68]

Average (metal+oxide) Corium Properties at vessel failure												
ρ (kg/M3)	8,336	8,390	8,364	8,281	8,561	8,402	8,479	8,369	8,518	8,571	8,291	8,396
Cp (J/kg)	615.6	582.3	588	588	594	556	583	608	580	580.8	588.3	604
k (W/m-K)	11.52	12.24	12.20	12.04	10.88	11.73	11.21	11.64	11.30	11.56	12.48	11.83
μ (kg/m-s)	0.3056	0.362	0.298	10.51	0.699	10.51	10.52	0.864	10.53	1.254	0.1752	0.423
Conditions at maximum corium flow												
Corium flow rate (kg/s)	11,600	6,769	10,450	8,467	11,130	5,551	7,799	14,680	7,339	5,468	5,950	13,71
Opening radius of Vessel Failure (m)	0.3093	0.286	0.303	0.311	0.325	0.249	0.296	0.37	0.29	0.26	0.2713	0.349
Corium Vel.(m/s)	4.593	3.24	4.29	3.33	3.87	3.38	3.29	4.06	3.21	3.13	3.21	4.39
Conditions in the Cavity												
Water Level from the Sump bottom (m)	8.18	8.19	8.35	8.32	8.30	8.32	8.35	8.29	7.91	8.31	8.03	8.22
Water Temp. (K)	352	350	362	353	351	336	360	352	325	343	331.5	334

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[Table 4-4, page D-69]

Table 4-4 Melt Conditions at Vessel Failure without Penetration (IOXIDHT=0) [Reference 32]

	Sequences											
	TLOESW 003	MLOCA003	LOOP004	SBO002	SBO005	SLOCA008	SLOCA007	SBO006	SGTR010	LLOCA	MLOCA	SLOCA
Conditions at vessel failure												
RCS pressure (bar)	1.46	1.204	2.43	2.46	2.64	1.69	2.22	2.98	2.22	2.2	2.17	3.57
Cavity Pres. (bar)	1.23	1.206	1.97	2.24	2.06	1.69	1.97	2.46	2.01	2,2	2.17	3.1
Total Corium Mass in LP (ton)	199.5	195.6	196	148	131	162	132	196	155	200	199.2	196
Ave. Corium Temp. (K)	2,672	2,617	2,627	2,617	2,679	2,501	2,631	2,640	2,586	2,648	2.662	2,653
Corium Solidus Temp. (K)	2,149	2,175	2,170	2,187	2,222	2,188	2,215	2,165	2,175	2,165	2,166	2,167
Corium Liquidus Temp.e (k)	2,589	2,513	2,526	2,545	2,593	2,559	2,585	2,588	2,522	2,493	2,511	2,563
Steel Layer Temp. (K)	2,275	2,137	2,138	2,328	2,345	2,359	2,315	1,964	2,257	2,377	2,329	2,074
Corium Oxide Temp. (K)	2,765	2,681	2,690	2,689	2,727	2,707	2,718	2,725	2,675	2,689	2,709	2,734
Initial Vel. (m/s)	5.21	5.55	6.46	5.48	5.82	5.42	5.18	6.58	5.5	5.64	6.49	7.21
Corium composition and mass (ton) in lower plenum at vessel failure												
UO2	117.8	117.8	118	86.13	82.77	96.65	81.61	118	88.62	117.8	117.7	118
Zr	13.39	22.32	21.18	17.06	11.2	16.4	11.85	15.1	16.93	22.4	20.73	17.59
ZrO2	21.96	9.9	11.44	12.62	10.89	13.86	11.95	19.64	12.22	9.78	12.01	16.25
Cr	6.84	6.86	6.84	4.81	3.91	5.28	4.07	6.37	5.74	7.7	7.6	6.62
Cr2O3	0.317	0.114	0.16	0.0571	0.007	0.0665	0.0123	0.266	0.0441	0.11	0.13	0.231
Fe	28.12	28.27	28.2	19.78	16.08	21.7	16.75	26.3	23.59	31.8	31.41	27.34
FeO	1.3	0.392	0.554	0.235	0.022	0.274	0.0506	0.978	0.181	0.35	0.37	0.769
Ni	3.04	3.066	3.06	2.14	1.74	2.35	1.81	2.86	2.55	3.45	3.42	2.98
NiO	0.14	0.029	0.0418	0.0254	0.001	0.0296	0.00546	0.0851	0.0196	0.018	0.012	0.051
Etc	**6.593**	**6.849**	**6.524**	**5.143**	**4.38**	**5.390**	**3.892**	**6.401**	**5.105**	**6.592**	**5.818**	**6.169**
Average (metal+oxide) Corium Properties at vessel failure												
ρ (kg/M3)	8,332	8,455	8,438	8,289	8,561	8,395	8,485	8,368	8,331	8.438	8,417	8,391
Cp (J/kg)	618.8	593	597	593	600	566	590	606	592	606	611.7	608
k (W/m-K)	11.57	12.64	12.50	11.95	10.93	11.76	11.13	11.43	12.67	13.21	12.93	11.90
μ (kg/m-s)	0.2091	0.2209	0.217	0.953	0.2	10.51	10.53	1.09	10.51	0.053	0.058	0.229

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Conditions at maximum corium flow												
Corium flow rate (kg/s)	9,720	11,040	14,400	10,230	12,250	7,315	9,060	14,810	11,060	12,910	15,290	17,640
Radius of vessel failure opening (m)	0.317	0.333	0.335	0.334	0.338	0.287	0.316	0.376	0.341	0.362	0.363	0.367
Velocity of corium (m/s)	3.66	3.712	4.82	3.50	3.94	3.46	3.38	4.02	3.75	3.84	4.574	5.18
Conditions in the Cavity at vessel failure												
Water Level from the bottom of sump (m)	8.18	8.19	8.35	8.33	8.31	8.32	8.36	8.29	7.92	8.31	8.04	8.22
Water Temperature (K)	434	469	362	353	351	336	360	352	325	343	332	334