REQUEST FOR ADDITIONAL INFORMATION 460-3484 REVISION 1

9/16/2009

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

SRP Section: 06.05.02 - Containment Spray as a Fission Product Cleanup System
Application Section: 6.5.2

QUESTIONS for Component Integrity, Performance, and Testing Branch 1 (AP1000/EPR Projects) (CIB1)

06.05.02-7

Background

RAI 06.05.02-1 (Reference 1) requested that the applicant explain the rise in pH of the RWSP water under accident conditions. The importance of such a calculation is to ensure that iodine dissolved in RWSP water does not revolatilize, which it could do if the pH is not maintained above 7. In fact, acceptance criterion II.1.G of SRP 6.5.2 requires that pH of 7 should be achieved before the onset of containment sprays. Staff concern was motivated by the statement in DCD 6.3.2.2.5 that the primary pH control chemical (NaTB) would not be fully dissolved until 12 h.

The applicant's response (Reference 2) claimed that the pH would be raised above 7 very early in the accident by dissolution of fission product cesium, which would exist primarily as the strong base CsOH. Specifically, it was stated that in about 1 h, sufficient CsOH would be released from fuel, escape the RCS, and be washed into the RWSP, so as to raise the pH in the RWSP above 7.

The staff attempted to confirm this effect using rough estimates for the concentrations of CsOH and boric acid, but the result was a calculated pH well below 7; hence, the staff requested that the applicant confirm their own calculation and supply all the important variables to NRC. (Reference 3) In response, the applicant gave a very lengthy and detailed description of pH calculations for the entire accident transient, including effects of radiolytic acid generation and addition of sodium tetra-borate (NaTB). (Reference 4)

The applicant did not actually perform a separate calculation which included only the effect of CsOH in RWSP water. However, the response did furnish information for the staff to perform a more accurate confirmatory calculation, which is described below.

We assume the data as taken from the sources listed:

Temperature = 100°C
Water density = 0.95838 (CRC Handbook of Chemistry and Physics)
Total water (RCS + RWSP) = 3.33×10^6 L (Reference 4)
Total Cs released to water (30% of core inventory) = 1170 mol (Reference 4)
Concentration of boric acid = 4200 ppm (Reference 4)

Assuming that all Cs is CsOH, concentrations of boric acid and CsOH are about 0.3885 m (molal) and 0.0003666 m, respectively. We neglect acid formation as this would only lower pH further. Using the methodology of the EPRI Guidelines (Reference 5), the pH of such a solution was calculated to be about 5.29. However, the EPRI model begins to lose accuracy for ionic strengths above 0.2 m, so we appropriated the model of Palmer et al (Reference 6). log−This model includes ionic strength effects, so the pH is actually defined as $pH = {}_{10}(a_{H+})$, where a_{H+} is the chemical activity. Using the concentrations listed above, the calculated pH was 5.12. Thus, the staff is unable to confirm the applicant's assertion that CsOH alone is capable of raising the pH of the RWSP to 7 or above.

The staff is concerned that applicant is not considering the buffering effect of boric acid in the RWSP due to formation of polyborate species (as described in References 5 and 6). Nowhere in Reference 4 is this effect described.

Requested Information

Describe in more detail the calculation that indicates fission product cesium raises containment water pH above 7. Describe how boric acid buffering is included in the calculation, and what equilibria are used for the various polyborate species.

References

1. "Request for Additional Information No. 234-2040 Revision 1, SRP Section: 06.05.02 - Containment Spray as a Fission Product Cleanup System, Application Section: Section 6.5.2" dated February 26, 2009. (ADAMS Accession No. ML0906102970)

2. Letter from Yoshiki Ogata, MHI, to NRC dated April 22, 2009; Docket No. 52-021 MHI Ref: UAP-HF-09199; Subject: MHI's Second Response to US-APWR DCD RAI No. 234 (ADAMS Accession No. ML0911804351)

3. "Request for Additional Information No. 416-2912 Revision 0, SRP Section: 06.05.02 - Containment Spray as a Fission Product Cleanup System, Application Section: 6.5.2" dated June 29, 2009. (ADAMS Accession No. ML091830408)

4. Letter from Yoshiki Ogata, MHI, to NRC dated July 28, 2009; Docket No. 52-021 MHI Ref: UAP-HF-09407; Subject: MHI's Response to US-APWR DCD RAI No. 416-2912 Rev. 0 (ADAMS Accession No. ML092110671)

5. *Pressurized Water Reactor Primary Water Chemistry Guidelines*, Vol. 1, Rev. 6, Electric Power Research Institute (December 2007).

6. D. A. Palmer, P. Benezath, D. J. Wesolowski, "Boric Acid Hydrolysis: A New Look at the Available Data," *PowerPlant Chemistry* 2(5), 261-4 (2000).