



South Texas Project Electric Generating Station P.O. Box 289 Wadsworth, Texas 77483

June 10, 2010

U7-C-STP-NRC-100131

U. S. Nuclear Regulatory Commission
Attention: Document Control Desk
One White Flint North
11555 Rockville Pike
Rockville, MD 20852-2738

South Texas Project
Units 3 and 4
Docket Nos. 52-012 and 52-013
Response to Request for Additional Information

Attached is a response to an NRC staff question included in Request for Additional Information (RAI) letter number 401 related to Combined License Application (COLA) Part 2, Tier 2, Appendix 6C.

The Attachment addresses the response to the RAI question listed below:

RAI 06.02.02-27

There are no commitments in this response.

If you have any questions regarding this response, please contact me at (361) 972-7136, or Bill Mookhoek at (361) 972-7274.

DO91
NRO

I declare under penalty of perjury that the foregoing is true and correct.

Executed on 6/10/10



Scott Head
Manager, Regulatory Affairs
South Texas Project Units 3 & 4

jet

Attachment:

RAI 06.02.02-27

cc: w/o attachment except*
(paper copy)

Director, Office of New Reactors
U. S. Nuclear Regulatory Commission
One White Flint North
11555 Rockville Pike
Rockville, MD 20852-2738

Regional Administrator, Region IV
U. S. Nuclear Regulatory Commission
611 Ryan Plaza Drive, Suite 400
Arlington, Texas 76011-8064

Kathy C. Perkins, RN, MBA
Assistant Commissioner
Division for Regulatory Services
Texas Department of State Health Services
P. O. Box 149347
Austin, Texas 78714-9347

Alice Hamilton Rogers, P.E.
Inspection Unit Manager
Texas Department of State Health Services
P. O. Box 149347
Austin, Texas 78714-9347

C. M. Canady
City of Austin
Electric Utility Department
721 Barton Springs Road
Austin, TX 78704

*Steven P. Frantz, Esquire
A. H. Gutterman, Esquire
Morgan, Lewis & Bockius LLP
1111 Pennsylvania Ave. NW
Washington D.C. 20004

*Stacy Joseph
Two White Flint North
11545 Rockville Pike
Rockville, MD 20852

(electronic copy)

*George F. Wunder
*Stacy Joseph
Loren R. Plisco
U. S. Nuclear Regulatory Commission

Steve Winn
Joseph Kiwak
Eli Smith
Nuclear Innovation North America

Jon C. Wood, Esquire
Cox Smith Matthews

Richard Peña
Kevin Pollo
L. D. Blaylock
CPS Energy

RAI 06.02.02-27**QUESTION:**

The staff reviewed Supplemental response #2 to RAI 06.02.02-11 and determined the response is not complete. The aluminum corrosion calculations and solubility data used to analyze chemical effects were based on boron-containing solutions. These analysis tools do not apply directly to boron-free BWR coolant. In addition, the analysis did not include all relevant chemical debris sources. Therefore, the staff requests the following information:

- Analysis of aluminum chemical effects using corrosion and solubility data applicable to the post-LOCA ECCS fluid at STP 3&4.
- If the pH is expected to vary with time during the postulated 30-day post-LOCA period, provide an analysis of the chemical effects based on the predicted transient or explain how your approach is bounding. (For example, addition of sodium pentaborate from the standby liquid control system would increase pH over some time period.)
- Discuss your plans to address chemical effects not considered in the initial analysis, such as:
 - o Constituents dissolved from concrete in the coatings zone of influence (ZOI), since the NRC coatings guidance assumes removal of the coating within the ZOI. Concrete dissolution generates elements that can form chemical precipitates, including precipitates containing aluminum (e.g., sodium aluminum silicate).
 - o Zinc, which corroded at a low rate in testing related to PWRs but would be expected to corrode at higher rates in neutral and acidic solutions. This may result in levels of zinc particulate, zinc corrosion products, and zinc in solution that could contribute to other chemical precipitates.
 - o Corrosion products (iron oxide) resulting from iron or steel corrosion prior to or following a LOCA
 - o Any other material present in containment that would be exposed to the post-LOCA fluid and has not been addressed by an integrated chemical effects analysis for the ABWR environment.
- If your analysis predicts the formation of chemical debris, discuss your plans for addressing the impact of this debris on the ECCS strainers and fuel assemblies (e.g., integrated strainer testing or a simplified approach that relies on significant clean screen area).

RESPONSE:

In response to the first main bullet item, Enclosure 1 to this attachment provides an analysis based on a review of available technical literature showing that corrosion and solubility of aluminum in borated versus non-borated water is not significantly different for the pH range applicable to the STP 3 & 4 post-LOCA ECCS fluid. Based on this literature review, the evaluation of maximum surface area of aluminum that would stay in solution and not form precipitates, which was previously provided in the response to supplement 2 to RAI 06.02.02-11 (U7-C-STP-NRC-100044 dated February 22, 2010), is applicable to STP 3 & 4 for both non-borated (prior to injection of sodium pentaborate) and borated (after injection of sodium pentaborate) conditions.

The response to the second main bullet item is provided in the supplement 2 response to RAI 06.02.02-11 because that evaluation bounds the calculated scenarios of post-LOCA suppression pool pH. Specifically, Toshiba analyses show that to avoid a drop in suppression pool pH outside the range of pH values post-LOCA as described in DCD Tier 2 Subsection 3I.3.2.3, injection of sodium pentaborate from the Standby Liquid Control System (SLC) would be initiated, and the pH will remain above 8 for the remaining 29-30 days in the post-LOCA period. The limiting case in the earlier evaluation conservatively assumed the pH remained constant at 5.3 pH, whereas the quantity of latent aluminum that would corrode but stay in solution for a constant pH of 7 was over 30 times higher than the bounding case, and over 600 times higher than the bounding case for the constant 8.9 pH case.

In response to the first sub-bullet item under the third main bullet, STPNOC has re-evaluated the bounding case of latent aluminum provided in the supplement 2 response to RAI 06.02.02-11, assuming an exposed concrete area of 302 ft², based on the BWROG's Utility Resolution Guideline (URG), NEDO-32686 for postulated failure of qualified coatings. The results of this calculation show that for the bounding quantity of latent aluminum, a small quantity (less than 1 kg) of sodium aluminum silicate might be formed due to interaction with the 302 ft² of exposed concrete. A bench-top test is being conducted to establish the solubility of sodium aluminum silicate under bounding, post-LOCA suppression pool conditions to confirm that the small concentration of sodium aluminum silicate predicted for the bounding-case latent aluminum assumptions would not precipitate during the 30-day post-LOCA period. The confirmatory results from the bench-top test will be provided in a Supplement to this RAI by June 30, 2010.

The following two paragraphs address zinc corrosion (the second sub-bullet item under the third main bullet).

The one potential source of zinc in the suppression pool is inorganic zinc (IOZ) primer used in the qualified coatings system throughout primary containment. Such primers are generally a two-part coating system, with the zinc added to the carrier as zinc metal and zinc oxide particulate. Consistent with the URG, qualified coatings within the zone of influence (ZOI) for the postulated pipe break are assumed to fail and be transported to the suppression pool. Also from the URG and as discussed in STPNOC's response to RAI 06.02.02-8 (U7-C-STP-NRC-

090141 dated September 28, 2009), the quantity of IOZ in the assumed 85 lbs of failed coatings is about 47 lbs.

The conditions postulated for the post-LOCA period, according to DCD Tier 2 Subsection 3I.3.2.3, include a pH range of 5.3 to 8.9. In this pH range, zinc metal and zinc oxide can corrode into solution and precipitate from solution due to the electrochemical properties of the metal in an aqueous situation. However, there is a limited amount of zinc or zinc oxide available, which is all in particulate form. The corrosion products are also expected to be particulate. Therefore, no new type of chemical precipitate would result from zinc, and the particulate debris from the IOZ primer has already been evaluated and tested for its impact on strainer head loss for the Reference Japanese ABWR.

The following relates to corrosion products (iron oxide) of iron and steel (the third sub-bullet item under the third main bullet).

As noted in the response to RAI 06.02.02-6 (U7-C-STP-NRC-090141 dated September 28, 2009), the iron oxide or rust corrosion products were previously evaluated and tested for impact on strainer head loss for the Reference Japanese ABWR. As noted in that response, the quantity of rust is based on the URG value, which was later confirmed to be bounded by the operating experience for the oldest operating Japanese ABWRs (see response to RAI 06.02.02-25 provided in STPNOC Letter U7-C-STP-NRC-100007 dated January 13, 2010).

Relative to the fourth sub-bullet item under the third main bullet item, there is no other material present in the STP 3&4 containment that would be exposed to the post-LOCA fluid that has not been addressed by an integrated chemical effects analysis for the ABWR environment.

In response to the fourth main bullet item, there are no chemical effects predicted by the STP 3 & 4 analyses that are not in the form of particulates. Therefore, no additional testing for chemical effects impact on the suction strainer or the fuel assemblies is required.

There is no COLA change required as a result of this response.

Enclosure 1

Aluminum Corrosion and Solubility in Non-Borated vs. Borated Solutions

Purpose and Conclusion

The purpose of this paper is to address the question of whether the corrosion and solubility of aluminum would be different in borated vs. non-borated water, for the range of pH values applicable to the 30-day post-LOCA period at STP 3 & 4 (pH 5.3 to 8.9, according to DCD Tier 2 Subsection 3I.3.2.3).

Based on review of the technical literature documented in this paper, aluminum corrosion and solubility are a function of pH and temperature, not boron, for the near-neutral pH range applicable to STP 3 & 4 ECCS fluid.

Discussion

Aluminum corrosion in boric acid conditions is comparable to its corrosion in other acids for pH between 5 and 7, and is comparable to corrosion in borax buffered conditions for slightly alkaline conditions (pH between 7 and 9). Corrosion of aluminum in aqueous solutions is an electrochemical process (Reference 8). The evaluation results show that the ions in solution can affect aluminum corrosion in highly acidic and highly alkaline conditions, but not in nearly neutral solutions; for example, the STP 3 & 4 post-LOCA condition of 5.3 to 8.9 pH. The following examples illustrate this: in aqueous solutions, corrosion rates in hydrofluoric acid is at least 25 times greater than in acetic acid at pH=3, and the corrosion rate at pH=11 in sodium hydroxide is more than 25 times the rate in sodium disilicate at the same pH (Reference 2). All corrosion rates are low for the range of pH between 5 and 9. The presence of boron in the solution can affect the mass and structure of precipitates, but it does not affect the corrosion rate of aluminum, which is governed by the electrochemical properties of aluminum. Boron can adsorb onto the surface of precipitated aluminum hydroxide and it appears to prevent crystallization of the precipitate (Reference 7). However, it does not affect the solubility or corrosion rate of aluminum beyond the changes in pH of the solution.

Enclosure 1 (continued)

Key Points

- The main corrosion product in water for aluminum metal is aluminum oxy-hydroxide (AlOOH) (boehmite). (Chapter 9, Reference 2)
- Corrosion of aluminum in temperature greater than 200°C (not STP 3 & 4 conditions) pure water is very fast due to formation of non-adherent aluminum oxide corrosion products (not a layer adhered to the aluminum substrate). (Chapter 2, Reference 2). In low temperature pure water conditions, aluminum forms an aluminum oxide (Al₂O₃) coating and further corrosion will cease. (Figure 8, Chapter 2, Reference 2)
- Aluminum corrosion is very slight for pH in the range of 5 to 9. Outside of that range, various acids or bases affect the corrosion rate through the various ions in solution. (Figure 9, Chapter 2, Reference 2)
- If aluminum precipitates due to cooling (and therefore reduced solubility of the solution), boron presence in the solution leads to adsorption of boron onto the surface of the aluminum hydroxide either during precipitation or during the post precipitation aging process. (Section 5.2, Reference 7)

Additional data

- Corrosion rates for aluminum metal are given in Reference 2 for a wide range of pH and temperature.
 - Corrosion rate in water is dependent on water purity and oxygen content, especially for conditions of pH less than 5 and greater than 9. (Chapter 2, Reference 2)
 - Corrosion rate is at a minimum for pH about equal to 5.6. The solubility is at a minimum at a pH of about 5.2. (Chapter 2, Figure 9, Reference 3 and Figure 9, Reference 2)
 - Boron has little to no effect on aluminum corrosion rates. The main result is due to pH changes (boric acid vice borates which are generally alkaline). (References 5 and 6)
- Aluminum – Boron Compounds
 - Aluminum boron compounds are found naturally occurring as borosilicate minerals (the tourmalines). However, they are not formed at post-LOCA temperatures and pressures. Rather, they are formed at temperatures of 450-500°C and very high pressure (~2500 bar). (Reference 4)

Enclosure 1 (continued)

References

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