

PMSTPCOL PEmails

From: Tomkins, James [jjetomkins@STPEGS.COM]
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To: Joseph, Stacy
Subject: Draft RAI Responses
Attachments: 06 02 02-28 Response R1 110710.pdf; 06 02 02-29 Response final R5DRAFT.pdf; 06 02 02-30 Response final R7 DRAFT.pdf; 04 04-4 response final R5 DRAFT (2).pdf

Here are the draft RAI responses for 6.2.2-28, 6.2.2-29, 6.2.2-30, and 4.4.-4. We will be available to discuss on Wednesday, I will call you Monday to set a time. We should have the final chemical precipitate amounts in 6.2.2-29 and 6.2.2-30 by later this week as Westinghouse is in the final stages of having the calculations verified. Note that 6.2.2-28 will be a revision to the response sent in a week ago. I will be in Rockville Monday and Tuesday and in Bay City on Wednesday and Thursday.

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RAI 06.02.02-28 Revision**QUESTION:**

The June 10, 2010, response, to RAI 06.02.02-27 states that the sodium pentaborate from the Standby Liquid Control (SLC) System will be initiated during a LOCA in order to control the suppression pool pH. Please provide the calculated post-LOCA 30-day pH profile and describe the administrative controls that will be in place to ensure initiation of the SLC System injection.

REVISED RESPONSE:

The 30-day pH profiles for the STP 3&4 suppression pool following a LOCA are provided in the proprietary Toshiba Report No. SCO-2010-000050, dated September 14, 2010. This report is currently available for NRC review.

The Toshiba report evaluates the post-LOCA suppression pool pH both for Alternate Source Term (AST) and Design Basis Event (DBE) cases. The DBE cases do not assume fuel damage, and therefore include only production of nitric acid in the RPV as a contributor to changes in suppression pool pH. The AST cases, which assume that a severe accident results in release of radioactive inventory to the suppression pool, are not currently part of the STP 3&4 licensing basis, and would not apply to an assessment of the capability of the ECCS to prevent core damage.

For the DBE cases, the Toshiba report shows that suppression pool pH would gradually trend downward due to postulated nitric acid formation in the reactor pressure vessel, if sodium pentaborate is not injected via the Standby Liquid Control (SLC) system. For the AST (non-licensing basis) cases, the Toshiba report shows that the suppression pool pH would begin to drop much more quickly if sodium pentaborate is not injected via the SLC system. For both the DBE and AST cases, if sodium pentaborate is injected, the suppression pool pH would remain at about 8.4-8.6 for the 30-day post-LOCA period.

Post-LOCA pH control actions will be performed in accordance with plant procedures to maintain pH levels within the licensing basis limits of 5.3 to 8.9 as stated in DCD Tier 2, Subsection 3I.3.2.3. TSC actions will be based on containment parameters, including the initial pH in the Suppression Pool and/or any sample results taken post-LOCA and will be included in the procedures to be used by the technical staff in the Technical Support Center (TSC) during an emergency response.

Note that as discussed in previous RAI responses, the suppression pool pH profile is important to the evaluation of chemical effects on ECCS system components and fuel. Specifically, the licensing bounding values of pH (5.3 and 8.9) are used as appropriate to predict maximum corrosion rates of latent aluminum and zinc due to destroyed inorganic zinc primer from the coatings system. Additionally, in order to resolve NRC concerns about the use of solubility data, which is a function of post-LOCA suppression pool pH, STPNOC will conservatively take no credit for solubility of aluminum in either the form of aluminum oxyhydroxide or sodium

aluminum silicate. (STPNOC previously stated that it would take no credit for solubility of zinc corrosion products.) See revised RAI Response 06.02.02-30 for the impact of not crediting aluminum solubility of the post-LOCA suppression pool. Also, note that this change in chemical effects evaluation approach bounds the chemical effects within the licensing limits of 5.3 and 8.9 pH.

No COLA change is required as a result of this response.

DRAFT

RAI 06.02.02-29**QUESTION:**

The June 10, 2010, response, to RAI 06.02.02-27 states that the corrosion products from zinc are expected to be particulate, and that no new type of chemical precipitate would result from zinc (i.e., a type of precipitate different than the particulate evaluated for the reference Japanese ABWR). Please provide the technical basis for stating there will be no new type of precipitate, such as a gel-like precipitate. The next paragraph provides background information from the staff and is part of the basis for the need for additional information from the applicant.

It appears that the zinc in inorganic zinc (IOZ) coatings may corrode in a post-LOCA environment, but there is limited information about the rate and the form of the corrosion product. For example, the report from the Erlangen Tank Test Station (ML083510156) described pressure loss from an accumulation of zinc corrosion products in a mineral wool bed. The source of the zinc in that test was galvanized steel, but the zinc in IOZ coatings may also be subject to dissolution (corrosion) depending on water chemistry and temperature (e.g., NUREG-6873 and NUREG-6988). WCAP-16530-NP-A included a pH- and temperature-dependent corrosion-rate equation for zinc based on the test results for galvanized steel, but the amount was considered negligible for operating PWRs and not included in the chemical model. The Utility Resolution Guidance recommendation of 47 pounds of particles from IOZ coatings did not consider chemical dissolution (corrosion) of the zinc and subsequent precipitation in another form. The staff notes one source showing the solubility of amorphous and crystalline zinc hydroxide phases decreases by about four orders of magnitude when the pH increases from 7 to 9 at 25°C (Marcel Pourbaix, "Atlas of Electrochemical Equilibria in Aqueous Solutions," National Association of Corrosion Engineers, 1974).

RESPONSE:

The only source of zinc inside the STP 3&4 primary containment is the assumed destroyed inorganic zinc (IOZ) primer from the qualified coating within the break zone of influence. STP 3&4 design specifications prohibit the use of galvanized steel and any other source of zinc in the primary containment. The IOZ primer exists as 80% zinc particles and 20% zinc oxide particles (Reference 1). The corrosion of zinc in an aqueous environment yields zinc oxide, which, like zinc, is also a particulate for the elevated temperatures expected in the post-LOCA suppression pool (References 1 and 2). Because it is possible that the suppression pool temperatures may be lower than the temperature transient that is typically the bounding case (i.e., highest temperatures), it is possible that the zinc corrosion products that are produced during the 30-day post-LOCA period may not be particulate. To bound this possibility, such corrosion products will conservatively be assumed to be gelatinous instead of particulate.

Westinghouse has performed a calculation of the quantity of the postulated 47 lbs. of zinc in the destroyed coatings primer that would corrode over 30 days during the bounding post-LOCA temperature profile (highest corrosion rate). The calculation of the amount of zinc released is based on the methodology developed in WCAP-16530-P-A. The corrosion rate is a function of

exposed surface area. The 47 lbs. of IOZ primer (which was assumed to be 604 sq. ft. of 0.005 in. thick primer before destruction) is assumed to be 10 micron spheres after destruction, which translates into a total surface area of over 20,000 sq. ft. The calculation was performed for a pH of 5.3, which is the minimum allowable pH for the STP 3&4 licensing basis, and for a pH of 8.9, which is the maximum allowable pH for the STP 3&4 licensing basis (Reference DCD Tier 2, Subsection 3I.3.2.3). The use of a maximum and minimum pH will provide for the evaluation of the maximum amount of corrosion products as the corrosion of zinc increases with decreasing pH and the corrosion of aluminum increases with increasing pH. The calculation of corrosion products at limiting pH values and the use of the maximum amount of corrosion products provides for a conservative input to the fuel debris capture testing.

The time-dependent post-LOCA suppression pool temperature is based on that calculated for the STP 3&4 containment design analysis in WCAP-17058-P for the time period up to 13.89 hours, where that calculation ended. From 13.89 hours to 30 days, the temperature was assumed to vary linearly from the temperature at 13.89 hours to the maximum allowable normal operating suppression pool temperature of 95°F.

Two pH values were considered: a pH of 5.3 (minimum licensing basis limit) and a pH of 8.9 (maximum licensing basis limit). Based on the 20,000 sq. ft. of exposed surface area of zinc, a constant value of pH, the time-dependent suppression pool temperature post-LOCA, and the corrosion rates described in WCAP-16530-NP-A, the amount of zinc that becomes corrosion product is lbs. at pH = 5.3 and lbs. at pH = 8.9. The WCAP-16530-NP-A corrosion rates for zinc are applicable to STP 3 & 4 for the following reasons:

- The test used galvanized steel coupons. The galvanizing material is a coating of elemental zinc on the carbon steel coupon. The use of a galvanized surface maximized corrosion rates compared to zinc primer.
- Testing was conducted at a range of pH values and temperatures, covering the range of such conditions that might occur for STP 3 & 4.
- The duration of the tests were sufficiently short in time as to preclude the development of a passivation layer on the coupons, i.e., there was no mechanism to reduce the rate of zinc corrosion of the galvanized surfaces.

Thus, the corrosion rates from the testing of galvanized steel coupons reported in WCAP-16530-NP-A are taken to be conservative compared with those that would be expected for post-LOCA conditions in STP 3 & 4.

Conservatively, no credit is taken for solubility of the zinc corrosion products, or the remaining particulate zinc.

For the downstream effects on fuel testing, the maximum corrosion product source term from the two pH calculations will be used. All of the corrosion products, including non-particulate zinc corrosion product, will be represented by the same mass of aluminum oxyhydroxide. The use of this material as a surrogate for zinc corrosion products is based on the finding reported by Argonne National Laboratory that the aluminum oxyhydroxide generated using the method of

WCAP-16530-NP-A (Reference 3) resulted in higher pressure drops compared to the other corrosion products considered in the Argonne work (Reference 4).

The impact of zinc non-particulate precipitate on the STP 3&4 suction strainer head loss is minimal because:

- (1) Fibrous materials in the STP 3&4 containment that could provide a fiber bed for accumulation of this precipitate is limited to latent fibrous debris, and this amount does not result in the formation of a contiguous fiber bed, and
- (2) The amount of precipitate generated is small, which provides for a correspondingly small loading of non-particulate zinc precipitate debris on the large recirculation screen area.

The COLA changes will be included in the supplemental response to RAI 04.04-03.

References

1. Metals Handbook, Ninth Edition, Volume 13 Corrosion. ASM International Handbook Committee. Metals, Park, Ohio, 1987.
2. Zhang, Xiaoge Gregory. Corrosion and Electrochemistry of Zinc. New York: Plenum Press, 1996.
3. WCAP-16530-NP-A, "Evaluation of Post-Accident Chemical Effects in Containment Sump Fluids to Support GSI-191, Ann E. Lane, Timothy S. Andreychek, William A. Byers, Richard J. Jacko, Edward J. Lahoda, and Richard D. Reid, Westinghouse Electric Company LLC, March, 2008.
4. "Technical Letter Report on Evaluation of Head Loss by Products of Aluminum Alloy Corrosion," C. B. Bahn, K. E. Kasza, W. J. Shack, and K. Natesan, Argonne National Laboratory, August 11, 2008

RAI 06.02.02-30**QUESTION:**

The July 21, 2010, response, to RAI 06.02.02-27 described laboratory testing performed for South Texas Project 3 & 4 to determine if sodium aluminum silicate would precipitate in the postulated post-LOCA environment. Please provide the following additional information about this testing:

- a) Describe the basis for performing a test designed to measure dissolution of an existing solid rather than a test designed to detect the formation of the precipitate from solution.
- b) Explain how the sodium aluminum silicate used in the South Texas Project 3 & 4 benchtop testing is equivalent to the sodium aluminum silicate precipitate ($\text{NaAlSi}_3\text{O}_8$) modeled in WCAP-16530-NP. The chemical used in the STP 3 & 4 solubility tests is described in the Sigma-Aldrich Material Safety Data Sheet as “aluminum silicate” and “silicic acid, aluminum sodium salt.” The highly hydrated $\text{NaAlSi}_3\text{O}_8$ precipitate generated according to WCAP-16530-NP is prepared from aluminum nitrate and sodium silicate. It is not clear to the staff that the two aluminum solids are identical, or at least equivalent in terms of their dissolution/precipitation characteristics.
- c) Describe how the experimental procedure accounts for precipitates less than the 0.45 micrometer (μm) filter size. It is not clear to the staff that the measured cation concentrations accurately or conservatively represent the concentrations at the test conditions. Prior testing under the GSI-191 program has concluded that aluminum-based precipitates may be less than 0.2 μm in size and cause high head losses in laboratory testing.

RESPONSE:

- a) The purpose of the STP 3&4 bench test described in this RAI is to determine an aluminum solubility limit. Sodium aluminum silicate (SAS) to ion products is a reversible reaction. At equilibrium, the forward, or dissolution, reaction is equal to the reverse, or precipitation, reaction. The soluble aluminum ion concentration at equilibrium is the same for either case. References 1 and 2 show that the dissolution of major cations increases very rapidly within the first 24 hours and then increases slowly, reaching equilibrium after 24 days. For albite, a SAS, the aluminum concentration in solution after 1 day appears to be about 10% of the final concentration after 24 days. Because the aluminum solubility determined in the STP 3&4 bench testing was based on the measured aluminum concentration after 1 day of exposure, this indicates that the measured solubilities reported for that test are conservative.
- b) The two aluminum solids, as noted in the RAI, are not identical. The material that was used in WCAP-16530-NP-A was freshly prepared and would have yielded higher aluminum solubility than aged material. The STP 3&4 bench test program used aged material. Therefore, the STP 3&4 bench test yields a conservative value of solubility for aluminum.

- c) The 0.45 micron filters used in the STP 3&4 bench tests are the industry standard to separate soluble and insoluble fractions. This information is included in EPRI Report No. 1014986, "Pressurized Water Reactor Primary Water Chemistry Guidelines," Volume 1, Rev 6, page F-3, dated December 2007. Thus, the 0.45 micron filters are consistent with industry practice.

The filter used for WCAP-16530-NP-A work was a 1 micron filter. Thus, had the same sized filters used for the WCAP 16530-NP-A work been used in the STP 3&4 bench testing, the result would have been a higher apparent aluminum solubility because more precipitate would pass through the filter and show up as soluble aluminum. The use of the 0.45 micron filter in the STP 3&4 bench tests is therefore conservative.

In summary, the purpose of the STP 3&4 bench test program is to assess aluminum solubility, not to assess head loss across a debris bed. To that end, the use of aged material that results in lower solubility and the use of an industry standard filter size provide assurance that the recent test program yields a conservative value for aluminum solubility.

The above testing conservatively demonstrates that, with 4.5ft² of aluminum exposed to recirculating coolant post-LOCA, the amount of dissolved aluminum in solution will be under the solubility limit for aluminum by at least a factor of 10 from the minimum solubility limit. With controls in place to assure the latent aluminum does not exceed the equivalent of an aluminum surface area of 4.5 ft², the amount of dissolved aluminum is not expected to exceed this minimum solubility.

However, STPNOC will include aluminum chemical precipitates in downstream fuel effects testing. The amount of precipitate for this testing will be based on the following conservative assumptions;

- All of the aluminum that corrodes and forms SAS and aluminum oxyhydroxide will exist in precipitate form and not remain dissolved in solution. (Note that not taking credit for the solubility of aluminum oxyhydroxide is a change from previous RAI responses, and it is being made to resolve NRC questions about potential post-LOCA suppression pool pH profiles.)
- All of the corrosion products from zinc coatings will form precipitate that will be represented by an equal mass of aluminum oxyhydroxide.

The calculation of the amount of these corrosion products is based on the methodology developed in WCAP-16530-P-A and includes the following assumptions:

- (1) The surface area of submerged aluminum is 4.5 ft². This is conservative because there is no aluminum allowed in the STP 3&4 containment and the only credible source of aluminum is latent aluminum. As noted in the response to RAI 06.02.02-11 Supplement 2 (STPNOC Letter No. U7-C-STP-NRC-100044 dated February 22,

- 2010), the implementation of the STP 3&4 suppression pool cleanliness and FME programs will ensure that latent aluminum quantities would be less than this amount.
- (2) The mass of submerged aluminum is 10,000 lbs. This conservatively high value was chosen to ensure there is sufficient aluminum to continue the reaction.
 - (3) Two pH values are assumed in the calculations. For the first calculation, the pH assumed for the entire 30-day post-LOCA period is the maximum allowable design basis limit of 8.9 (Reference DCD Tier 2 Subsection 3I.3.2.3). As shown in Table 06.02.02-27-1 of the supplemental response to RAI 06.02.02-27 (STPNOC Letter No. U7-C-STP-NRC-100173 dated July 21, 2010), aluminum corrosion rate increases with higher pH, so this is a conservative assumption. A second calculation assuming a pH = 5.3, the minimum allowable design basis limit, is assumed for the entire 30-day post-LOCA period (Reference DCD Tier 2 Subsection 3I.3.2.3. This is conservative for zinc as zinc corrosion increases with decreasing values of pH. The amount of corrosion products for the downstream fuel effects testing is based on the higher total mass of combined zinc and aluminum corrosion products for these two pH extremes.
 - (4) The time-dependent post-LOCA suppression pool temperature is based on that calculated for the STP 3&4 containment design analysis in WCAP-17058-P for the time period up to 13.89 hours, where that calculation ended. From 13.89 hours to 30 days, the temperature was assumed to vary linearly from the temperature at 13.89 hours to the maximum allowable normal operating suppression pool temperature of 95°F.
 - (5) The area of exposed concrete is 302 ft². The conservatism of this assumption is discussed in the response to RAI 06.02.02-31 (STPNOC Letter No. U7-C-STP-NRC-100233 dated October 14, 2010.)
 - (6) A total surface area of over 20,000 sq. ft. of elemental zinc from inorganic zinc coatings (From the response to RAI 06.02.02-29).

The results of this calculation show that the quantity of SAS precipitate is ___ kg, the quantity of aluminum oxyhydroxide precipitate is ___ kg and the quantity of zinc corrosion product is ___ kg. The downstream fuel effects tests will simulate the combined mass of these three corrosion products as aluminum oxyhydroxide, based on the higher head loss exhibited by aluminum oxyhydroxide versus SAS.

The impact of SAS and aluminum oxyhydroxide precipitate on the STP 3&4 suction strainer head loss is minimal because:

- (1) Fibrous materials in the STP 3&4 containment that could provide a fiber bed for accumulation of this precipitate is limited to latent fibrous debris, and this amount does not result in the formation of a contiguous fiber bed, and
- (2) The amount of precipitate generated, as noted above, is small, which provides for a correspondingly small loading of SAS and aluminum oxyhydroxide precipitate debris on the large recirculation screen area.

Therefore, the head loss testing performed for the RJ-ABWR suction strainers, which includes such materials as fiber and calcium silicate which are prohibited at STP 3&4, remains a valid design basis for the STP 3&4 suction strainers.

A COLA markup providing a revision to Appendix 6C, which will include the amount of SAS and aluminum oxyhydroxide to be simulated in the downstream fuel effects test, will be provided as part of a supplemental response to RAI 04.04-3.

References

1. Wen H. Huang and Wen C. Kiang, American Minerologist, Volume 58, pages 1016-1022, 1973.
2. W. H. Huang and W.C. Kiang, American Minerologist, Volume 57, pages 1849-1859, 1972.

RAI 04.04-4**QUESTION:**

During the NRC staff audit (held on July 12, 2010) of the calculations supporting the downstream fuel effects test acceptance criterion of 5.076 psid (U7-C-STP-NRC-100044 dated February 22, 2010), the staff discovered that the calculations were based on Optima II fuel rather than the GE-7 fuel approved in the ABWR DCD. Explain how the proposed criterion is suitable for the fuel design that is currently the basis for the ABWR design.

RESPONSE:

The analysis that was reviewed by the NRC staff on July 12, 2010, which evaluates the effects of debris downstream of the ECCS sump strainers on fuel coolability, is also applicable to the GE-7 fuel used in the ABWR DCD. The reason the calculations also apply to GE-7 fuel is that the differences between the GE-7 and Optima2 fuel designs are not significant for purposes of these calculations. The calculations determine the maximum flow restriction to the hot channel that will maintain a two-phase flow through the channel and not cause any significant fuel heat up (Vapor Void Fraction ≤ 0.95). A void fraction of 0.95 is assumed as a conservative bound to prevent steam only heat transfer. As long as the voiding in the hot channel of the core never exceeds 0.95, it ensures that there is always water present, and that the steam does not become superheated. A void fraction limit of 0.95 ensures that there is always two phase flow through the core. This value is more conservative than the two phase criteria used in other Westinghouse LOCA analyses; the current Westinghouse BWR LOCA analysis assumes two phase flow up to a void fraction of 0.995.

As discussed in the STP 3&4 COLA markup to Section 6C provided with the response to RAI 04.04-3, the limiting break used in this analysis is a feedwater line break (FWLB). The FWLB was chosen instead of the main steamline break (MSLB) because the MSLB, being at a higher elevation, will produce a higher natural circulation flow and therefore is less limiting. Smaller breaks were considered but not analyzed, because they would result in less break flow and therefore a slower depressurization. The slower depressurization will reduce the injection flow and delay the potential accumulation of debris at the fuel inlet. The decay heat and therefore the assembly flow requirements would be less when the debris accumulates in the fuel. Small breaks also result in less jet impingement and debris generation. Therefore, small breaks produce less debris and require less flow through the fuel assembly inlet filters to provide makeup. Large breaks provide the limiting case for evaluating fuel filter blockage effects.

The analysis was performed using the GOBLIN computer code. The GOBLIN ABWR LOCA model uses two parallel channels to model the core: one represents the average core, and one represents the hottest assembly in the entire core. The hot assembly is modeled with a hot assembly power factor of 1.7. In solving the mass, energy, and momentum relations for this model, GOBLIN determines the flow distribution between the core channels. Using a bounding

power in the hot assembly maximizes the flow required and results in a conservative flow blockage criteria.

At the steady state condition following the FWLB, flow through the hot assembly is ~3 kg/s, and this value decreases after blockage is applied. This value is calculated by GOBLIN for a specific set of conditions and does not correspond to the ECCS injection rates. The ECCS injection to the downcomer maintains the level (and driving head) at the feedwater nozzle elevation. Injection flow in excess of the natural circulation through the core will spill out of the break.

In the ABWR, each assembly is encased within a channel. The power generated by the assembly is determined by the nuclear design of the core, the time after shutdown, and the decay heat, and is not dependent on the specific fuel mechanical design. Because each assembly is a closed channel, the flow into the assembly required to remove the specified assembly power without transitioning to steam cooling is also independent of the specific fuel mechanical design. The flow rate into the assembly is determined by the hydraulic head from the water in the downcomer and the hydraulic characteristics of the fuel assembly. Therefore, the hydraulic characteristics, such as resistance and bundle flows required to remove the specified power from the hot assembly and prevent steam-only cooling, must be similar for any fuel design.

In addition, the differences between the GE-7 and Optima2 mechanical designs are not significant for purposes of this calculation. Fuel assemblies used in the ABWR must be hydraulically similar in order for various design features of the ABWR to be met, including reactor internals hydraulic loads, Reactor Internal Pump (RIP) steady state, and coastdown performance. This is confirmed by Reference 1, which provides the NRC-approved methodology used by Westinghouse in providing replacement fuel for a BWR. The methodology described in Reference 1 has been applied for reload applications at a number of BWR's in the US supporting the Westinghouse SVEA-96 OPTIMA2 fuel design. This report demonstrates the application of the methodology by comparing several fuel designs, including the 8X8-2 design similar to the GE-7 fuel in the DCD, and a 9X9-9 design and the Westinghouse SVEA-96 (10X10, Watercross) design which is similar to Optima2. Sections 5.2.2, 5.3, and Appendix D.4 of this report show that the hydraulic characteristics of the various fuel designs are very similar, as is expected and required in a mixed core. The Westinghouse methodology is designed to assure the hydraulic similarity of the Westinghouse BWR fuel to the fuel specifications for a given BWR.

Additional assurance of the applicability of the results to GE-7 fuel is provided by the additional conservatism that have been included in the analysis as described below.

The test acceptance is based on the following relationship:

$$\left[\frac{\Delta p_f}{\Delta p_i} \right]_{Test-Measured} = \left[\frac{\Delta p_f}{\Delta p_i} \right]_{Aly} * \left(\frac{w_i}{w_f} \right)_{Aly}^2 * \left(\frac{w_f}{w_i} \right)_{Test-Measured}^2$$

where subscript “i” denotes initial (i.e. unfouled conditions), “f” indicates fouled conditions, “Aly” refers to analysis, “w” is the flow rate into the assembly and “Δp” is the pressure drop from the bundle inlet to downstream of the third grid.

The elements in the previous equation that are determined from analysis were calculated using the inlet blockage from the hydraulically limiting break case. This blockage loss factor from the analysis was used to determine the pressure drop from the bundle inlet to downstream of the third grid using subcooled water, similar to the fuel test configuration. Including the bundle inlet through the third grid for the test accounts for the effect of debris that passes through the inlet region and is captured in the grids. In addition, the acceptance criteria has been reduced by a factor of 4 to provide margin to bound any small differences in fuel designs that would be used in the ABWR. The comparisons in Appendix D.4 of Reference 1 indicate that the difference in the hydraulic characteristics between different fuel assembly designs is very small and certainly bounded by a factor of 4. The resulting acceptance criterion is:

$$\left[\frac{\Delta p_f}{\Delta p_i} \right]_{Test-Measured} \leq 1200 * \left(\frac{w_f}{w_i} \right)_{Test-Measured}^2$$

This conservative acceptance criterion assures that fuel designs, including the GE-7 fuel described in the ABWR certified design, will remain cooled after a design basis accident for the tested debris composition and quantity. This acceptance criterion allows for a range of values, as opposed to a specific value, which allows for test flexibility and minimizes the number of test iterations should a specific test value, such as flow rate, not be achieved.

References

1. CENPD-300-P-A, “Reference Safety Report for Boiling Water Reactor Reload Fuel”, ABB Combustion Engineering Nuclear Operations, July 1996.

As a result of this response, the license condition included in the response to RAI 04.04-3 Supplement 1 will be revised as shown below with gray shading showing the changes from that response. A future COLA markup will be provided as part of a supplemental response to RAI 04.04-3. This supplemental response will be provided no later than November 15, 2010.

PROPOSED LICENSE CONDITION

A downstream fuel effects test will be conducted and the results provided to the NRC no later than 18 months prior to fuel load. The test plan, analysis basis, and debris assumptions are described in Appendix 6C.3.1.8. The test procedure will be provided to the NRC no later than 24 months prior to fuel load. The acceptance criteria for this test will be

~~a fuel assembly inlet steady state pressure drop less than 5.076 psid.~~ are based on the following equation:

$$\left[\frac{\Delta p_f}{\Delta p_i} \right]_{\text{Test-Measured}} \leq 1200 * \left(\frac{w_f}{w_i} \right)_{\text{Test-Measured}}^2$$

where subscript “i” denotes initial (i.e. unfouled conditions), “f” indicates fouled conditions, “w” is the flow rate into the assembly and “Δp” is the pressure drop from the bundle inlet to downstream of the third grid.

DRAFT