AP1000DCDFileNPEm Resource

From: Adams II, Samuel L. [adamssl@westinghouse.com]
Sent: Friday, August 15, 2008 7:11 AM
To: Bill Gleaves
Cc: Perry Buckberg; Rhonda Carmon
Subject: FW: Emailing: AP1000 SRP 6.2.2 Sump RAIs SRXB SPCV CIB1.doc
Attachments: AP1000 SRP 6.2.2 Sump RAIs SRXB SPCV CIB1.doc

Hi Billy,

I acknowledge receipt of the attached RAIs and will let you know as soon as possible if a clarification call is needed.

Thanks.

Sam

-----Original Message-----
From: Bill Gleaves [mailto:Bill.Gleaves@nrc.gov]
Sent: Thursday, August 14, 2008 1:52 PM
To: Adams II, Samuel L.
Cc: Eileen McKenna; Christopher Jackson; David Terao; Michelle Hayes (NRO); Ruth Reyes; James Strnisha
Subject: Emailing: AP1000 SRP 6.2.2 Sump RAIs SRXB SPCV CIB1.doc

Sam,

Attached are 39 new RAIs from our SRP 6.2.2 based review of your proposed AP1000 design. Please review these draft RAIs and respond with a list of those draft RAIs with which you desire a teleconference and those RAIs that you accept. For the RAIs which you request a teleconference, we will consider them to be "draft" until the completion of the conference call. For those RAIs you accept, we will consider those to be "final" RAIs. We suggest a response time of 30 days.

We note that on August 7, 2008, Westinghouse sent a report on testing of the effects of debris on the core flow (APP-FA-01-T2R-001, R0 in both proprietary and non-proprietary form). Due to its submittal date, it has not been reviewed or incorporated into the PSER. As a result, we expect that you may 1) reference that report in response to some of our RAIs and 2) your report may not close an open item and a new RAI may result from that situation.

Sincerely,
Billy

William Gleaves
Sr Project Manager
AP1000 Projects Branch 2
Division of New Reactor Licensing
US Nuclear Regulatory Commission

Hearing Identifier: AP1000_DCD_Review
Email Number: 78

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From: Adams II, Samuel L.

Created By: adamssl@westinghouse.com

Recipients:
"Perry Buckberg" <Perry.Buckberg@nrc.gov>
Tracking Status: None
"Rhonda Carmon" <Rhonda.Carmon@nrc.gov>
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SRP 6.2.2
39 Requests for Additional Information
On AP1000 Sump Strainer Performance
Submitted by SRSB, CIB1, SPCV

RAI-SRP 6.2.2-SRSB-01
In the AP1000 DCD Section 6.3.2.2.7.3, Westinghouse stated that:

> "When the recirculation lines initially open, the water level in the IRWST is higher than the containment water level and water flows from the IRWST backwards through the containment recirculation screen. This back flow tends to flush debris located close to the recirculation screens away from the screens."

The back flow of water through the recirculation screens may cause a significant amount of water to be injected into the sump cavity. Although this flow through both recirculation screens causes the materials to be flushed from the screens, the backflow could cause enough turbulence in the cavity to lift up the debris from the bottom of the cavity, which collects during the early part of the LOCA, and once the water flow reverses into the screens this debris is available to be collected on the screens.

a. Describe the potential for blockage with the addition of uplifted debris.
b. Identify whether or not the addition of the zinc coatings or the higher density epoxy coatings, that were assumed to be collected at the bottom of the cavity, provide a source of blockage to the screens.
c. Identify whether these coatings add to the chemical impurities that could enter the core region.

RAI-SRP 6.2.2-SRSB-02
In TR 26, Revision 3, on page 8, in the "Applicability to the AP1000 Design" subsection, Westinghouse states that:

> "The flow velocities have been reduced further by the increase in face area of the screens (approximately 55% larger for containment recirculation)."

Since Westinghouse credits the low flow velocities in minimizing the potential for a LOCA to generate debris challenging the recirculation flow path, the staff requests additional information to assess the velocities during every phase of the transient.

Identify the calculated flow velocities through the IRWST screens (leading to the intact and broken DVI lines, respectively), the containment recirculation screens, and the reactor vessel during all phases of the transient including the reverse flow through the recirculation screens when the IRWST is switched to recirculation. For example, when recirculation flow starts, identify the velocity of the initial reverse flow through the recirculation screens and the velocity variation across the screens once all water has filled the recirculation sump cavity.

RAI-SRP 6.2.2-SRSB-03
In TR 26, Revision 3, on page 8 in "Applicability to the AP1000 Design" subsection, Westinghouse states that metal reflective insulation (MRI) is used on components that may be subjected to jet impingement loads; MRI is not transported to the AP1000 Containment Recirculation Screens with low flow rates; and as a result, there is no fibrous debris generated

by the LOCA blowdown.   On page 11 in “Break Selection Criteria” subsection, Westinghouse states that the density of the MRI material ensures that any debris generated by the damage of this insulation material to settle in the containment sump and not be transported onto the screens.

The staff notes there is a significant amount of MRI in the AP1000. In the SER for NEI 04-07, on page 7, the staff stated that MRI is assumed to degrade to 75 percent small fines and 25 percent large pieces.

a. Describe testing or evaluations that show that this type of insulation, once it has been damaged by the LOCA jet, will not become debris that will cause potential plugging of the screens.
b. Verify that the same degradation for the MRI as described in the NEI 04-07 SER exists in the AP1000 or identify what the degradation would be. Describe the impact of the degradation on the debris loading.
c. Was an evaluation performed showing that the MRI material under AP1000 break conditions will not migrate to the containment sump and screens? If so, provide the reference or detailed information in the reference.
d. Is there any chemical residual associated with the MRI that could impact the screen blockage or the downstream blockage in the core? If so, what is the impact to the screens and to the core blockage?
e. Are there any other objects in the zone of influence that can be damaged by jet impingement and contribute to the debris (e.g., cable insulation, instrumentation, hot/cold leg temperature instrumentation, nuclear instrumentation, signs, caulking…)?
f. Is there any fiber insulation encased in MRI that could contribute to the debris? If so, are the configurations qualified for jet impingement? Provide the qualification details.
g. How will lack of debris generating materials in the zone of influence be verified?

RAI-SRP 6.2.2-SRSB-04

In TR 26, Revision 3, on page 9, in the “Evaluation Approach” subsection, Westinghouse states that the post-accident chemical products were estimated using a tool generated by the PWR Owners Group and design features of the AP1000.

Since the amount of post-accident chemical products is an important contributor to plugging, debris build-up and scaling in the core, the software and/or analytical tools used to assess the impact of debris on the AP1000 strainers and core should be identified and validated.

Identify the software and/or analytical tools used to perform these evaluations and describe how the software/tools have been validated to perform chemical evaluations using the design features of the AP1000.

RAI-SRP 6.2.2-SRSB-05

In TR 26, Revision 3, on page 10, Westinghouse states that debris samples removed from operating plants and visual observations during plant walk downs provide the basis for the debris composition as particulate material (85% by volume), coatings (5% by volume) and fiber (10% by volume).

a. Provide the references or sources of the operating plant walkdowns and debris samples. Confirm that the percentages of various debris types are based on total volume, as reported, and not total mass (NRC SE of NEI 04-07 recommends that fiber be 15% of total mass).

b. Explain why these references and data are representative of the AP1000.
c. Describe whether there could be other types of latent materials in the AP1000 that are different from the operating plants.
d. Explain how actual as-designed and operated AP1000 will be verified to be consistent with this data both prior to start-up and during the life of the plant? Propose appropriate surveillance testing and/or programmatic controls that will be necessary to ensure the actual plant is operated consistent with the analysis assumptions

RAI-SRP 6.2.2-SRSB-06
In TR 26, Revision 3, on page 11 in the "Break Selection Criteria" subsection, Westinghouse indicated that it applied applicable portions of the guidance in NEI 04-07 for the selection of break location within a PWR and its effect on debris generation and composition to AP1000, and that because of different design in AP1000, it modified the selection criteria to determine the maximum amount of latent debris that can be transported to the containment recirculation, IRWST screens as well as to the core. Westinghouse also listed the following three break locations that resulted in the limiting amount of debris to be transported to the containment recirculation and IRWST screens and the core: a break of a DVI line at the reactor vessel, a break in the automatic depressurization system stages 1, 2, and 3 lines near the top of the pressurizer, and a break on the inlet line of the core makeup tank.

a. Identify the applicable portions of NEI 04-07, Revision 0, "Pressurized Water Reactor Sump Performance Evaluation Methodology," and the modifications to the break selection criteria that were applied to the AP1000.
b. Identify whether the study correlating the AP1000 to current PWRs on break selection is documented. Provide the assumptions used for the amount of debris that is transported into the screens and core region for each selected break location for AP1000.

RAI-SRP 6.2.2-SRSB-07
In TR 26, Revision 3, in the "Break Selection Criteria" subsection on page 12, Westinghouse states:

> "As the tables show, approximately 24 lbm of latent debris would be expected to be transported to the AP1000 Containment Recirculation Screens through direct impingement, immersion or from being washed down during a high energy line break."

As stated in NUREG-1793, Section 6.2.1.8.3, "Pool Transport and Head Loss Evaluation of the Containment Recirculation Screens, the staff noted that Westinghouse's analysis assumed a mass of resident debris in the containment of 227 kg (500 lb) and that was consistent with estimates made with current generation PWRs in the GSI 191 parametric study (NUREG/CR-6772). In TR-26, Revision 3, on page 16, Westinghouse identified 200 lbm of latent containment debris based on an NRC safety evaluation performed on NEI 04-07. The staff, in its review of the NRC safety evaluation performed on NEI 04-07 (ML043280007), does not find the reference of 200 lbm that Westinghouse identifies in TR-26. Further, the staff notes that the total debris of 24 lbm and .24 ft^3 that were referenced in Table 1 of TR-26 is a very small amount of mass and volume from the whole containment (500 lbs) that may accumulate at the recirculation screens.

a. Explain the apparent discrepancy between the mass of resident debris in the containment of 227 kg (500 lb) in NUREG-1793 Section 6.2.1.8.3 and the 90.8 kg (200 lb) identified in TR-26, and justify the TR-26 number, as it is not included in the referenced SER.

b. Explain how the volumetric values of debris presented in Tables 1 & 2 were derived. For example, how was the .01 cubic foot of epoxy coatings derived given all of the coatings in the containment that can flow into the sump region? Provide a basis for each of the volumetric values given. Include identification of areas assumed for each break path by type of surface (horizontal, walls, equipment or piping), area of surface, and average volume of debris from operating plant. Identify the operating plant walkdown and actual debris values used to determine the average volume of debris for each area. Identify how and where the "25% conservatism" identified in TR 26 is added.
c. The epoxy density is given as 94 lb/ft^3 in Tables 1 and 2, but as 105 lb/ft^3 in DCD Rev. 16, Table 6.2.1.1-8. Explain the difference between these two values.
d. Section 3.6 of the NRC safety evaluation on NEI 04-07 discusses debris transport methodology. Provide the criteria and methodology used in TR 26, including debris transport factors and flow velocities. Identify model for debris transport off the protective plates and the basis for associated calculations and assumptions.

RAI-SRP 6.2.2-SRSB-08
In TR 26, Revision 3, in the "Post-Accident Chemical Effects" subsection on page 13, Westinghouse states:

> "An analysis was performed to determine the type and quantity of chemical precipitants which may form in the post-LOCA recirculation fluid for the AP1000 design. The analysis evaluated these post-LOCA chemical effects using the methodology developed in WCAP-16530-NP, "Evaluation of Post-Accident Chemical Effects in Containment Sump Fluids to Support GSI-191" (Reference 7)."

The staff notes that the chemical composition of the AP1000 containment is significantly different from the PWR study (WCAP-16530-NP).

Provide the details of the calculation, including assumptions, which resulted in the predicted chemical precipitate formation in Table 4 of TR-26, Revision 3.

RAI-SRP 6.2.2-SRSB-09
In the AP1000 DCD Revision 16, Section 6.3.2.2.7.2, Westinghouse states that:

> "During a LOCA, steam vented from the reactor coolant system condenses on the containment shell, drains down the shell to the operating deck elevation and is collected in a gutter. It is very unlikely that debris generated by a LOCA can reach the gutter because of its location. The gutter is covered with a trash rack which prevents larger debris from clogging the gutter or entering the IRWST through the two 4 inch drain pipes. The inorganic zinc coating applied to the inside surface of the containment shell is one potential source of debris that may enter the gutter and the IRWST. As described in subsection 6.1.2.1.5, failure of this coating produces a heavy powder which if it enters the IRWST through the gutter will settle out on the bottom of the IRWST because of its high specific gravity. Settling is enhanced in the IRWST by low velocities in the tank and long tank drain down times."

The staff notes that this collection gutter appears to be potential collection point for debris because runoff from the upper containment enters this gutter system and then flows into the top of the IRWST. The staff also notes that there are no screens in this system, only a trash rack, and a debris flow path could easily be formed from the entry point at the top of the IRWST to the bottom of the IRWST where the flow exits through the IRWST screens into the flow path to the reactor vessel. Westinghouse stated in DCD Section 6.3.2.2.7.2 that much of the debris that enters through the gutter system settles to the bottom of the IRWST. In Table 2 of TR 26, Revision 3, Westinghouse indicated that some debris was caught in the IRWST screens, 2.47 kg (5.44 lbm).

Justify the calculated IRWST screen debris mass and volumes for Table 2 in TR26, and discuss in the justification how the significant runoff from the containment into the IRWST during a LOCA was specifically factored into the calculation. Also discuss in your justification how this relates to the total residue mass in the containment that you assumed to be (i.e., 227 kg (500 lb)) as documented in NUREG-1793 Section 6.2.1.8.2.

RAI-SRP 6.2.2-SRSB-10

In TR 26, Revision 3, in the "Break Selection Criteria" subsection on page 13, Westinghouse states:

> "Note that the debris reaching the core is based on a DVI LOCA in the loop compartment. For this event the containment water level rises above the break so that some water can enter the reactor coolant system (RCS) directly and thereby bypass the Containment Recirculation Screens. It is calculated for such an event that no more than 60% of the total recirculation flow will bypass the screens. As a result, the core debris is set at 60% of the Containment Recirculation Screen amount."

The staff notes that in Table 3 the best estimate total mass bypass to the core is 14.35 lbm, and requests the following information.

a. Clarify, since the amount of bypass debris is significant for determining the effect on the core, the basis for the 60% number.
b. Describe how this relates to the total residue mass in the containment of 227 kg (500 lb) that you assumed, as documented in NUREG-1793, Section 6.2.1.8.2.
c. Clarify whether the total mass number to the core includes bypass debris from the recirculation and IRWST screens.

RAI-SRP 6.2.2-SRSB-11

Provide responses to the following questions related to APP-PXS-GLR-001, Revision 0, "Impact on AP1000 Post-LCOA Long Term Cooling of Postulated Containment Sump Debris," issued April 28, 2008:

a. In the DEDVI break cases, it is noted that the containment water level exceeds the elevation of the break so that water can flow directly into the reactor pressure vessel bypassing the sump screens. For each of the cases analyzed, including the two sensitivity cases, provide the debris and chemical loading for the water bypassing the sump screens and that taken downstream of the sump screens.
b. Provide the hydraulic head of the IRWST, and the hydraulic head (i.e., water elevation in the containment) over the DVI break location and the recirculation screens with respect to time, the losses in the broken DVI line, and the core inlet resistance for each case analyzed, including the two sensitivity cases.
c. Provide plots of the integrated core boiloff rate and integrated core inlet flow rate for each of the cases analyzed, including the two sensitivity cases.
d. Figure 2-2 indicates the core collapsed level is decreasing. Explain why the level with the unblocked core inlet would decrease while those for the sensitivity cases, Figures 3.1-2 and 3.2-2, decrease for approximately 1500 seconds, then level off for the remainder of the

transient. Also explain why the core collapsed liquid levels in the two sensitivity cases are generally higher than the base case.

e. Considering the differences in the core inlet flow rates between the base case and the sensitivity cases as shown by the intact and broken DVI line mixture flow rates (Figures 2-13, 2-14, 3.1-13, 3.1-14, 3.2-13, and 3.2-14), explain why the upper plenum collapsed liquid levels remain almost the same between the base and sensitivity cases (Figures 2-8, 3.1-8 and 3.2-8).
f. Discuss the local heatup effects due to capture of the debris and potential precipitates on fuel rods within the spacer grids and between the spacer grids. The discussion should also consider maximum pre-existing cladding oxide and crud. Justify the amount of oxide and crud assumed for the analysis.
g. On page 1 of APP-PXS-GLR-001, the staff notes that credit is taken for cooling the core from the bypass flow through the broken DVI line from the containment to the downcomer. In DCD Section 15.6.5.4B.3.1, on page 15.6-39, Westinghouse stated that a venturi was inline to limit the flow out the break is located in the DVI line. The bypass flow that flows to the core carries debris through this venturi.

   Confirm that the plugging of this venturi has been factored into the cooling flow for the core. If not considered or factored in, please provide an evaluation.
h. In Section 1, "Introduction," Westinghouse provides five reasons or considerations for selecting the DCD long-term cooling case [DVI line break] as the base for the sensitivity study. The first bullet describes the amount of debris bypassing the containment recirculation screens and being transported to the core for cold leg and hot leg breaks. The second bullet describes a DEDVI break in a PXS room would make available only a small portion of the debris that would be available for a loop break. Explain how these two bullets justify the DEDVI break being the limiting break for long-term cooling sensitivity study. Explain why the DEDVI break chosen is the limiting case from a head-loss standpoint for the IRWST screens, recirculation screens and the core. Also explain when the analyses were begun ad why debris would not be present prior to the analysis.

RAI-SRP 6.2.2-SRSB-12

TR 26, Revision 3, relies on the NUREG/CR-6224 correlation for head loss calculation in the reactor vessel without supporting analytical data. The NRC safety evaluation of NEI 04-07 recommends the correlation be validated using head-loss data from tests performed on the particular type of insulations and range of parameters to ensure its applicability. Additionally TR 26 concludes that there would not be continuous fiber debris bed on the fuel bottom nozzles without data supporting this assertion.

Provide a rationale that is supported by data that demonstrates that the NUREG/CR-6224 correlation is applicable to the AP1000 and the conclusion that the resulting head loss at the bottom of the fuel is negligible.

RAI-SRP 6.2.2-SRSB-13

In TR 26, Revision 3, in Section VII, "Ex-Vessel Downstream Effects Evaluation of AP1000 Recirculation Flow Paths," on page 22, Westinghouse states:

> "In summary, the evaluation performed using the applicable methods and models in WCAP-16406-P (Reference 11) consistent with the applicable amendments, limits and conditions of the associated NRC SE on the WCAP (Reference 12) demonstrates that the AP1000 PXS equipment utilized in post-LOCA recirculation is acceptable for the expected debris loading in the recirculating fluid resulting from a postulated LOCA."

a. Describe the details of this evaluation, including the specific methods and models used from WCAP-16406-P.
b. Identify in detail how each of the differences between the PWR flow paths and the AP1000 flow paths were evaluated.
c. Identify whether the use of applicable PWR methods and models in WCAP-16406 has been validated with respect to the AP1000 design.

RAI-SRP 6.2.2-SRSB-14
In TR 26, Revision 3, in Section VII, "In-Vessel (Core) Downstream Effects Evaluation Method," on page 23, Westinghouse states:

> "The calculation method of the LOCADM spreadsheet is described in WCAP-16793 (Reference 13). The evaluation makes some simplifications to the required inputs that are conservative for this evaluation. These data and methods are applicable to the AP1000 for the following reasons …"

Provide a more detailed description of those simplifications and justify why those simplifications are conservative for the AP1000. Confirm that the simplifications presented on pages 23 and 24 of TR-26 are the only simplifications made to the original PWR analyses.

RAI-SRP 6.2.2-SRSB-15
In APP-PXS-GLR-001, Revision 0, "Impact on AP1000 Post-LOCA Long-Term Cooling of Postulated Containment Sump Debris," Westinghouse states, on page 2, the following:

> "Also note that during recirculation, water from the IRWST continues to flow into the PXS room and maintains its level; the water flow from the IRWST passes through the IRWST screen, which would remove the debris that would be in the water."

In TR-26 evaluations, all velocities through the screens were considered to be low. The break in the PXS room causes the velocity through the IRWST screen to increase significantly. Additionally, with this significantly higher velocity through the screen, the latent debris in the IRWST has a greater probability of being swept away and into the IRWST screens, which causes a greater chance of debris passing the screens and directly into the core through the break.

Provide the analysis for this additional debris bypass concern and the impact on core cooling and chemical deposits on the fuel. Discuss, in the analysis, the potential for scaling build-up on the fuel from the new chemical products from the AP1000, and if they could impede the heat transfer characteristics of the fuel.

RAI-SRP 6.2.2-CIB1-01
The use on non-safety injection systems is not described in any of the applicant submittals. Provide an evaluation of the effects of using non-safety active systems for removing core and containment heat while mitigating a LOCA, including:

a. Address the effects of possible additional amounts of debris ingested as a result of use of the active systems.
b. What impact does debris transported by non-safety systems have on recirculation performance and debris accumulation on recirculation and IRWST Screens and the core? Explain how you come to these conclusions.
c. Address how ingested debris could affect the capability of these active systems for long-term cooling. When these systems are used early in the event and encounter blockage or

wear as a result, their capability to function adequately for long-term cooling (post-72 hours) could be impaired.

d. Address how ingested debris could affect the pressure integrity, leakage, and containment isolation function of these active systems. When these systems are used early in the event with higher levels of debris laden water, some components, such as pump seals, may encounter excessive wear and fail. The resulting leakage outside containment would then require the isolation and loss of the active system unction, and isolation valves will be required to close and not leak excessively under the higher debris laden conditions.
e. Address whether leakage through pump seals or other components could increase local dose rates so that credited operator actions, if any, would not be met.

RAI-SRP 6.2.2-CIB1-02
Please clarify why transport of coating debris for the AP1000 was assumed to be limited to the resident debris. TR 26, Revision 3, page 11 states the only debris that can be transported to the AP1000 screens following a LOCA is resident debris. For operating reactors a Zone of Influence (ZOI) must be identified, and coatings both inside the ZOI are assumed to fail as particles. In addition, all unqualified coatings both inside and outside the ZOI are assumed to fail.

RAI-SRP 6.2.2-CIB1-03
Please discuss the amounts of qualified vs. unqualified coatings in containment and the assumptions made about failure of qualified and unqualified coatings during a LOCA. This distinction between qualified and unqualified coatings does not appear to be addressed in the DCD or in TR 26, Revision 3. Please discuss the basis for any differences between the AP1000 and operating pressurized water reactors in the way unqualified coatings are addressed.

RAI-SRP 6.2.2-CIB1-04
Please provide the basis for not including degraded-qualified coatings in the debris source term as recommended by the NRC safety evaluation of NEI 04-07. It is not clear to the staff how the amount of coating debris assumed in the AP1000 analysis relates to the condition of coatings in containment (e.g., degraded coatings identified during routine coating inspections).

RAI-SRP 6.2.2-CIB1-05
Section 6.1.2.1.2 of the DCD states the gutters will be made of either stainless steel or epoxy-coated steel without primer. Please discuss how degraded coatings in the gutters have been considered as a potential debris source in the analysis for long-term recirculation cooling following a LOCA.

RAI-SRP 6.2.2-CIB1-06
Please provide a quantitative discussion of the basis for assuming there is no transport of epoxy coating debris to screens due to the high density of the coatings. In addressing coatings debris, page 14 of 19 of the RG 1.82 Assessment Matrix indicates non-safety coatings inside containment are specified with a high density, and therefore the debris from these coatings does not transport in the post-LOCA water. Section 6.1.2.1.5 of Rev. 16 of the AP1000 DCD states that the density specification is 100 lb/ft^3 and, qualitatively, that the transport under these conditions is "limited."

RAI-SRP 6.2.2-CIB1- 07
Provide the results of the evaluation performed for plugging and wear of the PXS piping system with the assumed latent and coatings debris for the necessary mission time. What is the amount and composition of debris in the downstream flow path, other than latent debris and the

assumed addition of coatings debris? Provide an evaluation of its effect on possible plugging and wear in the downstream flow path components.

RAI-SRP 6.2.2-CIB1- 08
Address the plugging and wear of components in the downstream flow paths for a limiting direct vessel injection (DVI) line break. For the DVI line break LOCA in the AP1000 design, the water level in containment permits direct entry of debris laden water into the DVI line at the break location. This could result in a significantly higher concentration of debris and larger pieces of debris into the core cooling flow path than if all cooling water first passed through the screen.

RAI-SRP 6.2.2-CIB1- 09
Address the effects of debris in the recirculation water during a LOCA on the accuracy of instruments strapped to the outside of the PXS piping. Such instruments make use of the velocity of sound through the fluid medium, which could be affected by the type and quantity of suspended debris, chemical composition, and presence of gases.

RAI-SRP 6.2.2-CIB1- 10
Address the effects of PXS flow rates which could be less than the minimum value assumed for assessing debris settling. For flow rates less than the minimum assumed value (e.g. during system flow initiation or realignment), could significant debris settlement occur which would prevent necessary system core cooling flow? The PXS is a gravity-driven system that uses little differential head to force flow. If any condition (such as system startup or realignment) could result in a momentary, relatively small flow, this could result in increased settling of suspended debris. Increased settling would produce additional system resistance to flow, with a possible result being a negative feedback condition wherein decreased flow produces increased resistance that, in turn, produces further decreased flow.

RAI-SRP 6.2.2-CIB1- 11
Provide an evaluation of the effects of settling or precipitation of boric acid and other chemicals on possible blockage of the downstream flow path prior to entering the vessel.

RAI-SRP 6.2.2-CIB1-12
Since it is expected that during PXS cooling, in addition to steam, there will be some carryover of liquid downstream of the reactor vessel, address the effects of debris entrained in the carryover liquid and boric acid and other chemicals in the liquid which could settle or precipitate in the flow path downstream of the reactor vessel (i.e., flow path from the vessel back to the break location.)

RAI-SRP 6.2.2-CIB1- 13
Provide an evaluation of the effects of the possible collection of non-condensible gases in high points in the PXS flow path, including gases which may evolve out of solution in the piping system, gaseous chemicals, and gases which may form as a result of chemical reactions. Gases in sufficient quantities which collect and are trapped at high points could cause unacceptable pressure losses and restriction of system cooling flow, especially in a gravity-driven system.

RAI-SRP 6.2.2-CIB1-14
Discuss the difference in the temperature transients for the AP1000 post-LOCA water pool and the testing range in WCAP-16530. How did you conclude this did not affect the applicability of WCAP-16530?

RAI-SRP 6.2.2-CIB1-16
TR 26, Revision 3, in the section called "Post-Accident Chemical Effects," page 14 of 26, there is a statement that the AP1000 containment "has little concrete that can come in contact with the post accident water as a result of the use of structural steel module construction." Please provide a detailed explanation of how the amount of calcium phosphate listed in Table 4 of TR 26 was determined based on the amount of concrete that can contact the post-accident water.

RAI-SRP 6.2.2-CIB1-17
Please clarify how the amounts of Al-containing precipitates were calculated. Table 4 of TR 26, Revision 3, includes 19.7 Kg of AlOOH and 1.5 Kg of $NaAlSi_3O_8$ as chemical precipitates in the recirculating water. The associated text states that although the only source of aluminum is the excore detectors that will be enclosed in stainless steel to isolate the aluminum from the containment water, a limited amount of aluminum was arbitrarily included in the calculations. In addition, explain the basis for the selection of 53 pounds for the amount of aluminum assumed in the analysis of downstream effects.

RAI-SRP 6.2.2-CIB1-18
Please discuss how your analysis of chemical effects includes the possibility that coatings could dissolve and produce material that affects head loss.

RAI-SRP 6.2.2-CIB1-19
Please discuss your analysis of the potential for chemical precipitates to affect flow to the core following a LOCA. The discussion of "In-Vessel (Core) Downstream Effects" in TR 26, Revision 3 addresses the potential for deposition of chemical precipitates on fuel, but it does not appear to address the potential for chemical precipitates to block the core inlet.

(Note that RAI numbers RAI-SRP 6.2.2-SPCV-01 thru -05 are current RAIs)

RAI-SRP 6.2.2-SPCV-06
Per 10CFR50.34(b)(2), the FSAR must include the evaluations required to show that component safety functions will be accomplished. When and how will the FSAR be updated to include a complete description of the sump design basis and safety analysis?

RAI-SRP 6.2.2-SPCV-07
Compare the testing done for the AP1000 with the guidance in NRC GR on Head Loss and identify any differences. For the differences please provide an explanation why the testing done remains acceptable. Specifically,

a. Provide the minimum submergence of the screens under small-break loss of coolant accident (SBLOCA) and large-break loss of coolant accident (LBLOCA) conditions and explain if vortexing is possible and any effects. Do the IRWST screens remain submerged throughout all accidents? If not, explain the impact on recirculation performance.
b. Provide the basis for the selection of the head loss test termination criteria.
c. State whether temperature/viscosity was used to scale the results of the head loss tests to actual plant conditions. If scaling was used, provide the basis for concluding that boreholes or other differential-pressure induced effects did not affect the morphology of the test debris bed.
d. How was the operation of the non-safety related injection systems considered in the testing?

RAI-SRP 6.2.2-SPCV-08
Provide a summary of the containment housekeeping programmatic controls in place to control or reduce the latent debris burden. The programmatic controls need to assure that design-basis

assumptions regarding debris sources and transport remain valid. Specifically, provide a description of programmatic controls to maintain the latent debris fiber source term into the future to ensure assumptions and conclusions regarding inability to form a thin bed of fibrous debris remain valid.

RAI-SRP 6.2.2-SPCV-09
Provide a description of how permanent plant changes inside containment are programmatically controlled so as to not change the analytical assumptions and numerical inputs of the licensee analyses supporting the conclusion that the reactor plant remains in compliance with 10 CFR 50.46 and related regulatory requirements.

RAI-SRP 6.2.2-SPCV-10
Provide a description of how maintenance activities including associated temporary changes are assessed and managed in accordance with the Maintenance Rule, 10 CFR 50.65.

RAI-SRP 6.2.2-SPCV-11
TR 147, Revision 1, Section II, page 4 identifies design requirements for both sets of screens including SSE seismic loads and application of jet impingement forces. It does not address design requirements for head loss or protection from missiles or other large debris, as required by RG 1.82, revision 3, C-1.1.1.6. How will it be demonstrated that screens meet this regulatory position?

References
TR 26 : Technical Report 26 ,APP-GW-GLR-079, Revision 3, “AP1000 Verification of Water Sources for Long-Term Recirculation Cooling Following a LOCA”, March 2008.

TR 147: Technical Report 147, APP-GW-GLN-147, Revision 1 “AP1000 Containment Recirculation and In-Containment Refueling Water Storage Tank (IRWST) Screen Design” March 2008

Impact Document 02: APP-GW-GLE-002, Revision 1, “Impacts to the AP1000 DCD to Address Generic Safety Issue (GSI)-191, June 2008 (these changes were also included in TR 134 Revision 5)

NEI 04-07, Revision 0 “Pressurized Water Reactor Sump Performance Evaluation Methodology,” December 2004. ADAMS ML050550138

NRC SE of NEI 04-07, “Safety Evaluation by the Office of Nuclear Reactor Regulation Related to NRC Generic Letter 2004-02,” Revision 0, December 2004. ADAMS ML043280007

RG 1.82 Assessment Matrix, AP1000 Regulatory Guide 1.82, Revision 3, “Water Sources for Long-Term Recirculation Cooling Following a Loss-of-Coolant Accident” Assessment Matrix, April 2008. ADAMS ML081020229

NRC GR on Head Loss: “NRC Staff Review Guidance Regarding Generic Letter 2004-02 Closure in the Area of Strainer Head Loss and Vortexing”, March 2008. ADAMS ML080230038

WCAP-16406-P, Revision 1 “Evaluation of Downstream Sump Debris Effects In Support of GSI-191,” May 2006.

WCAP-16914-P, Revision 0: “Evaluation of Debris Loading Head Loss Tests for AP1000 Recirculation Screens and In-Containment Tank Screens” March 2008

Final Safety Evaluation for Pressurized Water Reactor Owners Group (PWROG) Topical Report WCAP-16406-P, “Evaluation of Downstream Sump Debris Effects In Support of GSI-191,” Revision 1, December 2007.

APP-PXS-GLR-001, Revision 0, "Impact on AP1000 Post-LOCA Long-Term Cooling of Postulated Containment Sump Debris," April 2008.

Letter from Robert Sisk, Westinghouse Electric Company, to USNRC, “Methodologies Used for the AP1000 Evaluation of Long-Term Core Cooling”, June 3, 2008.