Response to

Request for Additional Information No. 111 (1446, 1471, 1508), Revision 0

11/03/2008

U. S. EPR Standard Design Certification
AREVA NP Inc.
Docket No. 52-020
SRP Section: 06.02.02 - Containment Heat Removal Systems
Application Section: FSAR Ch. 6

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

Question 06.02.02-8:

In ANP-10293, dated February 2008, the applicant assesses the U.S. EPR design with respect to RG 1.82 Revision 3 (November 2003). All reference material, used in development of ANP-10293, was published prior to September 2004. Since September 2004, substantial experimental and analytical work has been performed to address the resolution of GSI-191. In December 2004, in an effort to aid resolution of Generic Safety Issue (GSI)-191, "Assessment of Debris Accumulation on PWR Sump Performance," (issued in September 1996), the NRC staff evaluated industry guidance to resolve GSI-191 that was submitted through NEI. The NEI submission, as approved in accordance with the staff safety evaluation, provides an acceptable overall guidance methodology for evaluation of emergency core cooling system (ECCS) performance following any postulated accident for which ECCS recirculation is required, with specific attention given to the potential for debris accumulation that could impede or prevent the ECCS from performing its intended safety functions.

The applicants' submittal (FSAR) and the subsequent technical report (ANP-10293) provided the staff with a high level overview of sump design features and selected results. However, in accordance with available guidance, more details are needed on AREVAs methods and evaluation techniques, selected to meet NRC's regulations, in order to complete an evaluation of emergency core cooling system (ECCS) performance following any postulated accident for which ECCS recirculation is required, with specific attention given to the potential for debris accumulation that could impede or prevent the ECCS from performing its intended safety functions. As such, several areas require additional information or clarification and form the basis for the following RAIs.

In each area below, the level of detail provided should include a summary, with information needed to address the area, description of the methodology used to reach the conclusion, basis for methods and key assumptions not consistent with NRC-approved guidance, and sufficient information to show correct application of any NRC-approved guidance.

RAI-SRP 6.2.2-SPCV-01

A. Thin Bed effect

   AREVA states, in ANP-10293, that no relevant thin-bed effects were observed during AREVA performed strainer validation testing. In addition, AREVA states they will evaluate additional empirical data to further assess the presence or lack of thin-bed effects. ANP-10293 also states in section 3.2.3, under test conditions, a uniform debris bed was formed in all cases on the ECCS sump strainer. Thin-bed effect is discussed in RG 1.82 and NRC SE on NEI 04-07 GR. Thin-bed effect refers to the debris bed condition in a fibrous/particulate bed of debris whereby a relatively high head loss can occur because of a relatively thin layer of debris, by itself or embedded as a stratified layer within other debris, because the bed porosity is dominated by the particulate, and the bed porosity approached that of the corresponding particulate sludge. The latest staff criteria for thin-beds are addressed in "Review Guidance for Strainer Head Loss and Vortexing" (ADAMS ML080230038).

   1. What is the calculated thickness of the EPR fiber debris bed? Provide analysis inputs and assumptions. Explain the basis for how these analysis inputs and assumptions are conservative.

2. Does U.S. EPR design have the potential to develop a thin-bed as described in NEI GR and RG 1.82?
3. For those plants that can substantiate that the formation of a thin bed which can collect particulate debris will not occur, the staff finds that coating debris should be sized based on plant specific analyses for debris generated from within the ZOI and from outside the ZOI, or that a default area equivalent to the area of the sump-screen openings, be used for coatings size. Provide details of analysis, as applicable.
4. The testing methodology and guidance on thin beds has improved over the last few years. For thin bed testing, please describe how particulate and fiber debris additions were sequenced. Describe basis for methods and key assumptions not consistent with NRC-approved guidance (e.g. NRC SE on NEI 04-07 GR and Review Guidance for Strainer Head Loss and Vortexing).

B. Break Selection
ANP-10293, states the hot leg is the limiting break location but does not provide justification.

1. Describe and provide the basis for the break selection criteria used in the evaluation.
2. Discuss the basis for reaching the conclusion that break size(s) and location(s) chosen present the greatest challenge to post-accident sump performance.

C. Debris Generation/Zone of Influence (excluding coatings)
ANP-10293 Section 3.1.1.1 states AREVA selected a ZOI that corresponds to a sphere with a radius of seven pipe diameters but does not provide justification.

1. Describe the methodology AREVA used to determine the ZOI for generating debris. Identify which debris analyses used approved methodology default values. For materials with ZOIs not defined in the guidance report/SE, or if using other than default values, discuss methods to determine ZOI and the basis for each.
2. Provide destruction ZOIs and the basis for the ZOIs for each applicable debris constituent. How does AREVA account for two phase jet effects (see SE on NEI GR, section 3.4.2.2)?
3. Identify if destruction testing was conducted to determine ZOIs. If such testing has not been previously submitted to the NRC for review or information, describe the test procedure and results with reference to the test reports(s).
4. Provide the quantity of each debris type generated for each break location evaluated. If more than four break locations were evaluated, provide data for the four most limiting locations.
5. In ANP-10293 AREVA states that reflective metal insulation (RMI) is used extensively on RCS components (section 2.5) and makes up a portion of the debris source term (Table 3-1). In addition, FSAR section 6.3.2.2.2 claims RMI is not subject to transport to the SIS sumps.
    a. Describe testing or evaluations that show that the EPR selected RMI insulation, once it has been damaged by the LOCA, will not become debris that will cause potential plugging of the screens.

b. Verify that the same degradation for the RMI as described in the NEI 04-07 SE exists in the U.S. EPR or identify what the degradation would be. Describe the impact of the degradation on the debris loading.

c. Did AREVA conduct testing with RMI as part of their limiting fiber and particulate (and chemical) case? If so, what amount of RMI was present on the strainer surface?

d. Is there any chemical residual associated with the RMI 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. Is there any fiber insulation or particulate encased in RMI that could contribute to the debris? If so, are the configurations qualified for jet impingement? Provide the qualification details.

6. Are there any other objects or devices 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 and associated insulation, nuclear instrumentation, signs, caulking, fire barrier material…)?

D. Debris Characteristics

In ANP-10293, AREVA states the assessment of the ECCS sump strainer blockage is conservatively bounded by the assumption that all available insulation and debris within the ZOI is transported to the IRWST. In addition, AREVA states bounding assumptions were assumed for debris. AREVA does not provide a listing of these assumptions to assess if these assumptions are bounding and conservative.

1. Provide the assumed size distribution for each type of debris.

2. Provide bulk densities (i.e., including voids between the fibers/particles) and material densities (i.e., the density of the microscopic fibers/particles themselves) for fibrous and particulate debris.

3. If mainly relying on calculations (limited testing), provide assumed specific surface areas for fibrous and particulate debris.

4. Provide the technical basis for any debris characterization assumptions that deviate from NRC-approved guidance.

5. Section 2.5 of ANP-10293, states jet impact resistant, cassette type encapsulated mineral wool is used as RCS insulation. In section 3 the debris source term (Table 3-1) lists mineral wool in cassettes, in fiber glass cloth protected by stainless steel, and in mattress around auxiliary pipes protected by stainless steel sheet. Mineral wool may be manufactured using a number of materials with varying characteristics. What specific type of mineral wool was selected when conducting head loss testing? What type of mineral wool is specified for installation in U.S. EPR? Clarify and differences between tested condition and U.S. EPR design, as applicable.

E. Latent Debris

AREVA assumed 110 lb of latent debris in the analysis. AREVA states the value is conservative and is based upon operating experience and sampling performed on operating plants. No further characterization of the debris was provided.

1. Provide the methodology used to estimate quantity and composition of latent debris.

2. Provide the basis for assumptions used in the evaluation.
3. Provide results of the latent debris evaluation, including amount of latent debris types and physical data for latent debris as requested for other debris under D. above (debris characteristics).
4. Provide amount of sacrificial strainer surface area allotted to miscellaneous latent debris.
5. 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.

F. Debris Transport
Debris transport analysis estimates the fraction of debris that would be transported from debris sources within containment to the sump suction strainers. AREVA states that conservative bounding assumptions are employed. These assumptions and/or analysis were not provided to assess whether they are conservative or bounding.

1. According to FSAR Chapter 6.3, trash racks and weirs are considered components of IRWST. When AREVA states in ANP 10293 that all debris in ZOI is transported to IRWST, does this include trash racks and weirs or does it indicate all debris enters the water of the IRWST?
2. In ANP 10293, Section 3.0, AREVA states, “It was assumed that all dislodged material is transported to the IRWST and that all of this material is deposited on the strainer of one ECCS train, What debris is included in the term dislodged material? What material is excluded? How is this approach conservative? Is it consistent with NRC guidance?
3. Describe the methodology used to analyze debris transport during the blowdown, washdown (as applicable), and recirculation phases of an accident.
4. Provide the technical basis for assumptions and methods used in the analysis that deviate from the approved guidance.
5. Provide a summary of, and supporting basis for, any credit taken for debris interceptors such as weirs, curbs, baskets, trash racks etc.
6. State whether fine debris (individual fibers and fine particulates) were assumed to settle and provide basis for any settling credited.
7. Provide the calculated debris transport fractions and the total quantities of each type of debris transported to the IRWST water.
8. In ANP-10293 Section 3.1.1.2 “Debris Transport Scenarios” latent debris, paint chips, and metal debris are assumed to settle out within the loop area or the IRWST. Settling prior to reaching the strainer represents a non-conservative assumption unless the settling can be shown to be representative of actual plant conditions. Provide basis for crediting settling. Provide a description of the scaling analysis used to justify settling, if used, during head-loss testing.
9. In ANP 10293, AREVA states 1) ”Debris which passes through the retaining baskets will not encounter any turbulence due to IRWST size.” and 2) “…suspended particulates were not directly considered downstream of retaining basket.” (see page

A-19 of ANP-10293). Describe testing or analytical tools used to validate these inputs and assumptions.

10. What Non Safety systems, in containment, may be in operation during a LOCA that could contribute to debris transport to either the heavy floor or IRWST? For example, containment spray is a non-safety system and may be placed in service. When this system operates post-LOCA (operator action), assess its potential impact on debris transport.

G. Coatings Evaluation
Please provide adequate discussion and justification for coatings debris generation (ZOI determination and unqualified coatings), characteristics, transport analysis, and assumptions.

1. The staff position (SE on NEI GR) on ZOI for destruction of coatings is 10D unless plant specific analysis was conducted which is based upon experimental data over the range of pressures and temperatures of concern using coating samples correlated to EPR specified coatings. Based on either approach, what is EPRs worst case coatings ZOI volume and coating debris quantity and characterization of this coating debris?

2. SE on NEI GR requires 100% failure of non qualified coatings inside or outside the ZOI. How are unqualified coatings accounted for in the debris source term for EPR?

3. The debris source term in Table 3-1 of ANP 10293 lists 110 lb of paint chips (separate from latent debris). What is the basis for treating this source term debris as "chips", how are these chips characterised? How is this characterization consistent with recent NRC guidance documents? Does this amount include qualified and unqualified coatings within the ZOI for destruction of coatings? Does it include all unqualified coatings outside the ZOI for destruction of coatings?

H. Head Loss
Please provide additional information related to head loss determinations.

1. Meeting RG 1.82 Regulatory Position 1.3.4.5 requires the head loss caused by debris blocking the sump strainers to be estimated from empirical data. ANP-10293 states in section 3.2.1 that debris addition equivalent to approximately 1/20 of the debris postulated for a LBLOCA was added to a test loop. Table 3-1 lists 1230 ft^3 of mineral wool assumed in the evaluation. 1/20 of 1230 ft^3 = 62 ft^3 of mineral wool. Explain why only 6.2 ft^3 of mineral wool was added? In addition, 220 lb of microporous insulation was assumed in the analysis but only 8.3 lb was used versus 11 lb (1/20 * 220 = 11). Explain the basis for selecting 8.3 lb? Are these values conservative? How large was the heavy floor? This affects the flow velocity and debris settling. What was the debris size distribution in the experiments and how does it correspond to the debris size expected at the plant? The debris size affects debris settling and debris retention by the trash racks. How much debris was retained on the heavy floor and by the trash racks in the experiments? The debris was added to a separate mixing chamber and not directly to the heavy floor, as in the plant. How much of the debris remained in the mixing chamber without reaching the heavy floor? Much more data is needed about the tests in order to assess their validity.

2. Provide information on how the test debris was prepared and how the debris was prototypical or conservative with respect to the plant design. For example, In ANP-

10293 section 3.2.2, AREVA states "…part of the mineral wool would still contain binder…which would reduce the amount of fine debris available for transport". The GR and SE require the 100% of mineral wool to be reduced to small fines – which is the basic constituent – an individual fiber. How was debris added, diluted during addition?

3. Per ANP 10293, maximum sump screen approach velocities of 0.8 inches/sec are assumed in the analysis. What is the basis for selecting this value as conservative and what method was used to determine this value? How does the approach velocity used in the analysis differ from the tested condition? Provide basis for any differences.
4. What is the assumed approach velocity of the fluid transiting from the heavy floor to the trash racks in the analysis? What is the basis for selecting this value as conservative and what method was used to determine this value? How does the approach velocity used in the analysis differ from the tested condition? Provide basis for any differences.
5. Describe the constituent parts of the debris bed? Is the bed stratified or mixed?
6. What amounts, sizes, and types of particulate material are assumed to reach the retaining basket? What is the basis for this assumption?
7. What amounts (if any) and types of particulate material is assumed to reach the sump screen? What is the basis for this assumption?
8. AREVA reports that a strainer testing program validates the design of the EPR ECCS recirculation system. If the testing procedure has not been previously submitted to the NRC for review or information, please provide a copy of the test procedure and completed test report(s). Did the test include chemical effects?
9. AREVA indicated that Alden labs independently concluded that the test loop scaling was conservative and is likely to provide conservative test results. If ALDENs report has not been previously submitted to the NRC for review or information, describe the extent of their review process (to include what was not reviewed by ALDEN) and basis for their conclusions, with reference to the any report(s).
10. AREVA describes test scaling in ANP 10293. Discuss key scaling inputs described and why they are conservative for debris and velocity scaling.
11. In ANP-10293 section 3.2.3, the report states that the head loss across the strainers – with conservative assumptions - only reached about 3% of the design value. Explain conditions and 'conservative' assumptions that resulted in 3% head loss and list the design value. How does this compare with the 0.15 psi head loss @ 2.2 psi design value discussed in the same section? (0.15 psi >> 3% of 2.2 psi)
12. Provide the minimum submergence of the strainer under loss of coolant accident conditions. If submergence is not greater than head loss, an evaluation of the acceptability of this circumstance should be included.
13. Provide a summary of the methodology, assumptions and results of the vortexing evaluation to include design considerations for the reduction of vortexing. Provide bases for key assumptions such as minimum submergence, fluid temperature, and flow rate (velocity).
14. Provide the basis for the strainer design maximum head loss.

15. Describe significant margins and conservatisms used in the head loss and vortexing calculations.
16. Provide a summary of the methodology, assumptions, bases for the assumptions, and results for the clean strainer head loss calculation.
17. Provide a summary of the methodology, assumptions, bases for the assumptions, and results for the debris head loss analysis on the strainer.
18. Provide a summary of the methodology, assumptions, bases for the assumptions, and results for the clean retaining basket head loss calculation.
19. Provide a summary of the methodology, assumptions, bases for the assumptions, and results for the debris head loss analysis on the retaining basket.
20. 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.
21. State whether containment accident pressure was credited in evaluating whether flashing would occur across the strainer surface, and if so, summarize the methodology used to determine the available containment pressure.
22. How is operation of the non-safety related injection systems (CSS) considered in the head loss assessment or testing?
23. In ANP 10293 Areva states “Even without crediting debris hold-up by the retaining baskets, the installed strainer has sufficient area to accommodate the maximum amount of debris and still operate within its design envelope?” Please define what is meant by maximum amount of debris and specify the design envelope. For debris, include characteristics such as source, sizing and amount of fiber, particulate and other debris on strainer surface and the corresponding head loss.
24. If the all retaining baskets were deemed inoperable during power operation (loss of filtering function), will the strainer design and performance support continued power operation?
25. If all the strainers were deemed inoperable (loss of filtering function) during power operation, will the retaining baskets design and performance support continued power operation?

I. NPSH

The applicant in Table 3-2 of ANP-10293 provides the NPSH assessment. More details are necessary for the staff to reach a conclusion.

1. Provide applicable pump flow rates, the total recirculation sump flow rate, sump temperature(s), and minimum containment water level and describe the assumptions used in the calculations for the above parameters and the sources/bases of the assumptions.
2. Provide the basis for the NPSH Required values, e.g., three percent head drop or other criterion.
3. Describe how friction and other flow losses are addressed.

4. Describe the operational status for each ECCS and all other pumps whose suction source is the sump, before and after the initiation of recirculation.
5. Describe the single failure assumptions relevant to pump operation and sump performance.
6. Describe how the containment sump water level is determined.
7. Describe how the level in the retaining basket is determined (calculated) or measured.
8. The retaining baskets possibly constitute hold-up volumes should fibers and particulates "coat" the basket mesh. What is the hold-up volume created from the top of the lowest operating level of the retaining baskets to the spill-over level, and is this hold-up volume explicitly considered in the NPSH calculation?
9. Provide assumptions that are included in the analysis to ensure a minimum (conservative) water level is used in determining NPSH margin.
10. Describe whether and how the following volumes have been accounted for in pool level calculations: empty spray pipe, water droplets, hold up in retaining basket and heavy floor, condensation and holdup on horizontal and vertical surfaces. If any are not accounted for, explain why.
11. Provide assumptions (and their bases) as to what equipment will displace water resulting in higher pool level.
12. Provide assumptions made that minimize the containment accident pressure and maximize the sump water temperature.
13. Specify the containment accident pressure (value and units) selected in the NPSH analysis.

J. Upstream Effects
AREVA provided a limited discussion on holdup or choke points, resulting in the following questions.

1. Summarize the evaluation of flowpaths from the postulated break locations (include potential for washdown, as applicable) to identify potential choke points in the flow field upstream of the sump.
2. In several instances, ANP-10293 refers to an annular space that drains to the IRWST. Define the annular space, as used in ANP-10293, and the annular space flowpaths that route water and debris to the IRWST. Describe how blockage of this flowpath has been evaluated, including likelihood of blockage and amount of expected holdup.
3. Summarize measures taken to mitigate potential choke points
4. Summarize evaluation of water holdup at installed curbs, debris interceptors or a full retaining basket.
5. Describe how potential blockage of reactor cavity and refueling cavity drains has been evaluated, including likelihood of blockage and amount of expected holdup.
6. The trash racks form a potential blockage point for all flow in the recirculation system (less that from the annular space). The grid pattern of the trash racks - 4" x 4" - combined with the heavy floor opening size, may sustain complete blockage. Given

the stated debris source term analyzed in DCD chapter 6 and ANP 10293, combined with the undocumented effects of the rupture and convection foils, address whether there is enough large debris to theoretically cover the entire set of trash rack openings? Provide an evaluation that shows that the 4”x4” grating will not become blocked to such an extent that prevents adequate water supply/head to ECCS pumps.

K. DCD Section 6.2 and 6.3 and ANP-10293 questions related to GSI-191.

1. No data sheets were provided in Tier 2 of the DCD on the Retaining baskets either as a separate data sheet or as part of the IRWST design parameters data sheet. The baskets are fully contained within the IRWST. If the baskets are credited in debris management for long term core cooling, provide detailed specifications and arrangement within IRWST to allow assessment.

2. No data sheet was provided in Tier 2 of DCD for trash racks/weir installed over the four heavy floor openings as a separate data sheet or as part of the IRWST design parameters data sheet. If these racks/weirs are credited in debris management for long term core cooling, provide listing of specifications. (Note: FSAR 6.3.2.2.2 considers trash racks and weirs as “…components of the IRWST.”)

3. FSAR Section 6.3.2.2.2 discusses buffering solution. Please clarify how chemical buffer (TSP) is arranged within the boundary perimeter of the weir/trash rack.

4. Provide a listing or diagram of all the potential pathways that water and steam exiting the limiting break is routed or returned to the IRWST, post accident. What, if any, paths do not have trash/debris racks? What paths, if any, do not go to a retaining basket?

5. Does water from the limiting break location (a single hot leg), that spills out onto the heavy floor and eventually flows to the IRWST, drain to the IRWST via all four heavy floor openings (via the trash racks)? Or, is the break waters access to the IRWST restricted or constrained to the one heavy floor opening/trash rack that is contained by the structures/components in the loop compartment with the break? Are there any components that are required to operate/actuate in order to allow break water (water spilling from the pipe break onto the heavy floor in one RCS loop vault area) to access all four heavy floor openings to the IRWST?

6. Describe how water spilling out of a break near the pressurizer (within pressurizer compartment) reaches the IRWST?

7. There are four retaining baskets within the IRWST. During a LOCA, baskets receive water flow as it spills through openings from the heavy floor above. Two of the four retaining baskets are split into two compartments, with the smaller compartment dedicated to receive water from the “annular space”. What amount of retaining basket surface area is available and credited (for each retaining basket) for flow from the heavy floor. What amount of retaining basket surface area is available or dedicated to the flow from the annular space? In the two compartment retaining basket, is there a common surface area that is credited for heavy floor flow and annular space flow?

8. In ANP-10293 the basket compartment designed for annular space flow has a reduced volume as compared to the other compartment (heavy floor flow) and the

other two retaining baskets – 530 ft3 vs. 1766 ft3 and 3000 ft3, respectively. Is the 3000 ft3 a total volume for two baskets or does each basket have 3000 ft3?

9. Per ANP-10293, each of the retaining baskets has approximately the same screen surface area for screening out debris. Please provide a sketch or drawings that outline how these baskets and subcompartments, as applicable, are arranged and highlight credited surface areas used to perform their design functions. What is the minimum basket volume and surface area needed to support flow from the heavy floor? What is the minimum basket volume and surface area needed to support flow into the compartment dedicated to annular flow? Provide the basis for these volumes and surface areas.
10. The basket compartment receiving flow from the annular space is lower in height and is designed to minimize water retention in the annular space. What is the expected water retention in the annular space? What is the expected debris loading into the annular space? How is it transported to IRWST? What is the makeup of this debris loading – fiber, particulate? What are expected flow rates? What happens if the annular space compartment screen surface areas are clogged? Where does it overflow? Can the annular space water bypass the retaining basket compartment screens? Can debris from the heavy floor clog credited screen surface area from the annular compartment?
11. Table 6.3-4—IRWST Design Parameters lists ceiling area, wall area, and bottom area. Please explain the area difference between the IRWST bottom ~ 5800 ft^2 and the ceiling ~ 1800 ft^2.
12. Describe any access to the IRWST water surface or subsurface, during a LOCA, other than through the four trash rack protected heavy floor openings and the annular space drains. Assess potential debris entry into the IRWST through these access points and its impact on sump strainer head loss.
13. In section 2.3.3, "IRWST (ECCS) Sump Strainers, AREVA states a bounding approach was used for sizing the ECCS Strainer. What are the inputs and assumptions selected to size the strainer to achieve a conservative bounding design?
14. FSAR Section 6.2.1 specifies installation of rupture and convection foils. In a response to Question 6.2.1-07a AREVA states: The rupture and convection foils are made of austenitic steel with an intermediate layer of plastic to establish the compartmental atmospheric seal during normal plant operation. Upon rupture, how are the foil materials accounted for regarding their potential to transport and block or clog recirculation water flowpaths to the IRWST leading to water holdup (upstream effects) and possible contribution to strainer head loss or NPSH concerns.
15. Per FSAR section 6.3.2.2.2, the IRWST is connected to the core spreading area by pipes and valves. During a LBLOCA, how is IRWST single failure protection achieved with respect to these IRWST valves and piping components? If a valve or valve(s) were to open, what is the resultant change in IRWST tank level? Would this tank level support NPSH requirements?
16. Meeting RG 1.82 RP 1.1.1.12 requires the downstream effects of the debris passing the sump screen (e.g., damage to the pumps or blockage of flow through the fuel assemblies) to be assessed. The Technical Report ANP-10293 revision 0 states that the components handling IRWST water post-accident include a requirement of being

capable of handling particulates of 0.09 inches or less (Appendix A, item 1.1.1.12) or 0.08 x 0.08 inches or less (Section 3.1.1.6). Why is this requirement not included in the FSAR?

Response to Question 06.02.02-8 (A) - Thin Bed Effect

1. AREVA NP tested the functionality of the debris retention system. In all tests, the debris layer on the sump strainer screen had a fairly even thickness (visual observation). Direct measurement of the thickness on the vertical screen was not possible because the debris dropped off the screen when the test pump was turned off. Testing concluded the following:

    - In all cases, a uniform debris bed formed on the strainer. Considering the efficiency of the retaining basket, the amount of debris on the strainer was limited, leading to head loss across the strainer of less than 10 mbar (compared to a design value of 150 mbar at 40°C).

    - Tests with the strainer alone, without other filtering features, shows that the head loss remains below the design value even when the maximum amount of debris is introduced into the test loop.

2. AREVA NP conducted two tests to evaluate the potential for thin bed effects. For both tests with the retaining basket inserted, there was no thin bed effect observed. The head loss through the strainer remained small (1.6 mbar). The only significant impact was on the water level in the retaining basket. The water level increased with the amount of fibers and not with ratio of particulates to fibers. AREVA NP concluded that—due to the mechanisms influencing the debris deposition in the retaining basket—there was no relevant thin bed effect.

3. The response will be provided by June 23, 2009.

4. The response will be provided by June 23, 2009.

Response to Question 06.02.02-8 (B) - Break Selection

1. The debris generation was evaluated for postulated large, medium, and small breaks. The most penalizing location of the break for producing the maximum volume of debris corresponds to a large break loss of coolant accident (LBLOCA) located on the primary hot leg entrance in the steam generator (SG). The break selection is based on the maximum quantity of debris that could reach one strainer during the recirculation phase after a LBLOCA, considering the maximum quantity of debris produced from the zone of influence (ZOI), the quantity of debris carried to the strainers, and the flow paths to the in-containment refueling water storage tank (IRWST).

2. Refer to the response to Question 06.02.02-8 (B.1).

Response to Question 06.02.02-8 (C) - Debris Generation/Zone of Influence (excluding coatings)

1. The response will be provided by April 1, 2009.

2. The response will be provided by April 1, 2009.

3. Destruction testing was not conducted to determine the zone of influence (ZOI) for the U.S. EPR.

4. ANP-10293, "U.S. EPR Design Features to Address GSI-191, Technical Report," Table 3-1 provides the estimated itemized debris sources for the maximum volume of debris generated by the limiting break, which corresponds to the double-ended rupture of the hot leg at the entrance to the steam generator. All potential debris materials within this ZOI are included in the debris source estimate and are assumed to be transported towards the IRWST. The ZOI for this most limiting break bounds any other break locations for the maximum amount of debris generated and for the impact on the U.S. EPR sump blockage mitigation design features.

5.a. AREVA performed a series of tests to validate the effectiveness of the U.S. EPR defense-in-depth design against filter clogging due to post-accident debris generation. The test results concluded the following about the reflective metal insulation (RMI):

[ ]

Figure 06.02.02-8-1—Simulated RMI Debris

b. The response will be provided by April 1, 2009.

c. Tests were conducted tests with RMI as part of the limiting fiber and particulate case, and it was concluded no RMI was present on the strainer surface. Refer to the response to Question 06.02.02-8 (C.5.a).

d. There is no known chemical residual associated with RMI that could impact the screen blockage or the core blockage.

e. The response will be provided by April 1, 2009.

6. For the U.S. EPR, there are no other known objects or devices in the ZOI that can be damaged by jet impingement and contribute to the debris.

Response to Question 06.02.02-8 (D) - Debris Characteristics

1. The size and distribution for each type of debris was developed from the maximum quantity of debris that might reach one strainer after a LBLOCA. The maximum amount and type of debris are:

   - 35 m^3 of mineral wool

     The 35 m^3 of mineral wool debris is based on the 100% mineral wool quantity that could be released from the EPR ZOI. The entire amount is assumed to be transported to the IRWST. Metallic pieces from broken jackets of mineral mattress are heavy debris and will not be transported to the strainers inside the IRWST because they will either stay on the floors or will be retained by the weirs, the trash racks, and the retaining baskets. In addition, the flow velocity in the IRWST is low and cannot transport metallic pieces. The inability of metal debris to reach the strainer is substantiated by testing.

     For initial strainer testing, debris from metallic cassettes, jackets, and mineral wool mattresses of about 10 different sizes were used. The mineral wool used for testing was thermally aged and mechanically fragmented using a shredder.

     Note: The 35 m^3 of mineral wool was the value assumed for evaluation and development of the strainer design. For the U.S. EPR, most of the 35 m^3 of mineral wool is replaced with RMI, resulting in significantly less debris transport to the IRWST. Refer to ANP-10293, Table 3-1 (Total Debris Source)

   - 3 m^3 of RMI

     For the EPR, 3 m^3 of RMI was selected as the amount released (from the reactor coolant pump) by the LBLOCA event. Tests showed the RMI is resistant to the effects of debris transport. For the U.S. EPR, most of the 35 m^3 of mineral wool is replaced with RMI. Refer to the response to Question 06.02.02-8 (C.5) for details of the RMI testing.

   - 50 kg of paint chips

     It is assumed the coatings within the ZOI are destroyed by the jet impact. Since with this assumption the amount of paint chips generated would be very small, a conservative value of 50 kg of paints chips was selected. Due to the density of the paint chips, the testing shows most of them will settle. The paint chips were prepared by applying the paint to plastic foil, drying for seven days, removing the paint from the plastic foils, and fragmenting the paint pieces by hand. This procedure provided paint chips ranging in size from about 1x1 mm to 3x3 cm.

   - 50 kg of latent debris

     The U.S. EPR design does not have a containment spray system actuation for a LOCA event. Consequently, the amount of latent debris transported to the IRWST is significantly less than otherwise. The amount of latent debris is dependant on the housekeeping practices that will be used by the plant operator. Based on industry experience and sampling performed on operating plants, a conservative latent debris value of 50 kg is used. For testing, a mixture of dust and concrete particles were used. Concrete particles were smaller than 1 mm.

- 100 kg of microporous insulating material

  The amount of microporous insulating material debris selected is 100 kg based on containment layout and insulation constraints. Testing revealed the microporous insulation material had very limited impact on the strainer pressure drop. Preparation of the microporous insulation material for testing involved reducing the Microtherm material to a powder.

2. The response will be provided by March 1, 2009.

3. The development of the EPR strainer design did not exclusively rely on calculations. The report describing the assumed surface areas for debris is available for NRC inspection.

4. The response will be provided by March 1, 2009.

5. The type of mineral wool selected for the EPR strainer head loss testing is ISOVER MD2. The U.S. EPR design differs in that the mineral wool amount will be replaced predominately with RMI as indicated in ANP-10293, Table 3-1.

Response to Question 06.02.02-8 (E) - Latent Debris

1. The response will be provided by February 15, 2009.

2. The amount of latent debris depends on the cleanliness practices of the plant operator. Based on operating experience and sampling performed on operating plants, a value of 110 lb was conservatively selected. Because of the large filtering area provided by the four retaining baskets and four emergency core cooling system (ECCS) strainers, a significant amount of latent debris would be required to have an impact on screen head loss.

   The amount of material dislodged from the limiting ZOI (L/D = 7) was conservatively estimated by neglecting the protective features provided by compartmentalized components. It was assumed that all dislodged material is transported to the IRWST and this material is deposited on the strainer of one ECCS train, except the material collected in one retaining basket.

3. The latent debris tested was a mixture of dust and concrete particles ranging in size from 10-100 microns, and with an average density of 156.08 lb/ft^3.

4. The response will be provided by February 15, 2009.

5. This is a combined license (COL) information item. Refer to U.S. EPR FSAR, Tier 2, Section 1.8.1, Table 1.8-1, Item No. 6.3-1: "A COL applicant that references the U.S. EPR design certification will describe the containment cleanliness program which limits debris within containment." The amount of latent debris depends on the plant operator's housekeeping practices.

Response to Question 06.02.02-8 (F) - Debris Transport

1. All debris in the ZOI is assumed to enter the water of the IRWST where the majority of debris is captured in the retaining baskets.

2. The term “dislodged material” refers to the Total Debris Source indicated in Table 3-1 of ANP-10293 Section 3.1.1.1. None of the dislodged material for the debris source term is excluded from entering the IRWST. This approach is conservative in that the Table 3-1 total debris source is assumed to enter only one heavy floor opening and pass into only one retaining basket. Any debris that reaches the one ECCS strainer will result in the maximum expected debris loading. Credit is not taken for other ECCS train flow paths through additional heavy floor openings and retaining baskets that could capture debris during the LOCA event and lessen the impact on strainer clogging.

3. The debris transport in containment depends on the fluid flowing from the break as well as condensation and washdown effects. Since the U.S. EPR has no containment spray actuation for the LOCA event, the washdown effects that contribute to debris transport are limited. The U.S. EPR design approach conservatively assumed that 100 percent of the debris material is transported to the IRWST.

4. ANP-10293, Appendix A, Section 1.3.3 provides the U.S. EPR conformance assessment for the R.G. 1.82 guidance related to R.G. 1.82 debris transport. The EPR design does not deviate from the guidance in R.G. 1.82, Section 1.3.3. Specifically:

   - The U.S. EPR analysis conforms to Subsections 1.3.3.1, 1.3.3.2, 1,3,3,3, 1.3.3.5, 1.3.3.8, and 1.3.3.9.
   - Subsections 1.3.3.4 and 1.3.3.7 are not applicable for the U.S. EPR.
   - Testing will be performed to confirm consistency with the guidance of Subsection 1.3.3.6.

5. The U.S. EPR design takes credit for the following installed multiple barriers (debris interceptors) that significantly limit the amount of postaccident debris reaching the ECCS strainers:

   - Weirs around the heavy floor openings promote settling of debris on the reactor coolant system (RCS) loop area floor.
   - Trash racks above the heavy floor openings prevent large debris from being transported to the IRWST.
   - Retaining baskets below the heavy floor openings capture the remaining debris contained in weir overflow.

   Though the above three barriers are part of the U.S. EPR design, testing with the strainer alone shows that the strainer head loss remains well below the design value even when the maximum amount of debris is introduced in the test loop.

6. Fine debris is not assumed to settle in the IRWST. Based on experimental data, the low flow velocity in the IRWST, and the large IRWST volume, more than 50 percent of the

debris is expected to settle in the IRWST. However, for the design of the strainers, it was conservatively assumed that all the debris entering the IRWST are collected on the strainer, except for that which will be collected in one retaining basket.

Tests showed that large amounts of mineral wool debris introduced to the water flow showed a strong tendency to agglomerate and then settle quickly. To keep the mineral wool debris entrained and without significant agglomeration during the test run, additional measures were taken. These included pre-mixing and weighing the debris before adding to the test facility, and adding the debris with the test pump operating.

7. AREVA NP assumes 100 percent debris transport to the IRWST for each type of debris identified in ANP-10293, Table 3-1 (Total Debris Source).

8. Debris settling occurred during screen testing. For debris settling within the loop and IRWST, the tests showed:

   - In the region were the break flow drops on the heavy floor, the water flow is turbulent causing debris to move radially away from this region. With increasing distance from this region, flow velocities decrease causing debris to settle on the floor, beginning with the heavier pieces. The deposited debris acts as an obstacle in the flow path and retains smaller debris. Generally, only smaller and lighter parts of the debris reach the weirs, where more material is deposited in front of the weirs. Because of the small size of the debris transported to the weirs, no build up of "debris dams" higher than the weirs occurs.
   - The flow velocities at the bottom of the IRWST are very low. Even with minimal flow movement mainly caused by the mini flow line, there is a large amount of debris settling (including fine debris) on the IRWST floor that is not deposited on the sump screen. In all tests, more than 50 percent of the material that penetrated the retaining basket screen or dropped outside of the retaining basket was deposited on the floor with a maximum value close to 80 percent.

   A scaling analysis was not necessary to justify settling during head-loss testing.

9. Refer to the response to Question 06.02.02-8 (F.8).

10. During a LOCA, there are no operating non-safety systems in containment that could contribute to debris transport to either the heavy floor or IRWST. The containment spray function of the severe heat removal system is reserved for beyond design basis events.

Response to Question 06.02.02-8 (G) - Coatings

1. The response will be provided by June 23, 2009.
2. The response will be provided by June 23, 2009.
3. The response will be provided by June 23, 2009.

Response to Question 06.02.02-8 (H) - Head Loss

1. The strainer test report 0mineral wool value of 0.175 m^3 (6.2 ft^3) is a typo and should actually be 1.75 m^3 (62 ft^3). Strainer testing used the correct amount of mineral wool equivalent to 140 kg (1.75m^3 x 80 kg/m^3 density) = 1.75 m^3 (62 ft^3).

   As indicated in Table 3-1 of ANP-10293, the debris source for microporous insulating material is 220 lb (100 kg). An original value of 165 lb (75 kg) was used in the design phase and for strainer testing (1/20 scaling x 165 lb, approximately 8.3 lb). Due to plant layout changes, the original value for microporous insulating material was subsequently revised to 220 lb (100 kg). The increase from 75 kg to 100 kg of insulating material has a negligible impact on the test results as indicated by the large margins revealed during strainer testing.

   Refer to the Test Scaling Summary in the response to Question 06.02.02-8(H.10).

   For the test conduct and results, refer to the test documents in the response to RAI 90.

2. The use of thoroughly aged mineral wool is a conservative approach applied to testing because it yields more fine fibers compared to installed mineral wool that would still contain a binder even after years of operation. This binder would reduce the amount of fine debris available for transport.

   The debris materials are mixed in a homogeneous way before being introduced at the entrance of the test loop. Mineral wool, Microtherm, concrete dust, and paint chips were premixed before adding to the test facility. They are premixed in a stainless steel vessel with 1.5 m^3 of water and equipped with three mixing devices to prevent deposition of material. The debris material for the tests were weighed before adding and added in batch mode. During this procedure the debris pump was continuously running. Metal sheets were manually added to the heavy floor because they could not be pumped.

3. The U.S. EPR flow velocity is actually ≈0.08 inches/sec (0.2 cm/sec). The ≈0.08 inches/sec value is provided as a flow velocity estimate, and is representative of data that are applicable to the U.S. EPR generated from experiments performed for utilities using mineral wool. Actual strainer testing showed a flow velocity at the strainer of approximately 0.3 cm/sec.

4. For the U.S. EPR, a specific approach velocity is not assumed because the analysis did not take credit for debris settling on the heavy floor. Instead, the analysis assumed that 100 percent of the debris is transported directly into the IRWST. All debris is assumed to reach the strainer except the debris that is captured by the retaining basket.

5. Testing concluded that the strainer debris bed consisted of mostly fibrous material. Only very fine fibrous debris penetrates the retaining basket screen and is transported to the sump screen. In all tests, the debris layer on the sump strainer screen appeared to have a fairly even thickness.

6. All the debris source term is assumed to reach the retaining basket. Refer to the response to Question 06.02.02-8 (D.1) for the debris characteristics. The basis for this assumption is that the retaining basket is in the direct flow path of the ECCS break flow,

which arrives on the heavy floor and passes through the heavy floor opening directly into the retaining basket.

7. For the design of the IRWST strainers, it was conservatively assumed that all the debris entering the IRWST is collected on the strainer, except for that which is collected in one retaining basket. This approach allowed for a conservative strainer design. The results of strainer testing concluded that mostly fibrous debris reached the strainer.

8. The data report that provides details of the sump strainer testing evaluation is available for NRC inspection. The testing did not include chemical effects. The U.S. EPR chemical effects testing and evaluation are scheduled to be completed by March, 2009, with results scheduled to be available in the second quarter of 2009.

9. Alden Research Laboratory (Alden) reviewed the test loop scale to assess possible scale effects on the test results. The evaluation included the heavy floor area, weir and trash rack, retaining basket and falling jet into the basket, trash rack opening and retaining basket screen characteristics, IRWST sump area, strainer design and performance, and jet simulation from the mini flow line. Alden concluded:

   Test loop scaling is conservative. The Test Loop is likely to provide test data that are conservative in predicting the IRWST strainer performance in terms of percentage of debris transported to the strainer, blockages of the Retaining Basket Screens as well as the Strainer and the resulting head losses.

10. The vertical scale of the test loop is approximately 1:1 to realistically simulate turbulences introduced by the break flow. Horizontal scaling was 1:20 based on the ratio of the strainer screen size. Transport velocities and transport distances were scaled conservatively (transport velocities were higher than the 1:20 scaled velocities and transport distances were shorter than the 1:20 scaled distances). Table 06.02.02-8-1 provides the test scaling summary.

Table 06.02.02-8-1—Test Scaling Summary

Parameter	Test Environment	Plant Environment	Scaling	Comments
Vertical	1	1	1:1	All vertical scaling is ~1:1
Horizontal	1	20	1:20	Horizontal scaling is ~1:20. Transport velocities and transport distances were scaled differently.
Screen Area	37.7 ft^2 (3.5 m^2)	753.5 ft^2 (70 m^2)	1:20	
Screen Mesh	0.083 in x 0.083 in (2.1 mm x 2.1 mm)	0.083 in x 0.083 in (2.1 mm x 2.1 mm)	1:1	
Retaining Basket	34.4 ft^2 (3.2 m^2)	688.9 ft^2 (64 m^2)	1:20	Only one side facing the strainer is screened. The other three sides are solid.
Heavy Floor Area	64.6 ft^2 (6 m^2)	Large (greater than 20:1)	< 1:20	Area above sump where debris arrives first. Plant area would be much larger than the test area that includes additional flow obstacles
Weir (Debris Interceptor)	5.9 in (0.15 m)	5.9 in (0.15 m)	1:1	Vertical scaling 1:1
Trash Rack Opening Area	3.9 in x 3.9 in (10 cm x 10 cm)	3.9 in x 3.9 in (10 cm x 10 cm)	1:1	
Heavy Floor Opening Above Retaining Basket	2.48 ft^2 (0.23 m^2)	49.51 ft^2 (4.6 m^2)	1:20	
IRWST Area (Sump Area)	53.82 ft^2 (5 m^2)	5866.33 ft^2 (545 m^2)	1:109	Area of sump where retaining basket and strainer are located. Plant area is ~109 times the test area. Therefore, higher flow velocities and shorter transport distances in the test area than in the plant.
Total Flow Rates (Flow Thru Strainer)	187.56 gal/min (42.6 m^3/hr)	3755.65 gal/min (853 m^3/hr)	1:20	Assuming one of four trains running (100% of flow)
Flow Thru Retaining Basket	149.7 gal/min (34 m^3/hr)	3015.96 gal/min (685 m^3/hr)	1:20	Assuming one of four trains running (80% of flow)
Flow Thru Mini-Flow Line	36.98 gal/min (8.4 m^3/hr)	739.68 gal/min (168 m^3/hr)	1:20	Assuming one of four trains running (20% of flow)
Screen Approach Velocity	0.011 ft/sec (12.1 m/hr)	0.011 ft/sec (12.1 m/hr)	1:1	~0.01 ft/sec
Debris Quantities	1/20	1	1:20	

11. Strainer design is based on a head loss design value of 150 mbar (2.2 psi). Testing showed a head loss of about 3 percent (4.5 mbar or 0.07 psi). ANP-10293 (Section 3.2.3) states: "…a head loss across the strainer of less than 0.15 psi." The test results are conservative in that 0.07 psi is less than 0.15 psi.

12. The minimum submergence of the strainer is approximately 2.1 ft under loss of coolant accident conditions based on the following:

    - Bottom of IRWST: elevation -6.15m (-20.18 ft).
    - Minimum IRWST level during LOCA: elevation -3.11m (-10.2 ft).
    - Strainer maximum height: 2.4m (7.8 ft).
    - Elevation of strainer top structure: -6.15m elevation + 2.4m = -3.75m elevation (-12.3 ft)
    - Strainer submergence: -3.11m elevation – (-3.75m) = 0.64m elevation (2.1 ft).

    Strainer submergence is not greater than the head loss observed in strainer testing. Refer to the response in Question 06.02.02-8 (H.23).

13. The response will be provided by March 1, 2009.

14. The strainer maximum design head loss is based on providing a conservative design approach in which all debris entering the IRWST is collected on the strainer, with the exception of that debris which is collected in one retaining basket. This results in the strainer functioning with a conservative head loss margin. Refer to the responses to Question 06.02.02-8 (F.2) and Question 06.02.02-8 (H.11)

15. The response will be provided by March 1, 2009.

16. The response will be provided by March 1, 2009.

17. The response will be provided by March 1, 2009.

18. The response will be provided by March 1, 2009.

19. The response will be provided by March 1, 2009.

20. Temperature and viscosity were not used to scale the results of the head loss tests to actual plant conditions. The head loss calculations to size the strainer area were conservative and used a temperature of 40°C (104°F). Similarly, strainer testing was conservative using a water temperature of 40°C (104°F). The head losses through the debris bed depend strongly on the temperature of the water in the IRWST, with lower temperatures having more head loss impact. For the accident, temperatures increase up to 100°C (212°F) for the short term and decrease in the long term. Thus, a lower temperature of 40°C (104°F) was used for strainer sizing and testing to produce a conservative design and conservative test results.

21. Containment accident pressure was not credited in evaluating whether flashing would occur across the strainer surface.

22. The operation of the non-safety-related injection systems (CSS) is not considered in the head loss assessment or testing. Refer to the response to Question 06.02.02-8 (H.10).

23. ANP-10293, Section 3.1.1.3 states: "Even without crediting debris hold-up by the retaining baskets, the installed strainer has sufficient area to accommodate the maximum amount of debris and still operate within its design envelope."

    The maximum amount of debris (147.6 kg) is that amount which was introduced into the test loop for strainer test V9. Testing with the strainer alone and without other filtering features (i.e., retaining basket) showed that the head loss remained below the design value even when the maximum amount of debris was introduced in the test loop. The test results showed a head loss of approximately 20 mbar, compared to a design value of 150 mbar The data report that provides details of the sump strainer testing evaluation is available for NRC inspection.

24. For a condition with all retaining baskets being declared inoperable, continued power operation may be possible. Tests with the strainer alone (without other filtering features) showed that the strainer head loss remains below the design value even when the maximum amount of debris is introduced in the test loop.

25. For a condition with all strainers being declared inoperable, continued power operation would not be permitted. However, tests with the retaining basket installed showed the amount of debris passing the one retaining basket was approximately 5 percent of the total amount of debris introduced to the test loop. The 5 percent of the debris reaching the strainer resulted in a pressure loss across the strainer of 10 mbar, which is below the design value of 150 mbar.

Response to Question 06.02.02-8 (I) – NPSH

1. The requested information is as follows:
    - LHSI pump flow rate = 2860 gpm
    - MHSI pump flow rate = 1100 gpm
    - Total recirculation sump flow rate = 3960 gpm (per train)
    - Sump temperature = 212°F
    - Minimum containment water level = -10.20 ft (IRWST level)

   The assumptions used in the ECCS pump net pump suction head (NPSH) assessment and pressure drop across the IRWST strainers are:
    - All debris generated at the break reaches the IRWST strainers in less than 30 minutes so that they are accounted for in the ECCS pump NPSH assessment.
    - The pressure drop across the IRWST strainers is calculated assuming a conservative sump temperature of 104°F, thereby increasing the pressure drop value.
    - A margin of 1.6 ft was included in the IRWST strainer pressure drop calculation for added conservatism.
    - All the debris are assumed to be loaded into one retaining basket and one strainer, although in the design there are six retaining baskets and four ECCS strainers. (Two of the six retaining baskets capture annulus flow returning to the IRWST.)

2. The basis and additional information for NPSH values in ANP-10293, Table 3-2 are:
    - "Minimum NPSH required @ Q" is based on NPSH values obtained from the LHSI and MHSI pump characteristic curves.
    - "Available NPSH, Clean filter" of 12.1ft (low head safety injection pump, LHSI) and 15.4ft (medium head safety injection pump, MHSI) is based on calculated values for a clean strainer in the ECCS suction flow path.

   Available NPSH (assumes 2.3 ft head loss plus 1.6 ft for margin) is based on a calculated head loss of 3.9 ft (2.3 ft strainer head loss plus a 1.6 ft margin) for a debris-laden strainer.

3. The response will be provided by March 15, 2009.

4. At power operation (Mode 1) and in Modes 2 through 4, the system is maintained with the safety injection system / residual heat removal system (SIS/ RHR) trains in standby configuration ready to be started in SIS mode for injection into the cold legs, either automatically by an SI signal or manually by the operator.

During an accident (e.g., LOCA), in all plant operating modes one train is assumed to be in maintenance, a second train is unavailable due to the single failure criteria, a third one is lost to the break, and the last train has complete functionality

The safety injection (SI) signal automatically starts the MHSI and LHSI pumps and initiates a partial cooldown of the secondary system. This cools the primary system and lowers the RCS pressure.

5. U.S. EPR FSAR, Tier 2, Table 6.3-7 shows the mode evaluation for the safety injection system. Each SIS/RHRS suction line is supplied with its own IRWST suction supply line. Each IRWST suction supply line is designed as a concentric double pipe. The concentric double pipe consists of a guard pipe that protects each suction line. The guard pipe serves as a second (backup) containment boundary. Each sump suction line and guard pipe assembly is routed from the IRWST sump pit (containment) to the downstream sump isolation valve in the Safeguards Building. The IRWST downstream sump isolation valve is normally open to support an SIS/RHRS standby line-up for ECCS. During an event challenging the IRWST, any leakage in the suction line upstream of the sump isolation valve is trapped within the guard pipe of the concentric double pipe. Leakage occurring in the suction line downstream of the sump isolation valve is terminated after the leakage is identified and the immediate sump isolation valve is closed. In the event the sump isolation valve does not close, a second downstream isolation valve is available to isolate the suction line. The IRWST sump isolation valves and downstream valves are powered from Class 1E power supplies for reliable operation.

   There are two isolable ECCS cross-connects between LHSI Trains 1 and 2, and LHSI Trains 3 and 4. These cross-connects, which are isolated using motor-operated gate valves, are used to mitigate the effect of degraded LHSI delivery due to steam entrainment during a large break scenario in the RCS cold leg, when the available LHSI is located adjacent to the broken cold leg. However, both of the ECCS cross-connects will only be utilized (with their isolation valves' electrical breakers racked-out to avoid a single failure) when one of the LHSI train is undergoing preventive maintenance. Otherwise, both of the ECCS cross-connects are isolated to maintain train separation.

6. The IRWST minimum water level (sump level) is based on ECCS pump NPSH requirements during accident conditions. The IRWST minimum water level for pump NPSH requirements considers the following:

   - Release of steam and water from the RCS inside containment (RCS inventory and ECCS accumulator injection).

   - Water recirculation inside the reactor building, taking into consideration:
     - Water remaining in the steam phase.
     - Steam condensation on structures (concrete walls, reactor building containment walls, and ceilings).
     - Residual water retained on the reactor building floors

Based on the above, the IRWST required minimum water level for maintaining the required ECCS pump NPSH is at elevation -10.2 ft. The IRWST water level at elevation -10.2 ft is based on the IRWST bottom at elevation -20.17 ft.

7. The response will be provided by March 15, 2009.

8. The response will be provided by March 15, 2009.

9. The response will be provided by March 15, 2009.

10. The response will be provided by March 15, 2009.

11. The only equipment located in the IRWST that will displace water are the retaining baskets and the sump strainers.

12. NPSH values were calculated assuming 212°F for the short term and 203°F for the long term, while the pressure in the IRWST corresponds to the saturation pressure at these temperatures.

13. The response will be provided by February 1, 2009.

Response to Question 06.02.02-8 (J) – Upstream Effects

1. The response will be provided by March 15, 2009.

2. The annular space is the circumferential space within the containment and between the containment wall and the wall separating the major RCS components. The annular space is provided with wall openings that allow water to drain into the IRWST retaining baskets. Approximately 83 percent of the ECCS return flow will pass through the heavy floor openings. Approximately 17 percent of ECCS return flow drains through the annular openings to the IRWST retaining baskets. The annular space locations were assessed for potential debris transport, with consideration given to containment layout, RCS components and structures, LOCA release paths, location of the ZOI, the debris source, and sizing of the debris retention components. Based on the evaluation it was concluded that since most debris and return water falls to the heavy floor, debris entrapment and blockage in the annular spaces is not a concern. In addition, in the unlikely event that an annular space drain path via the wall opening to the IRWST retaining basket becomes blocked with debris, the return water would drain to the IRWST via an alternate annular wall opening.

3. No choke (holdup) points in the LOCA release return flow paths can impede ECCS operation. The containment layout and design of the ECCS sump blockage mitigation features allows the LOCA release water to readily drain and flow back to the IRWST sump strainers to support ECCS operation. Refer to ANP-10293, Section 2.0 and the response to Question 06.02.02-8 (J.1).

4. The water level on the heavy floor is limited to the 2 inch height of the weirs surrounding the heavy floor openings, plus the slight increase in level attributable to the water flow over the weirs. Following a LOCA, only smaller and lighter debris materials reach the weirs, where they become deposited in front of the weirs. Because of the small size of the debris transported up to the weirs, there is no build-up of “debris dams” higher than the weirs.

   Since there are multiple pathways through the heavy floor for water to drain back to the IRWST, complete blockage of all pathways to the IRWST via the trash racks is unlikely. Strainer testing with the weir and trash rack installed revealed that most debris was retained on the heavy floor without blocking the water flow. The water level in the retaining basket is self-regulating and increases as the lower portion of the basket becomes filled with debris. If the retaining basket becomes full of debris, water can overflow the basket.

5. The debris transport in containment depends on the fluid flowing from the break and the condensation and washdown effects. Most of the debris and water released from the LOCA event will fall and drain to the reactor building heavy floor. Since the U.S. EPR has no containment spray actuation for the LOCA event, the condensation and washdown effects that contribute to debris transport are limited. As RCS fluid condenses on the containment surfaces, it will drain toward the reactor building cavities. The draining condensate may entrain fine debris on these surfaces and wash it toward the cavities. Some of this fine debris may ultimately be transported via the reactor

building cavity drains to the IRWST. The cavity drain lines each consist of 6 inch piping that combine into a common 8 inch line which drains to the IRWST. The drain lines are conservatively sized to preclude blockage from potentially fine debris transported by condensation and washdown.

6. The trash racks are designed so that the return path cannot be blocked. The shape and large area of the four trash racks, their diverse locations on the heavy floor, and their mesh size (4 in. x 4 in. grating) prevent the trash racks from becoming completely clogged by large debris. In the region were the break flow drops on the heavy floor, the water flow is turbulent and the debris move radially away from this region. With increasing distance the flow velocities decrease, causing debris to settle on the floor, beginning with the heaviest materials. The deposited debris acts as additional obstacles in the flow path and as retention devices for smaller debris. Considering their large surface area and the low flow velocity, the larger debris settles around the opening but does not block the trash rack. Tests have demonstrated the effectiveness of the weir and trash rack assembly, including the ability of the trash rack to remain free from complete blockage. The tests have also demonstrated that only one trash rack is sufficient; however, in the event of a LOCA there will be four trash racks (and four parallel flow paths) in the heavy floor to accept the return flow to the IRWST.

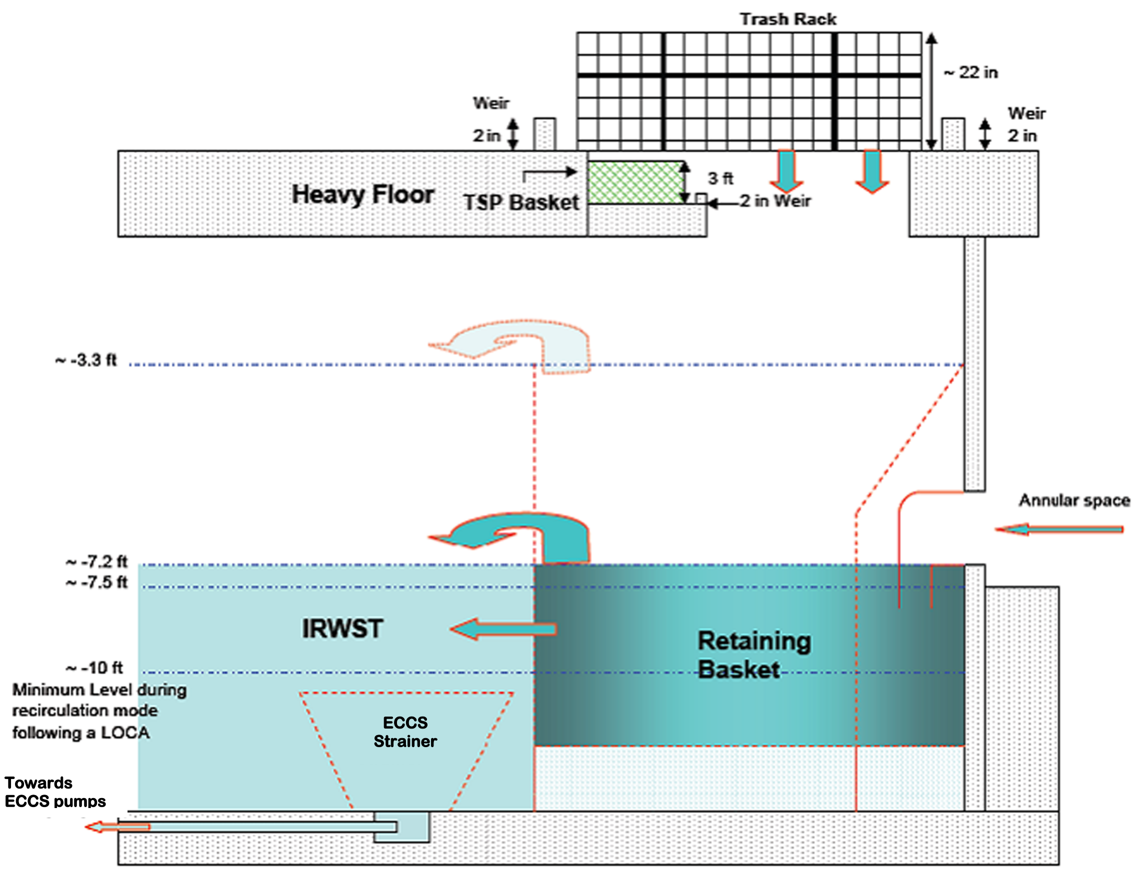
Response to Question 06.02.02-8 (K) - DCD Section 6.2 and 6.3 and ANP-10293 questions related to GSI-191

1. The response will be provided by March 15, 2009.

2. The response will be provided by March 15, 2009.

3. The tri-sodium phosphate (TSP) baskets are located in the containment heavy floor opening below the IRWST trash racks. Figure 06.02.02-8-2 shows the location of the TSP basket for each of the four heavy floor openings and its relation to the ECCS sump blockage mitigation design features.

Figure 06.02.02-8-2—TSP Basket Location With Respect to the ECCS Sump Blockage Design Mitigation Features



4. Water that exits the break returns to the IRWST through the heavy floor openings and must pass through the trash racks into the retaining baskets. The steam that exits the break returns as condensate to the IRWST through the annulus space openings into the retaining baskets. These openings do not have trash racks but the condensate flows into the retaining baskets. The flow paths back to the IRWST flow into the single or double compartment retaining baskets.

5. Water that exits the break drains back to the IRWST through the four heavy floor openings via the trash racks. The water from the break is not restricted or constrained to the loop compartment and drains to the heavy floor. There are no components required to operate or actuate to allow water from the break to reach any of the four heavy floor openings.

6. The response will be provided by March 15, 2009.

7. The surface area of the single compartment retaining basket is 721 ft^2 and the surface area of the double compartment retaining basket is 990 ft^2. The surface area of the smaller compartment for the annulus opening is 269 ft^2. For the two-compartment retaining basket design, there is no common surface area credited for heavy floor flow and annular space flow.

8. The total combined volume of the two single compartment retaining baskets is 3000 ft^3.

9. See Figure 06.02.02-8-2 in item 3 above. The minimum requirements for the retaining baskets needed to support the heavy floor are 1589 ft^3 and 721 ft^2. The minimum requirements for the smaller compartment of the double compartment retaining basket needed to support the annular space are 530 ft^3 and 269 ft^2. These sizes are based on collecting all debris in one retaining basket.

10. The response will be provided by March 15, 2009.

11. The response will be provided by February 1, 2009.

12. During a LOCA, there are no access points to the IRWST water surface or subsurface other than through the four trash racks protecting the heavy floor openings and the annular space drains.

13. The assumptions used to size the IRWST sump strainers are:
    - The maximum quantity of debris that might reach one strainer during the recirculation phase of a LBLOCA.
    - The nature of the debris.
    - No debris retention in the Containment Building.
    - The head loss across the strainer is limited to 2.18 psi at 104°F.
    - The zone of Influence of the break (L=7D).
    - The head loss correlations for the debris as function of the thickness of the debris bed on the strainer.

- The maximum pressure losses that are acceptable for the NPSH margin for the LHSI and MHSI pumps, and the mechanical strength of the strainer.

The data report that provides the assumption details for the development of the sump strainer design is available for NRC inspection.

14. The response will be provided by April 1, 2009.

15. There are two connections from the IRWST to the core spreading area. Each connection has two motorized isolation valves and one passive flooding valve between the IRWST and the core spreading area. The normal position for the passive flooding valve is closed and the normal position for the motorized isolation valves is open. If the passive flooding valve fails open then the motorized isolation valves can be closed. Since there are two motorized isolation valves in the connection, the single failure requirement is met.

16. Technical Report ANP-10293 is incorporated by reference in the U.S. EPR FSAR (see FSAR Supplement 1, February 7, 2008).

FSAR Impact:

The U.S. EPR FSAR will not be changed as a result of this question.

Question 06.02.02-9:

Provide the limiting characterization and properties of ECCS post-LOCA debris laden recirculation water including the content of latent debris, chemicals, coatings, and other solids. Address the abrasiveness of the debris laden fluid on the wetted ex-vessel downstream components. Also, include the additional amounts of debris and the larger pieces of debris that could be ingested downstream as a result of possible use of the non-safety back flush system.

Response to Question 06.02.02-9:

The response will be provided by April 15, 2009.

Question 06.02.02-10:

For the limiting debris laden recirculation water conditions, provide the results of a detailed evaluation of the plugging and wear of the ex-vessel downstream ECCS flow path components for their necessary mission time. Describe the plugging and wear models used and their bases. Address all individual components including: piping, valve disks and seats, pump wear rings, pump bearings and seals, pump rotors and shafts, and heat exchanger tubes and shells. Also include the effects of individual equipment strainers, cyclone separators, branch lines, pump recirculation lines, and other components that may become plugged. Provide the limiting assumptions included in the evaluation to address possible variations in operational lineup and use of various systems (e.g., use of either HPSI or MHSI versus using only LPSI for hot leg injection or use of only one train versus multiple trains of ECCS flow).

Response to Question 06.02.02-10:

AREVA NP understands that downstream effects to the ECCS components and the reactor fuels are generic unresolved NRC issues/concerns. This issue will be further assessed based on the results of industry consensus regarding confirmation of downstream effects.

The U.S. EPR ECCS pumps (both LHSI and MHSI pumps) are designed with increased clearances, appropriate hardening of parts for wear, and a filtration system for the mechanical seals to provide long-term performance under limiting debris-laden recirculation water conditions.

Analysis of the operation of the EPR ECCS pumps showed negligible impact on the pump performances when operating under debris-laden recirculation water conditions. The analysis was validated against existing qualification tests under equivalent pumping conditions.

Additionally, fouling factors have been incorporated in the LHSI heat exchanger performance calculation for the U.S. EPR thermal-hydraulic analysis.

FSAR Impact:

The U.S. EPR FSAR will not be changed as a result of this question.

Question 06.02.02-11:

For the limiting debris laden recirculation water conditions, provide an evaluation of changes in system or equipment operation caused by wear of components (e.g., increased pump vibration due to shaft wear or the increase of pump internal bypass flow that decreases performance and may further accelerate internal wear.) Assess whether the system or component flow resistance changes or alters flow balances as a result of wear. Assess whether the system piping vibration response changes due to wear such that system integrity or its safety function may be affected. Address the capability to isolate components under debris laden conditions, including pump seals that encounter excessive wear, such that they will not leak excessively. Include those components in the non-safety SAHRS and CSS that may leak and require isolation as a result of ingesting debris laden water. 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.

Response to Question 06.02.02-11:

The response will be provided by April 15, 2009.

Question 06.02.02-12:

Provide the design features of the mechanical seals of the ECCS pumps that will ensure their long term performance with debris laden water containing solid particles greater than 0.08 inches. The ANP-10293 report paragraph 3.1.1.6 states that the downstream components (e.g., ECCS pumps) are designed to accommodate fluid with solid particles having dimensions of 0.08 x 0.08 inches or less. However, the square mesh screen openings of 0.08 x 0.08 inches can allow solid particles that have a major dimension as large as 0.113 inches to pass through on the diagonal. In addition, longer needle-like particles, i.e., metal whiskers, and significantly larger deformable particles can also penetrate the screen. The ECCS pumps have single mechanical seals that could potentially be damaged by particles that have major dimensions greater than 0.08 inches.

Response to Question 06.02.02-12:

The U.S. EPR ECCS pumps (both LHSI and MHSI pumps) are designed with increased clearances, appropriate hardening of parts for wear, and a filtration system for the mechanical seals to provide long-term performance with debris-laden water, thereby preventing potential damage to the mechanical seals.

Tests have shown that the combination of weirs, trash racks, and retaining baskets prevent most of the debris from reaching the strainers.

Testing indicated only 10 ppm or less particulates in the downstream effluent as a result of the three-tiered debris retention design of the ECCS recirculation system. Additionally, water samples of recirculation flow downstream of the test strainers indicated a fibrous material length of less than approximately 0.04 inches.

The data report that provides details of the sump strainer testing evaluation is available for NRC inspection.

FSAR Impact:

The U.S. EPR FSAR will not be changed as a result of this question.

Question 06.02.02-13:

Address the effects of debris, chemicals, and gases in the ECCS recirculation water on instrument tubing connected to the ECCS piping and on the accuracy of instruments strapped to the outside of the ECCS piping. Instrument tubing will not function properly if plugged, and strapped-on 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.

Response to Question 06.02.02-13:

AREVA NP understands that downstream effects to the ECCS components and the reactor fuels are generic unresolved NRC issues/concerns. This issue will be further assessed based on the results of industry consensus regarding confirmation of downstream effects.

The U.S. EPR design does not have instruments strapped onto the ECCS piping. Tests performed for the three-tiered debris retention design of the ECCS recirculation system showed a negligible amount of debris transported downstream of the IRWST strainers, so there will be no impact on the proper function and accuracy of instrument tubing connected to the ECCS piping.

Furthermore, instrument tubes are typically tapped off the top or side of the ECCS piping and will not be blocked by debris, which will settle on the bottom of the pipes.

FSAR Impact:

The U.S. EPR FSAR will not be changed as a result of this question.

Question 06.02.02-14:

Address the effects of ECCS flow velocities which could be less than the minimum value required to prevent settling of suspended debris in the downstream flow path. For flow velocities less than the required minimum value (e.g. during system flow initiation or realignment), could significant debris settlement occur that would restrict necessary system core cooling flow?

Response to Question 06.02.02-14:

AREVA NP understands that downstream effects to the ECCS components and the reactor fuels are generic unresolved NRC issues/concerns. This issue will be further assessed based on the results of industry consensus regarding confirmation of downstream effects.

The velocities within the ECCS piping and through heat exchangers are usually significantly greater than the screen approach velocity which is very low (~0.08 – 0.12 inches /sec). Therefore, settling is not expected in the piping systems and is more likely to occur prior to the strainer. Additionally, the U.S. EPR IRWST strainers are designed with inverted side screens to promote gravitational release of debris beds in low flow condition. Coupled with the three-tiered debris retention design, a negligible amount of debris is expected downstream of the strainers in the event of ECCS low flow velocities (e.g., during system flow initiation), thus providing unrestricted core cooling flow.

FSAR Impact:

The U.S. EPR FSAR will not be changed as a result of this question.

Question 06.02.02-15:

Provide an evaluation of the effects of settling or precipitation of boric acid and other chemicals on possible blockage of the downstream ex-vessel flow path. In addition to the flow path leading to the reactor vessel, address the effects of entrained debris, boric acid, and other chemicals in carryover liquid exiting the core that could settle or precipitate in the flow path downstream of the reactor vessel (i.e., the flow path from the vessel back to the break location.)

Response to Question 06.02.02-15:

Analysis performed for a spectrum of breaks indicated that the U.S. EPR design features for the control of boric acid, for intentional depressurization of the steam generators during small breaks, and for transfer of a portion of the LHSI system injection to the RHRS letdown nozzles on the hot leg for large breaks, are effective in controlling the buildup of boric acid in the reactor core. This prevents the precipitation of boric acid that could lead to possible blockage of the downstream ex-vessel flow path.

The velocities within the ECCS piping and through heat exchangers are usually significantly greater than the screen approach velocity which is very low (~0.08 – 0.12 inches /sec). Settling is not expected in the piping systems and would more likely occur at the strainer. From industry testing, the chemical debris is comprised of primary particles (flocculi) of submicron size, and will likely break up under shear. Thus, the turbulent flows within the ECCS components would likely break up the chemical debris constituent.

FSAR Impact:

The U.S. EPR FSAR will not be changed as a result of this question.

Question 06.02.02-16:

Provide an evaluation of the effects of the possible collection of non-condensable gases in high points in the ECCS flow path, including gases which may be entrained or evolve out of solution in the recirculation water, chemicals that become gaseous, 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.

Response to Question 06.02.02-16:

As discussed in U.S. EPR FSAR, Tier 2, Section 6.3.2.5, the ECCS suction piping is continuously vented to keep it full of coolant whenever the system is required to be operable. This prevents loss of pump suction pressure that could result from accumulation of gases in the piping.

Additionally, the ECCS flow path inside the containment is sloped up to preclude gases from being trapped, thus preventing pressure losses and cooling flow restrictions.

FSAR Impact:

The U.S. EPR FSAR will not be changed as a result of this question.

Question 06.02.02-17:

Containment Atmospheric Circulation System
FSAR Section 6.2.2

1. Instead of active containment atmospheric heat removal and circulation equipment, the US-EPR relies on a system of foils, doors and dampers to promote circulation and to ensure that the internal containment heat structures are effective in maintaining post accident containment pressure and temperature at acceptable levels. As this equipment is relied upon to mitigate design basis accidents, it should be considered to be safety related as defined in 10 CFR 100 Appendix A Section III.(c) and should conform to all applicable NRC requirements for safety related equipment. Describe the how the design of the containment circulation equipment meets NRC requirements for safety related equipment including those for redundancy, electric power, inspection, testing, environmental qualification and seismicity.
2. The containment circulation dampers are described as being opened by motors and a spring in ANP-10268P or by solenoid operated actuators (FSAR Section 6.2.5). The pressure required for opening is stated to be 0.5 psid or 17 psia in FSAR Section 6.2.5. In the response to RAI No. 1 Table 6.2.1-07-3, the opening differential pressure is stated to be 7.252 psi. In the response to RAI No. 40 Table 06.02-11-3, the opening differential pressure is stated to be 7.25 psi. The MAAP4 input deck which Areva provided to the NRC staff uses opening differential pressures of 7.0 psi. The NRC staff understands that the actual opening differential pressure is 0.7 psi. Describe the design of the dampers including the opening mechanism and the design opening pressure. Provide appropriate corrections to the information previously provided to the NRC staff.

Response to Question 06.02.02-17:

1. The response will be provided by April 1, 2009.
2. The response will be provided by February 1, 2009.