Response to

Request for Additional Information No. 90 (1077), Revision 0

10/3/2008

U. S. EPR Standard Design Certification
AREVA NP Inc.
Docket No. 52-020
SRP Section: 06.02.02 - Containment Heat Removal Systems
Application Section: 6.2.2

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

Question 06.02.02-2:

Generic Safety Issue (GSI) 191 addresses the potential for debris accumulation on PWR sump screens to affect emergency core cooling system (ECCS) pump net positive suction head margin. The NRC has issued Bulletin 2003-01, "Potential Impact of Debris Blockage on Emergency Sump Recirculation at Pressurized Water Reactors," (Reference 1) and Generic Letter (GL) 2004-02, "Potential Impact of Debris Blockage on Emergency Recirculation During Design Basis Accidents at Pressurized Water Reactors," (Reference 2) related to the GSI-191 resolution. GL 2004-02 requests, in part, that licensees evaluate the maximum head loss postulated from debris accumulation (including chemical effects) on the submerged sump screen. Chemical effects are corrosion products, gelatinous material, or other chemical reaction products that form as a result of interaction between the PWR containment environment and containment materials after a loss-of-coolant accident (LOCA).

To satisfy the requirements of GDC 38 and 10 CFR 50.46(b)(5) regarding the long-term spray system(s) and ECCS(s), the containment emergency sump(s) in PWRs and suppression pools in BWRs should be designed to provide a reliable, long-term water source for ECCS and CSS pumps. In order to meet these regulatory criteria, SRP Section 6.2.2, "Containment Heat Removal Systems," recommends following the guidance of Regulatory Guide 1.82, Revision 3 (Reference 3), as an acceptable method.

For the US EPR design, with respect to addressing the concerns of GSI-191 and GL 2004-02, DCD Rev. 0 Supplement 1, Section 6.3.2.5 referenced the AREVA Technical Report ANP-10293, Rev.0, "U.S. EPR Design Features to Address GSI-191," dated February, 2008 (Reference 4).

Requested Information:

ANP10293 Section 3.3.1 indicates that chemical effects between the buffering solution, insulation material and latent debris are expected to be minimal with regard to the amount of precipitate formation. "NRC Staff Review Guidance Regarding Generic Letter 2004-02 Closure in the Area of Plant-Specific Chemical Effect Evaluation" dated March 2008 (Reference 5) provides a detailed methodology for performing chemical effects evaluations. Using Figure 1 of this report as a detailed guide, or other appropriate guidance, please provide a detailed analysis that shows how the assumptions and chemical effects conclusions reported in ANP10293 are justified.

References

1. Bulletin 2003-01, "Potential Impact of Debris Blockage on Emergency Sump Recirculation at Pressurized Water Reactors, dated June 9, 2003, ADAMS Accession No. ML0316002590
2. Generic Letter (GL) 2004-02, "Potential Impact of Debris Blockage on Emergency Recirculation During Design Basis Accidents at Pressurized Water Reactors, dated September 13, 2004, ADAMS Accession No. ML0423605860
3. Regulatory Guide 1.82, Revision 3, Water Sources For Long-Term Recirculation Cooling Following A Loss-Of-Coolant Accident, dated November 2003, ADAMS Accession No. ML033140347
4. ANP-10293, Rev.0, "U.S. EPR Design Features to Address GSI-191," dated February, 2008 ML0804201490

5. NRC Staff Review Guidance Regarding Generic Letter 2004-02 Closure in the Area of Plant-Specific Chemical Effect Evaluations, dated March 2008, ADAMS Accession No. ML080380214," Enclosure 3 to letter from William H. Ruland, NRC, to Anthony Pietrangelo, NEI, dated March 28, 2008, Subject "Revised Guidance for Review of Final Licensee Responses to Generic Letter 2004-02, "Potential Impact Of Debris Blockage on Emergency Recirculation During Design Basis Accidents At Pressurized-Water Reactors"," ADAMS Accession No. ML080230112

Response to Question 06.02.02-2:

AREVA NP document ANP-10293, Section 3.3.1 states that chemical effects between the buffering solution, insulation material, and latent debris are expected to be minimal with regard to the amount of precipitate formation. The basis for this statement is that the U.S. EPR design approach is to predominantly use reflective metallic insulation (RMI) for the reactor coolant system (RCS) piping and major components, including the reactor vessel, the steam generators, reactor coolant pump casings, and the hot, cold, and crossover legs. Jet impact-resistant, cassette-type encapsulated mineral wool insulation is used in locations not suitable for RMI, such as small or irregular areas. The use of fibrous and particulate generating insulation materials (e.g., micro-porous insulation) is limited, and no calcium silicate insulation is used on the RCS. As part of the U.S. EPR GSI-191 program, AREVA NP has scheduled chemical effects testing to support the conclusions of ANP-10293, Section 3.3.1. The U.S. EPR chemical effects testing and evaluation are scheduled to be competed by March, 2009, and the results will be available in the second quarter of 2009.

FSAR Impact:

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

Question 06.02.02-3:

ANP 10293 does not address the potential for deposition of post LOCA chemical products on the fuel cladding and the consequential effects on clad temperatures. Please provide the rationale and technical bases to reasonably demonstrate that potential deposition of post LOCA chemical products on the EPR fuel cladding are acceptable as they related to compliance with 10CFR50.46(b)(5).

Response to Question 06.02.02-3:

Testing and evaluation to address the potential for deposition of post-LOCA chemical products on the fuel cladding, and the potential consequential effects on cladding temperature, are part of the U.S. EPR design process. Refer to RAI No. 32, response to Question 6.3-3.

FSAR Impact:

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

Question 06.02.02-4:

ANP10293, Revision 0 provides some of the assumptions and analysis performed to determine the debris transport under post LBLOCA accident conditions. Please provide the following detail regarding these assumptions and analysis:

1. It is reported that the amount of material dislodged from the limiting zone of influence (ZOI) was conservatively estimated. Please provide the details on how this estimate was performed.
2. It is assumed that latent debris, paint chips and metal debris will settle and not be transported because of their density. Please provide the calculations or tests results to support this assumption.
3. It is reported that non safety related coatings will not be used in containment ZOIs. However, section 6.1.2 of the FSAR indicates that Service Level 2 coatings will be used in containment. How will it be ensured that non safety related coatings will not be exposed to the potential ZOI's or transferred by other means to the IRWST since the principal heat transfer mechanism for limiting containment pressure following a LBLOCA is through condensation on heat sink surfaces and drainage to the IRWST?
4. Regulatory Guide 1.206 Section C.I.6.1.2 Organic Materials specifies that "The applicant should identify and quantify all organic materials that exist in significant amounts within the containment building. Such organic materials include wood, plastics, lubricants, paint or coatings, electrical cable insulation, and asphalt. Plastics, paints and other coatings should be classified and references listed. Coatings not intended for 40-year service without overcoating should include total coating thickness expected to be accumulated over the service life of the substrate surface." How are these organic materials accounted for, if at all, in the evaluation and testing performed and reported in ANP 10293?
5. Regulatory Guide 1.206 Section C.I.6.1.1.2 (1) states "All soluble acids and bases within the containment building should be identified and quantified." How are these soluble acids and bases accounted for, if at all, in the evaluation and testing performed and reported in ANP 10293?
6. Regulatory Guide 1.206 Section C.I.1.1.2 (6) states: "Provide information concerning the proposed approach to control the chemistry of the water used for ECCS and CSS and during the operation of the systems. Describe the methods and bases to evaluate the short term-term compatibility (during the mixing process) and long-term compatibility of the water used for the ECCS and CSS with all safety –related components within the containment." The US-EPR does not use the CSS for DBAs. However, how do the testing results in ANP 10293 support and satisfactorily fulfill the above expected evaluations for short and long term compatibility of the post LBLOCA sump water with the safety-related components within the containment?
7. EPR FSAR Section 15.0.3.12 provides an evaluation of post accident Reactor Building water chemistry control. What impact or relationship, if any, does this water chemistry control evaluation have on the results of the testing performed and reported in ANP 10293? Were the concentrations of nitrates, chlorides and organic matter resulting from the hypalon, PVC and electrical cable degradation accounted for as contaminant components in the testing program summarized in ANP 10293?

Response to Question 06.02.02-4:

1. Dislodged Material

   AREVA NP technical report ANP-10293, Section 3.0.1 states: “The amount of material dislodged from the limiting ZOI (L/D of 7) was conservatively estimated by neglecting the protective features provided by compartmentalized components.”

   Credit was not taken for protective features, such as structural barriers (which prevent further expansion of the break flow in a given direction) to reduce the impact of dislodged material from the ZOI. Eliminating the effects of these protective features in the ZOI results in a more conservative estimate. In addition, the U.S. EPR design is based on the most penalizing break location for debris generation, which is a large break LOCA at the primary hot leg entrance (insulated with reflective metallic insulation) in the steam generator. All potential debris material within this ZOI is included in the debris source estimate and is assumed to be 100% transported towards the in-containment refueling water storage tank (IRWST).

2. Debris Settling

   AREVA NP has performed tests to validate the effectiveness of the U.S. EPR defense-in-depth design against filter clogging due to postaccident debris. These tests concluded:

   - Metal fragments and paint chips settled very quickly or were captured in the retaining basket. Most of the debris was retained on the heavy floor. Almost none of the metal debris passed the weir due to the low flow velocity on the heavy floor. No metal pieces or paint chips passed the retaining basket, except a few small paint chips that dropped outside the retaining basket.

     These few small paint chips were attributable to the test equipment configuration that caused a small amount of the water flow passing through the opening of the heavy floor to drop outside the retaining basket. This was due to the retaining basket overlapping the cross section of the heavy floor opening by approximately 10 cm on each side. The U.S. EPR has a retaining basket cross section overlap of approximately 15.8 inches (40) cm on each side, which will eliminate this water flow bypass.

   - Flow velocities at the bottom of the IRWST are very low, resulting in a large fraction of fine debris (including latent debris) settling on the IRWST floor and not deposited on the sump screen.

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

3. Non-Safety-Related Coatings

   Refer to the response to RAI No. 81, Question 06.01.02-1.

4. Organic Materials

   The response will be provided by November 21, 2008.

5. Soluble Acids and Bases

   The response will be provided by November 21, 2008.

6. Water Chemistry Compatibility

   The response will be provided by November 21, 2008.

7. Water Chemistry Control

   The response will be provided by November 21, 2008.

FSAR Impact:

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

Question 06.02.02-5:

ANP10293, Revision 0 reports sump screen testing results. Please provide the following details regarding the reported testing:

1. The details of the evaluation of the empirical data that were used to come to the conclusions in the report. What were the chemical tests performed, (if any) the measured concentrations of Al, Si, and Ca as a function of time and temperature, and the actual measured pH during the testing? Did these measured values match the predicted values?
2. ANP-10293, Appendix B, Table B-1; GL 2004-02 Item 2.(d)(iii); Requested Information states in part "In addition to debris generated by jet forces, from the pipe rupture, debris created by the resulting containment environment (thermal and chemical) and CSS washdown shall be considered in the analysis. Examples of this type debris are disbonded coatings in the forms of chips and particulates and chemical precipitants caused by chemical reactions in the pool." AREVA's Observation/Comment in response to this item is "Approved coatings will be used based on assessment of the chemical effects on materials relative to debris generation." Although AREVA does not use the CSS in response to a LBLOCA event, significant washdown does occur since the heat sink surface area in the AREVA containment building design is nearly twice that of a comparable dry PWR containment. How does AREVA take into consideration, if at all, the other containment debris mention above and its generation both thermally and chemically in the AREVA design and confirmatory testing reported in ANP-10293?
3. ANP-10293, Appendix A, Items 2.3.1.7 and 2.3.2.3 include AREVA's commitment to provide an estimate of the resident material debris in the IRWST prior to the LBLOCA event. What is the AREVA estimate of the resident material debris in the IRWST, the bases of the data on which the estimate was developed and the process under which the estimate was calculated?
4. AREVA's Conformance Assessment response in ANP-10293, Appendix A, to Item 1.1.2.3 states "The need to address the potential impact of chemical reaction with the debris sources, filter differential pressure and other downstream effects is recognized by the U.S. EPR design program. This issue will be further assessed based on the results of industry consensus regarding confirmation of downstream effects." Please provide AREVA's plan and schedule for the resolution of this Item 1.1.2.3 of Appendix A.
5. What was the differential pressure on the screen material as a function of time? What was the corresponding temperature profile of the test?
6. The no calcium-silicate insulation statement and other items mentioned on the bottom of page 1-1 refer only to insulation type materials to be use (or not used) on the reactor coolant system (RCS), and not the total of other materials that may be subjected to the post-LBLOCA harsh environment in the containment building. At the bottom of page 2-10, the last sentence is another insulation related statement regarding "only the RCS insulation". Please confirm that cal-sil material is not used in the containment building as stated on page 5-1. If cal-sil is used in the containment building please provide the rationale for excluding this material consideration in the testing performed and reported in ANP-10293.
7. What was the identity of the precipitated material collected on the sump screens during the testing and was it expected in both chemical form and quantity?

Response to Question 06.02.02-5:

1. Testing Details

   AREVA NP technical report ANP-10293 provides sump screen testing results. The data reports that provide the details of these tests are available for inspection.

   The sump screen testing did not involve chemical testing. The U.S. EPR chemical effects testing and evaluation is scheduled to be competed by March, 2009, and results will be available in the second quarter of 2009.

   The sump screen testing used a total debris source that is documented in Table 3-1 of ANP-10293. The tests showed that even without crediting debris hold-up by the retaining baskets, the installed strainer had sufficient area to accommodate the maximum amount of debris and still operate within its design envelope. The U.S. EPR strainer will operate with significant design margins (in excess testing predicted values) because of:

   - Debris hold-up by the retaining baskets.
   - The extensive use of reflective metallic insulation in lieu of mineral wool (see ANP-10293, Table 3-1).

2. Wash Down

   GL 2004-02 Item 2.(d)(iii) Requested Information states, in-part, "In addition to debris generated by jet forces, from the pipe rupture, debris created by the resulting containment environment (thermal and chemical) and CSS wash down shall be considered in the analyses." Since the U.S. EPR does not use a containment sump strainer (CSS), debris created by the effects of wash down was not considered in the analysis. The testing reported in ANP-10293 considered containment debris of insulation, paint chips, and latent debris.

   The U.S. EPR chemical effects testing and evaluation is scheduled to be competed by March, 2009, and results will be available in the second quarter of 2009.

3. Resident Material Debris

   ANP-10293, Appendix A item 2.3.1.7 states: "The amount of particulates contained in the IRWST prior to a LOCA is expected to be insignificant. Materials of construction for the IRWST are compatible with contained fluid chemistry; hence, no corrosion products are expected. In addition, the fuel pool purification system (FPPS) provides for incontainment refueling water storage tank (IRWST) cleaning and the tank internals and liner are constructed of austenitic stainless steel."

   In addition, the confines of the IRWST are to be designated as a controlled/confined space with restricted personnel access implemented by site programs and procedures. Foreign material exclusion (FME) requirements will be implemented and mandated for personnel entering the IRWST. As part of the FME provisions to prevent entry of debris and foreign material into the IRWST, IRWST close-out inspections will be performed. During plant shutdown and at the times personnel could potentially approach the vicinity of any IRWST opening, procedural controls will be in-place to restrict personnel access and prevent inadvertent entry of debris or foreign material.

Based on the above, no latent or resident debris are expected within the IRWST.

4. Chemical Effects

   The U.S. EPR chemical effects testing and evaluation is scheduled to be competed by March, 2009, and the results will be available in the second quarter of 2009.

5. Differential Pressure and Test Temperatures

   The response will be provided by November 21, 2008.

6. Calcium-silicate insulation

   Calcium-silicate insulation is not used in the U.S. EPR Containment Building.

7. Precipitated Material Identity

   The response will be provided by November 21, 2008.

FSAR Impact:

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

Question 06.02.02-6:

The materials and their quantities listed at the bottom of ANP-10293 page 3-8 were used in the testing reported in ANP-10293 and only represent debris postulated from AREVA's determined zone of influence (ZOI) only and do not include the other potentially available sources from the entire containment building. Therefore, the staff requests the following information:

1. What is the mass of all other insulating materials (non-RMI) that is used in the plant design and how was it represented in the testing performed and report, if at all?
2. ANP-10293, Appendix A page A-20 RG 1.82 item 1.3.3.6, under AREVA's "Conformance Assessment" includes the statement "As part of the U.S. EPR design program, testing with different ratios of particulate to fiber volume will validate the above assumption (i.e. assess thin bed layer effects)". Has this testing referred to in Appendix A been completed and if so what were the results? If this testing has not been performed what is the current schedule for the completion of these tests and reporting the evaluation results?

Response to Question 06.02.02-6:

1. Insulating Materials Mass

   The materials and their quantities listed at the bottom of page 3-8 of AREVA NP technical report ANP-10293 were used in the testing reported in that document, and represent debris postulated from AREVA's determined ZOI. Insulating materials other than reflective metallic insulation outside the ZOI were not considered, and therefore were not represented in the tests.

2. Particulate-to-Fiber Ratios

   ANP-10293, Appendix A, Item 1.3.3.6 states: "As part of the U.S. EPR design program, testing with different ratios of particulate-to-fiber volume will validate the above assumption (i.e., assess thin bed layer effects)." The subject testing and evaluation is scheduled to be completed by March, 2009, and the results will be available in the second quarter of 2009.

FSAR Impact:

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

Question 06.02.02-7:

The EPR FSAR provides only a very limited description of the TSP-C material packaging and its location. the description, in Tier 2 section 6.3.2.2 pages 6.3-9 - 6.3-10 reads as follows: “Coolant pH adjustment baskets containing granulated trisodium phosphate dodecahydrate (TSP-C) are strategically placed in the inlet flow path to the IRWST within the boundary perimeter of the weirs at the four heavy floor openings of the RB.” (Reactor Building) “Flow through the baskets dissolves the TSP-C into the coolant that returns to the IRWST to passively neutralize entrained acids and maintain the alkalinity of the coolant.” Drawings and figures in the FSAR and ANP-10293 do not show any components in the locations mentioned above except the retaining baskets. However, the location described above does allow drainage from the containment annular flow path to bypass the TSP material and flow into the IRWST thereby provide a diluting stream of primary coolant condensate following a LBLOCA event. Please provide:

1. Information (drawings, figures, schematics, etc.) that shows the specific locations of the TSP-C packaged material and their support structures. In addition, provide a description of the coolant condensate drainage flow paths and estimated quantities that are directed towards the TSP-C material and those that bypass the TSP-C material.
2. A description of the impacts on pH control of the IRWST considering the bypass flow that does not come in contact with the TSP-C packaged material before entering the IRWST and the potential blockage of expected condensate flow paths to the TSP-C packaged material.
3. The purity specifications that have been developed by AREVA for the TSP-C material particularly related to low concentration impurities such as lead (Pb) (since TSP-C is also a chelating agent) which is a common impurity of TSP-C.

Response to Question 06.02.02-7:

1. Drainage Flow Paths

   The trisodium phosphate (TSP) baskets are located in the containment heavy floor opening below the in-containment refueling water storage tank (IRWST) trash racks. Figure 06.02.02-7-1 below shows the location of the TSP basket for each of the four heavy floor openings, and their relation to the emergency core cooling system (ECCS) sump blockage mitigation design features. Figure 06.02.02-7-2 shows the structure of the TSP basket.

   The drainage flow path from the released coolant following a loss of coolant accident (LOCA) condenses on the walls of the loop compartment and flows down to the heavy floor at the bottom of the loop compartments. The LOCA water collects on the reactor building heavy floor and drains to the IRWST through four separate flow openings in the heavy floor. Each of the four openings contains an assembly consisting of a weir, trash rack, and TSP basket. Approximately 83% of the ECCS return flow will pass through the heavy floor openings, dissolving the TSP chemical in each of the four TSP baskets. The remaining 17% of ECCS return flow drains through the annular openings to the IRWST. The ECCS return flow (83%) that passes through each of the heavy floor openings and TSP baskets drains into the IRWST retaining baskets. The remainder of the ECCS return flow (17%) that drains through the annular openings also drains to the IRWST retaining baskets.

Figure 06.02.02-7-1—TSP Basket Location with Respect to the ECCS Sump Blockage Design Mitigation Features

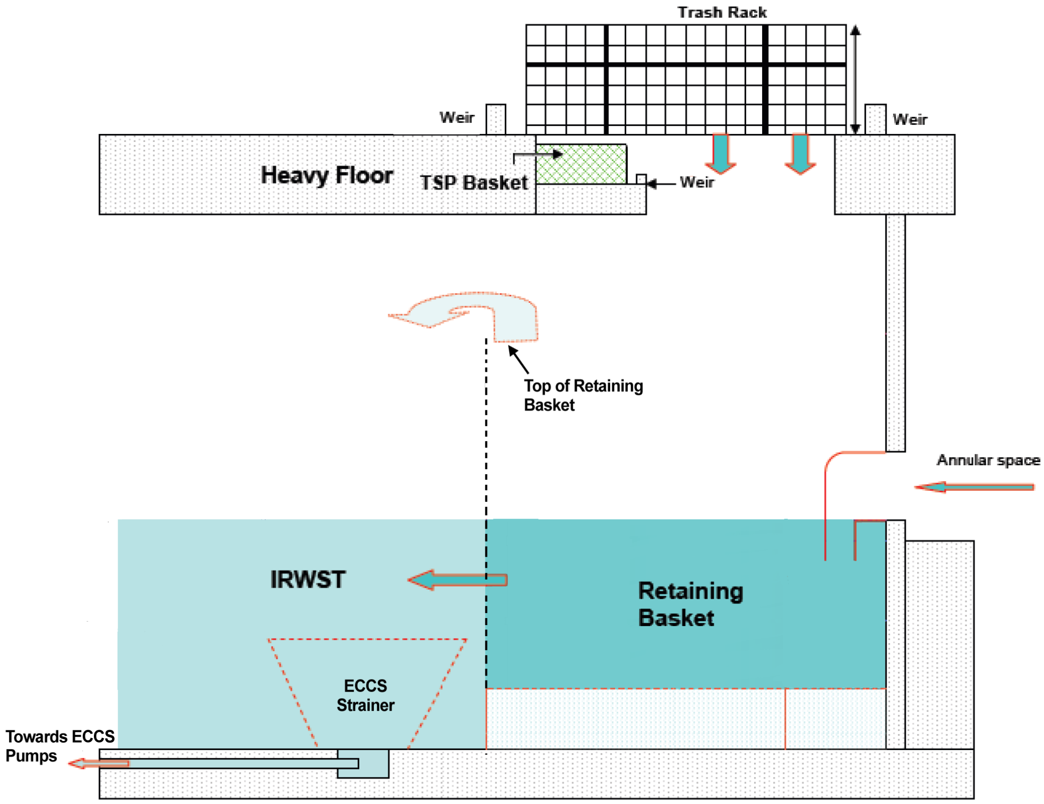
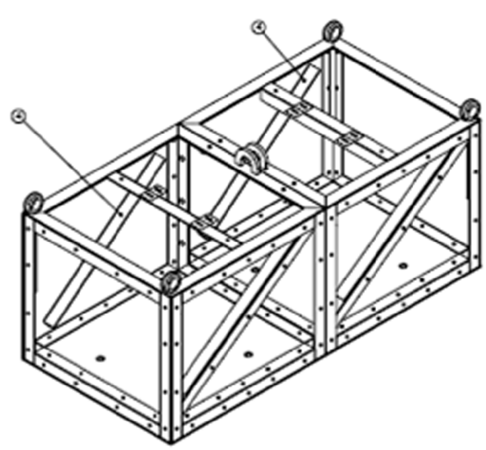


Figure 06.02.02-7-2—TSP Basket Structural Configuration (typical of four)



2. pH Control Impact

   There is no impact on pH control of the IRWST after a large break LOCA. Following blowdown, a refill period occurs where the ECCS provides liquid at 884 lbm/s to fill the lower head/plenum region of the reactor vessel. When the ECCS water reaches the bottom of the core, the refill period is complete and the reflood phase begins. Since ECCS is injecting into the cold leg pump discharge piping, all of the steam generated in the core will exit out of the break at 150 lbm/s. While the steam will initially be superheated, it will quickly become saturated as the core quenches. The steam condenses on the containment walls and drains back to the IRWST through the annulus space openings. The remainder of the ECCS liquid exits the break, falls to the floor, and returns to the IRWST through the heavy floor openings. Therefore, 17% of the ECCS liquid is expected as bypass flow and the remaining 83% of the ECCS flow will pass through the heavy floor openings, dissolving the TSP material.

3. TSP Impurity Specification

   Table 06.02.02-7-1—TSP-C Quality Specification provides the quality specification for the TSP-C material for the U.S. EPR.

FSAR Impact:

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

Table 06.02.02-7-1—TSP-C Quality Specification

Trisodium Phosphate Dodecahydrate, Na3PO4•12H20, CAS# 10101-89-0			
Item	**Parameter**	**Grade (ppm)**	**Grade (%)**
1	Assay (as Na_3PO_4), minimum[1]	N/A	92.0
2	Free Alkali (as NaOH), maximum[2]	30,000	3.0
3	Water-Insoluble Matter, maximum	2,000	0.20
4	Chloride (Cl), maximum	300	0.03
5	Sulfate (SO_4), maximum[3]	3000	0.30
6	Heavy Metals (as Pb), maximum	10	0.001
7	Iron (Fe), maximum	50	0.005
8	Arsenic (As), maximum	5	0.0005
9	Fluoride (F), maximum	50	0.005

Notes:

1. When assayed after drying at 120°C ± 5°C for 2-hours and 800°C ± 25°C for 30 minutes.
2. When co-crystallized in the presence of excess sodium hydroxide to obtain the dodecahydrate form.
3. When co-crystallized in the presence of sodium sulfate to obtain free-flowing non-caking properties.

Additional Information:

1. As a hydrate, CAS# 10101-89-0 is exempt from Toxic Substance Control Act (TSCA) inventory requirements.
2. Appearance: odorless white granules.
3. Molar Weight: 380.12 g/mole.
4. CAS# 10101-89-0 loses water of hydration (as vapor) in air.
5. One percent equals 10,000 ppm.