

ArevaEPRDCPEm Resource

From: WILLIFORD Dennis (AREVA) [Dennis.Williford@areva.com]
Sent: Tuesday, December 13, 2011 4:11 PM
To: Tesfaye, Getachew
Cc: BENNETT Kathy (AREVA); DELANO Karen (AREVA); ROMINE Judy (AREVA); RYAN Tom (AREVA); GUCWA Len (EXTERNAL AREVA)
Subject: Response to U.S. EPR Design Certification Application RAI No. 363, FSARCh. 6, Supplement 6
Attachments: RAI 363 Supplement 6 Response US EPR DC.pdf

Getachew,

AREVA NP Inc. (AREVA NP) provided a schedule for responding to the 2 questions in RAI 363 on March 16, 2010, and revised the schedule in Supplement 1 on April 22 and in Supplement 2 on May 20, 2010. AREVA NP submitted Supplement 3 response to RAI 363 on June 2, 2010 to provide a response to the 2 questions. Supplement 4 response to RAI 363 was submitted on March 31, 2011 to provide a revised response to Question 06.02.02-43. Supplement 5 response to RAI 363 was submitted on November 8, 2011 to revise the responses to Question 06.02.02-43 and Question 06.02.02-44.

The attached file, "RAI 363 Supplement 6 Response US EPR DC.pdf," provides a revised response to Question 06.02.02-43. This response supersedes prior responses to Question 06.02.02-43 in its entirety. Because of the number of prior revisions, the response to this question is being provided with change bars in the margin to indicate changes made since the original response provided in RAI 363, Supplement 3.

The following table indicates the respective pages in the response document, "RAI 363 Supplement 6 Response US EPR DC.pdf," that contain AREVA NP's response to the subject question.

Question #	Start Page	End Page
RAI 363 — 06.02.02-43	2	14

This concludes the formal AREVA NP response to RAI No. 363, and there are no questions from this RAI for which AREVA NP has not provided responses.

Sincerely,

Dennis Williford, P.E.
U.S. EPR Design Certification Licensing Manager
AREVA NP Inc.
7207 IBM Drive, Mail Code CLT 2B
Charlotte, NC 28262
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Email: Dennis.Williford@areva.com

From: WILLIFORD Dennis (RS/NB)
Sent: Tuesday, November 08, 2011 8:05 AM
To: Getachew.Tesfaye@nrc.gov
Cc: BENNETT Kathy (RS/NB); DELANO Karen (RS/NB); ROMINE Judy (RS/NB); RYAN Tom (RS/NB); GUCWA Len (External RS/NB)
Subject: Response to U.S. EPR Design Certification Application RAI No. 363, FSARCh. 6, Supplement 5

Getachew,

AREVA NP Inc. (AREVA NP) provided a schedule for responding to the 2 questions in RAI 363 on March 16, 2010, and revised the schedule in Supplement 1 on April 22 and in Supplement 2 on May 20, 2010. AREVA NP submitted Supplement 3 response to RAI 363 on June 2, 2010 to provide a response to the 2 questions. Supplement 4 response to RAI 363 was submitted on March 31, 2011 to provide a revised response to Question 06.02.02-43.

The attached file, "RAI 363 Supplement 5 Response US EPR DC.pdf," supersedes portions of prior responses to Question 06.02.02-43 and Question 06.02.02-44 provided in the Supplement 3 and Supplement 4 submittals provided on June 2, 2010 and March 31, 2011, respectively.

The following table indicates the respective pages in the response document, "RAI 363 Supplement 5 Response US EPR DC.pdf," that contain AREVA NP's response to the subject questions.

Question #	Start Page	End Page
RAI 363 — 06.02.02-43	2	6
RAI 363 — 06.02.02-44	7	7

This concludes the formal AREVA NP response to RAI No. 363, and there are no questions from this RAI for which AREVA NP has not provided responses.

Sincerely,

Dennis Williford, P.E.
U.S. EPR Design Certification Licensing Manager
AREVA NP Inc.

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From: WELLS Russell (RS/NB)
Sent: Thursday, March 31, 2011 5:20 PM
To: Tesfaye, Getachew
Cc: GUCWA Len (External RS/NB); BENNETT Kathy (RS/NB); DELANO Karen (RS/NB); ROMINE Judy (RS/NB); RYAN Tom (RS/NB)
Subject: Response to U.S. EPR Design Certification Application RAI No. 363, FSARCh. 6, Supplement 4

Getachew,

AREVA NP Inc. (AREVA NP) provided a schedule for responding to the 2 questions in RAI 363 on March 16, 2010, and revised the schedule on April 22 and May 20, 2010. AREVA NP submitted Supplement 3 to the response on June 2, 2010 to provide a response to the 2 questions.

The attached file, "RAI 363 Supplement 4 Response US EPR DC.pdf" provides a technically correct and complete revised response to items 4, 5, 12, 14, and 21c of Question 06.02.02-43.

The following table indicates the respective pages in the response document, "RAI 363 Supplement 4 Response US EPR DC.pdf," that contain AREVA NP's response to the subject questions.

Question #	Start Page	End Page
RAI 363 — 06.02.02-43 (items 4, 5, 12, 14, and 21c)	2	6

This concludes the formal AREVA NP response to RAI 363, and there are no questions from this RAI for which AREVA NP has not provided responses.

Sincerely,

Russ Wells
U.S. EPR Design Certification Licensing Manager
AREVA NP, Inc.
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From: BRYAN Martin (EXT)
Sent: Wednesday, June 02, 2010 2:32 PM
To: Tesfaye, Getachew
Cc: DELANO Karen V (AREVA NP INC); ROMINE Judy (AREVA NP INC); BENNETT Kathy A (OFR) (AREVA NP INC); GUCWA Len T (EXT)
Subject: Response to U.S. EPR Design Certification Application RAI No. 363, FSARCh. 6, Supplement 3

Getachew,

AREVA NP Inc. (AREVA NP) provided a schedule for responding to the 2 questions in RAI 363 on March 16, 2010, and revised the schedule on April 22 and May 20, 2010. The attached file, "RAI 363 Supplement 3 Response US EPR DC.pdf," provides a technically correct and complete response to the 2 remaining questions.

The following table indicates the pages in the response document, "RAI 363 Supplement 3 Response US EPR DC.pdf," that contain AREVA NP's response to the subject questions.

Question #	Start Page	End Page
RAI 363 — 06.02.02-43	2	15
RAI 363 — 06.02.02-44	16	17

This concludes the formal AREVA NP response to RAI 363, and there are no questions from this RAI for which AREVA NP has not provided responses.

Sincerely,

Martin (Marty) C. Bryan
U.S. EPR Design Certification Licensing Manager
AREVA NP Inc.
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Martin.Bryan.ext@areva.com

From: BRYAN Martin (EXT)
Sent: Thursday, May 20, 2010 4:17 PM
To: 'Tesfaye, Getachew'
Cc: KOWALSKI David J (AREVA NP INC); BENNETT Kathy A (OFR) (AREVA NP INC); ROMINE Judy (AREVA NP INC);

GUCWA Len T (EXT)

Subject: Response to U.S. EPR Design Certification Application RAI No. 363, FSARCh. 6, Supplement 2

Getachew,

AREVA NP Inc. (AREVA NP) provided a schedule for responding to the 2 questions in RAI 363 on March 16, 2010, and revised the schedule on April 22, 2010.

The responses to RAI 363 are dependent upon other ongoing GSI-191 evaluations for demonstrating sump strainer performance. Because of these ongoing activities, AREVA NP is postponing the response to RAI 363 by two weeks. This delay has been discussed with and accepted by the NRC staff. The revised schedule for a technically correct and complete response to RAI 363 is provided below.

Question #	Response Date
RAI 363 — 06.02.02-43	June 2, 2010
RAI 363 — 06.02.02-44	June 2, 2010

Sincerely,

Martin (Marty) C. Bryan
U.S. EPR Design Certification Licensing Manager
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From: BRYAN Martin (EXT)
Sent: Thursday, April 22, 2010 6:20 PM
To: 'Getachew.Tesfaye@nrc.gov'
Cc: DELANO Karen V (AREVA NP INC); ROMINE Judy (AREVA NP INC); BENNETT Kathy A (OFR) (AREVA NP INC); GUCWA Len T (EXT)
Subject: Response to U.S. EPR Design Certification Application RAI No. 363, FSARCh. 6, Supplement 1

Getachew,

AREVA NP Inc. (AREVA NP) provided a schedule for responding to the 2 questions in RAI 363 on March 16, 2010. The responses to RAI 363 are dependent upon the results of ongoing GSI-191 evaluations for demonstrating sump strainer performance. Because of these ongoing activities, AREVA NP is not providing a response at this time. The revised schedule for a technically correct and complete response to RAI 363 is provided below.

Question #	Response Date
RAI 363 — 06.02.02-43	May 20, 2010
RAI 363 — 06.02.02-44	May 20, 2010

Sincerely,

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From: BRYAN Martin (EXT)
Sent: Tuesday, March 16, 2010 2:32 PM
To: 'Tesfaye, Getachew'
Cc: DELANO Karen V (AREVA NP INC); ROMINE Judy (AREVA NP INC); BENNETT Kathy A (OFR) (AREVA NP INC); GUCWA Len T (EXT)
Subject: Response to U.S. EPR Design Certification Application RAI No. 363, FSARCh. 6

Getachew,

Attached please find AREVA NP Inc.'s response to the subject request for additional information (RAI). The attached file, "RAI 363 Response US EPR DC.pdf" provides a schedule since a technically correct and complete response to the 2 questions is not provided.

The following table indicates the respective pages in the response document, "RAI 363 Response US EPR DC.pdf," that contain AREVA NP's response to the subject questions.

Question #	Start Page	End Page
RAI 363 — 06.02.02-43	2	3
RAI 363 — 06.02.02-44	4	4

A complete answer is not provided for the 2 questions. The schedule for a technically correct and complete response to this question is provided below.

Question #	Response Date
RAI 363 — 06.02.02-43	April 22, 2010
RAI 363 — 06.02.02-44	April 22, 2010

Sincerely,

Martin (Marty) C. Bryan
Licensing Advisory Engineer
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From: Tesfaye, Getachew [<mailto:Getachew.Tesfaye@nrc.gov>]
Sent: Tuesday, February 16, 2010 4:43 PM
To: ZZ-DL-A-USEPR-DL
Cc: Ashley, Clinton; Jackson, Christopher; Snodderly, Michael; Carneal, Jason; Colaccino, Joseph; ArevaEPRDCPEm Resource
Subject: U.S. EPR Design Certification Application RAI No. 363 (4136), FSARCh. 6

Attached please find the subject requests for additional information (RAI). A draft of the RAI was provided to you on January 26, 2010, 2009, and on February 15, 2010, you informed us that the RAI is clear and no further clarification is needed. As a result, no change is made to the draft RAI. The schedule we have established for review of your application assumes technically correct and complete responses within 30 days of receipt of RAIs. For any RAIs that cannot be answered within 30 days, it is expected that a date for receipt of this

information will be provided to the staff within the 30 day period so that the staff can assess how this information will impact the published schedule.

Thanks,
Getachew Tesfaye
Sr. Project Manager
NRO/DNRL/NARP
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Hearing Identifier: AREVA_EPR_DC_RAIs
Email Number: 3619

Mail Envelope Properties (2FBE1051AEB2E748A0F98DF9EEE5A5D4A02946)

Subject: Response to U.S. EPR Design Certification Application RAI No. 363, FSARCh. 6, Supplement 6
Sent Date: 12/13/2011 4:11:29 PM
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Response to

Request for Additional Information No. 363, Supplement 6

2/16/2010

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 and 6.3

**QUESTIONS for Containment and Ventilation Branch 1 (AP1000/EPR Projects)
(SPCV)**

Question 06.02.02-43:

This request for additional information is based primarily on an audit conducted on AREVA document 51-9125267-000, Revision 0, "US EPR STRAINER TEST PROTOCOL", dated October 26, 2009.

Describe how testing of the US EPR containment sump debris interceptors (weirs, trash racks, retaining basket (RB), and strainer) is prototypical or conservative (bounding) in comparison to the plant. The following list provides examples where additional information is requested:

1. Describe the scaling methodology and explain how it ensures prototypical or bounding test data.
 - a. What similarities between test and plant conditions are preserved?
 - b. Identify any assumptions in the scaling analysis and evaluate the impact on debris interceptor performance, particularly suction strainer head loss.
2. Identify important control parameters which must be considered in the design and operation of the test facility and explain the effects of the test facility design and operation on these important parameters.
3. Discuss how AREVA's approach to the number of tests conducted will provide results that are bounding.
4. Provide the basis for the water fall height in the test and how this height is prototypical or conservative in comparison to the plant.
5. Describe the potential for the cross brace support located at the entrance to the plants RB and extending above the basket wall to cause debris laden water to splash outside the basket (bypassing basket filtering) and how this bypass potential is accounted for in the test protocol.
6. Describe how delivering water flow to the RB during the test (pipe nozzles) is prototypical or conservative with respect to the plant arrangement (trapezoidal opening). Explain how the manner in which flow is delivered to the RB impacts the ability of the debris bed to form prototypically or conservatively inside the RB.
7. What is the basis for placing the RB bottom at the same elevation as the strainer bottom and how is this prototypical or conservative?
8. Describe the RB scaling approach. Explain how the tested RB surface area and tested RB volume are prototypical or conservative when compared to the plant.
 - a. What is the basis for selecting the RB screened area on one side only (facing strainer) and having the other normally screened surfaces tested as solid surfaces? How is this arrangement prototypical or conservative?
9. How do the hydraulic conditions internal to the tested RB compare with the plant design RB hydraulic conditions?
10. What measurements are planned specific to the RB?
11. How is the RB small compartment (only receives flow from the annular floor wall opening) and its postulated debris source term bounded by the testing for the large compartment?

12. Describe how the flow rate to the retaining basket is determined.
13. How are drains that introduce debris between RB and strainer (example: refueling pool) accounted for in the test protocol?
14. The strainer flow rate listed in the test protocol and selected for scaling analysis is a certain value per strainer. ANP-10293 lists strainer flow at a different value. What is the correct flow rate through the plant strainer and what is the basis for this flow rate? In addition describe how all scaled flow values selected for testing are prototypical or conservative.
15. Describe how the flow conditions (velocities and turbulence levels) in the test flume region between the RB and strainer are prototypical or conservative in comparison to the plant.
16. What is the basis for the visual observation criteria that may be used to decide if a thin bed test will be conducted?
17. Justify chemical introduction location and why it is representative or conservative.
18. How is the tested strainers slope/angle for the nearly vertical face representative or conservative with respect to the plant design?
19. Describe how the selected test termination criteria are realistic or conservative.
20. Provide a simplified drawing (single line) depicting the debris interceptors test set-up.
21. Provide the following test and plant parameters, and scaling justification for each, as applicable.
 - a) Screen mesh size for RB and strainer
 - b) Distance between strainer and RB
 - c) Debris source term amounts for testing
 - d) Test termination – number of flume turnovers

Response to Question 06.02.02-43:

This response supersedes the prior responses to RAI 363, Question 06.02.02-43 in their entirety. Changes made to the original response provided in Supplement 3 are indicated by change bars in the margin.

1. The development approach taken for the test facility scaling was to conservatively represent plant conditions with respect to the propensity to develop head-loss in the strainer. The general approach represented the vertical dimensions of the in-containment refueling water storage tank (IRWST) at full scale to minimize differences between plant and test facility design. Test protocol and facility design are based on the following conservative assumptions:
 - One hundred percent of design basis debris load is introduced into one retaining basket (RB).
 - One hundred percent of the flow is introduced into one RB. This represents a bounding scenario for the test apparatus RB and strainer.

Items in the U.S. EPR test apparatus that require scaling are the strainer, RB, flow, and design basis debris source term. The U.S. EPR strainer is shaped like an upside down trapezoidal prism (see Figure 06.02.02-43-1). Modeling one side (see 06.02.02-43, Face B) and a portion of the top (see Figure 06.02.02-43-1, Side A) of the strainer conservatively allows the test strainer to be aligned perpendicular to the flow, which maximizes the ability for debris to form a bed on the strainer. The slope angle of the slanted face of the test facility strainer is identical to the strainer designed for plant operation. A 0.75 foot portion on the bottom of the strainer is comprised of a skirt and support feet. This bottom portion has only limited active screen area and is not credited as strainer screen area in the scaling process. The skirt is not replicated in the test facility strainer.

The minimum water level required for safety injection system (SIS) operation is approximately 10 feet. To maintain the prototypical strainer submergence, the test apparatus utilizes a water level of 9.25 feet to account for the 0.75 feet skirt not represented in the test facility. Dimension A (see Figure 06.02.02-43-1) is determined by the requirement to model the sump suction with respect to the strainer faces conservatively.

Figure 06.02.02-43-2 shows the layout of the strainer supports with respect to the sump cover (intake path for flow to the safety injection pump) for a strainer in the IRWST. To conservatively represent the flow within the strainer, the test facility represents the strainer face with the minimum clearance from the sump cover to the face of the strainer. Figure 06.02.02-43-1, Dimension A is determined by matching the distance from the strainer face directly to the leading edge of the sump cover. The sump cover size is scaled by flow area to the flow rate of the test flume.

The strainer width (not depicted in Figure 06.02.02-43-1) is determined by the physical size of the onsite test facility flume (5 feet width). The screened area of the modeled strainer in the test facility was determined by calculating the surface area using the test strainer's slanted screen height (7.5 feet), length (6.62 feet), and width (5 feet). Dividing the test flume strainer surface by the actual minimum strainer surface area for the U.S. EPR design yields a scale factor of 9.37 percent. Scaling the strainer as a single face perpendicular to the flow is conservative to the plant design and will provide a maximum head loss with respect to the U.S. EPR strainer.

The U.S. EPR design utilizes single and double RB designs in the IRWST. The double RB is separated into a front and back basket. The back basket is designed to capture debris-laden water that may have entered the IRWST from the annular area of containment. The front portion of the double basket is located directly under a heavy floor opening. The screened surface area of the front basket of the double RB design at full height contains less screened surface area than the single basket design. It is conservative to model the front portion of the double RB design in the test apparatus. The screened area that was scaled for the test apparatus includes the front, left, right, and bottom faces of only the front portion of the double RB design. For conservatism, the screened divider between the front and back portions of the double RB was not included in the surface area.

Table 06.02.02-43-1 illustrates that the surface area and volume of the double RB maintain the scaling factor of 9.37 percent. The double RB is housed on pedestals 0.66 feet above the IRWST floor. The bottom surface area of the RB is covered with the same meshed screen as the remainder of the RB. The test apparatus RB is raised above the test floor, screened, and scaled by 9.37 percent of the RB bottom. Subtracting the scaled bottom

portion of the RB from the scaled total surface area provides the scaled vertical portion of the test apparatus RB. The test apparatus maintains a one-to-one vertical scale, and the test RB height is approximately 16.5 feet above the test apparatus floor, which is identical to plant design. The test RB width is determined by dividing the RB vertical surface area by the vertical height in the test apparatus (this does not include the height of the pedestal). The test apparatus RB length (screened front face to back wall) is determined by dividing the scaled volume by the RB scaled height and width. This provides the RB with an equivalent flow per unit volume. The values for the double RB design and values for test apparatus design are summarized in Table 06.02.02-43-1.

Conservatively, the RB is modeled to be open on the side of the facility that is facing the strainer. This RB arrangement allows debris to propagate preferentially from the RB towards the strainer.

The distance between the modeled RB and strainer is designed to represent the shortest straight line distance in the IRWST. This conservatively limits the distance that debris may settle along the test apparatus floor. The distance between the RB and strainer in the test apparatus is 5 feet, which is approximately 2 feet less than the minimum distance measured between any edge of a RB and the top of the strainer base skirt in the U.S. EPR design.

The flow rate scale factor is calculated by matching the flow per unit area of strainer in the plant and test facility. The total active strainer flow rate consists of the flow supplied to the break and the pump mini-flow recirculation lines, which return flow directly back to the IRWST. A difference in flow rates in the plant exists between the retention basket flow and the strainer flow because of the mini-flow lines that circulate a small portion of water in the strainer back to the IRWST (not through the RB). The difference between these flows in the test flume is represented by the scaled mini-flow, which is taken from the strainer suction piping and returned back to the test flume IRWST. The scaled mini-flow is added to the test facility overall flow through two rectangular nozzles mounted on the floor of the test apparatus IRWST. These two nozzles face each other, issuing flow perpendicular to the overall bulk transport velocity between the retention basket and the strainer. The nozzles are designed to conservatively prevent debris settling between the RB and strainer. The nozzles are at least 20 inches away from any strainer's face to verify that the modeled mini-flow does not disturb any debris bed formation on the strainer face.

Flow from the test apparatus heavy floor is simulated through two nozzles mounted above the water surface of the retention basket. The height of the test apparatus nozzles above the water surface is approximately 8 feet. The vertical distance between the trash rack weir and the IRWST water surface in the plant is approximately 15.3 feet. To conservatively account for the momentum that could be gained from the approximately 7.3 feet fall ($15.3 - 8 \text{ feet} = 7.3 \text{ feet}$), the velocity of the water exiting the nozzles was increased by adjusting the nozzle outlet. The nozzles introduced flow towards the back of the RB to prevent disruption of debris bed formation on the RB's screened front face. The nozzle location results in conservative flow conditions within the RB.

The total debris source term is scaled by 9.37 percent. This permits the proper amount of debris per unit area of strainer. The debris amount conservatively assumes that 100 percent of the debris enters a single RB.

The test apparatus design and scaling methodology creates a conservative and bounding approach to the U.S. EPR strainer testing. Modeling the strainer and RB to face one another with minimal lateral separation distance conservatively promotes debris transport towards the strainer. Testing with 100 percent of the flow and 100 percent of the scaled design basis debris source term creates the a bounding scenario for the U.S. EPR strainer.

a. Preserved similarities between test and plant conditions:

The overall vertical scaling of the test apparatus and plant were preserved, with two exceptions. The first exception is that the strainer in the test apparatus does not have a skirt and pedestal prototypical to plant design, and it is 0.75 feet shorter than plant conditions. To address this exception, the test apparatus water level is 0.75 feet less than plant conditions to maintain a prototypical strainer submergence level. The second exception is that the height from the heavy floor to the RB water surface is approximately 7.3 feet less than plant conditions. The velocity of the water was increased to conservatively represent the correct momentum the water could achieve from the heavy floor to the IRWST water surface in the plant design.

The strainer and RBs were scaled variants of the design strainer and RB. The shape of the strainer prototypically models one sloped vertical face and a portion of the strainer top. The slope of the front face of the strainer was preserved. The RB prototypically represents one side of a RB, along with the scaled bottom surface area. Both the strainer and the RB are conservatively designed so that their respective faces point towards each other and are aligned with the flow. The test apparatus flow prototypically matches the flow per unit screen area for both the strainer and RB. The test apparatus flow includes the prototypical mini-flow. The screen mesh employed in testing matches that specified for the U.S. EPR strainer and RB designs.

b. Identification of assumptions in the scaling analysis and an evaluation of the impact on debris interceptor performance, particularly suction strainer head loss:

Two conservative and bounding assumptions were made regarding scaling. The first assumption is that 100 percent of the flow enters one RB. Though improbable, assuming 100 percent of the flow into one basket is conservative because it promotes high approach velocities in the test apparatus, preventing debris settling on the flume floor. The second assumption is that 100 percent of the total debris source term enters one RB. This is improbable but conservative to testing because there are more debris available to potentially develop a higher head loss across the strainer. The flow introduction into the RB is arranged so that possible non-conservative effects due to assigning 100 percent of the flow to one RB are eliminated.

2. Important factors in the test facility are the screen area, flow rate, and debris quantity. The base facility dimensions determine the amount of screen area available for modeling, which determines the scale factor and the flow rate. The scale factor determines the debris quantity used. For prototypical debris movement, the vertical dimensions must maintain a one-to-one scale and are replicated based on containment design. The water level, screen submergence, and RB height are relevant parameters.

Regarding control parameters during operation, both flow rate and water level are applicable parameters because the RB can withhold water and cause a non-prototypical screen submergence decrease in the test flume.

3. AREVA NP's approach to the number of tests conducted to provide bounding results is to test a conservative and bounding case using the maximum debris source term generated in the U.S. EPR containment. These tests include the introduction of the non-chemical and chemical debris, followed by a minimum of 15 flume turnovers (approximately 3.5 hours) after the addition of the debris as part of the termination criteria. Test termination is based on achieving a steady-state peak head loss, which is determined by experimental observations. Conservatively, AREVA NP assumes that 100 percent of the debris generated from a loss of coolant accident (LOCA) enters one of four RBs in the IRWST. AREVA NP conservatively assumes 100 percent of the flow through one retention basket to limit debris settling between the RB and strainer. These conservatisms produce a bounding result for the U.S. EPR strainer head loss tests.
4. The majority of the flow downstream of the strainer excluding the mini-line flow was reintroduced to the test flume with nozzles above the RB. This was accomplished to represent ECCS flow from the break location onto the heavy floor then into one of the four RBs through a heavy floor opening. The plant conditions provide ≈ 15.3 feet of water freefall prior to the water reaching the surface of the in-containment refueling water storage tank (IRWST). The test flume represents an adjusted one-to-one vertical scale of the U.S. EPR IRWST. To conserve the vertical scale in the test facility, the momentum produced by the water freefall must be conserved or simulated. The test facility ceiling limits the freefall of water to ≈ 8 feet. The velocity of the water exiting the nozzles above the flume RB is increased to represent the plant's actual water freefall conditions using Equation 1:

$$mgH = mgh + \frac{1}{2}mv^2$$

$$\therefore (32.174) * (15.3) = (32.174)(8) + \frac{1}{2}v^2$$

Equation 1: Conservation of Energy

$$v = 21.7 \text{ ft/sec}$$

Where:

m = Mass of water (lb_m).g = Gravity (32.174 ft/sec²).

H = Height from heavy floor to IRWST water surface (ft).

h = Flume height from heavy floor to IRWST water surface (ft).

v = Water velocity (ft/sec).

The test facility used two nozzles to simulate flow from the heavy floor onto the flume IRWST water surface. The diameter of each exit nozzle was 1.59 inches (0.133 feet). The exit velocity of the water is calculated using Equation 2. The area of one nozzle exit is calculated as the following:

$$\text{One Exit Area} = \pi * r^2 = \pi * 0.0665^2 = 0.0139 \text{ ft}^2$$

Because there are two exit nozzles, the total exit area is two times the calculated area, or 0.0278 ft². The flow through the nozzles in ft³/sec is shown as the following:

$$\text{Main Flow} = \frac{296.1 \text{ gallons}}{1 \text{ min}} * \frac{1 \text{ min}}{60 \text{ sec}} * \frac{1 \text{ ft}^3}{7.4805 \text{ gallons}} = 0.6597 \text{ ft}^3 / \text{sec}$$

The velocity of the test flume water exiting the nozzles is calculated by the flow in Equation 2:

$$\text{Velocity} = \frac{\text{Flow}}{\text{Area}} = \frac{0.6597 \text{ ft}^3 / \text{sec}}{0.0278 \text{ ft}^2} = 23.7 \text{ ft} / \text{sec} \quad \text{Equation 2: Flow}$$

The water velocity exiting the nozzles is greater than the 21.7 ft/sec velocity where water impacts the surface in the plant's IRWST design. The water freefall in the test apparatus is bounding to plant conditions.

5. The cross brace support forms an "X" shape on top of the double compartment RB. The width of one of the braces is approximately 3.6 inches. The perimeter of a trash rack that receives flow from a loss of coolant accident (LOCA) break on the heavy floor is approximately 291 inches. Assuming an equal distribution of flow around the trash rack (sides and front) into the IRWST, there are four areas where the flow may impact the cross brace. Dividing the width of the four brace impact areas by the trash rack perimeter equates to approximately five percent of the flow that may impact the brace. Of this flow, a high percentage would still be contained in the basket.

According to the test plan, approximately 10 percent (0.21 lbm) of the fibrous debris source term was added between the RB and the strainer. This conservatively bounds any fibrous debris that may hit the RB support beams and splash outside the basket.

6. The delivery of water into the test apparatus RB is conservative to plant conditions. In the plant, water is introduced to a RB through one of four heavy floor openings. The screened perimeter of the RB overlaps the heavy floor openings on the sides to capture debris laden water received from the heavy floor.

The test apparatus delivery system uses two nozzles to simulate flow from the heavy floor into the RB. The two nozzles are used to increase the velocity of the water to conservatively match the momentum gained during the freefall of water in the plant design. The nozzles are separated by 1 foot, and sit approximately 1 foot away from the sides of the RB providing a test apparatus RB overlap perimeter prototypical to plant conditions. Scaling 100 percent of the flow into one basket creates a conservative level of turbulence in the RB to keep debris suspended and transportable. Locating the nozzles toward the back of the RB introduces a large amount of energy into the RB volume while minimizing its influence on debris bed formation.

7. The RB bottom sits on top of a pedestal approximately 0.66 feet above the floor in the U.S. EPR IRWST. The test facility was redesigned in January 2010 to include the 0.66 foot RB pedestal prototypical to plant design conditions. The strainer skirt, which has a small amount of open area, is ignored in open screen calculations and not modeled in the test flume. The resulting relative elevation difference of the RB and strainer is conservative regarding debris settling because the screened portion of the strainer is closer to the floor.
8. Refer to Part 1 of this response for more information.

- a. The basis for and conservatism of selecting the RB screened area on one side only (facing strainer) and having the other normally screened surfaces tested as solid surfaces:

Conservatively, the RB is modeled to only be open on the side of the facility that is facing the strainer. This arrangement promotes debris transport from the RB towards the strainer. Between the RB and the strainer, the mini-flow lines are positioned to maintain a conservative level of turbulence to keep debris suspended between the RB and strainer surface. Modeling the sides of the RB may be prototypical, but not conservative for the following reasons:

- ◆ Modeling of three sides of the RB would reduce the width of each side to approximately 1 foot (this was determined by using the scaled RB total width (3.07') and dividing that number by three sides). The cross-sectional area of this narrow column would create scaling dilemmas concerning a prototypical scaled RB bottom surface area and scaled RB volume.
 - ◆ Modeling the RB to have three screened sides would create low flow areas on the sides of the basket that may facilitate non-conservative debris settling.
9. Momentum from the heavy floor is prototypically introduced using two nozzles placed towards the back of the RB. This nozzle placement allows the conservative amount of momentum added to the RB to keep debris suspended in the back area of the RB and make it available for transport to the RB screen. The arrangement chosen for the nozzles and RB basket result in hydraulic conditions, which cause conservative debris suspension without affecting prototypical debris bed formation on the RB screen.
 10. The RB water level difference with respect to the main flume level is measured during the entire test. The water level difference between the RB and the strainer area is referred to as the RB head-loss.
 11. The U.S. EPR design has been modified to re-direct water from draining to the annular area. The response to RAI 242, Supplement 3, Question 06.02.02-31 provides additional details.
 12. The total test apparatus flow rate is calculated by applying the same scaling factor (9.37 percent) to the flow designed for SIS operation (≈ 3447 gpm). The mini-flow, prototypical to plant conditions, routes a portion of strainer suction flow back into the IRWST, bypassing the RB. The plant mini-flow, ≈ 287 gpm, was scaled by 9.37 percent and applied to the test apparatus. Assuming that 100 percent of the heavy floor flow enters one RB, the flow allocated to the test apparatus RB was calculated by scaling the difference of the total flow minus the mini-flow.
 13. The cavity drain lines each consist of 6 inch piping that combine into a common 8 inch line, which drains into the IRWST between the RB and strainer. During the loss of coolant accident (LOCA) event, there is no system water flow in the cavity drain line. The U.S. EPR design does not rely on containment spray for the design basis accident. A limited amount of atmospheric condensation can enter the drain line. The upstream openings of the cavity drain line are remote from the LOCA debris source and do not contribute to debris transport to the IRWST. The cavity drain line is not considered a debris supply path to the IRWST water volume and is not accounted for in the test protocol. Refer to Technical Report ANP-10293P, Revision 4, Appendix A, Table A.1, Item 1.1.1.5.
 14. Technical Report ANP-10293P, Revision 4 reflects the strainer flow rate in the test protocol. The actual strainer flow rate is ≈ 3447 gpm. The strainer flow rate for head loss testing is

scaled to 9.37 percent of the actual strainer flow rate (≈ 323 gpm). The basis for the strainer flow rate is provided in Table 06.02.02-43-2. The scaled flow values selected for testing are prototypical because they are uniformly scaled down to 9.37 percent of the actual plant values as detailed in the U.S. EPR FSAR.

15. The flow conditions are conservative to plant conditions. The main turbulence source in the IRWST is the flow from the heavy floor, which is conservatively represented in the scaled test. Turbulence generated in the RB has prototypical paths available towards the strainer, either through the RB screen under normal conditions or down the overflow under over-topping conditions. The momentum and velocity between the RB and strainer are represented conservatively as the flow momentum is directed at the strainer and little room exists for diffusion. Effort is made to avoid strong jetting toward the strainer to prevent non-conservative interaction between the RB and strainer. The flume is constructed to provide an orderly transition for the flow between the RB and the strainer.
16. The visual observation criterion for determining whether thin bed testing would be conducted was based on observing clean strainer surface area. Because of visibility difficulties caused by the introduction of debris during testing, this criterion was not used to determine if a thin bed test would be conducted.
17. In the U.S. EPR containment design, trisodium phosphate (TSP) baskets are located at each of the four heavy floor openings. It is a representative and logical location for the chemicals to first precipitate in the IRWST. This logic is applied in the test procedure with the introduction of chemical precipitant between the RB and strainer test modules.
18. The slope angle of the strainer's vertical face in the U.S. EPR design is approximately 20° . The test loop's screened vertical face measures to approximately 88.1 inches, and the overhang of the strainer in the test flume is approximately 30.5 inches. The slope of the vertical face in the test apparatus is approximately 20° . Because the test loop utilizes one-to-one vertical scaling of the U.S. EPR design, using the identical slope for the vertical face of the strainer is prototypical.
19. The U.S. EPR strainer head loss test plan provides conservative termination criteria for the strainer head loss test. The design basis head loss test includes adding 100 percent of the design basis debris load to the test apparatus. Test termination is based on satisfying the following criteria:
 - A minimum of 15 flume turnovers has occurred.
 - The change in head loss is less than 1 percent in the last 30 minute time interval.
 - The test is terminated by the test engineer based on experimental observations including stabilization of the RB change in head loss.

It is unrealistic to run the design basis head loss test for the entire post-LOCA mission time. Debris introduction occurs at a slow rate to allow debris to transport away from the debris introduction site to prevent agglomeration. First, the particulate is added to the test apparatus followed by the fibrous debris. Chemical injection takes place over a period of 12 hours to prevent non-prototypical over concentration of the chemical debris in the test apparatus. After chemical injection is complete, another waiting period of 15 flume turnovers (3.5 hours) is allotted to allow the differential pressure across the strainer to stabilize.

The data acquisition computer continually measures the differential pressure across the strainer and the RB. The test facility data acquisition computer calculates the average percent change in head loss over the previous 30 minutes time period for both the strainer and the RB. The average change in head loss across both the strainer and the RB will determine the stability of the debris bed on the strainer and the RB.

The average change in head loss across the RB may affect the strainer head loss. If the differential pressure across the RB is decreasing (not steady-state), then the debris on the RB may be eroding. The eroded debris from the basket may transport to the strainer, causing an increase in strainer head loss. The test engineer uses experimental observation to assess the stability of both the RB and strainer to determine the final test termination.

The same termination criterion for strainer performance testing has been utilized by AREVA NP while testing U.S. operating plants.

20. Simplified drawings depicting the debris interceptors test set-up are provided in Technical Report ANP-10293P, Revision 4, Appendix E, Figures E.3-1, E.3-2, E.3-3, and E.3-4.
21. The requested test and plant parameters and scaling justification for each are as follows:
 - a. Screen mesh size for RB and strainer:

The screen mesh for the RB and the strainer in the U.S. EPR plant design has an ≈ 0.08 inch aperture (i.e., opening between adjacent parallel wires) with ≈ 0.03 inch thick wire diameter. The test apparatus uses a wire mesh of the same dimensions.

- b. Distance between strainer and RB:

The distance between the modeled RB and strainer was chosen to represent the shortest straight line distance between the plant's strainer and RB. The lateral distance between the top of the strainer base skirt and RB in the test apparatus is approximately 5 feet, which is approximately 2 feet less than the minimum distance measured between any edge of a RB and the top of any strainer base skirt in the U.S. EPR design. This conservatively limits the lateral travel for the debris, limiting the potential for settling along the test apparatus floor.

- c. Debris source term amounts for testing:

Table 06.02.02-43-3 presents the debris source term amounts used for the U.S. EPR strainer testing accomplished from November 2010 to February 2011. With the exception of coating chips, these amounts are based on a U.S. EPR debris generation calculation and sump chemistry model calculation and then scaled by 9.37 percent to match apparatus scaling. Qualified epoxy coatings account for approximately 33 percent of the total amount of epoxy coatings generated in a postulated LOCA for the U.S. EPR design. The amount of qualified epoxy coatings were tested as particulate and chips for conservatism.

- d. Test termination – number of flume turnovers:

For information regarding the test termination/number of flume turnovers, refer to Part 19 of this response.

Table 06.02.02-43-1—Retaining Basket (RB) Scaling

Description	Value	Units
Scale	9.37 percent	percent
Total RB Surface Area	642.0	ft ²
Scaled RB Surface Area	60.2	ft ²
RB Floor Surface Area	120.4	ft ²
Scaled RB Floor Surface Area	11.3	ft ²
Plant Vertical RB Surface Area	521.6	ft ²
Test Apparatus Vertical Surface Area	48.9	ft ²
RB Vertical Height	16.6	ft
RB Pedestal Height	0.7	ft
RB Screened Vertical Height	15.9	ft
Test Apparatus RB Width	3.1	ft
Plant RB Volume	2024.0	ft ³
Scaled RB Volume	189.7	ft ³
Test Apparatus RB Length ¹	3.9	ft

Notes:

1. A retaining basket length of 3.7 feet is utilized in the test flume. This length creates the correct scaling for the surface area on the bottom of the test retaining basket and conservatively increases the flow per unit volume.

Table 06.02.02-43-2—Basis for the Strainer Flow Rate

U.S. EPR ECCS Flow (≈gpm)		9.37 Percent Scaled Flow for Strainer Head Loss Testing (≈gpm)
Flow to Reactor Coolant System (RCS) Cold Leg	3160	296
ECCS Pump Miniflow Bypass to IRWST	287	26.9
Total ECCS Flow to Strainer	3447	323

Table 06.02.02-43-3—Debris Totals for the Design Basis Strainer Head Loss Test

Scaled 9.37 Percent	Scaled Amount (lb_m)	Description / Surrogate
Reflective Metal Insulation (RMI)	0	Based on 0.0813 lb _m /ft ² for RMI
Microtherm®	1.55	N/A
NUKON® Fiber	2.2	All Shredded NUKON® Fines
Epoxy Coatings	35.60	Acrylic Powder
Epoxy Chips	12.00	≈5/8 inch chips (≈4 - 12 mils thick)
Inorganic Zinc (IOZ) Coatings	90.40	Tin Powder
Latent Dirt and Dust	12.20	Dirt and Dust Mix
Sodium Aluminum Silicate	15.91	Aluminum Oxyhydroxide
Calcium Phosphate	16.74	N/A

Figure 06.02.02-43-1—Strainer Profile Depicting Modeled Portion

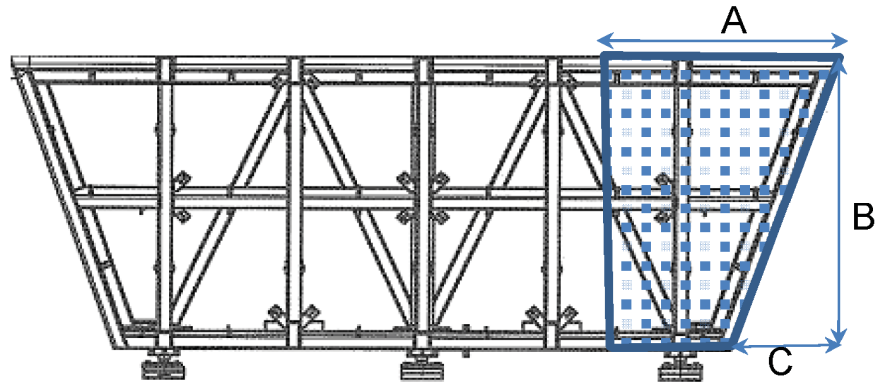
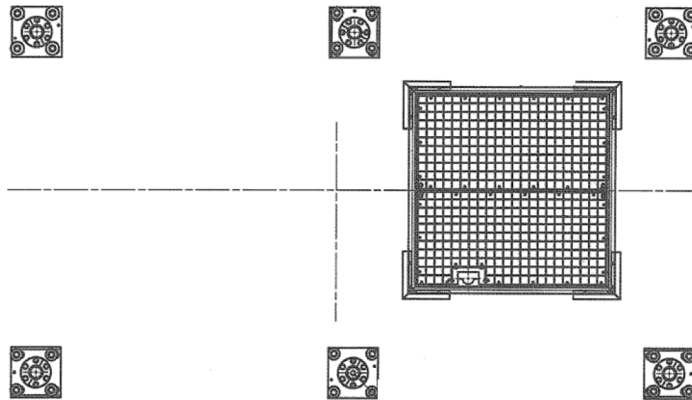


Figure 06.02.02-43-2—Over-head View of Strainer Support and Sump Cover



FSAR Impact:

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