ArevaEPRDCPEm Resource

From: BRYAN Martin (EXTERNAL AREVA) [Martin.Bryan.ext@areva.com]
Sent: Thursday, November 18, 2010 11:41 AM
To: Tesfaye, Getachew
Cc: DELANO Karen (AREVA); ROMINE Judy (AREVA); BENNETT Kathy (AREVA); GUCWA Len (EXTERNAL AREVA)
Subject: Response to U.S. EPR Design Certification Application RAI No. 428 , FSAR Ch. 15
Attachments: RAI 428 Response US EPR DC.pdf

Getachew,

Attached please find AREVA NP Inc.'s response to the subject request for additional information (RAI). The attached file, "RAI 428 Response US EPR DC.pdf," provides technically correct and complete responses to 3 of the 17 questions.

The following table indicates the respective pages in the response document, "RAI 428 Response US EPR DC.pdf," that contain AREVA NP's response to the subject questions.

Question #	Start Page	End Page
RAI 428 — 15.06.05-81	2	2
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A complete answer is not provided for 14 of the17 questions. The schedule for a technically correct and complete response to these questions is provided below.

Question #	Response Date
RAI 428 — 15.06.05-81	March 31, 2011
RAI 428 — 15.06.05-82	March 31, 2011
RAI 428 — 15.06.05-83	March 31, 2011
RAI 428 — 15.06.05-84	March 31, 2011
RAI 428 — 15.06.05-85	March 31, 2011
RAI 428 — 15.06.05-86	March 31, 2011
RAI 428 — 15.06.05-87	March 31, 2011
RAI 428 — 15.06.05-88	March 31, 2011
RAI 428 — 15.06.05-92	March 31, 2011
RAI 428 — 15.06.05-93	March 31, 2011
RAI 428 — 15.06.05-94	March 31, 2011

RAI 428 — 15.06.05-95	March 31, 2011
RAI 428 — 15.06.05-96	March 31, 2011
RAI 428 — 15.06.05-97	March 31, 2011

Sincerely,

Martin (Marty) C. Bryan
U.S. EPR Design Certification Licensing Manager
AREVA NP Inc.
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From: Tesfaye, Getachew [mailto:Getachew.Tesfaye@nrc.gov]
Sent: Wednesday, October 20, 2010 10:00 AM
To: ZZ-DL-A-USEPR-DL
Cc: Forsaty, Fred; Lu, Shanlai; Thomas, George; Donoghue, Joseph; Carneal, Jason; Colaccino, Joseph; ArevaEPRDCPEm Resource
Subject: U.S. EPR Design Certification Application RAI No. 428 (4299), FSARCh. 15

Attached please find the subject requests for additional information (RAI). A draft of the RAI was provided to you on July 21, 2010, and discussed with your staff on September 13, 2010. Draft RAI Questions 15.06.05-78, 15.06.05-79, 15.06.05-80 were deleted, and Draft RAI Questions 15.06.05-86, 15.06.05-87, 15.06.05-88, 15.06.05-94 were modified as a result of that discussion. 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
(301) 415-3361

Hearing Identifier: AREVA_EPR_DC_RAIs
Email Number: 2276

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From: BRYAN Martin (EXTERNAL AREVA)

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Response to

Request for Additional Information No. 428(4922), Revision 0

10/20/2010

U. S. EPR Standard Design Certification
AREVA NP Inc.
Docket No. 52-020
SRP Section: 15.06.05 - Loss of Coolant Accidents Resulting From Spectrum of Postulated Piping Breaks Within the Reactor Coolant Pressure Boundary
Application Section: Downstream

QUESTIONS for Reactor System, Nuclear Performance and Code Review (SRSB)

Question 15.06.05-81:

The ΔP acceptance criteria for fuel assembly flow blockage for the U.S. EPR design have been determined for several different classes of LOCA conditions based on break location and ECCS injection performance. For each ΔP acceptance criterion established, list the assumptions used to derive the available driving head. In particular, identify the assumptions related to the following aspects.

(1) Two-phase fluid conditions and properties including void fraction distribution in the core region and other participating regions that contain two-phase coolant mixture as participating and accounted for in the driving head balance analyses.

(2) Single phase liquid coolant conditions and properties including temperature profile in regions occupied by liquid coolant only as participating and accounted for in the driving head balance analyses.

(3) Availability, geometry, and flow resistance coefficients associated with each steam flow path available for steam venting from the upper plenum region and as considered for in the pressure balance across the reactor coolant system.

(4) Containment backpressure conditions and related assumptions taking into account post-LOCA containment pressurization.

(5) ECCS flow performance and availability as affected by containment post-LOCA conditions and other related factors and assumptions.

Identify any analytical tools and software codes applied to determine the applicable ΔP acceptance criteria.

Response to Question 15.06.05-81:

A response to this question will be provided by March 31, 2011.

Question 15.06.05-82:

Explain how the analyses, performed to determine ΔP acceptance criteria for U.S. EPR, take into account variation in time of thermal-hydraulic conditions in the primary reactor coolant system and in the reactor containment. With regard to the containment thermal-hydraulic response, address effects associated with limiting LOCA conditions associated with most restrictive ΔP acceptance criteria.

Response to Question 15.06.05-82:

A response to this question will be provided by March 31, 2011.

Question 15.06.05-83:

Explain how the analyses, performed to determine ΔP acceptance criteria for U.S. EPR, take into account effects associated with certain thermal-hydraulic phenomena that can take place in the primary reactor coolant system in the post-LOCA period. Such phenomena can have a major impact on the assumptions and pressure balance equations used in ΔP acceptance criteria derivation analyses. Specifically, address the following the thermal-hydraulic phenomena identified below.

(1) Reactor downcomer boiling.

(2) Loop seal reformation in individual primary coolant loops.

(3) Partial loop seal liquid blockage in individual primary coolant loops

(4) Non-uniform flow and void distribution in the core region.

(5) Boric acid accumulation in the reactor core region.

Response to Question 15.06.05-83:

A response to this question will be provided by March 31, 2011.

Question 15.06.05-84:

U.S. EPR RAI 241 Question 15.06.05-51 addresses the reactor two-phase mixture level response during long term cooling. RAI 241 Question 15.06.05-52 considers the core region thermal-hydraulic conditions for the boric acid precipitation analysis. Explain how the core region thermal-hydraulic assumptions and conditions, as applied in the ΔP acceptance criteria analyses for core blockage evaluation, compare to assumptions and conditions considered in RAI 251 Question 15.06.05-51 and in RAI 251 Question 15.06.05-52. Explain and quantify any significant differences related to the same class of LOCA conditions.

Response to Question 15.06.05-84:

A response to this question will be provided by March 31, 2011.

Question 15.06.05-85:

Provide evidence that introducing the fiber load in larger batches rather than in a series of smaller batches during fuel assembly blockage testing produces results that are representative of the physical process of gradual debris accumulation. For this purpose, comparative results produced with incremental fibrous debris load introduction in smaller amounts, such as 2 gram fiber per batch or less, can be used.

Response to Question 15.06.05-85:

A response to this question will be provided by March 31, 2011.

Question 15.06.05-86:

The approach currently applied in assessing downstream effects on U.S. EPR core cooling employs fuel assembly blockage testing for determining fuel head loss and separate sump screen bypass testing for assessing the downstream fiber load. Whereas similar fiber surrogate material is used in both types of testing, in reality length distribution of downstream fiber can differ significantly from that of source fibrous debris upstream of the retaining basket as a result of retention and bypass processes caused by the retaining basket and the sump strainer.

Explain how the fiber length distribution of fibrous source material used in strainer bypass testing for the U.S. EPR can impact the strainer bypass test results. Demonstrate the appropriateness and applicability of sump strainer bypass test results obtained with fibrous surrogate material of certain length distribution characteristics for the purpose of investigating downstream effects on core cooling resulting from fuel assembly blockage. In particular, consider any possible interdependency between fiber length distribution of source fiber material used in sump strainer bypass testing, fiber length distribution of fiber material used in downstream fuel assembly blockage testing, and sump strainer bypass ratio

Response to Question 15.06.05-86:

A response to this question will be provided by March 31, 2011.

Question 15.06.05-87:

The applicant presented an experimentally derived curve based on existing data from fuel assembly blockage testing. The curve gives a relationship between the observed fuel assembly head loss and the particulates-to-fiber mass ratio in tests performed with a varying amount of particulates and a constant fiber mass load. The curve shows a maximum in the measured head loss at a certain particulates-to-fiber mass ratio. For mass ratios larger or smaller than this observed critical value, the curve predicts a smaller head loss for the specific fiber load considered.

If such a curve is used to determine particulates-to-fiber mass ratios for U.S. EPR fuel assembly blockage testing, present data that support the applicability of such a relationship to the U.S. EPR fuel assembly design. Describe the conditions and assumptions used in obtaining and qualifying the applied test data. Comment on data accuracy, repeatability, and applicability to U.S. EPR prototypical core conditions. Identify and explain key participating and competing mechanisms that cause such a maximum in the observed head loss. Discuss effects related to and appropriateness of values applied for the total fiber mass load, batch size of fiber addition, and coolant mass flow rate on the established head loss versus particulates-to-fiber mass ratio dependency as applicable to the U.S. EPR design.

Response to Question 15.06.05-87:

A response to this question will be provided by March 31, 2011.

Question 15.06.05-88:

With regard to U.S. EPR fuel assembly blockage testing, address effects associated with length distribution of surrogate fiber material on test results obtained under limiting conditions for determining the maximum applicable ΔP. In addition, consider such effects on test data used in establishing the limiting ΔP versus particulates-to-fiber mass ratio. Demonstrate the conservatism associated with using fibrous surrogate material of certain length distribution characteristics in evaluating the U.S. EPR downstream effects on core cooling.

Response to Question 15.06.05-88:

A response to this question will be provided by March 31, 2011.

Question 15.06.05-89:

Explain how the strainer bypass testing accounts for effects associated with possible debris basket overflow leading to an increased amount of debris available to reach the strainer surface. In particular, describe testing protocols related to identifying the spillage fiber fraction for partial load (such as ¼ load) or full load.

Response to Question 15.06.05-89:

AREVA NP Test Plan document "US EPR Strainer Performance Test Plan," which is available for NRC review, documents the fiber-only bypass test protocols and the effects associated with possible debris basket overflow leading to an increased amount of fiber available to reach the strainer. In particular, Attachment 13 and Attachment 14 of this document detail two fiber bypass tests methodologies used during testing. The results of the two bypass methodologies are utilized to determine which test method results in the worst case bypass condition. The methodologies of the two tests are:

<u>Bypass Methodology 1:</u>

Test 3B (Attachment 13 of AREVA NP Test Plan) provides the protocol to determine if a greater bypass fraction is possible with less fiber added to the retaining basket and strainer, since larger fiber loads may create a filtering bed. The test measures fiber bypass with only approximately 23 percent (partial load) of the total fiber added to the retaining basket assuming that approximately 23 percent of the debris enters one of the four retaining baskets (approximately two percent is inserted downstream of the retaining basket). The quantity of fiber introduced downstream of the retaining basket is dependent upon the amount of fiber that created an overflow condition for the retaining basket in the thin bed test, Test 4A (Attachment 11). If the retaining basket overflows with less than approximately 23 percent of the total fiber added to the retaining basket, then the portion of fiber that created the overflow condition and the remaining fiber up to the approximately 23 percent fiber load is introduced downstream of the retaining basket for Test 3B. Attachment 13 utilizes inputs from thin bed testing as required by Note 3 of Step 13.8 in the test plan. Note 3 of Step 13.8 states:

> Note 3: Results from the Thin Bed Tests (Test 4A) may influence the location of debris addition. If during Test 4A the retaining basket reaches an overflow condition before 1.25 lbm of fiber has been added to the retaining basket, then the difference between the 1.25 lbm of fiber and the portion of fiber that was added to the retaining basket prior to overflow will be added between the retaining basket and the strainer.

The test protocol in Attachment 13 determines the partial load bypass for approximately 23 percent (two percent added between retaining basket and strainer) of total fiber addition. The process is repeated for the remaining 75 percent of debris and bypass is determined after each 25 percent addition to ensure the limiting bypass case for partial debris load bypass.

<u>Bypass Methodology 2:</u>

Test 3C of Attachment 14 provides the protocol for the full load bypass condition. This test also utilizes inputs from thin bed testing. Note 2 of Step 14.8 in the test plan in the AREVA NP Test Plan document states:

Results from the Thin Bed Tests (Test 4A) may influence the location of debris addition. If during Test 4A the retaining basket reaches an overflow condition while adding fiber to the retaining basket, then that mass of fiber that created the overflow condition, along with the subsequent fiber added after the overflow, will be added to the this test flume between the retaining basket and the strainer. The fiber added to the retaining basket that caused the water level to rise during Test 4A will still be added to the retaining basket for Test 3C.

This step conservatively accounts for the spillage fiber fraction for the full load. During the thin bed test, pre-weighed incremental batch additions are slowly added to the retaining basket. The batch of fiber that creates an overflow condition, plus the fiber that has not yet been added to the retaining basket will be added between the retaining basket and strainer during the Test 3C in Attachment 14. Bypass percentage for the test in Attachment 14 will be determined by the full load (100 percent of total fiber addition). Method 2 will determine if the arrival of 100 percent of the debris load at one strainer results in a more limiting bypass rate than the incremental arrival utilized in method 1.

FSAR Impact:

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

Question 15.06.05-90:

Explain how the strainer bypass testing approach accounts for the most limiting conditions with regard to the number of ECCS trains assumed in operation and the associated uniform or other probable ways of debris distribution among participating strainers.

Response to Question 15.06.05-90:

The U.S. EPR test apparatus conservatively assumes only one of four emergency core cooling system (ECCS) trains are operable and that 100 percent of the debris source term generated by a postulated design basis accident (DBA) challenges the one operating train. It is conservative to use 100 percent of the debris source term for design basis head loss testing. This, however, may not be conservative when testing the amount of fiber bypass. The Fiber Bypass Test measures the mass of fiber that bypasses the retaining basket-strainer combination in relation to the mass of fiber introduced into the test apparatus. Dividing the mass of fiber that bypasses the strainer by the mass of fiber inserted in the test apparatus provides a fiber bypass fraction.

Inserting 100 percent of the design basis fiber into one retaining basket may not be conservative because it may produce a non-prototypical amount of fiber filtering on the retaining basket and strainer surface area. Utilizing the 100 percent fiber debris load on one ECCS train increases the chances that a filtering fiber bed will form on the retaining basket, reducing bypass.

To reduce the chance of a filtering fiber bed on the basket the AREVA ECCS Test Plan, which is available for NRC review, was revised to test bypass with a more conservative method. The revised method is to first introduce only 25 percent of the design basis fiber load to the test apparatus. This assumes that all four trains receive an equal distribution of fiber. This fiber loading is prototypical since approximately 70 percent of the fiber generated from a postulated DBA is latent fiber debris that is assumed to be equally distributed throughout containment prior to any accident. The bypass percentage is determined after 25 percent of the fiber is added to the test apparatus (25 percent of the 100 percent design basis portion). To ensure the most limiting bypass percentage is determined, additional fiber will be incrementally introduced until 100 percent of the debris basis fiber load is added to the test apparatus. The fiber bypass rates will be measured after each 25 percent addition of fiber during Test 3B, such as bypass rates for 25 percent, 50 percent, 75 percent and 100 percent of design basis fiber.

FSAR Impact:

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

Question 15.06.05-91:

Explain how the fiber length distribution of fibrous source material used in strainer bypass testing for the U.S. EPR can impact the strainer bypass test results. Demonstrate the appropriateness and applicability of strainer bypass test results obtained with fibrous material of certain length distribution characteristics for the purpose of investigating downstream effects from fuel assembly blockage and resulting impact on core coolability.

Response to Question 15.06.05-91:

Current NRC guidance provides input to the makeup of latent fiber, average diameter of latent fiber, and a recommended latent fiber surrogate debris source. Utilizing the recommended latent fiber surrogate as prepared in a conservative manner leads to appropriate and applicable strainer bypass test results. The U.S. EPR test protocol utilized the current industry guidance for fiber surrogates.

The U.S. EPR debris generation calculation generates fibrous debris via two forms; NUKON® fiber from destroyed piping insulation and latent fiber. NRC guidance in Volume II of NEI 04-07 provides the size distribution for destroyed NUKON® insulation from piping insulation as 60 percent "larges" and 40 percent "small fines". Larges are considered pieces larger than four inches square in size. Fiber length and size distribution impacts strainer bypass test results since longer and larger pieces of fiber can bridge screen openings creating a filtering fiber bed and preventing fiber bypass. Similarly, agglomerated fibrous debris can more easily bridge screen openings preventing bypass. Using "large" pieces of fiber would not be conservative to bypass testing since large pieces, similar to agglomerated debris, would create a filter bed on the retaining basket or strainer and prevent bypass.

The U.S. EPR ECCS strainer testing conservatively utilized all fiber fines for bypass testing increasing the probability for fiber bypass. The fine NUKON® fiber was prepared by Performance Contracting Incorporated (PCI) by processing fine pieces of NUKON® insulation through a shredder. Prior to the shredding, the NUKON® was heat treated to remove binding agents that keep NUKON® insulation together. During testing, the fine NUKON® debris was first pre-mixed with hot water and a power mixer. The pre-mixed debris was then inserted into a debris injection hopper at a ratio of approximately one part fiber to approximately 45 parts water. This created a diluted mix of NUKON® without agglomeration. This diluted mix was observed by the NRC staff during testing in July and August, 2010.

Appendix VII in Volume II of NEI 04-07 details U.S. NRC initiated studies through Los Alamos National Laboratory (LANL). The results of these studies were later published as NUREG/CR-6877, "Characterization and Head-Loss Testing of Latent Debris from Pressurized-Water-Reactor Containment Buildings." The studies at LANL characterized latent debris samples from five individual volunteer plants. The work included the physical attributes and hydraulic parameters of latent fiber. The studies determined that the head loss associated with latent debris fibers can be conservatively assessed using fiberglass insulation properties. NUREG/CR-6877 also determined that the characterization of latent fiber samples led LANL to conclude that it is conservative to assume that the latent fiber component has similar hydraulic properties to those of fiberglass. Only the fiber thickness and/or diameter were analyzed using scanning electron microscopy (SEM). The majority of the diameters analyzed by LANL fell between 12 and 14 μm in diameter. Though the lengths were not analyzed, NUREG/CR-6887 states “the fibers were very long compared with the diameter”.

The NRC Staff Review Guidance Regarding Generic Letter 2004-02, "Closure in the Area of Strainer Head Loss and Vortexing," prepared in March 2008, provides guidance on testing to determine whether a thin bed will form. Section 6.2.2 of this guidance indicates that NUKON® may be used as a surrogate for latent fibers.

FSAR Impact:

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

Question 15.06.05-92:

The U.S. EPR fuel assembly blockage testing as well as the sump bypass testing has not used a micro-porous insulating material. The U.S. EPR design uses Microtherm, which is a micro-porous insulating material. Justify why micro-porous insulating material is not used in the tests. Demonstrate that the test data obtained with a different particulate material are representative for the prototypical U.S. EPR conditions with regard to the type of particulate debris being present.

Response to Question 15.06.05-92:

A response to this question will be provided by March 31, 2011.

Question 15.06.05-93:

The presented EPRDM debris deposition model and core thermal analysis results for the U.S. EPR design revealed that the maximum cladding temperature was predicted to occur almost at the onset of the of the analyzed 30-day time period (about an hour or so into the process). As such, the limiting value for this safety criterion is determined by the initial thermal-hydraulic conditions assumed in the core region.

U.S. EPR RAI 241 Question 15.06.05-51 addresses the reactor two-phase mixture level response during long term cooling and RAI 241 Question 15.06.05-52 considers the core region thermal-hydraulic conditions for the boric acid precipitation analysis. Explain how the core region thermal-hydraulic assumptions and conditions applied in demonstrating acceptability of the clad temperature response during long term core cooling using the EPRDM model compare to assumptions and conditions considered in RAI 251 Question 15.06.05-51, RAI 251 Question 15.06.05-52, and in the ΔP acceptance criteria analyses for core blockage evaluation. Explain and quantify any significant differences under comparable LOCA conditions.

Response to Question 15.06.05-93:

A response to this question will be provided by March 31, 2011.

Question 15.06.05-94:

The presented EPRDM debris deposition model and analysis results for the U.S. EPR design revealed that the maximum thickness of debris deposition occurred at the end of the analyzed 30-day time period. As debris deposition rates were based on predicted boiling rates, provide description of the boiling model for each control volume along with corresponding steam generation rates. Consider effects associated with non-uniformity in growth of deposition layers on fuel surfaces, as well as their physical properties determination. In addition, list assumptions made with regard to debris transportation.

Response to Question 15.06.05-94:

A response to this question will be provided by March 31, 2011.

Question 15.06.05-95:

The EPRDM debris deposition model and analysis results for the U.S. EPR design used a limiting thickness criterion for the debris buildups based on the as-designed fuel geometry. Consider effects associated with ballooning and conditions related in post-LOCA long term cooling analyses.

Response to Question 15.06.05-95:

A response to this question will be provided by March 31, 2011.

Question 15.06.05-96:

The U.S. EPR IRWST sump chemistry modeling was performed assuming certain pool thermal-hydraulic conditions. Identify the assumptions and models used in determining the pool fluid temperature response in time. In particular, describe assumptions related to available energy and mass sources and losses as well as initial conditions used in balance equations to determine the pool temperature. Show that the assumptions and conditions are conservative with regard to downstream effects on core cooling and explain the relevance to assumptions used in containment response analyses.

Response to Question 15.06.05-96:

A response to this question will be provided by March 31, 2011.

Question 15.06.05-97:

In assessing the impact of chemical debris for the purpose of determining strainer bypass and fuel assembly head loss in any U.S. EPR-specific tests, explain how the type and amount of surrogate for chemical precipitates, as and if applied in such tests, account for the types, characteristics, generation rates, transportation mechanisms, and deposition rates of chemical compounds present in the U.S. EPR ECCS water. Identify any conservatism in the approach that has been implemented to account for the presence of chemical debris in evaluating downstream effects on U.S. EPR core cooling.

Response to Question 15.06.05-97:

A response to this question will be provided by March 31, 2011.