AREVA

November 7, 2008
NRC:08:089

Document Control Desk
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555-0001

Response to U.S. EPR Design Certification Application RAI No. 48, Supplement 1

Ref. 1: E-mail, Getachew Tesfaye (NRC) to Ronda Pederson, et al (AREVA NP Inc.), "U.S. EPR Design Certification Application RAI No. 48 (885,887,888,889,894,1076), FSAR Ch 3," August 21, 2008.

Ref 2: Letter, Sandra M. Sloan (AREVA NP Inc.) to Document Control Desk (NRC), "Response to U.S. EPR Design Certification Application RAI No. 48," NRC:08:072, September 18, 2008.

In Reference 1, the NRC provided a request for additional information (RAI) regarding the U.S. EPR design certification application (i.e., RAI No. 48). In Reference 2, AREVA NP provided technically correct and complete responses to 15 of the 18 questions and indicated that the responses to the remaining questions would be provided to the NRC by November 7, 2008. Accordingly, technically correct and complete responses to RAI No. 48, Supplement 1, Questions 03.06.03-10, 03.06.03-12, and 03.06.03-13 are enclosed with this letter.

The enclosed response consists of the following:

Question #	Start Page	End Page
RAI 48—03.06.03-10	2	2
RAI 48—03.06.03-12	3	4
RAI 48—03.06.03-13	5	6

Also enclosed are affected pages of the U.S. EPR Final Safety Analysis Report in redline-strikeout format which support the response to RAI 48, Supplement 1, Question 03.06.03-12.

This concludes the formal AREVA NP response to RAI 48, and there are no questions from this RAI for which AREVA NP has not provided responses.

AREVA NP considers some of the material contained in the enclosure to be proprietary. As required by 10 CFR 2.390(b), an affidavit is enclosed to support the withholding of the information from public disclosure. Proprietary and non-proprietary versions of the enclosure to this letter are provided.

D077
NRO

If you have any questions related to this submittal, please contact me by telephone at (434) 832-2369 or by e-mail at sandra.sloan@areva.com.

Sincerely,

Sandra M. Sloan

Sandra M. Sloan, Manager
New Plants Regulatory Affairs
AREVA NP Inc.

Enclosures

cc: J. Rycyna
G. Tesfaye
Docket No. 52-020

AFFIDAVIT

COMMONWEALTH OF VIRGINIA)
) ss.
CITY OF LYNCHBURG)

1. My name is Sandra M. Sloan. I am Regulatory Affairs Manager for New Plants, for AREVA NP Inc. and as such I am authorized to execute this Affidavit.

2. I am familiar with the criteria applied by AREVA NP to determine whether certain AREVA NP information is proprietary. I am familiar with the policies established by AREVA NP to ensure the proper application of these criteria.

3. I am familiar with the AREVA NP information contained in "Response to U.S. EPR Design Certification Application RAI No. 48, Supplement 1," and referred to herein as "Document." Information contained in this Document has been classified by AREVA NP as proprietary in accordance with the policies established by AREVA NP for the control and protection of proprietary and confidential information.

4. This Document contains information of a proprietary and confidential nature and is of the type customarily held in confidence by AREVA NP and not made available to the public. Based on my experience, I am aware that other companies regard information of the kind contained in this Document as proprietary and confidential.

5. This Document has been made available to the U.S. Nuclear Regulatory Commission in confidence with the request that the information contained in this Document be withheld from public disclosure. The request for withholding of proprietary information is made in accordance with 10 CFR 2.390. The information for which withholding from disclosure is

requested qualifies under 10 CFR 2.390(a)(4) "Trade secrets and commercial or financial information".

6. The following criteria are customarily applied by AREVA NP to determine whether information should be classified as proprietary:

(a) The information reveals details of AREVA NP's research and development plans and programs or their results.

(b) Use of the information by a competitor would permit the competitor to significantly reduce its expenditures, in time or resources, to design, produce, or market a similar product or service.

(c) The information includes test data or analytical techniques concerning a process, methodology, or component, the application of which results in a competitive advantage for AREVA NP.

(d) The information reveals certain distinguishing aspects of a process, methodology, or component, the exclusive use of which provides a competitive advantage for AREVA NP in product optimization or marketability.

(e) The information is vital to a competitive advantage held by AREVA NP, would be helpful to competitors to AREVA NP, and would likely cause substantial harm to the competitive position of AREVA NP.

The information in the Document is considered proprietary for the reasons set forth in paragraphs 6(a), 6(b) and 6(c) above.

7. In accordance with AREVA NP's policies governing the protection and control of information, proprietary information contained in this Document have been made available, on a limited basis, to others outside AREVA NP only as required and under suitable agreement providing for nondisclosure and limited use of the information.

8. AREVA NP policy requires that proprietary information be kept in a secured file or area and distributed on a need-to-know basis.

9. The foregoing statements are true and correct to the best of my knowledge, information, and belief.

Sandra M. Sloan

SUBSCRIBED before me this 6th

day of November, 2008.

Kathleen A. Bennett

Kathleen A. Bennett
NOTARY PUBLIC, COMMONWEALTH OF VIRGINIA
MY COMMISSION EXPIRES: 8/31/2011

KATHLEEN ANN BENNETT
Notary Public
Commonwealth of Virginia
110864
My Commission Expires Aug 31, 2011

Response to

Request for Additional Information No. 48 Supplement 1
(885,887,888,889,894,1076), Revision 0

8/21/2008

U. S. EPR Standard Design Certification
AREVA NP Inc.
Docket No. 52-020
SRP Section: 03.06.03 - Leak-Before-Break Evaluation Procedures
Application Section: FSAR Ch 3
CIB1 Branch

Question 03.06.03-10:

Subsection 3.6.3.5 – General Methodology:

It appears that air-fatigue morphology was assumed for the leak-rate calculations. This is the least conservative assumption that can be made because for the same amount of flow, it results in smaller leakage crack sizes (and larger critical crack size margins) than other crack morphology assumptions like PWSCC or IGSCC. While SRP 3.6.3 states that Alloy 690/52/152 (which will be used in the EPR) is not currently considered susceptible to PWSCC for the purposes of LBB applications, these materials are NOT immune to PWSCC. There are references that show the effect of assuming PWSCC or IGSCC leakage crack morphologies. If an SCC or corrosion morphology is assumed in the calculations (as a lower bound conservative case) each and every one of the ALL diagrams will change. Please provide the justification for the use of air versus corrosion fatigue crack morphology.

Response to Question 03.06.03-10:

As a part of the demonstration for leak-before-break (LBB) analysis for a piping system, each of the potential active degradation mechanisms is reviewed to demonstrate that these are not applicable to the LBB piping candidate system. The details of this review and evaluation are provided in U.S. EPR FSAR Tier 2, Section 3.6.3.3. For the U.S. EPR, Alloy 52 weld metal is used which results in primary water stress corrosion cracking (PWSCC) not being a credible degradation mechanism. The responses to RAI No. 48, Question 03.06.03-1 (Reference 1) and RAI No. 48, Supplement 1, Question 03.06.03-13 provide additional information to further demonstrate that the main coolant loop (MCL) and surge line (SL) piping are not susceptible to PWSCC. The crack morphology parameters for corrosion fatigue were also evaluated (see NUREG/CR-6004 (Reference 2) and NUREG/CR-6861 (U.S. EPR FSAR Tier 2, Section 3.6.3.8, Reference 22)). The MCL piping and the SL piping for the U.S. EPR are fabricated from stainless steel. The referenced NUREG/CRs do not provide corrosion fatigue parameters for stainless steel piping, although they do provide air-fatigue parameters for stainless steel piping.

The leak rate analyses for the MCL piping and the SL piping are performed considering the fatigue crack morphology with crack opening displacement (COD) calculations using the Paris-Tada method. The Paris-Tada method is considered a conservative method (Reference 3, Section 3.2.3.1).

Additionally, air-fatigue morphology has been used in LBB applications when it has been demonstrated that other potential sources of pipe rupture have been precluded. For example, in Generic Letter 84-04, Section 3.4, "Leak Rate Calculations," NRC states: "To calculate the frictional pressure drop, the relative surface roughness was estimated from fatigue-cracked stainless steel specimens." This implies that air-fatigue morphology was used. Furthermore, an industry report provided to NRC (Reference 4, Section 1.2, "Application of LBB to Alloy 82/182 Components") notes that LBB applications for operating plants have assumed that crack growth by fatigue is the only credible cracking mechanism, and hence the determination of leakage through flaws has been based on crack morphology consistent with fatigue cracks. Therefore, the use of air-fatigue morphology is appropriate for LBB applications for the U.S. EPR.

References for Response to Question 03.06.03-10:

1. Letter, Sandra M. Sloan (AREVA NP Inc.) to Document Control Desk (NRC), "Response to U.S. EPR Design Certification Application RAI No. 48," NRC:08:072, September 18, 2008.

2. NUREG/CR-6004, "Probabilistic Pipe Fracture Evaluations for Leak-Rate-Detection," U.S. Nuclear Regulatory Commission, April 1995.

3. NUREG/CR-6300, "Refinement and Evaluations of Crack-Opening-Area Analysis for Circumferential Through-Wall Cracks in Pipes," U.S. Nuclear Regulatory Commission, April 1995.

4. EPRI Report 1011808, "Materials Reliability Program: Leak-Before-Break Evaluation for PWR Alloy 82/182 Welds (MRP-140)," Electric Power Research Institute, November 2005 (NRC Accession Number ML052240239).

FSAR Impact:

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

Question 03.06.03-12:

Subsection 3.6.3.5.4 – Flaw Stability Analysis Method:

The following questions concern the stability analyses:

a) It is claimed that the pressure and bend solution is valid only for R/t=10 and R/t=20, and use the R/t=10 solution conservatively. Most of the systems analyzed are R/t≤6. In the next section on the surge line, it is claimed that the pressure and bend solutions cannot be used since the R/t=5, so only a bending solution is used. This is in conflict with the previous paragraph where it is stated that the R/t=10 can be used. Please clarify the assumption in these analyses.

b) For the SL, a bending only solution is used to calculate an "effective" moment for the axial load by equating the stress intensities. However, the collapse moment used is not modified and the axial load will lower the collapse moment. Please demonstrate how the use of the "effective" bending moment correction can correctly capture the driving force for the pressure and bending case.

c) Curve fits of the GE/EPRI F and h functions were used for extrapolating to the lower R/t values. Please clarify the extrapolation of curve fits and the method used (i.e., 4th order polynomials are not good for extrapolation but work well for interpolation).

d) How were secondary loads considered in these analyses? Were 100% of the displacement-controlled stresses used in calculating the TWC subcritical growth and the TWC critical flaw size?

Response to Question 03.06.03-12:

a) The explanation for why the bending only solution was utilized for the surge line (SL) analysis in U.S. EPR FSAR Tier 2, Section 3.6.3.5.4 requires further clarification. The reason for using the bending solution is not just that R/t = 5, but also that for the tension and bending solution there is no h1 function for the R/t = 5 and n =7 case that is applicable to the surge line (SL) piping. U.S. EPR FSAR Tier 2, Section 3.6.3.5.4 will be revised to reflect this clarification.

b) When the solution for combined bending and tension is not available, the equivalent moment method is used to convert axial force into an effective moment which is then combined with the applied external moment to obtain the total moment to which the pipe is subjected. A given moment is considered to be equivalent to the axial force when the Mode I stress intensity factor, K_I, due to bending moment is same as K_I due to axial force.

In this method, the collapse moment used is not modified to account for the effect of the axial load. For the SL piping, the applied external moment in consideration is significantly greater than the axial load multiplied by the mean radius for all the possible flaw sizes. Even if the potential reduction in the collapse moment due to the axial load is considered, the relative difference in the results of the collapse moment is less than 1.5%.

c) A review of the flaw stability analysis methods for the main steam line (MSL), main coolant loop (MCL), and surge line (SL) determined that no extrapolations of curve fits are used for lower R/t values in order to obtain F and h functions for stability analysis. For the MSL (R/t=7.88) and MCL (R/t=5.8), the tabulated values for R/t=10 in EPRI NP-5596 are used for the fully plastic solution of the circumferential crack in a straight pipe in tension and bending. For the SL (R/t=4.68), only the solutions for bending are used. For this application, EPRI NP-5596 provides solutions for R/t=5, 10 and 20 and the solution for R/t=5 was used for conservatism purposes. Therefore, the approximation methods are properly used in the flaw stability analysis for the MSL, MCL and SL piping.

d) The secondary loads (i.e., 100% of the normal operating steady state condition thermal expansion loads) are considered for both the leak rate analysis and the flaw stability analysis in the generation of maximum moment also as defined in U.S. EPR FSAR Tier 2, Section 3.6.3.5.1.

FSAR Impact:

U.S. EPR FSAR Tier 2, Section 3.6.3.5.4 will be revised as described in the response and indicated on the enclosed markup.

Question 03.06.03-13:

Subsection 3.6.3.5 – General Methodology:

As stated previously, Alloy 690/52/152 is not immune to PWSCC. Contributing factors which could increase susceptibility to PWSCC include welding processes, control of welding parameters (i.e., heat input), dilution effects on dissimilar metal welds (DMW), chromium content on DMW. Please provide a discussion identifying the controls that will be considered to minimize the susceptibility to PWSCC. These controls may include minimizing dilution effects but maximizing chromium content of nickel-based welds, reducing welding residual stress by weld sequence optimization, and other adjustments to primary water chemistry.

Response to Question 03.06.03-13:

The response to RAI No. 48, Question 03.06.03-1(a) (Reference 1), describes reactor coolant chemistry controls to prevent primary water stress corrosion cracking (PWSCC).

Alloy 52 has been demonstrated to be more resistant to PWSCC initiation than Alloy 600/82/182 through both laboratory testing and operating experience (Reference 2). **[**

]

Based on the above information, Alloy 52/152 welds in the U.S. EPR LBB piping are not susceptible to PWSCC.

Additionally, ID weld repairs tend to produce tensile residual stresses at the wetted ID surface. Therefore, weld repairs are limited to the extent practical. However, where necessary, weld repair of DMWs in contact with primary fluids are performed using repair methods selected to achieve compressive (or as low as reasonably achievable tensile) stress conditions on the wetted ID surface.

References for Response to Question 03.06.03-13:

1. Letter, Sandra M. Sloan (AREVA NP Inc.) to Document Control Desk (NRC), "Response to U.S. EPR Design Certification Application RAI No. 48," NRC:08:072, September 18, 2008.

2. EPRI Report 1009801, "Materials Reliability Program (MRP), Resistance to Primary Water Stress Corrosion Cracking of Alloys 690, 52, and 152 in Pressurized Water Reactors (MRP-111)," Electric Power Research Institute, March 2004 (NRC Accession Number ML041680546).

FSAR Impact:

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

U.S. EPR Final Safety Analysis Report Markups

where:

R = the pipe mean radius

t = the pipe thickness

I = area moment of inertia of the pipe section

a = the flaw size or one-half the leakage crack size

b = one-half the pipe circumference

c = uncracked ligament (b – a)

E = Young's modulus

M = the bending moment

P = the tensile load

σ_o and ε_o= the reference stress and reference strain in the Ramberg-Osgood material model

γ = the crack half-angle

F_B and F_T = the tabulated elastic solution coefficients for bending and axial loading (functions of geometry only {– a/b and R/t}) as provided in Reference 23.

h_1 = the tabulated fully plastic solution parameter, function of (material strain hardening exponent, n and geometry, a/b and R/t)

Since the parameter (h_1) of the plastic portion of the EPRI J-integral combined tension and bending solution is provided only for R/t = 10 and R/t =20 in Reference 23, the h_1 values for R/t = 10 are conservatively used in the analysis of MCL piping with R/t < 6. For the MSL piping, the elastic solution coefficients (F_B and F_T) from the EPRI reports are linearly interpolated where applicable to generate the solution for the specific R/t geometry that is being evaluated.

Surge Line Piping

A J-integral solution for a circumferentially through-wall cracked cylinder subjected to bending loads is used in the analysis for the SL piping. This EPRI/GE solution is provided in Reference 23. The alpha term in the solution is corrected based on Reference 24. This particular J-integral solution is chosen since the SL geometry has an R_m/t ratio of approximately five (with Ramberg-Osgood material constant n=7) and the h-function for R_m/t = 5 is available for through-wall cracks in bending. For the SL piping, the J-integral solution for combined tension and bending provided above (main coolant loop and main steam line piping) is not used, since the coefficients for this solution are only developed for R_m/t of 10 or greater.