ArevaEPRDCPEm Resource

From: WILLIFORD Dennis (AREVA) [Dennis.Williford@areva.com]
Sent: Thursday, May 26, 2011 8:58 AM
To: Tesfaye, Getachew
Cc: BENNETT Kathy (AREVA); DELANO Karen (AREVA); ROMINE Judy (AREVA); RYAN Tom (AREVA); HAMMOND Philip (AREVA)
Subject: Response to U.S. EPR Design Certification Application RAI No. 458, FSAR Ch. 3, Supplement 3
Attachments: RAI 458 Supplement 3 Response US EPR DC.pdf

Getachew,

AREVA NP Inc. (AREVA NP) provided a schedule for a technically correct and complete response to RAI No. 458 on December 6, 2010. The schedule for a technically correct and complete response to RAI No. 458 was revised in Supplement 1 and Supplement 2, submitted on March 21, 2011 and April 19, 2011 respectively, to allow additional time for AREVA NP to interact with the NRC.

The attached file, "RAI 458 Supplement 3 Response US EPR DC.pdf" provides a technically correct and complete FINAL response to 3 of the 12 questions, as committed. The following table indicates the respective pages in the response document, "RAI 458 Supplement 3 Response US EPR DC.pdf", which provide the responses to the 3 questions.

Question #	Start Page	End Page
RAI 458 — 03.09.01-13	2	6
RAI 458 — 03.09.01-14	7	10
RAI 458 — 03.09.01-15	11	17

The schedule for a technically correct and complete response to the remaining 9 questions is unchanged and is provided below.

Question #	Response Date
RAI 458 — 03.09.02-146	June 15, 2011
RAI 458 — 03.09.02-147	June 15, 2011
RAI 458 — 03.09.02-148	June 15, 2011
RAI 458 — 03.09.02-149	June 15, 2011
RAI 458 — 03.09.02-150	June 15, 2011
RAI 458 — 03.09.02-151	June 15, 2011
RAI 458 — 03.09.02-152	June 15, 2011
RAI 458 — 03.09.02-153	June 15, 2011
RAI 458 — 03.09.02-154	June 15, 2011

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

Phone: 704-805-2223
Email: Dennis.Williford@areva.com

From: WELLS Russell (RS/NB)
Sent: Tuesday, April 19, 2011 4:25 PM
To: 'Tesfaye, Getachew'
Cc: HAMMOND Philip (RS/PT); 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. 458, FSAR Ch. 3, Supplement 2

Getachew,

AREVA NP Inc. (AREVA NP) provided a schedule for a technically correct and complete response to RAI No. 458 on December 6, 2010. The schedule for a technically correct and complete response to RAI No. 458 was revised with Supplement 1 on March 21, 2011.

The schedule for a technically correct and complete response to RAI No. 458 is revised to allow additional time for AREVA NP to interact with the NRC and is provided below.

Question #	Response Date
RAI 458 — 03.09.01-13	June 15, 2011
RAI 458 — 03.09.01-14	June 15, 2011
RAI 458 — 03.09.01-15	June 15, 2011
RAI 458 — 03.09.02-146	June 15, 2011
RAI 458 — 03.09.02-147	June 15, 2011
RAI 458 — 03.09.02-148	June 15, 2011
RAI 458 — 03.09.02-149	June 15, 2011
RAI 458 — 03.09.02-150	June 15, 2011
RAI 458 — 03.09.02-151	June 15, 2011
RAI 458 — 03.09.02-152	June 15, 2011
RAI 458 — 03.09.02-153	June 15, 2011
RAI 458 — 03.09.02-154	June 15, 2011

Sincerely,

Russ Wells
U.S. EPR Design Certification Licensing Manager
AREVA NP, Inc.
3315 Old Forest Road, P.O. Box 10935
Mail Stop OF-57
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434-942-6375 (cell)
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Russell.Wells@Areva.com

From: WELLS Russell (RS/NB)
Sent: Monday, March 21, 2011 10:14 AM
To: 'Tesfaye, Getachew'

Cc: HAMMOND Philip (RS/PT); 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. 458, FSAR Ch. 3, Supplement 1

Getachew,

AREVA NP Inc. (AREVA NP) provided a schedule for a technically correct and complete response to RAI No. 458 on December 6, 2010.

The schedule for a technically correct and complete response to RAI No. 458 is revised to allow additional time for AREVA NP to interact with the NRC and is provided below.

Question #	Response Date
RAI 458 — 03.09.01-13	May 5, 2011
RAI 458 — 03.09.01-14	May 5, 2011
RAI 458 — 03.09.01-15	May 5, 2011
RAI 458 — 03.09.02-146	May 5, 2011
RAI 458 — 03.09.02-147	May 5, 2011
RAI 458 — 03.09.02-148	May 5, 2011
RAI 458 — 03.09.02-149	May 5, 2011
RAI 458 — 03.09.02-150	May 5, 2011
RAI 458 — 03.09.02-151	May 5, 2011
RAI 458 — 03.09.02-152	May 5, 2011
RAI 458 — 03.09.02-153	May 5, 2011
RAI 458 — 03.09.02-154	May 5, 2011

Sincerely,

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Russell.Wells@Areva.com

From: BRYAN Martin (External RS/NB)
Sent: Monday, December 06, 2010 4:54 PM
To: 'Tesfaye, Getachew'
Cc: DELANO Karen (RS/NB); ROMINE Judy (RS/NB); BENNETT Kathy (RS/NB); HAMMOND Philip (RS/PT)
Subject: Response to U.S. EPR Design Certification Application RAI No. 458, FSAR Ch. 3

Getachew,

Attached please find AREVA NP Inc.'s response to the subject request for additional information (RAI). The attached file, "RAI 458 Response US EPR DC.pdf," provides a schedule since a technically correct and complete response to the RAI 458 questions is not provided.

The following table indicates the respective pages in the response document, “RAI 458 Response US EPR DC.pdf,” that contain AREVA NP’s response to the subject questions.

Question #	Start Page	End Page
RAI 458 — 03.09.01-13	2	2
RAI 458 — 03.09.01-14	3	3
RAI 458 — 03.09.01-15	4	4
RAI 458 — 03.09.02-146	5	5
RAI 458 — 03.09.02-147	6	6
RAI 458 — 03.09.02-148	7	7
RAI 458 — 03.09.02-149	8	8
RAI 458 — 03.09.02-150	9	9
RAI 458 — 03.09.02-151	10	10
RAI 458 — 03.09.02-152	11	11
RAI 458 — 03.09.02-153	12	12
RAI 458 — 03.09.02-154	13	13

A complete answer is not provided for 12 of the 12 questions. The schedule for a technically correct and complete response to these questions is provided below.

Question #	Response Date
RAI 458 — 03.09.01-13	March 30, 2011
RAI 458 — 03.09.01-14	March 30, 2011
RAI 458 — 03.09.01-15	March 30, 2011
RAI 458 — 03.09.02-146	March 30, 2011
RAI 458 — 03.09.02-147	March 30, 2011
RAI 458 — 03.09.02-148	March 30, 2011
RAI 458 — 03.09.02-149	March 30, 2011
RAI 458 — 03.09.02-150	March 30, 2011
RAI 458 — 03.09.02-151	March 30, 2011
RAI 458 — 03.09.02-152	March 30, 2011
RAI 458 — 03.09.02-153	March 30, 2011
RAI 458 — 03.09.02-154	March 30, 2011

Sincerely,

Martin (Marty) C. Bryan
U.S. EPR Design Certification Licensing Manager
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From: Tesfaye, Getachew [mailto:Getachew.Tesfaye@nrc.gov]
Sent: Friday, November 05, 2010 8:40 AM
To: ZZ-DL-A-USEPR-DL
Cc: Wu, Cheng-Ih; Wong, Yuken; Dixon-Herrity, Jennifer; Miernicki, Michael; Colaccino, Joseph; ArevaEPRDCPEm Resource
Subject: U.S. EPR Design Certification Application RAI No. 458 (5149,5152),FSAR Ch. 3

Attached please find the subject requests for additional information (RAI). A draft of the RAI was provided to you on October 29, 2010, and on November 3, 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
(301) 415-3361

Hearing Identifier: AREVA_EPR_DC_RAIs
Email Number: 3034

Mail Envelope Properties (2FBE1051AEB2E748A0F98DF9EEE5A5D4727C24)

Subject: Response to U.S. EPR Design Certification Application RAI No. 458, FSAR Ch. 3, Supplement 3
Sent Date: 5/26/2011 8:58:05 AM
Received Date: 5/26/2011 8:58:11 AM
From: WILLIFORD Dennis (AREVA)

Created By: Dennis.Williford@areva.com

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Files	**Size**	**Date & Time**
MESSAGE	8346	5/26/2011 8:58:11 AM
RAI 458 Supplement 3 Response US EPR DC.pdf		269989

Options
Priority: Standard
Return Notification: No
Reply Requested: No
Sensitivity: Normal
Expiration Date:
Recipients Received:

Response to

Request for Additional Information No. 458, Supplement 3

11/05/2010

U.S. EPR Standard Design Certification
AREVA NP Inc.
Docket No. 52-020
SRP Section: 03.09.01 - Special Topics for Mechanical Components
SRP Section: 03.09.02 - Dynamic Testing and Analysis of Systems Structures and Components
Application Section: 3.9

QUESTIONS for Engineering Mechanics Branch 1 (AP1000/EPR Projects) (EMB1)
QUESTIONS for Engineering Mechanics Branch 2 (ESBWR/ABWR Projects) (EMB2)

Question 03.09.01-13:

FSAR Section 3.12.5.19 states that “the effects of reactor coolant environment, using the methodology described in RG 1.207, are considered when performing fatigue analyses for Class 1 piping and components.” RG 1.207 recommends using Fen method presented in NUREG/CR-6909. The staff reviewed the design basis documentation (Document #: 32-9119032-002, “Fatigue Modules for US EPR Piping System”, 07/16/2010). The staff has identified the discrepancies between the design basis document and NUREG/CR-6909 as follows:

NUREG/CR-6909		AREVA Document #: 32-9119032-002
Eq. 23	T* = T – 150 (150 < T ≤350°C)	T* = T – 302 (302 < T ≤662°F)
Eq. 25	ε* = ln(0.001) (ε* < 0.001%/s)	ε* = ln(1.0E-5) (ε* < 0.001%/s)

The staff requests AREVA to clarify and correct the differences.

The staff noted that the AREVA document indicated that the threshold strain amplitude of 0.1% is considered for all type material. However, the threshold strain amplitude of 0.07% for carbon steel and low alloy steel is defined in Section 4.2.13 of NUREG/CR-6909. Please clarify.

The staff also noted that AREVA’s weighted average Fen method is not consistent with existing method identified in NUREG/CR-6909. AREVA states that the weighted average Fen method is conservative. The staff’s concern is that final Fen may be reduced if partial Fen=1.0 for some stress components due to threshold consideration. The staff requests AREVA to demonstrate the conservatism of the proposed weighted average Fen method.

Response to Question 03.09.01-13:

Item a:

U.S. EPR FSAR Tier 2, Section 3.12.5.19 states that the methodology described in RG 1.207 is used to perform fatigue analyses for Class 1 piping and components. Equation 25, referred to in this question, was incorrectly documented in the subject calculation and has been modified. The equation is correctly programmed in the software. Equation 23, referred to in this question, is converted from °C to °F, which accounts for the differences with NUREG/CR-6909. A direct conversion in Equation 23 from °C to °F resulted in an incorrect value of transformed temperature for the calculation of Fen. The formula has been revised and yields a transformed temperature for input values in °F (see Table 03.09.01-13-2) that is consistent with the NUREG/CR-6909 formula.

Table 03.09.01-13-1 resolves the discrepancies between the AREVA NP calculation and NUREG/CR-6909. Table 03.09.01-13-2 provides examples for the application of the temperature conversion formula to determine the transformed temperature for calculation of Fen values.

Item b:

FatTool ASME V1.1 incorrectly used the threshold strain amplitude of 0.1 percent for the materials. FatTool ASME V1.2 corrects this discrepancy. Two categories of materials with different strain amplitude thresholds are identified, according to NUREG/CR-6909, and are being used in FatTool:

- Carbon and low-alloy steels with strain amplitude threshold of 0.07 percent.
- Austenitic stainless steels and Ni-Cr-Fe alloys with strain amplitude threshold of 0.1 percent.

Item c:

Calculation of peak stress using ASME Code Section III, Paragraph NB-3653.2, Equation 11 results in stresses (strains) for each load component (pressure and thermal gradients) separately. NUREG/CR-6909 indicates that the Fen factor evaluation should be based on the combined strain in the piping/component. This approach is applied using the requirements of ASME Code Section NB-3200. For U.S. EPR piping applications, the strain time histories of each load component is produced, and a separate partial Fen (Fen_i) is calculated for each time history using the methods of NUREG/CR-6909.

The FatTool ASME V1.1 procedure calculation is the following:

1. The combined strain amplitude, calculated using Sa from ASME Code Section III, Paragraph NB-3653.6, Equation 14 divided by the Young's Modulus (E), is compared to the applicable threshold value, per NUREG/CR-6909. Where the strain (*Sa*/*E*) is higher than the applicable threshold value, a partial Fen factor (Fen_i) is calculated according to NUREG/CR-6909, Equations 27, 28, and 38 for carbon steel, low alloy steel, and stainless steel, respectively, for each of the load components (thermal moments, gradients, and pressure) of *Sa* separately. In other cases, the total Fen is considered equal to one, as NUREG/6909 indicates.
2. After calculating the partial Fen_i factors for each stress component using the modified rate approach in NUREG/CR-6909, Paragraph 4.2.14, a weighted average *Fen* is calculated for the respective stress amplitude according to Equation (1):

$$Fen(Sa)=\frac{\sum_k Fen_k\sigma_k+\sqrt{Fen_{Mx}{}^2\sigma_{Mx}{}^2+Fen_{My}{}^2\sigma_{My}{}^2+Fen_{Mz}{}^2\sigma_{Mz}{}^2}}{\sum_k \sigma_k+\sqrt{\sigma_{Mx}{}^2+\sigma_{My}{}^2+\sigma_{Mz}{}^2}} \qquad (1)$$

The following instances apply to this equation:

a) FatTool can only yield either the *Fen* or Fen_i factor equal to one in the following cases:

   – When the strain amplitude evaluated at the beginning of calculations as *Sa*/*E* for the considered material is less than the strain amplitude threshold value, *Fen* is one.

   – When a partial Fen_i is predefined (e.g., earthquake load) to be equal to one.

   In other cases, the minimum value of *Fen* or Fen_i calculated by FatTool ASME V1.1 is in accordance with NUREG/CR-6909, Equations 27, 28, and 38 for carbon steel, low alloy steel, and stainless steel, respectively. For example, in the case of austenitic stainless steels:

$$Fen=\exp(0.734)=2.08 \quad (2)$$

b) The moments *Mx*, *My*, and *Mz* do not include any earthquake induced moments. The weighted average of Equation (1) does not include other loads that can be defined with a Fen_i equal to one.

The following example demonstrates and explains the conservatism of the method.

Example

Table 03.09.01-13-3 shows two stress amplitude values and their respective load components (pressure, thermal moments, and moments resulting from earthquake load).

Step 1

Each strain amplitude is checked with the threshold value of NUREG/CR-6909, which is 0.001 for stainless steel.

29603/28,300,000=0.00104 > 0.001, and therefore a partial Fen_i will be evaluated for each load component of the stress amplitude *Sa*=29603 psi.

15424/28,300,000=0.00054 < 0.001, therefore no further evaluations are performed, and a *Fen* = 1 is assigned to the stress amplitude S_a = 15424 psi.

Step 2

For the stress components corresponding to the stress amplitude of 29603 psi, FatTool ASME V1.1 calculates the partial Fen_i factors for each load component separately, as Table 03.09.01-13-4 shows.

Using Equation (1), the average *Fen* is calculated as:

$$Fen = \frac{5.06 * 19000 + \sqrt{2.90^2 * 15600^2 + 2.90^2 * 19500^2 + 2.90^2 * 14200^2}}{19000 + \sqrt{15600^2 + 19500^2 + 14200^2}} = 3.76$$

The *Fen* = 3.76 is applied to the cumulative usage factor calculated using an alternating stress (S_a) of 29603 psi, that is to the effects of the loads, including the earthquake load. This is a conservative approach because the loading components with a partial Fen_i equal to one are not considered in the weighted average.

FSAR Impact:

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

Table 03.09.01-13-1—Resolution of Discrepancies in NUREG 6909 Equations

NUREG/CR 6909		AREVA calculation	Resolution
Eq. 23	$T^* = T - 150$ $(150 < T \leq 350^oC)$	$T^* = T - 302$ $(302 < T \leq 662^oF)$ **Corrected** $T^* = (T - 302)/1.8$ $(302 < T \leq 662^oF)$	The transformed temperature equation for carbon steel and temperature higher than 150°C has been corrected in the document and FatTool ASME V1.2 Code, as shown on the left. The formula yields the same value for transformed temperature for input values in °C or °F. See Table 03.09.01-13-2 for examples.
Eq. 25	$\varepsilon^* = \ln(0.001)$ $(\varepsilon^* < 0.001\%/s)$	$\varepsilon^* = \ln(1.0E-05)$ $(\varepsilon^* < 0.001\%/s)$	This was a typographical error in the AREVA document that was corrected to agree with NUREG/CR-6909. This error did not translate to the software coding of FatTool ASME.

Table 03.09.01-13-2—Example of Calculation of Transformed Temperature for Corrected Formula

Temperature, T (°F)	Temperature, T (°C)	T*=[(T-302)/1.8] (T in °F)	T* = (T-150) (T in °C)
302	150.00	0.00	0.00
303	150.56	0.56	0.56
350	176.67	26.67	26.67
400	204.44	54.44	54.44
450	232.22	82.22	82.22
500	260.00	110.00	110.00
550	287.78	137.78	137.78
600	315.56	165.56	165.56
650	343.33	193.33	193.33

Table 03.09.01-13-3—Example of Alternating Stresses for a Piping System

a/a	S_a (psi)	σ_P (psi)	$\sigma_{MThermal}$			$\sigma_{MEarthquake}$		
			σ_{Mx} (psi)	σ_{My} (psi)	σ_{Mz} (psi)	σ_{Mx} (psi)	σ_{My} (psi)	σ_{Mz} (psi)
1	29603	19000	15600	19500	14200	8300	5500	6300
2	15424	13500	8000	11200	10560	0	0	0

Table 03.09.01-13-4—Partial *Fen_i* Evaluated by FatTool ASME V1.1

a/a	S_a	σ_P (psi)	$\sigma_{MThermal}$			$\sigma_{MEarthquake}$		
			σ_{Mx} (psi)	σ_{My} (psi)	σ_{Mz} (psi)	σ_{Mx} (psi)	σ_{My} (psi)	σ_{Mz} (psi)
1	29603	19000	15600	19500	14200	8300	5500	6300
	Fen_i	5.06	2.90	2.90	2.90	1.0	1.0	1.0

Table 03.09.01-13-5—Nomenclature

Fen	Environmental fatigue correction factor
Fen_i	Partial environmental fatigue correction factor addressing all load components
Fen_k	Partial environmental fatigue correction factor for load components other than moments
S_a	Alternating stress amplitude
σ_P	Stress range due to internal pressure
σ_{Mx}	Stress range due to induced moment in the *x* direction
σ_{My}	Stress range due to induced moment in the *y* direction
σ_{Mz}	Stress range due to induced moment in the *z* direction

Question 03.09.01-14

The staff reviewed the design basis documentation (Document, "Program Verification of PC Version of P91232", 02/16/2001). P91232 stratification option is used to calculate equivalent linear profile with top and bottom temperature and ΔT4 which has been used to calculate local thermal stress.

The staff noted that the AREVA methodology developed to calculate the temperature profile on pipe cross-section (@ mid-thickness) should be verified and benchmarked by a computer program which is recognized in the public domain and has had sufficient history of use to justify its applicability and validity (e.g. ANSYS). The staff requests AREVA to provide the benchmark comparison.

Rev. 1 of the FatTool (Document #: 32-9119032-001) defined that local thermal stratification stress equals to EαΔT4/ (1- n). Rev. 2 the FatTool (Document #: 32-9119032-002) defined that local thermal stratification stress equals to EαΔT4. The staff requests the benchmark justification for the local thermal stratification stress.

Response to Question 03.09.01-14:

a) AREVA NP has benchmarked the thermal stratification functionality of the internally developed program P91232 with a commercially available finite element computer code, ANSYS R12.1. The benchmarking methodology consists of comparing the results from ANSYS with results from P91232 and CASS. P91232 is currently benchmarked to CASS in the calculation in this question.

   The benchmarking comparison shows the temperature profile along the pipe cross section at mid-thickness. The two loading cases benchmarked are the same as the two loading cases documented in the AREVA NP calculation, reviewed by the NRC staff during their onsite audit. The comparison between the results from P91232, CASS, and ANSYS is performed by plotting the results on one graph for each loading case, as shown in Figure 03.09.01-14-1 and Figure 03.09.01-14-2.

   The results comparison between ANSYS and P91232 shows good agreement, and P91232 produces reliable results.

b) Reference 1 describes the basis for the U.S. EPR piping stresses methodology resulting from the nonlinear portion of the top-to-bottom temperature difference (i.e., ΔT4). Dividing a calculated stress by the difference between unity and Poisson's Ratio (i.e., 1-0.3 = 0.7) is performed when the stress is biaxial and the stresses in the two directions are approximately equal. When the axial stress component is approximately equal to the hoop stress component, the combined stress may be calculated by dividing the calculated uniaxial stress component by the quantity of unity minus Poisson's Ratio. This is performed for the stress component caused by thermal radial gradients (i.e., ΔT1 and ΔT2), as defined by the ASME Code, because these gradients cause a biaxial stress with stresses in the axial and hoop direction of the pipe wall that have approximately equal magnitudes.

   The portion of stress caused by ΔT4 is purely axial because it represents the excess axial stress not included in the calculation of bending moments resulting from a linear top-to-bottom temperature difference. Because this stress is caused only by restrained thermal growth in the axial direction, the correct formula for calculation of this portion of axial stress is the product of the Young's Modulus (E), the thermal expansion coefficient (α), and ΔT4 (i.e., (E)(α)(ΔT4)).

References

1. Blumer, U., Steffen, G., and Meissner, H., "Fatigue in Piping Caused by Fluid Stratification – An Extension to Piping Codes", Transactions of the 9th International Conference on Structural Mechanics in Reactor Technology (SMiRT), Volume D, pp. 335 – 342.

FSAR Impact:

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

Figure 03.09.01-14-1—Temperature Profile along the Pipe-Cross Section at Mid-Thickness (Case 1)

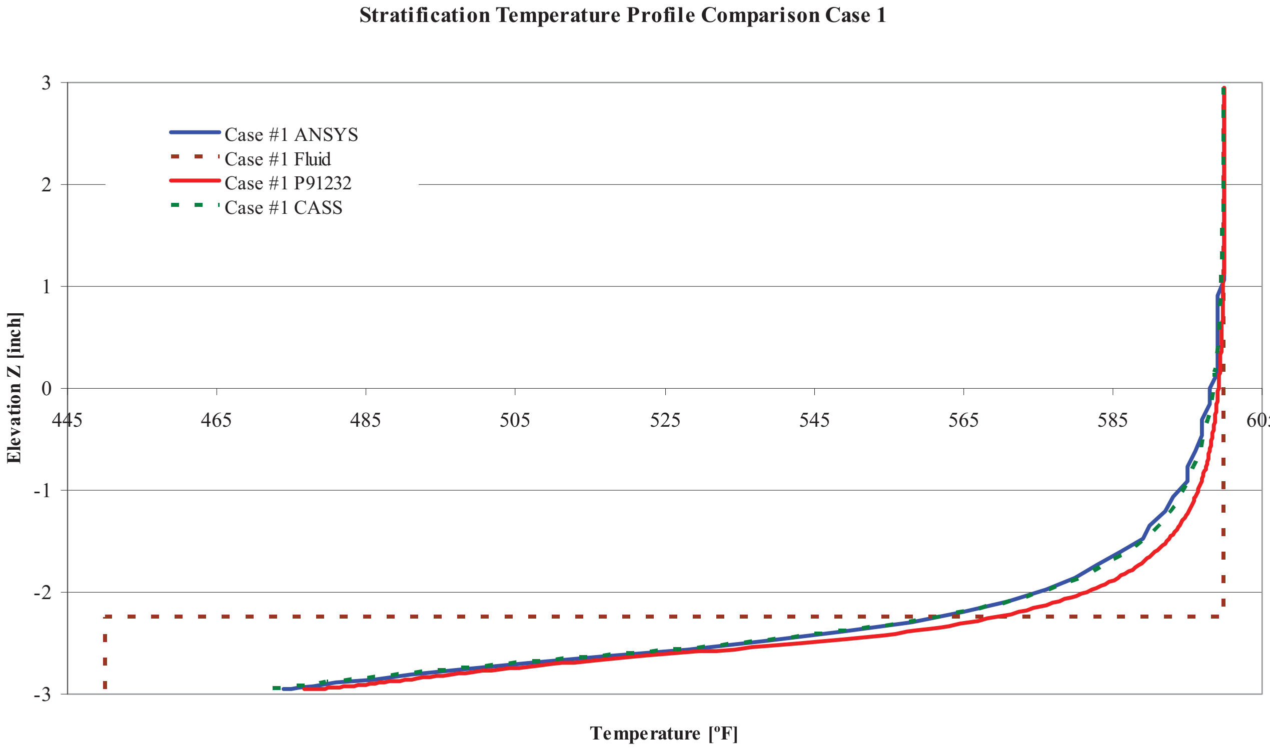
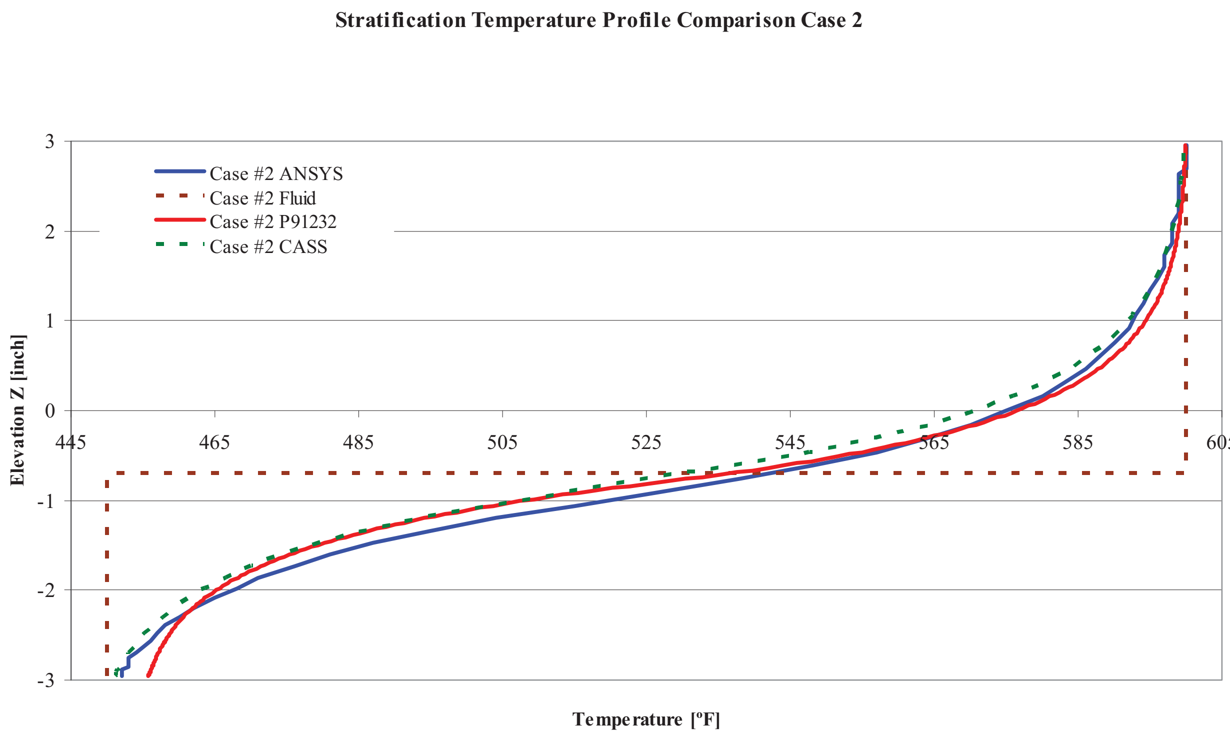


Figure 03.09.01-14-2—Temperature Profile along the Pipe-Cross Section at Mid-Thickness (Case 2)



Question 03.09.01-15:

FSAR 3.9.1.2 identified that computer program RESPECT is to be used for EPR design. The staff reviewed the supporting documents for the program RESPECT and noted that the validation is not found for RESPECT computer program that generates response spectrum from an acceleration time history for un-broaden and broaden spectra that will be used in the downstream response spectrum piping analysis. The staff requests AREVA to provide validation for this computer program.

Response to Question 03.09.01-15:

The validation of the following functionalities for RESPECT software is performed:

1. Generate a response spectrum (RS) from an acceleration time history input.
2. Perform peak-broadening to an un-broadened response spectrum input.

Validation of RESPECT Functionality to Generate RS from Time Histories

The acceptance criteria for the benchmarking of RESPECT results are obtained from Reference 1, Chapter 6. The benchmark case contained in Reference 1 is the north-south component of the ground motion recorded at a site in El Centro, California during the Imperial Valley, California earthquake of May 18, 1940.

Reference 1, Appendix 6 provides the benchmark input time history. Reference 1, Figure 6.6.4 for damping ratios of 0, 2, 5, 10 and 20 percent show the resultant determined, pseudo-response spectrum acceleration.

The time history from Reference 1, Appendix 6 is input into RESPECT and executed using the same parameters. The output response spectrum plots from Reference 1, Figure 6.6.4 for the 5 percent and 2 percent damping are plotted against the respective RESPECT output response spectrum. The resultant plots are shown in Figure 03.09.01-15-1 and Figure 03.09.01-15-2. The comparison of the un-broadened response spectrum between RESPECT and Reference 1 shows good agreement. Therefore, RESPECT is validated for the functionality of response spectrum generation from a given time history.

A supplement validation, which compares RESPECT results against *RESPEC* (validated AREVA NP internal software) results, as shown in Figure 03.09.01-15-3 and Figure 03.09.01-15-4, also indicates that RESPECT adequately generates a response spectrum given a time history input.

Validation of RESPECT Functionality to Peak-Broaden Input Response Spectra

The RESPECT software is tested for its ability to peak-broaden an input raw (un-broadened) seismic response spectrum. Calculations at specified locations are performed to validate the RESPECT results according to the requirements of peak-broadening in RG 1.122. Calculations are performed at select localized peaks to test the +20 percent and -20 percent peak-broadening functionality of RESPECT as demonstrated in Figure 03.09.01-15-5 and Figure 03.09.01-15-6.

Figure 03.09.01-15-5 and Figure 03.09.01-15-6 show that the RESPECT resultant peak-broadening envelopes the shifted input response spectra. These figures also confirm that the RESPECT resultant peak-broadening follows along the path of the shifted input response spectra at appropriate locations. The RESPECT functionality to perform peak-broadening is validated. Results are considered sufficient to validate a peak-broadening of 20 percent and any other percentage.

References:

1. Chopra, Anil K., "Dynamics of Structures – Theory and Application to Earthquake Engineering," 3rd Edition (2007); Pearson Prentice Hall; Upper Saddle River, New Jersey (ISBN10: 013156174X)

FSAR Impact:

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

Figure 03.09.01-15-1—Comparison of Unbroadened 5% Spectrum

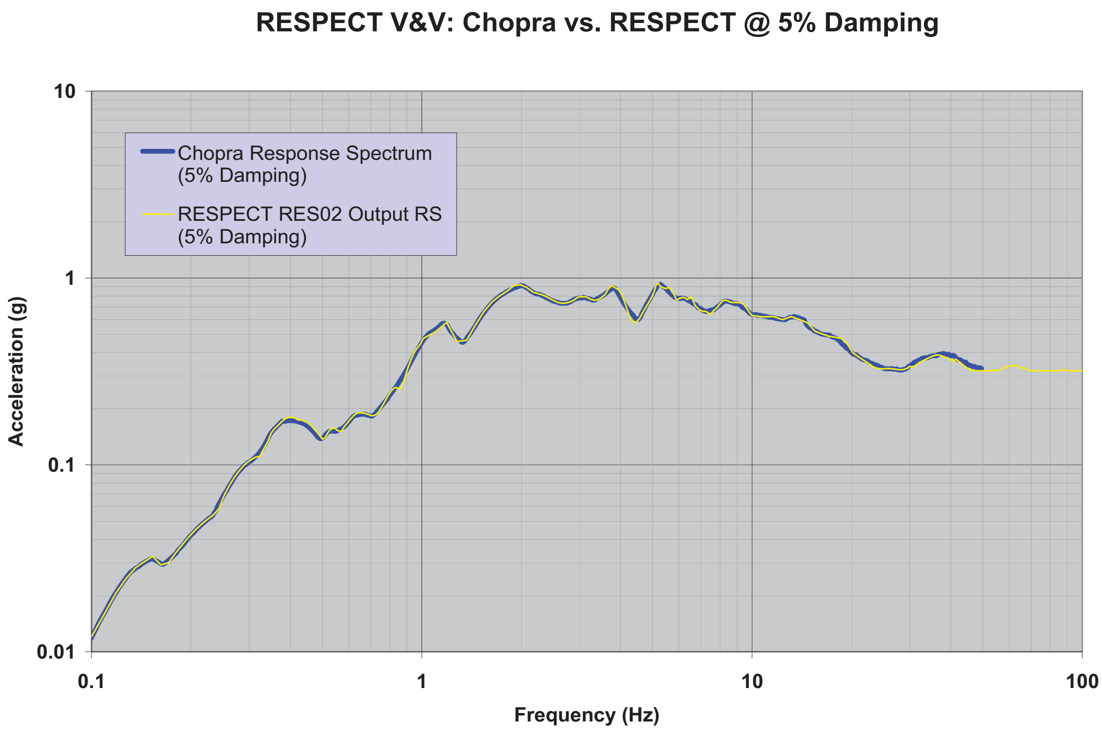


Figure 03.09.01-15-2—Comparison of Unbroadened 2% Spectrum

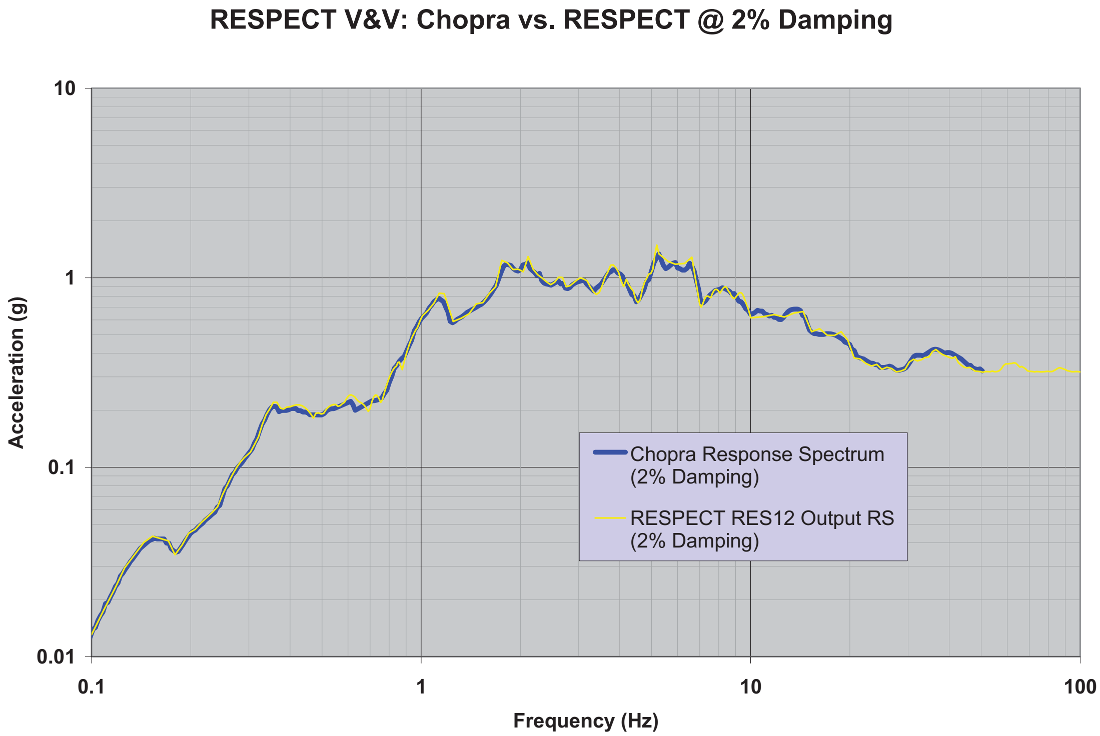


Figure 03.09.01-15-3: Comparison of 5% Response Spectrum between RESPECT and RESPEC

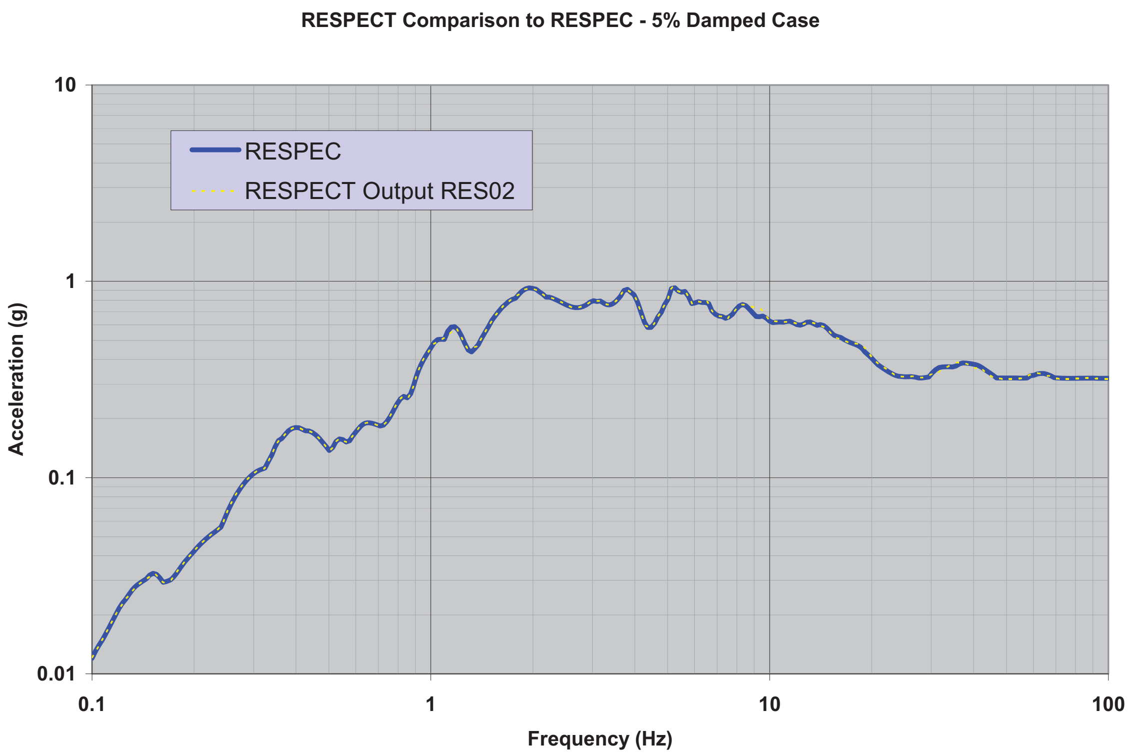


Figure 03.09.01-15-4—Comparison of 2% Response between RESPECT and RESPEC

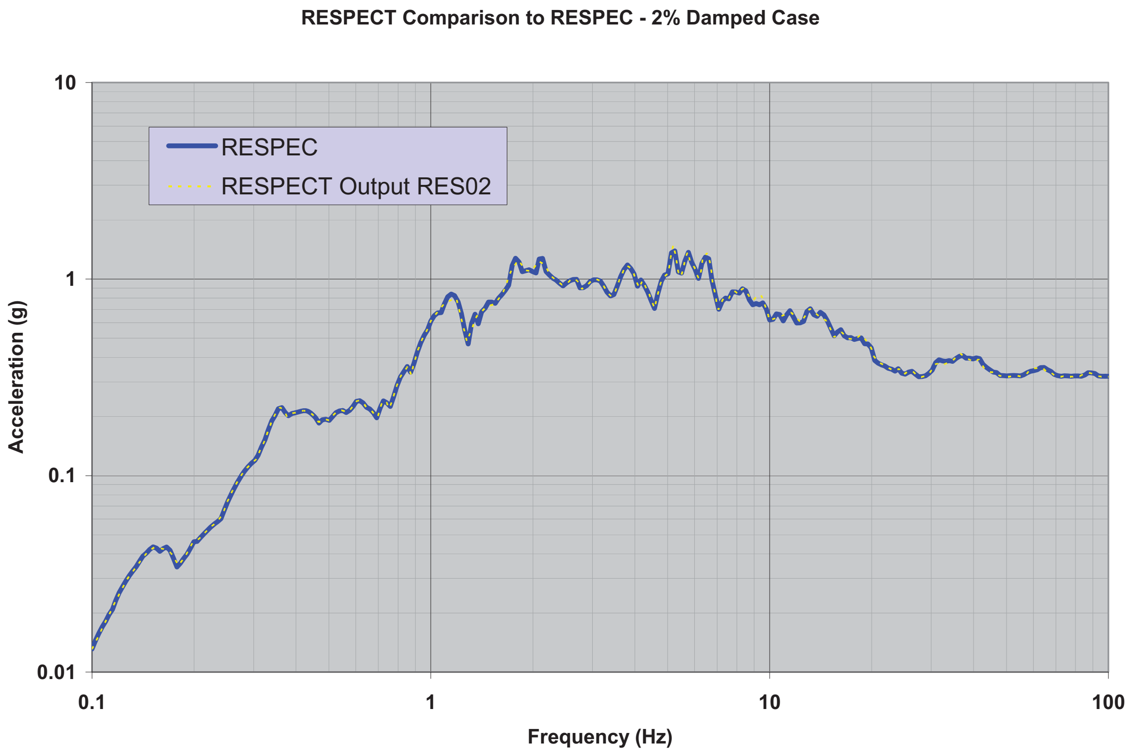


Figure 03.09.01-15-5—Validation of 20% Peak-Broadening for RESPECT (5% Damping)

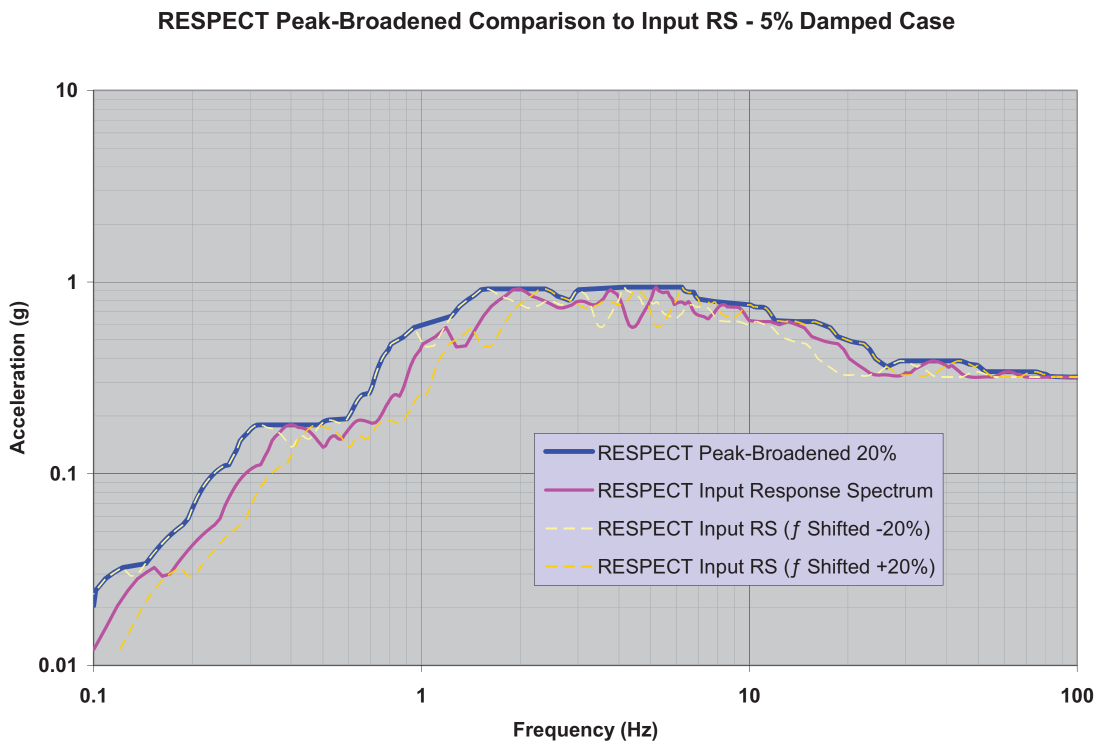


Figure 03.09.01-15-6—Validation of 20% Peak-Broadening for RESPECT (2% Damping)