ArevaEPRDCPEm Resource

From: BRYAN Martin (EXT) [Martin.Bryan.ext@areva.com]
Sent: Thursday, April 08, 2010 2:55 PM
To: Tesfaye, Getachew
Cc: DELANO Karen V (AREVA NP INC); BENNETT Kathy A (OFR) (AREVA NP INC); ROMINE Judy (AREVA NP INC); HAMMOND Philip R (AREVA NP INC)
Subject: Response to U.S. EPR Design Certification Application RAI No. 331, FSAR Ch. 3, Supplement 2
Attachments: RAI 331 Supplement 2 Response US EPR DC.pdf

Getachew,

AREVA NP Inc. provided a schedule for a technically correct and complete response to RAI No. 331 on January 7, 2010. AREVA NP submitted Supplement 1 to the response on March 2, 2010 to address 3 of the 7 remaining questions. The attached file, "RAI 331 Supplement 2 Response US EPR DC" provides technically correct and complete responses to the 4 remaining questions, as committed.

Appended to this file are affected pages of the U.S. EPR Final Safety Analysis Report in redline-strikeout format which support the response to RAI 331 Question 03.09.02-63.

Appended to this file are affected pages of technical report ANP-10306NP, 'Comprehensive Vibration Assessment Program for U.S. EPR™ Reactor Internals Technical Report' in redline-strikeout format which support the response to RAI 331 Question 03.09.02-65.

The following table indicates the respective pages in the response document, "RAI 331 Supplement 2 Response US EPR DC," that contain AREVA NP's response to the subject questions.

Question #	Start Page	End Page
RAI 331 — 03.09.02-63	2	2
RAI 331 — 03.09.02-64	3	4
RAI 331 — 03.09.02-65	5	6
RAI 331 — 03.09.02-66	7	8

This concludes the formal AREVA NP response to RAI 331, and there are no questions from this RAI for which AREVA NP has not provided responses.

Sincerely,

Martin (Marty) C. Bryan
Licensing Advisory Engineer
AREVA NP Inc.
Tel: (434) 832-3016
Martin.Bryan.ext@areva.com

From: BRYAN Martin (EXT)
Sent: Tuesday, March 02, 2010 1:00 PM
To: 'Tesfaye, Getachew'
Cc: DELANO Karen V (AREVA NP INC); BENNETT Kathy A (OFR) (AREVA NP INC); ROMINE Judy (AREVA NP INC);

HAMMOND Philip R (AREVA NP INC)
Subject: Response to U.S. EPR Design Certification Application RAI No. 331, FSAR Ch. 3, Supplement 1

Getachew,

AREVA NP Inc. provided a schedule for a technically correct and complete response to RAI No. 331 on January 7, 2010. The attached file, "RAI 331 Supplement 1 Response US EPR DC.pdf," provides technically correct and complete responses to 3 of the remaining 7 questions, as committed.

Appended to this file are affected pages of the U.S. EPR Final Safety Analysis Report in redline-strikeout format which supports the response to RAI 331 Questions 03.09.02-62 and 03.09.02-67.

The following table indicates the respective pages in the response document, "RAI 331 Supplement 1 Response US EPR DC.pdf," that contain AREVA NP's response to the subject questions.

Question #	Start Page	End Page
RAI 331 — 03.09.02-62	2	4
RAI 331 — 03.09.02-67	5	9
RAI 331 — 03.12-22	10	10

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

Question #	Response Date
RAI 331 — 03.09.02-63	April 8, 2010
RAI 331 — 03.09.02-64	April 8, 2010
RAI 331 — 03.09.02-65	April 8, 2010
RAI 331 — 03.09.02-66	April 8, 2010

Sincerely,

Martin (Marty) C. Bryan
Licensing Advisory Engineer
AREVA NP Inc.
Tel: (434) 832-3016
Martin.Bryan@areva.com

From: Pederson Ronda M (AREVA NP INC)
Sent: Thursday, January 07, 2010 6:28 PM
To: 'Tesfaye, Getachew'
Cc: BENNETT Kathy A (OFR) (AREVA NP INC); DELANO Karen V (AREVA NP INC); HAMMOND Philip R (AREVA NP INC)
Subject: Response to U.S. EPR Design Certification Application RAI No. 331, FSAR Ch. 3

Getachew,

Attached please find AREVA NP Inc.'s response to the subject request for additional information (RAI). The attached file, "RAI 331 Response US EPR DC.pdf," provides the schedule for technically correct and complete responses to these questions.

The following table indicates the respective pages in the response document, "RAI 331 Response US EPR DC.pdf," that contain AREVA NP's response to the subject questions.

Question #	Start Page	End Page
RAI 331 — 03.09.02-62	2	3
RAI 331 — 03.09.02-63	4	4
RAI 331 — 03.09.02-64	5	5
RAI 331 — 03.09.02-65	6	7
RAI 331 — 03.09.02-66	8	8
RAI 331 — 03.09.02-67	9	11
RAI 331 — 03.12-22	12	12

The schedule for technically correct and complete responses to these questions is provided below.

Question #	Response Date
RAI 331 — 03.09.02-62	March 4, 2010
RAI 331 — 03.09.02-63	April 8, 2010
RAI 331 — 03.09.02-64	April 8, 2010
RAI 331 — 03.09.02-65	April 8, 2010
RAI 331 — 03.09.02-66	April 8, 2010
RAI 331 — 03.09.02-67	March 4, 2010
RAI 331 — 03.12-22	March 4, 2010

Sincerely,

Ronda Pederson

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Licensing Manager, U.S. EPR Design Certification
AREVA NP Inc.
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3315 Old Forest Road
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From: Tesfaye, Getachew [mailto:Getachew.Tesfaye@nrc.gov]
Sent: Monday, November 30, 2009 12:04 PM
To: ZZ-DL-A-USEPR-DL
Cc: Spicher, Terri; Hsu, Kaihwa; Dixon-Herrity, Jennifer; Patel, Jay; Miernicki, Michael; Colaccino, Joseph; ArevaEPRDCPEm Resource
Subject: U.S. EPR Design Certification Application RAI No. 331 (4024, 4026),FSAR Ch. 3

Attached please find the subject requests for additional information (RAI). A draft of the RAI was provided to you on November 18, 2009, and on November 24, 2009, 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: 1303

Mail Envelope Properties (BC417D9255991046A37DD56CF597DB7105CA6287)

Subject: Response to U.S. EPR Design Certification Application RAI No. 331, FSAR Ch. 3, Supplement 2
Sent Date: 4/8/2010 2:55:20 PM
Received Date: 4/8/2010 2:55:33 PM
From: BRYAN Martin (EXT)

Created By: Martin.Bryan.ext@areva.com

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"DELANO Karen V (AREVA NP INC)" <Karen.Delano@areva.com>
Tracking Status: None
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Tracking Status: None
"Tesfaye, Getachew" <Getachew.Tesfaye@nrc.gov>
Tracking Status: None

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Files	Size	Date & Time
MESSAGE	6197	4/8/2010 2:55:33 PM
RAI 331 Supplement 2 Response US EPR DC.pdf		166059

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

Response to

Request for Additional Information No. 331, Supplement 2

11/30/2009

U.S. EPR Standard Design Certification
AREVA NP Inc.
Docket No. 52-020
SRP Section: 03.09.02 - Dynamic Testing and Analysis of Systems Structures and Components
SRP Section: 03.12 - ASME Code Class 1, 2, and 3 Piping Systems and Piping Components and Their Associated Supports

Application Section: FSAR Chapter 3

QUESTIONS for Engineering Mechanics Branch 1 (AP1000/EPR Projects) (EMB1)

Question 03.09.02-63:

Follow-up to Question 03.09.02-41:

The applicant responded to **RAI 03.09.02-15** in their Response to Request for Additional Information No. 160, Revision 0, by stating that the vibration monitoring evaluation method VMG-2, as described in Reference 3 of U.S. EPR FSAR Tier 2, Section 3.9.2.7, is used to evaluate the Level A and Level B vibrations in the U.S. EPR piping systems. VMG-2 is the method by which the vibration is evaluated, involving beam calculations of the piping to develop conservative criteria for vibration velocity and displacement based on limiting the stress to the fatigue stress limit. As stated in U.S. EPR FSAR Tier 2, Section 3.9.2.1.1, in the event that vibrations arising from Level A or Level B loads in Phase I and Phase II tests are observed to be excessive when compared to those computed using the VMG-2 method, more detailed analyses based on VMG-1 methodology may be performed to demonstrate the acceptability of measured vibrations. If unacceptable results are obtained, appropriate corrective actions will be performed and included in the results of the comprehensive vibration assessment program, which is the responsibility of the COL holder as noted in U.S. EPR FSAR Tier 2, Table 1.8-2. The staff reviewed the applicant's response and could not determine if the applicant will perform additional testing after corrective action is taken. In addition, a reference to a comprehensive vibration program that includes piping vibration assessment was not identified in U.S. EPR FSAR Tier 2, Table 1.8-2. Therefore, the staff issued follow up **RAI 03.09.02-41** to request that further information be provided regarding additional testing after corrective action is taken. The applicant responded to **RAI 03.09.02-41** in their response to Request for Additional Information No. 245 (2981, 3036), Revision 0, by stating that if unacceptable results are obtained, corrective actions will be performed and included in the results of the comprehensive vibration assessment program for piping and steam generator upper internals, and additional testing will be performed after corrective action is taken. The staff accepts that the applicant's commitment to perform additional testing after corrective action is performed meets the recommendations of SRP 3.9.2. However, as stated in U.S. EPR FSAR Tier 2, Section 1.8.1 "COL Information Items", Table 1.8-2—U.S. EPR Combined License Information Items, lists the COL information items ***and the section where the information is discussed***. A COL applicant that references the U.S. EPR design certification will identify the FSAR section, or provide a list, that demonstrates how the COL information items have been addressed. The staff could not locate the FSAR section in U.S. EPR FSAR Tier 2, Table 1.8-2 that references a comprehensive vibration program or a list that demonstrates how the COL information items have been addressed for all piping systems specified in U.S. EPR FSAR Tier 2, Section 3.9.2.1. Therefore, AREVA is requested to address this issue.

Response to Question 03.09.02-63:

COL Item 3.9-1 in U.S. EPR FSAR Tier 2, Table 1.8-2 will be modified to address piping systems specified in U.S. EPR FSAR Tier 2, Section 3.9.2.1.

FSAR Impact:

U.S. EPR FSAR Tier 2, Table 1.8-2 will be revised as described in the response and indicated on the enclosed markup.

Question 03.09.02-64:

Follow-up to Question 03.09.02-43

In response to **RAI 03.09.02- 17**, the applicant stated that pressure-flow oscillations travel through the entire affected piping system with little attenuation and the vibrations from acoustic resonances are readily identifiable throughout an affected piping system. This is a basis for monitoring only representative trains of piping systems.

In follow up to **RAI 03.09.02- 17,** the staff issued **RAI 03.09.02-43**, and asked the applicant for clarification of the following (2) areas with respect to monitoring only representative trains of piping systems during start up testing:

1. explain how the applicant will localize a problem area so that corrective action can be taken, and
2. because conditions just below and just above that range of conditions where resonant lock-in occurs may produce locally high response levels, describe how measuring representative piping systems will determine that excessive vibration is not occurring in non-instrumented piping systems.

In response, the applicant described the screening methodology for flow excited acoustic resonance in the design of the reactor coolant system (RCS) and attached piping. The staff noted that the description of the design screening methodology does not explain how the applicant will localize a problem area so that corrective action can be taken, or describe how measuring representative piping systems will determine that excessive vibration is not occurring in non-instrumented piping systems. Therefore, AREVA is requested to address this issue.

Response to Question 03.09.02-64:

Representative piping systems may be regarded as such only if they are all part of the same overall plant system (e.g. Main Steam System), and have the same components and similar piping routing, particularly for branch piping. To be considered representative piping systems, the main piping needs to be of the same diameter, and have essentially the same flow conditions. Distances to the first upstream elbow, and distances between standpipes need to be essentially the same. Branch piping needs to have the same length and diameter in the systems. If an acoustic resonance occurs on one line, the same is expected at nearly the same flow conditions in the other representative lines.

The frequency of the flow excited resonance, along with the flow rate at which it occurs, provide characteristics that identify the wavelength which indicates the length of the affected branch line. The Strouhal number $\frac{Frequency * Diameter}{Velocity}$ at which resonance occurs is in the range 0.3 to 0.63, per S. Ziada and S. Shine, “Strouhal Numbers of Flow- Excited Acoustic Resonance of Closed Side Branches”, Journal of Fluids and Structures, Volume 13, Issue 1, January 1999, pages 127 to 142. This identifies the range of diameters of the branch line opening at which resonance occurs.

With the length and diameter information, the branch line experiencing resonance may be identified on the line that is measured and the branch lines on other representative lines.

Should this occur, corrective actions will be taken to solve the resonance issue for all of the representative lines.

FSAR Impact:

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

Technical Report Impact:

ANP-10306P, “Comprehensive Vibration Assessment Program for U.S. EPR Reactor Internals Technical Report,” Revision 1 incorporates the changes as described in the response.

Question 03.09.02-65:

Follow-up to Question 03.09.02-58

In response to **RAI 03.09.02- 25**, the applicant states that excessive vibrations due to acoustic resonances as a result of flow in attached piping systems are eliminated by verifying that the piping systems are screened for this phenomenon in the design phase. In follow up to **RAI 03.09.02- 25,** the staff issued **RAI 03.09.02-58**, and requested that the applicant provide:

1. the methodology used in screening the U.S. EPR steam system design for potential flow-excited and structural resonances, and
2. the results of its implementation of the methodology for the U.S. EPR design, and
3. discuss the performance of scale model testing to confirm the validity of the methodology in predicting resonance in the U.S. EPR steam system, and
4. include the methodology and scale modeling testing information in DCD, Tier 2 Section 3.9.2.

The applicant responded as follows:

1. The methodology used in screening for sources of acoustic resonance in the U.S. EPR is described ASME Journal of Pressure Vessel Technology, Volume 108/267, August 1986, titled "Flow-Induced Vibration in Safety Relief Valves," by R.M. Baldwin and H.R. Simmons, (also see the Response to RAI 160, RAI **03.09.02-25**). The response to **RAI 03.09.02-43** expands on the design criteria described by R.M. Baldwin and H.R. Simmons to provide an overview of the methodology to be incorporated into the design criteria for the reactor coolant system (RCS) piping as well as the design of piping attached to the steam generator (SG). This design objective and its evaluation will be included in the comprehensive vibration assessment program for the steam generator (SG) and applicable piping systems (RCS, main steam system (MSS), and feedwater system (MFWS)).
2. Implementation of the methodology will be performed later in the design process.
3. The screening methodology provided in the Response to **RAI 03.09.02-43** is based on testing of 40 in-service valves and standoff branch lines and is the method typically followed by the industry when screening for this source of excitation.
4. Scale model testing was not a part of the confirming the validity of the methodology.

The staff reviewed the applicant's response and noted that the methodology described in the response to **RAI 03.09.02-43** and the referenced ASME journal, is intended to prevent the possibility of vortex shedding over stand pipes, branch lines and cavities from coupling into acoustic and structural resonances of piping. The applicable systems are RCS, Main Steam, and Main Feedwater. The methodology outlined by the applicant follows that described in the referenced ASME journal by Baldwin and Simmons (1986). The applicant stated that the screening methodology is described in the response to **RAI 03.09.02-43** and that the approach to screen piping systems that may require corrective action is based upon Baldwin's research. Piping systems that may require corrective action have a Strouhal number in the range between 0.3 and 0.6. The applicant further stated in the response to **RAI 03.09.02-43** that if standoff pipes are found to be susceptible to acoustic resonance, as determined by a Strouhal number between 0.3 and 0.6, through the entire operating range of flow, then measures will be taken to redesign the piping so that acoustic resonance will not occur.

The staff noted that other applicants for new plant design base their screening on more recent studies, such as Ziada and Shine (1999). The Ziada and Shine study indicates that there are piping system configurations for which the Strouhal number range should be expanded to between 0.3 and 0.63. The difference between the Ziada and Shine study and the Baldwin and Simmons is that Baldwin and Simmons examined the case of a single side branch located in a straight section of pipe, whereas Ziada and Shine extended the work to include the interactions between a small set of piping components and configurations. The Ziada and Shine study involved more detailed configurations that included a side branch just downstream of an elbow, two side branches on the same side of the pipe and two side branches opposite of each other. The Ziada and Shine study demonstrates that for conservative screening purposes, there are piping configurations for which an upper Strouhal number is 0.63.

The applicant is requested to justify why an upper Strouhal number of is 0.6 is used in the piping screening criteria for the basis of determining that flow excitation in cavities of safety relief valves, standoff pipes and branch lines cannot occur. It is suggested that the applicant review the Ziada and Shine study, especially Figure 14 (flow past a side branch downstream of an elbow) and determine the applicability of a higher Strouhal number for screening criteria.

Reference:

S. Ziada, S. Shine, “Strouhal Numbers Of Flow-Excited Acoustic Resonance Of Closed Side Branches,” Journal of Fluids and Structures, Volume 13, Issue 1, January 1999, Pages 127-142.

Response to Question 03.09.02-65:

Screening for acoustic resonance will be performed in accordance with “Strouhal Numbers of Flow- Excited Acoustic Resonance of Closed Side Branches” with a Strouhal number range of 0.3 to 0.63, rather than 0.3 to 0.6. Technical report ANP-10306P, ‘Comprehensive Vibration Assessment Program for U.S. EPR™ Reactor Internals Technical Report’,” submitted to NRC for review December 11, 2009, will be revised to reflect the modified screening criteria as indicated on the enclosed markup.

FSAR Impact:

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

Question 03.09.02-66:

Follow-up to Question 03.09.02-60

In a follow up RAI to **03.09.02-26,** the staff issued RAI **03.09.02-60** requesting the applicant to provide the information previously requested in RAI **03.09.02-26**. "For example, AREVA did not address the consideration of sensitivities in the arrangement, design, size, and operating conditions of the U.S. EPR steam system that can influence flow-excited and structural resonances. Further, AREVA did not explain which U.S. EPR operating conditions could lead to resonance conditions in the steam generators, or discuss how the startup test plan will demonstrate that no flow-induced resonance effects will occur during the design life of the plant that could lead to excessive vibration and damage to components in the steam generation system. The NRC staff requests that AREVA address these considerations in its response to this RAI and include in DCD, Tier 2 Section 3.9.2."

The applicant stated that RAI **03.09.02-60** is addressed by their response to RAI **03.09.02-40** which states that the Initial Test Program (ITP) contains several tests that will require monitoring vibration and dynamic effects. The applicant further stated in their response to question **03.09.02-60** that the ITP "will demonstrate that no flow-induced resonance effects will occur during the design life of the plant that could lead to excessive vibration and damage to components in the steam generation system."

The staff reviewed the applicant's response and reference RAI **03.09.02-40** and U.S. EPR FSAR Tier 2, Section 14.2. The applicant cited tests 164 and 165 in U.S. EPR FSAR Tier 2, Section 14.2 as examples of the tests that apply to measurement of the steam system vibration response. The staff examined these referenced tests, as well as others located in U.S. EPR FSAR Tier 2, Section 14.2 and noted that they are presented as abstracts and not actual test procedures. Upon further review, the staff noted that detailed information requested in RAI **03.09.02-60,** such as sensitivities of the steam system components and operating points which could result in flow-induced resonance in the steam piping or steam generator could not be located. In addition, the staff could not locate where the applicant discussed how the startup test plan will demonstrate that no flow-induced resonance effects will occur during the design life of the plant that could lead to excessive vibration and damage to components in the steam generation system. Therefore, AREVA is requested to address this issue.

Response to Question 03.09.02-66:

As addressed in the responses to RAI 331 Questions 03.09.02-64 and 03.09.02-65, screening for acoustic resonances will be performed to determine if acoustic resonances will occur, and preventive actions will be taken if needed in the design of the piping.

Measurements of accelerometers attached to piping, with Power Spectral Densities (PSD's) of the data, have effectively shown acoustic resonances, with very high Q-factor peaks at a specific frequency in a critical range of flow rates as determined by the Strouhal number. With regard to sensitivities in the arrangement, design, size and operating conditions of the Main Steam System, these are lengths and diameters of standpipes, distances to the first upstream elbow, distances between standpipes, and flow velocity in the main line, as discussed in the response to RAI 331 Question 03.09.02-64. The pre-operational / start-up testing will be performed over the entire range of power and flow conditions at appropriate increments of power and flow rates. The specific details of the test plan will be developed later in the design process.

As a minimum, all safety-related piping systems will be included in the test program, as well as other important piping systems such as the Condensate System.

The piping vibration program will be based on ASME OM-S/G Part 3, and the test specification will include the systems to be tested, including boundaries, pretest requirements or conditions, test conditions and hold points, measurements to be made, locations of measurements, and acceptable limits of measurements.

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

Table 1.8-2—U.S. EPR Combined License Information Items
Sheet 18 of 48

03.09.02-63

Item No.	Description	Section	Action Required by COL Applicant	Action Required by COL Holder
3.9-1	A COL applicant that references the U.S. EPR design certification will submit the results from the vibration assessment program for the U.S. EPR RPV internals, and piping systems specified in U.S. EPR FSAR Tier 2, Section 3.9.2.1, in accordance with RG 1.20.	3.9.2.4		Y
3.9-2	A COL applicant that references the U.S. EPR design certification will prepare the design specifications and design reports for ASME Class 1, 2, and 3 components, piping, supports and core support structures that comply with and are certified to the requirements of Section III of the ASME Code.	3.9.3		Y
	The COL applicant will address the results and conclusions from the reactor internals material reliability programs applicable to the U.S. EPR reactor internals with regard to known aging degradation mechanisms such as irradiation-assisted stress corrosion cracking or void swelling.			
3.9-3	A COL applicant that references the U.S. EPR design certification will examine the feedwater line welds after hot functional testing prior to fuel loading and at the first refueling outage, in accordance with NRC Bulletin 79-13. A COL applicant that references the U.S. EPR design certification will report the results of inspections to the NRC, in accordance with NRC Bulletin 79-13.	3.9.3.1.1		Y
3.9-4	As noted in ANP-10264NP-A, a COL applicant that references the U.S. EPR design certification will confirm that thermal deflections do not create adverse conditions during hot functional testing.	3.9.3.1.1		Y

Comprehensive Vibration Assessment Program for U.S. EPR Reactor Internals Technical Report Markups

8.0 REFERENCES

1. U.S. Nuclear Regulatory Guide 1.20 (Rev 03), "Comprehensive Vibration Assessment Program for Reactor Internals during Preoperational and Initial Startup Testing," March 2007.
2. Blevins, Robert D., Flow-Induced Vibrations, 2nd edition, 2001.
3. Vibrations des structures – Interactions avec les fluides – Sources d'excitations aléatoires - R.J. GIBERT – Eyrolles Editions, 1988.
4. M. K. Au-Yang, "Flow-Induced Vibration of Power and Process Plant Components." New York: ASME Press, 2001.
5. NRC Regulatory Guide 1.207, "Guidelines for Evaluating Fatigue Analyses Incorporating the Life Reduction of Metal Components Due to the Effects of the Light-Water Reactor Environment for New Reactors," March 2007.
6. NUREG/CR-6909 (ANL-06/08), "Effect of LWR Coolant Environments on the Fatigue Life of Reactor Materials," February 2007.
7. B. Brenneman, "Random Vibrations Due to Small-Scale Turbulence with the Coherence Integral Method," ASME Journal of Vibration, Acoustics, Stress, and Reliability in Design, Vol. 109, April 1987.
8. A. Powell, "On the Fatigue Failure of Structures Due to Vibrations Excited by Random Pressure Fields," Journal of Acoustical Society of America, Vol. 30, No. 12, 1958, pp. 1130-1135.
9. ASME Boiler and Pressure Vessel Code, 2004 Edition with no Addenda
   a. Section III, Appendix N-1300 (non-mandatory appendix)
   b. Section II, Part D, Design Stress Intensity Values, Allowable Stresses, Material Properties.
   c. Section III, Appendix I.
10. Regulatory Guide 1.68 Revision 3, "Initial Test Programs for Water-Cooled Nuclear Power Plants," March 2007.
11. Regulatory Guide 1.70 Revision 3 "Standard Format and Content of Safety Analysis Reports for Nuclear Power Plants," November 1978.

03.09.02-65

12. ASME OM-S/G 2007, "Operation and Maintenance of Nuclear Power Plants," Part 3
13. S. Ziada, S. Shine, "Strouhal Numbers of Flow-Excited Acoutic Resonance of Closed Side Branches," Journal of Fluids and Structures, Volume 13, Issue 1, January 1999, Pages 127-142.
14. "Impedance-Coupled Valve and Fluid System Instability," John Lynch, Advances in Mathematics, Computations and Reactor Physics, Volume 3, International Topical Meeting among American Nuclear Society, Atomic Energy Society of Japan, and European Nuclear Society, 1991.

Equation 3: $$S = \frac{Cd}{4LU}$$

These pulsations can be further amplified by the main pipe resonance if the standing wave has a maximum velocity near the side branch entrance. The acoustic impedances will match with that frequency, and the side branch resonance will couple with the main pipe resonance. This scenario may cause significant vibration of the safety relief valves or other structures in the piping systems whose structural frequencies are coincident with the acoustic and vortex-shedding frequencies. This condition may also cause safety relief valves to leak and chatter. Conversely, if the side branch is located near a main piping velocity node (pressure maximum), an impedance mismatch occurs and the stub standing wave will attenuate.

To prevent the generation of noise and the subsequent acoustic resonant condition, testing was performed by Baldwin and Simmons (Reference 13) and combined with field data for 40 valves to conclude that the lowest Strouhal number where no coupling should occur is about 0.63. Substituting U/C = M (Mach number) into the expression for the Strouhal number and setting the Strouhal number equal to 0.63 yields the following design relationship, where acoustic resonance conditions will not occur. The Mach number is a function of the fluid composition, state point and local free stream velocity:

03.09.02-65

Equation 4: $$\frac{d}{L} > 2.4M$$

The maximum allowable length-to-diameter ratio of the cavity is defined by the Mach number of the flow past the side branch. By following this design criterion, a Strouhal number of no less than 0.63 is maintained for maximum flow velocity for plant operating conditions.

Additional research (Reference 16) indicates the blend radius (r) at the mouth of the cavity is also important, depending on the forged piping connection being a sweepolet, vesselet, or other type: the critical flow velocity scales with blend radius (r) + standpipe inside diameter (d). The modified diameter (d+ r) can be viewed to be the equivalent “d” after the blend radius is taken into consideration. Therefore, Equation 1 can be further refined as:

Equation 5: $$f = \frac{SU}{(d + r)}$$