AREVA

March 24, 2011
NRC:11:027

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

Response to U.S. EPR Design Certification Application RAI No. 422, Supplement 13

In Reference 1, the NRC provided a request for additional information (RAI) regarding the U.S. EPR design certification application. Reference 2 provided a schedule for technically correct and complete responses to RAI No. 422. Reference 3 provided a technically correct and complete response to 2 of the 63 questions. Reference 4 provided a revised schedule for a technically correct and complete response to the remaining 61 questions based on additional evaluations. Reference 5 provided a revised schedule for a technically correct and complete response to 6 of the remaining 61 questions based on additional evaluations. Reference 6 provided a revised schedule for a technically correct and complete response to 16 of the remaining 61 questions to allow additional time for AREVA NP to interact with the NRC. Reference 7 provided a technically correct and complete response to 11 of the remaining 61 questions. Reference 8 provided a revised schedule for a technically correct and complete response to 13 of the remaining 50 questions to allow additional time for AREVA NP to interact with the NRC. Reference 9 provided a revised schedule for a technically correct and complete response to 5 of the remaining 50 questions to allow additional time for AREVA NP to address NRC comments. Reference 10 provided a revised schedule for a technically correct and complete response to 3 of the remaining 50 questions based on additional evaluations. Reference 11 provided a revised schedule for a technically correct and complete response to 13 of the remaining 50 questions to allow additional time for AREVA NP to interact with the NRC. Reference 12 provided a revised schedule for a technically correct and complete response to 13 of the remaining 50 questions based on additional evaluations. Reference 13 provided a revised schedule for a technically correct and complete response to 16 of the remaining 50 questions based on additional evaluations. Reference 14 provided a revised schedule for a technically correct and complete response to 18 of the remaining 50 questions to allow additional time for AREVA NP to interact with the NRC.

The attached file, "RAI 422 Supplement 13 Response US EPR DC - Proprietary.pdf" provides a technically correct and complete response to 1 of the 50 remaining questions. AREVA NP considers some of the material contained in the attached response to be proprietary. As required by 10 CFR 2.390(b), an affidavit is attached to support the withholding of the information from public disclosure.

The following table indicates the respective pages in the response document, "RAI 422 Supplement 13 Response US EPR DC - Proprietary.pdf," that contain AREVA NP's response to the subject question.

Question #	Start Page	End Page
RAI 422 — 03.09.02-126	2	5

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NRO

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The schedule for the technically correct and complete response to the remaining 49 questions is unchanged and is provided below.

Question #	Response Date
RAI 422 — 03.09.02-82	May 5, 2011
RAI 422 — 03.09.02-84	April 7, 2011
RAI 422 — 03.09.02-85	April 7, 2011
RAI 422 — 03.09.02-87	April 28, 2011
RAI 422 — 03.09.02-88	April 28, 2011
RAI 422 — 03.09.02-89	April 28, 2011
RAI 422 — 03.09.02-90	April 28, 2011
RAI 422 — 03.09.02-91	April 28, 2011
RAI 422 — 03.09.02-92	April 28, 2011
RAI 422 — 03.09.02-93	April 28, 2011
RAI 422 — 03.09.02-94	April 28, 2011
RAI 422 — 03.09.02-95	April 28, 2011
RAI 422 — 03.09.02-96	April 28, 2011
RAI 422 — 03.09.02-97	April 28, 2011
RAI 422 — 03.09.02-98	May 5, 2011
RAI 422 — 03.09.02-99	April 6, 2011
RAI 422 — 03.09.02-100	April 6, 2011
RAI 422 — 03.09.02-101	April 6, 2011
RAI 422 — 03.09.02-102	April 6, 2011
RAI 422 — 03.09.02-103	April 6, 2011
RAI 422 — 03.09.02-104	April 6, 2011
RAI 422 — 03.09.02-105	April 6, 2011
RAI 422 — 03.09.02-106	April 6, 2011
RAI 422 — 03.09.02-107	April 6, 2011
RAI 422 — 03.09.02-108	April 6, 2011
RAI 422 — 03.09.02-109	April 7, 2011
RAI 422 — 03.09.02-110	April 6, 2011
RAI 422 — 03.09.02-111	April 6, 2011
RAI 422 — 03.09.02-112	April 6, 2011
RAI 422 — 03.09.02-113	April 7, 2011
RAI 422 — 03.09.02-114	April 7, 2011
RAI 422 — 03.09.02-115	April 7, 2011
RAI 422 — 03.09.02-116	April 7, 2011
RAI 422 — 03.09.02-117	April 7, 2011
RAI 422 — 03.09.02-118	April 7, 2011
RAI 422 — 03.09.02-119	April 7, 2011
RAI 422 — 03.09.02-120	April 7, 2011
RAI 422 — 03.09.02-121	April 7, 2011
RAI 422 — 03.09.02-122	April 7, 2011
RAI 422 — 03.09.02-123	April 7, 2011
RAI 422 — 03.09.02-124	April 28, 2011
RAI 422 — 03.09.02-127	April 28, 2011
RAI 422 — 03.09.02-131	April 7, 2011

Question #	Response Date
RAI 422 — 03.09.02-134	April 28, 2011
RAI 422 — 03.09.02-138	April 28, 2011
RAI 422 — 03.09.02-140	April 28, 2011
RAI 422 — 03.09.02-142	April 28, 2011
RAI 422 — 03.09.02-144	April 7, 2011
RAI 422 — 03.09.02-145	May 5, 2011

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

Sincerely,

Sandra M. Sloan

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

Enclosures

cc: G. Tesfaye
Docket No. 52-020

References

Ref. 1: E-mail, Getachew Tesfaye (NRC) to Martin C. Bryan (AREVA NP Inc.), "U.S. EPR Design Certification Application RAI No. 422 (4792), FSAR Ch. 3," August 3, 2010.

Ref. 2: E-mail, Martin C. Bryan (AREVA NP Inc.) to Getachew Tesfaye (NRC), "Response to U.S. EPR Design Certification Application RAI No. 422, FSAR Ch. 3," September 2, 2010.

Ref. 3: E-mail, Martin C. Bryan (AREVA NP Inc.) to Getachew Tesfaye (NRC), "Response to U.S. EPR Design Certification Application RAI No. 422, FSAR Ch. 3, Supplement 1," September 9, 2010.

Ref. 4: E-mail, Martin C. Bryan (AREVA NP Inc.) to Getachew Tesfaye (NRC), "Response to U.S. EPR Design Certification Application RAI No. 422, FSAR Ch. 3, Supplement 2," September 27, 2010.

Ref. 5: E-mail, Martin C. Bryan (AREVA NP Inc.) to Getachew Tesfaye (NRC), "Response to U.S. EPR Design Certification Application RAI No. 422, FSAR Ch. 3, Supplement 3," November 2, 2010.

Ref. 6: E-mail, Martin C. Bryan (AREVA NP Inc.) to Getachew Tesfaye (NRC), "Response to U.S. EPR Design Certification Application RAI No. 422, FSAR Ch. 3, Supplement 4," November 22, 2010.

Ref. 7: E-mail, Martin C. Bryan (AREVA NP Inc.) to Getachew Tesfaye (NRC), "Response to U.S. EPR Design Certification Application RAI No. 422, FSAR Ch. 3, Supplement 5," December 22, 2010.

Ref. 8: E-mail, Martin C. Bryan (AREVA NP Inc.) to Getachew Tesfaye (NRC), "Response to U.S. EPR Design Certification Application RAI No. 422, FSAR Ch. 3, Supplement 6," January 12, 2011.

Ref. 9: E-mail, Martin C. Bryan (AREVA NP Inc.) to Getachew Tesfaye (NRC), "Response to U.S. EPR Design Certification Application RAI No. 422, FSAR Ch. 3, Supplement 7," January 13, 2011.

Ref. 10: E-mail, Martin C. Bryan (AREVA NP Inc.) to Getachew Tesfaye (NRC), "Response to U.S. EPR Design Certification Application RAI No. 422, FSAR Ch. 3, Supplement 8," January 27, 2011.

Ref. 11: E-mail, Martin C. Bryan (AREVA NP Inc.) to Getachew Tesfaye (NRC), "Response to U.S. EPR Design Certification Application RAI No. 422, FSAR Ch. 3, Supplement 9," February 8, 2011.

Ref. 12: E-mail, Martin C. Bryan (AREVA NP Inc.) to Getachew Tesfaye (NRC), "Response to U.S. EPR Design Certification Application RAI No. 422, FSAR Ch. 3, Supplement 10," February 10, 2011.

Ref. 13: E-mail, Martin C. Bryan (AREVA NP Inc.) to Getachew Tesfaye (NRC), "Response to U.S. EPR Design Certification Application RAI No. 422, FSAR Ch. 3, Supplement 11," February 17, 2011.

Ref. 14: E-mail, Russell Wells (AREVA NP Inc.) to Getachew Tesfaye (NRC), "Response to U.S. EPR Design Certification Application RAI No. 422, FSAR Ch. 3, Supplement 12," March 16, 2011.

AFFIDAVIT

COMMONWEALTH OF VIRGINIA)
) ss.
COUNTY OF CAMPBELL)

1. My name is Sandra M. Sloan. I am Manager, New Plants Regulatory Affairs 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 "RAI 422 Supplement 13 Response US EPR DC - PROPRIETARY.pdf" 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(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 has 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

day of March 24, 2011.

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. 422(4792), Revision 0, Supplement 13

8/3/2010

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
Application Section: 3.9.2

QUESTIONS for Engineering Mechanics Branch 2 (ESBWR/ABWR Projects) (EMB2)

Question 03.09.02-126:

This is related to RAI 03.09.02-48d.

Based on the upper limit discussed in CVAP section 4.3.2.1, the applicant is requested to expand CVAP Figure 4-28 to include the full range of CVAP Figure 4.29 and the analysis of the FDD so that the conservatism of the turbulent pressure spectrum can be assessed.

Response to Question 03.09.02-126:

Technical Report ANP-10306P, Figure 4-28 is reproduced in this response as Figure 03.09.02-126-1. The x-axis is expanded to include the dimensionless frequency F=16 or the maximum frequency of 206.8 Hz (or approximately 200 Hz), as depicted in Technical Report ANP-10306P, Figure 4-29. Refer to Table 03.09.02-129-1 for a correlation between the dimensionless and the dimensional frequencies.

The frequency cutoff limit for the analysis of the flow distribution device (FDD) was approximately 250 Hz, and the highest modal frequency determined for the FDD below this limit is [ ] Hz, as shown in Technical Report ANP-10306P, Figure 4-27. The flow induced vibration (FIV) analysis of the FDD was performed using a dimensional power spectral density (PSD) that was developed based on the higher velocity in the reactor vessel (RV) downcomer ([ ] ft/sec). The actual velocity through the FDD varies between [ ] and [ ] ft/sec. Figure 03.09.02-126-2 provides the dimensional pressure PSD for the three PSDs shown in Figure 03.09.02-126-1. In Figure 03.09.02-126-2, the x-axis is extended to include the range of frequencies evaluated for the FDD.

Referring to Figure 03.09.02-126-2, the pressure PSD is unconservative beyond approximately 155 Hz (or F=12). The response of modes 8, 9, and 10 are underpredicted with the PSD shown in Technical Report ANP-10306P, Figure 4-28. Because the response of the FDD decays with frequency as shown in Technical Report ANP-10306P, Figure 4-30, the contribution of these modes to the total response of the FDD is negligible. As predicted with the analysis and shown in Technical Report ANP-10306P, Figure 4-30, the response of these higher modes is less than four orders of magnitude than the maximum response determined for the largest contributing modes in the 60 to 70 Hz range.

Considering the conservatisms that are inherent in the PSD at the lower frequencies, the analytical evaluation of the FDD was conservative. However, the FDD analysis for random turbulence was revised to consider the PSD developed during the HYDRAVIB mockup flow test for the lower plenum of the reactor pressure vessel (RPV). Technical Report ANP-10306P, Section 4.3.2, Figure 4-29, Section 4.3.4, and Table 4-13 through Table 4-16 will be revised to provide the response of the FDD for the new PSD.

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 0, Section 4.3.2, Figure 4-29, Section 4.3.4, and Table 4-13 through Table 4-16 will be revised as described in the response and indicated on the enclosed markup.

Figure 03.09.02-126-1—Comparison of RPV PSDs with Expanded X-Axis (Technical Report ANP-10306P, Figure 4-28)

Figure 03.09.02-126-2—Comparison of RPV Dimensional PSDs

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

4.3 Flow Distribution Device (FDD)

The assessment for the vibratory behavior of the FDD is based on 1/8 scale flow testing and full scale theoretical analysis. The primary objectives of the testing on the FDD are as follows:

- To verify that an adequate distribution of the flow is created through the fuel bundle for various RCP operating combinations.
- To verify that vortices are not created by the FDD to avoid flow excitation from vortex shedding.
- To assess the hydrodynamic mass effects of the FDD by determining the in-air and the in-water experimental natural frequencies.

4.3.1 Testing Performed for the FDD

Flow testing for the FDD was performed as part of the HYDRAVIB test program. The 1/8 scale FDD mockup is used to identify the horizontal, vertical and torsional modes for both the in-air and in-water environments at ambient temperature. The FDD was instrumented with accelerometers and excited in different directions to determine the modal frequencies and mode shapes of the FDD. The modal frequencies for the 1/8 scale mockup of the FDD are reported in Table 4-11.

4.3.2 Theoretical Analysis of the Flow Distribution Device

A full scale theoretical evaluation of the FDD is performed. The flow-induced vibration phenomenon of concern for the FDD is random turbulence excitation resulting from the downcomer flow going through and past the FDD. The narrow band acoustic pressure fluctuations associated with the RCP rotational speed ([ ] Hz) and the pump blade passing frequency ([ ] Hz) are also a potential source of excitation. ~~This narrow band pressure fluctuation is superimposed upon the pressure PSD for turbulence in the lower plenum to account for this source of excitation to the FDD.~~ 03.09.02-126

The measures identified in Section 4.2.5.2.2 for the lower internals will also be implemented for the FDD to assess the excitation of the FDD to other sources of acoustic pressure fluctuations (e.g., acoustic resonance and loop acoustics).

The base excitation of the FDD resulting from the CB beam mode (~ [ ] Hz, See Table 4-5 and Table 4-6) is well separated from the beam mode of the FDD (~ [ ] Hz, See Table 4-12). [ ] and is not represented in the theoretical analysis.

The in-water natural frequencies and mode shapes of the FDD structure

The in-water frequencies and mode shapes are determined with the AREVA NP "CASS" finite element program. The presence of the primary fluid surrounding the FDD induces a fluid-structure coupling which is taken into account by means of a hydrodynamic added mass. This added mass is determined from in-water testing of the FDD beam mode and is overestimated for the cylindrical shell modes of the FDD. However, this mass is conservatively considered with the shell modes of the FDD to provide a set of natural frequencies that are lower than expected and thus more susceptible to turbulent excitation. The cylindrical shell and the square flow channels of the FDD are modeled with plate elements. The support columns of the FDD were modeled with three dimensional beam elements. The in-water natural frequencies selected for FIV analysis are provided in Table 4-12.

The structural damping of the FDD structure

The structural damping ratio ([ ]) was set to two times the viscous damping ratio ([ ]) to achieve the equivalent structural damping at resonance. This total damping value is a conservative composite of the following damping mechanisms:

- Damping due to the non-linearity of the bolted connection between the FDD column supports and the lower core support plate.
- Damping due to the viscosity of the fluid.
- Damping associated with hysteresis, which is typically about 0.5 percent for stainless steel materials.

03.09.02-126

The pressure PSD function for parallel flow random turbulence excitation~~-and RCP acoustic pressure fluctuation~~

The unique PSD for the turbulence in the RV lower plenum described in Section 4.2.2.4.3 was used for the FIV analysis of the FDD. The non-dimensional PSD is conservatively converted to a dimensional pressure PSD "$G_p(f)$" considering the primary flow velocity and hydraulic diameter of the RV downcomer. The pressure PSD that is applied in the FIV analysis of the FDD is shown in Figure 4-29.~~The unique PSD for the turbulence in the flow through the FDD is not measured during the HYDRAVIB flow test. The PSDs for the turbulence in the RV downcomer and lower plenum described in Section 4.2.2.4 were defined after the FIV analysis of the FDD was performed. Therefore, a single phase PSD is assumed for the evaluation of the FDD and later confirmed to be bounding as shown in Figure 4-28.~~

~~The PSD applied to the FDD FIV evaluation is representative of an upper bound curve for the turbulence in the downcomer of another RV design, which is taken from Reference 4, Figure 8.17 and reproduced in Figure 4-29.~~

~~The non-dimensional PSD is conservatively converted to a dimensional pressure PSD "$G_p(f)$" considering the primary flow velocity and hydraulic radius of the RV downcomer as opposed to the RV lower plenum.~~

Figure 4-28 ~~Comparison of RV PSDs (Log vs. Linear Scale)~~Deleted

03.09.02-126

Figure 4-29—Pressure PSD Loading for FDD (Log vs. Linear Scale)

03.09.02-126

4.3.3 FIV Acceptance Criteria for FDD

4.3.3.1 Acceptance Criteria for Displacements

Displacement limits are typically imposed to prevent impacts with the adjacent structures. Because such interfacing structures do not exist for the FDD, displacement limits for the FDD are not applicable.

4.3.3.2 Acceptance Criteria for High Cycle Fatigue

The FDD is primarily fabricated from stainless steel type F304LN. The acceptance criterion for the stress and high cycle fatigue limits of the FDD is identical to the criteria established for the RV lower internals (Section 4.2.6.2) for loading generated from random turbulence. The allowable stress for fatigue curve "A" at 10^{13} cycles is [ ] psi, rms is applicable to the FDD structure.

Since, the response of the FDD to the RCP acoustic pressure fluctuations are in units of (0-peak), the ASME fatigue curve "A" shown in Figure 4-21 is applicable. The allowable high cycle fatigue stress is [ ] psi (0-peak) at 10^{11} cycles.

4.3.4 Response of the FDD

The response of the FDD to the turbulence in the RV lower plenum resulting from the full power, steady normal operating condition and the acoustic pressure fluctuations associated with the RCP blade passing frequencies is reported in this section. The response of the FDD during HFT (Test #17, See Table 5-4) is assessed based upon the results for the full power normal operating condition and the ratio of the dynamic pressure term between the two operating conditions or ([ ]).

The results show that the FIV acceptance criteria established in Section 4.3.3 for the FDD are satisfied.

4.3.4.1 ~~Overall~~ Response of FDD to Random Turbulence

The response PSD (displacement) of the FDD at seven nodal locations around the circumference of the cylinder is shown in Figure 4-30. The figure shows the response at each of the natural frequencies of the FDD with a major response occurring at the fundamental frequency ([ ]). A significant response of the shell mode ([ ]) is also shown. ~~The response of the FDD at the blade passing frequency ([ ]) is evident even though the response amplitude is not very large (because the natural frequencies of the FDD are not very close to the blade passing frequency).~~

The RMS responses at the seven node locations are listed in Table 4-13. The table shows that the responses at [

03.09.02-126

] At the other two locations

([

]

The statistical frequencies for the FDD are zero crossing frequencies. The zero crossing frequency is defined as the number of times per second the response curve crosses the zero response line (assuming the mean has been subtracted out). This effective frequency is determined using the relation shown below considering the weighted integrals of the single-sided displacement response PSD, $G_d(f)$:

$$f_0^2 = \frac{\int_0^\infty f^2 G_d(f)df}{\int_0^\infty G_d(f)df}$$ defintion of the zero crossing frequency.

The AREVA NP computer program "PCRANDOM" uses this definition to determine the zero crossing frequencies. The crossing frequencies reported in Table 4-13 for the discrete locations along the circumference of the FDD cylindrical shell are below the natural frequencies of the FDD. The reason for this discrepancy is based on the method by which the effective zero crossing frequencies are computed by PCRANDOM through the weighting of the integral of the single-sided displacement response PSD, $G_d(f)$. Because the effective zero crossing frequency is determined by the integration of the response PDS between 0 and approximately ~~200~~225 Hz, the weighting of the PSD at the lower frequencies (below the fundamental frequency of the FDD) skews this computation. 03.09.02-126

4.3.4.1.1 FDD Support Column Stress

The support column moments at the fixed locations are reported for six of the 24 support columns in Table 4-14. Because the FDD is a symmetrical structure, the moments from the six columns (one quadrant) define the behavior of the FDD. The highest bending stress in the support column is ~~approximately~~ [ ] psi, rms. Assuming a conservative value of [ ] for the FSRF to account for discontinuities, the maximum rms stress is [ ] psi, rms.

Considering the beam modal frequency of the FDD ([ ] Hz, See Table 4-12), a 60 year life and a capacity factor of 100 percent, an endurance limit of [ ] rms is obtained from Figure 4-21. A safety factor of ~~safety of~~[+] for the FDD column supports, and high cycle fatigue failure of this component is not expected.

03.09.02-126

03.09.02-126

Table 4-13—RMS Response at Different Shell Locations

Notes for Table 4-13:

1. See Figure 4-31 for node locations.

03.09.02-126

Table 4-14—Maximum Stress for the FDD Support Columns

Table 4-15—Support Column Reaction Forces

03.09.02-126

03.09.02-126

Table 4-16—FDD Cylindrical Shell Stresses (psi, rms)

Notes for Table 4-16:

1. See Figure 4-32 for element locations.

Figure 4-30—FDD Cylindrical Shell Response PSD

03.09.02-126
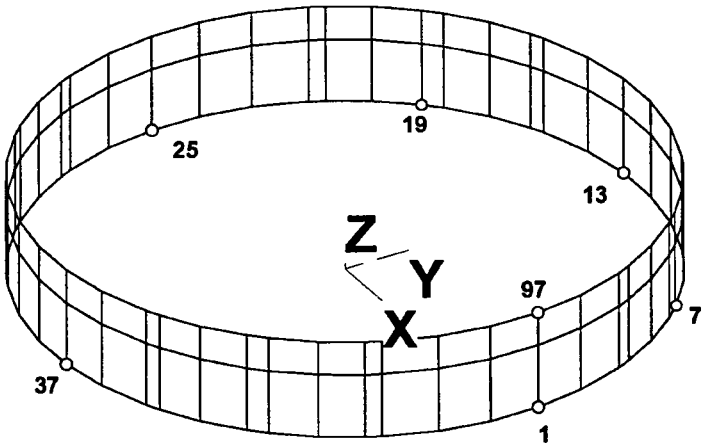
Figure 4-31—Nodal Locations for the Shell Response PSDs