ENCLOSURE 8

TENNESSEE VALLEY AUTHORITY
BROWNS FERRY NUCLEAR PLANT (BFN)
UNITS 1, 2, AND 3

TECHNICAL SPECIFICATIONS (TS) CHANGES TS-431 AND TS-418 EXTENDED POWER UPRATE (EPU)

CDI REPORT NO. 08-05NP, "ACOUSTIC AND LOW FREQUENCY HYDRODYNAMIC LOADS AT CLTP POWER LEVEL ON BROWNS FERRY NUCLEAR UNIT 2 STEAM DRYER TO 250 HZ WITH NOISE REMOVED"

(NON-PROPRIETARY VERSION)

Attached is the **Non-Proprietary Version** of CDI Report No. 08-05, "Acoustic and Low Frequency Hydrodynamic Loads at CLTP Power Level on Browns Ferry Nuclear Unit 2 Steam Dryer to 250 Hz with Noise Removed."

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C.D.I. Report No. 08-05NP

Acoustic and Low Frequency Hydrodynamic Loads at CLTP Power Level on Browns Ferry Nuclear Unit 2 Steam Dryer to 250 Hz with Noise Removed

Revision 0

Prepared by

Continuum Dynamics, Inc.
34 Lexington Avenue
Ewing, NJ 08618

Prepared under Purchase Order No. 00053157 for

TVA / Browns Ferry Nuclear Plant
Nuclear Plant Road, P. O. Box 2000 PAB-2M
Decatur, AL 35609

Approved by

Alan Bilanin

Alan J. Bilanin

Prepared by

Milton E. Teske

March 2008

Executive Summary

Measured strain gage time-history data in the four main steam lines at Browns Ferry Nuclear Unit 2 (BFN2) were processed by a dynamic model of the steam delivery system to predict loads on the full-scale steam dryer. These measured data were first converted to pressures, then positioned on the four main steam lines and used to extract acoustic sources in the system. A validated acoustic circuit methodology was used to predict the fluctuating pressures anticipated across components of the steam dryer in the reactor vessel. The acoustic circuit methodology included a low frequency hydrodynamic contribution, in addition to an acoustic contribution at all frequencies. This pressure loading was then provided for structural analysis to assess the structural adequacy of the steam dryer in BFN2.

This effort provides BFN2 with a dryer dynamic load definition that comes directly from measured BFN2 full-scale data and the application of a validated acoustic circuit methodology, at a power level where data were acquired.

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1. Introduction

In Spring 2005 Exelon installed new stream dryers into Quad Cities Unit 2 (QC2) and Quad Cities Unit 1. This replacement design, developed by General Electric, sought to improve dryer performance and overcome structural inadequacies identified on the original dryers, which had been in place for the last 30 years. As a means for confirming the adequacy of the steam dryer, the QC2 replacement dryer was instrumented with pressure sensors at 27 locations. These pressures formed the set of data used to validate the predictions of an acoustic circuit methodology under development by Continuum Dynamics, Inc. (C.D.I.) for several years [1]. One of the results of this benchmark exercise [2] confirmed the predictive ability of the acoustic circuit methodology for pressure loading across the dryer, with the inclusion of a low frequency hydrodynamic load. This methodology, validated against the Exelon full-scale data and identified as the Modified Bounding Pressure model, is used in the effort discussed herein.

This report applies this validated methodology to the Browns Ferry Nuclear Unit 2 (BFN2) steam dryer and main steam line geometry. Strain gage data obtained from the four main steam lines were used to predict pressure levels on the BFN2 full-scale dryer at Current Licensed Thermal Power (CLTP).

2. Modeling Considerations

The acoustic circuit analysis of the BFN2 steam supply system is broken into two distinct analyses: a Helmholtz solution within the steam dome and an acoustic circuit analysis in the main steam lines. This section of the report highlights the two approaches taken here. These analyses are then coupled for an integrated solution.

2.1 Helmholtz Analysis

A cross-section of the steam dome (and steam dryer) is shown below in Figure 2.1, with BFN2 dimensions as shown [3]. The complex three-dimensional geometry is rendered onto a uniformly-spaced rectangular grid (with mesh spacing of approximately 1.5 inches to accommodate frequency from 0 to 250 Hz in full scale), and a solution, over the frequency range of interest, is obtained for the Helmholtz equation

$$\frac{\partial^2 P}{\partial x^2}+\frac{\partial^2 P}{\partial y^2}+\frac{\partial^2 P}{\partial z^2}+\frac{\omega^2}{a^2}P=\nabla^2 P+\frac{\omega^2}{a^2}P=0$$

where P is the pressure at a grid point, ω is frequency, and a is acoustic speed in steam.

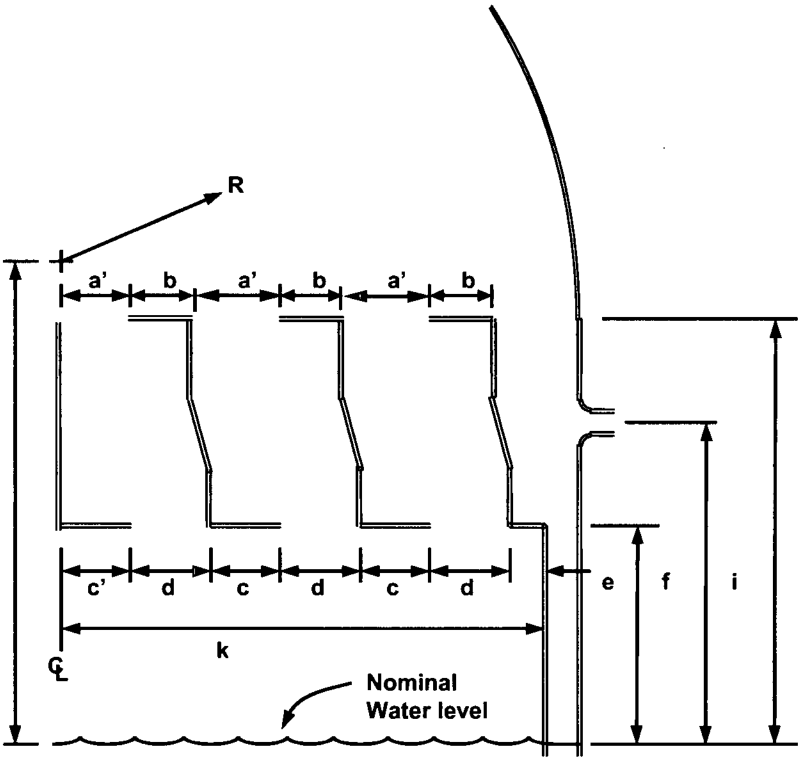

Figure 2.1. Cross-sectional description of the steam dome and dryer, with the BFN2 dimensions of a' = 16.0 in, b = 16.0 in, c' = 24.0 in, c = 14.5 in, d = 17.5 in, e = 15.5 in, f = 74.0 in, g = 163.0 in, i = 97.5 in, j = 189.0 in, k = 121.0 in, and R = 125.7 in (dimensions deduced from [3] to within 1.5 inches).

This equation is solved for incremental frequencies from 0 to 250 Hz (full scale), subject to the boundary conditions

$$\frac{dP}{dn} = 0$$

normal to all solid surfaces (the steam dome wall and interior and exterior surfaces of the dryer),

$$\frac{dP}{dn} \propto \frac{i\omega}{a} P$$

normal to the nominal water level surface, and unit pressure applied to one inlet to a main steam line and zero applied to the other three.

2.2 Acoustic Circuit Analysis

The Helmholtz solution within the steam dome is coupled to an acoustic circuit solution in the main steam lines. Pulsation in a single-phase compressible medium, where acoustic wavelengths are long compared to transverse dimensions (directions perpendicular to the primary flow directions), lend themselves to application of the acoustic circuit methodology. If the analysis is restricted to frequencies below 250 Hz, acoustic wavelengths are approximately 8 feet in length and wavelengths are therefore long compared to most components of interest, such as branch junctions.

Acoustic circuit analysis divides the main steam lines into elements which are each characterized, as sketched in Figure 2.2, by a length L, a cross-sectional area A, a fluid mean density $\bar{\rho}$, a fluid mean flow velocity $\bar{U}$, and a fluid mean acoustic speed $\bar{a}$.

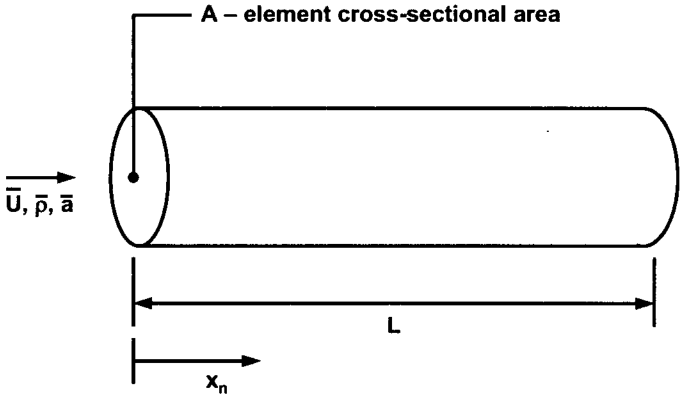

Figure 2.2. Schematic of an element in the acoustic circuit analysis, with length L and cross-sectional area A.

Application of acoustic circuit methodology generates solutions for the fluctuating pressure P_n and velocity u_n in the n^{th} element of the form

$$P_n = \left[A_n e^{ik_{1n}x_n} + B_n e^{ik_{2n}x_n}\right] e^{i\omega t}$$

$$u_n = -\frac{1}{\rho \bar{a}^2}\left[\frac{\left(\omega + \bar{U}_n k_{1n}\right)}{k_{1n}} A_n e^{ik_{1n}x_n} + \frac{\left(\omega + \bar{U}_n k_{2n}\right)}{k_{2n}} B_n e^{ik_{2n}x_n}\right] e^{i\omega t}$$

where harmonic time dependence of the form $e^{i\omega t}$ has been assumed. The wave numbers k_{1n} and k_{2n} are the two complex roots of the equation

$$k_n^2 + i\frac{f_n\left|\bar{U}_n\right|}{D_n \bar{a}^2}\left(\omega + \bar{U}_n k_n\right) - \frac{1}{\bar{a}^2}\left(\omega + \bar{U}_n k_n\right)^2 = 0$$

where f_n is the pipe friction factor for element n, D_n is the hydrodynamic diameter for element n, and $i = \sqrt{-1}$. A_n and B_n are complex constants which are a function of frequency and are determined by satisfying continuity of pressure and mass conservation at element junctions.

The solution for pressure and velocity in the main steam lines is coupled to the Helmholtz solution in the steam dome, to predict the pressure loading on the steam dryer.

The main steam line piping geometry is summarized in Table 2.1.

Table 2.1. Main steam line lengths at BFN2. Main steam line diameter is 26 inch (ID = 24.0 in).

Main Steam Line	Length to First Strain Gage Measurement (ft)	Length to Second Strain Gage Measurement (ft)
A	9.5	38.1
B	9.5	39.8
C	9.5	39.5
D	9.5	38.2

2.3 Low Frequency Contribution

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(3)]]

3. Input Pressure Data

Strain gages were mounted on the four main steam lines of BFN2. Three data sets 120 seconds long were examined in this analysis. The first data set recorded the strain at CLTP conditions with 10 volts of excitation to the strain gages (recovering the signals with their background noise), the second data set recorded the strain at CLTP conditions with 0.01 volts of excitation to the strain gages (recovering the background noise only), and the third data set recorded the strain at 19% power level with 10 volts of excitation to the strain gages [4].

The strain gage signals were converted to pressures by the use of the conversion factors provided in [4] and summarized in Table 3.1. Background noise was filtered from the Fourier transformed signals by the use of the equation

$$P(\omega) \leftarrow P(\omega)\left[1-\left|\frac{N(\omega)}{P(\omega)}\right|\right]$$

where $P(\omega)$ is the pressure with background noise and $N(\omega)$ is the background noise (the parameter in brackets is restricted to values between 0 and 1). Exclusion frequencies were used to remove extraneous signals, as also identified in [4] and summarized in Table 3.2. These signals were further processed by the coherence factor and mean filtering as described in [2]. Coherence at CLTP conditions is shown in Figure 3.1.

The resulting main steam line pressure signals may be represented in two ways, by their minimum and maximum pressure levels, and by their PSDs. Table 3.3 provides the pressure level information, while Figures 3.2 to 3.5 compare the frequency content at the eight measurement locations. The frequency content around 218 Hz has been removed from the signals plotted here, in anticipation of the use of inserts in the blank standpipes on main steam lines A and D [5] to mitigate this load.

Table 3.1. Conversion factors from strain to pressure [4]. Channels are averaged to give the average strain; blank sensors indicate that the sensor was inoperative.

	Strain to Pressure (psid/μstrain)	Channel Number	Channel Number	Channel Number	Channel Number
MSL A Upper	3.088	1	2	3	4
MSL A Lower	2.987	5	6	7	8
MSL B Upper	3.070	9		11	
MSL B Lower	3.040	13	14	15	16
MSL C Upper	3.008		18	19	20
MSL C Lower	3.041	21	22	23	24
MSL D Upper	3.017		26	27	28
MSL D Lower	3.022	29	30	31	

Table 3.2. Exclusion frequencies for BFN2 strain gage data, as suggested in [4]. VFD = variable frequency drive. Recirc = recirculation pumps

Frequency Range (Hz)	Exclusion Cause
0 – 2	Mean
59.9 – 60.1	Line Noise
119.9 – 120.1	Line Noise
179.9 – 180.1	Line Noise
239.9 – 240.1	Line Noise
44.7 – 46.0	VFD (1x)
90.8 – 91.0	VFD (2x)
136.1 – 136.5	VFD (3x)
181.6 – 181.8	VFD (4x)
227.1 – 227.4	VFD (5x)
112.7 – 113.2	Recirc Pump A Speed (5x)
110.4 – 111.7	Recirc Pump B Speed (5x)
218.6 – 220.2	Standpipe Excitation

Table 3.3. Main steam line (MSL) pressure levels in BFN2.

	CLTP Minimum Pressure (psid)	CLTP Maximum Pressure (psid)	CLTP RMS Pressure (psid)
MSL A Upper	-2.99	2.15	0.51
MSL A Lower	-1.90	2.09	0.48
MSL B Upper	-1.77	1.77	0.45
MSL B Lower	-2.54	2.09	0.50
MSL C Upper	-2.07	2.08	0.50
MSL C Lower	-3.23	2.30	0.59
MSL D Upper	-2.49	2.44	0.55
MSL D Lower	-2.33	2.34	0.51

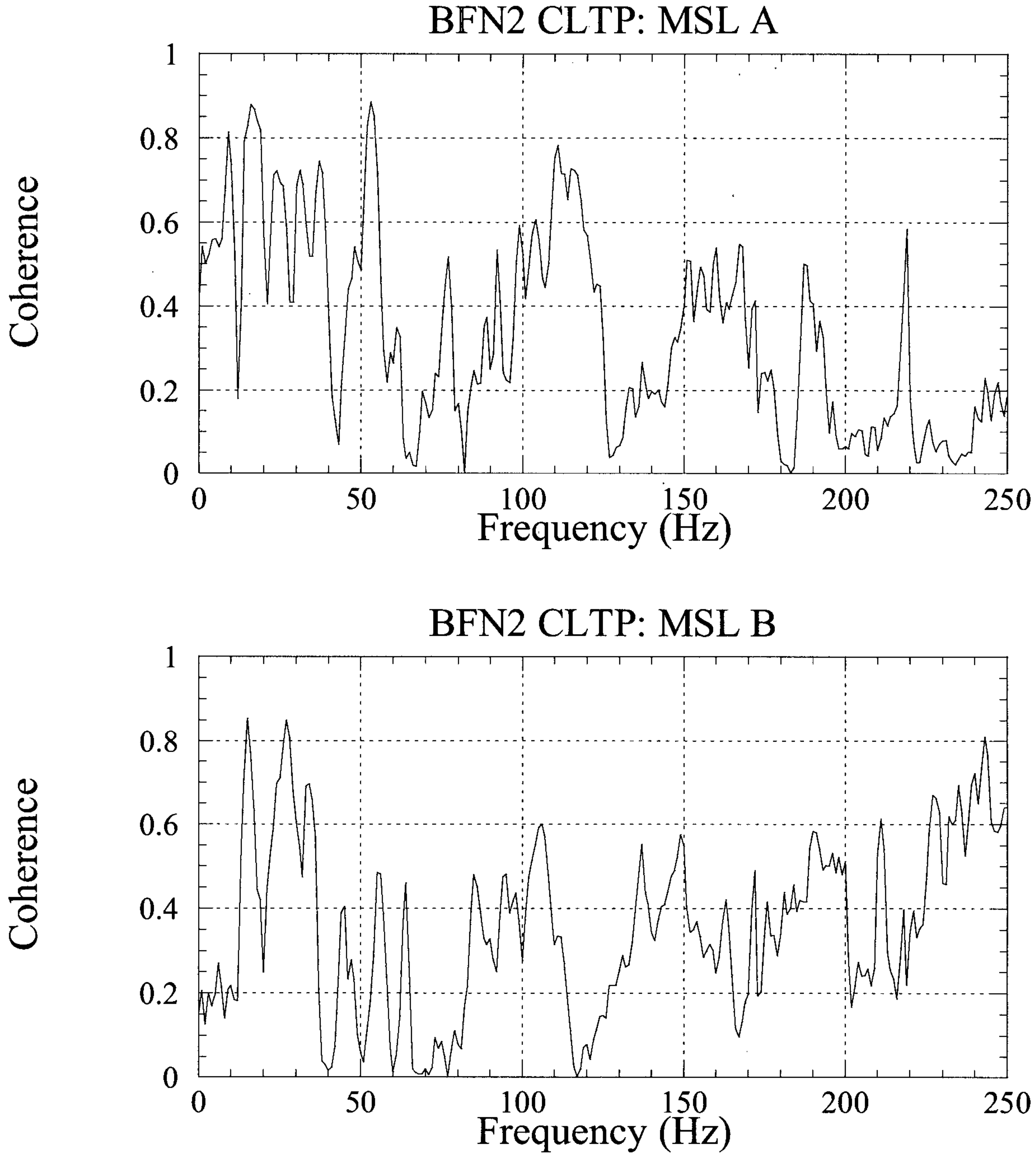


Figure 3.1a. Coherence between the upper and lower strain gage readings at BFN2: main steam line A (top); main steam line B (bottom).

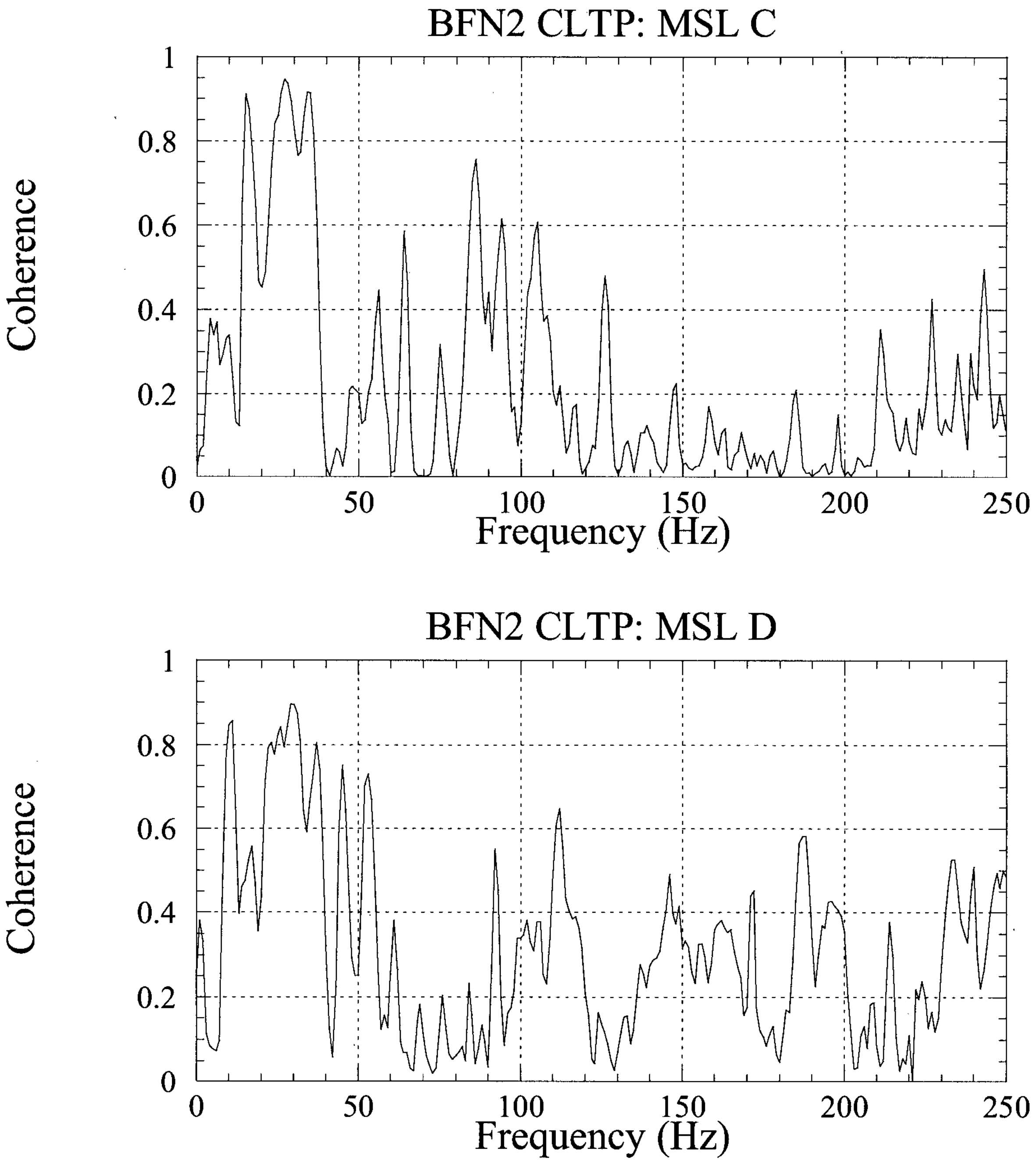


Figure 3.1b. Coherence between the upper and lower strain gage readings at BFN2: main steam line C (top); main steam line D (bottom).

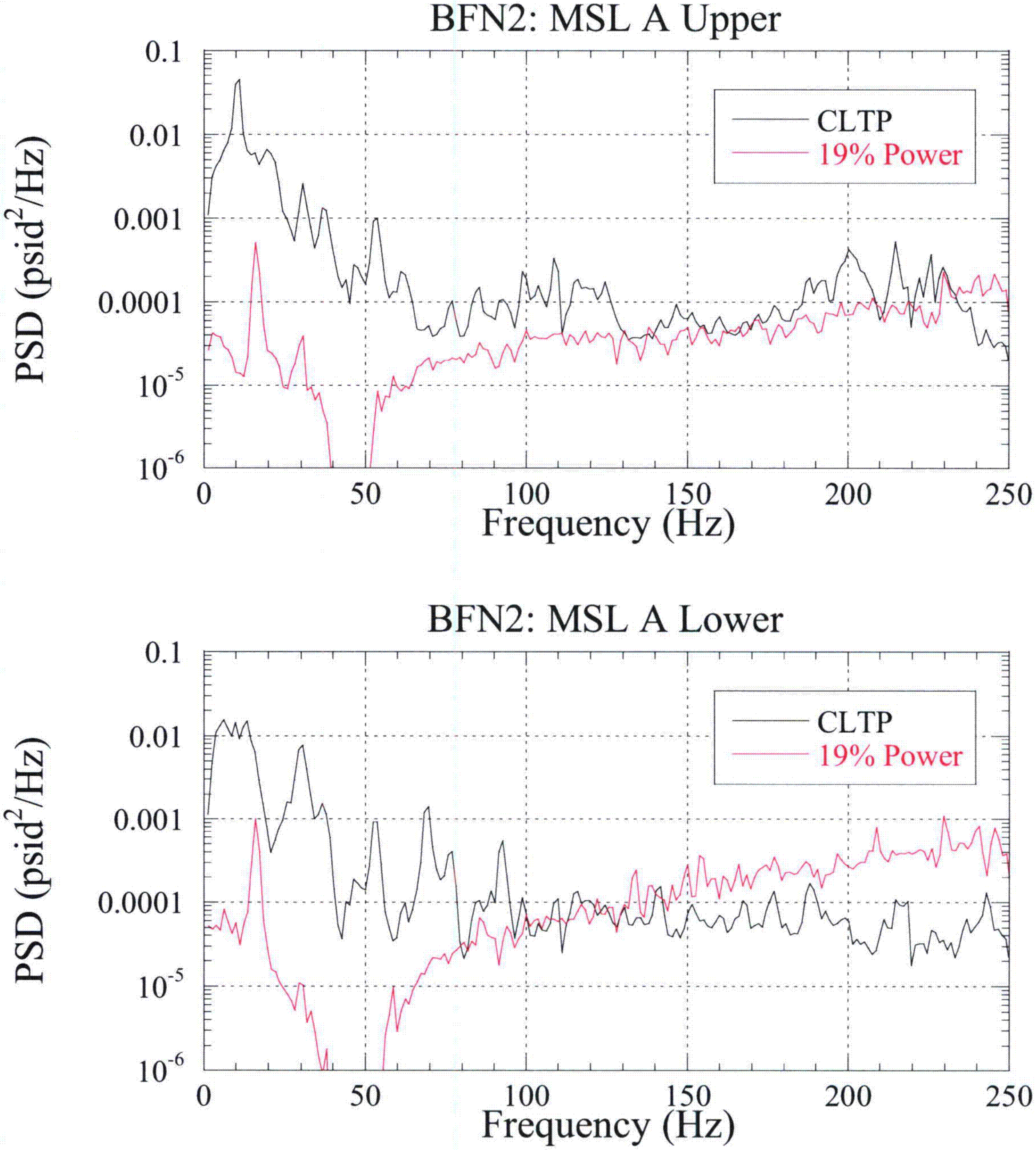


Figure 3.2. PSD comparison of pressure measurements on main steam line A at strain gage locations upper (top) and lower (bottom), for CLTP and 19% power conditions.

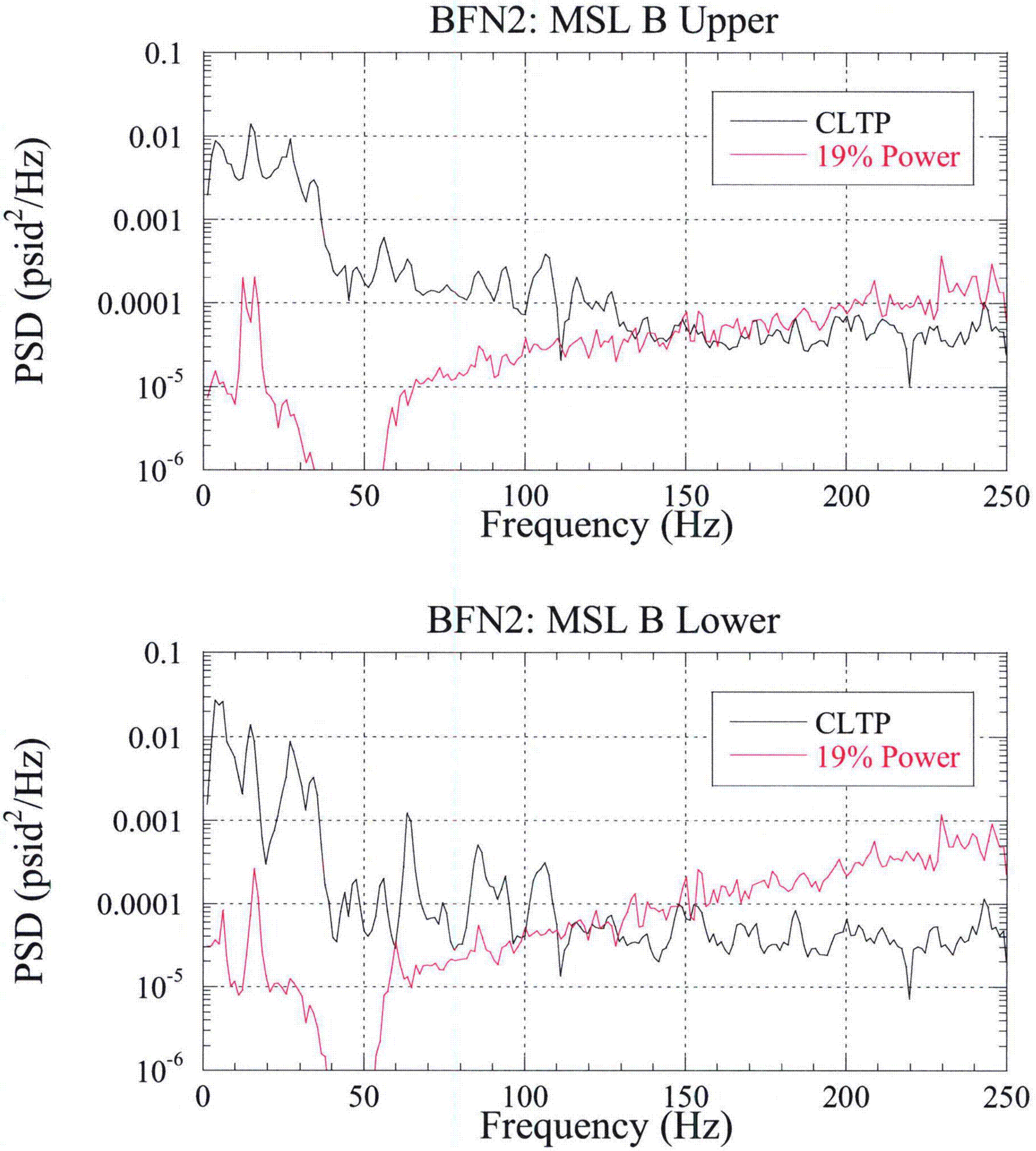


Figure 3.3. PSD comparison of pressure measurements on main steam line B at strain gage locations upper (top) and lower (bottom), for CLTP and 19% power conditions.

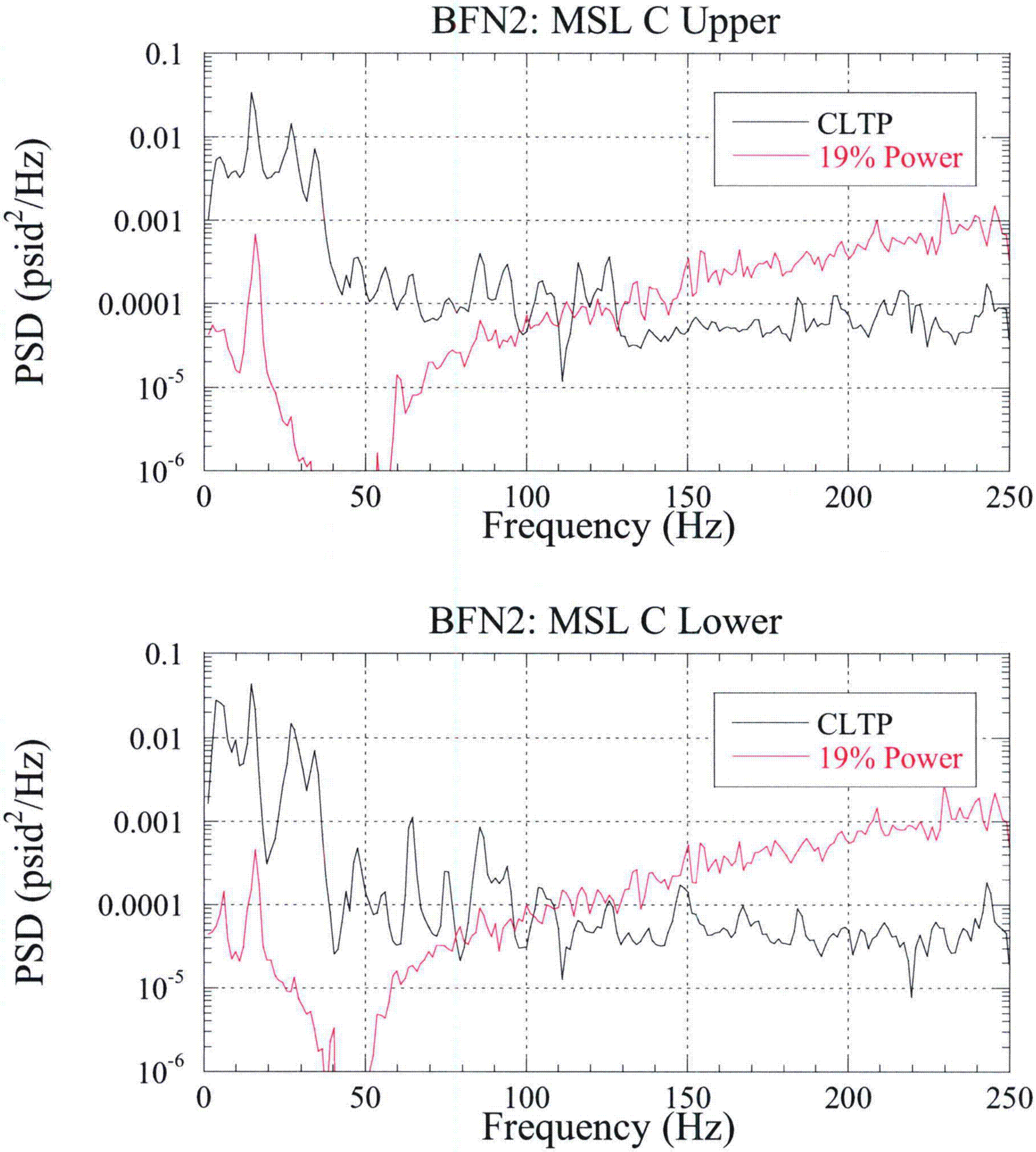
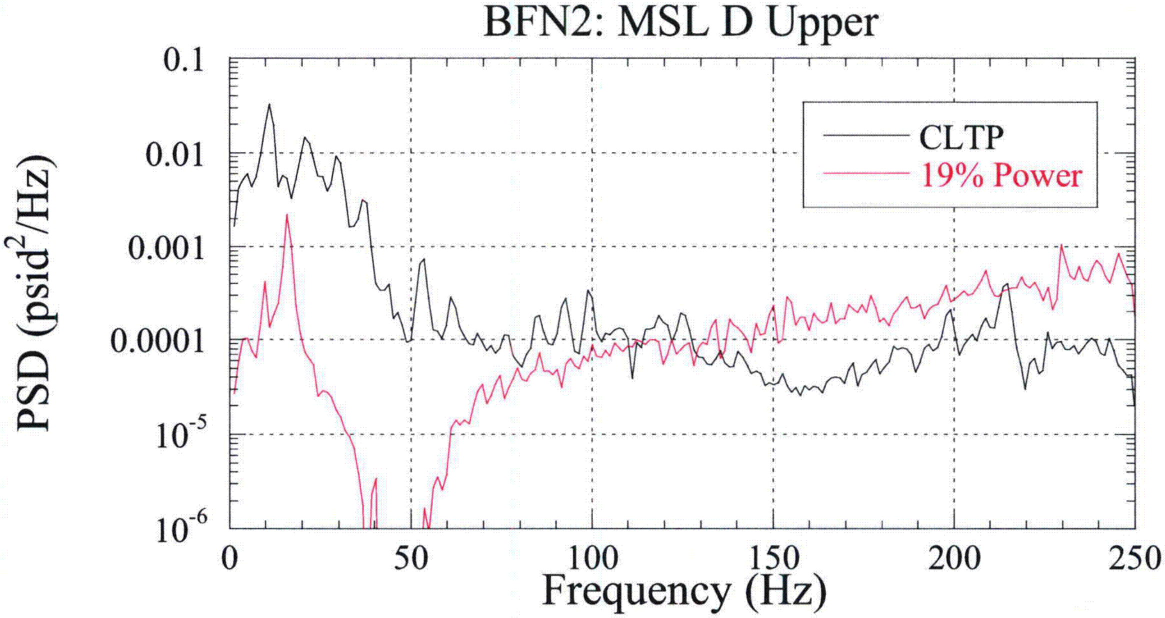


Figure 3.4. PSD comparison of pressure measurements on main steam line C at strain gage locations upper (top) and lower (bottom), for CLTP and 19% power conditions.



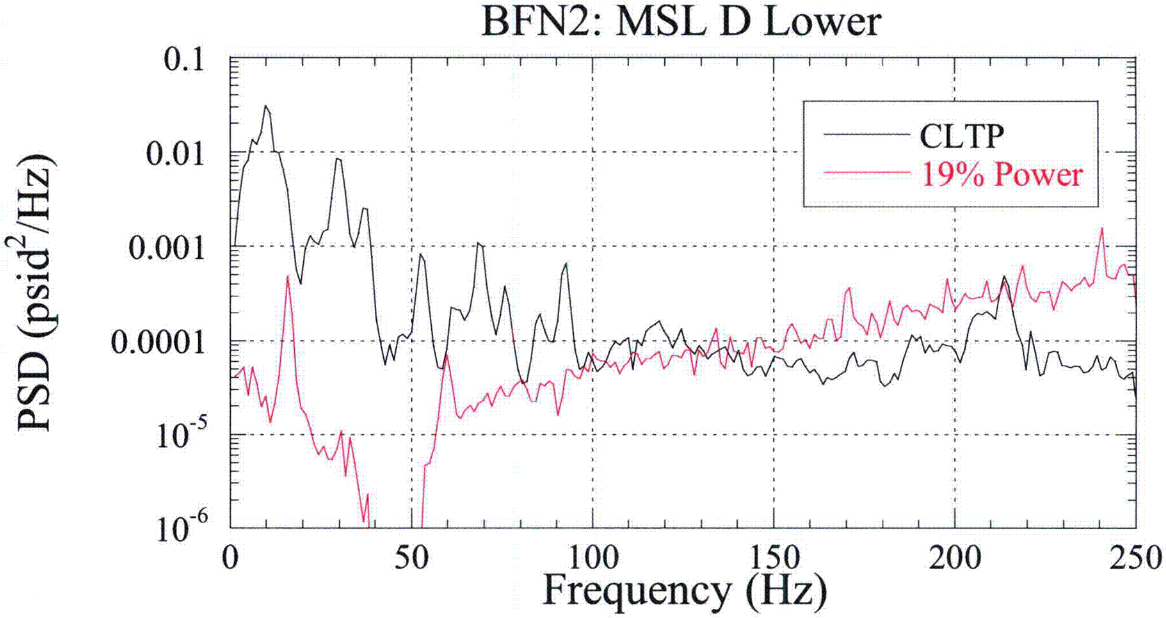


Figure 3.5. PSD comparison of pressure measurements on main steam line D at strain gage locations upper (top) and lower (bottom), for CLTP and 19% power conditions.

4. Results

The measured main steam line pressure data were used to drive the validated acoustic circuit methodology for the BFN2 steam dome coupled to the main steam lines to make a pressure load prediction on the BFN2 dryer. A low resolution load, developed at the nodal locations identified in Figures 4.1 to 4.4, produces the maximum differential and RMS pressure levels across the dryer as shown in Figure 4.5. PSDs of the peak loads on either side of the dryer are shown in Figure 4.6.

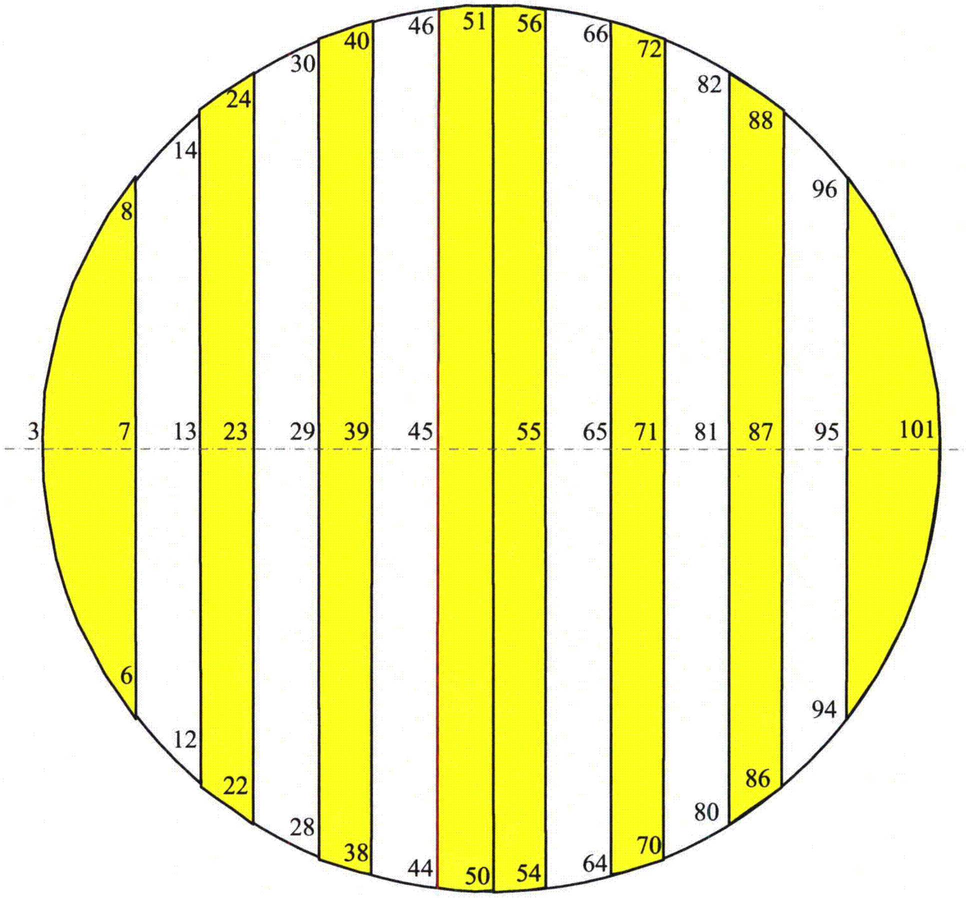


Figure 4.1. Bottom plates pressure node locations (low resolution), with pressures acting downward in the notation defined here.

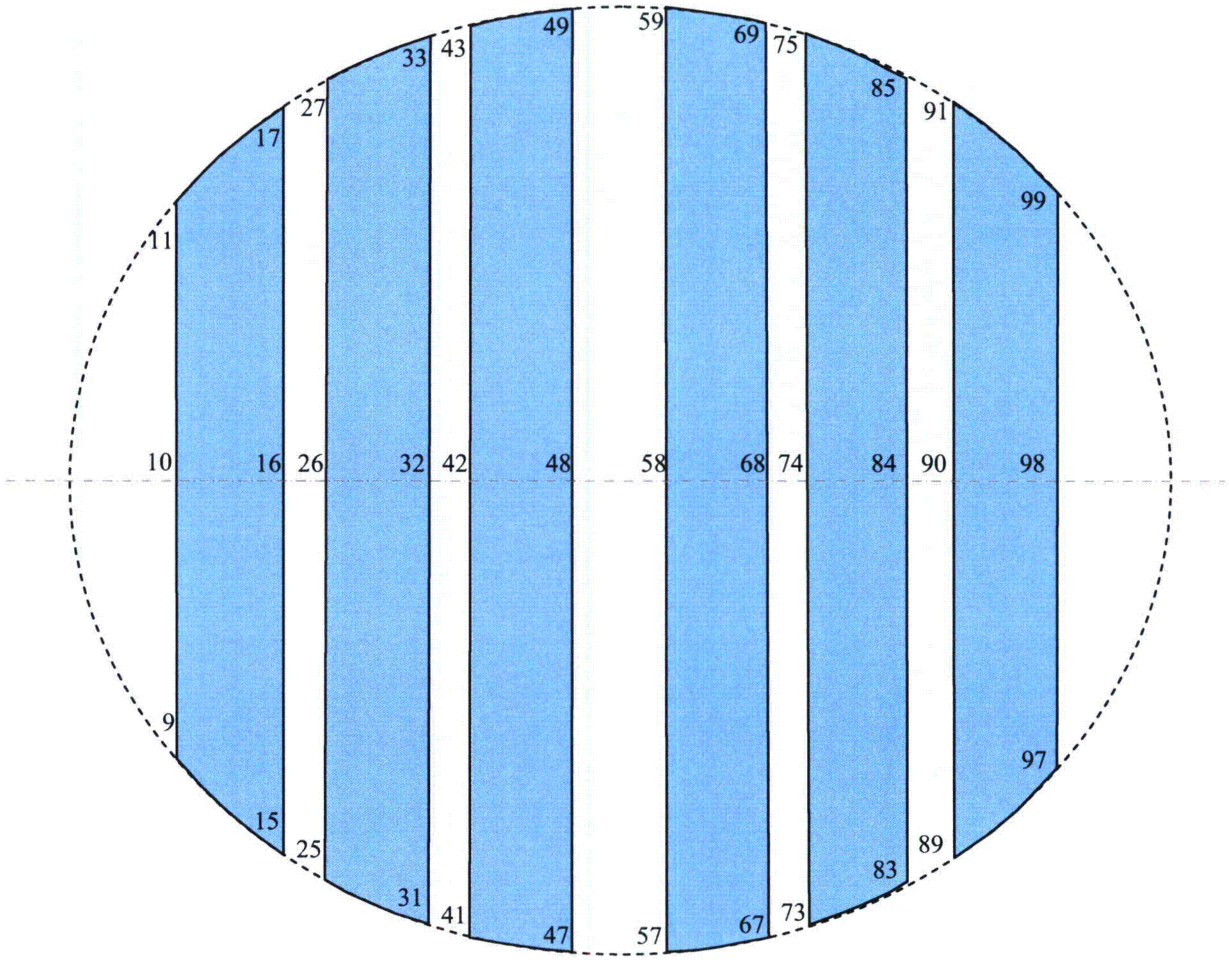


Figure 4.2. Top plates pressure node locations (low resolution), with pressures acting downward in the notation defined here.

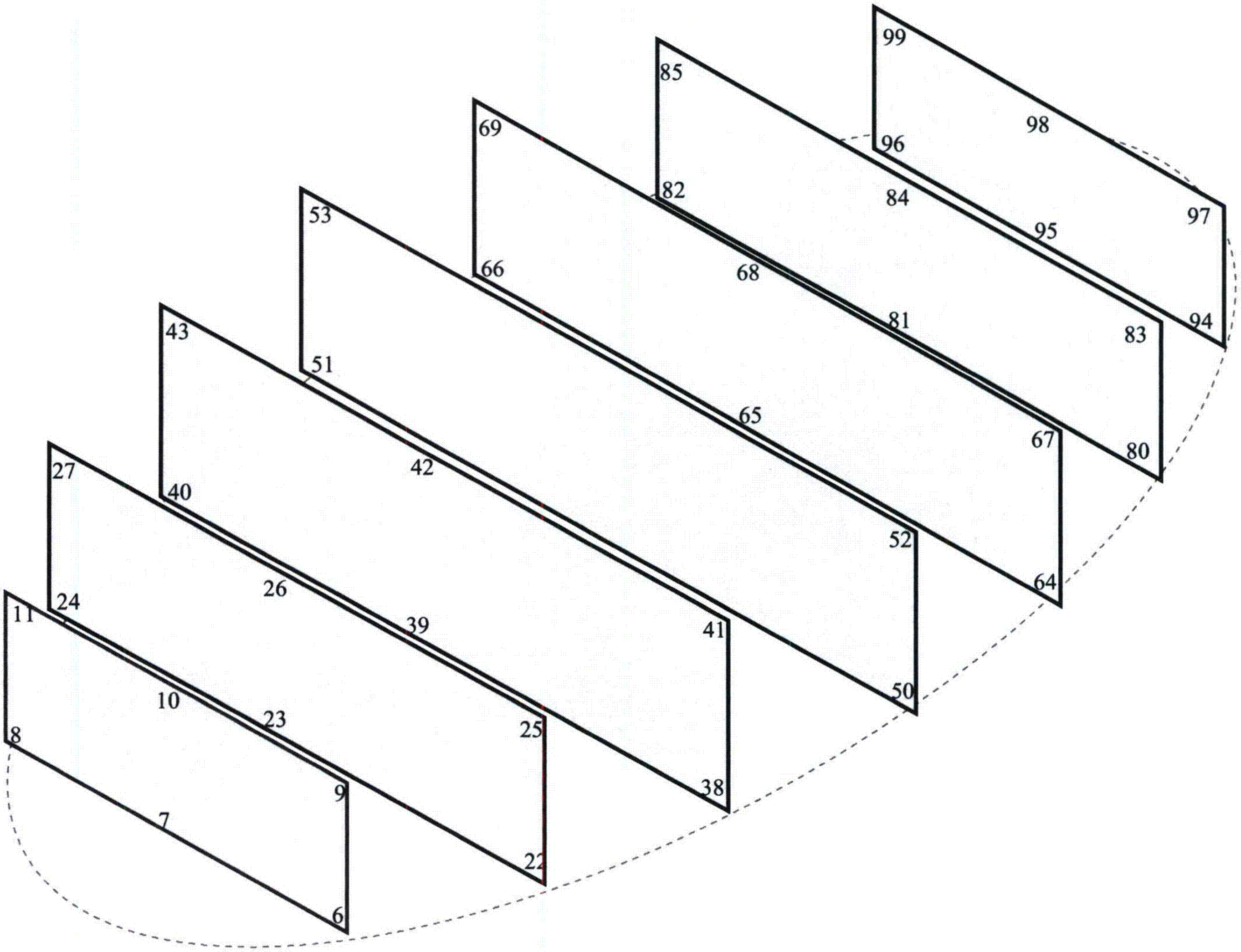


Figure 4.3. Vertical plates: Pressures acting left to right on panels 6-11, 22-27, 38-43, and 50-54; acting right to left on panels 64-69, 80-85, and 94-99 (low resolution).

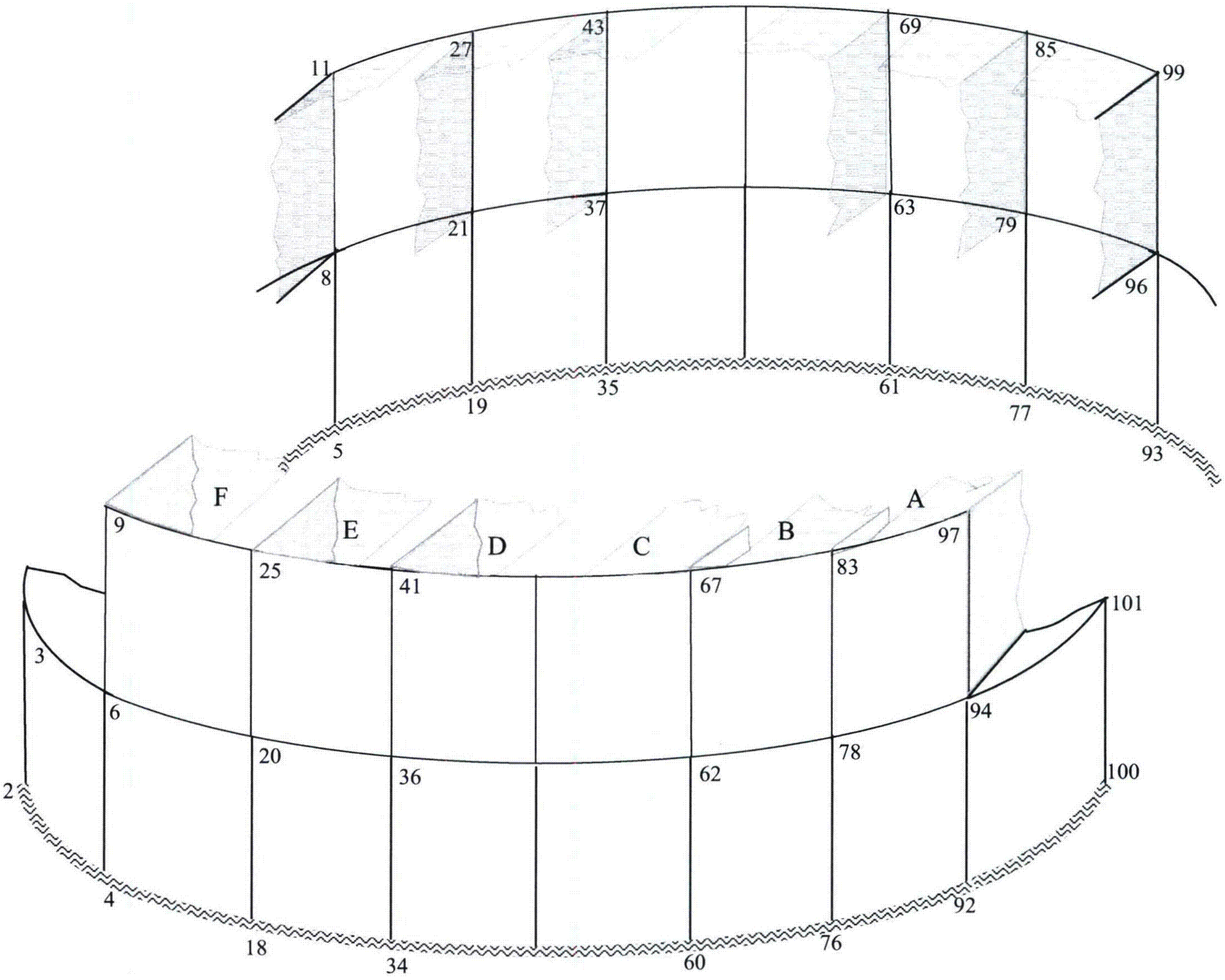


Figure 4.4. Skirt plates: Pressure acting outward on the outer dryer 0°/180° surfaces and the skirt (low resolution).

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(3)]]

Figure 4.5. Predicted CLTP loads on the low resolution grid identified in Figures 4.1 to 4.4, as developed by the Modified Bounding Pressure model, to 250 Hz. Low-numbered nodes are on the C-D side of the dryer, while high-numbered nodes are on the A-B side of the dryer.

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Figure 4.6. PSD of the maximum pressure loads predicted on the C-D side of the BFN2 dryer (top) and A-B side of the BFN2 dryer (bottom) at CLTP conditions.

5. Uncertainty Analysis

The analysis of potential uncertainty occurring at BFN2 consists of several contributions, including the uncertainty from collecting data on the main steam lines at locations other than the locations on Quad Cities Unit 2 (QC2) and the uncertainty in the Modified Bounding Pressure model. QC2 dryer data at Original Licensed Thermal Power (OLTP) conditions were used to generate an uncertainty analysis of the Acoustic Circuit Methodology (ACM) [2] for BFN2.

The approach taken for bias and uncertainty is similar to that used by Vermont Yankee for power uprate [6]. In this analysis, six "averaged pressures" are examined on the instrumented replacement dryer at QC2: averaging pressure sensors P1, P2, and P3; P3, P5, and P6; P7, P8, and P9; P10, P11, and P12; P18 and P20; and P19 and P21. These pressure sensors were all on the outer bank hoods of the dryer, and the groups are comprised of sensors located vertically above or below each other.

Bias is computed by taking the difference between the measured and predicted RMS pressure values for the six "averaged pressures", and dividing the mean of this difference by the mean of the predicted RMS. RMS is computed by integrating the PSD across the frequency range of interest and taking the square root

$$\mathrm{BIAS} = \frac{\frac{1}{N}\sum(\mathrm{RMS}_{\mathrm{measured}} - \mathrm{RMS}_{\mathrm{predicted}})}{\frac{1}{N}\sum \mathrm{RMS}_{\mathrm{predicted}}} \tag{5.1}$$

where $\mathrm{RMS}_{\mathrm{measured}}$ is the RMS of the measured data and $\mathrm{RMS}_{\mathrm{predicted}}$ is the RMS of the predicted data. Summations are over the number of "averaged pressures", or N = 6.

Uncertainty is defined as the fraction computed by the standard deviation

$$\mathrm{UNCERTAINTY} = \frac{\sqrt{\frac{1}{N}\sum(\mathrm{RMS}_{\mathrm{measured}} - \mathrm{RMS}_{\mathrm{predicted}})^2}}{\frac{1}{N}\sum \mathrm{RMS}_{\mathrm{predicted}}} \tag{5.2}$$

ACM bias and uncertainty results are compiled for specified frequency ranges of interest, as directed by [7] and summarized in Table 5.1. Other random uncertainties, specific to BFN2, are summarized in Table 5.2 and are typically combined with the ACM results by SRSS methods to determine an overall uncertainty for BFN2.

Table 5.1. BFN2 bias and uncertainty for specified frequency intervals. A negative bias indicates that the ACM overpredicts the QC2 data in that interval.

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(3)]]

Table 5.2. Bias and uncertainty contributions to total uncertainty for BFN2 plant data.

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(3)]]

6. Conclusions

The C.D.I. acoustic circuit analysis, using full-scale measured data for BFN2:

a) [[(3)]]

b) Predicts that the loads on dryer components are largest for components nearest the main steam line inlets and decrease inward into the reactor vessel.

7. References

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ENCLOSURE 9

TENNESSEE VALLEY AUTHORITY
BROWNS FERRY NUCLEAR PLANT (BFN)
UNITS 1, 2, AND 3

TECHNICAL SPECIFICATIONS (TS) CHANGES TS-431 AND TS-418
EXTENDED POWER UPRATE (EPU)

CDI TECHNICAL NOTE NO. 08-13NP, "LIMIT CURVE ANALYSIS WITH ACM REV. 4 FOR POWER ASCENSION AT BROWNS FERRY NUCLEAR UNIT 2"

(NON-PROPRIETARY VERSION)

Attached is the **Non-Proprietary Version** of CDI Technical Note No. 08-13NP, "Limit Curve Analysis with ACM Rev. 4 for Power Ascension at Browns Ferry Nuclear Unit 2."

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C.D.I. Technical Note No. 08-13NP

Limit Curve Analysis with ACM Rev. 4 for Power Ascension at Browns Ferry Nuclear Unit 2

Revision 0

Prepared by

Continuum Dynamics, Inc.
34 Lexington Avenue
Ewing, NJ 08618

Prepared under Purchase Order No. 00053157 for

TVA / Browns Ferry Nuclear Plant
Nuclear Plant Road, P. O. Box 2000 PAB-2M
Decatur, AL 35609

Approved by

Alan Bilanin

Alan J. Bilanin

Prepared by

Milton E. Teske

March 2008

Table of Contents

1. Introduction

During power ascension of Browns Ferry Nuclear Unit 2 (BFN2), from Current Licensed Thermal Power (CLTP) to Extended Power Uprate (EPU), TVA is required to monitor the dryer stresses at plant power levels that have not yet been achieved. Limit curves provide an upper bound safeguard against the potential for dryer stresses becoming higher than allowable, by estimating the not-to-be-exceeded main steam line pressure levels. In the case of BFN2, in-plant main steam line data have been analyzed at CLTP conditions (based on Unit 2 data) to provide steam dryer hydrodynamic loads [1]. EPU is 120% of Original Licensed Thermal Power (OLTP); CLTP is 105% of OLTP. A finite element model stress analysis has been undertaken on the CLTP loads [2]. These existing loads provide the basis for generation of the limit curves to be used during BFN2 power ascension.

Continuum Dynamics, Inc. (C.D.I.) has developed an acoustic circuit methodology (ACM) that determines the relationship between main steam line data and pressure on the steam dryer [3]. This methodology and the use of a finite element model analysis provide the computational algorithm from which dryer stresses at distinct steam dryer locations can be tracked through power ascension. Limit curves allow TVA to limit dryer stress levels, by comparing the main steam line pressure readings – represented in Power Spectral Density (PSD) format – with the upper bound PSD derived from existing in-plant data.

This technical note summarizes the proposed approach that will be used to track the anticipated stress levels in the BFN2 steam dryer during power ascension, utilizing Rev. 4 of the ACM [4], and the options available to TVA should a limit curve be reached.

2. Approach

The limit curve analysis for BFN2, to be used during power ascension, is patterned after the approach followed by Entergy Vermont Yankee (VY) in its power uprate [5]. In the VY analysis, two levels of steam dryer performance criteria were described: (1) a Level 1 pressure level based on maintaining the ASME allowable alternating stress value on the dryer, and (2) a Level 2 pressure level based on maintaining 80% of the allowable alternating stress value on the dryer. The VY approach is summarized in [6].

To develop the limit curves for BFN2, the stress levels in the dryer were calculated for the current plant acoustic signature, at CLTP conditions, and then used to determine how much the acoustic signature could be increased while maintaining stress levels below the stress fatigue limit. During power ascension, strain gage data will be converted to pressure in PSD format at each of the eight main steam line locations, for comparison with the limit curves. The strain gage data will be monitored throughout power ascension to observe the onset of discrete peaks, if they occur.

The finite element analysis of in-plant CLTP data found a lowest alternating stress ratio of 1.65 [2] as summarized in Table 1. The minimum stress ratios include the model bias and uncertainties for specific frequency ranges as suggested by the NRC [7]. The results of the ACM Rev. 4 analysis (based on Quad Cities Unit 2, or QC2, in-plant data) are summarized in Table 2 (a negative bias is conservative). The standpipe excitation frequency of the main steam safety relief valves in BFN2 is anticipated to be 111 Hz [8], and thus the uncertainty determined around the QC2 excitation frequency of 155 Hz has been applied to the 109 to 113 Hz frequency interval. Note also that it is anticipated that the 218 Hz will be mitigated by plugging the blank standpipes prior to power ascension, and that the stress analysis is based on this modification. The additional bias and uncertainties, as identified in [9], [10], [11], [12], [13], and [14], are shown in Table 3. SRSS of the uncertainties, added to the ACM bias, results in the total uncertainties shown in Table 4. These uncertainties were applied to the finite element analysis, resulting in the minimum stress ratio of 1.65.

Table 1. Peak Stress Limit Summary for ACM Rev. 4

Peak Stress Limit	13,600 psi (Level 1)	10,880 psi (Level 2)
Minimum Stress Ratio	1.65	1.32

Table 2. Bias and uncertainty for ACM Rev. 4

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Table 3. BFN2 additional uncertainties (with references cited)

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(3)]]

Table 4. BFN2 total uncertainty

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(3)]]

3. Limit Curves

Limit curves were generated from the in-plant CLTP strain gage data collected on Unit 2 in December 2006 and reported in [1]. These data were filtered across the frequency ranges shown in Table 5 to remove noise and extraneous signal content, as suggested in [15]. The resulting PSD curves for each of the eight strain gage locations were used to develop the limit curves, shown in Figures 1 to 4. Level 1 limit curves are found by multiplying the main steam line pressure PSD base traces by the square of the corrected limiting stress ratio ($1.65^2 = 2.72$), while the Level 2 limit curves are found by multiplying the PSD base traces by 0.64 of the square of the corrected limiting stress ratio (recovering 80% of the limiting stress ratio, or $0.80^2 \times 1.65^2 = 0.64 \times 2.72 = 1.74$), as PSD is related to the square of the pressure.

Consistent with the stress analysis [2], the peaks at 218 Hz on all eight strain gage signals were also filtered from the main steam line data prior to the development of the limit curves. BFN2 intends to mitigate the effect of the eight blind standpipes on main steam lines A and D, prior to power ascension.

Table 5. Exclusion frequencies for BFN2 at CLTP conditions
(VFD = variable frequency drive, Recirc = recirculation pumps)

Frequency Range (Hz)	Exclusion Cause
0 – 2	Mean
59.9 – 60.1	Line Noise
119.9 – 120.1	Line Noise
179.9 – 180.1	Line Noise
239.9 – 240.1	Line Noise
44.7 – 46.0	VFD (1x)
90.8 – 91.0	VFD (2x)
136.1 – 136.5	VFD (3x)
181.6 – 181.8	VFD (4x)
227.1 – 227.4	VFD (5x)
112.7 – 113.2	Recirc Pump A Speed (5x)
110.4 – 111.7	Recirc Pump B Speed (5x)

[[

(3)]]

Figure 1. Level 1 (black) and Level 2 (red) limit curves for main steam line A, compared against the base curves (blue) over the frequency range of interest: A upper strain gage location (top); A lower strain gage location (bottom).

[[

(3)]]

Figure 2. Level 1 (black) and Level 2 (red) limit curves for main steam line B, compared against the base curves (blue) over the frequency range of interest: B upper strain gage location (top); B lower strain gage location (bottom).

[[

(3)]]

Figure 3. Level 1 (black) and Level 2 (red) limit curves for main steam line C, compared against the base curves (blue) over the frequency range of interest: C upper strain gage location (top); C lower strain gage location (bottom).

[[

(3)]]

Figure 4. Level 1 (black) and Level 2 (red) limit curves for main steam line D, compared against the base curves (blue) over the frequency range of interest: D upper strain gage location (top); D lower strain gage location (bottom).

4. References

1. Continuum Dynamics, Inc. 2008. Acoustic and Low Frequency Hydrodynamic Loads at CLTP Power Level on Browns Ferry Nuclear Unit 2 Steam Dryer to 250 Hz with Noise Removed (Rev. 0). C.D.I. Report No. 08-05 (Proprietary).

2. Continuum Dynamics, Inc. 2008. Stress Assessment of Browns Ferry Nuclear Unit 2 Steam Dryer (Rev. 0). C.D.I. Report No. 08-07 (Proprietary).

3. Continuum Dynamics, Inc. 2005. Methodology to Determine Unsteady Pressure Loading on Components in Reactor Steam Domes (Rev. 6). C.D.I. Report No. 04-09 (Proprietary).

4. Continuum Dynamics, Inc. 2007. Methodology to Predict Full Scale Steam Dryer Loads from In-Plant Measurements, with the Inclusion of a Low Frequency Hydrodynamic Contribution (Rev. 1). C.D.I. Report No. 07-09 (Proprietary).

5. Entergy Nuclear Northeast. 2006. Entergy Vermont Yankee Steam Dryer Monitoring Plan (Rev. 4). Docket 50-271. No. BVY 06-056. Dated 29 June 2006.

6. State of Vermont Public Service Board. 2006. Petition of Vermont Department of Public Service for an Investigation into the Reliability of the Steam Dryer and Resulting Performance of the Vermont Yankee Nuclear Power Station under Uprate Conditions. Docket No. 7195. Hearings held 17-18 August 2006.

7. NRC Request for Additional Information on the Hope Creek Generating Station, Extended Power Uprate. 2007. TAC No. MD3002. RAI No. 14.67.

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9. Structural Integrity Associates, Inc. 2006. Evaluation of Browns Ferry Unit 2 Strain Gage Uncertainty and Pressure Conversion Factors (Rev. 0). SIA Calculation Package No. BFN-11Q-301.

10. Continuum Dynamics, Inc. 2005. Vermont Yankee Instrument Position Uncertainty. Letter Report Dated 01 August 2005.

11. Exelon Nuclear Generating LLC. 2005. An Assessment of the Effects of Uncertainty in the Application of Acoustic Circuit Model Predictions to the Calculation of Stresses in the Replacement Quad Cities Units 1 and 2 Steam Dryers (Rev. 0). Document No. AM-21005-008.

12. Continuum Dynamics, Inc. 2007. Finite Element Modeling Bias and Uncertainty Estimates Derived from the Hope Creek Unit 2 Dryer Shaker Test (Rev. 0). C.D.I. Report No. 07-27 (Proprietary).

13. NRC Request for Additional Information on the Hope Creek Generating Station, Extended Power Uprate. 2007. RAI No. 14.79.

14. NRC Request for Additional Information on the Hope Creek Generating Station, Extended Power Uprate. 2007. RAI No. 14.110.

15. Structural Integrity Associates, Inc. 2006. Main Steam Line 100% CLTP Strain Data Transmission. SIA Letter Report No. GSZ-06-017.

ENCLOSURE 10

TENNESSEE VALLEY AUTHORITY
BROWNS FERRY NUCLEAR PLANT (BFN)
UNITS 1, 2, AND 3

TECHNICAL SPECIFICATIONS (TS) CHANGES TS-431 AND TS-418 EXTENDED POWER UPRATE (EPU)

AFFIDAVITS

Attached are CDI's affidavits for the proprietary information contained in Enclosures 1, 2, 3, and 4.

Continuum Dynamics, Inc.

(609) 538-0444 (609) 538-0464 fax 34 Lexington Avenue Ewing, NJ 08618-2302

AFFIDAVIT

Re: Browns Ferry Nuclear Plant (BFN) – Units 1, 2, and 3 – Technical Specifications (TS) Changes TS-431 and TS-418 – Extended Power Uprate (EPU) – Response to Round 15 and Round 16 Requests for Additional Information (RAI) Regarding Steam Dryer Analyses, Group 3

I, Alan J. Bilanin, being duly sworn, depose and state as follows:

1. I hold the position of President and Senior Associate of Continuum Dynamics, Inc. (hereinafter referred to as C.D.I.), and I am authorized to make the request for withholding from Public Record the Information contained in the documents described in Paragraph 2. This Affidavit is submitted to the Nuclear Regulatory Commission (NRC) pursuant to 10 CFR 2.390(a)(4) based on the fact that the attached information consists of trade secret(s) of C.D.I. and that the NRC will receive the information from C.D.I. under privilege and in confidence.

2. The Information sought to be withheld, as transmitted to TVA Browns Ferry as attachment to C.D.I. Letter No. 08068 dated 31 March 2008 Browns Ferry Nuclear Plant (BFN) – Units 1, 2, and 3 – Technical Specifications (TS) Changes TS-431 and TS-418 – Extended Power Uprate (EPU) – Response to Round 15 and Round 16 Requests for Additional Information (RAI) Regarding Steam Dryer Analyses, Group 3.

3. The Information summarizes:

   (a) a process or method, including supporting data and analysis, where prevention of its use by C.D.I.'s competitors without license from C.D.I. constitutes a competitive advantage over other companies;
   (b) Information which, if used by a competitor, would reduce his expenditure of resources or improve his competitive position in the design, manufacture, shipment, installation, assurance of quality, or licensing of a similar product;
   (c) Information which discloses patentable subject matter for which it may be desirable to obtain patent protection.

   The information sought to be withheld is considered to be proprietary for the reasons set forth in paragraphs 3(a), 3(b) and 3(c) above.

4. The Information has been held in confidence by C.D.I., its owner. The Information has consistently been held in confidence by C.D.I. and no public disclosure has been made and it is not available to the public. All disclosures to third parties, which have been limited, have been made pursuant to the terms and conditions contained in C.D.I.'s Nondisclosure Secrecy Agreement which must be fully executed prior to disclosure.

5. The Information is a type customarily held in confidence by C.D.I. and there is a rational basis therefore. The Information is a type, which C.D.I. considers trade secret and is held in confidence by C.D.I. because it constitutes a source of competitive advantage in the competition and performance of such work in the industry. Public disclosure of the Information is likely to cause substantial harm to C.D.I.'s competitive position and foreclose or reduce the availability of profit-making opportunities.

I declare under penalty of perjury that the foregoing affidavit and the matters stated therein are true and correct to be the best of my knowledge, information and belief.

Executed on this 31st day of MARCH 2008.

Alan Bilanin

Alan J. Bilanin
Continuum Dynamics, Inc.

Subscribed and sworn before me this day: March 31, 2008

Eileen P. Burmeister
EILEEN P. BURMEISTER
NOTARY PUBLIC OF NEW JERSEY
MY COMM. EXPIRES MAY 6, 2012

Continuum Dynamics, Inc.
(609) 538-0444 (609) 538-0464 fax 34 Lexington Avenue Ewing, NJ 08618-2302

AFFIDAVIT

Re: C.D.I. Report No. 08-05P "Acoustic and Low Frequency Hydrodynamic Loads at CLTP Power Level on Browns Ferry Nuclear Unit 2 Steam Dryer to 250 Hz with Noise Removed," Revision 0 dated March 2008

I, Alan J. Bilanin, being duly sworn, depose and state as follows:

1. I hold the position of President and Senior Associate of Continuum Dynamics, Inc. (hereinafter referred to as C.D.I.), and I am authorized to make the request for withholding from Public Record the Information contained in the documents described in Paragraph 2. This Affidavit is submitted to the Nuclear Regulatory Commission (NRC) pursuant to 10 CFR 2.390(a)(4) based on the fact that the attached information consists of trade secret(s) of C.D.I. and that the NRC will receive the information from C.D.I. under privilege and in confidence.

2. The Information sought to be withheld, as transmitted to TVA Browns Ferry as attachment to C.D.I. Letter No. 08069 dated 31 March 2008 C.D.I. Report No. 08-05P "Acoustic and Low Frequency Hydrodynamic Loads at CLTP Power Level on Browns Ferry Nuclear Unit 2 Steam Dryer to 250 Hz with Noise Removed," Revision 0 dated March 2008.

3. The Information summarizes:

   (a) a process or method, including supporting data and analysis, where prevention of its use by C.D.I.'s competitors without license from C.D.I. constitutes a competitive advantage over other companies;
   (b) Information which, if used by a competitor, would reduce his expenditure of resources or improve his competitive position in the design, manufacture, shipment, installation, assurance of quality, or licensing of a similar product;
   (c) Information which discloses patentable subject matter for which it may be desirable to obtain patent protection.

   The information sought to be withheld is considered to be proprietary for the reasons set forth in paragraphs 3(a), 3(b) and 3(c) above.

4. The Information has been held in confidence by C.D.I., its owner. The Information has consistently been held in confidence by C.D.I. and no public disclosure has been made and it is not available to the public. All disclosures to third parties, which have been limited, have been made pursuant to the terms and

conditions contained in C.D.I.'s Nondisclosure Secrecy Agreement which must be fully executed prior to disclosure.

5. The Information is a type customarily held in confidence by C.D.I. and there is a rational basis therefore. The Information is a type, which C.D.I. considers trade secret and is held in confidence by C.D.I. because it constitutes a source of competitive advantage in the competition and performance of such work in the industry. Public disclosure of the Information is likely to cause substantial harm to C.D.I.'s competitive position and foreclose or reduce the availability of profit-making opportunities.

I declare under penalty of perjury that the foregoing affidavit and the matters stated therein are true and correct to be the best of my knowledge, information and belief.

Executed on this 31st day of MARCH 2008.

Alan Bilanin
Alan J. Bilanin
Continuum Dynamics, Inc.

Subscribed and sworn before me this day: March 31, 2008

Eileen P. Burmeister
EILEEN P. BURMEISTER
NOTARY PUBLIC OF NEW JERSEY
MY COMM. EXPIRES MAY 6, 2012

Continuum Dynamics, Inc.
(609) 538-0444 (609) 538-0464 fax 34 Lexington Avenue Ewing, NJ 08618-2302

AFFIDAVIT

Re: C.D.I. Report No. 08-07P "Stress Assessments of Browns Ferry Nuclear Unit 2 Steam Dryer," Revision 1 dated April 2008

I, Alan J. Bilanin, being duly sworn, depose and state as follows:

1. I hold the position of President and Senior Associate of Continuum Dynamics, Inc. (hereinafter referred to as C.D.I.), and I am authorized to make the request for withholding from Public Record the Information contained in the documents described in Paragraph 2. This Affidavit is submitted to the Nuclear Regulatory Commission (NRC) pursuant to 10 CFR 2.390(a)(4) based on the fact that the attached information consists of trade secret(s) of C.D.I. and that the NRC will receive the information from C.D.I. under privilege and in confidence.

2. The Information sought to be withheld, as transmitted to TVA Browns Ferry as attachment to C.D.I. Letter No. 08073 dated 2 April 2008 C.D.I. Report No. 08-07P "Stress Assessments of Browns Ferry Nuclear Unit 2 Steam Dryer," Revision 1 dated April 2008.

3. The Information summarizes:

   (a) a process or method, including supporting data and analysis, where prevention of its use by C.D.I.'s competitors without license from C.D.I. constitutes a competitive advantage over other companies;
   (b) Information which, if used by a competitor, would reduce his expenditure of resources or improve his competitive position in the design, manufacture, shipment, installation, assurance of quality, or licensing of a similar product;
   (c) Information which discloses patentable subject matter for which it may be desirable to obtain patent protection.

   The information sought to be withheld is considered to be proprietary for the reasons set forth in paragraphs 3(a), 3(b) and 3(c) above.

4. The Information has been held in confidence by C.D.I., its owner. The Information has consistently been held in confidence by C.D.I. and no public disclosure has been made and it is not available to the public. All disclosures to third parties, which have been limited, have been made pursuant to the terms and conditions contained in C.D.I.'s Nondisclosure Secrecy Agreement which must be fully executed prior to disclosure.

5. The Information is a type customarily held in confidence by C.D.I. and there is a rational basis therefore. The Information is a type, which C.D.I. considers trade secret and is held in confidence by C.D.I. because it constitutes a source of competitive advantage in the competition and performance of such work in the industry. Public disclosure of the Information is likely to cause substantial harm to C.D.I.'s competitive position and foreclose or reduce the availability of profit-making opportunities.

I declare under penalty of perjury that the foregoing affidavit and the matters stated therein are true and correct to be the best of my knowledge, information and belief.

Executed on this 2ND day of APRIL 2008.

Alan J. Bilanin
Continuum Dynamics, Inc.

Subscribed and sworn before me this day: April 2. 2008

EILEEN P. BURMEISTER
NOTARY PUBLIC OF NEW JERSEY
MY COMM. EXPIRES MAY 6, 2012

Continuum Dynamics, Inc.
(609) 538-0444 (609) 538-0464 fax 34 Lexington Avenue Ewing, NJ 08618-2302

AFFIDAVIT

Re: C.D.I. Technical Note No. 08-13P "Limit Curve Analysis with ACM Rev. 4 for Power Ascension at Browns Ferry Nuclear Unit 2," Revision 0 dated March 2008

I, Alan J. Bilanin, being duly sworn, depose and state as follows:

1. I hold the position of President and Senior Associate of Continuum Dynamics, Inc. (hereinafter referred to as C.D.I.), and I am authorized to make the request for withholding from Public Record the Information contained in the documents described in Paragraph 2. This Affidavit is submitted to the Nuclear Regulatory Commission (NRC) pursuant to 10 CFR 2.390(a)(4) based on the fact that the attached information consists of trade secret(s) of C.D.I. and that the NRC will receive the information from C.D.I. under privilege and in confidence.

2. The Information sought to be withheld, as transmitted to TVA Browns Ferry as attachment to C.D.I. Letter No. 08070 dated 31 March 2008 C.D.I. Technical Note No. 08-13P "Limit Curve Analysis with ACM Rev. 4 for Power Ascension at Browns Ferry Nuclear Unit 2," Revision 0 dated March 2008.

3. The Information summarizes:

   (a) a process or method, including supporting data and analysis, where prevention of its use by C.D.I.'s competitors without license from C.D.I. constitutes a competitive advantage over other companies;
   (b) Information which, if used by a competitor, would reduce his expenditure of resources or improve his competitive position in the design, manufacture, shipment, installation, assurance of quality, or licensing of a similar product;
   (c) Information which discloses patentable subject matter for which it may be desirable to obtain patent protection.

   The information sought to be withheld is considered to be proprietary for the reasons set forth in paragraphs 3(a), 3(b) and 3(c) above.

4. The Information has been held in confidence by C.D.I., its owner. The Information has consistently been held in confidence by C.D.I. and no public disclosure has been made and it is not available to the public. All disclosures to third parties, which have been limited, have been made pursuant to the terms and conditions contained in C.D.I.'s Nondisclosure Secrecy Agreement which must be fully executed prior to disclosure.

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I declare under penalty of perjury that the foregoing affidavit and the matters stated therein are true and correct to be the best of my knowledge, information and belief.

Executed on this 31st day of MARCH 2008.

Alan Bilanin

Alan J. Bilanin
Continuum Dynamics, Inc.

Subscribed and sworn before me this day: March 31. 2008

Eileen P Burmeister

EILEEN P. BURMEISTER
NOTARY PUBLIC OF NEW JERSEY
MY COMM. EXPIRES MAY 6, 2012