ENCLOSURE 7

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. 07-30P, "LIMIT CURVE ANALYSIS WITH ACM REV. 4 FOR POWER ASCENSION AT BROWNS FERRY NUCLEAR UNIT 1"

(NON-PROPRIETARY VERSION)

Attached is the non-proprietary version of CDI Technical Note No. 07-30, "Limit Curve analysis with ACM Rev 4 for Power Ascension at Browns Ferry Nuclear Unit 1."

C.D.I. Technical Note No. 07-30NP

Limit Curve Analysis with ACM Rev. 4 for Power Ascension at Browns Ferry Nuclear Unit 1

Revision 2

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March 2009

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1. Introduction

During power ascension of Browns Ferry Nuclear Unit 1 (BFN1), 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 BFN1, in-plant main steam line data have been analyzed at CLTP conditions (based on Unit 1 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 loads provide the basis for generation of the limit curves to be used during BFN1 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 BFN1 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 BFN1, 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 BFN1, 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 2.80 [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, 8]. 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 BFN1 is anticipated to be 111 Hz [9], 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 [10], [11], [12], [13], [14], and [15], 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 2.80.

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	2.80	2.24

Table 2. Bias and uncertainty for ACM Rev. 4

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(3)]]

Table 3. BFN1 additional uncertainties (with references cited)

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(3)]]

Table 4. BFN1 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 1 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 [16]. 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 ($2.80^2 = 7.84$), 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 $0.80^2 \times 2.80^2 = 0.64 \times 7.84 = 5.02$), 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. BFN1 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 BFN1 at CLTP conditions
(VFD = variable frequency drive, Recirc = recirculation pumps)

Frequency Range (Hz)	Exclusion Cause
0 – 2	Mean
59.8 – 60.2	Line Noise
119.9 – 120.1	Line Noise
179.8 – 180.2	Line Noise
239.9 – 240.1	Line Noise
51.3 – 51.7	VFD (1x)
127.0 – 128.5	Recirc Pumps A, B Speed (5x)
217.9 – 219.6	Standpipe Excitation

[[

[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).

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(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).

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(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).

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(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 1 Steam Dryer to 250 Hz (Rev. 3). C.D.I. Report No. 08-04 (Proprietary).

2. Continuum Dynamics, Inc. 2008. Stress Assessment of Browns Ferry Nuclear Unit 1 Steam Dryer (Rev. 3). C.D.I. Report No. 08-06 (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. RAI No. 14.67.

8. Continuum Dynamics, Inc. 2008. Flow-Induced Vibration in the Main Steam Lines at Browns Ferry Nuclear Units 1 and 2, With and Without Acoustic Side Branches, and Resulting Steam Dryer Loads (Rev. 0). C.D.I. Report No. 08-14 (Proprietary).

9. Structural Integrity Associates, Inc. 2007. Evaluation of Browns Ferry Unit 1 Strain Gage Uncertainty and Pressure Conversion Factors (Rev. 0). SIA Calculation Package No. BFN-12Q-302.

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. NRC Request for Additional Information on the Browns Ferry Generating Station, Extended Power Uprate. 2009. RAI No. 204/168 (Draft).

16. Structural Integrity Associates, Inc. 2007. Browns Ferry Unit 1 Main Steam Line 100% CLTP Strain Data Transmission. SIA Letter Report No. KKF-07-012.

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 AFFIDAVIT

Attached is the CDI affidavit for the proprietary information contained in Enclosures 2, 3, and 4.

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

AFFIDAVIT

Re: C.D.I. Report 08-15P "Stress Assessment of Browns Ferry Nuclear Unit 1 Steam Dryer with Tie-Bar Modifications," Revision 3;
C.D.I. Report 08-04P "Acoustic and Low Frequency Hydrodynamic Loads at CLTP Power Level on Browns Ferry Nuclear Unit 1 Steam Dryer to 250 Hz," Revision 3; and
C.D.I. Technical Note 07-30P "Limit Curve Analysis with ACM Rev. 4 for Power Ascension at Browns Ferry Nuclear Unit 1" Revision 2

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. 09032 dated 6 March 2009 C.D.I. Report No. 08-15P "Stress Assessment of Browns Ferry Nuclear Unit 1 Steam Dryer with Tie-Bar Modifications," Revision 3; C.D.I. Report 08-04P "Acoustic and Low Frequency Hydrodynamic Loads at CLTP Power Level on Browns Ferry Nuclear Unit 1 Steam Dryer to 250 Hz," Revision 3; and C.D.I. Technical Note 07-30P "Limit Curve Analysis with ACM Rev. 4 for Power Ascension at Browns Ferry Nuclear Unit 1" Revision 2

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 6 day of March 2009.

Alan J. Bilanin
Continuum Dynamics, Inc.

Subscribed and sworn before me this day: March 6, 2009

Eileen P. Burmeister, Notary Public

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