ATTACHMENT 3

CDI TECHNICAL NOTE NO. 09-17NP (NON-PROPRIETARY), LIMIT CURVE ANALYSIS WITH ACM REV. 4 FOR POWER ASCENSION AT NINE MILE POINT UNIT 2, REV. 0

Certain information, considered proprietary by CDI, has been deleted from this Attachment. The deletions are identified by double square brackets.

C.D.I. Technical Note No. 09-17NP

Limit Curve Analysis with ACM Rev. 4 for Power Ascension at Nine Mile Point Unit 2

Revision 0

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1. Introduction

During power ascension of Nine Mile Point Unit 2 (NMP2), from Current Licensed Thermal Power (CLTP) to Extended Power Uprate (EPU), Constellation Energy Group 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 NMP2, in-plant main steam line data have been analyzed at CLTP conditions to provide steam dryer hydrodynamic loads [1]. EPU is 120% of Original Licensed Thermal Power (OLTP); CLTP is 104.3% 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 NMP2 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 Constellation 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 NMP2 steam dryer during power ascension, utilizing Rev. 4 of the ACM [4], and the options available to NMP2 should a limit curve be reached.

2. Approach

The limit curve analysis for NMP2, 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 NMP2, 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 2.89 [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 NMP2 is anticipated to be 224 Hz [8], and thus the uncertainty determined around the QC2 excitation frequency of 155 Hz has been applied to the 222 to 226 Hz frequency interval. 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 2.89 for ASME Level A load combinations.

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	2.89	2.31

Table 2. Bias and uncertainty for ACM Rev. 4

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Table 3. NMP2 additional uncertainties (with references cited)

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Table 4. NMP2 total uncertainty

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3. Limit Curves

Limit curves were generated from the in-plant CLTP strain gage data 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] and [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 ($2.89^2 = 8.35$), 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 $(0.80 \times 2.89)^2 = 2.31^2 = 5.34$), as PSD is related to the square of the pressure.

Table 5. Exclusion frequencies for NMP2 at CLTP conditions

Frequency Range (Hz)	Exclusion Cause
0.0 – 2.0	Mean
58.85 – 60.15	Line Noise
119.9 – 120.1	Line Noise
179.6 – 180.4	Line Noise
239.8 – 240.2	Line Noise
148.85 – 149.15	Recirculation Vane Passing Frequency: 100%
87.9 – 88.1	Extraneous Non Identified Electrical Source
112.8 – 113.2	Extraneous Non Identified Electrical Source
134.1 – 134.9	Extraneous Non Identified Electrical Source
27.9 – 28.1; 33.5 – 34.5	MSL A Pipe Vibrations
68.9 – 71.1; 79.9 – 81.1	MSL B Pipe Vibrations
12.7 – 13.4	MSL C Pipe Vibrations
39.6 – 40.4; 91.2 – 91.6	MSL D Pipe Vibrations

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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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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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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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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

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