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ATTACHMENT 2

Hope Creek Generating Station

Facility Operating License NPF-57
Docket No. 50-354

Limit Curve Analysis with ACM Rev. 4 for
Power Ascension at Hope Creek Unit 1
C.D.I. Technical Note No. 07-29NP, Revision 1

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Limit Curve Analysis with ACM Rev. 4 for Power Ascension at Hope Creek Unit 1

Revision 1

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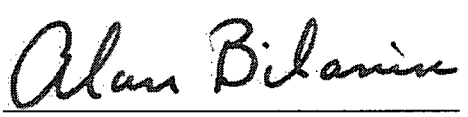

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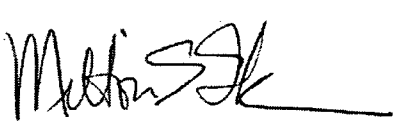

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1. Introduction

During power ascension of Hope Creek Unit 1 (HC1), from Current Licensed Thermal Power (CLTP) to Extended Power Uprate (EPU), PSEG 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 HC1, in-plant main steam line data have been analyzed at CLTP conditions to provide steam dryer hydrodynamic loads [1]. EPU is 115% of CLTP. A finite element model stress analysis has been undertaken on the estimated EPU loads [2]. EPU loads were obtained by multiplying the CLTP plant data at the eight main steam line strain gage locations by bump-up factors determined from subscale test data [3, 4]. These loads provide the basis for generation of limit curves to be used during HC1 power ascension.

Limit curves allow PSEG to monitor 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 HC1 steam dryer during power ascension, utilizing Rev. 4 of the ACM [5], and the options available to PSEG should a limit curve be reached.

Due to the limitations of the high pressure (HP) turbine being installed in the Fall 2007 outage, the Target Power Uprate (TPU) for at least the operating cycle between Fall 2007 and Spring 2009 will be limited to approximately 111.5% CLTP.

2. Approach

The limit curve analysis for HC1 parallels the approach followed by Entergy Vermont Yankee (VY) in its power uprate [6]. 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. Should Level 2 be reached or exceeded (under the rules discussed below), reactor power ascension was to be suspended until an engineering evaluation concluded that further power ascension was justified. Should Level 1 be reached or exceeded, reactor power was to be returned to a previously acceptable power level while an engineering evaluation was undertaken.

To develop the limit curves upon which Level 1 and Level 2 were based, VY calculated the stress levels in the dryer corresponding to the current plant acoustic signature, and then determined how much the acoustic signature could be increased while maintaining stress levels below the 13,600 psi stress fatigue limit. A Level 1 limit curve was then constructed by scaling up the current plant acoustic signature at each point along the frequency spectrum of interest by this overall factor. A Level 2 limit curve was produced in the same manner except at 80% of the fatigue limit, or 10,880 psi, arbitrarily selected by VY, to determine the overall factor. During power ascension, the Level 2 limit curve was reached at discrete frequencies at three power levels. In each case VY stopped the power ascension, determined the impact of the new acoustic signature on the dryer stresses, and developed revised Level 2 limit curves to use at higher power steps. Their Level 1 limit curve was never reached. The VY approach is summarized in [7].

HC1 steam dryer data and evaluations will be performed as required per Attachment 3 "Dryer Data Collection" (Test No. 101) of HC.OP-FT.ZZ-0004(Q), "Extended Power Uprate Power Ascension Testing" (PSEG).

The finite element analysis using the estimated HC1 EPU data found a lowest/minimum alternating stress ratio of 2.10, as summarized in Table 1. The minimum stress ratios include the model bias and uncertainties for specific frequency ranges as suggested by the NRC [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). Note that the standpipe excitation frequency in HC1 is anticipated to be 118 Hz, and that the uncertainty determined around the QC2 excitation frequency of 155 Hz has been applied to the 116 to 120 Hz frequency interval. The additional bias and uncertainties, as identified in [9 – 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 alternating stress ratio of 2.10.

Table 1. Alternating Stress Limit Summary

ASME Code Stress Limit	13,600 psi (Level 1)	10,880 psi (Level 2)
Minimum Alternating Stress Ratio	2.10	1.68

Table 2. Bias and uncertainty for ACM Rev. 4

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Table 3. HC1 additional uncertainties (with references cited)

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Table 4. HC1 total uncertainty

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3. Limit Curves

Limit curves were generated from the in-plant CLTP strain gage data collected in February 2007 [1]. These data were filtered across the frequency ranges shown in Table 5 to remove noise and extraneous signal content, as in [15]. The resulting PSD curve for each of the eight strain gage locations was then multiplied by its one-eighth scale bump-up factor, frequency by frequency, then used to develop the limit curves, shown in Figures 1 to 4. Level 1 limit curves are found by multiplying the estimated EPU main steam line pressure PSD traces by the square of the minimum alternating stress ratio, while the Level 2 limit curves are found by multiplying the EPU PSD traces by 0.64 of the square of the minimum alternating stress ratio, as PSD is related to the square of the pressure. The minimum alternating stress ratio for Hope Creek is 2.10.

The SRV acoustic response peak shown in Figures 1 to 4 has been centered at 118 Hz. The actual SRV acoustic resonance may be as low as 116 Hz and as high as 122 Hz, due to resonant frequency estimation uncertainties. During power ascension, any peak observed between 116 Hz and 122 Hz will be centered on the peak of the limit curve prior to making a Level 1 or Level 2 assessment.

Table 5. Exclusion frequencies for HC1

Frequency Interval (Hz)	Exclusion Cause
0.0 to 2.0	Mean
59.8 to 60.2	60 Hz Line Noise
119.8 to 120.2	120 Hz Line Noise
179.8 to 180.2	180 Hz Line Noise
104.9 to 105.3	B Recirculation Pump
106.5 to 106.9	A Recirculation Pump

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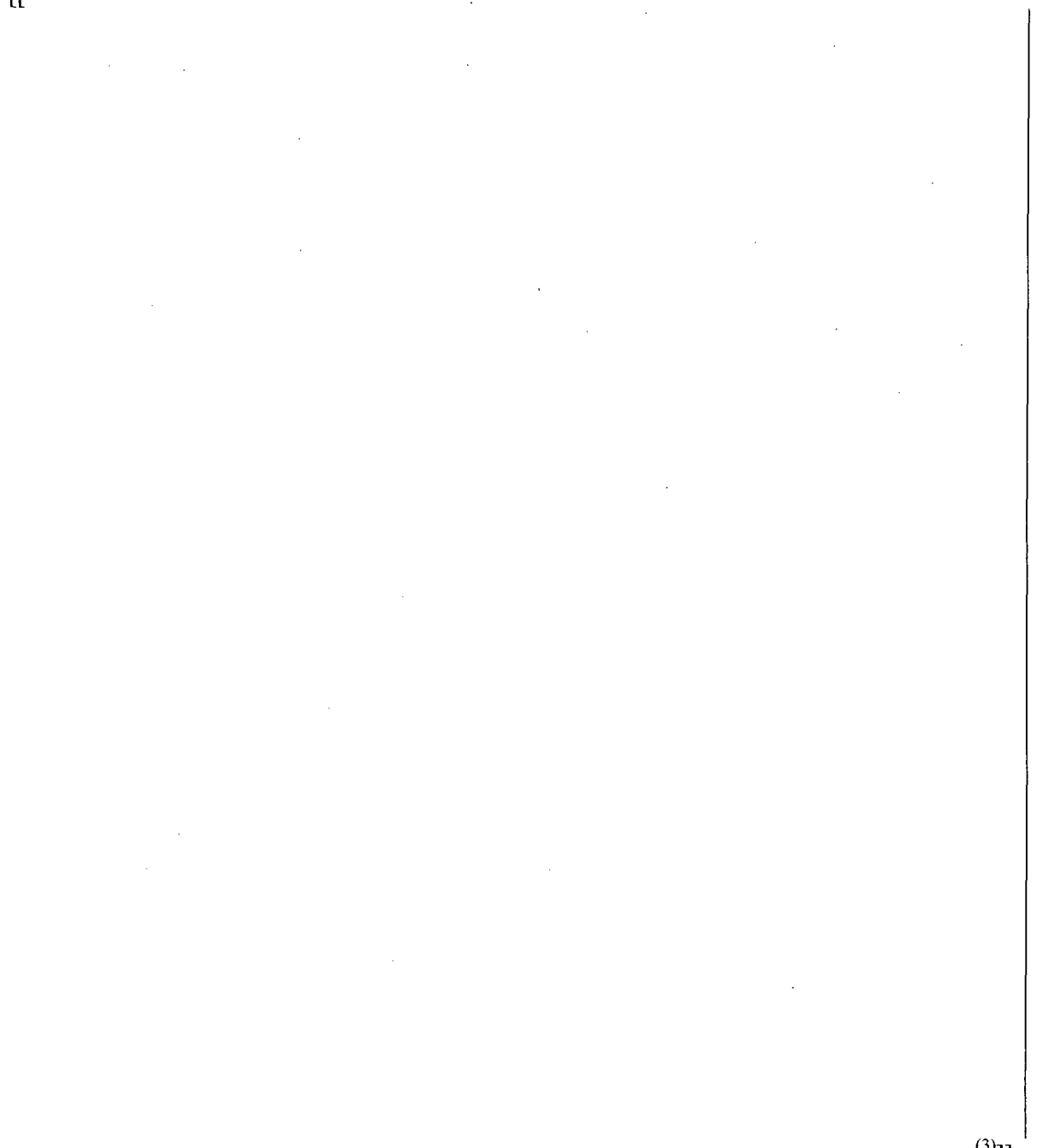

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Figure 1. Level 1 (black) and Level 2 (red) limit curves for main steam line A, compared against the base curves (blue) over the frequency range of interest: A upper strain gage location (top); A lower strain gage location (bottom).

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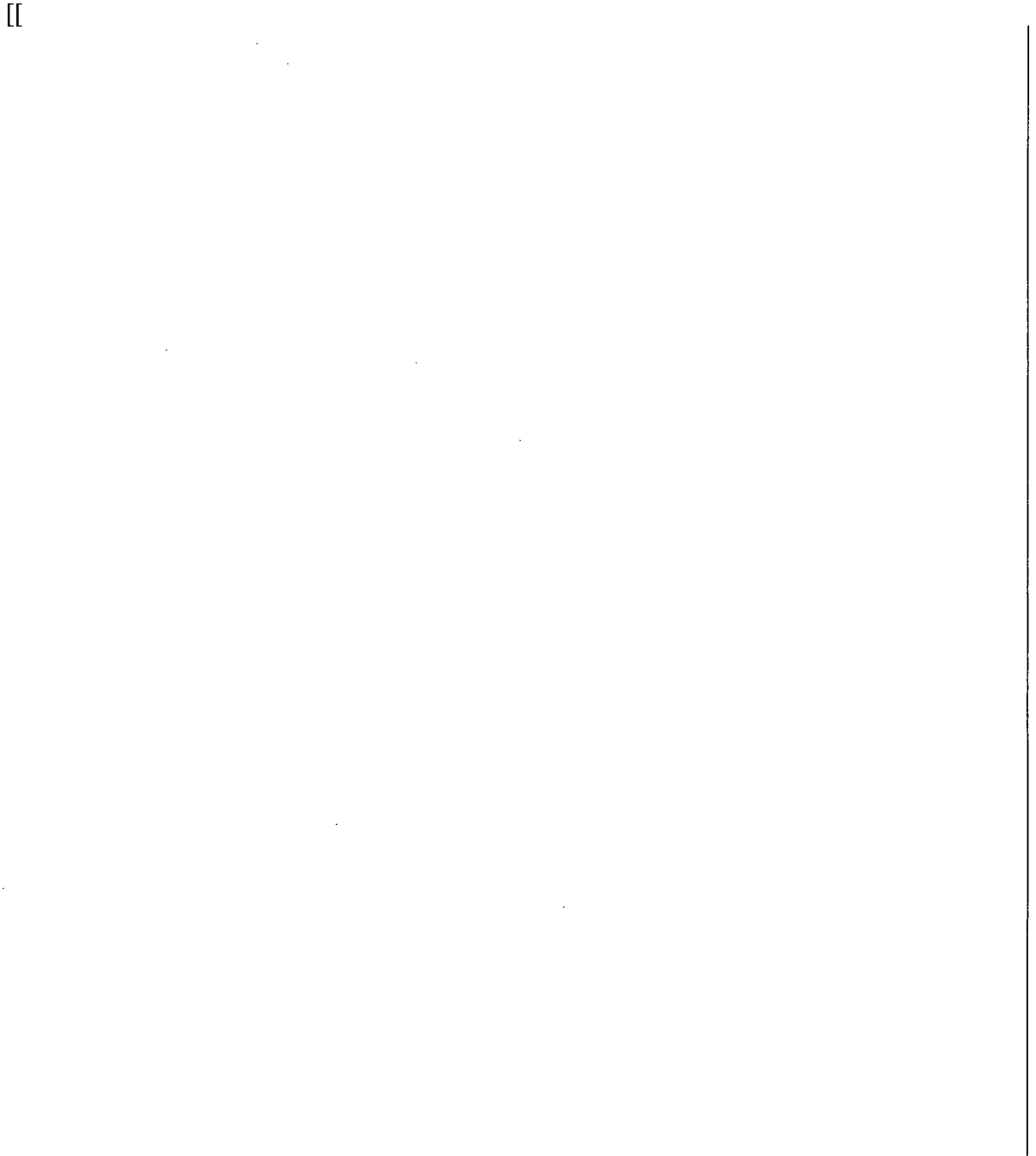

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Figure 2. Level 1 (black) and Level 2 (red) limit curves for main steam line B, compared against the base curves (blue) over the frequency range of interest: B upper strain gage location (top); B lower strain gage location (bottom).

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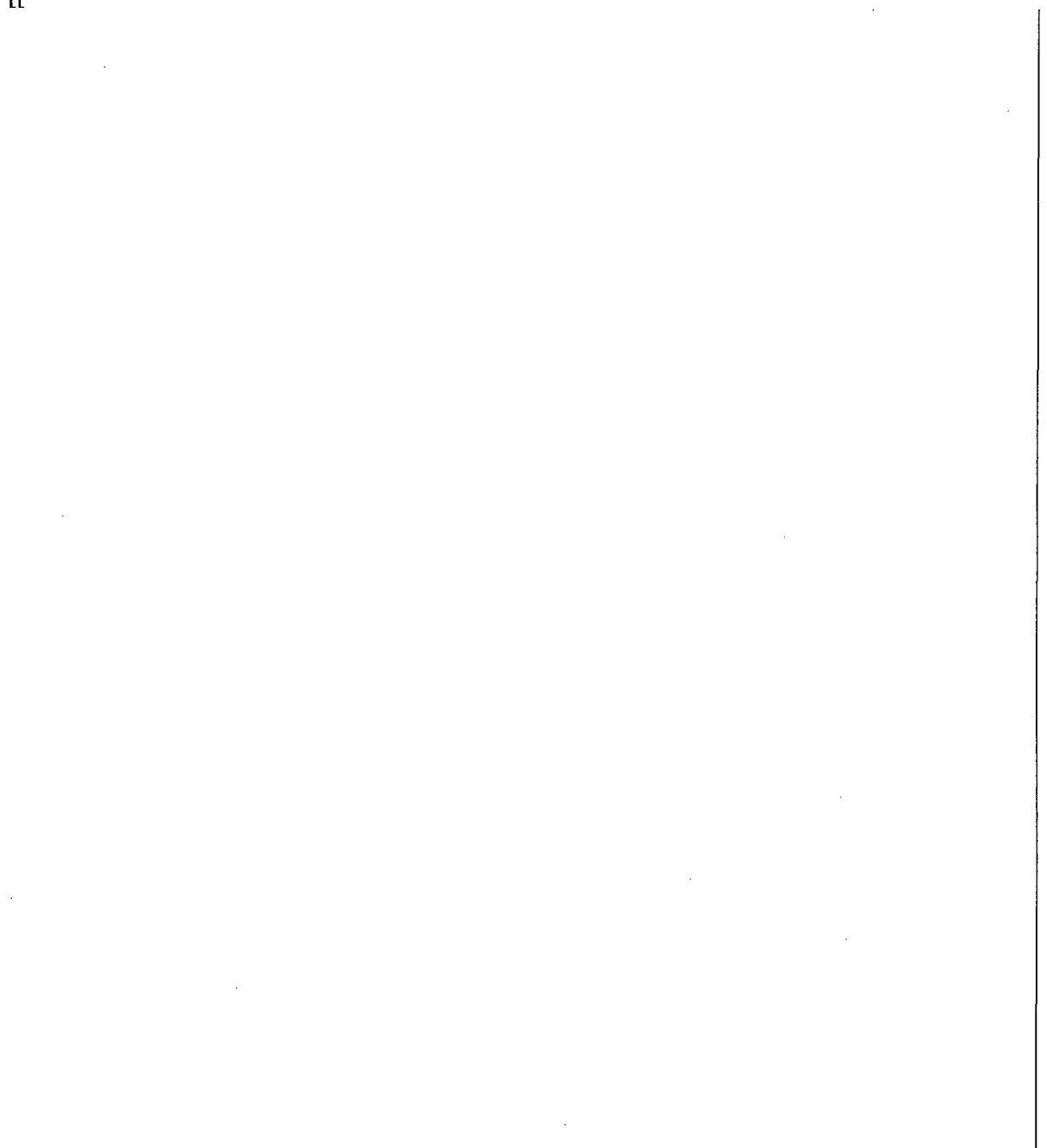

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Figure 3. Level 1 (black) and Level 2 (red) limit curves for main steam line C, compared against the base curves (blue) over the frequency range of interest: C upper strain gage location (top); C lower strain gage location (bottom).

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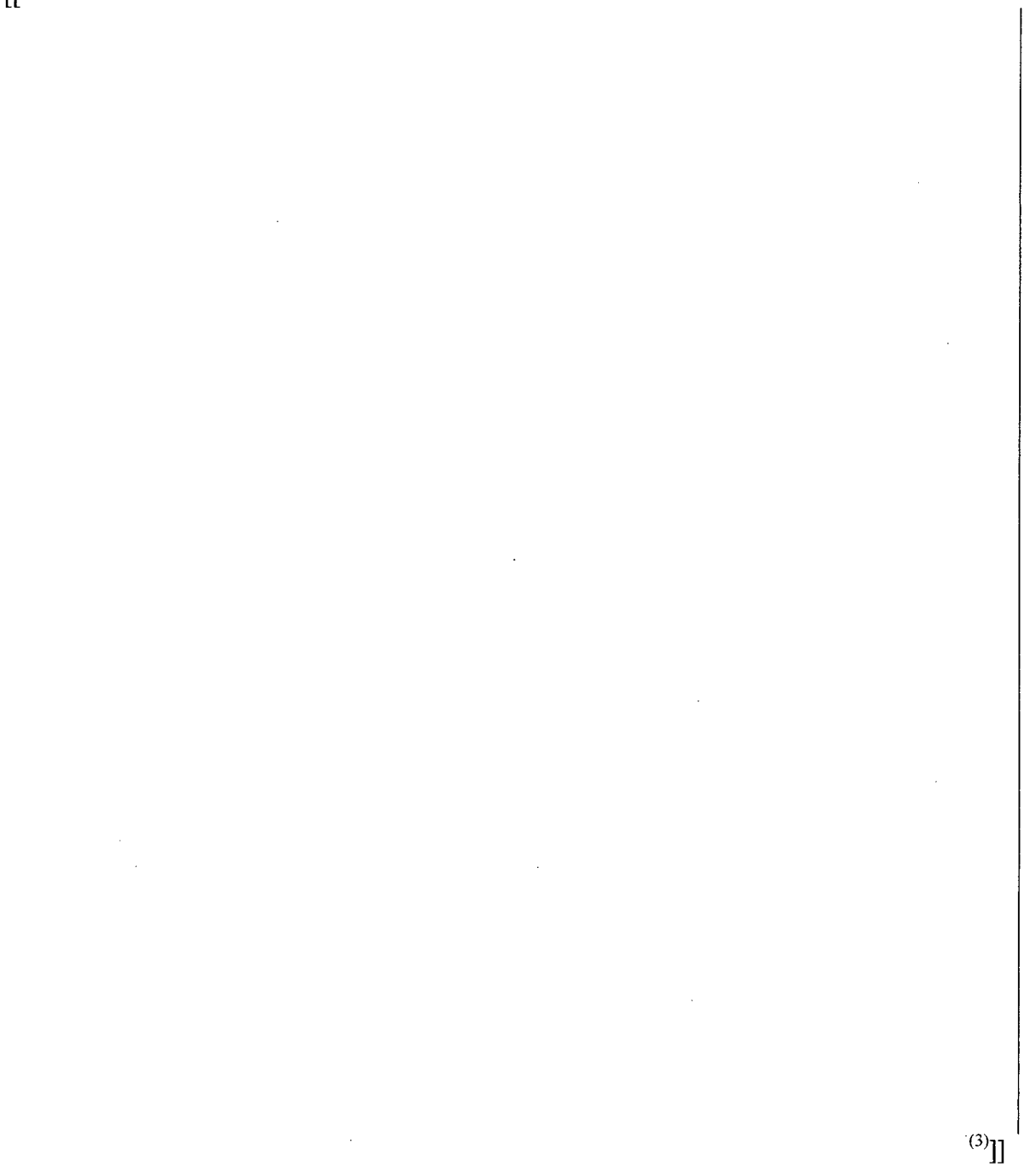

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Figure 4. Level 1 (black) and Level 2 (red) limit curves for main steam line D, compared against the base curves (blue) over the frequency range of interest: D upper strain gage location (top); D lower strain gage location (bottom).

4. References

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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. 2007. Hope Creek Main Steam Line Strain Gage Data Reduction. File No. HC-30-301.