Attachment 2

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Hope Creek Generating Station
Facility Operating License NPF-57
Docket No. 50-354

Extended Power Uprate

Limt Curve Analysis for Dryer Stress Prediction During Power Ascension of Hope Creek Unit 1
C.D.I. Technical Note No. 07-19NP, Revision 0
May 2007

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Limit Curve Analysis for Dryer Stress Prediction During Power Ascension of Hope Creek Unit 1

Revision 0

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1. Introduction

PSEG is planning power ascension of Hope Creek Unit 1 (HC1). During ascension, it is required to monitor the dryer stresses anticipated at plant power levels that have not yet been achieved. A convenient way to track these stresses is through the use of limit curves. 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, main steam line data have been analyzed at Current Licensed Thermal Power (CLTP) in-plant [1] and in subscale tests [2], and at Extended Power Uprate (EPU) in subscale tests [3]. EPU at HC1 is 115% of CLTP. A finite element model stress analysis has been undertaken on the EPU subscale test data [4]. These existing data provide the basis for generation of the limit curves to be used during HC1 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 [5]. This methodology, and the use of a finite element model analysis, provides the computational engine behind which dryer stresses at distinct steam dryer locations may be tracked through power ascension. Limit curves allow the PSEG engineer to estimate dryer stress levels conservatively, by simply comparing the main steam line pressure readings (represented in Power Spectral Density, or PSD, format) with the upper bound PSD derived from existing in-plant and subscale test 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, and the options available to PSEG should a limit curve be reached.

2. Approach

The limit curve analysis for HC1 parallels the approach followed by Entergy Vermont Yankee (VY) in its power uprate [6]. In their 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 to be 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 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].

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" supplied by PSEG. The following power ascension approach is proposed for monitoring steam dryer stresses:

1. During power ascension, plant data will be collected, as a minimum, every 1% (of CLTP) for trending, every 2.5% (of CLTP) for evaluation, and every 5% (of CLTP) for evaluation and transmittal to the NRC. Target Power Uprate (TPU) is 111.5% of CLTP. Thus, the 2.5% intervals are at 102.5% and 107.5% CLTP, and the power plateaus are at 105.0%, 110.0%, and 111.5% CLTP. TPU is treated as a plateau.

2. At each data point the pressure data from the eight main steam line strain gages will be recorded. [[

(3)]]

3. Should any power level produce main steam line pressure signals that exceed discrete frequencies in the Level 2 limit curves, a finite element model, which evaluates the limiting points on the dryer, will be run to generate revised limit curves.

4. It is not anticipated that the Level 1 limit curves will be reached.

A previous finite element analysis of subscale EPU data found a lowest alternating stress ratio of 1.96 [4]. ACM bias and uncertainty were summarized previously in [8] and are shown in Table 2.1 (a negative bias is conservative).

Table 2.1. Bias and uncertainty for HC1 [8].

Term	Bias (%)	Uncertainty (%)
Strain Gage Conversion	0.0	7.2
Strain Gage Location	0.0	4.2
Quad Cities Unit 2 Dryer Pressure Measurement	-3.0	2.9
ACM Low Frequency Limitation	3.0	0.0
ACM Accuracy	-10.8	25.7
SUBTOTALS	-10.8	27.2

[[

(3)]]

Limit curves may then be generated based on the limiting stress ratio and the VY practice of assigning the Level 2 limit curves at 80% of the Level 1 limit curves.

3. Limit Curves

Limit curves were generated from the subscale EPU pressure transducer data collected in May 2006 and reported in [3]. [[

(3)]] Level 1 limit curves are found by multiplying the main steam line pressure PSD traces by the square of the corrected limiting stress ratio, while the Level 2 limit curves are found by multiplying the PSD traces by 0.64 of the square of the corrected limiting stress ratio (recovering 80% of the limiting stress ratio), as PSD is related to the square of the pressure.

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[3]]]

[[

(3)]]

4. Discussion

As in-plant data were previously recorded at CLTP conditions, and reported in [1], it is instructive to compare these data with the Level 2 limit curves determined above. These results are shown in Figures 4.1 and 4.2. It may be seen that the Level 2 limit curves bound the full scale CLTP results across all frequencies of interest.

The strategy to be invoked for power ascension is the following:

[[1.

(3)]]

[[2.

(3)]]

3. Upon achieving TPU for the fuel cycle, PSEG may elect to perform a complete finite element calculation.

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(3)]]

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(3)]]

5. References

1. Continuum Dynamics, Inc. 2007. Revised Hydrodynamic Loads on Hope Creek Unit 1 Steam Dryer to 200 Hz (Rev. 0). C.D.I. Report No. 07-01 (Proprietary).

2. Continuum Dynamics, Inc. 2007. EPU Conditions in the Main Steam Lines at Hope Creek Unit 1: Additional Subscale Four Line Tests (Rev. 0). C.D.I. Technical Note No. 07-01 (Proprietary).

3. Continuum Dynamics, Inc. 2007. Estimating High Frequency Flow Induced Vibration in the Main Steam Lines at Hope Creek Unit 1: A Subscale Four Line Investigation of Standpipe Behavior (Rev. 2). C.D.I. Report No. 06-16 (Proprietary).

4. Continuum Dynamics, Inc. 2007. Stress Analysis of the Hope Creek Unit 1 Steam Dryer at EPU Conditions using One-Eighth Scale Model Pressure Measurement Data (Rev. 2). C.D.I. Report No. 06-27.

5. 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).

6. Entergy Nuclear Northeast. 2005. Vermont Yankee Nuclear Power Station Technical Specification Proposed Change No. 263 – Supplement No. 26: Extended Power Uprate – Steam Dryer Analyses and Monitoring, Attachment 2. Letter No. BVY 05-034 to Document Control Desk, U. S. Nuclear Regulatory Commission. Dated 31 March 2005.

7. 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.

8. PSEG. 2007. Hope Creek Generating Station Facility Operating License NPF-57 Docket No. 50-354: Request for License Amendment Extended Power Uprate Steam Dryer Evaluation. Attachment No. 7 (Rev. 1). Dated April 2007.