Docket 50-271
BVY 06-056

Attachment 1

Vermont Yankee Nuclear Power Station

Steam Dryer Monitoring Plan Rev 4

Entergy Vermont Yankee
Steam Dryer Monitoring Plan

Revision 4
June 29, 2006

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Entergy Vermont Yankee
Steam Dryer Monitoring Plan

List of Revisions

Revision	Date	Changes
Original	February 26, 2006	Original Issue
1	March 25, 2006	Incorporated new ACM. Incorporated revisions to FEM. Updated uncertainty evaluation and Limit Curves based on updated models and strain gage data evaluation at 1671 MWt.
2	April 20, 2006	Updated uncertainty evaluation and Limit Curves based on updated strain gage data evaluation at 1792 MWt.
3	May 4, 2006	Incorporated allowance for use of FEM/Strain Gage Evaluation (F-factor). Provided allowance for up to 1Hz shift in limit curve peak frequencies. Updated Limit Curves Based on 1872 MWt Data Clarified schedule for completion of final Full Power Steam Dryer Load Analysis
4	June 29, 2006	Document completion of Power Ascension and related testing. Provide final load definition, uncertainty assessment, and dryer stress evaluation.

VERMONT YANKEE NUCLEAR POWER STATION
STEAM DRYER MONITORING PLAN

Introduction and Purpose

The Vermont Yankee Steam Dryer Monitoring Plan (SDMP) describes the course of action for monitoring and evaluating the performance of the Vermont Yankee Nuclear Power Station (VYNPS) steam dryer during power ascension testing and operation above 100% of the original licensed thermal power (OLTP), i.e., 1593 MWt, to the full 120% extended power uprate (EPU) condition of 1912 MWt to verify acceptable performance. The SDMP also addresses long-term actions necessary to implement proposed License Condition 3.M. Through operating limits, periodic surveillances, and required actions, the impact of potentially adverse flow effects on the structural integrity of the steam dryer will be minimized.

The SDMP also provides information about the equipment and computer analysis methodologies used to monitor Steam Dryer performance.

Unacceptable steam dryer performance is a condition that could challenge steam dryer structural integrity and result in the generation of loose parts, cracks or tears in the steam dryer that result in excessive moisture carryover. During reactor power operation, performance is demonstrated through the measurement of a combination of plant parameters.

Scope

The SDMP is primarily an initial power ascension test plan designed to assess steam dryer performance from 100% OLTP (i.e., 1593 MWt) to 120% OLTP (i.e., 1912 MWt) and to perform confirmatory inspections for a period of time following initial and continued operation at uprated power levels. Power ascension to 120% OLTP will be achieved in a series of power step increases and holds at plateaus corresponding to 80 MWt increments above OLTP. Elements of this plan will be implemented before EPU power ascension testing, and others may continue after power ascension testing.

There are three main elements of the SDMP:

1. Slow and deliberate power ascension with defined hold points and durations, allowing time for monitoring and analysis;

2. A detailed power ascension monitoring and analysis program to trend steam dryer performance (primarily through the monitoring of steam dryer load signals and moisture carryover); and

3. A long term inspection program to verify steam dryer performance at EPU operating conditions.

Several elements of the SDMP also provide for completion of the necessary actions to satisfy the requirements of license conditions associated with the EPU license amendment. A complete tabulation of the provisions of the license condition and the implementing strategy to complete them is contained in Table 3.

Power Ascension

VYNPS procedure ERSTI-04-VY1-1409-000, "Power Ascension Test Procedure for Extended Power Conditions 1593 to 1912 MWth," (PATP) will provide controls during power ascension testing and confirm acceptable plant performance. Other procedures may be entered to conduct specialized testing, such as condensate and feedwater testing. The VYNPS power ascension will occur over an extended period with gradual increases in power, hold periods, and engineering analyses of monitored data that must be approved by station management prior to subsequent power increases. Relevant data and evaluations will be transmitted to the NRC staff in accordance with the provisions of the license condition. The PATP includes:

1. Power ascension rate of 16 MWt/hr;
2. Hourly monitoring of steam dryer performance during power ascension (required by License Condition 3.M);
3. *Four hour holds at each 40 MWt; and*
4. *Minimum 96 hour holds at each 80 MWt power plateau to perform steam dryer analysis* allowing for NRC review, as appropriate (required by License Condition 3.M).

Monitoring Plans

Table 1 outlines the steam dryer surveillance requirements during reactor power ascension testing for EPU. The monitoring of moisture carryover and main steam line (MSL) pressure data provide measures for ensuring acceptable performance of the steam dryer. Frequent monitoring of these parameters provides early detection capability of off-normal performance.

Proposed License Condition 3.M requires that steam dryer performance criteria are met and prompt action is taken if unacceptable performance is detected. Entergy has established two performance levels (Level 1 criteria and Level 2 criteria) as described in Table 2 for evaluating steam dryer performance during EPU power ascension testing. The Level 1 criteria correspond to the limits specified in the proposed license condition, while the Level 2 criteria are operating action levels that may indicate reductions in margin.

The comparison of measured plant data against defined criteria derived from the steam dryer analyses described below provides a means to assess continued steam dryer structural integrity under EPU conditions.

Main Steam Fluctuating Pressure Monitoring System (Details contained in VYC-3001)

- Main Steam Line Strain Gages
  Entergy has installed strain gages at two locations on each of the four MSLs in the primary containment and a data acquisition system (DAS) designed to reduce uncertainties in the evaluation of steam dryer loads. These strain gages and the associated data acquisition system have been selected and configured to maximize sensitivity and reliability while reducing data uncertainty.
- Acoustic Circuit Model (ACM)
  The CDI Acoustic Model has been improved based on results of the instrumented Steam Dryer at Exelon's Quad Cities Station. The revision has resulted in reduced uncertainty and a more conservative representation of the peak frequencies.

- Finite Element Model (FEM)

  In response to industry operating experience with steam dryer cover plate cracking, the ANSYS FEM has been updated to include more refined analysis of key dryer structural components such as the lower cover plate, the gussets, gusset shoes, and associated welds.

  Since Entergy/GE started using the FEM to evaluate stresses on the VY dryer during power ascension, the contribution of the key in-plant forcing frequencies has been calculated. By understanding the impact on stress due to increases in each of the key in-plant forcing frequencies, the change in steam dryer stress with changes in strain gage signal can be determined directly. Use of these frequency contributions (known as 'F' factors) allows the relationship of the strain gages, ACM, and FEM to be more directly determined based on the plant-specific assessment of ACM/FEM results.

  In addition, the Steam Dryer Strain Gage Monitoring and FEM frequency assessments have determined that in-plant acoustic signal frequencies have been shown to change slightly with increased stream flow. While the observed changes (<1Hz) have negligible impact to the dryer structure, they can result in an unnecessary challenge to the limit curve. To address the shifts of in-plant acoustic frequencies, the limit curve may be shifted to the right or to the left less than or equal to 1Hz. The limit curve criteria is considered satisfied as long as the acoustic signal from the shifted peak falls under the shifted limit curve.

- Acoustic Circuit Analysis (ACA) System Uncertainty Evaluation

  The VY Acoustic Circuit Model (ACM) has been updated. The revised ACM was developed to bound maximum pressure loads from three sets of test data from the instrumented QC2 dryer testing performed in 2005. This updated ACM uncertainty assessment is based on the enhanced VY strain gage and data acquisition system and the revised CDI Bounding Pressure model parameters. The Scale Model Test (SMT) benchmark evaluation and previous 790 MWe QC2 benchmark assessment that provided the uncertainty bases for the prior ACM have been accordingly deleted from this calculation.

  The ACA uncertainty included both a non-conservative Bias and an Uncertainty. These are summarized below.

Summary of ACA Bias and Uncertainties	**Bias**	**Uncertainty**
ACM ability to match response at the peak frequencies:	-21%	15%
Difference in Sensor Locations from QC2 to VY	0%	7%
The application of a model tuned to QC2 applied to Vermont Yankee.	0%	0%
The selection of a 2 second analysis interval to produce peak stress	-6%	0%
SG and DAS ability to measure pressure in Pipe	0%	11%
Uncertainty of Dryer Pressure data Measurements at QC2	0%	3%
Combined Bias	**-27%**	

The Bias terms are added. The Uncertainty terms are independent and are therefore combined by the square root sum of the squares (SRSS) method. The frequency uncertainty value is not included in the summary above. Table 2 includes a summary of the time step summary stress results provided in Attachment J. In this table we also calculate the maximum increase in stress for the frequency sensitivity runs; -10%, -5%, -2.5%, +2.5%, +5%, +10% for each of the dryer subcomponents. These maximum values are then combined by the SRSS method with the ACA load uncertainties summarized above to provide a specific uncertainty for each dryer component. Finally, the -27% bias is subtracted from the resulting uncertainty to provide the combined uncertainty for each dryer component.

Entergy also performed an additional bounding assessment of FIV fatigue stress. This sensitivity study determined that a worst case combination of the bias and uncertainties would result in a bias of 75% and an ACA uncertainty of 17%. Even with these extremely conservative values the total dryer stress of 9169 psi would have 33% margin to the ASME Curve C endurance limit.

- CFD Load Uncertainty (Remains unchanged from Revision 0 of VYC 3001)
  The CFD predictions using the Large Eddy Simulation runs for VY are on average 118% above the RMS values of in-plant data with a standard deviation of 82%. Therefore a conservative estimate of uncertainty is 118% - 82% = +36%. This would support 0% uncertainty for the CFD load. Conservatively, VY has maintained a 15% CFD load uncertainty in the Limit Curve Factor assessment.

  The CFD analysis with the +/-10% change in load step had an impact on the limiting stress by 4%. Therefore the CFD frequency uncertainty is determined to be 4%. The total CFD uncertainty; uncCFD= sqrt(15^2 + 4^2) = 16%.

- System Monitoring Requirements (During Power Ascension)

  - During power ascension, steam dryer performance will be monitored hourly through the evaluation of pressure fluctuation data collected from strain gages installed on the MSLs.
  - The strain gage data collected hourly during power ascension will be compared against the stress limit curve that is provided as Figures 1 - 8 of the SDMP and is based on Entergy Calculation VYC-3001. If any frequency peak from the MSL strain gage data exceeds the stress limit curve (Level 1), Entergy will reduce the reactor power to a level at which the stress limit curve is not exceeded.
  - Additionally, Entergy will monitor data collected from accelerometers mounted to the main steam piping inside the drywell to provide additional insights into the strain gage signals.
  - During hold points at each 80 MWt power level above current licensed thermal power, the collected data, along with a comparison to the steam dryer limit curve, will be transmitted to the NRC staff.
  - For any circumstance requiring a revision to the steam dryer limit curve, Entergy will resolve uncertainties in the steam dryer analysis and provide the results of that evaluation to the NRC staff prior to further increases in reactor power.
  - Entergy will resolve uncertainties in the steam dryer analysis with the NRC staff within 90 days of issuance of the EPU license amendment. If resolution is not made within this time interval, reactor operation will not exceed 1593 MWt. These planned actions are in compliance with proposed License Condition 3.M.

Moisture Carryover

- Moisture carryover trending provides an indicator of steam dryer integrity. At each 40 MWt step, moisture carryover data will be taken and compared to the predetermined acceptance criteria (Table 2).
- Level 1 criterion (0.35%) is based on the maximum analyzed value.
- The data taken at each 80 MWt plateau will be evaluated and documented in the assessment sent to the NRC for information.

Other Monitoring

- Plant data that may be indicative of off-normal steam dryer performance will be monitored during power ascension (e.g., reactor water level, steam flow, feed flow, steam flow distribution between the individual steam lines). Plant data can provide an early indication of unacceptable steam dryer performance. The enhanced monitoring of selected plant parameters will be controlled by the PATP and other plant procedures.

NRC Notifications

- In accordance with proposed License Condition 3.M., at discrete power levels, and if the steam dryer stress limit curve (i.e., Level 1 criterion) is exceeded, Entergy will provide notifications to the NRC staff consisting of data and evaluations performed during EPU power ascension testing above 1593 MWt. Detailed discussions regarding new plant data, inspections, and evaluations will be held with NRC staff upon request. The designated NRC point of contact for such information is the NRC Project Manager for the VYNPS EPU.
- The results of the SDMP will be submitted to the NRC staff in a report within 60 days following the completion of all EPU power ascension testing. This will include the final full EPU power performance criteria spectra (i.e., steam dryer stress limit curve). In accordance with License Condition 3.M the uncertainty questions associated with the ACM will be resolved and submitted to the NRC staff within 90 days of license amendment issuance. Contemporary data and results from steam dryer monitoring will be available on-site for review by NRC inspectors as it becomes available. The written report on steam dryer performance during EPU power ascension testing will include evaluations or corrective actions that were required to obtain satisfactory steam dryer performance. The report will include relevant data collected at each power step, comparisons to performance criteria (design predictions), and evaluations performed in conjunction with steam dryer structural integrity monitoring.

<u>Long Term Monitoring</u>

The long-term monitoring of plant parameters potentially indicative of steam dryer failure will be conducted, as recommended by General Electric Service Information Letter 644, Rev. 1 and consistent with License Condition 3.M.

Moisture Carryover

Per VYNPS station operating procedure OP-0631, "Radiochemistry," moisture carryover is periodically monitored for moisture carryover during normal plant operations. VYNPS off-normal procedure ON-3178, "Increased Moisture Carryover," provides guidance to evaluate any

elevated moisture carryover results including that resulting from potential vessel internals damage. This monitoring will also provide insight into changes in moisture carryover values during changing reactor core configurations (control rod patterns)

Strain Gage Monitoring

As the strain gages will remain operational and can provide for future data collection, additional strain gage monitoring will be performed as determined appropriate during the remainder of the operating cycle following EPU implementation.

Inspections

The VYNPS steam dryer will be inspected during the refueling outages scheduled for the Spring 2007, Fall 2008, and Spring 2010. The inspections conducted after power uprate implementation will be comparable in scope to the inspection conducted during the Spring 2004 refueling outage and will be in accordance with the guidance in SIL 644, Rev. 1.

Reporting to NRC

Steam Dryer Visual Inspections: The results of the visual inspections of the steam dryer conducted during the next three refueling outages shall be reported to the NRC staff within 60 days following startup from the respective refueling outage.

Results of Steam Dryer Monitoring Plan

Power Ascension

Power was raised in small (16 MWt and 8 MWt) increments to achieve each plateau. Monitoring in accordance with the Power Ascension Test Plan (PATP) was completed with no significant monitoring equipment issues. As expected signals on the Main Steam Line Strain Gages detected increased strain signals and the predicted frequencies associated with the branch lines from the Main Steam Lines. In accordance with the SDMP and the PATP, when the signal at any frequency reached predetermined administrative limits (Level 2) the power ascension was put on hold, additional, preestablished analyses were completed and the results provided to the NRC for review. These holds occurred at 105, 112.5 and 117.5 percent power and in each case the reanalysis demonstrated that the actual load on the dryer remained very low.

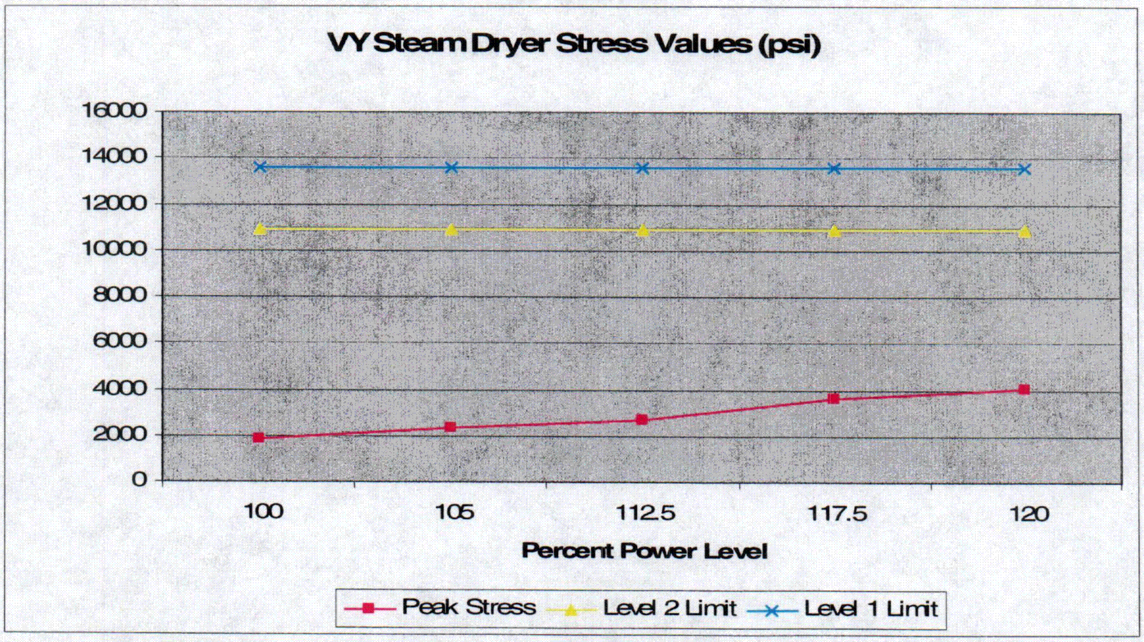
Steam Dryer Stress Analysis

- Peak ACA Steam Dryer Load at 1593 MWt (100% Power) 1857 psi
- Peak ACA Steam Dryer Load at 1912 MWt (120% Power) 4762 psi
  (Note: This value includes use of Rayleigh damping anchored at 20 and 150Hz for additional conservatism)

- Load Limit Factors

Peak Stress Limit	13,600 psi	0.8 x 13,600
	ASME C Limit LCF1	80% of ASME C Limit LCF2
Minimum Load Factor	2.85	2.28
Uncertainty of Load Factor	0.92	0.73
Load Factor Minus Uncertainty	1.93	1.55

- Peak CFD Stress 599 psi
  (Note: Most limiting of 100% and 120% CFD Cases)
- Trending of acoustic signals
  A detailed review of the plots from 90% OLTP to 120% OLTP indicates that there has been an increasing trend at 143 Hz. It is likely the sources of these acoustic signals are the Dresser safety valve branch lines. It was calculated that that the onset of resonance was 150 ft/sec and resonance was calculated to occur at 170 ft/sec. In addition, small shifts (<1 Hz) in the frequency peak were also noted as power increased and allowance was made to shift the limit curve up to 1 Hz up or down to account for these changes.
- A technique was developed to determine directly, based on experiential data, the impact on dryer stress of a change in strain gage signal at existing peak frequencies. This technique is applicable for the assessment of signal changes, not for the assessment of new signals that are outside the frequency bands evaluated in the previous acoustic circuit and stress analysis.



Notes:
1) Stress Calculated with 1% Rayleigh damping Anchored at 20 and 80 Hz.
2) Power Level expressed as percent of original licensed thermal power, 1593 MWt.

Final Uncertainty Evaluation

Based on refinements made to the strain gage monitoring system, the ACA, and the FEM an updated uncertainty assessment was completed. The revised assessment includes both biases and uncertainties to best characterize the performance of the models. The ACA uncertainty included both a non-conservative Bias and an Uncertainty. These are summarized below.

Summary of ACA Bias and Uncertainties	Bias	Uncertainty
ACM ability to match response at the peak frequencies:	-21%	15%
Difference in Sensor Locations from QC2 to VY	0%	7%
The application of a model tuned to QC2 applied to Vermont Yankee.	0%	0%
The selection of a 2 second analysis interval to produce peak stress	-6%	0%
SG and DAS ability to measure pressure in Pipe	0%	11%
Uncertainty of Dryer Pressure data Measurements at QC2	0%	3%
Combined Bias	**-27%**	

Moisture Carryover

During Power Ascension Moisture Carryover was monitored per the PATP and results reported to the NRC. The original Level 2 Criteria (0.1%) was reached at 1872 MWt (117.5% Power). Evaluations in accordance with plant procedures determined the final 1912 MWt Level 2 Criteria to be 0.16%. At 1912 MWt all data remains below 0.15%. Significant Margin remains to the Level 1 Criteria (0.35%).

Conclusion

As shown above, after reduction for uncertainties, the VY dryer maintains a 93% margin to the 13.6 ksi endurance limit under FIV loads.

License Condition Criteria (3.M.2.c, 3.M.2.f)

- Obtain measurements from the main steam line strain gauges – On May 5, 2006 VY reached 1912 MWt (120% Power) and obtained the full power main steam line strain gage signature from all eight main steam line strain gage locations. The averaged signals from the array of strain gages at each location are shown on Figures 1 through 8 of the SDMP (Figures 9 through 12 are expanded versions of certain frequency signatures).
- Establish the steam dryer flow-induced vibration load fatigue margin – Based on the results of the steam dryer stress analysis using the 120% load definition the limit factors specified above were calculated. These limit factors are shown graphically in Figures 1 though 8 of the SDMP.
- Update the steam dryer stress report – The Steam Dryer stress report has been updated based on the 120% load definition and is included in Entergy calculation VYC-3001. This report, GE-NE-0000-0054-1378P-R0, Vermont Yankee Nuclear Power station Steam Dryer Stress Analysis at Extended Power Uprate Conditions, Revision 0, Class III (GE Proprietary Information), dated June 2006 will be provided separately to the NRC.

- Reestablish the SDMP limit curve with the updated acoustic circuit model load definition and revised instrument uncertainty values – The updated SDMP limit curves are shown on Figures 1 through 8 of the SDMP (Figures 9 through 12 are expanded versions of certain frequency signatures).
- Develop the final steam dryer load definition – The final Steam Dryer Load definition is represented by the eight main steam line strain gage signatures shown in Figures 1 through 8 of the SDMP (Figures 9 through 12 are expanded versions of certain frequency signatures). A conservative 2 second sample from these signatures was used in the Acoustic Circuit Analysis.

Table 1
Steam Dryer Surveillance Requirements During Reactor Power Operation Above a Previously Attained Power Level

Parameter	Surveillance Frequency
1. Moisture Carryover	Every 24 hours (Notes 1 and 2)
2. Main steam line pressure data from strain gages	Hourly when initially increasing power above a previously attained power level AND At least once at every 40 MWt (nominal) power step above 100% OLTP (Note 3)
3. Main steam line data from accelerometers	At least once at every 40 MWt (nominal) power step above 100% OLTP (Note 3) AND Within one hour after achieving every 40 MWt (nominal) power step above 100% OLTP

Notes to Table 1:

1. If a determination of moisture carryover cannot be made within 24 hours of achieving an 80 MWt power plateau, an orderly power reduction shall be made within the subsequent 12 hours to a power level at which moisture carryover was previously determined to be acceptable. For testing purposes, a power ascension step is defined as each power increment of 40 MWt, i.e., at thermal power levels of approximately 102.5%, 105%, 107.5%, 110%, 112.5%, 115%, 117.5%, and 120% OLTP. Power level plateaus are nominally every 80 MWt.

2. Provided that the Level 2 performance criteria in Table 2 are not exceeded, when steady state operation at a given power exceeds 168 consecutive hours, moisture carryover monitoring frequency may be reduced to once per week.

3. The strain gage surveillance shall be performed hourly when increasing power above a level at which data was previously obtained. The surveillance of both the strain gage data and MSL pressure data is also required to be performed once at each 40 MWt power step above 1593 MWt and within one hour of achieving each 40 MWt step in power, i.e., at thermal power levels of approximately 102.5%, 105%, 107.5%, 110%, 112.5%, 115%, 117.5%, and 120% OLTP (i.e., 1593 MWt). If the surveillance is met at a given power level, additional surveillances do not need to be performed at a power level where data had previously been obtained.

   If valid strain gage data cannot be recorded hourly or within one hour of initially reaching a 40 MWt power step from at least three of the four MSLs, an orderly power reduction shall be made to a lower power level at which data had previously been obtained. Any such power level reduction shall be completed within two hours of determining that valid data was not recorded.

Table 2
Steam Dryer Performance Criteria and Required Actions

Performance Criteria Not to be Exceeded	Required Actions if Performance Criteria Exceeded and Required Completion Times
Level 2: • Moisture carryover exceeds 0.1% OR • Moisture carryover exceeds 0.1% and increases by > 50% over the average of the three previous measurements taken at > 1593 MWt OR • Pressure data exceed Level 2 Spectra[1]	1. Promptly suspend reactor power ascension until an engineering evaluation concludes that further power ascension is justified. 2. Before resuming reactor power ascension, the steam dryer performance data shall be reviewed as part of an engineering evaluation to assess whether further power ascension can be made without exceeding the Level 1 criteria.
Level 1: • Moisture carryover exceeds 0.35% OR • Pressure data exceed Level 1 Spectra[1]	1. Promptly initiate a reactor power reduction and achieve a previously acceptable power level (i.e., reduce power to a previous step level) within two hours, unless an engineering evaluation concludes that continued power operation or power ascension is acceptable. 2. Within 24 hours, re-measure moisture carryover and perform an engineering evaluation of steam dryer structural integrity. If the results of the evaluation of steam dryer structural integrity do not support continued plant operation, the reactor shall be placed in a hot shutdown condition within the following 24 hours. If the results of the engineering evaluation support continued power operation, implement steps 3 and 4 below. 3. If the results of the engineering evaluation support continued power operation, reduce further power ascension step and plateau levels to nominal increases of 20 MWt and 40 MWt, respectively, for any additional power ascension. 4. Within 30 days, the transient pressure data shall be used to calculate the steam dryer fatigue usage to demonstrate that continued power operation is acceptable.

[1] The EPU spectra shall be determined and documented in an engineering calculation or report. Acceptable Level 2 spectra shall be based on maintaining ≤ 80% of the ASME allowable alternating stress (S_a) value at 10^{11} cycles (i.e., 10.88 ksi). Acceptable Level 1 Spectra shall be based on maintaining the ASME S_a at 10^{11} cycles (i.e., 13.6 ksi).

Table 3
Steam Dryer License Conditions

License Condition	Requirement	Implementing Actions
3.M.1.a	Entergy shall monitor hourly the 32 main steam line (MSL) strain gages during power ascension above 1593 MWt for increasing pressure fluctuations in the steam lines.	COMPLETE - During initial power ascension above 1593 MWt, data from at least 32 strain gages will be collected and evaluated by Entergy's power ascension test team to verify that acoustic signals indicative of increasing pressure fluctuations in the steam lines are not challenging the steam dryer stress limit curve. Monitoring will be conducted hourly during any power ascension above a previously attained power level. (Reference ERSTI-04-VY1-1409-000) (Reference PCRS tracking item WT-VTY-2005-00000-01803)
3.M.1.b	Entergy shall hold the facility for 24 hours at 105%, 110%, and 115% of OLTP (i.e., 1593 MWt) to collect data from the 32 MSL strain gages required by License Condition 3.M.1.a, conduct plant inspections and walkdowns, and evaluate steam dryer performance based on these data; shall provide the evaluation to the NRC staff by facsimile or electronic transmission to the NRC project manager upon completion of the evaluation; and shall not increase power above each hold point until 96 hours after the NRC project manager confirms receipt of the transmission.	COMPLETE - The PATP has established test plateau increments of approximately 80 MWt (corresponding to 105%, 110%, and 115% of 1593 MWt). Reactor power will not be increased above the plateau for a minimum of 96 hours. During the first 24 hours of steady state operation at each plateau, strain gage data will be collected from all available strain gages (minimum of 32) and evaluated to demonstrate acceptable steam dryer performance. Additionally, moisture carryover measurements will be made at each plateau and every 24 hours during power ascension testing. At the 80 MWt plateau hold points, Entergy will conduct plant walkdowns and inspections of plant equipment, including piping and components identified as potentially vulnerable to flow-induced vibration (FIV) in accordance with the PATP and other plant procedures. Steam dryer performance will be evaluated based on these data. The 24-hour period and the 96-hour period may overlap once the transmittal is provided to the NRC staff. The evaluations of steam dryer performance, based on the data collected during each of the 80 MWt plateaus, as well as the results of walkdowns and other measurements of FIV for various piping and plant components, will be provided to the NRC staff. Arrangements have been made for electronic transmission through email and/or uploading to a designated website. Upon the NRC Project

License Condition	Requirement	Implementing Actions
		Manager confirming receipt of the steam dryer data and performance evaluation, the 96 hours of hold time will commence. Power will not be increased above each of the 80 MWt hold points until the expiration of the 96-hour hold. If during the hold periods, or at any other time, the NRC staff requests a discussion or requires clarification of the engineering evaluations provided in fulfillment of this requirement, Entergy will promptly arrange for such discussions. Entergy will maintain a power ascension control center, including management oversight, available 24/7 on-site during power increases to previously unattained power levels. (Reference ERSTI-04-VY1-1409-000) (Reference PCRS tracking item WT-VTY-2005-00000-01803)
3.M.1.c	If any frequency peak from the MSL strain gage data exceeds the limit curve established by Entergy Nuclear Operations, Inc. and submitted to the NRC staff prior to operation above OLTP, Entergy Nuclear Operations, Inc. shall return the facility to a power level at which the limit curve is not exceeded. Entergy Nuclear Operations, Inc. shall resolve the uncertainties in the steam dryer analysis, document the continued structural integrity of the steam dryer, and provide that documentation to the NRC staff by facsimile or electronic transmission to the NRC project manager prior to further increases in reactor power.	COMPLETE - The steam dryer stress limit curve provided herewith contains Level 1 and Level 2 criteria. If frequency peaks from MSL strain gage data exceed either Level 1 or Level 2 criteria, prompt action will be taken in response to the potential adverse flow effects that might result. Similar actions will occur if moisture carryover is excessive and previously established Level 1 or Level 2 criteria are exceeded. The Level 2 criteria represent a conservative action level for evaluation and close monitoring of steam dryer performance—not a limit. The Level 1 criteria represent analytical limits and additional actions may be warranted. If any frequency peak from the MSL strain gage data exceeds the Level 1 steam dryer stress limit curve, Entergy will reduce reactor power to a power level at which the limit curve is not exceeded. (Reference ERSTI-04-VY1-1409-000) Prior to any further increase in power above the reduced power level, Entergy will (1) resolve the uncertainties in the steam dryer analysis, (2) evaluate and document the adequate structural integrity of the steam dryer, and (3) provide that documentation to the NRC staff. Any revision to the limit curve based on this evaluation will be provided to the NRC staff. (Reference PCRS tracking item WT-VTY-2005-00000-01803)

License Condition	Requirement	Implementing Actions
3.M.1.d	In addition to evaluating the MSL strain gage data, Entergy Nuclear Operations, Inc. shall monitor reactor pressure vessel water level instrumentation or MSL piping accelerometers on an hourly basis during power ascension above OLTP. If resonance frequencies are identified as increasing above nominal levels in proportion to strain gage instrumentation data, Entergy Nuclear Operations, Inc. shall stop power ascension, document the continued structural integrity of the steam dryer, and provide that documentation to the NRC staff by facsimile or electronic transmission to the NRC project manager prior to further increases in reactor power.	COMPLETE - Accelerometers mounted on MSL piping will be monitored on an hourly basis during power ascension testing to identify if resonances are increasing above nominal levels in proportion to MSL strain gage data. If abnormally increasing resonant frequencies are detected, power ascension will be halted. Prior to any further increase in power, Entergy will (1) evaluate and document the adequate structural integrity of the steam dryer, and (2) provide that documentation to the NRC staff. (Reference ERSTI-04-VY1-1409-000) (Reference PCRS tracking item WT-VTY-2005-00000-01803)
3.M.1.e	Following start-up testing, Entergy Nuclear Operations, Inc. shall resolve the uncertainties in the steam dryer analysis and provide that resolution to the NRC staff by facsimile or electronic transmission to the NRC project manager. If the uncertainties are not resolved within 90 days of issuance of the license amendment authorizing operation at 1912 MWt, Entergy Nuclear Operations, Inc. shall return the facility to OLTP.	COMPLETE - After collecting strain gage data at approximately the EPU full power level, Entergy will resolve the uncertainties in the steam dryer analysis and provide documentation of the resolution to the NRC staff. If these actions cannot be achieved within 90 days of issuance of the license amendment, reactor power will be limited to 1593 MWt. This uncertainty evaluation may be prepared and provided to the NRC prior to reaching EPU full power levels associated with any proposed revision to the steam dryer limit curve. (Reference PCRS tracking item WT-VTY-2005-00000-01803)
3.M.2.a	Prior to operation above OLTP, Entergy Nuclear Operations, Inc. shall install 32 additional strain gages on the main steam piping and shall enhance the data acquisition system in order to reduce the measurement uncertainty associated with the acoustic circuit model (ACM).	COMPLETE - To enhance performance and improve the accuracy of the steam dryer measurement system, Entergy has installed 48 strain gages on MSL piping and will maintain a minimum of 32 operable strain gages during power ascension testing. The data acquisition system (DAS) was upgraded to reduce the uncertainty associated with the ACM. (Reference Entergy VYNPS Temporary Alteration TA-2005-15 R1)
3.M.2.b	In the event that acoustic signals are identified that challenge the limit	COMPLETE - As part of the evaluation performed at 1673MWt Entergy Vermont Yankee employed a

License Condition	Requirement	Implementing Actions
	curve during power ascension above OLTP, Entergy Nuclear Operations, Inc. shall evaluate steam dryer loads and re-establish the limit curve based on the new strain gage data, and shall perform a frequency-specific assessment of ACM uncertainty at the acoustic signal frequency.	new revision of the Acoustic Circuit Model. In association with the benchmarking of the new ACM a frequency specific assessment of the ACM uncertainty was performed and is contained in Calculation VYC-3001, Rev. 1. (Reference ERSTI-04-VY1-1409-000) (Reference VYC-3001 Rev. 1)
3.M.2.c	After reaching 120% of OLTP, Entergy Nuclear Operations, Inc. shall obtain measurements from the MSL strain gages and establish the steam dryer flow-induced vibration load fatigue margin for the facility, update the steam dryer stress report, and re-establish the steam dryer monitoring plan (SDMP) limit curve with the updated ACM load definition and revised instrument uncertainty, which will be provided to the NRC staff.	COMPLETE - After collecting strain gage data at approximately the EPU full power level, Entergy will establish the steam dryer flow-induced vibration load fatigue margin for the facility, update the steam dryer stress report, and re-establish the stress limit curve with the updated ACM load definition and revised instrument uncertainty. This information will be included in the report to the NRC staff being made in accordance with License Condition 3.M.1.e. (Reference PCRS tracking item WT-VTY-2006-00000-00249)
3.M.2.d	During power ascension above OLTP, if an engineering evaluation is required in accordance with the SDMP, Entergy Nuclear Operations, Inc. shall perform the structural analysis to address frequency uncertainties up to ±10% and assure that peak responses that fall within this uncertainty band are addressed.	COMPLETE - As part of the evaluation performed at 1673MWt Entergy Vermont Yankee completed revisions to the VY Steam Dryer model used in the Finite Element Model (FEM). Additional analysis of the FEM output was performed to assess the frequency uncertainties. The results of this assessment are contained in Calculation VYC-3001, Rev. 1. (Reference ERSTI-04-VY1-1409-000)
3.M.2.e	Entergy Nuclear Operations, Inc. shall revise the SDMP to reflect long-term monitoring of plant parameters potentially indicative of steam dryer failure; to reflect consistency of the facility's steam dryer inspection program with General Electric Services Information Letter 644, Revision 1; and to identify the NRC Project Manager for the facility as the point of contact for providing SDMP information during power ascension.	COMPLETE - The revised SDMP provides long-term monitoring of steam dryer performance in accordance with GE SIL 644 Rev. 1. (Reference PCRS tracking item WT-VTY-2006-00000-00250) COMPLETE - The SDMP and the PATP identify the NRC Project Manager for the VYNPS EPU as the point of contact for providing SDMP information during power ascension. (Reference ERSTI-04-VY1-1409-000) COMPLETE - For moisture carryover, procedures OP-0631 and ON-3178 provide for long-term monitoring and controls.

License Condition	Requirement	Implementing Actions
3.M.2.f	Entergy Nuclear Operations, Inc. shall submit the final extended power uprate (EPU) steam dryer load definition for the facility to the NRC upon completion of the power ascension test program.	COMPLETE - The final EPU steam dryer load definition will be included in the report provided to the NRC staff in accordance with License Conditions 3.M.1.e. and 3.M.2.c. (Reference PCRS tracking item WT-VTY-2006-00000-00251)
3.M.2.g	Entergy Nuclear Operations, Inc. shall submit the flow-induced vibration related portions of the EPU startup test procedure to the NRC, including methodology for updating the limit curve, prior to initial power ascension above OLTP.	COMPLETE - Entergy letter BVY 06-019 forwards the FIV-related portions of the EPU power ascension test procedure to the NRC. (Reference ERSTI-04-VY1-1409-000) The methodology for updating the steam dryer stress limit curve is as follows: Prerequisite: Generate report resolving uncertainties in the steam dryer analysis. 1. Collect representative data from 32 strain gages at eight MSL locations. 2. Using a plant-specific ACM, analyze strain gage data to determine steam dryer loads. 3. Input ACM loads into a finite element model to determine dryer stresses. 4. Perform an updated uncertainty evaluation. 5. Generate revised steam dryer stress limit curve(s). (Reference PCRS tracking item WT-VTY-2006-00000-00252)
3.M.3(a)	Entergy shall prepare the EPU startup test procedure to include the stress limit curve to be applied for evaluating steam dryer performance.	COMPLETE - The steam dryer stress limit curve to be applied for evaluating steam dryer performance during power ascension is provided herewith. The limit curve was developed on the basis of calculation VYC-3001, which is incorporated by reference into the EPU PATP. (Reference ERSTI-04-VY1-1409-000)
3.M.3(b)	Entergy shall prepare the EPU startup test procedure to include specific hold points and their duration during EPU power ascension.	COMPLETE - Specific hold points and durations are specified in the PATP. (Reference ERSTI-04-VY1-1409-000)
3.M.3(c)	Entergy shall prepare the EPU startup test procedure to include activities to be accomplished during	COMPLETE - Activities to be accomplished during hold points are specified in the PATP. (Reference ERSTI-04-VY1-1409-000)

License Condition	Requirement	Implementing Actions
	hold points.	
3.M.3(d)	Entergy shall prepare the EPU startup test procedure to include plant parameters to be monitored.	COMPLETE - Plant parameters to be monitored are specified in Attachment 9 to the PATP. (Reference ERSTI-04-VY1-1409-000)
3.M.3(e)	Entergy shall prepare the EPU startup test procedure to include inspections and walkdowns to be conducted for steam, feedwater, and condensate systems and components during the hold points.	COMPLETE - Inspections and walkdowns to be conducted for steam, feedwater, and condensate systems and components during hold points are specified in Attachment 9 to the PATP. (Reference ERSTI-04-VY1-1409-000)
3.M.3(f)	Entergy shall prepare the EPU startup test procedure to include methods to be used to trend plant parameters.	COMPLETE - Methods to be used to trend plant parameters are specified in Attachment 9 to the PATP. (Reference ERSTI-04-VY1-1409-000)
3.M.3(g)	Entergy shall prepare the EPU startup test procedure to include acceptance criteria for monitoring and trending plant parameters, and conducting the walkdowns and inspections.	COMPLETE - Acceptance criteria for monitoring and trending plant parameters, and conducting the walkdowns and inspections are specified in Attachment 9 to the PATP. (Reference ERSTI-04-VY1-1409-000)
3.M.3(h)	Entergy shall prepare the EPU startup test procedure to include actions to be taken if acceptance criteria are not satisfied.	COMPLETE - Actions to be taken if acceptance criteria are not satisfied are specified in the PATP. (Reference ERSTI-04-VY1-1409-000)
3.M.3(i)	Entergy shall prepare the EPU startup test procedure to include verification of the completion of commitments and planned actions specified in the license amendment application and all supplements to the application in support of the EPU license amendment request pertaining to the steam dryer.	COMPLETE - Verification of the completion of commitments and planned actions specified in the license amendment application and all supplements to the application in support of the EPU license amendment request pertaining to the steam dryer is specified in the PATP. (Reference ERSTI-04-VY1-1409-000)

3.M.4	When operating above OLTP, the operating limits, required actions, and surveillances specified in the SDMP shall be met. The following key attributes of the SDMP shall not be made less restrictive without prior NRC approval: a. During initial power ascension testing above OLTP, each test plateau increment shall be approximately 80 MWt; b. Level 1 performance criteria; and c. The methodology for establishing the stress spectra used for the Level 1 and Level 2 performance criteria. Changes to other aspects of the SDMP may be made in accordance with the guidance of NEI 99-04.	These restrictions are provided in the PATP and/or the SDMP. (Reference ERSTI-04-VY1-1409-000)
3.M.5	During each of the three scheduled refueling outages (beginning with the spring 2007 refueling outage), a visual inspection shall be conducted of all accessible, susceptible locations of the steam dryer, including flaws left "as is" and modifications.	The VYNPS steam dryer will be inspected during the refueling outages scheduled for the Spring 2007, Fall 2008, and Spring 2010. The inspections conducted after power uprate implementation will be comparable to the inspections conducted during the Spring 2004 and Fall 2005 refueling outages and will be in accordance with the guidance in SIL 644, Rev. 1. (Reference PCRS tracking item WT-VTY-2006-00000-00253) (Reference PCRS tracking item WT-VTY-2006-00000-00254) (Reference PCRS tracking item WT-VTY-2006-00000-00255)

3.M.6	The results of the visual inspections of the steam dryer conducted during the three scheduled refueling outages (beginning with the spring 2007 refueling outage) shall be reported to the NRC staff within 60 days following startup from the respective refueling outage. The results of the SDMP shall be submitted to the NRC staff in a report within 60 days following the completion of all EPU power ascension testing.	The VYNPS steam dryer will be inspected during the refueling outages scheduled for the Spring 2007, Fall 2008, and Spring 2010. The inspections conducted after power uprate implementation will be comparable to the inspections conducted during the Spring 2004 and Fall 2005 refueling outages and will be in accordance with the guidance in SIL 644, Rev. 1. The results will be documented in a report and submitted to the NRC within 60 days following completion of all EPU power ascension testing. (Reference PCRS tracking item WT-VTY-2006-00000-00256) (Reference PCRS tracking item WT-VTY-2006-00000-00257) (Reference PCRS tracking item WT-VTY-2006-00000-00258)
3.M.7	The requirements of paragraph 3.M.4 above for meeting the SDMP shall be implemented upon issuance of the EPU license amendment and shall continue until the completion of one full operating cycle at EPU. If an unacceptable structural flaw (due to fatigue) is detected during the subsequent visual inspection of the steam dryer, the requirements of paragraph 4 shall extend another full operating cycle until the visual inspection standard of no new flaws/flaw growth based on visual inspection is satisfied.	When operating above 1593 MWt, the operating limits, required actions, and surveillances specified in the SDMP will be met. Those key attributes of the SDMP specified in License Condition 3.M.4 will not be made less restrictive without prior NRC approval. (Reference PCRS tracking item WT-VTY-2006-00000-00259)
3.M.8	This license condition shall expire upon satisfaction of the requirements in paragraphs 5, 6, and 7 provided that a visual inspection of the steam dryer does not reveal any new unacceptable flaw or unacceptable flaw growth that is due to fatigue.	(Reference PCRS tracking item WT-VTY-2006-00000-00260)

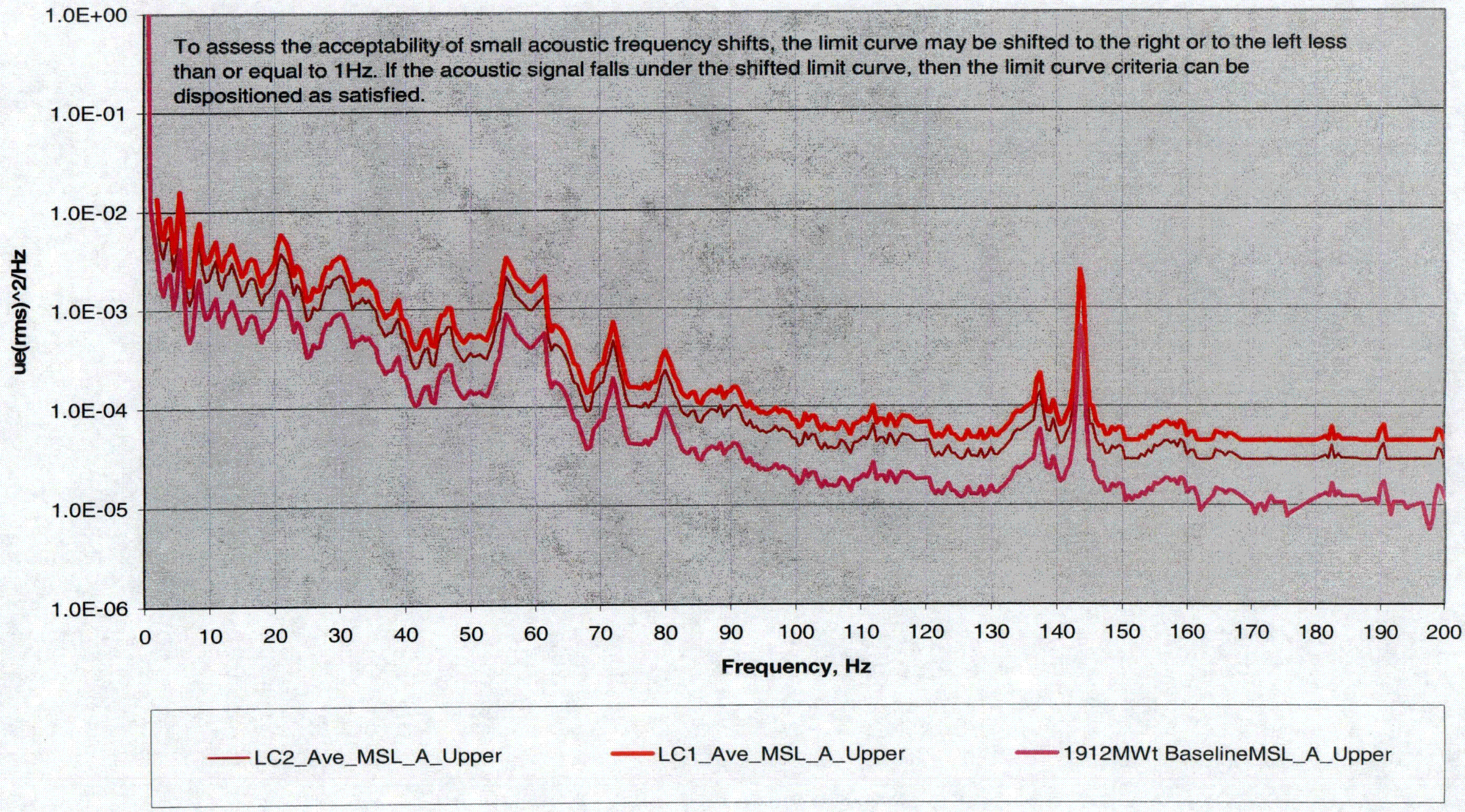


Figure 1: Steam Dryer Stress Limit Curve – MSL 'A' Upper

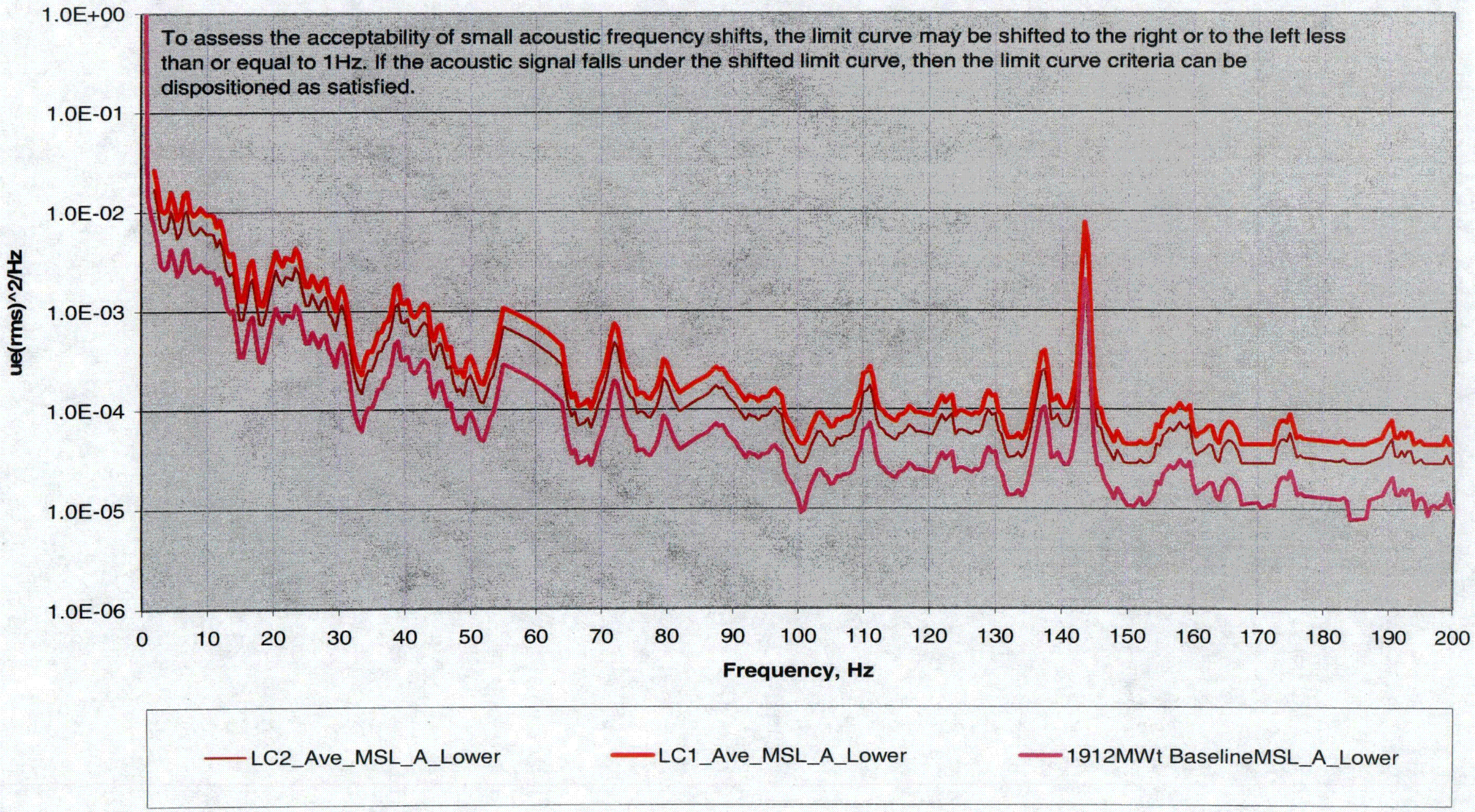


Figure 2: Steam Dryer Stress Limit Curve – MSL 'A' Lower

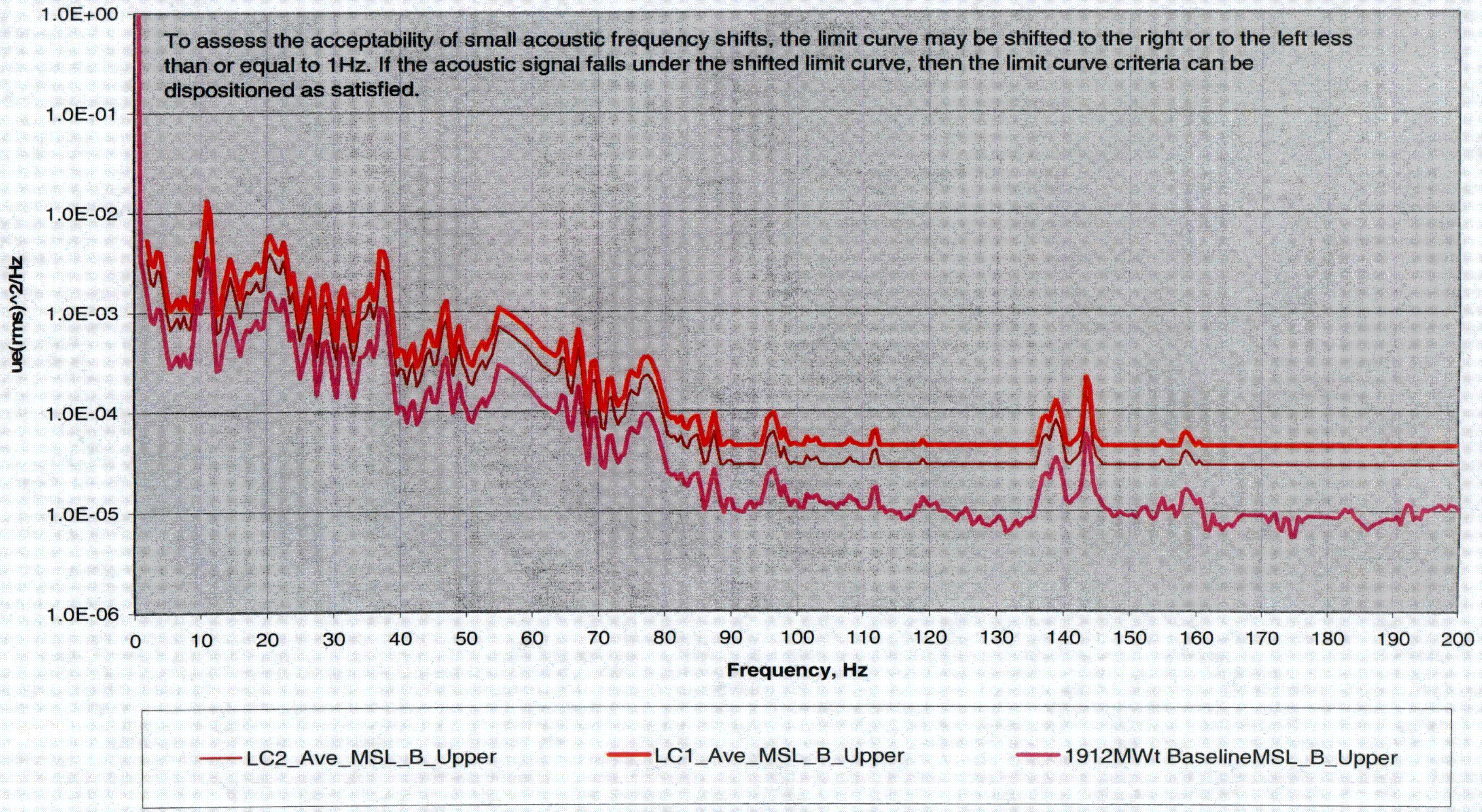


Figure 3: Steam Dryer Stress Limit Curve – MSL 'B' Upper

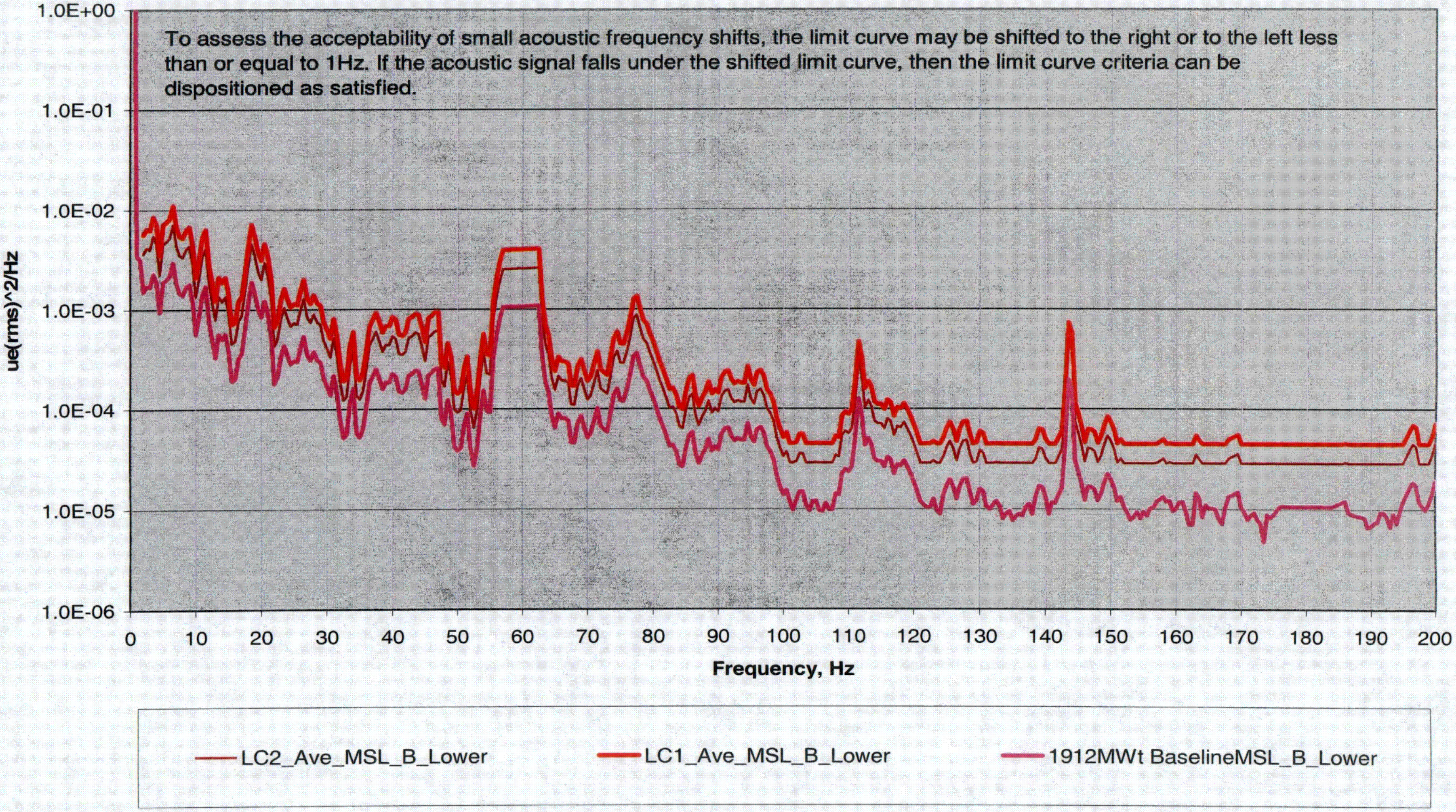


Figure 4: Steam Dryer Stress Limit Curve – MSL 'B' Lower

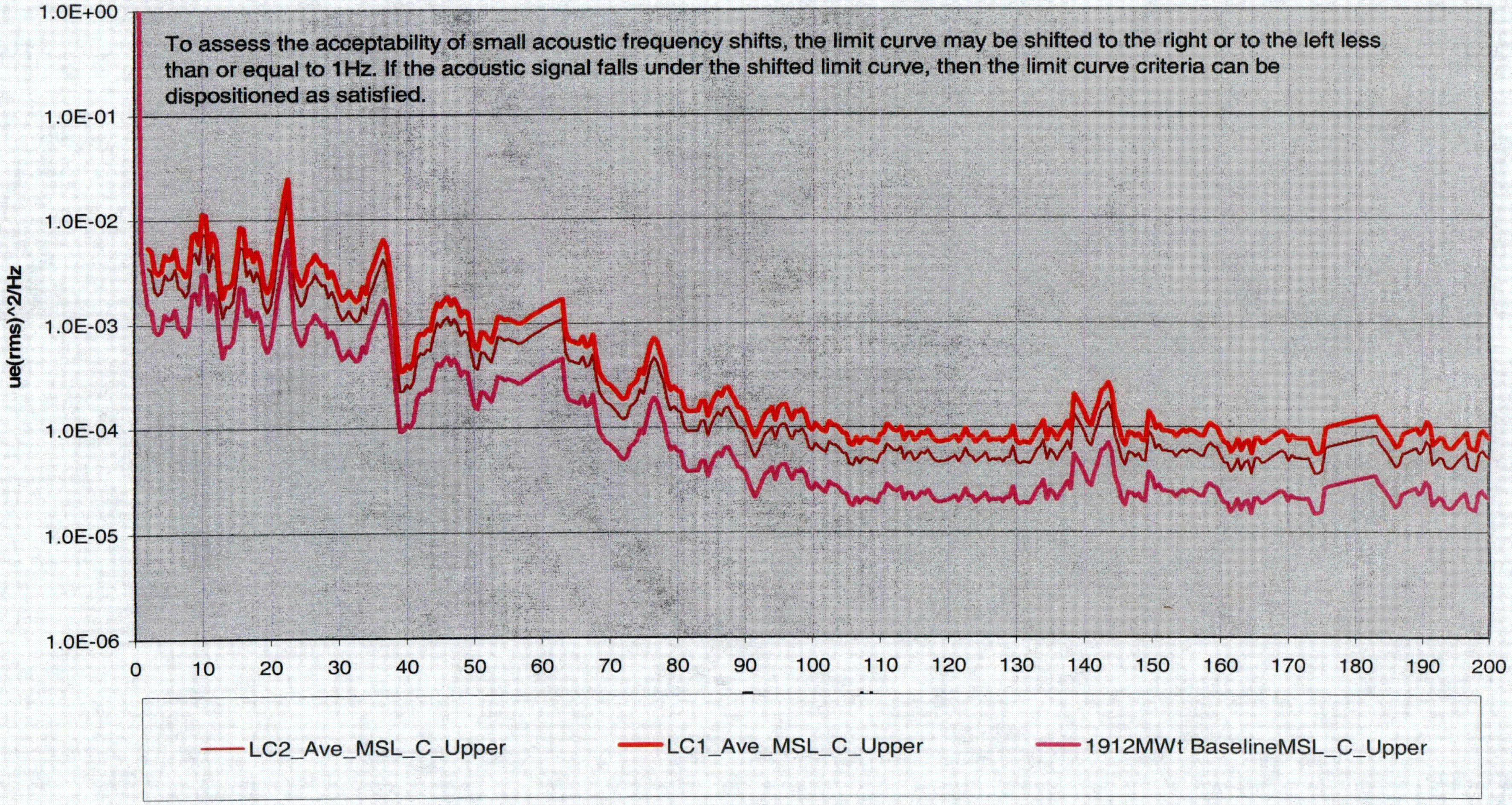


Figure 5: Steam Dryer Stress Limit Curve – MSL 'C' Upper

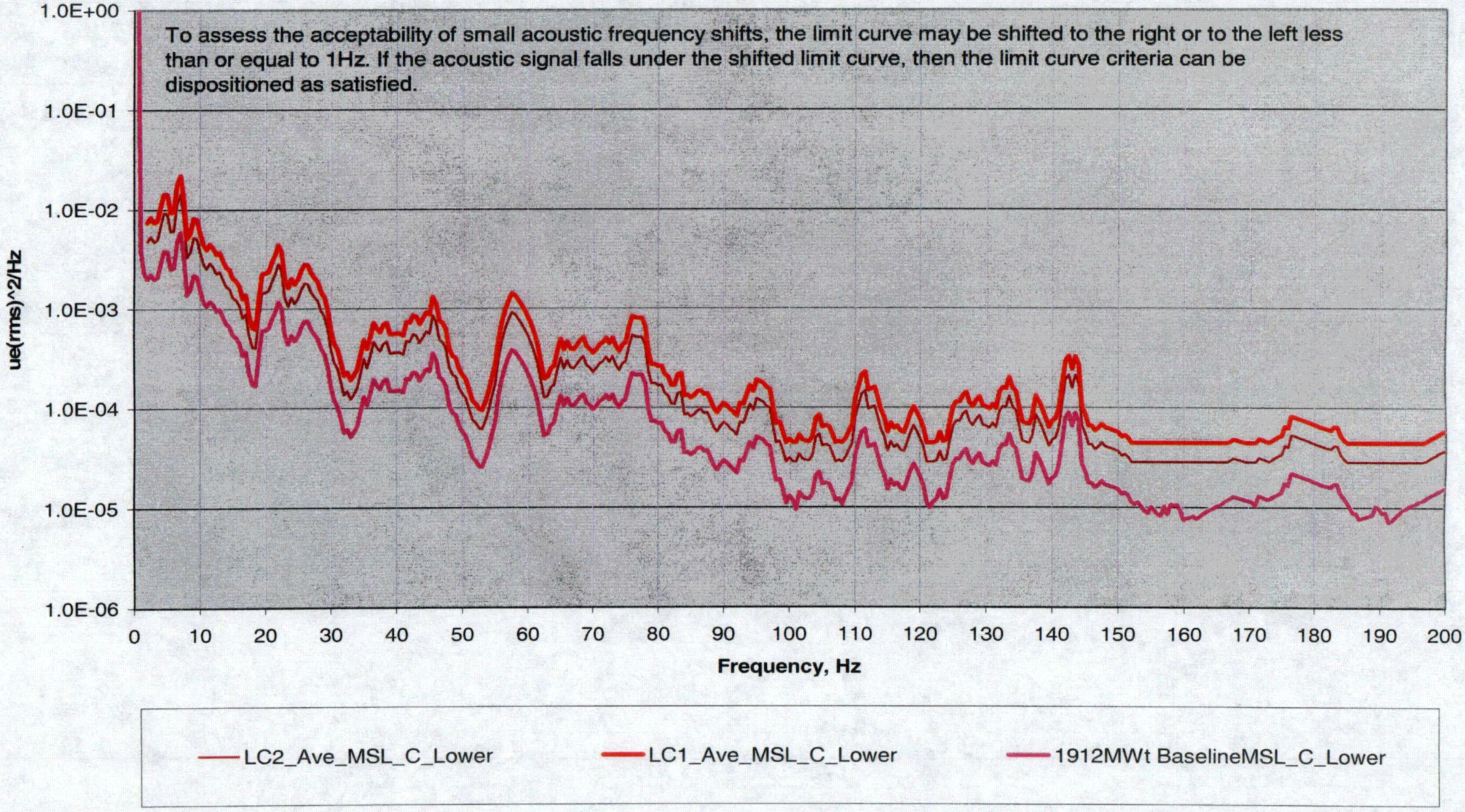


Figure 6: Steam Dryer Stress Limit Curve – MSL 'C' Lower

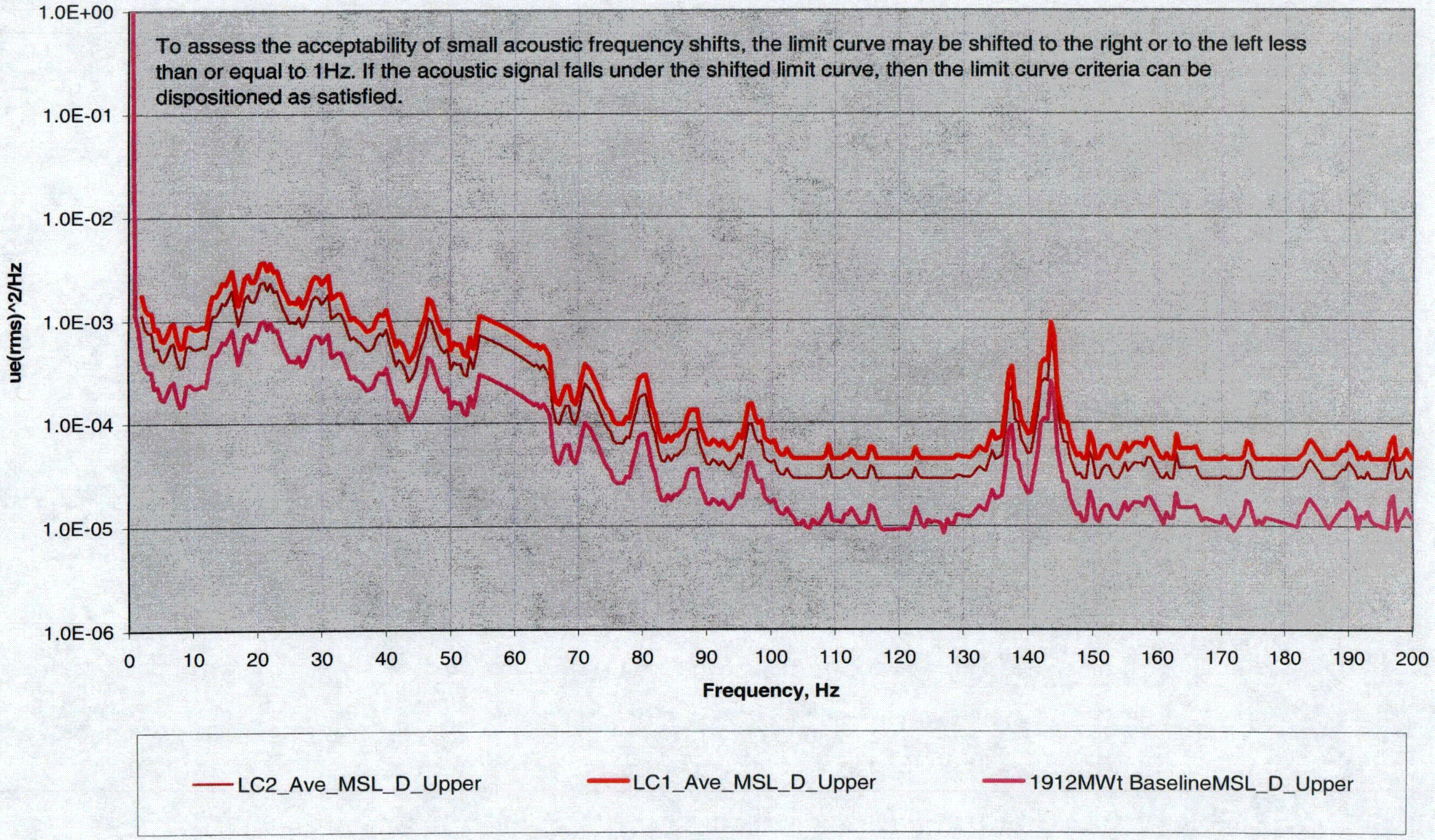


Figure 7: Steam Dryer Stress Limit Curve – MSL 'D' Upper

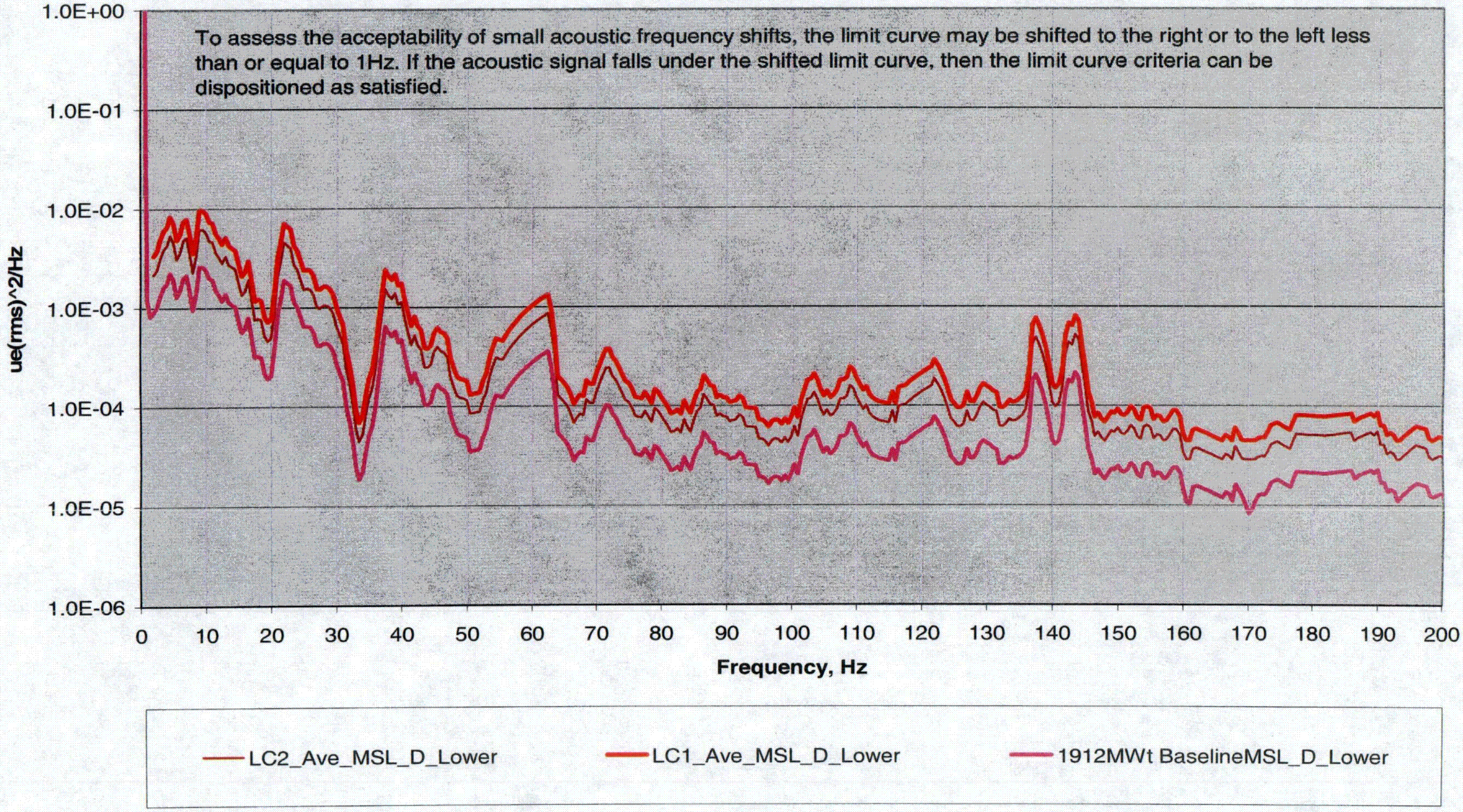


Figure 8: Steam Dryer Stress Limit Curve – MSL 'D' Lower

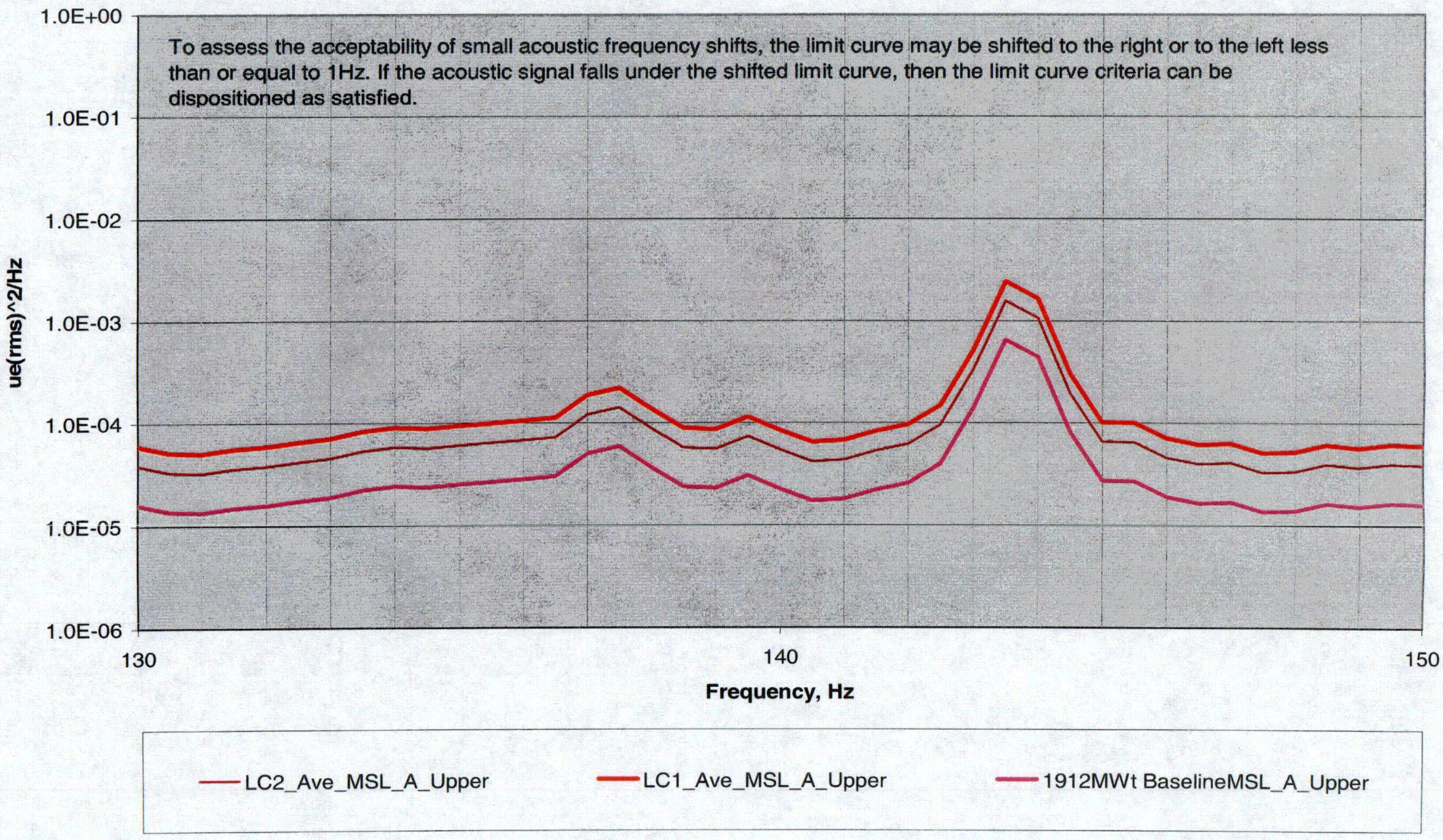


Figure 9: Steam Dryer Stress Limit Curve – MSL 'A' Upper Expanded

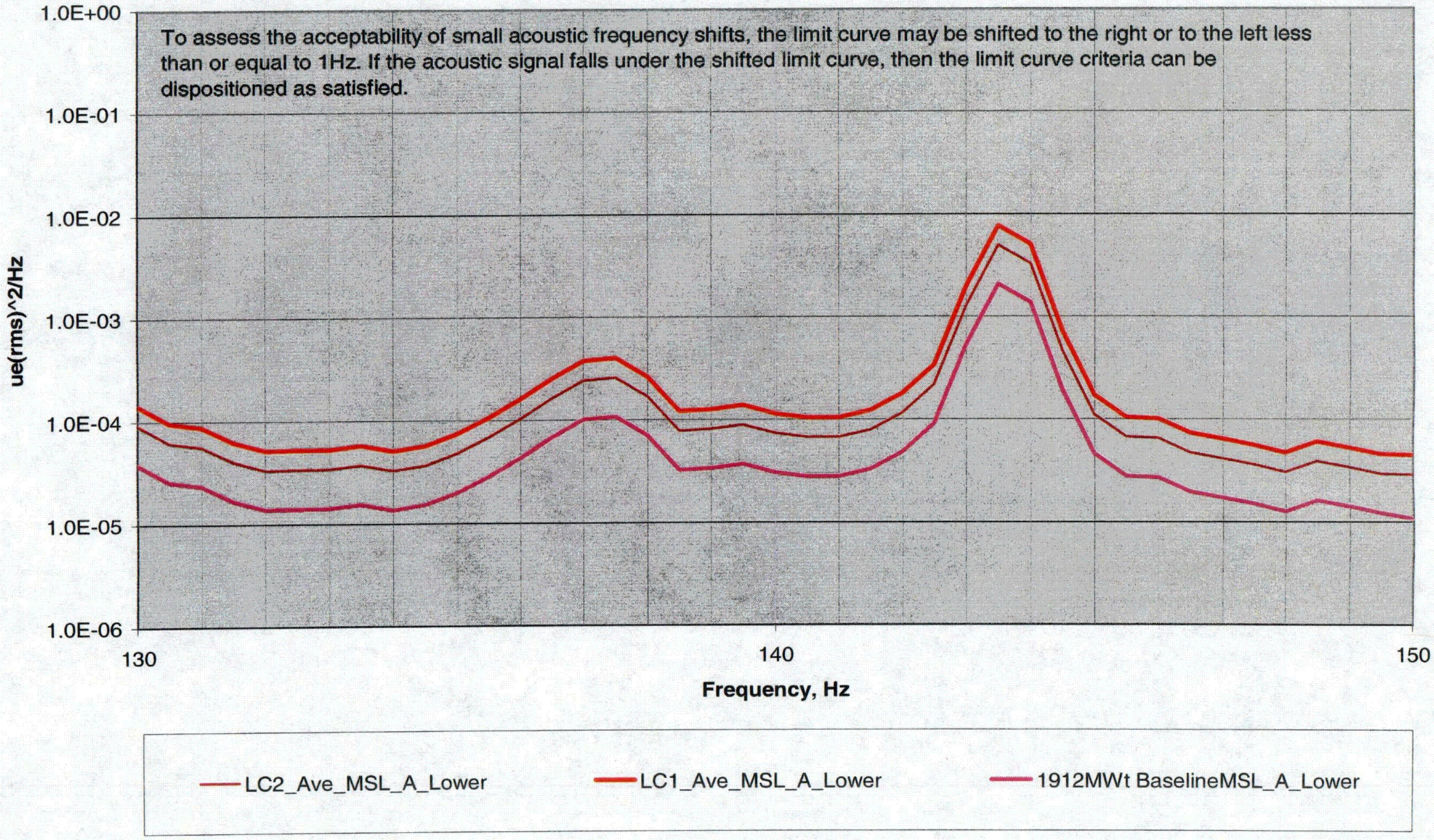


Figure 10: Steam Dryer Stress Limit Curve – MSL ‘A’ Lower Expanded

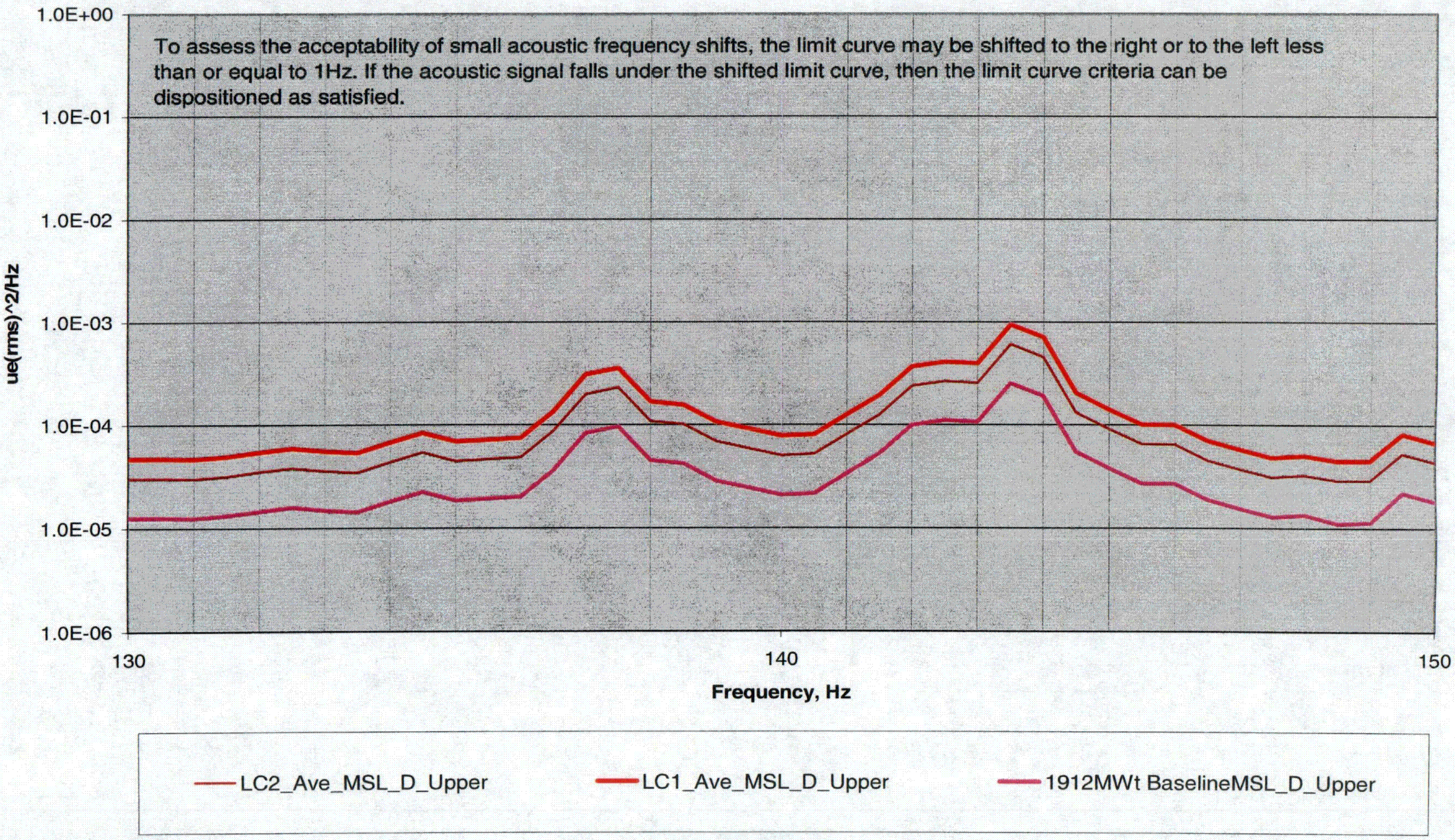


Figure 11: Steam Dryer Stress Limit Curve – MSL 'D' Upper Expanded

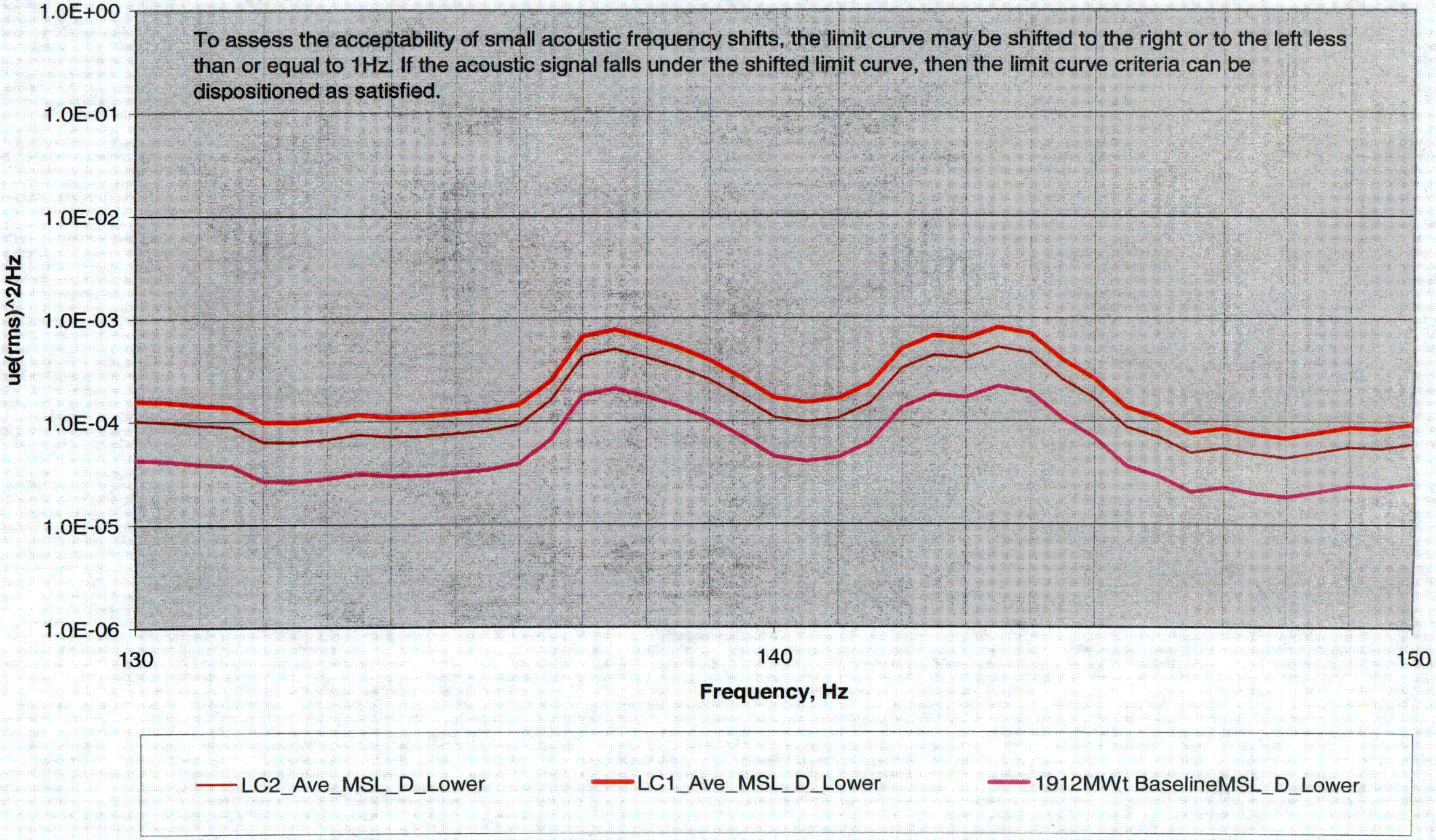


Figure 12: Steam Dryer Stress Limit Curve – MSL 'D' Lower Expanded

Attachment 3

Vermont Yankee Nuclear Power Station

Affidavit for Withholding GE-NE-0000-0054-1378P-R0 from Public Disclosure

General Electric Company

AFFIDAVIT

I, Louis M. Quintana, state as follows:

(1) I am Manager, Licensing, General Electric Company ("GE"), have been delegated the function of reviewing the information described in paragraph (2) which is sought to be withheld, and have been authorized to apply for its withholding.

(2) The information sought to be withheld is contained in GE proprietary report, GE-NE-0000-0054-1378P-R0, *Vermont Yankee Nuclear Power Station Steam Dryer Stress Analysis at Extended Power Uprate Conditions*, Revision 0, Class III (GE Proprietary Information), dated June 2006. The proprietary information is delineated by a double underline inside double square brackets. Figures and large equation objects are identified with double square brackets before and after the object. In each case, the superscript notation[3] refers to Paragraph (3) of this affidavit, which provides the basis for the proprietary determination.

(3) In making this application for withholding of proprietary information of which it is the owner, GE relies upon the exemption from disclosure set forth in the Freedom of Information Act ("FOIA"), 5 USC Sec. 552(b)(4), and the Trade Secrets Act, 18 USC Sec. 1905, and NRC regulations 10 CFR 9.17(a)(4), and 2.390(a)(4) for "trade secrets" (Exemption 4). The material for which exemption from disclosure is here sought also qualify under the narrower definition of "trade secret", within the meanings assigned to those terms for purposes of FOIA Exemption 4 in, respectively, Critical Mass Energy Project v. Nuclear Regulatory Commission, 975F2d871 (DC Cir. 1992), and Public Citizen Health Research Group v. FDA, 704F2d1280 (DC Cir. 1983).

(4) Some examples of categories of information which fit into the definition of proprietary information are:

a. Information that discloses a process, method, or apparatus, including supporting data and analyses, where prevention of its use by General Electric's competitors without license from General Electric constitutes a competitive economic 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 reveals aspects of past, present, or future General Electric customer-funded development plans and programs, resulting in potential products to General Electric;

d. 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 (4)a and (4)b above.

(5) To address 10 CFR 2.390 (b) (4), the information sought to be withheld is being submitted to NRC in confidence. The information is of a sort customarily held in confidence by GE, and is in fact so held. The information sought to be withheld has, to the best of my knowledge and belief, consistently been held in confidence by GE, no public disclosure has been made, and it is not available in public sources. All disclosures to third parties including any required transmittals to NRC, have been made, or must be made, pursuant to regulatory provisions or proprietary agreements which provide for maintenance of the information in confidence. Its initial designation as proprietary information, and the subsequent steps taken to prevent its unauthorized disclosure, are as set forth in paragraphs (6) and (7) following.

(6) Initial approval of proprietary treatment of a document is made by the manager of the originating component, the person most likely to be acquainted with the value and sensitivity of the information in relation to industry knowledge. Access to such documents within GE is limited on a "need to know" basis.

(7) The procedure for approval of external release of such a document typically requires review by the staff manager, project manager, principal scientist or other equivalent authority, by the manager of the cognizant marketing function (or his delegate), and by the Legal Operation, for technical content, competitive effect, and determination of the accuracy of the proprietary designation. Disclosures outside GE are limited to regulatory bodies, customers, and potential customers, and their agents, suppliers, and licensees, and others with a legitimate need for the information, and then only in accordance with appropriate regulatory provisions or proprietary agreements.

(8) The information identified in paragraph (2), above, is classified as proprietary because it documents the dynamic, stress and fatigue analyses that demonstrate the adequacy of the BWR steam dryer using GE-developed structural analysis techniques and methodology. Development of the test methods, the methodology for analysis of this information and the steam dryer performance, and its application for the analyses methodologies and processes for the determination of the acceptability of the steam dryer at Extended Power Uprate conditions was achieved at a significant cost to GE, on the order of approximately two million dollars.

The development of the dryer performance evaluation process along with the interpretation and application of the analytical results is derived from the extensive experience database that constitutes a major GE asset.

(9) Public disclosure of the information sought to be withheld is likely to cause substantial harm to GE's competitive position and foreclose or reduce the availability of profit-making opportunities. The information is part of GE's comprehensive BWR safety and technology base, and its commercial value extends beyond the original development cost. The value of the technology base goes beyond the extensive physical database and analytical methodology and includes development of the expertise to determine and apply the appropriate evaluation process. In addition, the technology base includes the value derived from providing analyses done with NRC-approved methods.

The research, development, engineering, analytical and NRC review costs comprise a substantial investment of time and money by GE.

The precise value of the expertise to devise an evaluation process and apply the correct analytical methodology is difficult to quantify, but it clearly is substantial.

GE's competitive advantage will be lost if its competitors are able to use the results of the GE experience to normalize or verify their own process or if they are able to claim an equivalent understanding by demonstrating that they can arrive at the same or similar conclusions.

The value of this information to GE would be lost if the information were disclosed to the public. Making such information available to competitors without their having been required to undertake a similar expenditure of resources would unfairly provide competitors with a windfall, and deprive GE of the opportunity to exercise its competitive advantage to seek an adequate return on its large investment in developing these very valuable analytical tools.

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

Executed on this 23rd day of June 2006.

Louis M. Quintana
General Electric Company

Docket 50-271
BVY 06-056

Attachment 4

Vermont Yankee Nuclear Power Station

GE-NE-0000-0054-1378NP-R0

(Non-Proprietary Information)

GE Energy, Nuclear
3901 Castle Hayne Rd
Wilmington, NC 28401

GE-NE-0000-0054-1378NP-R0
DRF 0000-0050-8392
Revision 0
Class I
June 2006

Non-Proprietary Version

Entergy Nuclear Operations Incorporated

Vermont Yankee Nuclear Power Station Steam Dryer Stress Analysis at Extended Power Uprate Conditions

Principal Contributors:

B. Vandenplas
M. Dick

Principal Verifier:

T. Boermans

NON PROPRIETARY NOTICE

This is a non-proprietary version of the document GE-NE-0000-0054-1378P, which has the proprietary information removed. Portions of the document that have been removed are indicated by an open and closed bracket as shown here [[ ]].

IMPORTANT NOTICE REGARDING THE CONTENTS OF THIS REPORT

Please Read Carefully

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Acronyms and Abbreviations

Item	Short Form	Description
1	ACM	Acoustic Circuit Model
2	ACA	Acoustic Circuit Analysis
3	ASME	American Society of Mechanical Engineers
4	BWR	Boiling Water Reactor
5	CDI	Continuum Dynamics, Inc.
6	EPU	Extended Power Uprate
7	CFD	Computational Fluid Dynamics
8	FEA	Finite Element Analysis
9	FEM	Finite Element Model
10	FFT	Fast Fourier Transform
11	FIV	Flow Induced Vibration
12	GE	General Electric
13	GENE	General Electric Nuclear Energy
14	Hz	Hertz
15	ksi	Thousand pounds per square inch
16	LES	Large Eddy Simulation
17	Mlbm/hr	Million pounds mass per hour
18	MS	Main Steam
19	MSL	Main Steam Line
20	MW_{th}	Megawatt Thermal
21	NA	Not Applicable
22	NRC	Nuclear Regulatory Commission
23	OBE	Operational Basis Earthquake
24	OLTP	Original Licensed Thermal Power
25	Pb	Primary Bending Stress
26	Pm	Primary Membrane Stress
27	PSD	Power Spectral Density
28	psi	Pounds per square inch
29	RAI	Request for Additional Information
30	Ref.	Reference
31	RMS	Root-Mean-Squared
32	RPV	Reactor Pressure Vessel
33	S_{alt}	Alternating Stress Intensity
34	SCF	Stress Concentration Factor

Item	Short Form	Description
35	SDMP	Steam Dryer Monitoring Plan
36	S.I.	Stress Intensity
37	SIL	Service Information Letter
38	SRSS	Square Root Sum of Squares
39	SRV	Safety Relief Valve
40	SS	Stainless Steel
41	SSE	Safe Shutdown Earthquake
42	S_u	Ultimate Strength
43	TSV	Turbine Stop Valve
44	VYNPS	Vermont Yankee Nuclear Power Station
45	UF	Undersize Factor

1.0 Executive Summary

This report provides the results of Finite Element Analysis (FEA) of the modified Vermont Yankee Nuclear Power Station (VYNPS) steam dryer. The analyses consisted of dynamic time-history analyses that used two sources for the fluctuating loads that impact the steam dryer at 120% Extended Power Uprate (EPU) operating conditions. These fluctuating load definitions are from an Acoustic Circuit Analysis (ACA) that used in-plant measurements from the VYNPS steam lines and from a Computation Fluid Dynamics (CFD) Large Eddy Simulation (LES) model for vortex shedding. In addition, ASME-based load cases were also applied to the finite element model.

The VYNPS acoustic circuit model was developed based on plant design/operation configuration and used VYNPS-specific measured pressure fluctuation data as input. The LES model characterizes the nature and magnitude of unsteady flow effects across the face of the dryer at the entrance to the main steam line nozzles. Each model generated time history pressure profiles that were input to the ANSYS finite element program to determine associated FIV stress intensities.

Maximum acoustic pressure stresses and vortex shedding stress intensities were extracted from separate finite element analyses. The stress intensities were conservatively combined and, where appropriate, multiplied by stress concentration factors that account for weld shape and size. The time history analyses were done with varying time step changes to conservatively account for uncertainty in the frequency content of the FIV loads.

The resulting maximum FIV stress intensities calculated for EPU conditions, including uncertainties and biases, were about 54% of the 13,600 psi ASME endurance limit. In addition, normal, upset and faulted stresses were calculated and compared to ASME Code allowable, with all conditions showing acceptable stresses.

2.0 Background and Introduction

As a result of significant steam dryer cover plate fatigue cracking at Quad Cities Unit 2, GE issued SIL 644 in August of 2002 to provide information to all BWR utilities on cover plate related failures. In September of 2003, GE added Supplement 1 to SIL No. 644 in order to describe additional steam dryer fatigue cracking at Quad Cities 2, and to explain that the root cause of the second event was different than the first. SIL 644 applied to BWR/3-style steam dryer design plants. Supplement 1 to SIL No. 644 provided recommendations applicable to plants with BWR/4 and later design steam dryers. The objective of this report is to detail the latest analyses of the Vermont Yankee Nuclear Power Station (VYNPS) steam dryer that were performed for the modified dryer configuration. The purpose of these analyses is to confirm that the modified dryer meets ASME criteria for fatigue initiation and other ASME-based acceptance criteria concerning the ability of the steam dryer to maintain structural integrity under steady-state normal, transient upset, and design basis accident loading conditions.

The VYNPS steam dryer modifications were installed in early 2004 and included replacing the ½ inch outer vertical plates and portions of the top hood plates with 1-inch plates, removing internal brackets that attached the internal braces to the outer hood plates, replacing the ¼ inch thick cover plate with 5/8 inch thick material, and adding three long gussets at the outer vertical hood plate and cover plate junction. Each gusset is triangular in shape, 53 inches high, with no more than 1.0-inch width at the top. The top of each gusset is welded around and has a smooth transition to the modified front hood. Each gusset extends to within 5.5 inches of the top of the modified front hood. Transition between each gusset and the modified lower cover plate is accomplished via the use of a U-shaped "gusset extension", also called a "shoe", that is welded to both the lower cover plate and to each gusset. The replacement lower cover plate is attached with 1/2-inch welds all around except for the corner intersection with the dryer support ring where 5/8-inch welds are used for a distance of four inches. The existing tie-bars are replaced with a modified tie bar design. Figures 2-1 and 2-2 show the modified dryer configuration.

The original VYNPS dryer assembly was manufactured from solution heat-treated SS304 conforming to applicable ASTM standards at the time of manufacture. The modification plate is made from SS316L. Minimum of SS304L and 316L properties from [7] are used for steam dryer structural analysis to conservatively envelop the properties of the unmodified components and the modification plate. In actuality the

stress intensity limit, S_m, of SS304 is slightly greater than SS304L[1]. Therefore the use of SS304L material properties for unmodified dryer components is conservative. The applicable properties are shown in Table 2-1.

The Nuclear Regulatory Commission (NRC) safety evaluation report [12] for approval of the VYNPS EPU licensing amendment request included licensing commitments by Entergy for EPU power ascension data gathering in order to determine the increase in acoustic fluctuating loading on the steam dryer. Specifically, the VYNPS EPU safety evaluation commitment is as follows: "After reaching 120% of OLTP, Entergy Nuclear Operations, Inc. shall obtain measurements from the MSL strain gages and establish the steam dryer flow-induced vibration load fatigue margin for the facility, update the dryer stress report, and re-establish the steam dryer monitoring plan (SDMP) limit curve with the updated ACM load definition and revised instrument uncertainty, which will be provided to the NRC staff."

This report updates the Reference [1] steam dryer structural evaluation that was supplemented by additional Entergy submittals to the NRC [2][3] in response to requests for additional information (RAIs) during the NRC review of the VYNPS EPU licensing amendment request.

[1] The ASME code 1971 and 1989 editions have the following material properties for SS304:
ASME 1971 – S_m = 17.4 ksi at 500°F, S_m = 16.4 ksi at 600°F
ASME 1989 – S_m = 17.5 ksi at 500°F, S_m = 16.4 ksi at 600°F

[[ ]]

Figure 2-1 Modified Dryer

[[ ]]

Figure 2-2 Modification Details

Table 2.1 Properties of SS304L and SS316L

Material / Property	Room temperature 70°F	Operating temperature 545°F
SS304L		
S_m, Stress intensity limit, psi	16,700	14,400
S_y, Yield strength, psi	25,000	15,940
S_u, Ultimate strength, psi	70,000	57,200
S_{alt}, Endurance limit, psi		13,600
E, Elastic modulus, psi	28,300,000	25,575,000
SS316L		
S_m, Stress intensity limit, psi	16,700	13,995
S_y, Yield strength, psi	25,000	15,495
S_u, Ultimate strength, psi	70,000	61,600
S_{alt}, Endurance limit, psi		13,600
E, Elastic modulus, psi	28,300,000	25,575,000

3.0 Acceptance Criteria

3.1 Original Steam Dryer Design Acceptance Criteria

The VYNPS steam dryer was originally procured and supplied as a non-safety related, non-seismic category I, non-ASME component. There was no design specification for the dryer and, as such, the service conditions for the steam dryer were not specifically defined. However, as late as 1969, an internal GE design report, 257HA760, was prepared for BWR-3 style steam dryers. In the 257HA760 report the following service condition and acceptance criterion were stated:

- The principal design loads considered in the analysis of the steam dryer assembly are the weight loads and the pressure loads, which are present during accident conditions.
- In the event of a guillotine steam line break outside the drywell, dryer design must preclude the possibility of dryer debris entering the steam line and interfering with isolation valve closure.
- The structural elements, which hold the dryer in place, are designed to accommodate the pressure loading due to a break outside the isolation valves within the ASME Code, Section III stress criteria. The flat panels, which form partitions in the dryer, are designed so that the elastic collapse loading on these panels is not exceeded under these same pressure loadings.

3.2 Acceptance Criteria for Modified Steam Dryer at EPU Conditions

The original steam dryer acceptance criteria continue as design bases for the modified VYNPS steam dryer at EPU conditions. The VYNPS steam dryer design basis continues to be structural integrity after a steam line break outside of containment. However, due to the operating experience related to steam dryer structural integrity associated with normal operation, specific emphasis has been placed in the analysis for EPU conditions to ensure that fatigue failure does not occur that could cause a loss of steam dryer structural integrity. In addition, this analysis includes Normal and Upset case loading combinations, using ASME Code, Section III stress criteria. Analysis of Normal and Upset cases addresses the concern that frequent and moderately frequent events which do not require an immediate inspection of the dryer should not degrade the dryer condition to the point that it might not meet its faulted condition design criteria.

3.2.1 Fatigue Criteria

The fatigue evaluation consists of calculating the alternating stress intensity from flow induced vibration (FIV) loading in the steam dryer structure and comparing it to the allowable fatigue design threshold stress intensity. The fatigue threshold stress intensity from ASME Code Curve C is 13,600 psi. The fatigue design criteria for the dryer is based on Figure I-9.2.2 of ASME Section III [7], which provides the fatigue threshold values for use in the evaluation of stainless steels. ASME Code fatigue Curve C assumes a mean stress equal to the material yield strength. The shell finite element model of the full dryer is not refined enough to predict the full stress concentrations in the welds. Therefore, additional weld factors are applied to the maximum stress intensities obtained from the shell finite element time history analyses at weld locations [13]. A key component of the fatigue alternating stress calculation at a location is the appropriate value of the stress concentration factor (SCF). The stress intensities with the applied weld factors are then compared to the fatigue criteria given above.

3.2.2 Acceptance Criteria for Normal, Upset and Faulted Conditions

The analysis uses the ASME Code [8] as a design guide although the dryer is not an ASME Code component. Specifically, structural adequacy for Service Level A and B loads is investigated using the corresponding stress limits of [8] with the exception of application of the weld quality factors. Weld quality factors are described in the ASME code Table NG-3352-1 for safety components, such as the reactor pressure vessel, that contain radioactive fluid. Because the steam dryer is not a safety-related pressure retaining component [[

]] In addition, inspection of the VYNPS steam dryer modification after 18-months of in-service operation showed no degradation of the modification welds. The requirement of 'no loose parts' during Service Level D events is investigated using stress limits of Subsection NG and Appendix F of the ASME Code [9]. The stress limits are summarized in Table 3.2-1. (Note that for completeness, application of the seismic loading in the [[ ]] direction is considered).

Table 3.2-2 shows the ASME Code Section III load combinations used in the VYNPS steam dryer primary stress evaluation. The [[

]] term

in load cases 4 and 5 (Levels B3 and B4). The [[ ]] load cases 6 and 7 (Levels B5 and B6). The faulted condition [[ ]] term in load cases 8 and 9 (Levels D1 and D2). [[ ]]term in load cases 10 and 11 (Levels D3 and D4). [[ ]]

Table 3.2-1 Primary Stress Limits

Service level	Stress category	Stress limit
Service levels A & B	P_m	S_m
	$P_m + P_b$	$1.5\ S_m$
Service level D	P_m	$\min(2.4S_m, 0.7S_u)$
	$P_m + P_b$	$\min(3.6S_m, 1.05S_u)$

P_m: Primary membrane stress intensity
P_b: Primary bending stress intensity
S_m: Stress intensity limit
S_u: Ultimate strength

Table 3.2-2 ASME Code Section III Load Combinations

Case	Service Level	Load Combination
1	Level A	[[
2	Level B 1	
3	Level B 2	
4	Level B 3	
5	Level B 4	
6	Level B 5	
7	Level B 6	
8	Level D 1	
9	Level D 2	
10	Level D 3	
11	Level D 4	]]

4.0 Inputs

This section describes the key inputs that are used for the steam dryer structural analysis.

4.1 Operation Pressure Loading

The flow-induced vibration (FIV) loading as a result of the passage of steam through the steam dryer vane banks is a significant cyclic loading that has the potential to initiate and grow fatigue cracking. This FIV loading in the form of distributed fluctuating pressures is highly complex in that it varies as a function of the location and phasing, and has complex frequency content. The FIV pressure loading was calculated from two sources: (1) Acoustic Circuit Modeling, and (2) Large Eddy Simulation (LES).

4.1.1 Acoustic Pressures

The acoustic circuit based pressure fluctuations were developed by Continuum Dynamics Inc. (CDI) [4] and supplied by Entergy as input to GE. The acoustic circuit model for the VYNPS steam path (i.e., steam dome, dryer and the steam lines) was developed by CDI and used VYNPS-specific measured pressure fluctuation data as input. The acoustic circuit based pressure fluctuations, used in this analysis, were determined by the measurement of VYNPS main steam line piping strains at the steam flow associated with the EPU power level of 1912 megawatt thermal (MWth). Evaluation of the in-plant acoustic pressure data by Entergy showed important acoustic loading frequency content at 77, 82, 137, and 143.5 Hz. The ACA model conservatively produces additional loads at 102, 115, and 155 Hz. These loads are at frequencies where there is little or no acoustic signal in the steam lines. Entergy and CDI have indicated that loads at these frequencies are conservative and could be reduced. However, the load definition used in this analysis [4] conservatively did not perform any filtering or reduction of the loading at 102, 115, and 155 Hz.

4.1.2 Vortex Shedding Pressures and Stress Intensities

The large eddy simulation (LES) model and determination of unsteady vortex shedding pressures using computational fluid dynamics (CFD) on the VYNPS modified steam dryer at EPU operating conditions are documented in [5]. Determination of the stress intensities with the application of the vortex shedding pressures was performed by Entergy and was documented in [2]. This stress calculation was performed using an ANSYS finite element model of the VYNPS modified steam dryer upper structure without inclusion of the steam dryer skirt. As stated in [3], inclusion of the dryer skirt in the ANSYS model would reduce the governing outer hood stress intensities since including the dryer skirt in the FEA model raises the dryer model fundamental frequency away from alignment with the CFD load frequency of 62 Hz.

Therefore, for this analysis, the conservative CFD load stress intensities from [2] are used in combination with the FIV stresses calculated in this analysis using the VYNPS EPU operating condition acoustic loads.

4.1.3 Seismic Loading

The seismic loads for the Operational Basis Earthquake (OBE) and the Safe Shutdown Earthquake (SSE) on the VYNPS dryer are documented in [10]. These seismic loads are unchanged with EPU. The accelerations are listed below.

[[

]]

4.1.4 Steady State, Upset Transient, and Faulted Condition Loads

The other normal operating (steady state), transient and faulted pressure loadings on the dryer components for the ASME Code Section III Load Combination evaluations are described for EPU conditions in Appendix A.

4.1.5 Uncertainty and Bias for FIV Loads

The uncertainties and Biases associated with the acoustic circuit analysis (ACA) and CFD (vortex shedding pressures) analysis as applied to the VYNPS EPU steam dryer structural analysis were provided by Entergy [6]. They are listed below:

ACA Bias – Twenty-Seven Percent (27%)
ACA Uncertainty – Twenty Percent (20%)
CFD Uncertainty – Sixteen Percent (16%)

5.0 Steam Dryer Model and Analysis

5.1 Steam Dryer Finite Element Model

The ANSYS finite element model is a full dryer model, as shown in Figures 5-1 through 5-3, which incorporates the modifications made to the VYNPS dryer in 2004. The model is primarily composed of shell elements since the physical dryer construction is mostly plate. The dryer support ring and dryer crossbeams are modeled as solid elements. The dryer modification gusset shoes, part of the front hood gusset and the gusset to cover plate weld and gusset shoe to gusset weld are also modeled as solid elements. Since the lower third of the dryer skirt is submerged under water, the

water mass in this region is modeled as a super-element using ANSYS Fluid-80 elements.

5.2 Mode Shapes of FEA Model

Frequency calculations were performed using the ANSYS 8.1 finite element analysis program in order to determine the significant mode shapes of the steam dryer model. The steam dryer has 390 modes between zero and 200 Hertz. However, the majority of these 390 modes are either due to dryer skirt modes, or modes associated with the steam dryer baffle plates. The first skirt mode occurs at approximately 5 Hz with subsequent modes about every 1 Hertz. The baffle plate first mode occurs at 19.5 Hz. The dryer front (outer) hood first frequency occurs at approximately 83 Hz. Other mode significant mode shapes between 0-200 Hz for the dryer front hoods are shown in Figure 5-4

5.3 Structural Damping for Finite Element Analysis

Due to the use of super-elements in the VYNPS steam dryer model, the direct integration solution method in ANSYS must be used. Previous time-history analyses of the VYNPS steam dryer without the super-elements were performed under modal superposition using a constant one-percent of critical damping.

Previous time-history analyses using direct integration [2][3] used Rayleigh damping constants of: Alpha = 2.0106, Beta = 0.00003183. These constants provide 1% damping at 20 and 80 Hertz. At 150 Hertz, the damping is 1.5%.

In order to provide an additional degree of conservatism in the dryer structural analysis with the ACM loads at EPU conditions, Rayleigh damping constants of: Alpha = 2.2176, Beta = 0.00001872 are used in the direct integration solution. These constants provide 1% damping at 20 and 150 Hertz. Figure 5-5 shows the effect of damping constants on the damping ratio.

5.4 Application of Acoustic Pressure Loading to FEA Model

The ACM data set for the EPU transient analysis consists of 2.5 seconds of data at a sampling frequency of 4096 hertz. This quantity of data would make the finite element analysis run times on the order of several weeks using super-computing resources and would produce result files on the order of several terabytes. Therefore, a resampling routine was developed to remove the last 0.5 seconds of data and downsample the resultant data to 1200 hertz. This results in 2400 load steps of data applied to the finite element analysis. Verification of this process confirmed that all frequency content of the loading was preserved and that there was no aliasing of the

data. A GE developed ANSYS macro is used to translate the resampled ACM pressures into input pressures for the GE ANSYS finite element model.

5.5 Time History FIV Analysis

The stress analysis is performed using the direct integration routine of the ANSYS finite element code Version 8.1 [11]. The nominal time step value used in the analysis is 0.000833 second. Two sets of analyses are performed using this nominal time step, one with Rayleigh damping of 1% at 20 and 80 Hz and a second analysis with Rayleigh damping of 1% at 20 and 150 Hz. The purpose of these comparative runs is to determine the effect of using more conservative damping parameters on the stress analysis.

It is an accepted engineering practice to assess the sensitivity of the calculated stresses to such factors as differences in modal frequency due to geometric and material variations, random variations in pressure time history, etc. A sensitivity assessment is conducted by varying the time interval between the pressure time steps by $\pm$ 10%. This is equivalent to peak broadening in the response spectrum analysis method. The 10% variation is judged to be a reasonable value to capture instances where a structural mode that contributes significant response may have its frequency very close to any one of the frequencies present in the fluctuating pressure time history. To further study the sensitivity of the stress analysis due to a shift in the time step, additional analyses are performed using time shifts of +/- 2.5% and +/- 5%. All of the sensitivity analyses are performed with conservative Rayleigh damping constants of Alpha = 2.2176, Beta = 0.00001872 (damping of 1% at 20 and 150 Hz.)

5.6 FIV Stress Determination

The FIV stress intensities are taken as a combination of the acoustic and vortex shedding contributions. The acoustic pressure FEA results for each dryer component of interest are screened for the maximum stress intensity throughout the 2400 time steps. The search routine finds the maximum surface stress intensity of the component top and bottom surface. The larger of the top or bottom surface stress intensity is conservatively used as the acoustic contribution to the FIV stress amplitude.

The stress intensity from the acoustic pressure analysis is multiplied by the bias term of the ACA (Section 4.1.5) and then combined with the maximum stress range from

the vortex shedding pressure analysis via the square root of the sum of the squares (SRSS) method.

5.7 Weld Stress Concentration Factors and Weld Undersized Factors

The following stress concentration factors (SCFs) are used in this evaluation: fillet weld, 1.8; butt weld, 1.4. These SCFs were applied to the calculated peak stresses from the finite element analyses. The use of peak stress to multiply with SCFs provides alternating stresses at welds consistent with recommended SCFs in the ASME Code. The technical basis for these values is provided in [13].

The calculation of the stress concentration factor to account for undersized welds is the square of the ratio of plate thickness to the weld size. For example, in the modified dryer stress analysis, a 1/2--inch fillet weld is used for the 5/8- inch thick lower cover plate; the stress factor to convert the plate stress to the fillet weld stress is $(0.625/0.500)^2 = 1.56$.

5.8 Calculation of FIV Stress Intensity

The equation for the calculation of the FIV stress intensity, that includes the ACA bias term, but does not include the uncertainty terms of either the ACA or the CFD analysis is as follows:

$$\text{FIV Stress Intensity} = \sqrt{((1 + \text{ACA Bias}) \times \text{ACA S.I.})^2 + (\text{CFD S.I.})^2} \times \text{Weld SCF} \times \text{Weld UF}$$

Where

ACA Bias = ACA Bias Term

ACA S.I. = Stress Intensity for component from FEA analysis using ACA Loads

CFD S. I. = Stress Intensity for component from FEA analysis using CFD Loads

Weld SCF = Weld Stress Concentration Factor

Weld UF = Weld Undersize Factor

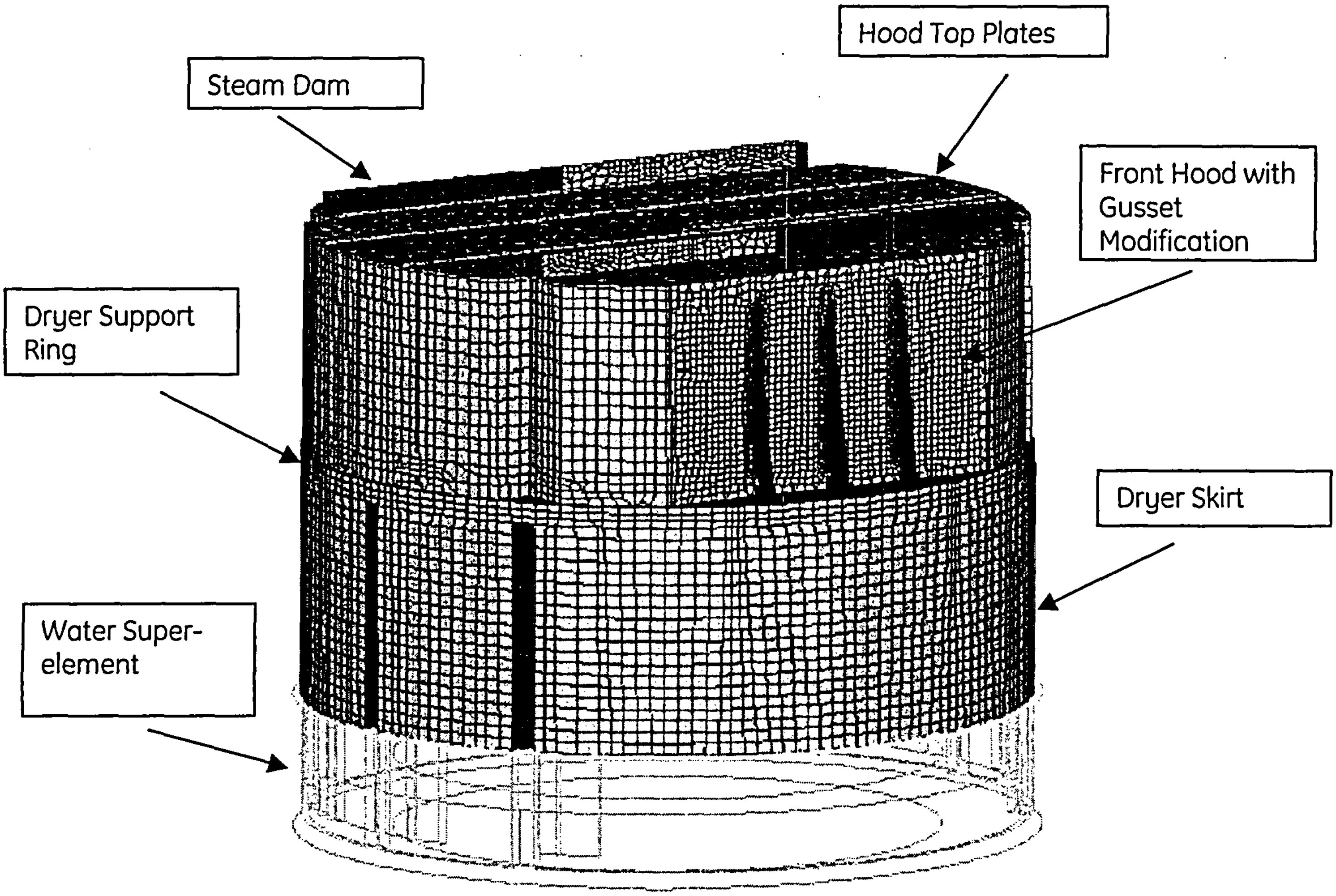


Figure 5-1 Modified Full Dryer Analysis Model

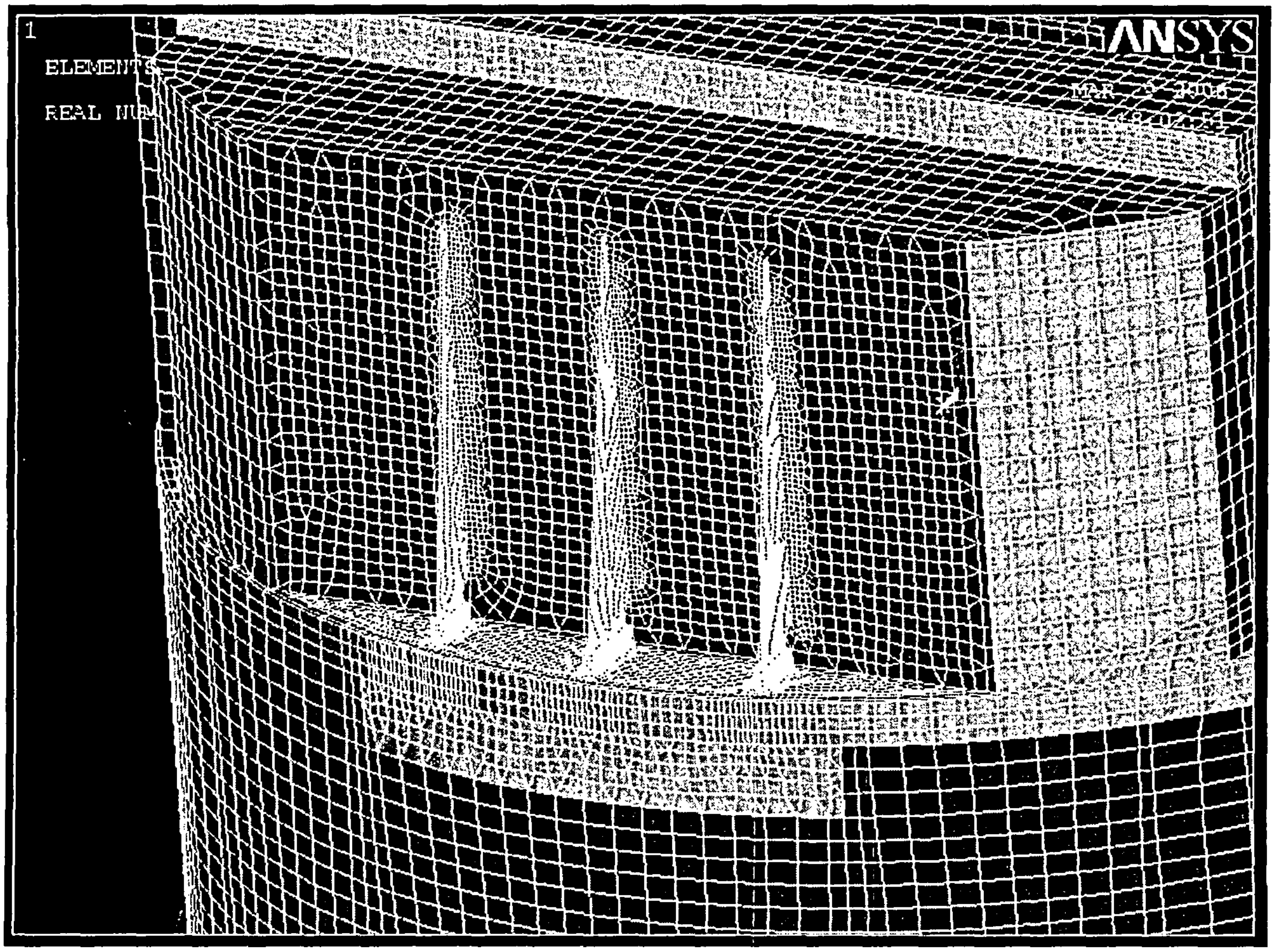


Figure 5-2 Details of Analysis Model Showing Front Hood, Support Ring and Skirt

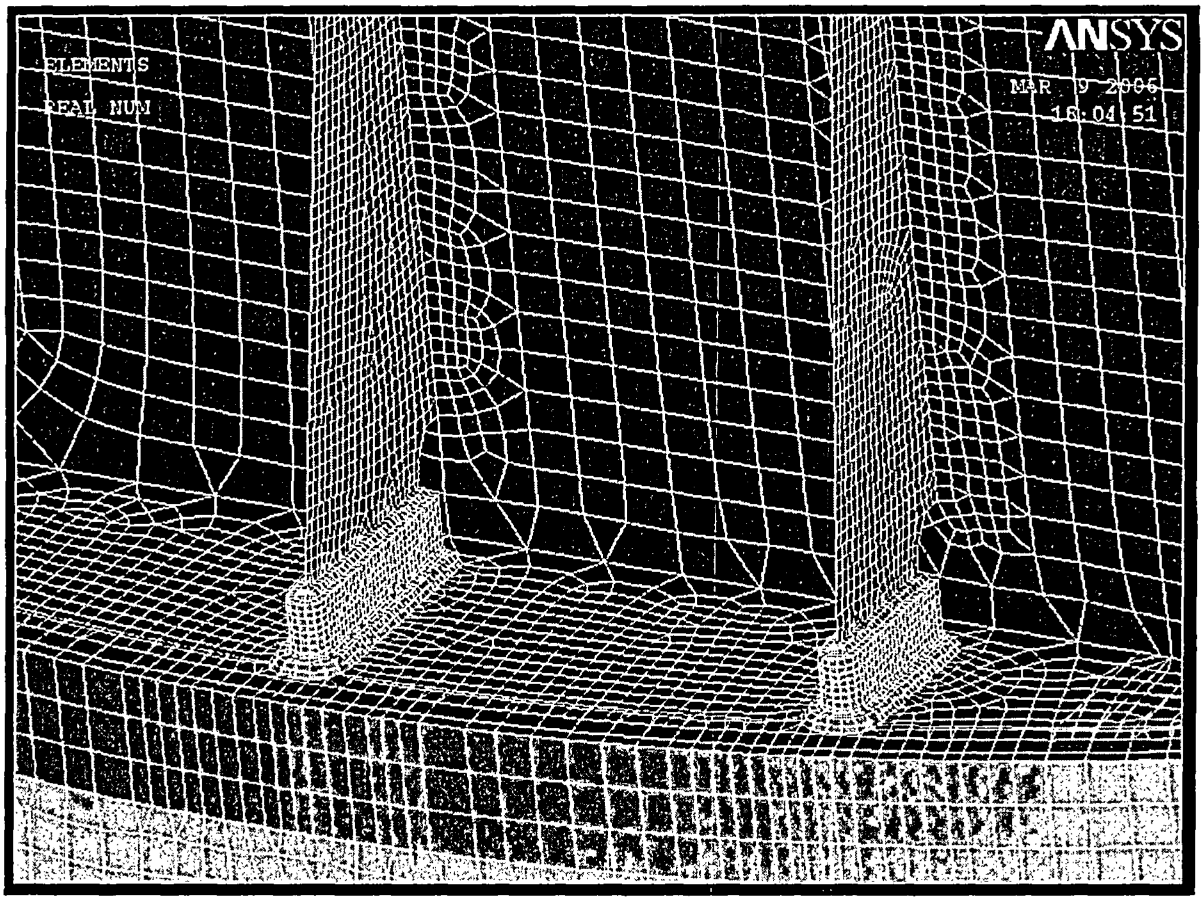
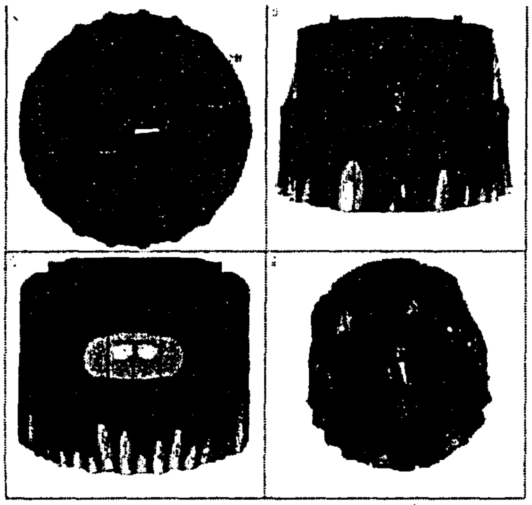
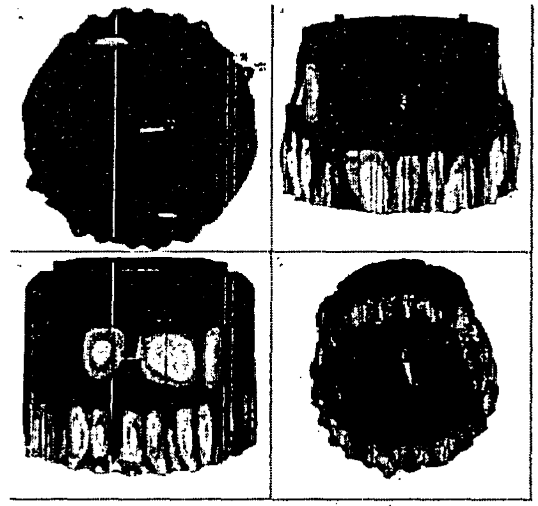


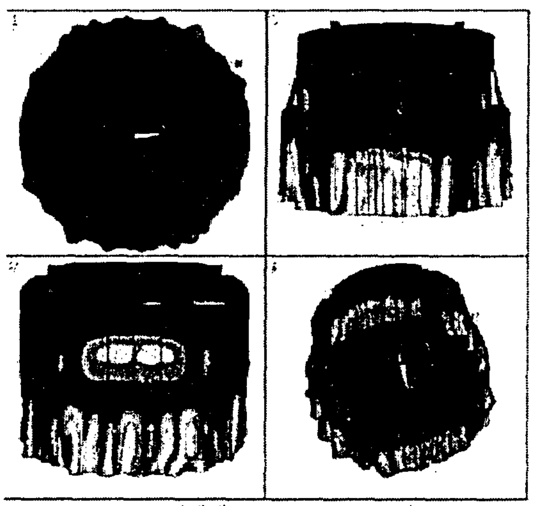
Figure 5-3 Details of Analysis Model Showing Front Hood Gussets



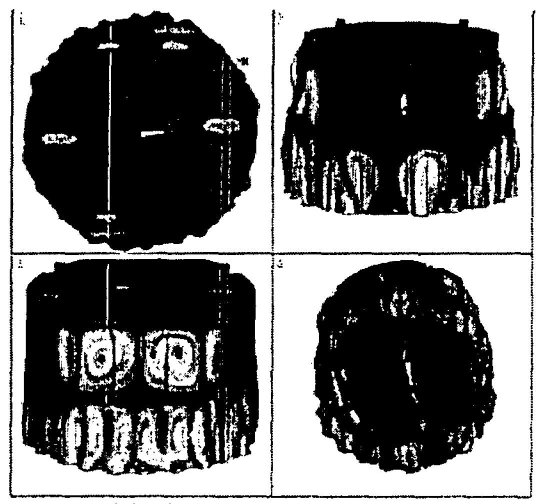
Mode 120 – 82.9 Hz



Mode 145 - 94.9 Hz

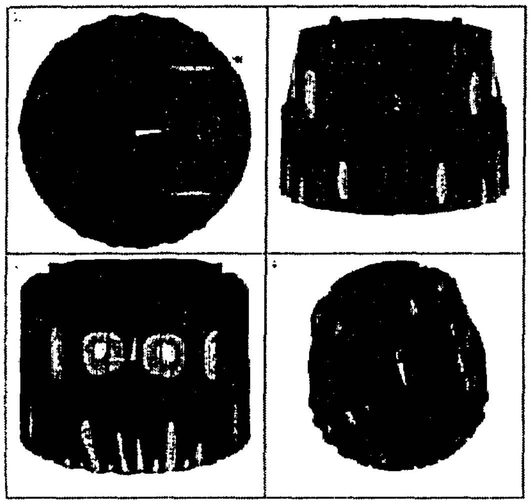


Mode 128 – 85.4 Hz

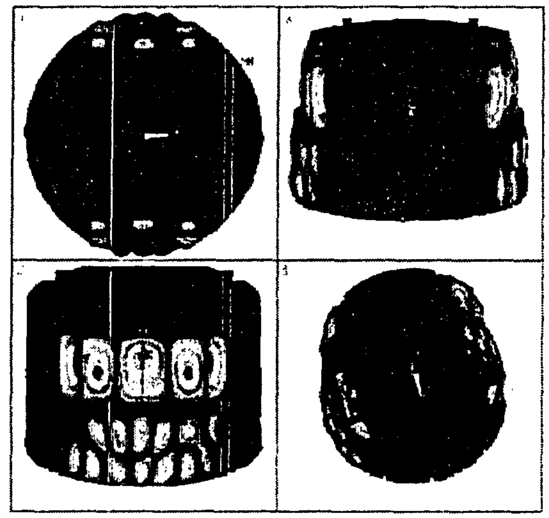


Mode 154 – 97.7 Hz

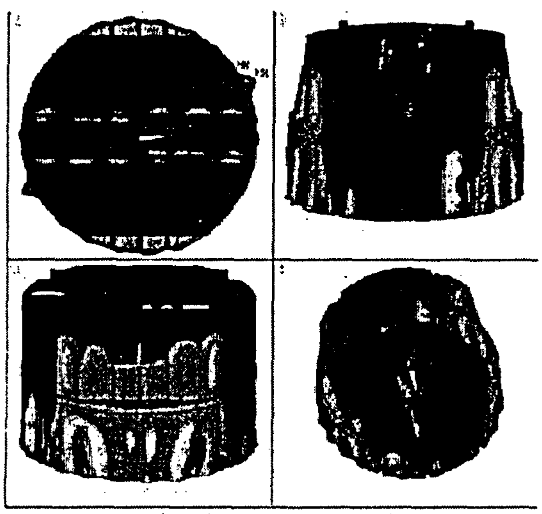
Figure 5-4 FEA Model Mode Shapes for Outer Dryer Hood



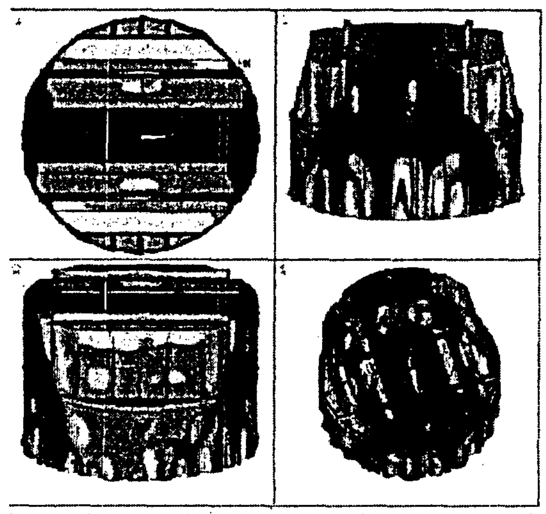
Vermont Yankee Dryer, Mode 167, frequency = 102.210146
Mode 167 – 102.2 Hz



Vermont Yankee Dryer, Mode 193, frequency = 117.747774
Mode 193 – 117.7 Hz

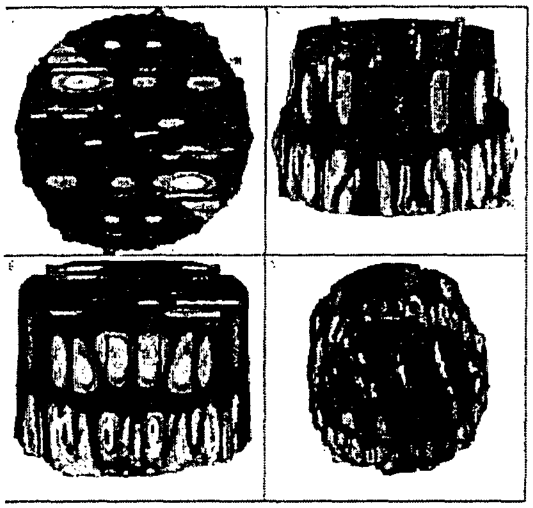


Vermont Yankee Dryer, Mode 175, frequency = 107.962841
Mode 175 – 107.7 Hz



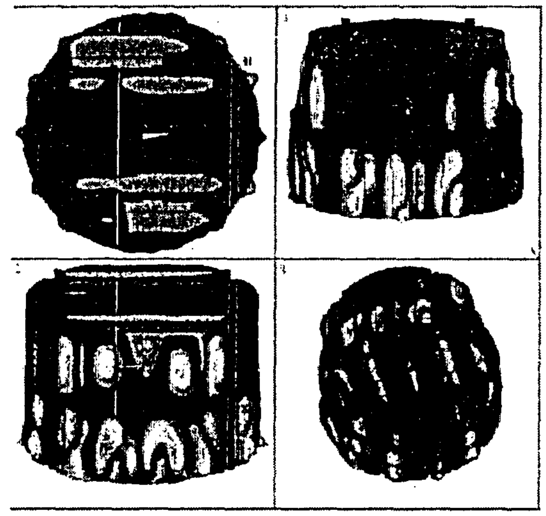
Vermont Yankee Dryer, Mode 226, frequency = 135.065345
Mode 226 – 135.1 Hz

Figure 5-4 FEA Model Mode Shapes for Outer Dryer Hood



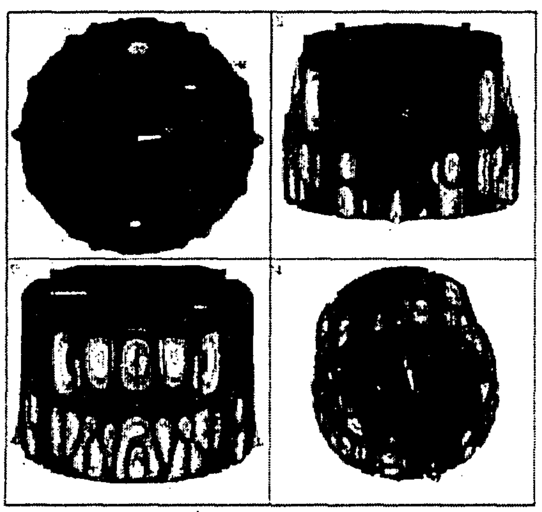
Vermont Yankee Dryer, Mode 240, frequency = 142.742783

Mode 240 – 142.7 Hz



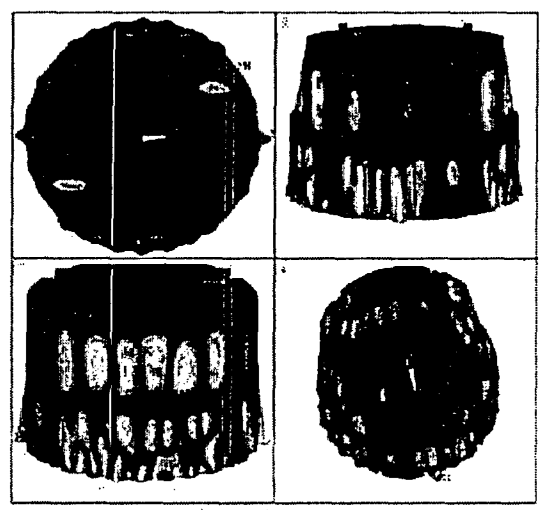
Vermont Yankee Dryer, Mode 265

Mode 265 – 153.2 Hz



Vermont Yankee Dryer, Mode 261

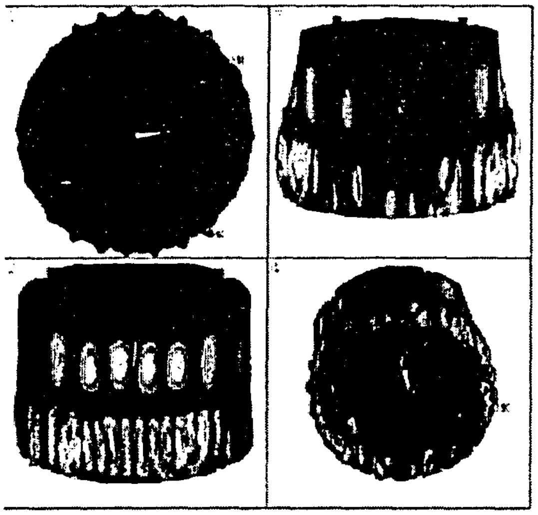
Mode 261 – 151 Hz



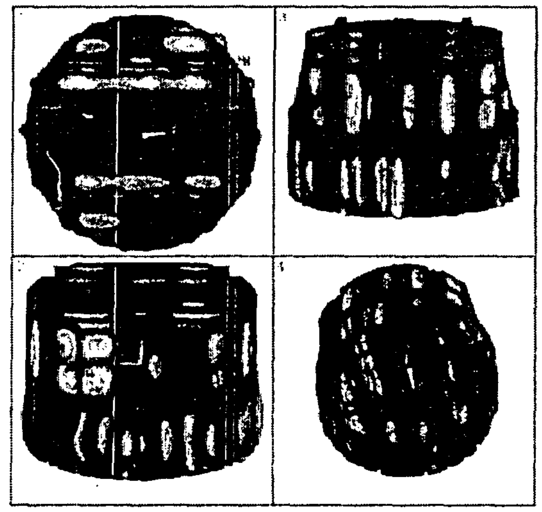
Vermont Yankee Dryer, Mode 286

Mode 286 – 166.4 Hz

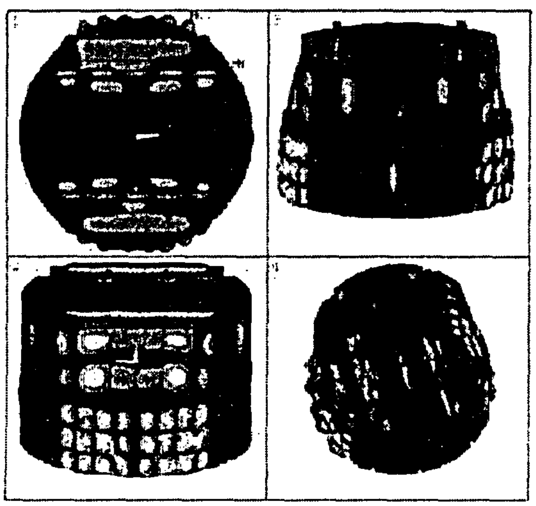
Figure 5-4 FEA Model Mode Shapes for Outer Dryer Hood



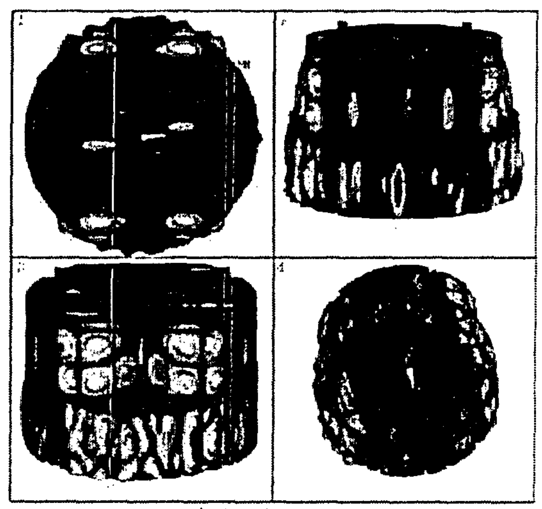
Mode 291 – 168.4 Hz



Mode 351 – 187.8 Hz



Mode 322 – 178.5 Hz



Mode 355 – 189.1 Hz

Figure 5-4 FEA Model Mode Shapes for Outer Dryer Hood

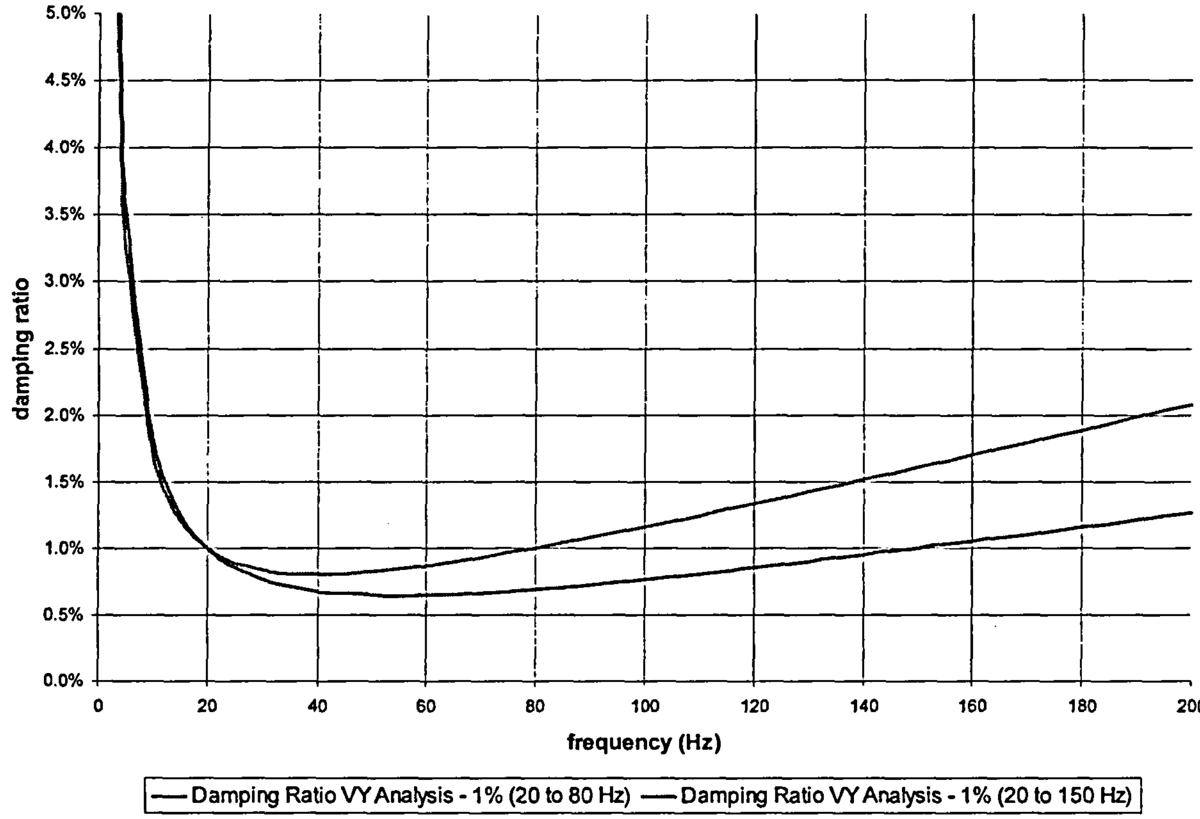


Figure 5-5 Rayleigh Damping

6.0 Modified Dryer Analysis Results

6.1 Evaluation of Flow Induced Vibration Stress Intensities

Table 6-1 shows the comparison of the nominal time step analysis with a variation in the Rayleigh damping constants. As expected, the use of the more conservative damping constants results in an increase in the stress intensity for each component. Observation of Table 6-1 shows that the average stress intensity increase is 16% with the largest increase of approximately 30% in the skirt region. In order to more fully study the effect of the Rayleigh damping constants, time-history data was extracted from the nominal FEA stress result analysis files, nominal case with 1% damping at 20-80 Hz and 1% damping at 20-150 Hz, for the modification gusset shoe (Group 27). Figures 6-1 and 6-2 provide a comparison of the stress result power spectral density (PSD) and the stress result spectrum. As seen in Figures 6-1 and Figures 6-2, the key frequency contributors to the increase in stress intensity with the more conservative damping constants are at 74.5 Hz and 135 Hz. Other frequencies show smaller stress intensity changes in this comparison.

Table 6-2 shows the results of the nominal and time-step variation cases with all analyses performed with conservative Rayleigh damping constants of 1% damping at 20 and 150 Hz. The stress intensity tabulations in Table 6-2 include the ACA bias term but do not include ACA or CFD uncertainties. The results of these studies show that the maximum percentage variation for ACA load input, maximum stress intensity for all time steps versus nominal time step stress intensity, is 44% and occurs for the hood partition plates, Group 16. The hood partition plates are lightly stressed components and have a FIV stress intensity at EPU condition of approximately 10% of the allowable endurance limit. For the components that experience the highest stress intensities at EPU conditions, the percentage variation between the nominal and time step variation maximum stress intensities for the ACA load input is as follows:

Gusset Shoes	4%	-10% time shift
Lower Cover plate	25%	-10% time shift
Outer hood plates	7%	+5% time shift
Skirt Components	20%	+5% time shift

The dryer component with the highest stress intensity for all time-step variations is the modified top hood with a peak FIV stress intensity of 6,668 psi. This stress

intensity is approximately 50% of the FIV stress intensity acceptance criterion of 13,600 psi. Due to the large margins remaining to the acceptance criterion for FIV, it is concluded that the time step variations applied to the VYNPS dryer analysis are acceptable to show that no resonance peaks are expected that would result in further large increases in FIV stresses.

6.1.1 FIV stress results with Uncertainties

The equation for the calculation of the FIV stress intensity, that includes the ACA bias term and the uncertainty terms of the ACA and the CFD analysis is as follows:

$$\text{FIV Stress Intensity} = \sqrt{((1 + \text{ACA Bias} + \text{ACAU}) \times \text{ACA S.I.})^2 + (\text{CFDU} \times \text{CFD S.I.})^2} \times \text{Weld SCF} \times \text{Weld UF}$$

Where

ACA Bias = ACA Bias Term

ACAU = ACA Uncertainty

ACA S.I. = Stress Intensity for component from FEA analysis using ACA Loads

CFDU = CFD Uncertainty

CFD S. I. = Stress Intensity for component from FEA analysis using CFD Loads

Weld SCF = Weld Stress Concentration Factor

Weld UF = Weld Undersize Factor

Table 6.4 shows the stress intensities for all components with ACA Bias, ACA uncertainty and CFD uncertainty included. The components with the highest peak stress intensity at EPU conditions is the modified top hood (Group 5) with a peak stress intensity of 7406 psi for the case run with a plus 10% time shift. This peak stress intensity is approximately 54% of the ASME design allowable endurance limit of 13,600 psi. The modification gusset shoe (Group 27) has a peak stress intensity of 7282 psi for the case run with a minus 10% time shift. This peak stress intensity is also approximately 54% of the ASME design allowable endurance limit of 13,600 psi.

6.2 Evaluation of Primary Stresses under ASME Code Section III Loads

Each of the load combination tabulated in Table 3.2-2 has been analyzed for the modified dryer in [1]. The nominal surface stress intensity at EPU conditions with the inclusion of ACA bias, ACA uncertainty and CFD uncertainty is conservatively used as

the flow-induced vibration contribution for each load combination even though the FIV surface stress intensity includes secondary stresses. In the ASME Code Section III load analysis, the dynamic loads, such as OBE, SSE and TSV loads should be combined by square root of the sum of the square (SRSS). This analysis combined the dynamic loads by algebraic sum. Because the OBE and SSE have been input in both the positive and negative directions and both results are compared with the allowable limits, the results are equivalent to absolute sum results. Therefore, the load combinations are conservative. The TSV and MSL Break pressure [[
]] in the input for ANSYS analyses.

Table 6.4 tabulates the stresses for each weld with the undersize weld factor included. For Service Levels A and B, the maximum stress ratio is 0.827, at the modification gusset, due to the Service Level B-3 load combination. For Service D the maximum stress ratio is 1.003, at the modification gusset due to the Service Level D-4 load combination. [[

]] Therefore, the component is considered acceptable.

		Remeshed Ring and Solid Modeling		1912	MWth Loads		120	%OLTP		1% Raleigh Damping (20 - 80 Hz)	1% Raleigh Damping (20 - 150 Hz)
Post Processing Group Number			Acoustic Stress intensity nominal time step	Acoustic Stress intensity nominal time step	Vortex Shedding Max Surface Stress Intensity (psi)	Weld Conc. Factor	Plate Thickness (in)	Weld Size (in)	Undersize Factor	Peak Stress Intensity - (SRSS(1+2))*5*6	Peak Stress Intensity - (SRSS(1+2))*5*6
			(1)	(1)	(2)	(5)			(6)	Nominal	Nominal
			20-80Hz	20-150Hz						Time Step	Time Step
		Horizontal plates:							Maximum	6,225	6,623
1		Inner hood base plate	1665	1973	624	1.80	0.500	0.500	1.000	3,968	4,648
2		Modified outer cover plate5/8", both tips 4"	1413	1810	437	1.80	0.625	0.625	1.000	3,325	4,212
3		Modified outer cover plate, exclude tips	2095	2482	439	1.00	0.625	0.625	1.000	2,697	3,183
32		Weld line outer cover plate exclude tips to support ring	1114	1297	439	1.80	0.625	0.500	1.563	4,166	4,794
4		Original top hood (all hood)	722	870	943	1.80	0.50	0.50	1.00	2,368	2,615
5		Modified top hood (outer hood)	604	717	1,112	1.80	1.000	0.625	2.560	6,225	6,623
6		Hood top plates(inner hood)	1328	1536	1,964	1.40	0.500	0.500	1.000	3,624	3,875
		Vertical plates:									
7		Original outer Hood, strips	1047	1300	108	1.80	0.50	0.500	1.000	2,401	2,978
8		Modified outer hood, top weld	612	703	301	1.80	1.00	0.625	2.560	3,841	4,342
9		Modified outer hood, bottom weld	608	699	725	1.80	1.00	1.000	1.000	1,907	2,063
10		Hood vertical plates (inner hood)	812	1018	761	1.40	0.50	0.500	1.000	1,794	2,100
11		Hood end plates,(inner hood)	646	752	536	1.80	0.50	0.500	1.000	1,764	1,971
12		Hood end plates (outer hood)	1241	1498	322	1.80	0.50	0.500	1.000	2,896	3,473
13		Inner Hood Brackets(gussets)	1084	1288	573	1.40	0.50	0.500	1.00	2,088	2,427
14		Steam 'dam'	487	578	807	1.80	0.50	0.500	1.000	1,830	1,964
15		Steam 'dam' gussets	654	791	941	1.80	0.50	0.500	1.000	2,259	2,478
		Other Plates									
16		Hood partition plates	294	363	94	1.80	0.50	0.500	1.000	693	847
17		Baffle plates	1183	1432	1,144	1.80	0.50	0.500	1.000	3,399	3,867
18		Outlet plenum ends	702	864	1,891	1.80	0.50	0.500	1.000	3,763	3,935
		Ring, Beams & Gussets									
19		Dryer support ring	475	587	675	1.80	3.00	3.000	1.000	1,630	1,810
20		Bottom cross beams	363	407	135	1.80	3.00	3.000	1.000	865	962
21		Cross beam gussets	1546	1743	414	1.80	0.50	0.500	1.000	3,612	4,054
		Gussets for outer Cover plate and hood									
22		Outer Hood Gusset	2234	2662	820	1.00	0.500	0.500	1.000	2,953	3,479
23		Gusset solid to gusset shell transition	1333	1595	490	1.00	0.500	0.500	1.000	1,762	2,084
27		Solid Gusset Shoes	4018	4762	490	1.00	0.500	0.500	1.000	5,126	6,068
28		Gusset shoe weld to cover plate	1950	2312	490	1.80	0.500	0.500	1.000	4,544	5,358
29		Shoe weld to solid gusset	2026	2400	490	1.80	0.500	0.500	1.000	4,715	5,557
30		Solid part of Gusset	1785	2119	490	1.00	0.500	0.500	1.000	2,319	2,735
31		Outer Hood Gusset weld line to front hood	925	1076	820	1.80	0.500	0.750	1.000	2,579	2,869
		Skirt Area									
24		Skirt	1051	1345	0	1.40	0.500	0.500	1.000	1,869	2,391
25		Drain Boxes (Channels)	678	876	0	1.40	0.500	0.500	1.000	1,203	1,558
26		Guide Rod and Support Lug Channels	695	864	0	1.40	0.500	0.375	1.778	2,197	2,731

Table 6-1 Damping Ratio Effect on Nominal FIV Stress Intensities

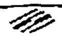
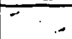
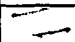
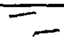
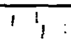
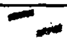
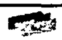
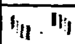
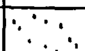
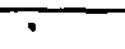
			Remeshed Ring and Solid Modeling of Gusset Shoes (2400 Load Steps)							1912 MWth Loads		120 %OLTP			1% Rayleigh (20-150Hz) Damping						
Post Processing Group Number			Acoustic Stress intensity nominal time step	Acoustic Stress Intensity Plus 10% time step	Acoustic Stress Intensity Minus 10% time step	Acoustic Stress Intensity Plus 2.5% time step	Acoustic Stress Intensity Minus 2.5% time step	Acoustic Stress Intensity Plus 5% time step	Acoustic Stress Intensity Minus 5% time step	Vortex Shedding Max Surface Stress Intensity (psi)	Weld Conc. Factor	Plate Thickness (in)	Weld Size (in)	Undersize Factor	Peak Stress Intensity - (SRSS(1+2))*5*6	Peak Stress Intensity - (SRSS(1+2))*5*6	Peak Stress Intensity - (SRSS(1+2))*5*6	Peak Stress Intensity - (SRSS(1+2))*5*6	Peak Stress Intensity - (SRSS(1+2))*5*6	Peak Stress Intensity - (SRSS(1+2))*5*6	Peak Stress Intensity - (SRSS(1+2))*5*6
			(1)	(1)	(1)	(1)	(1)	(1)	(1)	(2)	(5)			(6)	Nominal Time Step 6.623	Plus 10% Time Step 6.668	Minus 10% Time Step 6.627	Plus 2.5% Time Step 6.564	Minus 2.5% Time Step 6.434	Plus 5% Time Step 6.403	Minus 5% Time Step 6.424
		Horizontal plates:												Maximum							
1		Inner hood base plate	1973	1544	1130	1989	1835	1480	1513	624	1.80	0.500	0.500	1.000	4,648	3,704	2,818	4,684	4,343	3,565	3,637
2		Modified outer cover plate5/8", both tips 4"	1810	1662	1336	1802	1406	1937	1221	437	1.80	0.625	0.625	1.000	4,212	3,880	3,154	4,191	3,309	4,497	2,900
3		Modified outer cover plate, exclude tips	2482	2201	2574	2369	2285	2211	2360	439	1.00	0.625	0.625	1.000	3,183	2,830	3,298	3,040	2,935	2,812	3,029
32		Weld line outer cover plate exclude tips to support ring	1297	1428	1622	1470	1477	1310	1336	439	1.80	0.625	0.500	1.563	4,794	5,248	5,924	5,394	5,418	4,839	4,929
4		Original top hood (all hood)	870	789	842	782	766	754	721	943	1.80	0.50	0.50	1.00	2,615	2,477	2,566	2,465	2,439	2,419	2,366
5		Modified top hood (outer hood)	717	729	718	701	665	656	662	1,112	1.80	1.000	0.625	2.560	6,623	6,668	6,627	6,564	6,434	6,403	6,424
6		Hood top plates(inner hood)	1536	1182	872	1547	1271	1276	986	1,964	1.40	0.500	0.500	1.000	3,875	3,461	3,157	3,889	3,559	3,565	3,261
		Vertical plates:																			
7		Original outer Hood , strips	1300	1372	988	1300	968	1385	1149	108	1.80	0.50	0.500	1.000	2,978	3,142	2,267	2,978	2,221	3,172	2,634
8		Modified outer hood, top weld	703	650	700	717	681	734	624	301	1.80	1.00	0.625	2.560	4,342	4,049	4,325	4,419	4,236	4,514	3,906
9		Modified outer hood, bottom weld	699	656	624	724	681	737	653	725	1.80	1.00	1.000	1.000	2,063	1,988	1,933	2,108	2,031	2,131	1,986
10		Hood vertical plates (inner hood)	1018	819	718	997	859	907	817	761	1.10	0.50	0.500	1.000	2,100	1,804	1,663	2,068	1,862	1,933	1,801
11		Hood end plates,(inner hood)	752	673	729	780	626	648	700	536	1.80	0.50	0.500	1.000	1,971	1,816	1,926	2,027	1,726	1,768	1,869
12		Hood end plates (outer hood)	1498	1541	980	1448	1102	1586	1275	327	1.80	0.50	0.500	1.000	3,473	3,570	2,314	3,360	2,585	3,672	2,972
13		Inner Hood Brackets(gussets)	1288	1085	1320	1145	1135	1193	1266	573	1.40	0.50	0.500	1.00	2,127	2,089	2,480	2,188	2,172	2,268	2,390
14		Steam 'dam'	578	587	564	609	491	490	559	807	1.80	0.50	0.500	1.000	1,964	1,978	1,942	2,012	1,836	1,834	1,935
15		Steam 'dam' gussets	791	747	547	895	607	688	601	941	1.80	0.50	0.500	1.000	2,478	2,405	2,105	2,656	2,190	2,311	2,181

Table 6-2 FIV Stress Intensities with Time Step Variation

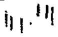
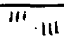
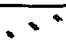
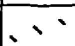
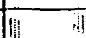
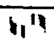
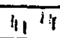
Post Processing Group Number			Remeshed Ring and Solid Modeling of Gusset Shoes (2400 Load Steps) — Acoustic Stress intensity nominal time step (1)	Acoustic Stress Intensity Plus 10% time step (1)	Acoustic Stress Intensity Minus 10% time step (1)	Acoustic Stress Intensity Plus 2.5% time step (1)	Acoustic Stress Intensity Minus 2.5% time step (1)	Acoustic Stress Intensity Plus 5% time step (1)	Acoustic Stress Intensity Minus 5% time step (1)	1912 MWth Loads — Vortex Shedding Max Surface Stress Intensity (psi) (2)	Weld Conc Factor (5)	120 °F OLTP — Plate Thickness (in)	Weld Size (in)	Undersize Factor (6)	1% Rayleigh (20-150Hz) Damping — Peak Stress Intensity - (SRSS(1+2))*5*6 Nominal Time Step	Peak Stress Intensity - (SRSS(1+2))*5*6 Plus 10% Time Step	Peak Stress Intensity - (SRSS(1+2))*5*6 Minus 10% Time Step	Peak Stress Intensity - (SRSS(1+2))*5*6 Plus 2.5% Time Step	Peak Stress Intensity - (SRSS(1+2))*5*6 Minus 2.5% Time Step	Peak Stress Intensity - (SRSS(1+2))*5*6 Plus 5% Time Step	Peak Stress Intensity - (SRSS(1+2))*5*6 Minus 5% Time Step
		Other Plates																			
16		Hood partition plates	363	310	311	523	287	480	410	94	1.80	0.50	0.500	1.000	837	729	731	1,207	678	1,110	952
17		Baffle plates	1132	1601	1320	1569	1226	1655	1280	1,144	1.80	0.50	0.500	1.000	3,867	4,199	3,653	4,136	3,478	4,302	3,578
18		Outlet plenum ends	864	835	505	924	647	804	613	1,891	1.80	0.50	0.500	1.000	3,935	3,902	3,591	4,006	3,711	3,868	3,681
		Ring, Beams & Gussets	0																		
19		Dryer support ring	587	551	598	542	536	543	496	675	1.80	3.00	3.000	1.000	1,810	1,800	1,829	1,735	1,726	1,732	1,662
20		Bottom cross beams	407	378	362	397	426	350	348	135	1.80	3.00	3.000	1.000	962	898	862	940	1,004	836	832
21		Cross beam gussets	1743	1385	1108	1809	1829	1248	1367	414	1.80	0.50	0.500	1.000	4,054	3,253	2,640	4,202	4,247	2,919	3,213
		Gussets for outer Cover plate and hood																			
22		Outer Hood Gusset	2662	2257	2645	2641	2300	2270	2435	820	1.00	0.500	0.500	1.000	3,479	2,981	3,458	3,453	3,034	2,992	3,199
23		Gusset solid to gusset shell transition	1595	1428	1558	1575	1420	1482	1381	490	1.00	0.500	0.500	1.000	2,081	1,879	2,038	2,059	1,869	1,915	1,821
27		Solid Gusset Shoes	4762	4192	4941	4571	4375	4227	4555	490	1.00	0.500	0.500	1.000	6,068	5,346	6,294	5,826	5,578	5,391	5,806
28		Gusset shoe weld to cover plate	2312	2036	2389	2203	2128	2063	2192	490	1.80	0.500	0.500	1.000	5,358	4,737	5,532	5,113	4,914	4,708	5,088
29		Shoe weld to solid gusset	2400	2136	2473	2314	2217	2134	2294	490	1.80	0.500	0.500	1.000	5,557	4,962	5,722	5,363	5,144	4,957	5,318
30		Solid part of Gusset	2119	1875	2157	2053	1924	1903	1987	490	1.00	0.500	0.500	1.000	2,735	2,431	2,783	2,653	2,492	2,466	2,571
31		Outer Hood Gusset weld line to front hood	1076	1153	1363	1064	1113	963	1190	820	1.80	0.500	0.750	1.000	2,869	3,021	3,148	2,845	2,911	2,650	3,095
		Skirt Area																			
24		Skirt	1345	1159	1220	1382	1441	1502	1212	0	1.40	0.500	0.500	1.000	2,391	2,061	2,169	2,457	2,562	2,671	2,155
25		Drain Boxes (Channels)	876	744	847	978	891	1041	788	0	1.40	0.500	0.500	1.000	1,558	1,323	1,506	1,739	1,584	1,851	1,401
26		Guide Rod and Support Lug Channels	864	927	639	861	715	990	809	0	1.40	0.500	0.375	1.778	2,731	2,930	2,020	2,722	2,260	3,129	2,547

Table 6-2 FIV Stress Intensities with Time Step Variation

			Remeshed Ring and Solid Modeling of Gusset Shoes (2400 Load Steps)							1912 MWth Loads		120 °F OLTP			1% Rayleigh (20-150Hz) Damping							
Post Processing Group Number			Acoustic Stress intensity nominal time step	Acoustic Stress Intensity Plus 10% time step	Acoustic Stress Intensity Minus 10% time step	Acoustic Stress Intensity Plus 2.5% time step	Acoustic Stress Intensity Minus 2.5% time step	Acoustic Stress Intensity Plus 5% time step	Acoustic Stress Intensity Minus 5% time step	Vortex Shedding Max Surface Stress Intensity (psi)	Weld Conc. Factor	Plate Thickness (in)	Weld Size (in)	Undersize Factor	Peak Stress Intensity - (SRSS(1+2)) *5*6	Peak Stress Intensity - (SRSS(1+2)) *5*6	Peak Stress Intensity - (SRSS(1+2)) *5*6	Peak Stress Intensity - (SRSS(1+2)) *5*6	Peak Stress Intensity - (SRSS(1+2)) *5*6	Peak Stress Intensity - (SRSS(1+2)) *5*6	Peak Stress Intensity - (SRSS(1+2)) *5*6	Maximum Percent of 13,600 psi FIV Criterion
			(1)	(1)	(1)	(1)	(1)	(1)	(1)	(2)	(3)			(6)	Nominal Time Step	Plus 10% Time Step	Minus 10% Time Step	Plus 2.5% Time Step	Minus 2.5% Time Step	Plus 5% Time Step	Minus 5% Time Step	
		Horizontal plates:												Maximum	7,352	7,406	7,356	7,280	7,124	7,085	7,111	54%
1		Inner hood base plate	1973	1541	1140	1989	1835	1480	1513	621	1.80	0.500	0.500	1.000	5,359	4,261	3,250	5,409	5,004	4,009	4,182	40%
2		Modified outer cover plate5/8", both tips 4"	1819	1662	1336	1802	1406	1937	1221	437	1.80	0.625	0.625	1.000	4,864	4,479	3,635	4,813	3,816	5,105	4,340	38%
3		Modified outer cover plate, exclude tips	2482	2201	2574	2369	2285	2211	2360	439	1.00	0.625	0.625	1.000	3,679	3,270	3,813	3,514	3,392	3,281	3,501	28%
32		Weld line outer cover plate exclude tips to support ring	1297	1428	1622	1470	1477	1310	1336	439	1.80	0.625	0.500	1.563	5,525	6,052	6,837	6,221	6,250	5,577	5,681	50%
4		Original top hood (all hood)	870	789	842	782	766	754	721	943	1.80	0.50	0.50	1.00	2,940	2,775	2,882	2,761	2,730	2,706	2,612	22%
5		Modified top hood (outer hood)	717	729	718	701	665	656	662	1,112	1.80	1.000	0.625	2.560	7,352	7,406	7,356	7,280	7,124	7,085	7,111	54%
6		Hood top plates(inner hood)	1536	1182	872	1547	1271	1276	986	1,964	1.40	0.500	0.500	1.000	4,332	3,832	3,467	4,118	3,951	3,958	3,590	32%
		Vertical plates:																				
7		Original outer Hood , strips	1300	1372	988	1100	968	1385	1119	108	1.80	0.50	0.500	1.000	3,436	3,636	2,623	3,416	2,570	3,671	3,047	27%
8		Modified outer hood, top weld	703	650	700	717	684	731	624	301	1.80	1.00	0.625	2.560	4,991	4,619	4,971	5,081	4,868	5,192	4,453	38%
9		Modified outer hood, bottom weld	699	656	624	721	681	737	655	725	1.80	1.00	1.000	1.000	2,323	2,213	2,168	2,376	2,285	2,404	2,231	18%
10		Hood vertical plates (inner hood)	1018	819	718	977	859	907	817	761	1.40	0.50	0.500	1.000	2,389	2,039	1,871	2,351	2,108	2,191	2,036	18%
11		Hood end plates (inner hood)	752	671	729	780	626	648	700	516	1.80	0.50	0.500	1.000	2,215	2,062	2,191	2,311	1,955	2,005	2,124	17%
12		Hood end plates (outer hood)	1198	1511	960	1118	1102	1586	1275	322	1.80	0.50	0.500	1.000	4,013	4,125	2,667	3,882	2,982	4,213	3,431	31%
13		Inner Hood Brackets(gussets)	1288	1085	1320	1115	1135	1193	1266	573	1.40	0.50	0.500	1.00	2,788	2,394	2,851	2,510	2,491	2,603	2,735	21%
14		Steam 'dam'	578	587	564	609	491	490	549	807	1.80	0.50	0.500	1.000	2,188	2,205	2,162	2,246	2,034	2,032	2,153	17%
15		Steam 'dam' gussets	791	747	517	895	607	688	604	911	1.80	0.50	0.500	1.000	2,776	2,690	2,129	2,989	2,431	2,577	2,420	22%

Table 6-3 FIV Stress Intensities with Time Step Variation and Uncertainty

Post Processing Group Number			Remeshed Ring and Solid Modeling of Gusset Shoes (2400 Load Steps) Acoustic Stress Intensity nominal time step (1)	Acoustic Stress Intensity Plus 10% time step (1)	Acoustic Stress Intensity Minus 10% time step (1)	Acoustic Stress Intensity Plus 2.5% time step (1)	Acoustic Stress Intensity Minus 2.5% time step (1)	Acoustic Stress Intensity Plus 5% time step (1)	Acoustic Stress Intensity Minus 5% time step (1)	1912 MWth Loads Vortex Shedding Max Surface Stress Intensity (psi) (2)	Weld Conc. Factor (5)	120 % OLTP Plate Thickness (in)	Weld Size (in)	Undersize Factor (6)	1% Rayleigh (20-150Hz) Damping Peak Stress Intensity - (SRSS(1+2)) *5*6 Nominal Time Step	Peak Stress Intensity - (SRSS(1+2)) *5*6 Plus 10% Time Step	Peak Stress Intensity - (SRSS(1+2)) *5*6 Minus 10% Time Step	Peak Stress Intensity - (SRSS(1+2)) *5*6 Plus 2.5% Time Step	Peak Stress Intensity - (SRSS(1+2)) *5*6 Minus 2.5% Time Step	Peak Stress Intensity - (SRSS(1+2)) *5*6 Plus 5% Time Step	Peak Stress Intensity - (SRSS(1+2)) *5*6 Minus 5% Time Step	Maximum Percent of 13,600 psi FIV Criterion
		Other Plates																				
16		Hood partition plates	363	310	311	523	287	480	410	94	1.80	0.50	0.500	1.000	978	840	843	1,396	783	1,283	1,100	10%
17		Baffle plates	1432	1601	1320	1569	1226	1655	1280	1,144	1.80	0.50	0.500	1.000	4,390	4,782	4,137	4,707	3,930	4,909	4,048	36%
18		Outlet plenum ends	864	835	505	924	647	804	613	1,891	1.80	0.50	0.500	1.000	4,320	4,280	3,902	4,406	4,046	4,239	4,009	32%
		Ring, Beams & Gussets	0																			
19		Dryer support ring	587	581	598	512	536	543	496	675	1.80	3.00	3.000	1.000	2,031	2,019	2,053	1,941	1,930	1,913	1,853	15%
20		Bottom cross beams	407	378	362	397	426	350	348	135	1.80	3.00	3.000	1.000	1,108	1,034	993	1,083	1,157	962	957	9%
21		Cross beam gussets	1743	1385	1108	1809	1829	1248	1367	414	1.80	0.50	0.500	1.000	4,681	3,752	3,616	4,893	4,906	3,398	3,709	36%
22		Outer Hood Gusset	2662	2257	2645	2641	2380	2270	2135	820	1.60	0.500	0.500	1.000	4,012	3,431	3,987	3,981	3,194	3,352	3,687	29%
23		Gusset solid to gusset shell transition	1595	1428	1558	1575	1420	1482	1381	490	1.00	0.500	0.500	1.000	2,403	2,164	2,350	2,375	2,153	2,242	2,098	18%
27		Solid Gusset Shoes	4762	4192	4931	4571	4375	4227	4555	490	1.00	0.500	0.500	1.000	7,020	6,185	7,282	6,740	6,453	6,236	6,717	54%
28		Gusset shoe weld to cover plate	2312	2036	2389	2203	2128	2063	2192	490	1.80	0.500	0.500	1.000	6,191	5,470	6,392	5,906	5,710	5,541	5,877	47%
29		Shoe weld to solid gusset	2400	2136	2473	2314	2217	2114	2291	490	1.80	0.500	0.500	1.000	6,421	5,731	6,612	6,196	5,913	5,726	6,134	49%
30		Solid part of Gusset	2119	1875	2157	2053	1924	1903	1987	490	1.00	0.500	0.500	1.000	3,159	2,806	3,211	3,064	2,877	2,817	2,968	21%
31		Outer Hood Gusset weld line to front hood	1076	1153	1363	1061	1113	963	1190	820	1.80	0.500	0.750	1.000	3,261	3,410	3,911	3,233	3,347	3,003	3,427	29%
		Skirt Area																				
21		Skirt	1315	1159	1220	1382	1411	1502	1212	0	1.10	0.500	0.500	1.000	2,768	2,385	2,511	2,841	2,966	3,091	2,491	23%
25		Drain Boxes (Channels)	876	744	847	978	891	1041	798	0	1.40	0.500	0.500	1.000	1,801	1,531	1,743	2,013	1,834	2,142	1,622	16%
26		Guide Rod and Support Lug Channels	864	927	639	861	715	990	800	0	1.40	0.500	0.375	1.778	3,161	3,392	2,338	3,150	2,616	3,622	2,960	27%

Table 6-3 FIV Stress Intensities with Time Step Variation and Uncertainty

Modified dryer stresses at the outer cover plate						120	%OLTP		
Service Level		(A) Pm+Pb stress intensity	Modified cover plate thickness	Fillet weld size	(C) weld stress factor	(E) FIV without weld stress factor	FIV+ (Pm+Pb), (A+E)x(C) at weld	ASME (Pm+Pb) Allowable stress	(D) Primary stress ratio
Level A	1	818	0.625	0.500	1.56	1973	4362	20993	0.208
Level B	1	1721	0.625	0.500	1.56	1973	5773	20993	0.275
Level B	2	1842	0.625	0.500	1.56	1973	5962	20993	0.284
Level B	3	3072	0.625	0.500	1.56	1973	7883	20993	0.376
Level B	4	2988	0.625	0.500	1.56	1973	7752	20993	0.369
Level B	5	1216	0.625	0.500	1.56	1973	4983	20993	0.237
Level B	6	878	0.625	0.500	1.56	1973	4455	20993	0.212
Level D	1	2841	0.625	0.500	1.56	0	4439	50382	0.088
Level D	2	3036	0.625	0.500	1.56	0	4744	50382	0.094
Level D	3	10279	0.625	0.500	1.56	1973	19144	50382	0.380
Level D	4	10411	0.625	0.500	1.56	1973	19351	50382	0.384

Modified dryer stress at the original front hood both side strips							120	%OLTP	
Service Level		(A) Pm+Pb stress intensity	Modified cover plate thickness	Fillet weld size	(C) weld stress factor	(E) FIV without weld stress factor	FIV+ (Pm+Pb), (A+E)x(C) at weld	ASME (Pm+Pb) Allowable stress	(D) Primary stress ratio
Level A	1	1831	0.500	0.500	1.00	1915	3746	20993	0.178
Level B	1	3776	0.500	0.500	1.00	1915	5691	20993	0.271
Level B	2	4069	0.500	0.500	1.00	1915	5984	20993	0.285
Level B	3	4847	0.500	0.500	1.00	1915	6762	20993	0.322
Level B	4	4544	0.500	0.500	1.00	1915	6459	20993	0.308
Level B	5	1700	0.500	0.500	1.00	1915	3615	20993	0.172
Level B	6	1973	0.500	0.500	1.00	1915	3888	20993	0.185
Level D	1	5111	0.500	0.500	1.00	0	5111	50382	0.101
Level D	2	5588	0.500	0.500	1.00	0	5588	50382	0.111
Level D	3	17231	0.500	0.500	1.00	1915	19146	50382	0.380
Level D	4	17697	0.500	0.500	1.00	1915	19612	50382	0.389

Table 6-4 ASME Load Combination Results

Modified dryer stress at the front hood lower weld						120	%OLTP		
Service Level		(A) Pm+Pb stress intensity	Modified cover plate thickness	Fillet weld size	(C) weld stress factor	(E) FIV without weld stress factor	FIV+ (Pm+Pb), (A+E)x(C) at weld	ASME (Pm+Pb) Allowable stress	(D) Primary stress ratio
Level A	1	903	1.000	0.500	1.00	1328	2231	20993	0.106
Level B	1	1082	1.000	0.500	1.00	1328	2410	20993	0.115
Level B	2	1925	1.000	0.500	1.00	1328	3253	20993	0.155
Level B	3	2787	1.000	0.500	1.00	1328	4115	20993	0.196
Level B	4	2686	1.000	0.500	1.00	1328	4014	20993	0.191
Level B	5	1213	1.000	0.500	1.00	1328	2541	20993	0.121
Level B	6	964	1.000	0.500	1.00	1328	2292	20993	0.109
Level D	1	2586	1.000	0.500	1.00	0	2586	50382	0.051
Level D	2	2783	1.000	0.500	1.00	0	2783	50382	0.055
Level D	3	9024	1.000	0.500	1.00	1328	10352	50382	0.205
Level D	4	9219	1.000	0.500	1.00	1328	10547	50382	0.209

Modified dryer stress at the un-modified top hood						120	%OLTP		
Service Level		(A) Pm+Pb stress intensity	Modified cover plate thickness	Fillet weld size	(C) weld stress factor	(E) FIV without weld stress factor	FIV+ (Pm+Pb), (A+E)x(C) at weld	ASME (Pm+Pb) Allowable stress	(D) Primary stress ratio
Level A	1	463	0.500	0.500	1.00	1683	2146	20993	0.102
Level B	1	1041	0.500	0.500	1.00	1683	2724	20993	0.130
Level B	2	1060	0.500	0.500	1.00	1683	2743	20993	0.131
Level B	3	1006	0.500	0.500	1.00	1683	2689	20993	0.128
Level B	4	1013	0.500	0.500	1.00	1683	2696	20993	0.128
Level B	5	640	0.500	0.500	1.00	1683	2323	20993	0.111
Level B	6	495	0.500	0.500	1.00	1683	2178	20993	0.104
Level D	1	1591	0.500	0.500	1.00	0	1591	50382	0.032
Level D	2	1624	0.500	0.500	1.00	0	1624	50382	0.032
Level D	3	2044	0.500	0.500	1.00	1683	3727	50382	0.074
Level D	4	2070	0.500	0.500	1.00	1683	3753	50382	0.074

Table 6-4 ASME Load Combination Results

Modified dryer stress at the modified top hood					120	%OLTP			
Service Level		(A) Pm+Pb stress intensity	Modified cover plate thickness	Fillet weld size	(C) weld stress factor	(E) FIV without weld stress factor	FIV+ (Pm+Pb), (A+E)x(C) at weld	ASME (Pm+Pb) Allowable stress	(D) Primary stress ratio
Level A	1	270	1.000	0.625	2.56	1666	4956	20993	0.236
Level B	1	584	1.000	0.625	2.56	1666	5759	20993	0.274
Level B	2	600	1.000	0.625	2.56	1666	5800	20993	0.276
Level B	3	504	1.000	0.625	2.56	1666	5555	20993	0.265
Level B	4	506	1.000	0.625	2.56	1666	5560	20993	0.265
Level B	5	307	1.000	0.625	2.56	1666	5050	20993	0.241
Level B	6	282	1.000	0.625	2.56	1666	4986	20993	0.238
Level D	1	800	1.000	0.625	2.56	0	2048	50382	0.041
Level D	2	833	1.000	0.625	2.56	0	2132	50382	0.042
Level D	3	1411	1.000	0.625	2.56	1666	7877	50382	0.156
Level D	4	1430	1.000	0.625	2.56	1666	7925	50382	0.157

Modified dryer stress at the front hood gussets shoe weld to cover plate								120	%OLTP
Service Level		(A) Pm+Pb stress intensity	Modified cover plate thickness	Fillet weld size	(C) weld stress factor	(E) FIV without weld stress factor	FIV+ (Pm+Pb), (A+E)x(C) at weld	ASME (Pm+Pb) Allowable stress	(D) Primary stress ratio
Level A	1	4509	0.500	2x0.375	1.00	3446	7955	20993	0.379
Level B	1	9040	0.500	2x0.375	1.00	3446	12486	20993	0.595
Level B	2	9505	0.500	2x0.375	1.00	3446	12951	20993	0.617
Level B	3	13921	0.500	2x0.375	1.00	3446	17367	20993	0.827
Level B	4	13455	0.500	2x0.375	1.00	3446	16901	20993	0.805
Level B	5	5146	0.500	2x0.375	1.00	3446	8592	20993	0.409
Level B	6	4711	0.500	2x0.375	1.00	3446	8157	20993	0.389
Level D	1	11598	0.500	2x0.375	1.00	0	11598	50382	0.230
Level D	2	12336	0.500	2x0.375	1.00	0	12336	50382	0.245
Level D	3	46367	0.500	2x0.375	1.00	3446	49813	50382	0.989
Level D	4	47077	0.500	2x0.375	1.00	3446	50523	50382	1.003

Table 6-4 ASME Load Combination Results

Modified dryer stress at the vertical side hood						120	%OLTP		
Service Level		(A) Pm+Pb stress intensity	Modified cover plate thickness	Fillet weld size	(C) weld stress factor	(E) FIV without weld stress factor	FIV+ (Pm+Pb), (A+E)x(C) at weld	ASME (Pm+Pb) Allowable stress	(D) Primary stress ratio
Level A	1	1796	0.500	0.500	1.00	2234	4030	20993	0.192
Level B	1	3577	0.500	0.500	1.00	2234	5811	20993	0.277
Level B	2	3746	0.500	0.500	1.00	2234	5980	20993	0.285
Level B	3	3499	0.500	0.500	1.00	2234	5733	20993	0.273
Level B	4	3307	0.500	0.500	1.00	2234	5541	20993	0.264
Level B	5	1497	0.500	0.500	1.00	2234	3731	20993	0.178
Level B	6	1890	0.500	0.500	1.00	2234	4124	20993	0.196
Level D	1	4247	0.500	0.500	1.00	0	4247	50382	0.084
Level D	2	4488	0.500	0.500	1.00	0	4488	50382	0.089
Level D	3	13797	0.500	0.500	1.00	2234	16031	50382	0.318
Level D	4	14106	0.500	0.500	1.00	2234	16340	50382	0.324

Table 6-4 ASME Load Combination Results

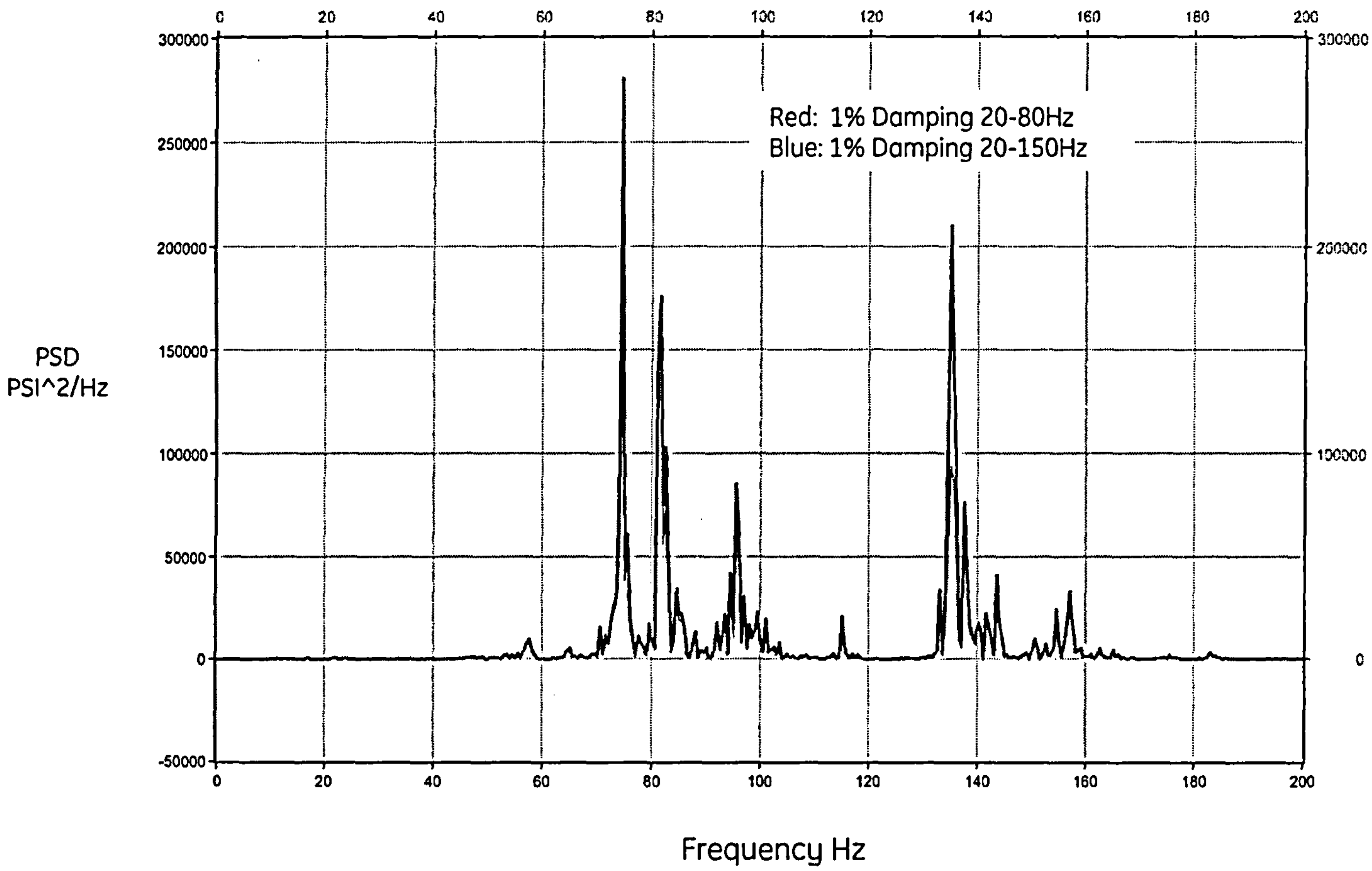


Figure 6-1 Power Spectral Density Comparison of Nominal Case Damping

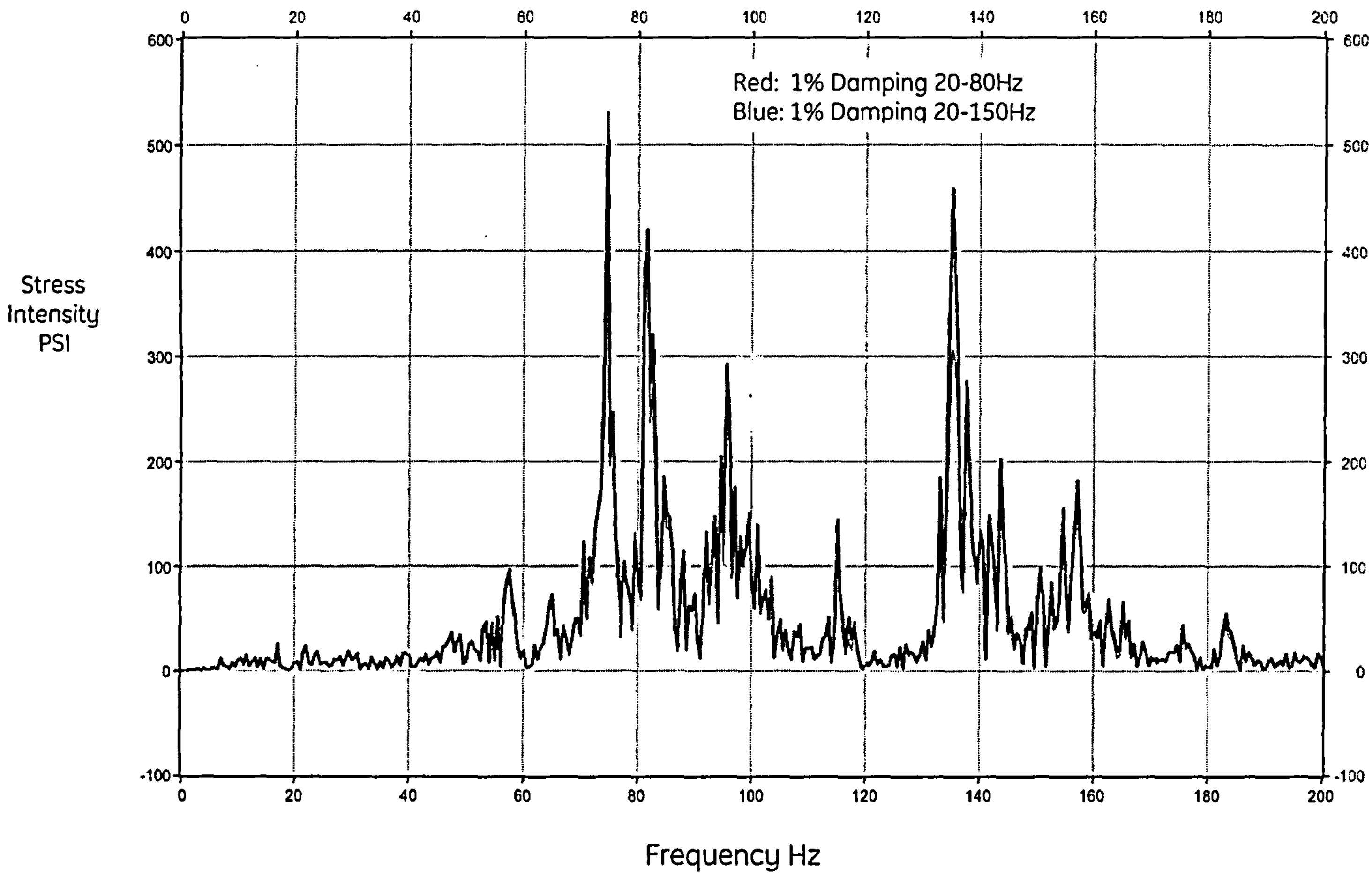


Figure 6-2 Stress Spectrum Comparison of Nominal Case Damping

7.0 Conclusion

7.1 Fatigue Alternating Stresses

The FIV alternating stresses for the modified dryer at EPU conditions are well below the endurance limit. The FIV alternating stress for the limiting dryer components with consideration of biases and uncertainties are approximately 54% of the endurance limit of 13,600 psi.

7.2 ASME Primary Stresses Evaluation

The modified dryer is acceptable for meeting the ASME Code Section III, Service Level A, B, and D, primary stress criteria for all the load combinations tabulated in Table 3.2-2 using conservative methods of analysis.

The VYNPS modified steam dryer is acceptable for continuous operation at Extended Power Uprate conditions.

8.0 References

[1] GE-NE 0000-0038-0963P, Class III, DRF Section 0000-0038-0936, Vermont Yankee Nuclear Power Station Steam Dryer Stress Analysis, March 2005.

[2] Entergy letter (BVY 05-084) to NRC dated September 14, 2005, "Vermont Yankee Nuclear Power Station, Technical Specification Proposed Change No. 263, Supplement No. 33, Extended Power Uprate - Response to Request for Additional Information." – Attachment 5 - Revised Exhibit EMEB-B-143-1

[3] Entergy letter (BVY 05-084) to NRC dated September 14, 2005, "Vermont Yankee Nuclear Power Station, Technical Specification Proposed Change No. 263, Supplement No. 33, Extended Power Uprate - Response to Request for Additional Information." – Attachment 2 - Revised response to RAI EMEB-B-39, consideration of steam dryer skirt in the structural finite element analysis

[4] C.D.I. letter F445/0136, M. Teske (CDI) to E. Betti (Entergy), dated 17 May 2006, "Dryer Loads for Vermont Yankee at 120% Power"

[5] Entergy letter (BVY 05-061) to NRC dated June 2, 2005, "Vermont Yankee Nuclear Power Station, Technical Specification Proposed Change No. 263, Supplement No. 29, Extended Power Uprate - Computational Fluid Dynamics."

[6] Letter from Craig J. Nichols (Entergy) to Michael J. Dick (GE), "VY Load Definition Input and Uncertainty Values for use in GE Steam Dryer Analysis Report", PUPVY-06-470, June 15, 2006.

[7] American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code, Section III, Appendix I, 1989 Edition with no Addenda.

[8] American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code, Section III, Subsection NG, 1989 Edition with no Addenda.

[9] American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code, Section III, Appendix F, 1989 Edition with no Addenda.

[10] MPR Calculation Number 319-002-01, transmitted by MPR letter H. William McCurdy to JR Hoffman, "Vermont Yankee Seismic Data for Increased Core Flow Evaluation," May 29, 1997.

[11] ANSYS, Release 8.1, ANSYS, Incorporated, 2005.

[12] Safety Evaluation by the Office of Nuclear Reactor Regulation Related to Amendment No. 229 to Facility Operating License No. DPR-28 Entergy Nuclear Vermont Yankee, LLC and Entergy Nuclear Operations, Inc. Vermont Yankee Nuclear Power Station Docket No. 50-271, March 2006

[13] "Recommended Weld Quality and Stress Concentration Factors for Use in the Structural Analysis of Exelon Replacement Steam Dryer," GENE Report, e-DRF#0000-0034-6079, February 2005.

Appendix A Vermont Yankee Steam Dryer Differential Pressures

The pressure differentials across the steam dryer are calculated for three categories of events; normal, upset, and faulted conditions. Normal conditions are the steady-state operating conditions. Upset conditions are the anticipated transient events. [[

]] Faulted conditions are the design basis accident events (e.g. main steam line break). The [[

]]

The pressure differentials across the steam dryer for the normal conditions at EPU power level are summarized in Table A-1.

Table A-1 Steam Dryer Pressure Differentials for Normal Conditions at EPU

Description	Value(1) (psid)	Value(1) (psid)
[[		

]]

The pressure differentials across the steam dryer due to [[ ]] for upset conditions at EPU power level are summarized in Table A-2.

Table A-2 Dryer Delta-P for EPU [[ ]] Upset Conditions

Description	Value (psid)
[[	
	]]

The maximum [[ ]] loads on the dryer face at EPU power level for the Turbine Stop Valve (TSV) fast closure event are summarized in Table A-3. Typical pressure time history is shown in Figure A-1.

Table A-3 Maximum TSV [[ ]] Load on the Dryer Face at EPU

[[

]]

[[ ]]

Figure A-1 Typical TSV Load Time Histories

[[

]]

The maximum [[ ]] loads on the dryer face at EPU power level due to the [[ ]] for the Main Steam Line Break event are summarized in Table A-4.

Table A-4 Maximum MSL Break [[ ]] Load on the Dryer Face at EPU

[[

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