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September 14, 2005

Docket No. 50-271
BVY 05-084
TAC No. MC0761

ATTN: Document Control Desk
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

Subject: **Vermont Yankee Nuclear Power Station**
Technical Specification Proposed Change No. 263 – Supplement No. 33
Extended Power Uprate – Response to Request for Additional Information

References:
1) Entergy letter to U.S. Nuclear Regulatory Commission, "Vermont Yankee Nuclear Power Station, License No. DPR-28 (Docket No. 50-271), Technical Specification Proposed Change No. 263, Extended Power Uprate," BVY 03-80, September 10, 2003

2) Entergy letter to U.S. Nuclear Regulatory Commission, "Vermont Yankee Nuclear Power Station, License No. DPR-28 (Docket No. 50-271), Technical Specification Proposed Change No. 263, Supplement No. 31 – Response to Request for Additional Information," BVY 05-074, August 4, 2005

This letter provides additional information regarding the application by Entergy Nuclear Vermont Yankee, LLC and Entergy Nuclear Operations, Inc. (Entergy) for a license amendment (Reference 1) to increase the maximum authorized power level of the Vermont Yankee Nuclear Power Station (VYNPS) from 1593 megawatts thermal (MWt) to 1912 MWt.

This submittal responds to the remaining items from NRC's audit of the VYNPS steam dryer analysis of August 22 through 25, 2005 and clarifies information contained in Entergy's response to request for additional information dated August 4, 2005 (Reference 2).

As a result of the discussions held during the steam dryer audit, Entergy has performed or will take the following actions:

1. In order to address the NRC staff's questions regarding steam dryer analysis uncertainties, the VYNPS steam dryer analysis computational fluid dynamics (CFD) and acoustic circuit model (ACM) uncertainty evaluations were expanded to include:

   a) ACM uncertainty considering all 27 Quad Cities 2 (QC2) 790 MWe benchmark pressure sensors predictions.

A001

Animated Data CD
In File Center

b) CFD model uncertainty based on comparisons to full scale BWR instrumented dryer data.

c) Strain gage measurement uncertainty to address potential under-prediction in hoop strain at individual response frequencies.

Revised VYNPS dryer load definition uncertainty is described in the updated response to RAI EMEB-B-18 and Exhibit EMEB-B-18-1. This supersedes the previous version of the RAI response. In the event that acoustic signals are identified that challenge the VYNPS limit curve during extended power uprate (EPU) power ascension, Entergy will perform a frequency specific assessment of ACM uncertainty at the acoustic signal frequency to assess if an increase in the value established in EMEB-B-18-1 is required. The instrument uncertainty will be revised to reflect the planned installation of additional strain gages and associated data acquisition equipment.

2. To improve the accuracy of the steam dryer measurement system, Entergy will install 32 additional strain gages on the main steam piping during the Fall 2005 refueling outage (RFO-25) and will enhance the data acquisition system prior to extended power uprate (EPU) operation in order to reduce the measurement uncertainty associated with the ACM.

   a) Entergy will monitor both the additional strain gage data and existing strain gage data during power ascension.

   b) In the event that acoustic signals are identified that challenge the VYNPS dryer monitoring performance limit curve during EPU power ascension, Entergy will evaluate dryer loads and reestablish the limit curve based on the new strain gage data.

   c) Main steam (MS) piping arrangement drawings that depict the arrangement of the main steam piping and branch lines, new strain gages, existing ACM monitoring points, and MS system accelerometers has been included in Figure EMEB-B-77-1.

   d) The specifications for enhanced strain gage and data acquisition systems are included in Attachment 12.

3. After reaching 120% of current licensed thermal power (CLTP), i.e., 1912 MWt, Entergy will obtain measurements from the strain gages and establish the VYNPS dryer flow induced vibration (FIV) load fatigue margin, update the dryer stress report, and re-establish steam dryer monitoring plan (SDMP) limit curve with the updated ACM load definition and revised instrument uncertainty. This information will be provided to the NRC staff.

4. Responses to the NRC staff's questions generated during its audit of General Electric's (GE) scale model test (SMT) facility are included in Attachment 7.

5. During power ascension, if an engineering evaluation is required in accordance with the SDMP, the structural analysis will continue to address frequency uncertainties up to

+/-10% and assure that peak responses that fall within this uncertainty band are addressed.

6. The VYNPS steam dryer skirt was added to the finite element analysis (FEA) and evaluated as described in the revised response to RAI EMEB-B-39 (Attachment 2).

7. A more comprehensive evaluation of potential VYNPS main steam system acoustic resonators in vortex shedding frequencies is provided in the revised response to RAI EMEB-B-77 in Attachment 3. Included in this response revision is a drawing showing the relative locations of VYNPS main steam system cavities (potential resonators), ACM input measurement locations and piping FIV monitoring accelerometers.

8. An update of the VYNPS steam dryer stress analysis, incorporating the revised ACM and CFD model uncertainty values, is provided in a revision to Exhibit EMEB-B-143-1, Attachment 5. This revised Exhibit also describes how not exceeding the VYNPS steam dryer limit curve assures that the fatigue endurance limit will not be exceeded during power ascension and dryer structural integrity will be maintained.

9. The EPU power ascension SDMP has been revised to reflect long term monitoring of plant parameters potentially indicative of a dryer failure. The SDMP was additionally revised to reflect consistency of the VYNPS steam dryer inspection program with SIL 644 Rev. 1, identification of the NRR Project Manager for VYNPS as the point of contact for providing SDMP information during power ascension. Submittal to the NRC of the final 120% EPU VYNPS load definition will be made upon completion of the power ascension test program.

10. Entergy will submit to NRC the FIV related portions of the EPU startup test procedure, including methodology for updating the limit curve, prior to power ascension.

The RAI responses and information provided in Attachments 1, 5 and 7 contain Proprietary Information as defined by 10CFR2.390 and should be handled in accordance with the provisions of that regulation. Attachments 8, 9 and 10 are non-proprietary versions of Attachments 1, 5 and 7, respectively. Affidavits supporting the proprietary nature of the GE documents are provided as Attachment 11.

Entergy believes that with this submittal Entergy has fully responded to all the information requested by the NRC staff on steam dryer analyses, and that the information provided supports the preparation of the NRC staff's safety evaluation report for EPU. Entergy submits that the information provided in response to the NRC staff's requests demonstrates that VYNPS can be safely operated at up to 120% CLTP.

This submittal also provides as an enclosure CD-ROM data disks (proprietary information) associated with the GE response to the Scale Model Test facility audit.

The following attachments are included in this submittal:

Attachment	Title
1	Revised response to RAI EMEB-B-18 and Exhibit EMEB-B-18-1, VYNPS dryer load uncertainty
2	Revised response to RAI EMEB-B-39, consideration of steam dryer skirt in the structural finite element analysis
3	Revised response to RAI EMEB-B-77, estimate of main steam system resonator natural and vortex shedding frequencies
4	Revised response to RAI EMEB-B-96
5	Revised Exhibit EMEB-B-143-1
6	Revised Steam Dryer Monitoring Plan
7	GE Scale Model audit question responses
8	Non-proprietary version of Attachment 1
9	Non-proprietary version of Attachment 5
10	Non-proprietary version of Attachment 7
11	GE affidavits for Attachments 1, 5 and 7
12	Additional strain gage equipment and data acquisition system specifications

This supplement to the license amendment request provides additional information to clarify Entergy's application for a license amendment and does not change the scope or conclusions in the original application, nor does it change Entergy's determination of no significant hazards consideration.

There are no new regulatory commitments contained in this submittal. However, acceptance of the proposed license condition will result in certain actions with respect to steam dryer monitoring and evaluations.

If you have any questions or require additional information, please contact Mr. James DeVincentis at (802) 258-4236.

I declare under penalty of perjury that the foregoing is true and correct.

Executed on September 14, 2005.

Sincerely,

Jay K. Thayer
Site Vice President
Vermont Yankee Nuclear Power Station

Attachments (12)
Enclosure (1)

cc: Mr. Richard B. Ennis, Project Manager
Project Directorate I
Division of Licensing Project Management
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Mail Stop O 8 B1
Washington, DC 20555

Mr. Samuel J. Collins (w/o attachments)
Regional Administrator, Region 1
U.S. Nuclear Regulatory Commission
475 Allendale Road
King of Prussia, PA 19406-1415

USNRC Resident Inspector (w/o attachments)
Entergy Nuclear Vermont Yankee, LLC
P.O. Box 157
Vernon, Vermont 05354

Mr. David O'Brien, Commissioner (w/o proprietary information)
VT Department of Public Service
112 State Street – Drawer 20
Montpelier, Vermont 05620-2601

BVY 05-084
Docket No. 50-271

Attachment 2

Vermont Yankee Nuclear Power Station

Proposed Technical Specification Change No. 263 – Supplement No. 33

Extended Power Uprate

Response to Request for Additional Information

Revised Response to EMEB-B-39

Total number of pages in Attachment 2 (excluding this cover sheet) is 12.

NRC RAI EMEB-39

In Attachment 6 to Supplement 26, the modified dryer is shown in Figures 3.1-1 (Page 17) and 3.7.1 (Page 21) for CFD analysis and ANSYS analysis, respectively. The recent hammer test performed for a new steam dryer at Quad Cities indicated that significant coupling exists between the upper portion of the dryer and the skirt with pressure loading applied to the full dryer including the skirt. Confirm whether the full steam dryer model in the CFD and ANSYS analyses consists of both upper dryer banks, supporting ring, and the skirt. If the skirt is not included in the analysis, provide a justification.

Revised Response to RAI EMEB-B-39

The ANSYS models for the VYNPS steam dryer analysis include the dryer support ring, dryer hoods, end plates, cover plates, upper dryer banks, cross beams, bottom support plates, tie bars and gussets. The ANSYS model previously used for determining dryer stress intensities did not include the dryer skirt. Details of the ANSYS model without the dryer skirt were previously supplied in the response to RAI EMEB-B-1.

As discussed below, the VYNPS steam dryer upper structure is more likely to be dynamically isolated from the dryer skirt through the support ring. This is a result of the overall flexibility of the support ring structure with its cross bracing from the dryer support plates, and bottom beams. It is noted that the support ring construction for the VYNPS steam dryer is significantly different than that of the new steam dryer at Quad Cities. The support ring and cross beams in the VYNPS steam dryer are constructed of solid forgings, while the support ring and cross beams for the new steam dryer at Quad Cities are constructed of induction bent tube steel with much smaller section properties (bending stiffness about both major and minor axes and torsional rigidity about tangential axis). The reason for the difference in construction is that the support ring for the new steam dryer at Quad Cities serves a dual purpose for providing added dryer structural support and for providing part of the steam dryer moisture removal drain path.

The effect of the skirt on the natural frequencies of the front hood and the cover plate has been studied. The skirt provides additional stiffness to the dryer ring in the vertical direction. The gussets are welded on the cover plate and the front hood and supported at the dryer ring. If the skirt is included in the model, the gusset support stiffness at the dryer ring is significantly increased. The fundamental frequencies of the front hood and cover plate are increased commensurately. This is due to the fact that the skirt improves the structural effectiveness of the gusseted support of the cover.

Because the dryer skirt thickness is 0.25" and the dryer ring has a solid, rectangular cross section of 6" high by 3" wide and is stiffened by the cross beams, the horizontal modes of the skirt are isolated by the dryer ring. Consequently, in the horizontal direction, there is no significant dynamic interaction between the dryer skirt and the dryer cover plate and front hood.

Figures EMEB-B-39-1 through EMEB-B-39-5 demonstrate the effect on the front hood fundamental frequencies when the skirt is included in the dryer model. As shown in Figures EMEB-B-39-1 and EMEB-B-39-2, there are strong modes for the dryer front hood at both 53 and 62 Hz for the model without the dryer skirt. Figures EMEB-B-39-3 through EMEB-B-39-5 show that there are no significant modes for the front hood in this frequency range when the skirt is included in the dryer model. Figures EMEB-B-39-6 and EMEB-B-39-7 show that the first fundamental frequencies for the front hood do not appear until 85 and 94 Hz when the dryer skirt is included in the FEA model.

Furthermore, there are no significant acoustic sources identified in the VYNPS steam system at 100% CLTP. The transient loads from the CFD loads evaluation are hydrodynamic loads that have frequency content up to approximately 62 Hz. Entergy has run a load step uncertainty assessment for this CFD loading. This assessment demonstrated that stiffening the structure would reduce the stress. See the response to EMEB-B-143-1 for further information.

The VYNPS steam dryer FEA model without skirt has 234 modes from 0-200 Hz. The number of modes increases to 391 modes when the skirt is included in the model. The increased number of modes with the dryer skirt included is entirely due to the additional skirt modes. The effect of including the skirt into the dryer model to determine whether there was a significant change in fundamental frequencies in the upper dryer structure was also studied. The results of the study show that the mode shapes for the upper dryer structure components for the model without skirt are preserved for the model with the skirt. This provides evidence that there is insignificant coupling between the upper dryer structure and the dryer skirt. As an example, Figures EMEB-B-39-8 through EMEB-B-39-11 show comparisons of the modified outer hood top hood fundamental frequencies for the dryer model with and without the skirt. As discussed in the response to RAI EMEB-B-110, this location has one of the highest peak stress intensities in the VYNPS dryer. The modal displacements for the dryer top hood are insignificantly changed when the skirt is included in the dryer model.

During the August 2005 audit of the VYNPS steam dryer analysis, the NRC questioned Entergy concerning the stress intensity of the dryer skirt. A time history evaluation of the VYNPS FEA model with the dryer skirt included was performed, using the ACM loads as input, in order to provide a quantitative response. Figure EMEB-B-39-12 shows a graphical representation of the FEA model with the dryer skirt included. The key components of the dryer skirt are the skirt plates, the interior drain channels and the guide rod/support lug channels. A damping value of 1% of critical damping was used in the time history analysis. Plots of the peak stress intensity are shown in Figure EMEB-B-13 through EMEB-B-15. The results of the time history analysis are shown in Table EMEB-B-39-1. The steam velocity inside of the dryer skirt is about five ft/second. Flow velocity on the outside of the steam dryer skirt is essentially zero. Therefore, hydrodynamic oscillating loads on the dryer skirt are considered insignificant. The dryer skirt stresses are not the governing stresses for determination of the VYNPS Level 1 and 2 power ascension performance criteria spectra.

Table EMEB-B-39-1 – VYNPS Skirt Component Acoustic Stress Intensities

Component	Acoustic Maximum Surface Stress Intensity (psi)	Weld Concentration Factor	Weld Undersize Factor	CLTP Peak Acoustic Stress Intensity (psi)
Skirt Plates	738	1.40	1.00	1033
Drain Channel	559	1.40	1.78	1393
Guide Rod/Support Lug Channels	508	1.40	1.00	711

In summary, a stiffer model would reduce CFD stress and increase ACM stress. Entergy has considered a +/-10% frequency uncertainty in the analysis. The VYNPS Level 1 and 2 power ascension performance criteria spectra will be conservatively reduced to account for ACM and CFD load uncertainty. Based on the factors described in Exhibit EMEB-B-143-1, the VYNPS performance criteria spectra would require re-evaluation of the dryer at strain gage readings at level equivalent to 10% of the PSD amplitude experienced by QC2. Further sensitivity analysis is not warranted until a discernable VYNPS signature is observed. Entergy expects to use the finite element model with the dryer skirt included for the performance of any additional finite element analysis that may be required during EPU power ascension.

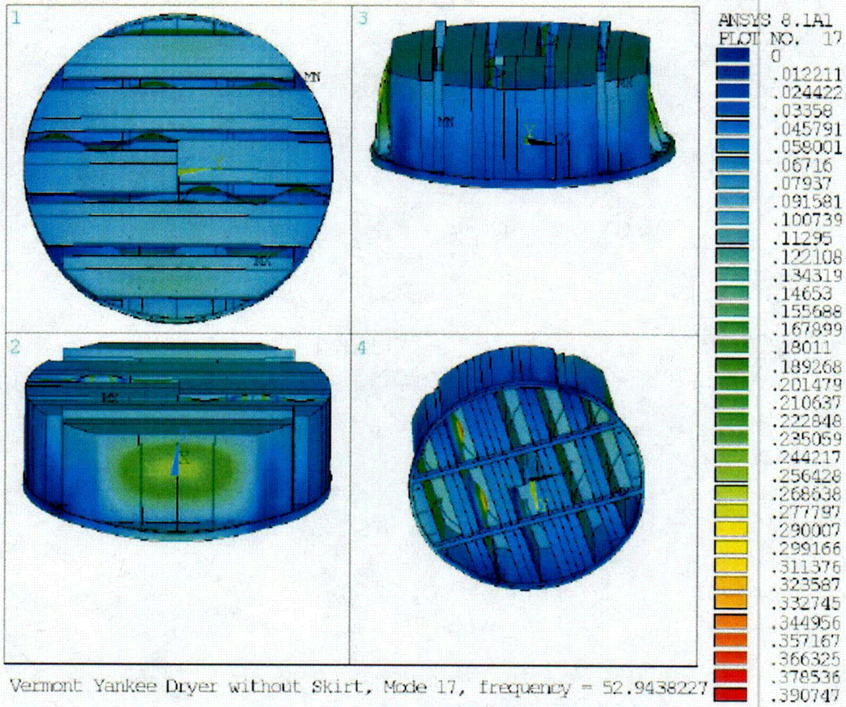

Figure EMEB-B-39-1 Dryer Model without skirt 53 Hz Mode

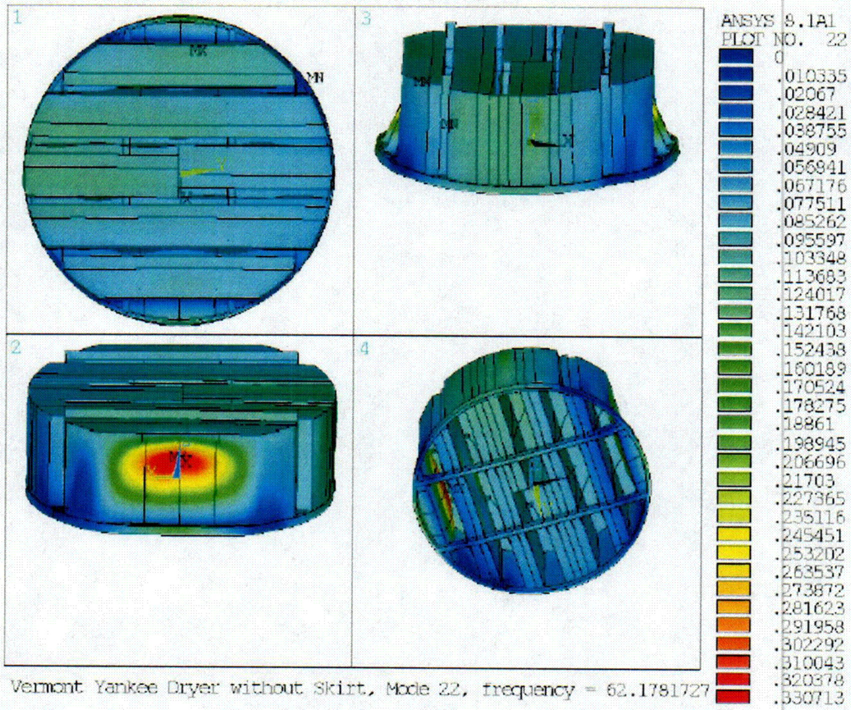

Figure EMEB-B-39-2 Dryer Model without skirt 62 Hz Mode

C01

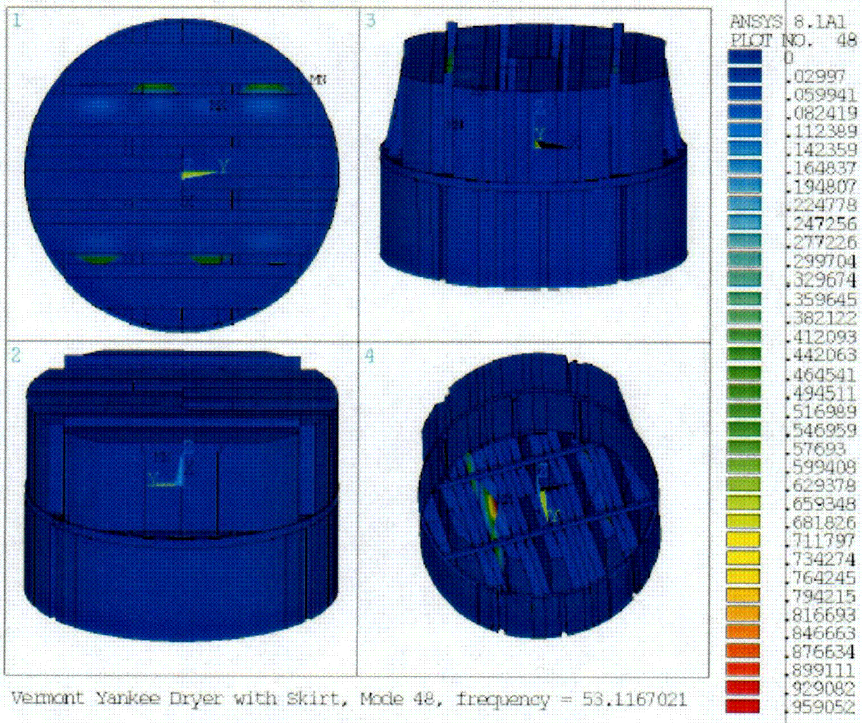

Figure EMEB-B-39-3 Dryer Model with skirt 53 Hz Mode

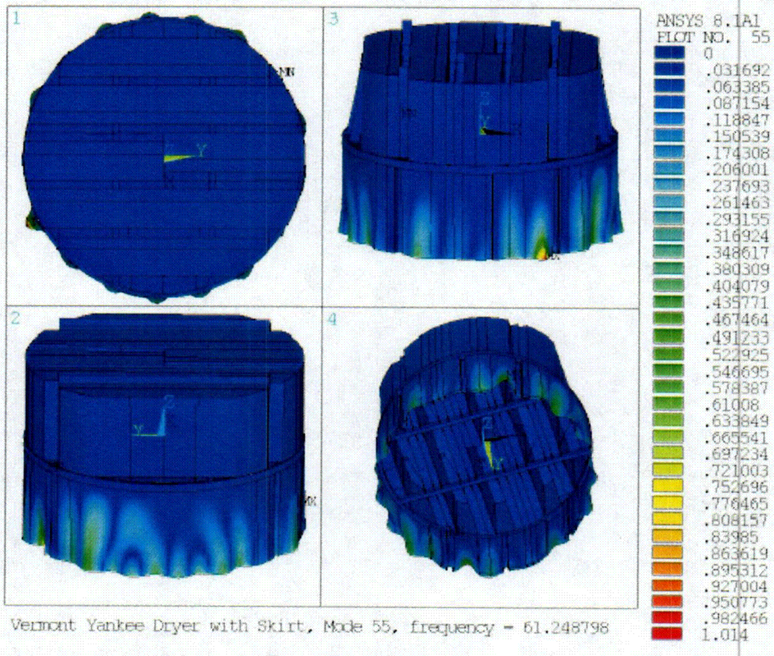

Figure EMEB-B-39-4 Dryer Model with skirt 61 Hz Mode

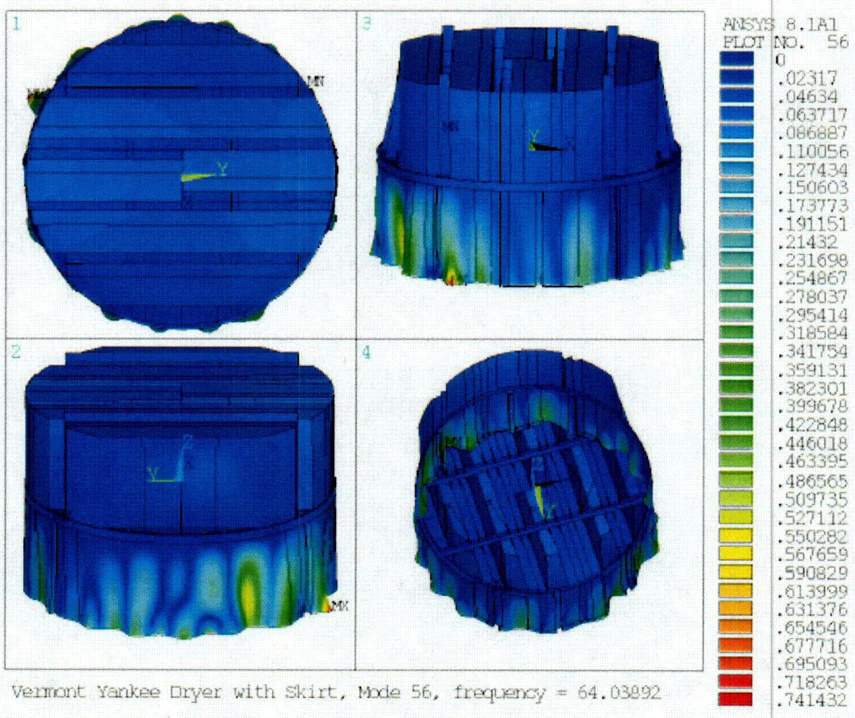

Figure EMEB-B-39-5 Dryer Model with skirt 64 Hz Mode

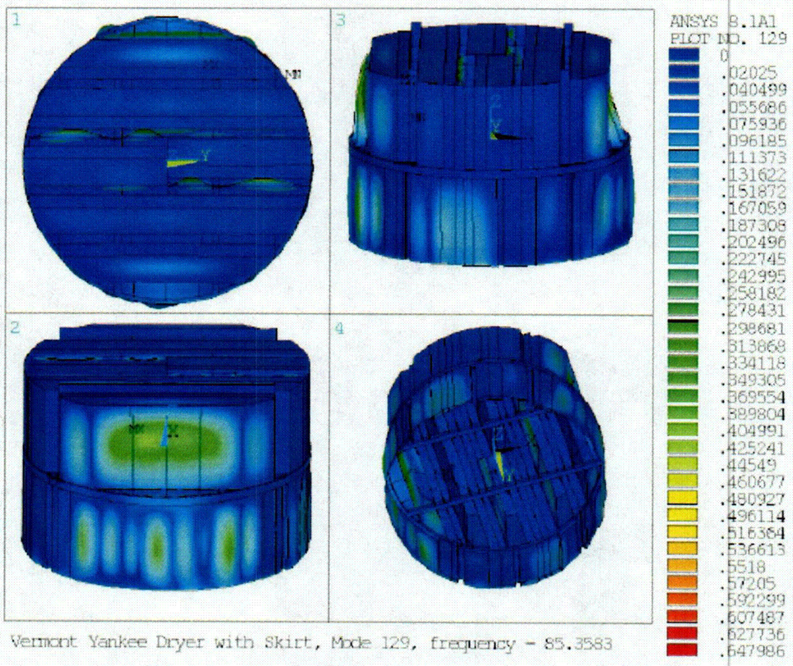

Figure EMEB-B-39-6 Dryer Model with skirt 85 Hz Mode

C03

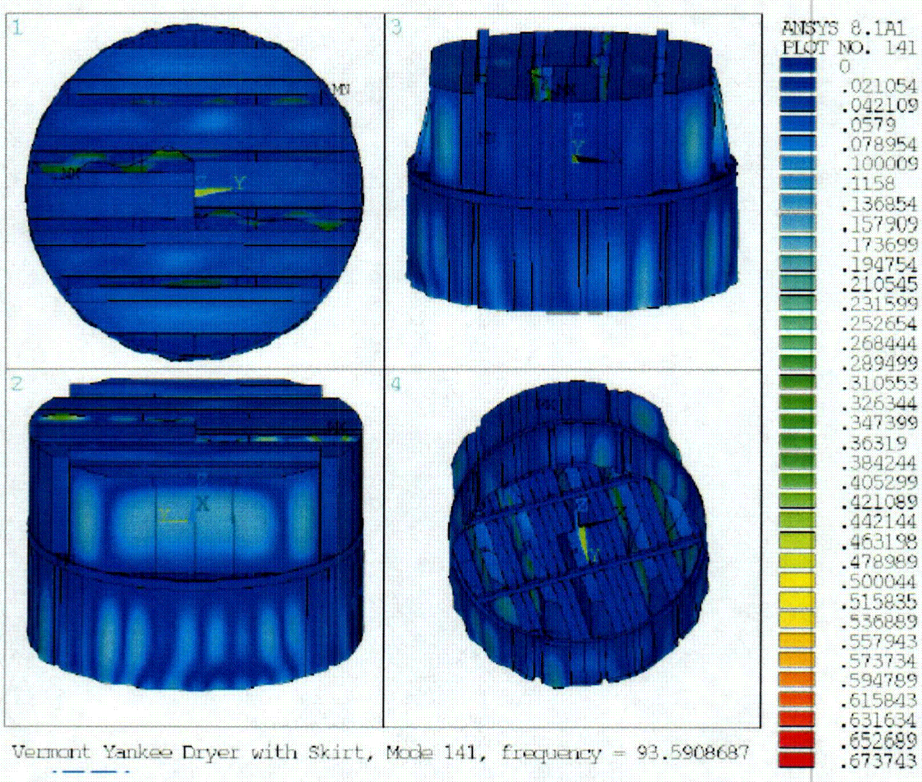

Figure EMEB-B-39-7 Dryer Model with skirt 94 Hz Mode

C04

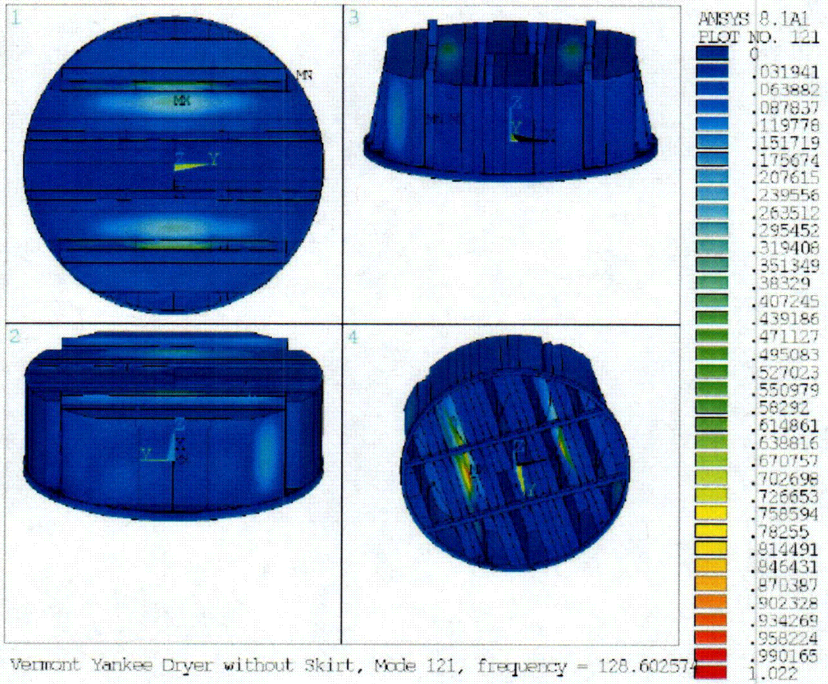

Figure EMEB-B-39-8 Dryer Model without skirt 128 Hz Mode

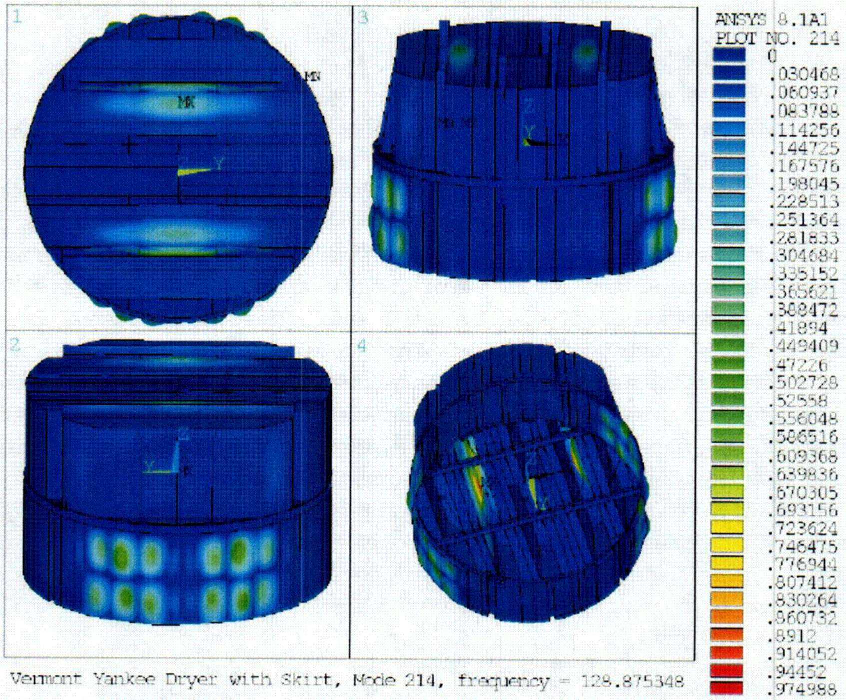

Figure EMEB-B-39-9 Dryer Model with skirt 128 Hz Mode

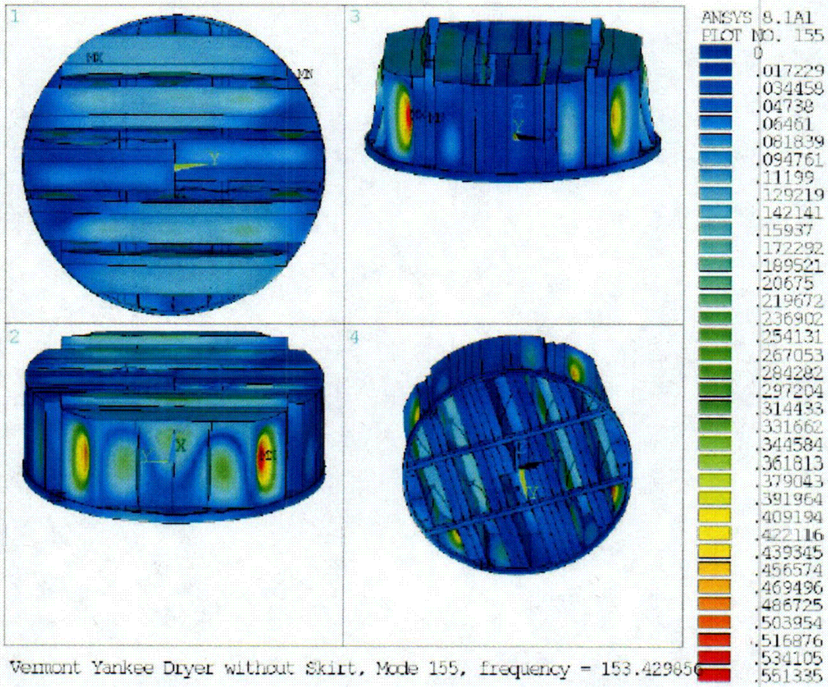

Figure EMEB-B-39-10 Dryer Model without skirt 153 Hz Mode

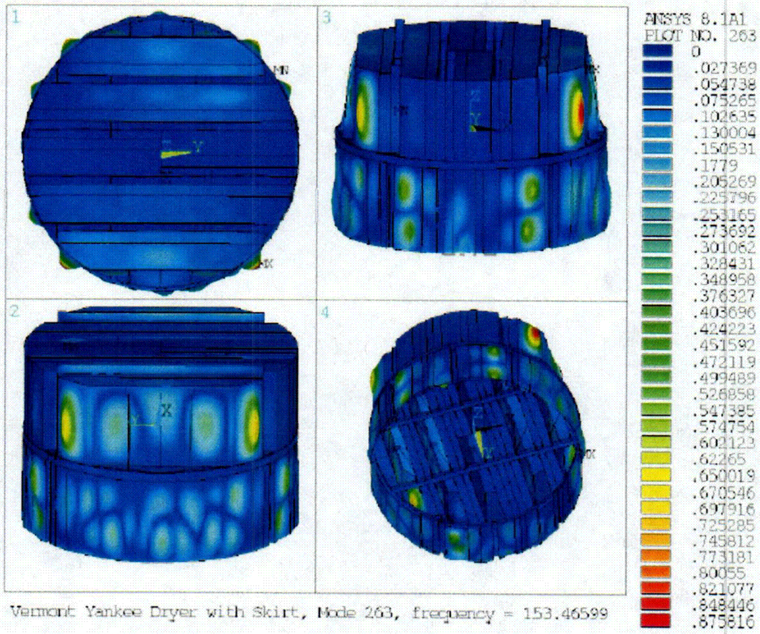

Figure EMEB-B-39-11 Dryer Model with skirt 153 Hz Mode

C06

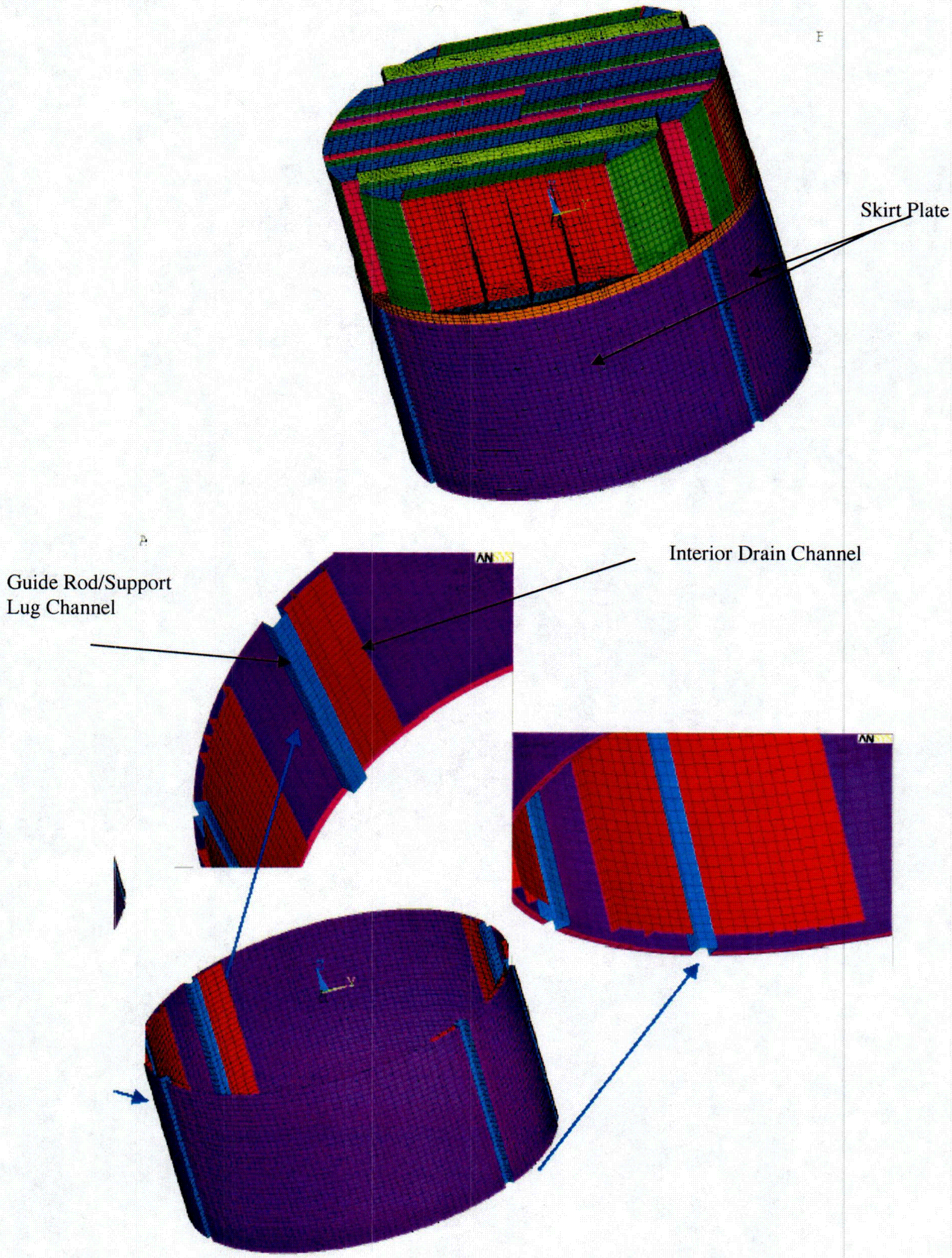

Figure EMEB-B-39-12 - VYNPS Dryer Model with skirt

C07

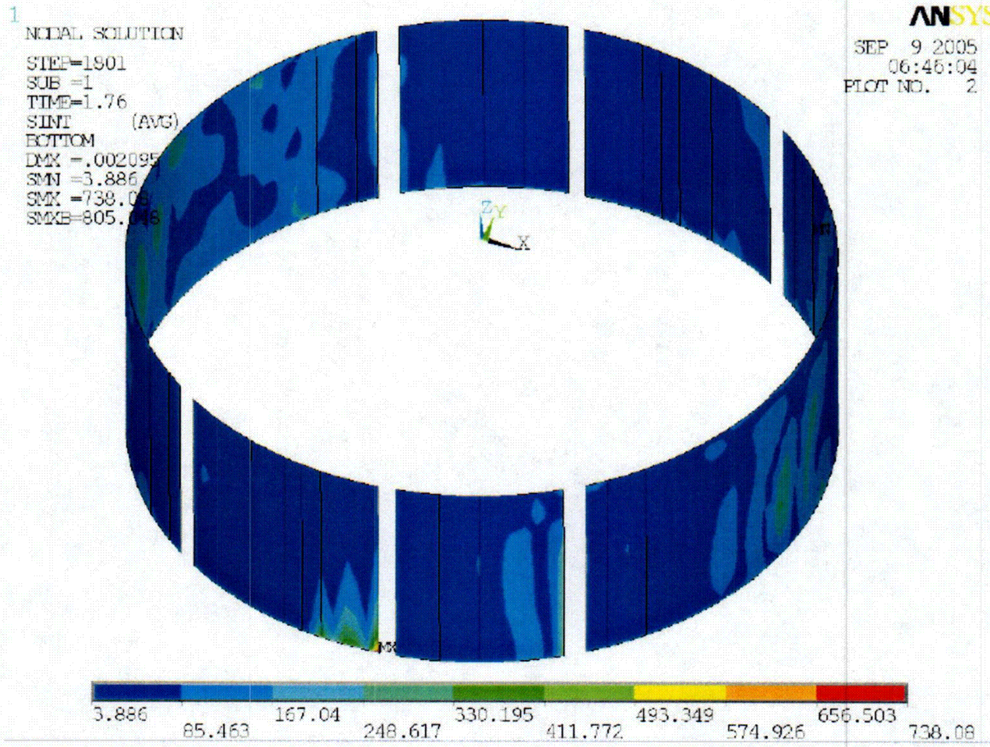

Figure EMEB-B-39-13 – Skirt Peak Stress Intensity

c08

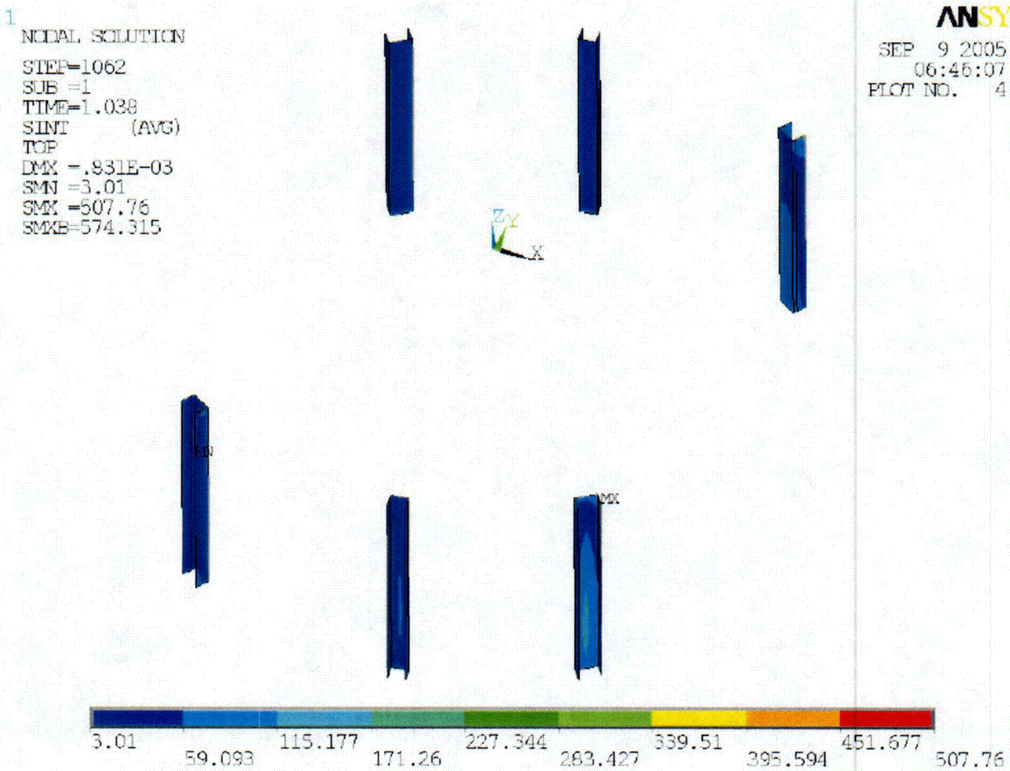

Figure EMEB-B-39-14 – Guide Rod/Support Lug Channel Peak Stress Intensity

C09

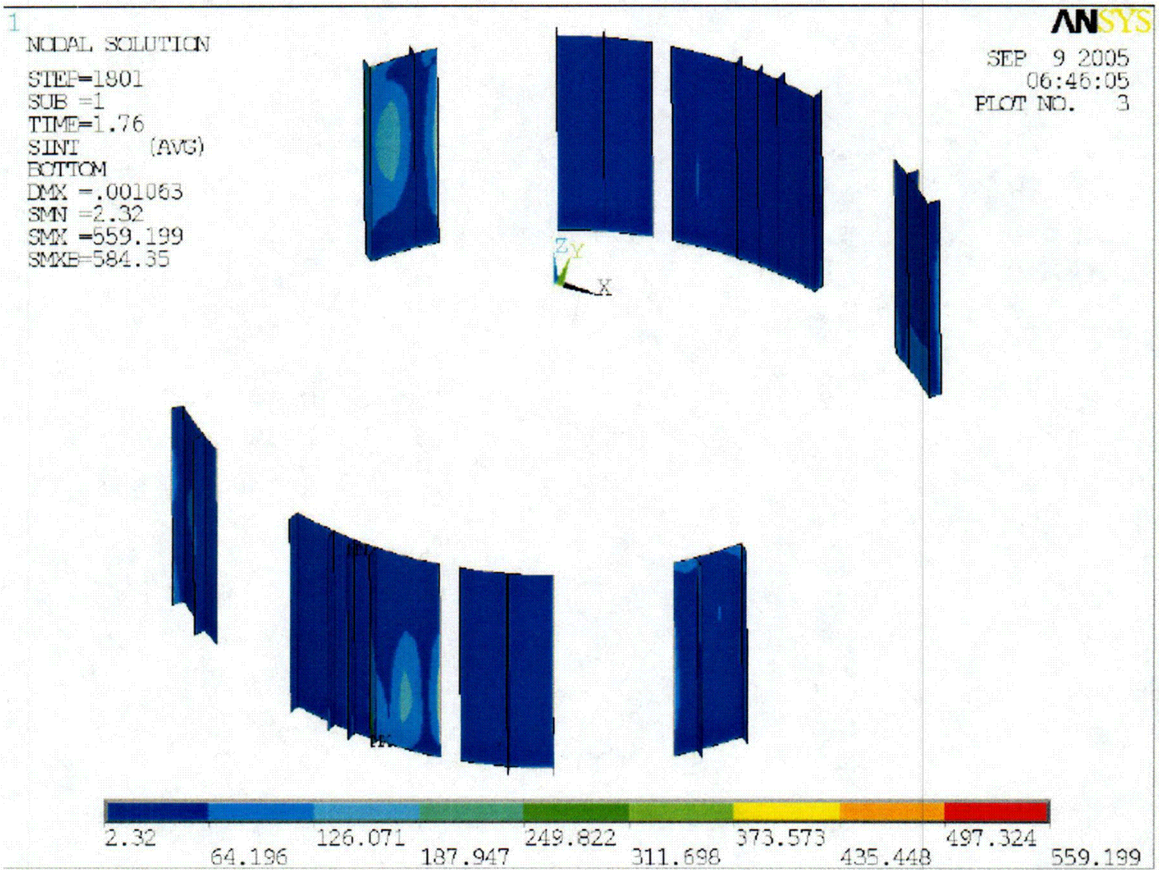

Figure EMEB-B-39-15 – Drain Channel Peak Stress Intensity

C10

BVY 05-084
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Attachment 3

Vermont Yankee Nuclear Power Station

Proposed Technical Specification Change No. 263 – Supplement No. 33

Extended Power Uprate

Response to Request for Additional Information

Revised Response to EMEB-B-77

Total number of pages in Attachment 3 (excluding this cover sheet) is 31.

RAI EMEB-B-77

The Executive Summary of NEDC-33192P (Conclusions 8 - 10 for Plant Data and Conclusion 2 for SMT) mentions that existing data from VYNPS MSL strain gauges and venturi lines show no evidence of any "singing" in downstream valves. In other BWR-3 plants, and in the GE SMT data, singing in valves has been observed, and can lead to high acoustic pressure loads on the steam dryer. Entergy should explain whether there is a potential of acoustic pressure loads (on the dryer) induced by valve singing between pre-EPU and EPU conditions, and provide any estimates of valve singing frequencies (with respect to power level).

Revised Response to RAI EMEB-B-77

Entergy evaluated the potential acoustic source frequencies in the VYNPS main steam lines by estimating the natural frequencies of known cavities and the shear wave instabilities caused by steam flow over the cavity openings. Figure EMEB-B-77-1 sheet 1 shows the location of the VYNPS main steam line cavities including Safety Relief Valves (SRV's), Spring Safety Valves (SSV's), HPCI steam supply line and RCIC steam supply line. In addition, sheet 2 shows the location of the proposed location for the additional 32 strain gages, sheet 3 shows the location of the measurement locations used as input to the VYNPS acoustic circuit model, and sheet 4 shows the locations of the accelerometers for FIV monitoring. Appendix 1 contains Entergy's evaluation of the potential cavity resonant frequencies and comparison to the calculated vortex shedding frequencies at both current licensed thermal power and EPU conditions.

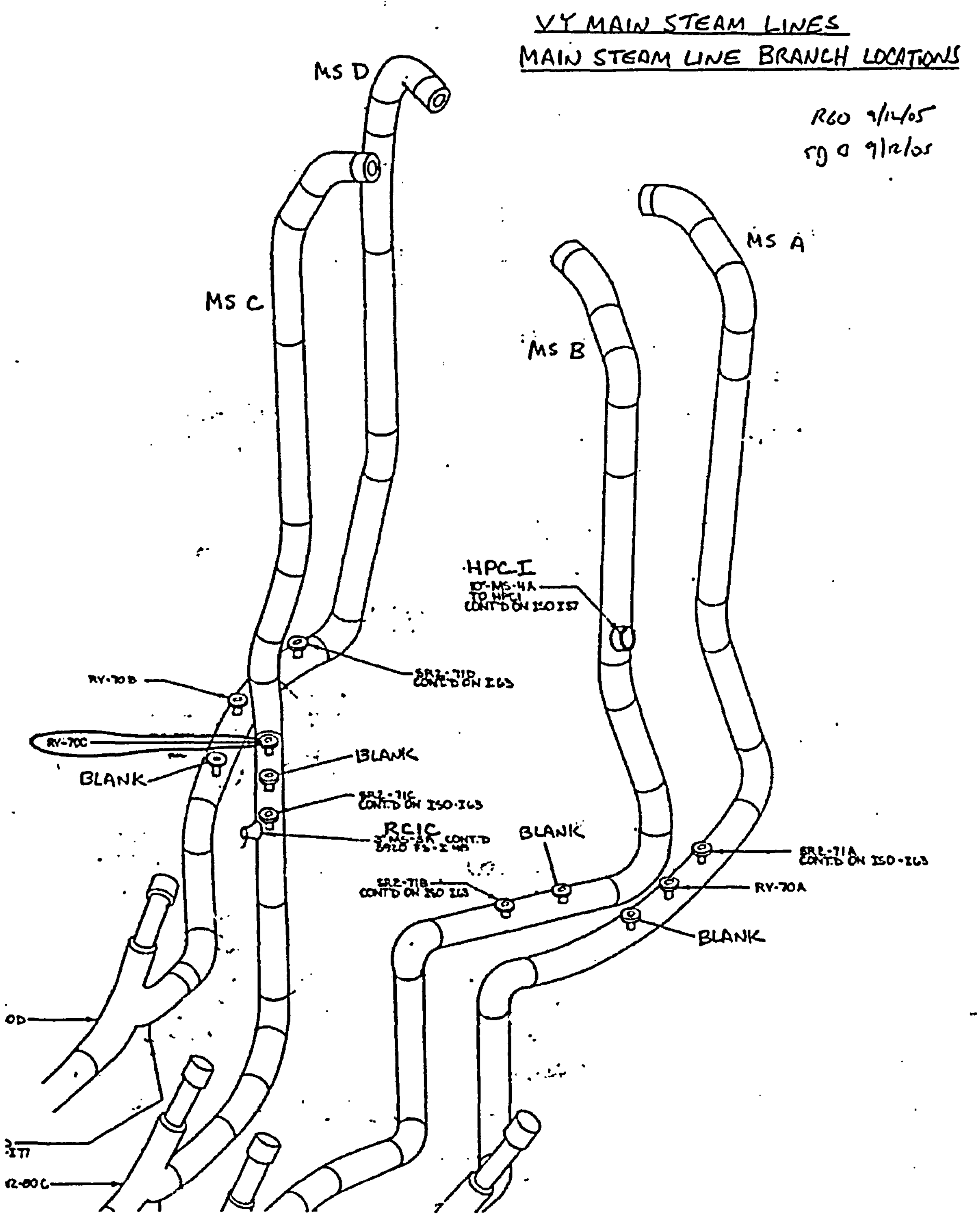

Figure EMEB-B-77-1 – Sheet 1: VYNPS Main Steam Piping Cavities and ACM Measurement Locations

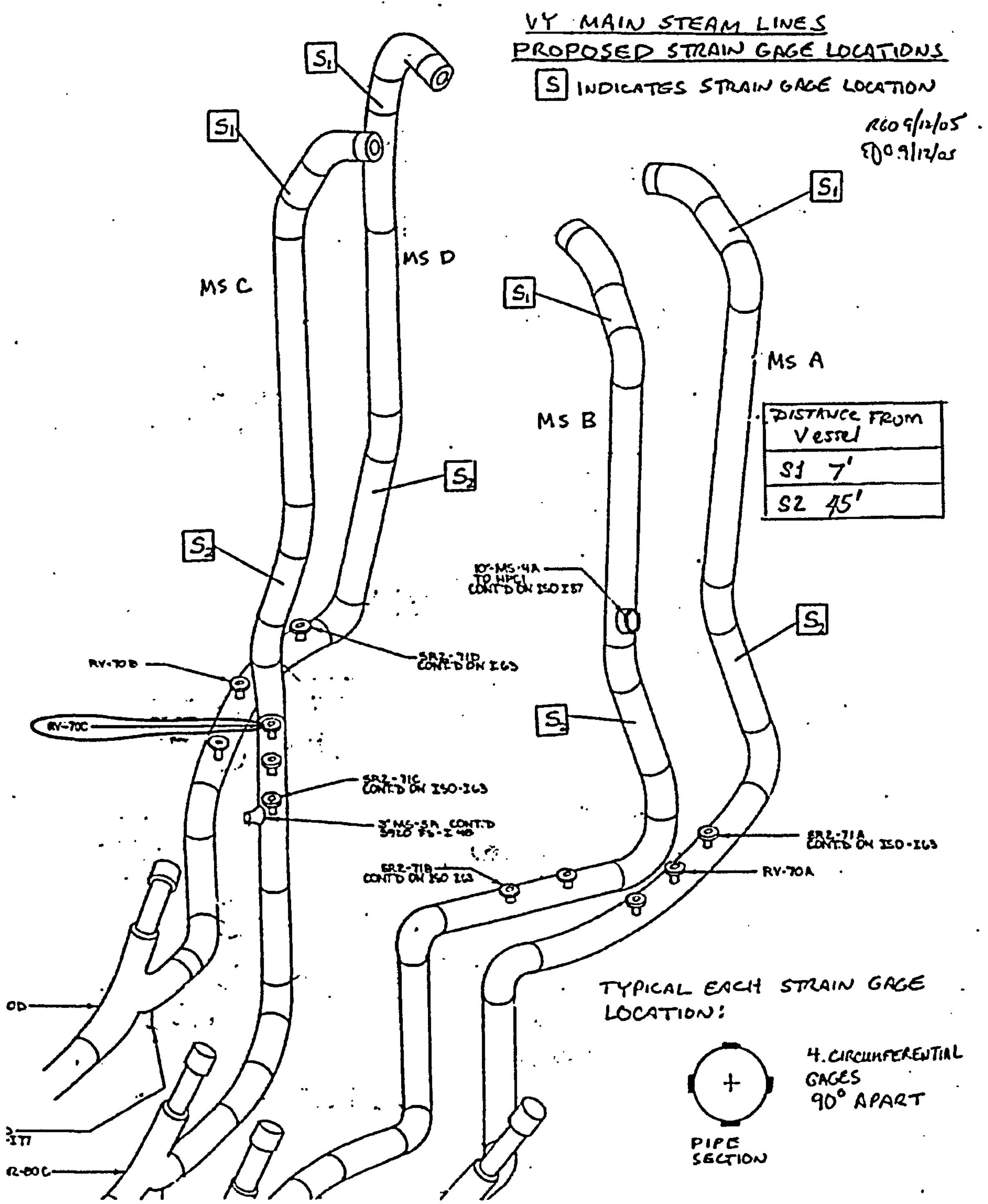

Figure EMEB-B-77-1 – Sheet 2: VYNPS Main Steam Piping Cavities and ACM Measurement Locations

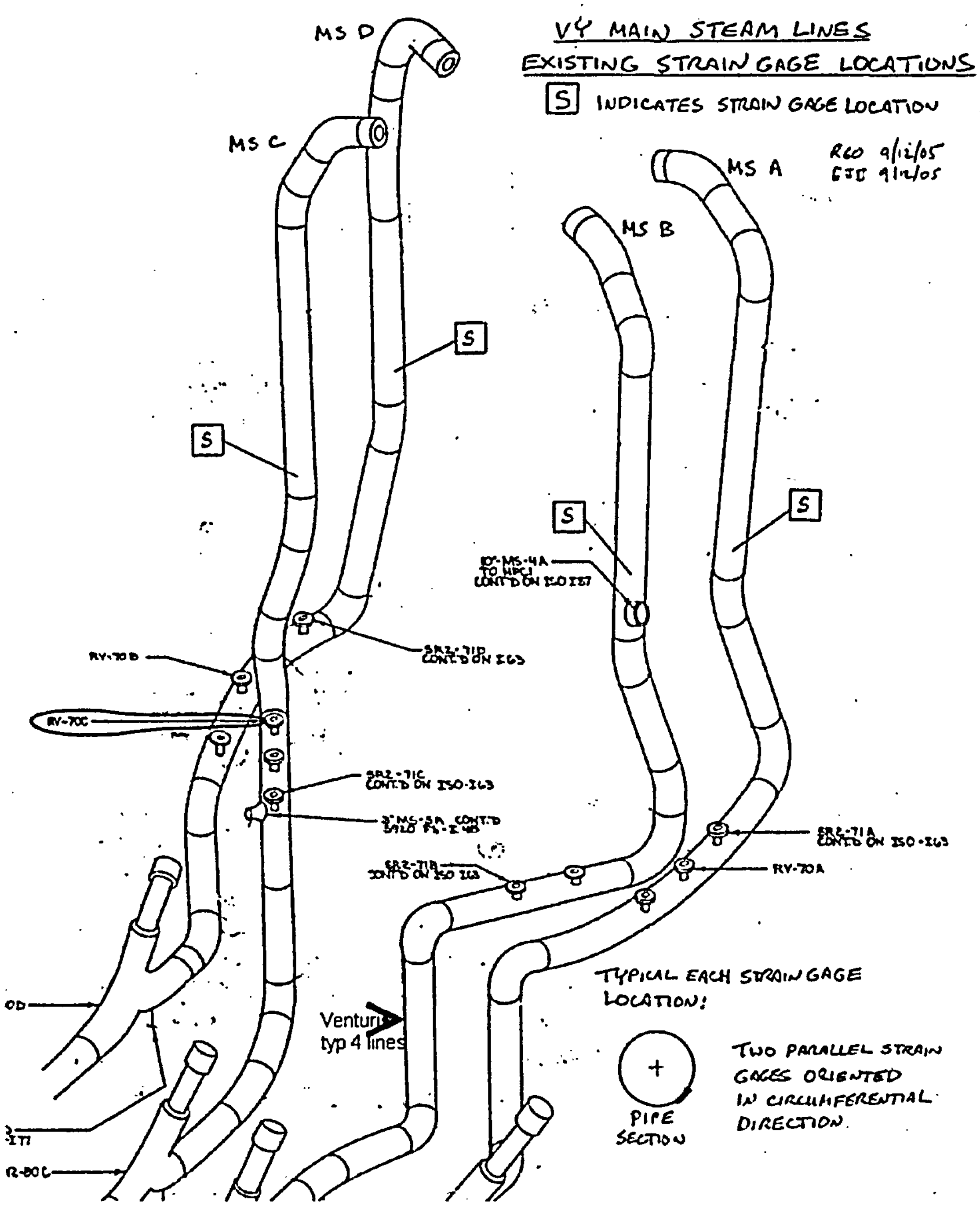

Figure EMEB-B-77-1 – Sheet 3: VYNPS Main Steam Piping Cavities and ACM Measurement Locations

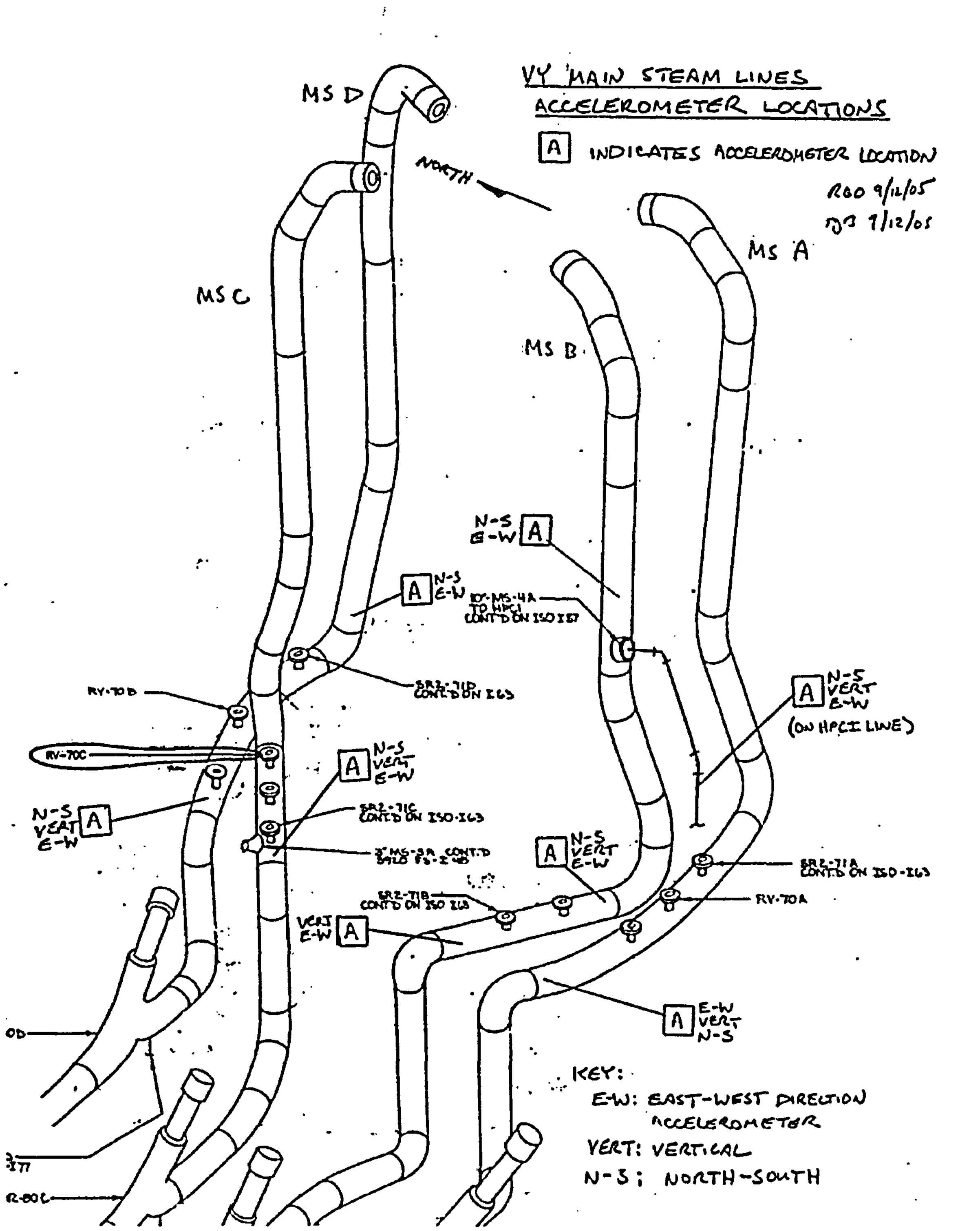

Figure EMEB-B-77-1 – Sheet 4: VYNPS Main Steam Piping Cavities and ACM Measurement Locations

Revised Response to EMEB-B-77

Appendix 1

Calculation VYC-2431 VYNPS Main Steam System Potential Acoustic Frequencies

CALCULATION COVER PAGE

☐ IP-2	☐ IP-3	☐ JAF	☐ PNPS	☒ VY

Calculation No.VYC-2431	This revision incorporates the following MERLIN DRNs or Minor Calc Changes: NA	Sheet 1 of 19 Att. A: 3 pages Att. B: 3 pages
Title: VYNPS Main Steam System Potential Acoustic Frequencies		☐QR ☒NQR
Discipline: Civil-Structural	Design Basis Calculation? ☐Yes ☒No	
This calculation supersedes/voids calculation: NA		
Modification No./Task No/ER No: ER 05-0738		

☒ No software used
☐ Software used and filed separately (Include Computer Run Summary Sheet). If "YES', Code:
☐ Software used and filed with this calculation. If "YES', Code:

System No./Name: Main Steam

Component No./Name: Main Steam Piping, Steam Dryer
(Attach additional pages if necessary)

Print/Sign

REV #	STATUS (Prel, Pend, A, V, S)	PREPARER	REVIEWER/ DESIGN VERIFIER	OTHER REVIEWER/ DESIGN VERIFIER	APPROVER	DATE
0	Pend	R.G. Orner R.G.Orner	E.J. Betti EJB	NA	S. D. Goodwin S.D.Goodwin	9.12.05

RECORD OF REVISIONS

Calculation Number: VYC-2431

Revision No.	Description of Change	Reason For Change
0	N/A	Original Issue

Calculation No. VYC-2431 Revision No. 0

CALCULATION OBJECTIVE:

The objective is to calculate the resonant acoustic frequencies of the fluid contained in the cavities formed by branch piping on the Main Steam System in the Drywell, and the vortex shedding frequencies resulting from shear wave instabilities in the steam flow across the cavity openings. A comparison will be made to determine if resonance occurs, both at CLTP (Current Licensed Thermal Power) and for the higher flow condition at EPU (Extended Power Uprate).

CONCLUSIONS:

The HPCI and RCIC lines fundamental frequencies are very low, 1.29 Hz and 1.89 Hz, respectively. The lowest vortex shedding frequency associated with these lines (HPCI) is 43 Hz at CLTP and 52 Hz at EPU. Therefore any excitation of these lines would be at higher harmonics and therefore are not expected to have significant contribution to system resonance.

The SSV and RV branch lines have the potential to be excited below 80% CLTP. These branches should not be excited from CLTP through EPU operation. There is 1 blank flanged RV line on each MSL that may be excited at EPU conditions. The fundamental frequency of this branch is ~223 Hz. In the EPU Power Ascension Test Program VY will monitor steam line signals through 300 Hz to assure that this resonance is identified and measured in the event it occurs.

ASSUMPTIONS:

None

DESIGN INPUT DOCUMENTS:

See Calculation Section 5.0 on page 7 and Section 6.0 on pages 8 and 9 (References 6-34, 36).

AFFECTED DOCUMENTS:

None

METHODOLOGY:

Manual calculations using standard industry accepted references.

TABLE OF CONTENTS

LIST OF EFFECTIVE PAGES

PAGE	REV.	PAGE	REV.	PAGE	REV.
1-19	0				
Att. A	0				
Att. B	0				

1.0 Background

EPU (Extended Power Uprate) will result in higher Main Steam flow rates, which may change the acoustical response in the piping. This change in acoustical response may result in changes in the loads on the steam dryer in the reactor vessel. One factor in the acoustical response in the Main Steam piping is the potential resonance driven by vortex shedding over branch piping (SRV/SSV, HPCI, and RCIC) cavities.

2.0 Purpose

The purpose of this calculation is to calculate the resonant acoustic frequencies of the fluid contained in the cavities formed by branch piping on the Main Steam System in the Drywell, and the vortex shedding frequencies resulting from shear wave instabilities in the steam flow across the cavity openings. A comparison will be made to determine if resonance occurs, both at CLTP (Current Licensed Thermal Power) and for the higher flow condition at EPU (Extended Power Uprate).

3.0 Method of Analysis

The natural frequencies of a cavity may be excited by the shear wave instabilities flowing over the cavity opening. The potential sources in the VY Main Steam lines may be evaluated by estimating the natural frequencies of the known cavities and the shear wave instabilities due to steam flow over the cavity openings. The resonator is excited when the two frequencies match.

The methods of References 1 & 2 are used to calculate cavity natural frequencies and the steam flow shear wave instability (vortex shedding) frequencies.

4.0 Assumptions

None.

5.0 Design Input

Reactor Operating Conditions:

(Reference Att. A ERFIS Plant Data)

Operating Pressure: 1012.6 psig

Main Steam Line Data:

(Reference Att. A ERFIS Plant Data)

VY CLTP MS Line Steam Flow Rate

	MS A	MS B	MS C	MS D
ERFIS	B64	B65	B66	B67
Mlb/hr	1.697	1.598	1.595	1.666

Branch Line Geometry Data:

SRV/SSV/Blanks:	Reference 6, 8, 9, 29-34
HPCI:	Reference 7, 10, 12-15, 19, 20
RCIC:	Reference 7, 11, 16-18, 21, 22

Branch Diameters

	HPCI	RCIC	SSV/SRV/Blank	
Pipe Size	10"	3"	6"	
Schedule	80	160	160	
ID (ft)	0.797	0.219	0.432	Ref. 35

Main Steam Line Geometry Data: (Reference 34, 35)

Nominal Pipe Size:	18" Schedule 80	
OD	=	18"
Wall thickness	=	0.938"
ID	=	16.124"
	=	1.344'

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28. VY Dwg VYI-HPCI-Part 8, Rev. 0, Reactor Core Isolation Cooling (RCIC) Part 8 Reactor Building
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7.0 Analysis

7.1 Potential CLTP Acoustic Frequencies

The natural frequencies of a cavity may be excited by the shear wave instabilities flowing over the cavity opening. The potential sources in the BWR steam lines may be evaluated by estimating the natural frequencies of the known cavities and the shear wave instabilities due to steam flow over the cavity openings. The resonator is excited when the two frequencies match.

Resonator Cavity Natural Frequency

The geometry of the resonator cavity is the critical parameter. The two most common geometries are the organ pipe and the Helmholtz resonator.

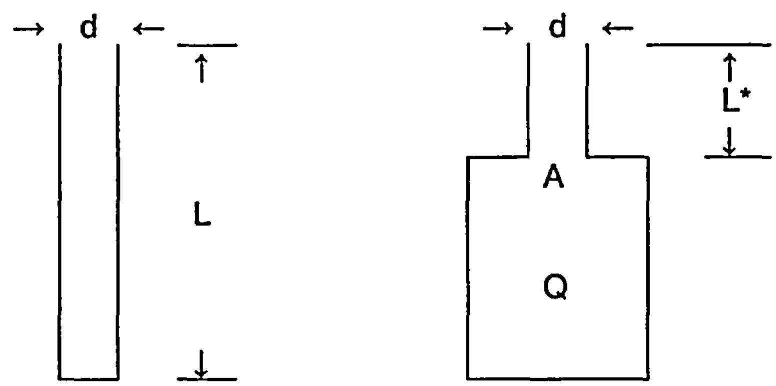


Figure 1
Resonator Geometry

The "organ pipe" type resonator (left image, above) is a cavity with the diameter of the opening equal to the diameter of the resonator volume. A Helmholtz resonator (right image, above) is defined as a cavity with a narrow opening that expands to a large volume.

The following expression represents the natural frequencies of an "organ pipe" type resonating cavity [Reference 1, Page 378 and Reference 2, Table 13.2, Page 340]:

$$f_a \approx \frac{jc}{4L};\ j=1,3,5,7,\ldots\ ;\quad \text{for a cavity with } \frac{L}{d}>1 \qquad (1)$$

The expression above is suitable for the HPCI and RCIC branch lines since the pipe geometries are good approximations of the organ pipe. The closed end is represented by the first isolation valve.

A better approximation of the fundamental frequency of relatively short pipes is obtained from the following formula [Reference 2, Page 360]:

$$f_a \approx \frac{c}{4\,L^{0.5}\,(L+4L_o)^{0.5}} \quad ; \quad \text{where } L_o = 0.24 \times \text{radius} \qquad (2)$$

The expression above is best suited for the SRV/SSV stub pipes and valve body cavity below the disc.

A Helmholtz resonator is defined as a cavity with a narrow opening that expands to a large volume. The natural frequency for a Helmholtz resonator is estimated from the following expression [Reference 1, Page 378 and Reference 2, Table 3-3, Page 355]:

$$f_a \approx \frac{c}{2\pi}\sqrt{\frac{A}{QL^*}} \qquad (3)$$

The area of the Helmholtz opening is "A"; the volume of the resonator is "Q"; and L* in the equation is the length of the opening plus a correction factor equal to the radius of the opening times 1.6 to account for an effective depth.

The natural frequency of the resonator is a function of the speed of sound and the geometry. It does not depend on the steam velocity. As a result, these frequencies will not change at EPU conditions.

<u>Theoretical Shear Wave Instabilities</u>

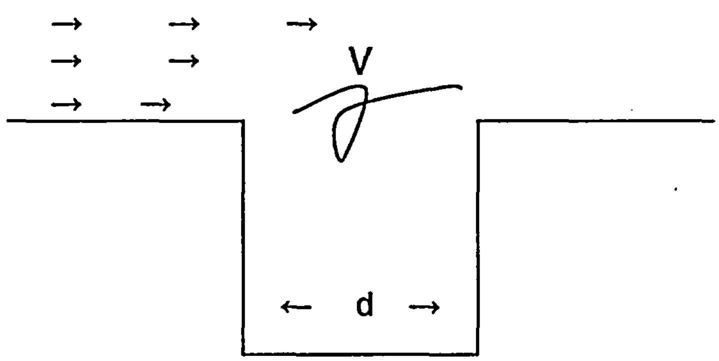


Figure 2
Vortices generated from flow over discontinuities

Vortices generated from flow over bluff objects shed at a frequency which is proportional to the flow velocity and inversely proportional to the diameter of the discontinuity. The constant of proportionality is called the Strouhal number. The vortex shedding frequency for this geometry is the following [Reference 3, Page 138]:

$$f_s = S\frac{V}{D} \qquad (4)$$

The Strouhal number is dependent on the Reynolds number. The Reynolds Number (R_e) for the CLTP steam line flow conditions is calculated below using the data from Table 1 and the ASME Steam Tables [Reference 5].

$$R_e = \frac{DV\rho}{\mu} = \frac{1.347\,ft \times 140\,ft\cdot s^{-1} \times 2.29\,lbm\cdot ft^{-3} \times 32.2\,lbf\cdot s^2\cdot lbm^{-1}\cdot ft^{-1}}{4.0(10^{-7})\,lbf\cdot s\cdot ft^{-2}} = 3.5(10^{10})$$

The vortex shedding frequency for turbulent boundary layer flow over discontinuities, such as cavities, have the following estimated shedding frequency [Reference 1, Page 376]:

$$f_a \approx \frac{0.33(\alpha - 0.25)V}{D} \quad ; \quad \text{where } \alpha = 1, 2, 3, \ldots \qquad (5)$$

Equations (4) and (5) have the same form and the Strouhal number in Equation (5) seems to be the quantity 0.33(α-0.25). The Strouhal number is determined experimentally. However, Equations (5) could be used along with a measured shedding frequency to obtain the Strouhal number.

The shedding frequency is a function of the steam velocity and the geometry. Unlike the resonator frequency, the shedding frequency will change at EPU conditions.

The shedding frequencies calculated by the above expression correspond to sharp edges at the cavity entrance. The spectral resolutions of the SRV and HPCI should be poor as a result of the Sweepolet® and welding tee, respectively. Experimental data from Reference 1 [Figure 9-21, Page 379] shows the effect on the attenuation of shallow cavity acoustic oscillations due to ramping the cavity perimeter. The peaks are broad and the amplitude is lower. The RCIC branch uses a Weldolet®. This fitting has a sharper corner than the tee and Sweepolet.

The reactor operating pressure is 1012.6 + 14.7 = 1027.3 psia (Ref. Att. A) corresponding to a saturation temperature of 548°F, and a vapor density (ρ) of 2.31 lb/ft^3 (Ref. 5). The speed of sound in the saturated steam mixture is approximately 1484.3 f/s (References 23, 24, based on an operating pressure of 1020 psia).

The following tables provide the VY data during the CLTP steam line measurements at 100% power and plant geometries for the branch lines of interest:

Table I
VY CLTP MS Line Steam Velocity

	MS A	MS B	MS C	MS D	
ERFIS	B64	B65	B66	B67	
Flow Rate Mlb/hr	1.697	1.598	1.595	1.666	Ref. Sect. 5.0
MS Pipe ID (ft)	1.344				Ref. Sect. 5.0
MS Pipe Area (ft^2)	1.419				
V* (f/s)	143.8	135.4	135.2	141.2	
V (f/s)	139 (Average)				

*Based on the equation V = Flow rate / (ρ)(Area)

Cavity Resonance Frequency

The VY geometries of interest resemble the "organ pipe" type geometries that include both long and short pipes (e.g., RCIC, HPCI branches and SSV/SRV/Blanks branches, respectively).

Natural frequencies were calculated using Equation 1 for the HPCI and RCIC branch lines and Equation 2 for the SSV/SRV/Blanks branch lines. The lengths (cavity depths) used in Eq. 1 for the HPCI and RCIC piping were based on the lengths of piping to the (normally closed) V23-14 and V13-131 valves (287.7 ft. and 195.9 ft., respectively, based on the piping isometrics and spool piece sketches listed in Section 5.0). The SSV/SRV/Blanks cavity depths and frequencies were calculated in a spreadsheet (Attachment B). Note that the individual cavity depths for the SSV/SRV/Blanks vary slightly due to differences in branch stub lengths, resulting in slightly different frequencies for individual locations. The results are presented in the following Table.

Table II
Fundamental Resonance Frequencies for MS Line Geometry

Geometry	Resonance Frequency (Hz)
HPCI	1.29
RCIC	1.89
SSV	140, 141, 142
SRV	118, 114, 119
Blank	222, 223

Vortex Shedding Frequency over Discontinuities

Vortex shedding frequencies were calculated using Equation 5 for all the branch line discontinuities. The frequency range provided in the results is due to the variation in steam line velocities observed during the 100% CLTP data acquisition.

Table III
Vortex Shedding Frequency (CLTP)
Generated from Turbulent Boundary Layer Flow over Discontinuities

Source of Instability	Frequency (Hz)
HPCI	43 ± 2 101 ± 3 158 ± 5 216 ± 6
RCIC	157 ± 4 367 ± 10
SSV/SRV/Blanks	80 ± 2 186 ± 5 292 ± 8

Note that the highest mode calculated was the first above 200 Hz, which is normally the cutoff frequency VY will use for data acquisition.

Table IV provides a summary of potential harmonic signatures in the VY steam line.

Table IV
Excitation Frequencies in the VY MS Lines (CLTP)

Source of Instability	Shedding Frequency (Hz)	Resonance Frequency (Hz)
HPCI MS "B" only	43 ± 2 101 ± 3 158 ± 5 216 ± 6	1.29 × j where j = 1,3,5,7... j = 33 f = 43 Hz j= 78 f = 101 Hz j = 122 f = 157 Hz j = 167 f = 215 Hz
RCIC MS "C" only	157 ± 4 367 ± 10	1.89× j where j = 1,3,5,7... j = 83 f = 157 Hz j = 194 f = 367 Hz
SSV* All MS Lines	80 ± 2 186 ± 5 292 ± 8	f = 141**
SRV* All MS Lines	80 ± 2 186 ± 5 292 ± 8	f = 116**
Blanks* All MS Lines	80 ± 2 186 ± 5 292 ± 8	f = 223**

*The resonance value is an approximate average for each set of SSVs, SRVs or Blanks.
** The SSV, SRV, and Blank RV Lines would not be excited at 100% power. These are flagged here because at lower power the 186 Hz and 292 Hz excitation frequencies would be lower and potentially excite these branch fundamental frequencies.

7.2 Potential EPU Acoustic Frequencies

The VYNPS potential acoustic natural frequencies at the current licensed thermal power (CLTP) level have been previously estimated. The CLTP evaluation concluded that natural frequencies of resonators are a function of the speed of sound and the geometry. Also, the vortices generated from flow over bluff objects shed at a frequency that is proportional to the steam flow velocity and inversely proportional to the diameter of the discontinuity. Unlike the resonator frequency, the shedding frequency will change at the extended power up-rate (EPU) conditions. The following evaluation repeats the CLTP assessment using the power up-rate steam flow. The same methodology is being used.

The EPU results are provided below. The frequency uncertainty is the same that was used in the CLTP evaluation.

Table V
Vortex Shedding Frequency (EPU)
Generated from Turbulent Boundary Layer Flow over Discontinuities

Source of Instability	Frequency (Hz)
HPCI	52 ± 2 121 ± 3 190 ± 5 259 ± 6
RCIC	188 ± 4 440 ± 10
SSV/SRV/Blanks	96 ± 2 223 ± 5 350 ± 8

The results summarized on the following table show resonances between the shear wave excitation frequencies and the cavity acoustic frequencies that may exist at EPU conditions.

Table VI
Excitation Frequencies in the VY MS Lines (EPU)

Source of Instability	Shedding Frequency (Hz)	Resonance Frequency (Hz)
HPCI MS "B" only	52 ± 2 121 ± 3 190 ± 5	1.29 × j where j = 1,3,5,7, j = 40 f = 52 Hz j = 94 f = 121 Hz j = 147 f = 190 Hz
RCIC MS "C" only	188 ± 4 440 ± 10	1.89× j where j = 1,3,5,7,... j =99 f = 187 Hz j =233 f = 440 Hz
SSV All MS Lines	96 ± 2 223± 5 350 ± 8	f = 141
SRV All MS Lines	96 ± 2 223± 5 350 ± 8	f = 116
Blanks All MS Lines	96 ± 2 223± 5 350 ± 8	f = 223

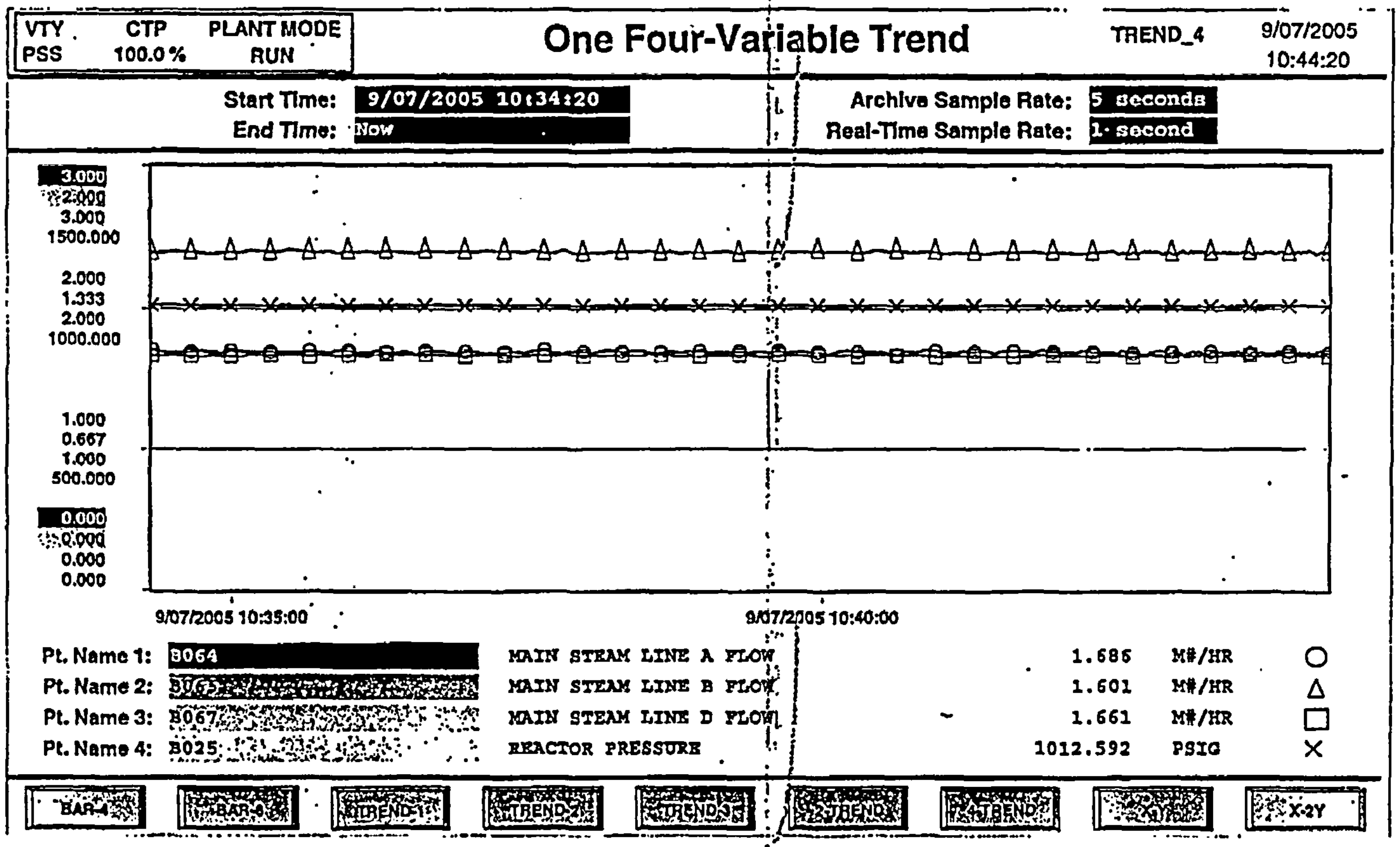
8.0 Conclusions

The HPCI and RCIC lines fundamental frequencies are very low, 1.29 Hz and 1.89 Hz, respectively. The lowest vortex shedding frequency associated with these lines (HPCI) is 43 Hz at CLTP and 52 Hz at EPU. Therefore any excitation of these lines would be at higher harmonics and therefore are not expected to have significant contribution to system resonance.

The SSV and RV branch lines have the potential to be excited below 80% CLTP. These branches should not be excited from CLTP through EPU operation. There is 1 blank flanged RV line on each MSL that may be excited at EPU conditions. The fundamental frequency of this branch is ~223 Hz. In the EPU Power Ascension Test Program VY will monitor steam line signals through 300 Hz to assure that this resonance is identified and measured in the event it occurs.

ATTACHMENT A

VYC-2431 Rev. 0
VY ERFIS Data



VYC-2431 Rev. 0
Att. A P.2

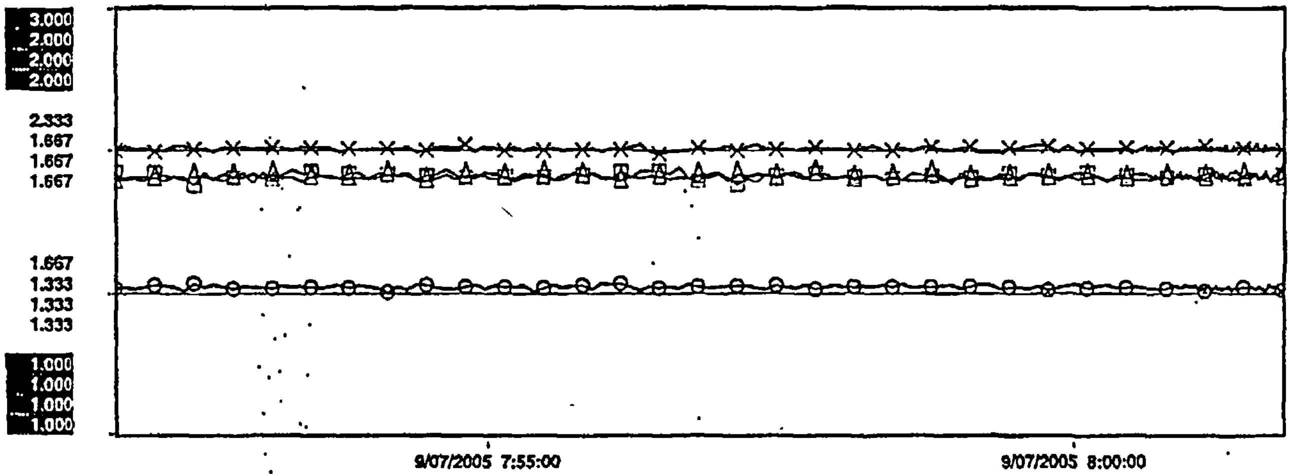
VTY	CTP	PLANT MODE
PSS	99.9 %	RUN

One Four-Variable Trend

TREND_4 9/07/2005 8:01:51

Start Time:
End Time:

Archive Sample Rate:
Real-Time Sample Rate:



Pt. Name 1:	B064	MAIN STEAM LINE A FLOW	1.697	M#/HR	○
Pt. Name 2:	B065	MAIN STEAM LINE B FLOW	1.598	M#/HR	Δ
Pt. Name 3:	B066	MAIN STEAM LINE C FLOW	1.595	M#/HR	□
Pt. Name 4:	B067	MAIN STEAM LINE D FLOW	1.666	M#/HR	×

BAR-4 BAR-6 TREND-1 TREND-2 TREND-3 2-TREND 4-TREND X-Y X-2Y

VYC-2431 Rev. 0
Att. A P.3

ATTACHMENT B

VYC-2431 Rev. 0
SSV/SRV/Blanks Natural Frequency Calculation

SSV/SRV/Blanks Natural Frequency Calculation

Pipe Inside radius	8.1 inches	0.675 feet	Ref. 34, 35
SRV Bore Length	18.7 inches	1.558 feet	Ref. 8
RV Bore Length	12 inches	1.000 feet	Ref. 29
Sch 160 Inside Diam	5.187 inches	0.432 feet	Ref. 35
Sonic Velocity	1483 Ft/sec		Ref. 23, 24

		1st Branch		2nd Branch		3rd Branch	
Steam Line A		Feet	Inches	Feet	Inches	Feet	Inches
	Vert Dim PS-1-2 Ref 32, 36	4	6.5	4	6.5	4	6.5
	Vert Dim	2	4.625	2	4.125	2	3.625
	Vert Dim	2	1.875	2	2.375	2	2.875
Length	(ft)	2.15625		2.197917		2.239583	
Valve No		SRV-71A		RV-70A		Blank	
Bore Length	(ft)	1.558		1.000		0	
L	(ft)	3.040		2.523		1.565	
Lo	(ft)	0.05187		0.05187		0.05187	
Frequency	Hz	118		141		223	
		1st Branch		2nd Branch		3rd Branch	
Steam Line B		Feet	Inches	Feet	Inches	Feet	Inches
	Vert Dim PS-1-6 Ref 30, 36			4	6.5	4	6.5
	Vert Dim			2	3.5625	2	3.1875
	Vert Dim			2	2.9375	2	3.3125
Length	(ft)			2.244792		2.276042	
Valve No		None		Blank		SRV-71B	
Bore Length	(ft)			0.000		1.558	
L	(ft)			1.570		3.159	
Lo	(ft)			0.05187		0.05187	
Frequency	Hz			222		114	
		1st Branch		2nd Branch		3rd Branch	
Steam Line C		Feet	Inches	Feet	Inches	Feet	Inches
	Vert Dim PS-1-10 Ref 31, 36	4	6.5	4	6.5	4	6.5
	Vert Dim	2	3.8125	2	3.5625	2	3.1875
	Vert Dim	2	2.6875	2	2.9375	2	3.3125
Length	(ft)	2.223958		2.244792		2.276042	
Valve No		RV-70C		Blank		SRV-71C	
Bore Length	(ft)	1.000		0		1.558	
L	(ft)	2.549		1.570		3.159	
Lo	(ft)	0.05187		0.05187		0.05187	
Frequency	Hz	140		222		114	
		1st Branch		2nd Branch		3rd Branch	
		Feet	Inches	Feet	Inches	Feet	Inches
Steam Line D							
	Vert Dim PS-1-14 Ref 33, 36	4	6.5	4	6.5	4	6.5
	Vert Dim	2	4.875	2	4.375	2	3.625
	Vert Dim	2	1.625	2	2.125	2	2.875
Length	(ft)	2.135417		2.177083		2.239583	
Valve No		SRV-71D		RV-70B		Blank	
Bore Length	(ft)	1.558		1.000		0	
L	(ft)	3.019		2.502		1.565	
Lo	(ft)	0.05187		0.05187		0.05187	
Frequency	Hz	119		142		223	

Notes:

1. Safety Relief Valves (SRV) are numbered SRV-xxx, and Safety Valves (SSV) are numbered RV-xxx. "Blank" refers a blind flanged spare branch location.
2. Branch No. (1st Branch, 2nd Branch, etc) refers to the branch location on each steam line in order starting from the one nearest the Reactor Vessel.

SSV/SRV/Blanks Natural Frequency Calculation

			Summary					
MSL	A	PS-1-2	SRV-71A		RV-70A		Blank	
			118	Hz	141	Hz	223	Hz
MSL	B	PS-1-6	None		Blank		SRV-71B	
			0		222	Hz	114	Hz
MSL	C	PS-1-10	RV-70C		Blank		SRV-71C	
			140	Hz	222	Hz	114	Hz
MSL	D	PS-1-14	SRV-71D		RV-70B		Blank	
			119	Hz	142	Hz	223	Hz

Attachment 4

Vermont Yankee Nuclear Power Station

Proposed Technical Specification Change No. 263 – Supplement No. 33

Extended Power Uprate

Response to Request for Additional Information

Revised Response to EMEB-B-96

Total number of pages in Attachment 4 (excluding this cover sheet) is 1.

RAI EMEB-B-96

As discussed in Attachment 1 to Supplement No. 27, "VYNPS Acoustic Model Benchmark - Dryer Acoustic Load Methodology," a "blind" benchmark test was performed using the GE SMT facility to evaluate the ability of CDI's acoustic circuit methodology to predict dryer loads. The purpose of the evaluation is not clear because of the use of terms, like the "viability of the methodology." Entergy should clearly state the purpose of the evaluation. If a purpose of the report is to use the SMT results to show that a bounding pressure loading can be obtained for the VYNPS dryer using the CDI ACA methodology, then Entergy should demonstrate that the SMT adequately represents the VYNPS steam dryer, the associated steam space, and the VYNPS MSLs.

Response to RAI EMEB-B-96

The purpose of the benchmark was to evaluate the ability of the CDI acoustic load methodology to predict loads on the SMT dryer using only data measured on the main steam lines. The SMT model was not intended to be representative of VYNPS configuration or operating conditions. The SMT also was not intended to be used to develop bounding or nominal VYNPS steam dryer loads. Entergy compared the benchmark ACA calculated loads to the measured loads at key SMT locations and concluded that the ACA methodology provided a reasonably accurate prediction. It was Entergy's intent to use the results of the benchmark to establish the uncertainty of the methodology. The uncertainty of the ACA was evaluated based on model predictions and data from the SMT benchmark. Exhibit EMEB-B-18-1 (see Attachment 1) provides the results of this evaluation and shows that the uncertainty of the ACA can be established as 130%. This uncertainty value has been applied to the VYNPS ACA load definition (see responses to RAI EMEB-B-40 and 52).

Attachment 6

Vermont Yankee Nuclear Power Station

Proposed Technical Specification Change No. 263 – Supplement No. 33

Extended Power Uprate

Revised Steam Dryer Monitoring Plan

Total number of pages in Attachment 6 (excluding this cover sheet) is 8.

VERMONT YANKEE NUCLEAR POWER STATION
REVISED STEAM DRYER MONITORING PLAN

Introduction and Purpose

This plan 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. Unacceptable dryer performance is a condition that could challenge steam dryer structural integrity and result in the generation of loose parts or cracks or tears in the dryer that result in excessive moisture carryover. During reactor power operation, performance is demonstrated through the measurement of a combination of plant parameters. The comparison of measured plant data against defined criteria, based on the steam dryer structural analysis of record, will provide predictive capabilities toward determining steam dryer structural integrity under EPU conditions.

The Steam Dryer Monitoring Plan (SDMP) is applicable during initial power ascension to 1912 MWt and continues after full EPU conditions, as specified below. A license condition for steam dryer monitoring is proposed to require operational surveillances as well as visual inspections of the steam dryer, which will be conducted during specific scheduled refueling outages following achievement of full uprate conditions.

Entergy will accept a license condition for VYNPS that is based on the SDMP.

Scope

The SDMP is primarily an initial power ascension test plan designed to assess steam dryer performance from 100% OLTP to 120% OLTP (i.e., 1912 MWt). Assuming that a license amendment authorizing EPU is granted during the next operating cycle, power ascension will be achieved in one step: Elements of this plan will be implemented before EPU power ascension testing, and others may continue after power ascension testing.

Operating Specifications

When initially operating at a power level above 1593 MWt, the parameters identified in Table 1- which are indicative of steam dryer integrity - shall be monitored at the frequencies specified and shall meet applicable performance criteria specified in Table 2. The surveillance requirements of Table 1 will be effective during power ascension to any power level that was not previously attained. Any change to the performance criteria, required actions, or surveillance requirements in Tables 1 or 2 can only be made in accordance with the proposed steam dryer license condition (see Table 3).

Initial EPU power ascension testing above 100% OLTP will be conducted in 2.5% of OLTP steps and 5% of OLTP plateaus. The initial power ascension will include hold points at each 2.5% step and at each 5% plateau. The maximum power increase will not exceed a nominal 5% of OLTP in a 24-hour period.

Table 2 establishes the criteria for verifying acceptable steam dryer performance based on moisture carryover and main steam line pressure data. If the Level 1 or Level 2 performance criteria are exceeded, the actions and completion times specified shall be met for the given condition. Reactor power operation that results in moisture carryover and steam pressures that are less than the Level 2 performance criteria in Table 2 is representative of fully acceptable steam dryer performance.

Additionally, if the performance criteria in Table 2 are exceeded, the following actions will be taken depending upon the criteria exceeded:

1. Either suspend reactor power ascension (Level 2 Acceptance Criteria) or reduce reactor power (Level 1 Acceptance Criteria), initiate a Condition Report, and evaluate the cause of any exceedance of the performance criteria.

2. Prior to increasing reactor thermal power to a level higher than any previously attained, the plant conditions relevant to steam dryer integrity and associated evaluation results shall be reviewed by the on-site safety review committee, and a recommendation shall be made to the General Manager, Plant Operations prior to increasing power for each 5% power plateau.

3. Strain gage pressure and moisture carryover data collected at each 5% power plateau will be made available to the NRC through its resident inspector.

4. Each initial increase in reactor thermal power to the next higher 5% power plateau above 100% OLTP must be authorized by the General Manager, Plant Operations.

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 2.5% (nominal) power step above 100% OLTP. (Note 3)
3. Main steam line pressure data from pressure transducers	At least once at every 2.5% (nominal) power step above 100% OLTP. (Note 3) AND Within one hour after achieving every 2.5% (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 a 5% power plateau, an orderly power reduction shall 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 2.5% (nominal) over OLTP, 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 5% of OLTP greater than 100% (i.e., approximately 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 main steam line pressure data is also required to be performed once at each 2.5% power step above 100% OLTP and within one hour of achieving each 2.5% 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. If the surveillance is met at a given power level,

additional surveillances do not need to be performed at that 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 2.5% power step from at least three of the four main steam lines, 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 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 1.25% and 2.5% of OLTP, 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 $\leq$ 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).

Data Collection

During initial EPU power ascension, plant data will be measured and recorded, as a minimum, at power steps corresponding to approximately 102.5%, 105%, 107.5%, 110%, 112.5%, 115%, 117.5%, and 120% OLTP. In addition, Entergy will monitor pressure data from the main steam strain gages hourly during initial power ascension. The plant will be held at each 5% power plateau to allow sufficient time to evaluate data measurements relative to performance criteria. Depending upon actual performance, smaller power increase increments may be used. Data collected will consist of:

- Dynamic pressure measurements taken from four pressure transducers installed on transmitters associated with each main steam line venturi.
- Measurements taken from strain gages located on each of the four main steam lines between the reactor pressure vessel nozzles and the closest inboard safety/safety relief valve.
- Moisture carryover measurements will be made during power ascension testing above 100% OLTP in accordance with SIL 644[1].
- Plant data that may be indicative of off-normal dryer performance will be monitored during power ascension (e.g., level, steam flow, feed flow, etc.). Plant data can provide an early indication of unacceptable dryer performance.

Evaluations

Data collected at each power ascension step will be evaluated relative to the performance criteria.

In addition, other reactor operational parameters that may be influenced by steam dryer integrity (e.g., steam flow distribution between the individual steam lines) will be monitored with the intent of detecting structural degradation of the steam dryer during plant operation (e.g., flow distribution between individual main steam lines). The enhanced monitoring of selected plant parameters will be controlled by plant procedures.

If any of the performance criteria in Table 2 are exceeded, the plant conditions relevant to steam dryer integrity and the associated evaluation results shall be reviewed by the on-site review committee at every 5% power plateau and prior to increasing power. Permission to ascend in power will be granted by the General Manager, Plant Operations.

Reporting to NRC

1. Steam Dryer Visual Inspections: The results of the visual inspections of the steam dryer conducted during the next three refueling outages shall be reported

[1] GE Nuclear Energy, Services Information Letter, SIL No. 644, Revision 1, "BWR Steam Dryer Integrity," November 9, 2004

to the NRC staff within 60 days following startup from the respective refueling outage.

2. SDMP: 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. In addition the final full EPU power performance criteria spectra (limit curve) will be submitted to the NRC staff within 120 days. Contemporary data and results from 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 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 dryer integrity monitoring.

Long Term Actions

The VYNPS steam dryer will be inspected during the refueling outages scheduled for the Fall 2005, Spring 2007 Fall 2008 and Spring 2010. The inspections conducted after power uprate implementation will be comparable to the inspection conducted during the Spring 2004 refueling outage and will meet the recommendations of SIL 644, Rev. 1.

Following completion of power ascension testing, moisture carryover measurements will continue to be made periodically, and other plant operational parameters that may be affected by steam dryer structural integrity will continue to be monitored, in accordance with GE SIL 644 and plant procedures.

Equipment associated with temporarily installed pressure monitoring sensors and strain gages may be removed from service following the achievement of one operating cycle after issuance of the EPU license amendment and satisfaction of the license condition requiring steam dryer inspection.

Table 3
PROPOSED STEAM DRYER LICENSE CONDITION

1. When operating above 1593 MWt (i.e., at extended power uprate conditions), the operating limits, required actions, and surveillances specified in the Steam Dryer Monitoring Plan (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 1593 MWt, 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[2].

2. 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.

3. 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.

4. The requirements of Item 1 above 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 Item 1 above shall extend another full operating cycle until the visual inspection standard of no new flaws/flaw growth based on visual inspection is satisfied.

5. This license condition shall expire upon satisfaction of Items 2, 3 and 4 above, 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.

[2] Nuclear Energy Institute, "Guidelines for Managing NRC Commitment Changes," NEI 99-04, Revision 0, July 1999

BVY 05-084
Docket No. 50-271

Attachment 8

Vermont Yankee Nuclear Power Station

Proposed Technical Specification Change No. 263 – Supplement No. 33

Extended Power Uprate

Response to Request for Additional Information

Revised Response to EMEB-B-18 and Exhibit EMEB-B-18-1

NON-PROPRIETARY VERSION

Total number of pages in Attachment 8
(excluding this cover sheet) is 80.

RAI EMEB-B-18

On Page 6 of Attachment 1 to Supplement 26, Entergy states that input for the acoustic circuit model is obtained from pressure transducers installed on instrument lines from the four main steamline (MSL) venturi instrument racks and from strain gauges on each of the four MSLs between the reactor pressure vessel (RPV) nozzles and main steam safety relief valves (SRVs). Provide the basis for the assumption that the venturi pressure transducer measurements are capable of detecting very small pressure fluctuations in the MSL flow that will provide accurate and synchronized input for the acoustic circuit methodology in determining the steam dryer loads. Discuss the validation of the accuracy and synchronization of the venturi pressure transducer measurements in comparison to the MSL strain gauge data.

Revised Response to RAI EMEB-B-18

In order to assess the uncertainty in using venturi instrument line pressure data to determine main steam line pressure, the impacts of the following key potential sources of uncertainty were evaluated:

1. The uncertainty acoustic modeling and methodology used to develop the transfer function of the sensing lines.
2. The uncertainty in the Rosemount dynamic properties, referred to here as compliance.
3. The accuracy of the instrumentation used in the mockup testing.
4. The accuracy of the instrumentation used to collect the plant data.
5. The accuracy of the predicted load based on relative location of sensing point in the steam line versus the location of the sampling point used in the benchmark test.

This acoustic load uncertainty evaluation is included in Exhibit EMEB-B-18-1. These uncertainty values described in the evaluation have been incorporated into the Vermont Yankee Nuclear Power Station (VYNPS) steam dryer acoustic load definition.

Entergy will install 32 new strain gages on the main steam piping and enhance the data acquisition system in order to reduce the measurement uncertainty associated with the acoustic circuit model (ACM).

- Attachment 3, revised response to RAI EMEB-B-77, includes a figure EMEB-B-77-1 that shows the arrangement of the main steam piping and branch lines, the location of the new strain gages, the location of the existing acoustic circuit analysis (ACA) monitoring points, and location of the accelerometers used for vibration monitoring.
- Attachment 12 contains specifications for strain gage and two data acquisition systems being considered for stain gage data acquisition. We are currently

bench testing the data acquisition units for comparison of noise and resolution of the National Instrument and Yokogawa systems.

- Entergy will monitor plant alternating data up to 300Hz. Entergy will monitor both the new strain gage data and existing strain gage data during power ascension.

- In the event that acoustic signals are identified that challenge the VYNPS dryer monitoring performance limit curve during EPU power ascension, Entergy will evaluate dryer loads based on the new strain gage data. The structural analysis will continue to address frequency uncertainties up to +/-10% and assure that peak responses within this uncertainty band are addressed.

Acoustic Load Uncertainty

The performance of the Acoustic Circuit Model (ACM) has been benchmarked on the GE Scale Model Test (SMT) Facility and at Quad Cities Unit 2(QC2). These benchmarks provide information that supports Entergy's assessment of the performance of this model in predicting steam dryer loads based on dynamic or hydrodynamic steam line data.

There were differences in the method of determining the steam line pressure signals used in the SMT and QC2 benchmark tests and the VYNPS steam lines. This section will address the uncertainties introduced by these differences.

The uncertainty in the ACM loads is driven by the following sources:

1. UncACM1: Maximum of uncertainty of the ACM based on QC2 data and SMT benchmark data and location.

2. UncACM2: The uncertainty introduced by steam line pressure measurement method.

The purpose here is to define the uncertainty in the VYNPS calculated steam dryer load from each of these sources. These uncertainties will then be combined by the (SRSS) method to assess the ACM load uncertainty.

UncACM=Sqrt(UncACM1^2+ UncACM2^2)

This approach will be applied for the Root Mean Squared (RMS) uncertainty and the maximum load uncertainty. The maximum of these two results will be used to define the UncACM uncertainty used in the limit curve factor assessment.

Uncertainty Identified in the SMT Benchmark Tests

The Entergy benchmark report, supplied in Attachment 1 to Supplement 27 (BVY 05-038 dated April 5, 2005), provided graphs comparing ACM predictions with SMT measurements in the form of power spectral density (PSD), RMS and maximum pressure values on all vertical faces and cover plate microphones. From the PSD plots it was found that the ACM was generally conservative at frequencies between 240 Hz (20 Hz full scale) and 3200 Hz (270 Hz full scale). The ACM was determined to be non-conservative below 240 Hz. The source of the signals below 240 Hz appears to be due to flow turbulence and is not associated with acoustic signals. Based on these findings, Entergy applied an unsteady computational fluid dynamics model (CFD) large eddy simulation (LES) analysis using the VYNPS operating conditions as inputs to generate representative hydrodynamic loads. Both ACA and CFD loads were used in the structural evaluation of the VYNPS dryer. The uncertainty associated with the CFD loads is discussed in Attachment 5 to this Exhibit.

In the process of assessing the ACM load uncertainty, it was noted that that the non-conservative RMS and maximum pressure conditions shown on the benchmark report plots involved test case conditions with flow: VY6RUN2, Burst with 81 CFM Flow and

VY12R1, Chirp with 81 CFM Flow. Review of the PSDs also suggested the under predictions occurred at microphones associated with significant frequency content less than 240 Hz.

To assess this rigorously, the SMT data for VY6RUN2 and VY12R1 were reprocessed applying a 240 Hz High Pass filter. The revised, filtered plots Max and RMS signal plots are included as Figures EMEB-B-18-1-1, EMEB-B-18-1-2, EMEB-B-18-1-3, and EMEB-B-18-1-4. As noted with the low frequency turbulence signal removed, the RMS and maximum ACM predictions bound the measured data. This work has been independently reviewed by signal consultant LMS, Inc.

As reported in Attachment 1 (VY-RPT-05-00006) to Supplement 27 the quantified SMT instrument uncertainties including microphone accuracy are less than 6% which is insignificant (~ one tenth) when compared to the overall ACM uncertainty and therefore not included in this assessment.

The data is also summarized for all conditions in the following Table EMEB-B-18-1-1.

BURST NO FLOW					
Source	(MaxCDI-MaxSMT)/MaxSMT			(RMSCDI-RMSSMT)/RMSSMT	
VY3R2	Max	53%		Max	52%
VY3R2	Min	2%		Min	19%
BURST & 81 CFM Filtered <240 Hz					
	(MaxCDI-MaxSMT)/MaxSMT			(RMSCDI-RMSSMT)/RMSSMT	
VY6RUN2	Max	55%		Max	31%
VY6RUN2	Min	4%		Min	3%
CHIRP & 81 CFM Filtered <240 Hz					
	(MaxCDI-MaxSMT)/MaxSMT			(RMSCDI-RMSSMT)/RMSSMT	
VY12R1	Max	67%		Max	40%
VY12R1	Min	1%		Min	8%
CHIRP NO FLOW					
	(MaxCDI-MaxSMT)/MaxSMT			(RMSCDI-RMSSMT)/RMSSMT	
VY13R1	Max	101%		Max	59%
VY13R1	Min	12%		Min	16%
Summary of all 4 Cases					
	(MaxCDI-MaxSMT)/MaxSMT			(RMSCDI-RMSSMT)/RMSSMT	
All Cases	Max	101%		Max	59%
All Cases	Min	1%		Min	3%

Table EMEB-B-18-1-1. Summary of SMT Time Domain Signal Comparison

Acoustic Model Benchmark

Appendix E Filtered <240 Hz, VY6RUN2 Burst Random with 81 CFM Flow

Microphone Mall Max

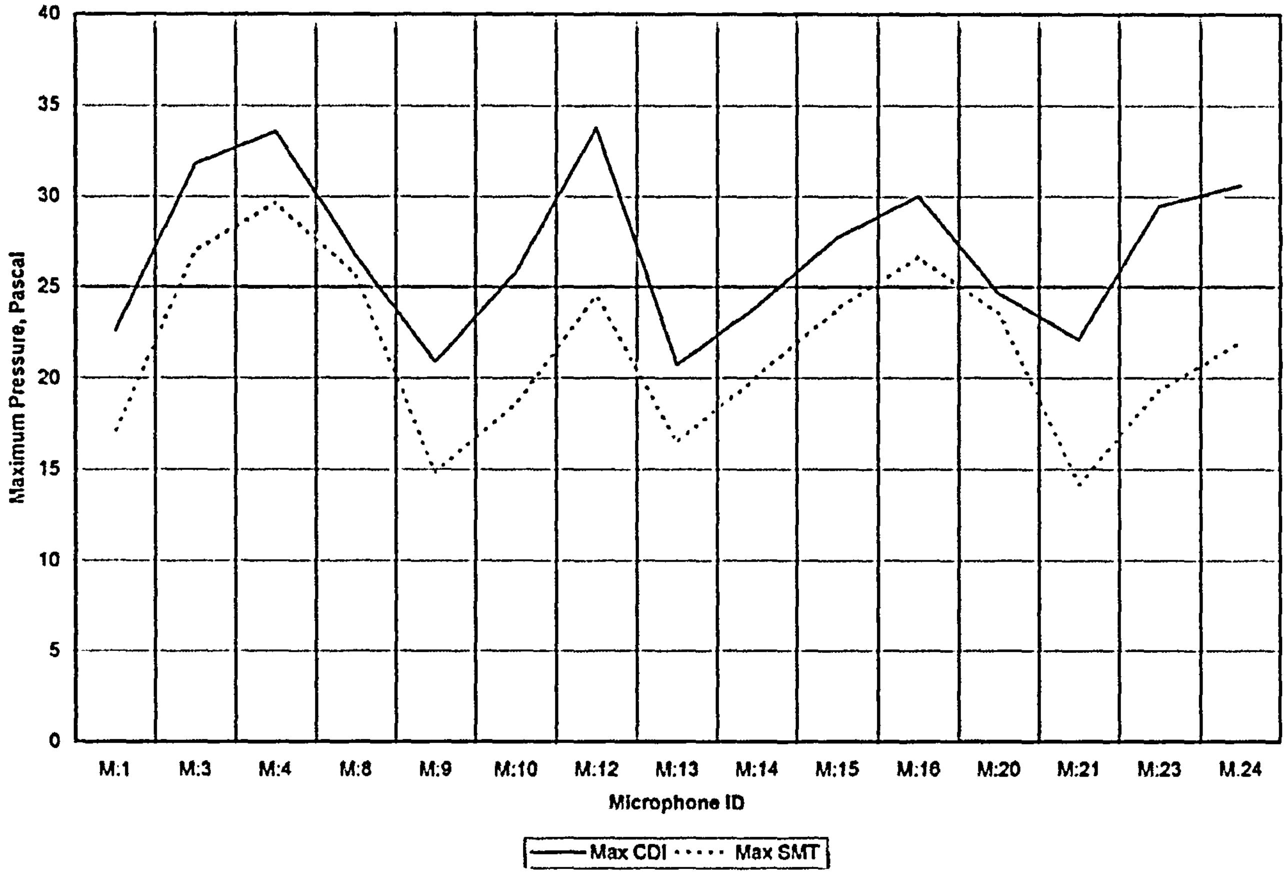


Figure EMEB-B-18-1-1

Appendix E Filtered <240 Hz, VY6RUN2 Burst Random with 81 CFM Flow
Microphone Mall Prms

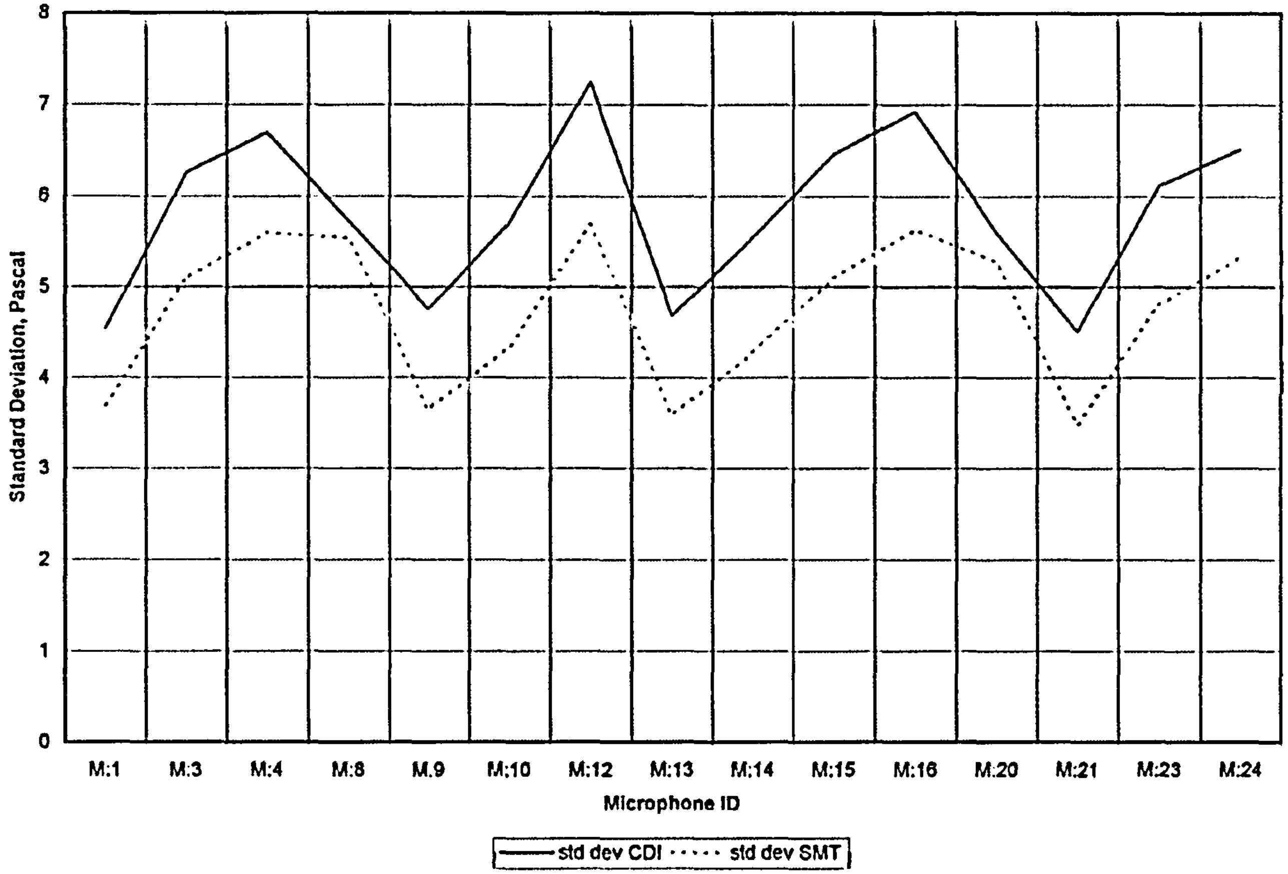


Figure EMEB-B-18-1-2

Exhibit EMEB-B-18-1 Rev. 1 -VYNPS Steam Dryer Load Uncertainty
NON-PROPRIETARY INFORMATION

Acoustic Model Benchmark
Appendix G Filtered <240 Hz, VY12R1 Chirp with 81 CFM Flow
Microphone Mall Max

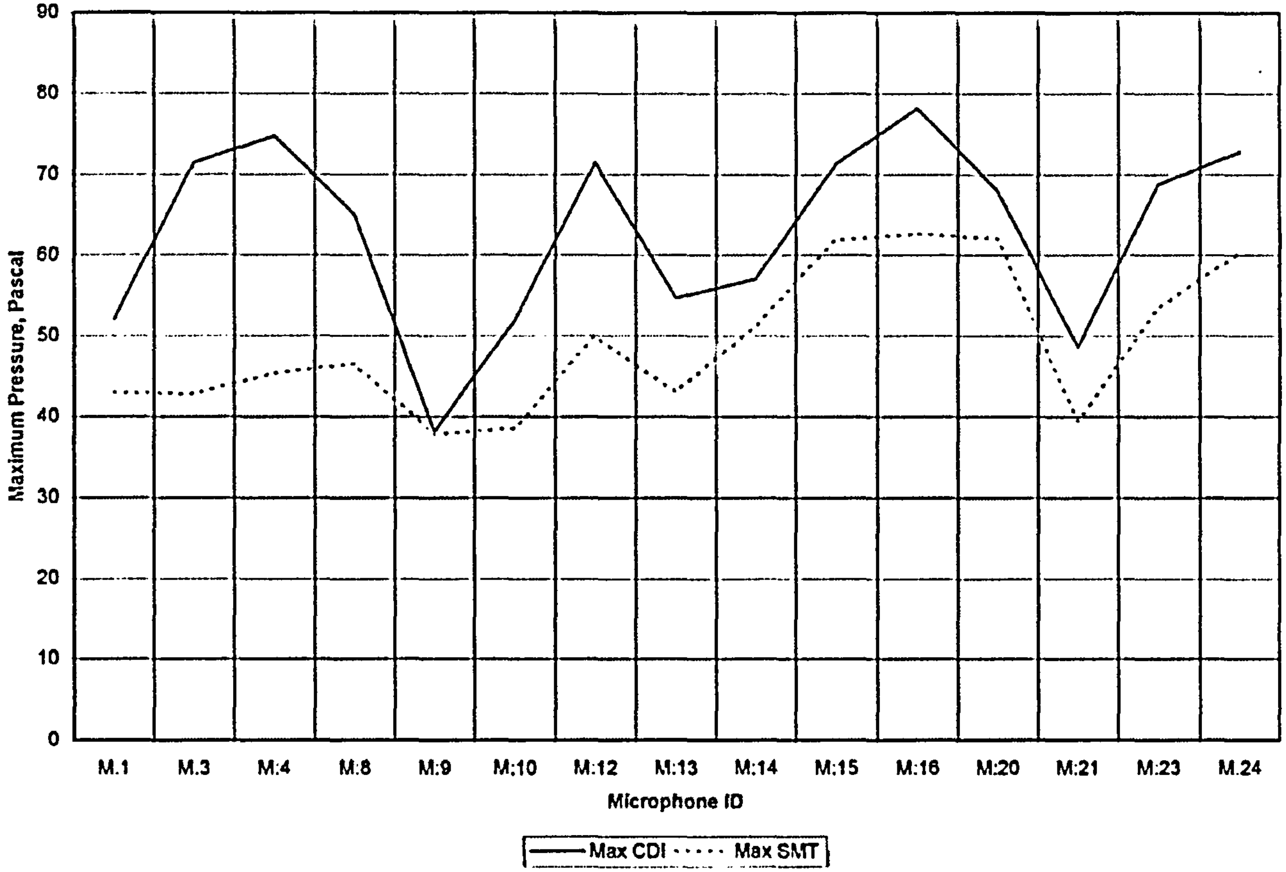


Figure EMEB-B-18-1-3

Exhibit EMEB-B-18-1 Rev. 1 -VYNPS Steam Dryer Load Uncertainty
NON-PROPRIETARY INFORMATION

Acoustic Model Benchmark
Appendix G Filtered <240 Hz, VY12R1 Chirp with 81 CFM Flow
Microphone Mall Prms

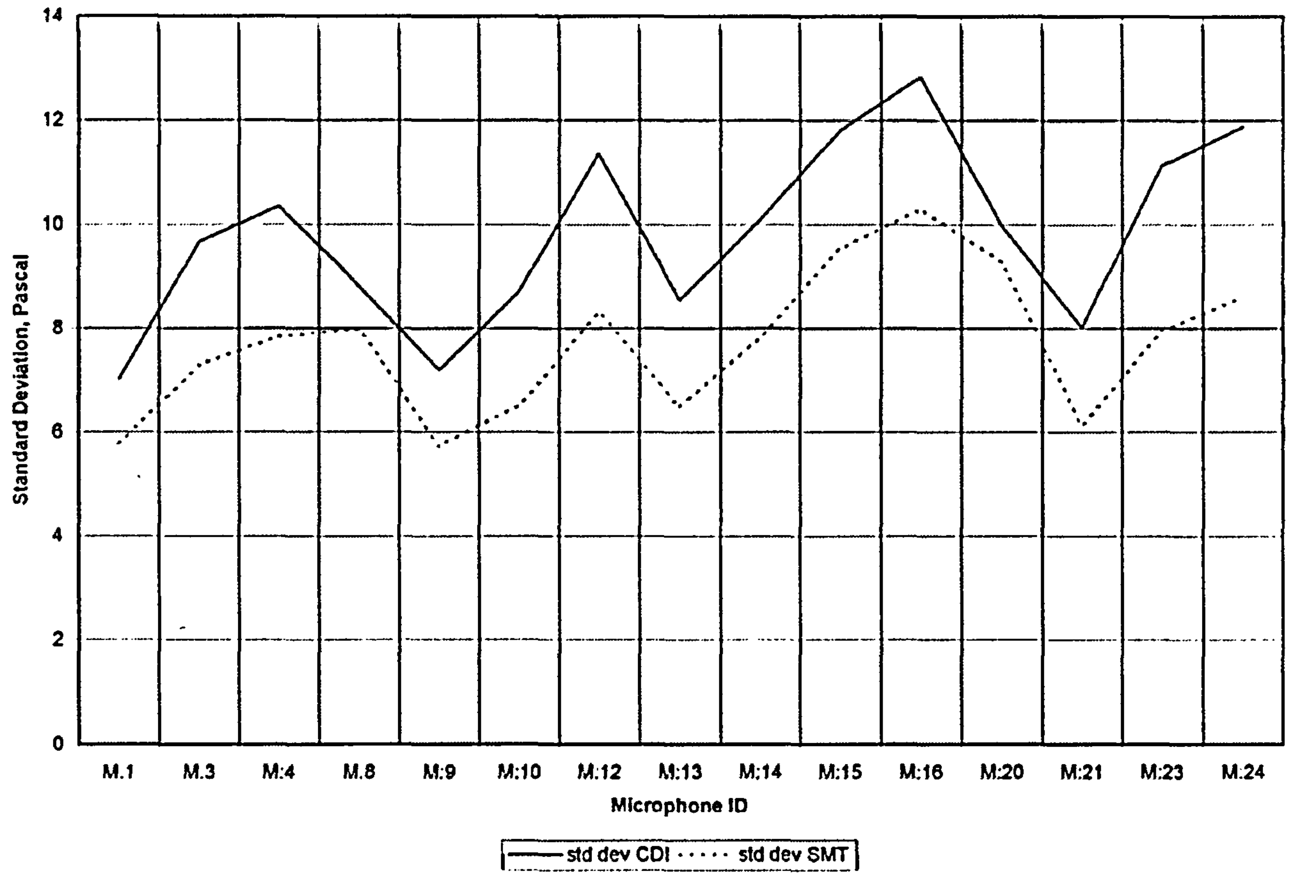


Figure EMEB-B-18-1-4

Based on the cases studied, in terms of load magnitude between 240 Hz (20Hz Full Size) and 3200 Hz (280 Hz full scale), the ACM was conservative in maximum load prediction and RMS values for all four conditions. The minimum margin above 240 Hz was 1% based on the maximum load predictions. While no additional amplitude uncertainty should be required because the ACM was shown to be conservative, a 5% ACM load uncertainty was conservatively assigned from this test.

Entergy originally stated that the ACM enveloped most of the frequency content between 240 and 3200 Hz when a +/- 10% time step was applied. The VYNPS structural assessment indicated that application of the +/- 10 % time step in the VYNPS model resulted in an increase in peak stress range for a plus time step (and a decrease in load for a minus time step). The increase in stress, as shown below based on controlling locations on the dryer, results in a load uncertainty due to frequency mismatch of approximately 20%.

Frequency Uncertainty Peak Stress (PSI)	Base Case	+10% TS	%Change
Front Vertical Hood Top Weld	2417	2900	20%
Front Hood Gusset	3238	3535	9%

Table EMEB-B-18-1-2

The uncertainty estimated from the SMT benchmark is 20%.

Uncertainty Identified in the QC2 Benchmark Tests

The CDI benchmark report, CDI 95-10 [1], provides a summary of blind benchmark predictions from QC2 at 790 MWe. At this power level, the average flow velocity in the main steamlines is about the same as that for VYNPS at EPU conditions. This ACM was done with the original parameters that matched damping, acoustic speed and reflective boundary assumptions used in the VYNPS load generation report (CDI 05-06). Therefore, this benchmark is applicable for the current VY ACA load uncertainty. It should be noted that Exelon updated their model based on this benchmark and additional tests at EPU power on QC2 to provide further improvements in the accuracy of their ACA for their plants. The CDI report CDI 95-10 included limited 790 MWe pressure transmitter location measurements and ACA predictions.

Entergy contracted CDI [3] to use existing strain gage data from Quad Cities Unit 2 (QC2) to predict the pressure sensor data at all locations recorded on the steam dryer at 790 MWe. The purpose of this effort was to obtain a more comprehensive ACA uncertainty assessment than was available in CDI report 95-10. The steps in this prediction process included the following:

1. The 790 MWe strain gage data recorded at QC2 power ascension test condition TC32 were used. These data are the same data used to generate the 790 MWe benchmark evaluation for QC2 as reported in [1]. These data contain a trigger signal that matches the strain gage record (at 2000 samples per second) with the pressure sensor record (at 2048 samples per second). With time zeroed at trigger initiation, the data were grouped into three time intervals, each containing 131,072 time increments. The second of these time intervals was used in the benchmark comparison, and that time interval was used here as well. Thus, the strain gage data (and the pressure sensor predictions) begin at 65.536 seconds.

2. The 790 MWe blind benchmark acoustic circuit model parameters were used. These parameters are the same model parameters used to generate the VYNPS in-plant load prediction described in [2].

3. The 790 MWe blind benchmark used only one strain gage in each strain gage pair. Subsequently in the QC2 benchmark analysis, it was decided that strain gage pairs should be averaged at each main steam line location. This averaging was done here as well.

4. The 790 MWe blind benchmark did not filter any strain gage data. Subsequently in the QC2 benchmark analysis, it was decided that the 60 Hz noise spike should be filtered.

Table EMEB-B-18-1-3 compares the QC2 test data at 790 MWe to the ACA predictions. The RMS and maximum pressure range of the results are both included. This data is also presented in the Bar Graphs shown in Figures EMEB-B-18-1-5 and EMEB-B-18-1-6. This data indicates that the ACM based on the VYNPS parameters is biased low in predicting dryer load. This summary includes all 27 pressure sensors. In addition, an assessment was performed of the pressure differential at the three locations where there are sensors on the inside and outside of the dryer; P3-P13, P20-P14, and P22-P23.

Table EMEB-B-18-1-4 presents the summed RMS and Range values for all the measured and predicted data at 27 pressure transmitter locations and the 3 delta P comparisons. As shown in Table EMEB-B-18-1-6 the dryer loads are 73% higher than the loads predicted by the ACM. Based on this result, a 100% uncertainty is assigned to the ACA methodology using the VYNPS modeling parameters. The predicted loads plus 100% uncertainty have been recalculated and included in Table EMEB-B-18-1-5 and Figures EMEB-B-18-1-5 and EMEB-B-18-1-6.

Figures EMEB-B-18-1-7 through EMEB-B-18-1-10 provide a comparison of the PSD's from the test data with the PSD from the ACA predictions factored to reflect the 100% uncertainty for dryer sensors P3, P6, P9 and P12. The PSD comparisons for all locations are included in Attachment 4. Figures EMEB-B-18-1-11 through EMEB-B-18-1-13 provide the location of the QC2 dryer pressure sensors.

In general the ACM predicted reasonably well the dryer loads in the area of the steam nozzles and under predicted the loads in the other areas of the dryer. Applying a 100% uncertainty provides for a conservative overall load prediction. The Entergy steam line signals are broad band with no evidence of acoustic signal. Therefore applying a high uncertainty in the development of the VYNPS dryer limit curve factor is the best means to establish a conservative operating limit curve for power ascension monitoring.

In the event that acoustic signals are identified that challenge the VYNPS limit curve during EPU power ascension, Entergy will perform a frequency specific assessment of ACM uncertainty at the acoustic signal frequency to assess if an increase in the 100% uncertainty is required.

The frequency load uncertainty was based on the +/-10% time step assessment in the ANSYS finite element analysis. The maximum increase in stress from this analysis was 20%. Therefore the frequency uncertainty was determined to be 20%.

Exhibit EMEB-B-18-1 Rev. 1 -VYNPS Steam Dryer Load Uncertainty
NON-PROPRIETARY INFORMATION

Table EMEB-B-18-1-5 (page 1 of 2)
Test Data vs. Predictions: Comparison of RMS and Maximum Pressure Range 790 MWe

Location	P1	P2	P3	P4
RMS (Test Data)	0.1453	0.1624	0.1848	0.1041
RMS (Prediction)	0.0483	0.0658	0.1556	0.0458
RMS (Pred + Uncert)	0.0966	0.1315	0.3113	0.0915
Location	P1	P2	P3	P4
Range (Test Data)	1.1815	1.2350	1.4479	0.9088
Range (Prediction)	0.3930	0.5689	1.2298	0.3684
Range (Pred + Uncert)	0.7859	1.1378	2.4595	0.7367
Location	P5	P6	P7	P8
RMS (Test Data)	0.1160	0.1507	0.1212	0.1629
RMS (Prediction)	0.0647	0.0979	0.0441	0.0669
RMS (Pred + Uncert)	0.1295	0.1958	0.0882	0.1337
Location	P5	P6	P7	P8
Range (Test Data)	0.9627	1.2720	0.9184	1.2499
Range (Prediction)	0.5172	0.8118	0.3471	0.5518
Rang (Pred + Uncert)	1.0345	1.6235	0.6942	1.1035
Location	P9	P10	P11	P12
Range (Test Data)	0.1786	0.1271	0.1434	0.2268
Range (Prediction)	0.1099	0.0462	0.0707	0.1506
Range (Pred + Uncert)	0.2198	0.0925	0.1413	0.3011
Location	P9	P10	P11	P12
RMS (Test Data)	1.2772	1.0526	1.2264	1.6111
RMS (Prediction)	0.8805	0.3727	0.5838	1.2425
RMS (Pred + Uncert)	1.7609	0.7454	1.1676	2.4849
Location	P13	P14	P15	P16
Range (Test Data)	0.0765	0.1435	0.2278	0.0806
Range (Prediction)	0.0302	0.0301	0.0829	0.0311
Range (Pred + Uncert)	0.0604	0.0602	0.1658	0.0622
Location	P13	P14	P15	P16
Range (Test Data)	0.6543	0.8673	1.5022	0.5706
Range (Prediction)	0.1753	0.1728	0.7009	0.1902
Range (Pred + Uncert)	0.3506	0.3455	1.4019	0.3803

Exhibit EMEB-B-18-1 Rev. 1 -VYNPS Steam Dryer Load Uncertainty
NON-PROPRIETARY INFORMATION

Table EMEB-B-18-1-5 (page 2 of 2)
Test Data vs. Predictions: Comparison of RMS and Maximum Pressure Range 790 MWe

Location	P17	P18	P19	P20
RMS (Test Data)	0.1085	0.1869	0.1136	0.2072
RMS (Prediction)	0.0437	0.0543	0.0603	0.2009
RMS (Pred + Uncert)	0.0875	0.1086	0.1205	0.4017

Location	P17	P18	P19	P20
Range (Test Data)	0.8581	1.1786	0.9971	1.5425
Range (Prediction)	0.3403	0.4272	0.4588	1.3741
Range (Pred + Uncert)	0.6805	0.8543	0.9176	2.7482

Location	P21	P22	P23	P24
Range (Test Data)	0.3466	0.1731	0.0560	0.1082
Range (Prediction)	0.3002	0.1075	0.0293	0.0874
Range (Pred + Uncert)	0.6003	0.2151	0.0586	0.1747

Location	P21	P22	P23	P24
RMS (Test Data)	2.5073	1.4137	0.4610	0.9339
RMS (Prediction)	1.8061	0.9239	0.1637	0.7075
RMS (Pred + Uncert)	3.6123	1.8477	0.3273	1.4151

Location	P25	P26	P27
Range (Test Data)	0.1780	0.0503	0.0908
Range (Prediction)	0.1219	0.0315	0.0306
Range (Pred + Uncert)	0.2437	0.0629	0.0613

Location	P25	P26	P27
Range (Test Data)	1.3449	0.3897	0.6019
Range (Prediction)	1.0051	0.1882	0.1802
Range (Pred + Uncert)	2.0101	0.3764	0.3604

Location	P3 - P13	P20 - P14	P22 - P23
RMS (Test Data)	0.2067	0.2427	0.1556
RMS (Prediction)	0.1540	0.1991	0.1049
RMS (Pred + Uncert)	0.3079	0.3982	0.2098
		0	0

Location	P3 - P13	P20 - P14	P22 - P23
Range (Test Data)	1.6118	1.7344	1.2872
Range (Prediction)	1.2217	1.3819	0.8463
Range (Pred + Uncert)	2.4435	2.7638	1.6926

Exhibit EMEB-B-18-1 Rev. 1 -VYNPS Steam Dryer Load Uncertainty
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Table EMEB-B-18-1-6
Test Data vs. Predictions: Summation of RMS and Maximum Pressure Range 790 MWe
Development of Uncertainty Values

Sum RMS Test Data all Sensors	4.57
Sum RMS Predicted all Sensors	2.66
Ratio (Sum Test) / (Sum Predicted)	1.71
Sum Range Test Data all Sensors	34.8
Sum Range Predicted all Sensors	20.1
Ratio (Sum Test) / (Sum Predicted)	1.72
Maximum Ration RMS & Range	173%
Uncertainty=Ratio – 100%	73%
Recommended Uncertainty	100%

References

[1] Continuum Dynamics, Inc. 2005. Evaluation of Continuum Dynamics, Inc. Steam Dryer, Load Methodology. C.D.I. Report No. 05-10.

[2] Continuum Dynamics, Inc. 2005. Analysis of Steam Dryer Differential Pressure Loads at Vermont Yankee. C.D.I. Technical Memorandum No. 05-06.

[3] Entergy Purchase Order No. 4500531980 Revision 0, A Further Examination of Quad Cities Unit 2 In-Plant Data at 790 MWe, Continuum Dynamics, Inc. Technical Note No. 05-38, 09 September 2005.

Exhibit EMEB-B-18-1 Rev. 1 -VYNPS Steam Dryer Load Uncertainty
NON-PROPRIETARY INFORMATION

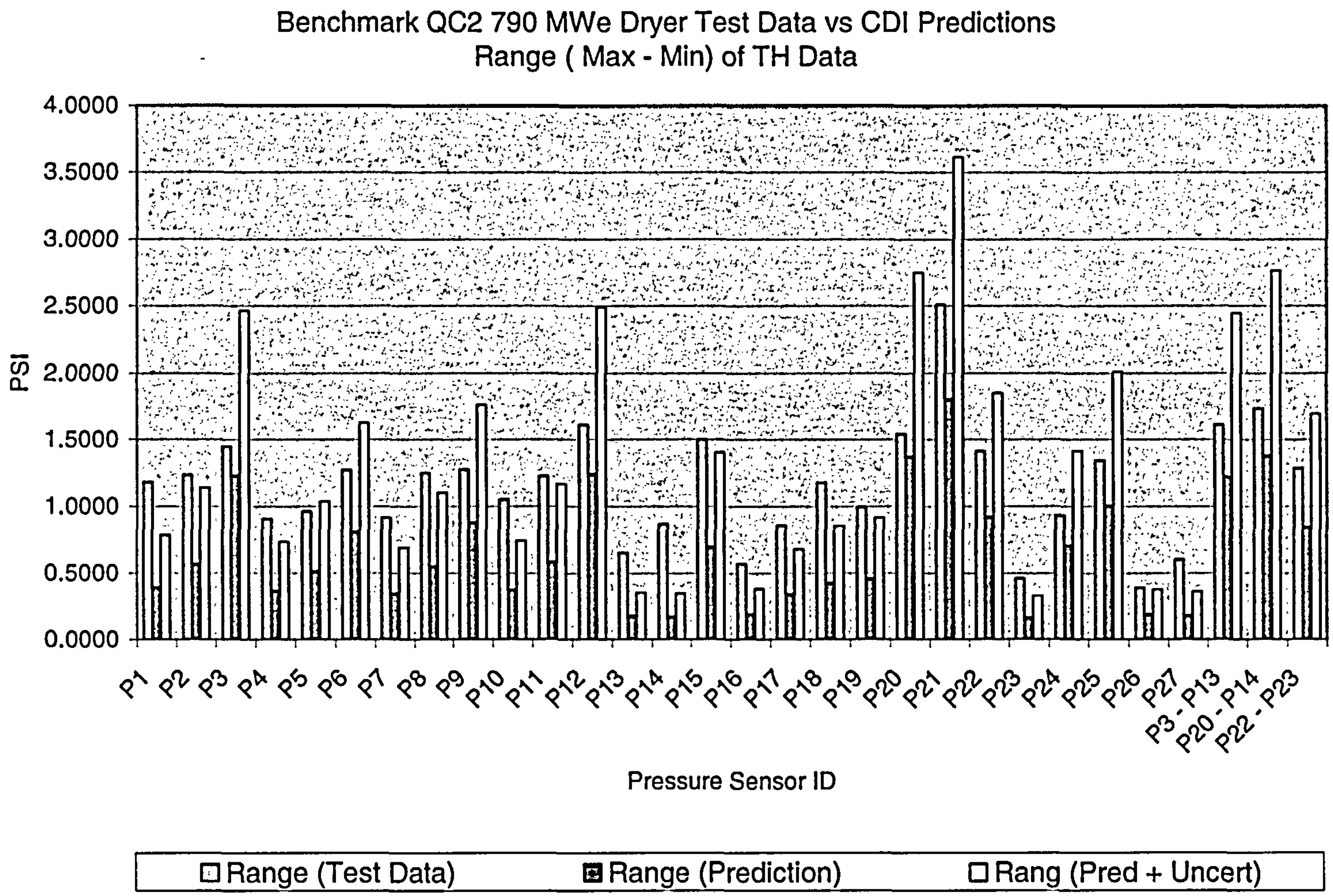

Figure EMEB-B-18-1-5

Exhibit EMEB-B-18-1 Rev. 1 -VYNPS Steam Dryer Load Uncertainty
NON-PROPRIETARY INFORMATION

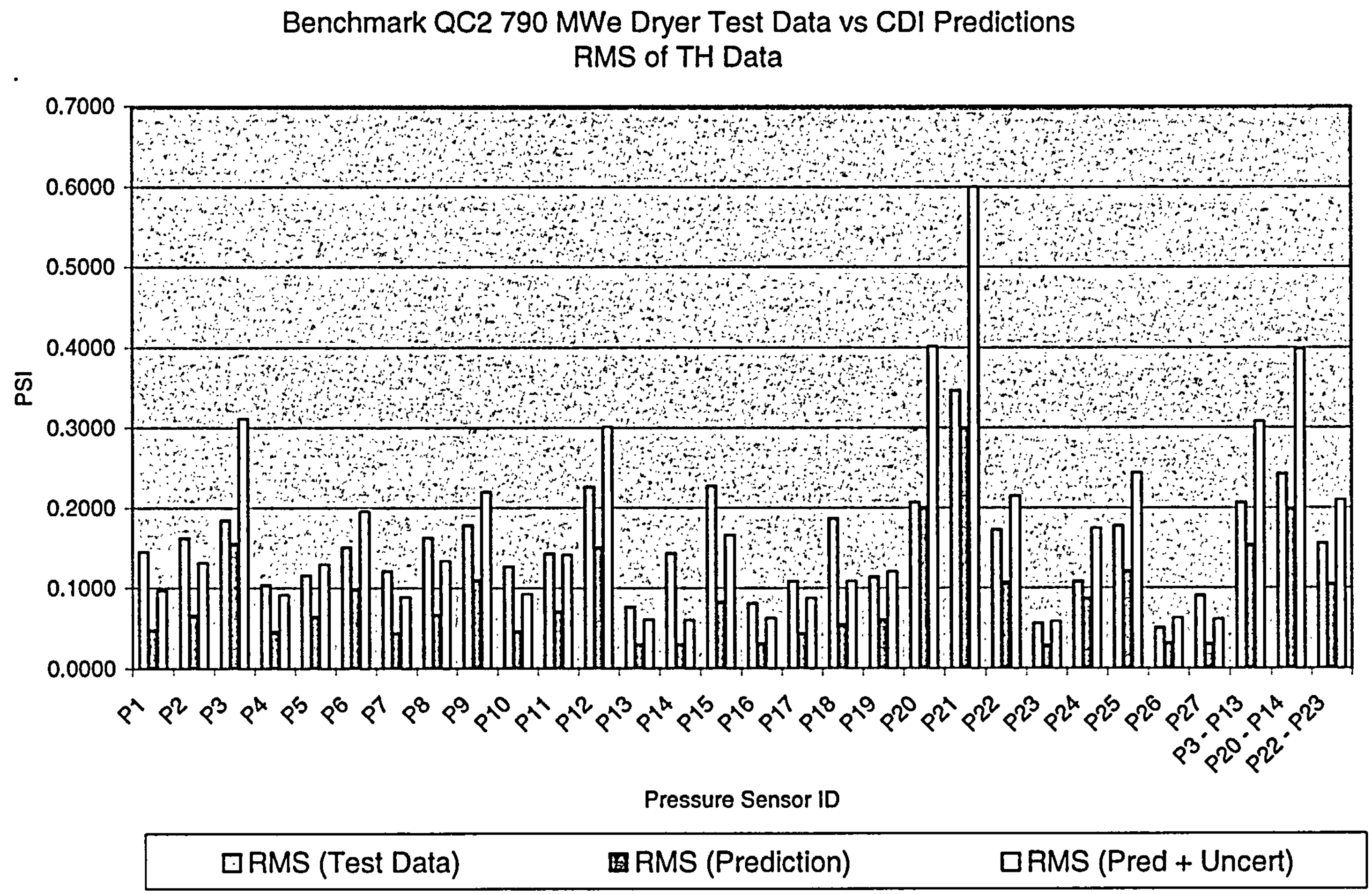

Figure EMEB-B-18-1-6

Exhibit EMEB-B-18-1 Rev. 1 -VYNPS Steam Dryer Load Uncertainty
NON-PROPRIETARY INFORMATION

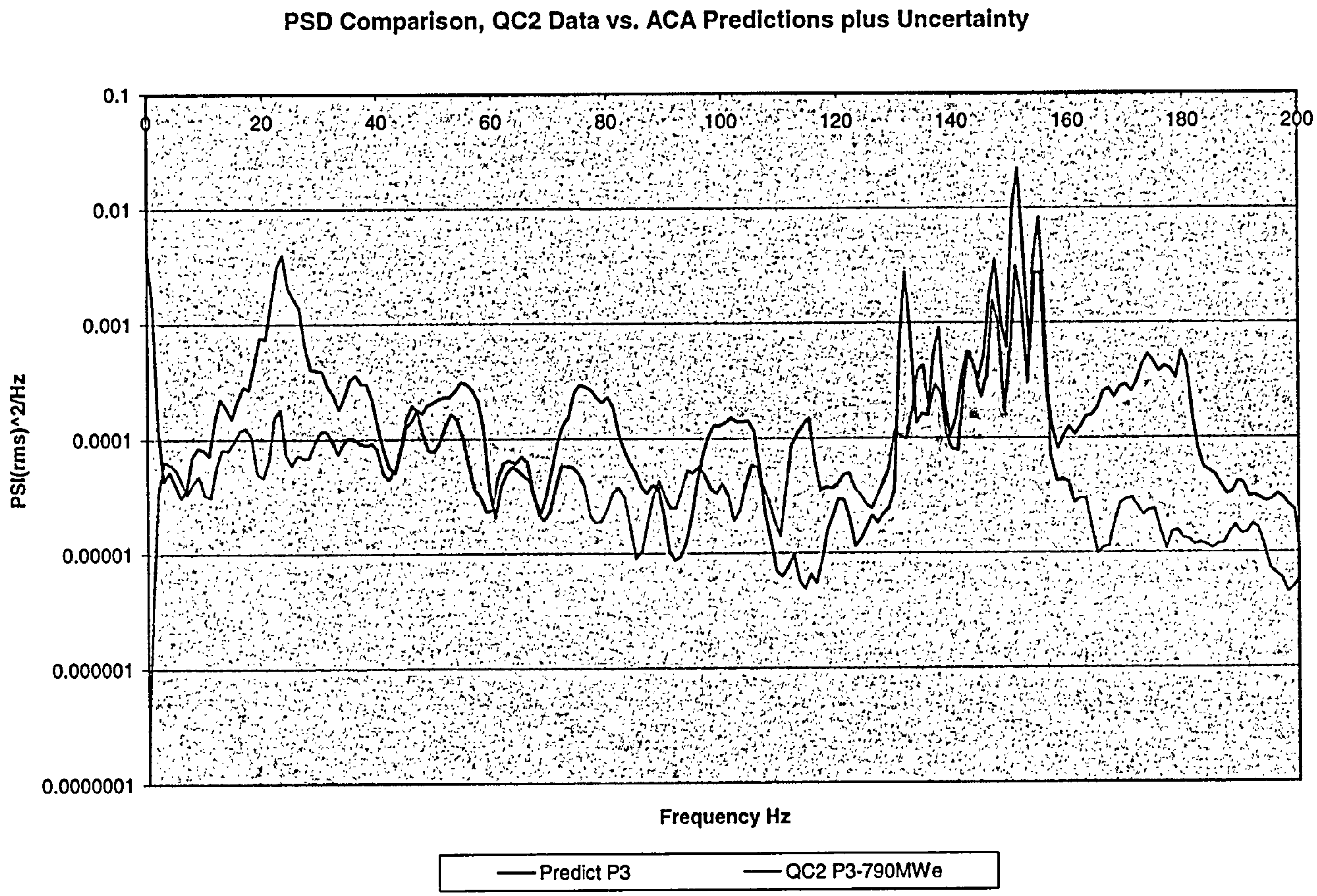

Figure EMEB-B-18-1-7

Exhibit EMEB-B-18-1 Rev. 1 -VYNPS Steam Dryer Load Uncertainty
NON-PROPRIETARY INFORMATION

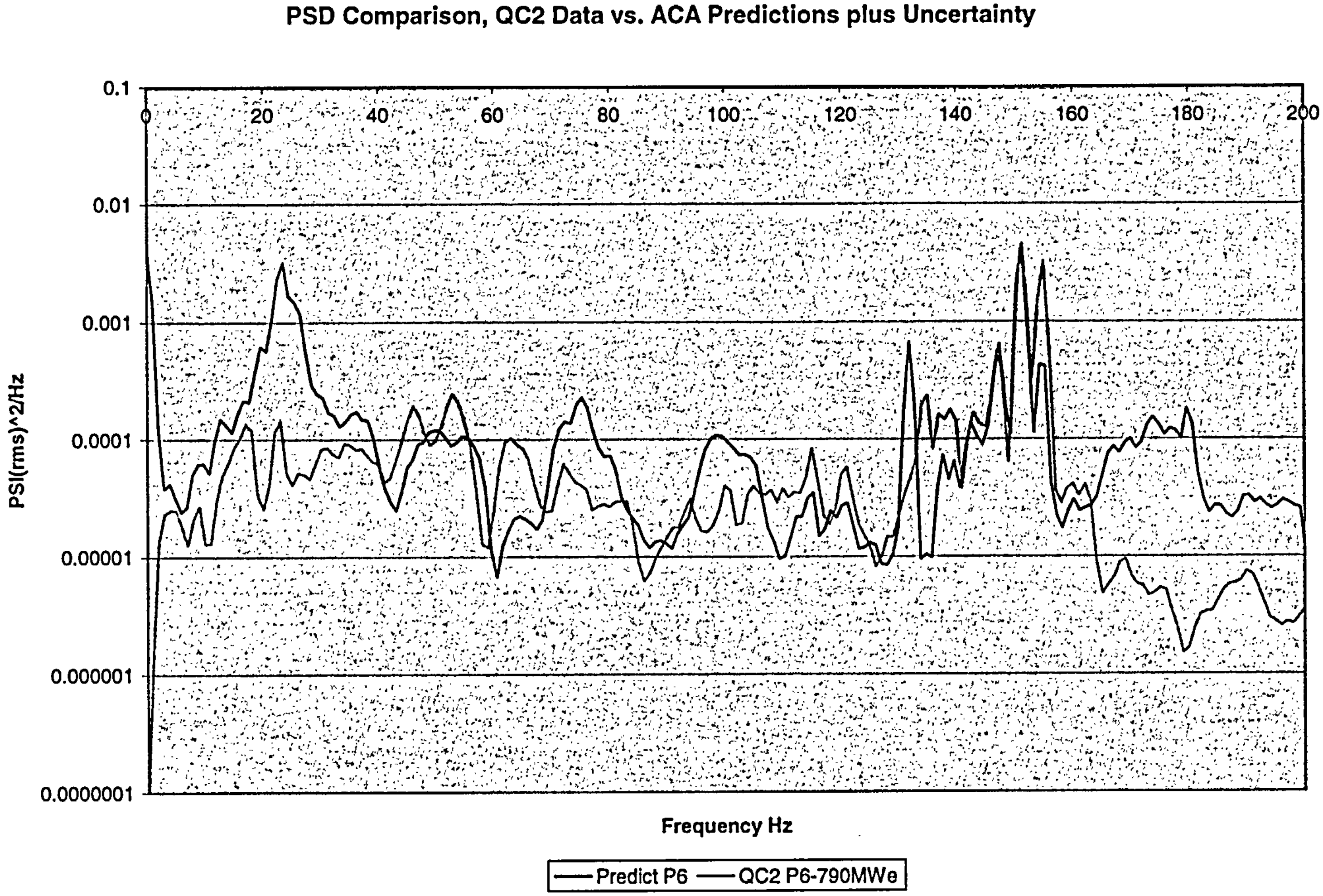

Figure EMEB-B-18-1-8

Exhibit EMEB-B-18-1 Rev. 1 -VYNPS Steam Dryer Load Uncertainty
NON-PROPRIETARY INFORMATION

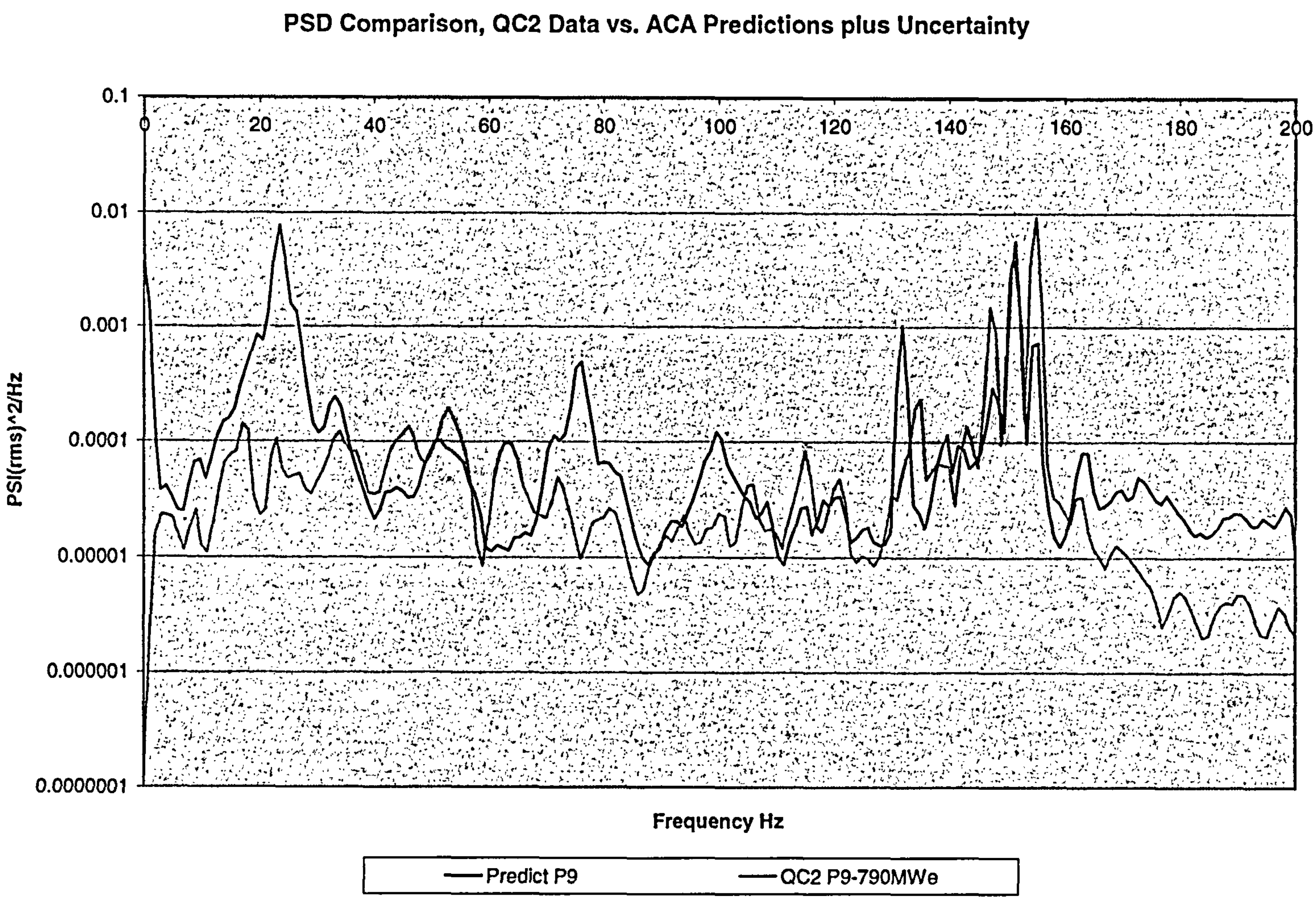

Figure EMEB-B-18-1-9

Exhibit EMEB-B-18-1 Rev. 1 -VYNPS Steam Dryer Load Uncertainty
NON-PROPRIETARY INFORMATION

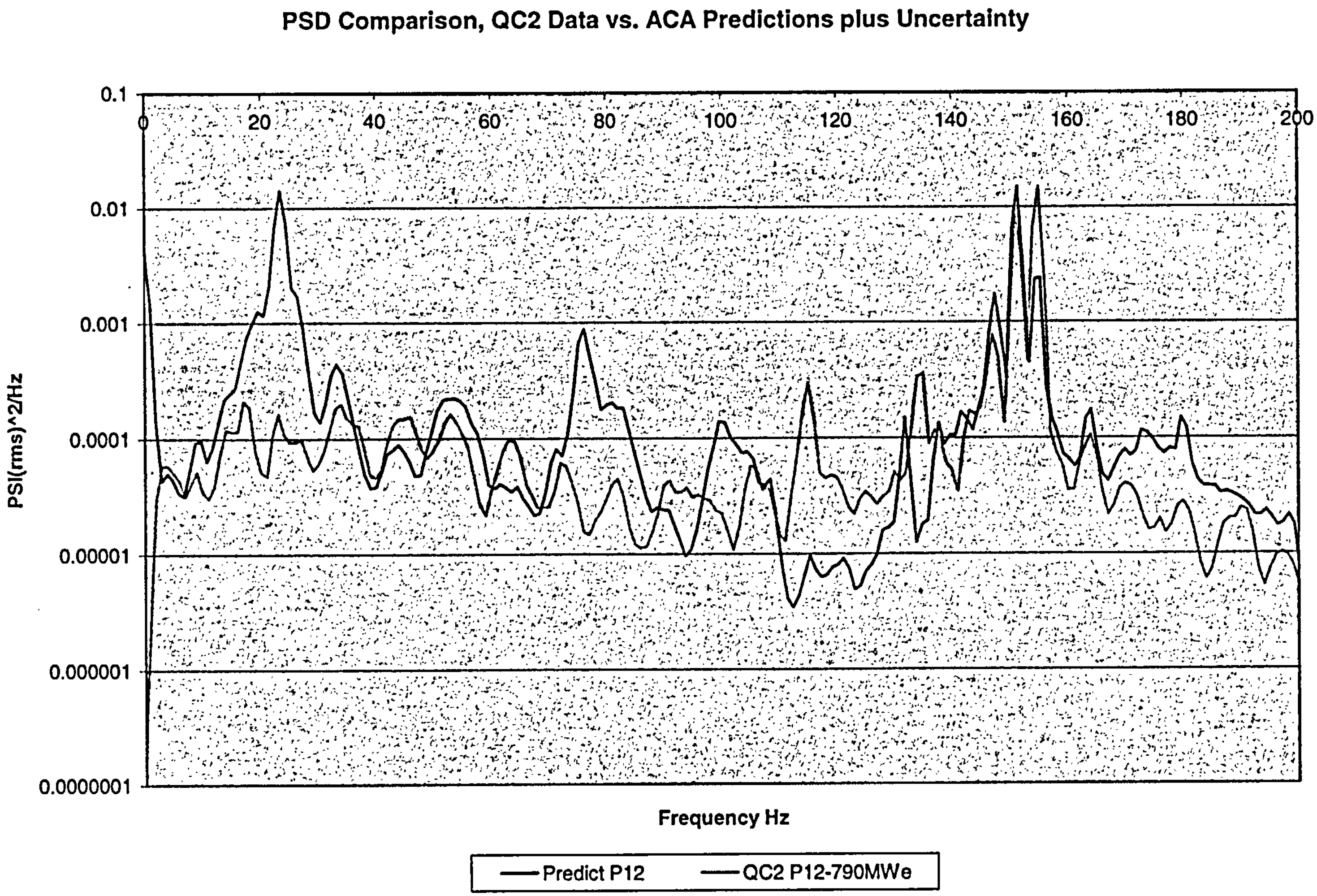

Figure EMEB-B-18-1-10

Exhibit EMEB-B-18-1 Rev. 1 -VYNPS Steam Dryer Load Uncertainty
NON-PROPRIETARY INFORMATION

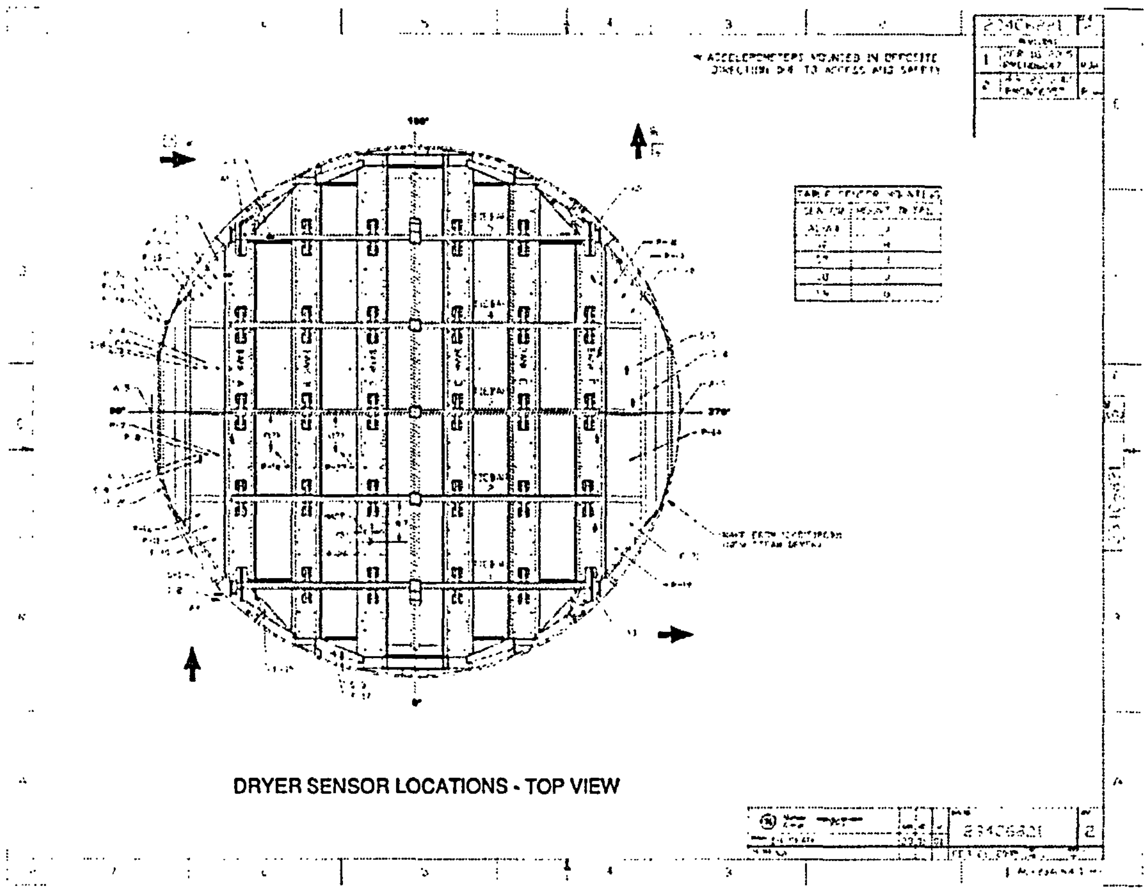

Figure EMEB-B-18-1-11
QC2 Dryer Pressure Sensor Locations

Exhibit EMEB-B-18-1 Rev. 1 -VYNPS Steam Dryer Load Uncertainty
NON-PROPRIETARY INFORMATION

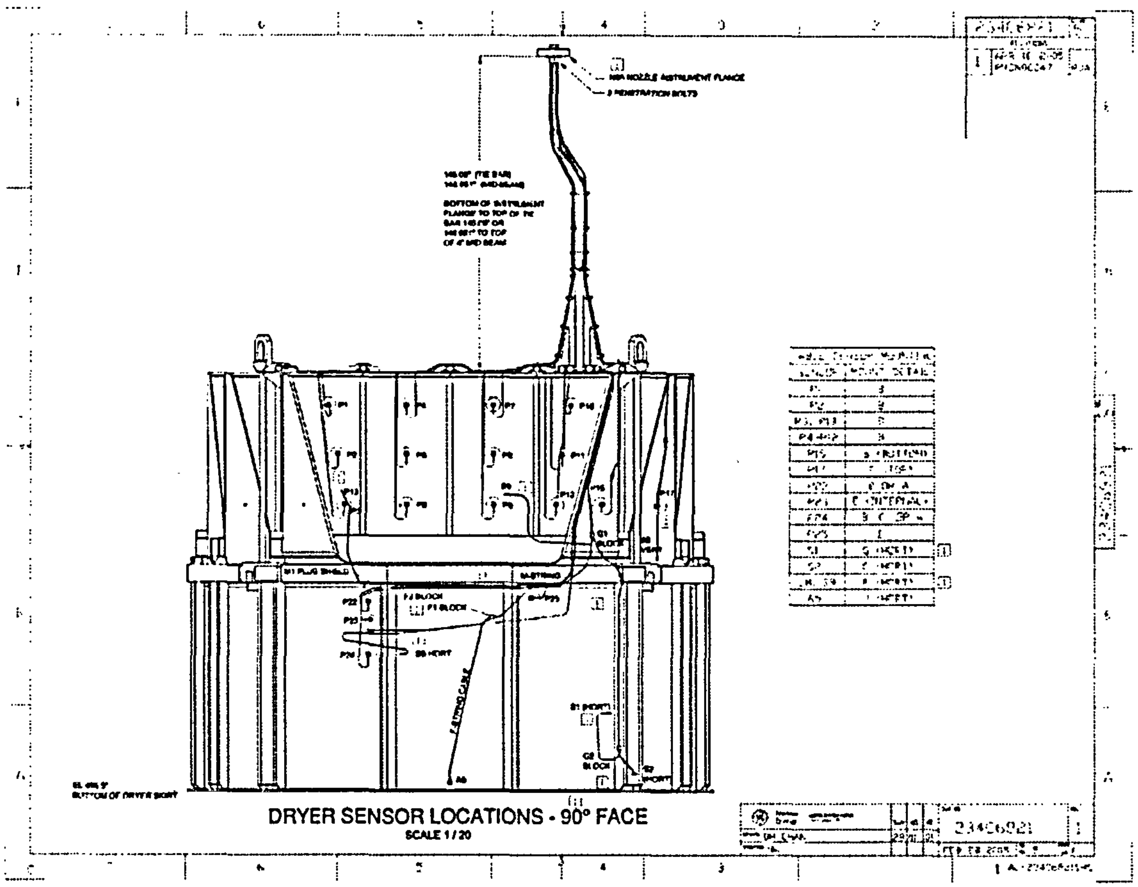

Figure EMEB-B-18-1-12
QC2 Dryer Pressure Sensor Locations

Exhibit EMEB-B-18-1 Rev. 1 -VYNPS Steam Dryer Load Uncertainty
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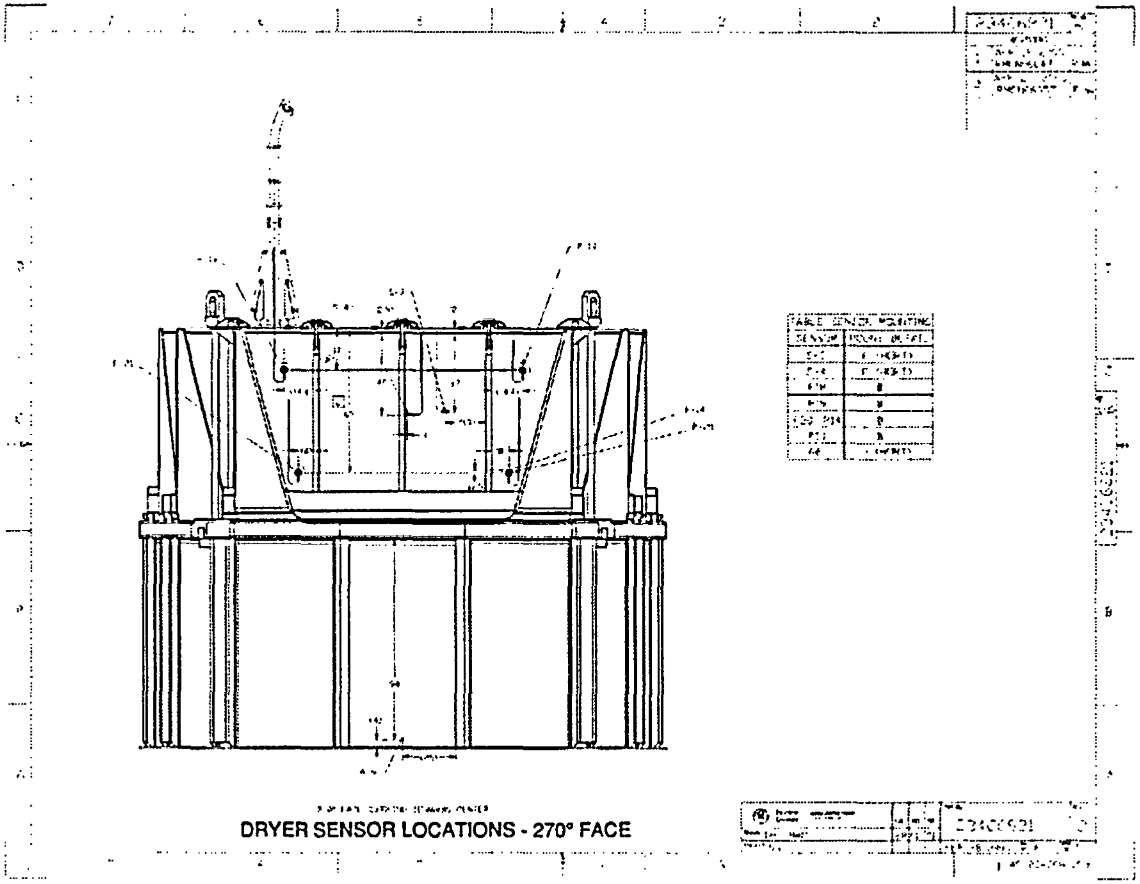

Figure EMEB-B-18-1-13
QC2 Dryer Pressure Sensor Locations

Uncertainty Introduced by the Measurement Location

The accuracy of the predicted load is based on relative location of sensing point in the steam line vs. the location of the sampling point used in the Benchmark Assessment. Table EMEB-B-18-1-7 compares the VYNPS measurement locations to those used in the SMT and QC2 Benchmarks.

Acoustic Model Pressure Sensor Location					
Facility	Description	MSL A	MSL B	MSL C	MSL D
VY Plant	Strain Gage Location (ft)	37.13	37.13	37.13	37.13
VY Plant	Venturi Line Entrance (ft)	96.84	80.88	80.88	96.84
GE SMT	P1 (ft)	1.474	1.391	1.391	1.474
GE SMT	P2 (ft)	4.438	5.094	5.161	4.438
GE SMT	P1 scaled By 17.3	25.50	24.06	24.06	25.50
GE SMT	P2 scaled By 17.3	76.78	88.13	89.29	76.78
QC2 Benchmark	Elev 651 (ft)	9.50	9.50	9.50	9.50
QC2 Benchmark	Elev 624 (ft)	41.00	41.33	41.33	41.00

Table EMEB-B-18-1-7

As noted the sensors in the QC2 benchmark were closer to the reactor steam nozzles than they are in the VYNPS plant. Therefore due to acoustic losses in the steam line CDI performed an assessment of the uncertainty introduced in the benchmark load associated with this difference in location and the difference in optimal QC damping developed from the steam line QC 2 benchmark and the damping used in the VY model. The maximum measurement location uncertainty in QC dryer loads from the assessment included in Attachments 1, 2, and 3 was an RMS uncertainty of 53%.

Maximum Uncertainty of the ACA Methodology

From this evaluation of the VYNPS SMT benchmark and QC2 benchmark, the VYNPS ACA methodology uncertainty (uncACM1) is calculated by the SRSS method to be 115%. Table EMEB-B-18-1-8 summarizes the uncertainty contributions.

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Bounding Benchmark Uncertainties		
ACM Benchmark Uncertainty	QC2 790 BM	SMT BM
Frequency Peak Uncertainty	20%	20%
Minimum RMS/Max Uncertainty	100%	5%
Sensor Location uncertainty	53%	
SRSS of Uncertainty	115%	21%
Maximum ACA Uncertainty for VYNPS Model	115%	

Table EMEB-B-18-1-8

Uncertainty Introduced by the Measurement Method

A parametric study was performed by CDI to assess the variation in VYNPS dryer loads as a function of variation in input data magnitude. This study provided nine sets of time history loads across the dryer. The first set is the base case used in the analysis of the VYNPS dryer. The balance varied each of the eight sets that were derived by varying one input parameter by 10% and determined the impact on the dryer transient loads.

From the structural analysis it was observed that the dryer response under the acoustic loads was driven by loads on the vertical face of the dryer. The PSD of the dryer loads shown in CDI Report 05-06 (Supplement 26, Attachment 7) shows that there are no outstanding acoustic signals of note from 0 through 200 Hz. The dryer load could be characterized as a broad band signal. Therefore, to assess the impact of input variations on dryer loads, peak response and RMS values were used to assess the change in dryer load as a function of input change. Points 7 and 99 as shown in Figure 9 of CDI report 05-06 (Supplement 26, Attachment 7) are at the location of maximum RMS and peak pressures on the dryer face. Therefore, these points were used in the assessment. The result of the CDI parametric evaluation is included as Attachment 1 to this Exhibit. Tables EMEB-B-18-1-1-1 and EMEB-B-18-1-1-2 provide copies of the final values:

The venturi measurement uncertainty is driven by four sources:

1) UncVent1: The uncertainty acoustic modeling and methodology used to develop the transfer function of the sensing lines.
2) UncVent2: The uncertainty in the dynamic properties of the Rosemount transmitters mounted on the sensing lines, referred to here as compliance.
3) UncVent3: The accuracy of the instrumentation used in the mockup testing.
4) UncVent4: The accuracy of the instrumentation used to collect the plant data.

These uncertainties are then combined by the SRSS method to assess the venturi measurement uncertainty for both the RMS and maximum response of the signal.

$$UncVent=Sqrt\ (UncVent1^2 + UncVent2^2 + UncVent3^2 + UncVent4^2)$$

Attachment 2 to this Exhibit provides the methodology to assess UncVent1, the transfer function uncertainty and UncVent2 the uncertainty in the steam transfer function as a function of the uncertainty in the Rosemount compliance. Table EMEB-B-18-1-9 provides a summary of uncertainty input and calculated values.

The transfer function uncertainty was calculated based on evaluations performed on four steam line signals from QC2. In this uncertainty assessment Entergy used the maximum value from the four tests.

The Rosemont transmitters have isolation diaphragm that can be included in the steam acoustic model of the sensing system as a mass/spring/damper. The spring is the most important parameter and the combined characteristics are referred to as compliance. In CDI 95-06 the compliance values were based on published values by Rosemount along with detailed and proprietary information on the construction of the Rosemount transmitter that pertains to characterizing the dynamic properties of the transmitter.

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There was no uncertainty information available from Rosemount on the published stiffness data. In Attachment 2 CDI provides the change in the transferred signal based on a 1% change in the 100% compliance (value provided by the manufacturer). The assessment shown in Table 9 provides a acoustic load uncertainty assessment assumed an uncertainty of 30% in the compliance, UncVent2.

The test instruments used in the CDI mockup and the VYNPS plant were Sensotec high speed pressure transducers (0.25% accuracy) with a 16 bit data acquisition system. An uncertainty of 5% was used as a conservative bound to this equipment's uncertainty. It should be noted that the total uncertainty is primarily influenced by the transfer function uncertainty, uncVent1. Because the compliance uncertainty and pressure instrument uncertainty have a small impact on the total uncertainty, further refinement of these values was not deemed necessary.

Venturi RMS Signal Uncertainty							
		UncVent(RMS)	UncVent1	UncVent2		UncVent3	UncVent4
		Venturi Line Total Uncertainty	Maximum Transfer Function Uncertainty	Instrument Compliance Uncertainty	Transfer Function Error Due to % Compliance Uncertainty	Uncertainty due to Instrument Error at Mockup	Uncertainty due to Instrument Error at in Plant
A	Venturi Inlet	179%	177%	30%	82%	5.00%	5.00%
B	Venturi Inlet	177%	177%	30%	33%	5.00%	5.00%
C	Venturi Inlet	177%	177%	30%	35%	5.00%	5.00%
D	Venturi Inlet	179%	177%	30%	86%	5.00%	5.00%
Venturi Maximum Signal Uncertainty							
		UncVent	UncVent1	UncVent2		UncVent3	UncVent4
		Venturi Line Total uncertainty	Maximum Transfer Function Uncertainty	Instrument Compliance Uncertainty	Transfer Function Error Due to % Compliance Uncertainty	Uncertainty due to Instrument Error at Mockup	Uncertainty due to Instrument Error at in Plant
A	Venturi Inlet	128%	128%	30%	25%	5.00%	5.00%
B	Venturi Inlet	128%	128%	30%	23%	5.00%	5.00%
C	Venturi Inlet	128%	128%	30%	32%	5.00%	5.00%
D	Venturi Inlet	128%	128%	30%	30%	5.00%	5.00%

Table EMEB-B-18-1-9

Uncertainty in the dryer loads is driven by uncertainty in the input pressure as calculated from VYNPS SG data. The uncertainty is from two sources:

a. UnSG1: The uncertainty of using the VYNPS equipment to measure pressure in the pipe. Entergy has used strain gages and a National Instrument DAS acquisition to collect stain gage data and correlate that data to average hoop strain and pressure. This uncertainty value includes the uncertainty of the strain acquisition equipment and the uncertainty in pipe thickness.

b. UncSG2: At very low strain levels, data from QC2 demonstrated that the dynamic signal can vary azimuthally around the pipe. VYNPS has two strain gages orientated in the hoop direction at one azimuth location. Data from QC2 with four strain gages 90 degrees apart demonstrate that when there are high flow induced vibration (FIV) signals the local pipe distortion can add significant content to the signal. This uncertainty is added to reflect the non-conservative uncertainty introduced by using a single strain input to assess average circumferential strain.

The UncSG1 uncertainty values were developed by Structural Integrity Associate (SIA) in Calculation VY-13Q-305. Based on VYNPS pipe thickness data and the accuracy of the VYNPS SG data acquisition equipment, SIA calculated a measurement uncertainty of 8.74%. Therefore a conservative assignment was made of UncSG1 = 10%.

The strain gage (SG) configuration used in the development of acoustic loads for the VYNPS dryer included two strain gages at the same circumferential location on the pipe. The strain gage signal was converted to a pressure signal assuming the strain could be directly correlated to hoop strain. It had been subsequently determined through QC2 testing that local pipe strain (e.g., due to bending) can add additional signal that is not related to hoop strain. This additional strain signal appears as a higher pressure input to the ACM and results in a conservative over-prediction of the pressure loads on the steam dryer. Benchmarking of the ACM found that averaging the strain signals from 4 points 90 degrees around the pipe provided a significant reduction in the extraneous signals. Figures EMEB-B-18-1-14 through EMEB-B-18-1-17 show the individual strain signals compared to the averaged strain signal. These comparisons show the magnitude of the extraneous signals. Table EMEB-B-18-1-10 compare the RMS and range of the individual signals to the RMS and Range of the averaged signals. As noted, both the RMS and range data from a single strain gage are, in all cases, more conservative than the averaged data.

Summary of QC 2 data Comparing Averaged SG Data to the data from Each Gage				
	Range	RMS	Range	RMS
Ave MSL B 651'	3.28	0.39	gage/ave	gage/ave
S7	4.42	0.49	35%	26%
S9	4.99	0.68	52%	75%
S8	3.78	0.50	15%	30%
S10	5.68	0.76	73%	98%
	Range	RMS	Range	RMS
Ave MSL B 621'	2.47	0.30	gage/ave	gage/ave
S11	4.74	0.58	92%	96%
S11A	3.03	0.38	23%	30%
S12	4.30	0.51	74%	72%
S12A	4.77	0.60	93%	104%
	Range	RMS	Range	RMS
Ave MSL C 651'	3.85	0.49	gage/ave	gage/ave
S31	4.03	0.58	5%	18%
S33	5.96	0.58	55%	17%
S32	5.77	0.87	50%	77%
S34	5.73	0.75	49%	51%
	Range	RMS	Range	RMS
Ave MSL C 621'	2.10	0.25	gage/ave	gage/ave
S35	3.04	0.38	45%	54%
S35A	4.30	0.58	104%	136%
S36	3.84	0.50	83%	103%
S36A	4.48	0.54	113%	118%
			Range	RMS
			gage/ave	gage/ave
		Minimum	5%	17%
		Maximum	113%	136%

Table EMEB-B-18-1-10

In response to RAI EMEB-B-118 and based on the above comparison, Entergy assessed that the VYNPS SG data was broad band and therefore RMS and Max values were an appropriate method of comparison. Entergy assigned an additional 10% uncertainty to this the condition where a spike may challenge the VYNPS Limit Curve.

As a result of discussions during the August 2005 VYNPS Dryer analysis audit, Entergy considered application of a more conservative assessment and incorporating statistical evaluation of the signal at peak frequencies. Entergy concluded that this type of assessment would be more appropriate for the condition where a pressure spike challenges the VYNPS limit curve.

Entergy's assessment is provided in Tables EMEB-B-18-1-11 and EMEB-B-18-1-12.

The upper section of Table EMEB-B-18-1-11 provides a summary of the QC2 strain gage PSD data at peak response frequencies. The PSD values for single SG are shown along with the PSD value for the averaged time domain signal from the 4 gages. Table EMEB-B-18-1-12 provides the error associated with the single Strain Gage value when compared with the average value. These error values are calculated as

%Error=Sqrt(PSDsg/PSDavg)-100%

The radical converts the Error from PSD, PSIrms^2/Hz, to Pressure, PSI.

In summary, using the ¼ point data would likely result in a very conservative estimate of average strain. Individual signals at the peak frequencies were on average 57% higher than hoop strain. The standard deviation in the data was 117%. Therefore the SG non-conservative uncertainty was established as 57.3% - 116.7% = -59%.

The Limit Curve Uncertainty has been recalculated based on the 60% SG uncertainty (rounded up from 59%). Two strain gage signals contribute to dryer loads on each face. Therefore it would be unlikely that the SG signal would be underestimated in two lines. Entergy has also committed to install 4 SGs at two addition points on each line and monitor all SG signals during power ascension. Including the 60% SG Uncertainty in the development of the VYNPS Limit Curve is a very conservative approach that is to be used for the establishing the initial curve. Once additional data from multiple SGs is available and the Limit Curve developed based on this new data, additional 60% uncertainty can be eliminated.

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Table EMEB-B-18-1-11

QC2 Strain Gage 1/4 Bridge PSD Data, PSI(rms)^2/Hz, Sampled at Peak Frequencies									
Frequency	**98.6**	**138.7**	**139.6**	**151.4**	**152.3**	**154.3**	**155.3**	**160.2**	**161.1**
S7	1.7E-03	1.5E-02	4.0E-03	5.6E-03	6.2E-03	2.8E-02	2.5E-02	1.1E-02	2.9E-03
S9	1.9E-03	1.1E-02	2.1E-03	1.5E-01	1.8E-02	1.7E-02	1.5E-02	4.1E-03	1.4E-03
S8	8.5E-05	5.0E-03	2.7E-03	1.8E-02	2.1E-02	1.3E-02	1.2E-02	4.3E-03	1.1E-03
S10	6.8E-05	1.8E-02	2.3E-03	1.5E-01	1.8E-02	7.0E-02	6.3E-02	3.5E-04	3.0E-04
Ave MSL B 651'	**3.8E-04**	**1.9E-03**	**9.3E-04**	**3.3E-02**	**5.7E-03**	**1.6E-02**	**1.4E-02**	**5.5E-04**	**1.6E-04**
S11	9.7E-05	7.2E-02	1.6E-02	3.4E-02	5.7E-03	1.9E-03	1.8E-03	1.7E-02	8.0E-03
S11A	9.6E-05	5.5E-03	7.0E-04	1.7E-02	2.0E-03	3.4E-03	3.0E-03	8.2E-03	4.5E-03
S12	1.2E-04	1.9E-02	4.8E-03	4.7E-02	8.3E-03	4.0E-03	3.0E-03	2.2E-03	2.3E-03
S12A	5.8E-05	3.2E-02	5.1E-03	2.2E-02	5.8E-03	5.4E-02	4.9E-02	9.6E-03	5.0E-03
Ave MSL B 621'	**6.1E-05**	**9.4E-03**	**2.1E-03**	**8.1E-04**	**9.9E-04**	**5.0E-03**	**4.4E-03**	**7.6E-03**	**3.9E-03**
S31	2.0E-04	3.3E-03	2.1E-03	9.3E-02	1.8E-02	1.3E-02	1.1E-02	1.4E-03	1.0E-03
S33	1.8E-04	2.6E-03	2.3E-03	9.9E-02	1.7E-02	2.4E-02	2.2E-02	5.4E-04	6.9E-04
S32	7.0E-03	3.7E-02	6.9E-03	2.0E-01	2.1E-02	4.8E-02	4.2E-02	6.5E-03	9.2E-03
S34	5.2E-03	8.1E-02	3.3E-02	8.7E-02	1.4E-02	2.5E-02	2.2E-02	1.3E-03	1.6E-03
Ave MSL C 651'	**1.9E-03**	**6.5E-03**	**2.2E-03**	**8.4E-02**	**9.5E-03**	**6.6E-03**	**5.8E-03**	**6.8E-04**	**6.7E-04**
S35	2.8E-03	4.6E-03	5.9E-03	8.5E-03	2.1E-02	1.8E-02	1.5E-02	2.0E-03	5.1E-03
S35A	1.5E-03	4.0E-02	5.1E-02	4.2E-02	2.3E-02	6.1E-03	5.2E-03	2.8E-04	6.0E-04
S36	2.9E-03	1.3E-02	1.8E-02	4.7E-02	9.7E-03	7.9E-03	6.4E-03	6.5E-04	6.7E-04
S36A	2.1E-03	2.6E-02	3.4E-02	2.8E-02	1.7E-02	1.1E-02	8.9E-03	1.1E-03	2.3E-03
Ave MSL C 621'	**1.2E-03**	**5.1E-03**	**7.9E-03**	**2.5E-03**	**2.2E-03**	**1.6E-03**	**1.3E-03**	**3.7E-04**	**1.2E-03**

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Table EMEB-B-18-1-12

Percent Error (1/4 Brdge vs Average)= Sqrt (Value / Average) -100%									
Frequency	98.6	138.7	139.6	151.4	152.3	154.3	155.3	160.2	161.1
MSL B 651'									
S7	110%	182%	108%	-59%	5%	32%	33%	354%	320%
S9	123%	137%	51%	114%	78%	3%	2%	173%	189%
S8	-53%	63%	72%	-26%	91%	-9%	-10%	179%	158%
S10	-58%	204%	58%	113%	79%	109%	109%	-21%	36%
MSL B 621'									
S11	26%	176%	179%	545%	139%	-39%	-36%	50%	43%
S11A	25%	-24%	-42%	358%	44%	-17%	-17%	4%	7%
S12	42%	41%	52%	663%	189%	-11%	-18%	-46%	-24%
S12A	-2%	85%	56%	417%	142%	229%	232%	12%	13%
MSL C 651'									
S31	-83%	-70%	-45%	-31%	-8%	-48%	-48%	-55%	-67%
S33	-84%	-73%	-43%	-29%	-10%	-29%	-28%	-71%	-73%
S32	16%	-33%	-54%	50%	22%	39%	38%	120%	137%
S34	66%	253%	290%	2%	20%	95%	95%	41%	56%
MSL C 621'									
S35	-2%	-41%	-42%	-57%	47%	50%	55%	75%	176%
S35A	-27%	74%	70%	-5%	55%	-12%	-9%	-34%	-6%
S36	16%	-29%	-27%	29%	-25%	-14%	-15%	-23%	-46%
S36A	35%	128%	107%	234%	181%	156%	161%	71%	41%

Statistics All Uncertainty Data

Min= -84% Average: 57.3%
Max= 663% StdDev= 116.7%
(Average) - (StandardDeviation) = -59%

Exhibit EMEB-B-18-1 Rev. 1 -VYNPS Steam Dryer Load Uncertainty

NON-PROPRIETARY INFORMATION

Figure EMEB-B-18-1-14

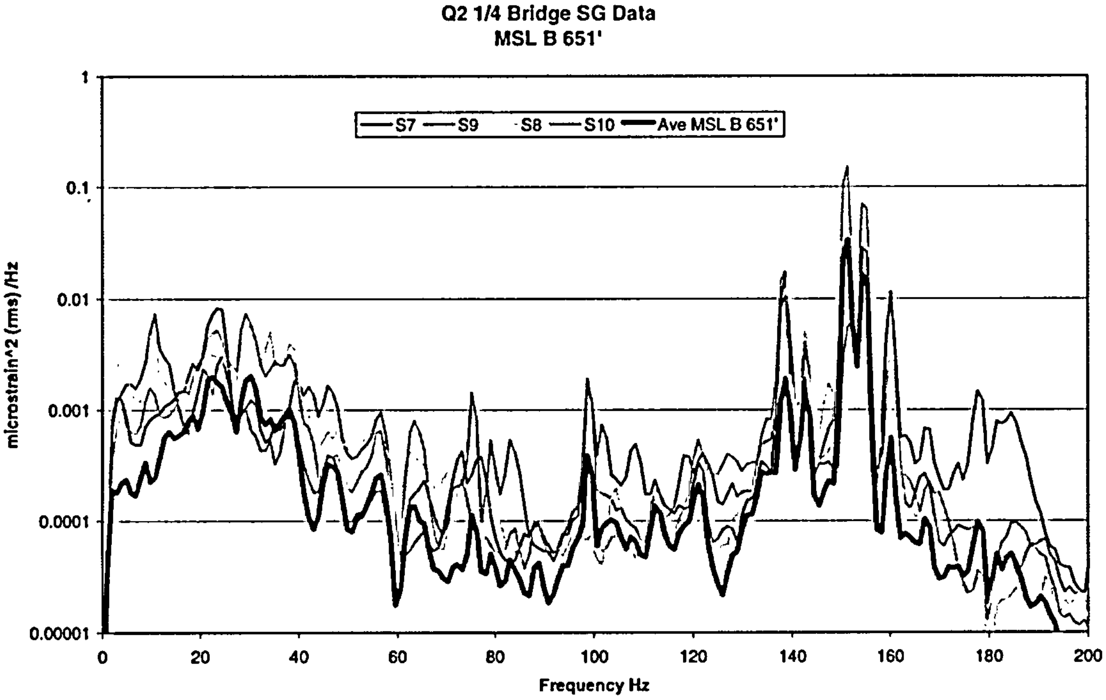


Figure EMEB-B-18-1-15

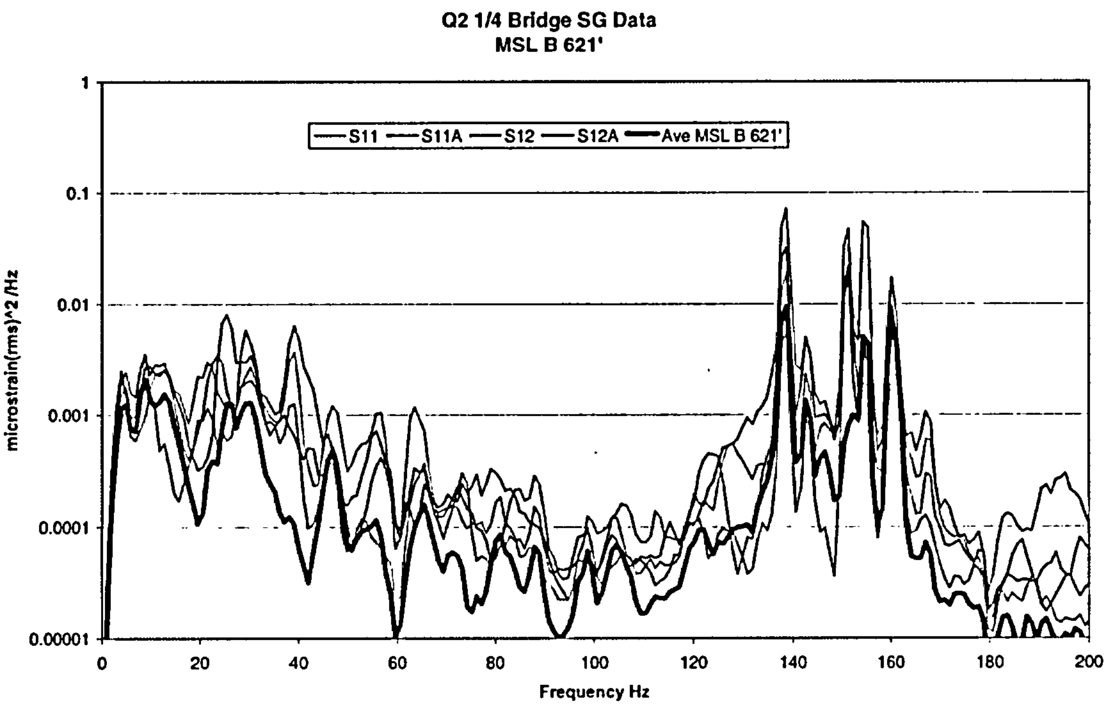


Exhibit EMEB-B-18-1 Rev. 1 -VYNPS Steam Dryer Load Uncertainty
NON-PROPRIETARY INFORMATION

Figure EMEB-B-18-1-16

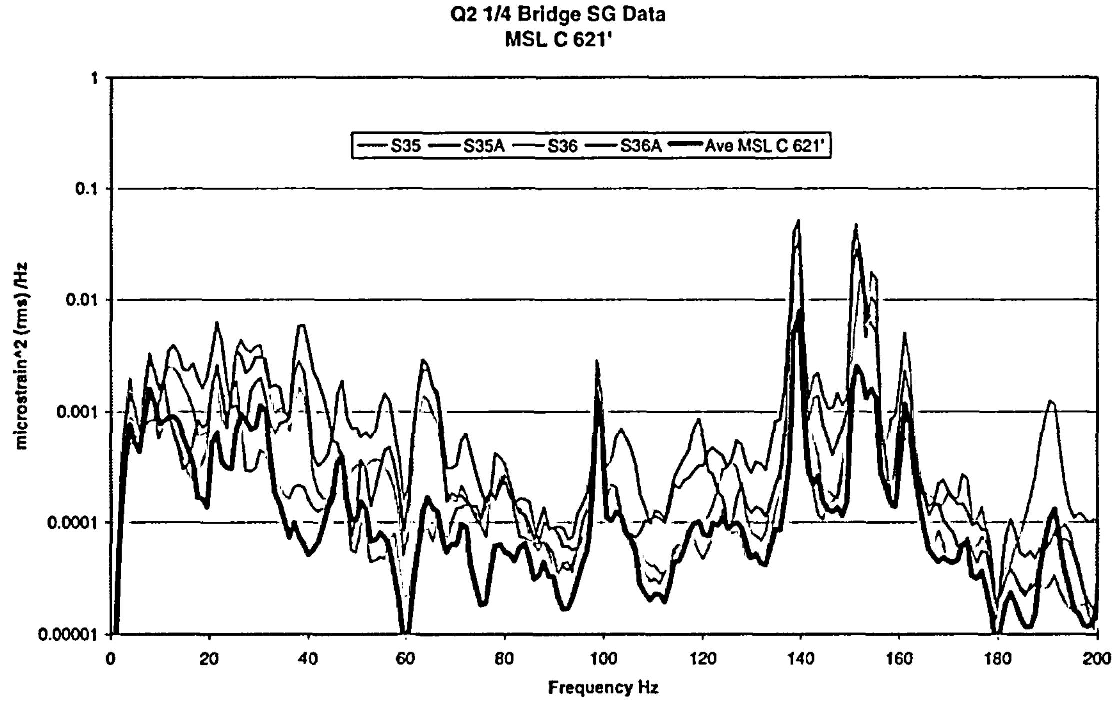
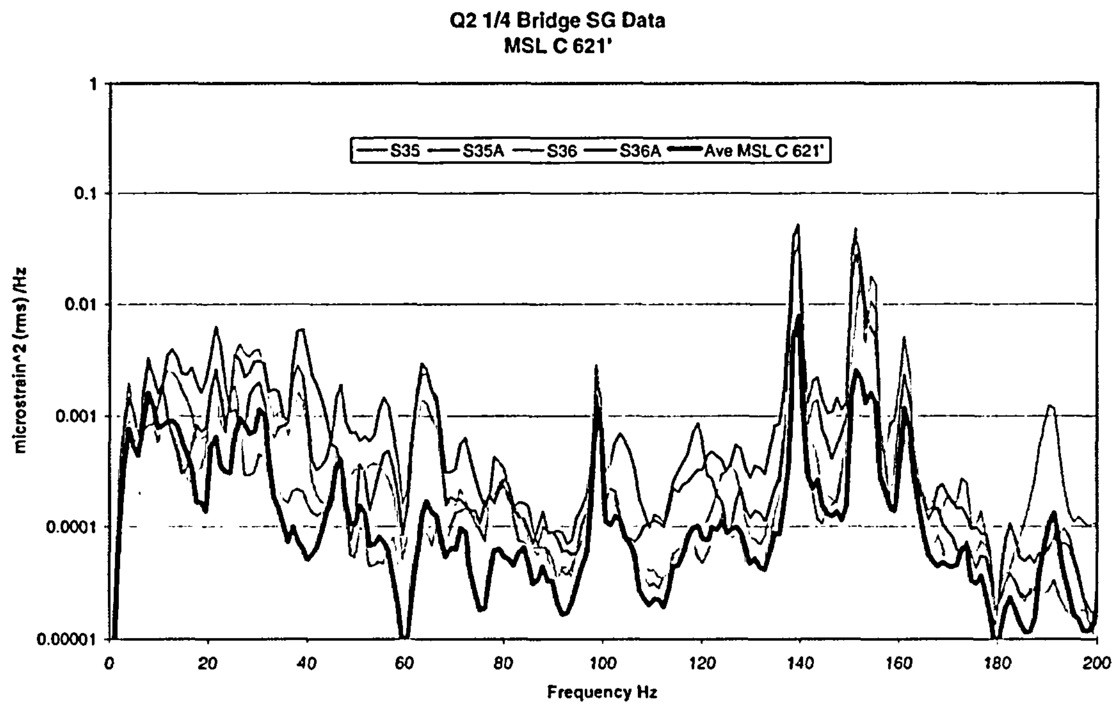


Figure EMEB-B-18-1-17



These uncertainties were combined by the SRSS method to assess the SG Measurement Uncertainty for both the RMS and Maximum Response of the signal. The resulting strain gage signal uncertainty values are summarized in Table EMEB-B-18-1-13. Note these values are the same for the four steam lines.

Strain Gage (SG) RMS Signal Uncertainty

	UncSG SG Signal Total Uncertainty	UncSG1 SG Uncertainty due to Instrument and Thickness	UncSG2 SG Uncertainty due to 1 vs 4 SG Sensors
A Strain Gage	61%	10%	60%
B Strain Gage	61%	10%	60%
C Strain Gage	61%	10%	60%
D Strain Gage	61%	10%	60%

Strain Gage (SG) RMS Signal Uncertainty

	UncSG SG Signal Total Uncertainty	UncSG1 SG Uncertainty due to Instrument and Thickness	UncSG2 SG Uncertainty due to 1 vs 4 SG Sensors
A Strain Gage	61%	10%	60%
B Strain Gage	61%	10%	60%
C Strain Gage	61%	10%	60%
D Strain Gage	61%	10%	60%

Table EMEB-B-18-1-13

In Tables EMEB-B-18-1-14 and EMEB-B-18-1-15, the SG RMS and venturi RMS signal uncertainties for each line are multiplied by the sensitivity values to determine the impact on dryer loads. Because the transfer function uncertainty could be related to a common characteristic of the ACA of the sensing line, the venturi uncertainty from each of the four lines is first added by absolute sum. Then this absolute sum is combined by the SRSS method with the affect of the SG uncertainty on each line to find the total load uncertainty due to signal error on each side of the dryer. This is done to both RMS and maximum uncertainty values. Then the maximum uncertainty value determined from both sides of the dryer and both the RMS and maximum uncertainties is used to represent the uncertainty on dryer loads due to signal uncertainty.

Dryer Load Uncertainty due to Venturi RMS Signal Uncertainty

		P7 Side Un=F1 x TU	P99 Side Un=F2 x TU	Del Ld/Del Signal F1	Del Ld/Del Signal F2	Venturi Line Total Uncertainty TU
A	Venturi Inlet	0%	4%	0	0.024	179%
B	Venturi Inlet	0%	37%	0	0.208	177%
C	Venturi Inlet	48%	0%	0.27	0	177%
D	Venturi Inlet	3%	0%	0.014	0	179%
	abs sum	50%	41%			

Dryer Load Uncertainty due to Strain Gage SG RMS Signal Uncertainty

		P7 Side Un=F1 x TU	*P99 Side* Un=F2 x TU	Del Ld/Del *Signal* F1	Del Ld/Del *Signal* F2	SG Signal Total *Uncertainty* TU
A	Strain Gage	0%	24%	0	0.397	61%
B	Strain Gage	0%	25%	0	0.403	61%
C	Strain Gage	23%	0%	0.374	0	61%
D	Strain Gage	23%	0%	0.372	0	61%

Table EMEB-B-18-1-14

Exhibit EMEB-B-18-1 Rev. 1 -VYNPS Steam Dryer Load Uncertainty

NON-PROPRIETARY INFORMATION

Dryer Load Uncertainty due to Venturi Maximum Signal Uncertainty

		P7 Side Un=F1 x TU	P99 Side Un=F2 x TU	Del Ld/Del Signal F1	Del Ld/Del Signal F2	Venturi Line Total uncertainty TU
A	Venturi Inlet	0%	1%	0	0.01	128%
B	Venturi Inlet	0%	39%	0	0.307	128%
C	Venturi Inlet	14%	0%	0.106	-0.001	128%
D	Venturi Inlet	1%	0%	0.011	-0.001	128%
	abs sum	15%	40%			

Dryer Load Uncertainty due to Strain Gage SG Maximum Signal Uncertainty

		P7 Side Un=F1 x TU	P99 Side Un=F2 x TU	Del Ld/Del Signal F1	Del Ld/Del Signal F2	SG Signal Total Uncertainty TU
A	Strain Gage	0%	15%	0	0.24	61%
B	Strain Gage	0%	27%	0	0.444	61%
C	Strain Gage	22%	0%	0.36	0	61%
D	Strain Gage	32%	0%	0.521	0	61%

	P7 Side	P99 Side
UncACM2 = SRSS Dryer Load Uncertainty	**P7 Side**	**P99 Side**
SRSS (ABS Venturi and SRSS SG RMS Signal Uncertainty)	**60%**	**54%**
SRSS (ABS Venturi and SRSS SG MAX Signal Uncertainty)	**41%**	**51%**
Bounding Uncertainty RMS, Max, Either Side	**60%**	

<u>Table EMEB-B-18-1-15</u>

Exhibit EMEB-B-18-1 Rev. 1 -VYNPS Steam Dryer Load Uncertainty
NON-PROPRIETARY INFORMATION

Total ACM Uncertainty

As summarized in Table EMEB-B-18-1-16, the total measurement uncertainty was calculated to be 130 %.

Final ACM Uncertainty	
UncACM1: Maximum Benchmark Uncertainty	115%
UncACM2: Signal Uncertainty	60%
SRSS(UncACA1, UncACA2)	130%

Table EMEB-B-18-1-16

CFD Load Uncertainty

The comparison of the turbulence energy in the LES runs was shown to be higher than in RANS comparison runs. In EMEB-B-18-1 Rev 1 Attachment 5 Entergy provides further benchmark of these loads against operating data. As demonstrated in Attachment 5 the CFD prediction for VYNPS 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% = +37%. This would support 0 uncertainty for the CFD load. Conservatively, Entergy 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 to the limiting stress of 4%. Therefore the CFD frequency uncertainty is determined to be 4%. The total CFD uncertainty; uncCFD= sqrt(15^2 + 4^2) = 16%.

Attachments to this Exhibit:

Attachment 1: CDI Parametric Assessment of Dryer Loads as a Function of Instrument Uncertainty

Attachment 2: CDI Uncertainty Assessment of Venturi Instrument Line Transfer Function

Attachment 3: CDI Uncertainty Assessment of Sensing Point Distance from RPV

Attachment 4: PSD Plots ACA Benchmark QC2 790MWe, Comparison to All Measured Data

Attachment 5: CFD Uncertainty Assessment

Attachment 1
Vermont Yankee Error Analysis

The error analysis is carried out at locations on the outer bank hood directly between the steam lines at the cover plate elevation (low resolution node numbers 7 and 99). The acoustic circuit analysis can be used directly to access errors in load predictions based on errors in measurement. Using the 100% power data set, the change in predicted RMS pressures are computed as a function of changing the strain gage and venturi pressure measurements, with results shown in the first table. Results for a similar calculation, for predicted peak pressures, are shown in the second table.

Pressure Data Location on MSL	$\Delta\%(P_7/P_{7RMS})/\Delta\%$	$\Delta\%(P_{99}/P_{99RMS})/\Delta\%$
A Venturi Inlet	0.000	0.024
B Venturi Inlet	0.000	0.208
C Venturi Inlet	0.270	0.000
D Venturi Inlet	0.014	0.000
A Strain Gage	0.000	0.397
B Strain Gage	0.000	0.403
C Strain Gage	0.374	0.000
D Strain Gage	0.372	0.000
SRSS	0.593	0.603

Table EMEB-B-18-1-1-1
Sensitivity of RMS Dryer Loads to Errors in Main Steam Line (MSL) Pressures

Pressure Data Location on MSL	$\Delta\%(P_7/P_{7Peak})/\Delta\%$	$\Delta\%(P_{99}/P_{99Peak})/\Delta\%$
A Venturi Inlet	0.000	0.010
B Venturi Inlet	0.000	0.307
C Venturi Inlet	0.106	-0.001
D Venturi Inlet	0.011	-0.001
A Strain Gage	0.000	0.240
B Strain Gage	0.000	0.444
C Strain Gage	0.360	0.000
D Strain Gage	0.521	0.000
SRSS	0.642	0.591

Table EMEB-B-18-1-1-2
Sensitivity of Peak Dryer Loads to Errors in MSL Pressures

Attachment 2
Vermont Yankee Instrument Line Error Analysis

The instrument line error analysis is carried out by comparing the transfer function developed by the instrument line experiment and the instrument line acoustic circuit model (which was subsequently applied to the VYNPS instrument lines). The instrument line experiment was patterned after the four venturi instrument lines in Quad Cities Unit 2; thus, the EPU data available from Exelon for these lines were used to compute the sensitivity of RMS and peak pressure predictions at the four main steam lines. Here, subscript "mod" refers to the transfer function developed by acoustic circuit methodology, while subscript "emp" refers to the transfer function developed empirically.

The rationale for the analysis is based on the premise that the venturi line mocked up in CDI's laboratories when modeled by acoustic circuit analysis introduces the same amount of uncertainty as would be introduced by modeling a venturi line in a plant. By experimentally measuring the transfer function (see Ref. B-1) with two transducer errors Δ_T, and comparing the pressure predicted at the MSL of Quad Cities Unit 2 computed from the ACM (P_{RMSmod}) to that computed using the empirically determined transfer function P_{RMSemp} (with error Δ_E) provides an estimate of the acoustic circuit error in correcting the venturi measurement. The error fraction $\Delta_{TransFunct}$ is shown for venturi data taken on all four lines (A-D)

Results are shown in the following tables.

Pressure Data Location	$\lvert(P_{RMSmod}-P_{RMSemp}) / P_{RMSemp}\rvert = \Delta_{TransFunct}$
A Venturi	0.475
B Venturi	0.639
C Venturi	0.581
D Venturi	0.278
Average	0.493

Table EMEB-B-18-1-2-1
Error RMS MSL Pressures to Transfer Function Accuracy in Instrument Lines

Pressure Data Location	$\lvert(P_{Peakmod}-P_{Peakemp}) / P_{Peakemp}\rvert = \Delta_{TransFunct}$
A Venturi	0.524
B Venturi	0.561
C Venturi	0.434
D Venturi	0.321
Average	0.460

Table EMEB-B-18-1-2-2
Error Peak MSL Pressures to Transfer Function Accuracy in Instrument Lines

Compliance Effects

The tests conducted as described in Ref. B-1 did not include transducers that exist on branch lines on the instrument racks. However, manufacturer supplied data indicate that these transducers in the frequency range (0-200 Hz) introduce a compliance (spring) into the system.

The compliance error analysis is carried out by running the instrument line code for various percent compliance ($\Delta\%$), and computing the sensitivity of RMS and peak pressure predictions at the four main steam lines. Results are shown in the following tables.

Pressure Data Location	$\lvert\Delta\%(P/P_{RMS})/\Delta\%\rvert$
A Instrument Line	0.817
B Instrument Line	0.330
C Instrument Line	0.347
D Instrument Line	0.864
Average	0.590

Table EMEB-B-18-1-2-3
Sensitivity of RMS MSL Pressures to Compliance in Instrument Lines

Pressure Data Location	$\lvert\Delta\%(P/P_{Peak})/\Delta\%\rvert$
A Instrument Line	0.251
B Instrument Line	0.233
C Instrument Line	0.319
D Instrument Line	0.296
Average	0.275

Table EMEB-B-18-1-2-4
Sensitivity of Peak MSL Pressures to Compliance in Instrument Lines

The total error in RMS measured venturi instrument line data corrected to the main steam line consists of four terms:

$$\text{Error} = \text{SRSS}\left(\Delta_T + \left|\Delta_{TransFunct}\right| + \Delta_{\varepsilon} + \left|\frac{\Delta\%(P/P_{RMS})}{\Delta\%}\right| \times \Delta_C\right)$$

where Δ_T is the pressure transducer error, associated with the measurement of the empirically determined transfer function, $\Delta_{TransFunct}$ is the transfer function error provided in Tables EMEB-B-18-1-2-1 and 2, Δ_{ε} is the pressure measurement error of the transducer in the plant, and $\left|\frac{\Delta\%(P/P_{RMS})}{\Delta\%}\right|$ is the sensitivity of compliance error provided in Tables EMEB-B-18-1-2-3 and 4. The last term is multiplied by Δ_C, the compliance error as a fraction of the compliance specified by the manufacturer.

Attachment 3
Vermont Yankee Instrument Position Uncertainty

With pressures measured at two locations on a MSL, it is possible to compute the pressure at a third location. This is used to estimate the error associated with measuring the pressure on the MSL at the venturi location which is further downstream than strain gage pressure measurements which were made at QC1 and QC2.

The error analysis is carried out by first computing the pressure on the main steam lines at the same location of the first strain gage location in Quad Cities Unit 2 (9.50 feet from the RPV nozzle), using the VYNPS strain gage data (at 37.13 feet) and the pressure at the venturi instrument line entrance (at 96.84 feet for main steam lines A and D, and 80.88 feet for main steam lines B and C). Comparisons of this pressure are made with model predictions for the VYNPS acoustic circuit model and the benchmarked acoustic circuit model with modeling parameters used for Quad Cities. The difference in prediction estimates the error associated with moving the measurement to the venturi location. An error analysis (for Quad Cities) showed that a 5.03% error in strain gage RMS pressure measurements results in a 3.56% change in RMS dryer loads. This factor (0.708) is then applied to the difference in predictions, and an error associated with instrument locations is determined, as shown in the table.

Venturi Location	$(P_{VY}-P_{QC})/P_{VY}$	Dryer Load Error Fraction
A	0.437	0.309
B	0.736	0.521
C	0.738	0.523
D	0.468	0.331
Average	0.595	0.421

Table EMEB-B-18-1-3-1
Error - RMS Dryer Loads to Instrument Position Uncertainty

Reference

B-1. "Test Report for Validating an Instrumentation Line Acoustic Transmission Model," Revision 0, CDI Report No. 04-12 prepared for Exelon Generation LLC, July 2004.

Exhibit EMEB-B-18-1 Rev. 1 -VYNPS Steam Dryer Load Uncertainty
NON-PROPRIETARY INFORMATION

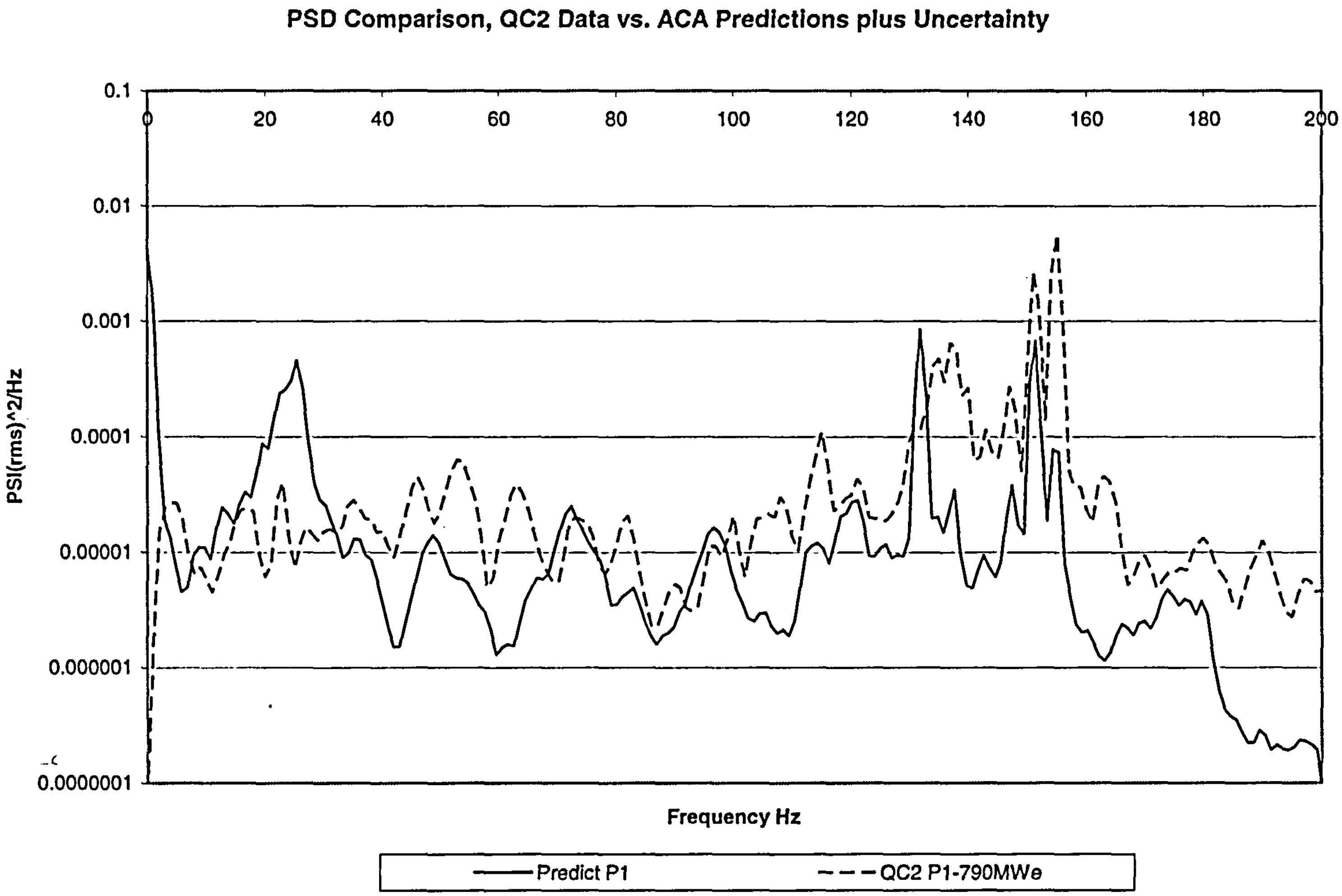


Figure EMEB-B-18-1-4-1

Exhibit EMEB-B-18-1 Rev. 1 -VYNPS Steam Dryer Load Uncertainty
NON-PROPRIETARY INFORMATION

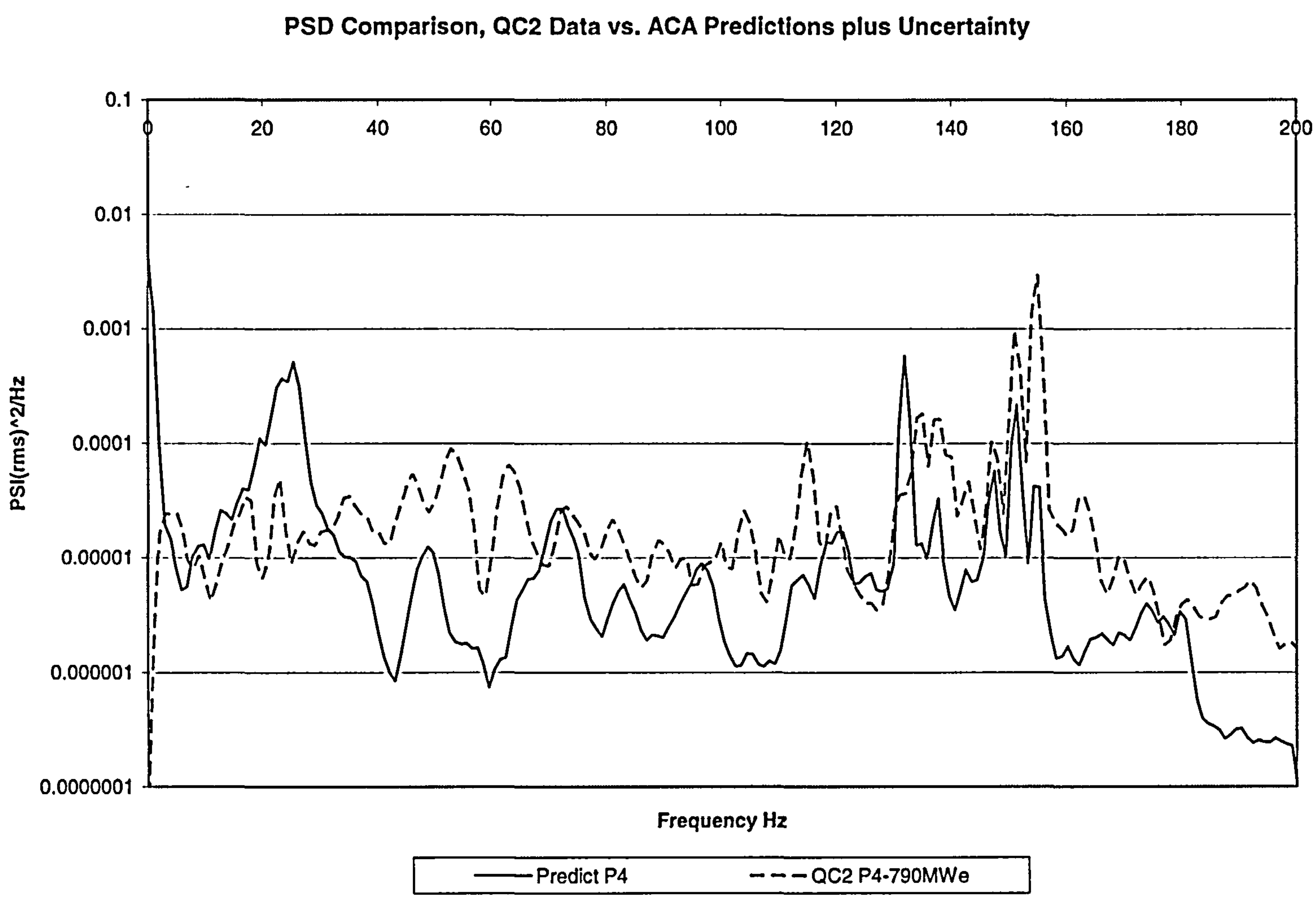


Figure EMEB-B-18-1-4-2

Exhibit EMEB-B-18-1 Rev. 1 -VYNPS Steam Dryer Load Uncertainty
NON-PROPRIETARY INFORMATION

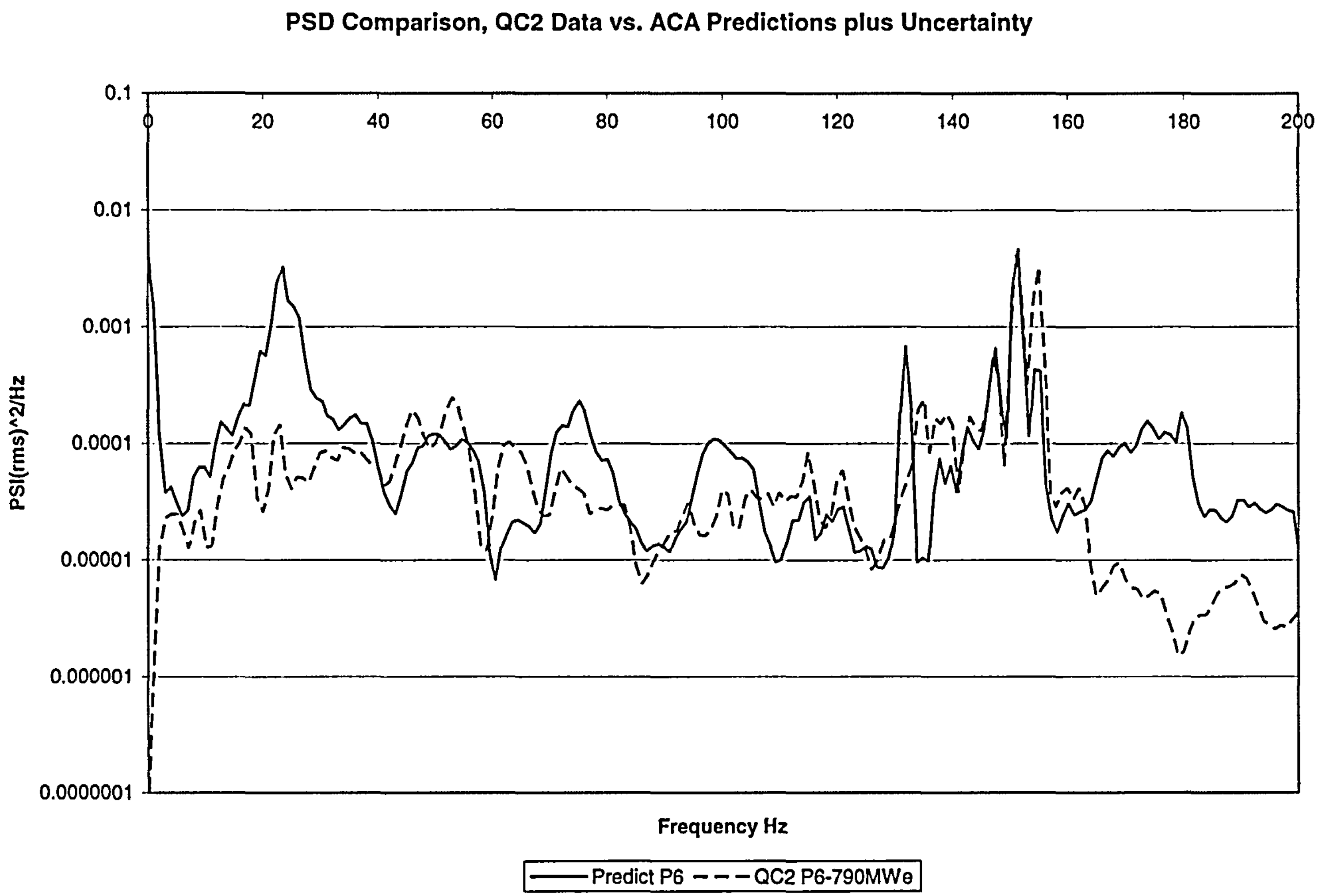


Figure EMEB-B-18-1-4-3

Exhibit EMEB-B-18-1 Rev. 1 -VYNPS Steam Dryer Load Uncertainty
NON-PROPRIETARY INFORMATION

PSD Comparison, QC2 Data vs. ACA Predictions plus Uncertainty

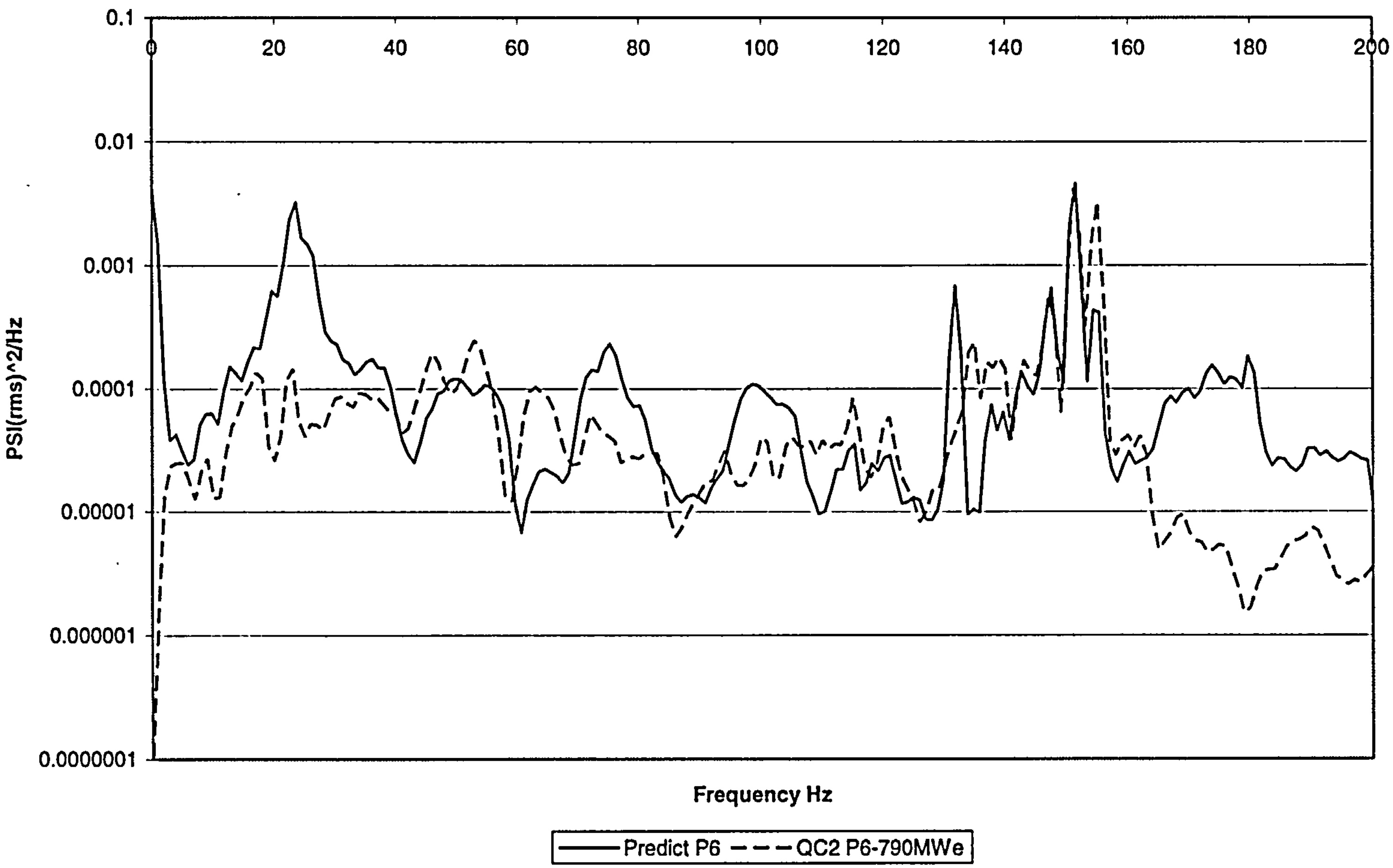


Figure EMEB-B-18-1-4-4

Exhibit EMEB-B-18-1 Rev. 1 -VYNPS Steam Dryer Load Uncertainty
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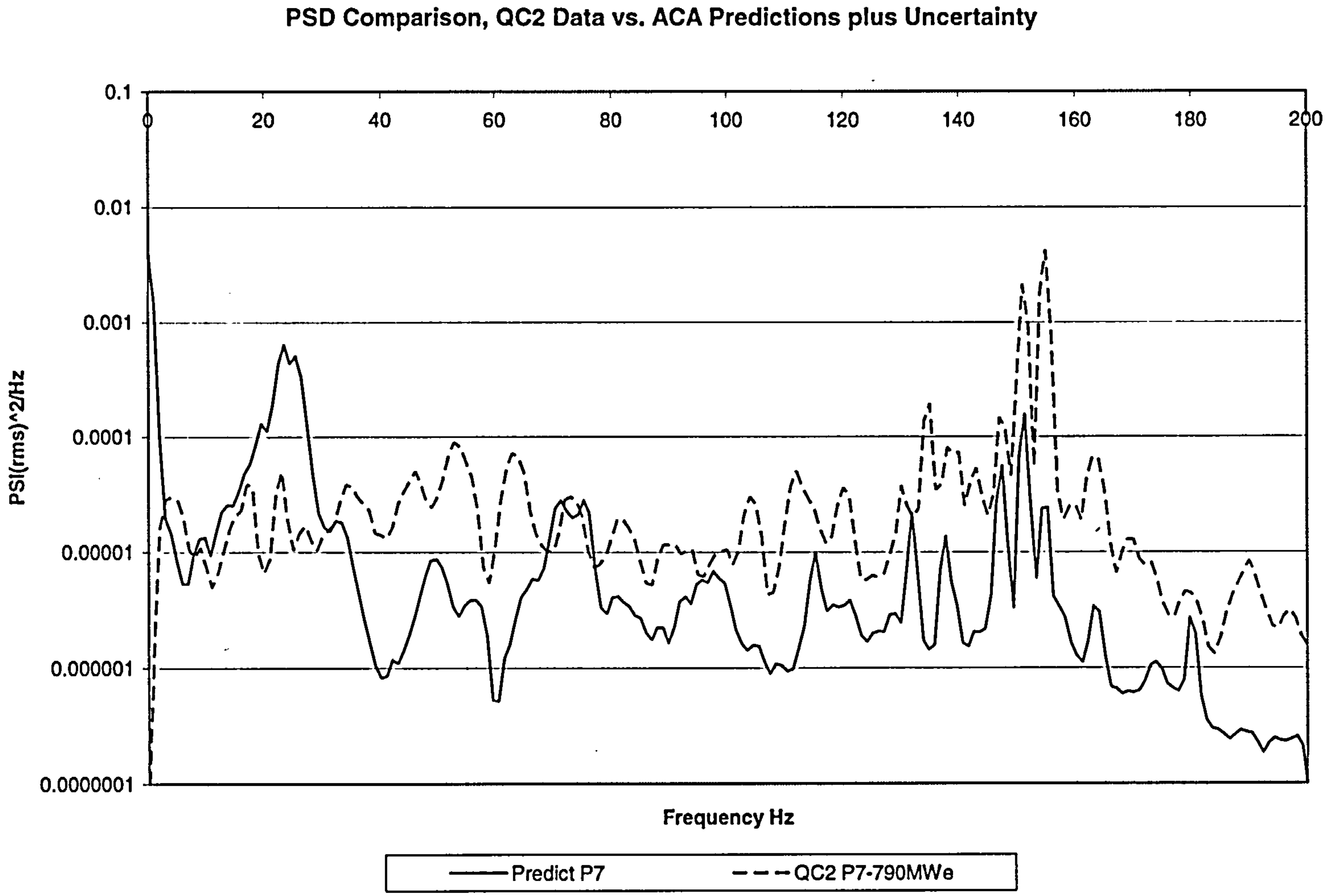

Figure EMEB-B-18-1-4-5

Exhibit EMEB-B-18-1 Rev. 1 -VYNPS Steam Dryer Load Uncertainty
NON-PROPRIETARY INFORMATION

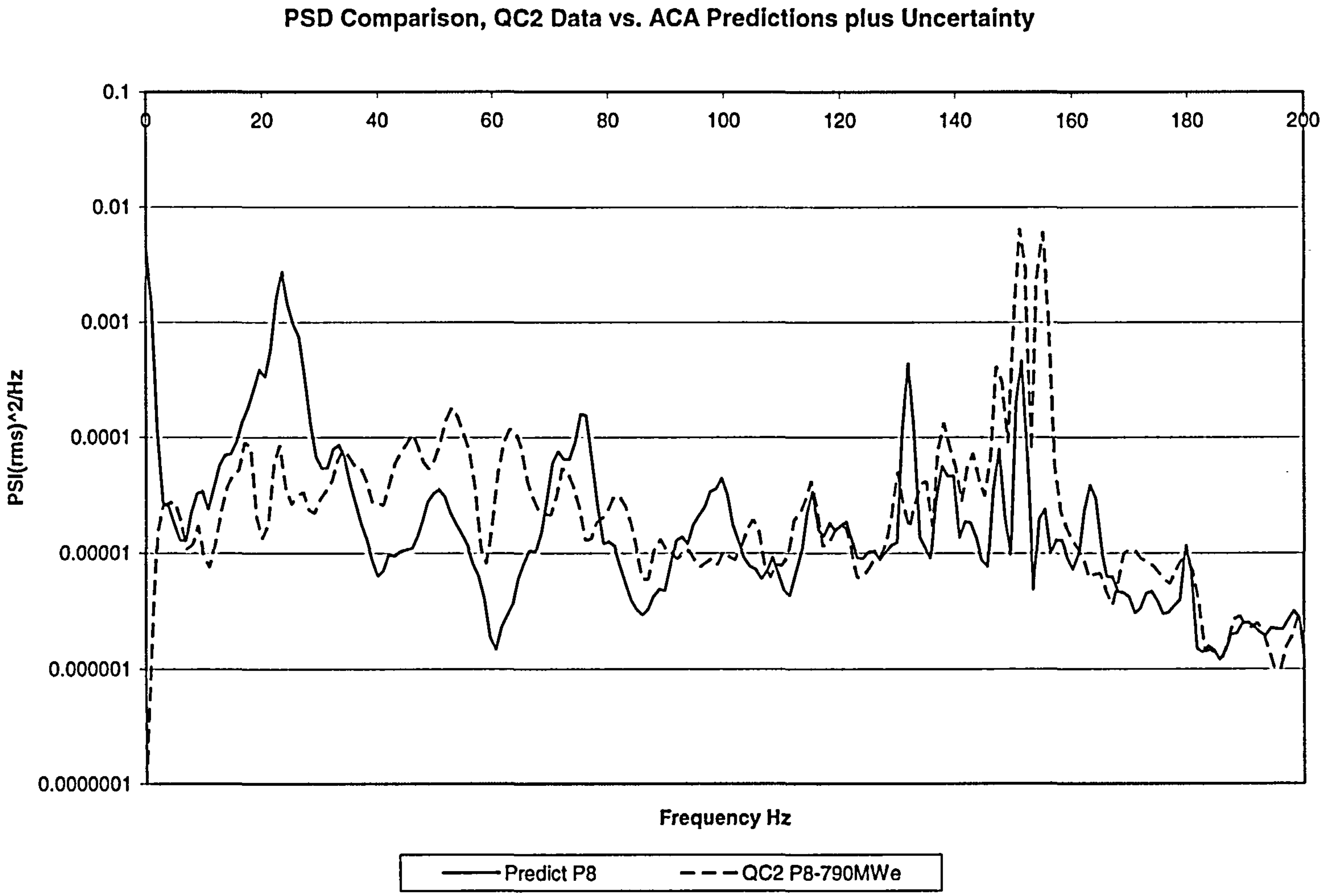

Figure EMEB-B-18-1-4-6

Exhibit EMEB-B-18-1 Rev. 1 -VYNPS Steam Dryer Load Uncertainty
NON-PROPRIETARY INFORMATION

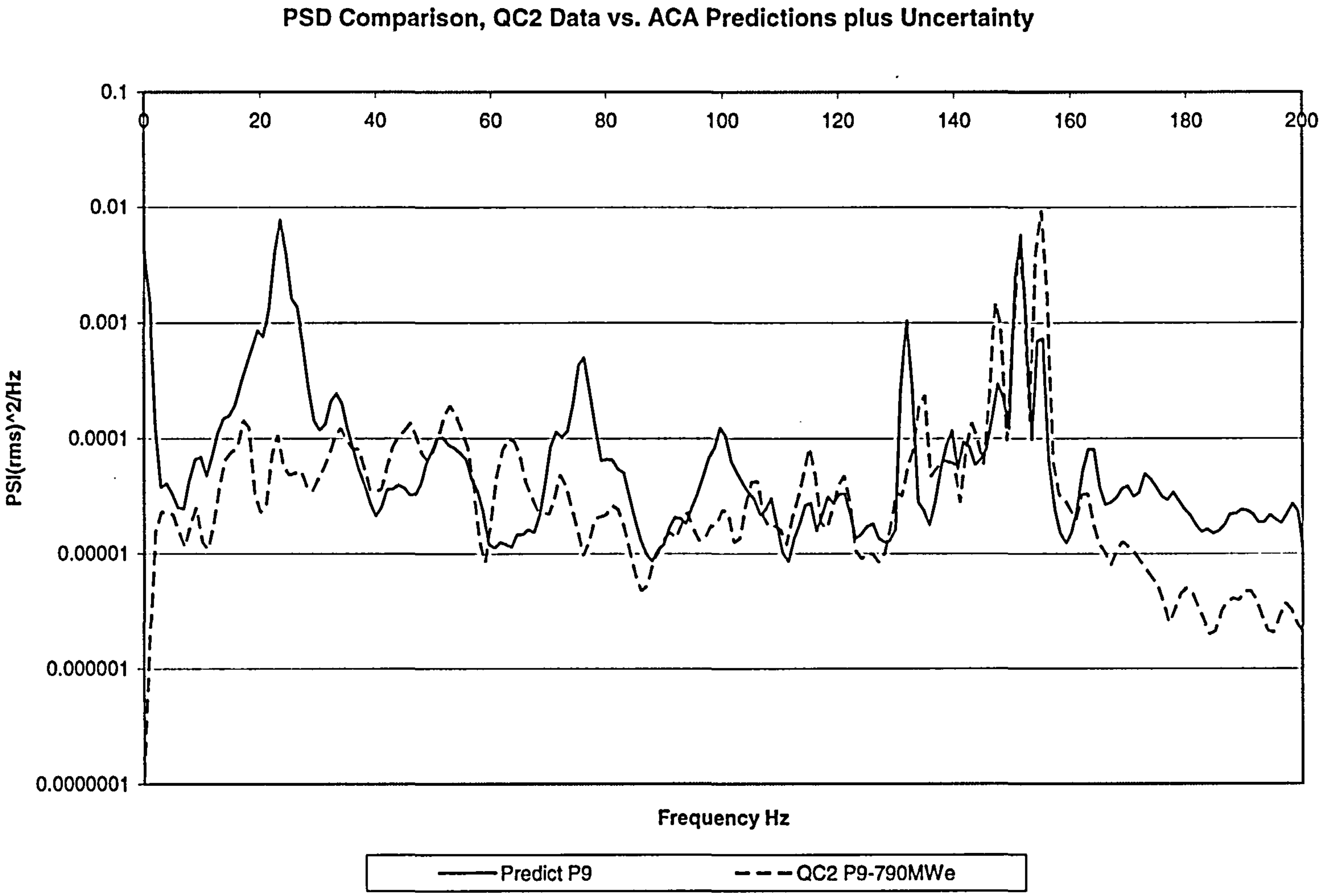

Figure EMEB-B-18-1-4-7

Exhibit EMEB-B-18-1 Rev. 1 -VYNPS Steam Dryer Load Uncertainty
NON-PROPRIETARY INFORMATION

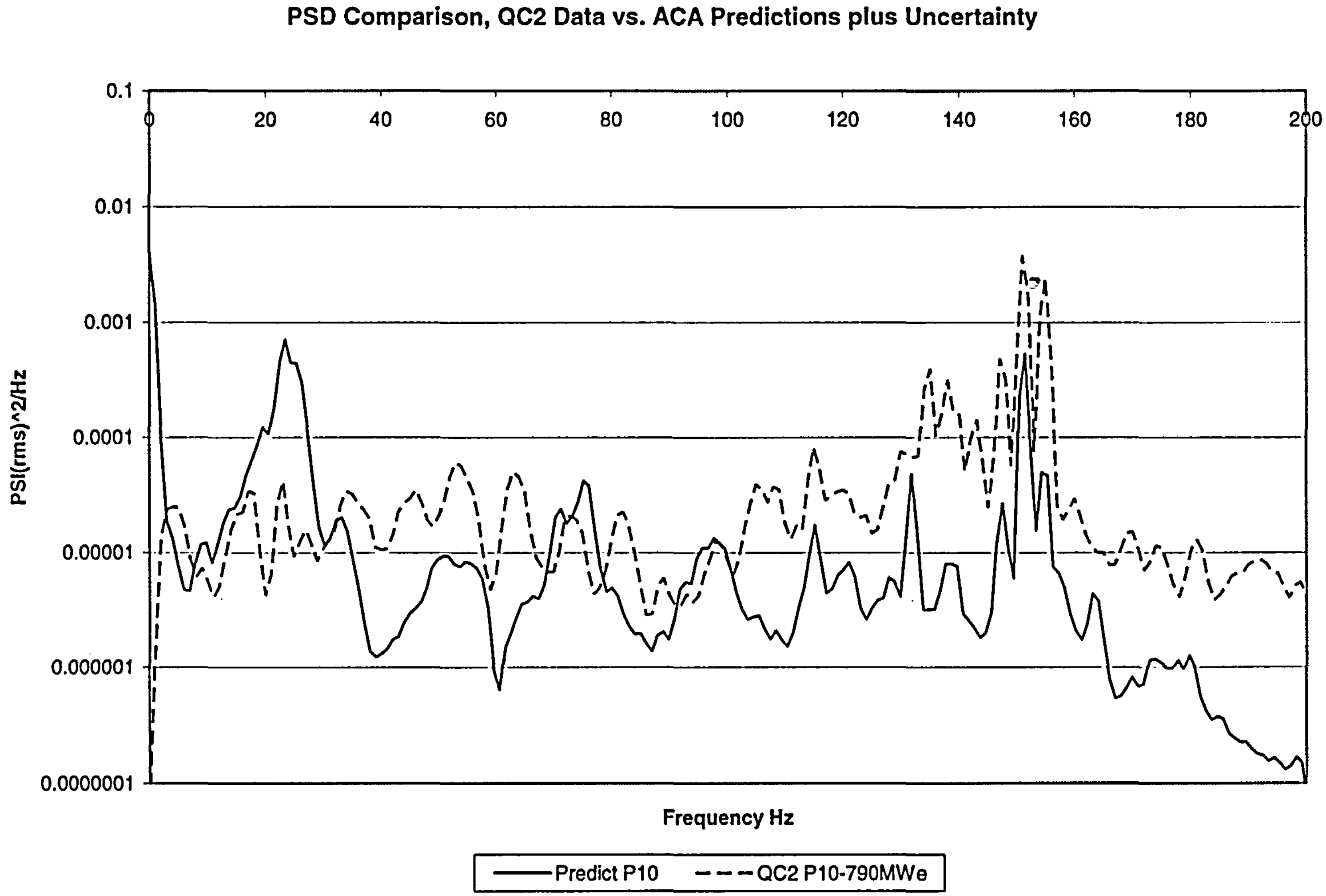

Figure EMEB-B-18-1-4-8

Exhibit EMEB-B-18-1 Rev. 1 -VYNPS Steam Dryer Load Uncertainty
NON-PROPRIETARY INFORMATION

PSD Comparison, QC2 Data vs. ACA Predictions plus Uncertainty

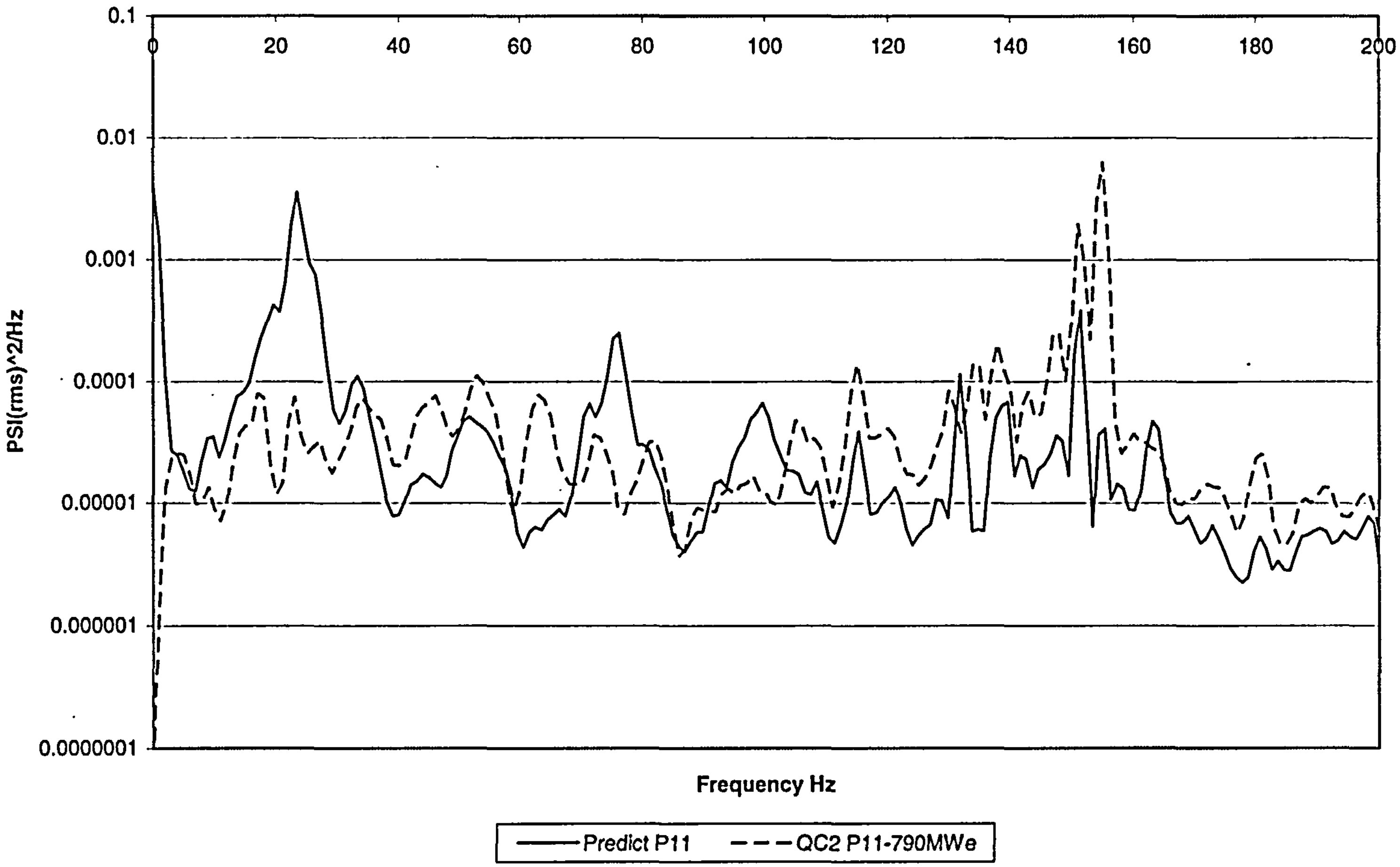

Figure EMEB-B-18-1-4-9

Exhibit EMEB-B-18-1 Rev. 1 -VYNPS Steam Dryer Load Uncertainty
NON-PROPRIETARY INFORMATION

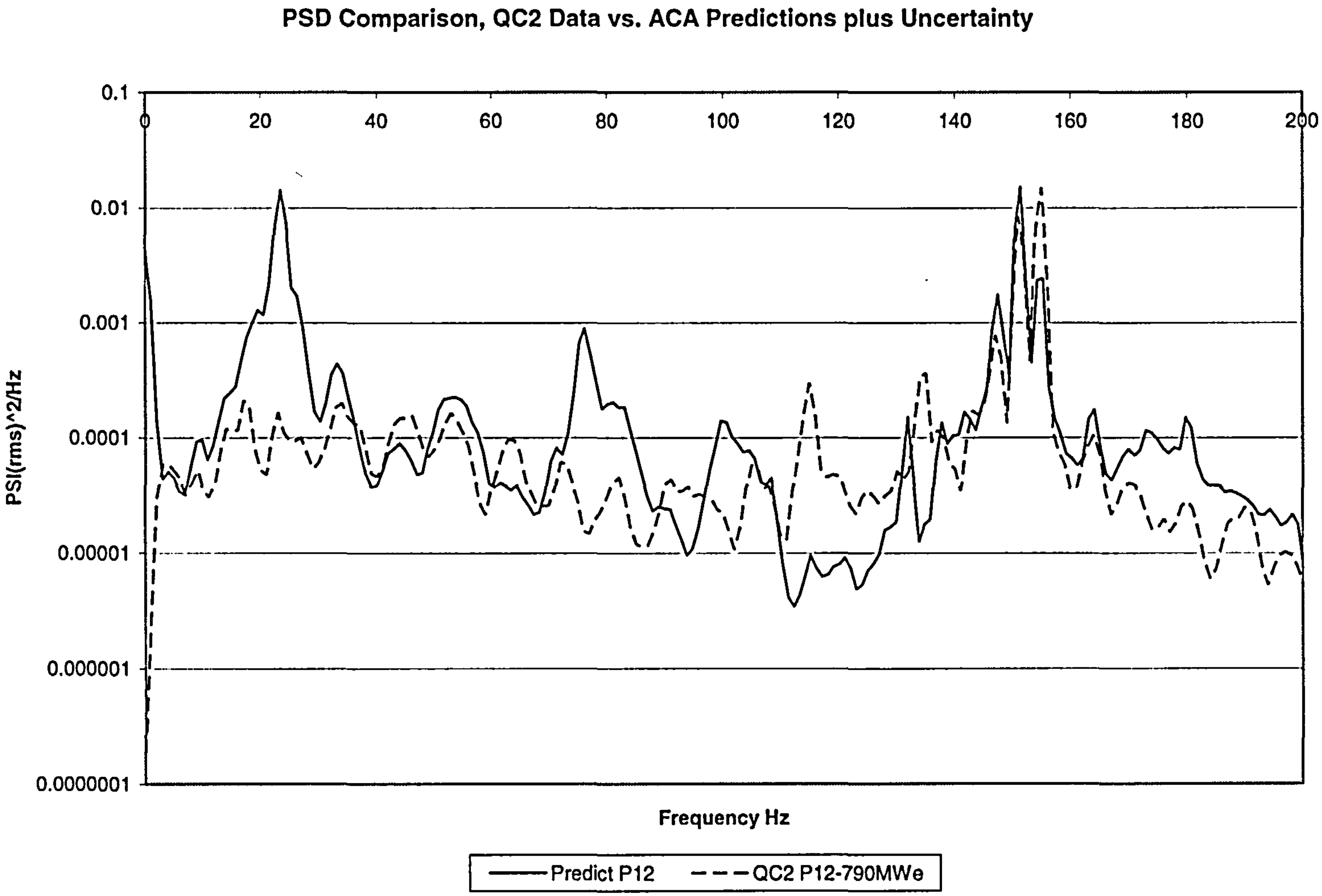

Figure EMEB-B-18-1-4-10

Exhibit EMEB-B-18-1 Rev. 1 -VYNPS Steam Dryer Load Uncertainty
NON-PROPRIETARY INFORMATION

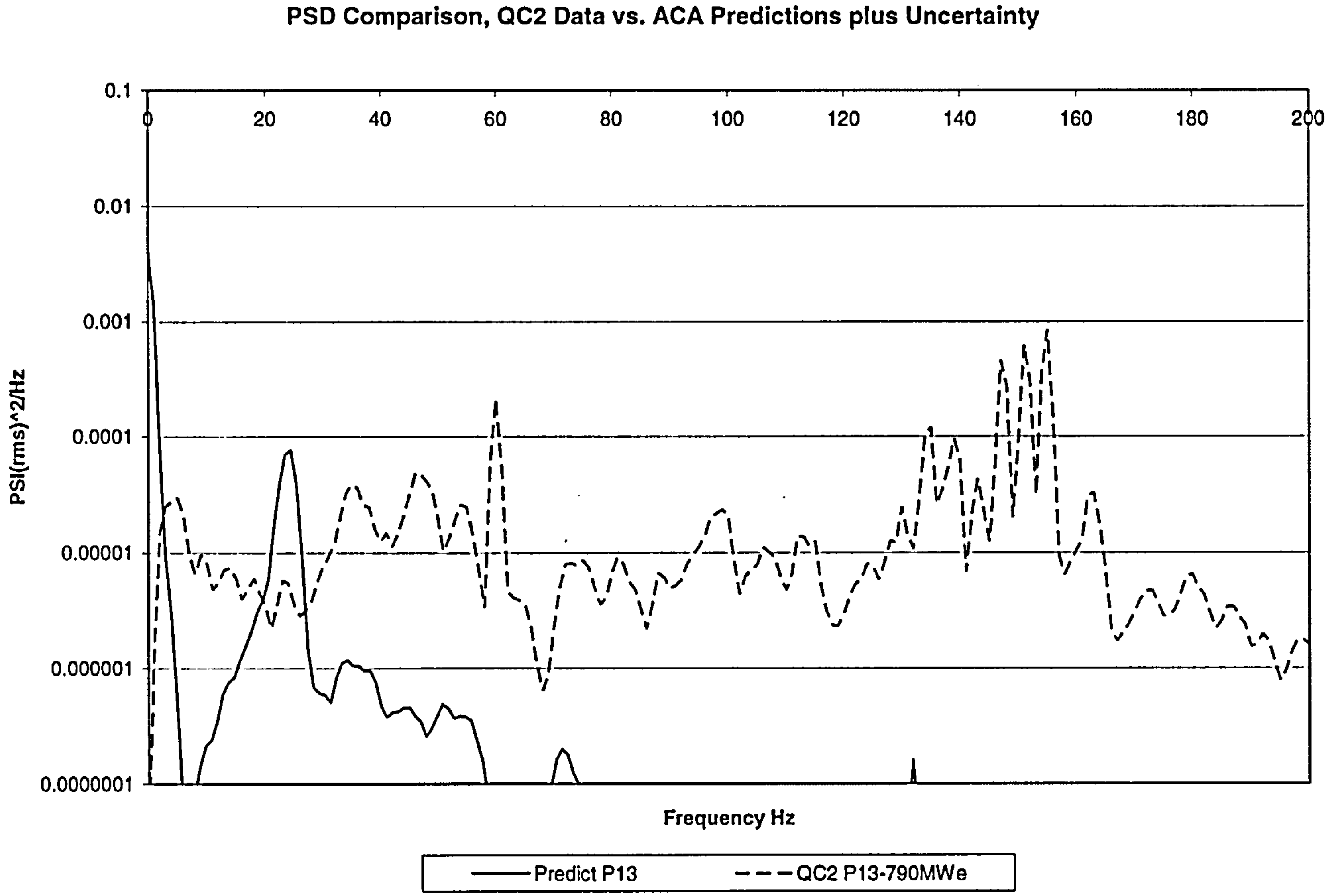

Figure EMEB-B-18-1-4-11

Exhibit EMEB-B-18-1 Rev. 1 -VYNPS Steam Dryer Load Uncertainty
NON-PROPRIETARY INFORMATION

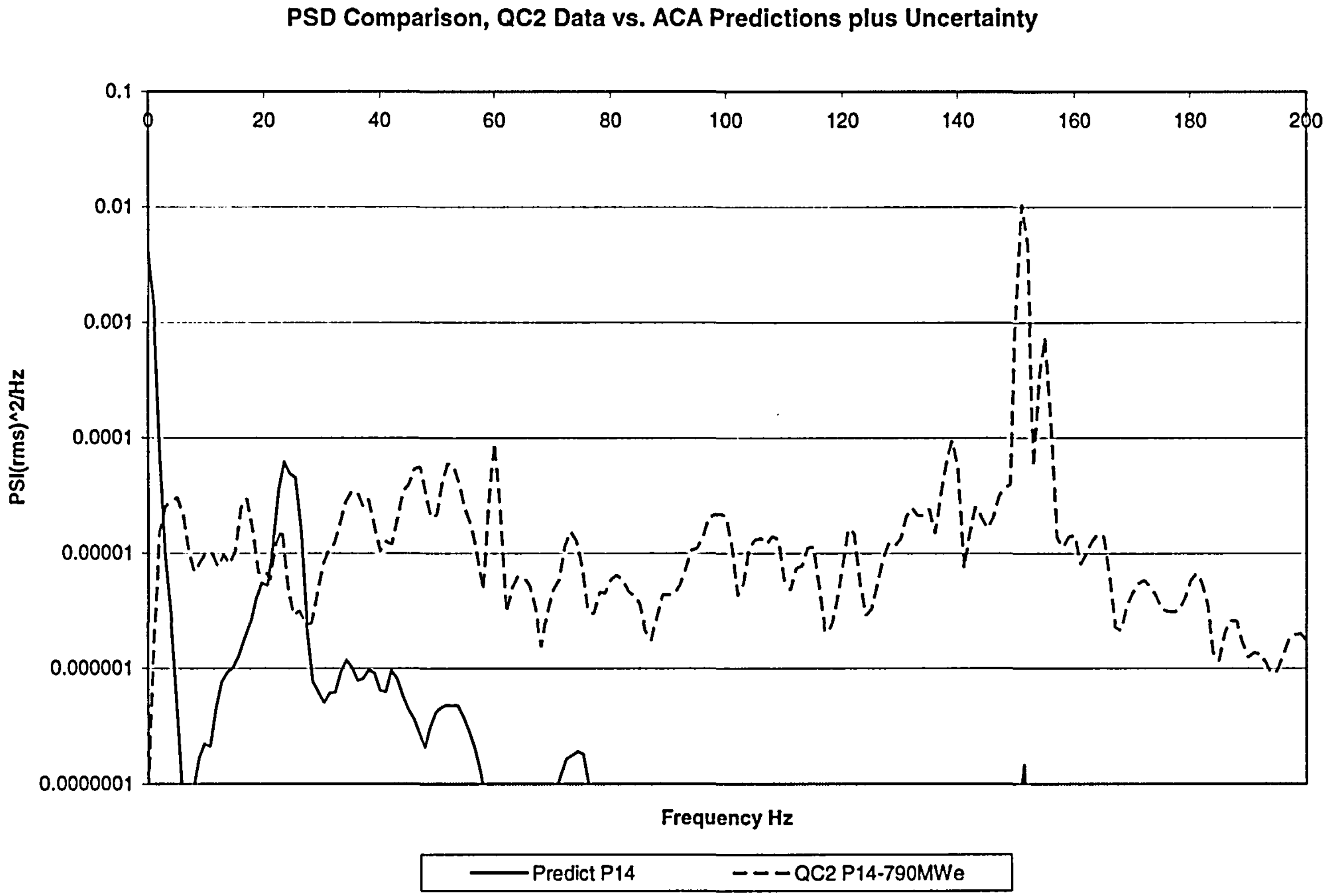

Figure EMEB-B-18-1-4-12

Exhibit EMEB-B-18-1 Rev. 1 -VYNPS Steam Dryer Load Uncertainty
NON-PROPRIETARY INFORMATION

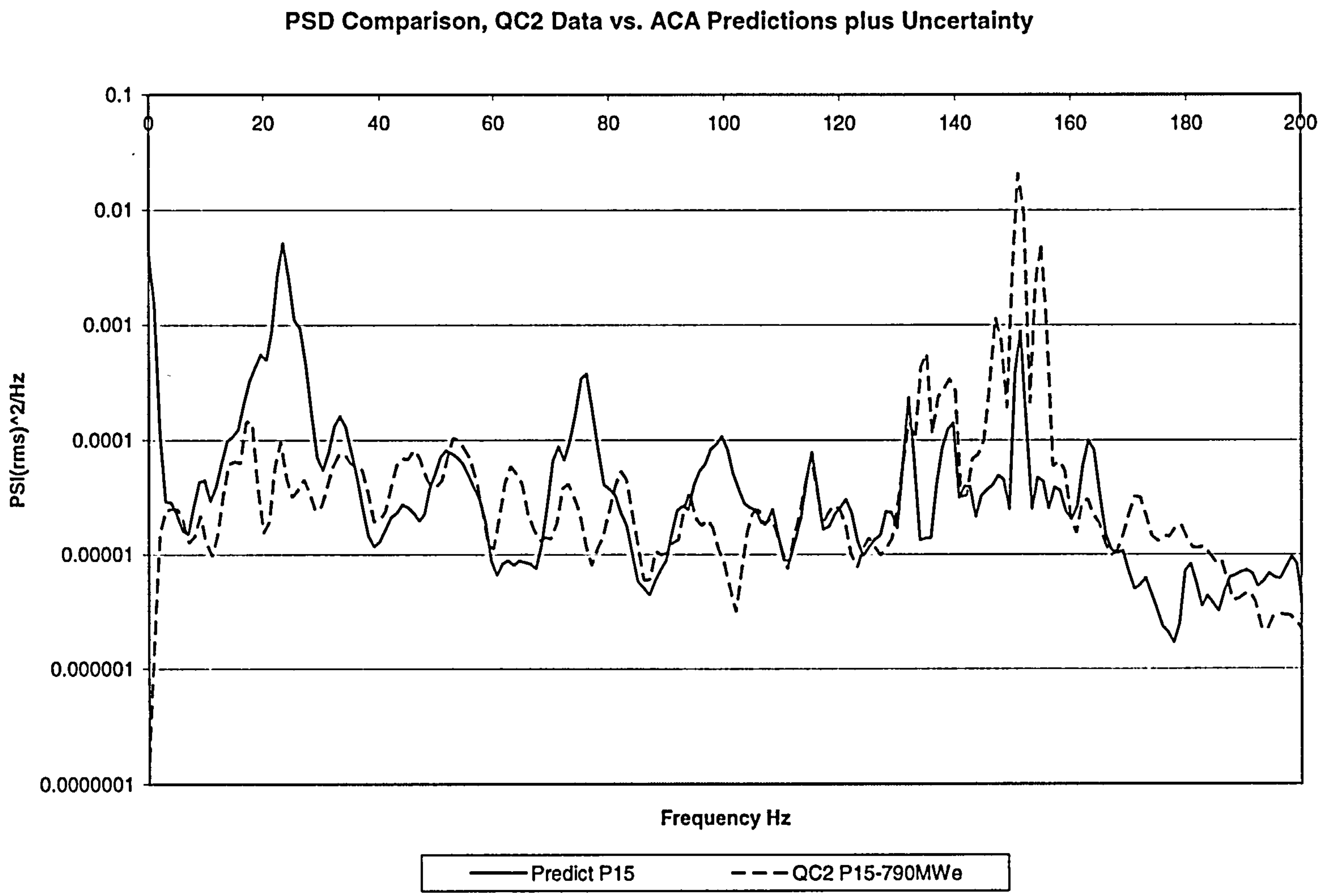

Figure EMEB-B-18-1-4-13

Exhibit EMEB-B-18-1 Rev. 1 -VYNPS Steam Dryer Load Uncertainty
NON-PROPRIETARY INFORMATION

PSD Comparison, QC2 Data vs. ACA Predictions plus Uncertainty

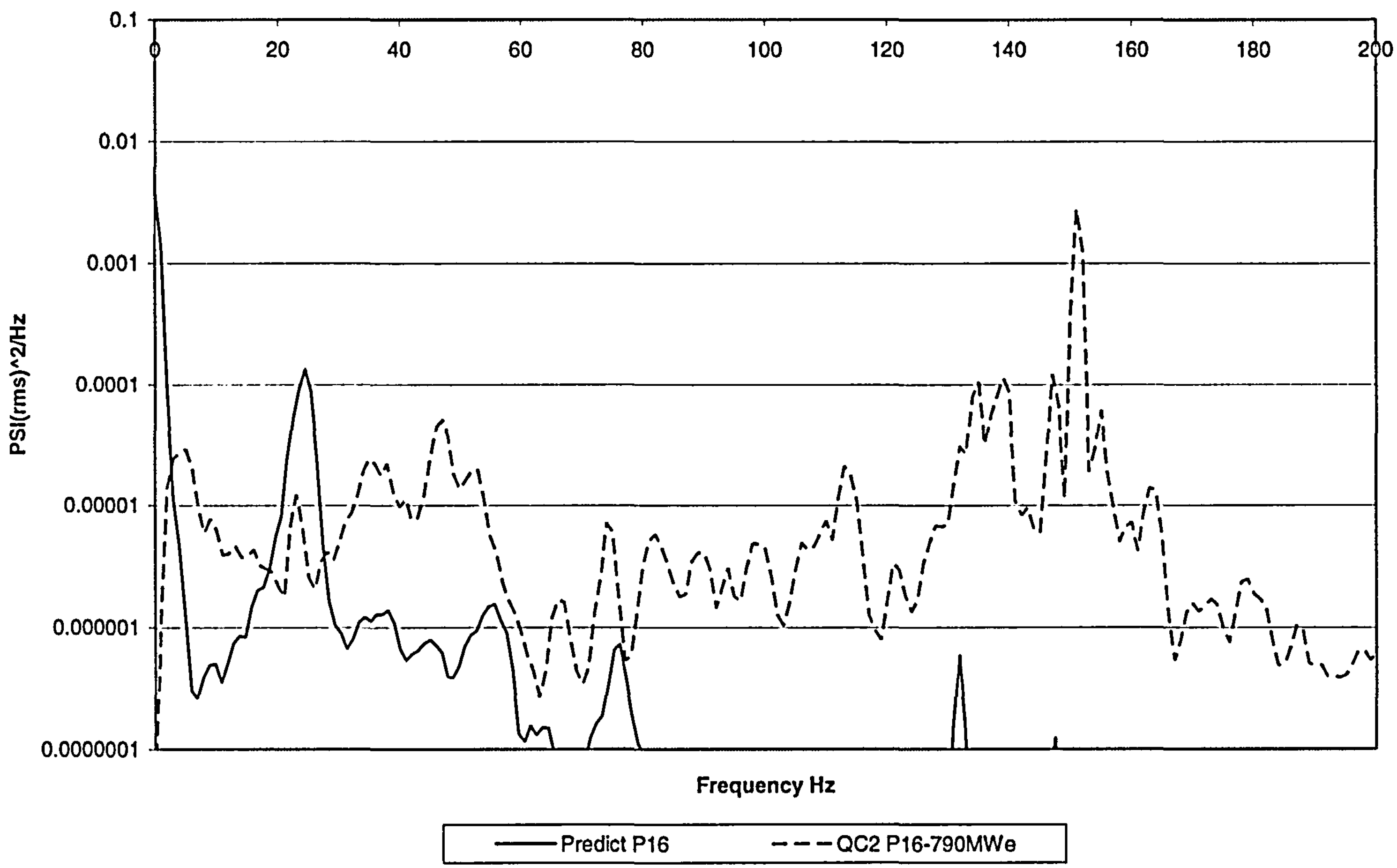

Figure EMEB-B-18-1-4-14

Exhibit EMEB-B-18-1 Rev. 1 -VYNPS Steam Dryer Load Uncertainty
NON-PROPRIETARY INFORMATION

PSD Comparison, QC2 Data vs. ACA Predictions plus Uncertainty

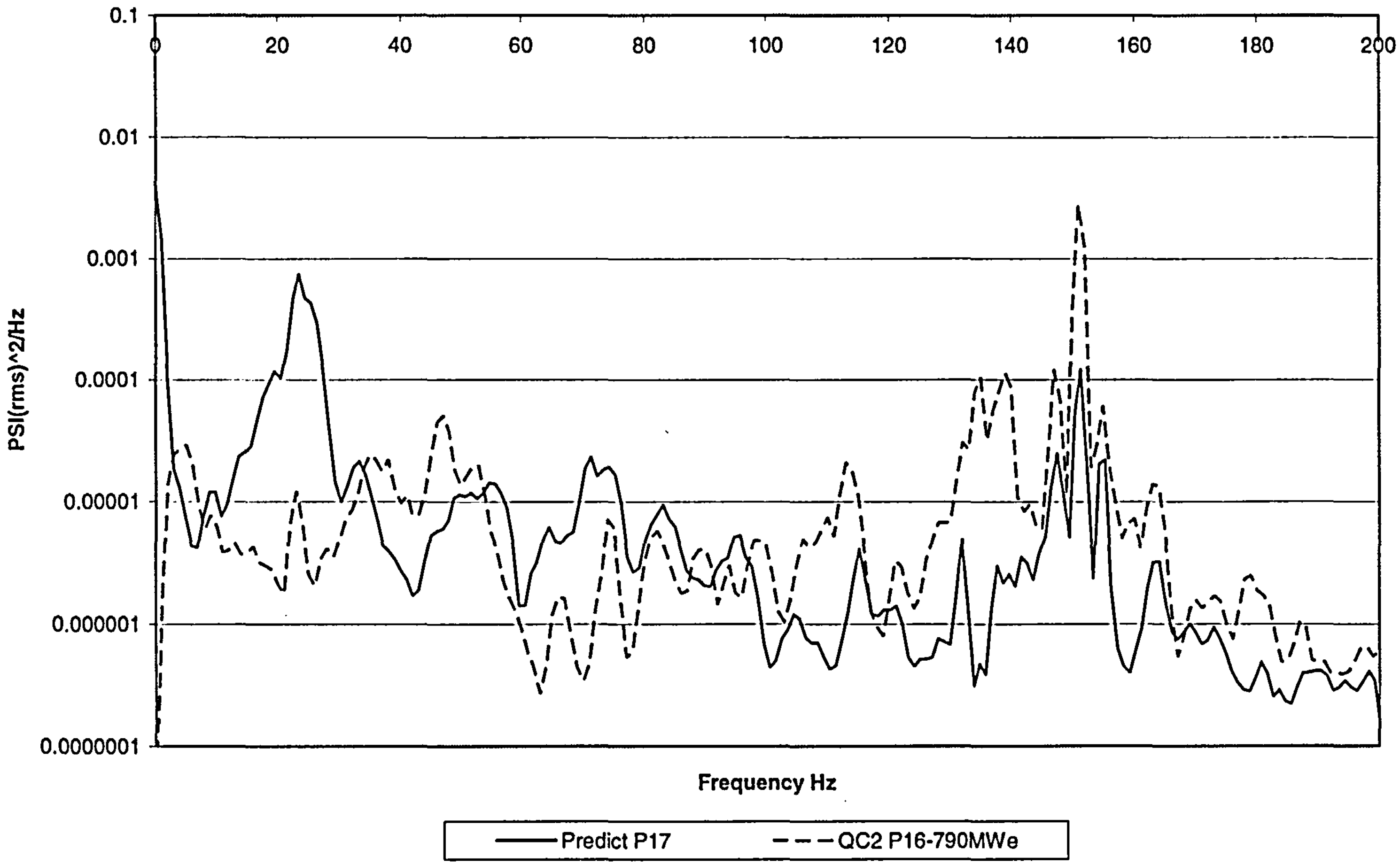

Figure EMEB-B-18-1-4-15

Exhibit EMEB-B-18-1 Rev. 1 -VYNPS Steam Dryer Load Uncertainty
NON-PROPRIETARY INFORMATION

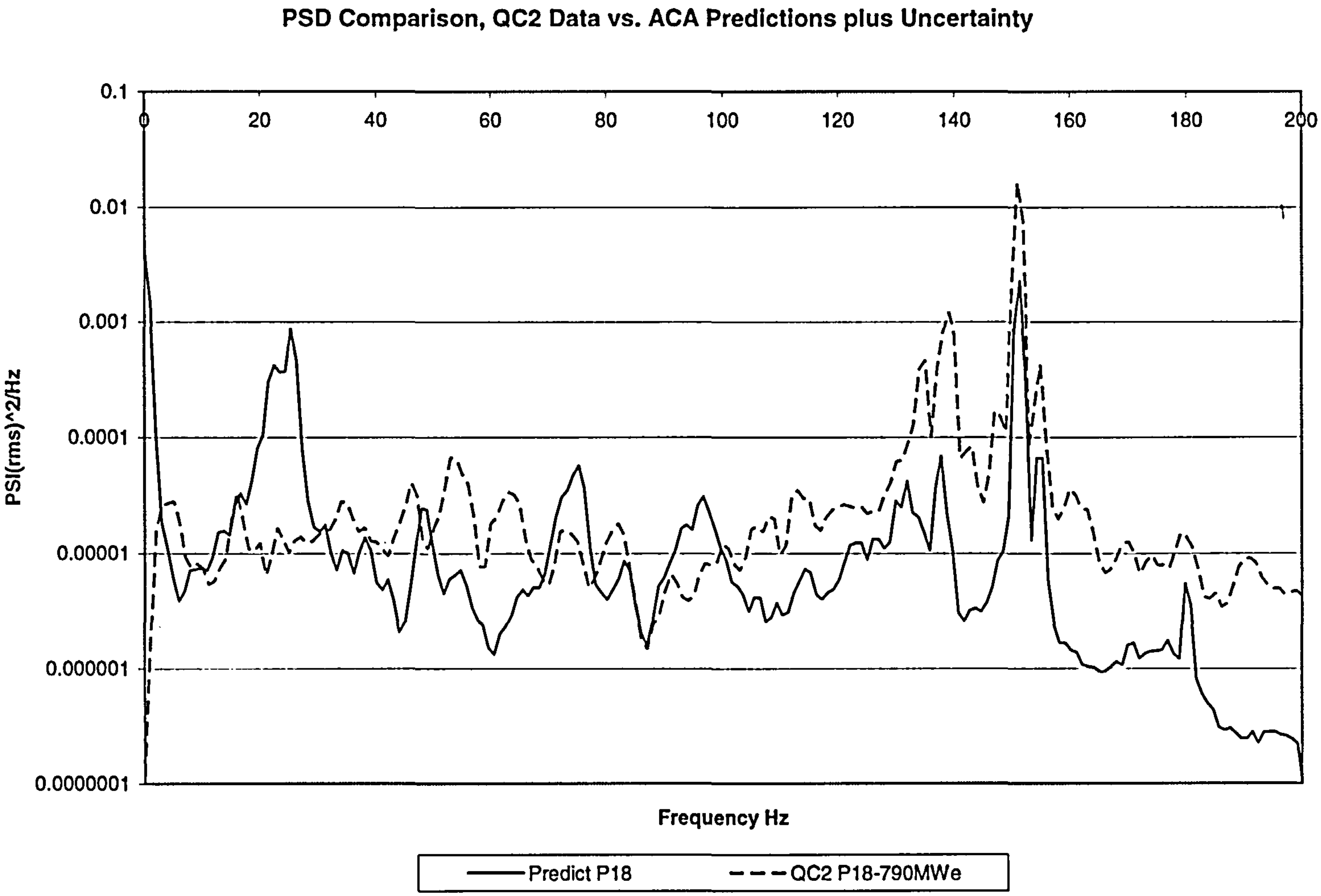

Figure EMEB-B-18-1-4-16

Exhibit EMEB-B-18-1 Rev. 1 -VYNPS Steam Dryer Load Uncertainty
NON-PROPRIETARY INFORMATION

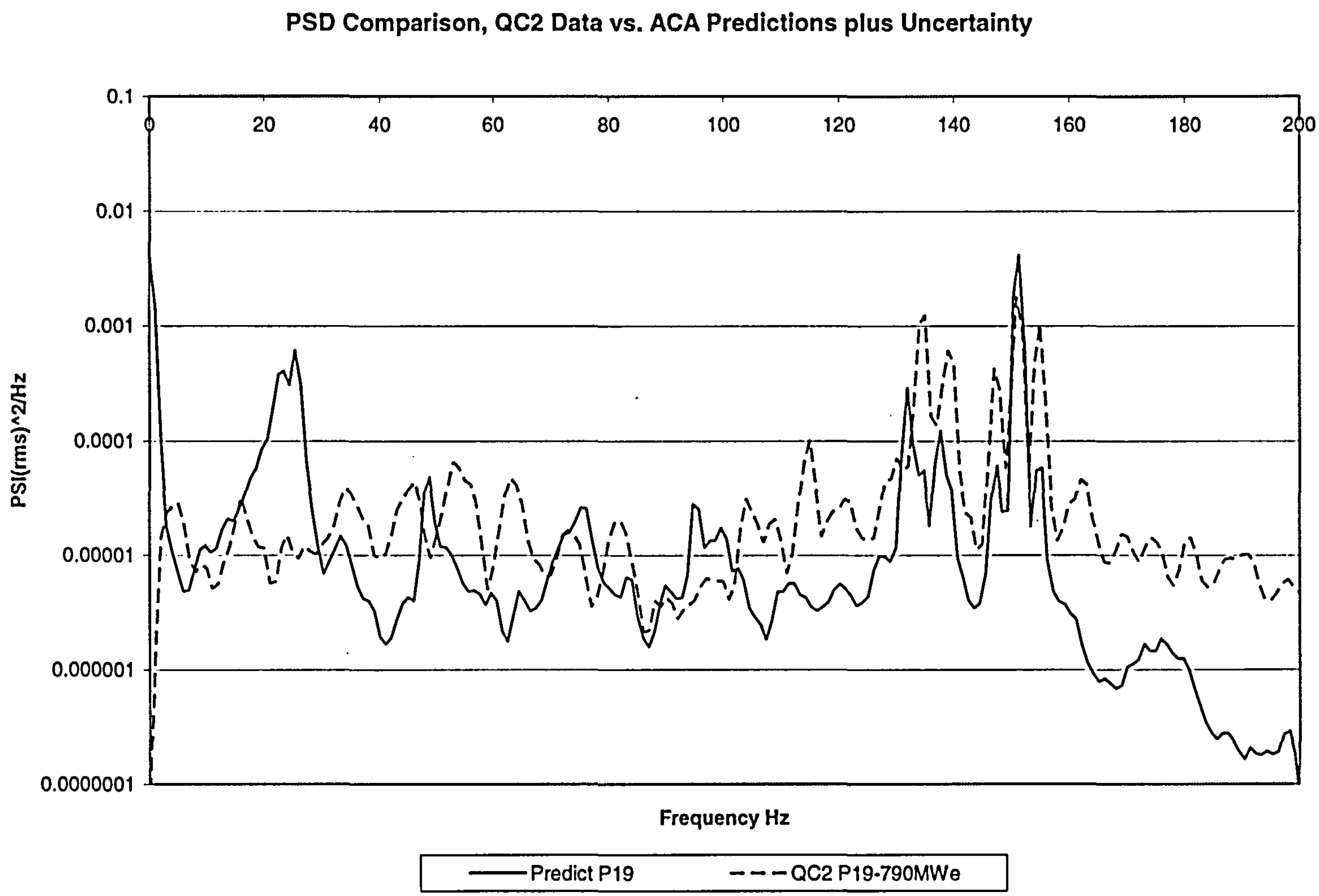

Figure EMEB-B-18-1-4-17

Exhibit EMEB-B-18-1 Rev. 1 -VYNPS Steam Dryer Load Uncertainty
NON-PROPRIETARY INFORMATION

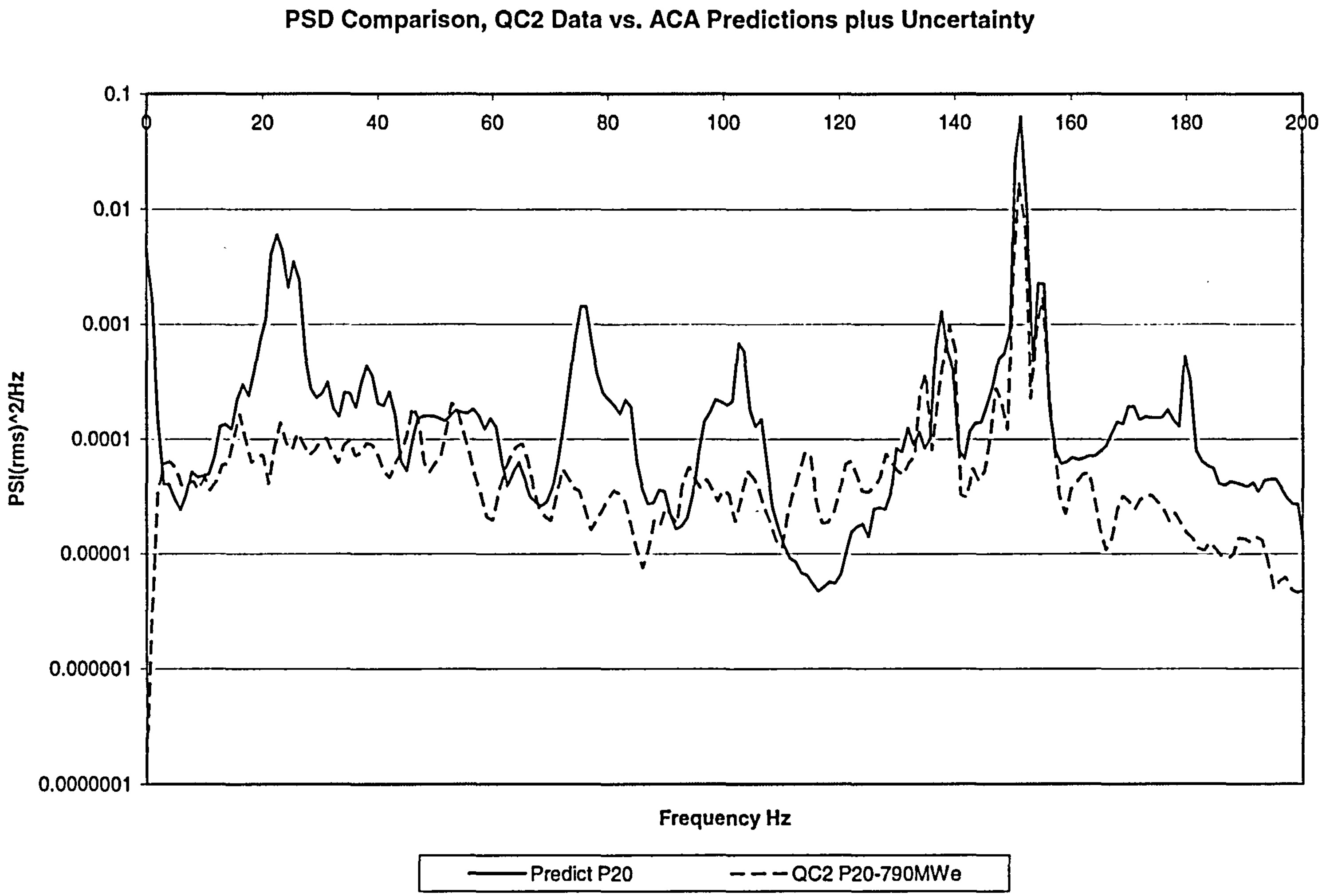

Figure EMEB-B-18-1-4-18

Exhibit EMEB-B-18-1 Rev. 1 -VYNPS Steam Dryer Load Uncertainty
NON-PROPRIETARY INFORMATION

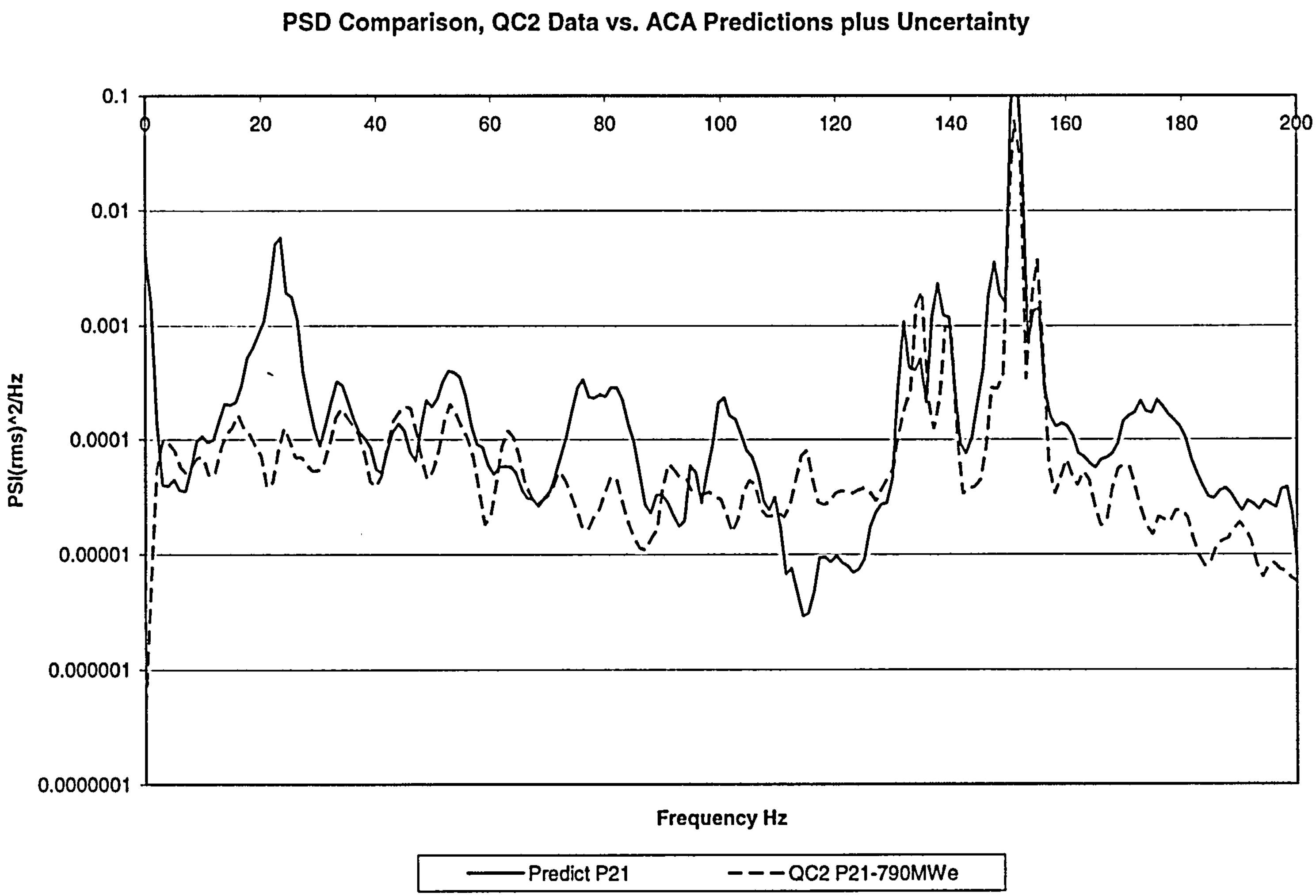

Figure EMEB-B-18-1-4-19

Exhibit EMEB-B-18-1 Rev. 1 -VYNPS Steam Dryer Load Uncertainty
NON-PROPRIETARY INFORMATION

PSD Comparison, QC2 Data vs. ACA Predictions plus Uncertainty

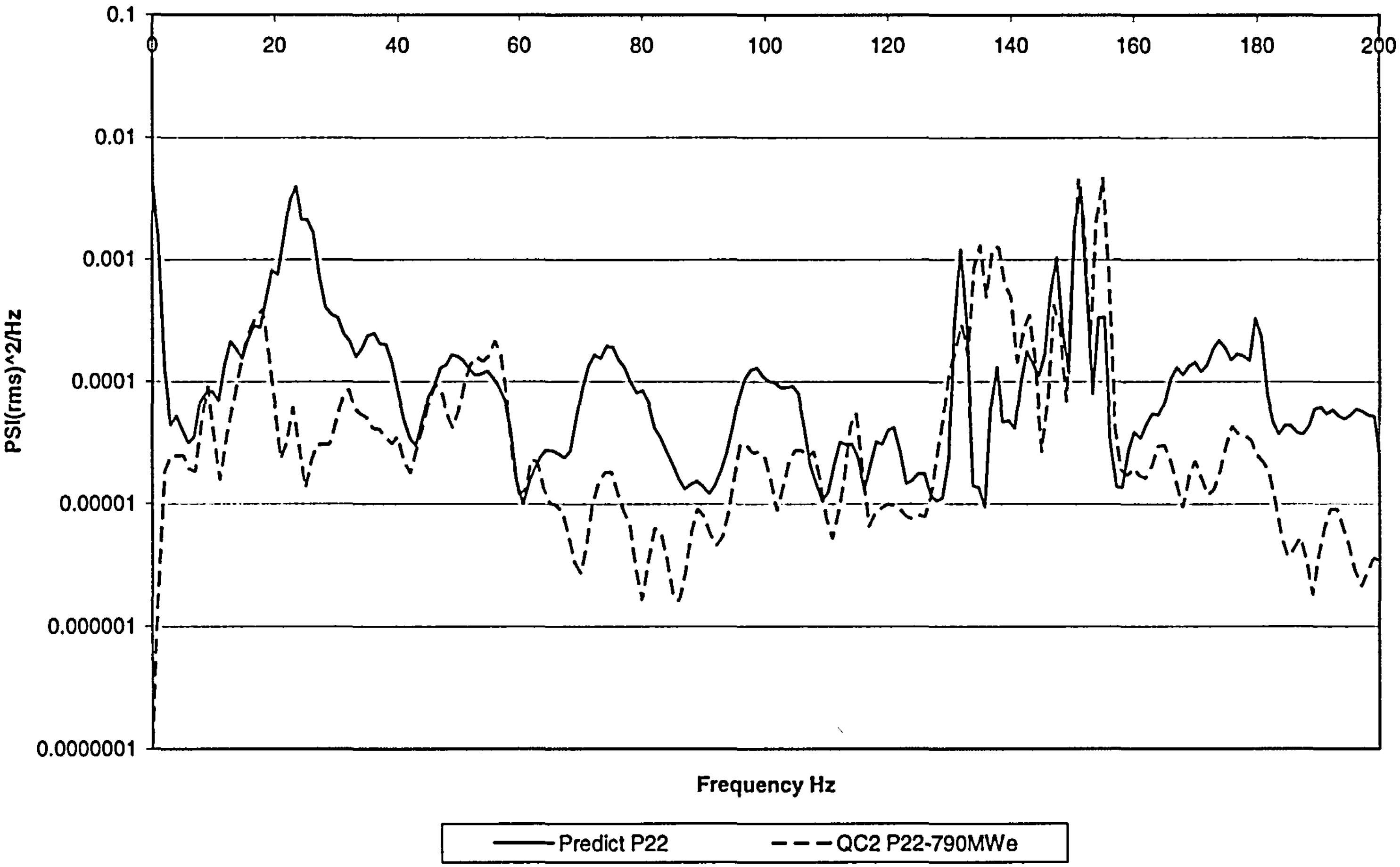

Figure EMEB-B-18-1-4-20

Exhibit EMEB-B-18-1 Rev. 1 -VYNPS Steam Dryer Load Uncertainty
NON-PROPRIETARY INFORMATION

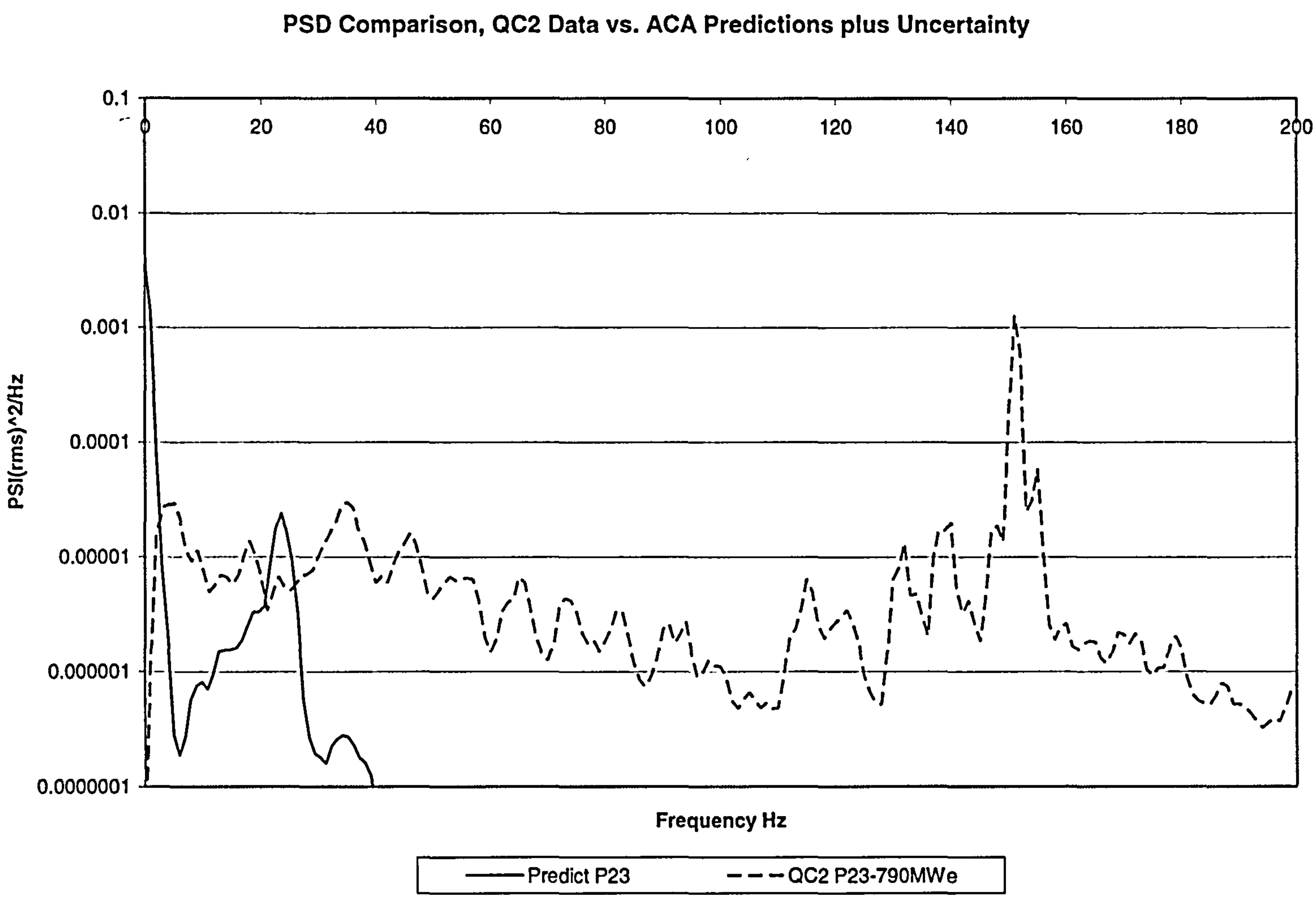

Figure EMEB-B-18-1-4-21

Exhibit EMEB-B-18-1 Rev. 1 -VYNPS Steam Dryer Load Uncertainty
NON-PROPRIETARY INFORMATION

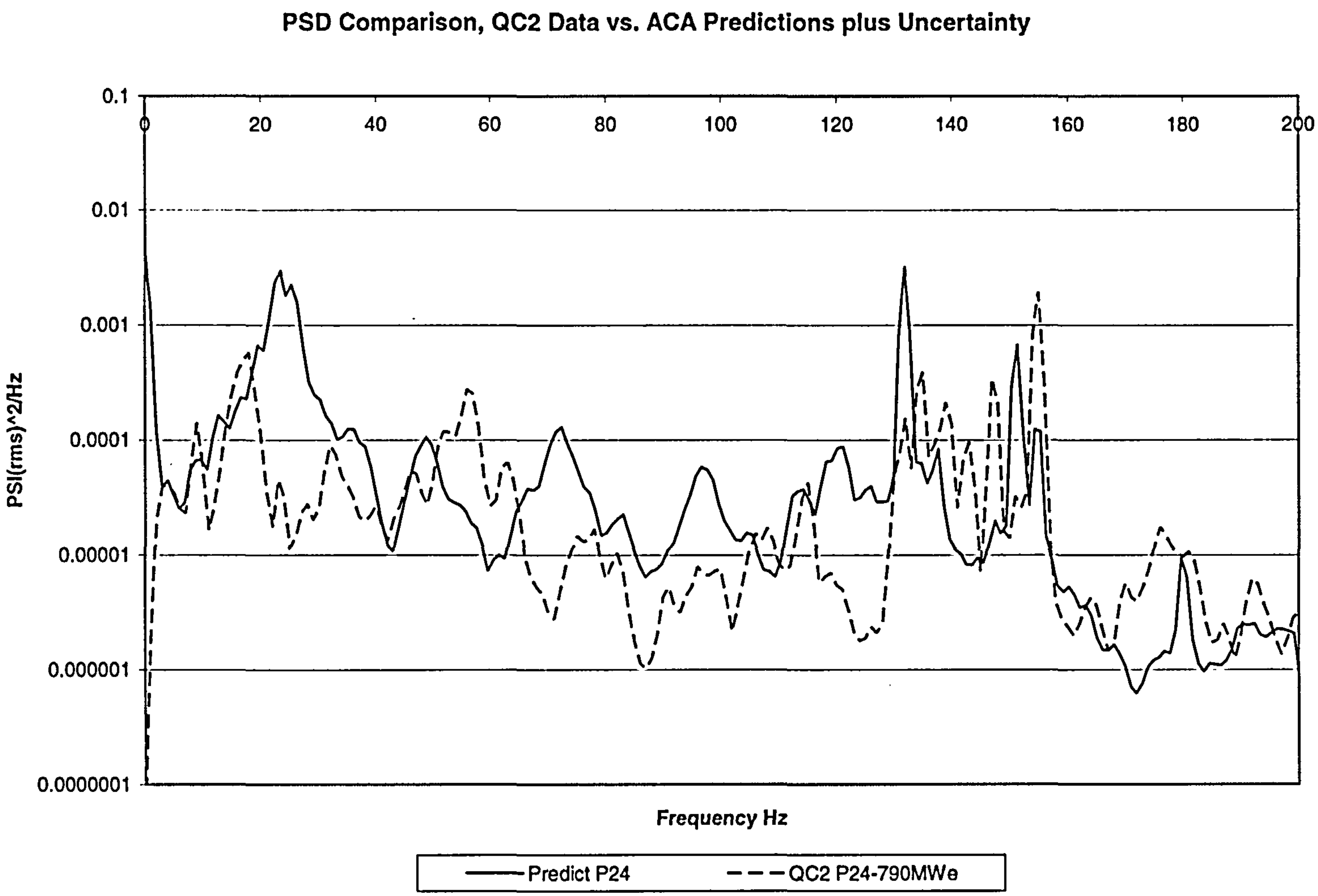

Figure EMEB-B-18-1-22

Exhibit EMEB-B-18-1 Rev. 1 -VYNPS Steam Dryer Load Uncertainty
NON-PROPRIETARY INFORMATION

PSD Comparison, QC2 Data vs. ACA Predictions plus Uncertainty

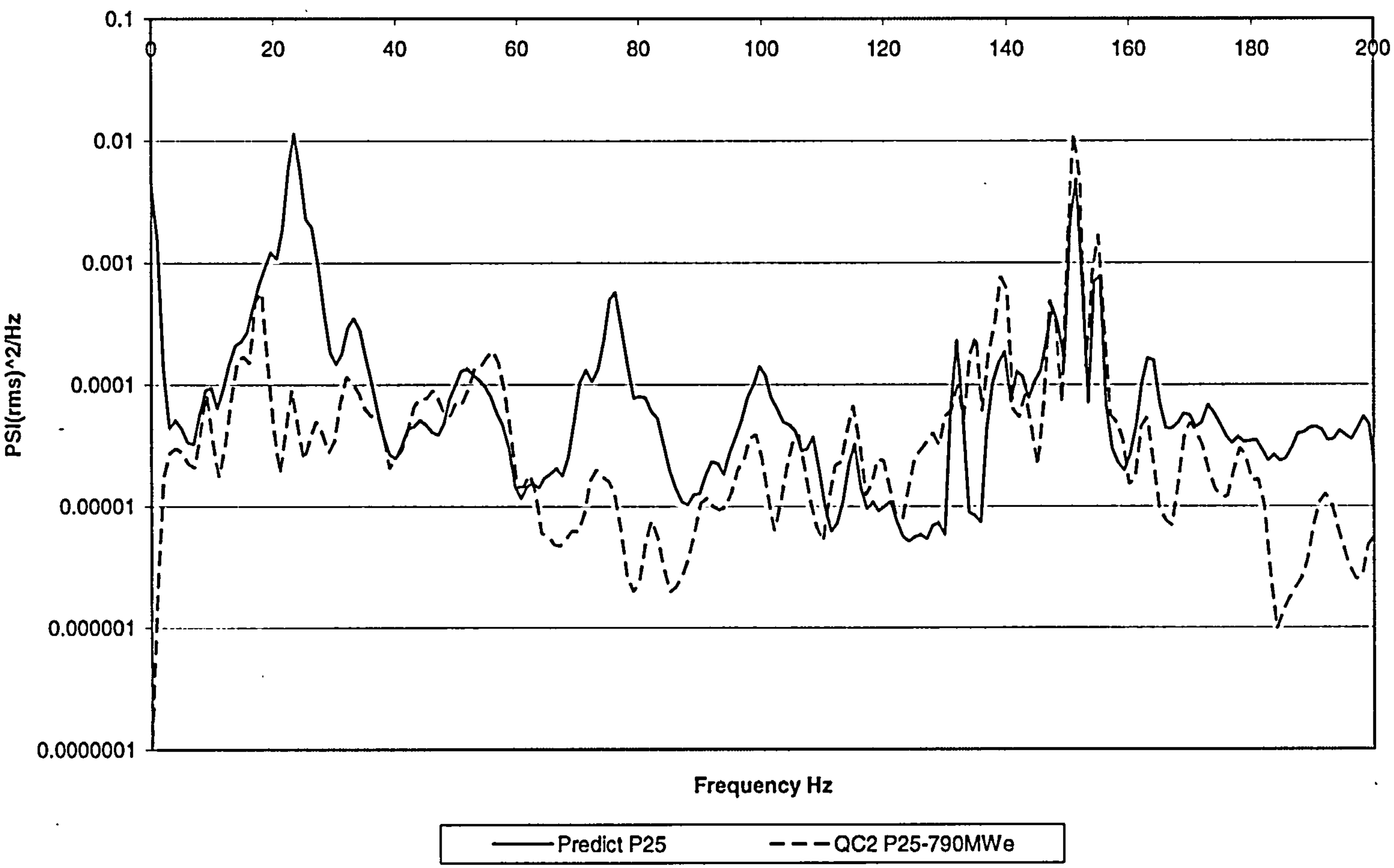

Figure EMEB-B-18-1-4-23

Exhibit EMEB-B-18-1 Rev. 1 -VYNPS Steam Dryer Load Uncertainty
NON-PROPRIETARY INFORMATION

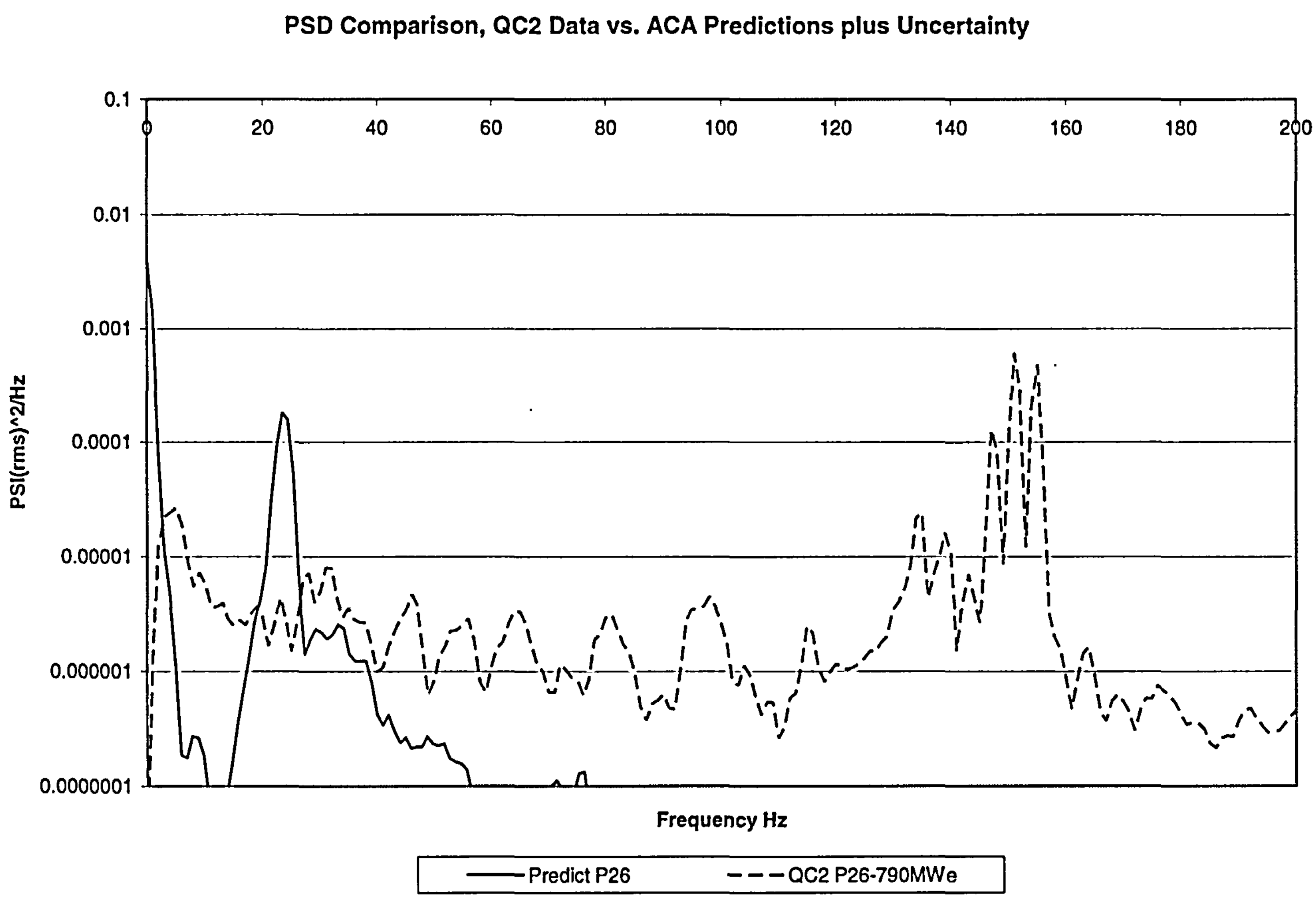

Figure EMEB-B-18-1-4-24

Exhibit EMEB-B-18-1 Rev. 1 -VYNPS Steam Dryer Load Uncertainty
NON-PROPRIETARY INFORMATION

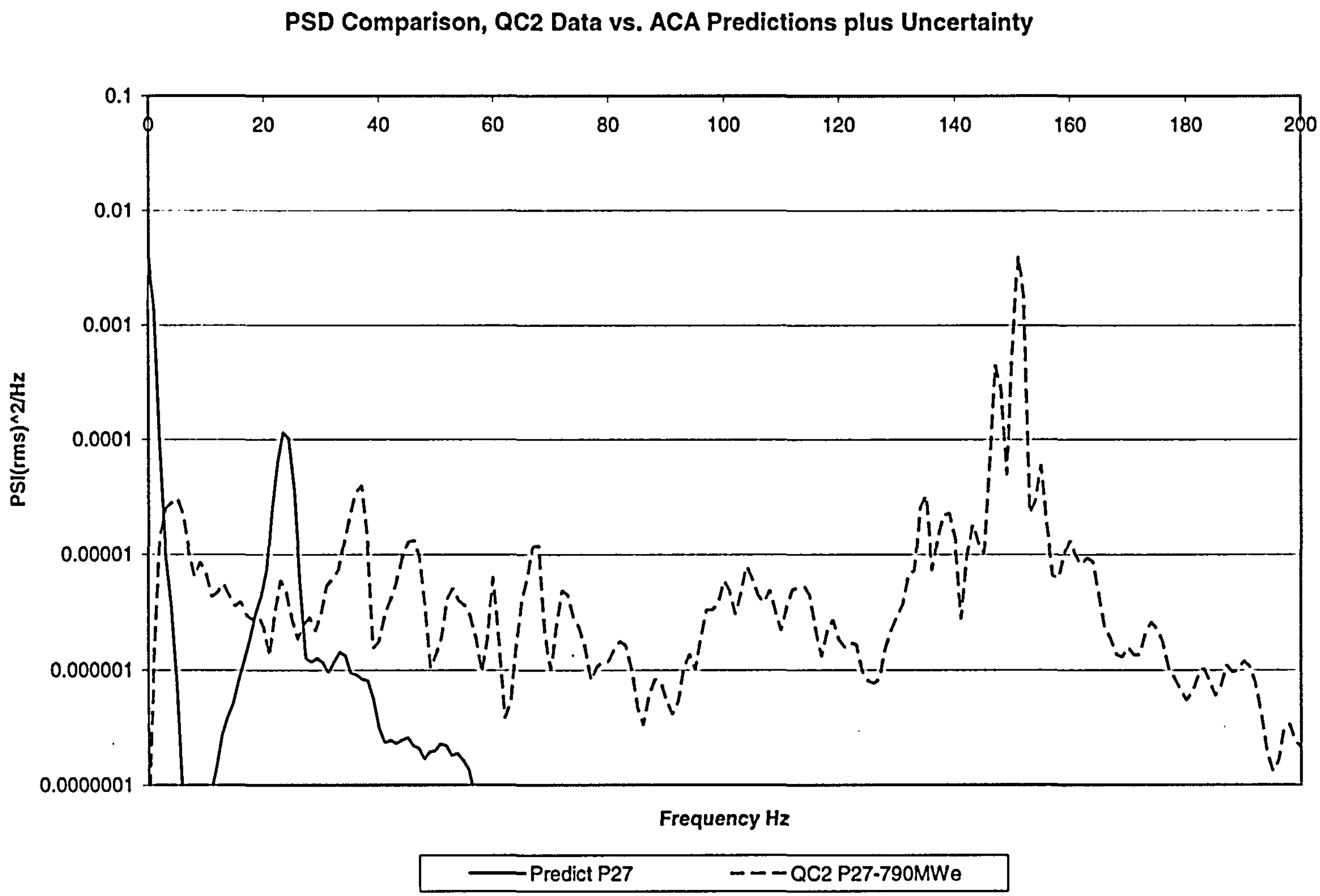

Figure EMEB-B-18-1-4-25

Exhibit EMEB-B-18-1 Rev. 1 -VYNPS Steam Dryer Load Uncertainty
NON-PROPRIETARY INFORMATION

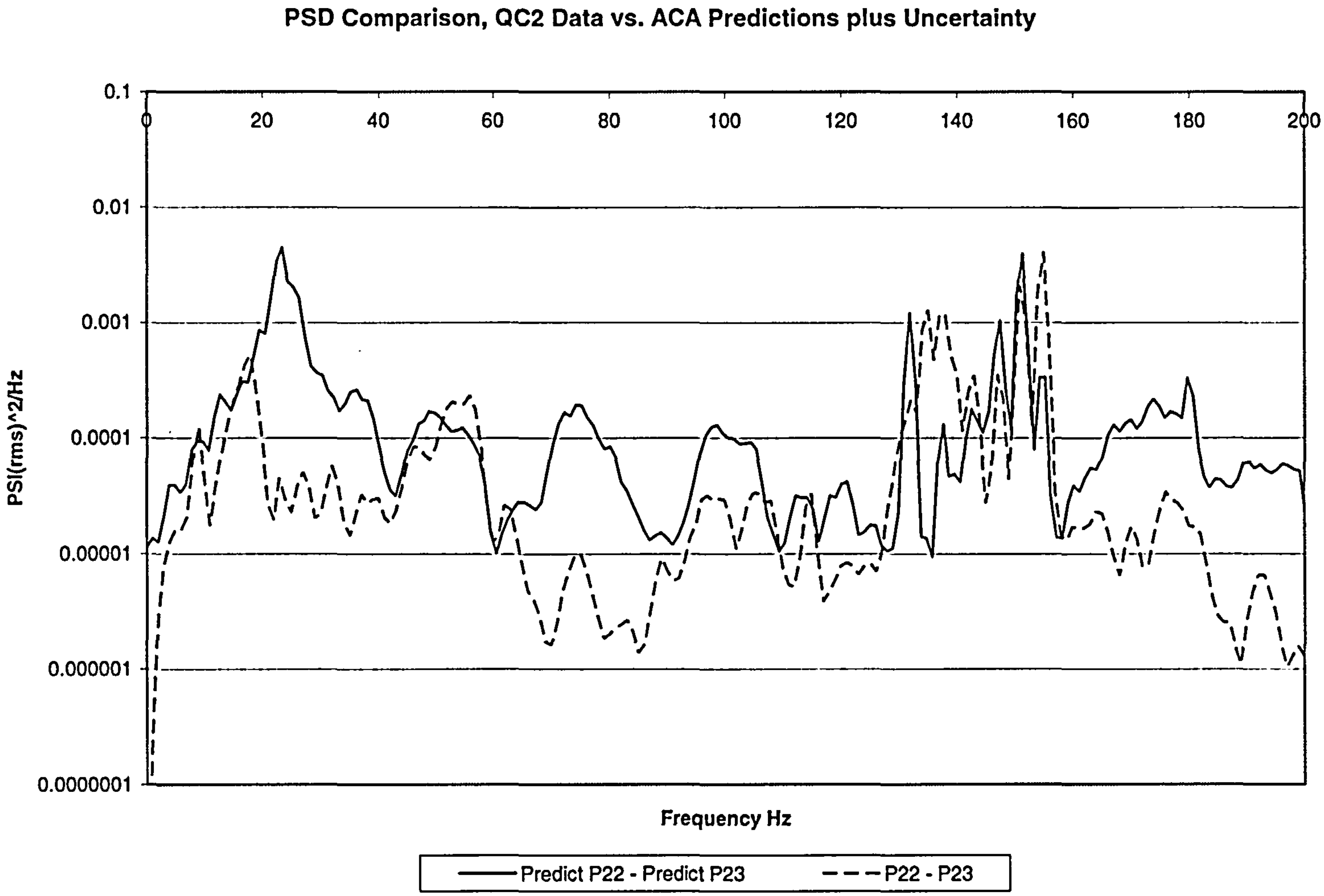

Figure EMEB-B-18-1-4-26

Exhibit EMEB-B-18-1 Rev. 1 -VYNPS Steam Dryer Load Uncertainty
NON-PROPRIETARY INFORMATION

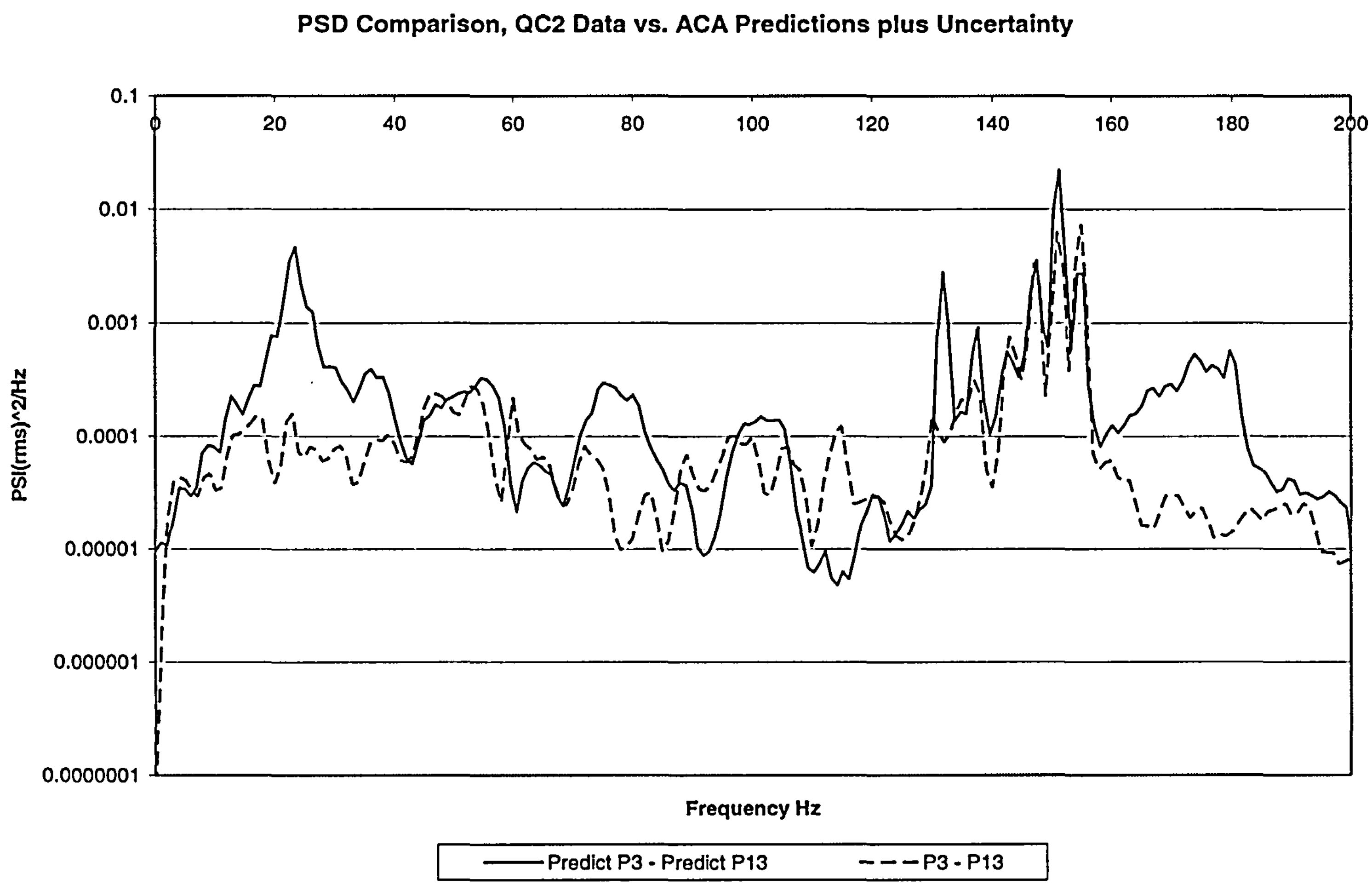

Figure EMEB-B-18-1-4-27

Attachment 5
Vermont Yankee CFD Load Uncertainty

The VYNPS CFD results at 120% power were compared against the available measurements from in-plant testing with instrumented dryers in order to estimate the uncertainty associated with the CFD prediction. The comparison locations are summarized in Table EMEB-B-18-5-1. Locations 1, 2, and 4 are in the skirt region. Location 3 is on the lower horizontal cover plate. Location 5 is on the side of the dryer hood. The CFD predictions at these locations were compared with the individual in-plant sensor measurement.

Locations 6 through 9 are the 4 quadrants of the VYNPS vertical face as delineated by the vertical gussets. Fluent provided the averaged pressure time history data for each of these quadrants. These locations were compared with the averaged pressure time history data of the corresponding column of three sensors in the 4x3 array on the face of the dryer.

Previous reviews of the amplitude of the pressure loads acting on the dryer show that the amplitude in the frequency range of interest (below 100 Hz) can be correlated with the average steamline flow velocity. Because the in-plant measurements were taken at steamline flow velocities lower than those expected for VYNPS at 120% power, the in-plant data measurements were scaled by the square of the ratio of the steamline flow velocities:

$$\text{Amplitude}_{\text{scaled}} = \text{Amplitude}_{\text{measured}} \times (V_{\text{in-plant}}/V_{\text{VY}})^2$$

The operating conditions for the in-plant measurements and for VYNPS are shown in Table EMEB-B-18-5-2.

Table EMEB-B-18-5-3 presents a comparison of the RMS values for the VYNPS CFD prediction and the scaled in-plant measurements at each of the sensor locations. With the exception of one point, the VYNPS CFD analysis at 120% power bounds the in-plant data. The CFD prediction was 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% = +37%. Entergy has assigned a -15% uncertainty to the CFD loads. This is based on the Fluent experimental scale benchmark study of confined swirling coaxial jets using an LES model, referenced in response to RAI EMEB-B-73. Therefore based on comparison with available plant data the 15% uncertainty is conservative.

The one exception was Location 3, where the CFD RMS pressure is low by about 33%. Location 3 is on the lower horizontal cover plate at the base of the vertical face. Because of the proximity of the sensor to the vertical face, it is expected that the pressure at this location is representative of the pressure on the vertical face. However, the vertical face comparison for Locations 6-9 show that the CFD results bound the in-plant measurements. There is insufficient information to determine if the difference in these face comparisons is due to the type of sensor used in the Plant C instrumentation (i.e., strain gauges vs. pressure sensors at the other plants) or if the configuration of the dryer hood has an effect on the pressure loading on the face.

Exhibit EMEB-B-18-1 Rev. 1 -VYNPS Steam Dryer Load Uncertainty
NON-PROPRIETARY INFORMATION

Figures EMEB-B-18-5-1 through EMEB-B-18-5-6 present a comparison of the frequency spectra at each of the sensor locations, again with the in-plant measurements scaled to VYNPS operating conditions. In general, the CFD predictions bound the in-plant measurements throughout the frequency range of interest (<100 Hz). There are a few frequencies where the in-plant measurements are slightly higher than the CFD predictions; however, given the variation in vessel sizes and dryer types between the plants being compared, an exact correlation in the frequency spectra is not expected. In addition, there are similar peaks in the CFD predictions at nearby frequencies; the +/-10% frequency shift in the finite element analysis will bound the observed variations.

Of particular note is the frequency comparison for Location 3 (the lower cover plate) shown in Figure EMEB-B-18-5-3. The VYNPS dryer was modified with external gussets; the Plant C dryer does not have these gussets. Therefore, several locations from the CFD analysis were compared with the in-plant measurement. CFD cover plate locations 1 and 4 are outside the outer gussets and are in the region of the vessel steam outlet nozzles. CFD cover plate locations 2 and 3 are near the center gusset and are in the vicinity of the in-plant Location 3. The in-plant measurement shows a strong peak at approximately 25 Hz. The CFD prediction shows a strong peak at approximately 5 Hz. It is not known what, if any, effect the external gussets may have on the frequency content of the pressure loading on the face of the dryer. However, the cover plate and hood modifications made to the VYNPS dryer have raised the fundamental frequencies of these components well above this frequency range. Therefore, this potential difference in frequency for the pressure load is not expected to be structurally significant.

Based on the comparisons of amplitude and frequency spectra between the VYNPS CFD prediction for 120% power and the available in-plant measurements, an uncertainty of 15% is assigned to the CFD results to account for the possibility that the CFD analysis may underpredict the pressure on the dryer face. Based on the ANSYS analysis for the +/-10% CFD load step assessment a 4% load step uncertainty is assigned. This results in a total CFD uncertainty of sqrt(15^2+4^2) =16%.

Table EMEB-B-18-5-1: Summary of Test Data Used in Benchmark

Location ID	Plant	Sensor	Azimuth (Degrees)	Location
1	Plant A	P1 (skirt)	90	47" Below Top of Support Ring
2	Plant B	P3 (skirt)	90	Top of Skirt Just Below Bottom of Support Ring
3	Plant C	S10	90	Top of Lower Horizontal Cover Plate
4	Plant D	P25	75	Under Support Ring Between 3rd and 4th Quadrant
5	Plant D	P17	20	about 30% of Bank Height Above Support Ring
6	Plant D	P1		Vertical Face 1st Quadrant
	Plant D	P2		Vertical Face 1st Quadrant
	Plant D	P3		Vertical Face 1st Quadrant
7	Plant D	P4		Vertical Face 2nd Quadrant
	Plant D	P5		Vertical Face 2nd Quadrant
	Plant D	P6		Vertical Face 2nd Quadrant
8	Plant D	P7		Vertical Face 3rd Quadrant
	Plant D	P8		Vertical Face 3rd Quadrant
	Plant D	P9		Vertical Face 3rd Quadrant
9	Plant D	P10		Vertical Face 4th Quadrant
	Plant D	P11		Vertical Face 4th Quadrant
	Plant D	P12		Vertical Face 4th Quadrant

Table EMEB-B-18-5-2: Plant Operating Conditions and Geometry

Plant	Average Steamline Flow Velocity (Ft/Sec)	Plant Power	Vessel ID (Inches)	Dryer Type
Plant A	149	100%	188	Square Hood
Plant B	141	100%	280	Curved Hood
Plant C	129	100%	251	Curved Hood
Plant D	170	84%	251	New Dryer
Vermont Yankee	168	120%	205	Square Hood

Exhibit EMEB-B-18-1 Rev. 1 -VYNPS Steam Dryer Load Uncertainty
NON-PROPRIETARY INFORMATION

Table EMEB-B-18-5-3: Comparison in RMS Values 0-100Hz, VY CFD Data vs. Plant Data

Location	VY CFD 120% RMS 0-100 Hz	In-Plant Measurements RMS 0-100 Hz*	Margin Above In-Plant Measurement
1	0.370	[[	246%
2	0.197		95%
3	0.192		-33%
4	0.202		183%
5	0.135		201%
6	0.110		101%
7	0.108		84%
8	0.113		99%
9	0.106	]]	90%

*In-plant RMS measurements scaled to VYNPS steamline flow velocity based on the ratio of steamline flow velocities squared.

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Figure EMEB-B-18-5-1

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Figure EMEB-B-18-5-2

Exhibit EMEB-B-18-1 Rev. 1 -VYNPS Steam Dryer Load Uncertainty
NON-PROPRIETARY INFORMATION

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Figure EMEB-B-18-5-3

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Figure EMEB-B-18-5-4

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Figure EMEB-B-18-5-5

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Figure EMEB-B-18-5-6

Attachment 9

Vermont Yankee Nuclear Power Station

Proposed Technical Specification Change No. 263 – Supplement No. 33

Extended Power Uprate

Response to Request for Additional Information

Revised Exhibit EMEB-B-143-1

NON-PROPRIETARY VERSION

Total number of pages in Attachment 9 (excluding this cover sheet) is 38.

Overview

This Exhibit summarizes the updated structural analysis of the VYNPS dryer for CFD loads that include data at both 100% and 120% power conditions. The stress report submitted in Attachment 5 to Supplement 26 (BVY 05-034 dated March 31, 2005) included analysis for 100% power (CLTP) CFD data. That report included a structural review of 17 time point snap shot cases to assess the magnitude of turbulent forces in the VYNPS dryer plenum. After submitting the stress report Entergy and Fluent continued to run the CFD analysis over the next two months and developed dynamic, transient solutions for both the 100% (CLTP) and 120% (EPU) power conditions. The structural analysis was updated with the new CFD loads.

Entergy also performed +/-10% time step evaluations of the CFD loads to assess the sensitivity of the results for load and structural frequency uncertainty.

This Exhibit also summarizes the evaluation of Acoustic and CFD load uncertainty. This evaluation is applicable only to the VYNPS dryer analysis and reflects the specific measurement and analytical methods used by Entergy. These uncertainties were used to calculate an uncertainty value for the limit curve factor, for application to the power ascension to confirm the structural integrity of the VYNPS modified steam dryer. To respond to NRC questions about VYNPS methodology uncertainty, the final limit curve factor is determined by subtracting uncertainty from the most limiting factor of any dryer component. If the100% plant steam line data stays below the limit curve factor between 100% and 120% operation, the attached information demonstrates that Code limits will be met and structural integrity will be maintained. This response demonstrates that the VYNPS modified dryer maintains considerable margin against code limits even with bounding uncertainties applied.

Summary

The following conservative uncertainty values were determined for the CFD and acoustic loads used in this assessment:

CFD Load Uncertainty	16%
ACM Load Uncertainty	130%

The load factor shown below is the minimum load factor considering all dryer components and both 100% and 120% CFD load conditions that could be applied to the acoustic circuit loads to maintain the peak stress limits shown:

Acceptance Level	Level 1	Level 2
Peak Stress Limit	13,600 psi ASME C Limit LCF1	0.8 x 13,600 80% of ASME C Limit LCF2
Minimum Load Factor	6.78	5.17
Uncertainty of Load Factor	3.91	3.02
Load Factor Minus Uncertainty	2.87	2.14

Normally in fatigue analysis, mean values of expected loads are used. The margin for uncertainty is contained in the conservative fatigue limits included in the ASME Code. These contain a factor of two for stress and twenty for the number of cycles. The load factor uncertainties shown above have been subtracted from the minimum load factors to demonstrate that the VYNPS modified steam dryer maintains considerable Code margin for EPU operation.

Discussion

The VYNPS steam dryer loads are generated from two fluid models; an acoustic circuit model (ACM) and a computational fluids dynamics model (CFD). Benchmarking of the ACM model demonstrated that it does a reasonable job of predicting loads above 20 Hz. Loading above 20 Hz is predominantly acoustic. The CFD model was used to establish the VYNPS load definition below 20 Hz, where fluid momentum effects are prevalent. Stress from both load cases are combined in the VYNPS dryer FIV assessment.

Development of CFD Loads

Transient data from the CFD simulation was saved at a .0001 sec time interval for dryer dP forces as well as steam line mass flow and other key parameters. Signal analysis of the new data demonstrated that the plenum region was experiencing more high frequency load content than indicated by the two discrete data points previously used to monitor results. Based on this difference, Entergy decided to use the new data to evaluate the dryer dynamically.

The CFD model was developed to depict hydrodynamic forces. The time step and model boundary conditions were selected to properly model hydrodynamic forces. The modeling however assumed compressible steam properties to provide a more realistic depiction of the turbulence at the outlet of the steam dome. The compressible properties also resulted in acoustic forces along with the hydrodynamic loads. The CFD load energy above 30 Hz, as depicted by the PSD charts in Attachment 1 to Supplement 29, is considered to predominantly reflect acoustic ringing.

Key stress results from three of the cases evaluated are summarized in Table EMEB-B-143-1-1, including:

- ACM results from the Supplement 26 stress report
- CFD analysis 100% power
- CFD analysis 120% power
- CFD analysis 120% power with a shortened time step. (The plus time step results were analyzed but not summarized because they had no increase to stress on limiting components.)
- CFD results for 100% and 120% power with filtered data

It is noted that the CFD stress is still low, but the transient analysis stress is higher than the static load developed from the original time point snap shot case data. There is not a significant difference between the stresses from CFD transient analysis at 100% and 120% power.

The time step change sensitivity assessment did not have a significant impact on the components most limiting from the standpoint of limit curve factor. The most limiting component was the modified top outer hood. Here the stress increased from 1112 psi to 1155 psi, or 4%.

The purpose of the CFD analysis was to define the hydrodynamic loads. The CFD model included compressibility and as a result a sizeable portion of the load above 30 Hz was determined to be acoustic ringing. The ACM model was used to define acoustic loads. To help characterize the impact of the CFD acoustic loads on the dryer stress the critical component of the CFD alternating stress was identified for all key stress locations. The stress data was then low-pass filtered at 30 Hz. A stress ratio was then calculated between the peak stress with filtering and peak stress before filtering. This ratio was then used to factor the CFD peak stress to remove the acoustic load.

These factored stresses are presented in the stress summary to help quantify the affect of hydrodynamic versus acoustic loads on fatigue stress. The significant reduction in the CFD stress supports the industry position that the important dryer loads are acoustic. The filtered stress was not used in the evaluation of combined stress or the limit curve factors presented here.

Calculation of FIV Loads

In order to address the issue of ACA load prediction capability at < 20 Hz and adequately quantify low frequency loads, Entergy decided to add the CFD hydrodynamic loads to the stress analysis. Since the acoustic signals in the VYNPS steam lines are very low the hydrodynamic forces could be a significant part of the dryer load.

Supplement 26 (BVY 05-034 dated March 31, 2005) reflected 17 time point snap shot load cases from the earlier CFD 100% run. The CFD loads were combined by absolute sum with the acoustic model stress results and compared with Code stress limits. This evaluation combines the results from the ACA and CFD transient analyses, two dynamic transient runs that are based on independent load sets. The SRSS combination is consistent with the VYNPS design basis for RPV internals. The acoustic and CFD loadings have frequency content that does not overlap. Therefore, a SRSS approach to combine the calculated stresses from these two sources is justified. Also, the SRSS approach is typically used to combine responses from various dynamic loads. For conservatism the maximum alternating value from each load set without credit for stress orientation is used.

Stress Equation for FIV Loads:

$$(CFD^2 + (LCF*ACM)^2)^{1/2} *Wf * Sif \leq Lf * Salt$$

Where:

LCF= Limit Curve Factor

Lf = Code Factor

Lf (Limit Curve 1)= Lf = 1.0

Lf (Limit Curve 2)= Lf = 0.8

Salt = Allowable Alternating Stress=13,600 psi

Wf=Weld Geometry Factor

Sif= Stress Intensification Factor

CFD = half the stress range from ANSYS analysis for CFD transient loads, psi. The most limiting of either the 100% power or 120% power loads were used.

ACM = half the stress range from ANSYS analysis for ACM transient loads, psi. Based on Plant 100% power Steam Line Data.

The stress summaries for the ACA loads with 100% and 120% CFD Loads are included in Tables EMEB-B-143-1-2 and EMEB-B-143-1-3. The stress summaries for ASME load combinations at selected locations and comparison with allowable values are shown in Tables EMEB-B-143-1-4 (a) through (g) for CLTP case. Tables EMEB-B-143-1-5 (a) through (g) show the corresponding values for the EPU case (120% power).

Note that the following revisions were considered in these revised tables:

- The FIV primary stress now includes weld size factor when combining with other loads to obtain total stress
- The faulted condition load combinations in these tables include the revision where combinations D3 and D4 include FIV stress instead of combinations D1 and D2.
- The acoustic and CFD stresses are combined by the square-root-of-sum-of-squires (SRSS) method rather than by conservative absolute sum method used in the March 2005 stress report.

The design basis event for Level D is the main steamline break outside containment. There are two basic load combinations on the dryer for this event. The first load combination is the acoustic rarefaction wave that is generated by the pipe opening. The second load combination is the two-phase level swell impact caused by the flashing of the water in the RPV. These two loads are separated in time and are analyzed separately. Load combinations D1 and D2 represent the level swell impact phase of the event. Load combinations D3 and D4 represent the acoustic wave impact phase of the event.

Earlier the load combinations D1 and D2 had the FIV stress included. However, the FIV stress need not be included in these combinations because the level swell in the annulus between the dryer and vessel wall and subsequent introduction of two-phase flow in the steamline will disrupt the acoustic sources that dominate the FIV load component.

On the other hand, for load combinations D3 and D4, where the acoustic loading from postulated break is considered, the FIV loading needs to be included. The arrival of the acoustic wave is the first indication to the dryer that the break has occurred. At the time of the acoustic wave impact, the normal operation DP and the normal operation FIV loads are present; therefore, FIV is now included in the faulted combinations D3, D4.

Method of Solution Considering Uncertainty

In the development of the limit curve factor, the following methodology was utilized to evaluate the uncertainty in this factor. Given $a \pm \sigma_a$ and $b \pm \sigma_b$, the following methodology is used by Entergy to evaluate the propagation of errors.

Addition

$$Q = a + b$$

$$\sigma_Q = [(\sigma_a)^2 + (\sigma_b)^2]^{1/2}$$

Subtraction

$$Q = a - b$$

$$\sigma_Q = [(\sigma_a)^2 + (\sigma_b)^2]^{1/2}$$

Multiplication

$$Q = a \cdot b$$

$$\sigma_Q = a \cdot b \cdot [(\sigma_a/a)^2 + (\sigma_b/b)^2]^{1/2}$$

Square

$$Q = a^2$$

$$\sigma_Q = a \cdot a \cdot [(\sigma_a/a)^2 + (\sigma_a/a)^2]^{1/2}$$

$$\sigma_Q = \mathrm{sqrt}(2)\, a^2 \cdot (\sigma_a/a)$$

Division to Assess Minimum Value (Minimum of Q-σ_Q)

$$Q = a / b$$

$$\sigma_Q = a / b - (a-\sigma_a) / (b+\sigma_b)$$

Evaluation of the limit curve factor with load uncertainty

Stress Equation for FIV Loads:

$$(CFD^2 + (LCF*ACM)^2)^{1/2} *Wf * Sif \leq Lf * Salt$$

Rearranging, the limit curve factor is derived:

$$LCF = [((Lf*Salt)/(Wf*Sif))^2 - CFD^2)^{1/2}]/ACM$$

Load Uncertainty Rations

UncCFD = CFD Load Uncertainty Ratio
= σ_{cfd} / CFD (expressed in percent).

UncACM = ACM Load Uncertainty Ratio
= σ_{acm} / ACM (expressed in percent).

Conservative code SIF and Code allowable limits maintained.

Step 1 solve the following term:

$a1 = ((Lf*Salt)/(Wf*Sif))^2 - CFD^2)$

The only uncertainty term to consider here is with the CFD term.

The uncertainty associated with CFD^2 is expressed as

$\sigma_1 = sqrt(2) * CFD^2 * \sigma_{cfd} / CFD = sqrt(2) * CFD^2 * UncCFD$

Step 2 solve the following term:

$a2 = ((Lf*Salt)/(Wf*Sif))^2 - CFD^2)^{1/2} = (a1)^{1/2}$

Here it is necessary to assess the uncertainty associated with performing the square root of a1. This is expressed as the inverse of the square expression used in step 1.

$\sigma_2 = (\sigma_1 * a2) / (sqrt(2) * a1)$

Step 3 solve the following term:

$LCF = [((Lf*Salt)/(Wf*Sif))^2 - CFD^2)^{1/2}]/ACM$

a3= a2/ACM

Here it is necessary to assess the uncertainty associated with performing division.

$\sigma_3 = a2 / ACM - (a2 - \sigma_2) / (ACM + \sigma_{acm})$

$\sigma_{acm} = UncACM * ACM$

$\sigma_3 = a2 / ACM - (a2 - \sigma_2) / (ACM + UncACM * ACM)$

Development Uncertainty Values used in this assessment

The ACM uncertainty was calculated as 130% in the ACA Uncertainty assessment included as Exhibit EMEB-B-18-1 Rev 1. Based on information from the CFD model sensitivity evaluation, Entergy has determined a CFD uncertainty value of 15% for the projected CFD loads. The comparison of the turbulence energy in the LES runs was shown to be higher than in RANS comparison runs. Entergy has provided further benchmark of these loads against operating data in Exhibit EMEB-B-18-1 Rev 1, Attachment 5. The CFD analysis with the +/- 10% change in load step had an impact to the limiting stress of 4%. Therefore the CFD frequency uncertainty is determined to be 4%. The total CFD uncertainty; uncCFD= sqrt(15^2 + 4^2) = 16%.

In Supplement 26 Attachment 5, load step run was used to find the maximum acoustic load stress on the dryer. When looking at uncertainty it is more appropriate to express the nominal stress based on the best estimate of load and structural frequencies and use of the +/- time step solutions to assess the uncertainty in the stress as a result of the frequency uncertainty. Therefore Table 5.1-2 of Attachment 5 to Supplement 26 has not been revised for this update.

Based on CFD/ACM load uncertainties of 16% and 130% respectively, Tables EMEB-B-143-1-2 and EMEB-B-143-1-3 provide a summary of the limit curve factors and limit curve factor uncertainty for ACA loads combined with the most limiting of either the CFD 100% power or CFD 120% power loads. The most limiting values from these two assessments were used as the final recommended values included in the summary above.

The limit curve that will serve as the Level 1 and 2 performance criteria described in the Steam Dryer Monitoring Plan (SDMP) contained in Attachment 6 is based on the 100% CLTP strain gage measurements used as input to the VYNPS ACA, plus uncertainty as defined in this revised Exhibit. This purpose of this limit curve is to assure that when main steam line strain gage measurements stay below the limit, VYNPS steam dryer structural integrity is maintained during power ascension to EPU conditions. The following describes Entergy's assessment of the limit curve relative to the applicable fatigue stress limit and concludes that if the limit curve is not exceeded, the structural integrity of the VYNPS steam dryer will be assured.

The ACA and the finite element analysis that calculated the peak stress from those loads are both linear analyses. Therefore if the steam line signals are factored linearly the ACA loads will increase by the same factor and the FEA peak stress results will in turn change by the same factor. Therefore by comparing the peak stress to code allowable, we can assess the available margin for increase in the steam line signal.

CDI provided additional documentation to support the assertion that the ACM is linear with respect to load amplitude. In order to prove this assumption, the QC2 790 MWe benchmark strain gage data were doubled, for the otherwise same conditions as used in the benchmark assessment described in Exhibit EMEB-B-18-1, and the acoustic circuit model was used to predict the pressure sensor data. One such result, for P12, is shown in Figure EMEB-B-143-1-1, where it may be seen that the PSD of the prediction is nominally four times the PSD of the prediction when the strain gage data were not doubled. A ratio of the two curves demonstrates a factor of four across the frequency range shown here. This exercise demonstrates that the acoustic circuit model is linear.

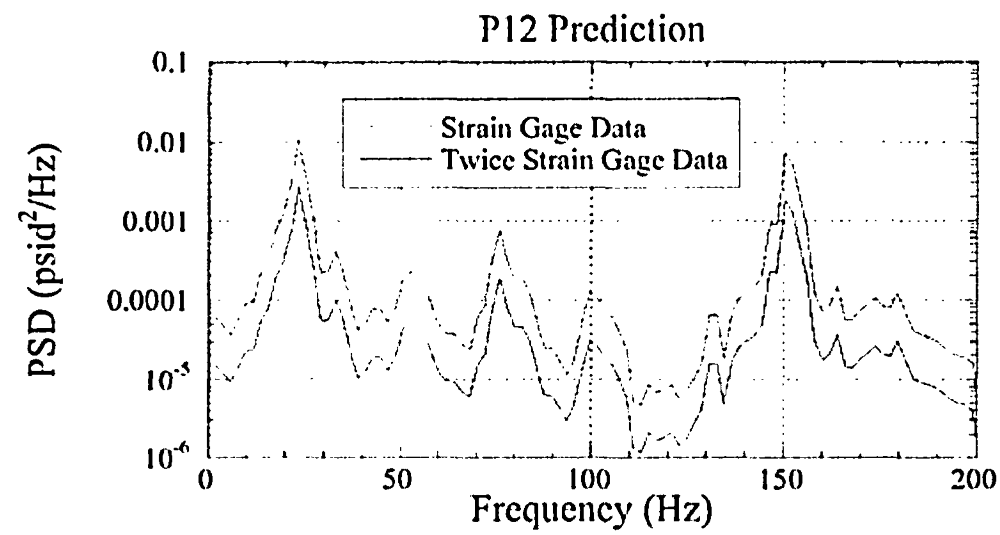

Figure EMEB-B-143-1-1: PSDs of Pressure Sensor P 12, with 1X and 2X Strain Gage Data.

Not only is the ACA model linear, the structural model is as well. The ANSYS analysis method used for this analysis is the Mode Superposition Method. No non-linear features were used in this analysis, as demonstrated in the following equation:

$$[M]\{u''\} + [C]\{u'\} + [K]\{u\} = \{F\}$$

The solution is performed in the Modal coordinate system and then expanded back to the nodal coordinate system. Further detail is available in the ANSYS Theory Manual

Chapter 15. Therefore if the load vector is increased by a factor LCF then the stress increases by the same factor.

In the FIV summary table EMEB-B-143-1-1, the most limiting stress location is the weld at the top of the vertical face. The CFD peak stress at this location is 5124 psi and the ACM stress is 1857 psi. If uncertainty is not considered, the allowable limit curve factor would be 6.78. Therefore if the steam line acoustic load increased by a 6.78 factor, the peak stress from the ACM load would be 6.78 x 1857 psi = 12,598 psi. The SRSS combination of the CFD and ACM stress would be SQRT(5124^2 + 12598^2)= 13,600 psi, the code endurance limit. This demonstrates that the limit curve would assure that the code endurance limit would not be exceeded and VYNPS steam dryer structural integrity would be maintained.

The limit curve factor, 6.78, was reduced by the limit curve factor uncertainty, 3.91, to an adjusted limit curve factor of 2.87. A 3.91 uncertainty is equivalent to a limit curve factor uncertainty of 136% and is calculated based on the ACM and CFD loads and load uncertainties of 130% and 16% as described on page 6 of this Exhibit. If the steam line acoustic load increased by a 2.87 factor in all 4 steam lines, the peak stress from the ACM load would be 2.87 x 1857 psi = 5330 psi. The SRSS combination of the CFD and ACM stress would be SQRT(5124^2 + 5330^2)= 7393 psi, well below the code endurance limit.

Entergy's criteria on the limit curve factor is to limit the signal in all four steam lines to less than the limit curve. Therefore if the signal challenged the curve on only one steam line, the resulting dryer stress would be less than the 7393 psi. Therefore Entergy's limit curve provides additional conservative in the application of the limit curve.

For the ASME load case assessment provided in Tables EMEB-B-143-1-6 and EMEB-B-143-1-7 the derived uncertainty in the acoustic loading is 130% and that in the CFD loading is 16%. Thus the acoustic loading stress was increased by 130% and the CFD loading stress was increased by 16% and then combined by SRSS method. The results at one limiting location are shown in Table EMEB-B-143-1-6. It is seen that there is still significant margin to allowable. The limiting primary stress margin (for Load Combination B3) case was further evaluated to determine the margin for ACM load.

It was determined that for the B3 load combination, the available margin to allowable stress is 164% in terms of the overall FIV stress. In other words, the FIV stress of 893 psi can increase by 164% before the allowable upset condition stress of 20588 psi is reached. It is noted that the calculated FIV stress of 893 psi already includes a 130% uncertainty on the acoustic stress and 16% uncertainty on the CFD stress.

The limiting component for ACM increase is B3 for the Long Gussets. The ACM available margin to allowable stress is 201% in terms of the overall FIV stress (see Table EMEB-B-143-7). In other words, the FIV stress can increase by a factor of 3.01 before the allowable upset condition stress of 20588 psi is reached. It is noted that the calculated FIV stress of 2387 psi already includes a 130% uncertainty on the acoustic stress and 16% uncertainty on the CFD stress. This clearly illustrates that even at the limiting location, significant structural margin exists to compensate any unforeseeable change in calculated acoustic loading stress. In addition the pressure stress used in the level B evaluation is based on a conservative value (see Appendix A). The 3.01 factor is higher than the minimum factor minus uncertainty (2.87) calculated for the fatigue stress assessment. Therefore fatigue margin is controlling in terms of ACM loading.

An assessment of the CFD loading at CLTP with uncertainty and ACM loading with uncertainty was also performed to ensure that the CFD loading at CLTP was not governing with respect to the available margin for the ASME load cases. It was determined that the minimum margin available using the CLTP CFD loading is 184% in terms of overall FIV stress and 202% in terms of ACM stress. Therefore, the EPU CFD loading conditions are governing with respect to the ASME cases.

Assessment of Structural Response to CFD transient Loads

The PSD plots CFD load time histories are shown in Figures EMEB-B-143-1-2 and EMEB-B-143-1-3. These figures demonstrate that the CFD load has significant frequency content above 30 Hz. Of particular importance for the dryer is the load peak at 62 Hz. Figure EMEB-B-143-1-4 provides a PSD for key stress locations under the CFD load condition. Most of the frequency content of the stress is at 62 Hz.

Figure EMEB-B-143-1-5 depicts the transient response of a key stress component. Here again the sinusoidal response demonstrates that most of the response is at 62 Hz. The structural response is also shown for the +/- time step sensitivity assessments. The results indicate shortening of the load period, corresponding to the 0.7273 millisecond time step, results in higher stresses. Lengthening the load period by 10% has relatively little impact. The PSD spectrum of Figure EMEB-B-143-1-4 shows energy peaks at 46, 55 and 62 Hz. The 55Hz peak is relatively minor.

The structural mode shapes with a strong component normal to the front face are shown in Figures EMEB-B-143-1-6, EMEB-B-143-1-7 and EMEB-B-143-1-8. Of particular note is mode 22 shown in Figure EMEB-B-143-1-7. This mode has a frequency of 62.7 Hz, well aligned with the 62 Hz peak in the CFD load.

The overall effect of shortening the load period is to 'push' these peaks upwards in frequency with resultant higher stresses. Lengthening the load period 'pushes' these peaks downwards in frequency. In both instances, the 62 Hz peak continues to contribute, but the 46 and 55 Hz peaks are further away from the 62.7 Hz with lengthened load period and closer with shortened load period.

Table EMEB-B-143-1: ANSYS Stress Results, Alternating Stress Amplitude		ACM CLTP Max Surface Stress (psi)	Acoustic Mem-brane Stress (psi)	Vortex Shedding Max Surface Stress at ACM Peak Location (psi)				
				CFD 100% Pwr	CFD 120% Pwr	CFD at 120% 10% Time Step	CFD 100% Pwr Filterd >30 Hz	CFD 120% Pwr Filtered >30 Hz
	Horizontal plates:							
1	Inner hood base plate	588	288	314	624	470		
2(a)	Modified outer cover plate5/8", both tips 4"	896	116	492	437	325	133	149
2(b)	Modified outer cover plate, exclude tips	530	75	492	439	325		
4(a)	Original top hood (all hood)	412	147	888	943	255		
4(b)	Modified top hood (outer hood)	403	71	935	1,112	1,155	94	167
4(c)	Hood top plates(inner hood)	456	405	1987	1,964	1,555	40	39
	Vertical plates:							
5(a)	Original outer Hood , strips	989	173	68	108	96	3	2
5(b)	Modified outer hood, top weld	430	57	381	301	364	42	60
5(c)	Modified outer hood, bottom weld	475	130	621	725	260	81	131
5(d)	Hood vertical plates (inner hood)	484	123	1214	761	905		
6	Hood end plates,(inner hood)	446	319	1040	536	1,273		
7	Hood end plates (outer hood)	1,029	340	713	322	185		
8	Outer Hood Brackets(gussets)	719	446	736	573	165	74	74
10	Steam 'dam'	399	16	818	807	730		
11	Steam 'dam' gussets	537	352	1598	941	793		
0	**Other Plates**							
12	Hood partition plates	288	116	149	94	233		
13	Baffle plates	686	24	1311	1,144	2,034	92	80
14	Outlet plenum ends	536	425	1806	1,891	1,411	54	95
0	Ring, Beams & Gussets							
15	Dryer support ring	527	not req	730	675	400		
16	Bottom cross beams	226	not req	368	135	274		
17	Cross beam gussets	626	40	778	414	1,061		
	Gussets for outer Cover plate and hood							
18(c)	New gusset on cover plate and front hood	1,071	952	730	820	907	204	221
18(a)	Gusset	350		1187	295	406	427	121
18(b)	Gusset foot weld to cover plate	471	440	599	490	244		

Table EMEB-B-143-1-1
FIV Alternating Stress Summary

Table EMEB-B-143-2: FIV Alternating Stress Summary with Hydrodynamic (CFD) Loads 100% Power		Part A: Fatigue Stress Assessment CFD Loads 100% Pwr						
		ACM CLTP Max Surface Stress (psi)	Vortex Shedding Max Surface Stress (psi)	Weld Conc. Factor	Plate Thickness (in)	Weld Size (in)	Under-size Factor	Peak Stress (psi) (*1)
ID	Dryer Component Name	(1)	(3)	(5)			(6)	
	Horizontal plates:							
1	Inner hood base plate	588	314	1.8	0.5	0.5	1.00	1200
2(a)	Modified outer cover plate5/8", both tips 4"	896	492	1.8	0.625	0.625	1.00	1840
2(b)	Modified outer cover plate, exclude tips	530	492	1.8	0.625	0.5	1.56	2034
4(a)	Original top hood (all hood)	412	888	1.8	0.5	0.5	1.00	1762
4(b)	Modified top hood (outer hood)	403	935	1.8	1	0.625	2.56	4692
4(c)	Hood top plates(Inner hood)	456	1987	1.4	0.5	0.5	1.00	2854
	Vertical plates:							
5(a)	Original outer Hood , strips	989	68	1.8	0.5	0.5	1.00	1784
5(b)	Modified outer hood, top weld	430	381	1.8	1	0.625	2.56	2647
5(c)	Modified outer hood, bottom weld	475	621	1.8	-	-	-	2034
5(d)	Hood vertical plates (inner hood)	484	1214	1.4	0.5	0.5	1.00	1830
6	Hood end plates,(inner hood)	446	1040	1.8	0.5	0.5	1.00	2037
7	Hood end plates (outer hood)	1029	713	1.8	0.5	0.5	1.00	2253
8	Outer Hood Brackets(gussets)	719	736	1.4	0.5	0.5	1.00	1440
10	Steam 'dam'	399	818	1.8	0.5	0.5	1.00	1638
11	Steam 'dam' gussets	537	1598	1.8	0.5	0.5	1.00	3034
	Other Plates							
12	Hood partition plates	288	149	1.8	0.5	0.5	1.00	584
13	Baffle plates	686	1311	1.8	0.5	0.5	1.00	2663
14	Outlet plenum ends	536	1806	1.8	0.5	0.5	1.00	3391
0	Ring, Beams & Gussets							
15	Dryer support ring	527	730	1.8	3	3	1.00	1621
16	Bottom cross beams	226	368	1.8	3	3	1.00	777
17	Cross beam gussets	626	778	1.8	0.5	0.5	1.00	1797
	Gussets for outer Cover plate and hood							
18(c)	New gusset on cover plate and front hood	1071	730	1.8	0.5	0.75	1.00	2333
18(a)	Gusset	350	1187	1	0.5	0.75	1.00	1238
18(b)	Gusset foot weld to cover plate	471	599	1.8	0.5	0.375	1.78	2438

Notes *1: Peak Stress = SRSS ((1), (3)) x (5) x (6)

Table EMEB-B-143-1-2
FIV Alternating Stress Summary with Hydrodynamic (CFD) Loads 100% Power

NON-PROPRIETARY VERSION

Table EMEB-B-143-2: FIV Alternating Stress Summary with Hydrodynamic (CFD) Loads 100% Power		Part B: Limit Curve Factor minus Uncertainty CFD Loads 100% Pwr					
		Level 1			Level 2		
ID	Dryer Component Name	LCF1	sig3	LCF1-sig3	LCF2	sig3	LCF2-sig3
	Horizontal plates:						
1	Inner hood base plate	12.84	7.26	5.58	10.27	5.80	4.46
2(a)	Modified outer cover plate5/8", both tips 4"	8.41	4.76	3.66	6.72	3.80	2.92
2(b)	Modified outer cover plate, exclude tips	9.08	5.14	3.94	7.24	4.10	3.14
4(a)	Original top hood (all hood)	18.21	10.31	7.90	14.51	8.22	6.29
4(b)	Modified top hood (outer hood)	6.95	3.98	2.97	5.38	3.11	2.27
4(c)	Hood top plates(Inner hood)	20.85	11.85	9.00	16.48	9.39	7.08
0	0						
	Vertical plates:						
5(a)	Original outer Hood , strips	7.64	4.32	3.32	6.11	3.45	2.66
5(b)	Modified outer hood, top weld	6.81	3.86	2.95	5.42	3.07	2.35
5(c)	Modified outer hood, bottom weld	9.08	5.14	3.94	7.24	4.10	3.14
5(d)	Hood vertical plates (inner hood)	19.91	11.28	8.64	15.86	8.99	6.87
6	Hood end plates,(inner hood)	16.78	9.51	7.27	13.35	7.57	5.78
7	Hood end plates (outer hood)	7.31	4.14	3.17	5.83	3.30	2.53
8	Outer Hood Brackets(gussets)	13.47	7.62	5.85	10.76	6.09	4.67
10	Steam 'dam'	18.82	10.66	8.17	15.01	8.50	6.51
11	Steam 'dam' gussets	13.75	7.82	5.93	10.86	6.19	4.66
	Other Plates						
12	Hood partition plates	26.23	14.83	11.40	20.98	11.86	9.12
13	Baffle plates	10.85	6.15	4.69	8.60	4.89	3.71
14	Outlet plenum ends	13.69	7.79	5.89	10.76	6.16	4.61
0	Ring, Beams & Gussets						
15	Dryer support ring	14.27	8.07	6.19	11.39	6.45	4.94
16	Bottom cross beams	33.39	18.88	14.51	26.70	15.10	11.60
17	Cross beam gussets	12.01	6.79	5.21	9.58	5.42	4.15
	Gussets for outer Cover plate and hood						
18(c)	New gusset on cover plate and front hood	7.02	3.97	3.05	5.60	3.17	2.43
18(a)	Gusset	38.71	21.90	16.81	30.90	17.49	13.41
18(b)	Gusset foot weld to cover plate	8.93	5.06	3.87	7.11	4.03	3.07
		MinLCF1-sig3			Min LCF2-sig3		
		2.95			2.27		

Table EMEB-B-143-1-2
FIV Alternating Stress Summary with Hydrodynamic (CFD) Loads 100% Power

Table EMEB-B-143-3: FIV Alternating Stress Summary with Hydrodynamic (CFD) Loads 120% Power		Part A: Fatigue Stress Assessment CFD Loads 120% Pwr						
		ACM CLTP Max Surface Stress (psi)	Vortex Shedding Max Surface Stress (psi)	Weld Conc. Factor	Plate Thickness (in)	Weld Size (in)	Under-size Factor	Peak Stress (psi) (*1)
ID	Dryer Component Name	(1)	(3)	(5)	0.00	0	(6)	0
	Horizontal plates:							
1	Inner hood base plate	588	624	1.80	0.5	0.5	1.00	1543
2(a)	Modified outer cover plate5/8", both tips 4"	896	437	1.80	0.625	0.625	1.00	1794
2(b)	Modified outer cover plate, exclude tips	530	439	1.80	0.625	0.5	1.56	1936
4(a)	Original top hood (all hood)	412	943	1.80	0.50	0.50	1.00	1852
4(b)	Modified top hood (outer hood)	403	1112	1.80	1	0.625	2.56	5450
4(c)	Hood top plates(Inner hood)	456	1964	1.40	0.5	0.5	1.00	2823
	Vertical plates:							
5(a)	Original outer Hood , strips	989	108	1.80	0.50	0.5	1.00	1791
5(b)	Modified outer hood, top weld	430	301	1.80	1.00	0.625	2.56	2419
5(c)	Modified outer hood, bottom weld	475	725	1.80	-	-	-	1936
5(d)	Hood vertical plates (inner hood)	484	761	1.40	0.50	0.5	1.00	1263
6	Hood end plates,(inner hood)	446	536	1.80	0.50	0.5	1.00	1255
7	Hood end plates (outer hood)	1029	322	1.80	0.50	0.5	1.00	1941
8	Outer Hood Brackets(gussets)	719	573	1.40	0.50	0.5	1.00	1287
10	Steam 'dam'	399	807	1.80	0.50	0.5	1.00	1620
11	Steam 'dam' gussets	537	941	1.80	0.50	0.5	1.00	1950
	Other Plates							
12	Hood partition plates	288	94	1.80	0.50	0.5	1.00	545
13	Baffle plates	686	1144	1.80	0.50	0.5	1.00	2401
14	Outlet plenum ends	536	1891	1.80	0.50	0.5	1.00	3538
0	Ring, Beams & Gussets							
15	Dryer support ring	527	675	1.80	3.00	3	1.00	1541
16	Bottom cross beams	226	135	1.80	3.00	3	1.00	474
17	Cross beam gussets	626	414	1.80	0.50	0.5	1.00	1351
	Gussets for outer Cover plate and hood							
18(c)	New gusset on cover plate and front hood weld	1071	820	1.80	0.5	0.75	1.00	2428
18(a)	Gusset	350	295	1.00	0.5	0.75	1.00	458
18(b)	Gusset foot weld to cover plate	471	490	1.80	0.5	0.375	1.78	2175

Notes *1: Peak Stress = SRSS ((1), (3)) x (5) x (6)

Table EMEB-B-143-1-3
FIV Alternating Stress Summary with Hydrodynamic (CFD) Loads 120% Power

NON-PROPRIETARY VERSION

Table EMEB-B-143-3: FIV Alternating Stress Summary		Part 3B: Limit Curve Factor minus Uncertainty CFD Loads 120% Pwr					
with Hydrodynamic (CFD) Loads 120% Power		Level 1			Level 2		
ID	Dryer Component Name	LCF1	sig3	LCF1-sig3	LCF2	sig3	LCF2-sig3
	Horizontal plates:						
1	Inner hood base plate	12.81	7.24	5.56	10.22	5.79	4.44
2(a)	Modified outer cover plate5/8", both tips 4"	8.42	4.76	3.66	6.73	3.81	2.92
2(b)	Modified outer cover plate, exclude tips	9.09	5.14	3.95	7.25	4.11	3.15
4(a)	Original top hood (all hood)	18.20	10.30	7.89	14.49	8.22	6.28
4(b)	Modified top hood (outer hood)	6.78	3.91	2.87	5.17	3.02	2.14
4(c)	Hood top plates(Inner hood)	20.86	11.85	9.01	16.49	9.40	7.09
0	0						
	Vertical plates:						
5(a)	Original outer Hood , strips	7.64	4.32	3.32	6.11	3.45	2.66
5(b)	Modified outer hood, top weld	6.83	3.86	2.96	5.45	3.08	2.36
5(c)	Modified outer hood, bottom weld	9.09	5.14	3.95	7.25	4.11	3.15
5(d)	Hood vertical plates (inner hood)	20.01	11.32	8.69	15.98	9.04	6.94
6	Hood end plates,(inner hood)	16.90	9.56	7.34	13.50	7.64	5.86
7	Hood end plates (outer hood)	7.34	4.15	3.19	5.87	3.32	2.55
8	Outer Hood Brackets(gussets)	13.49	7.63	5.86	10.78	6.10	4.68
10	Steam 'dam'	18.83	10.66	8.17	15.01	8.50	6.51
11	Steam 'dam' gussets	13.96	7.91	6.05	11.12	6.30	4.82
	Other Plates						
12	Hood partition plates	26.23	14.83	11.41	20.99	11.86	9.12
13	Baffle plates	10.89	6.17	4.72	8.65	4.91	3.74
14	Outlet plenum ends	13.65	7.78	5.87	10.71	6.13	4.58
0	Ring, Beams & Gussets						
15	Dryer support ring	14.28	8.08	6.20	11.40	6.45	4.95
16	Bottom cross beams	33.43	18.89	14.53	26.74	15.11	11.62
17	Cross beam gussets	12.05	6.81	5.24	9.63	5.45	4.19
	Gussets for outer Cover plate and hood						
18(c)	New gusset on cover plate and front hood weld	7.01	3.97	3.04	5.59	3.17	2.42
18(a)	Gusset	38.85	21.96	16.89	31.07	17.57	13.51
18(b)	Gusset foot weld to cover plate	9.0	5.1	3.9	7.1	4.0	3.1
		MinLCF1-sig3			Min LCF2-sig3		
		2.87			2.14		

Table EMEB-B-143-1-3

FIV Alternating Stress Summary with Hydrodynamic (CFD) Loads 120% Power

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Table EMEB-B-143-1-4 (a)

ASME Code Stresses at CLTP

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Table EMEB-B-143-1-4 (b)

ASME Code Stresses at CLTP

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Table EMEB-B-143-1-4 (c)

ASME Code Stresses at CLTP

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Table EMEB-B-143-1-4 (d)

ASME Code Stresses at CLTP

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Table EMEB-B-143-1-4 (e)

ASME Code Stresses at CLTP

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Table EMEB-B-143-1-4 (f)

ASME Code Stresses at CLTP

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Table EMEB-B-143-1-4 (g)

ASME Code Stresses at CLTP

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Table EMEB-B-143-1-5 (a)

ASME Code Stresses at EPU

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Table EMEB-B-143-1-5 (b)

ASME Code Stresses at EPU

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Table EMEB-B-143-1-5 (c)

ASME Code Stresses at EPU

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Table EMEB-B-143-1-5 (d)

ASME Code Stresses at EPU

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Table EMEB-B-143-1-5 (e)

ASME Code Stresses at EPU

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Table EMEB-B-143-1-5 (f)

ASME Code Stresses at EPU

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Table EMEB-B-143-1-5 (g)

ASME Code Stresses at EPU

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Table EMEB-B-143-1-6

ASME Code Stresses at EPU with 130%/16% ACM/CFD Uncertainty

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Table EMEB-B-143-1-7

ASME Code Stresses at EPU with 130%/16% ACM/CFD Uncertainty

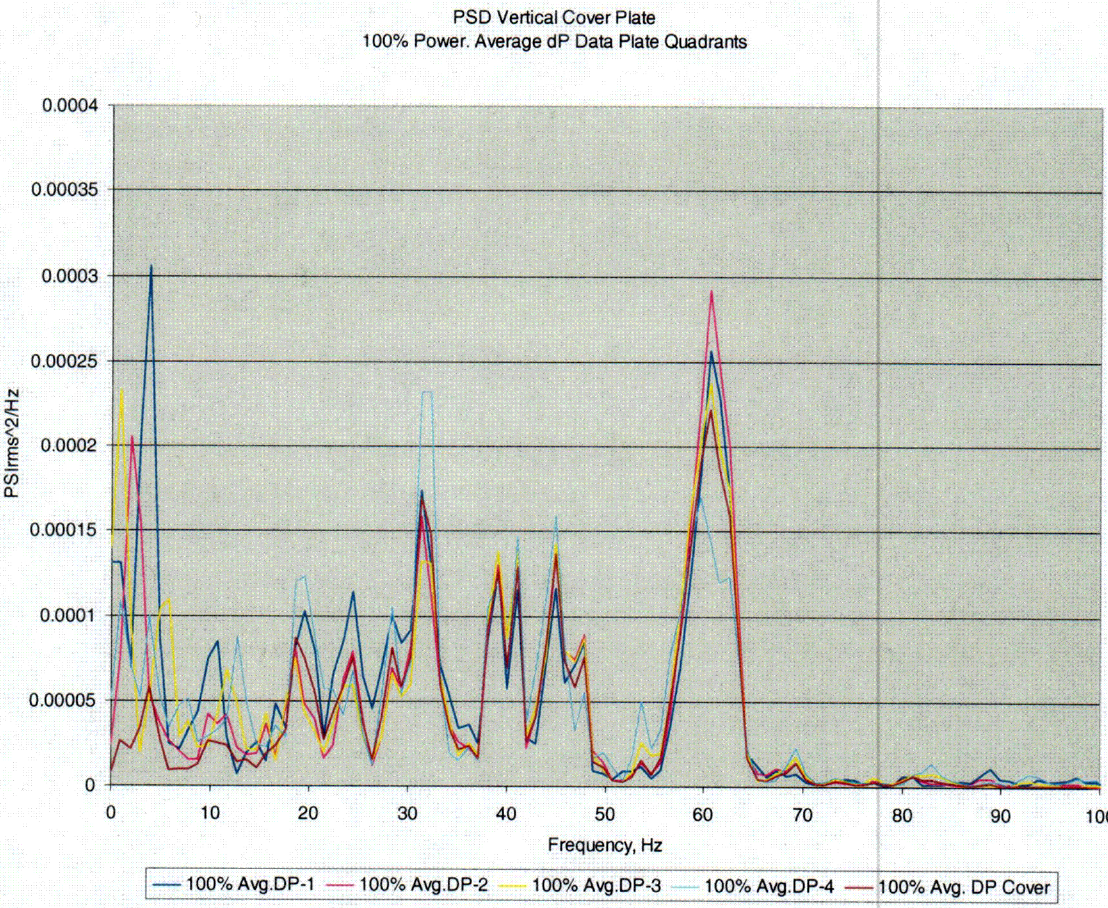


Figure EMEB-B-143-1-2

Four Quadrants of Cover Plate, Average Pressure Load, 100% Power PSD

C11

NON-PROPRIETARY VERSION

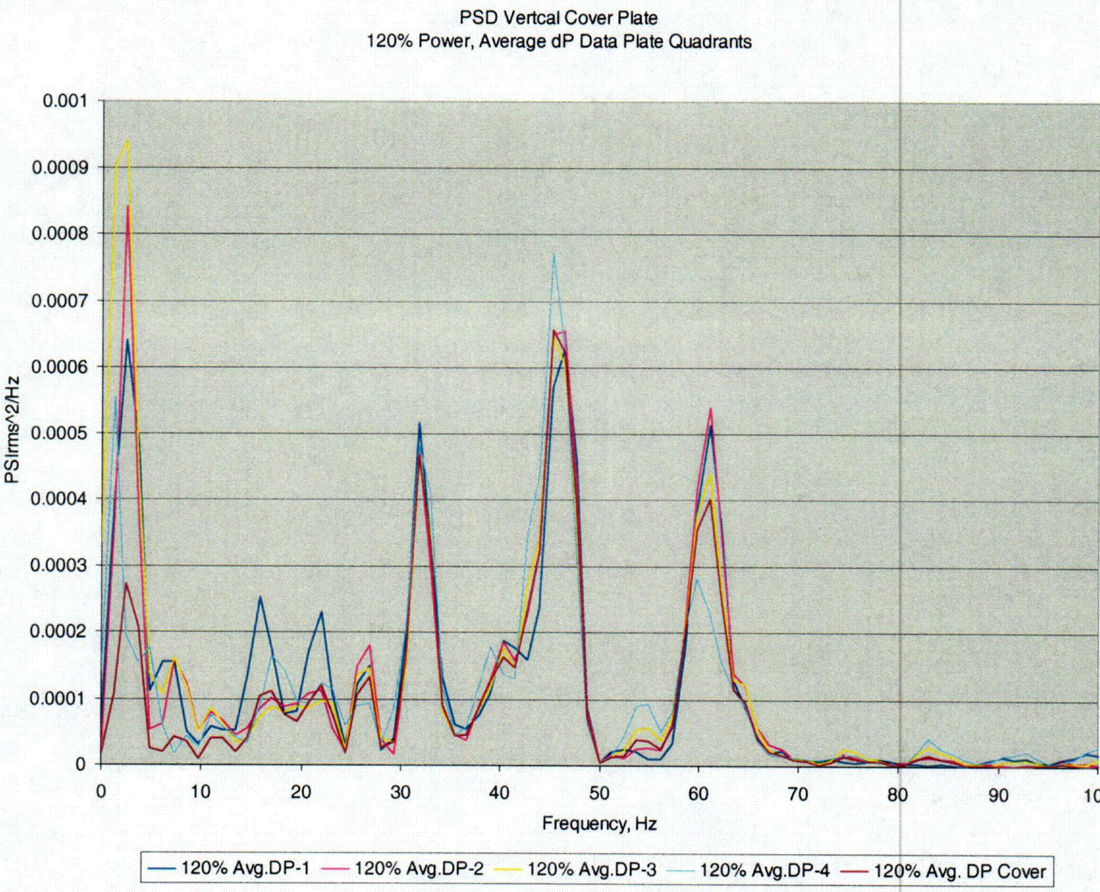


Figure EMEB-B-143-1-3

Four Quadrants of Cover Plate, Average Pressure Load, 120% Power PSD

C12

NON-PROPRIETARY VERSION

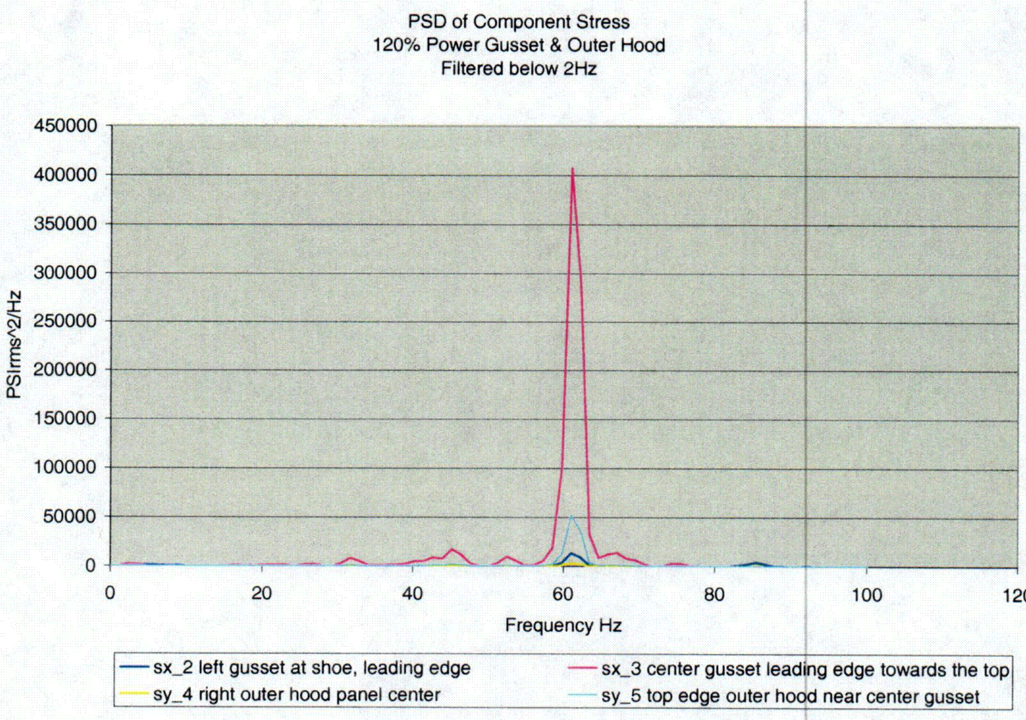


Figure EMEB-B-143-1-4

PSD of Component Stress Under CFD 120% Power Loads

C13

NON-PROPRIETARY VERSION

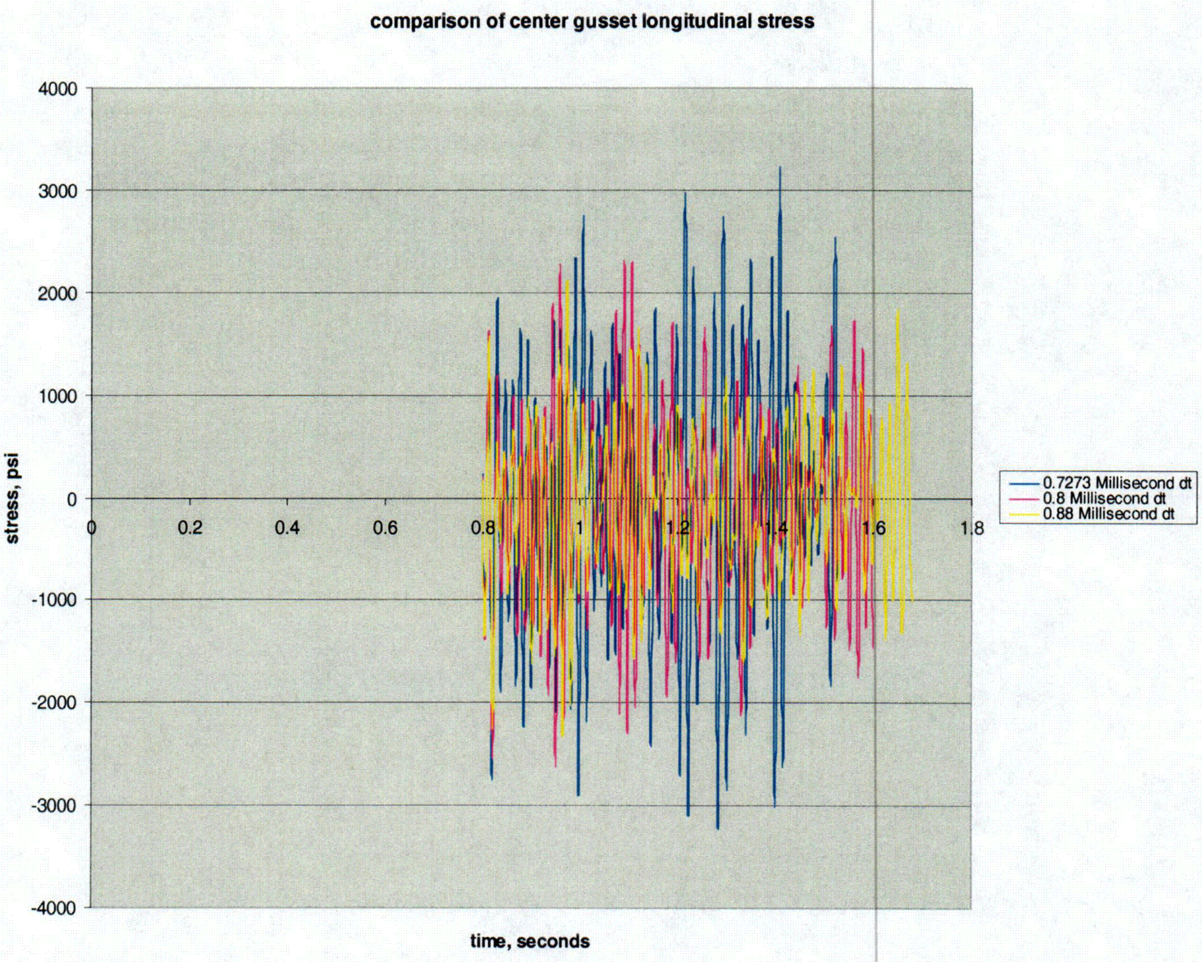
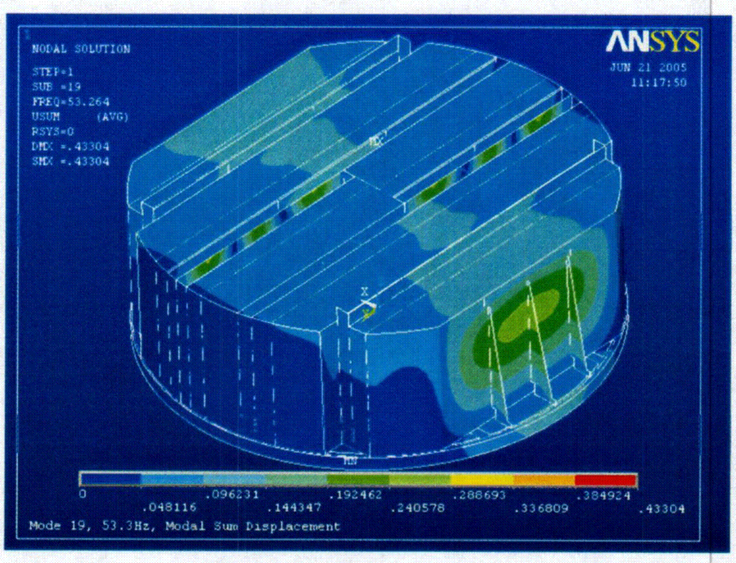


Figure EMEB-B-143-1-5

Stress Time History results 120% Power and +/- 10% Time Step Variation

C14

NON-PROPRIETARY VERSION



JAR Associates 6/22/05 VY Dryer
CFD Transient Analysis, Rev B

9

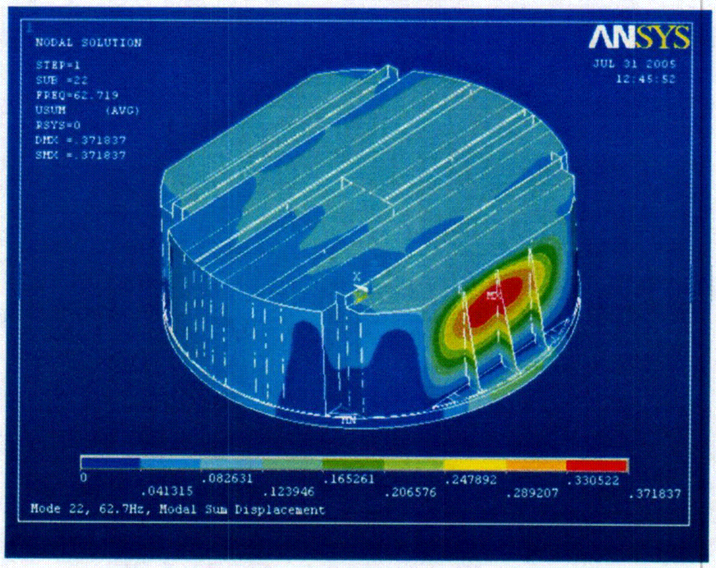
Figure EMEB-B-143-1-6

CFD Model Mode 19

Frequency 53.3 Hz

C15

NON-PROPRIETARY VERSION



JAR Associates 6/22/05 VY Dryer
CFD Transient Analysis, Rev B

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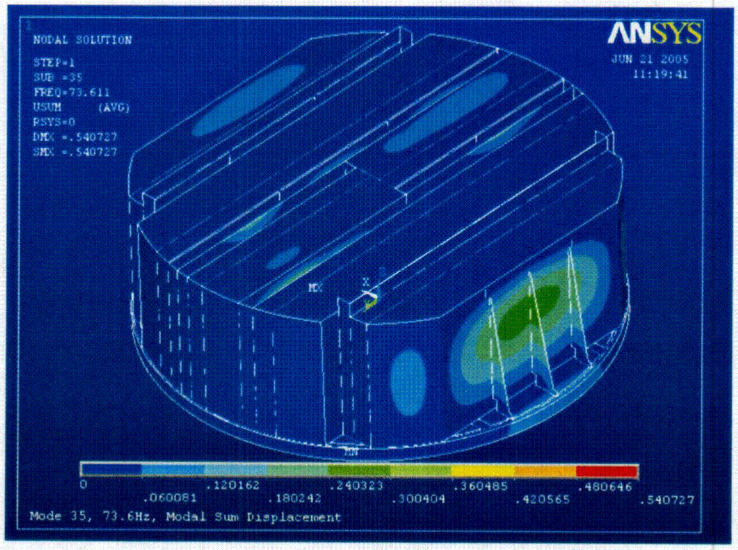
Figure EMEB-B-143-1-7

CFD Model Mode 22

Frequency 62.7 Hz

C16



JAR Associates 6/22/05 VY Dryer
CFD Transient Analysis, Rev B

12

Figure EMEB-B-143-1-8

CFD Model Mode 35

Frequency 73.6Hz

C17

BVY 05-084
Docket No. 50-271

Attachment 10

Vermont Yankee Nuclear Power Station

Proposed Technical Specification Change No. 263 – Supplement No. 33

Extended Power Uprate

Response to Request for Additional Information

GE Scale Model Test Facility Audit Responses

NON-PROPRIETARY VERSION

Total number of pages in Attachment 10
(excluding this cover sheet) is 17.

NON-PROPRIETARY INFORMATION

NRC SMT Review Question 1

Please provide a plot exhibiting the trend of fluctuating pressure with steam velocity for the high frequency content in the model (~1600-2000 Hz) and plant (~150-160 Hz). Comparison of the trends exhibited in the model and plant data will demonstrate whether the model replicates the excitation mechanism present in the plant for [[ ]]

Response to Review Question 1

The figures below show the trend of fluctuating pressure with main steam velocity. Figure 1 contains model data. The [[ ]] frequency corresponds to the [[ ]] resonance; whereas, the lower frequencies represent [[ ]] Figure 2 shows the plant data corresponding to the [[ ]] expressed over the same range of Mach number. Figure 3 shows the plant data over the entire power range. Both the model and the plant data show the same [[ ]] which supports the conclusion that the model preserves the excitation mechanism present in the plant for the safety and relief valve frequency content.

[[

]]

Figure 1: Model data fluctuating pressure trends for significant model frequencies.

NON-PROPRIETARY INFORMATION

[[

]]

Figure 2: Plant data fluctuating pressure trends for the [[

]]

NON-PROPRIETARY INFORMATION

[[

]]

Figure 3: Plant data fluctuating pressure trends for the [[
]]

NON-PROPRIETARY INFORMATION

NRC SMT Review Question 2

Please compare the MSL routing immediately upstream of the inboard MSIV for the model and plant.

Response to Review Question 2

The images below illustrate the plant (top) and model (bottom) MSL configurations. The pipe routing upstream of the MSIVs are identified by the circles; the pipe elbows upstream of the inboard MSIVs have been preserved in the model.

[[

]]

Figure 4: Plant MSL configuration.

NON-PROPRIETARY INFORMATION

[[

]]

Figure 5: Model MSL configuration.

<u>NRC SMT Review Question 3</u>

Please compare the MSIV geometry for the model and plant.

<u>Response to Review Question 3</u>

The digital images below illustrate a typical BWR valve body configuration. Shown in these images are the fixed guide in the flow stream and the shape of the valve body. The design drawing below shows the GE scale model representation of the MSIV. [[

]]

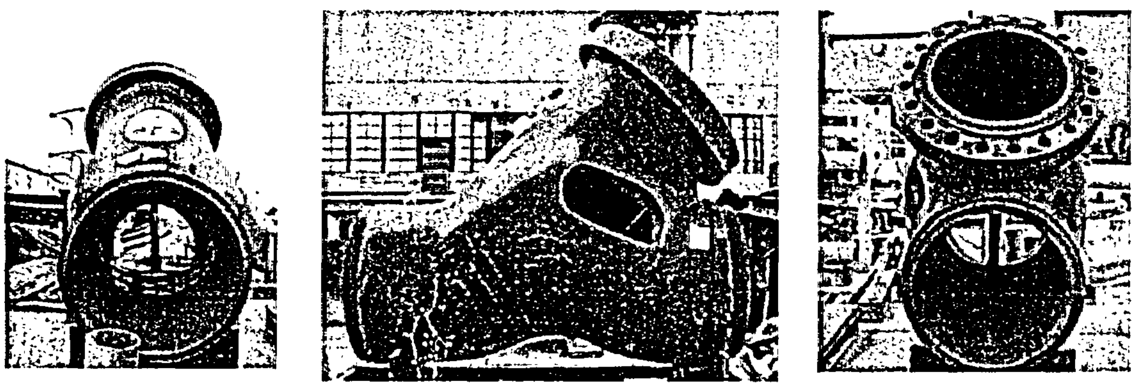


Figure 6: Digital images of a plant MSIV.

NON-PROPRIETARY INFORMATION

[[

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Figure 7: Assembly drawing of model MSIV.

NON-PROPRIETARY INFORMATION

NRC SMT Review Question 4

Please provide plots exhibiting the frequency content of a pressure transducer and strain gauge on the QC2 dryer skirt so that the presence of forcing frequencies consistent with the dryer structural response can be confirmed.

Response to Review Question 4

The sensor schematic below illustrates the plant instrumentation locations for pressure transducer P24 and strain gauge S8. Both of these instruments are located on the Quad Cities Unit 2 replacement dryer skirt in close proximity to each other. The linear averaged peak autopower spectrum shows an overlay of the frequency spectra obtained for each sensor. This plot illustrates that the [[

]]

[[

]]

Figure 8: Schematic of Quad Cities Unit 2 replacement steam dryer instrumentation locations.

NON-PROPRIETARY INFORMATION

[[

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Figure 9: Linear average peak auto power spectra of P24 and S8 at 930 MWe.

NON-PROPRIETARY INFORMATION

NRC SMT Review Question 5

Please document the boundary conditions applied to the acoustic finite element model of the model steam plenum and describe the effect that these boundary conditions created in the normal modes of the steam plenum.

Response to Review Question 5

The following boundaries exist in the acoustic finite element model and test apparatus:
[[

]]

For the modal analysis, all boundaries are considered [[ ]]

For the characterization testing and model correlation the following boundary conditions were applied:

[[

]]

NON-PROPRIETARY INFORMATION

[[

]]

Figure 10: Comparison of [[ ]], *Source at Main Steam Line Nozzle A on RPV*

NON-PROPRIETARY INFORMATION

[[

]]

Figure 11: Comparison of [[ ]], *Source at Main Steam Line Nozzle A on RPV*

NON-PROPRIETARY INFORMATION

NRC SMT Review Question 6

Please provide animations of the significant frequencies observed in the model data so that the spatial distribution of the applied pressures can be visualized.

Response to Review Question 6

Animations are provided as *.avi files in the compact disk as an enclosure. When interpreting the animations, the nodes in the wireframe mesh indicate microphone locations. The outer hoods and top plates of the dryer can be identified easily. The displacement of the animation is proportional to pressure amplitude. The figure below is a linear averaged peak frequency spectrum from the Replacement Dryer QC1 tests that can be used to identify the frequency content for which the .avi files illustrate the running modes of the pressure on the dryer outer surfaces. Also provided are the acoustic finite element model [[

]]

NON-PROPRIETARY INFORMATION

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Figure 12: Linear average peak autopower spectrum from replacement steam dryer model test

NON-PROPRIETARY INFORMATION

[[

]]

Figure 13: Acoustic mode shapes of test apparatus corresponding to model test data

NON-PROPRIETARY INFORMATION

NRC SMT Review Question 7

The NRC has concern that obtaining accurate predictions of the [[ ]] amplitudes using scaling relationships may prove very difficult.

Response to Review Question 7

GE recognizes that the task of providing accurate fluctuating pressure predictions from a model test is non-trivial. GE plans to evaluate the ability of the model and scaling methodology to provide conservative fluctuating pressure predictions in the final benchmark of the QC2 scale model against the QC2 plant data. For the preliminary comparison of the QC1 model data against the QC2 plant data it must be recognized that the QC1 & QC2 MSL configurations and [[ ]] are different; therefore, the [[ ]] at the two plants cannot be expected to be identical. In addition, geometric discrepancies have been identified in the QC1 MSL scale model and plant dimensions. GE is currently working to resolve the geometric discrepancies in the QC1 scale model and to build a QC2 scale model. After completing these tasks GE will have a better data set to evaluate the ability of the model and scaling approach to make accurate [[ ]] amplitude predictions.

NON-PROPRIETARY INFORMATION

NRC SMT Review Question 8

Please provide the following reference:

> Moody, F.J. "GE Scale Model of Steam Line Acoustic Excitation". August 23, 2004. GE Proprietary Information.

Response to Review Question 8

The requested document is provided as requested as an enclosure. A non-proprietary version of this report is not available.

BVY 05-084
Docket No. 50-271

Attachment 11

Vermont Yankee Nuclear Power Station

Proposed Technical Specification Change No. 263 – Supplement No. 33

Extended Power Uprate

Response to Request for Additional Information

GE Affidavits

Total number of pages in Attachment 11 (excluding this cover sheet) is 6.

General Electric Company

AFFIDAVIT

I, George B. Stramback, state as follows:

(1) I am Manager, Regulatory Services, 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 Enclosure 2 of GE letter, GE-VYNPS-AEP-402, *Revised Responses to VYNPS Steam Dryer RAIs*, dated September 13, 2005. The proprietary information in Enclosure 2, *Responses to NRC RAIs EMEB-39, 143, and Attachment 5 to EMEB-18-1*, 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 contains detailed results and conclusions from analyses of the Vermont Yankee Steam Dryer which encompass and takes into account analyses and repairs utilizing analytical models and methods, including computer codes, which GE has developed. Development of this information and its application for the design, procurement and analyses methodologies and processes for the Steam Dryer Program was achieved at a significant cost to GE, on the order of approximately two million dollars.

The development of the 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 13th of September 2005

George B. Stramback
General Electric Company

General Electric Company

AFFIDAVIT

I, George B. Stramback, state as follows:

(1) I am Manager, Regulatory Services, 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 Enclosures 2 and 3 of GE letter, GE-VYNPS-AEP-400, *Responses to NRC Questions from August 2005 Audit of GE Steam Dryer Scale Model Test Facility*, dated September 12, 2005. The proprietary information in Enclosure 2, *Responses to NRC Scale Model Testing Review Questions - Proprietary*, 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. The proprietary information in Enclosure 3 is the entire compact disk (CD) labeled *GE-VYNPS-AEP-400, Responses to NRC Scale Model Testing Review Question Number 6 and Question Number 8 — GE Proprietary Information*[3]. 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).

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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;

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(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 contains detailed results and conclusions from analyses of the Vermont Yankee Steam Dryer which encompass and takes into account analyses and repairs utilizing analytical models and methods, including computer codes, which GE has developed. Development of this information and its application for the design, procurement and analyses methodologies and processes for the Steam Dryer Program was achieved at a significant cost to GE, on the order of approximately two million dollars.

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(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.

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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 12th day of September 2005.

George B. Stramback
General Electric Company

BVY 05-084
Docket No. 50-271

Attachment 12

Vermont Yankee Nuclear Power Station

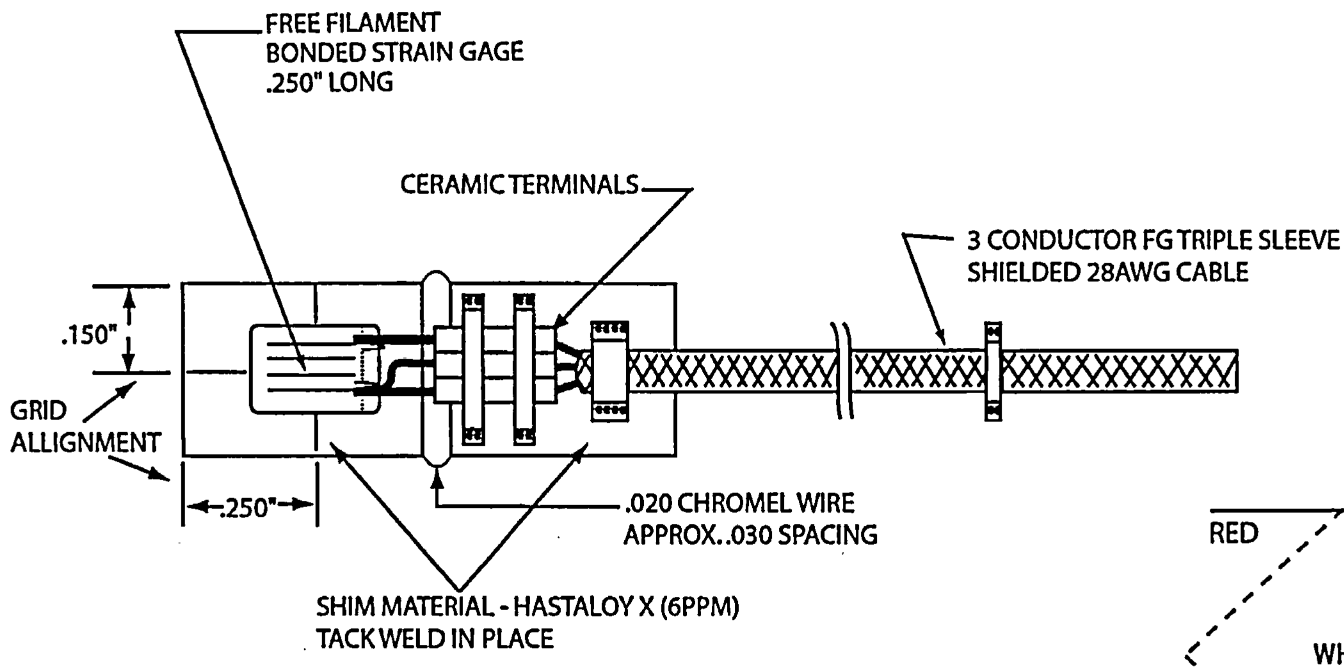
Proposed Technical Specification Change No. 263 – Supplement No. 33

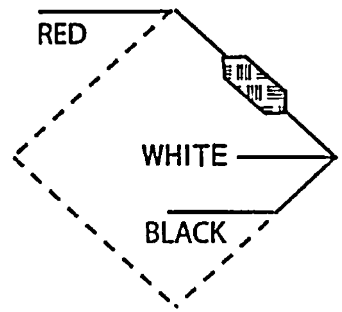
Extended Power Uprate

Response to Request for Additional Information

Additional Strain Gage and Data Acquisition System Specifications

Total number of pages in Attachment 12 (excluding this cover sheet) is 33.





SHIM SIZE: .30" w X .50" L X .005" THICK (2 PIECES WIRED TOGETHER)

GAGE RESISTANCE: 350 ± 1% OHMS AT GAGE

NOMINAL GAGE FACTOR: 2.0

GAGE LENGTH: .250 INCH

TEMPERATURE RANGE: 650°F OPERATION AT SENSORS

CERAMIC INSULATORS AND STRAPPING
INCLUDED TO COVER GAGE ASSEMBLY

TRIPLE SLEEVE SHIELDED FG WIRE 28AWG (STRANDED)
FIBERGLASS INSULATED NICKEL CLAD COPPER
RATED TO 900°F

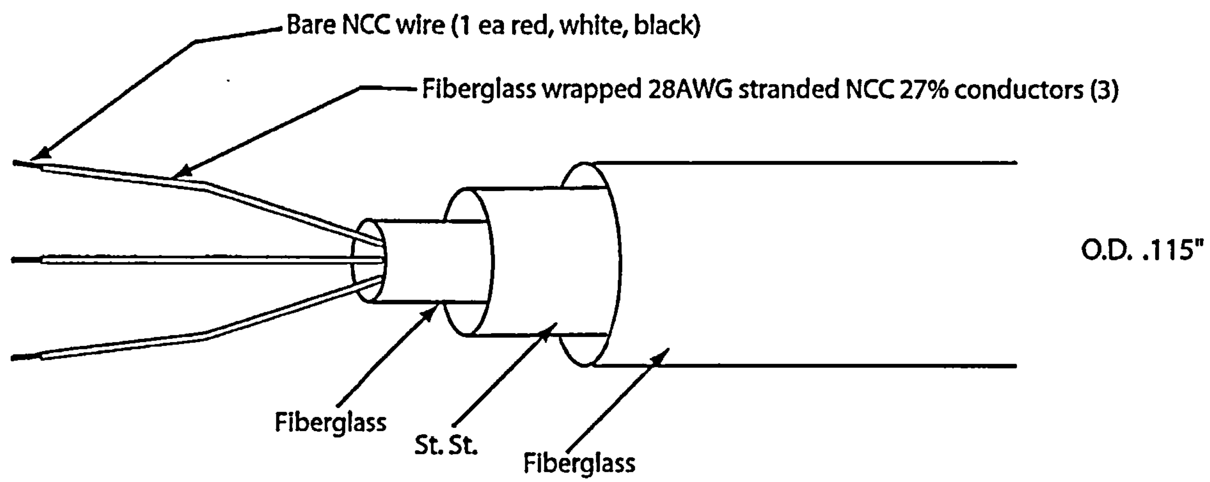
ENTERGY NUCLEAR VERMONT YANKEE, LLC

TOLERANCES (EXCEPT AS NOTED)	REVISIONS NO.	DATE	BY
DECIMAL ±	1.		
	2.		
FRACTIONAL ±	3.		
	4.		
ANGULAR ±	5.		

HBWAK-35-250-6-180FG-3XSHIELD

HITEC PRODUCTS, INC.

DRAWN BY YH	SCALE NTS	MATERIAL
CHK'D	DATE 9/9/05	DRAWING NO. 70-1205-VY
TRACED	APP'D	



Note: Stainless steel sleeve is cut back for strain gage assembly so it does not come in contact with the metal shim.

TOLERANCES (EXCEPT AS NOTED)	REVISIONS NO.	DATE	BY	FIBERGLASS TRIPLE SLEEVE SHIELDED CABLE		
DECIMAL ±	1.			HITEC PRODUCTS, INC.		
FRACTIONAL ±	2.			DRAWN BY YH	SCALE NTS	MATERIAL
	3.			CHK'D	DATE 8/24/05	DRAWING NO.
ANGULAR ±	4.			TRACED	APP'D	
	5.					

NATIONAL INSTRUMENTS SCXI DATA ACQUISITION SYSTEM

SCXI Chassis

NI SCXI-1000, NI SCXI-1000DC, NI SCXI-1001

- Shielded enclosures for SCXI modules
- Low-noise environment for signal conditioning
- Rugged, compact chassis
- Forced air cooling
- Optional USB data acquisition and control module
- Optional rack mounting
- 3 internal analog buses
- Timing circuitry for high-speed multiplexing
- AC, DC, or battery-power options
- NI-DAQmx driver software simplifies chassis configuration

Operating Systems
- Windows 2000/NT/XP

Recommended Software
- LabVIEW
- LabWindows/CVI
- Measurement Studio
- Lookout
- VI Logger

Driver Software[1]
- NI-DAQmx
- NI-SWITCH

[1] Included with DAQ device or switch

Overview
National Instruments offers rugged, low-noise SCXI chassis to house, power, and control your SCXI modules and conditioned signals. The unique SCXI chassis architecture includes the SCXIbus, which routes analog and digital signals and acts as the communication conduit between modules. Chassis control circuitry manages this bus, synchronizing the timing between each module and the DAQ device. With this architecture, you can scan input channels from several modules in several chassis at rates up to 333 kS/s for every DAQ device.

The versatility of SCXI lies in its various chassis options and expandability. You can choose from a number of different standard AC or DC power options. You can control the system by connecting directly to an M Series, E Series, B Series or USB multifunction DAQ device. You can even daisy-chain up to eight chassis for control by a single DAQ device. Regardless of your configuration, programming the system does not change. You use the same function calls you use with a DAQ device by itself. NI-DAQ or NI-SWITCH driver software handles all low-level programming.

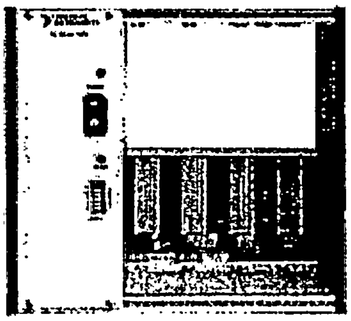
The SCXIbus
The SCXIbus is a guarded analog and digital bus located in the backplane of the SCXI chassis. Modules inserted into the chassis connect to this backplane automatically. This bus acts as a conduit for routing signals, transferring data, programming modules, and passing timing signals.

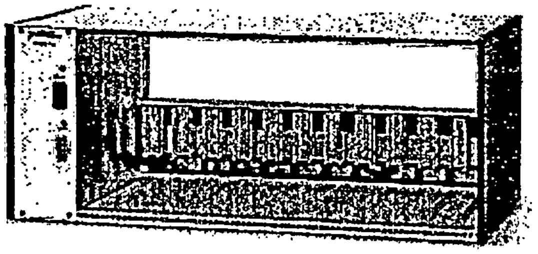
Chassis Control Circuitry
Each SCXI chassis includes control circuitry. This circuitry handles all signal routing on the SCXIbus. During high-speed analog input operations, it controls which input signals are connected to the bus and routed back to the DAQ device. It also ensures tight synchronization between the SCXI modules and the DAQ device.

Expandability
If your initial system requires more SCXI modules than one chassis can hold, or your system requirements change, simply add another chassis. With the SCXI expandable architecture, you can daisy-chain up to eight chassis to a single multifunction DAQ device. Whether you are using a single-chassis or multichassis system, you can still acquire data at rates up to 333 kS/s.

Power Options
These SCXI chassis offer a number of standard AC power options. Simply choose the option for your country or a country compatible with your power specifications. If you move your system to another country, you can easily reconfigure the system for any of the other AC power configurations.

SCXI Chassis



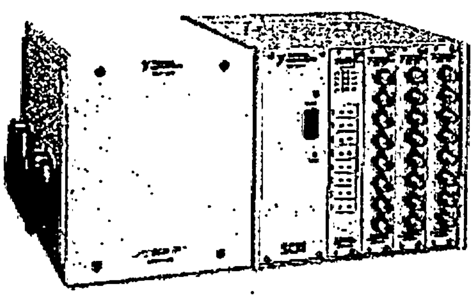


SCXI-1000

The NI SCXI-1000 is a 4-slot chassis available with a number of standard AC power options. This chassis is ideal for single-chassis or low-channel-count applications. If your application grows, you can daisy-chain two or more SCXI-1000 chassis. You can also use off-the-shelf true sine wave DC-to-AC power inverters to power AC chassis with a DC power supply.

SCXI-1001

The SCXI-1001 is a 12-slot chassis with a number of standard AC power options. As in the SCXI-1000 Series, you can daisy-chain up to eight chassis to acquire or control up to 3,072 channels with a single DAQ device. This chassis is ideal for high-channel-count systems. You can use off-the-shelf true sine wave DC-to-AC power inverters to power AC chassis with a DC power supply.



SCXI-1000DC

The SCXI-1000DC is a 4-slot chassis that accepts DC power. You can power it with any 9.5 to 16 VDC power supply, or use the optional SCXI-1382 12 VDC battery pack (shown in the picture). You should also consider the optional SCXI-1383 power supply/float charger to operate the chassis from an AC power outlet when necessary. This chassis is ideal for portable applications or other times when AC power is not always available.

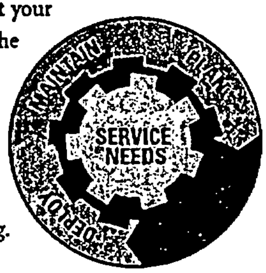
Ordering Information

NI SCXI-1000 .... 776570-0P[1]
NI SCXI-1000DC 776570-00
NI SCXI-1001 .... 776571-0P[1]

[1]To choose your power option, replace the "P" with the appropriate number for your country's power:
1 – U.S. 120 VAC
2 – Swiss 220 VAC
3 – Australian 240 VAC
4 – Universal Euro 240 VAC
5 – North American 240 VAC
6 – United Kingdom 240 VAC
7 – Japanese 100 VAC

NI Services and Support

NI has the services and support to meet your needs around the globe and through the application life cycle – from planning and development through deployment and ongoing maintenance. We offer services and service levels to meet customer requirements in research, design, validation, and manufacturing. Visit ni.com/services.



Training and Certification

NI training is the fastest, most certain route to productivity with our products. NI training can shorten your learning curve, save development time, and reduce maintenance costs over the application life cycle. We schedule instructor-led courses in cities worldwide, or we can hold a course at your facility. We also offer a professional certification program that identifies individuals who have high levels of skill and knowledge on using NI products. Visit ni.com/training.

Professional Services

Our Professional Services Team is comprised of National Instruments applications engineers, NI Consulting Services, and a worldwide National Instruments Alliance Partner program of more than 600 independent consultants and integrators. Services range from start-up assistance to turnkey system integration. Visit ni.com/alliance.

NATIONAL INSTRUMENTS
Certified Alliance Partner

OEM Support

We offer design-in consulting and product integration assistance if you want to use our products for OEM applications. For information about special pricing and services for OEM customers, visit ni.com/oem.

Local Sales and Technical Support

In offices worldwide, our staff is local to the country, giving you access to engineers who speak your language. NI delivers industry-leading technical support through online knowledge bases, our applications engineers, and access to 14,000 measurement and automation professionals within NI Developer Exchange forums. Find immediate answers to your questions at ni.com/support.

We also offer service programs that provide automatic upgrades to your application development environment and higher levels of technical support. Visit ni.com/ssp.

Hardware Services

NI Factory Installation Services

NI Factory Installation Services (FIS) is the fastest and easiest way to use your PXI or PXI/SCXI combination systems right out of the box. Trained NI technicians install the software and hardware and configure the system to your specifications. NI extends the standard warranty by one year on hardware components (controllers, chassis, modules) purchased with FIS. To use FIS, simply configure your system online with ni.com/pxiadvisor.

Calibration Services

NI recognizes the need to maintain properly calibrated devices for high-accuracy measurements. We provide manual calibration procedures, services to recalibrate your products, and automated calibration software specifically designed for use by metrology laboratories. Visit ni.com/calibration.

Repair and Extended Warranty

NI provides complete repair services for our products. Express repair and advance replacement services are also available. We offer extended warranties to help you meet project life-cycle requirements. Visit ni.com/services.

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National Instruments • info@ni.com

5340-321-101

SCXI Universal Strain Gauge Input Module

NI SCXI-1520

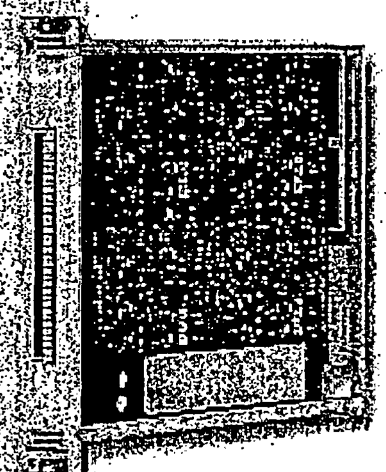
- 8 simultaneously sampled analog input channels
- Programmable excitation (0-10 V) per channel
- Programmable gain (1 to 1000) per channel
- Programmable 4-pole Butterworth filter (10 Hz, 100 Hz, 1 kHz, 10 kHz) per channel
- Quarter, half, and full-bridge completion
- 2 shunt calibration circuits per channel
- Remote sensing
- Random scanning
- Onboard calibration reference
- NI-DAQ driver software simplifies configuration, offset nulling, shunt calibration, scaling, and measurement

Operating Systems
- Windows 2000/NT/XP

Recommended Software
- LabVIEW
- LabWindows/CVI
- Measurement Studio
- VI Logger

Driver Software
- NI-DAQ 7

Calibration Certificate Included
See page 21



Overview

The National Instruments SCXI-1520 is an 8-channel universal strain-gauge input module that offers all of the features you need for simple or advanced strain and bridge-based sensor measurements. With this single module, you can read signals from strain, load, force, torque, and pressure sensors. Each NI SCXI-1520 is shipped with a NIST-traceable calibration certificate, and includes an onboard reference for automatic calibration in changing environments.

For accurate strain measurements, the SCXI-1520 offers a programmable amplifier and programmable 4-pole Butterworth filter on each channel. Each channel also has an independent 0-10 V programmable excitation source with remote sense per channel. In addition, the SCXI-1520 system offers a half-bridge completion resistor network in the module, and a socketed 350 quarter-bridge completion resistor in the SCXI-1314 terminal block. A 120 quarter-bridge completion resistor is also included with the terminal block. The SCXI-1520 also offers an automatic null compensation circuit, remote sensing, and two shunt calibration circuits per channel. In addition, the SCXI-1520 includes the simultaneous-sample-and-hold feature using track-and-hold (T/H) circuitry for simultaneous-sampling applications.

Each SCXI-1520 module can multiplex its signals into a single channel of the controlling DAQ device, and you can add modules to increase channel count. In NI-DAQ 7, parallel mode operation is available for high-speed acquisitions. In this mode, each channel is routed to a unique analog input channel of the DAQ device to which it is cabled. Parallel mode is not available in NI-DAQ Traditional.

Analog Input

Each of the eight analog inputs of the SCXI-1520 consists of a programmable instrumentation amplifier, 4-pole Butterworth filter, and simultaneous sample and hold circuit. You can program the gain of each channel individually to one of 49 input ranges from ±10 mV to ±10 V. You can also program each lowpass filter individually for 10 Hz, 100 Hz, 1 kHz, 10 kHz, or bypass mode. The 4-pole Butterworth filters provide a sharp cutoff to block noise while maintaining maximum flatness in the passband. Finally, the SCXI-1520 provides random scanning capability, so you acquire data from the channels you select in any order, thereby reducing your overall scan times. For applications requiring fewer than eight strain gauges, you can use the extra analog input channels for general-purpose analog signals.

Simultaneous Sampling

Each channel of the SCXI-1520 includes T/H circuitry so you can digitize simultaneous events with negligible skew time between channels. The outputs of the T/H amplifiers follow their inputs until they receive a hold signal from the DAQ device (typically at the start of a scan). At the hold signal, the T/H amplifiers simultaneously freeze, holding the input signal levels constant. The DAQ device then digitizes each frozen signal sequentially, giving you simultaneous sampling between channels. To calculate maximum sampling rates for the SCXI-1520, refer to page 795.

Module	Quarter-Bridge (120 , 350)	Half-Bridge (120 , 350)	Full-Bridge (120 , 350)	Force, Load, Torque, Pressure
SCXI-1520	✓	✓	✓	✓

Table 1. Signal Compatibility

SCXI Universal Strain Gauge Input Module

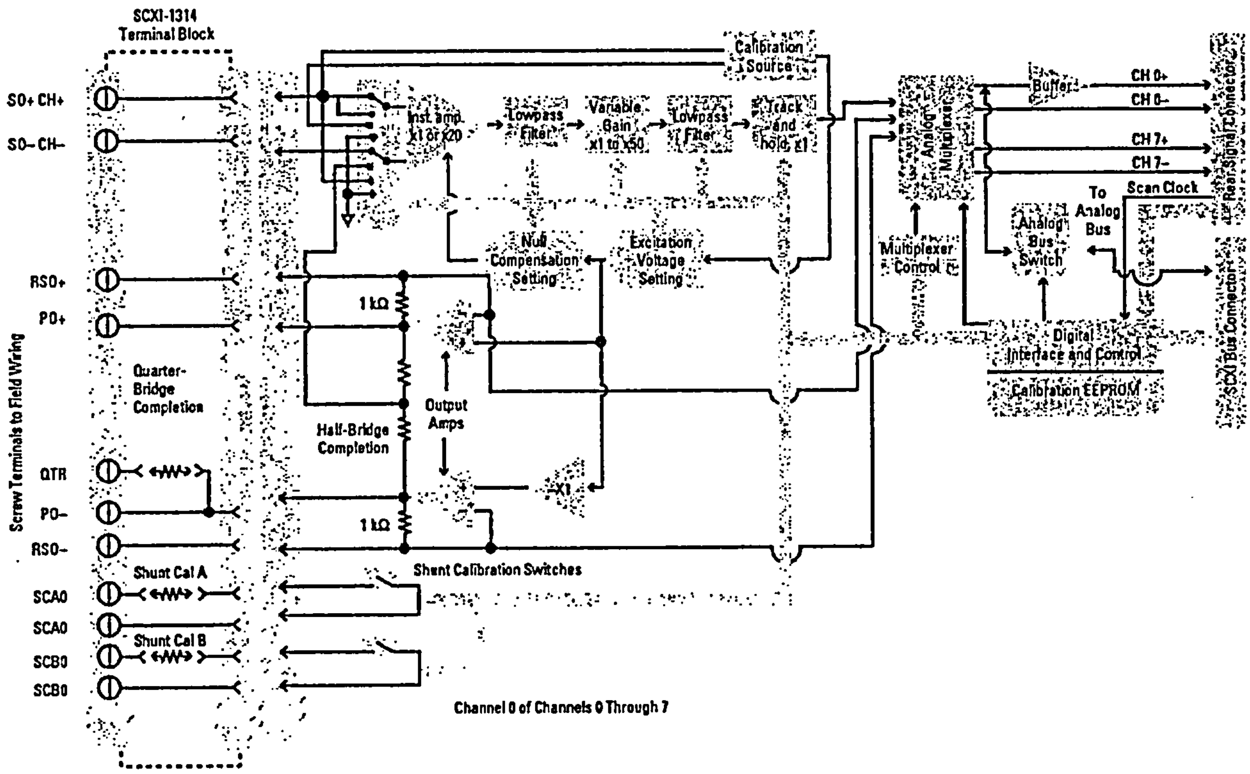


Figure 1. SCXI-1520 Block Diagram

Excitation

Each channel of the SCXI-1520 has an independent voltage excitation source. You can program each excitation channel to one of 17 voltage excitation levels from 0 to 10 V. These sources can drive a 350 W full bridge to the maximum 10 V level. Each excitation channel incorporates remote sensing circuitry to automatically compensate for voltage drops due to lead resistance. This circuitry corrects the excitation level on the fly so the programmed excitation level is accurately applied at the sensor. You can also monitor these excitation sources to detect open or fault situations.

Strain Gauge	Quarter-Bridge	Half-Bridge	Full-Bridge
120	6.25 V	6.9 V	3.125 V
350	10.00 V	10.0 V	10.000 V

Table 2. Excitation Values

Automatic Null Compensation

Each input channel of the SCXI-1520 includes a circuit to remove bridge offset voltage. Driver software nulls the offset voltage to zero in seconds. You do not need to manually adjust a potentiometer. By removing this offset through the measurement hardware, you can increase your system gain to achieve better measurement sensitivity and resolution.

Bridge Completion

The SCXI-1520 accepts quarter, half, and full-bridge sensors. Half-bridge completion is provided in the SCXI-1520, and you can enable it through software. The RN-55 style quarter-bridge completion resistors are provided in the SCXI-1314 front-mounting terminal block. They are socketed, so you can replace them with your own resistors.

Shunt Calibration

Each input channel of the SCXI-1520 includes two independent shunt calibration circuits, with which you can simulate two separate loading effects on your strain-based device and compensate for any possible gain errors. The RN-55 style shunt calibration resistors are in sockets and located in the SCXI-1314 front-mounting terminal block. You enable or disable the shunt resistors through software commands.

SCXI Universal Strain Gauge Input Module

Calibration

The SCXI-1520 provides simple yet powerful calibration capabilities. Each module includes a precision onboard calibration source, which you can programmatically route to any analog input channel. By using simple software commands, you perform calibrations to compensate for environmental changes without connecting external hardware. Each module has an onboard calibration EEPROM that stores calibration constants for each channel; factory calibration constants are stored in a protected area of the EEPROM. Additional user-modifiable locations mean calibration can occur under your exact operating conditions. NI-DAQ Traditional and NI-DAQ 7 transparently use the calibration constants to correct for gain and offset errors for each channel.

Ordering Information

NI SCXI-1520 777966-20

For information on extended warranty and value-added services, see page 20.

BUY ONLINE!

Visit ni.com/info and enter scxi1520

See page 276 to configure your complete SCXI system.

Terminal Block	Type	CJ Sensor	Compatible Modules	Cabling	Special Functions	Page
SCXI-1314 (777687-14)	Screw terminals	No	SCXI-1520 Front-mounting	–	Quarter-bridge completion	329

Table 3. Terminal Block Options for the SCXI-1520

Specifications

Typical for 25 °C unless otherwise noted

Complete Accuracy Table, Voltage

Module	Nominal Range*	Overall Gain*	Percent of Reading*	Offset*	System Noise (peak, 3 sigma)* Single Point	System Noise (peak, 3 sigma)* 100 Point Average	Temperature Drift Gain Drift (%/°C)	Temperature Drift Offset (µV/°C)
SCXI-1520	±10.0 V	1.0	±0.1	±3.0 mV	10.0 mV	1.0 mV	±0.03	±25
	±5.0 V	2.0	±0.1	±1.5 mV	5.0 mV	0.5 µV	±0.03	±25
	±1.8 V	4.2	±0.1	±0.5 mV	2.0 mV	0.2 mV	±0.03	±25
	±1.0 V	10.0	±0.1	±0.3 mV	1.0 mV	0.1 mV	±0.03	±25
	±500.0 mV	20.0	±0.1	±150.0 µV	0.5 mV	50.0 µV	±0.03	±5
	±180.0 mV	42.0	±0.1	±75.0 µV	0.2 mV	20.0 µV	±0.03	±5
	±100.0 mV	100.0	±0.1	±50.0 µV	100.0 µV	10.0 µV	±0.03	±5
	±50.0 mV	200.0	±0.1	±50.0 µV	50.0 µV	5.0 µV	±0.03	±5
	±18.0 mV	420.0	±0.1	±50.0 µV	20.0 µV	2.0 µV	±0.03	±5
	±10.0 mV	1000.0	±0.1	±50.0 µV	20.0 µV	2.0 µV	±0.03	±5

*Absolute Accuracy (15 to 35 °C). Absolute accuracy is (voltage reading) x (% of Reading) + (offset error) + (system noise). To include the effects of temperature drift outside the range 15 to 25 °C, add the term T x (Gain drift) x (Range) x T x (Offset Drift), where T is temperature difference between the module temperature and 15 or 35 °C, whichever is smaller. Bandwidth setting is 10 Hz and Scan rate for 100-point averages is 200 scans/s. Excitation is set to zero Volts. To calculate the absolute accuracy for the SCXI-1520 refer to page 194 or visit *ni.com/accuracy*

Complete Accuracy Table, Strain, GF = 2.0, Excitation = 5 V

Module	Bridge	Range	Gain	Percent of Reading*	Hardware Nulling Range	System Noise (peak, 3 sigma)* Single Point	System Noise (peak, 3 sigma)* 100 Point Average	Temperature Drift Gain Drift (%/°C)	Temperature Drift Offset (µε/°C)
SCXI-1520	Quarter-Bridge	±40,000 µε	100	±0.1	±80,000 µε	±40 µε	±4 µε	±0.03	±80
		±7,000 µε	560	±0.1	±80,000 µε	±7 µε	±2 µε	±0.03	±16
		±4,000 µε	1000	±0.1	±80,000 µε	±4 µε	±1 µε	±0.03	±8
	Half-Bridge	±2,500 µε	1000	±0.1	±40,000 µε	±2 µε	±0.5 µε	±0.03	±4
	Full-Bridge	±1,250 µε	1000	±0.1	±20,000 µε	±1 µε	±0.2 µε	±0.03	±2

*Absolute Accuracy (15 to 35 °C). Absolute accuracy is (voltage reading) x (% of Reading) + (offset error) + (system noise). To include the effects of temperature drift outside the range 15 to 25 °C, add the term T x (Gain drift) x (Range) + T x (Offset Drift), where T is temperature difference between the module temperature and 15 or 35 °C, whichever is smaller. Bandwidth setting is 10 Hz and Scan rate for 100-point averages is 200 scans/s. To calculate the absolute accuracy for the SCXI-1520 refer to page 194 or visit *ni.com/accuracy*

SCXI Universal Strain Gauge Input Module

Specifications

Analog Input Characteristics

Number of channels	8
Voltage gain settings	X1 to X1000 with the following gain settings: 1; 1.15; 1.3; 1.5; 1.8; 2; 2.2; 2.4; 2.7; 3.1; 3.6; 4.2; 5.6; 6.5; 7.5; 8.7; 10; 11.5; 13; 15; 18; 20; 22; 24; 27; 31; 36; 42; 56; 65; 75; 87; 100; 115; 130; 150; 180; 200; 220; 240; 270; 310; 360; 430; 560; 650; 750; 870; 1,000
Input signal ranges	See Complete accuracy table
Input coupling	DC
Maximum working voltage	Either input should remain within ±10 V of ground. Both inputs should be within ±10 V of one another.
Overvoltage protection	±35 V powered on, ±25 V powered off
Inputs protected	<0...7>

Transfer Characteristics

Nonlinearity	Better than 0.02%
Gain error	±.35% of setting, +0.1% of EEPROM value
Offset error	
Gain>20	150 μV maximum
Gain<20	3 mV maximum

Amplifier Characteristics

Input impedance (DC)	>1 G
Input bias current	±20 nA maximum
Input offset current	±20 nA maximum
Output range	±10 V
Output impedance	
Parallel	200
MUX	91

NMR (Normal Mode Rejection Ratio)

Filter	NMR at 60 Hz
10 Hz	62 dB typical

CMRR (Common Mode Rejection Ratio)

Gain	CMRR DC to 60 Hz
<20	60 dB
20	85 dB

Dynamic Characteristics

Multiplexer performance

Module	Scan Interval (Per Channel, Any Gain and Filter Setting)		
	Settle to ±0.0125 %	Settle to ±0.006 %	Settle to ±0.0015 %
SCXI-1520	3 μs	10 μs	20 μs

System noise	Complete Accuracy Table
Noise RTI, gain=200, 0.1 to 10 Hz	2.0 μV_{pp}
Spot noise RTI, gain=200, 1000 Hz	16 nV/ $\overline{Hz}$

Filter Characteristics

Lowpass filter type	4-pole Butterworth (24 dB octave rolloff)
Lowpass filter settings	10 Hz, 100 Hz, 1 kHz, 10 kHz, or bypass
Bandwidth, filter bypassed	-3 dB at 20 kHz

Track and Hold Characteristics

Hold mode settle time	1 μs typical
Interchannel skew	±200 ns typical
Intermodule skew	±250 ns typical
Droop rate	30 mV/s typical, 100 mV/s maximum

Analog Input Stability

Recommended warm-up time	15 minutes
Gain drift	±40 ppm/C maximum
Offset drift	
Gain>20	2 μV/°C typical, ±5 μV/ °C maximum
Gain<20	10 μV/°C typical, ±25 μV/ °C maximum

Null Compensation Characteristics

Range	±4% of excitation voltage, 20,000 counts of resolution (±80,000 με, 4 με resolution for quarter-bridge, GF = 2.0)

Excitation Characteristics

Type	Constant voltage
Settings	0.0 to 10.0 V in 0.625 V increments
Error	±20 mV +.3% absolute ±0.1% of EEPROM setting
Short circuit current limit	50 mA minimum
Regulation, no load to 120	
With remote sense	±0.003%
Without remote sense	±0.08%
Drift	±0.005%/C ±30 μV/C maximum
Noise	DC to 10 kHz: 200 μV
Remote sense	Error less than ±0.02%/ of lead resistance
Protection	Surge arrestors in parallel with excitation terminals, shunt to ground

Bridge Completion[1]

Half bridge	5 k precision resistor network internal to module
Quarter bridge	Resistor in accessory terminal block SCXI-1314

Shunt Calibration[2]

Type	2 independent points
Resistor	In terminal block
Switch resistance	32
Switch off leakage	<1 nA
Switch break-down voltage	±60 VDC

Physical

Dimensions	3.0 by 17.2 by 20.3 cm (1.2 by 6.9 by 8.0 in.)

Environment

Operating temperature	0 to 50 °C
Storage temperature	-20 to 70 °C
Relative humidity	10 to 90% noncondensing

Certifications and Compliances

European Compliance CE

EMC	EN 61326 Group I Class A, 10m, Table 1 Immunity
Safety	EN 61010-1

North American Compliance

EMC	FCC Part 15 Class A using CISPR

Australia & New Zealand Compliance

EMC	AS/NZS 2064.1/2 (CISPR-11)

Notes

[1]Half-bridge completion is inside the module and configured under software control. Quarter-bridge completion resistor is in SCXI-1314 terminal block and socketed. Resistors shipped with SCXI-1314 are 120 and 350 RN-55 style (0.25 W) Tolerance is ±0.1%. Temperature coefficient is ±10 ppm/°C max.

[2]Shunt calibration resistors are in SCXI-1314 terminal block and socketed. Resistors shipped with SCXI-1314 are 100 k RN-55 style (0.25 W) Tolerance is ±0.1%. Temperature coefficient is ±10 ppm/°C max.

For a definition of specific terms, please visit *ni.com/glossary*

Multifunction DAQ and SCXI Signal Conditioning Accuracy Specifications Overview

Every Measurement Counts

There is no room for error in your measurements. From sensor to software, your system must deliver accurate results. NI provides detailed specifications for our products so you do not have to guess how they will perform. Along with traditional data acquisition specifications, our E Series multifunction data acquisition (DAQ) devices and SCXI signal conditioning modules include accuracy tables to assist you in selecting the appropriate hardware for your application.

To calculate the accuracy of NI measurement products, visit ni.com/accuracy

Absolute Accuracy

Absolute accuracy is the specification you use to determine the overall maximum tolerance of your measurement. Absolute accuracy specifications apply only to successfully calibrated DAQ devices and SCXI modules. There are four components of an absolute accuracy specification:

- **Percent of Reading** – is a gain uncertainty factor that is multiplied by the actual input voltage for the measurement.
- **Offset** – is a constant value applied to all measurements.
- **System Noise** – is based on random noise and depends on the number of points averaged for each measurement (includes quantization error for DAQ devices).
- **Temperature Drift** – is based on variations in your ambient temperature.
- **Input Voltage** – the absolute magnitude of the voltage input for this calculation. The fullscale voltage is most commonly used.

Based on these components, the formula for calculating absolute accuracy is:

Absolute Accuracy = ±[(Input Voltage X % of Reading) + (Offset + System Noise + Temperature Drift)]

Absolute Accuracy RTI[1] = (Absolute Accuracy Input Voltage)
[1]RTI = relative to input

Temperature drift is already accounted for unless your ambient temperature is outside 15 to 35 °C. For instance, if your ambient temperature is at 45 °C, you must account for 10 °C of drift. This is calculated by:

Temperature Drift = Temperature Difference x % Drift per °C x Input Voltage

Absolute Accuracy for DAQ Devices

Absolute Device Accuracy at Full Scale is a calculation of absolute accuracy for DAQ devices for a specific voltage range using the maximum voltage within that range taken one year after calibration, the Accuracy Drift Reading, and the System Noise averaged value.

Below is the Absolute Accuracy at Full Scale calculation for the NI PCI-6052E DAQ device after one year using the ±10 V input range while averaging 100 samples of a 10 V input signal. In all the Absolute Accuracy at Full Scale calculations, we assume that the ambient temperature is between 15 and 35 °C. Using the Absolute Accuracy table on the next page, we see that that the calculation for the ±10 V input range for Absolute Accuracy at Full Scale yields 4.747 mV. This calculation is done using the parameters in the same row for one year Absolute Accuracy Reading, Offset and Noise + Quantization, as well as a value of 10 V for the input voltage value. You can then see that the calculation is as follows:

Absolute Accuracy = ±[(10 X 0.00037) + 947.0 µV + 87 µV] = ±4.747 mV

In many cases, it is helpful to calculate this value relative to the input (RTI). Therefore, you do not have to account for different input ranges at different stages of your system.

Absolute Acuracy RTI = (±0.004747/10) = ±0.0475%

The following example assumes the same conditions except that the ambient temperature is 40 °C. You can begin with the calculation above and add in the Drift calculation using the % Drift per °C from Table 2 on page 196.

Absolute Accuracy = 4.747 mV + ((40 – 35 °C) x 0.000006 /°C X 10 V) = ±5.047 mV

Absolute Acuracy RTI = (±0.005047/10) = ±0.0505%

Absolute Accuracy for SCXI Modules

Below is an example for calculating the absolute accuracy for the NI SCXI-1102 using the ±100 mV input range while averaging 100 samples of a 14 mV input signal. In this calculation, we assume the ambient temperature is between 15 and 35 °C, so Temperature Drift = 0. Using the accuracy table on page 313, you find the following numbers for the calculation:

Input Voltage = 0.014
% of Reading Max = 0.02% = 0.0002
Offset = 0.000025 V
System Noise = 0.000005 V

Absolute Accuracy = ±[(0.014 x 0.0002) + 0.000025 + 0.000005] V = ±32.8 µV

Absolute Accuracy RTI = ±(0.0000328 / 0.014) = ±0.234 %

The following example assumes the same conditions, except the ambient temperature is 40 °C. You can begin with the Absolute Accuracy calculation above and add in the Temperature Drift.

Absolute Accuracy = 32.8 µV + (0.014 x 0.000005 + 0.000001) x 5 = ±38.15 µV

Absolute Accuracy RTI = ±(0.00003815 / 0.014) = ±0.273 %

Multifunction DAQ and SCXI Signal Conditioning Accuracy Specifications Overview

For both DAQ devices and SCXI modules, you should use the Single-Point System Noise specification from the accuracy tables when you are making single-point measurements. If you are averaging multiple points for each measurement, the value for System Noise changes. The Averaged System Noise in the accuracy tables assumes that you average 100 points per measurement. If you are averaging a different number of points, use the following equation to determine your Noise + Quantization:

$$\text{System Noise} = \text{Average System Noise from table} \times \sqrt{(100/\text{number of points})}$$

For example, if you are averaging 1,000 points per measurement with the PCI-6052E in the ±10 V (±100 mV for the SCXI-1102) input range, System Noise is determined by:

NI PCI-6052E**
System Noise= 87.0 0 µV x $\sqrt{(100/1000)}$ = 27.5 0 µV

NI SCXI-1102
System Noise= 5 µV x SQRT $\sqrt{(100/1000)}$ = 1.58 µV

**The System Noise specifications assume that dithering is disabled for single-point measurements and enabled for averaged measurements.

See page 21 or visit ni.com/calibration for more information on the importance of calibration on DAQ device accuracy.

Absolute System Accuracy

Absolute System Accuracy represents the end-to-end accuracy including the signal conditioning and DAQ device. Because absolute system accuracy includes components set for different input ranges, it is important to use Absolute Accuracy RTI numbers for each component.

Total System Accuracy RTI = ±SQRT [(Module Absolute Accuracy RTI)2 + (DAQ Device Absolute Accuracy RTI)2]

The following example calculates the Absolute System Accuracy for the SCXI-1102 module and PCI-6052E DAQ board described in the first examples:

Total System Accuracy RTI = ± $\sqrt{[(0.00273)2 + (0.000505)2]}$ = ±0.278%

Units of Measure

In many applications, you are measuring some physical phenomenon, such as temperature. To determine the absolute accuracy in terms of your unit of measure, you must perform three steps:

1. Convert a typical expected value from the unit of measure to voltage
2. Calculate absolute accuracy for that voltage
3. Convert absolute accuracy from voltage to the unit of measure

Note: It is important to use a typical measurement value in this process, because many conversion algorithms are not linearized. You may want to perform conversions for several different values in your probable range of inputs, rather than just the maximum and minimum values.

For an example calculation, we want to determine the absolute system accuracy of an NI SCXI-1102 system with a NI PCI-6052E, measuring a J-type thermocouple at 100 °C.

1. A J-type thermocouple at 100 °C generates 5.268 mV (from a standard conversion table or formula)
2. The absolute accuracy for the system at 5.268 mV is ±0.82%. This means the possible voltage reading is anywhere from 5.225 to 5.311 mV.
3. Using the same thermocouple conversion table, these values represent a temperature spread of 99.3 to 100.7 °C.

Therefore, the absolute system accuracy is ±0.7 °C at 100 °C.

Benchmarks

The calculations described above represent the maximum error you should receive from any given component in your system, and a method for determining the overall system error. However, you typically have much better accuracy values than what you obtain from these tables.

If you need an extremely accurate system, you can perform an end-to-end calibration of your system to reduce all system errors. However, you must calibrate this system with your particular input type over the full range of expected use. Accuracy depends on the quality and precision of your source.

We have performed some end-to-end calibrations for some typical configurations and achieved the results in Table 1:

To maintain your measurement accuracy, you must calibrate your measurement system at set intervals over time.

For a current list of SCXI signal conditioning products with calibration services, please visit ni.com/calibration

Multifunction DAQ and SCXI Signal Conditioning Accuracy Specifications Overview

Module	Empirical Accuracy
SCXI-1102	±0.25 °C at 250 °C
	±24 mV at 9.5 V
SCXI-1112	±0.21 °C at 300 °C
SCXI-1125	±2.2 mV at 2 V

Table 1. Possible Empirical Accuracy with System Calibration

Nominal Range (V)		Absolute Accuracy: % of Reading		Absolute Accuracy	Absolute Accuracy: System Noise (mV)		Absolute Accuracy	Absolute Accuracy	Relative Accuracy: Resolution (µV)	
Positive FS	Negative FS	24 Hours	1 Year	Offset (µV)	Single Point	Averaged	Temp Drift (%/°C)	Absolute Accuracy at Full Scale (mV)	Single Point	Averaged
10.0	-10.0	0.0354	0.0371	947.0	981.0	87.0	0.0006	4.747	1145.0	115.0
5.0	-5.0	0.0054	0.0071	476.0	491.0	43.5	0.0001	0.875	573.0	57.3
2.5	-2.5	0.0354	0.0371	241.0	245.0	21.7	0.0006	1.190	286.0	28.6
1.0	-1.0	0.0354	0.0371	99.2	98.1	8.7	0.0006	0.479	115.0	11.5
0.5	-0.5	0.0354	0.0371	52.1	56.2	5.0	0.0006	0.243	66.3	6.6
0.25	-0.25	0.0404	0.0421	28.6	32.8	3.0	0.0006	0.137	39.2	3.9
0.1	-0.1	0.0454	0.0471	14.4	22.4	2.1	0.0006	0.064	27.7	2.8
0.05	-0.05	0.0454	0.0471	9.7	19.9	1.9	0.0006	0.035	25.3	2.5
10.0	0.0	0.0054	0.0071	476.0	491.0	43.5	0.0001	1.232	573.0	57.3
5.0	0.0	0.0354	0.0371	241.0	245.0	21.7	0.0006	2.119	286.0	28.6
2.0	0.0	0.0354	0.0371	99.2	98.1	8.7	0.0006	0.850	115.0	11.5
1.0	0.0	0.0354	0.0371	52.1	56.2	5.0	0.0006	0.428	66.3	6.6
0.5	0.0	0.0404	0.0421	28.6	39.8	3.0	0.0006	0.242	48.2	3.9
0.2	0.0	0.0454	0.0471	14.4	22.4	2.1	0.0006	0.111	27.7	2.8
0.1	0.0	0.0454	0.0471	9.7	19.9	1.9	0.0006	0.059	25.3	2.5

Table 2. NI PCI-6052E Analog Input Accuracy Specifications

Note: Accuracies are valid for measurements following an internal (self) E Series calibration. Averaged numbers assume averaging of 100 single-channel readings. Measurement accuracies are listed for operational temperatures within ±1 °C of internal calibration temperature and ±10 °C of external or factory-calibration temperature. One-year calibration interval recommended. The absolute accuracy at full scale calculations were performed for a maximum range input voltage (for example, 10 V for the ±10 V range) after one year, assuming 100 point averaging of data.

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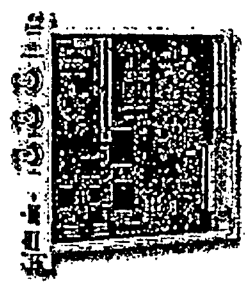

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- 16-bit resolution, 200 kS/s sampling rate
- External digital trigger, clock, and calibration co
- Multiplexes up to 352 channels per module
- Data Sheet

Description

The National Instruments SCXI-1600 is a full-featured 16-bit USB data acquisition and c module for SCXI analog input, analog output, digital I/O, and switching modules. The NI 1600 plugs into an SCXI chassis and provides data acquisition and control capabilities f modules in the chassis, communicating with a PC via a USB 2.0 connection. With the S 1600, you can turn any SCXI chassis into a plug-and-play data acquisition system. Eacl 1600 can multiplex up to 352 channels per module at an aggregate sampling rate of 20(with 16-bit resolution.

Resources

Manuals (8)
Product Certifications (1)
Data Sheet

Related Information

Choose the Right DAQ System

Do You Have Questions or Need a Quote?

Option 1: (800) 531-5066 (U.S.) worldwide contact info

Option 2: orders@ni.com

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SCXI Data Acquisition Systems – 16-Bit, 200 kS/s USB Data Acquisition Module

NEW

NI SCXI-1600

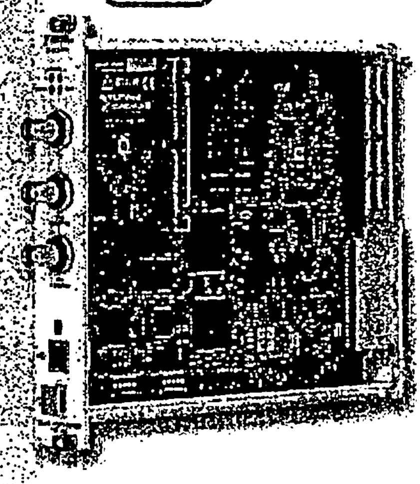
- 200 kS/s for up to 352 channels
- 16-bit resolution
- Controller and digitizer for SCXI chassis
- ±10 V input range
- USB 2.0 connectivity to PC
- BNC connectors for:
  - Digital start trigger
  - External clock source
  - External calibration
- Internal calibration source
- NI-DAQmx 7.3 to simplify configuration and measurements

Operating Systems
- Windows 2000/NT/XP

Recommended Software
- LabVIEW
- LabWindows/CVI
- Measurement Studio

Measurement Services Software (included)
- NI-DAQmx

Calibration Certificate Included
- See page 21



Device	Connection to PC	Analog Inputs	Resolution	Sampling Rate	Input Range	Triggers
SCXI-1600	USB 2.0 full-speed compliant	Up to 352[1]	16 bits	200 kS/s	±0.05 to ±10 V	Digital (1)

[1]Multiplexed through a single channel analog-to-digital converter

Table 1. SCXI-1600 Channel, Speed, and Resolution Specifications

Overview and Applications

The National Instruments SCXI-1600 USB data acquisition module acquires data from and controls SCXI signal conditioning modules installed in the chassis in which it resides, making the chassis a complete data acquisition system. Conditioned output signals from other SCXI modules in the chassis are automatically routed to the NI SCXI-1600, digitized, and transferred to the PC via USB. You can connect the SCXI-1600 directly to any standard USB port (1.0, 1.1, or 2.0).

Features

The SCXI-1600 is a full-featured 16-bit digitizer and control module for SCXI analog input, analog output, digital I/O, and switching modules. A USB 2.0 full-speed compliant connection makes the SCXI-1600 ideal for remote applications up to 150 ft away from the PC. In addition, the SCXI-1600 features an internal calibration source and external calibration connection to ensure absolute measurement accuracy over time.

Software

NI-DAQmx is the robust measurement services software included with all National Instruments data acquisition and signal conditioning products. This easy-to-use software tightly integrates the full functionality of your DAQ hardware to LabVIEW, LabWindows/CVI, and Measurement Studio. High-performance features include multidevice synchronization, networked measurements, and DMA data management. Bundled with NI-DAQmx, the Measurement & Automation Explorer utility simplifies the configuration of your measurement hardware with device test panels, interactive measurements, and scaled I/O channels. NI-DAQmx also provides numerous example programs for LabVIEW and other application development environments to get you started with your application quickly.

Ordering Information

NI SCXI-1600 776572-1600
Includes NI-DAQmx software.

BUY ONLINE!
Visit ni.com/info and enter SCXI1600.

SCXI Data Acquisition Systems – 16-Bit, 200 kS/s USB Data Acquisition Module

Specifications

These specifications are typical at 25 °C unless otherwise noted.

Nominal Range at Full Scale (V)	Absolute Accuracy: Gain Error (Percentage of Reading) 24 Hours	1 Year	Offset (µV)	Noise + Quantization (µV) Single Point	Averaged	Temperature Drift (%/°C)	Absolute Accuracy at Full Scale (mV)	Relative Accuracy Resolution (µV) Single Point	Averaged
±10	0.0546	0.0588	±1601	±1029	±92	0.0010	7.57	1205	120
±5	0.0146	0.0188	±811	±515	±46	0.0005	1.80	603	60.3
±0.5	0.0546	0.0588	±100	±66	±6	0.0010	0.40	78.4	7.9
±0.05	0.0546	0.0588	±29	±31	±3.0	0.0010	0.061	39.8	4.0

Note: Accuracies are valid for measurements following an internal calibration. Averaged numbers assume dithering and averaging of 100 single-channel readings. Measurement accuracies are listed for operational temperatures within ±1 °C of internal calibration temperature and ±10 °C of external or factory calibration temperature.

Analog Input

Input Characteristics

Type of ADC .... Successive approximation
Resolution .... 16 bits, 1 in 65,536
Sampling rate .... 200 kS/s

Device Gain	Range
0.5	±10 V
1	±5 V
10	±500 mV
100	±50 mV

Input coupling .... DC
FIFO buffer size .... 4,096 samples
Data transfers .... USB
Configuration memory size .... 512 words
Max working voltage
(signal + common mode) .... Each input should remain within ±11 V of ground
External calibration overvoltage protection
Powered on .... ±25 V
Powered off .... ±15 V

Accuracy Information

Transfer Characteristics

Integral nonlinearity (INL) .... ±1.5 LSB typ, ±2.0 LSB max
Differential nonlinearity (DNL) .... ±0.5 LSB typ, ±3.0 LSB max
No missing codes .... 16 bits
Offset error
- Pregain error after calibration .... ±1.0 µV max
- Pregain error before calibration .... ±28.8 mV max
- Postgain error after calibration .... ±157 µV max
- Postgain error before calibration .... ±40 mV max

Gain error (relative to calibration reference)
After calibration (gain = 1) .... ±74 ppm of reading max
Before calibration .... ±18,900 ppm reading max
Gain ≠ 1 with gain error
adjusted to 0 at gain = 1 .... ±200 ppm of reading max

Amplifier Characteristics

Input impedance (normal) .... 100 GΩ parallel with 100 pF
External calibration BNC input impedance
- Normal powered on .... 100 GΩ parallel with 100 pF
- Powered off .... 820 Ω
- Overload .... 820 Ω

Input bias current .... ±200 pA
Common-mode rejection ratio (CMRR), DC to 60 Hz

Gain	Bipolar
0.5, 1	85 dB
10, 100	96 dB

Dynamic Characteristics

Bandwidth

Signal	Bandwidth
Small (–3 dB)	413 kHz
Large (1% THD)	490 kHz

Settling time for full-scale step
Gain 100 .... ±4 LSB, 5 µs typ

[1]This value is the input protection resistor in front of the analog input mux.

[2]The input bias current is taken from the AD829 op amp specification sheet. This value is much larger than the other op amps. Since the AD829 is used as a single-ended op amp, the input bias current is the same as the input offset current. Therefore, offset current is not listed.

Gain 10, 1, 0.5 .... ±2 LSB, 5 µs max
System noise (LSB_{rms}, including quantization)

Gain	LSB_{rms}
0.5, 1.0	1.0
10.0	1.3
100	6.8

Stability

Recommended warm-up time .... 15 min
Offset temperature coefficient
Pregain .... ±20 µV/°C
Postgain .... ±175 µV/°C
Gain temperature coefficient .... ±20 ppm/°C

Triggers

AI triggers
Input .... AI START TRIG
AI REF TRIG
AI SAMP CLK
AI CONV CLK
AI GATE
SI SOURCE
Output .... AI Start Trigger,
AI Sample Clock
External sources .... PFI <0, 7>
Compatibility .... 5 V TTL
Response .... Rising or falling edge
Pulse width .... 10 ns min in edge-detect mode

Direction	Level	Min	Max
Input	Low voltage	0.0 V	0.8 V
	High voltage	2.0 V	5.0 V
Output	Low voltage (Iout = 5 mA)	—	0.4 V
	High voltage (Iout = 3.5 mA)	4.35 V	—

Calibration

Recommended warm-up time .... 15 min
Interval .... 1 year
External calibration reference .... >6 and <10 V
Onboard calibration reference
Level .... 5.000 V (±3.5 mV)
(over full operating temperature, actual value stored in EEPROM)
Temperature coefficient .... ±5 ppm/°C max
Long-term stability .... ±15 ppm/1,000 h

Power Requirements

+22 VDC .... 115 mA max
–22 VDC .... 135 mA max

Physical

Dimensions .... 18.3 by 17.3 by 3.1 cm
depth by height by width (7.2 by 6.8 by 1.2 in.)
I/O connector .... 3 BNC connectors, 1 USB front connector

SCXI Data Acquisition Systems – 16-Bit, 200 kS/s USB Data Acquisition Module

Maximum Working Voltage
Maximum working voltage refers to the signal voltage plus the common-mode voltage.

Channel-to-earth	11 V, Installation Category I
Channel-to-channel	11 V, Installation Category I

Environmental

Operating temperature	0 to 50 °C
Storage temperature	–20 to 70 °C
Relative humidity	10 to 90%, noncondensing
Maximum altitude	2,000 m
Pollution Degree (indoor use only)	2

Safety
The SCXI-1600 is designed to meet the requirements of the following standards of safety for electrical equipment for measurement, control, and laboratory use:

Note_ IEC 61010-1, EN 61010-1
Note_ UL 3111-1, UL61010B-1
Note_ CAN/CSA C22.2 No. 1010.1

For UL and other safety certifications, refer to the product label or visit *ni.com/hardref.nsf*, search by model number or product line, and click the appropriate link in the Certification column.

Electromagnetic Compatibility

Emissions	EN 55011 Class A at 10 m FCC Part 15A above 1 GHz
Immunity	EN 61326:1997 + A2:2001, Table 1
EMC/EMI	CE, C-Tick and FCC Part 15 (Class A) Compliant

For EMC compliance, operate this device with shielded cabling.

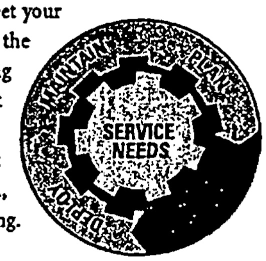
CE Compliance CE
The SCXI-1600 meets the essential requirements of applicable European Directives, as amended for CE marking, as follows:

Low-Voltage Directive (safety)	73/23/EEC
Electromagnetic Compatibility Directive (EMC)	89/336/EEC

Refer to the Declaration of Conformity (DoC) for this product for any additional regulatory compliance information. To obtain the DoC for this product, visit *ni.com/hardref.nsf*, search by model number or product line, and click the appropriate link in the Certification column.

NI Services and Support

NI has the services and support to meet your needs around the globe and through the application life cycle – from planning and development through deployment and ongoing maintenance. We offer services and service levels to meet customer requirements in research, design, validation, and manufacturing. Visit ni.com/services.



Training and Certification

NI training is the fastest, most certain route to productivity with our products. NI training can shorten your learning curve, save development time, and reduce maintenance costs over the application life cycle. We schedule instructor-led courses in cities worldwide, or we can hold a course at your facility. We also offer a professional certification program that identifies individuals who have high levels of skill and knowledge on using NI products. Visit ni.com/training.

Professional Services

Our Professional Services Team is comprised of NI applications engineers, NI Consulting Services, and a worldwide NI Alliance Partner Program of more than 600 independent consultants and integrators. Services range from start-up assistance to turnkey system integration. Visit ni.com/alliance.

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We also offer service programs that provide automatic upgrades to your application development environment and higher levels of technical support. Visit ni.com/ssp.

Hardware Services

NI Factory Installation Services

NI Factory Installation Services (FIS) is the fastest and easiest way to use your PXI or PXI/SCXI™ combination systems right out of the box. Trained NI technicians install the software and hardware and configure the system to your specifications. NI extends the standard warranty by one year on hardware components (controllers, chassis, modules) purchased with FIS. To use FIS, simply configure your system online with ni.com/pxiadvisor.

Calibration Services

NI recognizes the need to maintain properly calibrated devices for high-accuracy measurements. We provide manual calibration procedures, services to recalibrate your products, and automated calibration software specifically designed for use by metrology laboratories. Visit ni.com/calibration.

Repair and Extended Warranty

NI provides complete repair services for our products. Express repair and advance replacement services are also available. We offer extended warranties to help you meet project life-cycle requirements. Visit ni.com/services.

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YOKOGAWA DL750 SCOPECORDER SYSTEM

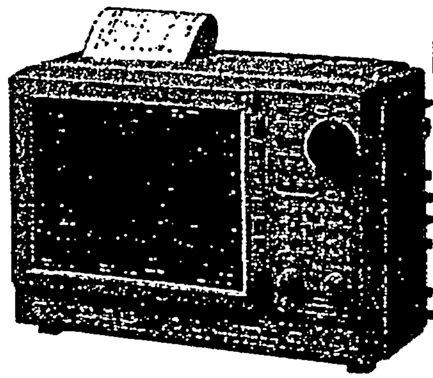
SCOPECORDER

YOKOGAWA

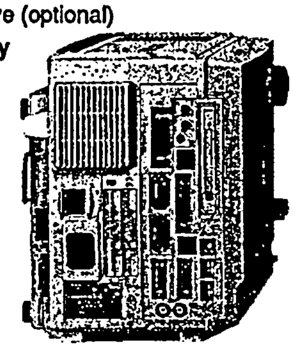
701210 ScopeCorder DL750

ScopeCorder

NEW



- Up to 16 analog channels and 16-bit logic input
- Up to 1 GigaWord total memory
- GIGAZoom function
- DualCapture function
- 10.4-inch SVGA color TFT liquid crystal display
- 10 MS/s, 12-bit A/D resolution, 2-channel isolation module
- Floppy disk, ZIP® disk and PC card drives available
- 20-GB internal hard drive (optional)
- **DC 12 V Power Supply Input Option** NEW



USB SCSI

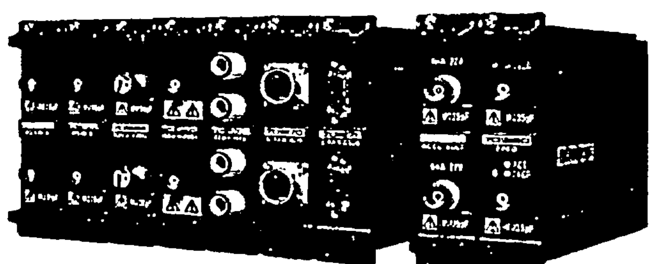
RS-232 GP-IB Ethernet

CE

3-Year Warranty

DL750(701210)
355 x 250 x 180 mm 9 kg
(13.98 x 9.8 x 7.09inch),
(Main unit and eight 701250 modules)

★
Safety Standards ; EN61010-1
Emission ; EN61326 Class A
Immunity Standard ; EN61326



701250 701251 701255 701260 701265 701270 701271 NEW 701275 NEW 701280

■ Module Selection Guide **Supports 16 CH • High Accuracy • High Noise Immunity • Low Internal Noise**

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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1 when using the 10:1 isolation probe (700929) 2 when using the 1:1 safety adapter lead (701901) 3 when using the 10:1 passive probe (701940)

Please refer to: http://www.yokogawa.com/tm/DL750/

SCOPECORDER

YOKOGAWA

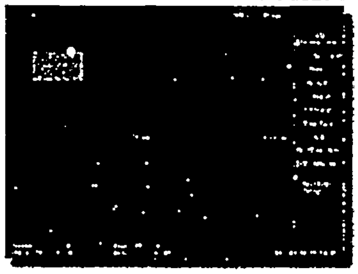
DL750

Innovative Solutions for Long-Term Recording

GIGAZoom Function for Instantaneous Full-Length Display of 1 GW of Data

A large-scale, high speed ASIC was created to give the DL750 the ability to show the entire 1 GW of data on the display in real time

Two zoom windows are available for displaying up to 500 MW of data. Zooming can be done in real-time or after data recording has stopped.



1 GW memory for full-length display and instantaneous zooming (to user-specified size)

	Maximum Recording Time			
Sample Rate	**Seconds**	**Minutes**	**Hours**	**Days**
10 MS/s	100 seconds	1.67	0.028	0.001
1 MS/s	600	10 minutes	0.167	0.007
100 kS/s	9000	150 minutes	2.5 hours	0.10
10 kS/s	72000	1200	20 hours	0.83 day
1 kS/s	864000	14400	240.0	10 days
200 S/s	2592000	43200	720.0	30 days

■ Amount of time data can be recorded with 1 GW memory

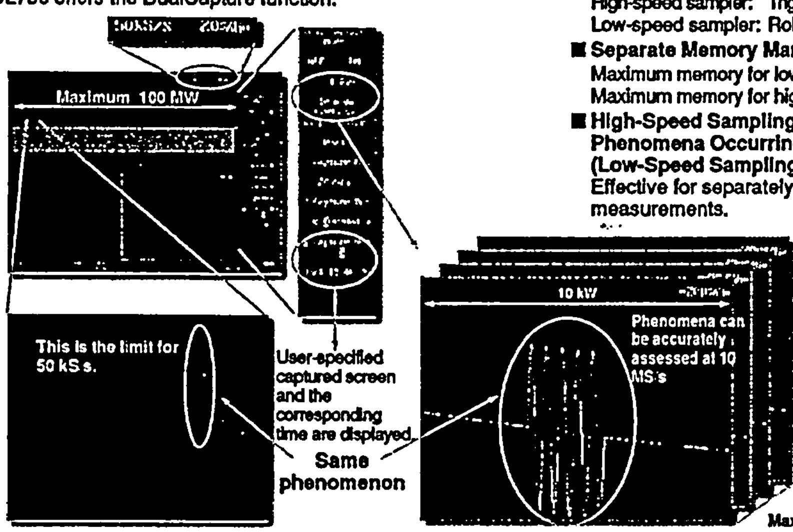
DualCapture: A Powerful Tool for Durability Test Data Analysis

Simultaneous High-Speed and Low-Speed Recording Using DualCapture

During durability testing, it is necessary to monitor the long-term trends of your data as well as capture the high speed transients that might occur. This presents a challenge as trend data is usually recorded at a slower sampling speed that might miss the transient phenomena. To meet this challenge, the DL750 offers the DualCapture function.

Using DualCapture, you can now record your trend data with a slow sampling speed and still be able to capture the transient phenomena with a faster sampling speed.

- **Integration of a High-Speed Sampler (Oscilloscope) and Low-Speed Sampler (Recorder) in a Single Unit**
  High-speed sampler: Trigger on abnormal high-speed phenomena
  Low-speed sampler: Roll recording (trend recording)
- **Separate Memory Management for Each Sampler**
  Maximum memory for low-speed sampler: 100 MW
  Maximum memory for high-speed sampler: 10 kW × 100 screens
- **High-Speed Sampling Triggered Only by Abnormal Phenomena Occurring During Long-Term Observation (Low-Speed Sampling)**
  Effective for separately capturing data at high speed during measurements.



- **Long Memory Equivalent to 1 Teraword**
  To acquire many hours of data at the higher sampling rate (10 MS/s) would require Terawords of memory
  (8 hr-240 hr) × 60 min × 60 sec × 10 MS/s × 16 channels
  = 4.6-138 TW

The waveform shown above was captured at a sampling rate of 50 kS/s. The occurrence of noise can be confirmed in the graph, but the time resolution is too low to capture the waveform accurately.

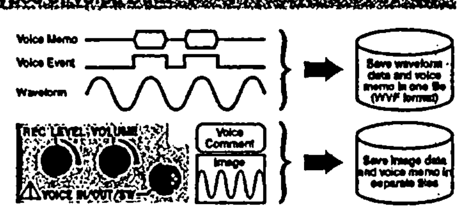
With DualCapture, the user sets triggers for capturing sudden phenomena. Up to 100 phenomena can be collected in a memory length of 10 kW at a maximum sampling rate of 10 MS/s.

Voice Memo Function: Save Audio Comments along with Waveform Data and Images

NEW VOICE MEMO

Enables You to Record and Playback 2 Types of Voice Data

- **Voice Memo**
  Simply press a switch to record your voice while simultaneously recording waveforms. Make multiple recordings per waveform (100 seconds total, min. 3 seconds per recording).
- **Voice Comment**
  Record and save an explanatory comment (approx. 3-10 seconds) together with your image files.
  The 701951 Earphone-Mic (with PUSH switch) is required to record voice memos and to listen to recorded voice memos.



SCOPECORDER

YOKOGAWA

DL750

Accurately Measure and Display Complex Signals

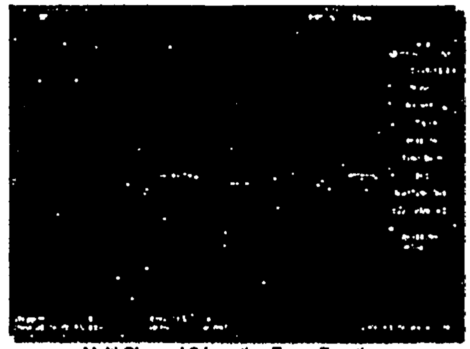
Capturing Signals Using the Longest Memory Capacity Ever

For Accurately Capturing Complex Signals of Long Waveforms

The DL750's standard memory capacity is 50 MW (2.5 MW per channel). This can be expanded (optional) to as much as 1 GW (50 MW per channel).

■ **Benefits of GigaWord Recording**
You can record data for 10 days (1 day/div) on the main screen, while displaying 1-second recordings (100 ms/div) in real time on the zoom screen. The large memory capacity lets you capture all of your data while still maintaining a sample rate fast enough to see any abnormal phenomena.

■ **Efficient Memory Use**
Sufficient memory length is available even when 16 channels are used, so you can conduct extended observations on multiple channels (2.5 MW per channel with standard memory, 50 MW per channel with maximum memory).



Multi-Channel 2-Location Zoom Function

A Wide Range of Trigger Functions for Accurately Capturing a Variety of Waveforms

Having a wide range of triggers is of course very useful for obtaining stable observations of variety of different waveforms. In addition, the GUI menu makes setting trigger conditions easy and intuitive.

Simple and Enhanced Triggers

SIMPLE/ENHANCED

Edge trigger:	Set a regular edge trigger
A → B (N):	Triggers the n-th time that condition B goes true after condition A has gone true.
A Delay B:	Triggers if condition B goes true after condition A has gone true and an interval at least equal to the delay setting has elapsed.
Edge on A:	Activates an edge trigger on another input during the interval when trigger condition A is true.
OR:	Triggers when any one of the individual channel conditions set with the patterns goes true.
B > TIME:	Triggers when the pulse width is longer than the set time
B < TIME:	Triggers when the pulse width is less than the time
B TIME OUT:	Triggers when a preset time-out time is reached
Period:	Triggers when a preset waveform frequency condition goes true.
Window:	Triggers when a trigger source enters or leaves a level set by two points
Wave Window:	Triggers when a signal leaves an automatically-defined "wave window" that surrounds the waveform

Action-On Trigger

Automatically Save Measured Data

When this trigger is activated, the DL750 performs a specified action each time a waveform is captured and displayed on the screen. This feature is useful for saving data automatically and reliably (e.g., for data collection in automated, continuous tests).

Manual Trigger

A Trigger Can Be Activated with Press of a Button

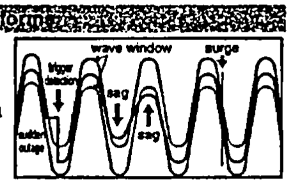
With this feature, a trigger can be executed whenever you like, separate from the preset trigger conditions.

MANUAL TRIG

Wave Window Trigger NEW

Automatically Triggers on Abnormalities in Power Supply Waveforms

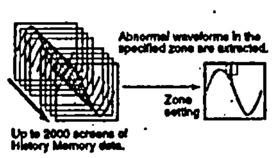
This function comes standard with the DL750 to allow observation power supply waveforms. In addition to traditional power supply troubles, such as sudden outages, sags, and surges, you can make efficient real time observations of frequency fluctuations and voltage drops. This trigger activates when a signal exceeds the allowable values determined by comparing a defined waveform (wave window) with an actual waveform in real time. Comparative waveforms can be automatically produced in real time based on measured waveforms. Detection on all 16 analog channels is available (with OR conditions).



History Memory and Smart Search for Effective Access to Large Amounts of Captured Data

History Memory and History Search (Zone Search) HISTORY

Occasionally, you may capture an abnormal waveform and then have it quickly disappear from the display as new data is acquired. It is not always possible to manually Start and Stop data acquisition to catch the abnormal waveform and have it displayed.
The History Memory function was designed for such situations. It divides long memory into a number of blocks and automatically stores up to 2000 previously captured waveforms. This means you can reliably save displayed waveforms to memory even when there are phenomena for which trigger conditions cannot be set.
The Zone Search function lets you define zones on the screen, and find all previously captured waveforms that either pass or don't pass through the user-defined zone. Up to four zones can be defined.



Search (Edge Search) and Zoom

The Edge Search counts rising and falling edges in the captured data. It automatically searches for the desired edges and displays them on a zoom screen.

ZOOM SEARCH

SCOPECORDER

YOKOGAWA

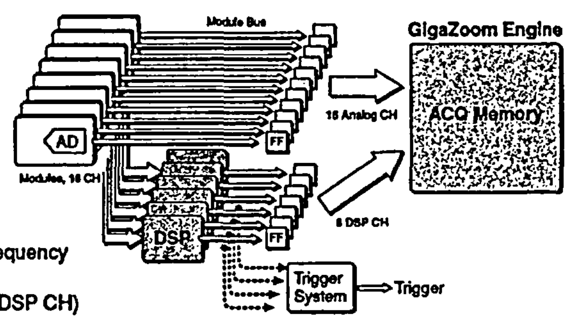
DL750

Analyze Captured Waveform Data

DSP Channel Real-Time Math Function (with the /G3 Option) NEW

New functions are now available with the DL750. Six digital signal processing (DSP) channels have been added. The DSP channels enable you to perform math and digital filtering in real time while acquiring waveforms. Each DSP channel can perform up to four arithmetic operations and filtering at high speed, without slowing down waveform acquisitions.

Architecture of DSP-CH



Features:

- Real-time display of calculated waveforms in roll mode
- Triggers on calculated waveforms
- Calculated parameters such as cutoff of digital filtering and frequency can be changed in real time
- Simultaneously display up to 16 channels (16 analog CH + 6 DSP CH)
- Provides the same memory length as with analog channels
- Arithmetic calculations between channels (addition, subtraction, multiplication, division), digital filtering (LPF, BFP, HPF), differentiation, and integration

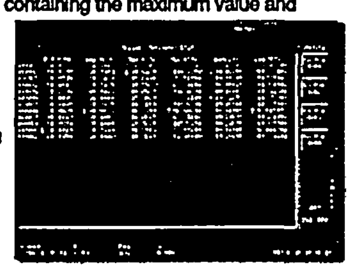
Automatically Measure Waveform Parameters

Easily Find and Display Waveform Frequency, Rise Time, and Other Parameters

Waveform parameters such as voltage, frequency, and RMS are measured automatically. In addition to general parameter measurement function, the DL750 comes standard with functions such as the following:

Cycle Statistical Calculation NEW

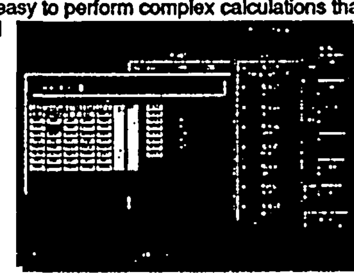
This function calculates statistical information about the waveform. Maximum value, minimum value, average value, and standard deviations are calculated automatically for each waveform parameter. In addition, you can instantaneously search for the cycle containing the maximum value and display it on the zoom screen. This cycle statistical calculation greatly improves your insight enabling you to analyze transient phenomena captured using the long recording memory.



User-Defined Math Function (with the /G2 Option)

Perform Complex Calculations

The DL750 comes standard with basic arithmetic operations (addition, subtraction, multiplication, division), FFT (power spectrum), and phase shifting (calculating a phase shift between channels). For more flexible and complex calculations, an optional user-defined math function package is available. With this option, you can define up to eight different formulas using a wide range of functions, including a triangle function, differentiation, integration, square root, digital filter, and seven different FFT functions. You can also specify the results of a calculation as a parameter in another formula. With these capabilities, the DL750 makes it easy to perform complex calculations that, in the past, could only have been done by loading data onto a PC.

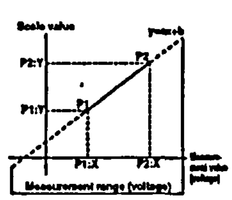


Linear Scaling

Convert Measured Voltage Values to Physical Values for Direct Reading

This function automatically performs the following calculation based on a scaling coefficient A and offset B: $Y = AX + B$ (X is a measured value and Y is the scale value)

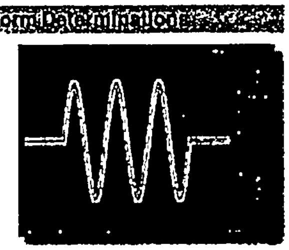
The results of this calculation are reflected in cursor measurement values and waveform parameter measurement values. In addition, user-determined scale values can be defined for any two measurement, P1 and P2.



GO/NO-GO Judgment

Automatic Waveform Determination

With this function, the user specifies a zone or waveform parameter for a measured waveform. The measurement signal is evaluated and a specified action is performed automatically based on the evaluation. Available actions include outputting a screenshot to a specified destination, saving waveform data to a specified storage medium, sounding a buzzer, and sending email.



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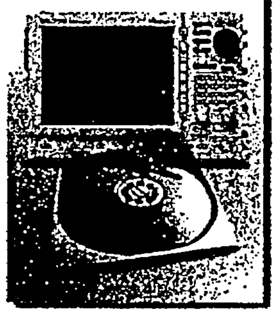
DL750

Display and Data Recording Functions

Real-Time Hard Drive Recording (with the /C8 Option)

Record the Real-Time Data Recording over Extended Periods

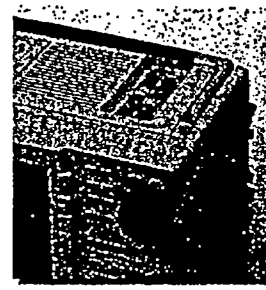
With the optional internal hard drive, you can record measurements to the hard drive in real time. This makes it easier to manage and analyze data using PCs and other tools.
Maximum data capacity: 1 GW
Maximum sampling rate: 100 kS/s (using 1 channel only)



Memory Backup Function

Protect Your Data Even if the Power Supply Goes Out

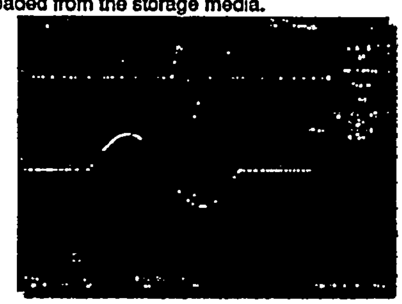
This function backs up about 10 hours of data saved to the acquisition memory immediately prior to power loss. Memory backup helps you avoid losing important data even if the power supply is unstable and gets cut off. (Backup time varies according to the usage environment. Four AA batteries are required for memory backup.)



Snapshot Function

Enables On-Screen Waveform Comparisons

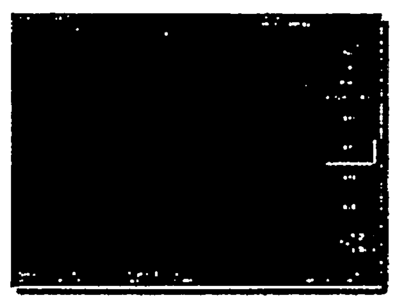
Using the snapshot function, you can keep the currently displayed waveform with the touch of a button. Snapshots are useful for comparing a reference waveform with an input waveform. In addition, snapshots can be saved to and loaded from the storage media.



X-Y Display Function

Display an Overlay of Up to Four X-Y Displays

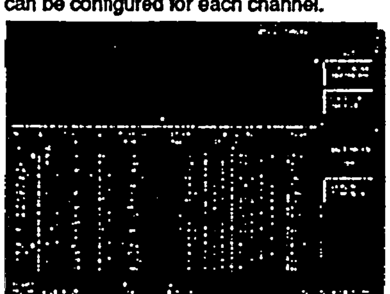
This function lets you display multiple X-Y plots together, making relative phase comparisons easy. The X-Y display function is a powerful tool for applications such as evaluating DC motors based on a Lissajous waveform.



All-Channel Setup Menu

Quickly View the Setup of All Channels

This menu lets you review and modify all of the channel setups from a single screen display. Parameters such as voltage axis sensitivity, screen scale settings, and linear scaling can be configured for each channel.



Wide Waveform Display

Increase the Viewing Area of Display

With the SVGA color TFT liquid crystal display, the number of display pixels has been greatly increased. For wide waveform display, set the resolution to 750 × 512 pixels.

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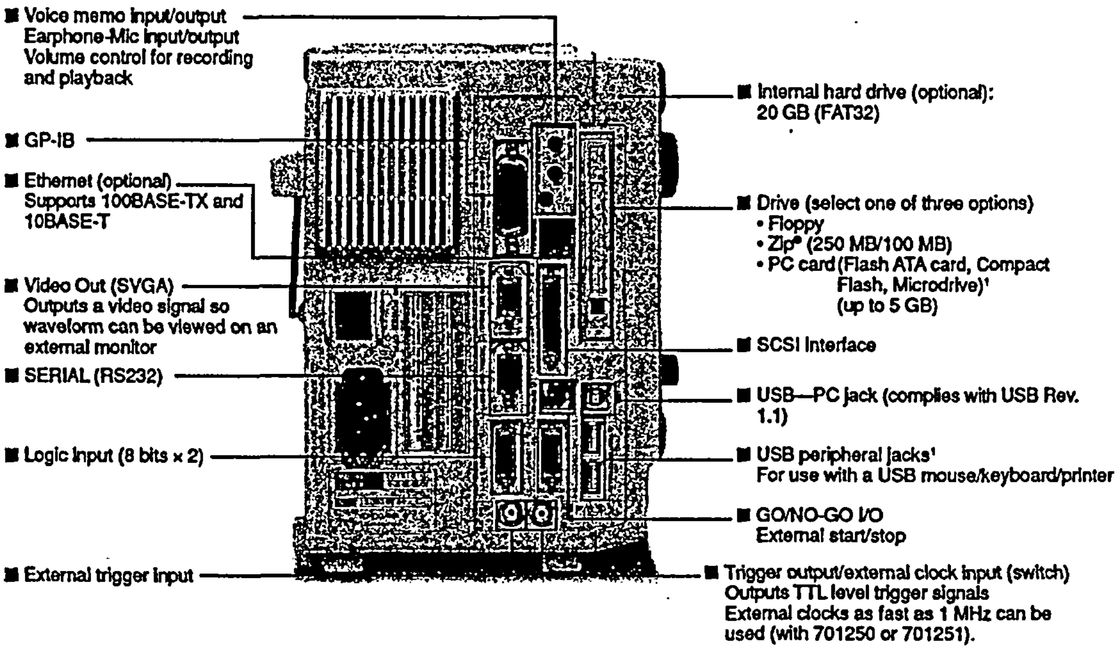
DL750

Complete Connectivity



1. Ask for information on compatible products.

USB

• Connecting to a PC

(Supported operating systems: Windows 98 SE, Windows 2000 Pro, Windows Me)

Just as for RS232 and GB-IB, you can write your own custom programs in Visual C++ 6.0 or Visual Basic 6.0 to control the DL750 through a USB interface.
PC communications are made easy with the Waveform Viewer and Wirepuller software programs.

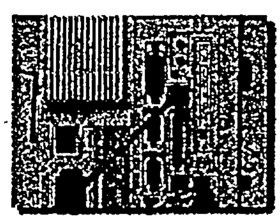
• Connecting USB Peripheral Equipment

USB keyboards, USB mouse and USB printers can be directly connected to the DL750.

Ethernet (Optional)

• Connecting to a PC

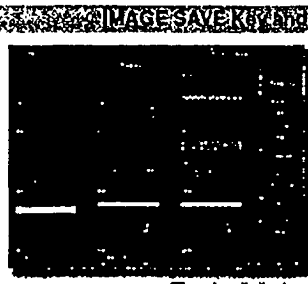
■ Web Server and FTP Server



The DL750 has a variety of server functions that let you perform remote controls or download waveform data and screen images onto a PC. You can also access the DL750 through the Internet Explorer. Just as for RS232 and GB-IB, you can write your own custom programs in Visual C++ 6.0 or Visual Basic 6.0 to control the DL750 through a USB interface.

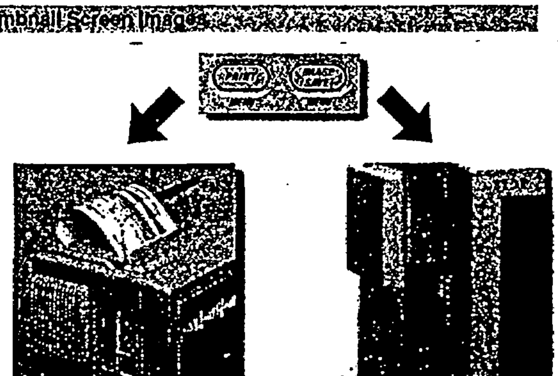
IMAGE SAVE Key and Thumbnail Screen Images

Simply press the IMAGE SAVE key to save image data to a CompactFlash card or other storage media. The saved image data (PNG, JPEG, BMP, or PostScript format) can then be displayed on the DL750's screen as thumbnails.



Thumbnail display

The PRINT key lets you output images to the DL750's build-in printer, a USB printer, or a network printer.



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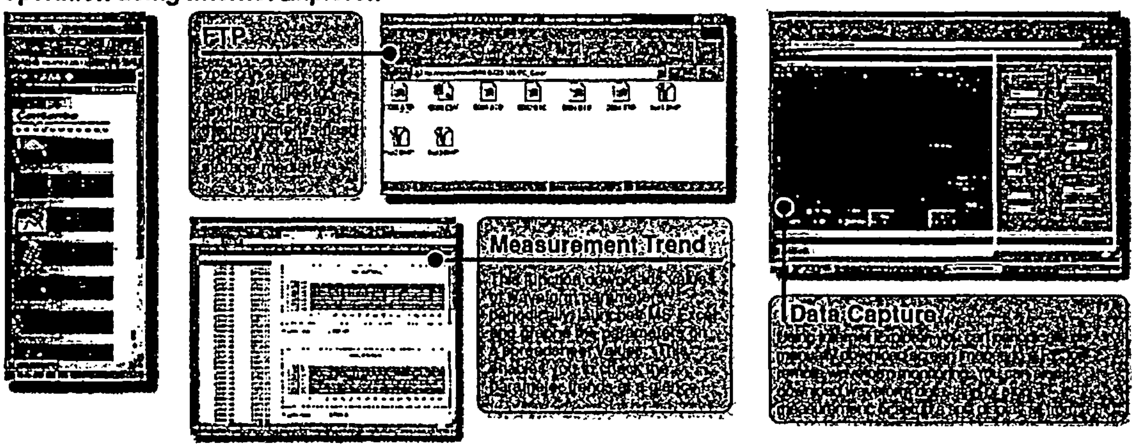
DL750

Advanced Networking and PC Connectivity

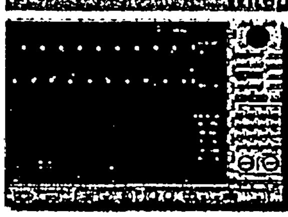
Web Server Functions

Connect the DL750 to your PC through the Ethernet connection. This allows for easy remote operation using Internet Explorer.



Software for Waveform Measurement on a PC
Software for Remotely Controlling the DL Series

Wirepuller

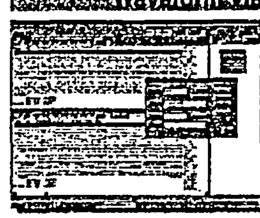


The Wirepuller software program displays a screen image of the DL's front panel on your PC so that you can monitor waveform signals. In addition, you can use the PC's mouse and keyboard to control the DL. The DL can be controlled via an Ethernet, USB, or GP-IB.

This software program can be downloaded from the following URL (requires registration):
http://www.yokogawa.com/tm/wirepuller/
Further details are available at the YOKOGAWA web site.

Software for Using Your PC to Check Waveform Data Captured in Long Memory

Waveform Viewer for DL Series



The Waveform Viewer software program lets you view waveform signals on your PC just as they appear on the DL screen. This includes zoom display, X-Y display and the history memory thumbnail displays. In addition, data can be converted to CSV format for use in programs like Excel.

A trial version of this software program can be downloaded from the following URL:
http://www.yokogawa.com/tm/700919/
Further details are available at the YOKOGAWA web site.

Main Unit Specifications

Basic Specifications	
● Input	
Type	Plug-in module (Each unit has a build-in A/D converter)
Slots	8
Logic inputs	16 (8 bits × 2)
● Horizontal	
Maximum record length	2.5 MW/CH, 50 MW total (standard) 10 MW/CH, 250 MW total (with /M1 option) 25 MW/CH, 500 MW total (with /M2 option) 50 MW/CH, 1 GW total (with /M3 option)
Time axis accuracy1	±0.005%
Sweep time	500 ns to 5 sec/div (in steps of 1, 2, or 5), 10 sec/div, 20 sec/div, 30 sec/div 3, 4, 6, 8, 10, 20, 30 sec/div 1 to 10 min/div (1 min steps), 12 min/div, 15 min/div, 30 min/div 1 to 10 h/div (1 h steps), 12 h/div 1 day/div, 2 days/div, 3 days/div
● Acquisition modes	
Normal	Maximum sampling rate: 10 MS/s
Envelope	Holds peak value at maximum sampling rate, regardless of time/div setting
Box average	Increases A/D resolution up to 4 bits (up to 16 bits)
Averaging	Number of averaging: 2 to 65,536 (2^n steps)
Roll	100 msec/div or less
● Triggers	
Modes	AUTO, AUTO LEVEL, NORMAL, SINGLE, SINGLE (N), LOG
Pretrigger	0 to 100% (in 0.1% step)
Simple trigger source	CH1 to CH16, DSP1 to DSP6, LINE, EXT, LOGIC_A, LOGIC_B, TIME
Slope selection	CH1 to CH16, DSP1 to DSP6: Rise, fall, rise-fall EXT (external trigger input), LOGIC_A, LOGIC_B: Rise, fall Time: Date (year/month/date), hour (hours/minutes), time interval (1 minute to 24 hours)
Enhanced trigger source	CH1 to CH16, LOGIC_A, LOGIC_B
Enhanced trigger type	A → B (N), A delay B, B > Time, B < Time, B Time Out, Period, Window, OR, Edge On A, Wave Window
● Screen updating rate	Maximum 30 screens/sec for a single waveform

1. Typical operating conditions: Ambient temperature of 23°C ± 5°C, ambient humidity (RH) of 55 ± 10%

Display		
Display		10.4-inch color TFT liquid crystal display
Effective screen size		211.2 mm × 158.4 mm
Resolution		800 × 600[1]
Waveform display pixels		650 × 512 (in normal waveform display mode) 750 × 512 (in wide waveform display mode)
Display modes	Split	Single, dual, triad, quad, octal
	Zoom	Main, Main & Z1, Main & Z1 & Z2, Main & Z2, Z1 Only, Z2 Only, Z1 & Z2 (Z1 and Z2 are abbreviations for zoom area 1 and zoom 2, respectively)
	XY	Single Mode (X is fixed, Y is set by user), Quad Mode (XY1, XY2, XY3, XY4)
Accumulation		PERSIST Overlays in one color.

1. The LCD may contain some pixels that are always off or always on. In addition, brightness may vary due to the characteristics of the liquid crystal display. This is not an indication of any problem with the display.

Recorder	
● Built-in printer	
Printing method	Thermal line-dot printing
Paper width	112 mm
Effective recording width	104 mm
Functions	Screen printing, long printing
● Real-time hard drive recording (with /C8 option)	
Data capacity	1 GW (for one time record)

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DL750

Main Unit Specifications

Maximum sampling rate 100 kS/s (using 1 channel)

DualCapture

This function captures the same waveform data at two different sampling rates.

Main (low-speed) maximum sampling rate
Roll mode area at 100 kS/s
Sub (high-speed) maximum sampling rate
10 MS/s
Main maximum memory length
100 MW (with /M3 option)
Sub memory length 10 kW (fixed)
Sub maximum number of captured screens
100

Analysis Functions

- Channel-to-channel calculation function
  - Definable math waveforms 8
  - Calculable record length 800 kW (using MATH1 only); 100 kW (using MATH1 through MATH8)
  - Standard operators Addition, subtraction, multiplication, division, binary conversion, phase shifting, FFT
    - FFT type PS (Power Spectrum)
    - Number of points 1000, 2000, 10,000
    - Window functions Rectangular, Hanning, Flat-Top
  - User-defined math function (with /G2 option)
    - Operators ABS, SQR, LOG, EXP, NEG, SIN, COS, TAN, ATAN, PH, DIF, DDIF, INTG, BIN, P2, P3, F1, F2, FV, PWHH, PWHL, PWLH, PWLL, PWXX, FILT1, FILT2, HLBT, MEAN, MAG, LOGMAG, PHASE, REAL, IMAG
    - FFT types LS, PS, PSD, CS, TF, CH
    - Number of points 1000, 2000, 10,000
    - Window functions Rectangular, Hanning, Flat-Top

DSP Channel Function (with the /G3 option)

DSP channels 8
Maximum sampling rate[1] 100 kS/s (when exceeding 100 kS/s, the sampling rate is resampled at 100 kS/s)
Operators Calculation between channels (addition, subtraction, multiplication, division), differentiation (w/ LPF), integration, digital filtering (LPF/HPF/BPF, FIR type, IIR type, variable cutoff frequency)
Digital filtering cutoff setting range
IIR type: 0.2 to 30% of sampling frequency
FIR type: 2 to 30% of sampling frequency
Calculation delay 4 sampling + digital filtering calculation delay

1. When the DSP channel is ON, the maximum sampling rate of the analog channel is 5 MS/s.

Waveform Measurement Functions

- Cursors
  - Types
    - Horizontal Two cursors
    - Vertical Two cursors
    - Marker Four markers
    - Degree Cursor measurement on the horizontal axis is displayed in a degree. (for TY display only)
    - H&V (for XY display only)
- Automatic measurement of waveform parameters
  - Maximum number of measured parameters 24
  - Measured parameters P-P, Max, Min, High, Low, Avg, Rms, Amp, StdDev, +Oshot, –Oshot, Rise, Fall, Freq, Period, +Duty, +Width, –Width, Pulse Burst1, Burst2, Avg Freq, Avg Period, Delay, Int1TY, Int2TY, Int1XY, Int2XY
- Cycle statistical process
  - Maximum number of cycles 24,000 (for one parameter)
  - Maximum total number of parameters 24,000 (total measured results)
  - Statistical values Maximum/minimum/average/standard deviations/number of samples
  - Maximum measurement range 10 MW
- Search function Edge, voice, auto scroll
- History search function Zone
- GO/NO-GO Judgment
  - Parameter: Make judgments using combinations of 16 waveform parameters.
  - Zone: Make judgments using combination of up to 6 waveform zones (AND, OR)
  - Actions: One or more of the followings: outputs screen image data, saves waveform data, sounds a buzzer, sends email

Screen Data Output (Printer)

Destinations Select built-in printer, external USB printer, or network printer (with /C10 option)
Formats
- Normal Outputs hard copy of screen shot
- Long Zooms displayed waveform along time axis and outputs (The zoom factor differs depending on the time/div.)

Screen Data Output (Image Saving)

Destinations Installed drive (floppy drive, Zip® drive, or PC card), external SCSI drive, internal hard drive (with /C8 option), network drive (with /C10 option)
Formats PNG, JPEG, BMP, PostScript

External I/O

- LOGIC input specifications
  - Input points 8 bits × 2
  - Maximum sampling rate 10 MS/s
  - Compatible probes 8-bit non-isolated (700986), 8-bit isolated (700987)
- EXT TRIG IN/EXT TRIG OUT
  - Connector RCA pin jack
  - Input/output level TTL (0 to 5 V)
- EXT Clock IN
  - Connector RCA pin jack
  - Input level TTL (0 to 5 V)
  - Input frequency Up to 1 MHz (for module 701250/701251/701255), up to 100 kHz (for module 701260/701270/701271, DSP-CH), up to 500 Hz (for module 701265)
- Communication interfaces
  GP-IB, USB peripheral equipment jacks (USB keyboards and USB printers), USB (complies with Rev. 1.1, for connection to PC), Ethernet (complies with 100BASE-TX and 10BASE-T; with /C10 option), serial (RS232), and SCSI
- GO/NO-GO I/O
  - Connector type Modular jack (RJ12)
  - I/O level TTL (0 to 5 V)
- Probe power terminal (with /P4 option)
  - Maximum number of probes powered 4
  - Compatible probes Current probes 700937 (15 Apeak) and 701930 (150 Arms)
  - Maximum number of current probes that can be used at one time 4 (for module 700937), 2 (for module 701930)

Voice Memo Function

- Voice memo
  - Record (roll mode)
    - Flexible: Multiple recording (min. 3 sec up to 100 sec, total 100 sec)
    - Fixed: Select from 5 sec × 20, 10 sec × 10, 20 sec × 5, 25 sec × 4, 50 sec 2, 100 sec × 1
  - Save Save together with waveform data (binary, same file)
  - Playback Voice data loaded on the main unit is outputted from microphone terminal and speaker output terminal (GO/NO-GO)
- Voice comment
  - Record 3 to 100 sec
  - Save When image saving is executed (separate file)
  - Playback Playback from microphone terminal and speaker output terminal (GO/NO-GO)

Acquisition Memory Backup

Batteries Four AA alkaline dry cells (AA/R6) (JIS and IEC type name: LR6) or four nickel metal-hydride rechargeable batteries
Backed up data Acquisition memory, waveform data, voice data
Backup duration (reference value)[2]
Approximately 10 hours (with /M3 option)

2. Actual backup duration will vary according to the usage conditions.

Media Drives

Internal media drives Floppy drive, Zip® drive, or PC card (choose one), and 20 GB hard drive (with /C8 option)

General Specifications

Rated supply voltage 100 to 120 VAC/200 to 240 VAC (automatically switched)
Rated supply frequency 50/60 Hz
Power consumed Approximately 200 VA-MAX
Maximum voltage 1500 VAC for one minute across power supply and ground
Insulating resistance 10 MΩ or greater at 500 VDC across power supply and ground
Exterior 355 × 250 × 180 mm (WHD), excluding knobs and protrusions
Weight Approx. 6.6 kg (main unit with full options, including M3, C8, C10, and P4)
Approx. 9 kg (main unit and eight 701250 modules)
Operating temperature range
5 to 40°C

High-Speed 10 MS/s 12-Bit Isolation Module (701250)

Input channels 2
Input couplings AC, DC, GND
Maximum sampling rate 10 MS/s
A/D conversion resolution 12 bits (150 LSB/div)
Input type Isolated unbalanced
Frequency range (–3 dB)[1] DC, up to 3 MHz
Input range (10:1) 50 mV/div to 200 V/div (in steps of 1, 2, or 5),
(1:1) 5 mV/div to 20 V/div (in steps of 1, 2, or 5)
Effective measurement range 20 div (display range: 10 div)
DC offset ±5 div
Maximum input voltage (1 kHz or less)
In combination with 700929 (10:1)[8]
600 V (DC + ACpeak)
Direct input (1:1)[4,10] 250 V (DC + ACpeak)
Maximum allowable in-phase voltage
In combination with 700929 (10:1)[8]
400 Vrms (CAT I), 300 Vrms (CAT II)
In combination with 7019In steps of 1, 2, or 5+701954 (1:1)[9]
400 Vrms (CAT I), 300 Vrms (CAT II)
Main unit only (1:1)[10] 42 V (DC + ACpeak) (CAT I and CAT II, 30 Vrms)
DC accuracy[1] ±(0.5% of 10 div)
Input impedance 1 MΩ ± 1%, approx. 35 pF

For detailed specifications, go to the following URL: http://www.yokogawa.com/tm/DL750/

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DL750

Plug-In Module Specifications

Connector type	Isolation type BNC connector
Input filter	OFF, 500 Hz, 5 kHz, 50 kHz, 500 kHz
Temperature coefficient	
Zero point	±(0.05% of 10 div)/°C (typical value)
Gain	±(0.02% of 10 div)/°C (typical value)

High-Speed 1 MS/s 16-Bit Isolation Module (701251)

Input channels	2
Input couplings	AC, DC, GND
Maximum sampling rate	1 MS/s
A/D conversion resolution	16 bits (2400 LSB/div)
Input type	Isolated unbalanced
Frequency range (–3 dB)[1]	DC, up to 300 kHz (20 V/div to 5 mV/div)
Input range (10:1)	10 mV/div to 200 V/div (in steps of 1, 2, or 5)
Input range (1:1)	1 mV/div to 20 V/div (in steps of 1, 2, or 5)
Maximum input voltage (1 kHz or less)	
In combination with 700929 (10:1)[8]	600 V (DC + ACpeak)
Direct input (1:1)[9,10]	140 V (DC + ACpeak)
Maximum allowable in-phase voltage	
In combination with 700929 (10:1)[3]	400 Vrms (CAT I), 300 Vrms (CAT II)
In combination with 701901+701954 (1:1)[6]	400 Vrms (CAT I), 300 Vrms (CAT II)
Main unit only (1:1)[11]	42 V (DC + ACpeak) (CAT I and CAT II, 30 Vrms)
DC accuracy[1]	
5 mV/div to 20 V/div	±(0.25% of 10 div)
2 mV/div	±(0.3% of 10 div)
1 mV/div	±(0.5% of 10 div)
Input impedance	1 MΩ ± 1%, approx. 35 pF
Connector type	Isolated type BNC connector
Input filter	OFF, 400 Hz, 4 kHz, 40 kHz
Temperature coefficient	
Zero point	5 mV/div to 20 V/div: ±(0.02% of 10 div)/°C (typical value) 2 mV/div: ±(0.05% of 10 div)/°C (typical value) 1 mV/div: ±(0.10% of 10 div)/°C (typical value)
Gain	1 mV/div to 20 V/div: ±(0.02% of 10 div)/°C (typical value)

High-Speed 10 MS/s 12-Bit Non-Isolation Module (701255)

Input channels	2
Input couplings	AC, DC, GND
Maximum sampling rate	10 MS/s
A/D conversion resolution	12 bits (150 LSB/div)
Input type	Non-isolated unbalanced
Frequency range (–3 dB)[1]	DC, up to 3 MHz
Input range (10:1)	50 mV/div to 200 V/div (in steps of 1, 2, or 5)
Input range (1:1)	5 mV/div to 20 V/div (in steps of 1, 2, or 5)
Effective measurement range	20 div (display range 10 div)
DC offset	±5 div
Maximum input voltage (1 kHz or less)	
In combination with 701940 (10:1)	600 V (DC + ACpeak)
Direct input (1:1)	250 V (DC + ACpeak)
DC accuracy[1]	±(0.5% of 10 div)
Input impedance	1 MΩ ± 1%, approx. 35 pF
Connector type	Metal type BNC connector
Input filter	OFF, 500 Hz, 5 kHz, 50 kHz, 500 kHz
Temperature coefficient	
Zero point	±(0.05% of 10 div)/°C (typical value)
Gain	±(0.02% of 10 div)/°C (typical value)
Adaptive passive probe (10:1)	701940

High-Voltage 100 kS/s 16-Bit Isolation Module (with RMS) (701260)

Input channels	2
Input couplings	AC, DC, GND, AC-RMS, DC-RMS
Maximum sampling rate	100 kS/s
A/D conversion resolution	16 bits (2400 LSB/div)
Input type	Isolated unbalanced
Frequency range (–3 dB)[1]	
Waveform measurement mode	DC, up to 40 kHz
RMS measurement mode	DC, 40 Hz to 10 kHz
Input range (10:1)	200 mV/div to 2000 V/div (in steps of 1, 2, or 5)
Input range (1:1)	20 mV/div to 200 V/div (in steps of 1, 2, or 5)
Effective measurement range	20 div (display range 10 div)
DC offset	±5 div
Maximum input voltage (1 kHz or less)	
In combination with 700929 (10:1)[2]	1000 V (DC + ACpeak)
In combination with 701901+701954 (1:1)[3]	850 V (DC + ACpeak)
Maximum allowable in-phase voltage	
In combination with 700929 (10:1)	H side: 1000 Vrms (CAT II)[4], L side: 400 Vrms (CAT II)[5]
In combination with 701901+701954 (1:1)	H side: 700 Vrms (CAT II)[7], L side: 400 Vrms (CAT II)[8]
Direct input (when using a cable which doesn't comply with the safety standard)	H/L sides: 30 Vrms (42 V DC + ACpeak)[10]
DC accuracy (waveform measurement mode)[1]	±(0.25% of 10 div)
DC accuracy (RMS measurement mode)[1]	±(1.0% of 10 div)
AC accuracy (RMS measurement mode)[1]	
Sine wave input	±(1.5% of 10 div)
Crest factor of 2 or less	±(2.0% of 10 div)
Crest factor of 3 or less	±(3.0% of 10 div)
Input impedance	1 MΩ ± 1%, approx. 35 pF
Connector type	Isolated type BNC connector
Input filter	OFF, 100 Hz, 1 kHz, 10 kHz
Temperature coefficient (waveform measurement mode)	
Zero point	±(0.02% of 10 div)/°C (typical value)
Gain	±(0.02% of 10 div)/°C (typical value)
Response time (RMS mode)	
Rise (0 to 90% of 10 div)	100 ms (typical)
Fall (100 to 10% of 10 div)	250 ms (typical)
Crest factor (only at RMS measurement)	3 or less

* Please use 701901 (1:1 safety adaptor lead) or 700929 (10:1 safety probe), which complies with the safety standard, for high-voltage input.
* It is very dangerous to use cables that do not comply with the safety standard.

Temperature/High-Precision Voltage Module (701265)

Input channels	2
Input couplings	TC (thermocouple), DC, GND
Input type	Isolated unbalanced
Applicable sensors (input coupling: TC)	K, E, J, T, L, U, N, R, S, B, W, iron-doped gold/chromel
Data updating rate	500 Hz
Frequency range (-3 dB)[1]	DC, up to 100 Hz
Voltage accuracy[1] (at voltage mode)	±(0.08% of 10 div + 2 μV)

Temperature measurement accuracy[1,12]

Type	Measured range	Accuracy
K	–200°C to 1300°C	±(0.1% of reading + 1.5°C)
E	–200°C to 800°C	except –200 to 0°C:
J	–200°C to 1100°C	±(0.2% of reading + 1.5°C)
T	–200°C to 400°C	
L	–200°C to 900°C	
U	–200°C to 400°C	
N	0°C to 1300°C	
R, S	0°C to 1700°C	±(0.1% of reading + 3°C) except 0 to 200°C: ±8°C 200 to 800°C: ±5°C
B	0°C to 1800°C	±(0.1% of reading + 2°C), except 400 to 700°C: ±8°C Effective range: 400 to 1800°C
W	0°C to 2300°C	±(0.1% of reading + 3°C)
Iron-doped gold/chromel	0 to 300 K	0 to 50 K: ±4 K 50 to 300 K: ±2.5 K

Maximum input voltage (1 kHz or less)	42 V (DC + ACpeak) (CAT I and CAT II, 30 Vrms)
Input range (for 10 div display)	100 μV/div to 10 V/div (in steps of 1, 2, or 5)
Input connector	Binding post
Input impedance	Approx. 1 MΩ
Input filter	OFF, 2 Hz, 8 Hz, 30 Hz
Temperature coefficient (for voltage)	
Zero point	±((0.01% of 10 div)/°C + 0.05 μV)/°C (typical value)
Gain	±(0.02% of 10 div)/°C (typical value)

Strain Module (NDIS) (701270)

Input channels	2
Input types	DC bridge input (automatic balancing), balanced differential input, DC amplifier (floating)
Automatic balancing method	Electronic auto-balance
Automatic balancing range	±10,000 μSTR (1 gauge method)
Bridge voltages	Select from 2 V, 5 V, or 10 V
Gauge resistances	120 to 1000 Ω (bridge voltage of 2 V) 350 to 1000 Ω (bridge voltage of 2/5/10 V)
Gauge rate	1.90 to 2.20 (variable in steps of 0.01)
A/D resolution	16 bits (4800 LSB/div: Upper=+FS, Lower=–FS)
Maximum sampling rate	100 kS/s
Frequency range (–3 dB)[1]	DC, up to 20 kHz
DC accuracy[1]	±(0.5% of FS + 5 μSTR)

Measurement range/measurable range

Measurement range (FS)	Measurable range (–FS to +FS)
500 μSTR	–500 μSTR to 500 μSTR
1000 μSTR	–1000 μSTR to 1000 μSTR
2000 μSTR	–2000 μSTR to 2000 μSTR
5000 μSTR	–5000 μSTR to 5000 μSTR
10,000 μSTR	–10,000 μSTR to 10,000 μSTR
20,000 μSTR	–20,000 μSTR to 20,000 μSTR

mV/V range support	mV/V range = 0.5 × (μSTR range/1000)
Maximum allowable input voltage (1 kHz or less)	10 V (DC + ACpeak)
Maximum allowable in-phase voltage	42 V (DC + ACpeak) (CAT I and CAT II, 30 Vrms)
Temperature coefficient	
Zero point	±5 μSTR/°C (typical value)
Gain	±(0.02% of FS)/°C (typical value)
Internal filter	OFF, 1 kHz, 100 Hz, 10 Hz
Input connector	NDIS standard
Accessory (a set of connector shell for solder connection)	2 NDIS connectors (A1002JC)
Recommended bridge head (NDIS type) (sold separately)	701955 (bridge resistance of 120 Ω) (w/ 5 m cable) 701956 (bridge resistance of 350 Ω) (w/ 5 m cable)

SCOPECORDER

YOKOGAWA

DL750

Plug-In Module Specifications

70271 STRAIN MODULE (DSUB) Shunt Cal

Input channels	2
Input types	DC bridge input (automatic balancing), balanced differential input, DC amplifier (floating)
Automatic balancing method	Electronic auto-balance
Automatic balancing range	±10,000 μSTR (1 gauge method)
Bridge voltages	Select from 2 V, 5 V, or 10 V
Gauge resistances	120 to 1000 Ω (bridge voltage of 2 V) 350 to 1000 Ω (bridge voltage of 2/5/10 V)
Gauge rate	1.90 to 2.20 (variable in steps of 0.01)
A/D resolution	16 bits (4800 LSB/div: Upper=+FS, Lower=–FS)
Maximum sampling rate	100 kS/s
Frequency range (–3 dB)[1]	DC, up to 20 kHz
DC accuracy[1]	±(0.5% of FS + 5 μSTR)

Measurement range/measurable range

Measurement range (FS)	Measurable range (–FS to +FS)
500 μSTR	–500 μSTR to 500 μSTR
1000 μSTR	–1000 μSTR to 1000 μSTR
2000 μSTR	–2000 μSTR to 2000 μSTR
5000 μSTR	–5000 μSTR to 5000 μSTR
10,000 μSTR	–10,000 μSTR to 10,000 μSTR
20,000 μSTR	–20,000 μSTR to 20,000 μSTR

mV/V range support: mV/V range = 0.5 × (μSTR range/1000)

Maximum allowable input voltage (1 kHz or less)
10 V (DC + ACpeak)

Maximum allowable in-phase voltage
42 V (DC + ACpeak) (CAT I and CAT II, 30 Vrms)

Temperature coefficient
Zero point: ±5 μSTR/°C (typical value)
Gain: ±(0.02% of FS)/°C (typical value)

Internal filter: OFF, 1 kHz, 100 Hz, 10 Hz

Input connector: DSUB

Accessory (a set of connector shell for solder connection)
2 DSUB connectors

Recommended bridge head (DSUB, Shunt-cal) (sold separately)
701957 (bridge resistance of 120 Ω) (w/ 5 m cable)
701958 (bridge resistance of 350 Ω) (w/ 5 m cable)

High-Speed Logic Probe (700986)

Number of inputs	8
Input types	Non-isolated (common ground for all bits; logic module and bits share common ground)

Maximum input voltage (1 kHz or less) (between probe tip and case ground)
42 V (DC +ACpeak) (CAT I and II, 30 Vrms)

Response time	1 μS or less
Input impedance	Approximately 100 kΩ
Threshold level	Approximately 1.4 V

Isolated Logic Probe (700987)

Number of inputs	8
Input types	Isolated (all individual bits are isolated)
Input connector	Safety connector (banana plug) × 8
Input switching capability	AC/DC input switching for each bit

Applicable input ranges
DC input: H/L detection for 10 V DC to 250 V DC
AC input: H/L detection (50/60 Hz) for 80 V AC to 250 V AC

Threshold levels
DC input: 6 V DC ± 50%
AC input: 50 V AC ± 50%

Response times
DC input: 1 ms or less
AC input: 20 ms or less

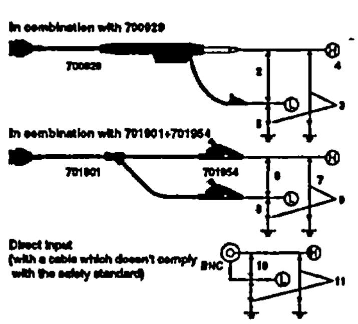
Maximum input voltage (1 kHz or less)
(between H and L of each bit) 250 Vrms (CAT I and II)

Maximum allowable in-phase voltage
250 Vrms (CAT I and II)

Maximum allowable voltage between bits
250 Vrms (CAT I and II)

Input impedance: Approximately 100 kΩ

1. Under reference operating conditions (ambient temperature of 23°C ± 5°C, ambient humidity (RH) of 55% ± 10%; after calibration following 30- minute warmup period)
12. Does not include reference contact compensation accuracy.



⚠Warning
Do not exceed the maximum input voltage, withstand voltage, or surge current. In order to prevent electric shock, be sure to ground the main unit. In order to prevent electric shock, be sure to tighten the module's screws. Electrical protective functions and mechanical protective functions will not be effective.

DL750 Model Number and Suffix Codes

Model	Suffix Code	Description
701210		DL750 ScopeCorder[1] AC100–120 V/200–240 V
Power cable	-D	UL and CSA standard
	-F	VDE standard
	-R	BS standard
	-Q	AS standard
	-H	GB standard (complies with the CCC)
Internal media drive	-J1	Floppy drive [2]
	-J2	Zip® drive [2]
	-J3	PC card interface[2]
Default language	-HE	English [3,4]
	-HJ	Japanese [3,4]
	-HC	Chinese [3,4]
	-HK	Korean [3,4]
	-HG	German [3]
	-HF	French [3]
	-HL	Italian [3]
	-HS	Spanish [3]
Memory expansion	/M1	Memory expansion 10 MW/CH [5]
	/M2	Memory expansion 25 MW/CH [5]
	/M3	Memory expansion 50 MW/CH [5]
Other	/C8	Internal 20 GB hard drive (FAT32)
	/C10	Ethernet interface
	/G2	User-defined math function
	/G3	DSP channel function
	/P4	Probe power (4-output)
	/DC	DC12 V power (DC10–18 V) [6]

1. Plug-in modules are not included.
2. Choose one.
3. Choose one. Default help language can be changed at any time by the user.
4. Menu items can be displayed in one of several possible languages.
5. Choose one.
6. One DC power supply connector (B8023WZ solder type) is included with this option. The DC power cable must be assembled using the connector. Otherwise, please purchase the 701970 or 701971 preassembled cable.

Standard Accessories

Product	Order Qty
Power cable	1
User's manuals (one set)	1
Transparent front cover	1
Printer roll paper (10 meters)	3
Cover panels (for blank module slots)	8
Rubber feet (four per set)	1
Soft case (for storing accessories)	1

Plug-In Module Model Numbers [1]

Model No.	Description
701250	High-Speed, 10 MS/s 12-bit Isolation Module (2 CH)
701251	High-Speed, 1 MS/s 16-bit Isolation Module (2 CH)
701255	High-Speed, 10 MS/s 12-bit Non-Isolation Module (2 CH)
701260	High-Voltage, 100 kS/s 16-bit Isolation Module (with RMS) (2 CH)
701265	Temperature/High-Precision Voltage Module (2 CH)
701270	Strain Module (NDIS, 2 CH)
701271	Strain Module (DSUB, supports shunt CAL, 2 CH)
701275	Acceleration/Voltage Module (with AAF) (2 CH)
701280	Frequency Module (2 CH)

1 Probes not included with any modules, probe must be purchased separately as accessories if required.

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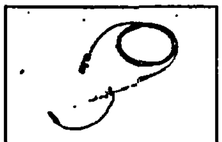
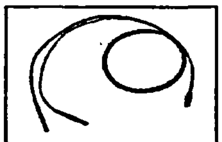
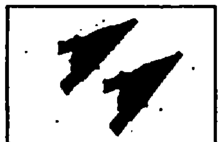
DL750

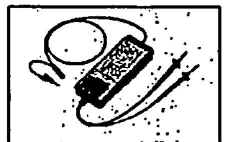
Accessories

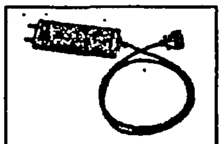

Isolated probe (700929)

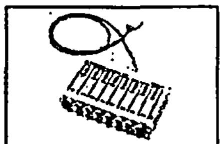

Passive probe for DL750 (701940)


Safety adaptor lead (701901)

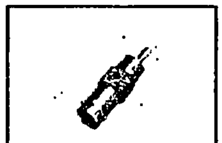

Alligator clip (701954)
Dolphin type, red/black

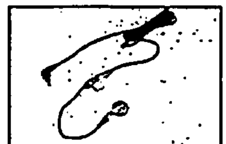

Differential probe (700924)
min. 1/100, 1/1000 (variable)
Max differential allowable voltage ±1400 V

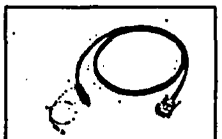

High-speed logic probe (700986)

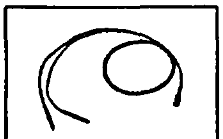

Isolated logic probe (700987)

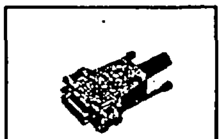

Bridge head (701955 & 701956)
NDIS-120 Ω/350 Ω, Enhanced Shield

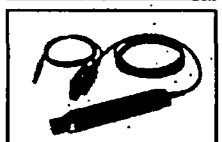

Conversion adaptor (366928)
For external trigger and external clock

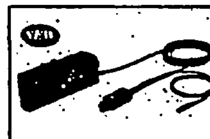

Earphone Mic (w/ PUSH switch) (701951)
For the voice memo function

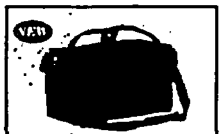

DC Power Supply Cable (701970)
(cigarette lighter plug type), 1.8 m

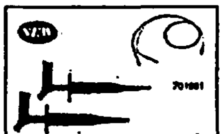

DC Power Supply Cable (701971)
(alligator clip type), 1.8 m

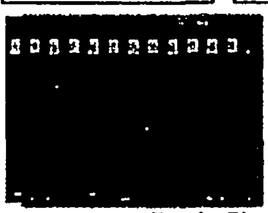

Bridge head (701955 & 701956)
NDIS-120 Ω/350 Ω, Enhanced Shield


50 MHz bandwidth current probe (700937)
Input range: 15 Apeak


10 MHz bandwidth current probe (701930)
Input range: 150 Arms


Soft Carrying Case (for DL750) (701963)
Specialized soft case available,
with 3 storage pockets.


Safety Mini-Clip (hook type) (701959)
Supports 1000 V-CAT2
For use in combination with 701901



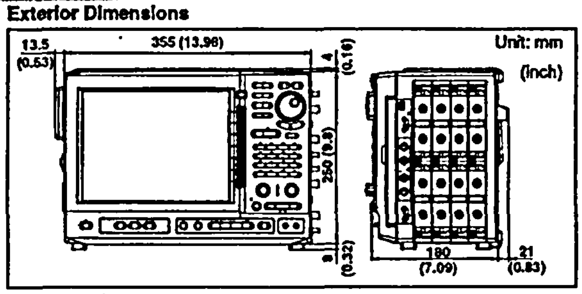
Measuring inverter I/O signals and control signals using the 10 MS/s high-speed 12-bit isolated module, current probe 700937 and isolated probe 700929
The model 700937 can be powered when the /P4 option is selected.

Probes, Cables, and Converters

Product	Model No.	Description[1]
Isolated probe	700929	10000 Vrms-CAT II for 701250, 701251, and 701260 (10:1)
1:1 BNC safety adapter lead (with combination with followings)	701901	1000 Vrms-CAT II for 701250, 701251, 701260 (10:1)
Safty Mini-Clip (Hook Type)	701959	1000 VrmsCAT II red, black, 2 sets
Large alligator clip (dolphin type)	701954	1000 Vrms-CAT II (2 per set)
Alligator adapter (rated voltage: 1000 V)	758929	1000 Vrms-CAT II (2 per set)
Alligator adapter (rated voltage: 300 V)	758922	300 Vrms-CAT II (2 per set)
Folk terminal adaptor set	758921	1000 Vrms-CATII (2 per set) (for 4-mm screw terminal)
Passive probe for DL750 (10:1)[2]	701940	Non-isolated 600 Vpk (701255) 42 V or less (other)
BNC alligator clip	366926	Non-isolated 42 V or less for 701250/51/55 (1:1)
Current probe	700937	15 Apeak, DC to 50 MHz, support probe power
Current probe	701930	150 Arms, DC to 10 MHz, support probe power
Current Probe[3]	701931	500 Arms DC-2 MHz, supports probe power
Soft Carrying Case (for the DL750)	701963	3 storage pockets, shoulder belt
Differential probe	700924	1400 pk, 1000 Vrms-CAT II
Bridge head (NDIS 120 Ω/350 Ω)	701955/56	With 5 m cable
Bridge head (DSUB shunt-CAL 120 Ω/350 Ω)	701957/58	With 5 m cable
GO/NO-GO cable	366973	GO/NO-GO input/output, start input
Earphone-Mic (w/ PUSH switch)	701951	For voice memo function
Speaker cable (for voice memo)	701952	For connection to external speakers
BNC adaptor	758924	500 Vrms-CAT II, BNC-banana conversion
Printer roll paper	B9988AE	10-meter roll x 10
High-speed logic probe	700986	8-bit, non-isolated, response speed: 1 μs
Isolated logic probe	700987	8-bit, each channel isolated, response speed: 20 ms (for AC)
Measurement lead set (75 cm)	758917	Isolated logic measurement lead (2 per set) Alligator clip is required separately.
Conversion adaptor	366928	BNC (jack)-RCA (plug) conversion
Safety BNC cable (1 meter)	701902	1000 Vrms-CAT II (BNC-BNC)
Safety BNC cable (2 meters)	701903	1000 Vrms-CAT II (BNC-BNC)
DC Power Cable	701970	Cigarette lighter plug type, 1.8 m
DC Power Cable	701971	Alligator clips type, 1.8 m
DC power Connector	B8023WZ	D-sub 3 pins, soldering type

1 Voltage that can actually be used is on the low end of the specifications
2 When using isolated type BNC input on the 701940, 42 V or less considered safe.
3 When using 701931 with the DL750's probe power supply, the measuring range from the power supply capacity limit is 500 A (DC+ACpeak), and 1 probe allowed.

Exterior Dimensions



16.12 Module Specifications

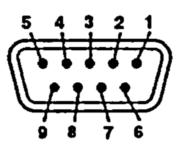
Strain Module (DSUB, Shunt-Cal) (701271) Specifications

Item	Specifications	
Standard operating conditions	Temperature: 23° C±5° C Humidity: 55%±10% RH After a 30-minute warm-up and after calibration and auto balance	
Effective measurement range	–FS to +FS (set using upper and lower limits)	
Number of input channels	2	
Maximum sample rate	100 kS/s	
Input format	DC bridge (auto balancing), balanced differential input, and isolated	
Auto balance type	Electronic auto balance	
Auto balance range	±10000 μ STR (1 gauge method)	
Bridge voltage	Select from 2 V, 5 V, and 10 V.	
Gauge resistance	120 Ω to 1000 Ω (bridge voltage: 2 V) 350 Ω to 1000 Ω (bridge voltage: 2 V, 5 V, and 10 V)	
Gauge factor	1.90 to 2.20 (set in 0.01 steps)	
Frequency characteristics[1]	(–3 dB point when a sine wave of amplitude ±3 divisions is input) DC to 20 kHz	
mV/V range support	Supports the strain gauge transducer unit system. mV/V range = 0.5×(μ STR range/1000)	
Measurement range (FS) and measurement range		
	When using STR range	
	Measurement Range (FS)	Measurement Range
	500 μ STR	–500 μ STR to +500 μ STR
	1000 μ STR	–1000 μ STR to +1000 μ STR
	2000 μ STR	–2000 μ STR to +2000 μ STR
	5000 μ STR	–5000 μ mSTR to +5000 μ STR
	10000 μ STR	–10000 μ STR to +10000 μ STR
	20000 μ STR	–20000 μ STR to +20000 μ STR
	When using mV/V range	
	Measurement Range (FS)	Measurement Range
	0.25 mv/V	–0.25mV/V to +0.25 mV/V
	0.5 mV/V	–0.5mV/V to +0.5 mV/V
	1 mV/V	–1mV/V to +1 mV/V
	2.5 mV/V	–2.5mV/V to +2.5 mV/V
	5 mV/V	–5mV/V to +5 mV/V
	10 mV/V	–10mV/V to +10 mV/V
DC accuracy[1]	±(0.5% of FS+5 μ STR)	
Maximum input voltage	Between Input+ and Input– 10 V (DC+ACpeak) (At 1 kHz or less)	
Maximum allowable common mode voltage (At 1 kHz or less)	Between each terminal and earth ground 42 V (DC+ACpeak) (CAT I and CAT II, 30 Vrms)	
Input connector	9-pin D-Sub connector (female)	
Common mode rejection ratio	80 dB (50/60 Hz) or more (typical[2])	
A/D conversion resolution	16 bit (4800 LSB/div: Upper = +FS, Lower = –FS)	
Temperature coefficient	Zero point: ±5 μ STR/° C (typical[2]) Gain: ±(0.02% of FS)/° C (typical[2])	
Bandwidth limit	Select from OFF, 1 kHz, 100 Hz, and 10 Hz Cutoff characteristics: –12 dB/OCT (typical[2])	
Function	mV/V support. Supports the strain gauge transducer unit system. Shunt calibration support. Built-in shunt calibration relay (1 gauge method).	
Standard accessories	Connector shell set for soldering A1520JD (9-pin D-Sub): 2 pieces, A1618JD (connector shell): 2 pieces	
Compatible accessories (sold separately)	Recommended bridge head 701957 (D-Sub 120 Ω, shunt-Cal, comes with a 5-m cable) Recommended bridge head 701958 (D-Sub 350 Ω, shunt-Cal, comes with a 5-m cable)	

Item	Specifications
Precautions	• Highly sensitive measurements are made in the µV level in strain measurements. Therefore, take measures against noise at the strain sensor perimeter, bridge head, and cable wiring. • Depending on the noise environment, an error may result in the balance. Check the influence before making measurements. • The bridge head specified by YOKOGAWA has high noise resistance. • When executing shunt calibration, be sure to calculate the shunt resistance in advance, and execute it in a range so that the measured values do not exceed the range even when the shunt resistance is ON. • Some of the strain gauge sensors and bridge heads made by other manufacturers do not have sensing wires connected. (No such problems with bridge heads made by YOKOGAWA.) If such products are used, an error may result in the bridge voltage leading to measurement errors, because sensing does not work effectively. Perform sensing as close to the bridge head as possible. (There is no conversion cable for sensing on D-Sub connector types.) • The connector shell is connected to the case potential. • When a bridge head (701957 or 701958) is used, the connector shell, cable shield, and the bridge head case are all connected to the case potential of the DL750. • When a bridge head (701957 or 701958) is used, the floating GND is connected to the bridge head case inside the bridge head. • Be sure to execute balancing again when you change the range or the bridge voltage.

1. Value measured under standard operating conditions (section 16.11).
2. Typical value represents a typical or average value. It is not strictly warranted.

Module front View



1: Floating common
2: Sense- (positive bridge voltage sensing)
3: Shuntcal- (negative shunt signal)
4: Shuntcal+ (positive shunt signal)
5: Sense+ (positive bridge voltage sensing)
6: Bridge- (negative bridge voltage)
7: Input- (negative measurement signal)
8: Input+ (positive measurement signal)
9: Bridge+ (positive bridge voltage)

WARNING

- Do not apply input voltage exceeding the maximum input voltage, withstand voltage, or allowable surge voltage.
- To prevent the possibility of electric shock, be sure to furnish protective earth grounding of the DL750.
- To prevent the possibility of electric shock, be sure to fasten the module screws. Otherwise, the electrical and mechanical protection functions will not be activated.
- Avoid continuous connection under an environment in which the allowable surge voltage may occur.

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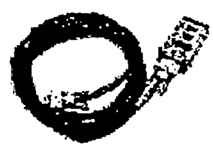
ScopeCorder

DL750

→ Product Home → Specifications → Features → Functions → Software → Application → Testimonials → Firmware • Accessories → Contact

Accessories

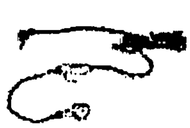
→ 701955·701956 NDIS bridge heads
NDIS cable (5 m) included
Bridge resistance: 120Ω (701955)
350Ω (701956)



→ 701957·701958 D-sub bridge heads
D-sub cable (5 m) included
Supports Shunt-Cal
Bridge resistance: 120Ω (701957)
350Ω (701958)

→ 700940 NDIS connector cable
A 1.5 m long connector-to-connector adapter cable complying with NDIS-MIL C26482. Used to connect a MIL-stan-dard cable to the strain module

→ A1002JC NDIS connector
An NDIS connector for direct connec-tion to a strain module.



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