GE Energy

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MFN 04-120
November 12, 2004

U.S Nuclear Regulatory Commission
Document Control Desk
Washington, D.C. 20852-2738

Attention: Chief, Information Management Branch
Program Management
Policy Development and Analysis Staff

Subject: **Proprietary Content of VY Steam Dryer Audit Report (TAC No. MC0761)**

By Reference 1, the NRC requested GE to provide a bracketed non-proprietary version of the subjected audit report and affidavit providing the reasons that GE considers the Bracketed information to be proprietary.

GE has completed its review and determined that certain information contained in the subject audit report is considered by GE to be proprietary in accordance with 10 CFR 2.390. Enclosure 1 contains non-proprietary (redacted) versions of the audit report. Enclosure 2 contains a proprietary version. The proprietary information is identified as discussed in the accompanying proprietary notice and the affidavit.

The affidavit contained in Enclosure 3 identifies that the information contained in Enclosures 2 has been handled and classified as proprietary to GE. GE hereby requests that the information of Enclosure 2 be withheld from public disclosure in accordance with the provisions of 10 CFR 2.390 and 9.17.

D065

If you have any questions, please contact, Mike Lalor at (408) 925-2443 or myself.

Sincerely,

George Stramback
Manager, Regulatory Services

Project No. 710

Reference:

1. MFN 04-112, Letter from Richard Ennis (NRC) to George Stramback (GE), *Vermont Yankee Nuclear Power Station - Technical Audit of Steam Dryer Analysis in Support of Extended Power Uprate Request (TAC No. MC0761),* dated October 13, 2004,

Enclosure:

1. Non-Proprietary (Redacted) Version of VY Audit Report
2. Proprietary Version of VY Audit Report
3. Affidavit, George B. Stramback, dated November 12, 2004

cc: M. Dick (GE/San Jose)
JF Harrison (GE/Wilmington)
JF Klapproth (GE/Wilmington)
MA Lalor (GE/San Jose)
LM Quintana (GE/Wilmington)

ENCLOSURE 3

MFN 04-120

AFFIDAVIT

General Electric Company

AFFIDAVIT

I, George B. Stramback, state as follows:

(1) I am Manager, Regulatory Services, General Electric Company ("GE") and 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 to GE letter MFN 04-120, George Stramback to NRC, *Proprietary Content of VY Steam Dryer Audit Report (TAC No. MC0761),* dated November 12, 2004. The Enclosure 2 proprietary information, *Proprietary Version of VY Audit Report,* is delineated by a double underline inside double square brackets. 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 2.790(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 2.790 (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 information in support of NEDC-33090P, *Safety Analysis Report for Vermont Yankee Nuclear Power Station Constant Pressure Power Uprate,* Class III (GE Proprietary Information), Revision 0, dated September 2003, which was submitted to the NRC. This power uprate report contains detailed results and conclusions from evaluations of the safety-significant changes necessary to demonstrate the regulatory acceptability for the power uprate of a GE BWR, utilizing analytical models, methods and processes, including computer codes, which GE has developed, obtained NRC approval of and applied to perform evaluations of the transient and accident events in the GE Boiling Water Reactor ("BWR"). The development and approval of these system, component, and thermal hydraulic models and computer codes was achieved at a significant cost to GE, on the order of several 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 12th day of November 2004.

George B. Stramback
General Electric Company

ENCLOSURE 1

MFN 04-120

Non-Proprietary (Redacted) Version of VY Audit Report

Technical Audit of Vermont Yankee Steam Dryer Analysis in Support of Extended Power Uprate Request

Proprietary Scope

Pages 8 and 9
Appendix C
Appendix D

Remaining pages of the audit report do not contain GE proprietary information

Rates significantly higher than expected were found in the higher frequency range (above 120 Hz), where most of the modified dryer natural frequencies occur. These higher rates can be an indicator of the transition to different flow regimes or the occurrence of new FIV excitation mechanisms.

The licensee had not evaluated potential fluid-elastic instabilities based on the assumption that displacements in the steam dryer structure will be small. However, fluid-elastic instabilities will be more likely to occur at EPU conditions. The licensee's extrapolation method does not resolve this uncertainty in the predicted results.

The licensee assumes that the acoustic peaks in the measured data are stable and that no new peaks will form and overtake the existing peaks when scaling the measured data to EPU conditions. The staff's review of the spectra revealed that most of the peak frequencies were similar to those used in the load definition and some were not in the definition. For example, data from one of the three reference plants above 100 Hz were not used, because the licensee did not have confidence in the higher frequency response of the transducer. In other spectra, peaks appeared at intermediate flow rates (above 50% CLTP conditions) and higher frequencies (above 100 Hz), but it is not apparent that all would disappear as flow rates were further increased.

The geometric scale factor used to size reactor internals and the main steam lines might be different for reactors with different CLTP levels. It is likely that the flow velocities over the top of the steam dryers in the different plants at CLTP will be similar, but might be different as the flow approaches the nozzle exits. This was revealed for Vermont Yankee and Quad Cities, but is not discussed for other reactors. The flow velocity gradients along the vertical face of the hood are significantly larger in the Quad Cities steam dryer. The licensee's analysis does not justify that extrapolation of the in-plant data should be based on average main steam line velocity instead the maximum velocity or velocities at specific dryer locations.

In summary, without experimental data or analytical/numerical results of fluid excitation forces at EPU conditions, extrapolation of fluid excitation forces from other plants to Vermont Yankee makes the prediction of stresses due to FIV speculative. For example, the licensee's assumption that the rate of increase of fluid excitation sources does not change at the EPU conditions is not confirmed by the available data on fluid pressure. Further, the licensee's assumption that the flow field and its effects on the dryer response to fluid excitation are in the same flow domain as those under CLTP conditions does not address the consideration that, in some cases, dynamic fluid/structure interactions can change drastically.

5. Dynamic Response Spectrum Methodology

The licensee's Dynamic Response Spectrum Methodology considers four different pressure time histories: three measured on the skirt and one measured on the cover plate of the steam dryers at three different BWR plants (two foreign and one domestic). In the methodology, each of the time histories is transformed to a pressure spectrum, which is then scaled to Vermont Yankee operating conditions and Vermont Yankee steam dryer locations. Subsequently, a synthetic time history is generated from the scaled pressure spectrum that has the new amplitudes but retains the original frequencies and phases. The scaling of the pressure spectrum is based on the Vermont Yankee main steam line velocity and the multipliers derived from scale-model testing. [[{3}]]

Using the synthetic pressure time history and assuming [redacted] for all vibration modes, the licensee generates a response spectrum for acceleration. (The response spectrum

[[{3}]]

does not contain the phasing information that is present in the synthetic pressure time history.) The licensee then [redacted]o account for the few frequencies that may be present at Vermont Yankee but were absent at the other three reference plants. The licensee follows this process for each of the four measured pressure time histories and develops the corresponding broadened response spectra. Then, the licensee envelops these response spectra and further broadens the enveloping spectrum.

[[{3}]]

Finally, the licensee uses the broadened, enveloped response spectrum and the ANSYS computer program to model the Vermont Yankee steam dryer and calculate the stresses in the steam dryer structural elements. The licensee applies the square-root-sum-of-the-square (SRSS) approach to combine the stress responses from each mode. The maximum calculated oscillating stress for the unmodified dryer at CLTP conditions is determined to be [redacted] per square inch (ksi) at the weld on the outer hood cover plate. The licensee assumes that, because the Vermont Yankee steam dryer has not experienced any high-cycle fatigue cracking, the maximum oscillating stress should be less than 27.2 ksi. Therefore, the licensee divides the maximum stress by 27.2 ksi and obtains a scaling factor of 29. The licensee applies this same scaling factor to the calculated oscillating stresses at all locations for both the unmodified and modified Vermont Yankee steam dryer at both CLTP and EPU conditions.

The staff considers the calculated oscillating stresses to be unrealistically high, even for a method intended to bound the structural response of the Vermont Yankee steam dryer. In addition, the details of the scale model testing, scaling of the in-plant measurements, and the assumptions of modal damping are lost due to the broadening of the response spectrum. Further, the licensee broadened the response spectrum twice to account for the uncertainties in the fluid pressure and structural model. Nevertheless, certain response frequencies might be present at Vermont Yankee but not revealed at the plants where data were collected. The broadening of the response spectrum indirectly excited many additional vibration modes of the Vermont Yankee steam dryer and resulted in the unrealistically high stresses. Also, the broadening of the response spectrum and the use of a scaling factor of 29 are likely to mask deficiencies in defining the pressure loading on the Vermont Yankee steam dryer. In addition, many modes of the steam dryer are closely spaced and, therefore, the use of an SRSS methodology to account for the phasing of these mode shapes is questionable. As a result, the staff considers the Dynamic Response Spectrum Methodology used for fatigue evaluation of the Vermont Yankee steam dryer to not be realistic.

6. Conservatism of the Response Calculation Methodology

The licensee's use of a scaling factor of 29 at the maximum stress location for the Vermont Yankee steam dryer in its unmodified configuration subject to CLTP conditions might be technically justified based on the absence of high-cycle fatigue cracking at that location. However, the use of the same scaling factor for all other locations on the unmodified and modified Vermont Yankee steam dryer under both CLTP and EPU conditions has not been justified. Scaling factors for locations other than the maximum stress location could be smaller in light of the absence of fatigue cracking at those locations. Therefore, the Dynamic Response Spectrum Methodology used for the fatigue evaluation of the Vermont Yankee steam dryer might not be conservative.

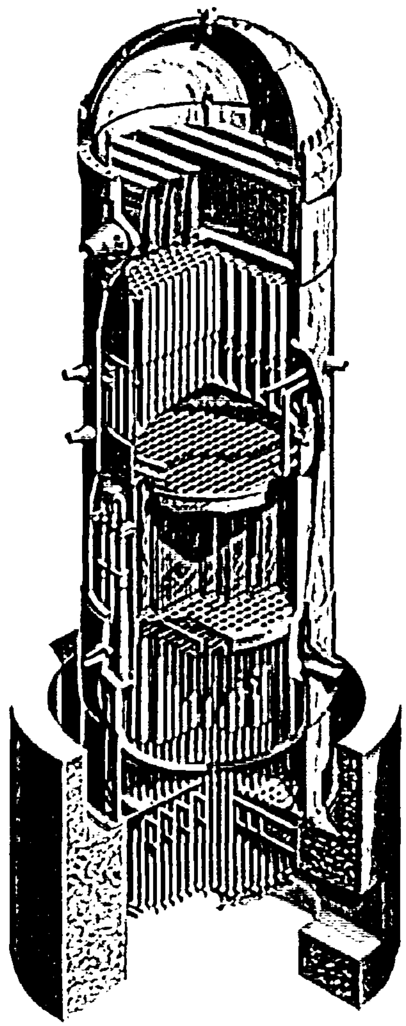
The stress results for the modified dryer subject to CLTP conditions indicate that the oscillating stress at the outer hood cover plate location (maximum stress location in the unmodified dryer) has decreased because the thickness of the cover plate was increased from 0.25 inches to 0.625 inches. However, the oscillating stresses have increased at some other locations in the modified dryer where the original plate thickness was not changed. In the modified dryer, the

APPENDIX C

STEAM DRYER FLOW INDUCED VIBRATION STRUCTURAL ANALYSIS TECHNIQUES

GE Nuclear Energy

Steam Dryer
Flow Induced Vibration
Structural Analysis Techniques



Richard Wu

August 24, 2004

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"Equivalent Static Method of Structural Analysis"

(November 2003)

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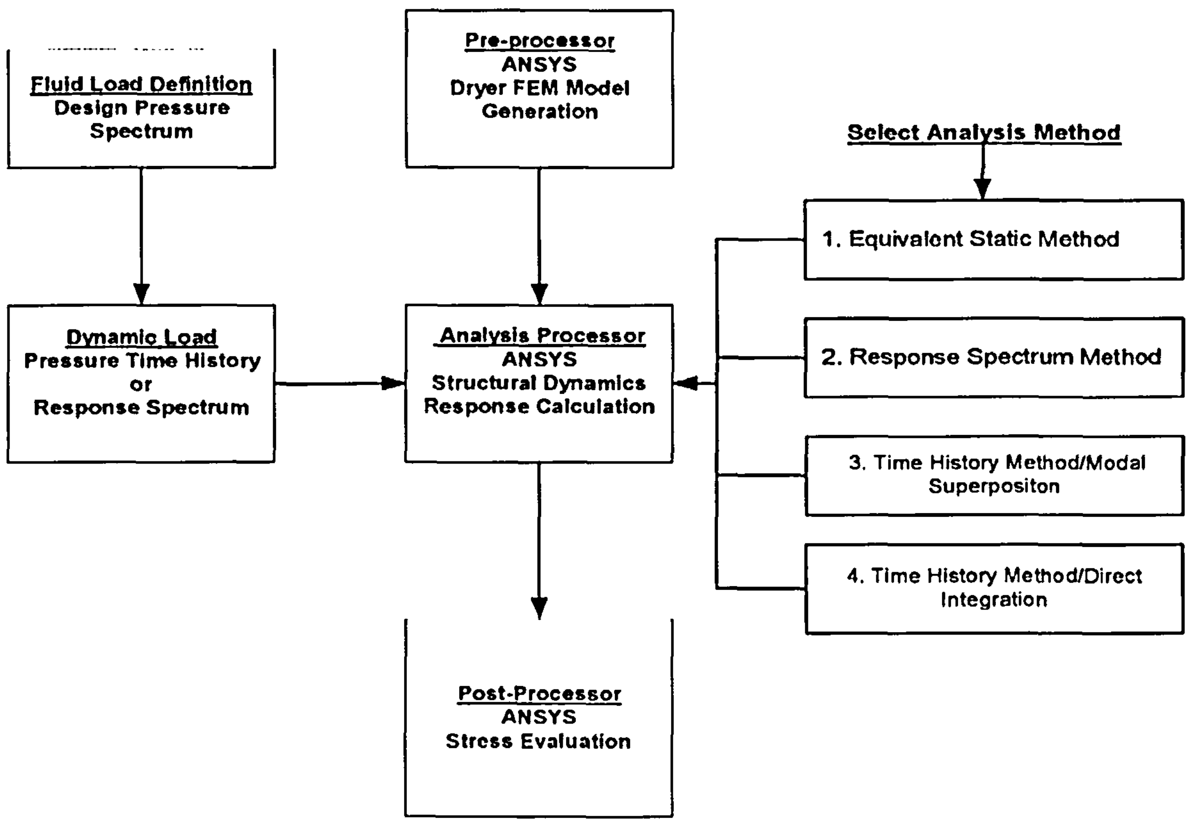
[3]]]

"Response Spectrum Method of Structural Analysis"

(February 2004)

Steam Dryer Structural Dynamic Analysis Procedure



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[3]]]

Equivalent Static Method

1. Start with the FEA model of the Original Dryer.

2. Compute dryer component (a) natural frequencies and (b) stresses from a reference 1-psi (unit) static pressure loading.

3. The Dynamic Stresses (DS) on the steam dryer components are computed as:

   DS = (Pm+Pb) x (FIV Load rms) x (P) x (SF) x (C) x (Q)

   where:

   DS = Intensified Dynamic Stress (psi)

   Pm+Pb = Surface stress (unintensified).

   FIV Load rms = pre-EPU Pressure load as a function of component frequency (root-mean-squared, rms, magnitude).

   P = Conversion factor from rms magnitude to Peak magnitude of the fluctuating pressure load.

Equivalent Static Method (continued)

C = Weld Stress Concentration Factor.

Q = Weld Quality Factor

SF = Scaling Factor (to account for the dynamics amplification and the load scaling)

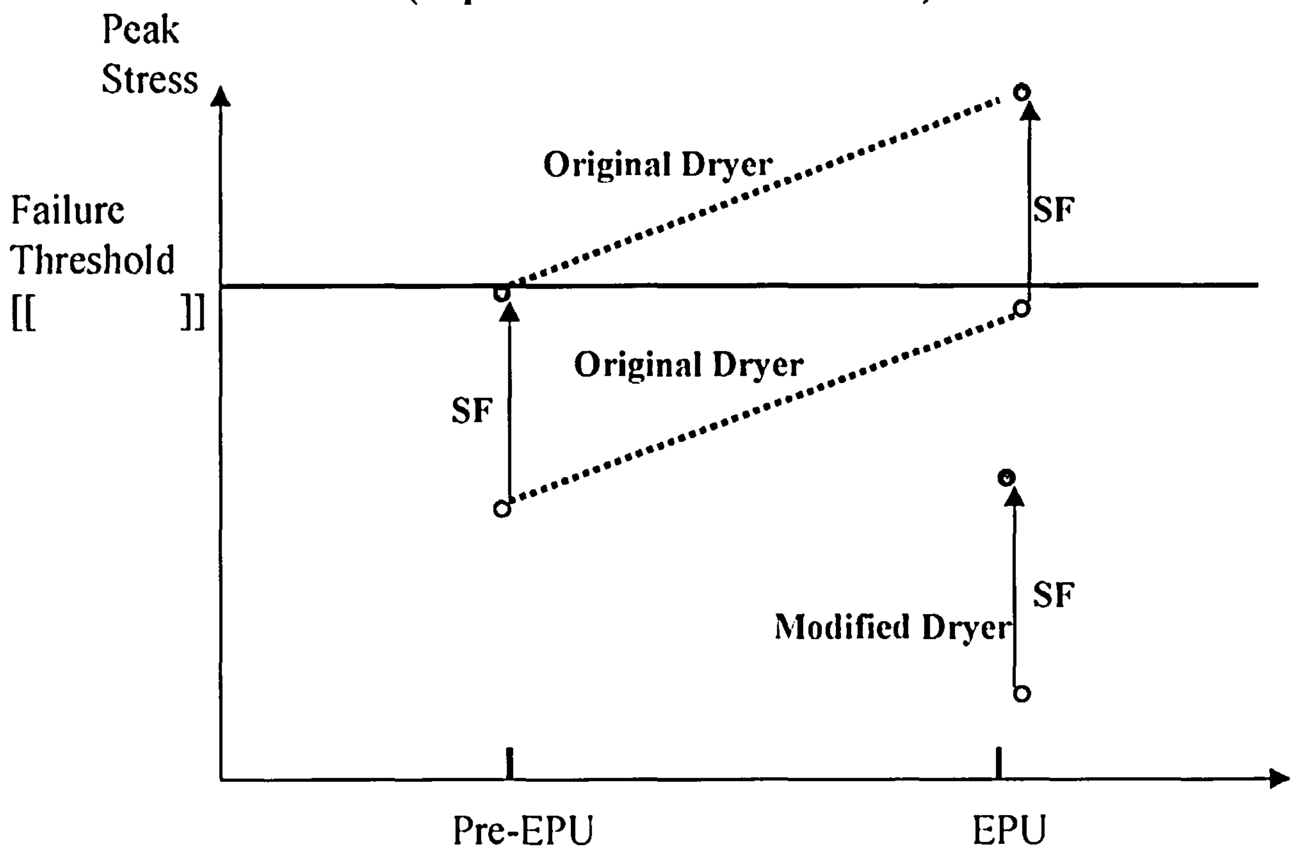
$$SF = \frac{[[\qquad\qquad]]}{(Pm + Pb)(FIVLoadrms)(P)(C)(Q)}$$

(No component of the Original dryer has failed at pre-EPU condition)

4. Repeat Step 1 to 3 with the Modified Dryer and EPU condition using the same SF as computed from Step 3.

Scaling Factor

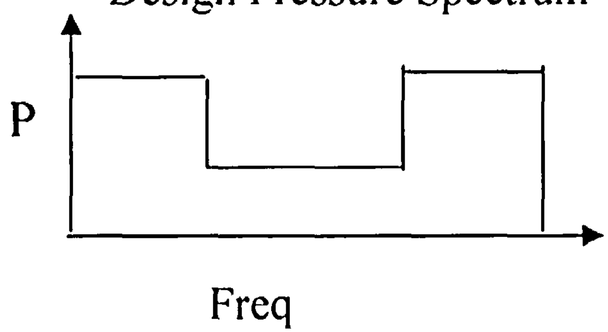
(Equivalent Static Method)



Dryer Structural Dynamic Response Calculation

Time History Method

Design Pressure Spectrum

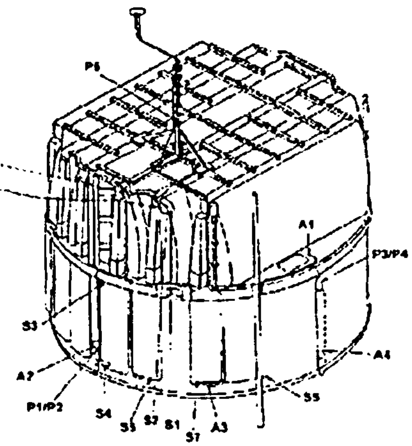


Inverse FFT

Synthetic Pressure Time History

Input

Dryer FEM Model

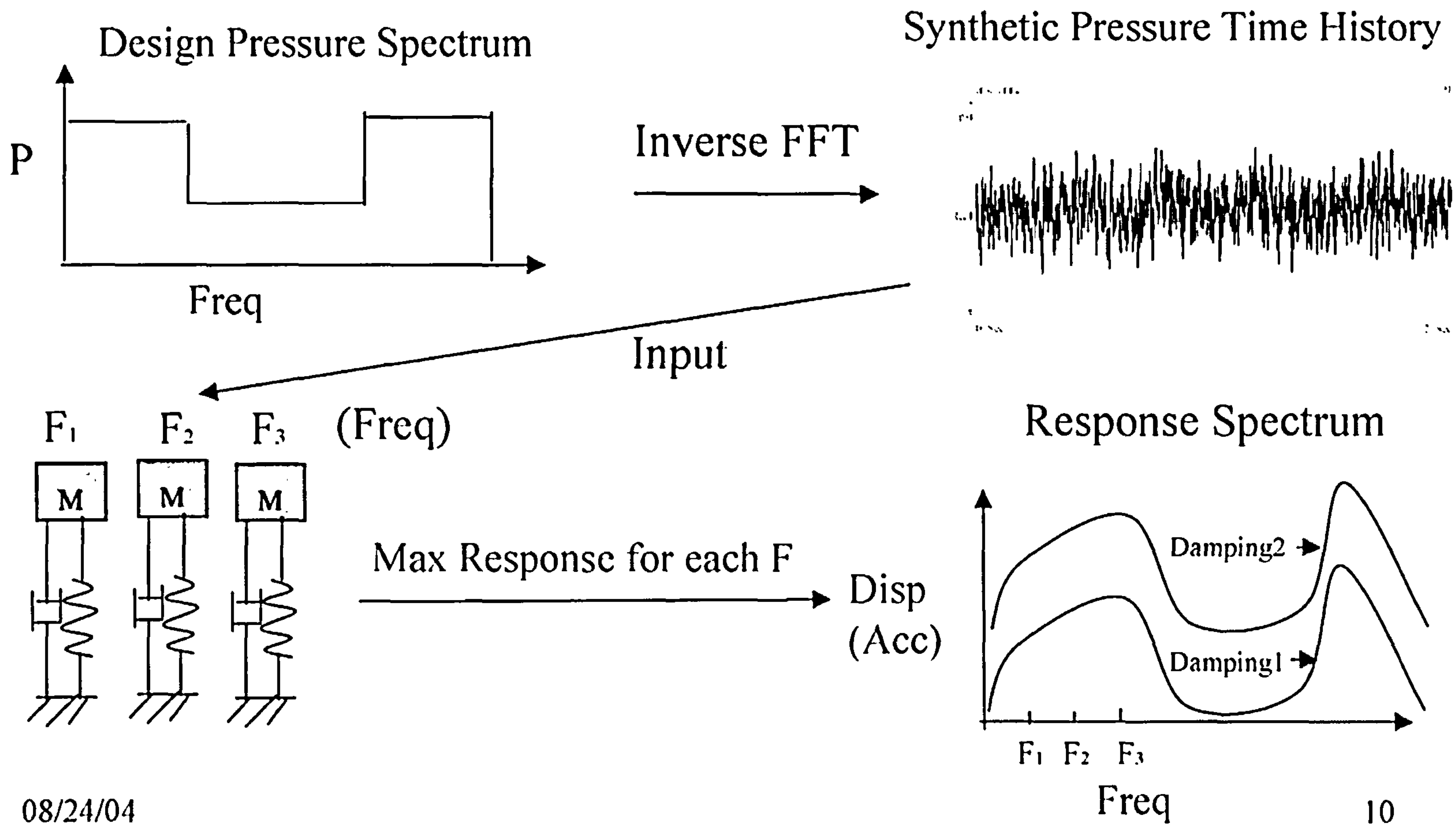


Time Integration

Response Time History

Dryer Structural Dynamic Response Calculation

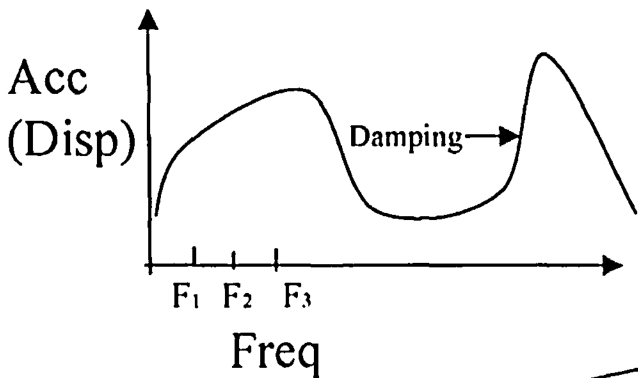
Response Spectrum Method



Dryer Structural Dynamic Response Calculation

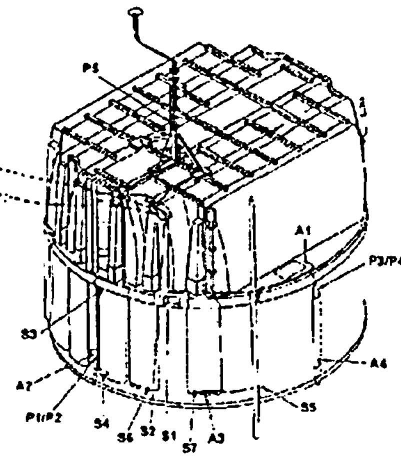
Response Spectrum Method (Concluded)

Response Spectrum



Input →

Dryer
FEM
Model



F_1, F_2, F_3, F_4, ---- F_n

Maximum Response for Each Dryer Vibration Mode:

Stress)mode 1

Stress)mode 2

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Stress)mode n

SRSS or
ABS

→

Final Maximum (peak) Stress

SPECA05V (GENE Level 2 Code)
Acceleration Response Spectrum Generation

Single Degree of Freedom System

Seismic Excitation

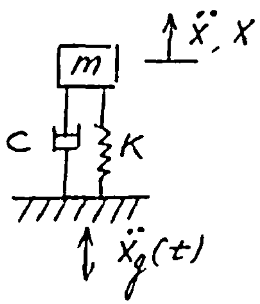
$$m\ddot{x} + c\dot{x} + kx = -m\ddot{x}_g(t)$$

$$\ddot{x} + \frac{c}{m}\dot{x} + \frac{k}{m}x = -\ddot{x}_g(t)$$

$$\boxed{\ddot{x} + 2\zeta\omega\dot{x} + \omega^2 x = -\ddot{x}_g(t)}$$

$\ddot{x}_g$ – Ground Motion Time History

$\ddot{x}_g$ – Input
$\ddot{x}$ – output



Forcing Excitation

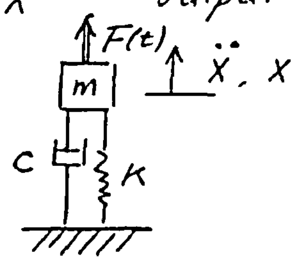
$$m\ddot{x} + c\dot{x} + Kx = F(t) = A\,P(t)$$

$$\ddot{x} + \frac{c}{m}\dot{x} + \frac{K}{m}x = \frac{A}{m}P(t)$$

$$\boxed{\ddot{x} + 2\zeta\omega\dot{x} + \omega^2 x = \frac{A}{m}P(t)}$$

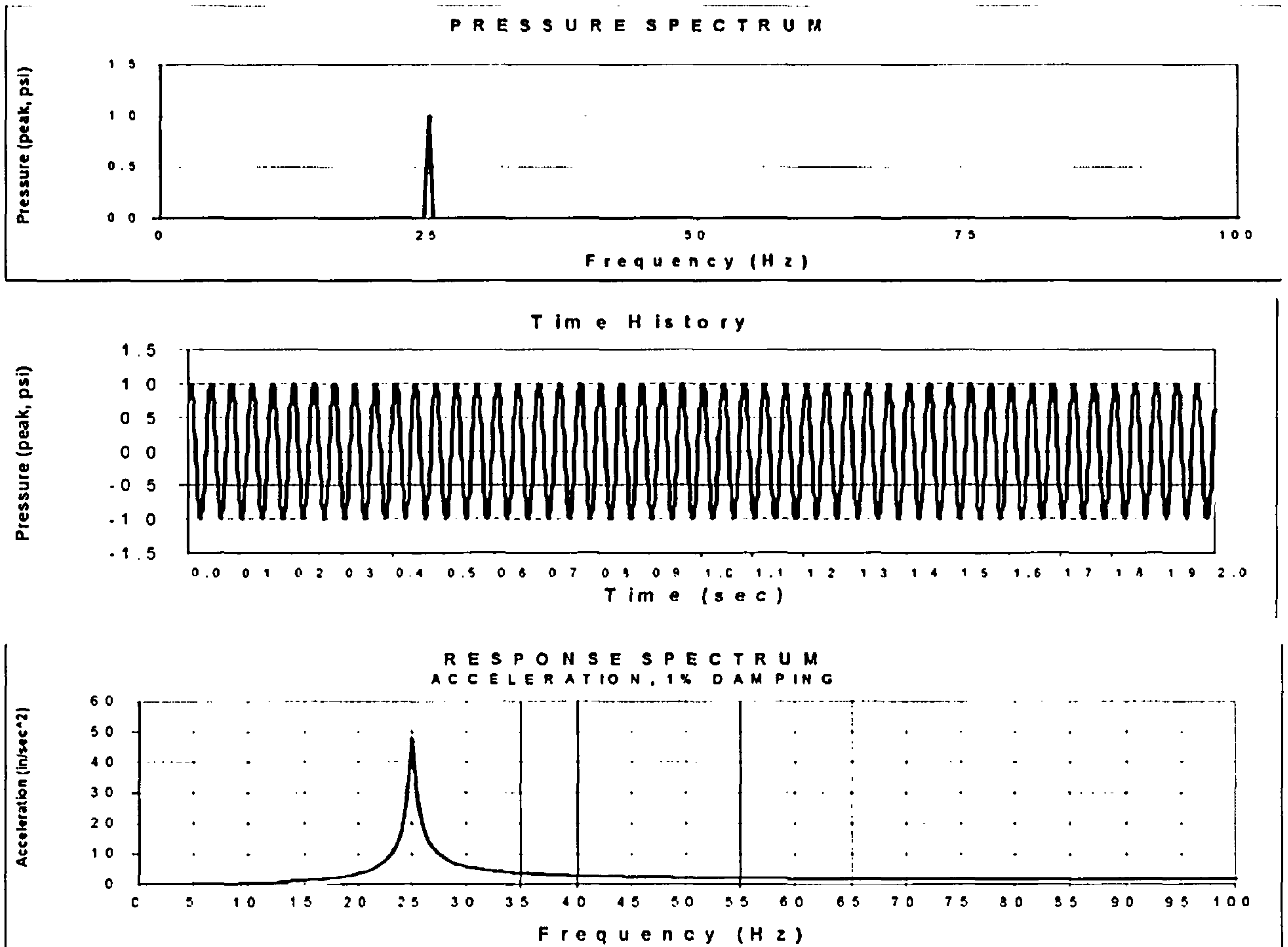
A – unit Area
m – unit Mass
P(t) – pressure time history

P(t) – Input
$\ddot{x}$ – output



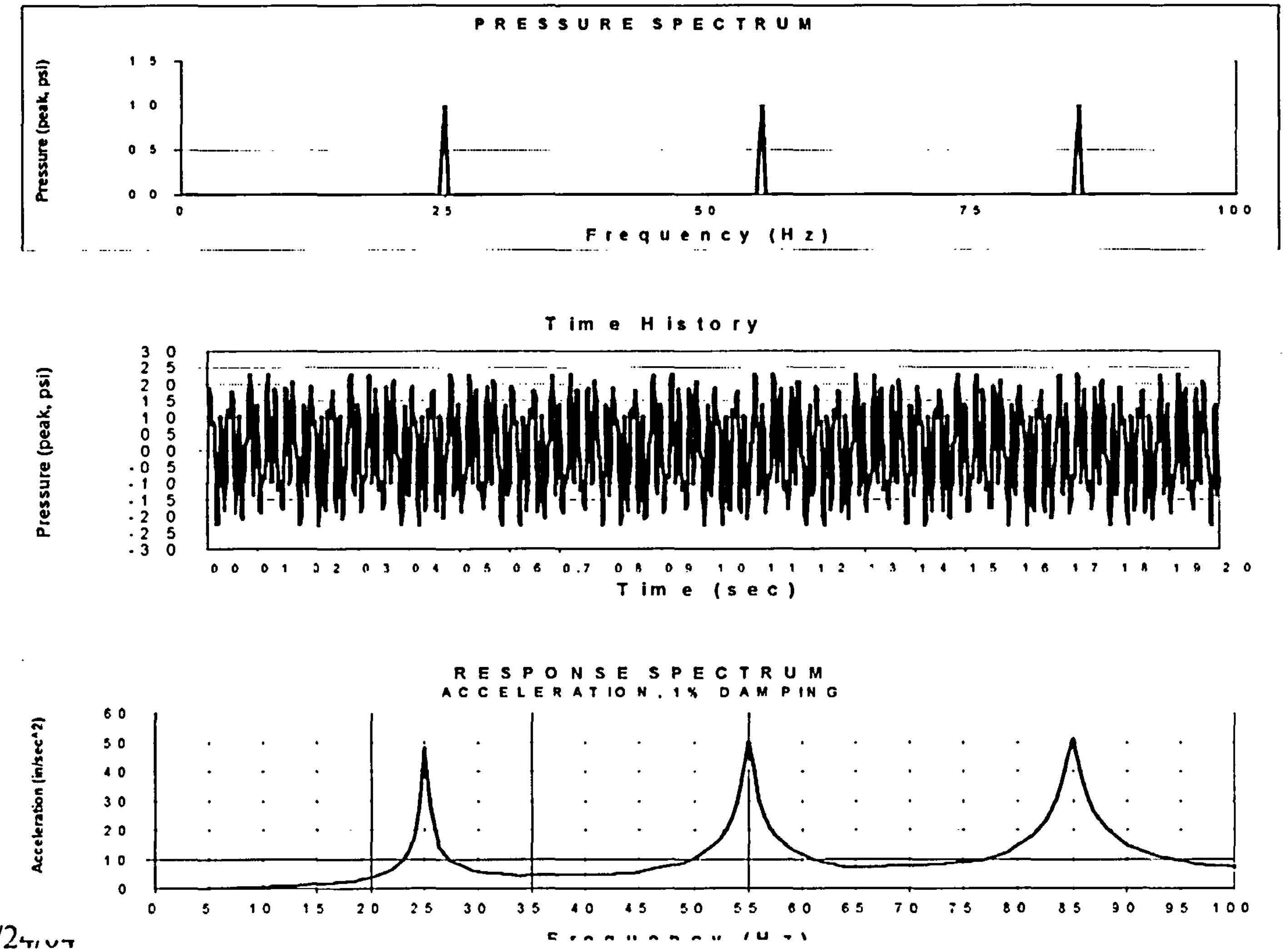
Single Sine Wave Pressure Input

(1 psi 0-peak, 25Hz)



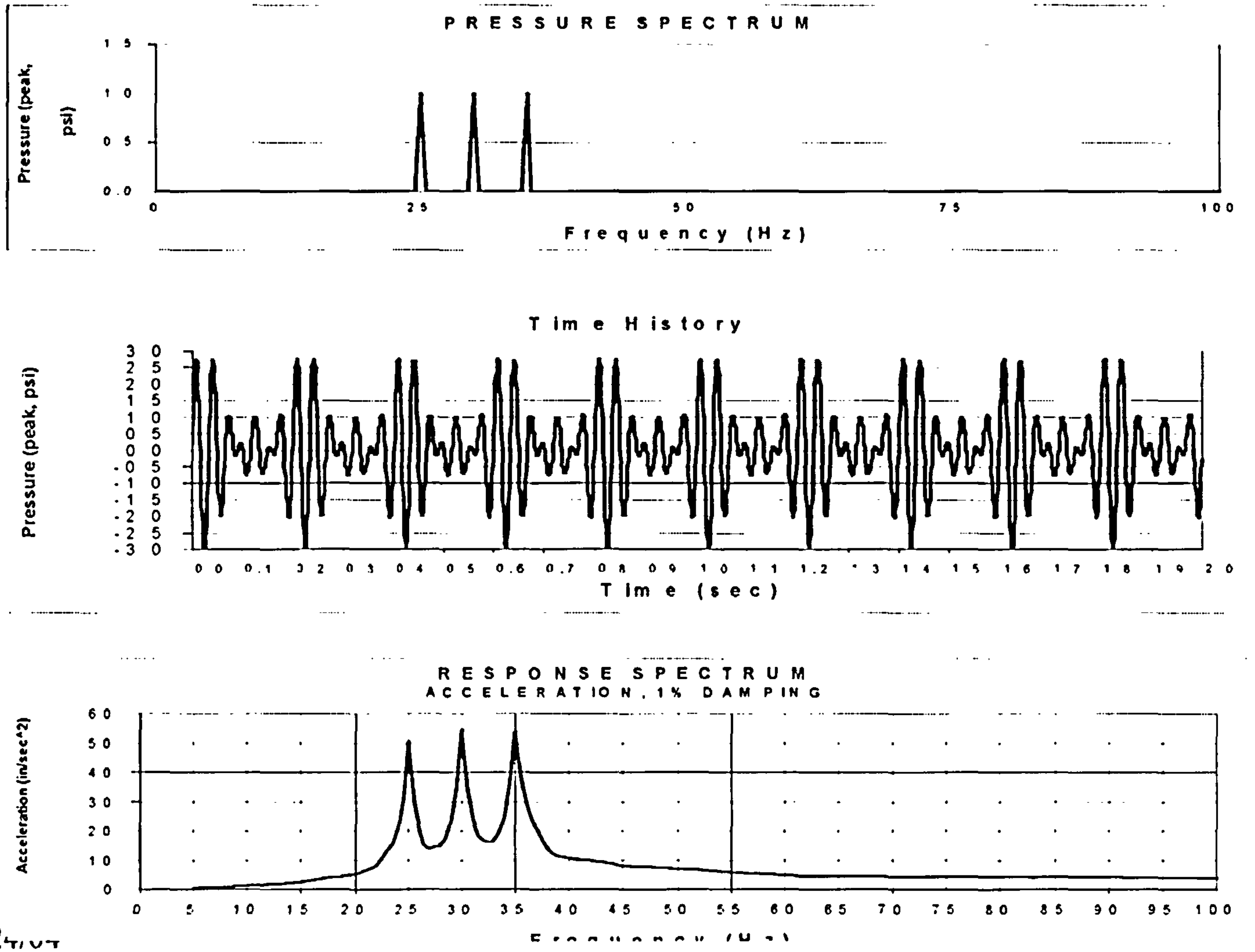
Three Sine Waves Pressure Input

(1 psi 0-peak, 25Hz, 55Hz, 85Hz)



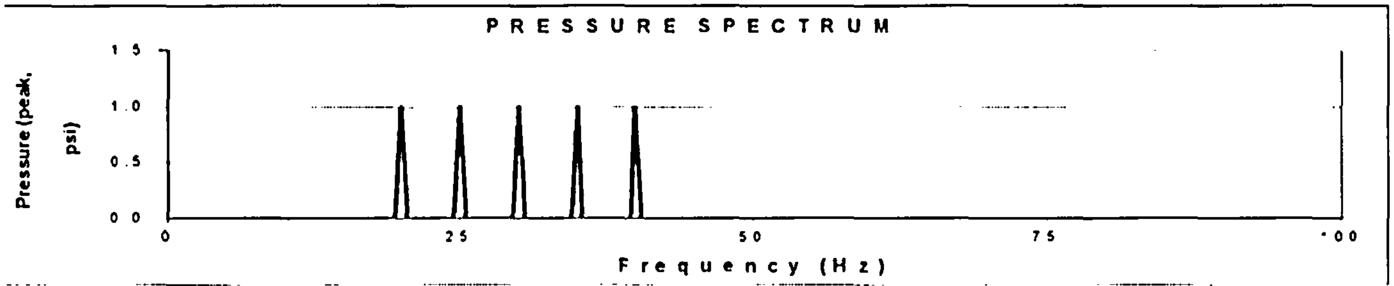
Three Sine Waves Pressure Input

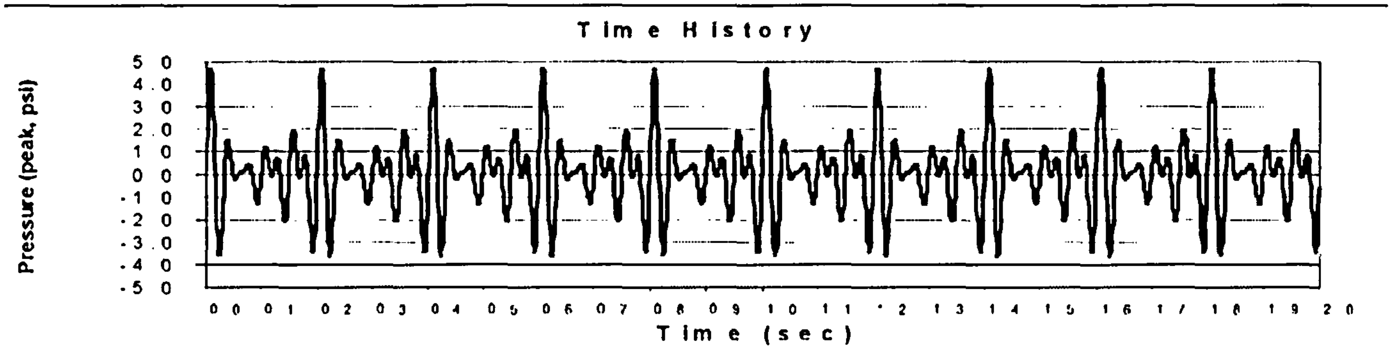
(1 psi 0-peak, 25Hz, 30Hz, 35Hz)

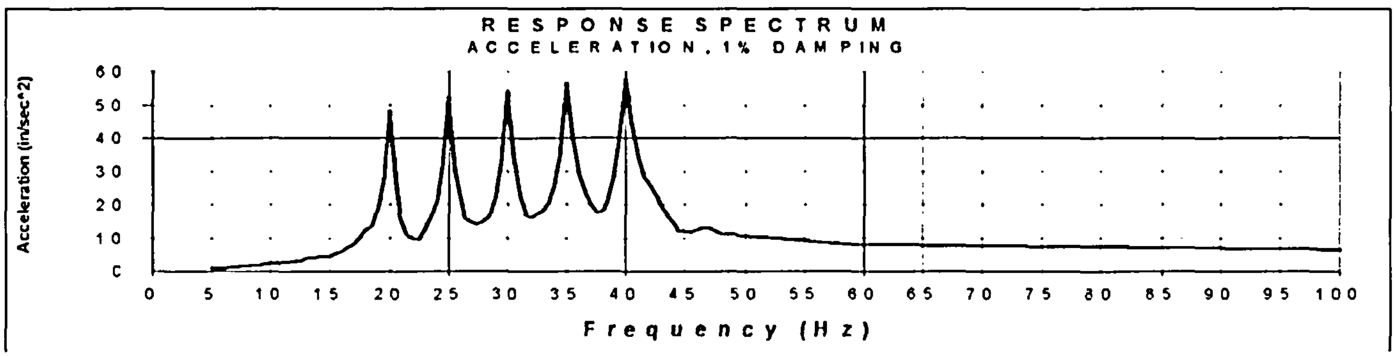


Five Sine Waves Pressure Input

(1 psi 0-peak, 20Hz, 25Hz, 30Hz, 35Hz, 40Hz)







Dynamic Response Calculation
Response Spectrum Method

Multi-Degree of Freedom System

Forcing Excitation

$$[M]\{\ddot{x}\} + [C]\{\dot{x}\} + [K]\{x\} = \{F(t)\} = \{A\,P(t)\}$$

$$\omega_i,\ \{\phi\}_i,\ q_i,\quad i = 1, \cdots N$$

$$\{x\} = \sum_{i=1}^{N} \{\phi\}_i\, q_i$$

$$\ddot{q}_i + 2\zeta_i \omega_i \dot{q}_i + \omega_i^2 q_i = \frac{\{\phi\}_i^T \{A\} P(t)}{\{\phi\}_i^T [M] \{\phi\}_i}$$

$$\{\phi\}_i^T [M] \{\phi\}_i = 1$$

$$q_i^{max} = \frac{\gamma_i S_i}{\omega_i^2} \quad \text{and} \quad x_i^{max} = \{\phi\}_i\, q_i^{max}$$

where $\gamma_i = \{\phi\}_i^T \{A\}$ modal participation Factor

S_i = Acceleration Response Spectral Value

$$X^{max} = SRSS\,(X_1^{max},\ X_2^{max} \cdots X_N^{max})$$

Note that the material dependent damping contribution is computed in the modal expansion phase, so that this damping contribution must be included there.

Participation Factors and Mode Coefficients

The participation factors for the given excitation direction are defined as:

$$\gamma_i = \{\phi\}_i^T [M] \{D\} \text{ for the base excitation option} \quad (17.7\text{–}2)$$

$$\gamma_i = \{\phi\}_i^T \{F\} \quad \text{for the force excitation option} \quad (17.7\text{–}3)$$

where:

γ_i = participation factor for the i^{th} mode

$\{\phi\}_i$ = eigenvector normalized using equation (17.3–6) (*Nrmkey* on the **MODOPT** command has no effect)

$\{D\}$ = vector describing the excitation direction (see equation (17.7–4))

$\{F\}$ = input force vector

ANSYS Input Procedure

$$\{r\}_i = \omega_i^m A_i \{\phi\}_i \qquad (17.7\text{–}12)$$

where:

$$m = \begin{cases} 0 & \text{if label = DISP} \\ 1 & \text{if label = VELO} \\ 2 & \text{if label = ACEL} \end{cases}$$

label = third field on the mode combination commands (**SRSS, CQC, GRP, DSUM, NRLSUM**)

A_i = mode coefficient (see below)

The mode coefficient is computed in five different ways, depending on the type of excitation (**SVTYP** command).

2. For **SVTYP**, 1 (force excitation)

$$A_i = \frac{S_{fi}\,\gamma_i}{\omega_i^2} \qquad (17.7\text{–}14)$$

where: S_{fi} = spectral force for the i^{th} mode (obtained from the input amplitude multiplier table at frequency f_i and effective damping ratio ξ_i').

3. For **SVTYP**, 2 (acceleration excitation of base)

$$A_i = \frac{S_{ai}\,\gamma_i}{\omega_i^2} \qquad (17.7\text{–}15)$$

where: S_{ai} = spectral acceleration for the i^{th} mode (obtained from the input acceleration response spectrum at frequency f_i and effective damping ratio ξ_i').

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(b)(4)]]

Vermont Yankee, CLTP Dryer Load 1

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[3]]]

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[3]]]

Vermont Yankee, CLTP Dryer Load 2

[[

(3)]]

Input Response Spectrum

1. Start with a (Single) Plant Measured Pressure Time History
2. Transform to Pressure Spectrum (Frequency, Amplitude, and Phase)
3. Scale the Pressure Spectrum Amplitude According to Plant Specific Operating Condition
4. Generate a new Pressure Time History with the new Amplitude and the Original Phase
5. Calculate a Response Spectrum based on the new Pressure Time History
6. Repeat Steps 1 through 5 with a Different Plant and/or a Different Gage Measured Pressure Time History
7. Envelope and Broaden the Response Spectra from Step 5
8. Input to ANSYS for Steam Dryer Dynamic Response Evaluation

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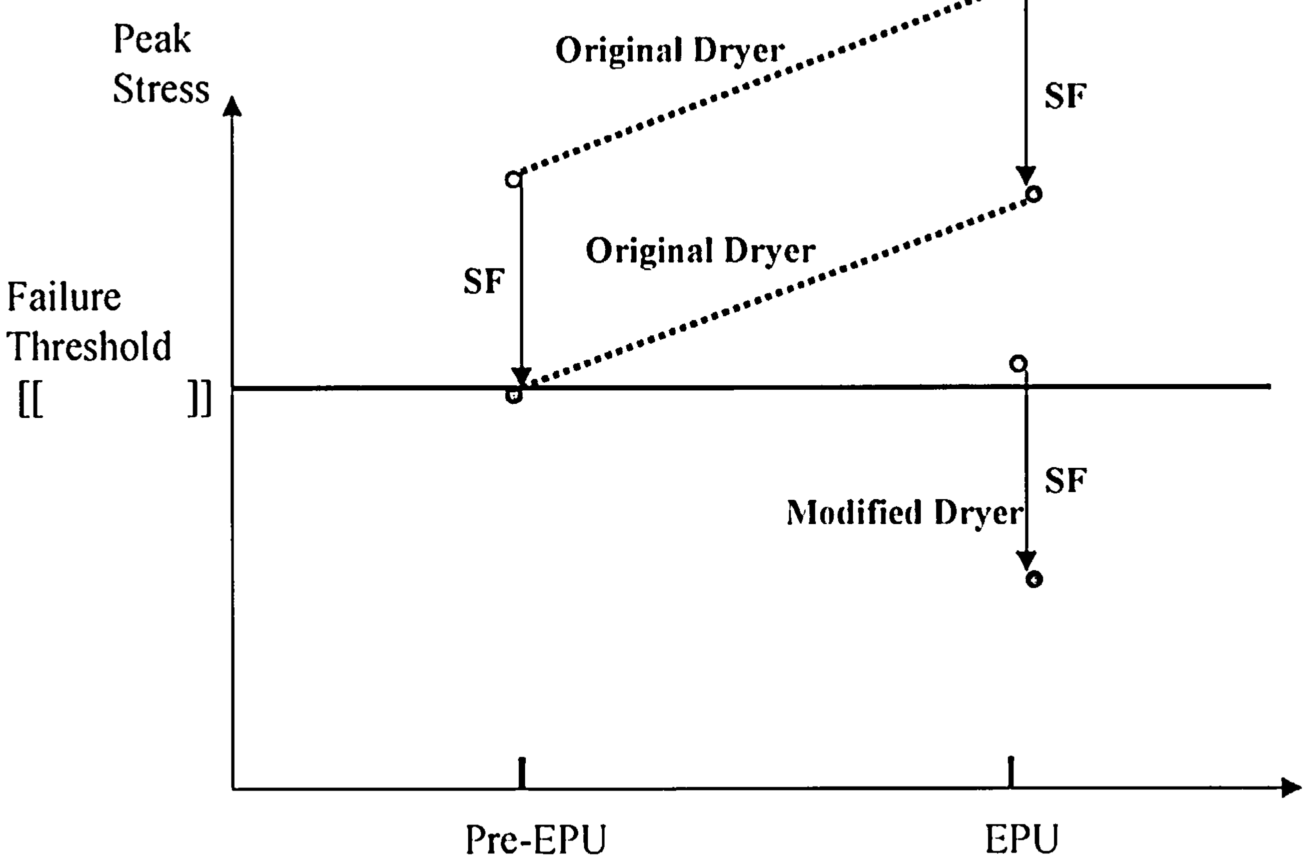
Scaling Factor

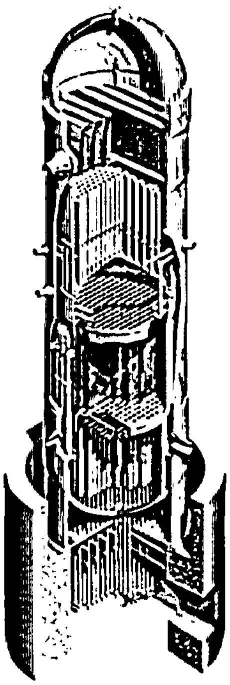
(Response Spectrum Method)



APPENDIX D

VERMONT YANKEE PLANT-SPECIFIC ANALYSIS

VY Plant Specific Analysis

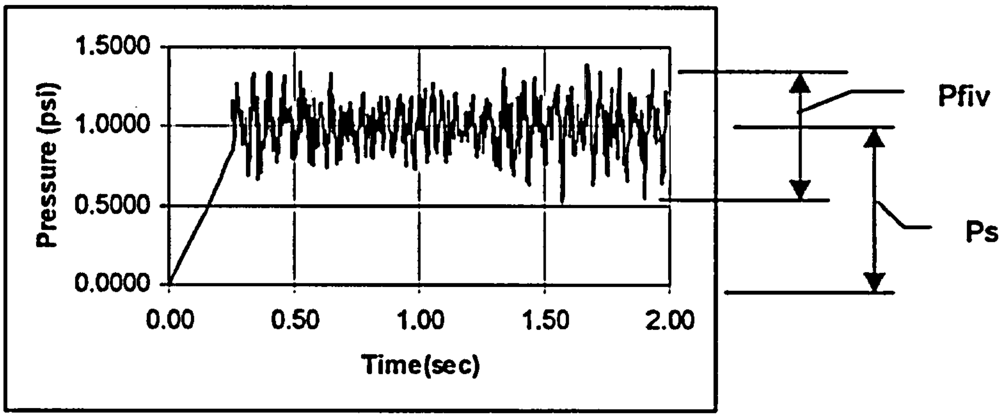


By : Henry Hwang

July 21, 2004

1.0 Dryer pressure loads

Example of dryer pressure time history is shown below:



The pressure time history can be divided to two parts, Ps and Pfiv,

Ps Static pressure on the dryer
Pfiv Fluctuation component causes **Flow Induced Vibration (FIV).**

From this morning meeting,

(1) QC steam dryer cracking was caused by high cycle fatigue.

(2) The fractures initiated at the weld toes.

(3) No dryer failures prior to QC power uprate.
VY MS LPU flow velocity is less than QC CLTP

Therefore, Pfiv is the major concern

2.0 FIV Alternating Stress by **Response spectrum analysis, peak broadened, enveloped and scaled**

The purpose of this section is to explain:

Stress distribution from response spectrum analyses (sec 2.1)
Example plots cover plate and front hood

Conversion of maximum shell stress to S_{alt} in the welds (sec 2.2)
Example Cover plate and front hood
Original dryer and modified dryer

Explain Normalized factor 29 (sec 2.3)

Explain the reasons: (sec 2.4)
Modified dryer cover plate stress reduction 17 times
Modified dryer front hood top weld stress reduction 3 times

Toe of Fillet weld stress from 2D-isoparametric solid detail model (sec 2.5)

Stress distribution from response spectrum analyses
Example plots cover plate and front hood

(2.1.1) Example stress distribution plots forVY original dryer lower cover plate, CLTP

[[

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(2.1-2) VY original dryer response spectrum analysis front hood stress distribution, CLTP

[[

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(2.1-3) Stress distribution plots forVY modifier dryer cover plate, CLTP

[[

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(2.1-4) VY Modified dryer response spectrum analysis, outer hood, CLTP-

[[

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(2.1-5) Stress distribution plots forVY modifier dryer cover plate, LPU

[[

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(2.1-6) VY Modified dryer response spectrum analysis, outer hood, LPU-

[[

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Conversion of maximum shell stress to S_{alt} in the welds
Example Cover plate and front hood
Original dryer and modified dryer

(2.2-1) Dryer plate thicknesses
Original Dryer

	plate thickness	Weld size	Under size factor	Weld factor	Total stresss factor
Original dryer Lower Cover plate	0.25	0.187	[[		
Original dryer, front hood	0.5	0.5			]]

Modifier Dryer

	Plate Thickness	Weld size at top plate	Under size factor	Weld factor	Total stresss factor
Modified dryer, lower cover plate, tip	0.625	0.625	[[		
Modified dryer, front hood top weld	1.0	0.625			]]

(2.2-2) S_{alt} Stress calculation

[[

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Original dryer, CLTP (Current Licensed Thermal Power)

	Max Surface Stress (psi)	Weld Factor	plate thick	weld size	under size factor (16)	CLTP Peak Stress (1)x(5)x(6)
	(1)	(5)			(6)	(9)
Outer cover plate 1/4", 3/16" weld	[[		0.250	0.188	[[	
Outer front hood		]]	0.50	0.500		]]

Modified dryer, CLTP and LPU (Licensed Power Uprate)

	CLTP Max Surface Stress (psi)	LPU Max Surface Stress (psi)	Weld Factor	plate thick	weld size	under size factor (16)	CLTP Peak Stress (1)x(5)x(6)	Repaired LPU Peak
	(1)	(2)	(5)			(6)	(9)	(10)
Outer cover plate tips	[[			0.625	0.625	[[		
Outer hood, top weld			]]	1.00	0.625			]]

(2.3) Explain Normalized factor [[ ]]

Because the dryer has not failed at the maximum stress location for years of operation, the peak stress value is normalized to the fatigue failure criterion [[ ]] for CLTP.

Stress limit ASME Appendix I, Figure I.9.2.2 Curve C

Allowable number of cycle = 10^{11}

Salt = 13,600 psi,

The maximum effect mean stress is included in Curve C.

The normalized factor, NF is back-calculated:

[[

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(2.4) Explain the reasons:
Modified dryer cover plate stress reduction 17 times
Modified dryer front hood top weld stress reduction 3 times

Alternating Stresses for the Original Versus the Modified Dryer at CLTP.

Item	Unmodified dryer	Modified dryer	Ratio	Remark
Cover plate weld	27,200	1,544	17.6	
Front Vertical hood weld	11,656	3,843	3.0	

2.5 Toe of Fillet weld stress from 2D-isoparametric solid model, plane strain

[[

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From analysis results of shell model for 1 psi static case.
The average forces at 3.5" away from the fillet weld front hood surface are as follows.

[[

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Cover plate thickness = 0.375"

The Fy acting on the fillet weld creates a moment of [[ ]] on the fillet weld

[[

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Factor used in the report:

[[

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Therefore, the factors are reasonable

3.0 Equivalent Static (Confirmation check)

The purpose of this section is to explain earlier edition of the VY dryer analysis report, which uses equivalent static analysis.

[[

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Item	Unmodified dryer	Modified dryer	Ratio
Cover plate weld	[[		
Front Vertical hood weld			]]

4.0 ASME loads and load Combinations

ASME Primary load stress limits:

Pm	General membrane stress
Pm+Pb	Primary membrane plus bending stress

	P_m	$Pm+P_b$
Service Levels A/B	$1.0\ S_m$ = [[ ]]	$1.5S_m$ = [[ ]]
Service Level D	$2.4S_m$= [[ ]]	$3.6S_m$ = [[ ]]

ASME Code Section III Load Combinations

Service Level	Load Combination
Level A	normal pressure + dead weight
Level B 1	upset pressure + dead weight + OBE
Level B 2	upset pressure + dead weight - OBE
Level B 3	normal pressure + dead weight + TSV + OBE
Level B 4	normal pressure + dead weight + TSV - OBE
Level B 5	normal pressure + dead weight + TSVflow-induced + OBE
Level B 6	normal pressure + dead weight + TSVflow-induced + OBE
Level D 1	faulted pressure + dead weight + SSE
Level D 2	faulted pressure + dead weight - SSE

The most limiting stress is Service Level B

Positive and negative seismic load are combined (equivalent to absolute sum)

For Modifier dryer the maximum stress occurs at long gusset listed below. All other locations are listed in stress report.

Long Gussets Welds ASME Primary and Secondary Stresses

Item	Service Level	Load Case	(A) Local membrane stress (psi)	(B) Surface maximum stress (psi)	Plate thickness (inch)	Fillet weld size (inch)	(C) Undersized Weld stress factor	P_m+P_b (A) x (C) at weld (psi)	Local membrane Allowable stress (psi)	(D) Primary stress ratio	$P_m + P_b + Q$ stress, (B)x(C) (psi)	Alternating stress, Salt (psi)
1	1 psi		[[		0.500	2x0.375	[[					
2	Level A	1			0.500	2x0.375						
3	Level B	1			0.500	2x0.375						
4	Level B	2			0.500	2x0.375						
5	Level B	3			0.500	2x0.375						
6	Level B	4			0.500	2x0.375						
7	Level B	5			0.500	2x0.375						
8	Level B	6			0.500	2x0.375						
9	Level D	1			0.500	2x0.375						
10	Level D	2		]]	0.500	2x0.375						]]

ASME Primary Stresses Evaluation, maximum stresses

Unmodified dryer, Pm+Pb Level B-4 = [[ ]] <1.5Sm
(This is at lower cover plate)

Modified dryer, Pm+Pb Level B-3 = [[ ]] < 1.5 Sm
(stress ratio= 0.676, This is at long gusset)

Fatigue usage factor due to ASME load cycles < 0.050
[[ ]]