ENCLOSURE 2

MFN 08-876

NEDO-33436

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Licensing Topical Report

GEH Boiling Water Reactor Steam Dryer - Plant Based Load Evaluation

IMPORTANT NOTICE REGARDING THE CONTENTS OF THIS REPORT

Please Read Carefully

INFORMATION NOTICE

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IMPORTANT NOTICE REGARDING THE CONTENTS OF THIS REPORT

Please Read Carefully

The information contained in this document is furnished for the purpose of obtaining NRC approval for the use of the Plant Based Load Evaluation Methodology for GEH Boiling Water Reactor Steam Dryers. The only undertakings of GE Hitachi Nuclear Energy respecting information in this document are contained in the contracts between GE Hitachi Nuclear Energy and the participating utilities in effect at the time this report is issued, and nothing contained in this document shall be construed as changing those contracts. The use of information by anyone other than that for which it is intended is not authorized; and with respect to any unauthorized use, GE Hitachi Nuclear Energy makes no representation or warranty, and assumes to liability as to the completeness, accuracy, or usefulness of the information contained in this document.

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ACRONYMS AND ABBREVIATIONS

Acronym / Abbreviation	Description
ABWR	Advanced Boiling Water Reactor
BWR	Boiling Water Reactor
ESBWR	Economic Simplified Boiling Water Reactor
ft/s	Feet per second
GEH	General Electric Hitachi Nuclear Energy
Hz	Hertz
MSL	Main Steam Line
NRC	U.S. Nuclear Regulatory Commission
PBLE	Plant Based Load Evaluation
RPV	Reactor Pressure Vessel
SRV	Safety Relief Valve

EXECUTIVE SUMMARY

Plant Based Load Evaluation (PBLE) refers to the methodology for defining the fluctuating pressure loads that are imposed upon the steam dryer used in the GEH-designed Boiling Water Reactors (BWRs). The PBLE load definition can be applied to a structural finite element model of the steam dryer in order to determine the steam dryer alternating stresses.

The PBLE is applicable to BWRs with parallel bank design steam dryers, including the BWR/2 through BWR/6, ABWR (Advanced Boiling Water Reactor), and ESBWR (Economic Simplified Boiling Water Reactor) product lines. The PBLE modeling and application methodology for the ESBWR (References 2 and 3) were submitted to the NRC for review and approval.

The NRC review of References 2 and 3 includes the PBLE methodology itself. Therefore, the discussion herein is limited to the application of the PBLE methodology to BWR/2 through BWR/6, and ABWR product lines.

As discussed herein, the PBLE methodology is applicable and acceptable for the BWR/2 through BWR/6 and ABWR product lines due to the evolutionary design of the BWR plant and similar operating conditions.

1. INTRODUCTION

The NRC has issued revised guidance, Regulatory Guide 1.20 Rev. 3, to address a comprehensive vibration assessment program acceptable for use in verifying the structural integrity of reactor internals, including steam dryers (Reference 1). The NRC guidance presents individual analytical, measurement, and inspection programs. GEH has developed the PBLE for parallel bank steam dryers contained in GEH-designed BWRs to address the analytical program of the revised NRC guidance.

PBLE refers to the methodology for defining the fluctuating pressure loads that are imposed upon the steam dryer used in the GEH-designed Boiling Water Reactors. The PBLE load definition will be applied to a structural finite element model of the steam dryer in order to determine the steam dryer alternating stresses.

The PBLE was submitted for NRC review and approval in References 2 and 3. These references provide the theoretical basis and benchmarking of the PBLE method that will be applied for determining the fluctuating pressure loads on the ESBWR steam dryer, describes the PBLE analytical model, determines the biases and uncertainties of the PBLE formulation and describes the application of the PBLE method to the development of the fluctuating pressure load definition for steam dryer structural analyses.

The PBLE is a three dimensional acoustic model of the steam dome and dryer region inside the reactor vessel. [[

]] Therefore, the PBLE is applicable to BWRs with parallel bank design steam dryers, including the BWR/2 through BWR/6, ABWR, and ESBWR product lines. The acceptability of the PBLE methodology to the BWR/2 through BWR/6 and ABWR is presented herein.

The NRC review of References 2 and 3 includes the PBLE methodology itself. The details of the methodology are not changed herein. Therefore, the discussion herein is limited to the application of the PBLE methodology to BWR/2 through BWR/6, and ABWR product lines.

2. APPLICABILITY

2.1 PBLE APPLICABILITY TO OPERATING PLANTS

The PBLE is applicable to BWRs with parallel bank design steam dryers. This includes the BWR/2 through BWR/6, ABWR, and ESBWR product lines. The evolutionary design of the

BWR plant has resulted in similar reactor vessel, steam dryer, and main steamline geometrical configurations, as well as similar plant operating conditions. As a result, the range of plant-to-plant variations that the PBLE must accommodate is small. These plant-to-plant variations in geometry and operating conditions would be addressed in the plant-specific application of the PLBE. In addition, the PBLE predictions have been benchmarked against [[ ]] taken in operating plants. Therefore, the ESBWR PBLE modeling and application methodology described in References 2 and 3 are also directly applicable to operating plants in the BWR/2 through BWR/6 and ABWR product lines.

2.2 GEOMETRICAL CONSIDERATIONS

2.2.1 Overall Reactor Configuration

The overall reactor assembly is shown in Figure 1. The steam dryer is located in the top of the vessel. The steam separator assembly, located directly below the steam dryer, forms part of the lower boundary of the PBLE. The steam flow path through the dryer is shown in Figure 2. Steam is generated in the reactor core and enters the upper plenum and steam separators as a two-phase mixture. The steam separators remove most of the water, sending moist steam up into the dryer. The chevron flow paths through the dryer vanes remove almost all the remaining moisture from the steam prior to the steam leaving the vessel through the main steam nozzles. The steam separator and dryer configuration is common to the BWR/2 through BWR/6, ABWR, and ESBWR product lines.

PBLE Application

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2.2.2 Steam Dryer Configuration

Figure 3 shows the basic configuration and components for a typical BWR steam dryer. The same basic GEH BWR steam dryer design has been used in BWR/2 through BWR/6, ABWR, and ESBWR plants. This basic design consists of four to six parallel banks supported by a circumferential ring at about mid height of the dryer. The banks consist of hood panels that direct the steam flow through the dryer vane assemblies. The skirt is suspended from the support ring and extends down below the reactor water level and outside the steam separator assembly. The skirt forms a water seal and directs the steam leaving the separators up through the vanes. Water removed from the steam is collected in troughs below the vane assemblies and returned to the RPV water through the drain channels.

The dryer hoods run parallel to the 0-180° vessel line with the steamlines symmetric about the 90-270° vessel line as shown in Figure 5. The cavity between the outer hood bank and the vessel wall forms an exit plenum for the steam flow leaving the steam dome. The steam flow velocities are low where the flow exits the dryer banks and in the steam dome. The flow accelerates in the outer hood region as the flows collect in exit plenum and accelerate into the steamlines. Most of the pressure loading acting on the dryer occurs on the outer hoods as the steam flows accelerate through this exit plenum region.

Four basic dryer hood shapes have been used in the operating plant steam dryers. These hood shapes are shown in Figure 4.

- BWR/2s and BWR/3s use square hood dryers. The BWR/2 steam dryer is similar to a square hood dryer; the difference between the two designs is that the vane assemblies are tilted approximately 20° off vertical in the BWR/2 design. However, the BWR/2 exterior hood shape is the same as the square hood dryer.
- Most BWR/4s use the slant hood design.
- Some of the later BWR/4 plants and later reactor designs used the curved hood dryer design.
- The Quad Cities replacement dryer used a flat plate slant hood design, while the Susquehanna replacement dryer replicated the original curved hood shape.

PBLE Application

In the PBLE modeling, the vessel acoustic region is defined by [[

]] This process allows the PBLE application methodology to accommodate different vessel sizes, RPV head shapes, and dryer designs. This process also ensures that the load definition generated by the PBLE acoustic model will accurately match the dryer structural model.

2.2.3 Main Steamline Configuration

The main steamline configuration for the BWR/2 through BWR/6, ABWR, and ESBWR product lines is similar across the plant product lines, particularly within the containment drywell where the limited space dictated a standardized pipe routing. Figures 6 and 7 show a typical BWR steamline layout from the RPV to the turbine for a plant with a Mark I containment. The main steam lines (MSLs) exit the vessel symmetrically offset about 18-20° from the 90-270° vessel line, then collect and exit the drywell along the 0-180° vessel line towards the turbine. Outside the drywell, the MSL configuration varies from plant to plant, [[

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The different containment types introduce only a minor difference in the main steamline configuration within the drywell. In the Mark I and Mark II containments, the steamlines drop down and exit the drywell at an elevation near the bottom of the RPV. For the Mark III, ABWR, and ESBWR containments, the steam lines do not drop as far and exit the drywell at roughly mid-height of the RPV. [[

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A few plants have a stagnant branch line, or deadleg, on some of the main steamlines. This steamline configuration is shown in Figure 8. These deadlegs serve as a mounting location for safety relief valves (SRVs). Acoustically, the deadleg provides a resonating chamber that may amplify the low frequency pressure content of the fluctuating pressure loads acting on the dryer. The PBLE modeling and qualification basis presented in Reference 3 includes a benchmark comparison of the PBLE prediction against [[ ]] for a plant with deadlegs. Therefore, the PBLE is qualified for application to plants with deadlegs.

BWR/2 plants differ from the typical steam line arrangement in that these plants have only two steamlines instead of four. The steamlines for these plants exit the vessel at 90-270° then follow the same routing as the other Mark I plants. [[

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The SRV standpipes could generate acoustic resonances that can acoustically couple with the RPV and produce a pressure load on the dryer. Whether a standpipe will generate a resonance and, if so, whether that resonance couples with the RPV is highly plant-specific and depends on several geometric and flow dependent parameters. [[

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PBLE Application

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2.3 OPERATING CONDITIONS

The evolutionary nature of the BWR design has dictated that the reactor operating conditions (e.g. pressures, temperatures, flow velocities) remain within a fairly narrow range in order to ensure that the plant operation are within the experience base and supporting licensing bases (e.g., fuel thermal/hydraulic performance tests, transient and accident analysis codes). Plant power output was initially accommodated in the original plant designs by scaling the size of the reactor and components, which keep the operating conditions within the experience base. [[

]] References 2 and 3 describe how these parameters and properties are addressed for a plant-specific application.

2.4 PLANT OBSERVATIONS

Steam dryers on several plants have been instrumented. [[

]] Figures 9 through 12 show the frequency content of the pressure load acting on the dryer. Table 1 provides a comparison of the plant characteristics for the four plants from which the measurements in Figures 9 through 12 were taken. [[

]] The high quality SRV resonance peaks occur above 100 Hz. The frequency is dependent on the SRV branch line cavity depth; whether or not the SRV acoustic resonance actually produces a pressure load that acts on the dryer depends on whether or not the SRV acoustically couples with the vessel through the steamline. [[

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These observations reinforce the conclusion that the PBLE is applicable across the GE BWR product lines. [[

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2.5 PBLE QUALIFICATION BASIS

The PBLE methodology has been benchmarked against [[ ]] taken on instrumented replacement dryers in operating plants. In Reference 2, the PBLE was benchmarked against the data taken at Quad Cities Unit 2. [[

]] In Reference 3, the PBLE was benchmarked against the data taken at Susquehanna Unit 1. [[

]] These two benchmarks provide confidence that the PBLE will provide accurate predictions over the full frequency range of interest for any plant application.

3. CONCLUSIONS

The PBLE modeling and application methodology described in References 2 and 3 are applicable to BWRs with parallel bank design steam dryers. This includes the BWR/2 through BWR/6, ABWR, and ESBWR product lines. The evolutionary design of the BWR plant has resulted in similar reactor vessel, steam dryer, and main steamline geometrical configurations, as well as similar plant operating conditions. [[

]] These plant-to-plant variations in geometry and operating conditions are addressed in the plant-specific application of the PLBE. [[

]] This approach allows the PBLE to be applied to a wide variety of configurations. In addition, the PBLE predictions have been benchmarked against [[
]] taken in operating plants and provide confidence that the PBLE will provide accurate predictions over the full frequency range of interest for any plant application. Therefore, the ESBWR PBLE modeling and application methodology described in References 2 and 3 are also directly applicable to operating plants in the BWR/2 through BWR/6 and ABWR product lines.

4. REFERENCES

1. Regulatory Guide 1.20 Rev. 3, "Comprehensive Vibration Assessment Program for Reactor Internals During Preoperational and Initial Startup Testing," March 2007.

2. NEDC-33408P, "ESBWR Steam Dryer – Plant Based Load Evaluation Methodology," February 2008.

3. NEDC-33408P Supplement 1, "ESBWR Steam Dryer – Plant Based Load Evaluation Methodology," October 2008.

Table 1
Comparison of Plant Characteristics

Product Line	RPV Diameter (inch)	Average MSL Velocity (ft/s)	Dryer Hood Design	Containment Type	Figure
BWR/3	188	149	Square	Mark I	9
BWR/3 (Quad Cities 2)*	251	200	Slanted	Mark I	10
BWR/4 (Susquehanna 1)*	251	129	Curved	Mark II	11
ABWR	280	139	Curved	ABWR	12

* Plants used for PBLE benchmarking.

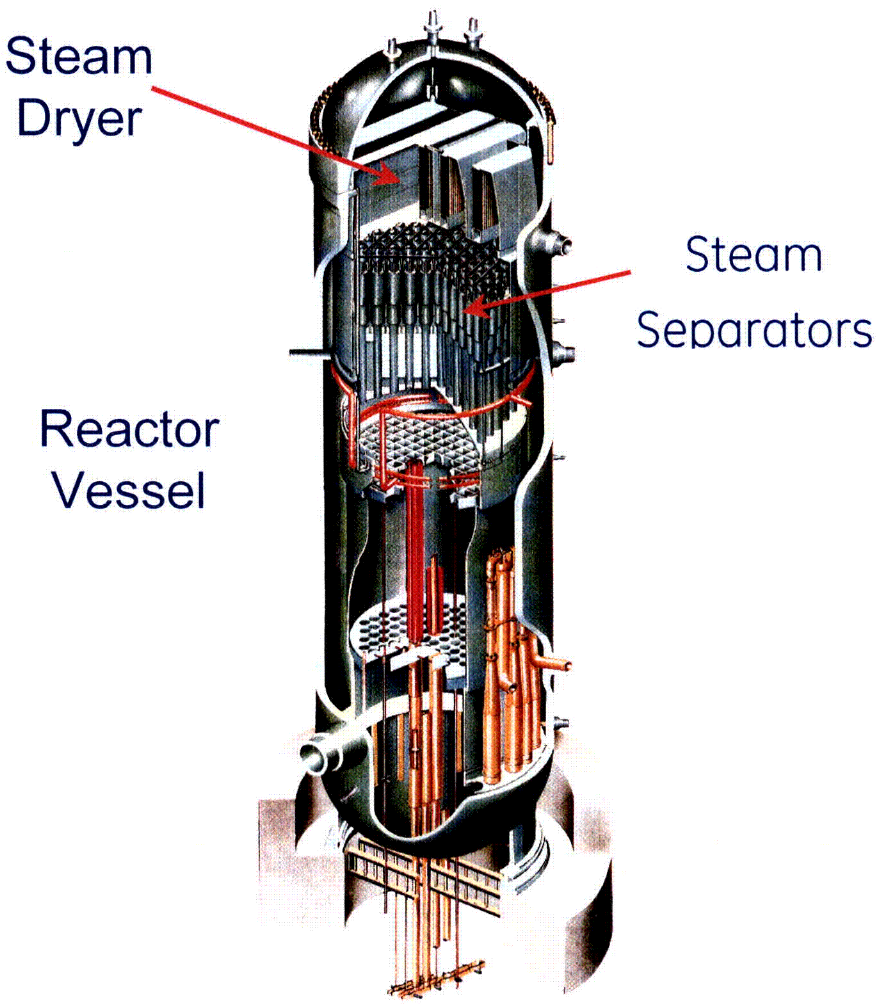

Figure 1: Reactor Vessel Configuration

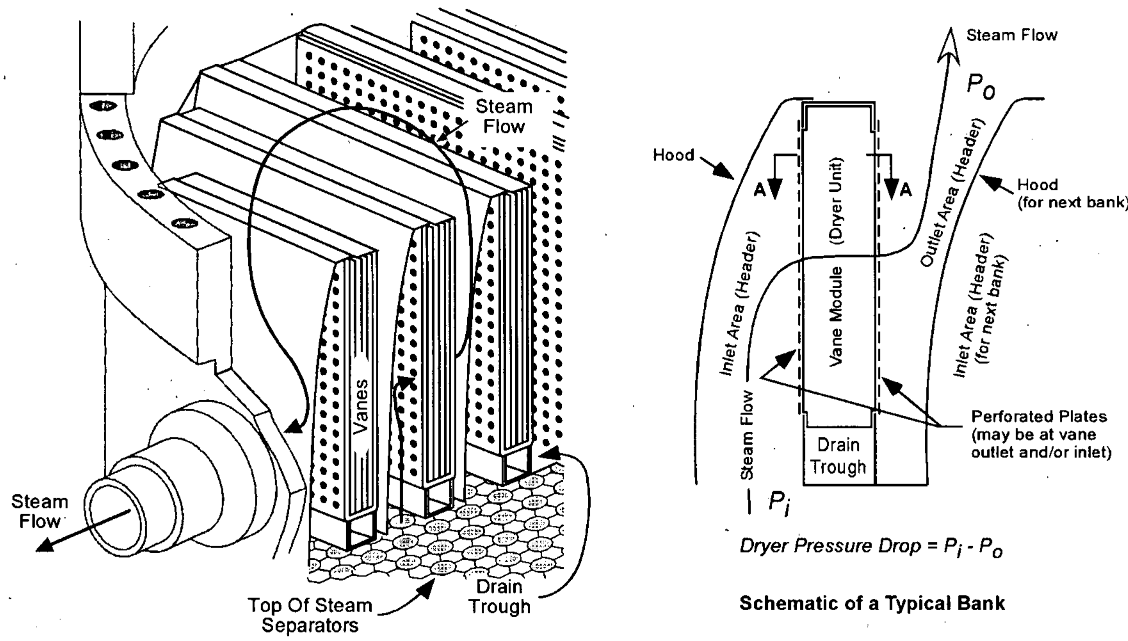

Figure 2: Steam Flow Path Through Dryer

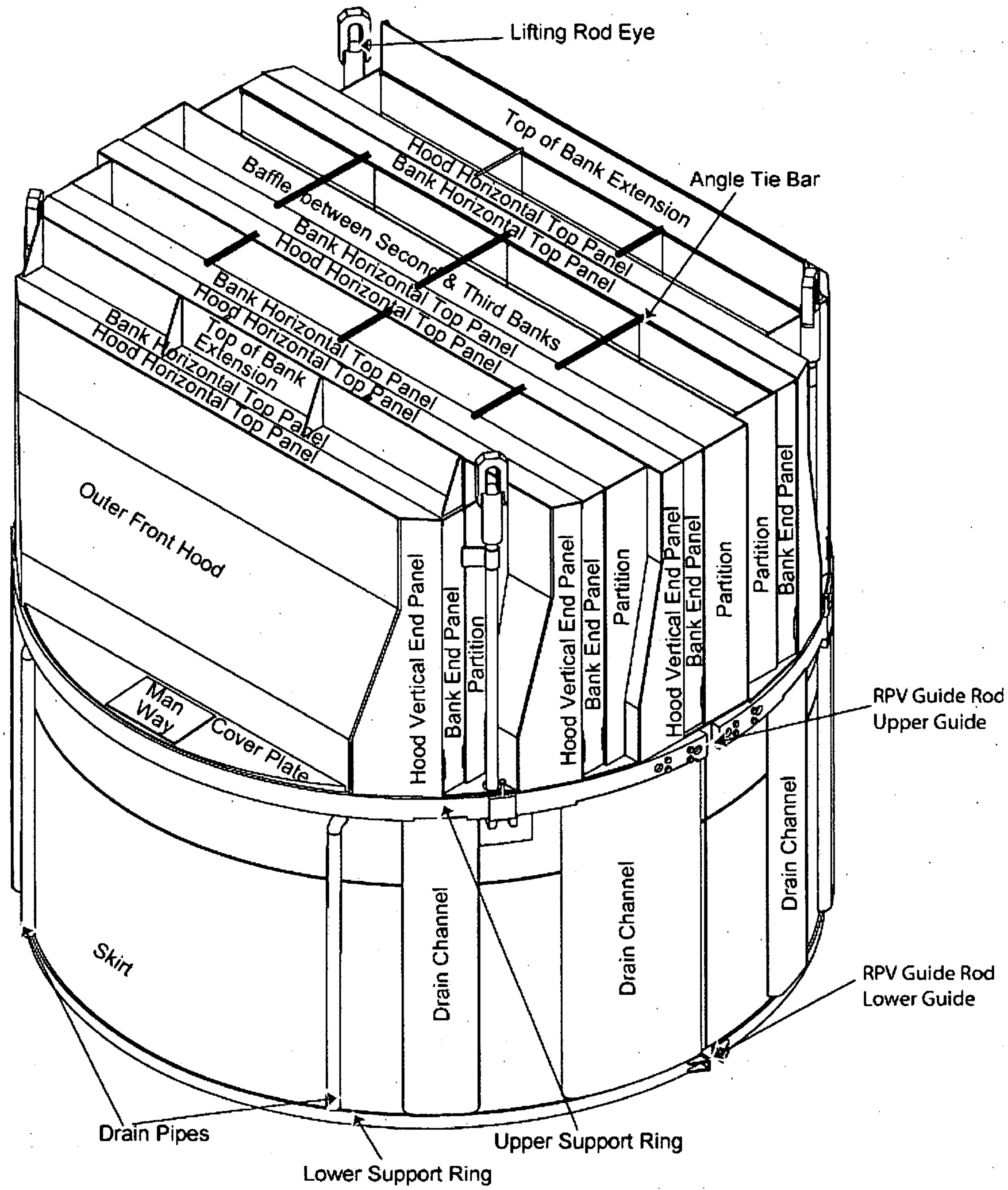

Figure 3: Typical Steam Dryer (BWR/4 Slant Hood Design Shown)

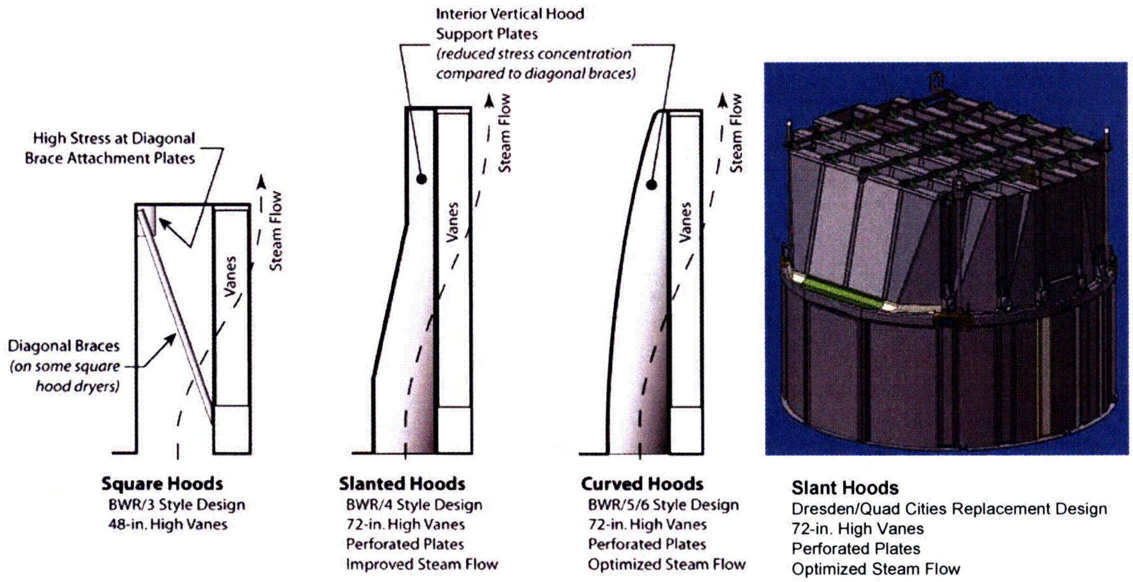

Figure 4: BWR Dryer Hood Designs

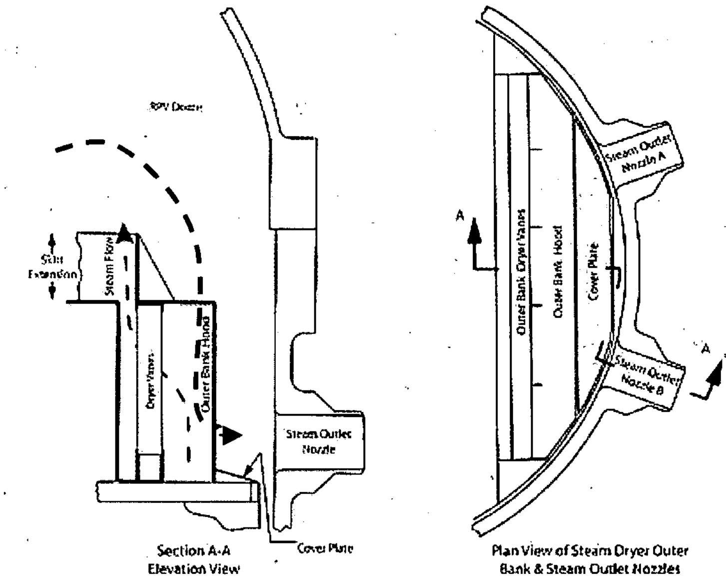

Figure 5: Orientation of Main Steam Nozzles to Steam Dryer

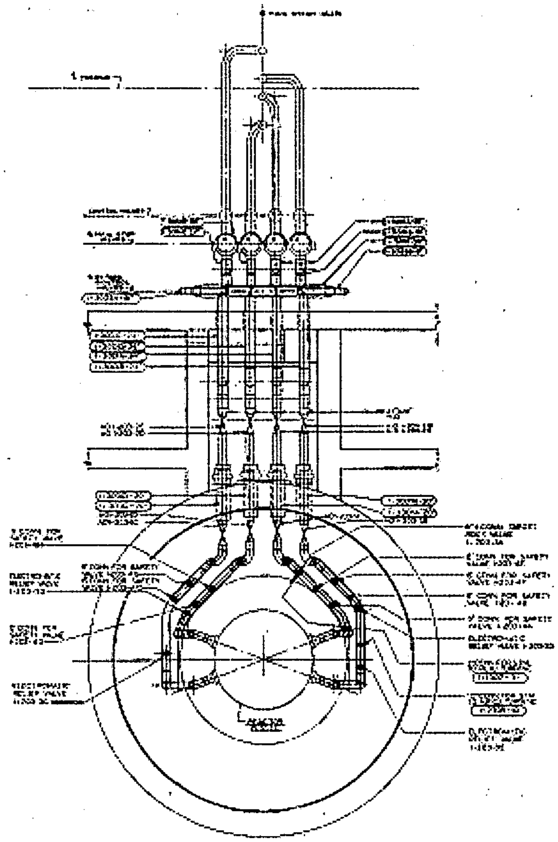

Figure 6: Typical Main Steam Line Layout Between RPV and Turbine (plan view)

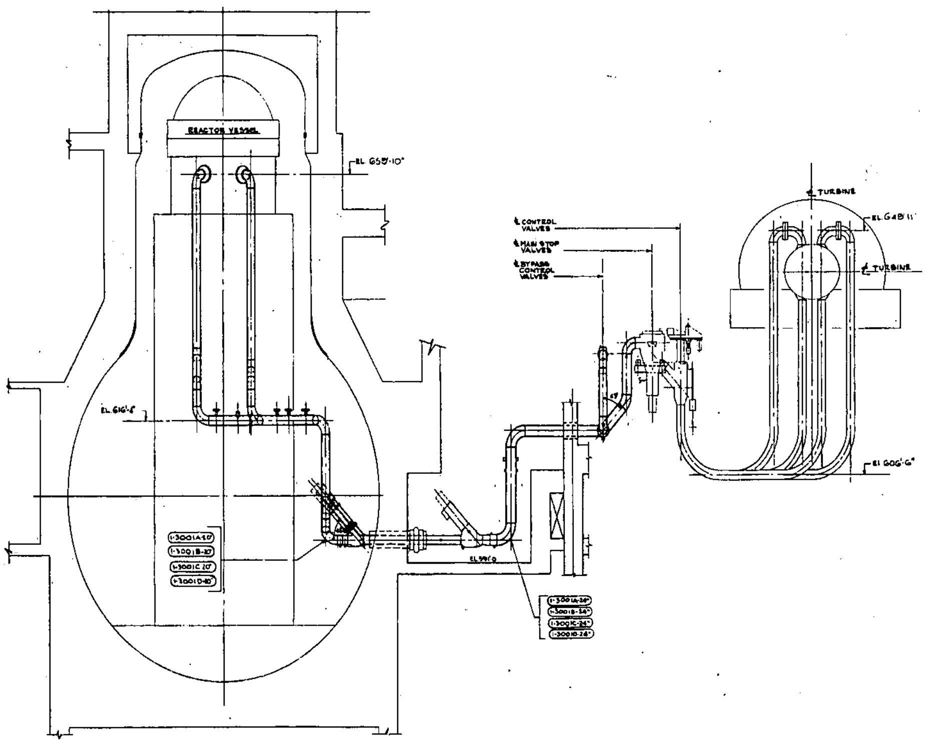

Figure 7: Typical Main Steam Line Layout Between RPV and Turbine (elevation view)

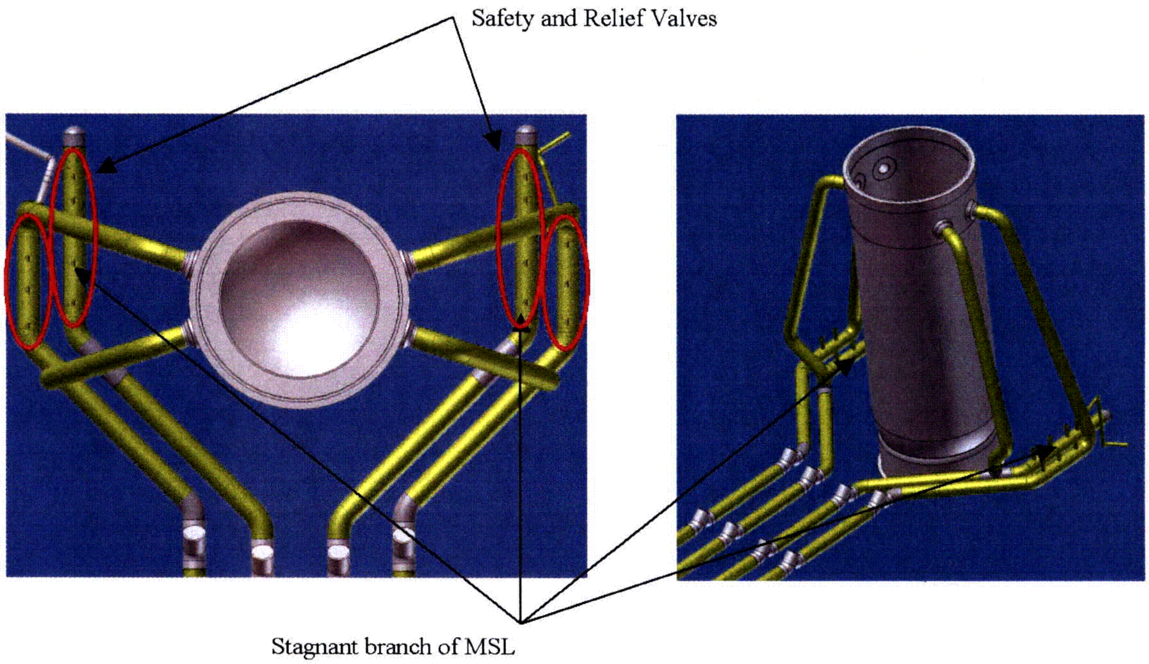

Figure 8: MSL Layout Showing S/RVs Located on Stagnant Branch Lines

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Figure 9: Pressure on Skirt Below Cover Plate (188” BWR/3, Square Hood Dryer)

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Figure 10: Pressure on Skirt Below Cover Plate (251" BWR/3, Slant Hood Dryer)

Note: Both figures show the same data. The scale has been changed on the lower figure to better show the frequency content outside the 150-160 Hz range.

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Figure 11: Pressure on Cover Plate (251" BWR/4, Curved Hood Dryer)

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Figure 12: Pressure on Skirt Below Cover Plate (280" ABWR, Curved Hood Dryer)

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Figure 13: PBLE Acoustic Regions and Boundaries

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Figure 14: Comparison of Steam Flow over Outer Hood, BWR/2 and Later Plants

ENCLOSURE 3

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Affidavit

GE-Hitachi Nuclear Energy Americas LLC

AFFIDAVIT

I, **James F. Harrison,** state as follows:

(1) I am Vice President, Fuels Licensing, Regulatory Affairs, GE-Hitachi Nuclear Energy Americas LLC ("GEH"), 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 GEH's Licensing Topical Report NEDC-33436P, "*GEH Boiling Water Reactor Steam Dryer - Plant Based Load Evaluation*," November 2008. GEH proprietary information is identified by a dotted underline inside double square brackets. [[This sentence is an example.{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 or licensee, GEH 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 GEH's competitors without license from GEH 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 GEH customer-funded development plans and programs, resulting in potential products to GEH;

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 GEH, 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 GEH, 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, or subject to the terms under which it was licensed to GEH. Access to such documents within GEH 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 for technical content, competitive effect, and determination of the accuracy of the proprietary designation. Disclosures outside GEH 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 GEH design information for defining the fluctuating loads that are to be used in the design and analysis of the BWR steam dryers. GEH utilized prior design information and experience from its operating BWRs with significant resource allocation in developing the methodology over several years at a significant investment.

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 GEH asset.

(9) Public disclosure of the information sought to be withheld is likely to cause substantial harm to GEH's competitive position and foreclose or reduce the availability of profit-making opportunities. The information is part of GEH's comprehensive 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 GEH.

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.

GEH's competitive advantage will be lost if its competitors are able to use the results of the GEH 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 GEH 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 GEH of the opportunity to exercise its competitive advantage to seek an adequate return on its large investment in developing and obtaining 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 5th day of November 2008.

James F. Harrison

James F. Harrison
Vice President, Fuels Licensing
GE-Hitachi Nuclear Energy Americas LLC