MFN 07-615

Enclosure 2

Licensing Topical Report NEDO-33313, "ESBWR Steam Dryer Structural Evaluation," November 2007

Non-Proprietary Version

HITACHI

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Licensing Topical Report

ESBWR Steam Dryer Structural Evaluation

IMPORTANT NOTICE REGARDING THE CONTENTS OF THIS REPORT

Please Read Carefully

The information contained in this document is furnished as reference to the NRC Staff for the purpose of obtaining NRC approval of the ESBWR Certification and implementation. The only undertakings of GE Hitachi Nuclear Energy (GEH) with respect to information in this document are contained in contracts between GEH and participating utilities, and nothing contained in this document shall be construed as changing those contracts. The use of this information by anyone other that for which it is intended is not authorized; and with respect to any unauthorized use, GEH makes no representation or warranty, and assumes no liability as to the completeness, accuracy, or usefulness of the information contained in this document.

Table of Contents

1.0 INTRODUCTION

This topical report will document the finite element stress analyses of the ESBWR steam dryer. At this point the load definition and detailed steam dryer design are not finalized, as they depend heavily on ongoing industry and regulatory interaction. Because the stress analysis depends directly on these inputs, Revision 0 of this report only includes a description of the analysis approach and design criteria. A detailed finite element model (FEM) will be used to perform the structural dynamic analyses in order to predict the steam dryer's susceptibility to fatigue under flow induced vibration (FIV) during normal operation. The same FEM will be used to predict the stresses resulting from specified ASME load combinations.

The load definition for the ESBWR steam dryer will be contained in NEDE 33312P, Reference 1. When these loads are defined, the fatigue analysis and ASME load combination analysis described within will be completed. At that point the necessary design iterations will be made to include the resultant stresses and fatigue margins demonstrating the ESBWR steam dryer is structurally acceptable for end use.

2.0 STEAM DRYER DESCRIPTION

The ESBWR steam dryer consists of a center support ring with dryer banks on top and a skirt below to make up the steam dryer assembly. A typical steam dryer is shown in Figure 2-1. The steam dryer units, made up of steam drying vanes and perforated plates, are arranged in six parallel rows called dryer banks. The upper support ring is supported by reactor pressure vessel (RPV) support brackets. The steam dryer assembly does not physically connect to the chimney head and steam separator assembly. The cylindrical skirt attaches to the support ring and projects downward to form a water seal around the array of steam separators. Normal operating water level, approximately mid-height on the steam dryer skirt, is provided as input to the analysis.

During normal refueling outages, the ESBWR steam dryer is supported from the floor of the equipment pool by the lower support ring that is located at the bottom edge of the skirt. The steam dryer is installed and removed from the RPV by the reactor building overhead crane. A steam dryer lifting device, which attaches to four steam dryer lifting rod eyes, is used for lifting the steam dryer. Guide rods in the RPV are used to aid steam dryer installation and removal. Upper and lower guides on the steam dryer assembly are used to interface with the guide rods.

3.0 MATERIAL PROPERTIES

The steam dryer will be manufactured from low carbon wrought 300 series stainless steel and Grade CF3 stainless steel castings conforming to the requirements of GEH material and fabrication specifications. Specific material properties at operating temperature will be taken from Reference 2.

4.0 DESIGN CRITERIA

The steam dryer, including the dryer units, is a non-safety related item and is classified as an Internal Structure per Reference 3, as defined in Reference 4, Subsection NG, Paragraph NG-1122. The steam dryer is not an ASME Code component, but shall comply to the applicable requirements of ASME Code Subsection NG, to the extent possible.

4.1 FATIGUE CRITERIA

The steam dryer fatigue evaluation consists of calculating the alternating stress intensity from FIV loading at all locations in the steam dryer structure and comparing it with the allowable design fatigue threshold stress intensity requirements from Reference 5. [[

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4.2 ASME CODE STRESS LIMITS FOR LOAD COMBINATIONS

The ASME Code stress limits from Subsection NG of Reference 4 are listed in Table 4.1.

Table 4.1 ASME Code Stress Limits [Reference 4]

Service level	Stress category	Core Support Structures Stress limits (NG)
Service Levels A&B	P_m	S_m
	$P_m + P_b$	$1.5S_m$
Service Levels C	P_m	$1.5S_m$
	$P_m + P_b$	$2.25S_m$
Service level D	P_m	Min(.7S_u or 2.4 S_m)
	$P_m + P_b$	1.5(P_m Allowable)

Legend:

P_m: General primary membrane stress intensity

P_b: Primary bending stress intensity

S_m: ASME Code Design Stress Intensity

S_U: Ultimate strength

Note: Service Level Limits for Service Levels A, B and C are according to NG-3221 and Appendix F Paragraph F-1331 for Level D. Upset condition stress limits are increased by 10% above the limits shown in these table per NG-3223(a).

5.0 STEAM DRYER FEA MODEL AND APPLIED LOADS

5.1 FULL STEAM DRYER SHELL FINITE ELEMENT MODEL

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5.2 DYNAMIC PRESSURE LOADS

The FIV loading time history and any necessary loading scale factors will be taken from Reference 1. [[

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5.3 ASME LOADS

The loads representing normal plant operation and other operating events as described in Section 8 will be generated for the FEM.

6.0 VIBRATION ANALYSIS AND PREDICTED COMPONENT STRESSES

6.1 APPROACH

The ANSYS finite element code will be used to obtain the structural responses of the steam dryer to the FIV loads at operating temperature. The dynamic analysis will be performed [[

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6.2 STRESS RECOVERY

The maximum stress intensity [[

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If warranted by initial analysis, additional analysis will be performed to further refine the stress prediction. [[

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7.0 FATIGUE PREDICTION

7.1 FATIGUE CALCULATION

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]] These stresses will then be compared to the criteria from Section 4.1

7.2 FREQUENCY CONTENT OF THE STRUCTURAL RESPONSE

In order to understand the structural [[

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8.0 ASME LOAD COMBINATIONS

8.1 ASME LOAD COMBINATIONS

Table 8.1 provides the load combinations and describes the load cases to be used in the ASME load combinations stress analysis.

Table 8.1 ASME Load Combinations and Conditions

Service Level	Plant Events	Load Combination	Note
A	N	DW + DPn ± FIVn+L_T+C	
B	Plant/System Operating Transients (SOT)	DW + DPn ± FIVn +L_T+C +SRV	
		DW + DPn± FIVn+ L_T+C + TSV1	4
		DW + DPn+ L_T+C + TSV2	2
C	Infrequent Operating Transient (IOT), ATWS	DW + DPn ± FIVn+ L_T+C +SRV	5
D	LOCA (SBL)	DW + DPn ± FIVn+ L_T+C +$[HVL^2+CHG^2+SRV^2]^{1/2}$	5
D	LOCA (SBL) + SSE	DW + DPn ± FIVn+ L_T+C +$[HVL^2+CHG^2+SRV^2+ SSE^2]^{1/2}$	5
D	LOCA(LBL) + SSE	DW + DPn + L_T+C + $[SSE^2 + AC1^2 + FIVn^2]^{1/2}$	1
		DW+ L_T+C + $[DPf1^2 + SSE^2]^{1/2}$	3

Notes:

1. Loads from independent dynamic events are combined by the square root sum of the squares method.
2. In the listed B combination, FIVn is not included because the reverse flow through the steamlines will disrupt the acoustic sources that dominate the FIVn load component.
3. In the listed D combinations, FIVn is not included because the level swell in the annulus between the steam dryer and vessel wall will disrupt the acoustic sources that dominate the FIVn load component.
4. For bearing stress assessment only, the square root of the sum of the squares method may be used to combine TSV1 and FIVn (load combination B).
5. The most limiting load combination case among SRV(1), SRV(2) and SRV(ADS).

Definition of Load Acronyms

AC1	Acoustic load due to Main Steam Line Break (MSLB) outside containment, at the Rated Power and Core Flow (Hi-Power) Condition.
C	Constraint from internals
CHG	Chugging loads
DW	Dead Weight.
DPn	Differential 'static' Pressure Load During Normal Operation.
DPf1	Differential Pressure Load in the Faulted condition, due to Main Steam Line Break outside containment at the Rated Power and Core Flow (Hi-Power) condition.
FIVn	Flow Induced Vibration Load during Normal Operation.
HVL	Horizontal Vent Chugging loads
L_T	Temperature effect
SRV	Safety Relief Valve
SSE	Safe Shutdown Earthquake.
TSV1	The Initial Acoustic Component of the Turbine Stop Valve (TSV) Closure Load. (Inward load on the outermost hood closest to the nozzle)
TSV2	The Flow Impingement Component (following the Acoustic phase) of the TSV Closure Load; (Inward load on the outermost hood closest to the nozzle)

8.2 ASME APPROACH

The structural responses of the steam dryer to the ASME load combinations will be evaluated using the ANSYS finite element code and loading from Section 5.3. [[
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8.3 ASME LOAD CASE STRESS RESULTS

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]] These stresses will then be compared to the criteria from Section 4.2

9.0 CONCLUSIONS

Revision 0 of this report describes how a detailed finite element model of the ESBWR steam dryer will be used to predict steam dryer structural responses to FIV loads and ASME load combinations. When the FIV loads from Reference 1 become available, the analysis will be performed as described, and the results will be used to iterate on a steam dryer design that will be meet the required fatigue and ASME load combination stress criteria

10.0 REFERENCES

[1] NEDE 33312P, "License Topical Report, ESBWR Steam Dryer Acoustic Load Definition".

[2] American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code, Section II Part D, 2001 Edition, 2003 Addenda.

[3] 26A6642AK, Rev. 4, ""ESBWR Design Control Document", Tier 2, Chapter 3, Sections 3-9-3-11.

[4] American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code, Section III, 2001 Edition, 2003 Addenda.

[5] 26A6642AN rev. 4, "ESBWR Design Control Document", Tier 2, Chapter 3, Appendices 3G to 3L.

[6] ANSYS Release 10.0, ANSYS Incorporated, 2005.

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Figure 2-1. [[ ]]

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Figure 5-1. [[ ]]

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Figure 5-2. [[ ]]

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Figure 5-3. [[

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Figure 5-4. [[ ]]

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Figure 7-1. [[ ]]

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Enclosure 3

Affidavit

GE Hitachi Nuclear Energy

AFFIDAVIT

I, David H. Hinds, state as follows:

(1) I am the Manager, New Units Engineering, GE Hitachi Nuclear Energy ("GEH"), 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 1 of GEH letter MFN 07-615, Mr. James C. Kinsey to U.S. Nuclear Regulatory Commission, entitled *Transmittal of Licensing Topical Report NEDE-33313P, "ESBWR Steam Dryer Structural Evaluation,"* dated November, 2007. The GEH proprietary information in Enclosure 1, which is entitled *Licensing Topical Report NEDE-33313P, "ESBWR Steam Dryer Structural Evaluation," November 2007 - GEH Proprietary Information,* is delineated by a [[dotted underline inside double square brackets.{3}]]. 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. A non-proprietary version of this information is provided in Enclosure 2, *Licensing Topical Report NEDO-33313, "ESBWR Steam Dryer Structural Evaluation," November 2007 - Non-Proprietary Version.*

(3) In making this application for withholding of proprietary information of which it is the owner, 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 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, 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 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 identifies detailed GE ESBWR design information for the ESBWR Steam Dryers. GE utilized prior design information and experience from its fleet with significant resource allocation in developing the system over several years at a substantial cost.

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 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 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 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 15th day of November 2007.

David H. Hinds
GE Hitachi Nuclear Energy