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Proprietary Notice
This letter forwards proprietary information in accordance with 10CFR2.390. Upon the removal of Enclosure 1, the balance of this letter may be considered non-proprietary.

MFN 08-841

Docket No. 52-010

November 4, 2008

U.S. Nuclear Regulatory Commission
Document Control Desk
Washington, D.C. 20555-0001

Subject: **Response to Portion of NRC Request for Additional Information Letter No. 234 – Related to ESBWR Design Certification Application – RAI Number 21.6-120**

The purpose of this letter is to submit the GE Hitachi Nuclear Energy (GEH) response to the U.S. Nuclear Regulatory Commission (NRC) Request for Additional Information (RAI) sent by the Reference 1 NRC letter. GEH response to RAI Number 21.6-120 is addressed in Enclosures 1, 2 and 3.

Enclosure 1 contains GEH proprietary information as defined by 10 CFR 2.390. GEH customarily maintains this information in confidence and withholds it from public disclosure. Enclosure 2 is the non-proprietary version, which does not contain proprietary information and is suitable for public disclosure.

The affidavit contained in Enclosure 3 identifies that the information contained in Enclosure 1 has been handled and classified as proprietary to GEH. GEH hereby requests that the information in Enclosure 1 be withheld from public disclosure in accordance with the provisions of 10 CFR 2.390 and 10 CFR 9.17.

If you have any questions or require additional information, please contact me.

Sincerely,

Richard E. Kingston

Richard E. Kingston
Vice President, ESBWR Licensing

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NRO

References:

1. MFN 08-629 Letter from U.S. Nuclear Regulatory Commission to Robert E. Brown, GEH, *Request For Additional Information Letter No. 234 Related To ESBWR Design Certification Application,* dated August 5, 2008

Enclosures:

1. MFN 08-841 – Response to Portion of NRC Request for Additional Information Letter No. 234 – Related to ESBWR Design Certification Application – RAI Number 21.6-120 – GEH Proprietary Information
2. MFN 08-841 – Response to Portion of NRC Request for Additional Information Letter No. 234 – Related to ESBWR Design Certification Application – RAI Number 21.6-120 – Non-Proprietary Version
3. MFN 08-841 – Response to Portion of NRC Request for Additional Information Letter No. 234 – Related to ESBWR Design Certification Application – RAI Number 21.6-120 – Affidavit

cc:	AE Cubbage	USNRC (with enclosures)
	RE Brown	GEH/Wilmington (with enclosures)
	DH Hinds	GEH/Wilmington (with enclosures)
	eDRF	0000-0091-1643

Enclosure 2

MFN 08-841

Response to Portion of NRC Request for

Additional Information Letter No. 234

Related to ESBWR Design Certification Application

RAI Number 21.6-120

Non-Proprietary Version

NRC RAI 21.6-120

Tube side and secondary side heat transfer uncertainty.

NEDE 33083P, Supp. 3:, Chapter 5, Table 5-1 - Bounding input Q2 and Q5:

In Table 5-1 (page 40), the bias and deviation for Q2 tube-side condensation capacity is listed as [[ ]]; and for Q5 secondary-side heat transfer are [[ ]], respectively. However, the comments indicate bounding input [[ ]]. The discussion on page 54 in Section 5.1 for Q2 IC tube side condensation capacity, Q5 IC secondary side heat transfer also seems to indicate that the uncertainty in these heat transfer correlations is bounded by a design basis [[ ]]. Are the Kuhn-Schrock-Peterson and the Forster-Zuber heat transfer correlations ignored? Is it assumed that the design basis fouling factor bounds these heat transfer correlation uncertainties?

GEH Response

Are the Kuhn-Schrock-Peterson and the Forster-Zuber heat transfer correlations ignored?

No. The tube side and pool side heat transfers are not ignored in ESBWR TRACG transient analysis.

The heat transfer through the Isolation Condenser (IC) tubes consists of three components: Tube side condensation (Kuhn-Schrock-Peterson correlation), IC tube wall conduction, and pool side boiling heat transfer. Chen correlation has been used in TRACG transient analysis for the pool side heat transfer. Chen correlation has two additive parts, one of which is the modified Forster-Zuber correlation discussed in Section 6.6.4.1 of Reference [2]. The uncertainty of the Chen correlation is [[ ]] which is shown in Section 5.1 of Reference [1], parameter C1 discussion. For tube side condensation heat transfer, the standard deviation is [[ ]] when compared to pure steam data.

The second paragraph under the Q2 and Q5 headings on page 54 of Reference [1] will be revised to clarify that Chen correlation has been used for pool side heat transfer and to provide its uncertainty.

The content of the identifiers Q2 and Q5 in Table 5-1 of Reference [1] will be revised accordingly.

Is it assumed that the design basis fouling factor bounds these heat transfer correlation uncertainties?

Yes. It is assumed that the design basis fouling factor bounds these heat transfer correlation uncertainties. The discussions in the following paragraphs show that this assumption is valid. The clean tube wall thickness is [[ ]] (Reference 1), and [[ ]] has been used as the IC tube wall thickness in TRACG transient calculations. The additional thickness [[ ]] is the equivalent

Inconel wall thickness based on the design basis fouling factor [[ ]], which represents the analytical thermal resistance limit due to the crud at the end of reactor life.

Three portions of thermal resistance take up approximately [[ ]] (tube side), [[ ]] (tube wall conduction) and [[ ]] (pool side), respectively. The [[ ]] uncertainty of heat transfer on the tube side and the [[ ]] uncertainty on the pool side amounts to only [[ ]] of the total thermal resistance uncertainty, which is equivalent to [[ ]] IC tube wall thickness.

The middle-of-life fouling factor [[ ]] can be taken as a realistic fouling factor, and the equivalent Inconel wall thickness is [[ ]]. Therefore, for middle-of-life fouling factor along with tube-side and pool-side heat transfer uncertainty, the increased wall thickness would be [[ ]]. A conservatively bigger value of wall thickness [[ ]] has been applied in TRACG transient base model, which is equivalent to the design limit fouling factor. Therefore, applying the design basis fouling factor provides a conservative bound to the heat transfer correlation uncertainties.

In the fourth paragraph under the Q2 and Q5 headings on page 54 of Reference [1], the [[ ]] will be changed to [[ ]] in the revised LTR. Also, text in this paragraph will be revised consistent with the responses to the current RAI.

It should be noted that in the ESBWR ITAAC's Reference [4], the acceptance criterion for the ICS train unit heat removal capacity is greater than or equal to [[ ]] for the reactor at or above normal operating pressure. Periodical Technical Specification surveillance also ensures that each IC is capable of removing the required heat load of [[ ]] (Reference [3]). In TRACG analysis, the heat removal from each IC train under normal operating pressure is conservatively modeled to be less than the minimum required heat load mentioned above. In summary, IC heat transfer is periodically validated in the actual plant to be higher than the safety analysis value.

The discussions above about bounding input Q2 and Q5 are also applicable for Reference [5], Section 5 and Table 5.1-2. The markup for Reference [5] is also provided with this RAI response.

References:

1. NEDE-33083P, Supplement 3, “TRACG Application for ESBWR Transient Analysis”, December 2007
2. NEDE-32176P, “TRACG Model Description”, Revision 4, January 2008
3. 226A6642AT, ESBWR Design Control Document/Tier 2, Revision 5, Chapter 16, page 3.5.4-2
4. 26A6641AB, ESBWR Design Control Document/Tier 1, Revision 5, Table 2.4.1-3
5. NEDE-33083P, Supplement 2, “TRACG Application For ESBWR Anticipated Transient Without Scram Analyses”, Revision 1, February 2008

DCD or LTR Impact

No DCD changes will be made in response to this RAI.

Changes to NEDE-33083P, Supplement 2 and NEDE-33083P, Supplement 3 are shown in the attached markup.

Attachment

Revision Pages for NEDE-33083P, Supplement 2

and

Revision Pages for NEDE-33083P, Supplement 3

separation of droplets from the steam in the dryer, and therefore evaluates the steam line response with dry steam. This conservatively maximizes the velocity of sound in the steam line and produces a bounding power peak for the pressurization event.

Q2 IC Tube Side Condensation Capacity, H; Q5 IC Secondary Side Heat Transfer, H

TRACG utilizes the Kuhn-Schrock-Peterson correlation (Reference 38) for the calculation of condensation heat transfer inside tubes. [[{3}]]

Chen correlation has been used in TRACG calculation for the poolside heat transfer. Chen correlation has two additive parts, one of which is the modified Forster-Zuber correlation discussed in Subsection 6.6.4.1 of Reference 14. The standard deviation of Chen correlation is [[{3}]] against test data.

Comparisons with prototypical PANTHERS data (Reference 15) have shown good agreement between the measured and predicted heat transfer. The IC heat removal rate was calculated with [[{3}]](Reference 15).

Uncertainties in the wall conduction are also included in this PIRT. It should be noted that the PANTHERS tests were carried out with clean tubes and do not include the effect of crud formation that may occur with continued IC operation. [[

{3}]]

It should be noted that in the ESBWR ITAAC, Table 2.4.1-3 in Reference 39, the acceptance criterion for the ICS train unit heat removal capacity is greater than or equal to [[{3}]] for the reactor at or above normal operating pressure. Periodical tech-spec surveillance also ensures that each IC is capable of removing the required heat load ([[{3}]]) (Chapter 16 in Reference 40). In TRACG analysis, the heat removal from each IC train under normal operating pressure is conservatively modeled to be less than the minimum required heat load mentioned above. In summary, IC heat transfer is periodically validated in the actual plant to be higher than the safety analysis value.

~~Q2 Isolation Condenser Capacity~~

~~Full scale tests were performed of an Isolation Condenser (IC) module in the PANTHERS test facility. Comparisons with TRACG results showed a negative bias of [[{3}]] and a 1σ uncertainty of [[{3}]] in the total heat removal rate [15].~~

~~Q5 Isolation Condenser Secondary Side Heat Transfer~~

~~The uncertainties in the secondary side heat transfer are included in the data for the overall condenser heat removal (Q2) above.~~

{3}]]

10-26 Supplemental Information for Plant Modifications to Eliminate Significant In-Core Vibrations", NEDE-21156, Jan 1976

10-27 B. S. Shiralkar and R. E. Gamble, "ESBWR Test and Analysis Program Description", NEDC-33079P, August 2002 (section 3.3).

10-28 J. P. Walkush, "High Pressure counterflow CHF", EPRI Report 292-2, January 1975

10-29 V. P. Carey, Liquid-Vapor-Phase-Change Phenomena, Hemisphere Publishing, 1992.

10-30 R. E. Dimenna, et al., RELAP5/MOD2 Models and Correlations, NUREG/CR-5194 (EGG-2531), August 1988.

10-31 D. C. Groeneveld, S. C. Cheng and T. Doan, 1986 AECL-UO Critical Heat Flux Lookup Table, Heat Transfer Engineering 7, 1986 (pp. 46-62).

10-32 B. S. Shiralkar, et al., The GESTR-LOCA and SAFER Models for the Evaluation of the Loss-of-Coolant Accident, Volume III: SAFER/GESTR Application Methodology, NEDE-23785-1-PA, Rev. 1, October 1984.

10-33 P. Saha, A Study of Heat Transfer to Superheated Steam in a 4x4 Rod Bundle, NEDE-13462, June 1976

10-34 B. S. Shiralkar, et al., SBWR Test and Analysis Program Description, NEDC-32391P, Rev.C, August 1995.

10-35 Takashi Hara, et al., *TRACG Application to Licensing Analysis*, (ICONE-7311), 7th International Conference on Nuclear Engineering, Tokyo, April 19-23, 1999.

10-36 R. D. Blevins, Applied Fluid Dynamics Handbook, Van Nostrand, 1984.

10-37 G. B. Wallis, One-Dimensional Two-Phase Flow, McGraw-Hill, 1969.

10-38 S.Z. Kuhn, V.E. Schrock, and P.F. Peterson, Final Report on U. C. Berkeley Single Tube Condensation Studies, University of California, Berkeley Report UCB-NE- 4201, August 1994.

10-39 GE Hitachi Energy Nuclear, ESBWR Design Control Document, Tier 1, Rev. 5, May 2008.

10-40 GE Hitachi Energy Nuclear, ESBWR Design Control Document, Tier 2, Rev. 5, May 2008.

Table 5-1
High and Medium Ranked Model Parameters for ESBWR AOO, IE, and SE Transient Analysis

[[					
					]]

Sudden closure of the turbine stop valves or control valves results in the propagation of a pressure pulse at sonic speed from the valve to the steam dome. The timing of the arrival of the pressure pulse has a significant impact on the severity of the transient. The propagation of the pulse may be affected by uncertainty in the sonic propagation velocity for the steam. [[

]]

Q1 IC Pressure drop, H

This determine the cold water drainage from the IC in the initial part of the actuation, [[
]]

Q2 IC Tube Side Condensation Capacity, H; Q5 IC Secondary Side Heat Transfer, H

TRACG utilizes the Kuhn-Schrock-Peterson correlation [69] for the calculation of condensation heat transfer inside tubes. [[
]]

Chen correlation has been used in TRACG calculation for the pool side heat transfer. Chen correlation has two additive parts, one of which is the modified Forster-Zuber correlation discussed in Subsection 6.6.4.1 of Reference 8. The standard deviation of Chen correlation is [[ ]] against test data.~~The IC secondary side heat transfer is controlled by the nucleate pool boiling phenomenon, which is modeled by the Forster – Zuber correlation in TRACG. The Forster-Zuber correlation typically falls in the middle of other well-known correlations used for pool boiling. [[ ]] This is not the limiting resistance for heat transfer across the IC tube wall, and the sensitivity to the assumed uncertainty is small.~~

Comparisons with prototypical PANTHERS data [49] have shown good agreement between the measured and predicted heat transfer. The IC heat removal rate was calculated with [[
]][49].

Uncertainties in the wall conduction are also included in this PIRT. It should be noted that the PANTHERS tests were carried out with clean tubes and do not include the effect of crud formation that may occur with continued IC operation. [[

]]

It should be noted that in the ESBWR ITAAC, Table 2.4.1-3 of Reference 74, the acceptance criterion for the ICS train unit heat removal capacity is greater than or equal to [[ ]] for the reactor at or above normal operating pressure. Periodical tech-spec surveillance also ensures that each IC is capable of removing the required heat load [[ ]] (Chapter 16 of Reference 75). In TRACG analysis, the heat removal from each IC train under normal operating pressure is conservatively modeled to be less than the minimum required heat load mentioned above. In summary, IC heat transfer is periodically validated in the actual plant to be higher than the safety analysis value.

R1 Flow Dynamics, H; R2 Temperature Dynamics, H

In the ESBWR these can affect the response of the transients because the sub-cooling transients are limiting, therefore bounding parameters will be used for the analysis of the transients affected by the FW dynamics and temperature.

JSME/ASME Joint International Conference on Nuclear Engineering, New Orleans, March 1996.

[64] A. M. C. Chan, Void Fraction Measurements in Large Diameter Pipes with Thick Metal Walls or Complex Internal Geometries, Proceedings of the National Heat Transfer Conference, American Nuclear Society, 1992 (pp. 236-244).

[65] A. M. C. Chan and D. Bzovey, Measurements of Mass Flux in High Temperature High Pressure Steam-Water Two-Phase Flow using a Combination of Pitot Tubes and a Gamma Densitometer, Journal of Nuclear Engineering and Design, V. 122, 1990 (pp. 95-104).

[66] J. F. Wilson, R. J. Grenda and J. F. Patterson, Steam Volume Fraction in a Bubbling Two-Phase Mixture, Trans. ANS 4(2), 1961 (pp. 356-357).

[67] G. G. Bartolomei, V. A. Suvorov and S. A. Tevlin, Hydrodynamics of Steam Generation in a Two-Circuit Nuclear Power Plant, Teploenergetika 10(1), 1963 (pp. 52-57).

[68] M. Petrick and E. A. Spleha, Thermal Hydraulic Performance Characteristics of EBWR, ANL 6693, May 1963.

[69] S.Z. Kuhn, V.E. Schrock, and P.F. Peterson, Final Report on U. C. Berkeley Single Tube Condensation Studies, University of California, Berkeley Report UCB-NE- 4201, August 1994.

[70] Congdon, Bentley, Bolger, LTR GE14 for ESBWR – Critical Power Correlation, Uncertainty, and OLMCPR Development, March 2006.

[71] S. B. Shelton, LTR GE14 for ESBWR Fuel Rod Thermal-Mechanical Design Report, NEDC-33242P, Rev. 1, February 2007.

[72] GE-Hitachi Nuclear Energy, "ESBWR Feedwater Temperature Operating Domain Transient and Accident Analysis", NEDO-33338 Class I, Revision 0, October 2007.

[73] GENE, "ESBWR Heat Balance 100% Power, 102%Power, 104.2% Power/105% Rated Steam Flow," neDRF Sec. 0000-0034-6115, March 10, 2005.

[74] GE Hitachi Nuclear Energy, ESBWR Design Control Document, Tier 1, Rev. 5, May 2008.

[75] GE Hitachi Nuclear Energy, ESBWR Design Control Document, Tier 2, Rev. 5, May 2008.

Enclosure 3

MFN 08-841

Response to Portion of NRC Request for

Additional Information Letter No. 234

Related to ESBWR Design Certification Application

RAI Number 21.6-120

Affidavit

GE-Hitachi Nuclear Energy Americas LLC

AFFIDAVIT

I, David H. Hinds, state as follows:

(1) I am General Manager, New Units Engineering, GE Hitachi Nuclear Energy ("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 enclosure 1 of GEH's letter, MFN 08-841, Mr. Richard E. Kingston to U.S. Nuclear Energy Commission, entitled "*Response to Portion of NRC Request for Additional Information Letter No. 234 – Related to ESBWR Design Certification Application – RAI Number 21.6-120,*" dated November 4, 2008. The proprietary information in enclosure 1, which is entitled "*MFN 08-841 – Response to Portion of NRC Request for Additional Information Letter No. 234 – Related to ESBWR Design Certification Application – RAI Number 21.6-120 – GEH Proprietary Information,*" Proprietary information of GEH is indicated as the content contained between opening double brackets ([[) and closing double brackets (]]). Figures and large objects are contained between opening double brackets and closing double brackets. The superscript notation, e.g., {3}, refers to Paragraph (3) of the enclosed 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) is classified as proprietary because it contains details of GEH's design and licensing methodology. The development of the methods used in these analyses, along with the testing, development and approval of the supporting methodology was achieved at a significant cost to GEH.

(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 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 4th day of November 2008.

David H. Hinds
GE-Hitachi Nuclear Energy Americas LLC