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Proprietary Notice

This letter forwards proprietary information in accordance with 10CFR2.390. Upon the removal of Enclosures 1 and 2, the balance of this letter may be considered non-proprietary.

MFN 12-077, Revision 2

Docket number: 05200010

February 15, 2013

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

Subject: **NRC Requests for Additional Information Related to the Audit of the Economic Simplified Boiling Water Reactor (ESBWR) Steam Dryer Design Methodology Supporting Chapter 3 of the ESBWR Design Control Document – GEH Final Responses to RAIs 3.9-285 and 3.9-286**

References:

1. MFN 12-037, Letter from USNRC to Jerald G. Head, GEH, Subject: Request for Additional Information Letter No. 414 related to ESBWR Design Certification Application (DCD) Revision 9, received May 1, 2012
2. MFN 12-076, Letter from Jerald G. Head, GEH, to USNRC, Subject: NRC Requests for Additional Information (RAI) Related to the Audit of the Economic Simplified Boiling Water Reactor (ESBWR) Steam Dryer Design Methodology Supporting Chapter 3 of the ESBWR Design Control Document – Draft Response for RAI 3.9-285, dated June 19, 2012
3. MFN 12-077, Letter from Jerald G. Head, GEH, to USNRC, Subject: NRC Requests for Additional Information (RAI) Related to the Audit of the Economic Simplified Boiling Water Reactor (ESBWR) Steam Dryer Design Methodology Supporting Chapter 3 of the ESBWR Design Control Document – Draft Response for RAI 3.9-286, dated June 20, 2012
4. MFN 12-077, Revision 1, Letter from Jerald G. Head, GEH, to USNRC, Subject: NRC Requests for Additional Information (RAI) Related to the Audit of the Economic Simplified Boiling Water Reactor (ESBWR) Steam Dryer Design Methodology Supporting Chapter 3 of the ESBWR Design Control Document – Revised Draft Responses for RAIs 3.9-285 and 3.9-286, dated October 17, 2012

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NRO

In regard to the Requests for Additional Information transmitted in your May 1, 2012 Letter, Reference 1, to support the NRC ESBWR Steam Dryer Methodology Audit conducted March 21 – 23, 2012 Docket 05200010, please find attached the final responses for RAIs 3.9-285 and 3.9-286, which supersede the responses provided in References 2 through 4.

Enclosures 1 and 2 contain the complete responses for RAI 3.9-285 and RAI 3.9-286, respectively, with proprietary information identified within brackets [[ ]], and designated in red and dotted underline text, to assist in identification. The proprietary information, as identified by GE Hitachi Nuclear Energy, Americas LLC, should be protected accordingly.

Enclosure 3 is a duplicate of Enclosure 1 with the proprietary information redacted, and is acceptable for public release. Enclosure 4 is a duplicate of Enclosure 2 with the proprietary information redacted, and is also acceptable for public release. Enclosure 5 provides an affidavit which sets forth the basis for requesting that Enclosures 1 and 2 be withheld from the public.

If you have any questions concerning this letter, please contact Peter Yandow at 910-819-6378.

I declare under penalty of perjury that the foregoing information is true and correct to the best of my knowledge, information, and belief.

Sincerely,

Peter M Yandow FOR

Jerald G. Head
Senior Vice President, Regulatory Affairs

Commitments: No additional commitments are made in this response.

Enclosures:

1. GEH Final Response to RAI 3.9-285 – Proprietary Version
2. GEH Final Response to RAI 3.9-286 – Proprietary Version
3. GEH Final Response to RAI 3.9-285 – Public Version
4. GEH Final Response to RAI 3.9-286 – Public Version
5. Affidavit for MFN 12-077, Revision 2

cc: David Misenhimer, NRC
Glen Watford, GEH
Peter Yandow, GEH
Patricia Campbell, GEH
Mark Colby, GEH
Scott Bowman, GEH
Tim Enfinger, GEH
Gerald Deaver, GEH
eDRF Section 0000-0147-3912, R2

Enclosure 5

MFN 12-077, Revision 2

Affidavit

GE-Hitachi Nuclear Energy Americas LLC

AFFIDAVIT

I, **Peter M. Yandow**, state as follows:

(1) I am Senior Engineer, Regulatory Affairs of 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 Enclosures 1 and 2 of GEH's letter MFN 12-077, Revision 2, Mr. Jerald G. Head (GEH) to USNRC, "NRC Requests for Additional Information Related to the Audit of the Economic Simplified Boiling Water Reactor (ESBWR) Steam Dryer Design Methodology Supporting Chapter 3 of the ESBWR Design Control Document – GEH Final Responses to RAIs 3.9-285 and 3.9-286," dated February 15, 2013. The GEH proprietary information in Enclosures 1 and 2 of MFN 12-077 Revision 2, is identified by a [[dark red font with a dotted underline placed within 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.

GEH does not consider this document to be transmitted to the NRC as a record. Rather, the document is provided solely for purposes of facilitating NRC/GEH discussion in a timely manner. GEH will submit final responses using its normal process and include a separate affidavit accordingly. Providing this affidavit to cover proprietary information that the NRC may have in its posession for purposes of performing a review of informaiton during said discussions is consistent with NRC guidance (see NRC MC 0620).

(3) In making this application for withholding and determination 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 qualifies 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, 975 F2d 871 (DC Cir. 1992), and Public Citizen Health Research Group v. FDA, 704 F2d 1280 (DC Cir. 1983).

(4) The information sought to be withheld is considered to be proprietary for the reasons set forth in paragraphs (4)a and (4)b. Some examples of categories of information that 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 GEH and/or other companies.

b. Information that, if used by a competitor, would reduce their expenditure of resources or improve their competitive position in the design, manufacture, shipment, installation, assurance of quality, or licensing of a similar product.

c. Information that reveals aspects of past, present, or future GEH customer-funded development plans and programs, that may include potential products of GEH.

d. Information that discloses trade secret and/or potentially patentable subject matter for which it may be desirable to obtain patent protection.

(5) To address 10 CFR 2.390(b)(4), the information sought to be withheld is being submitted to the 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, not been disclosed publicly, and not been made available in public sources. All disclosures to third parties, including any required transmittals to the NRC, have been made, or must be made, pursuant to regulatory provisions or proprietary and/or confidentiality agreements that provide for maintaining the information in confidence. The initial designation of this information as proprietary information and the subsequent steps taken to prevent its unauthorized disclosure are as set forth in the following paragraphs (6) and (7).

(6) Initial approval of proprietary treatment of a document is made by the manager of the originating component, who is the person most likely to be acquainted with the value and sensitivity of the information in relation to industry knowledge, or who is the person most likely to be subject to the terms under which it was licensed to GEH. Access to such documents within GEH is limited to 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 and/or confidentiality agreements.

(8) The information identified in paragraph (2) above is classified as proprietary because it communicates sensitive business information regarding commercial communications, plans, and strategies associated with future actions related to GEH's extensive body of ESBWR technology, design, and regulatory information and it's protection is important to the design certification process.

(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 15th day of January 2013.

Peter M. Yandow
GE-Hitachi Nuclear Energy Americas LLC

Enclosure 3

MFN 12-077, Revision 2

GEH Final Response to RAI 3.9-285

Non-Proprietary Version

This is a non-proprietary version of Enclosure 1, from which the proprietary information has been removed. Portions of the document that have been removed are identified by white space within double brackets, as shown here [[ ]].

NRC RAI 3.9-285

Summary: The staff's question is in regard to clarifying the "peak" stress from the shell model.

During the audit, the staff and GEH discussed at length the calculation methods identified in Section 4.1 and Figure 4-1 of Reference 1, related to the prediction of the alternating peak stress intensity for the fatigue evaluation of fillet welds. As an example, GEH described in detail its response to a GGNS RAI that addressed the same issue. The response to the GGNS RAI provided a single comparison between 2 methods discussed in NEDE 33313P, Rev 2 for fillet welds. These are method (1) calculation of a [[ ]]; *and method (2)* [[ ]].

The staff requested clarification of the peak stress from the shell model. GEH explained that this [[ ]]. *In the example presented by GEH, there are* [[ ]] *sharing the target node. The local geometry is very complex. GEH* [[ ]]. *This value is compared directly to the material fatigue endurance limit* [[ ]].

Based on the one example presented, method (2) produced an acceptable result, compared to method (1). GEH has developed a post-processing procedure (which is discussed in the LTR on page 5 of 37) to calculate [[ ]], *for use in method (1).*

There was no theoretical basis presented for method (2). Based on GEH's response to staff questions at the audit, there does not appear to be one. GEH apparently developed method (2) based on comparison of a very limited sample set.

At this time, the staff is seeking a more comprehensive, quantitative technical basis for GEH's conclusion that method (2) provides equal or greater conservatism, compared to method (1). To this end, the staff requests GEH to perform a series of simple confirmatory analyses that the staff can reference in its safety evaluation of this issue. The basic model is a T-connection of 304 stainless steel plates, which may be considered to be of infinite longitudinal length. A unit strip may be used, reducing the problem to 2-D. The basic loading is in-plane membrane force and out-of-plane bending moment applied to the free end of the vertical (web) plate. The horizontal (flange) plate is constrained at both ends.

The staff requests the applicant to conduct a parametric study, varying the lengths and thicknesses of the 2 plates, and the ANSYS shell element refinement. The shell element

refinement should be varied by a factor of ten, and should envelope typical shell element lengths used in the steam dryer shell models. For each configuration, analyze a "unit" membrane force, a "unit" bending moment, and both applied simultaneously.

Using the shell element stress results from the ANSYS analyses, calculate the peak alternating stress intensities using method (1) and method (2), for each permutation. In the method (1) calculation, assume a range of acceptable fillet weld sizes, based on the thicknesses of the plates being joined. In the method (2) calculation, tabulate the results with [[ ]] *defined in the last paragraph on page 5 of 37 of Reference 1. Given the simplicity of the model and loading, an extensive parametric study should be designed and implemented, to confirm the validity of method (2). In addition, as a check on the implementation of method (1), compare the results of method (1) to alternating stress intensity predictions "using traditional weld stress formulas", as defined in B. on page 5 of 37, assuming complete load reversal* [[ ]], *for a representative subset of cases.*

<u>GEH Response</u>

1.0 <u>REFERENCES</u>

1.) Letter from Richard E. Kingston, (GEH), to NRC, "Response to Portion of NRC RAI Letter No. 339 Related to ESBWR Design Certification Application - DCD Tier 2, Section 3.9 - Mechanical Systems and Components; RAI Numbers 3.9- 215 S01 Parts A, B, C & D (revised) and 3.9-244 S01 (revised)," July 10, 2009 (ADAMS Accession No. ML091950502).

2.) NEDE-33313P-A rev. 2, "ESBWR Steam Dryer Structural Evaluation", October 2010. Note: This report is being revised.

3.) ANSYS Release 11.0, ANSYS Incorporated.

2.0 <u>SUMMARY</u>

For this T-joint weld stress study, comparing methods 1 and 2, method 2 with its [[ ]] with NEDE-33313P-A (ref. 2) section 4.1.

3.0 BACKGROUND

The example provided during the 2012 NRC staff audit was RAI 3.9-215S01 Part B (ref. 1). The Staff member requested background on GEH's three (3) approaches to determining stress in steam dryer welds. These (3) approaches are described in GEH's response to RAI 3.9-215S01 Part B:

1) [[ ]], the SCF of 4 is applied [ ]].
2) [[ ]], the SCF of 1.8 is applied [[ ]].
3) [[ ]], the SCF of 1.8 is applied [[ ]].

The theoretical basis was explained by GEH during the audit; additional information can be found in NEDE-33313P-A (ref. 2) and the response to RAI 3.9-215S01 Part B (ref. 1). These approaches were previously accepted by the NRC Staff as documented in NEDE-33313P-A. The RAI questions the basis for method (2) and GEH's limited presentation of the method's proof of acceptability during a recent NRC Staff audit.

4.0 ANALYSIS INPUT

To provide information to conclude that method (2) provides a more conservative result than method (1) the NRC Staff requested GEH to perform additional analyses. The NRC Staff requested that GEH use a T-joint for the analyses and to reduce the configuration to a 2-D approach. A typical double sided fillet welded T-joint used for ESBWR steam dryer design is shown in Figure 4.0, an ASME B&PV Code Section III NG-3352 Type V weld joint.

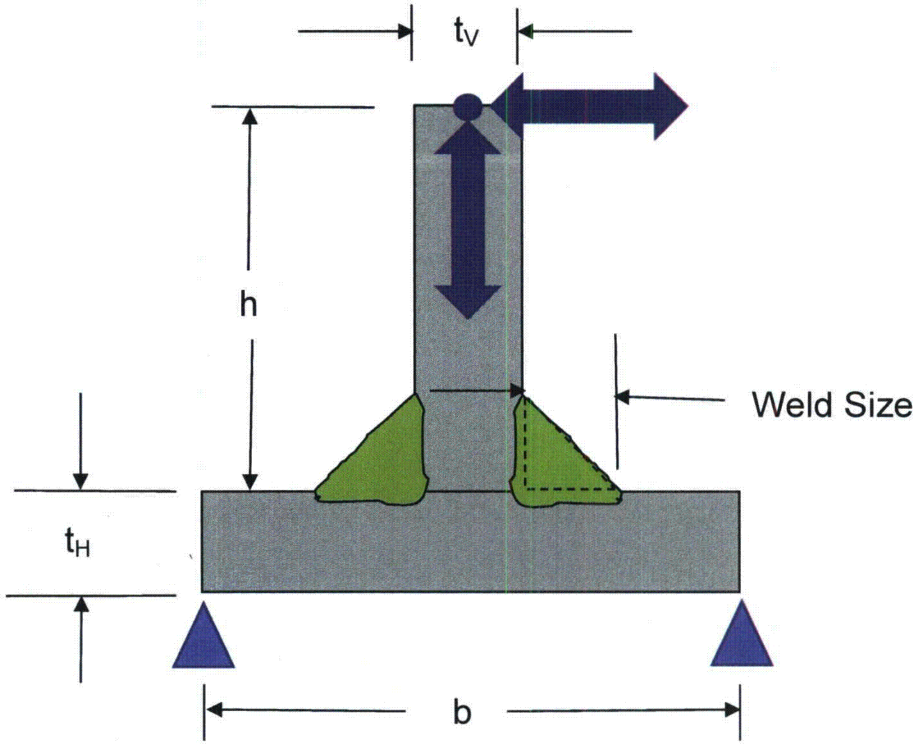

Figure 4.0: Double sided fillet welded T-joint with nomenclature for analyses

The typical T-joint shown in Figure 4.0 is made up of a horizontal continuous member, a vertical stem member, and equal size fillet welds.

5.0 ANALYSIS

5.1 SET-UP

The following conditions were set up for the analysis:

a.) Horizontal and vertical plate thicknesses, t_H and t_V respectively, were selected to be representative of austenitic stainless steel plate used in ESBWR steam dryer T-joint design. See Table 5.1. To be representative $t_V \leq t_H$ for all configurations.

b.) Fillet weld sizes "w" were selected that represent the range that would be used for the plate thickness combination. See Table 5.1. Configurations 4s, 5s and 9s were added to simulate conditions where a weld size reduction factor would be needed (see 5.3 below for more information). The "s" in 4s indicates small weld size. These small welds are fictitious since the ESBWR steam dryer would not contain small welds for structural purposes.

c.) Horizontal plate length "b" [[

]].

d.) Vertical plate height "h" was set equal to "b".

e.) The NRC Staff stated GEH may use a T connection assuming infinite length and reduce the model to 2-D model elements, [[

]]. For additional information on ESBWR steam dryer plate section thickness see the section 7 response to comment 6.

Table 5.1: Model and Weld Dimensions (inches)

[[

]]

f.) T-Joint models were created similar to the sketch in Figure 5.1a for selected plate dimensions and weld size shown in Table 5.1. Since the global steam dryer FEM uses [[ ]] (ref. 3), the T-joint models were created using the same element types. This particular element type is advantageous for [[

]] at each node.

[[

]]

Figure 5.1a: Shell model for T-joint representative of Figure 4.0

g.) Nominal [[

]]. Models were created with the following mesh sizes; see Figure 5.1b:

[[

]]

For additional information on ESBWR mesh size selection see section 7 responses to comments 2 and 3.

[[

]]

Figure 5.1b: Shell models for T-joints arranged according to mesh density (from left to right: [[ ]])

h.) Three (3) load cases were evaluated. For additional information on the loading magnitudes selected see section 7 response to comment 1.

1.) F_X = [[ ]]

2.) F_Z = [[ ]]

3.) Forces F_X and F_Z were simultaneously applied parallel and perpendicular to the free end of the vertical plate, see Figure 5.1c

[[

]]

Figure 5.1c: ANSYS model showing boundary conditions and loading applications.

5.2 ANALYSIS PROCEDURE – METHOD 1

[[ ]].

a.) For a given model, the element from the peak (highest) stress was selected.

- For the [[

  ]].
- For the [[

  ]].
- For the [[
  ]] as shown in Figure 5.2a.
- For the [[
  ]].

[[

]

Figure 5.2a: [[ ]]

b.) The forces and moments along the element were obtained. For example, for Configuration 1, [[

]]

[[

]] of the vertical element.

The element location and loading [[

]].

c.) The stress was determined using the forces and moments obtained by the [[

]]. This particular example provides forces and moments in all directions, see Figure 5.2b.

[[

]]

Figure 5.2b: Coordinate system for weld analysis, [[
]]

[[

]]

d.) The [[ ]] was multiplied by the FSRF = 4.

The example provided above is for a 2" mesh using combined load case. See Tables 5.5.1a through 5.5.1c for all mesh sizes, load cases and configurations.

5.3 ANALYSIS PROCEDURE – METHOD 2

FEA results from shell model

a.) For a given model, the [[ ]].

b.) In addition, the [[

]].

5.4 ANALYSIS PROCEDURE – TRADITIONAL

Hand calculations using loads applied to T-joint structure.

a.) A given loading is selected. For example under the combined loading configuration, [[ ]].

b.) Assume [[ ]].

c.) Using classical equations the [[ ]].

[[

]]

d.) The [[ ]] was multiplied by the FSRF = 4.

5.5 ANALYSIS RESULTS

5.5.1 STRESS

The [[

]] in these results.

VERTICAL FORCE ONLY

The highest stress is shown below using each of the methods, configurations and mesh sizes. In all cases the [[
]]

Table 5.5.1a: Stress results (psi) using F_V

[[

]]

Nomenclature Legend:
Config. = Configuration
M(x)y, [[ ]].
Trad. = Traditional weld stress analysis method using [[
]]
properties.

Configurations 1, 2, and 3 have the [[

]].

Classical [[

]]

As shown in Figure 5.5.1a, Method 1 stress is [[

]]

Similar to a structural attachment [[

]] weld stress results, see Figure 5.5.1b.

HORIZONTAL FORCE ONLY

The highest stress is shown below using each of the methods, configurations and mesh sizes. In all cases the [[ ]] in section 5.2a above.

Table 5.5.1b: Stress results (psi) using F_H

[[

]]

Nomenclature Legend:
Config. = Configuration
M(x)y, [[ ]].
Trad. = Traditional weld stress analysis method using [[

]]

properties.

Configurations 2, 3, 4, and 6 have the [[

]] as shown in Figure 5.5.1c.

[[

]]

The [[

]]

The traditional weld [[

]] Method 1 results.

VERTICAL AND HORIZONTAL FORCE COMBINED

The highest stress is shown below using each of the methods, configurations and mesh sizes. In all cases the [[ ]].

Table 5.5.1c: Stress results (psi) using $F_V + F_H$

[[

]]

Nomenclature Legend:
Config. = Configuration
M(x)y, [[ ]].
Trad. = Traditional weld stress analysis method using [[

]]

properties.

The moment in the [[

]] case.

Configurations 2, 3, 4, and 6 have the [[

]] and shown in Figure 5.5.1d.

F_V and F_H applied to a [[

]] to Table 5.5.1c for comparison to the shell model results for method 2 and are shown in Figure 5.5.1d.

The [[

]]

The traditional [[

]] Method 1 results.

For additional information with respect to method 2 results higher than method 1 see section 7 response to comment 5.

[[

]]

Nomenclature Legend: See Table 5.5.1a.

Figure 5.5.1a: Stress Results Comparing Method 1 and 2 with F_V Applied

[[

]]

Nomenclature Legend: See Table 5.5.1a.

Figure 5.5.1b: Stress Results Comparing Method 1 and Traditional Weld Stress Method with F_V Applied, Method 1's Horizontal Plate Bending Stresses Removed

[[

]]

Nomenclature Legend: See Table 5.5.1b

Figure 5.5.1c: Stress Results Comparing Method 1 and 2 with F_H Applied

[[

]]

Nomenclature Legend: See Table 5.5.1c.

Figure 5.5.1d: Stress Results Comparing Method 1 and 2 with $F_V + F_H$ Applied

5.5.2 CONVERGENCE

Convergence results are shown in Table 5.5.2 as percent change between stress values determined for incremental mesh sizes. All stress values are shown to [[ ]].

Table 5.5.2: Method 1 and Method 2 Convergence of Stress Values

[[

]]

5.5.3 WELD SIZE REDUCTION FACTOR

The results of three (3) select cases from Table 5.1 are shown below.

VERTICAL FORCES ONLY

The highest stress is shown below using each of the methods, configurations and mesh sizes. In all cases the [[
]].

Table 5.5.3a: Stress results (psi) using F_V

[[
]]

Nomenclature Legend:
Config. = Configuration
M(x)yz, [[
]].
Trad. = Traditional weld stress analysis method using [[
]] properties.

Configurations 4 and 5 have the [[
]].

Classical [[
]].

As shown in Figure 5.5.3a, Method 1 stress is [[
]].

Similar to a structural attachment [[

]] weld stress results, although much less than Method 2 stress results. See Figure 5.5.3b.

HORIZONTAL FORCE ONLY

The highest stress is shown below using each of the methods, configurations and mesh sizes. In all cases the [[ ]] in section 5.2a above.

Table 5.5.3b: Stress results (psi) using F_H

[[

]]

Nomenclature Legend:
Config. = Configuration
M(x)yz, [[
]].
Trad. = Traditional weld stress analysis method using [[

]] properties.

[[

]]

The [[

]].

The traditional [[
]].

VERTICAL AND HORIZONTAL FORCE COMBINED

The highest stress is shown below using each of the methods, configurations and mesh sizes. In all cases the [[ ]].

Table 5.5.3c: Stress results (psi) using $F_V + F_H$

[[

]]

Nomenclature Legend:
Config. = Configuration
M(x)yz, [[
]].
Trad. = Traditional weld stress analysis method using [[

]] properties.

The moment in the [[
]] case.

F_V and F_H applied to a [[

]] to Table 5.5.3c for comparison to the shell model results for method 2 and are shown in Figure 5.5.3d.

The [[
]].

The traditional [[
]].

[[

]]

Figure 5.5.3a: Stress Results Comparing Method 1 and 2 + WR factor with F_V Applied

[[

]]

Figure 5.5.3b: Stress Results Comparing Method 1 and Traditional Weld Stress Method with F_V Applied, Method 1's Horizontal Plate Bending Stresses Removed

[[

]]

Figure 5.5.3c: Stress Results Comparing Method 1 and 2 + WR factor with F_H Applied

[[

]]

Figure 5.5.3d: Stress Results Comparing Method 1 and 2 + WR factor with $F_V + F_H$ Applied

6.0 CONCLUSIONS

a.) For vertical loading (see figure 4.0), the shell model predicts the highest stress location [[

]] load.

b.) When selecting an element that represents a groove weld butt joint, obtaining the [[

]].

c.) Method 1 obtained the [[

]] stress is conservative for this model.

d.) For horizontal loading, the shell model [[

]] load.

e.) The traditional weld [[

]].

f.) The Method 1's [[

]] bending for weld sizes for a given plate sizes typically found in ESBWR steam dryers.

g.) Method 1's [[

]] weld stress results.

h.) Method 2, using typical ESBWR steam dryer weld size for a given plate size, is appropriate for [[

]] than method 1.

i.) The convergence of the stress results using [[
]] that the models behave as expected under the unit applied loadings.

7.0 RESPONSES TO COMMENTS FROM NRC STAFF

In a teleconference November 14, 2012, the NRC Staff provided 6 comments. The comments are shown below in *italics* with the GEH response below each comment.

1. *The stress in the vertical member at the weld produced by the vertical force of* [[

]]. *Please explain why.*

As stated in the response section 6.h, the [[

]] in this study.

2. *In the first round of comments, on the initial draft response, the staff noted that the mesh refinement study needed to include meshes that are* [[

]] *is*

representative of actual production analyses. Explain why a more suitable distribution of meshes, that bracket typical production analysis meshes, was not implemented in the revised response.

Based on the convergence results in Section 5.5.2, the mesh sizes were suitable for this study. The initial mesh sizes of [[

]] mesh was already being used.

3. *From the results presented in the revised response to RAI 3.9-285, it appears that* [[
]]. *With respect to steam dryer analyses previously performed, please explain the process for selecting element size, assessing stress convergence, and for determining the corresponding stress bias error.*

The process for selecting element size, assessing stress convergence, and for determining the corresponding stress bias error is described in NEDE-33313P-A ESBWR steam dryer structural analysis methodology Section 5.1 (ref. 2) as follows:

[[

]]

This process was used in the previous analysis on a BWR/6 replacement steam dryer and a BWR/4 replacement steam dryer.

4. *Quote from response page 8 of response section 5.2 Analysis Procedure Method 1. The calculated maximum show stresses including edge effects. The staff intent in requesting this study was to simplify problem so a direct comparison to a strength of materials approach could be made. Therefore, inclusion of edge effects is not appropriate. Response states:*
   "The element location and loading [[

   ]]."

   Comment: It appears that for the case of horizontal loading by itself, there is no edge effect, and this case represents best comparison to strength of materials calculation. Please confirm this, or clarify the above quote.

For the horizontal load case, the loads other than [[

]] close to the edge.

5. *The detailed tabulated results are still being evaluated. From the horizontal force only (table 5.5.1B) results, there appears to be [[*

   ]]. Additional staff questions may be forthcoming after complete review of the data provided in the revised response.

(a) NRC Staff Statement: "From the horizontal force only (table 5.5.1B) results, there appears to be a [[

]]

See Figure 5.5.1c.

6. *Are there any locations where welded plates have different thicknesses?*

Steam dryer weld joint locations where plates may have different thicknesses are locations using T-joints, corner joints and lap joints, but not locations using butt joints. Examples of fillet weld T-joints with different thicknesses are shown in the response Table 5.1 above.

ESBWR Licensing Basis Impact

ESBWR DCD Revision 9 Impact:

The following changes will be made to 26A6642AK, Section 3.9 of the ESBWR DCD:

Section 3.9.2.3, change "peak component stress" to "highest component stress", one place.

Section 3.9.2.3, change "peak stress" to "highest stress", three places.

The following changes will be made to 26A6642AN, Appendix 3L of ESBWR DCD:

Section 3L.3.3, change “peak stress” to “highest stress”, one place.

Section 3L.5.2, change “peak stresses” to “highest stresses”, two places.

Section 3L.5.5.2.1, change “peak stress” to “highest stress”, two places.

Section 3L.5.5.2.2, change “peak stress” to “highest stress”, one place.

Engineering Report Impact:

The following changes will be made to NEDE-33313P-A (ref. 2).

Section 4.1, 2nd paragraph, change “peak stress” to “highest stress”, two places.

Section 4.1, 3rd paragraph, change “peak stress” to “highest stress”, one place.

Section 4.1, 7th paragraph:

FROM:
The [[

]]

TO:
A [[

]]

Section 4.1, 8th paragraph, item A:

FROM:

- [[ ]]

TO:

- [[ ]]

Section 4.1, 9th paragraph, change “peak stress” to “highest stress”, two places.

Section 4.1 10th paragraph:

FROM:

[[ ]]

TO:

[[ ]]

Section 4.1, 11th paragraph, change “peak stress” to “highest stress”, one place.

Section 4.1, 13th paragraph, change “peak stress” to “highest stress”, one place.

Figure 4.1, change “peak stress” to “highest stress”, one place.

Section 5.1, change “peak stress” to “highest stress”, one place.

Section 5.2.2, change “peak stress” to “highest stress”, three places.

Section 5.2.4, change “peak stress” to “highest stress”, 21 places.

Section 5.2.4, change “peak stresses” to “highest stresses”, two places.

Section 9.1, change “peak stress location” to “highest stress location”, one place.

Section 9.2, change “peak stress” to “highest stress”, nine places.

Section 9.2, change “peak alternating stress” to “highest alternating stress”, one place.

Enclosure 4

MFN 12-077, Revision 2

GEH Final Response to RAI 3.9-286

Non-Proprietary Version

This is a non-proprietary version of Enclosure 2, from which the proprietary information has been removed. Portions of the document that have been removed are identified by white space within double brackets, as shown here [[ ]].

NRC RAI 3.9-286

Summary: The staff's question is in regard to developing alternating peak stress intensity predictions using the solid element submodel approach for a representative set of cases, and to compare the results with the corresponding method (1) and method (2) results.

During the audit, the staff and GEH also discussed the solid element submodel approach identified in Section 4.1 and Figure 4-1 of Reference 1, for predicting the alternating peak stress intensity for the fatigue evaluation of fillet welds. This method is applied when [[
]] *(top of page 6 of 37).*

In prior RAI responses, GEH has stated that the submodel approach is used when [[
]], *and that the submodel approach leads to reduced stresses. The staff inquired how many submodels are typically developed. GEH indicated that for GGNS, there are* [[ ]] *developed. Alternating peak stress intensity at all other locations are based on the shell model results. In a solid element submodel, the fillet is added. The fillet representation in the submodel is textbook – triangular with the design leg length. While multiple solid elements are used* [[
]]. *As stated in Reference 1, top of page 6 of 37, "...,* [[

]]*."*

As an adjunct to the parametric study comparing methods (1) and (2) for shell models (see Question 4), the staff requests GEH to develop alternating peak stress intensity predictions using the solid element submodel approach for a representative set of cases, and to compare the results with the corresponding method (1) and method (2) results. Include one example calculation that demonstrates the procedure defined in the statement quoted in the preceding paragraph.

GEH Response

1.0 REFERENCES

1.) Letter from Richard E. Kingston, (GEH), to NRC, "Response to Portion of NRC RAI Letter No. 339 Related to ESBWR Design Certification Application - DCD Tier 2, Section 3.9 - Mechanical Systems and Components; RAI Numbers 3.9-215 S01 Parts A, B, C & D (revised) and 3.9-244 S01 (revised)," July 10, 2009 (ADAMS Accession No. ML091950502).

2.) NEDE-33313P-A rev. 2, "ESBWR Steam Dryer Structural Evaluation", October 2010. Note: This report is being revised.

3.) ANSYS Release 11.0, ANSYS Incorporated.

2.0 SUMMARY

For this T-joint weld stress study, comparing Methods 1, 2 and 3, Method 2 with [[ ]] with LTR 33313P-A (ref. 2) section 4.1.

3.0 BACKGROUND

The discussion about submodels during the 2012 NRC staff audit was with respect to RAI 3.9-215S01 Part B (ref. 1). In the RAI 3.9-215S01 response, GEH stated relatively few fillet weld regions needed [[ ]]. For additional information on solid model application see section 7 response to comment 2.

NEDE-33313P-A (ref. 2) states if the [[ ]].

The Staff member requested background on GEH's three (3) approaches to determining stress in steam dryer welds. These (3) approaches are described in GEH's response to RAI 3.9-215S01 Part B (ref. 1):

1) [[ ]], the SCF of 4 is applied [[ ]].
2) [[ ]], the SCF of 1.8 is applied [[ ]].
3) [[ ]] the SCF of 1.8 is applied [[ ]].

These approaches were previously accepted by the NRC Staff as documented in NEDE-33313P-A. To provide information to establish validity of Method 3, the NRC Staff requested GEH to perform additional analyses.

4.0 <u>ANALYSIS INPUT</u>

A typical double sided fillet welded T-joint used for ESBWR steam dryer design is shown in Figure 4.0 (same as in GEH response to RAI 3.9-285), an ASME B&PV Code Section III NG-3352 Type V weld joint.

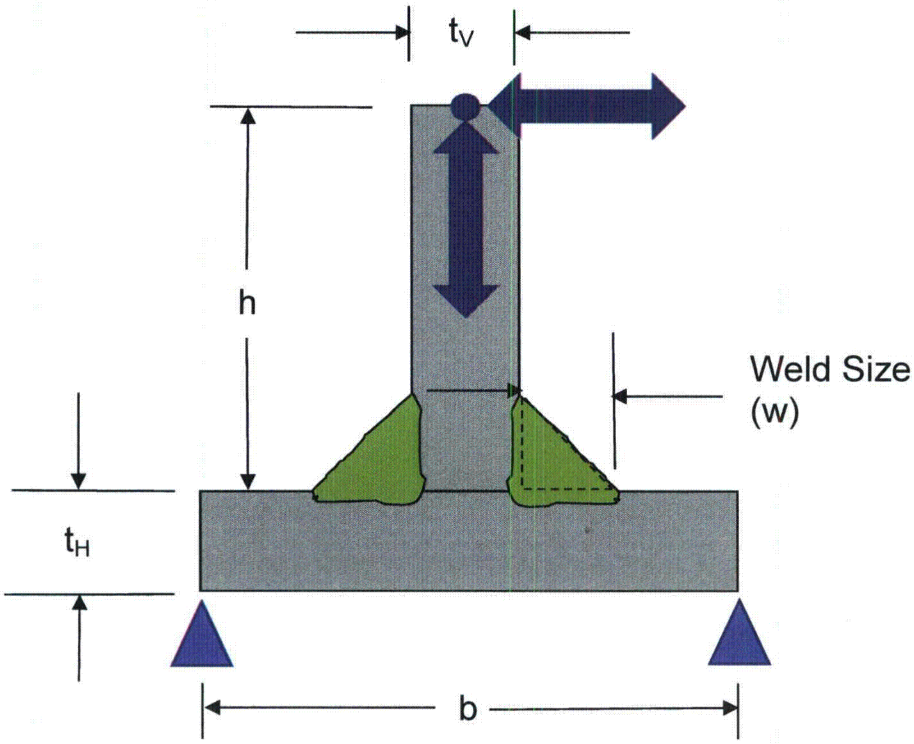

Figure 4.0: Double sided fillet welded T-joint with nomenclature for analyses

The typical T-joint shown in Figure 4.0 is made up of a horizontal continuous member and a vertical stem member.

5.0 <u>ANALYSIS</u>

5.1 SET-UP

The following conditions were set up for the analysis:

a.) [[ ]].
The 3 configurations specify horizontal plate thickness, vertical plate thickness, and weld fillet sizes (t_H, t_V and w respectively) to be representative of austenitic stainless steel plate used in ESBWR steam dryer T-joint design. See Table 5.1.

Table 5.1: Model Dimensions (inches)

[[

]]

b.) Horizontal plate length "b" [[

]].

c.) Vertical plate height "h", and joint length "l" was set equal to "b".

d.) Solid models were created using [[

]] problems. For additional information on solid model mesh size application see section 7 responses to comment 4 and 5. For additional information on a fillet weld's connection at the intersection of two plates see section 7 response to comment 6.

e.) Three (3) load cases were evaluated. See Figure 5.1a.

1) F_X = [[ ]]
2) F_Z = [[ ]]
3) Forces F_X and F_Z were simultaneously applied parallel and perpendicular to the free end of the vertical plate.

[[

]]

Figure 5.1a: Solid model for T-joint representative of Figure 4.0

[[

]]

Figure 5.1b: Example ANSYS model showing boundary conditions and load application

5.2 ANALYSIS PROCEDURE – METHOD 3

a.) A solid model configuration and loading condition were selected.

b.) From the [[
]] was located.

c.) Within the solid model, [[
]]. (See Figure 5.2a).

[[

]]

Figure 5.2a: [[ ]]
weld size.

For the [[

]]. For additional information see section 7 response to comment 3.

[[

]]

Figure 5.2b: Configuration 8, [[ ]] in the weld region

d.) The [[ ]] were defined.

e.) Using the [[

]] see section 7 responses to comment 7 and 9.

[[

]]

Figure 5.2c: [[
]] mesh

f.) The [[
]].

g.) These steps were repeated for each configuration and loading condition.

h.) In addition, for comparison, the [[

]]. For additional information on application of SCF see section 7 response for comment 8.

5.3 ANALYSIS RESULTS

Stress results for solid and shell models using Method 3 are compared to the Method 1 and 2 results (from RAI 3.9-285 response Tables 5.5.1a through 5.5.1c).

5.3.1 SHELL MAXIMUM STRESS VS SOLID MODEL STRESS [[
]].

The Method 2's 2" shell model maximum stress is provided in Table 5.3.1a through Table 5.3.1c along with [[

]] for Method 1.

For this T-joint study, among all loadings, configurations, and mesh sizes, the Method 2 weld stress was [[ ]].

VERTICAL FORCE ONLY

Table 5.3.1a: Stress results (psi) using F_V [[ ]] in both models

[[ ]]

Nomenclature Legend:
M(x)y, where x = method (1, 2 or 3), [[ ]]

The Method 3 stress result's range, [[ ]].

As can be observed in Table 5.3.1a and Figure 5.3.1a, the Method 1 approach, where [[ ]] the stress.

Method 2 stress results, for [[ ]] results.

HORIZONTAL FORCE ONLY

Table 5.3.1b: Stress results (psi) using F_H [[ ]] in both models.

[[ ]]

Nomenclature Legend:
M(x)yz, where x = method (1, 2 or 3), [[ ]].

The Method 3 stress result's range, [[ ]].

As can be observed in Table 5.3.1b and Figure 5.3.1b, Method 2 stress results, [[ ]] configurations.

VERTICAL AND HORIZONTAL FORCE COMBINED

Table 5.3.1c: Stress results (psi) using $F_V + F_H$ [[ ]] in both models

[[ ]]

Nomenclature Legend:
M(x)yz, where x = method (1, 2 or 3), [[ ]].

The Method 3 stress result's range, [[

]].

As can be observed in Table 5.3.1c and Figure 5.3.1c, Method 2 stress results, [[

]] configurations.

[[

]]

Figure 5.3.1a: Comparing stress results for all Methods from F_V applied, [[
]]

[[

]]

Figure 5.3.1b: Stress Results Comparing Methods 1, 2 and 3 with F_H applied, [[
]]

[[

]]

Figure 5.3.1c: Stress Results Comparing Methods 1, 2 and 3 with F_v+F_H applied, [[
]].

5.3.2 SHELL MAXIMUM STRESS VS SOLID MODEL [[ ]]

The Method 2 shell model [[

]] forces and moments.

VERTICAL FORCE ONLY

Table 5.3.2a: Stress results (psi) using F_V, Method 3 and Method 2

[[

]]

Table 5.3.2b: Stress results (psi) using F_V, Method 1 and Traditional

[[

]]

Nomenclature Legend:
M(x)y, where x = method (1, 2 or 3), [[

]].

The Method 3 stress result's range, [[

]]

As can be observed in Table 5.3.2b, and Figure 5.3.2b, the Method 1 approach, [[

]] the stress.

Method 2 stress results, [[ ]] results.

HORIZONTAL FORCE ONLY

Table 5.3.2c: Maximum stress results (psi) using F_H, Method 3 and Method 2

[[

]]

Table 5.3.2d: Maximum stress results (psi) using F_H, Method 1 and Traditional

[[

]]

Nomenclature Legend:
M(x)yz, where x = method (1, 2 or 3), [[

]].

The Method 3 stress result's range, [[

]].

As can be observed in Table 5.3.2c, and Figure 5.3.2c, Method 2 stress results, [[

]] configurations.

VERTICAL AND HORIZONTAL FORCE COMBINED

Table 5.3.2e: Maximum stress results (psi) using $F_V + F_H$, Method 3 and Method 2

[[

]]

Table 5.3.2f: Maximum stress results (psi) using $F_V + F_H$, Method 1 and Traditional

[[

]]

Nomenclature Legend:
M(x)yz, where x = method (1, 2 or 3), [[

]].

The Method 3 stress result's range, [[

]].

As can be observed in Table 5.3.2e, and Figure 5.3.2d, Method 2 stress results, [[

]] configurations.

[[

]]

Figure 5.3.2a: Stress Results Comparing Methods 1, 2 and 3 for F_V Applied

[[

]]

Figure 5.3.2b: Finer Mesh Stress Results Comparing Method 1 with Selected Loads Removed with Methods 2 and 3 for F_V Applied

[[

]]

Figure 5.3.2c: Stress Results Comparing Methods 1, 2 and 3 for F_H Applied

[[

]]

Figure 5.3.2d: Stress Results Comparing Methods 1, 2 and 3 for F_V+F_H Applied

5.3.3 CONVERGENCE

Convergence results are shown below in Tables 5.3.3a and 5.3.3b as percent change between stress values determined for two mesh sizes.

Table 5.3.3a: Method 3 Convergence of Results for Tables in Section 5.3.1

[[

]]

Table 5.3.3b: Method 3 Convergence of Results for Tables in Section 5.3.2

[[

]]

The [[

]].

The stress [[ ]] mesh size.

6.0 <u>CONCLUSIONS</u>

a.) Weld stress results using [[ ]] weld stress results.

b.) The Traditional [[ ]].

c.) Although the [[ ]] stress results.

d.) Method 2 provides a [[ ]] is necessary.

7.0 <u>RESPONSES TO COMMENTS FROM NRC STAFF</u>

In a teleconference November 14, 2012, the NRC Staff provided 9 comments. The comments are shown below in *italics* with the GEH response below each comment.

1. Quoting page 2 of response, "*The Staff member requested background on GEH's three (3) approaches to determining stress in steam dryer welds. These approaches are described in GEH's response to RAI 3.9-215S01 Part B:*

   1) [[ ]], *the SCF of 4 is applied* [[ ]].

   2) [[ ]], *the SCF of 1.8 is applied* [[ ]].

   3) [[ ]], *the SCF of 1.8 is applied* [[ ]].

   These approaches were previously accepted by the NRC Staff as documented in NEDE-33313P-A. <u>*To provide information to conclude that*</u> [[

]] *the NRC Staff requested GEH to perform additional analyses."*

The underlined sentence above is not the intent of RAI 3.9-286. The intent is to establish technical validity of [[

]]. *The staff has identified a number of areas, for which that enhanced basis is being reevaluated, to ensure a safe design. This includes calculation of alternating peak stress intensities for fatigue analysis.*

Response has been reworded. See section 3.0 above.

2. *Quoting from page 2 under Section 3.0 background:*
   "The discussion about submodels during the 2012 NRC staff audit was with respect to RAI 3.9-215S01 Part B (ref. 1). In the RAI 3.9-215S01 response, GEH stated relatively few places needed the application of [[
   ]]."

   Explain the meaning of "relatively few places needed the application of [[.

   ]] *were calculated? Provide the approximate number in each of the (3) categories.*

The statement [[

]]. The sentence has been reworded, see response section 3.0 above. Since a [[

]] applied in completing a steam dryer structural analysis.

3. *Quoting from page 7 very top of page:*
   "For the [[

   ]]."

   The staff notes that it left the selection of mesh sizes up to applicant. The stress results do not appear to be [[

]] *change in the predicted stress.*

GEH agrees [[

]].

Table 7.3 Stress for Configuration 10 (combined load) [[ ]]

[[

]]

4. *How do the mesh sizes used in this current study compare to actual solid element meshes used in production analyses? If they differ, provide an explanation. Was solution convergence with mesh size studied in the production analyses?*

There are [[

]]

steam dryers will be applied.

[[

]]

Figure 7.4: Contours of highest stress showing [[ ]] replacement steam dryer

5. *To what extent does the thickness of the vertical (loaded) member control the solid element mesh size? Is there a minimum number of solid elements specified to simulate shell bending?*

For using [[ ]] to simulate shell bending.

Table 7.5 Stress comparison of a [[ ]]

[[

]]

In the three geometry configurations (8, 9 and 10), the [[

]].

6. *In a solid element submodel, the fillet welds are discretely modeled and provide connectivity between vertical member and horizontal member. The nodes at the lower end of the vertical member and the corresponding nodes on the top surface of the horizontal member should not be connected in the analysis. Please confirm that the solid element submodels used in this study and in previous production analyses incorporate proper modeling of the filet weld joints. If not, provide a detailed technical basis why the results are acceptable, or reanalyze to correct the modeling error.*

It is confirmed that the solid element models used in this study have the nodes connected correctly for the parallel fillet weld configurations, i.e. the nodes at the lower end of the vertical member and the corresponding nodes on the top surface of the horizontal member are not connected.

In the production analyses of the steam dryer it is confirmed that the elements are attached to one another correctly as well. Furthermore, there is no parallel fillet weld configuration in the current steam dryer design.

7. *Quoting page 7 of response, last sentence "Using the* [[ ]] *to that shown in Figure 5.2c". In Figure 5.2c identify the stressed component being plotted. How many stressed components are* [[ ]].

(a) *In Figure 5.2c identify the stressed [[ ]].*

[[ ]]

(b) [[ ]]?

[[ ]]

(c) [[ ]]?

[[ ]]

(c) [[ ]].

[[ ]] reaches minimum.

8. *Would the "membrane" times a SCF=4.0 be comparable to method 1 using the shell model? If not, explain the difference.*

The 'membrane' stress intensity [[ ]], as shown in the table below.

Table 7.8: Comparison of the [[ ]]

[[ ]]

The 'membrane' stress intensity and the 'stress by method 1' are two different concepts.

(a) In the [[ ]].

(b) [[ ]] applied on the weld.

9. Provide a curve similar to figure 5.2c for the [[ ]].

A plot of [[

]] as in Figure 5.2C.

[[

]]

Figure 7.9: [[

]]

ESBWR Licensing Basis Impact

No change is proposed for the DCD or referenced Engineering Reports.