HITACHI

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.

GE Hitachi Nuclear Energy

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MFN 12-049

Docket number: 05200010

June 25, 2012

Attn: David Misenhimer
US Nuclear Regulatory Commission
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 – Draft Response for RAI 3.9-278**

Reference:

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

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 5200010, please find attached the draft response for RAI 3.9-278.

Enclosure 1 contains the complete draft response, 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, should be protected accordingly.

Enclosure 2 contains the draft response with the proprietary information redacted, and is acceptable for public release. Enclosure 3 provides an affidavit which sets forth the basis for requesting that Enclosure 1 be withheld from the public.

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

Sincerely,

Jerald G. Head
Senior Vice President, Regulatory Affairs

Commitments: No commitments are made.

Enclosures:

1. Draft Response to RAI 3.9-278 – Proprietary version
2. Draft Response to RAI 3.9-278 – Non-Proprietary version
3. Affidavit for MFN 12-049

cc: Glen Watford, GEH
Peter Yandow, GEH
Patricia Campbell, GEH
Mark Colby, GEH
Scott Bowman, GEH
Draft eDRF Section 0000-0148-6724

Enclosure 2

MFN 12-049

Draft Response for RAI 3.9-278

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 [[ ]].

DRAFT RESPONSE FOR REVIEW

NRC RAI 3.9-278

Summary: The staff's question is in regard to describing the potential for loose parts resulting from the failure of welds.

GEH is requested to discuss the potential for loose parts resulting from the failure of welds (such as partial penetration welds). GEH is requested to discuss the design criterion that the steam dryer must retain its structural integrity without the generation of loose parts in the reactor coolant and main steam systems. GEH is requested to discuss this design criterion in comparison to its evaluation of the report dated January 24, 2012, reviewed during the audit.

GEH Response

NRC staff members reviewed GEH internal documentation (i.e., the report dated January 2012) related to Partial Joint Penetration (PJP) groove welds during the March 21 – 23 audit. NRC staff members reviewed this documentation again during an inspection of the Economic Simplified Boiling Water Reactor (ESBWR), conducted at the GEH facility in Wilmington, NC, on April 16 – 17, 2012. During the inspection, NRC staff identified three concerns that were captured by GEH for corrective action. Some of the information from the GEH corrective action response has been incorporated [1]. Discussions with the NRC staff did not identify any new technical concerns, but were limited to the adequacy of the documentation that was reviewed.

In the response to RAI 3.9-277 (and earlier, in the response to RAI 3.9-214 S02) GEH explains that it intends to eliminate the application of PJP welds in the design of the ESBWR steam dryer. On this basis, a hypothetical failure of a steam dryer PJP weld is not likely to pose a concern for the ESBWR steam dryer. However, this response discusses steam dryer PJP groove welds and loose parts in general (i.e., in the context of the January 2012 report reviewed by the staff).

1. Operating Experience Summary

Steam dryer Operating Experience (OE) is relevant to the discussion of potential loose parts resulting from the failure of welds. GEH steam dryer designs and design practices have remained relatively consistent over the years and PJP welds have never been prohibited (as well as fillet welds, intermittent welds, and other types of welded joints that could be considered to have reduced strength in comparison to a full penetration groove weld). Furthermore, the Quad Cities and Dresden events are the only known instances of steam dryer fatigue cracking and degradation that resulted in the generation of loose parts within a reactor. Other than these events, which had some unique assignable causes, OE demonstrates that GEH steam dryer designs are able to perform adequately and have a low potential for creating loose parts.

1.1 The Quad Cities and Dresden Failures

The operational history of BWRs has identified three instances in two sister plants where the presence of a significant resonance peak associated with the acoustic loads at Extended Power Uprate (EPU) conditions, in combination with the steam dryer structural design, resulted in significant structural failures and the generation of loose parts. In the first occurrence, continued operation post failure resulted in the generation of a loose part that was transported to the main steamline (MSL). The confluence of several key factors led to the outer hood failures experienced at Quad Cities and the fatigue cracking experienced at Dresden:

- The BWR/3 square hood dryer (bank) design used in the Quad Cities and Dresden units was vulnerable to high pressure loads. The hood panels are supported only on the periphery, resulting in long unsupported spans. The long unsupported hood panels made the hood susceptible to pressure loading at low frequencies. In addition, gusset plates for internal diagonal hood braces were used in the interior corner between the vertical hood panel and the top panel. The corners of these gusset plates introduced stress risers in the hood panels where the fatigue cracks initiated.
- The MSL flow velocities, which drive the pressure loading on the dryer during normal operation, are approximately 15 % higher at Quad Cities and Dresden than the rest of the BWR fleet.
- A resonance peak was introduced at increased steam flow conditions at the Quad Cities plant and was the result of plant specific geometry in the Safety Relief Valve (SRV) standpipes in the MSL[1]. The SRV acoustic resonance (driven by the vortex shedding phenomenon due to steam flow across the entrance to the SRV standpipe) had matched the cover plate natural frequency, which created excessive vibration and led to a high cycle fatigue failure.

As a result of these failures in 2002 and 2003, the BWR industry has taken actions that provide assurance that this type of event will not occur in the future. Specifically, these actions have included the use of improved steam dryer mechanical designs, the development and qualification of advanced acoustical methods for predicting loads, implementation of detailed structural evaluations, installation and monitoring of instrumentation on MSLs, and rigorous inspection programs for existing and new steam dryers.

From the EPU operating experience at Quad Cities, Dresden, and the remainder of the BWR fleet, it can be concluded that the EPU steam dryer fatigue cracking experienced at the Quad Cities and Dresden plants was the result of a unique combination of

[1] The Dresden units are virtually identical to Quad Cities with the exception that Dresden did not experience the extreme SRV resonance loads at full power. The Dresden SRV standpipe design is a smaller diameter than the standpipes at Quad Cities and, as a result, the acoustic resonance occurs at lower MSL flow velocities. The plant passes through the SRV resonance before reaching full power.

factors[2]. These factors have not been observed in the rest of the BWR fleet and do not indicate a concern for PJP welds. The combination of improved dryer design, relatively low MSL flow velocities at EPU, and lower potential SRV acoustic resonance loads make significant dryer structural integrity issues unlikely at EPU for the rest of the BWR fleet, even for plants using the original steam dryers. New plants, such as the ESBWR, can take advantage of the lessons learned from Quad Cities and Dresden to design a "quiet plant."

1.2 Power Uprates Approved Prior to the Quad Cities Failures

Almost all of the domestic BWRs have implemented stretch power uprates (~105% of original licensed thermal power). Several plants have implemented EPU in the same time frame as the Quad Cities plants. These plants are listed in Table 1-1. The EPU license amendment submittals were all approved by the NRC prior to the failures observed at Quad Cities.

The plants listed in Table 1-1 all use the original steam dryers. The steam dryer structural evaluations performed in support of the EPU licensing for these plants were limited to demonstrating that the primary stress acceptance criteria were met for normal, upset, and faulted conditions. No detailed plant-specific structural evaluations were performed to assess the potential for fatigue cracking during normal operation at EPU conditions. Minor modifications were made to the Brunswick dryers following the Quad Cities failures; no modifications were made to the dryers for the other plants.

Table 1-1 Steam dryer EPU operating experience – Plants approved prior to Quad Cities

Plant (Dryer Model[3])	Dryer Design	Uprate Information
Monticello (BWR/3)	Original (same design as QC)	106% (1998)
Hatch 1 (BWR/4)	Original Equipment	115% (13% in 1998, 15% in 2003)
Hatch 2 (BWR/5)	Original Equipment	115% (13% in 1998, 15% in 2003)
Duane Arnold (BWR/4)	Original Equipment	120% (2001)
Brunswick 1 & 2 (BWR/4)	Modified (minor)	120% (2002)
Clinton (BWR/6)	Original Equipment	120% (2002), currently operating at 117%
Cofrentes (BWR/6)	Original Equipment	112% (2003)

There have been no fatigue cracking issues reported for the dryers in Table 1-1 that have been attributed to EPU operation. At the Cofrentes plant, fatigue cracks were observed in the attachment welds for the outlet end plate after reaching the current EPU

[2] An unabridged discussion of the Quad Cities and Dresden events is provided in Reference 1.
[3] In general, BWR/3 plants use the square hood design. Similarly, the slant hood design was introduced with the BWR/4, and the curved hood design has been applied in BWR/5 and 6 plants. Note that Hatch 2 is a BWR/4, but has a curved hood steam dryer.

power level; however, cracks in these locations have also been reported in other curved hood dryers operating at Original Licensed Thermal Power (OLTP) and stretch power uprate conditions. This fatigue cracking experience is indicative of a weakness in the design of the outlet end plate attachment for those dryers. The outlet end plate has been redesigned for the replacement steam dryers.

1.3 Post Quad Cities Power Uprates

Following the Quad Cities dryer failures, detailed steam dryer structural evaluations have been required as part of the EPU licensing submittals. In addition to the primary stress evaluations, these plant-specific analyses use measured plant acoustic load data to demonstrate that the dryers have adequate fatigue margin during normal operation at EPU conditions to preclude the type of dryer failure experienced at Quad Cities. The fatigue analysis results must show that there is sufficient structural margin to bound analytical bias errors and uncertainties and demonstrate a substantial margin to the alternating stress limit. The need to be able to explicitly demonstrate this degree of structural margin has resulted in substantial steam dryer modifications (Vermont Yankee, Hope Creek, and Nine Mile Point 2) or dryer replacements (Susquehanna 1 and 2, Monticello, and Grand Gulf). These modifications or replacements make the potential for significant dryer structural integrity issues at EPU conditions even more remote. Table 1-2 provides a summary of relevant OE. There have been no crack indications or concerns related to PJP welds.

Table 1-2 Power uprates approved after December 2001

Plant	Uprate Information	Last Inspection[4]	Comment
Quad Cities 1	17.8% (2001)	[[	
Quad Cities 2	17.8% (2001)		
Dresden 2	17% (2001)		
Dresden 3	17% (2001)		
Vermont Yankee	20% (2006)		
Hope Creek	15% (2008)		
Nine Mile Point 2	15% (2011)		
Susquehanna 1	13% (2008)		
Susquehanna 2	13% (2008)		

[4] Refueling Outage (RFO)

Plant	Uprate Information	Last Inspection[4]	Comment
Monticello	12.9% (TBD)		
Grand Gulf	13.1% July 2012 (planned)		]]

1.4 Susquehanna Specific Experience

On March 7, 2006, an In-Vessel Visual Inspection (IVVI) conducted on the original Susquehanna Steam Electric Station (SSES) Unit 1 steam dryer revealed [[

]] The original Unit 1 dryer had operated for more than 20 years [[

]]

Figure 1-1 also provides an illustration (visualization) of a typical application of a "minor" or secondary weld [6,7,8] in a dryer. [[

]] Considering that ease of manufacturing may be desirable, fillet and PJP welds can be applied to connect small joints where strength is not the primary design consideration; [[

]] In contrast, connections between larger parts or components are typically designed with substantially stronger welds that are intended to bear loads. The use of PJP welds is typically limited to those locations where a full depth weld is not practical (e.g., distortion versus strength requirement) or even possible (geometry considerations are prohibitive), or needed (e.g., welding in a threaded lifting rod or edge weld when butting two dryer vane units together).

[5] For inspection purposes, the dryer banks are labeled A through F, sequentially, starting from one outer hood and ending at the other. Banks C and D are interior banks.
[6] It is not uncommon to classify structures or members according to their application. For example, the Reference 3 guidance for welded connections and structures provides terminology such as "primary" (or fracture critical) and "secondary." A primary structure covers elements whose sole failure would be catastrophic. A secondary structure covers elements whose failure would not lead to catastrophic collapse. The guidance notes that for some structures, failure of a single brace or its end connection is not likely to lead to collapse under normal or even moderately severe loads.
[7] Reference 4 states that primary welds transfer the entire load at the point where it is located and must have the same strength properties as the members (if the weld fails, the member will fail). Secondary welds are those that simply hold the parts together to form a built-up member.
[8] The ASME Boiler and Pressure Vessel Code, Section III, Division I, article NF-1215 contains similar definitions (primary and secondary members).

[[

]]

Figure 1-1 [[ ]] on the 0° side end panel for dryer bank C

Figure 1-2 shows [[

]] In general, PJP welds in steam dryers have been relatively minor from an overall structural strength standpoint and the dryer subcomponents are constrained by other, higher strength welds. As evidenced by Figure 1-1, [[{3}]] failed, loose parts would not have been generated. The major dryer components that have PJP welds (e.g., [[ ]]) do not have high risk of becoming loose parts in the event of cracking and subsequent degradation in the PJP weld areas.

[[

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Figure 1-2 Original SSES steam dryer bank design

As stated earlier, the comparable location [[

]]

2. Summary and Conclusions

The steam dryer does not perform a safety function and is not required to prevent or mitigate the consequences of accidents. Although the steam dryer is not a safety related component, the steam dryer is designed to withstand design basis events without the generation of loose parts. For a potentially degraded steam dryer, the structural integrity is considered to be adequate if the safety consequences of any loose parts that may be generated have been previously analyzed to be acceptable. The ability to shut down the reactor (control rod insertion), provide adequate core cooling, and the ability to isolate the main steamlines must be assured. [[

]] The GEH Failure Modes and Effects Analysis (FMEA) performed after the Quad Cities and Dresden events determined that safe reactor operation will not be compromised by a potentially degraded steam dryer [2]. Regardless, the design objective is to avoid fatigue cracking that would pose a concern for loose parts.

Section 1 provided a discussion of BWR fleet operating experience with a focus on the Quad Cities and Dresden experience. Industry experience with dryer fatigue cracking has demonstrated that specific assignable causes drove the observed failures. These

circumstances are not expected in other plants and not related to the application of PJP welds in steam dryers. Furthermore, based on BWR fleet operating experience, original steam dryer designs are successfully operating at EPU conditions. In summary, a review of BWR fleet experience (lessons learned from Quad Cities and Dresden, power uprated plants using original and replacement dryers, and SSES specific OE) does not indicate that there are general fatigue concerns for PJP welds.

Operating BWR plants have completed a vibratory assessment program in order to demonstrate satisfactory performance under licensed operating conditions. Ongoing inspections (e.g., adherence to BWRVIP guidelines) should be sufficient to manage any steam dryer crack indications that may emerge over time. Similarly, regulatory requirements applied to operating plant changes (e.g., power uprate) or new reactors should be sufficient to prevent any unanticipated consequences due to flow-excited resonances or FIV [5]. In either case (i.e., original equipment or new/replacement dryers), partial penetration welds are not expected to lead to fatigue cracking, degradation, and subsequently generate loose parts.

2.1 Relevance to the ESBWR

As noted in the introduction, the GEH response to RAI 3.9-277 states that GEH intends to eliminate PJP welds in the ESBWR steam dryer design. Based on this, as well as the fact that the design must conform to regulatory requirements and licensing commitments, a hypothetical failure of a steam dryer PJP weld is not likely to pose a concern for the ESBWR.

3. References

1. PRC 11-71 Supplement 1, Class II, June 2012.
2. GENE-0000-0018-1060-R0, *Technical Assessment – Dresden Units 2 and 3, Quad Cities Units 1 and 2 – Failure Modes and Effects Evaluation for Steam Dryer Components*, Class III, June 2003.
3. ANSI/AWS D1:1998, An American National Standard, Structural Welding Code – Steel, 16th Edition.
4. Welding Handbook, 8th Edition, Volume 1, “Welding Technology,” American Welding Society, 550 N.W. LeJeune Road, Miami, FL 33135, Page 163.
5. Regulatory Guide 1.20, *Comprehensive Vibration Assessment Program for Reactor Internals During Preoperational and Initial Startup Testing*, Revision 3, March 2007.

DCD/LTR Changes

No change is proposed for the DCD or referenced License Topical Reports.

Enclosure 3

MFN 12-049

Affidavit

GE-Hitachi Nuclear Energy Americas LLC

AFFIDAVIT

I, **Jerald G. Head**, state as follows:

(1) I am the Senior Vice President, 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 Enclosure 1 of GEH's letter MFN 12-049, Jerald G. Head (GEH) to David Misenhimer (NRC), "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 – Draft Response for RAI 3.9-278," dated June 25, 2012. The GEH proprietary information in Enclosure 1 of MFN 12-049, is identified by a [[dark red font with 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.

(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 25th day of June, 2012.

Jerald G. Head
GE-Hitachi Nuclear Energy Americas LLC