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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 12-043

Docket number: 05200010

September 27, 2012

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 – Draft Response for RAIs 3.9-269 and 3.9-270

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 (RAIs) 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 GEH's draft response for RAIs 3.9-269 and 3.9-270.

Enclosures 1 and 2 contain proprietary information. The proprietary information is contained within brackets [[ ]] and is designated in red font with dotted underline to assist in identification. This RAI contains proprietary information identified by GE Hitachi Nuclear Energy, Americas LLC, and should be protected accordingly.

Enclosure 1 contains the RAIs and the draft, summary combined response. Enclosure 2 contains a detailed combined response in a "white paper" format. 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

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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.

Sincerely,

Jerald G. Head
Senior Vice President, Regulatory Affairs

Commitments: No commitments are made.

Enclosures:
1. Draft Summary Response to RAIs 3.9-269 and 3.9-270 – Proprietary version
2. Draft Detailed Response to RAIs 3.9-269 and 3.9-270 – Proprietary version
3. Draft Summary Response to RAIs 3.9-269 and 3.9-270 – Non-Proprietary version
4. Draft Detailed Response to RAIs 3.9-269 and 3.9-270 – Non-Proprietary version
5. Affidavit for MFN 12-043

cc: David Misenhimer, NRC
Glen Watford, GEH
Peter Yandow, GEH
Patricia Campbell, GEH
Mark Colby, GEH
Scott Bowman, GEH
Tim Enfinger, GEH
eDRF Section 0000-0146-9749

Enclosure 3

MFN 12-043

Draft Summary Response to RAIs 3.9-269 and 3.9-270

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 3.9-269

GEH is requested to submit an end-to-end frequency-dependent steam dryer strain simulation validation using steam dryer loads computed using the GEH Plant-Based Load Evaluation (PBLE) method 1 [[ ]]*, along with described adjustments to the methodology and/or bias and uncertainty to ensure the strain gage spectra for an instrumented steam dryer are bounded.*

Specifically, GEH is requested to plot the upper envelopes of the simulated strain spectra at several locations on a steam dryer (based on calculations spanning [[ ]]*), augmented with PBLE, finite element (FE), and all other bias errors and uncertainties, and show that the measured strain spectra are bounded. The spectra for each time-shifted calculation should be shifted upward and downward in frequency accordingly* [[ ]]*, and an upper bound generated. The upper bound should then be adjusted according to all bias errors and uncertainties and compared to the measurements.*

In the event the strains are not bounded, GEH is requested to provide and describe adjustments in bias error/uncertainty and/or the methodology to ensure they are bounded.

Also, GEH is requested to provide a pictorial set of links between the steam dryer strain gages and all high stress regions to establish the relevance of the benchmark.

Finally, if the steam dryer analysis for the [[ ]] *EPU license amendment is used as the end-to-end platform to support the ESBWR design certification application, GEH should submit the reasons why fatigue cracks occurred near the* [[ ]].

NRC RAI 3.9-270

GEH is requested to submit an updated PBLE method 2 [[ ]] *benchmark that resolves the errors and concerns raised by the NRC regarding the QC2 benchmark (such as* [[ ]]*, geometric modeling errors, and nozzle errors). As part of this submittal, GEH is requested to provide the "Susquehanna* [[ ]] *Summary Statistics using [[ ]]," and GEH Engineering Calculation Sheet DRF 0000-0117-4341R0 (dated September 30, 2010). If the SSES platform is used for this benchmark, GEH should ensure that the nozzle area and other SSES issues are resolved. GEH is requested to provide both* [[ ]] *data, including plots of simulated and measured point pressure spectra.*

DRAFT RESPONSE – FOR REVIEW ONLY

GEH Draft Response

GEH Summary Response

There are two methods used to predict loads for steam dryer Flow Induced Vibration (FIV) analyses as described in References 1 and 2. The Plant-Based Load Evaluation (PBLE) methodology can calculate acoustic loads for the steam dryer using measurements from [[ ]]. In References 1 and 2 these techniques are referred to as [[ ]] methods.

As described in the ESBWR Design Control Document (DCD), Section 3.9.2.3, Tier 2* information (pg. 3.9-17), for the prototype ESBWR steam dryer, [[ ]]. However, during the ESBWR steam dryer initial design phase no on-dryer or MSL-based measurements specific to an ESBWR will be available to the designer. For this reason, on-dryer measurements from existing BWR/ABWRs have been used to develop a conservative load definition for the prototype ESBWR (see References 3 and 4). During startup of the prototype ESBWR, [[ ]]

Results of the initial ESBWR steam dryer prototype testing and subsequent ESBWR steam dryer startup testing will be included in reports of the reactor internals vibration program monitoring as described in NRC Regulatory Guide 1.20, Revision 3.

In the Reference 2 description of the [[ ]] a demonstration of the method was provided and summarized in several tables and figures. The specific biases and uncertainties for [[ ]] data were provided for information and to demonstrate the ability of PBLE Method II to predict steam dryer loading. This demonstration was based on the [[ ]], as well as an acoustic Finite Element (FE) model developed at that time. [[ ]] The biases and uncertainties associated with this benchmark are summarized in Table 10 [[ ]] and Figures 26 and 27 [[ ]] of Reference 2. These support values are associated with [[ ]] and will not be used in the ESBWR dryer design.

The [[ ]] biases and uncertainties will be considered in the initial ESBWR dryer design (i.e., the initial FIV evaluation using the ***design basis loads***) as discussed in Section 4.1 of Reference 3 and Section 5.2.2 of Reference 4[1]. Following this first analysis to support the initial design phase of the ESBWR dryer, these loads will not be used in any further ESBWR steam dryer FIV analyses.

There are two basic questions to be answered in response to RAI 3.9-269 and 3.9-270. For RAI 3.9-270, an alternate demonstration of the [[ ]] benchmark documented in Reference 2. Since these biases and uncertainties will not be used in the ESBWR analyses (i.e., the prototype is based on [[ ]] and while follow-on ESBWR plants will be analyzed using [[ ]], an ESBWR specific [[ ]] and associated biases and uncertainties will be applied) the benchmarks in this response are provided as an alternate demonstration of the capability of [[ ]] to adequately predict steam dryer loads. These alternate benchmarks (Susquehanna, as requested in the RAI, and Grand Gulf Nuclear Station) provide adequate demonstrations of the [[ ]] PBLE load prediction methodology.

For RAI 3.9-269, an independent benchmark is presented in this response using data obtained during the 2012 power ascension program for the Grand Gulf Nuclear Station (GGNS) replacement steam dryer. This demonstration is an independent validation of the PBLE methodology including the application of the FE model biases and uncertainties documented in Reference 2 (based on the Susquehanna benchmark). This demonstration is a form of validation (or "blind test"), since it represents an application of the analysis process that is completely independent of the development cases and related data (i.e., QC2 and SSES replacement dryer benchmarks). The results support several conclusions: (1) that the PBLE acoustic model produces reasonably accurate loads, either driven by [[ ]] when compared with measured data, (2) the structural analysis method (including application of the FE model biases and uncertainties described in Reference 2) results in conservative projections of acceleration and strain when compared to on-dryer measurements, (3) the PBLE method can be used to reproduce (drive) the FIV loads defined in Reference 3 for application to the initial ESBWR dryer design, and (4) the method has been sufficiently benchmarked to support application to the prototype and subsequent ESBWR dryers as described in the ESBWR DCD and the supporting licensing topical reports.

[1] This section of the topical report states [[

]] In this passage, Reference 8 is Letter MFN 09-509 from Richard E. Kingston (GEH) to USNRC Document Control Desk, "Response to Portion of NRC RAI Letter No. 220 and 339 Related to ESBWR Design Certification Application – DCD Tier 2 Section 3.9 – Mechanical Systems and Components; RAI Numbers 3.9-213 and 3.9-217 S01," July 31, 2009, Docket Number 52-010.

References:

1. NEDC-33408P-A, *ESBWR Steam Dryer Plant Based Load Evaluation Methodology*, Revision 1, October 2010.
2. NEDC-33408 Supplement 1P-A, *ESBWR Steam Dryer – Plant Based Load Evaluation Methodology Supplement 1*, Revision 2, October 2010.
3. NEDE-33312P-A, *ESBWR Steam Dryer Acoustic Load Definition*, Revision 2, October 2010.
4. NEDE-33313P-A, *ESBWR Steam Dryer Structural Evaluation*, Revision 2, October 2010.

GEH Detailed Response

GEH believes the most expedient manner to respond to RAIs 3.9-269 and 3.9-270 is as a combined response. Please see Enclosure 2 (proprietary) or Enclosure 4 (public) for the detailed (draft) combined response.

DCD/LTR Changes

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

Enclosure 4

MFN 12-043

Draft Detailed Response to RAIs 3.9-269 and 3.9-270

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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 [[ ]].

GEH

GEH Draft Detailed Response to RAIs 3.9-269 and 270

Draft for Review

Contents

DRAFT RESPONSE – FOR REVIEW ONLY

1 NRC Requests for Additional Information

1.1 Request for Additional Information 3.9-269

GEH is requested to submit an end-to-end frequency-dependent steam dryer strain simulation validation using steam dryer loads computed using the GEH Plant-Based Load Evaluation (PBLE) method 1 [[ ]], along with described adjustments to the methodology and/or bias and uncertainty to ensure the strain gage spectra for an instrumented steam dryer are bounded. Specifically, GEH is requested to plot the upper envelopes of the simulated strain spectra at several locations on a steam dryer (based on calculations spanning [[ ]], augmented with PBLE, finite element (FE), and all other bias errors and uncertainties, and show that the measured strain spectra are bounded. The spectra for each time-shifted calculation should be shifted upward and downward in frequency accordingly [[ ]], and an upper bound generated. The upper bound should then be adjusted according to all bias errors and uncertainties and compared to the measurements. In the event the strains are not bounded, GEH is requested to provide and describe adjustments in bias error/uncertainty and/or the methodology to ensure they are bounded. Also, GEH is requested to provide a pictorial set of links between the steam dryer strain gages and all high stress regions to establish the relevance of the benchmark. Finally, if the steam dryer analysis for the [[ ]] EPU license amendment is used as the end-to-end platform to support the ESBWR design certification application, GEH should submit the [[ ]].

1.2 Request for Additional Information 3.9-270

GEH is requested to submit an updated PBLE method 2 [[ ]] benchmark that resolves the errors and concerns raised by the NRC regarding the QC2 benchmark (such as [[ ]], geometric modeling errors, and nozzle errors). As part of this submittal, GEH is requested to provide the "Susquehanna [[ ]] Summary Statistics using [[ ]]," and GEH Engineering Calculation Sheet DRF 0000-0117-4341R0 (dated September 30, 2010). If the SSES platform is used for this benchmark, GEH should ensure that the nozzle area and other SSES issues are resolved. GEH is requested to provide both [[ ]] data, including plots of simulated and measured point pressure spectra.

2 GEH Response

2.1 Introduction and Summary

There are two methods used to predict loads for steam dryer Flow Induced Vibration (FIV) analyses as described in References 1 and 2. The Plant-Based Load Evaluation (PBLE) methodology can calculate acoustic loads for the steam dryer using measurements from [[ ]]. In References 1 and 2 these techniques are referred to as [[ ]] methods. As

DRAFT RESPONSE – FOR REVIEW ONLY

described in the ESBWR Design Control Document (DCD), Section 3.9.2.3, Tier 2* information (pg. 3.9-17), for the prototype ESBWR steam dryer, [[

]]. However, during the ESBWR steam dryer initial design phase no on-dryer or MSL-based measurements specific to an ESBWR will be available to the designer. For this reason, on-dryer measurements from existing BWR/ABWRs have been used to develop a conservative load definition for the prototype ESBWR (see References 3 and 4). During startup of the prototype ESBWR, [[

]] Results of the initial ESBWR steam dryer prototype testing and subsequent ESBWR steam dryer startup testing will be included in reports of the reactor internals vibration program monitoring as described in NRC Regulatory Guide 1.20, Revision 3.

In the Reference 2 description of the [[ ]] a demonstration of the method was provided and summarized in several tables and figures. The specific biases and uncertainties for [[ ]] data were provided for information and to demonstrate the ability of PBLE Method II to predict steam dryer loading. This demonstration was based on the [[ ]], as well as an acoustic Finite Element (FE) model developed at that time. [[

]] The biases and uncertainties associated with this benchmark are summarized in Table 10 [[ ]] and Figures 26 and 27 [[ ]] of Reference 2. These support values are associated with [[ ]] and will not be used in the ESBWR dryer design.

The [[ ]] biases and uncertainties will be considered in the initial ESBWR dryer design (i.e., the initial FIV evaluation using the ***design basis loads***) as discussed in Section 4.1 of Reference 3 and Section 5.2.2 of Reference 4[1]. Following this first analysis to support the initial design phase of the ESBWR dryer, these loads will not be used in any further ESBWR steam dryer FIV analyses.

There are two basic questions to be answered in response to RAI 3.9-269 and 3.9-270. For RAI 3.9-270, an alternate demonstration of the [[

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[1] This section of the topical report states [[

]] In this passage, Reference 8 is Letter MFN 09-509 from Richard E. Kingston (GEH) to USNRC Document Control Desk, "Response to Portion of NRC RAI Letter No. 220 and 339 Related to ESBWR Design Certification Application – DCD Tier 2 Section 3.9 – Mechanical Systems and Components; RAI Numbers 3.9-213 and 3.9-217 S01," July 31, 2009, Docket Number 52-010.

DRAFT RESPONSE – FOR REVIEW ONLY

]] benchmark documented in Reference 2. Since these biases and uncertainties will not be used in the ESBWR analyses (i.e., the prototype is based on [[ ]] and while follow-on ESBWR plants will be analyzed using [[ ]], an ESBWR specific [[ ]] and associated biases and uncertainties will be applied) the benchmarks in this response are provided as an alternate demonstration of the capability of [[ ]] to adequately predict steam dryer loads. These alternate benchmarks (Susquehanna, as requested in the RAI, and Grand Gulf Nuclear Station) provide adequate demonstrations of the [[ ]] PBLE load prediction methodology.

For RAI 3.9-269, an independent benchmark is presented in this response using data obtained during the 2012 power ascension program for the Grand Gulf Nuclear Station (GGNS) replacement steam dryer. This demonstration is an independent validation of the PBLE methodology including the application of the FE model biases and uncertainties documented in Reference 2 (based on the Susquehanna benchmark). This demonstration is a form of validation (or "blind test"), since it represents an application of the analysis process that is completely independent of the development cases and related data (i.e., QC2 and SSES replacement dryer benchmarks). The results support several conclusions: (1) that the PBLE acoustic model produces reasonably accurate loads, either driven by [[ ]] when compared with measured data, (2) the structural analysis method (including application of the FE model biases and uncertainties described in Reference 2) results in conservative projections of acceleration and strain when compared to on-dryer measurements, (3) the PBLE method can be used to reproduce (drive) the FIV loads defined in Reference 3 for application to the initial ESBWR dryer design, and (4) the method has been sufficiently benchmarked to support application to the prototype and subsequent ESBWR dryers as described in the ESBWR DCD and the supporting licensing topical reports.

2.2 Alternate PBLE Benchmarks (RAI 3.9-270)

Alternate PBLE benchmarks are provided in response to RAI 3.9-270. Specifically, benchmarks are provided for the GGNS 100%B test condition (along with additional test conditions during power ascension), as well as the SSES benchmarks for test condition TC3D.

2.2.1 GGNS Test Condition

A comparison based on measurement data taken from GGNS has been selected to respond to the NRC's request for information. The measurements were taken and comparisons performed as part the GGNS power ascension test program in July 2012. A brief summary of plant conditions are provided in Table 1.

Table 1- GGNS Test Condition Summary (100B)

Parameter	Value
Reactor Power (MWt)	3,890
Dome Pressure (psia)	1,020
MSL Velocity (ft/s)	[[ ]]

DRAFT RESPONSE – FOR REVIEW ONLY

2.2.2 GGNS Acoustic Model and Load Definition

The GGNS acoustic model was applied in conjunction with [[ ]] to define the acoustic loads. The Grand Gulf acoustic FE model was updated as described in Appendix A. The mesh density for the GGNS acoustic FE model satisfies the [[ ]]; and the steamline nozzle area and steamline dimensions are accurately modeled in the analysis. Table 1 in Appendix A provides a summary of the acoustic model changes incorporated into the GGNS FIV reanalysis.

The GGNS Safety Relief Valve (SRV) resonance effects were relatively small at these power levels.

The bias and uncertainty values applied to GGNS reflect application of the [[ ]] The specific bias and uncertainty terms applied to GGNS are identical to those provided in Reference 2 (see footnote 1).

The instrument locations (pressure transducers) are shown in Appendix B.

2.2.3 GGNS [[ ]] Benchmark

Detailed results are presented in Appendix C. Figure 29 through Figure 43 in Appendix C show comparisons between the PBLE predicted pressure loads and the measured Pressure Transducer[2] (PT) responses for each of the on-dryer pressure sensors at test condition 100%B. The plots show a [[ ]] which is most clearly depicted in the bias plots, i.e., Figure 1 [[ ]] and Figure 2 [[

]]

[2] In the figures, the pressure transducer identification numbers are followed by either an "e" for exterior, or an "i" for interior.

DRAFT RESPONSE – FOR REVIEW ONLY

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Figure 1 - PBLE [[ ]]

[[

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Figure 2 - PBLE [[ ]]

DRAFT RESPONSE – FOR REVIEW ONLY

2.2.4 SSES [[ ]] Benchmark

The GGNS [[

]] are shown in Figure 3 and Figure 4. Table 3 – Uncertainty Summary Statistics provides a comparison between [[ ]] for QC2 and SSES for the major components.

Table 2 – SSES and QC2 Bias and Uncertainty Summary Statistics

[[						
						]]

Table 3 – Uncertainty Summary Statistics

[[						

DRAFT RESPONSE – FOR REVIEW ONLY

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DRAFT RESPONSE – FOR REVIEW ONLY

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Figure 3 – [[

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[[

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Figure 4 – [[

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2.2.5 [[ ]] Benchmark Summary

The GGNS and SSES acoustic load comparisons provide an adequate, alternate demonstration of PBLE [[ ]]. The method, together with appropriately defined biases and uncertainties, can be applied to determine acoustic FIV loads on a steam dryer.

2.3 GGNS [[ ]] Benchmark

As noted in Section 2.2.2, the on-dryer instrument locations are presented in Appendix B. This instrument set supported both the [[ ]] power ascension benchmarks for GGNS. For the purpose of this RAI response, it is useful to compare the acoustic loads determined from [[ ]] which give comparable results.

Detailed comparisons are provided in Appendix D. In the appendix, Figure 44 through Figure 58 show comparisons between the PBLE predicted pressure loads and the measured pressures for [[ ]] at test condition 100%B. These comparisons are based on [[ ]] It should be noted that the measured values for [[ ]]

The bias plots (Figure 5 and Figure 6) show the results of comparisons [[ ]]

DRAFT RESPONSE – FOR REVIEW ONLY

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Figure 5 - PBLE [[ ]]

[[

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Figure 6 - PBLE [[ ]]

DRAFT RESPONSE – FOR REVIEW ONLY

2.4 End-to-End Strain and Acceleration Comparisons (RAI 3.9-269)

A comparison based on measurement data taken from GGNS has been selected to respond to the NRC's request for information concerning a validation of the end-to-end strain simulation. The measurements were taken and comparisons performed as part the GGNS power ascension test program in July 2012. Test condition 100%B is selected for this validation.

2.4.1 Acoustic Model and Load Description

The acoustic model used for this simulation has been previously described. The bias and uncertainty values applied to GGNS reflect application of the [[ ]] The specific acoustic model bias and uncertainty terms applied to GGNS are identical to those provided in Reference 2.

2.4.2 On-Dryer Instrument Locations

The on-dryer instrument locations (Appendix B) were selected by using the GGNS model results to determine monitoring locations with good coherence with the high stress regions, as well as a level of redundancy. The instrumentation design objective was to find the "best" locations and avoid displacement nodes for key frequencies (e.g., potential resonance frequencies). The instrumentation locations (including graphics), rationale, and selection process is described in the responses to EMCB-GGNS1-SD-4-RAI-09 and EMCB-GGNS1-SD-6-RAI-9 (provided as Appendix E and Appendix F, respectively). However, it should be noted that there is no truly direct, one-to-one correlation with an on-dryer sensor and any particular high stress location. The dryer structure is a dynamic system. The response at any location generally represents the summation of both the global response and any local effects. Time domain ANSYS results (animations) illustrate this well. As a coupled system, the loading and displacement at any dryer location is directly affected by what is happening on the other side of the dryer. Also, similar to a spring-mass system, the peak stress will occur (in time) when the dryer motion is low and the potential (stored) energy is high; it is highly likely that the sensors will read low (near zero) at the moment of peak stress. This discussion, taken with the recognition that much of the dryer surface is not instrumented, emphasizes the fact the main objective of the global model benchmark is to appropriately characterize the acceleration and displacement of the dryer's major components. Once a good simulation of dryer motion is achieved, the FE model can be relied on to predict alternating stress (everywhere) with good confidence.

2.4.3 Dryer Structural Model Description

During the review of the GGNS Extended Power Uprate (EPU) license amendment application, the NRC staff asked questions concerning the fidelity of the structural model. The NRC's Request for Additional Information (RAI) EMCB-GGNS1-SD-4-RAI-08 (provided as Appendix G of this response) asked GEH to re-verify the structural model due to concerns associated with unconnected nodes, mesh quality and element shapes, as well as present the results of mesh density convergence studies. The response to this RAI was provided in Reference 8. Additional information regarding mesh convergence studies and disconnected nodes was provided in Reference 9, which was a response to EMCB-GGNS1-SD-6-RAI-02 (provided as Appendix H of this response). The FE model bias and uncertainty values applied to GGNS

DRAFT RESPONSE – FOR REVIEW ONLY

are based on the SSES benchmarking documented in Reference 2 (note that the [[

]]). The impact of applying these bias and uncertainty values is accounted for in the comparisons.

2.4.4 Dryer Response Comparisons [[ ]]

For each of the on-dryer instrument locations (accelerometers and strain gages), prior to the startup, the dryer response was predicted using the MSL-based loads using 2008 MSL data at comparable plant conditions. The FE model calculations were also [[

]] The methodology was also applied to all regions of the dryer and peak stresses were predicted for comparison to the fatigue limit. Knowing the peak stresses, a second set of projections were developed that would correspond to the dryer response expected when the fatigue limit is reached. These curves are referred to as the "Fatigue Limit Projection." The difference or "delta" between the maximum projected load and the envelope projected to the fatigue limit represents design margin (i.e., roughly a factor of two or half of the ASME fatigue limit).

Figure 7 through Figure 19 shows the results for individual sensors (in the frequency domain, i.e., power spectral density). Each plot shows the measured data ("Sensor Data"), the calculated [[

]]

The figures show that in general, the projected acceleration and strain values based on the model
[[

]]

[3] The ASME limit projection applies "noise floors" similar to those used in the SSES limit curves supporting the 2008 power ascension test program, i.e., 0.05 $\mu\varepsilon^2$/Hz and 750 $(in/s^2)^2$/Hz.

DRAFT RESPONSE – FOR REVIEW ONLY

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Figure 7 - Projected vs. measured acceleration for [[ ]]

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Figure 8 - Projected vs. measured acceleration for [[ ]]

DRAFT RESPONSE – FOR REVIEW ONLY

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Figure 9 - Projected vs. measured acceleration for [[ ]]

[[

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Figure 10 - Projected vs. measured acceleration for [[ ]]

DRAFT RESPONSE – FOR REVIEW ONLY

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Figure 11 - Projected vs. measured acceleration for [[ ]]

[[

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Figure 12 - Projected vs. measured acceleration for [[ ]]

DRAFT RESPONSE – FOR REVIEW ONLY

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Figure 13 - Projected vs. measured strain for [[ ]]

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Figure 14 - Projected vs. measured strain for [[ ]]

DRAFT RESPONSE – FOR REVIEW ONLY

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Figure 15 - Projected vs. measured strain for [[ ]]

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Figure 16 - Projected vs. measured strain for [[ ]]

DRAFT RESPONSE – FOR REVIEW ONLY

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Figure 17 - Projected vs. measured strain for [[ ]]

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Figure 18 - Projected vs. measured strain for [[ ]]

DRAFT RESPONSE – FOR REVIEW ONLY

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Figure 19 - Projected vs. measured strain for [[ ]]

2.4.5 End-to-End Bias and Uncertainty Summary

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DRAFT RESPONSE – FOR REVIEW ONLY

[[

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Figure 20 - GGNS bias and uncertainty [[ ]]

[[

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Figure 21 - GGNS bias and uncertainty [[ ]]

[[

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Figure 22 – FE model bias for GGNS and SSES

2.5 GGNS Power Ascension Testing as an Example

The ESBWR will follow the Regulatory Guide 1.20 process in the same manner as the GGNS and SSES plants during their respective power uprate programs. The ESBWR power ascension program will utilize an instrumented dryer and establish acceptance limits, just as GGNS and SSES have done. Also, like GGNS and SSES, the ESBWR dryer design process will ensure that adequate margin exists in order to avoid potential delays or redesign efforts during plant startup. In this regard, the only major difference between GGNS and SSES in comparison to the ESBWR is that both GGNS and SSES were able to leverage full power data (MSL-based) to inform their replacement steam dryer designs, where similar data will not exist for the initial design phase of the ESBWR dryer. Instead, in lieu of MSL-based data, the ESBWR dryer design process will begin with conservative assumptions regarding the load definition.

2.6 Conclusions

A strain and acceleration simulation for GGNS is presented. This GGNS analysis serves as a validation test of the PBLE based vibro-acoustic analysis process. For this comparison, the acoustic FIV loads were determined by applying [[

]] Based on this comparison of the projected structural response with GGNS on-dryer data, it is demonstrated that PBLE can be applied to evaluate a steam dryer design against fatigue criteria with a reasonable degree of conservatism. The comparisons highlight [[ ]] that tend to drive a conservative structural FE model response.

DRAFT RESPONSE – FOR REVIEW ONLY

The "end-to-end" results presented here [[ ]] The acoustic model comparisons for GGNS show that the [[ ]] Regardless, the ultimate objective of this RAI is to confirm that the analysis process is conservative so that potential sources of variation are reasonably bounded. This assurance is provided by the end-to-end strain and acceleration comparisons presented here, which demonstrates that despite the complexity (and corresponding concern for uncertainties) associated with the underlying physics and computer based models that determine the load definition, the analysis process produces reasonably bounded results at all frequencies of interest.

In the case of an ESBWR, conservatism will be imbued in the dryer mechanical design through the load definition provided in Reference 3, which is [[ ]] In essence, the ESBWR steam dryer will be designed considering the most severe FIV loads measured in the existing BWR fleet, despite the fact that many of the acoustic load sources can and will be "designed out" in the detailed design phase of the plant[4]. To a great extent, the degree of conservatism (i.e., margin to the fatigue limit) in the ESBWR dryer will really be set by the load definition applied to create the mechanical design. The analysis technique and application methodology (and biases and uncertainties referenced in the ESBWR topical reports) will have some impact on the FIV evaluation used in the design process, which is mainly to ensure that the design basis loads are implemented as intended. The actual degree of conservatism in the dryer mechanical design will be confirmed through compliance with the prototype program requirements[5], which will result in ESBWR specific benchmark comparisons, a customized [[ ]], and resulting biases and uncertainties.

2.7 DCD Changes

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

2.8 References

1. NEDC-33408P-A, *ESBWR Steam Dryer Plant Based Load Evaluation Methodology*, Class III, Revision 1, October 2010.
2. NEDC-33408 Supplement 1P-A, *ESBWR Steam Dryer – Plant Based Load Evaluation Methodology Supplement 1*, Class III, Revision 2, October 2010.
3. NEDE-33312P-A, *ESBWR Steam Dryer Acoustic Load Definition*, Class III, Revision 2, October 2010.
4. NEDE-33313P-A, *ESBWR Steam Dryer Structural Evaluation*, Class III, Revision 2, October 2010.

[4] See Section 5.1, "FIV Load Mitigation Through Design," of Reference 3

[5] The ESBWR licensing topical reports for the steam dryer support the implementation of the requirements of Regulatory Guide 1.20, "Comprehensive Vibration Assessment Program for Reactor Internals During Preoperational and Initial Startup Testing," Revision 3, March 2007.

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Appendix A. Action Item 11 from Letter GNRO-2011/00088

Note: Appendix A is an excerpt from Letter GNRO-2011/00088, Michael Krupa (Entergy) to the US NRC Document Control Desk, "Request for Additional Information Regarding Extended Power Uprate Grand Gulf Nuclear Station, Unit 1 Docket No. 50-416 License No. NPF-29," October 10, 2011. There may be minor formatting differences from the source document. References, figures, tables, etc., are numbered in context of the source document.

Action Item # 11

GGNS steam dryer stresses: The licensee is requested to provide a summary of the GGNS reanalysis of the replacement steam dryer stresses. This summary should include a list of changes made for the reanalysis and a comparison of the relevant stresses from reanalysis with those calculated in the original analysis submitted to the NRC. The licensee is also requested to explain whether the reanalysis led to any changes in the design of the replacement dryer.

Response

Appendix A, Section 8.2.6, of NEDC-33601P [1] provides a discussion [[ ]] applied to the original Grand Gulf Nuclear Station (GGNS) steam dryer evaluation. In early to mid-2011, the GGNS Flow Induced Vibration (FIV) analysis was rerun with corrections incorporated directly into the [[ ]], so that additional correction factors would be unnecessary. One of the objectives of this evaluation was to confirm that the correction factors applied to the GGNS analysis were adequately conservative.

As discussed in Section 3.3.2.2.1 of Reference 1, there is an [[ ]] because of the [[ ]]. For this reason, the PBLE methodology includes a provision for [[ ]]. Even though the methodology considers these differences, several discrepancies between the as-designed and as-analyzed dryer were identified, which have been explicitly evaluated. This includes a [[ ]] (NRC Action Item #10), as well as differences in [[ ]] used in the benchmarks (NRC Action Item #1). A complete list of items that have been addressed is provided in Table 1. The revised stress table that results from incorporating the Table 1 changes is provided in Table 2.

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Table 1 – Changes Incorporated into the GGNS FIV Reanalysis

Item	Description
New GGNS acoustic model	The GGNS acoustic model was modified to correct the [[ ]], to include the [[ ]] and to increase [[ ]].
Nozzle area error in benchmarks (NRC Action Item #1)	Both the QC2 and SSES acoustic models also contained the [[ ]]. The impact of the QC2 [[ ]] on GGNS dryer loads was evaluated by revising the [[ ]], as well as the [[ ]] using the corrected Frequency Response Functions (FRFs). This is discussed in the response to NRC Action Item #1. Because [[ ]] data was not used in the GGNS dryer load definition, the GGNS dryer loads were not impacted by the SSES [[ ].
Delta pressure data in benchmarks (NRC Action Item #6)	Both the QC2 and SSES replacement dryers were instrumented with a significant number of on-dryer pressure sensors. The measurements from the sensors were used to benchmark the PBLE predictions. Most of the sensors were installed on the exterior of the dryer. [[ ]]. The benchmarking of the [[ ]] in QC2 and SSES was performed in NRC Action Item #6, which results in an [[ ]]. The [[ ] is combined with other [[ ]].

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Item	Description
Vane passing frequency (NRC Action Item #7)	The impact of [[ ]] on GGNS dryer loads was addressed in NRC Action Item #7. The GGNS plant uses [[ ]].
Support ring (NRC Action Item #10)	The impact of the [[ ]] dimensional difference (as-designed versus as-analyzed) on the predicted dryer stresses is discussed in the response to NRC Action Item #10. [[ ]].
Revised Finite Element Bias and Uncertainty	It was noted that the [[ ]]. The RAI response was clear that the [[ ]] is used in the determination of the [[ ]]. In the GGNS stress analysis, the [[ ]] are reported as the peak stress for fatigue. Then the [[ ]] are used to adjust the peak stress. Therefore it is consistent and logical to use the [[ ]].

Acoustic to structural FE model [[ ]] were addressed in NRC audit item #3. [[ ]] were calculated for both structural model and acoustic model. The [[ ]]. Furthermore, the GGNS stress analysis has incorporated the NRC staff's recommendation for additional margin [reference 2], which addresses the fact that there are limited benchmarks for the PBLE methodology (and the staff's

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[1] [[ ]]

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concern for potential additional [[ ]]). Due to the [[

]] presented in Table 2.

Incorporating the modifications presented into Table 1, the GGNS final stresses and margins were recomputed for the fatigue evaluation. It was found that [[

]].

References

1. NEDC-33601P, Engineering Report Grand Gulf Replacement Steam Dryer Fatigue Stress Analysis Using PBLE Methodology, Revision 0, Class III, September 2010.
2. MFN 11-230, "Clarification of Intent on Methodologies for Demonstrating Steam Dryer Integrity for Power Uprate – GE-Hitachi Nuclear Energy," Robert Nelson (NRC) to Jerald Head (GEH), September 14, 2011.

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Table 2 - GGNS Reanalysis Stress Table

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Appendix B. GGNS On-Dryer Instrumentation Locations

Instrument locations (on-dryer) are provided in Table 4 and shown in Figure 23 through Figure 28. Sensors identified with an "A" are accelerometers. Similarly, "P" stands for pressure transducer and "S" stands for strain gage.

Table 4 - GGNS on-dryer instrument locations

Sensor ID	Location
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Figure 23 - GGNS replacement steam dryer instrument arrangement (top view)

DRAFT RESPONSE – FOR REVIEW ONLY

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Figure 24 - GGNS replacement steam dryer instrument arrangement (0° azimuth view)

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Figure 25 - GGNS replacement steam dryer instrument arrangement (90° azimuth view)

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Figure 26 - GGNS replacement steam dryer instrument arrangement (180° azimuth view)

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Figure 27 - GGNS replacement steam dryer instrument arrangement (270° azimuth view)

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Figure 28 - GGNS replacement steam dryer instrument arrangement (interior section E-E view)

DRAFT RESPONSE – FOR REVIEW ONLY

Appendix C. GGNS PBLE Benchmark – [[ ]]

Figure 29 through Figure 43 show comparisons between the PBLE predicted pressure loads and the measured Pressure Transducer (PT) responses for each of the on-dryer pressure sensors at Test Condition 100%B. Pressure transducer identification numbers are followed by either an "e" for exterior, or an "i" for interior

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Figure 29 - PBLE benchmark comparison at PT location [[ ]]

DRAFT RESPONSE – FOR REVIEW ONLY

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Figure 30 - PBLE benchmark comparison at PT location [[ ]]

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Figure 31 - PBLE benchmark comparison at PT location [[ ]]

DRAFT RESPONSE – FOR REVIEW ONLY

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Figure 32 - PBLE benchmark comparison at PT location [[ ]]

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Figure 33 - PBLE benchmark comparison at PT location [[ ]]

DRAFT RESPONSE – FOR REVIEW ONLY

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Figure 34 - PBLE benchmark comparison at PT location [[ ]]

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Figure 35 - PBLE benchmark comparison at PT location [[ ]]

DRAFT RESPONSE – FOR REVIEW ONLY

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Figure 36 - PBLE benchmark comparison at PT location [[ ]]

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Figure 37 - PBLE benchmark comparison at PT location [[ ]]

DRAFT RESPONSE – FOR REVIEW ONLY

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Figure 38 - PBLE benchmark comparison at PT location [[ ]]

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Figure 39 - PBLE benchmark comparison at PT location [[ ]]

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Figure 40 - PBLE benchmark comparison at PT location [[ ]]

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Figure 41 - PBLE benchmark comparison at PT location [[ ]]

DRAFT RESPONSE – FOR REVIEW ONLY

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Figure 42 - PBLE benchmark comparison at PT location [[ ]]

[[

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Figure 43 - PBLE benchmark comparison at PT location [[ ]]

DRAFT RESPONSE – FOR REVIEW ONLY

Appendix D. GGNS PBLE Benchmark – [[ ]]

Figure 44 through Figure 55 show comparisons between the PBLE predicted pressure loads and the measured Pressure Transducer (PT) responses for each of the on-dryer pressure sensors at Test Condition 100%B.

[[

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Figure 44 - PBLE benchmark comparison at PT location [[ ]]

DRAFT RESPONSE – FOR REVIEW ONLY

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Figure 45 - PBLE benchmark comparison at PT location [[ ]]

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Figure 46 - PBLE benchmark comparison at PT location [[ ]]

DRAFT RESPONSE – FOR REVIEW ONLY

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Figure 47 - PBLE benchmark comparison at PT location [[ ]]

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Figure 48 - PBLE benchmark comparison at PT location [[ ]]

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Figure 49 - PBLE benchmark comparison at PT location [[ ]]

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Figure 50 - PBLE benchmark comparison at PT location [[ ]]

DRAFT RESPONSE – FOR REVIEW ONLY

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Figure 51 - PBLE benchmark comparison at PT location [[ ]]

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Figure 52 - PBLE benchmark comparison at PT location [[ ]

DRAFT RESPONSE – FOR REVIEW ONLY

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Figure 53 - PBLE benchmark comparison at PT location [[ ]]

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Figure 54 - PBLE benchmark comparison at PT location [[ ]]

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Figure 55 - PBLE benchmark comparison at PT location [[ ]]

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Figure 56 - PBLE benchmark comparison at PT location [[ ]]

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Figure 57 - PBLE benchmark comparison at PT location [[ ]]

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Figure 58 - PBLE benchmark comparison at PT location [[ ]]

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Appendix E. EMCB-GGNS1-SD-4-RAI-09

Note: Appendix E is an excerpt from Letter GNRO-2012/00009, Michael Krupa (Entergy) to the US NRC Document Control Desk, "Response to Request for Additional Information Regarding Extended Power Uprate Grand Gulf Nuclear Station, Unit 1 Docket No. 50-416 License No. NPF-29," February 15, 2012. There may be minor formatting differences from the source document. References, figures, tables, etc., are numbered in context of the source document.

NRC Request for Additional Information

The staff notes that the licensee is planning to instrument the GGNS Replacement Steam Dryer (RSD). The licensee is requested to provide a strong, technically sound, defensible and convincing justification for the type, number, location, and redundancy of instruments to be used on the steam dryer. The licensee is also requested to provide the calibration and measurement errors associated with the instruments. In addition, the licensee is requested to describe (1) how the PBLE validation will be made using the actual GGNS plant data at various power plateaus during power ascension using main steam line (MSL) and on-dryer instrument data, particularly pressure differences between internal and external sensors; (2) how the validation of the overall end-to-end strain calculations will be made using the structural finite element model based on actual GGNS plant data at various power plateaus during power ascension using loads derived from [[ ]] instrument data, and (3) how the maximum fatigue stress location and magnitude will be determined during power ascension.

Response

GGNS is planning to install on-dryer instrumentation to [[ ]] The details of the planned design are outlined below. [[ ]]

Instruments

[[

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The locations are depicted in Figures 1 through 5.

The Quad Cities (QC2) and Susquehanna (SSES) dryer instrumentation design included [[

]]

The following table summarizes the basis for [[

]] Appendix A to Enclosure to Attachment 1 in GGNS the November 28, 2011 Submittal, GNRO 2011-107, (NRC Accession No. ML113320403). This was supporting information in Entergy's response to RAI 2, Round 4.

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In addition to the on-dryer instrumentation, [[

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In addition to the MSL strain gages, the four MSLs will have [[

]]

Calibration

The MSL strain gage bias and uncertainty is described in Appendix A of the SDAR. The current plan [[

]]

The Gage Factor (GF) determination is an important input into the dynamic strain equation, [[

]]

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Power Ascension Testing

On-dryer sensors will be used to [[

]]

At CLTP, GGNS-specific [[

]]

Power ascension above CLTP will be performed in accordance with [[

]]

GGNS End-to-End Bias and Uncertainty

The end-to-end bias and uncertainty values for projected stresses at high stress regions will be based [[

]]

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The test data will be used to assess [[

]]

The PBLE [[

]]

The dynamic pressure loading on the outer surface [[

]] (see response to Round 3 RAI 6, in Entergy letter "Request for Additional Information Regarding Extended Power Uprate", dated October 10, 2011, NRC Accession No. ML112840174).

Full FE Reanalysis

Projected pressure, strain, and acceleration data from the PBLE and FE results [[

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Summary of the Adjusted Stress Calculations Using [[ ]] as Described in Appendix A of the SDAR.

The FE analysis results [[

]]

To illustrate the process, [[

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Figure 1: Projected Instrument Arrangement GGNS Steam Dryer (Top View)

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Figure 2: Projected Instrument Arrangement GGNS Steam Dryer (180° Side)

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Figure 3: Projected Instrument Arrangement GGNS Steam Dryer (90° Side)

DRAFT RESPONSE – FOR REVIEW ONLY

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Figure 4: Projected Instrument Arrangement GGNS Steam Dryer (270° Side)

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Figure 5: Projected Instrument Arrangement GGNS Steam Dryer (0° Side)

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Appendix F. EMCB-GGNS1-SD-6-RAI-09

Note: Appendix F is an excerpt from Letter GNRO-2012/00016, Michael Krupa (Entergy) to the US NRC Document Control Desk, "Response to Request for Additional Information Regarding Extended Power Uprate Grand Gulf Nuclear Station, Unit 1 Docket No. 50-416 License No. NPF-29," March 13, 2012. There may be minor formatting differences from the source document. References, figures, tables, etc., are numbered in context of the source document.

RAI-09

Dryer instrumentation, Benchmark of B&U using GGNS-specific MSL & on-dryer Instrumentation, and Power Ascension

Based on the review of the response to RAI 9 (Attachment 1 to GNRO–2012/ 00009) the staff requests the following information:

i) The table on Page 49 of 66 (GNRO-2012/00009) for response to RAI 09 in Round #5 shows that each accelerometer is associated with several high stress locations. The licensee is requested to explain how the accelerometer measurements will be used in estimating the stresses at these locations.

ii) How the accelerometer data will be used in determining the end-to-end B&U at the high stress locations on the outer hood?

iii) On Page 51of 66 (GNRO-2012/00009) for response to RAI 09 in Round #5, it is stated, [[ ]] However, no criteria are presented in the response. Instead, it is stated, [[ ]] The licensee is requested to clarify when these criteria or the updated power ascension test plan will be submitted for the staff review.

iv) On Page 53 of 66 (GNRO-2012/00009) for response to RAI 09 in round #5, the use of [[ ]] in prediction of peak stress and its location is summarized. It appears that the [[ ]] would be able to identify the changes in the peak stress location as power is increased. <u>The licensee is requested to explain whether this specific use of [[ ]] has been validated.</u> In addition, the licensee is requested to confirm that

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a. Whether this determination of the peak stress and its location would be made at each hold period. Please identify the hold periods.

b. The results with sufficient details will be submitted to the staff for its review and approval.

v) In order to expedite the review process and not to lose the functionality of the on-dryer instruments, the licensee is requested to submit the following information. Please provide a detailed report outline including section titles, tables, plots and figures. Please identify all the data that will be submitted to the staff at power levels reaching to CLTP, CLTP, and each hold period above CLTP, so that the staff can make a decision about further power increase. As a minimum, the staff would like to review the following data:

a. Benchmarking of PBLE Methods 1 and 2

b. End-to-end benchmarking

c. Maximum stress and its location

d. Comparison with acceptance criteria

e. Projection to next hold period and to EPU

f. Any projected violation of acceptance criteria

g. Any revisions to limit curves

vi) Reanalysis of the GGNS RSD using the measured pressure loads at CLTP. Compare the stress results with the ones obtained using [[ ]]

Please note that the staff's review of the MSL and on-dryer instrumentation data and evaluations to be submitted by the licensee at CLTP condition may require longer than 96 hours due to complete reassessment of the first time use of PBLE methodology and end-to-end benchmark. The subsequent staff assessments of power ascension data at power plateaus above CLTP, however, will be subject to the usual 96 hour evaluation periods.

Response

Response to i) and ii)

The potential monitoring location areas depicted in Figures 1 through 5 in the response to Round 5 RAI 9 are evaluated using [[

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Response to iii)

The Round 5 RAI 09 response section "Full FE Reanalysis" describes the criteria considered for this determination. Item v) of this response includes a detailed summary of the information to be provided in each NRC report. The PAT Plan with the detailed criteria will be submitted for NRC review a minimum of 14 days before the CLTP plateau is achieved.

Response to iv)

Validation of Stress Adjustment Method:

In addition to the stress analysis performed OLTP conditions as part of the EPU license amendment request, GEH also performed complete dryer stress analyses at 1672 MWth, 1791 MWth, and 1912 MWth during the Vermont Yankee (VY) power ascension. GE performed a nominal time step analysis [[

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Response to iv) a and iv) b

The determination of the [[

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DRAFT RESPONSE – FOR REVIEW ONLY

Response to v)

Table 1 summarizes target test points for data acquisition and assessment for the power ascension up to the full EPU power level. Reports to the NRC will include data plots and tables at the indicated test point and for any test point since the last report. Table 2 summarizes the information to be generated at each test point. (Note the NRC a to g list of minimum items requested in this RAI section have been flagged in the description column of Table 2.)

Response to vi)

ANSYS FE Model Reanalysis at CLTP

The purpose of the instrumentation is to [[

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Acknowledgement of MSL and on-dryer instrumentation data review

Entergy understands the NRC may need additional time to review the initial results provided at CLTP conditions. With this information, it is requested that a review period of no more than 168 hours (7 days) be applied to the CLTP plateau review and that the 96-hour evaluation periods be applied to the data submitted at the 105% and 110% hold-point plateaus.

References

1. Engineering Report: "Susquehanna Replacement Steam Dryer Instrumentation Acceptance Criteria – Dryer Mounted Instrumentation", February 2008, ML080660255, Attachment 1.

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Appendix G. EMCB-GGNS1-SD-4-RAI-08

Note: Appendix G is an excerpt from Letter GNRO-2012/00011, Michael Krupa (Entergy) to the US NRC Document Control Desk, "Response to Request for Additional Information Regarding Extended Power Uprate Grand Gulf Nuclear Station, Unit 1 Docket No. 50-416 License No. NPF-29," February 20, 2012. There may be minor formatting differences from the source document. References, figures, tables, etc., are numbered in context of the source document.

EMCB-GGNS1-SD-4-RAI-08.

GGNS Steam Dryer Finite Element Model Verification

a. The licensee is requested to perform a thorough re-verification of the FE models (global model, sub-models, and shell-to-solid transition areas) used in the steam dryer analysis for GGNS and confirm that in the FE models used in the steam dryer analysis for GGNS: (a) all nodes are appropriately connected; (b) nodes that are supposedly to be connected are not left free inadvertently, and the load path is not shifted away from the critical areas; and (c) in case that there are any unconnected nodes, the licensee is requested to provide a description of such locations and the impact on the GGNS steam dryer stresses at EPU conditions.

b. The licensee is also requested to verify and confirm that the quality of the finite element mesh (shape or aspect ratios) is acceptable to ensure that there are no regions with poor mesh quality in the global model, in the submodels, and in shell to solid transition areas of the GGNS steam dryer FE model. In case that there is a poor quality mesh, the licensee is requested to provide a description of the impact on the GGNS steam dryer stresses at EPU conditions

c. The licensee is further requested to provide a summary of the results from the FE model mesh density convergence studies, used in the steam dryer analysis for GGNS, to validate proper stress convergence.

Response

a. The structural Finite Element (FE) model of the Grand Gulf Nuclear Station (GGNS) replacement dryer is relatively large ([[ ]]) and represents a somewhat complex structure. In order to check the nodal connections ("connectivity") in the steam dryer FE model, a detailed review was conducted for the global model and submodels (including shell-to-solid transition areas). The review was accomplished by performing a check, in which unit accelerations were applied to the steam dryer structure in the global X and Y directions, as well as a vertical acceleration replicating gravity (in positive global Z direction). Discontinuities in the resulting displacement plots could then be used to identify disconnected nodes.

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1. Global Model Evaluation

Some nodal disconnects were identified in the global model. There are totally [[ ]] that were misaligned. Two sets of disconnected nodes ([[ ]] adjacent node pairs at each location) are in the [[ ]] interconnection, which are symmetric about the dryer neutral axis, as depicted in Figure 1. Figure 2 shows the corrected model with connected nodes at these locations. The corrected model was used to evaluate the impact of the disconnected nodes on the dryer response.

After the [[ ]] of disconnected nodes were corrected, the global model was reanalyzed using the Flow Induced Vibration (FIV) nominal loads. Note that the reanalysis applied the [[ ]], which was shown to be consistent with the [[ ]] technique as discussed in the response to Round 5, RAI-04 (see Reference 1). Table 1 provides a comparison of maximum percentage stress intensity results for all thirty-three dryer components before and after the corrections of nodal disconnects. The maximum increase in stress intensity is observed in the [[ ]]. Figures 3 and 4 show the maximum stress intensity contour plots with disconnected nodes and corrected nodes in the [[ ]] junction, respectively. [[ ]].

It should be noted that in the cover plate and divider plate components, the maximum stress intensity decreased by [[ ] respectively once nodal connectivity was restored. In total, fifteen (15) of the thirty-three (33) GGNS steam dryer components showed a decrease in maximum stress intensity.

From the above results, it can be concluded that (1) the original calculated global model stresses are not substantially different from the corrected case and (2) new results did not show an increase in the limiting component stress. Considering a single figure of merit to characterize the impact of the change, based on the percent difference values from Table 1, the mean bias of all components is [[ ]], which is comparable to the accuracy of the finite element model (i.e., [[ ]]).

The other [[ ]] misaligned node pairs that were identified are all at different locations in the global model. Several disconnected node pairs are illustrated in Figure 5. The disconnected nodes are not located at corners or adjacent to one another. In all cases the disconnected nodes are along an edge with connected nodes on either side. The disconnected nodes are not located in the vicinity of maximum stress locations of the thirty three evaluated components. It has shown from the above analysis that the connecting [[ ]]nodal pairs in 2 locations did not significantly impact the stress results in any component, which further supports that the impact of these individual disconnections is negligible to the global stress results. The Grand Gulf Nuclear Station (GGNS) replacement dryer global finite element model (FEM) is based on the prototype Susquehanna Replacement dryer model with modifications in several dryer components due to the design changes. The SSES and GGNS models have very similar mesh density in most of the dryer components.

2. Submodel Evaluation

Four submodels with much finer mesh and employing solid elements were built and analyzed for GGNS replacement dryer. The stress ratios from [[ ]] submodel and [[ ]] submodel were used to adjust the final stress margins for these two components. Although the peak stress calculated from [[ ]] submodel was lower than that from shell global model, the more conservative stresses from global model were used to calculate the fatigue margin on the [[ ]]. The last submodel, the [[ ]] submodel was used to disposition a modeling discrepancy in the connection of top cap to divider plate. The results showed that the submodeling area is not the stress limiting location. So the results from this submodel were not applied to the final stress table as well.

All four GGNS dryer submodels were checked for possible nodal disconnects.

[[ ]] <u>Submodel</u>

All nodes are appropriately connected in this submodel region. The disconnected nodes in global model are relatively distant from the area of interest of the submodel and are not expected to impact the tie bar stress intensity results in the submodel.

[[ ]] <u>Submodel</u>

All nodes are appropriately connected in this submodel region. The disconnected nodes in the global model are relatively distant from the area of interest of the submodel and are not expected to impact the cover plate stress intensity results in the submodel.

One discrepancy was identified in this submodel compared to design. [[

]] This reinforcement fillet weld was not modeled in the submodel although nodal connectivity was modeled correctly. However, it is considered conservative not to model the fillet weld material. By not modeling the fillet weld, the [[

]]

[[ ]] <u>Submodel</u>

Disconnected nodes were identified in two locations in top cap submodel. One set is located across the [[ ]] edge length (as shown in Figure 6), which was [[ ]]

(Figure 7). The maximum stress intensity in the submodel could be influenced by these disconnected nodes. However, examining the model configuration, mesh size and applying engineering judgment, it would be expected that if nodal connectivity were restored and node-to-node contact established between these two local surfaces, the localized stress intensity results would not be changed significantly.

The other disconnected nodes are along the [[ ]] interface as shown in Figure 8. These disconnected nodes are away from the critical locations that through-wall linearized stresses are extracted; also the [[ ]]. So they are not expected to impact the stress intensity results in the submodel as well.

To validate the above observations, [[ ]] to the two [[ ]] submodels, i.e., the current submodel with disconnected nodes and submodel with both locations fixed. Figures 9a and 9b show the stress intensity contour plots for disconnected nodes and merged nodes at the [[ ]] edge length respectively, when [[ ]] to the structure, focusing on the maximum stress intensity region. The maximum stress intensity reduces by [[ ]] when nodal connectivity is corrected.

Figures 10a and 10b show the stress intensity contour plots for disconnected nodes and merged nodes at the [[ ]]. The maximum stress intensity reduces by [[ ]] when nodal connectivity is established.

All other model connections have been verified as correct.

[[ ]] <u>Submodel</u>

In the [[ ]] submodel, [[ ]]. There are two elements that join coincident nodes adjacent to the [[ ]]. See Figure 11 for the detailed locations. The maximum stress intensity from this submodel for the transient dynamic FIV loads stress analysis was [[ ]]. The same load step was analyzed using a static analysis, which produced a maximum stress intensity of [[ ]], shown in Figure 12(a). To confirm the influence on localized stress intensity results, the nodes were disconnected and the stresses were reevaluated using a static analysis for the same load step. Figure 12(b) shows the maximum stress intensity at the stress location of interest, i.e., the [[ ]. The two stress intensity magnitudes are within [[ ]] of each other ([[ ]]). It can be concluded that the erroneously connected nodes have a negligible effect on the calculated maximum stress intensity at the location of interest.

All other nodes are appropriately connected in this submodel region.

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In summary, the disconnected nodes found in global model and submodels have been justified to have negligible impact on the GGNS steam dryer stresses.

b. Mesh quality was checked by using automated ANSYS routines to test for shape and aspect ratios, and to verify that any elements flagged with "warnings" were remote relative to the areas of interest.

In the global model, there are [[ ]], as shown in Figure 13(a). The mesh at this location resulted in a stress singularity and caused the stress intensity to diverge when an [[ ]]. The mesh was corrected to address this issue. Figure 13(b) shows the modified mesh at the same location. The maximum stress intensity values presented in Figures 14 and 15 show that the [[ ]] component stress was reduced after the mesh modification. From the RAI 04 study (Reference 1), it is found that [[ ]]. Thus the mesh modification at [[ ]] does not impact the most limiting stress on the skirt.

There are also several [[ ]], as shown in Figure 16 (a). Figure 16 (b) shows the modified mesh at the same location. Figures 17 and 18 are stress intensity contour plots for the [[ ]] before and after the mesh modification (global model with [[ ]]) at the shell-to-solid interface. As stated in the response to RAI 04 (Reference 1), a detailed solid element submodel analysis was also performed in the area of interest, i.e., [[ ]], which indicates that the global model using the [[ ]] method provides a conservative stress prediction.

The submodels were also evaluated for mesh quality and determined to be adequate. All ANSYS warnings related to element aspect ratios are remote from the area of interest, i.e., the peak stress locations.

In summary, the locations discussed above (where the mesh was further evaluated to respond to questions regarding element shapes and aspect ratio) were determined to have adequately resolved dryer component stresses in the current analysis. Revising the mesh resulted in reductions in stresses in those locations. Thus, these mesh quality concerns were found to have no adverse impact on stresses in the dryer at EPU conditions.

c. The GGNS replacement dryer global FEM is based on the prototype Susquehanna replacement dryer model with modifications in several dryer components due to design changes. The SSES and GGNS models have very similar mesh density in most of the dryer components.

The mesh convergence study was performed in low frequency range for the SSES FEM to determine the adequacy of the mesh. The results are summarized in Table 2. For the top three (stress) limiting components, when the mesh is reduced by a factor of two, [[

]].

Table 3 shows mesh size comparisons between the SSES and GGNS finite element models. The LF peak stress elements from GGNS flow induced vibration (FIV) analysis were selected for comparison.

[[

]] highlighted (bold text) in Table 3, the mesh sizes of other components in GGNS model are equivalent or finer than SSES model. Therefore, [[

]] is applicable to these components.

In continuous regions of a finite element model, the mesh is considered fine enough if the difference between an unaveraged stress (element stress) and averaged stress (nodal stress) is relatively small. The element and nodal stresses for the four components with coarse mesh sizes in GGNS model are compared in Table 4. [[

]] Good agreement between results indicates that the mesh is adequate to resolve the stresses in these components.

In summary, the GGNS replacement dryer model mesh is adequate to resolve the stresses throughout the model. [[

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Reference:

1. Entergy letter, *Response to NRC Request for Additional Information Regarding Extended Power Uprate*, GNRO-2012/00009, dated February 15, 2012.

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Table 1: [[

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Table 2: Summary of SSES Mesh Refinement Results

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Table 3: Mesh Size Comparison at FIV Maximum Stress Location

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				]]

Table 4: Element and Nodal Stress Comparison for GGNS model

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Figure 1: [[ ]]

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Figure 2: [[ ]]

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Figure 3: [[

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Figure 4: [[

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Figure 5: [[ ]]

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Figure 6: [[ ]]

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Figure 7: [[ ]]

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Figure 8: [[ ]]

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Figure 9: [[

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Figure 10: [[

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Figure 11: [[ ]]

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Figure 12: [[

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Figure 13: [[

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Figure 16: [[

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Figure 17: Stress Intensity Contour Plot of the Cover Plate before Mesh Modification

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Figure 18: Stress Intensity Contour Plot of the Cover Plate after Mesh Modification

Appendix H. EMCB-GGNS1-SD-6-RAI-02

Note: Appendix H is an excerpt from Letter GNRO-2012/00018, Michael Krupa (Entergy) to the US NRC Document Control Desk, "Response to Request for Additional Information Regarding Extended Power Uprate Grand Gulf Nuclear Station, Unit 1 Docket No. 50-416 License No. NPF-29," March 21, 2012. There may be minor formatting differences from the source document. References, figures, tables, etc., are numbered in context of the source document.

EMCB-GGNS1-SD-6-RAI-02 (Follow-up to RAI 08 from previous Round #5)

Unconnected Nodes

(a) The licensee states that there are [[ ]] *in the GGNS replacement steam dryer (RSD). After correcting* [[ ]], *it reanalyzed the global model using the flow induced vibration (FIV) nominal loads. The licensee is requested to provide the following information:*
   - *(i) What is the minimum alternating stress ratio based on the reanalysis results?*
   - *(ii) What is the maximum non-conservative error introduced by the disconnected nodes? How this error may be affected by the FIV loads resulting from the consideration of the (+/- 10%) frequency shifts?*
   - *(iii) Why all* [[ ]] *were not corrected before performing the reanalysis? Is the finite element model mesh automatically generated using mesh generators or manually generated*

(b) In response to Part (c) of the response to RAI 8, Round 5, the licensee states that the mesh convergence study was performed in low frequency range for the Susquehanna steam electric station (SSES) finite element model (FEM) to determine the adequacy of the mesh. The licensee is requested to explain whether a similar study was performed in high frequency range.

*Entergy is requested to update their stress margin tables using the individual bias errors in Table 1 in their RAI response. They may *not* average the errors and add that value to their stresses – as the errors will naturally average to 0.*

GEH Response:

The Round 5 Request for Additional Information (RAI) 8 [1] notes that [[ ]], and that only [[ ]] prior to the reanalysis. In response to this RAI, analyses were performed in which [[ ]] The results of this evaluation are used to assess the impact of the [[ ]] to the dryer stress analysis results.

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Three load cases were run for both the low frequency (LF) and high frequency (HF) regimes (six cases total). The comparisons were performed for the [[ ]] load cases. The [[ ]] case was run to determine the overall impact of the [[ ]], and the other two load cases were investigated because they had provided the [[ ]] for the vast majority of the dryer components and, therefore, are the most relevant for assessing the impact on the Minimum Alternating Stress Ratio (MASR). Figures 1 and 2 provide bar charts depicting the differences in the maximum predicted stress intensity for each dryer component for the LF and HF regimes, respectively, for the [[ ]] These comparisons show that the [[ ]] result in a relatively small difference in the calculated stress intensities. Power spectral density (PSD) plots for the limiting components (i.e., those with the lowest MASRs) were also compared to determine if the [[ ]] affected the dynamic response of the dryer. Comparison plots for the five components with the lowest MASR, the [[ ]], are shown in Figures 3 through 7. These plots show that the predicted frequency response of the steam dryer was not significantly affected by the [[ ]]

The following information addresses the specific questions of the RAI.

(a) As mentioned above, [[ ]] were connected in a corrected version of the global Finite Element Model (FEM). The FEM was exercised using the [[ ]] load cases for both the LF and HF regimes. The maximum stress was scoped in the corrected FEM for every component and all time steps. This maximum stress for the [[ ]] load cases for each component was compared to the respective stress result from the uncorrected Finite Element Analysis (FEA) to determine an [[ ]] for each component. The [[ ]] is assumed for the remaining six load cases. The [[ ]] results are tabulated in Tables 1 and 2. Table 1 provides the [[ ]] for the LF stress for all components, and Table 2 provides these [[ ]] for the HF stress for all the components.

(i) The [[ ]] contained in Tables 1 and 2 are incorporated in the final MASR calculations and reflected in the final stress tables provided in the response to Round 6 RAI 06. The maximum stresses for each component and load case have been [[ ]] in the final stress calculations that are used to determine the MASR.

(ii) The [[ ]] for LF load cases and [[ ]] for HF load cases, and corresponds to the change in stress in the [[ ]] in both cases. The [[ ]] is the component with the lowest calculated stress in the dryer assembly. Components with an MASR predicted to be between [[ ]] in Round 4 RAI 05 [2] are highlighted in yellow in Tables 1 and 2. The [[ ]] for any of these components is [[ ]] for LF load cases and [[ ]] for HF load cases. These [[

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]] occur for the [[ ]] component for LF load cases and the [[ ]] component for HF load cases. The [[ ]] across the components highlighted in yellow for all load cases is colored tan.

(iii) The [[ ]] The finite element mesh has been manually generated for the replacement steam dryer global FEM for the GGNS analyses because some of the connections between the components are too complex for automatic mesh generators. Furthermore, manual mesh generation allows for better control of the FEM mesh quality.
Unlike the [[ ]] at different locations. The [[ ]] eluded standard detection methods and were difficult to find. Once a review for [[ ]] had been conducted and the [[ ]] identified, the re-analysis was performed. While this was on-going, an evaluation of the FEM was also being performed. This evaluation was to determine if the FEM contained any other errors. It was this evaluation that recognized the [[ ]] were corrected before performing the reanalysis documented in the response to this RAI.

(b) A mesh convergence study was not performed on the Susquehanna Steam Electric Station (SSES) FEM in the high frequency range. This was deemed unnecessary because the dryer [[ ]] The [[ ]] on the GGNS dryer is more significant, so a plant-specific high frequency mesh convergence study is performed. The response to Part (c) of RAI 8, Round 5 [1], demonstrated that the mesh size used in the GGNS FEM is consistent with the benchmarking study models. The mesh sensitivity is therefore accommodated by the assumed FEM [[ ]] from the benchmark. A limited mesh refinement study was performed in the high frequency range in response to part b of this RAI to address the adequacy of the mesh to provide a reasonably accurate stress prediction in the HF regime. This mesh refinement study was performed for the [[ ]] Figure 8 provides a contour plot of the stress intensity at this location. The FEM mesh in this region is shown in Figure 9. The mesh was refined (see Figure 10) by reducing the [[ ]], thus reducing the element's [[ ]]

The maximum stress intensity predicted for the [[ ]] in the [[ ]] in the refined mesh model and [[ ]] in the original mesh model. This is a [[ ]] in stress. The PSDs were calculated for the original and refined mesh at this location and are presented in Figure 11. The PSD comparison shows that the frequency response has not significantly changed. As mentioned above, the [[ ]] was also run with the refined mesh model. The [[ ]] PSD results are shown in Figure 12. Again, the frequency response of the stress is not significantly altered;

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however, the [[ ]] Although this [[ ]] value, and both refined mesh stress predictions are lower than the [[ ]] predicted by the original mesh. This [[ ]] has been conservatively used (and adjusted as described in the response to RAI 2a above) in the stress table calculation. Based on this study, it was concluded that the mesh size in the current GGNS FE model is adequately resolved in the high frequency range.

The [[ ]] contained in Tables 1 and 2 will be applied individually to the respective component and load case when determining the final MASR.

References

[1] Entergy letter to the NRC dated February 20, 2012, Response to Request for AdditionalInformation Regarding Extended Power Uprate (ML12054A038)

[2] Entergy letter to the NRC dated November 25, 2011, Response to Request for Additional Information Regarding Extended Power Uprate (ML113290137)

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Table 1: LF Stress Adjustment Factors per Component per Load Case

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Table 2: HF Stress Adjustment Factors per Component per Load Case

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Enclosure 5

MFN 12-043

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 12-043, J. 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 – Draft Response for RAIs 3.9-269 and 3.9-270," September 27, 2012. The GEH proprietary information in Enclosures 1 and 2 of MFN 12-043, is identified by a [[dark red, 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 27th day of September, 2012.

Jerald Head

Jerald G. Head
GE-Hitachi Nuclear Energy Americas LLC