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MFN 09-621

Docket No. 52-010

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

Subject: **Response to NRC Report of the August 25, 2009, and September 9, 2009, Regulatory Audit of Reactor Pressure Vessel Internals of the Economic Simplified Boiling Water Reactor**

The purpose of this letter is to submit the GE Hitachi Nuclear Energy (GEH) response to the U.S. Nuclear Regulatory Commission (NRC) "Report of the August 25, 2009, and September 9, 2009, Regulatory Audit of Reactor Pressure Vessel Internals of the Economic Simplified Boiling Water Reactor," Reference 1 and "Additional Follow-up Item #17", dated September 22, 2009, Reference 2.

Enclosure 1 contain GEH proprietary information as defined by 10 CFR 2.390. GEH customarily maintains this information in confidence and withholds it from public disclosure. Enclosure 2 contains a public copy of the response and affected public versions of Licensing Topical Reports.

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

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

Sincerely,

Stephen C Moen for Richard E. Kingston

Richard E. Kingston
Vice President, ESBWR Licensing

D068
NRO

References:

1. MFN 09-605-"Report of the August 25, 2009 and September 9, 2009, Regulatory Audit of Reactor Pressure Vessel Internals of the Economic Simplified Boiling Water Reactor at General Electric Hitachi (GEH) Office in Wilmington, NC," dated September 15, 2009
2. "Additional Follow-up Item 17", E-mail Zahira Cruz to Hugh Upton dated September 22, 2009

Enclosures:

1. Response to NRC Request for Document Improvements and Specific Changes to DCD Related to ESBWR Design Certification Application – DCD Tier 2 Section 3.9 – Mechanical Systems and Components – NRC Staff Audit, August 25, 2009 - GEH Proprietary Information
2. Response to NRC Request for Document Improvements and Specific Changes to DCD Related to ESBWR Design Certification Application – DCD Tier 2 Section 3.9 – Mechanical Systems and Components – NRC Staff Audit, August 25, 2009 – Public Version
3. Affidavit

| | | |
|---|---|---|
| cc: | AE Cubbage | USNRC (with enclosures) |
| | JG Head | GEH/Wilmington (with enclosures) |
| | DH Hinds | GEH/Wilmington (with enclosures) |
| | eDRF Section | 0000-0059-2494 |

Enclosure 2

MFN 09-621

Response to NRC Request for

Document Improvements and Specific Changes to DCD

Related to ESBWR Design Certification Application

DCD Tier 2 Section 3.9

Mechanical Systems and Components

NRC Staff Audit, August 25, 2009

Public Version

**NRC Comment 1**

*Provide a methodology or road map that incorporates GEH's [[*

*]]. Include references to design documents where specific information, processes, acceptance criteria, etc. are contained.*

**GEH response**

As GEH BWR reactor internal design has evolved from BWR/1 through BWR/6 then ABWR and now ESBWR, engineers have incorporated design modifications or improvements and lessons learned related to reactor design. [[

]] and acceptance criteria.

In addition, the ESBWR design identifies the key water chemistry parameters to be monitored, such that potential for IGSCC is minimized. For example, chlorine, fluorine, and conductivity are known to affect IGSCC potential, and this is documented in DCD Section 5.2.3.2.2. IASCC considerations are also documented in this DCD section, such as locating of the welds away from high fluence regions.

Below the methodology for the steam dryer has been outlined in a licensing information summary.

ESBWR Design Control Document, Tier 2, Chapter 3, Design of Structures, Components, Equipment, and Systems

- 3.9.2.3 Provides a summary of allowable stress for FIV fatigue assessments for the steam dryer. The steam dryer acceptance criteria have been updated as part of this audit response.

- 3.9.2.4 Provides a commitment for performing startup testing per RG1.20 and performing baseline and follow up inspections for damage, excessive wear, or loose parts.
- 3.9.5.2 Provides a general description of the Steam Dryer.
- 3.9.5.4 Refers to NEDE-33313 for information on dryer weld quality and fatigue methodology.

ESBWR Design Control Document, Tier 2, Chapter 3, Design of Structures, Components, Equipment, and Systems Appendix 3L.

- 3L.2.1 Explains that the initial assessment of an increase in dryer size and steam flow from the current ABWR dryer had no adverse effects on structural integrity, explains that the detailed program for dryer qualification is described in Section 3L.4, and that the ESBWR dryer will use a design patterned after the ABWR dryer and replacement steam dryer designs developed for BWR plants.
- 3L.4.1 Provides a summary description of the steam dryer and a comparison of the ESBWR and ABWR dryers. Explains that replacement dryer design improvements are being incorporated into the ESBWR dryer design.
- 3L.4.2 Describes that industry and replacement steam dryer practices are applied to the materials and fabrication.
- 3L.4.3 Provides a description of the load combinations applicable to the steam dryer. A more detailed description of the load combinations is provided in NEDE-33313P Rev 1.
- 3L4.4 Provides a discussion of the fluid loads (normal and transient differential pressures, FIV loads) acting on the dryer.
- 3L.4.5 Explains that the dryer structural evaluation is addressed in NEDE-33313.
- 3L.4.6 Describes the instrumentation and startup testing program for the dryer. Provides information on the dryer dynamic testing (frequency response testing). Provides a reference to the LTR that explains the basis for locating the startup test instruments. Describes the in-vessel test instrumentation. Provides a commitment to perform inspections of high stress areas consistent with industry guidance.

NEDE-33312P, ESBWR STEAM DRYER ACOUSTIC LOAD DEFINITION.

This LTR:

- Provides an overview of the procedure that will be used for designing and qualifying the dryer for FIV loads.
- Describes the dryer and steam dome geometry, CFD and Acoustic FE element modeling.
- Describes the method used to develop the FIV design loads for the ESBWR.

This LTR has been updated to include additional information from the response to RAI 3.9-206S1and as part of this audit response to provide the overall process for qualifying the dryer for FIV loads on the first and subsequent ESBWR plants.

NEDE-33313P, ESBWR STEAM DRYER STRUCTURAL EVALUATION

This LTR:

- Provides a summary of dryer support and handling.
- Describes the material properties.

- Describes the design criteria and how the ASME Code guidance is being applied to the dryer design.
- Describes the fatigue allowable stress values and the method to address weld stress.
- Describes the FE model and submodels with the requirements for submodels and mesh convergence studies.
- Describes the FIV loads and methods used to address the model frequency uncertainty and describes how the load definition, instrumentation and model biases and uncertainties will be addressed.
- Describes the dynamic testing and how the dynamic testing will be used to help determine the FE model bias and uncertainties.
- Defines the minimum time interval that will be evaluated and the time interval bias factor that will be used to define the peak stress response for endurance limit fatigue assessment.
- Provides the normal, transient and accident load combinations to be used for the dryer structural assessment.
- Describes the process to be used for locating the dryer test strain gage and accelerometer instrumentation.
- Describes the minimum sensitivity requirements for the main steam line sensors and requirements for low power testing for identifying non-acoustic signals.
- Provides the process for defining startup testing acceptance criteria for the initial ESBWR dryer as well as the criteria that will be used for subsequent ESBWR plants.

NEDC-33408 and NEDC-33408S1, ESBWR STEAM DRYER -PLANT BASED LOAD EVALUATION METHODOLOGY

Description of the GEH methodology for developing the FIV load definition for steam dryer evaluations based on in-plant measurements.

References:

(1) GEH specification 26A6631 rev. 1 “Reactor Pressure Vessel System”
(2) GEH specification 26A7859 rev. 0 “Core Support Structure”
(3) GEH specification 26A7870 rev. 0 “Control rod Drive Housing and In-Core Housing”
(4) GEH specification 26A7475 rev. 1 “Steam Dryer”
(5) GEH specification 26A7684 rev 1 “Reactor Internals Fabrication Requirements”
(6) GEH specification 26A7502 rev. 2 “Reactor Internals Material Requirements”

## DCD Impact

DCD Tier 2, Section 3L.4.6, 6th paragraph will be revised as noted in the attached markup.

## LTR Impact

LTR NEDE-33312P, Rev 1 Section 1.0 was re-titled and information added as noted in the attached markup.

LTR NEDE-33313P, Rev 1 Section 9.1 was created from existing text and the $5^{th}$, $6^{th}$, and $7^{th}$ paragraphs were added, and Section 9.2 (except last paragraph) was added as noted in the attached markup.

**NRC Comment 2**

*In Section 3L.4.6 of Appendix 3L to DCD Tier 2, the applicant provides acceptance criteria for the strains measured on the instrumented steam dryer during power ascension. This response is acceptable for the first few ESBWR plants where the steam dryers will be instrumented with strain gages. [[*

*]]*

**GEH response**

Please see response to item 5.

**DCD Impact**

No changes will be made to the DCD in response to this audit comment.

**LTR Impact**

No changes will be made to a LTR in response to this audit comment.

**NRC Comment 3**

*Ensure modifications to [[*

*]]*

*The applicant has also clarified that vibration data for all equipment listed in DCD Tier 2, Table 3L.4, will be acquired during initial startup and power ascension testing. [[*

*]]*

**GEH response**

To clarify this request, the item 5 that is referred to in the comment pertains to DCD Tier 2 and Section 3L.2.2 is titled "Evaluation Process – Part 2". GEH concurs that item 5 is confusing since items 1 through 4 in this section do not pertain to all the reactor internal components. Section 3L2.2 and 3L.1 have been revised as shown in the attachment to provide clarification. The items shown in items 1 through 4 only pertain to components where comparisons to prior BWR's can be performed; and therefore, new components such as the chimney and the SLC lines are not evaluated using these items; however, the evaluation of these components is included in reference 3L-1. Due to the complexity of the steam dryer, this component is not included in the evaluation provided in reference 3L-1, but is addressed in DCD Tier 2, section 3L.4, and DCD Tier 2 references 3L-5, 3L-6, 3L-8 and 3L-9.

In Section 3L.4.6 it was stated:
"During power ascension, the steam dryer instrumentation (strain gages, accelerometers and dynamic pressure transducers) is monitored against established limits to assure the structural integrity of the steam dryer is maintained. ... The acceptability of the steam dryer for continued operation is evaluated by revising the load definition based on the measured loading, repeating the structural analysis using the revised load definition, and determining revised operating limits based on the results of the structural analysis."

The above sentence is referring to benchmarking the PBLE methodology in the case that the predetermined power ascension limits are exceeded during the power ascension. NEDE-33312P has been revised to include benchmarking the PBLE and [[

]]. The attached markup to Table 3L.4 has been revised to reflect that commitment. Specifically, the table caveats "if problem occurs" have been deleted from the Location Basis column and "Pressure data, however, while recorded during startup testing, will not be evaluated in detail unless the primary vibration measurements indicate the need for further assessment" has been deleted from the footnote.

**DCD Impact**

DCD Tier 2, Section 3L.1, Subsection 3L.2.2 and Table 3L-4 will be revised as noted in the attached markup.

**LTR Impact**

No changes will be made to a LTR in response to this audit comment.

**NRC Comment 4**

*The staff is concerned about the structural integrity of [[*

*]].*

**GEH response**

To clarify that the ITAAC number 36 of Table 2.1.2-3 in Tier 1 applies to both the main steam piping components and the steam dryer, this ITAAC has been revised as shown in the attachment. The revised ITAAC also specifies that it is the first and second shear layer wave acoustic resonance of the main steam line and the SRV/SV standpipe that is specifically avoided. A corresponding change to Tier 2 section 3L.4.1 is also made as shown in the attachment to support the Tier 1 change. [[

]].

**DCD Impact**

DCD Tier 1, Section 2.1.2 and Table 2.1.2-3 will be revised as noted in the attached markup.

DCD Tier 2, Section 3L.4.1 will be revised as noted in the attached markup.

**LTR Impact**

LTR NEDE-33312P, Rev 1 Section 4.1 (3rd paragraph) was revised as noted in the attached markup.

**NRC Comment 5**

*GEH has stated that the dryer of the first ESBWR will be instrumented during power ascension to ensure that the [[*

*]]*

**GEH response**

DCD Section 3.9.2.3 states that in design "The fatigue analysis performed for the ESBWR steam dryer uses a fatigue limit stress amplitude of 93.7 MPa (13,600 psi). For the outer hood component, which is subjected to higher pressure loading in the region of the main steam-lines, the fatigue limit stress amplitude is 74.4 MPa (10,800 psi)." Section 3L.5.5.3 states that the strain and acceleration limits will be derived using the same fatigue limit stress amplitude values.

Following the startup testing of the first unit or if an acceptance limit is reached during power ascension, the load FIV load definition will be defined from the recorded dryer pressure and/or steam line data. The load definition bias and uncertainty will be benchmarked against the dryer pressure sensor data. A structural analysis will be performed to benchmark the FE model strain and acceleration predictions against the measured data. The full power dryer peak stress based on test data adjusted for load, FE model, and instrument bias and uncertainties will then be calculated. The adjusted peak stress will be maintained less than 93.7 MPa (13,600 psi).

On subsequent ESBWR steam dryers main steam line limits will be based on frequency domain curves developed from the initial unit test data factored by a limit curve factor. The limit curve factor will be determined based on the ratio of 13,600 psi over the projected peak stress on the initial plant dryer after adjustment for bias and uncertainty.

DCD Impact. Section 3L4.6 of the Tier 2, Chapter 3, Appendix L has been modified to state that additional information on power ascension testing, acceptance criteria, benchmarking loads, and benchmarking of the FE model for the first and subsequent ESBWR units is included in references 3L-5 and 3L-6 LTR NEDE-33312P and NEDE-33313P have been modified to include a summary of the applicable fatigue stress limits and methodology to be used to qualify the first and subsequent ESBWR dryers for FIV loads.

**DCD Impact**

DCD Tier 2, Subsection 3.9.2.3 and 3L.4.6 (7th paragraph), will be revised as noted in the attached markup.

**LTR Impact**

LTR NEDE-33313P, Rev 1 section 4.1 will be revised by adding a 2nd and 3rd paragraph, the last paragraph was added to Section 9.2 as noted in the attached markup or as described above.

**NRC Comment 6**

*GEH is asked to explain how it will determine the size of the [[*

*]]*

**GEH response**

The cut boundaries [[

]].

These requirements have been incorporated into the NEDE-33313P Rev 1 markup that is attached.

**DCD Impact**

No changes will be made to the DCD in response to this audit comment.

**LTR Impact**

LTR NEDE-33313P, Rev 1 section 5.1 will be revised as noted in the attached markup or as described above.

**NRC Comment 7**

*In NEDE-33259 Rev. 2, the support of the ESBWR shroud was changed from Rev. 1. Show the [[*

*]].*

**GEH response**

As explained in the audit meeting, the design of the shroud support in the [[

]].

[[

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]].

**DCD Impact**

No changes will be made to the DCD in response to this audit comment.

**LTR Impact**

No changes will be made to a LTR in response to this audit comment.

**NRC Comment 8**

*Explain the planned supports for the [[*

*]]*

**GEH response**

For the chimney partition assembly that will be designed to be removable at refueling outages, [[

]].

References:

(1) GEH [[ ]].

**DCD Impact**

No changes will be made to the DCD in response to this audit comment.

**LTR Impact**

No changes will be made to a LTR in response to this audit comment.

**NRC Comment 9**

*Verify that FIV stress analysis of the internal components has been repeated that accounts for the [[*

*]].*

**GEH response**

The evaluation work reported in NEDE-33259 revision 2 does include the newly designed components such as the [[

]].

References:

(1) GEH [[ ]].
(2) GEH [[ ]].
(3) GEH [[ ]].

**DCD Impact**

No changes will be made to the DCD in response to this audit comment.

**LTR Impact**

No changes will be made to a LTR in response to this audit comment.

**NRC Comment 10**

*GEH has proposed three approaches in calculating fatigue stress [[*

*]].*

**GEH response**

For weld stresses determined from [[

]].

**DCD Impact**

No changes will be made to the DCD in response to this audit comment.

**LTR Impact**

LTR NEDE-33313P, Rev 1, Section 4.1 will be revised by moving the previously 3rd paragraph to the now 8th paragraph and adding a now 9th paragraph as noted in the attached markup, in addition to revising figure 4-1.

**NRC Comment 11**

*GEH agreed that rejectable root defects will not always penetrate the surface. Therefore, for [[*

*]].*

**GEH response**

NEDE-33313 will be revised by adding the qualification requirements.

**DCD Impact**

No changes will be made to the DCD in response to this audit comment.

**LTR Impact**

LTR NEDE-33313P, Rev 1, section 4.2 will be revised as noted in the attached markup.

**NRC Comment 12**

*GEH agreed that the TRANSMATRIX coefficients used in the PBLE methodology [[*

*]]. GEH will modify NEDE-33312P to include this commitment.*

**GEH response**

NEDE-33312P has been revised to clarify that the steam line and dryer test data and the PBLE model will be used to [[

]].

NEDE-33313P has been modified to incorporate the requirements for the [[

]]. With adequate shielding and proper installation requirements, there have been no problems with GEH data acquisition systems or background plant noise issues in GEH main steam line data acquisition projects to date.

The instrument arrangement, electrical noise requirements, background noise, and acceptance limits text have been consolidated in NEDE-33313P Section 9. This includes moving the discussion on electrical noise that was in 3L.4.6 and the dryer acceptance limits information that was in 3L.5.5.2 to NEDE-33313P Section 9.

The discussion on the Comparative CFD Analysis in Section 2.2 of NEDE-33312P, has been clarified to state that [[

]].

**DCD Impact**

DCD Tier 2, Subsection 3L.5.5.2, 3L.5.5.3, 3L.4.6 (10th and 11th paragraphs) will be revised as noted in the attached markup.

**LTR Impact**

LTR NEDE-33312P, Rev 1 Section 2.2 was revised as noted in the attached markup.

LTR NEDE-33313P, Rev 1 Section 9.1 was created from existing text and the 5th, 6th, and 7th paragraphs were added, and Section 9.2 (except last paragraph) was added as noted in the attached markup.

**NRC Comment 13**

*In NEDE-33312P, GEH will clearly identify the ESBWR loads and where they come from. Additionally, the loads will be shown on a plot in NEDE-33312P.*

**GEH response**

The additional information on the ESBWR load definition provided in the Response to RAI 3.9-206 S01 (1) has been incorporated into the attached markup to NEDE-33312P section 4.1. [[

]].

References:

(1) GEH Letter MFN-09-471, Docket No. 52-010, Richard Kingston to USNRC, "Response to Portions of NRC RAI Letter No. 339 Related to ESBWR Design Certification Application – DCD Tier 2 Section 3.9 – Mechanical Systems and Components; RAO Number 3.9-206 S01" July 13, 2009.

(2) GEH Letter MFN-09-579, Docket No. 52-010, Richard Kingston to USNRC, "Transmittal of Revision 1 of GEH Licensing Topical Report (LTR) "ESBWR Steam Dryer - Plant Based Load Evaluation Methodology Supplement 1," NEDC-33408P, Supplement 1, Revision 1, August 2009."

**DCD Impact**

No changes will be made to the DCD in response to this audit comment.

**LTR Impact**

LTR NEDE-33312P, Rev 1 Section 4.1, 5th paragraph was revised, and 9th and 10th paragraphs added, as noted in the attached markup.

**NRC Comment 14**

*GEH has provided frequency-dependent bias errors and uncertainties in RAI responses, but has not committed to using them for ESBWR design purposes. GEH should provide a clear summary table of frequency dependent bias errors and uncertainties for both PBLE-based dryer loads, as well as dryer FE frequency response functions used for ESBWR stress calculations. The bias errors and uncertainties may be computed over [[ ]].*

**GEH response**

In the attached markup to NEDE-33313 details have added for the application of frequency dependent bias and uncertainty values for both PBLE design loads and for the FE model analysis for both initial dryer design as well as dryer qualification following startup testing. The bias errors to be used will be computed over [[ ]] as detailed in the attached markup. The discussion in NEDE-33313 Section 5 on the dynamic testing has been expanded to include the frequency response function used to evaluate the FE model bias and uncertainty based on testing. A reference was added in the DCD section 3L.4.6 that indicates that this information is in NEDE-33313.

**DCD Impact**

No changes will be made to the DCD in response to this audit comment.

**LTR Impact**

LTR NEDE-33312P, Rev 1 Section 4.1, now 11th paragraph broke into two paragraphs as noted in the attached markup.

LTR NEDE-33313, Rev 1, Section 5.2 will be revised by adding Subsections 5.2.1, 5.2.2, 5.2.3 and 5.2.4, and Section 11.0 will be revised as noted in the attached markup.

**NRC Comment 15**

*GEH should provide their planned procedure for ensuring any [[ ]] of dryer stresses will be conservative and included in NEDE-33312P.*

**GEH response**

[[ ]] has been added to NEDE-33313 Rev 1 Section 5.2.

**DCD Impact**

No changes will be made to the DCD in response to this audit comment.

**LTR Impact**

NEDE-33313 rev 1, Section 5.2 will be revised by adding Subsections 5.2.5 as noted in the attached markup.

**NRC Comment 16**

*GEH needs to update their PBLE bias error and uncertainty table to include the frequency dependent values they calculated and clarify their statement that PBLE bias errors and uncertainties [[ ]] in NEDE-33312P.*

**GEH response**

NEDC-33408 Supplement 1 (1) was revised to included updated bias and uncertainty data requested by the Staff. NEDE 33313 section 5.2 has been updated to clarify GEH's specific commitments for FIV bias an uncertainty values to be applied for the ESBWR dryer stress evaluation based on the audit comment.

Reference:

(1) GEH Letter MFN-09-579, Docket No. 52-010, Richard Kingston to USNRC, "Transmittal of Revision 1 of GEH Licensing Topical Report (LTR) "ESBWR Steam Dryer - Plant Based Load Evaluation Methodology Supplement 1," NEDC-33408P, Supplement 1, Revision 1, August 2009."

**DCD Impact**

DCD Tier 2, Section 3L.6 will be revised as noted in the attached markup

**LTR Impact**

NEDE-33313 rev 1, Section 5.2 will be revised by adding Subsections 5.2.1 and 5.2.2 as noted in the attached markup.

**NRC Comment 17**

*The supplemental audit comment below was submitted by Z. Cruz (NRC Staff) to H. Upton (GEH), on September 22, 2009.*

*Section 3.9.3.9 of the DCD addresses the radiation effects for threaded fasteners for the ESBWR reactor pressure vessel internals. Additionally, review of Chapters 4 and 5 of the DCD did not include the following information that the NRC requests:*

*(i) Locations of threaded fasteners used for the ESBWR RPV internals. What are the materials?*
*(ii) Provide a revised drawing of the connection between the chimney/shroud/top guide.*
*(iii) What is the estimated end-of-life fluence for these fasteners?*
*(iv) What may be the maximum radiation-induced stress relaxation? Will it cause loosening of the threaded fasteners?*
*(v) Are these fasteners susceptible to IASCC during the 60 years of service life?*
*(vi) What may be the loss of fracture toughness at the end of 60-year service life? Will it challenge the structural integrity of the fasteners?*

*Please provide data and other information supporting the answers to the above questions.*

**GEH response**

(i) The core plate hardware and the top guide hardware are the only ESBWR reactor pressure vessel internal fasteners that are located such that the effects of neutron radiation exposure are potentially significant. The core plate hardware is located at the outer periphery of the core plate and connects the support ring, core plate, and shroud lower flange. The top guide fasteners are located at the periphery of the top guide and connect the shroud upper flange, top guide, and chimney lower flange. The material of the studs and nuts is SA-479/SA-479M Type XM-19 for both of these applications.

(ii) The attached sketch is provided for information. The sketch provides a conceptual design of the connection between the shroud, chimney, and top guide. The use of a spherical washer for each stud, located at the top surface of the chimney flange (not shown in the sketch), may be considered during the hardware design development to compensate for angular variances between the stud and the flange.

[[ ]]

Concept Sketch of the Shroud, Chimney, and Top Guide Connection

(iii) The fast neutron fluence (E> 1 MeV) for the ESBWR top guide studs and core plate studs at the end of plant life of 54 Effective-Full-Power Years (EFPY) based on conservative estimation is shown below:

| | |
|---|---|
| Axial averaged fluence for the top guide stud at peak azimuth | **2.3E19 n/cm$^2$** |
| Axial averaged fluence for the core plate stud at peak azimuth | **1.0E20 n/cm$^2$** |

(iv) The expected [[

]]. The design document is based upon a combination of GEH internal reports and industry data to evaluate stress relaxation. The curves are GEH Proprietary information, and can be made available for NRC review upon request.

The design analyses for these fasteners compare the stud external loads with the stud minimum preload to ensure that sufficient preload is applied to prevent lift-off after accounting for thermal and irradiation induced relaxation over the design life. Additional margin is applied to these end-of-life load relaxation factors to ensure loosening does not occur due to vibration or other potential relaxation mechanisms.

(v) As noted in the response to item (iii) above, the expected end-of-life fluencies for the top guide and core plate fasteners are estimated to be 2.3E19 n/cm$^2$ and 1.0E20 n/cm$^2$, respectively. Based on an IASCC threshold of 5E20 n/cm$^2$ for stainless steel (Reference 1), IASCC is not considered a plausible degradation mechanism for the top guide and core plate fasteners.

(vi) As discussed in Reference 2, a threshold neutron dose of 2E20 n/cm$^2$ has been defined as the level below which irradiation has little or no effect on fracture toughness. As the estimated fluencies for the top guide and core plate fasteners is 2.3E19 n/cm$^2$ and 1.0E20 n/cm$^2$, respectively, irradiation is not expected to significantly affect the fracture toughness of the fasteners. Since the fracture toughness will not be significantly impacted, the structural integrity of the fasteners will not be challenged by fracture toughness.

References:

(1) BWRVIP-26-A, BWR Vessel and Internals Project, BWR Top Guide Inspection and Flaw Evaluation Guidelines, EPRI, Palo Alto, CA, 2004. 1009946.

(2) O. K. Chopra and W. J. Shack, "Crack Growth Rates and Fracture Toughness of Irradiated Austenitic Stainless steels in BWR Environments, " NUREG/CR-6960, March 2008.

## DCD Impact

No changes will be made to the DCD in response to this audit comment.

## LTR Impact

No changes will be made to a LTR in response to this audit comment.

## 2.1.2 Nuclear Boiler System

### Design Description

The Nuclear Boiler System (NBS) generates steam from feedwater and transports steam from the RPV to the main turbine.

The combined steamline volume from the RPV to the main steam turbine stop valves and steam bypass valves is sufficient to validate the assumptions in Anticipated analyses (see Table 2.11.1-1, Item 8).

The equipment qualification of the NBS components is addressed in Section 3.8.

The containment isolation requirements for the NBS are addressed in Subsection 2.15.1.

NBS software is developed in accordance with the software development program described in Section 3.2.

NBS alarms, displays, controls, and status indications in the MCR are addressed by Section 3.3.

Conformance with IEEE Standard 603 requirements by the safety-related control system, structures, systems, or components is addressed in Subsection 2.2.15.

(1) The functional arrangement of the NBS is as described in the Design Description of this Subsection 2.1.2, Tables 2.1.2-1 and 2.1.2-2, and as shown on Figures 2.1.2-1, 2.1.2-2, and 2.1.2-3.

(2) a1. The components identified in Table 2.1.2-1 as ASME Code Section III are designed in accordance with ASME Code Section III requirements.

a2. The components identified in Table 2.1.2-1 as ASME Code Section III shall be reconciled with the design requirements.

a3. The components identified in Table 2.1.2-1 as ASME Code Section III are fabricated, installed, and inspected in accordance with ASME Code Section III requirements.

b1. The piping identified in Table 2.1.2-1 as ASME Code Section III is designed in accordance with ASME Code Section III requirements.

b2. The as-built piping identified in Table 2.1.2-1 as ASME Code Section III shall be reconciled with the piping design requirements.

b3. The piping identified in Table 2.1.2-1 as ASME Code Section III is fabricated, installed, and inspected in accordance with ASME Code Section III requirements.

(3) a. Pressure boundary welds in components identified in Table 2.1.2-1 as ASME Code Section III meet ASME Code Section III non-destructive examination requirements.

b. Pressure boundary welds in piping identified in Table 2.1.2-1 as ASME Code Section III meet ASME Code Section III non-destructive examination requirements.

(4) a. The components identified in Table 2.1.2-1 as ASME Code Section III retain their pressure boundary integrity at their design pressure.

b. The piping identified in Table 2.1.2-1 as ASME Code Section III retains its pressure boundary integrity at its design pressure.

(5) The equipment identified in Table 2.1.2-1 and Table 2.1.2-2 as Seismic Category I can withstand Seismic Category I loads without loss of safety function.

(6) a. (Deleted)

b. (Deleted)

(7) a. Each NBS mechanical train located outside the containment is physically separated from the other train(s) so as not to preclude accomplishment of the intended safety-related function.

b. Each NBS mechanical train located inside the containment is physically separated from the other train(s) so as not to preclude accomplishment of the intended safety-related function.

(8) a. The MSIVs close upon command.

b. The Feedwater Isolation Valves (FWIVs) close upon command.

(9) (Deleted)

(10) MSIVs and FWIVs fail closed upon loss of electrical power to the actuating solenoid.

(11) Check valves listed in Table 2.1.2-1 open and close under system pressure, fluid flow, and temperature conditions.

(12) The throat diameter of each Main Steamline (MSL) flow restrictor is sized for design choke flow requirements.

(13) Each MSL flow restrictor has taps for two instrument connections to be used for monitoring the flow through its associated MSL.

(14) (Deleted)

(15) a. The MSIVs are capable of fast closing under design differential pressure, fluid flow, and temperature conditions.

b. The FWIVs are capable of fast closing under design differential pressure, fluid flow and temperature conditions.

(16) a. When all four inboard or outboard MSIVs are stroked from a full-open to full-closed position by their actuators, the combined leakage through the MSIVs for all four MSLs will be less than or equal to the design bases assumption value.

b. When all four FWIVs are stroked from full-open to full-closed position by their actuators, the combined liquid inflow leakage through the FWIVs for both feedwater lines will be less than or equal to the design bases assumption value.

c. When all four FWIVs are stroked from full-open to full-closed position by their actuators, the combined gas outflow leakage through the FWIVs for both feedwater lines will be less than or equal to the design bases assumption value.

(17) The opening pressure for the Safety Relief Valves (SRVs) setpoint in mechanical lift mode validates the overpressure protection analysis by lifting at its nominal setpoint pressure.

(18) The opening time for the SRVs in the overpressure operation of self-actuated or mechanical lift mode, which is measured from when the pressure exceeds the valve set pressure to when the valve is fully open, shall be less than or equal to the design opening time.

(19) The steam discharge capacity of each SRV validates (i.e., is greater than or equal to that used in) the overpressure protection analysis.

(20) The opening pressure for the Safety Valves (SVs) validates (i.e., is less than or equal to that used in) the overpressure protection analysis.

(21) The opening time for the SVs, measured from when the pressure exceeds the valve set pressure to when the valve is fully open, shall be less than or equal to the design opening time.

(22) The steam discharge capacity of each SV validates (i.e., is greater than or equal to that used in) the overpressure protection analysis.

(23) The relief-mode actuator (and safety-related appurtenances) can open each SRV with the drywell (DW) pressure at design pressure.

(24) The booster assembly opens each Depressurization Valve (DPV) in less than or equal to the design opening time (opening time to full rated capacity).

(25) Each DPV minimum flow capacity is sufficient to support rapid depressurization of the RPV (i.e., has a flow capacity that is greater than or equal to the design flow capacity under design basis conditions).

(26) (Deleted)

(27) (Deleted)

(28) Vacuum breakers are provided on SRV discharge lines to reduce the post-discharge reflood height of water in the discharge lines.

(29) The SRV discharge line vacuum breakers close to prevent steam bypass to the DW during SRV discharge, and open following a discharge completion to permit pressure equalization with the DW and prevent ingestion of a water slug into the SRV discharge lines.

(30) The pressure loss coefficient of each of the following components is within the uncertainty band of the pressure loss coefficient used in the natural circulation flow analysis:

- Steam separator
- Fuel bundle
- Fuel support piece orifice
- Control rod guide tubes
- Shroud support

(31) The free volume for each of the following components is within the uncertainty band of the free volume used in the natural circulation flow analysis:

- RPV
- Downcomer

- Core
- Chimney
- Separator/dryer

(32) The hydraulic diameter, geometry of the heated surfaces, and flow area in fuel assemblies are within the uncertainty band of the geometry used in the natural circulation flow analysis.

(33) (Deleted)

(34) (Deleted)

(35) (Deleted)

(36) The main steam line and SRV/SV branch piping geometry precludes first and second shear layer wave acoustic resonance conditions from occurring and avoids pressure loads on the steam dryer at plant normal operating conditions.

**Inspections, Tests, Analyses, and Acceptance Criteria**

Table 2.1.2-3 provides a definition of the inspections, tests and analyses, together with associated acceptance criteria for the NBS.

## Table 2.1.2-3

## ITAAC For The Nuclear Boiler System

| Design Commitment | Inspections, Tests, Analyses | Acceptance Criteria |
|---|---|---|
| 1. The functional arrangement of the NBS is as described in the Design Description of this Subsection 2.1.2, Tables 2.1.2-1 and 2.1.2-2 and as shown in Figures 2.1.2-1, 2.1.2-2, and 2.1.2-3. | Inspection of the as-built system will be performed. | The as-built NBS conforms to the functional arrangement described in the Design Description of this Subsection 2.1.2, Tables 2.1.2-1 and 2.1.2-2 and Figures 2.1.2-1, 2.1.2-2, and 2.1.2-3. |
| 2.a1. The components identified in Table 2.1.2-1 as ASME Code Section III are designed in accordance with ASME Code Section III requirements. | Inspection of ASME Code Design Reports (NCA-3550) and required documents will be conducted. | ASME Code Design Reports (NCA-3550) (certified, when required by ASME Code) exist and conclude that the design of the components identified in Table 2.1.2-1 as ASME Code Section III complies with the requirements of ASME Code Section III including those stresses applicable to loads related to fatigue (including environmental effects), thermal expansion, seismic, and combined. |
| 2.a2. The components identified in Table 2.1.2-1 as ASME Code Section III shall be reconciled with the design requirements. | A reconciliation analysis of the components identified in Table 2.1.2-1 as ASME Code Section III using as-designed and as-built information and ASME Code Design Reports (NCA-3550) will be performed. | ASME Code Design Report(s) (NCA-3550) (certified, when required by ASME Code) exist and conclude that design reconciliation has been completed, in accordance with ASME Code, for as-built reconciliation of the components identified in Table 2.1.2-1 as ASME Code Section III. The report documents the results of the reconciliation analysis. |

**Table 2.1.2-3**

**ITAAC For The Nuclear Boiler System**

| Design Commitment | Inspections, Tests, Analyses | Acceptance Criteria |
|---|---|---|
| 2.a3. The components identified in Table 2.1.2-1 as ASME Code Section III are fabricated, installed, and inspected in accordance with ASME Code Section III requirements. | Inspection of the components identified in Table 2.1.2-1 as ASME Code Section III will be conducted. | ASME Code Data Report(s) (including N-5 Data Reports, where applicable) (certified, when required by ASME Code) and inspection reports exist and conclude that the components identified in Table 2.1.2-1 as ASME Code Section III are fabricated, installed, and inspected in accordance with ASME Code Section III requirements. |
| 2.b1. The piping identified in Table 2.1.2-1 as ASME Code Section III is designed in accordance with ASME Code Section III requirements. | Inspection of ASME Code Design Reports (NCA-3550) and required documents will be conducted. {{Design Acceptance Criteria}} | ASME Code Design Report(s) (NCA-3550) (certified, when required by ASME Code) exist and conclude that the design of the piping identified in Table 2.1.2-1 as ASME Code Section III complies with the requirements of ASME Code Section III, including those stresses applicable to loads related to fatigue (including environmental effects), thermal expansion, seismic, and combined. {{Design Acceptance Criteria}} |

## Table 2.1.2-3

## ITAAC For The Nuclear Boiler System

| Design Commitment | Inspections, Tests, Analyses | Acceptance Criteria |
|---|---|---|
| 2.b2. The as-built piping identified in Table 2.1.2-1 as ASME Code Section III shall be reconciled with the piping design requirements. | A reconciliation analysis of the piping identified in Table 2.1.2-1 as ASME Code Section III using as-designed and as-built information and ASME Code Design Reports (NCA-3550) will be performed | ASME Code Design Report(s) (NCA-3550) (certified, when required by ASME Code) exist and conclude that design reconciliation has been completed, in accordance with ASME Code, for as-built reconciliation of the piping identified in Table 2.1.2-1 as ASME Code Section III. The report documents the results of the reconciliation analysis. |
| 2.b3. The piping identified in Table 2.1.2-1 as ASME Code Section III is fabricated, installed, and inspected in accordance with ASME Code Section III requirements. | Inspections of the piping identified in Table 2.4.2-1 as ASME Code Section III will be conducted. | ASME Code Data Report(s) (certified, when required by ASME Code) and inspection reports (including N-5 Data Reports where applicable) exist and conclude that the piping identified in Table 2.4.2-1 as ASME Code Section III is fabricated, installed, and inspected in accordance with ASME Code Section III requirements. |
| 3a. Pressure boundary welds in components identified in Table 2.1.2-1 as ASME Code Section III meet ASME Code Section III non-destructive examination requirements. | Inspection of the as-built pressure boundary welds in components identified in Table 2.1.2-1 as ASME Code Section III will be performed in accordance with ASME Code Section III. | ASME Code report(s) exist and conclude that ASME Code Section III requirements are met for non-destructive examination of pressure boundary welds in components identified in Table 2.1.2-1 as ASME Code Section III. |

**Table 2.1.2-3**

**ITAAC For The Nuclear Boiler System**

| Design Commitment | Inspections, Tests, Analyses | Acceptance Criteria |
|---|---|---|
| 3b. Pressure boundary welds in piping identified in Table 2.1.2-1 as ASME Code Section III meet ASME Code Section III non-destructive examination requirements. | Inspection of the as-built pressure boundary welds in piping identified in Table 2.1.2-1 as ASME Code Section III will be performed in accordance with ASME Code Section III. | ASME Code report(s) exist and conclude that ASME Code Section III requirements are met for non-destructive examination of pressure boundary welds in piping identified in Table 2.1.2-1 as ASME Code Section III |
| 4a. The components identified in Table 2.1.2-1 as ASME Code Section III retain their pressure boundary integrity at their design pressure. | A hydrostatic test will be conducted on those code components identified in Table 2.1.2-1 as ASME Code Section III that are required to be hydrostatically tested by ASME Code Section III. | ASME Code Data Report(s) exist and conclude that the results of the hydrostatic test of components identified in Table 2.1.2-1 as ASME Code Section III comply with the requirements of ASME Code Section III. |
| 4b. The piping identified in Table 2.1.2-1 as ASME Code Section III retains its pressure boundary integrity at its design pressure. | A hydrostatic test will be conducted on the code piping identified in Table 2.1.2-1 as ASME Code Section III that is required to be hydrostatically tested by ASME Code Section III. | ASME Code Data Report(s) exist and conclude that the results of the hydrostatic test of piping identified in Table 2.1.2-1 as ASME Code Section III comply with the requirements in ASME Code Section III. |
| 5. The equipment identified in Table 2.1.2-1 and Table 2.1.2-2 as Seismic Category I can withstand Seismic Category I loads without loss of safety function. | i. Inspection will be performed to verify that the Seismic Category I equipment identified in Table 2.1.2-1 and Table 2.1.2-2 are located in a Seismic Category I structure. | i. The equipment identified as Seismic Category I in Table 2.1.2-1 and Table 2.1.2-2 is located in a Seismic Category I structure. |

## Table 2.1.2-3

## ITAAC For The Nuclear Boiler System

| Design Commitment | Inspections, Tests, Analyses | Acceptance Criteria |
|---|---|---|
| | ii. Type tests, analyses, or a combination of type tests and analyses, of equipment identified in Table 2.1.2-1 and Table 2.1.2-2 as Seismic Category I, will be performed using analytical assumptions, or will be performed under conditions which bound the Seismic Category I equipment design requirements<br>iii. Inspection and analyses will be performed to verify that the as-built equipment identified in Table 2.1.2-1 and Table 2.1.2-2 as Seismic Category I, including anchorage, is bounded by the testing or analyzed conditions. | ii. The equipment identified in Table 2.1.2-1 and Table 2.1.2-2 as Seismic Category I can withstand Seismic Category I loads without loss of safety function.<br>iii. The as-built equipment identified in Table 2.1.2-1 and Table 2.1.2-2 as Seismic Category I, including anchorage, can withstand Seismic Category I loads without loss of safety function. |
| 6a. (Deleted) | | |
| 6b. (Deleted) | | |
| 7a. Each NBS mechanical train located outside the containment is physically separated from the other train(s) so as not to preclude accomplishment of the intended safety-related function | Inspections and analysis will be conducted for each of the NBS mechanical trains located outside the containment. | Each NBS mechanical train located outside containment is protected against design basis events and their direct consequences by spatial separation, barriers, restraints, or enclosures so as not to preclude accomplishment of the intended safety-related function. |

## Table 2.1.2-3

## ITAAC For The Nuclear Boiler System

| Design Commitment | Inspections, Tests, Analyses | Acceptance Criteria |
|---|---|---|
| 7b. Each NBS mechanical train located inside the containment is physically separated from the other train(s) so as not to preclude accomplishment of the intended safety-related function. | Inspections and analysis will be conducted for each of the NBS mechanical trains located inside the containment. | Each NBS mechanical train located inside containment is protected against design basis events and their direct consequences by spatial separation, barriers, restraints, or enclosures so as not to preclude accomplishment of the intended safety-related function. |
| 8a. The MSIVs close upon command | Valve closure tests will be performed on the as-built MSIVs using a manual closure command to simulate an isolation signal. | The MSIVs close upon command. |
| 8b. The Feedwater Isolation Valves (FWIVs) close upon command | Valve closure tests will be performed on the as-built FWIVs using a manual closure command to simulate an isolation signal. | The FWIVs close upon command |
| 9. (Deleted) | | |
| 10. MSIVs and FWIVs fail closed upon loss of electrical power to the valve actuating solenoid. | Tests will be conducted on the as-built valve under preoperational conditions | The MSIVs and FWIVs fail closed upon loss of electrical power to the valve actuating solenoid. |
| 11. Check valves listed in Table 2.1.2-1 open and close under system pressure, fluid flow, and temperature conditions. | Tests of installed valves for opening and closing, will be conducted under system preoperational pressure, fluid flow, and temperature conditions. | Based on the direction of the differential pressure across the valve, each check valve listed in Table 2.1.2-1 opens and closes. |
| 12. The throat diameter of each Main Steamline (MSL) flow restrictor is sized for design choke flow requirements. | Inspections of each as-built MSL flow restrictor throat diameter will be performed | The throat diameter of each MSL flow restrictor is less than or equal to 355 mm (14.0 in). |

Table 2.1.2-3

ITAAC For The Nuclear Boiler System

| Design Commitment | Inspections, Tests, Analyses | Acceptance Criteria |
|---|---|---|
| 13. Each MSL flow restrictor has taps for two instrument connections to be used for monitoring the flow through its associated MSL. | Inspections of the as-built installation of each MSL flow restrictor will be conducted to verify that it provides for two instrument connections. | Each as-built MSL flow restrictor provides for two instrument connections. |
| 14. (Deleted) | | |
| 15a. The MSIVs are capable of fast closing under design differential pressure, fluid flow and temperature conditions. | Type tests of the MSIV will be conducted in accordance with the design and purchase specifications to demonstrate that the MSIVs will fast close under design conditions. | The MSIVs are capable of fast closure in not less than 3 seconds and not more than 5 seconds under design conditions. |
| 15b. The FWIVs are capable of fast closing under design differential pressure, fluid flow and temperature conditions. | Type tests of the FWIVs will be conducted in accordance with the design and purchase specifications to demonstrate that the FWIVs will fast close under design conditions. | The FWIVs are capable of fast closure in not less than 10 seconds and not more than 15 seconds under design conditions. |
| 16a. When all four inboard or outboard MSIVs are stroked from full-open to full-closed position by their actuators, the combined leakage through the MSIVs for all four MSLs will be less than or equal to the design bases assumption value. | Tests at preoperational conditions along with analysis will be performed on the as-built MSIVs to determine the leakage as adjusted to the specified design conditions. | When all MSIVs are stroked from the full-open to full-closed position by their actuators, the combined leakage through the MSIVs for all four MSLs is less than or equal to a total combined leakage (corrected to standard conditions) of less than or equal to 94.4 liters/minute (3.33 $ft^3$/minute) for post-LOCA leakage. |

**Table 2.1.2-3**

**ITAAC For The Nuclear Boiler System**

| Design Commitment | Inspections, Tests, Analyses | Acceptance Criteria |
|---|---|---|
| 16b. When all four FWIVs are stroked from full-open to full-closed position by their actuators, the combined liquid inflow leakage through the FWIVs for both feedwater lines will be less than or equal to the design bases assumption value. | Tests using demineralized water and analysis will be performed on the as-built FWIVs to determine the liquid inflow leakage as adjusted to the specified design conditions. | When all FWIVs are stroked from the full-open to full-closed position by their actuators, the combined leakage through the FWIVs for both feedwater lines is less than or equal to a total combined liquid inflow leakage (corrected to standard conditions) of less than or equal to 900 cc/minute (0.238 gpm) for post-LOCA leakage. |
| 16c. When all four FWIVs are stroked from full-open to full-closed position by their actuators, the combined gas outflow leakage through the FWIVs for both feedwater lines will be less than or equal to the design bases assumption value. | Tests and analysis will be performed on the as-built FWIVs to determine the gas outflow leakage as adjusted to the specified design conditions. | When all FWIVs are stroked from the full-open to full-closed position by their actuators, the combined leakage through the FWIVs for both feedwater lines is less than or equal to a total combined gas outflow leakage (corrected to standard conditions) of less than or equal to 700 cc/minute (1.483 $ft^3$/hour) for post-LOCA leakage. |
| 17. The opening pressure for the Safety Relief Valves (SRVs) setpoint in mechanical lift mode validates the overpressure protection analysis by lifting at its nominal setpoint pressure. | Type tests or setpoint tests will be conducted in accordance with the ASME Code to certify the valves. | The mechanical lift nominal setpoint pressure of 8.366 $\pm$ 0.251 MPa gauge (1213 $\pm$ 36 psig). |

**Table 2.1.2-3**

**ITAAC For The Nuclear Boiler System**

| Design Commitment | Inspections, Tests, Analyses | Acceptance Criteria |
|---|---|---|
| 18. The opening time for the SRVs in the overpressure operation of self-actuated or mechanical lift mode, which is measured from when the pressure exceeds the valve set pressure to when the valve is fully open, shall be less than or equal to the design opening time. | Analysis and type tests will be conducted in accordance with the ASME Code to ensure that the valves open within the design opening time. | The opening time (as measured from when the pressure exceeds the valve set pressure to when the valve is fully open) for the SRVs in the overpressure operation of self-actuated or mechanical lift mode is less than or equal to 0.5 seconds. |
| 19. The steam discharge capacity of each SRV validates (i.e., is greater than or equal to that used in) the overpressure protection analysis. | Type tests will be conducted in accordance with the ASME Code Section IIIfor relief valve certification. | Valve capacity stamping on each SRV records the certified capacity at rated setpoint of 138 kg/s (304 lbm/s) minimum. |
| 20. The opening pressure for the Safety Valves (SVs) validates (i.e. is less than or equal to that used in) the overpressure protection analysis. | Type tests or setpoint tests will be conducted in accordance with the ASME Code Section III to certify the valve. | The mechanical lift nominal setpoint pressure of 8.503 $\pm$ 0.255 MPa gauge (1233 $\pm$ 37 psig). |
| 21. The opening time for the SVs, measured from when the pressure exceeds the valve set pressure to when the valve is fully open, shall be less than or equal to the design opening time. | Analysis and type tests will be conducted in accordance with the ASME Code Section III to ensure that the valves open within the design opening time. | The opening time (measured from when the pressure exceeds the valve set pressure to when the valve is fully open) for the SVs is less than or equal to 0.5 seconds. |
| 22. The steam discharge capacity of each SV validates (i.e., is greater than or equal to that used in) the overpressure protection analysis. | Type tests will be conducted in accordance with the ASME Code Section III for relief valve certification. | Valve capacity stamping on each SV records the certified capacity at rated setpoint of 140.2 kg/s (309 lbm/s) minimum. |

## Table 2.1.2-3

## ITAAC For The Nuclear Boiler System

| Design Commitment | Inspections, Tests, Analyses | Acceptance Criteria |
|---|---|---|
| 23. The relief-mode actuator (and safety-related appurtenances) can open each SRV with the DW pressure at design pressure. | An analysis and type test will be performed to demonstrate the capacity Section III of the relief-mode actuation for each SRV. | The relief-mode actuation has the capacity to lift the SRVs to the full open position one time with the DW pressure at the DW design pressure when the accumulator is isolated from its pneumatic pressure source. |
| 24. The booster assembly opens each Depressurization Valve DPV in less than or equal to the design opening time (opening time to full rated capacity). | Type testing will be performed on the booster assemblies to confirm that they are capable of opening the valve at design basis conditions. Type testing, along with analyses to adjust for design basis conditions will be performed to demonstrate that the booster opens each DPV within the design opening time (opening time to full rated capacity) and design conditions. | Each DPV opens when actuated by the booster assembly in less than or equal to 0.45 seconds with an inlet pressure of 7,584 kPa ± 685 kPaG (1100 psig ± 99 psi). |
| 25. Each DPV minimum flow capacity is sufficient to support rapid depressurization of the RPV (i.e., has a flow capacity that is greater than or equal to the design flow capacity under design basis conditions). | Analyses and type tests will be performed. | The DPV flow capacity is greater than or equal to 239 kg/s (527 lbm/s) at an inlet pressure of 7.480 MpaG (1085 psig). |
| 26. (Deleted) | | |
| 27. (Deleted) | | |

Table 2.1.2-3

ITAAC For The Nuclear Boiler System

| Design Commitment | Inspections, Tests, Analyses | Acceptance Criteria |
|---|---|---|
| 28. Vacuum breakers are provided on SRV discharge lines to reduce the post-discharge reflood height of water in the discharge lines. | An inspection and analysis will be performed to confirm that the vacuum breakers are installed and to demonstrate that the vacuum breaker capacity and setpoint limit the water column in the discharge line. | The vacuum breakers are installed on the SRV discharge lines and the vacuum breaker capacity and setpoint limit the water column in the discharge line. |
| 29. The SRV discharge line vacuum breakers close to prevent steam bypass to the DW during SRV discharge, and open following discharge completion to permit pressure equalization with the DW and prevent ingestion of a water slug into the SRV discharge lines. | Type test will be performed on the vacuum breaker for disk-closed leakage at line pressure during SRV discharge, disk cracking (unseating) pressure, and full-open flow capacity. | The following test criteria are met:<br>• At SRV discharge line pressure during SRV discharges, the vacuum breaker leak rate is less than or equal to design leak rate;<br>• The disk unseat begins at design cracking pressure; and,<br>• At disk full lift, the vacuum breaker achieves equal to or greater than design flow capacity. |

## Table 2.1.2-3

## ITAAC For The Nuclear Boiler System

| Design Commitment | Inspections, Tests, Analyses | Acceptance Criteria |
|---|---|---|
| 30. The pressure loss coefficient of each of the following components is within the uncertainty band of the pressure loss coefficient used in the natural circulation flow analysis:<br>• Steam separator<br>• Fuel bundle<br>• Fuel support piece orifice<br>• Control rod guide tubes<br>• Shroud support | As-built component records will be inspected and compared against inputs to the natural circulation analysis, considering uncertainty, performed to calculate pressure loss coefficients. | The pressure loss coefficient of each of the following components is within the uncertainty band of the pressure loss coefficient used in the natural circulation flow analysis:<br>• Steam separator<br>• Fuel bundle<br>• Fuel support piece orifice<br>• Control rod guide<br>• Shroud support |
| 31. The free volume for each of the following components is within the uncertainty band of the free volume used in natural circulation flow analysis:<br>• RPV<br>• Downcomer<br>• Core<br>• Chimney<br>• Separator/dryer | Inspection of as-built component records will be performed to determine the component free volume for each of the listed components. | The free volume of each of the following components is within the uncertainty band of the free volume used in the natural circulation flow analysis:<br>• RPV<br>• Downcomer<br>• Core<br>• Chimney<br>• Separator/dryer |

## Table 2.1.2-3

## ITAAC For The Nuclear Boiler System

| Design Commitment | Inspections, Tests, Analyses | Acceptance Criteria |
|---|---|---|
| 32. The hydraulic diameter, geometry of heated surfaces, and flow area in fuel assemblies are within the uncertainty band of the geometry used in the natural circulation flow analysis. | As-built dimension inspection and analyses will be performed to determine the geometry of the fuel assemblies to be loaded. | The hydraulic diameter, geometry of heated surfaces, and flow area in the fuel assemblies are within the uncertainty band of the geometry used in the natural circulation flow analysis. |
| 33. (Deleted) | | |
| 34. (Deleted) | | |
| 35. (Deleted) | | |
| 36. The main steam line and SRV/SV branch piping geometry precludes first and second shear layer wave acoustic resonance conditions from occurring and avoids pressure loads on the steam dryer at plant normal operating conditions. | Analysis of the as-built piping system and equipment analysis, for acoustic resonance at plant normal operating conditions, will be performed. | The main steam line and SRV/SV branch piping geometry precludes first and second shear layer wave acoustic resonance conditions from occurring and results in no significant pressure loads on the steam dryer at plant normal operating conditions. |

*Extensive predictive evaluations have been performed for the steam dryer loading and structural evaluation. These evaluations are described in Appendix 3L.4. ~~The~~In the dryer design and in the development of the initial strain and accelerations acceptance limits used during startup, the fatigue analysis performed for the ESBWR steam dryer uses a fatigue limit stress amplitude of 93.7 MPa (13,600 psi). For the outer hood component, which is subjected to higher pressure loading in the region of the main steamlines, the fatigue limit stress amplitude is 74.4 MPa (10,800 psi). Following the startup testing of the first unit or if an acceptance limit is reached during power ascension, the load FIV load definition is defined from the recorded dryer pressure or dryer pressure and steam line data. The load definition bias and uncertainty is benchmarked against the dryer pressure sensor data. A structural assessment is performed to benchmark the FE model strain and acceleration predictions against the measured data. The dryer peak stress based on test data, adjusted for load, FE model, and instrument bias and uncertainties, is then calculated and maintained less than 93.7 MPa (13,600 psi). The subsequent ESBWR steam dryers includes dryer FIV monitoring via main steam line instruments. The acceptance limits for subsequent plants is based on assuring that the stresses remain less than 93.7 MPa (13,600 psi) allowable stress. The ~~higher~~ limit is justified because first steam dryer is heavily instrumented, subsequent plants is also monitored for FIV loads, and the load and response is explicitly evaluated based on test data with consideration of bias and uncertainty. ~~t~~The steam dryer is a nonsafety-related component, performs no ~~non~~safety-related functions, and is only required to maintain its structural integrity (no loose parts generated) for normal, transient and accident conditions.*

*The dynamic loads caused by FIV of the steam separators have been determined using a full-scale separator test under reactor conditions. During the test, the flow rate through the steam separator was 226,000 kg/hr (499,000 lbm/hr) at 7% quality. This is higher than the ESBWR maximum separator flow of 100,700 kg/hr (222,000 lbm/hr) at rated power. Test results show a maximum FIV stress of less than 49.6 MPa (7200 psi), well below the GEH acceptance criterion of 68.9 MPa (10,000 psi). Thus it can be concluded that separator FIV effects are acceptable. Jet impingement from feedwater flow has no significant effect on the steam separator assembly since the separator outer-most cylindrical structure (also referred to as the separator "skirt") is above the feedwater flow impingement area.*]*

* Text sections that are bracketed and italicized with an asterisk following the brackets are designated as Tier 2*. Prior Nuclear Regulatory Commission (NRC) approval is required to change.

### *3.9.2.4 Initial Startup Flow Induced Vibration Testing of Reactor Internals*

A reactor internals vibration measurement and inspection program is conducted only during initial startup testing. This meets the guidelines of RG 1.20 with the exception of those requirements related to preoperational testing which cannot be performed for a natural circulation reactor.

**Initial Startup Testing**

Vibration measurements are made during reactor startup at conditions up to 100% rated flow and power. Steady state and transient conditions of natural circulation flow operation are evaluated. The primary purpose of this test series is to verify the anticipated effect of single- and two-phase flow on the vibration response of internals. Details of the initial startup vibration test program

# 3L. REACTOR INTERNALS FLOW INDUCED VIBRATION PROGRAM

## 3L.1 INTRODUCTION

A flow-induced vibration (FIV) analysis and testing program of the reactor internal components of the ESBWR initial plant demonstrates that the ESBWR internals design can safely withstand expected FIV forces for reactor operating conditions up to and including 100% power and core flow. Since ESBWR internals are similar to Advanced Boiling Water Reactor (ABWR) design, the ESBWR FIV program is considered to be non-prototype Category II per Reference 3L-1. This will require analysis and measurement of selected components as necessary and full inspection of reactor internals of the first plant. This program includes an initial evaluation phase that has the objective of demonstrating that the reactor internals are not subject to FIV issues that can lead to failures due to material fatigue. Throughout this part of the program, the emphasis is placed on demonstrating that the reactor components will safely operate for the design life of the plant. The results of this evaluation are shown in Reference 3L-1. This evaluation does not include the steam dryer since it is separately evaluated in References 3L-5, 3L-6, 3L-8 and 3L-9; however, an overview of the steam dryer evaluation program is explained in Section 3L.4. The second phase of the program is focused on preparing and performing the startup test program that demonstrates through instrumentation and inspection that no FIV problems exist. This part of the program meets the requirements of Regulatory Guide 1.20 with the exception of those requirements related to preoperational testing that are not applicable to a natural circulation plant.

## 3L.2 REACTOR INTERNAL COMPONENTS FIV EVALUATION

The ESBWR reactor internals are part of an evolutionary Boiling Water Reactor (BWR) design, but fundamentally the components and function of the reactor vessel and internals are very similar to past BWRs. To a large extent, the ESBWR design of the components relies heavily on the prior design of internals in operating plants to assure that new vibration issues are not introduced. Also, to assure that the flow of steam or water in the reactor vessel is comparable to prior reactors, efforts were made to maintain traditional spacing and dimensional relationships of components. A unique feature of the ESBWR, with respect to FIV, is the fact that ESBWR is a natural circulation plant where no recirculation pumps exist that would create pressure pulses from the pump vanes that would travel into the reactor vessel. The recirculation pump's excitation has caused failures in components inside previous BWR reactor vessels. For the ESBWR this source of flow excitation does not exist. The ESBWR reactor internals are shown in Figure 5.3-3.

### 3L.2.1 Evaluation Process – Part 1

The first step in the evaluation process was to establish selection criteria for reactor internal components related to susceptibility to vibration. All reactor internal components were considered as potential candidates for further evaluation. Each component is evaluated against the following selection criteria:

- Is the component safety-related?
- Is the component of a significantly different or new design compared to earlier BWRs?
- Does the component have a history of FIV-related problems?

The results of the Part 1 evaluation are contained in Reference 3L-1.

The chimney assembly was a new component where only limited operating experience was available. Also, the chimney assembly is a structure where the geometry of the partitions places limitations on the plate thicknesses, has a long extended length, and is subject to high velocity two-phase steam flow. From this initial selection, a test and analysis program was established and the results are discussed in Subsection 3L.3.3. For this case, testing was required since no prior relevant test data was available for this component.

A steam dryer initial assessment was performed to study the acoustic and flow effects of the ESBWR configuration in comparison to the ABWR steam dryer design. The initial assessment determined that the increase in the size of the steam dryer support ring and skirt design and the increase in steam velocity did not have any adverse effects on the steam dryer structural integrity. However, at the time of the initial assessment, it was also recognized that the evaluation of BWR operating plant steam dryer loads was an ongoing program that would need to be ultimately factored into the ESBWR steam dryer design and evaluation effort. The progress of the replacement steam dryer program is now at a stage that a meaningful effort can now be planned for the ESBWR steam dryer. The detailed program that is planned is described in Section 3L.4. As a result of the advances in the understanding of steam dryer vibration, differential pressure loads and steam dryer design improvements (see Subsection 3L.2.3), the ESBWR uses a steam dryer design patterned after the ABWR and replacement steam dryer designs developed for BWR plants.

The SLC internal piping is based on a new design and is safety-related. The SLC line is in the downcomer flow field and is subject to vortex shedding flow induced vibration. The vibration characteristics of the SLC internal piping is evaluated as described in Section 3L.5.5.1.4. The SLC line is instrumented as part of the startup test program as shown in Table 3L-4.

### 3L.2.2 Evaluation Process – Part 2

The next phase of the evaluation program performed additional work to demonstrate the adequacy of the components where Part 1 determined additional evaluations were required. The objective of this phase completes a more quantitative evaluation and documents the existing facts regarding the individual components. This part of the evaluation focuses on the following:

(1) Similarities and differences of the ESBWR component design configurations as compared to prior designs. In most cases the comparison design is ABWR components.

(2) A review of prior calculations for the components being evaluated, to establish the mode shapes and natural frequencies. Calculation of the ESBWR component natural frequencies is determined based on this data.

(3) Prior plant startup instrumentation data from the prototype ABWR plant is reviewed to establish the magnitude and frequency of the measured vibration data, and to review the resulting calculated stress for the components that were instrumented.

(4) A comparison of the flow paths and characteristics of the ESBWR design to prior BWR designs where a startup vibration test program was conducted.

~~(5)~~

Using the results of the above items, an assessment as to the likelihood of FIV issues is completed and documented in Reference 3L-1. This report does not include the steam dryer since it was evaluated in separate reports (see references 3L-5, 3L-6, 3L-8 and 3L-9). The evaluations for the chimney components and SLC lines are included in this report, but alternate methods to those described above have been used to evaluate FIV since these are new BWR components. This report concludes that FIV evaluations have been completed and that none of the reactor internal components are susceptible to FIV.There are two potential outcomes for the components evaluated using this process. The first potential outcome is that the evaluation conclusively demonstrate that FIV will not be an issue for that component and that plant safety-related functions are not adversely affected. In this case, no further evaluation is necessary. The other potential outcome is that the evaluation performed using Steps 1 through 4 is not sufficient to conclusively disposition potential FIV issues for the component. In this case, additional evaluations or instrumentation is necessary. For the components requiring further evaluation or instrumentation, no FIV issues are anticipated. The objective of further evaluation or instrumentation is to provide additional supporting information that clearly demonstrates that FIV is not an issue..

The results of these evaluations are documented in Reference 3L-1.

During the evaluation phase, the process as identified in Subsection 3.9.2.3 was followed to prepare finite element analysis (FEA) models per the details shown in Subsection 3L.5.5.1. This information will then be used as the basis for the instrumentation in the ESBWR startup test program. It should be noted that the SLC internal piping, steam dryer and chimney have already been identified in Section 3L.2.1 for inclusion in the startup test program.

### 3L.2.3 Design and Materials Evaluation

FIV-related fatigue cracking and intergranular stress corrosion cracking are major causes of reactor internal component degradation observed in operating BWRs. The ESBWR reactor internals are designed to resist fatigue loading. Design evaluations are conducted to evaluate load paths and streamline structural discontinuities thus reducing stress risers that contribute to fatigue failure. Welds are reduced by integrating components through machining or castings. Some components are specifically designed for intersections between larger components so groove welds can be used in lieu of fillet welds. Design evaluations are also conducted to stiffen the component structure moving component fundamental frequencies above the frequency range associated with hydrodynamic and acoustic loads.

The reactor internal materials, as specified in Subsection 4.5.2, are resistant to corrosion and stress corrosion cracking in the BWR steam/water environment.

# 3L.4 STEAM DRYER EVALUATION PROGRAM

## 3L.4.1 Steam Dryer Design and Performance

The ESBWR steam dryer consists of a center support ring with dryer banks on top and a skirt below. A typical steam dryer is shown in Figure 3L-2. The dryer units, made up of steam drying vanes and perforated plates, are arranged in six parallel rows called dryer banks. The ESBWR steam flow rate is approximately 15% higher than ABWR. The ESBWR RPV has a larger inner diameter at the vessel flange than ABWR, which allows dryer banks to be extended, thereby accommodating the higher steam flow. The additional dryer unit face area results in approximately the same flow velocity through the drying vanes as ABWR and helps maintain moisture removal performance requirements. The support ring is supported by RPV support brackets. The steam dryer assembly does not physically connect to the chimney head and steam separator assembly. The cylindrical skirt attaches to the support ring and projects downward to form a water seal around the array of steam separators. Normal operating water level is approximately mid-height on the steam dryer skirt.

Wet steam from the core flows upward from the steam separators into an inlet header, then horizontally through the inner perforated plate, the dryer vanes and the outlet perforated plates, then vertically in the outlet header and out into the RPV dome. Dry steam then exits the RPV through the steam outlet nozzles. Moisture (liquid) is separated from the steam by the vane surface and the hooks attached to the vanes. The captured moisture flows downward, under the force of gravity, to a collection trough that carries the liquid flow to vertical drain channels. The liquid flows by gravity through the vertical drain channels to the lower end of the skirt where the flow exists below the normal water level.

The prototype for the ESBWR steam dryer builds on the successful operating experience of the ABWR steam dryer. Although the ESBWR steam dryer will have a larger diameter and wider vane banks to accommodate close to 15% higher steam flow, the vane height, skirt length, outer hood setback from the main steam nozzle, and water submergence will be similar to the ABWR steam dryer. The ESBWR steam dryer also draws experience from operating plant replacement steam dryer program fabrication, testing and performance. Steam dryers recently tested and installed in BWR/3 and BWR/4 plants had experienced high pressure loads under extended power uprate operating conditions. These loads were characterized by an abnormally high pressure tone at approximately 155 Hz that emanated from an acoustic resonance in one or more of the safety relief valve (SRV) standpipes. The replacement steam dryers were specifically designed to withstand the FIV and acoustic resonance loading that led to fatigue failures in the steam dryers for these plants. In addition, the SRV/SV standpipes and main steamline branch lines in ESBWR are specifically designed to preclude first and second shear layer mode wave SRV/branch line acoustic resonances that could be a significant contributor to steam dryer loading at normal operating conditions. Table 3L-1 provides a comparison between major configuration parameters of the ESBWR, the ABWR prototype and a BWR/3 replacement steam dryer.

instrumented steam dryer measurements taken during startup testing for the lead ABWR. The ESBWR and ABWR have the same vessel diameter and vessel steam nozzle design (with flow restricting venturi), and similar main steamline layouts; therefore, it is expected that the frequency content of the ESBWR steam dryer pressure loads will be similar to those measured on the ABWR.

Reference 3L-9 provides the results of benchmarking and sensitivity studies of the pressure load definition methodology against measured pressure data taken during power ascension testing of a replacement steam dryer installed at an operating nuclear plant. Reference 3L-9 concludes that, based on comparisons of model predictions to actual measurements, the methodology predicts good frequency content and spatial distribution, and the safety relief valve resonances are well captured. The methodology provides accurate predictions of main steamline phenomena occurring downstream of the main steamline sensors, valve whistling (safety relief valve branch line) and broadband excitations (venturi, main steam isolation valve turbulence). The methodology also accurately predicts the dryer pressure loads resulting from vessel hydrodynamic phenomena.

### 3L.4.5 Structural Evaluation

A FEA is performed to confirm that the ESBWR steam dryer is structurally acceptable for operation. The FEA uses the load definitions described in Subsection 3L.4.4. The FEA is performed using a whole steam dryer analysis model to determine the most highly stressed locations, also see Subsection 3L.5.5.1.3. The FEA consists of dynamic analyses for the load combinations identified in Subsection 3L.4.3. If required, locations of high stress identified in the whole steam dryer analysis are further evaluated using solid finite element models to more accurately predict stresses at these locations. Additional analysis confirms that the RPV steam dryer support lugs accommodate the predicted loads under normal operation and transient and accident conditions. (Also see Subsection 3L.5.5.1.3.)

The structural evaluation of the ESBWR steam dryer design is presented in Reference 3L-6.

### 3L.4.6 Instrumentation and Startup Testing

The ESBWR steam dryer is instrumented with temporary vibration sensors to obtain flow induced vibration data during power operation. The primary function of this vibration measurement program is to confirm FIV load definition used in the structural evaluation is conservative with respect to the actual loading measured on the steam dryer during power operation, and to verify that the steam dryer can adequately withstand stresses from flow induced vibration forces for the design life of the steam dryer. The detailed objectives are as follows:

- Determine the as-built frequency response parameters: This is achieved by frequency response testing the steam dryer components. The results yield natural frequencies, mode shapes and damping of the components for the as-built steam dryer. These results are used to verify portions of the steam dryer analytical model.
- Confirm FIV loading: In order to confirm loading due to turbulence, acoustics and other sources, dynamic pressure sensors are installed on the steam dryer. These measurements will provide the actual pressure loading on the steam dryer under various operating conditions.

- Verify the design: Based on past knowledge gained from different steam dryers, as well as information gleaned from analysis, selected areas are instrumented with strain gages and accelerometers to measure vibratory stresses and displacements during power operation. The measured strain values are compared with the allowable values (acceptance criteria) obtained from the analytical model to confirm that the steam dryer alternating stresses are within allowable limits.

The objective of the steam dryer frequency response test is to identify the as-built frequencies and mode shapes of several key components of the steam dryer at ambient conditions. Different components of the steam dryer have different frequencies and mode shapes associated with them. The areas of interest are the drain channel, the outer hood panel, the inner hood panel, the side panel, ~~divider plates~~ and the skirt. These results are used to verify portions of the finite element model of the steam dryer.

The concern is that local natural frequencies may coincide with existing forcing functions to cause resonance conditions. The resonance could cause high stresses to occur in localized areas of the steam dryer. A finite element frequency response analysis can calculate the frequency and mode shape of a component, but they are only ideal approximations to the real values due to variations such as plate thickness, weld geometries, configuration tolerances and residual stresses that affect the assumed boundary conditions in the finite element model. The mode shapes and frequencies determined by the frequency response test are used to validate the finite element frequency response analysis and determine the uncertainty in the finite element model predictions of the frequency response. The FE model and experimental transfer functions are then used to derive frequency dependent amplitude bias and uncertainty of the the FE model for key areas of the dyer. This is described further in Reference 3L-6.

The frequency response test is performed following final assembly of the steam dryer. The tests are performed with the steam dryer resting on simulated support blocks similar to the way the steam dryer is seated inside the reactor vessel.

Two types of impact tests are performed on the steam dryer: (1) Dry frequency response test, and (2) Wet frequency response test with the steam dryer skirt and drain channels partially submerged in different water levels (to approximate in-reactor water level). Both tests are conducted in ambient conditions. Temporary bondable accelerometers are installed at predetermined locations for these tests. An instrumented input force is used to excite the steam dryer at several pre-determined locations and the input force and the structural responses from the accelerometers are recorded on a computer. The data is then used to compute experimental transfer functions mode shape, frequency and damping of the instrumented steam dryer components using appropriate software. The temporary sensors are then removed and the steam dryer is cleaned prior to installation in to the reactor vessel.

The steam dryer vibration sensors consist of strain gages, accelerometers and dynamic pressure sensors, appropriate for the application and environment. A typical list of vibration sensors with their model numbers is provided in Table 3L-3. The selection and total number of sensors is based on past experience of similar tests conducted on other BWR steam dryers. These sensors are specifically designed to withstand the reactor environment. The pressure instrument locations are selected to provide a good measure of the acoustic loading through the frequency range of interest. A proper distribution of the steam dryer pressure instruments facilitates accurate assessments of FIV loads. The layout of the steam dryer pressure instrument locations is evaluated using the RPV acoustic FEA Model. The distribution of steamline instruments is determined using the Plant Based Load Evaluation model (Reference 3L-8) to provide an adequate measure of the acoustic loading through the frequency range of interest. The instrument layout permits steam dryer load development with steam dryer data alone, steamline data alone, or a combination using both sets of data. The approach used to determine the number and locations of pressure instruments is described in Subsections 2.3.2 and 4.4.2 of Reference 3L-8 and Subsections 4.4.3.1 and 4.4.4 of Reference 3L-9.

The steam dryer startup test and monitoring power ascension limits are developed on a similar basis as the monitoring limits used for recent extended power uprate replacement steam dryers. The power ascension limits are based on the final FIV analysis performed for the as-built steam dryer. Strain gages and accelerometers are used to monitor the structural response during power ascension. Accelerometers are also used to identify potential rocking and to measure the accelerations resulting from support and vessel movements. The approach used to determine the number and locations of the strain gages and accelerometers is described in Section 9.0 of Reference 3L-6. Specific information utilized to verify the FIV load definition during startup testing is described further in References 3L-5~~8~~ and 3L-6~~9~~.

Each of the sensors are pressure tested in an autoclave prior to assembly and installation on the steam dryer. An uncertainty analysis is performed to calculate the expected uncertainty in the measurements.

Prior to initial plant start-up, strain gages are resistance spot-welded directly to the steam dryer surface. Accelerometers are tack welded to pads that are permanently welded to the steam dryer surface. Surface mounted pressure sensors are welded underneath a specially designed dome cover plate to minimize flow disturbances that may affect the measurement. The dome cover plate with the pressure transducer are welded to an annular pad that is welded permanently to the steam dryer surface. The sensor conduits are routed along a mast on the top of the steam dryer and fed through the RPV instrument nozzle flange to bring the sensor leads out of the pressure boundary. Sensor leads are routed through the drywell to the data acquisition area outside the primary containment.

Pressure transducers and accelerometers are typically piezoelectric devices, requiring remote charge converters that are located in junction boxes inside the drywell. The data acquisition system consists of strain gages, pressure transducers and accelerometer signal conditioning electronics, a multi-channel data analyzer and a data recorder. The vibration data from all sensors is recorded on magnetic or optical media for post processing and data archival. The strain gages, accelerometer and pressure transducers are field calibrated prior to data collection and analysis. The temporary vibration sensors are removed after the first outage.

In addition to the instrumentation on the steam dryer, the main steamlines are instrumented in order to measure the acoustic pressures in the main steamlines. The main steamline pressure measurements with the steam dryer pressure measurements are used as input to an acoustic model for determining the pressures acting on the steam dryer in order to provide a pressure load definition for use in performing confirmatory structural evaluations. ~~Reference 3L-9 describes the methodology for determining the pressures acting on the steam dryer using measured acoustic pressure in the main steam lines. Reference 3L-8 describes the methodology for determining the pressures acting on the steam dryer using measured acoustic pressure on the dryer. Zero volt excitation data is captured to determine the electrical noise present at the plant.~~

~~The averaged 0 volt power spectra density (PSD) data is plotted for each strain gage ring and compared with the bridge excitation data to separate the electrical sources from the acoustical ones. Noise associated with recirculation pump vane pass frequency is not an issue since the ESBWR does not use recirculation pumps. Plant noise (other than potentially the 60 Hz line noise) is typically not significant. For main steamline (MSL) strain gage locations, uncertainty due to variations in pipe wall thickness and diameter are accounted for as described in Reference 3L-9. At piping installation, pipe thickness and diameter measurements are taken to determine the local dimensions and variations in dimensions and to minimize uncertainty due to dimensional tolerances.~~

~~During the startup testing of the first ESBWR unit the main steamline pressure measurements are benchmarked with the steam dryer pressure measurements. The acoustic model predictions at the steam dryer locations where steam dryer pressure instrumentation is installed are benchmarked to the actual measured data from the steam dryer installed pressure instrumentation. This allows ESBWR specific uncertainty and bias values for the main steamline instrumentation based load definition to be developed. This information will then be applied to follow-on ESBWR units, where the main steam lines are instrumented, but steam dryer pressure instrumentation is either not installed or is reduced in quantity compared to the initial steam dryer.~~

During power ascension, the steam dryer instrumentation (strain gages, accelerometers and dynamic pressure transducers) is monitored against established limits to assure the structural integrity of the steam dryer is maintained. If resonant frequencies are identified and the vibrations increase above the pre-determined criteria, power ascension is stopped. The acceptability of the steam dryer for continued operation is evaluated by revising the load definition based on the measured loading, repeating the structural analysis using the revised load definition, and determining revised operating limits based on the results of the structural analysis.

It is expected that subsequent ESBWR units will be monitored using the main steam lines pressure data. Additional information on power ascension testing, acceptance criteria, benchmarking loads, and benchmarking of the FE model for the first and subsequent ESBWR units is included in references 3L-5 and 3L-6.

Specific steam dryer inspection recommendations for the ESBWR steam dryer design are developed based on the final as-built design and structural analysis results. The steam dryer inspection recommendations are consistent with Reference 3L-2, and consistent with Boiling Water Reactor Vessel Internals Program guidance issued by the BWR owners group specific to reactor internals vibration.

A dynamic finite element model of the steam dryer assembly is developed using the ANSYS computer code (References 3L-3 and 3L-6). Due to the complicated geometry and the large size of the analytical model, major components may be modeled with coarse meshes such that their dynamic contributions are accounted for in the whole steam dryer assembly vibration responses. Separate refined dynamic finite element models of the major components are then developed to provide a high resolution of the component's response calculation.

The structural material properties and density for the steam dryer components at temperature are used in the model. The effect of the water on the dynamic responses is accounted for by explicitly modeling the dynamic properties of the fluid in the submerged portions of the skirt, drain channels, and the base ring.

Prior analytical models have predicted that the vibration modes are closely spaced.

#### 3L.5.5.1.4 Standby Liquid Control Lines

There are two SLC pipes that enter the reactor vessel and are routed to the shroud. To accurately predict the vibration characteristic of the SLC line, a dynamic finite element model of the entire line is developed. In the model, the ends of the line are fixed anchor points since the lines are welded at the vessel nozzle and the shroud attachment points. The SLC line is supported at six places. The top vertical segment is supported at the RPV at two places along its length; the horizontal circular segment is supported by two symmetrically placed supports at the shroud; and the two vertical segments in the bottom length are supported at the shroud by one support in each segment.

### *3L.5.5.2 Stress Evaluation*

Table 3L-7 lists the methods that are used for each instrumented component for the FIV test program. Evaluation of all internals except the steam dryer is contained in this subsection; steam dryer structural evaluation is contained in ~~Subsection 3L.5.5.3~~ Reference 3L-6. For this section, Method I is used for components that have many closely spaced natural vibration modes and utilizes the strain energy weighting method applied to all modes over the frequency range of interest. This method has previously been applied to the ABWR prototype plant startup tests of In-core Monitor housings, and shroud. Method II is similar to Method I, except that it is applied to two frequency bands, 0-100 Hz and 100-200 Hz. Method III is used for components that have relatively few, distinct dominant natural modes that are matched to the analytical modes. This method has previously been applied to the in-core guide tubes.

Maximum stress amplitude values for evaluation against allowable limits are determined from the test data and finite element models using one of three different evaluation methods. The method used for a particular component depends on the complexity of that component's vibration characteristics. Each of these methods yield conservatively high predictions of the maximum stress anywhere on the structure. These conservatively high stress predictions are compared against conservatively low acceptance criteria to assure that none of the components is experiencing high stress vibrations that might cause fatigue failures. The acceptable fatigue limit stress amplitude for the reactor internals component material is 68.9 MPa (10,000 psi), with the exception of the steam dryer.

Method I is used for components that have many closely spaced vibration frequencies or closely spaced natural vibration modes distributed over a relatively narrow frequency range. The

It should be noted that this step conservatively assumes that the peak stress of each mode occurs at the same physical location on the structure and at the same time. In reality, the maximum stress locations for different modes may occur at different locations and at different times. Since the purpose of this calculation is just to confirm that the maximum stress is less than an acceptable limit, it is quite acceptable to add these conservatisms. However, it should be understood that the value calculated is conservatively high, and it is not an accurate prediction of the actual stress amplitude. If a stress calculated in this manner should exceed the limit in a few situations, then a less conservative calculation can be used in those few cases.

In summary, all three methods involve two significant conservatisms:

- The assumption of the maximum stresses occurring at the same location in a component, and
- The assumption that the maximum stresses for different modes occur at the same time.

Inclusion of these two significant conservatisms results in significantly higher calculated stresses.

### *3L.5.5.3 ~~Stress Evaluation Steam Dryer~~(Deleted)*

~~The structural analysis performed for the steam dryer design consists of a dynamic FEA. To address the uncertainty in the structural natural frequencies, the load definition frequencies are varied over a range of ±10% of nominal in 2.5% steps (nine cases total).~~

~~Similar to Subsection 3L.5.5.2, Step 5, for one dimensional (uni-axial) structural responses and with the strain gage located at the maximum stress location in the steam dryer, the determination of strain measurement acceptance criteria would be:~~

~~$\varepsilon = \sigma / (E)$~~

~~where~~

~~$\sigma$ = peak stress intensity allowable limit~~

~~$E$ = Young's Modulus, $1.78 \times 10^5$ MPa ($25.8 \times 10^6$ psi) at 288°C (550°F) for steam dryer material.~~

~~With a peak stress intensity allowable limit of 93.8 MPa (13,600 psi), the strain acceptance limit with the strain gage at the maximum stress location, is calculated as follows:~~

~~$\varepsilon = \sigma/(E) = 527$ με (zero-peak) or 1054 με (peak-peak)~~

~~For the steam dryer, the structural responses are multi-dimensional (multi-axial), and the strain gages are not necessarily located at the maximum stress location since the maximum stress location predicted from the stress analysis may be in locations where it is not practical nor possible to install the strain gages or accelerometers (steam dryer interior location).~~

~~There are two methods used to assess the instrument acceptance criteria for the strain gages and accelerometers based on the structural analysis results:~~

~~(1)Minimum load case method. In this method the minimum strain or accelerometer limit for the nine load cases is found and then reduced with respect to the instrument's uncertainty.~~

(2)Uncertainty assessment method. For each of the nine load cases, predicted strain and accelerometer values are determined that include location tolerance, and the instrument's measurement uncertainty. The mean and mean standard deviation of the predicted readings at each monitoring locations are calculated. The instrument limit is then based on the mean minus the standard deviation.

The most limiting strain and acceleration values from both the minimum load method case and the uncertainty assessment methods are used for the acceptance limits. The following procedure is followed in the minimum load case method:

(1)For each of the nine load cases, calculate the peak stress on the steam dryer to determine the minimum factor to the ASME B&PV Code Section III, Appendix I, Figure I-9.2.2, Curve C endurance limit for the highest stress components. For the outer hood components above the skirt, the "minimum factor" is calculated by dividing 74.5 MPa (10,800 psi), 80% of the endurance limit, by the steam dryer peak stress for the load case. For the balance of the components, the "minimum factor" is calculated by dividing 93.8 MPa (13,600 psi), by the steam dryer peak stress for the load case.

(2)For each of the nine load cases, calculate the maximum absolute value of the predicted strain at each of the strain gage locations. Two times the maximum strain is used as the p-p response. (This is consistent with the stress analysis where the peak stress intensity is used as ½ the peak alternating stress.) An equivalent assessment is performed for accelerometers based on the predicted acceleration at that location.

(3)For each of the nine load cases, take the product of the "minimum factor" (Step 1) times the maximum absolute value of strain at each of the strain gage locations (Step 2). An equivalent calculation is performed for the accelerometers.

(4)For each of the strain gages and the accelerometer locations, determine the minimum value of strain and acceleration from the nine load cases.

(5)The Level 1 strain limit is calculated by reducing the minimum strain and acceleration values calculated in Step 4 by the uncertainty in the overall measurement accuracy ($M_u$). Therefore, the minimum strain values were factored by (100% – ($M_u$)%) to determine the strain limit.

For the uncertainty assessment method, there were three key parameters that may impact the strain and acceleration limits:

(1)Location tolerance for mounting the strain gages and the accelerometers.

(2)Finite element model uncertainty in predicting the correct response at the mounting location.

(3)The strain and acceleration measurement uncertainties.

The physical location tolerance and angularity for the strain gages and accelerometers is determined. Where possible the instrument mounting locations are selected as potential areas of high response magnitude and low gradient. For the uncertainty assessment a population of strain or accelerometer predictions at each monitoring location are used; the specified locations and the predictions at four points with tolerance from the specified location.

The strain gage and accelerometer locations were selected away from discontinuities such as welds, changes of thickness, and junctions between components. In the structural assessment, stresses at and near discontinuities were bounded using conservative SCFs. For monitoring the structural response, however, the instruments are located where the model most accurately predicts the strain and acceleration response and away from regions with high gradients where a small change in sensor location results in a large change in the measured response.

In areas away from discontinuities, the major contribution for prediction uncertainty from the structural model will be due to variations in the frequency response resulting from material tolerances and the steam dryer fabrication. The frequency response uncertainty is addressed by the varying time step analyses. This included nine load cases that replicate frequency response variation of 0%, ±2.5%, ±5%, ±7.5%, ±10%. For this uncertainty assessment the evaluation assumes the response predictions for each of the nine cases had equal probability of occurrence. Therefore for each instrument locations there were 45 predictions, 5 locations and 9 load cases.

The instrument loop uncertainty is used in this assessment. This bounds the strain gage and accelerometer loop uncertainties for the instruments and data acquisition equipment to be used during testing. This uncertainty was then combined with the standard deviation of the 45 predictions by the square root of the sum of the squares (SRSS) method. The acceptance limit was then defined as the SRSS of the standard deviation of the prediction and the measurement uncertainty.

The fatigue analysis performed for the ESBWR steam dryer will use a fatigue limit stress amplitude of 93.8 MPa (13,600 psi). For all critical locations, including the outer bank hood component, which are subjected to higher pressure loading in the region of the main steamlines, the fatigue stress amplitude limit is 74.5 MPa (10,800 psi). The limit is justified because the steam dryer is a nonsafety-related component, performs no safety-related functions, and is only required to maintain its structural integrity (no loose parts generated) for normal, transient and accident conditions.

## 3L.6 REFERENCES

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3L-2 General Electric Company, "BWR Steam Dryer Integrity", Service Information Letter (SIL) 644 Revision 2, August 30, 2006.

3L-3 ANSYS Engineering Analysis System User's Manual, see Table 3D.1-1 for the applicable revision.

3L-4 Elements of Vibration Analysis, Leonard Meirovitch, McGraw Hill Book Co., 1975.

3L-5 GE Hitachi Nuclear Energy, "Steam Dryer - Acoustic Load Definition," NEDE-33312P, Revision 1, Class III (Proprietary), July 2009, and NEDO-33312, Revision 1, Class I (Non-Proprietary), July 2009.

3L-6 GE Hitachi Nuclear Energy, "Steam Dryer - Structural Evaluation," NEDE-33313P, Revision 1, Class III (Proprietary), July 2009, and NEDO-33313, Revision 1, Class I (Non-Proprietary), July 2009.

3L-7 (Deleted)

3L-8 GE Hitachi Nuclear Energy, "ESBWR Steam Dryer – Plant Based Load Evaluation Methodology," NEDC-33408P, Revision 1, Class III (Proprietary), July 2009, and NEDO-33408, Revision 1, Class I (Non-proprietary), July 2009.

3L-9 GE Hitachi Nuclear Energy, "ESBWR Steam Dryer - Plant Based Load Evaluation Methodology Supplement 1," NEDC-33408P, Supplement 1, Revision ~~0~~1, Class III (Proprietary), ~~October 2008~~August 2009, and NEDO-33408, Supplement 1, Revision ~~0~~1, Class I (Non-Proprietary), ~~October 2008~~August 2009.

# Table 3L-4

## Sensor Locations and Types

| Equipment Item | Location on Equipment | Sensor Type | Location Basis |
|---|---|---|---|
| Steam Dryer Support Ring | On top of support | Accelerometer (Acceleration Mode) | Past experience of steam dryer rocking |
| Steam Dryer Skirt | At bottom of steam dryer | Accelerometer (Displacement Mode) | Modal analysis |
| Steam Dryer Hood | Dryer bank hood and end plate | Strain Gage Pressure Transducer | Past experience of cracks at weld & to obtain forcing function data ~~if problem occurs~~ |
| Steam Dryer Drain Channel | At top & bottom, side edge of drain channels | Strain Gage | Modal analysis Past experience of cracks at weld |
| Steam Dryer Skirt | At top & bottom of skirt | Strain Gage Pressure Transducer | Modal analysis & to obtain forcing function data ~~if problem occurs~~ |
| Shroud | On the outside diameter near shroud bottom at maximum stress location | Strain Gage | Dynamic analysis |
| Separator Top | On the guide ring | Accelerometer | Past experience to measure separator motion |
| Vessel Dome Region | On steam dryer FIV instrument post. | Pressure Transducer | To obtain forcing function data ~~if problem occurs~~ |
| Chimney | On the middle of chimney at 4 different azimuths | Accelerometer | To obtain data on new design chimney vibration |
| Standby Liquid Control Line | Strain gages on the shroud penetration piping at the bottom along the principal stress directions<br>Accelerometer near the end of the circular header to measure radial and tangential accelerations | Strain Gage and accelerometers | New design and dynamic analysis |

(1) Vibration data for all equipment listed in Table 3L-4 will be acquired during initial startup and power ascension testing. ~~Pressure data, however, while recorded during startup testing, will not be evaluated in detail unless the primary vibration measurements indicate the need for further assessment.~~

# 1.0 INTRODUCTION

This document describes the Flow Induced Vibration (FIV) loads for the ESWR steam dryer. The development of the FIV loads as described here are in accordance with Regulatory Guide 1.20 Revision 3. The FIV loads will be used in combination with other design loads in order to qualify the steam dryer as described in NEDE-33313P.

The FIV loads are unsteady differential pressure loads created by the unsteady flow adjacent to the steam dryer (hydrodynamic FIV loads) and from acoustic pressure waves present in the reactor dome and and steam lines that create unsteady differential pressure forces on steam dryer components (acoustic loads). The loads addressed here are associated with normal operation of the plant.

There is no purely analytical methodology for accurately predicting the FIV loads resulting from hydrodynamic and acoustic load sources in a complex system such as the Reactor Pressure Vessel (RPV) reactor dome and steam lines. Therefore, the approach used on the ESBWR includes the following:

- [[
-
-
-
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]]

## 2.2 Comparative CFD Analysis

A comparison of the ABWR and ESBWR geometry and flow changes to the flow patterns and hydrodynamic loads on the steam dryer is further evaluated with computational fluid dynamics (CFD). The steam dome, outlet nozzle and a portion of the downstream steam line of the ABWR and ESBWR is modeled with CFD. The CFD study [[

]]

# 4.0 FIV LOAD DEFINITION BASED ON DATA FROM PLANT INSTRUMENTATION

## 4.1 FIV Loads Developed from Data from Multiple Plants

[[

]]

Figure 4.1-1 includes comparison of instrumented steam dryer data for [[

]]

Table 4.1-1 provides a comparison of geometry and flow parameters for the ESBWR, the ABWR at full power and the BWRs at extended power uprate conditions.

Figure 4.1-1 includes a comparison of PBLE load projections based on test data from both [[

]]

More information on the PBLE pressure loads and test data at test instrument locations of the BWR/3 and BWR/4 steam dryers is included in Reference (4). [[

]]

Figure 4.1-1 also includes the PSD curves for the measured differential pressure for the ABWR steam dryer at 100% power. [[

]]

A comparison of the RMS values of the selected plant data sets and the ABWR test data shown in Figure 4.1-1 is included in Table 4.1-2. The design loads RMS values are approximately 50% higher than the factored measured ABWR data.

The ESBWR steam dryer loads are generated by [[

]].

The structural assessment for each set includes a +/-10% frequency variation to provide a range of applied load frequencies. [[

]]

A frequency dependent bias and uncertainty evaluation is included in the structural evaluation for areas of the steam dryer with the highest alternating stress.

[[

]] This methodology identifies the acoustic load frequencies and associated steam dryer structural response modes that are most affected by FIV loads. [[

]]

# 4.0 DESIGN CRITERIA

The steam dryer, including the dryer units, is a non-safety related item and is classified as an Internal Structure per Reference 3, as defined in Reference 4, Subsection NG, Paragraph NG-1122. The steam dryer is not an ASME Code component, but the design shall comply to the applicable requirements of ASME Code Subsection NG-3000 except for the weld quality and fatigue factors as discussed in Subsections 4.1 and 7.

## 4.1 Fatigue Criteria

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

]].

The [[

]].

]].

[1] SPOINT, RSYS and NFORCE are ANSYS terms. See the ANSYS user manual for definitions.

If the [[

]].

The specified SCF [[

]]

## 4.2 Weld Quality Factor

For the case of the steam dryer, which is not a core support structure, it was [[

]]

[[

]]

**Figure 4-1. Weld [[** ]]

# 5.0 STEAM DRYER FEA MODEL AND APPLIED LOADS

## 5.1 Full Steam dryer Shell Finite Element Model

[[

]]

The procedural steps for sub modeling areas of the steam dryer that [[

]]

## 5.2 Dynamic Pressure Loads

### 5.2.1 FIV LOADS

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

]]

### 5.2.2 BIAS AND UNCERTAINTY OF THE STEAM DRYER FIV STRESS

Table 9 of the PBLE LTR S01 [7] provides the [[

]].

Section 4, Enclosure 2 of Reference [8] provides the GEH method to correct the FE model predicted peak stress based on changes in the frequency band response. This reference describes the theory and application of the F-factor [[

]].

### 5.2.3 DYNAMIC TESTING

On a new plant where there is more time and space to accommodate frequency response testing, shaker testing may be used in lieu of hammer testing. Either a hammer or a shaker with a force transducer will provide the excitation.

[[

]]. For each test, input force, accelerations, transfer functions, coherence at all accelerometers are measured. Multiple excitation locations are used. The transfer functions for each measurement location are calculated. [[

]]

### 5.2.4 PERIOD OF PEAK RESPONSE FOR FIV ASSESSMENT

The FIV loading used in the finite element stress analysis considers peak stress intensities that occur at frequencies as low as ~1 cycle per 100 seconds. [[

]]

### 5.2.5 BIAS AND UNCERTAINTY AND BENCHMARKING USING HARMONIC FE FIV SOLUTION

[[

]].

### 5.3 ASME Loads

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

# 9.0 STARTUP TEST

## 9.1 Instrumentation for Monitoring Steam Dryer Response

The ESBWR steam dryer is instrumented with temporary vibration sensors to obtain flow induced vibration data during power operation. The primary function of this vibration measurement program is to verify that the steam dryer can adequately withstand stresses from flow induced vibration forces for the design life of the steam dryer. Strain gages and accelerometers are used to monitor the structural response during power ascension and to validate the fatigue stress predictions in Section 7 for normal operation. Accelerometers are also used to identify potential rocking and to measure the accelerations resulting from support and vessel movements.

[[

]]

In addition [[

]].

## 9.2 Startup Testing Acceptance Criteria

The structural analysis performed for the steam dryer design consists of a dynamic FEA. To address the uncertainty in the structural natural frequencies, the load definition frequencies are varied over a range of $\pm 10\%$ of nominal in 2.5% steps (nine cases total).

Similar to Subsection 3L.5.5.2, Step 5, for one-dimensional (uni-axial) structural responses and with the strain gage located at the maximum stress location in the steam dryer, the determination of strain measurement acceptance criteria would be:

$$\varepsilon = \sigma / (E)$$

where

$\sigma$ = peak stress intensity allowable limit

$E$ = Young's Modulus, 1.78 x $10^5$ MPa (25.8 x $10^6$ psi) at 288°C (550°F) for steam dryer material.

With a peak stress intensity allowable limit of 93.8 MPa (13,600 psi), the strain acceptance limit with the strain gage at the maximum stress location, is calculated as follows:

$\varepsilon = \sigma/(E)$ = 527 $\mu\varepsilon$ (zero-peak) or 1054 $\mu\varepsilon$ (peak-peak)

[[

]]

# 11.0 REFERENCES

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

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

[3] 26A6642AK, Rev. 5, ""ESBWR Design Control Document", Tier 2, Chapter 3, Sections 3-9-3-11.

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

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

[6] ANSYS Release 11.0, ANSYS Incorporated, 2008.

[7] GE Hitachi Nuclear Energy, "ESBWR Steam Dryer - Plant Based Load Evaluation Methodology Supplement 1," NEDC-33408P, Supplement 1, Revision 1, Class III (Proprietary), August 2009."

[8] GEH 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," Dated July 31, 2009, Docket Number 52-010.

[9] GE Hitachi Nuclear Energy, "ESBWR Steam Dryer – Plant Based Load Evaluation Methodology," NEDC-33408P, Revision 1, Class III (Proprietary), July 2009, and NEDO-33408, Revision 1, Class I (Non-proprietary), July 2009.

MFN 09-621

Enclosure 3

Affidavit

## GE-Hitachi Nuclear Energy Americas LLC

## AFFIDAVIT

**I, Larry J. Tucker,** state as follows:

(1) I am the Manager, ESBWR Engineering, GE Hitachi Nuclear Energy ("GEH"), have been delegated the function of reviewing the information described in paragraph (2) which is sought to be withheld, and have been authorized to apply for its withholding.

(2) The information sought to be withheld is contained in Enclosure 1 of GEH letter MFN 09-621, Mr. Richard E. Kingston to U.S. Nuclear Regulatory Commission, entitled "Response to NRC Report of the August 25, 2009, and September 9, 2009, Regulatory Audit of Reactor Pressure Vessel Internals of the Economic Simplified Boiling Water Reactor." The GEH proprietary information in Enclosure 1, which is entitled "MFN 09-621, Response NRC Request for Document Improvements and Specific Changes to DCD Related to ESBWR Design Certification Application DCD Tier 2 Section 3.9 – Mechanical Systems and Components - NRC Staff Audit, August 25, 2009," is considered GEH Proprietary Information and is delineated by a [[dotted underline inside double square brackets.{3}]]. Figures and large equation objects are identified with double square brackets before and after the object. In each case, the superscript notation {3} refers to Paragraph (3) of this affidavit, which provides the basis for the proprietary determination.

(3) In making this application for withholding of proprietary information of which it is the owner, GEH relies upon the exemption from disclosure set forth in the Freedom of Information Act ("FOIA"), 5 USC Sec. 552(b)(4), and the Trade Secrets Act, 18 USC Sec. 1905, and NRC regulations 10 CFR 9.17(a)(4), and 2.390(a)(4) for "trade secrets" (Exemption 4). The material for which exemption from disclosure is here sought also qualify under the narrower definition of "trade secret," within the meanings assigned to those terms for purposes of FOIA Exemption 4 in, respectively, Critical Mass Energy Project v. Nuclear Regulatory Commission, 975F2d871 (DC Cir. 1992), and Public Citizen Health Research Group v. FDA, 704F2d1280 (DC Cir. 1983).

(4) Some examples of categories of information which fit into the definition of proprietary information are:

a. Information that discloses a process, method, or apparatus, including supporting data and analyses, where prevention of its use by GEH competitors without license from GEH constitutes a competitive economic advantage over other companies;

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

c. Information which reveals aspects of past, present, or future GEH customer-funded development plans and programs, resulting in potential products to GEH;

d. Information which discloses patentable subject matter for which it may be desirable to obtain patent protection.

The information sought to be withheld is considered to be proprietary for the reasons set forth in paragraphs (4)a, and (4)b, above.

(5) To address 10 CFR 2.390(b)(4), the information sought to be withheld is being submitted to NRC in confidence. The information is of a sort customarily held in confidence by GEH, and is in fact so held. The information sought to be withheld has, to the best of my knowledge and belief, consistently been held in confidence by GEH, no public disclosure has been made, and it is not available in public sources. All disclosures to third parties including any required transmittals to NRC, have been made, or must be made, pursuant to regulatory provisions or proprietary agreements which provide for maintenance of the information in confidence. Its initial designation as proprietary information, and the subsequent steps taken to prevent its unauthorized disclosure, are as set forth in paragraphs (6) and (7) following.

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

(7) The procedure for approval of external release of such a document typically requires review by the staff manager, project manager, principal scientist or other equivalent authority, by the manager of the cognizant marketing function (or his delegate), and by the Legal Operation, for technical content, competitive effect, and determination of the accuracy of the proprietary designation. Disclosures outside GEH are limited to regulatory bodies, customers, and potential customers, and their agents, suppliers, and licensees, and others with a legitimate need for the information, and then only in accordance with appropriate regulatory provisions or proprietary agreements.

(8) The information identified in paragraph (2), above, is classified as proprietary because it identifies detailed GEH ESBWR design information. GEH utilized prior design information and experience from its fleet with significant resource allocation in developing the system over several years at a substantial cost.

The development of the evaluation process along with the interpretation and application of the analytical results is derived from the extensive experience database that constitutes a major GEH asset.

(9) Public disclosure of the information sought to be withheld is likely to cause substantial harm to GEH's competitive position and foreclose or reduce the availability of profit-making opportunities. The information is part of GEH's comprehensive BWR safety and technology base, and its commercial value extends beyond the original development cost. The value of the technology base goes beyond the extensive physical database and analytical methodology and includes development of the expertise to determine and apply the appropriate evaluation process. In addition, the technology base includes the value derived from providing analyses done with NRC-approved methods.

The research, development, engineering, analytical and NRC review costs comprise a substantial investment of time and money by GEH.

The precise value of the expertise to devise an evaluation process and apply the correct analytical methodology is difficult to quantify, but it clearly is substantial.

GEH's competitive advantage will be lost if its competitors are able to use the results of the GEH experience to normalize or verify their own process or if they are able to claim an equivalent understanding by demonstrating that they can arrive at the same or similar conclusions.

The value of this information to GEH would be lost if the information were disclosed to the public. Making such information available to competitors without their having been required to undertake a similar expenditure of resources would unfairly provide competitors with a windfall, and deprive GEH of the opportunity to exercise its competitive advantage to seek an adequate return on its large investment in developing these very valuable analytical tools.

I declare under penalty of perjury that the foregoing affidavit and the matters stated therein are true and correct to the best of my knowledge, information, and belief.

Executed on this 8th day of October, 2009.

Larry J. Tucker
GE-Hitachi Nuclear Energy Americas LLC