Tennessee Valley Authority, 1101 Market Street, Chattanooga, Tennessee 37402

CNL-16-127

August 3, 2016

10 CFR 50.90

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

Browns Ferry Nuclear Plant, Units 1, 2, and 3
Renewed Facility Operating License Nos. DPR-33, DPR-52, and DPR-68
NRC Docket Nos. 50-259, 50-260, and 50-296

Subject: **Proposed Technical Specifications (TS) Change TS-505 - Request for License Amendments - Extended Power Uprate (EPU) - Supplement 28, Responses to Requests for Additional Information**

References:
1. Letter from TVA to NRC, CNL-15-169, "Proposed Technical Specifications (TS) Change TS-505 - Request for License Amendments - Extended Power Uprate (EPU)," dated September 21, 2015 (ML15282A152)
2. Letter from NRC to TVA, "Browns Ferry Nuclear Plant, Units 1, 2, and 3 - Request for Additional Information Related to License Amendment Request Regarding Extended Power Uprate (CAC Nos. MF6741, MF6742, and MF6743)," dated June 3, 2016 (ML16144A643)

By the Reference 1 letter, Tennessee Valley Authority (TVA) submitted a license amendment request (LAR) for the Extended Power Uprate (EPU) of Browns Ferry Nuclear Plant (BFN) Units 1, 2 and 3. The proposed LAR modifies the renewed operating licenses to increase the maximum authorized core thermal power level from the current licensed thermal power of 3458 megawatts to 3952 megawatts. The Reference 2 letter provided Nuclear Regulatory Commission (NRC) Requests for Additional Information (RAIs) related to the replacement steam dryers. The due date, provided by the Reference 2 letter, for the responses to NRC RAIs EMCB-RAIs 14, 15, 16, 18, and 21 is August 26, 2016.

Enclosure 1 to this letter provides the responses to NRC RAIs EMCB-RAIs 14, 15, 16, 18, and 21. Revised responses to NRC RAIs EMCB-RAIs 10 and 24 are also provided in Enclosure 1 to this letter. The responses to NRC RAIs EMCB-RAIs 10 and 24 were discussed with NRC representatives during a meeting on June 23, 2016. These discussions resulted in the revised responses to NRC RAIs EMCB-RAIs 10 and 24. GE-Hitachi Nuclear Energy Americas LLC (GEH) considers portions of the information provided in Enclosure 1 of this letter to be proprietary and, therefore, exempt from public disclosure pursuant to 10 CFR 2.390, Public inspections, exemptions, requests for withholding. An affidavit for withholding information, executed by GEH, is provided in Enclosure 3. Enclosure 2 to this letter provides a non-proprietary version of the responses to the RAIs provided in Enclosure 1. Therefore, on behalf of GEH, TVA requests that Enclosure 1 be withheld from public disclosure in accordance with the GEH affidavit and the provisions of 10 CFR 2.390.

Enclosure 4 to this letter provides the white paper "Basis and Application of Browns Ferry SRV Acoustic Load Factor," prepared by Continuum Dynamics, Inc. This white paper is referenced in the response to EMCB-RAI-15.

TVA has reviewed the information supporting a finding of no significant hazards consideration and the environmental consideration provided to the NRC in the Reference 1 letter. The supplemental information provided in this submittal does not affect the bases for concluding that the proposed license amendment does not involve a significant hazards consideration. In addition, the supplemental information in this submittal does not affect the bases for concluding that neither an environmental impact statement nor an environmental assessment needs to be prepared in connection with the proposed license amendment. Additionally, in accordance with 10 CFR 50.91(b)(1), TVA is sending a copy of this letter to the Alabama State Department of Public Health.

There are no new regulatory commitments associated with this submittal. If there are any questions or if additional information is needed, please contact Mr. Edward D. Schrull at (423) 751-3850.

I declare under penalty of perjury that the foregoing is true and correct. Executed on the 3rd day of August 2016.

Respectfully,

J. W. Shea
Vice President, Nuclear Licensing

Enclosures

cc: See Page 3

Enclosures:

1. Responses to NRC Requests for Additional Information EMCB-RAIs 10 (Revision 1), 14, 15, 16, 18, 21, and 24 (Revision 1) (Proprietary version)
2. Responses to NRC Requests for Additional Information EMCB-RAIs 10 (Revision 1), 14, 15, 16, 18, 21, and 24 (Revision 1) (Non-proprietary version)
3. General Electric Hitachi Affidavit
4. Basis and Application of Browns Ferry SRV Acoustic Load Factor

cc:

NRC Regional Administrator - Region II
NRC Senior Resident Inspector - Browns Ferry Nuclear Plant
State Health Officer, Alabama Department of Public Health (w/o Enclosure 1)

Withhold from Public Disclosure Under 10 CFR 2.390

ENCLOSURE 1

Responses to NRC Requests for Additional Information
EMCB-RAIs 10 (Revision 1), 14, 15, 16, 18, 21, and 24 (Revision 1)

(Proprietary version)

ENCLOSURE 2

Responses to NRC Requests for Additional Information
EMCB-RAIs 10 (Revision 1), 14, 15, 16, 18, 21, and 24 (Revision 1)

(Non-proprietary version)

EMCB-RAI-10

In Section 4.2.1.3, the licensee describes the use of [[ ]]. The licensee has identified the [[ ]]. Explain whether these Masters properly represent the [[ ]]. Show that the Masters preserve the natural frequencies [[ ]] and mode shapes of the corresponding [[ ]].

GEH Response Revision 1

Various guidelines to select [[ ]] are published in the literature. An analytical selection of [[ ]] is provided in Reference 10-1. This analytical selection procedure preserves lower frequency dynamic responses of the model predicted [[ ]]. This method provides guidance for selecting [[ ]] so that the dynamic characteristics and corresponding mode shapes [[ ]].

In the boiling water reactor (BWR) steam dryer design, the [[ ]] are used to remove the [[ ]]

In the dryer analysis, the [[ ]] in Reference 10-1 [[ ]] methodology, an evaluation of the [[ ]] was performed [[ ]] to determine the significance [[ ]]. The FIV analysis was performed using [[ ]] (see Figure 10-1).

[[ ]] The locations (and azimuth) of [[ ]] in Table 10-1. The sensor locations are also shown in NEDC-33824P Appendix C Figure C1-3 and Figure C1-4. [[ ]] at these sensor locations. Figure 10-2 shows the [[

]] in Table 10-1. It is noted that there are some errors in the description of the [[ ]] sensor locations in Table 10-1 of the original (Revision 0) RAI response. The errors are corrected in this revised response.

The results in Figure 10-2 show that the [[

]] These results indicate that [[ ]]. For the locations where an [[

]]. For example, the [[ ]]. This location also had the [[ ]]. Based on the results of this study, it is concluded that [[

]].

[[

]] In order to use the [[ ]] for the BFN replacement steam dryer FIV analyses, [[ ]] so that it also used the [[ ]].

[[ ]] are presented in Figure 10-3. [[

]] shown in Figure 4.2-6 of NEDC-33824P). In order to preserve the [[

]] was used in the end-to-end benchmark analyses in NEDC-33824P Appendix C.

During the NRC meeting on June 23, 2016, additional questions were asked by the reviewers regarding the [[ ]]. However, there was a misunderstanding about whether the modeling was applied consistently in [[ ]]. As described in NEDC-33824P, page 4-112, both the [[ ]]. This approach ensures the applicability of the [[

]], there is no need to perform any additional sensitivity studies [[ ]].

For the [[ ]] (see NEDC-33824P Figure 4.2-8) [[

]]

Table 10-1 [[ ]]

[[	
	]]

[[

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Figure 10-1 [[

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Figure 10-2 [[

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[[

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Figure 10-3 [[ ]]

Reference

10-1 V. N. Shah and M. Raymunds, "Analytical Selection of Masters for the Reduced Eigenvalue Problem," International Journal for Numerical Methods in Engineering, Vol. 18, 89-98 (1982).

Changes to NEDC-33824P Revision 0 – BFN Steam Dryer Analysis Report (SDAR)

None

EMCB-RAI-14

In section 4.1.4 of NEDC-33824P (Reference 6), General Electric Hitachi Nuclear Energy (GEH) has estimated dryer [[ ]] of the BFN dryers based on previous data from other plants. GEH describes the measures taken to ensure the [[ ]] are conservative. However, GEH's procedures do not appear to guarantee that conservative loading is applied to the BFN RSD models. Please repeat the [[ ]], but using dryer stress as a metric instead of [[ ]]. One possible approach is to perform this calculation in the frequency domain since the SRV loading is deterministic, saving significant computational time.

GEH Response

The safety relief valve (SRV) [[ ]] is described in Main Steam Dryer Analysis Report (SDAR - NEDC-33824P), Section 4.1.4.3, "[[ ]]".

As part of the submittal of NEDC-33824P, a full design of experiments (DOEs) [[ ]] was performed to optimize the steam dryer pressure loads [[ ]] NEDC-33824P, Figure 4.1-44.

In the NEDC-33824P submittal, [[ ]] (NEDC-33824P, Figure 4.1-34).

From the [[ ]] for the flow-induced vibration (FIV) stress analysis runs. The FIV stress results [[ ]]

Table 14-1 [[ ]]

[[ ]]

For this RAI response, the SRV [[ ]]

Figure 14-1 below (derived from NEDC-33824P, Figure 4.1-34) [[ ]]

[[

]]

Figure 14-1 [[

]]

The steam dryer loads were calculated for each of the [[

]]

As seen in these plots (Figure 14-2), there are no [[

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[[

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Figure 14-2 [[

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[[

]]

Figure 14-3 [[
]]

The FIV stress analyses were performed, then ASRs were calculated for [[
]]. Table 14-2 presents the summary results. [[
]]

Table 14-3 summarizes the FIV stress and ASR for [[
]]

In conclusion, the SRV [[
]]

Thus, this RAI response validates the MASR developed in the NEDC-33824P submittal.

Table 14-2 [[
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[[

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Table 14-3 [[

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[[

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Changes to NEDC-33824P Revision 0 – BFN Steam Dryer Analysis Report (SDAR)

None

EMCB-RAI-15

In Section 4.1.4.4.1 of NEDC-33824P (Reference 6) the [[

]]. The table below shows the main features of the MSLs in both of these plants. There are several important differences between the plants, including the number of safety relief valves on each MSL, their locations along the MSLs and the acoustic resonance frequencies. In addition, the dead legs in BFN piping are not present in the RP. Given these differences, it is not clear why it is reasonable to assume that the response of the target plant (BFN) [[

]] Since the acoustic resonance mechanism of the SRVs is basically a non-linear phenomenon, the conservatism of the approach used to scale the resonance peak from the RP to the target plant needs to be substantiated.

Plant data of SRVs

Plant	Browns Ferry (BFN)	Reference Plant (RP)
Resonance Frequency.	[[	]]
Dead legs	YES	NO
(d/D)*	≈ 0.22	≈ 0.32
SRVs on MSL **A**	3	2
SRVs on MSL **B**	2	2
SRVs on MSL **C**	1	2
SRVs on MSL **D**	3	2
Total No of SRVs exposed to steam flow	9	8

*d is the standpipe diameter and D is the MSL diameter

The RP has additional valves other than the SRVs (e.g., electromatic relief valves (ERVs) and target rock relief valves (TRVs)) that exhibited resonant response below EPU conditions, [[
]] for BFN may be used to [[
]] in the RP at their resonant operating conditions. Such an approach may validate the effects due to differences in number and location of valves, as well as differences in the resonance frequencies. The conservatism of using [[
]] can also be validated by means of this approach. The licensee is thus requested to substantiate/validate the [[
]] used to estimate the [[
]].

GEH Response

As discussed in NEDC-33824P, Section 4.1, the amplitude for the Browns Ferry Nuclear Plant (BFN) safety relief valve (SRV) acoustic resonance load was [[

]]. The [[ ]] factors noted in this RAI were [[ ]] in order to assure that the [[ ]] load bounded the [[ ]] load measured in the [[ ]].

To further substantiate that the BFN SRV resonance design load used in the NEDC-33824P analysis is conservative, [[

]]

The equivalent [[ ]] were calculated from the [[ ]]. Specifically, the steam dryer [[ ]] was calculated. The [[ ]] load was calculated using [[ ]]. The [[ ]] loads are extracted from a [[ ]]. The [[ ]] load was obtained from the [[ ]] as described in Section 4.1.4.4 of NEDC-33824P. The [[ ]] projection for the [[ ]] steam dryer is presented in NEDC-33824P, Figure 4.1-45. The plots for each steam dryer [[ ]] are presented in NEDC-33824P, Appendix D, Figures 5-7 to 5-20.

Table 15-1 presents the [[ ]]. As can be seen in Table 15-1, the minimum [[ ]]. Because this ratio is considerably greater than the SRV resonance load factor based on the [[ ]] (Reference 15-1), the BFN SRV resonance design load used in the replacement dryer design analyses conservatively bounds the interaction between multiple SRVs resonating on the MSLs.

Table 15-1 [[ ]]

[[															
															]]

An evaluation of the plant and MSL geometries (including SRV locations) for BFN Units 1, 2, and 3 shows that the [[

]]

In conclusion, the [[ ]]. This conclusion is substantiated by [[ ]]. Because this ratio is greater than the SRV resonance load factor based on [[ ]], the BFN SRV resonance design load used in the replacement dryer design analyses conservatively bounds the interaction between multiple SRVs resonating on the MSLs.

Reference

15-1 Alan Bilanin, "Basis and Application of Browns Ferry SRV Acoustic Load Factor Revision 0," CDI White Paper No. 16-11, July 2016.

Changes to NEDC-33824P Revision 0 – BFN Steam Dryer Analysis Report (SDAR)

None

EMCB-RAI-16

In the [[ ]], Section 4.1.4.4.1 of NEDC-33824P (Reference 6), the [[ ]] between EPU and CLTP conditions in Browns Ferry Plant [[ ]]. The staff does not agree with this approach because the resonance frequency is not the same in both plants. The licensee is, therefore, requested to utilize an approach such as the one considering Strouhal number similarity to convert the Browns Ferry's EPU [[ ]] to that of the RP.

GEH Response

The issue identified in EMCB-RAI-16 is addressed by the response to EMCB-RAI-15. The differences between the scaling approaches are bounded by the margins shown in the response to EMCB-RAI-15.

Changes to NEDC-33824P Revision 0 – BFN Steam Dryer Analysis Report (SDAR)

None

EMCB-RAI-18

The plant data comparisons provided in Figures 4.1-56 and 4.1-57 of NEDC-33824P (pages 4.104 & 4-105 of Reference 6) include plants with different diameters (D) of the MSLs and different diameters (d) of the SRV standpipes, MSL flow velocity (V), and Strouhal frequency (f). Therefore, the comparison between the BFN and the [[ ]] plants, which is used for [[ ]]. Additionally, the Strouhal number for acoustic resonances of the SRV standpipes depends on the ratio d/D, which is different for these plants (see the table in RAI-15). Therefore, the licensee is requested to provide a comparison between BFN and the reference plant based on the similarity of Strouhal number.

GEH Response

The issue identified in EMCB-RAI-18 is addressed by the response to EMCB-RAI-15. The differences between the scaling approaches are bounded by the margins shown in the response to EMCB-RAI-15.

Changes to NEDC-33824P Revision 0 – BFN Steam Dryer Analysis Report (SDAR)

None

EMCB-RAI-21

In Section 4.1.4.4.2 of NEDC-33824P (Reference 6), the [[ ]] used in estimating the [[ ]] of BFN at EPU conditions is based on [[ ]]. However, BFN and the RP have fundamental differences in the arrangement and resonance frequency of the SRVs. It is not clear why the [[ ]]. The licensee is requested to demonstrate that [[ ]]. Since the RP has additional valves other than the SRVs (e.g., ERV and TRV) which exhibited resonant response below EPU conditions, the resonant response of these other valves in the RP can be used to validate the [[ ]] which is used in BFN.

GEH Response

Two bias terms are defined in Section 4.1.4.4.2 of NEDC-33824P. [[

]] This bias is independent of its application to Browns Ferry Nuclear Plant (BFN) and completely independent of the arrangement and resonant frequency of the BFN SRVs. The equivalent bias adjustment for the BFN acoustic design load definition is included in the PBLE02 end-to-end benchmark bias and uncertainty values described in Section 4.2.5.1 of NEDC-33824P.

The second bias term addresses the difference in [[

]] (see response to EMCB-RAI-17).

The overall conservatism in the BFN SRV resonance design load is addressed in the response to EMCB-RAI-15.

Changes to NEDC-33824P Revision 0 – BFN Steam Dryer Analysis Report (SDAR)

None

EMCB-RAI-24

The [[ ]] that are plotted in Figures 3.2-2 to 3.2-7 (pages C-50 to C-52) of Appendix C (Reference 9) of NEDC-33824P are obtained from [[ ]]. The degree of variability between these plants can be evaluated by comparing the individual [[ ]] of the plants. Please provide overlaid plots comparing the values of each coefficient obtained from the three plants.

GEH Response Revision 1

Plots comparing the [[ ]] are provided in Appendix A of this RAI response.

The [[ ]] were not obtained [[ ]] obtained from [[ ]]. More specifically, the process for obtaining [[ ]] did not produce [[ ]].

[[ ]]

For context, it is pointed out that Figures 3.2-8 through 3.2-13 in Appendix C of NEDC-33824P show the [[ ]], as well as the variation between the [[ ]]. Figure 3.2-1 in Appendix C of NEDC-33824P is provided to indicate the variability in the coherence as a function of frequency.

[[ ]] The concept is that a strong coherence between the MSLs and the steam dryer response will [[ ]]

Figure 24-1 shows a comparison between the BWR/4 and the [[ ]]. As can be seen, [[

]]. It is expected that [[
]].

[[

]]

Figure 24-1 [[
]]

A [[ ]] was developed and benchmarked using just the [[ ]] data in order to show the [[

]] due to the differences in the coefficient values for the [[ ]] solutions. The BWR/4-specific [[ ]] that were used in developing the [[ ]]. Comparisons of the resulting [[ ]] are provided in Appendix A with [[ ]] components.

The [[ ]] benchmarks using [[ ]] data are shown in Figure 24-2 and Figure 24-3 for both the [[
]] projections in these plots are from Figure 3.2-8 and Figure 3.2-9 in NEDC-33824P Appendix C.

As can be seen, both [[ ]] show the same general behavior relative to predicting the benchmark on-dryer pressures.

[[

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[[

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Figure 24-2 [[

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[[

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Figure 24-3 [[
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[[

]] is more appropriate to use in the BFN replacement steam dryer (RSD) design analyses.

[[

]] may be used in the event of both the [[ ]] before reaching a power level [[ ]].

Specifically, the [[

]] are the primary means of [[ ]] as described in Section 5 of NEDC-33824P R0, Appendix E. The lead [[

]]. This set of information has two main functions in the power ascension process. [[ ]] will be used to measure the pressure loads on the dryer for the purpose of developing the [[

]] In the event that there are a substantial number of failures of the [[ ]] such that the remaining [[ ]] the dryer response during the power ascension, the [[

]].

Section 6 of NEDC-33824P R0, Appendix E describes the use of the [[

]]. The process described in Section 6 is intended to be used for the [[

]] developed from the measurements taken during the lead unit power ascension. The process in Section 6 can also be used for [[ ]] in the event of a [[ ]].

There are three potential scenarios to consider, depending on the extent and timing of the [[ ]]:

1) If all the [[ ]], the power ascension monitoring will use the [[ ]]. In this scenario, the [[ ]] will be used in [[ ]]. As described above, the [[ ]] in Appendix E.2. Use of the [[ ]] for the [[ ]] will therefore be consistent with the design analyses and the [[ ]].

2) [[ ]]

3) If all the [[ ]] at a power level above [[ ]], then the option of developing a [[ ]] developed in Appendix C and used in the NEDC-33824P design analyses. Previous studies have shown that the [[

]]. Power ascension monitoring would follow the process described in Section 6 using [[ ]]. The steam dryer loads will be compared against the [[ ]] provided in Appendix E Section 6.3 and Appendix E.2. This will assure that the pressure loads on the steam dryer remain within the design basis acoustic load definition used in the NEDC-33824P RSD analyses.

In all three of these scenarios, the [[ ]] will be adjusted following the process described in Appendix E Section 6.6.

Changes to NEDC-33824P Revision 0 – BFN Steam Dryer Analysis Report (SDAR)

The fourth paragraph of Appendix E Section 6.1 (page E-37) will be revised to read:

[[

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APPENDIX A

Comparison [[

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In support of GEH Response Revision 1 to EMCB-RAI-24

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Figure A-1 [[ ]]

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Figure A-2 [[ ]]

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Figure A-3 [[ ]]

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Figure A-4 [[ ]]

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Figure A-5 [[ ]]

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Figure A-6 [[ ]]

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Figure A-8 [[ ]]

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Figure A-46 [[ ]]

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Figure A-47 [[ ]]

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Figure A-48 [[ ]]

ENCLOSURE 3

General Electric Hitachi Affidavit

GE-Hitachi Nuclear Energy Americas LLC

AFFIDAVIT

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

(1) I am Vice President, NPP/Services Licensing, Regulatory Affairs, GE-Hitachi Nuclear Energy Americas LLC (GEH), and have been delegated the function of reviewing the information described in paragraph (2) which is sought to be withheld, and have been authorized to apply for its withholding.

(2) The information sought to be withheld is contained in Enclosure 1 of GEH letter 175528-020, "Third Set of GEH RAI Responses in Support of the Browns Ferry Steam Dryer Replacement," dated July 28, 2016. The GEH proprietary information in Enclosure 1, which is entitled "GEH Response to EMCB RAIs in Support of TVA Browns Ferry Replacement Steam Dryer," is identified by a dotted underline inside double square brackets. [[This sentence is an example.{3}]] Figures and large 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 or licensee, GEH relies upon the exemption from disclosure set forth in the *Freedom of Information Act* ("FOIA"), 5 U.S.C. Sec. 552(b)(4), and the *Trade Secrets Act*, 18 U.S.C. Sec. 1905, and NRC regulations 10 CFR 9.17(a)(4), and 2.390(a)(4) for trade secrets (Exemption 4). The material for which exemption from disclosure is here sought also qualifies under the narrower definition of trade secret, within the meanings assigned to those terms for purposes of FOIA Exemption 4 in, respectively, Critical Mass Energy Project v. Nuclear Regulatory Commission, 975 F.2d 871 (D.C. Cir. 1992), and Public Citizen Health Research Group v. FDA, 704 F.2d 1280 (D.C. Cir. 1983).

(4) The information sought to be withheld is considered to be proprietary for the reasons set forth in paragraphs (4)a. and (4)b. Some examples of categories of information that fit into the definition of proprietary information are:

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

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

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

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

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

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

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

(8) The information identified in paragraph (2), above, is classified as proprietary because it contains detailed GEH design information of the methodology used in the design and analysis of the steam dryers for the GEH Boiling Water Reactor (BWR). Development of these methods, techniques, and information and their application for the design, modification, and analyses methodologies and processes was achieved at a significant cost to GEH.

The development of the evaluation processes along with the interpretation and application of the analytical results is derived from the extensive experience and information databases that constitute 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 and obtaining these very valuable analytical tools.

I declare under penalty of perjury that the foregoing is true and correct.

Executed on this 28th day of July 2016.

Peter M. Yandow
Vice President, NPP/Services Licensing
Regulatory Affairs
GE-Hitachi Nuclear Energy Americas LLC
3901 Castle Hayne Road
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ENCLOSURE 4

Basis and Application of Browns Ferry SRV Acoustic Load Factor

CDI White Paper No. 16-11

Basis and Application of Browns Ferry SRV Acoustic Load Factor

Revision 0

Prepared by

Continuum Dynamics, Inc.
34 Lexington Avenue
Ewing, NJ 08618

Prepared under Purchase Order No. 2104480 for

TVA / Browns Ferry Nuclear Plant
Shaw & Nuclear Plant Road
Athens, AL 35611

Prepared by

Alan J. Bilanin

Reviewed by

Alexander H. Boschitsch

July 2016

Narrative

Standpipes on a main steam line may lock into acoustic resonance whereby the resonance of a standpipe is enhanced or amplified by the presence of other standpipes. In establishing a load definition for Browns Ferry steam dryers at EPU conditions during standpipe resonance, use is made of measured data on the Quad Cities Unit 2 steam dryer. A question has been raised as to whether sufficient SRV standpipe resonances were occurring at Quad Cities to establish a conservative load definition for the Browns Ferry steam dryer. This report documents an approach which can be used to establish a conservative Browns Ferry EPU steam dryer acoustic load definition, and which addresses questions regarding lock-in effects as well as concerns over directly estimating plant dryer loads from scaled test measurement data.

Approach

As a result of a plant being licensed to a given power level it is normally not possible to run the plant at a higher power level to obtain data. To get around this problem it is possible to use subscale testing as described in the Reference 1 to develop scaling factors to apply to plant data at one power level to estimate the data that is expected at the higher power level.

The process would be to measure main steam line pressure data at CLTP conditions in the plant. Then subscale tests would be conducted at CLTP and EPU conditions to develop bump up factors that can be applied to the plant CLTP data to estimate the loads at EPU conditions. In this manner, subscale data is not used in an absolute sense but as a ratio. Errors in magnitude that result from subscale testing occur at both power levels in approximately equal ways. Hence, by ratioing measurements, these errors effectively cancel.

Subscale tests of the Browns Ferry Units 1 and 2 main steam system have been carried out at approximately one-eighth scale. The locations of the safety valve steam pipes are shown in Figure 1 and the complete geometry is described in Reference 1. Photos of the subscale steam delivery system are shown in Figure 2 and 3.

Pressure transducers are located along the main steam lines at the exact scaled distances of the transducers in the plant. The scaled flows in the subscale facility correspond to CLTP and EPU conditions.

The bump-up factor is calculated as a function of frequency, converted from subscale to full scale, with the equation:

$$\text{Bump-Up Factor} = \sqrt{\frac{PSD_{EPU}}{PSD_{CLTP}}}$$

This involves dividing the EPU PSD at each frequency by the CLTP PSD at that frequency, and taking the square root. This equation is used for each of the eight strain gage locations in the frequency interval from 100 Hz to 120 Hz, thereby encompassing the anticipated standpipe/valve excitation frequency interval. Outside this interval, a velocity-squared bump-up factor of 1.35, based on anticipated and actual in-plant flow rate at BFN1 and BFN2, is used. The resulting bump-up factors are plotted in Figure 4.

The bump-up factor at each strain gage location would be used to multiply the strain gage readings at that location in the plant at CLTP conditions, on a frequency-by-frequency basis, to obtain the estimated main steam line strain gage readings at that location in the plant at EPU conditions. The subsequent dryer loads developed from the acoustic circuit model would be provided to a finite element model of the dryer for stress predictions at EPU conditions.

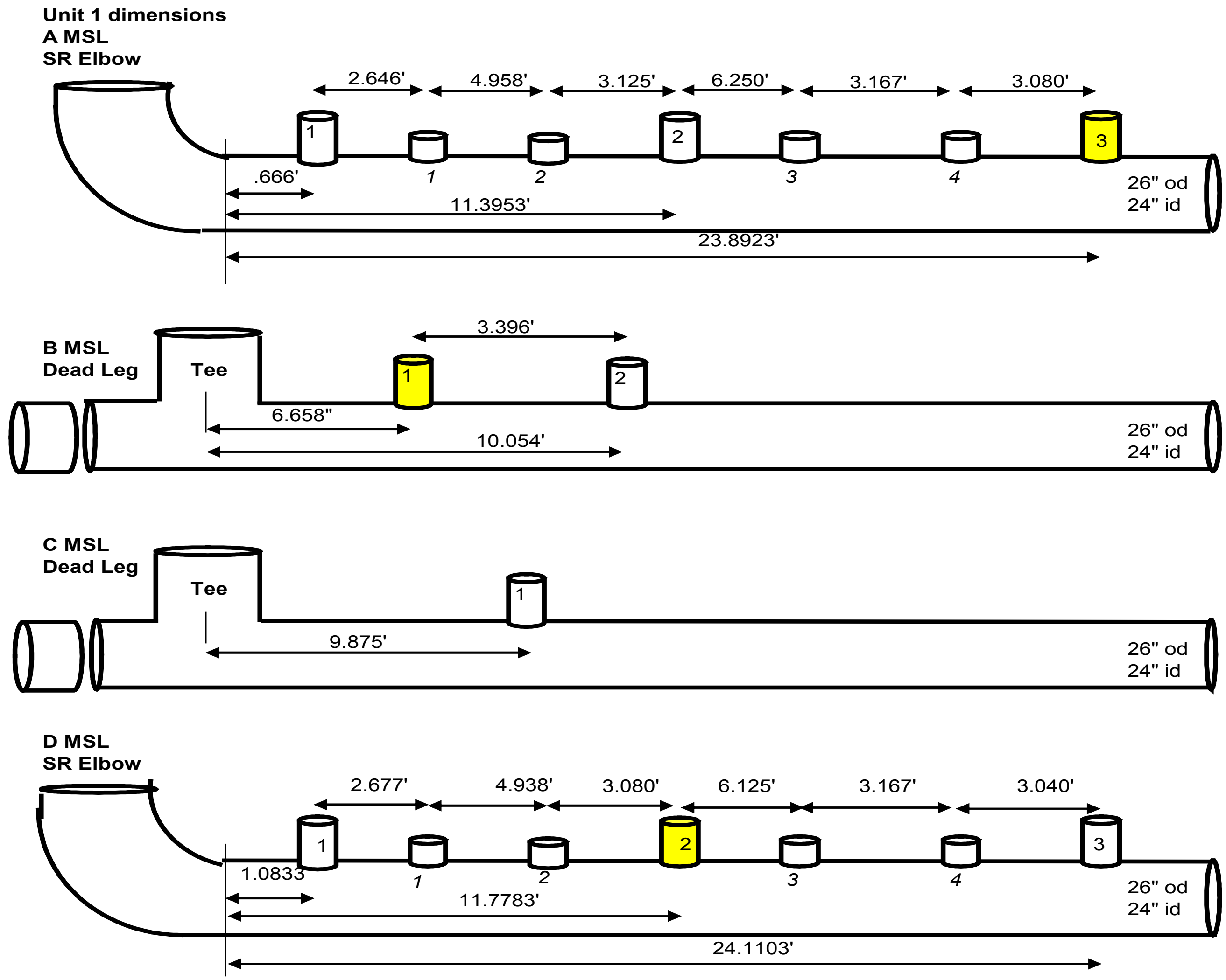

Figure 1. Schematic of the four main steam lines at BFN1. (Ref. 1).

Figure 2. Photographs of the steam delivery system at nominal one-eighth scale. (Ref. 1).

Figure 3. Additional photographs of the steam delivery system at nominal one-eighth scale. (Ref. 1)

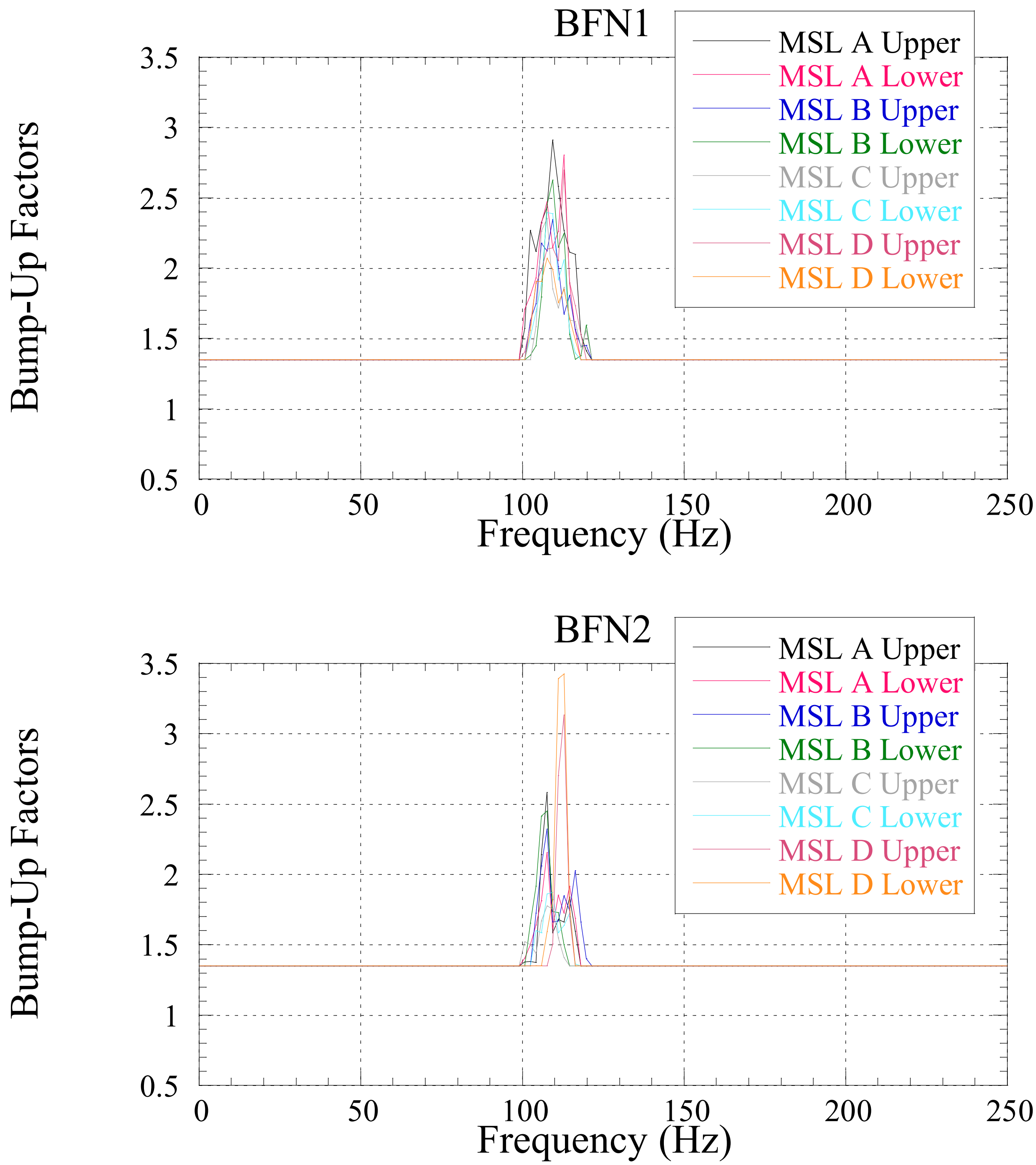

Figure 4. Bump-up factors developed from BFN1 (top) and BFN2 (bottom) subscale data. The eight locations are shown by the eight pressure transducer identifiers. (Ref. 1)

Conclusions

Using measured in plant Main Steam Line CLTP pressure data and bump up factors, an estimate of the Main Steam Line pressure at EPU conditions can be obtained. Based on the subscale model testing documented in Reference 1, and summarized in this report, a 3.5 bump up factor applied to CLTP data would conservatively bound EPU conditions. For example, a conservative application of the method would be to show that dividing the limiting dryer stress ratio at CLTP conditions by the maximum bump up factor of 3.5 still yields an acceptable stress ratio. It is noted that this bump up factor implicitly accounts for any acoustic resonance interaction from multiple in-line SRV standpipes.

References

1. Continuum Dynamics, Inc. 2008 Flow-Induced Vibration in the Main Steam Lines at Browns Ferry Nuclear Units 1 and 2, With and Without Acoustic Side Branches, and Resulting Steam Dryer Loads, C.D.I. Report No. 08-14P, Revision 0.