Tennessee Valley Authority, Post Office Box 2000, Decatur, Alabama 35609-2000

October 3, 2008

TVA-BFN-TS-418
TVA-BFN-TS-431

10 CFR 50.90

U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Mail Stop OWFN, P1-35
Washington, D. C. 20555-0001

Gentlemen:

In the Matter of	)	Docket Nos. 50-259
Tennessee Valley Authority	)	50-260
		50-296

BROWNS FERRY NUCLEAR PLANT (BFN) – UNITS 1, 2, AND 3 - TECHNICAL SPECIFICATION (TS) CHANGES TS-431 AND TS-418 – EXTENDED POWER UPRATE (EPU) – SUPPLEMENTAL RESPONSE TO ROUND 19 REQUEST FOR ADDITIONAL INFORMATION (RAI) AND RESPONSE TO ROUNDS 20 AND 21 RAI (TAC NOS. MD5262, MD5263, AND MD5264)

By letters dated June 28, 2004, and June 25, 2004 (ADAMS Accession Nos. ML041840109 and ML041840301), TVA submitted license amendment applications to the NRC for the EPU of BFN Unit 1 and BFN Units 2 and 3, respectively. The proposed amendments would change the operating licenses to increase the maximum authorized core thermal power level of each reactor by approximately 14 percent to 3952 megawatts.

On August 12, 2008, NRC staff issued a Round 19 RAI (ML082340002) regarding the EPU license amendment requests. By letter dated September 2, 2008 (ML082490169), TVA responded to the Round 19 RAI and noted that two RAIs (EMCB.147 and EMCB.192/150) would require additional research and analysis to fully provide the requested information. Additionally, during a telephone conference on September 9, 2008, the staff made follow-up information requests regarding the Round 19 response provided in the submittal dated September 2, 2008. Enclosure 1 addresses the remaining Round 19 RAIs along with the associated follow-up information requests.

On September 16, 2008, the NRC staff issued Round 20 RAI (ML082590709) which included five additional requests regarding the steam dryer analyses. The response to these RAIs is addressed in Enclosure 1. Enclosure 1 also addresses two additional draft RAIs regarding the steam dryer analyses that are expected to be issued as Round 21.

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NRR

As discussed in Enclosure 1, TVA is performing revised steam dryer stress analyses for Units 1 and 2 to address the remaining open issues associated with the steam dryers. The revised Unit 1 steam dryer stress analysis report and the 1/8 scale model test report are currently planned to be provided by October 31, 2008. The schedule for the Unit 2 stress analysis report is being developed. TVA will provide an update on the completion status of the Unit 2 stress analysis report by October 31, 2008.

TVA has determined that the additional information provided by this letter does not affect the no significant hazards considerations associated with the proposed TS changes. The proposed TS changes still qualify for a categorical exclusion from environmental review pursuant to the provisions of 10 CFR 51.22(c)(9).

No new regulatory commitments are made in this submittal. If you have any questions regarding this letter, please contact me at (256)729-2636.

I declare under penalty of perjury that the foregoing is true and correct. Executed on this 3rd day of October, 2008.

Sincerely,

D. T. Langley
Manager of Licensing
and Industry Affairs

Enclosure:

Supplemental Response to Round 19 Request for Additional Information (RAI) and Responses to Round 20 and Round 21 RAI

As discussed in Enclosure 1, TVA is performing revised steam dryer stress analyses for Units 1 and 2 to address the remaining open issues associated with the steam dryers. The revised Unit 1 steam dryer stress analysis report and the 1/8 scale model test report are currently planned to be provided by October 31, 2008. The schedule for the Unit 2 stress analysis report is being developed. TVA will provide an update on the completion status of the Unit 2 stress analysis report by October 31, 2008.

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D. T. Langley
Manager of Licensing
and Industry Affairs

Enclosure:

Supplemental Response to Round 19 Request for Additional Information (RAI) and Responses to Round 20 and Round 21 RAI

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ENCLOSURE

TENNESSEE VALLEY AUTHORITY
BROWNS FERRY NUCLEAR PLANT (BFN)
UNITS 1, 2, AND 3

TECHNICAL SPECIFICATIONS (TS) CHANGES TS-431 AND TS-418
EXTENDED POWER UPRATE (EPU)

SUPPLEMENTAL RESPONSE TO ROUND 19 REQUEST FOR ADDITIONAL INFORMATION (RAI) AND RESPONSES TO ROUND 20 AND ROUND 21 RAI

EMCB Response Status and Schedule

As described in the RAI responses in this submittal, TVA has performed additional assessments and evaluations of the remaining open issues associated with the steam dryer analyses related to EPU operation. This has led to a delay in the complete response to some of the outstanding RAIs. To address the remaining issues, TVA is in the process of performing the following actions.

- Revision of the Unit 1 and Unit 2 steam dryer stress analyses to address the appearance of any safety relief valve (SRV) resonance at EPU conditions. This evaluation will include the application of bump-up factors based on the 1/8 scale model test (SMT) results. See RAI EMCB.192/150 for details.
- Revision of the Unit 1 steam dryer stress analyses utilizing a load definition that includes a new electrical interference check (EIC) signal for the low flow (LF) signal. See RAI EMCB.182 Follow-up for details.
- Revision of the Unit 2 steam dryer stress analyses utilizing a new LF signal and associated EIC signal. See RAI EMCB.147 for details.

The revised Unit 1 steam dryer stress analysis report and the 1/8 SMT report are currently planned to be provided by October 31, 2008. The schedule for the Unit 2 stress analysis report is being developed. TVA will provide an update on the completion status of the Unit 2 stress analysis report by October 31, 2008.

RESPONSES TO ROUND 19 RAI

In the submittal dated September 2, 2008, "Response to Round 19 RAI" (ML082490169), TVA noted that two RAIs (EMCB.147 and EMCB.192/150) would require additional research and analysis to fully provide the requested information. The response to these RAIs is provided below

NRC RAI EMCB.147 (Unit 2 only)

Provide analysis and plots for Unit 2 similar to those provided for Unit 1 in response to RAI EMCB.172. Provide an explanation why the 19-percent power data shown in Figures 3.2 through 3.5 in CDI Report No. 08-05P, *Acoustic and Low Frequency Hydrodynamic Loads at CLTP Power Level on Browns Ferry Nuclear Unit 2 Steam Dryer to 250 Hz*, are higher than the data at CLTP for frequencies above about 120 Hz. Provide justification for removing any signal

from the Unit 2 CLTP source strengths without reliable background noise signals. TVA should include stress and stress ratio tables in CDI Report 08-16P, *Stress Assessments of Browns Ferry Nuclear Unit 2 Steam Dryer with Tie Bar and Hood Modifications*, using unfiltered MSL signals.

TVA Response to EMCB.147 (Unit 2 only)

TVA previously provided a response to this RAI in the September 2, 2008 submittal. In that response, power spectral density (PSD) plots of available Unit 2 data including 19% power, 30% power, current licensed thermal power (CLTP), and EIC were provided. At that time, TVA was in the process of generating a composite LF signal to confirm that the Unit 2 stress analysis results remain acceptable using this signal.

During September 2008, a planned shutdown on Unit 2 provided the opportunity to collect and evaluate additional main steam line (MSL) strain gage data at reduced power levels. TVA has taken data at several power levels and is in the process of evaluating this data in order to resolve the technical issues associated with the LF signal that is being used for Unit 2. Strain gage failures on MSL D Lower prevent the acquisition of data for this array. New data was recorded with an EIC signal taken in conjunction with each data set which allows treatment of electrical noise specific to the plant operating state. The new data indicates that the original low flow signal taken at 19% power and used for noise removal was atypical of the plant operating state. Therefore, it is being discarded from the dryer load definition.

The current approach is to utilize newly acquired LF signals taken at approximately 5% power with associated EIC signals to characterize Unit 2 noise. This requires substitution of MSL D data with that of symmetrical MSL A for the noise signal only. The CLTP signals currently used in the Unit 2 stress analyses are still valid and will continue to be used for the load definition.

The use of the new LF and LF EIC signal will require the re-performance of the stress analysis for the Unit 2 steam dryer. Initial indication is that the resultant dryer load will be larger than that used in the current stress analyses which may require additional dryer design efforts. The requested information for RAI EMCB.147 will be provided based upon the revised Unit 2 stress analysis.

The schedule for the revised stress analysis report is being developed. TVA will provide an update on the completion status of the Unit 2 stress analysis report by October 31, 2008.

NRC RAI EMCB.192/150 (Unit 1/Unit 2)

Provide the following information about the planned acoustic side branches (ASBs) for Units 1 and 2, including validation results:

(a) Identify which safety/relief valves the ASBs will be installed on;

(b) Provide the lengths of the various ASBs and the acoustic resonance frequencies associated with them;

(c) Describe the power level(s) at which these (new) acoustic resonances will be excited. If the new resonances are excited, discuss whether it will be locked in;

(d) Provide the estimated minimum alternating stress ratio of the dryer at flow conditions corresponding to the acoustic resonance of the standpipe-ASB combination; and,

(e) Address whether the ASBs will be designed by means of the scale-model test, if so provide the corresponding test results for review.

TVA Response to EMCB.192/150 (Unit 1/Unit 2)

Background

BFN has the potential for acoustic resonance of SRV standpipes based on calculations and SMT results. Calculations and SMT results indicate the potential for acoustic resonance of the SRVs around 110 hertz (Hz) at or above CLTP conditions. However, resonance is not observed in actual plant data at CLTP conditions. The initial plan to address SRV resonance was to determine a bump-up factor from 1/8 SMT results as described in the response to RAI EMCB.129/96 in the January 31, 2008 submittal, "Response to Round 15 RAI Regarding Steam Dryer Analyses" (ML080380560). This method estimates steam dryer loading at EPU conditions based on in-plant strain gage data taken at CLTP and scaled to EPU steam flow conditions by bump-up factors derived from 1/8 SMT results at each frequency.

In order to achieve the necessary margin to the acceptance criteria, steam dryer modifications were developed and additional analytical tools were employed to reduce alternating stresses. As part of this effort, a decision was made to preclude the potential for SRV resonance and the need to predict the effect on steam dryer stress at EPU conditions by installing ASBs as discussed in the revised response to RAI EMCB.129/96 in the June 16, 2008 submittal, "Response to Round 15 Group 4 and Round 17 RAIs," (ML081750080). The design intent of the BFN ASBs was to dampen any acoustic resonance by absorbing the energy of the acoustic standing wave associated with the SRV standpipe. Due to clearance limitations, 24 inch long ASBs used in the Quad Cities design were chosen for BFN. This design was expected to lower the resonant frequency such that the plant would operate closer to peak resonance between CLTP and EPU conditions but that the damping function would reduce the magnitude of any resonance to an insignificant level. Due to time constraints associated with design and installation for the upcoming Unit 1 refueling outage in October 2008, physical design, procurement and fabrication was undertaken in parallel with confirmation of acoustical design assumptions using 1/8 SMT of the ASB configuration installed on a model of the BFN MSLs.

Revised Plans to Address SRV Resonance

The results of the 1/8 SMT indicate that the resonance associated with the SRVs will be shifted in frequency as predicted but not reduced to an insignificant level as expected. This will necessitate the utilization of bump-up factors to predict the effect on steam dryer stress at EPU conditions with or without the installation of the ASBs. Evaluation of the steam dryer stresses at EPU conditions with and without the ASBs installed did not show a clear improvement in dryer stress with ASB installation. After considering the personnel dose projection associated with ASB installation and the margin reductions in other areas of plant safety analysis such as the additional pressure loss during operation of the SRVs to which the ASBs were connected, a decision was made not to implement the ASB design.

The impact of SRV resonance on steam dryer load will be assessed using an EPU bump-up factor derived from 1/8 SMTs conducted on each BFN unit MSL configuration. The ratio of EPU to CLTP pressure data from each MSL strain gage location on the SMT is used to develop eight frequency dependent bump-up factors. The eight bump-up factors are then applied to plant CLTP data which is used as input to the ACM to predict steam dryer load at EPU conditions.

The steam dryer stress results at bumped-up EPU conditions will be included in the revised steam dryer stress analyses. The SMT report is planned to be provided by October 31, 2008.

RESPONSES TO ROUND 19 RAI FOLLOW-UP

During a telephone conference on September 9, 2008, the staff presented follow-up requests regarding the Round 19 response provided in the submittal dated September 2, 2008. The responses to these requests are provided below.

NRC RAI EMCB.181 Follow-up (Unit 1 only)

Provide further explanation of the mean filter for 0-2 Hz listed in the exclusion filtering tables.

TVA Response to EMCB.181 Follow-up (Unit 1 only)

Strain gage measurements on the MSLs are used to record dynamic/unsteady strains which are then processed to yield unsteady pressures in the MSLs. Because the steady state stresses are very large compared to the unsteady stresses, the low frequency signal shows some drift and is eliminated from the unsteady signal to be analyzed by dropping the Fourier coefficients below 2 Hz. The question as to whether this low frequency load that has been dropped is significant with regard to loading the dryer is addressed by noting that the lowest structural resonant frequency of the dryer is 6.15 Hz. Figure EMCB.181-2 taken from *Mechanical Vibration* by JP Den Hartog shows that the dynamic amplification of loads below 2 Hz with a resonant frequency of 6.15 Hz i.e., $\omega/\omega n=0.33$ and having one percent of critical damping is negligible.

Further, referring to the cumulative root mean square (RMS) stress at node 97294 on Unit 2 (Figure 15c of CDI Report No. 08-16P, Enclosure 4 of the submittal dated June 16, 2008) provided as Figure EMCB.181-3 shows that no RMS stress accumulates until frequencies of about 15 Hz, so that clipping the signal below 2 Hz has no impact on peak fatigue stresses.

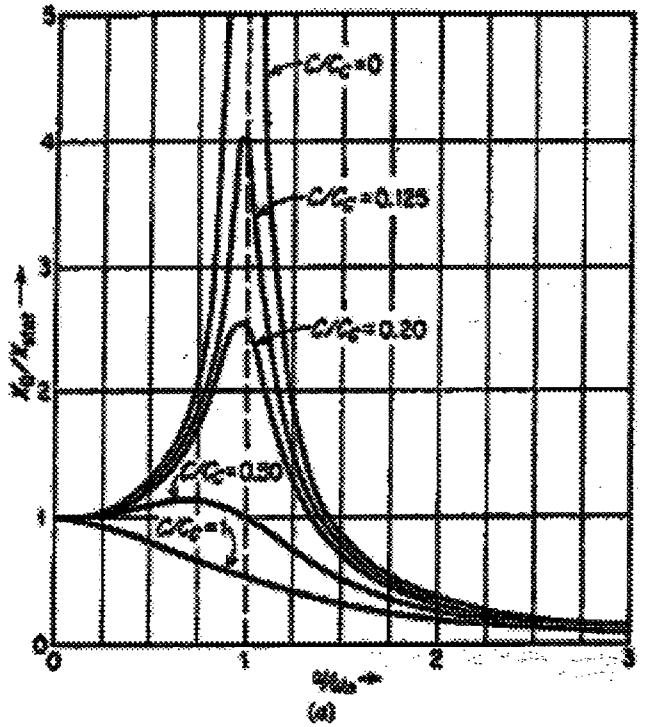


Figure EMCB.181-2: Dynamic Amplification

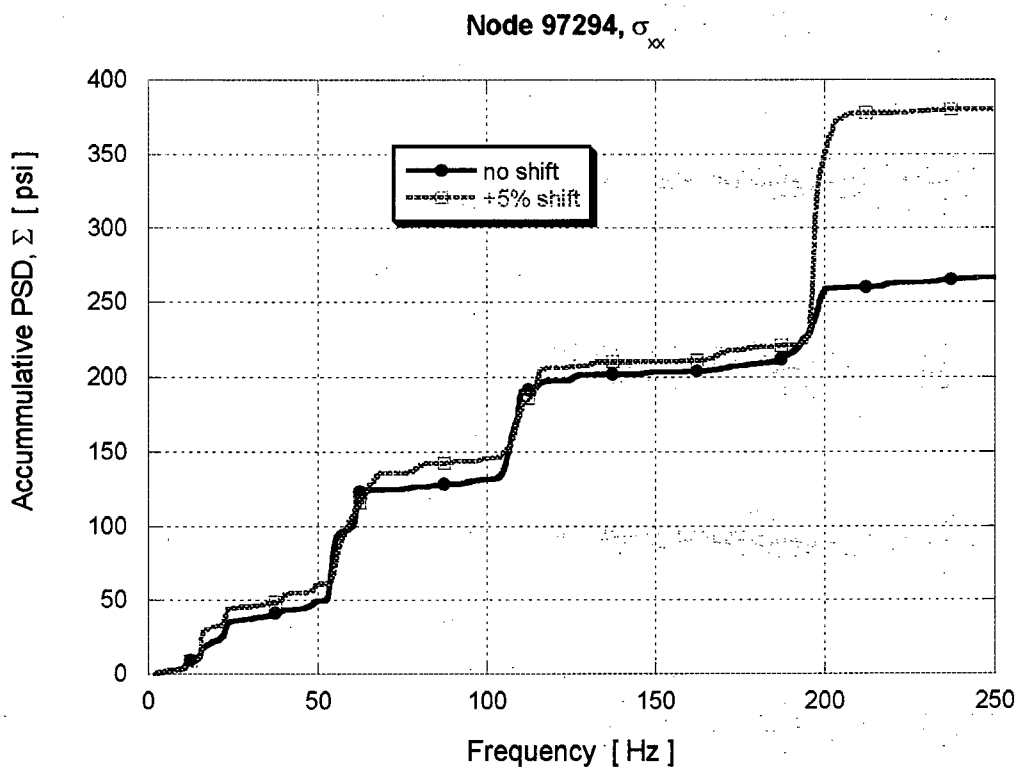


Figure EMCB.181-3: Accumulative PSD of the σ_{xx} Stress Response at Node 97294

NRC RAI EMCB.182 Follow-up (Unit 1 only)

The response to RAI EMCB.182 states that CDI is in the process of verifying that the stress analysis results included EIC subtraction from both the CLTP and 9% power data. Provide the results of this verification.

TVA Response to EMCB.182 Follow-up (Unit 1 only)

As discussed in the response to RAI EMCB.182 in the September 2, 2008, submittal, the 9% power plots in Figures 3.2 through 3.5 of CDI Report 08-04P (Enclosure 3 of the June 16, 2008 submittal) do not include EIC subtraction. On further review by CDI, it was discovered that the stress analyses used the incorrect data for the 9% power signal (EIC was not subtracted).

The stress analysis for Unit 1 is in the process of being revised and will include EIC removal from the 9% signal using a separate LF EIC signal as discussed in the response to RAI EMCB.198 in this submittal.

NRC RAI EMCB.183 Follow-up (Unit 1 only)

Does Table EMCB.183-1 represent the latest results including the proposed dryer modifications? Also, explain the variation in the SR-P values (why do some nodes increase while others decrease).

TVA Response to EMCB.183 Follow-up (Unit 1 only)

As stated in the response to RAI EMCB.183 in the September 2, 2008, submittal, the RAI response is based upon the analysis presented in CDI Report No. 08-06P (Enclosure 2 of the the submittal dated March 6, 2008, "Response to Round 15 RAI Regarding Steam Dryer Analyses, Group 2"). CDI Report No. 08-06P does not include the latest proposed dryer modifications and does not include any limiting of noise removal. This selection was made to maintain continuity with the response to RAI EMCB.170/138 provided in the submittal dated June 16, 2008, upon which RAI EMCB.183 was based.

Several values for SR-P were incorrectly transcribed to Table EMCB.183-1 which was provided in the September 2, 2008 submittal. These values have been corrected in the revised Table EMCB.183-1 below. In the original table, the "Freq. Shift" column reflected the frequency shift at the minimum SR-a. The SR-P provided in the original table was the minimum SR-P and did not necessarily correspond to the same frequency shift of the minimum SR-a. To facilitate comparison of the different filtering options, the SR-P values for all columns have been changed to reflect the same frequency shift as listed in the "Freq. Shift" column.

In addition, some non-linearity is expected in the stress as a function of noise removal amplitude due to the frequency dependence of both the dryer response and the noise signal. The dryer stress intensity at a given node results from the sum of stresses at all frequencies and noise removal affects each load frequency differently.

Table EMCB.183-1: List of nodes on welds in the BFN Unit 1 dryer having the lowest alternating stress ratios (Revised)

Location	Node	Freq. Shift (%)	Up to 100% amp. red.		Up to 50% amp. red.		No filtering	
			SR-P	SR-a	SR-P	SR-a	SR-P	SR-a
1. Top Cover Inner Hood/Top Cover Overlap/Top Perf. Plate	88059	+5	3.03	1.56	3.05	1.57	2.71	1.38
2. Top Cover/Tie Bar Base	107054	+10	3.47	1.59	3.54	1.64	3.07	1.43
3. Top Cover/Tie Bar Base	102407	+2.5	3.47	1.62	3.50	1.60	2.66	1.21
4. Top Cover Middle Hood/Top Perf. Plate/Top Cover Overlap	91420	+10	3.35	1.63	3.33	1.65	2.72	1.35
5. Top Cover/Tie Bar Base	96561	+10	3.96	1.94	3.90	1.94	3.45	1.68
6. Top Perf/Top Cover/Dam Plate	103088	+7.5	4.31	1.98	4.27	1.96	3.62	1.67
7. Submerged Drain Channel/Skirt	104539	+10	2.57	2.15	2.61	2.14	2.26	1.65
8. Dam Plate/Lock	102521	+7.5	4.76	2.19	4.57	2.10	3.74	1.71
9. Top Cover Inner Hood/Hood Support/Tie Bar Base	103094	+10	4.00	2.28	3.89	2.23	3.31	1.90
10. Top Perf/Top Cover/Dam Plate	103089	+5	5.14	2.40	5.09	2.37	4.18	1.97

NRC RAI EMCB.181 (Unit 1) & EMCB.147 (Unit 2) Follow-up

Explain why different variable frequency drive (VFD) and recirculation pump filtering were performed on CLTP and LF plots provided in the September 2, 2008 submittal.

TVA Response to EMCB.181 (Unit 1) & EMCB.147 (Unit 2) Follow-up

Figures EMCB.181-1a through 1d and Figures EMCB.147-1a through 1d for Units 1 and 2, respectively, were provided to illustrate example signal magnitudes and did not reflect the same filter processing utilized in the stress analyses as described in CDI Report Nos. 08-04P and 08-05P (Enclosures 3 and 5 of the submittal dated June 16, 2008).

The filtering used in the figures provided in the responses to EMCB.181 and EMCB.147 was minimized to provide the most representative plots of the actual signal. For example, the VFD frequency of approximately 16 Hz was not filtered from the Unit 1 9% power plots as the signal does not indicate a significant peak at this frequency. The same is true for the recirculation pump vane passing frequency of approximately 40 Hz in the Unit 2 19% power plots. This also led to the differing number of VFD harmonic frequencies removed from the Unit 2 plots compared to the Unit 1 plots.

NRC RAI EMCB.186 & EMCB.187 Follow-up (Unit 1 only)

The iterative method used in applying boundary conditions on the sub model would not appear to result in a unique solution. Provide additional detail on this methodology.

TVA Response to EMCB.186 & EMCB.187 Follow-up (Unit 1 only)

TVA is in the process of preparing information on this RAI request that will be presented during the upcoming public meeting with the NRC staff. Following the meeting, TVA will provide any requested follow-up information in a revised response to this RAI.

RESPONSES TO ROUND 20 RAI

On September 16, 2008, NRC staff issued a Round 20 RAI (ML082590709) regarding the EPU license amendment requests. Five RAIs were associated with the steam dryer analyses. The response to the five RAIs is provided below.

NRC RAI EMCB.194, 195, 196, 197/153 and /154

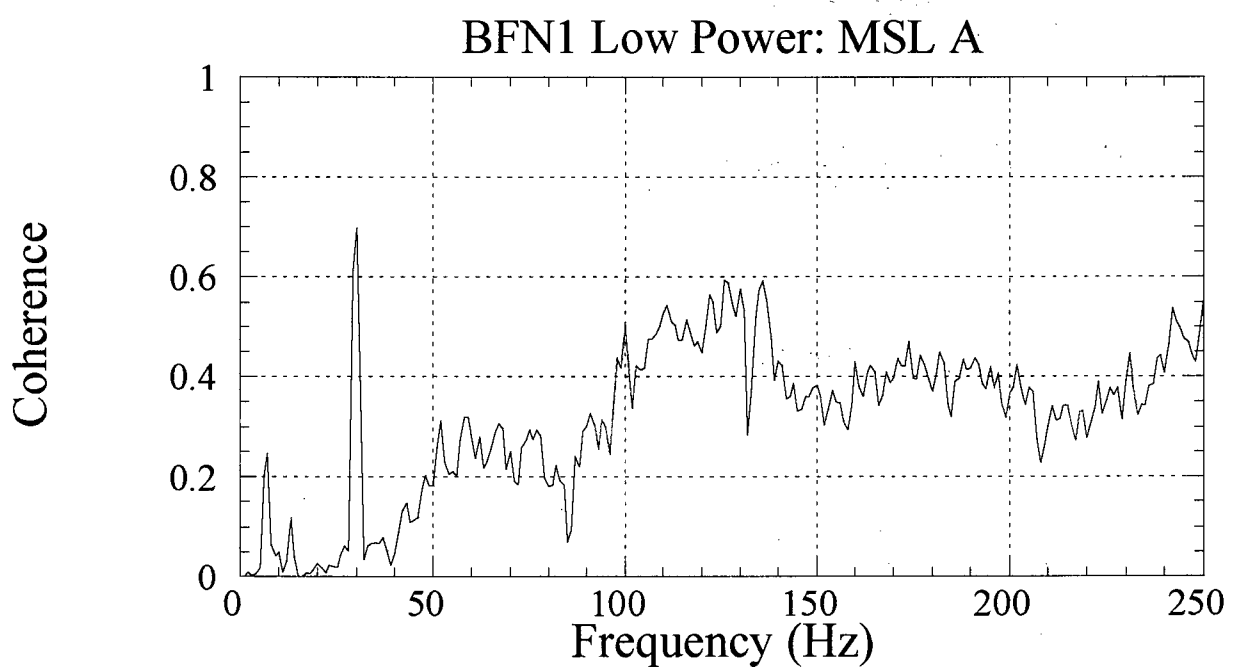
The following requests for additional information (RAI) are based on the conference call with the Tennessee Valley Authority (TVA) regarding the Browns Ferry Nuclear Plant (BFN), Units 1 and 2, extended power uprate (EPU) review on August 15, 2008. During this conference call, TVA presented their proposed response to U.S. Nuclear Regulatory Commission (NRC) Round 19 RAI questions 180 (Unit 1) and RAI 146 (Unit 2).

NRC RAI EMCB.194 (Unit 1 only)

Provide the coherence between upper and lower main steam line (MSL) signals for 9-percent flow. It should be noted that only coherent background noise should be subtracted from coherent current license thermal power (CLTP) data.

TVA Response to EMCB.194 (Unit 1 only)

Coherence plots between upper and lower MSL signals for 9% power are provided in Figures EMCB.194-1a and 1b. The 9% power signal has the LF EIC removed from it as described in the response to RAI EMCB.198 in this submittal prior to determining the coherence. Coherence filtering is performed on both the CLTP and LF signals prior to removing the noise (LF) from the CLTP signal.



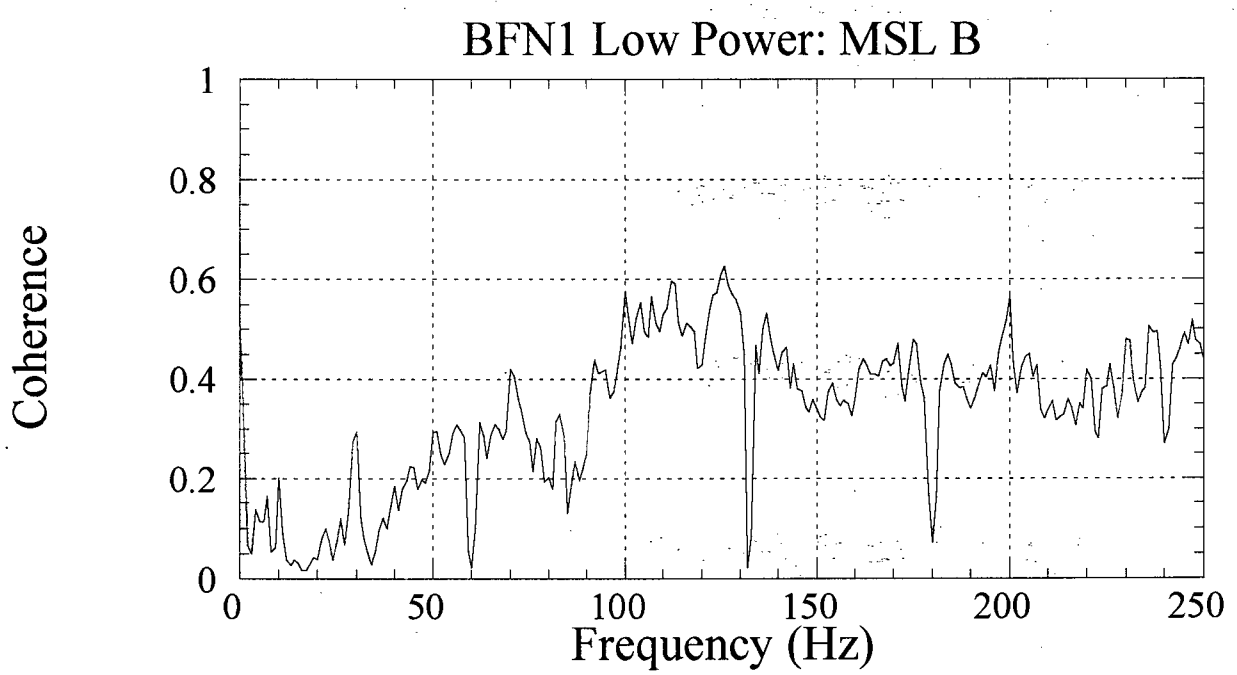
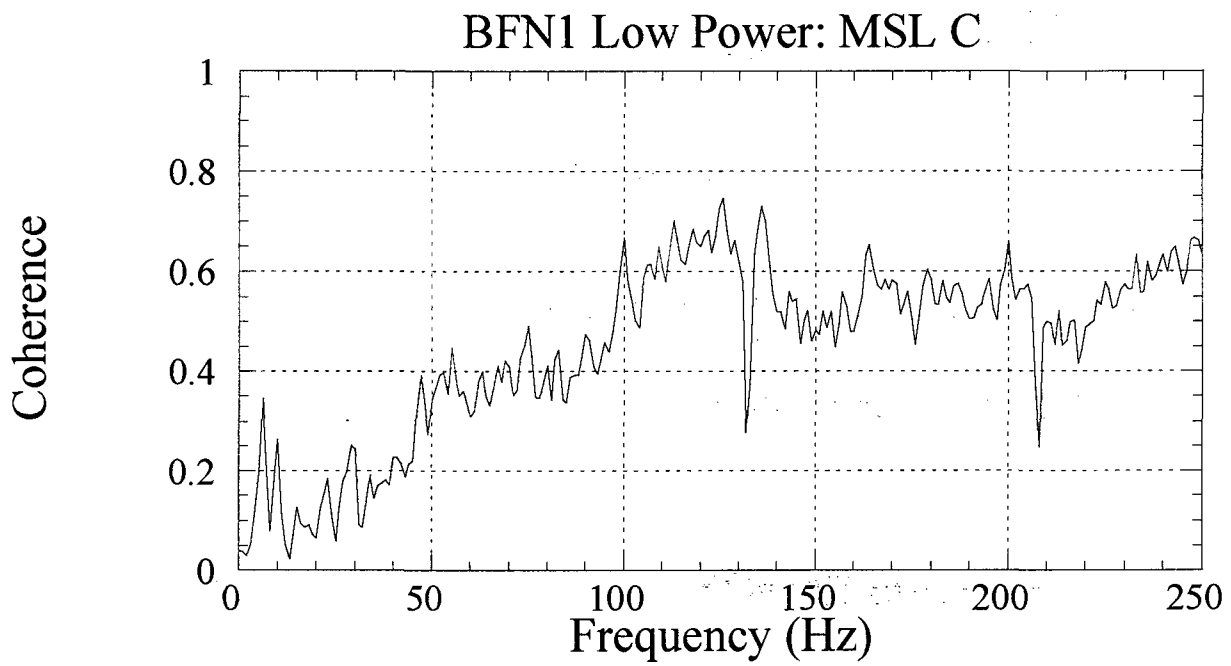


Figure EMCB.194-1a: Coherence between the upper and lower strain gage readings at BFN1 for 9% power data (MSLs A & B)



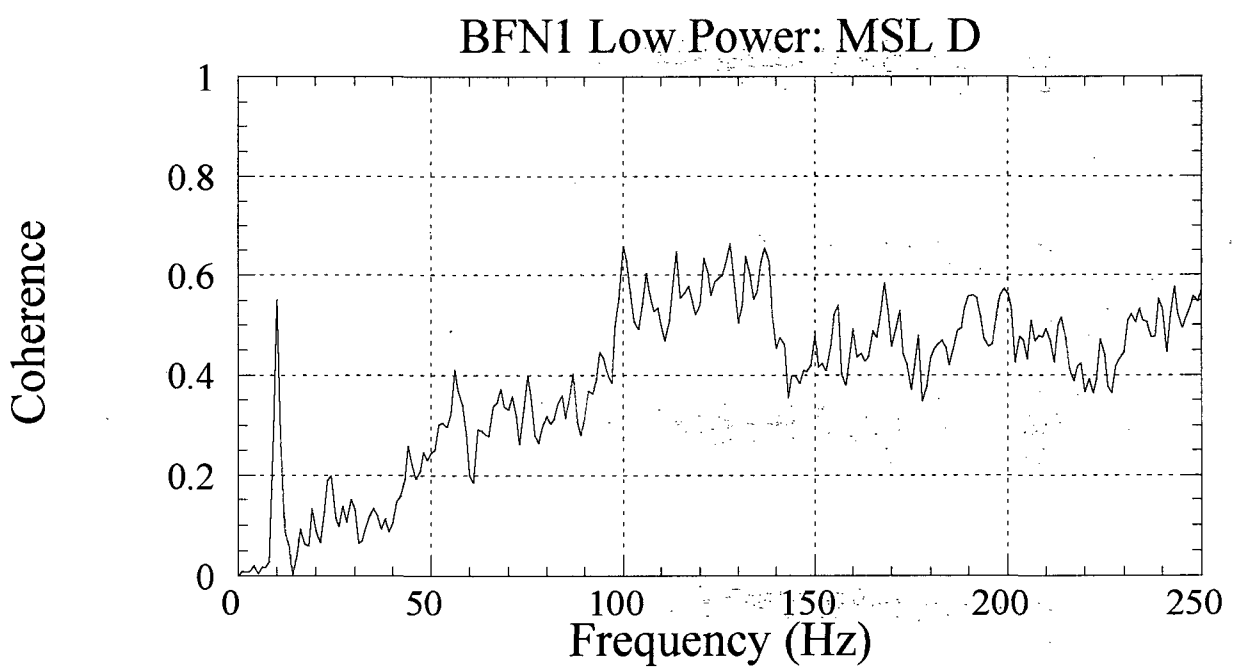


Figure EMCB.194-1b: Coherence between the upper and lower strain gage readings at BFN1 for 9% power data (MSLs C & D)

NRC RAI EMCB.195 (Unit 1 only)

During the conference call on August 15, 2008, TVA explained that the possible reason for broad-band noise in MSL signals for 9-percent flow is up to 25 operating drywell cooling fans within containment. Provide the following fan specifications to support its explanation: sizes, flow rates, rpm, number of blades, and the proximity to the MSLs. TVA should also provide information about where peak frequencies of broadband fan noise 'mounds' (broad humps of noise) occur and, based on the fan specifications, clarify whether the fan speeds change with plant power level. If available, provide other sensor spectra within containment that show 'mounded' noise signals. Also, if available, TVA should provide the coherence between the other sensor spectra and the MSL spectra.

TVA Response to EMCB.195 (Unit 1 only)

The BFN drywells are equipped with two banks of five drywell blower fans located on opposite sides of the containment as shown in Figure EMCB.195-1. Unit 1 has centrifugal fans which rotate at nominal 1800 revolutions per minute (rpm) (30 Hz) and Units 2 and 3 have axial flow fans which rotate at a nominal 3600 rpm. Eight to ten fans are normally running during power operation and the fan speed does not change. Unit 1 has nine-blade, 33 inch, 21,500 cubic feet per minute (cfm) fans with a blade passing frequency around 270 Hz. The cooler banks are situated on opposite sides of the containment at approximately 45 degrees and 225 degrees azimuth. The base of the cooler banks rests on the 563 foot elevation support steel and decking. The MSLs originate at approximately elevation 633 feet and exit containment at 180 degrees azimuth at elevation 568 feet.

As can be seen in several of the Unit 1 PSD graphs provided in the response to RAI EMCB.181 in the September 2, 2008 submittal (the PSD for Unit 1 MSL A Lower is duplicated in Figure EMCB.195-2 for convenience), an amplitude peak occurs near 30 Hz which corresponds to the shaft rotation of the fans. The peak is present in the 9% signal but not in the EIC signal indicating that the source is mechanical. The most likely mode of transmission to the MSL strain gages is vibration transmitted through the steel support framing in the drywell.

According to 1976 ASHRAE (E 35.11), equation 2 (shown below) allows construction of the spectral distribution of the broadband noise caused by the Unit 1 fans.

$$Lw = Kw + 10 \text{ Log } Q + 20 \text{ Log } P + BFI + Cn$$

where,

Lw = sound power level (dB)

Kw = specific sound power level depending on the type of fan from empirical data provided by fan manufacturer

Q = volume flow rate (cfm)

P = total pressure (inches of H_2O)

BFI = Blade Frequency Increment = correction for pure tone produced by the blade passing frequency (bpf), add this correction only to the octave band whose center frequency is closest to the blade passing frequency

Bpf = blade passing frequency = # of blades x rpm/60 (Hz)

Cn = efficiency correction (because fans that are operated off their optimum flow conditions get noisier) = 10 + 10 Log (1-n)/n where n = hydraulic efficiency of the fan

The magnitude of the fan noise is largest at the blade passing frequency of about 270 Hz. Table EMCB.195.1 lists expected values for one fan on Unit 1 with a nominal running speed of 1800 rpm.

Table EMCB.195.1: Fan Power Calculation at Given Frequencies

Hz	Sound Power	Lw	Kw	Q	P	BFI	Cn[1]
63	0.01421	101.53	35	21500	7	0	6.3
125	0.01421	101.53	35	21500	7	0	6.3
250	0.02252	103.53	34	21500	7	3[2]	6.3
500	0.00712	98.53	32	21500	7	0	6.3
1000	0.00566	97.53	31	21500	7	0	6.3
2000	0.00179	92.53	26	21500	7	0	6.3
4000	0.00028	84.53	18	21500	7	0	6.3
8000	0.00004	76.53	10	21500	7	0	6.3

Notes:

1. According to the data from the vendor, the fan operates at 70% efficiency at 21,500 cfm yielding Cn=6.3.

2. A BFI of 3 was applied at 250 Hz for a centrifugal fan with airfoil blades since the BPF is 270 Hz.

Figure EMCB.195-3 show the sound power as a factor of frequency. It can be seen that the Unit 1 fans produce significant acoustic energy in the range of 0 to 250 Hz. Noise mounding could not be identified in the other sensor spectrum available in containment.

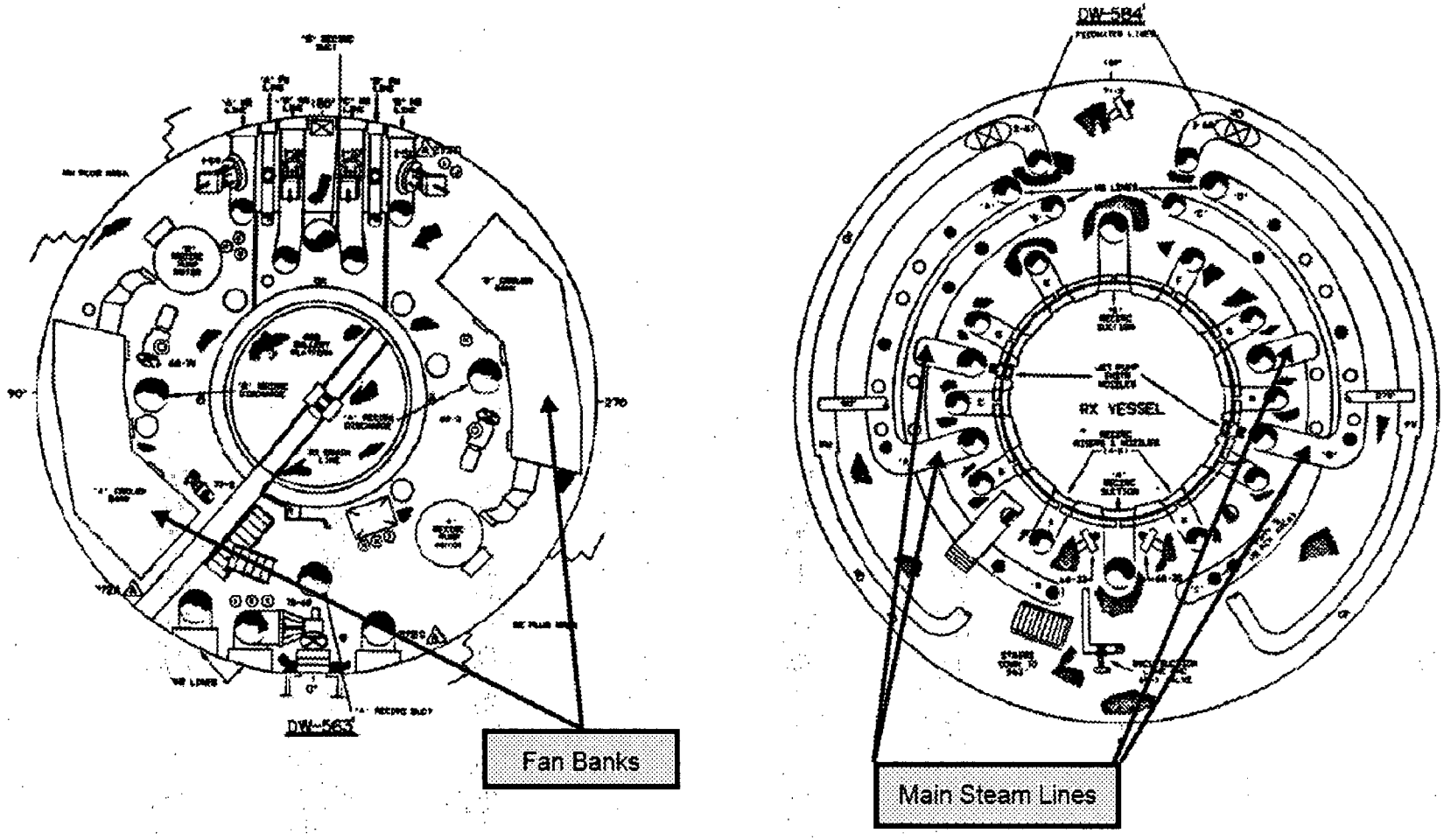


Figure EMCB.195-1: Drywell Elevations 563 feet and 584 feet

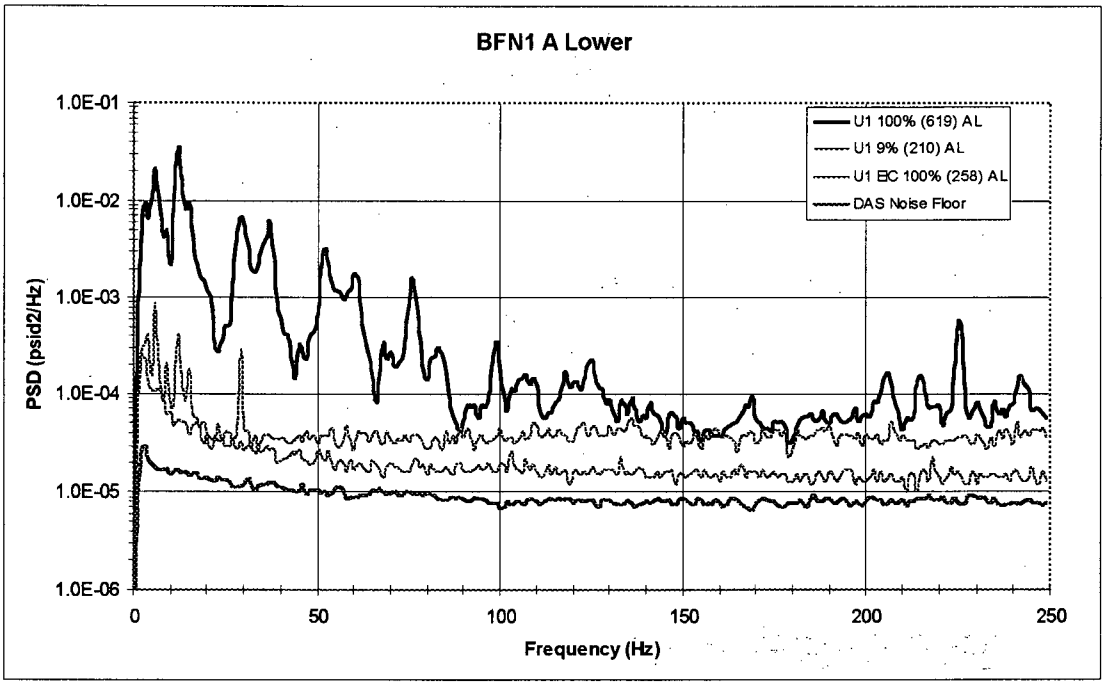


Figure EMCB.195-2: Unit 1 Data MSL A Lower

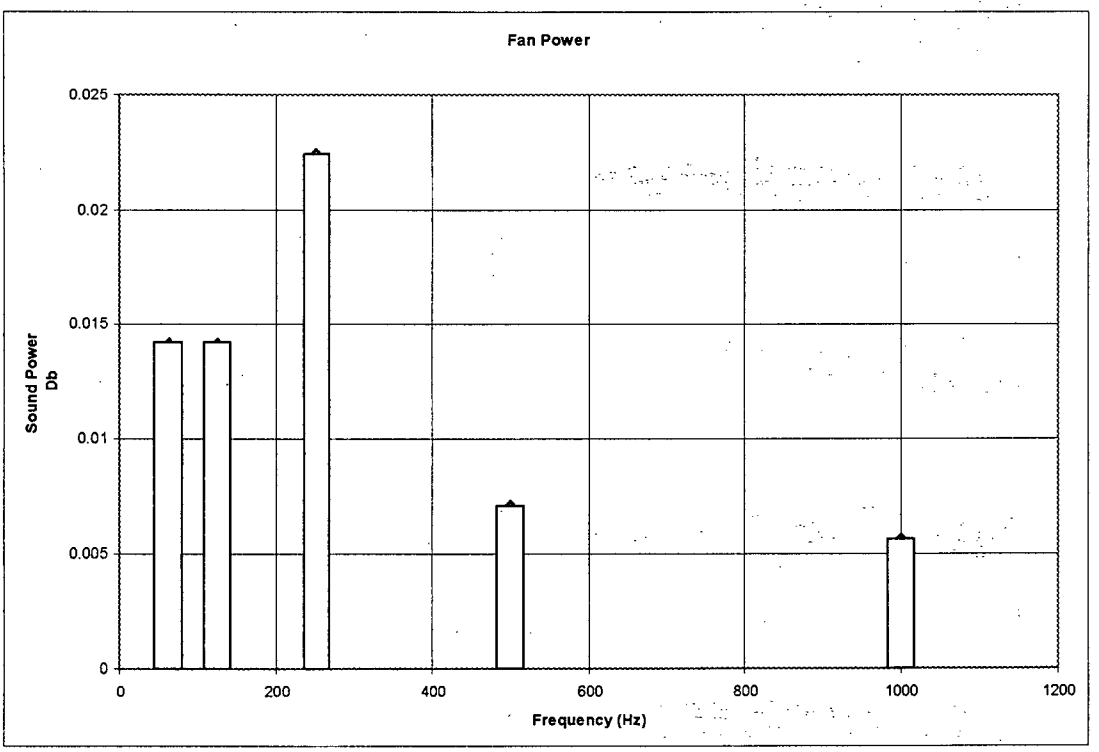


Figure EMCB.195-3: Fan Power

NRC RAI EMCB.196 (Unit 1 only)

Provide the curves for low voltage input signals for strain gages (where mechanical signals are very low, and only electrical background noise is visible) along with the plots at 9-percent and 100-percent power (CLTP).

TVA Response to EMCB.196 (Unit 1 only)

EIC signals, along with the low flow and CLTP signals, are plotted in Figures EMCB.181-1a through 1d for Unit 1 and Figures EMCB.147.1a through 1d for Unit 2 in the submittal dated September 2, 2008.

NRC RAI EMCB.197/153 (Unit 1/Unit 2)

During the conference call on August 15, 2008, TVA explained, that the tones in the 19-percent power signal are probably due to switching frequencies in the Variable Frequency Drive (VFD) controller for circulation pumps, driven by Pulse Width Modulated inverters. TVA has surmised that the electrical signals in the drive cables generate an electromagnetic field around the cables, which corrupts the signals in surrounding strain gage cables. The containment exits of the power cables were identified by TVA to be closer to the exits of the strain gage cables in Unit 2 than in Unit 1. Therefore, these signals are not seen for Unit 1. Provide the details on azimuth angles and elevations of the recirculation pump power cable penetrations and strain gage cable penetrations for both Units 1 and 2.

TVA Response to EMCB.197/153 (Unit 1/Unit 2)

The relative location of the MSL strain gage penetrations to the recirculation pump power cable penetrations for Units 1 and 2 was provided in Figures EMCB-1 and 2 in the submittal dated September 2, 2008.

NRC RAI EMCB.154 (Unit 2 only)

TVA indicated that the pumps are run at minimum speed at 9-percent flow. As the VFD speeds up, it is expected that the tones should move up in frequency out of the range of interest. Provide the power spectral densities up to 500 Hz (or higher) that demonstrate the tones are moving up in frequency at higher speeds. Provide the correlation with the tones observed in the strain gages based on a characteristic signal (voltage or current) in the power cables supplying the pumps.

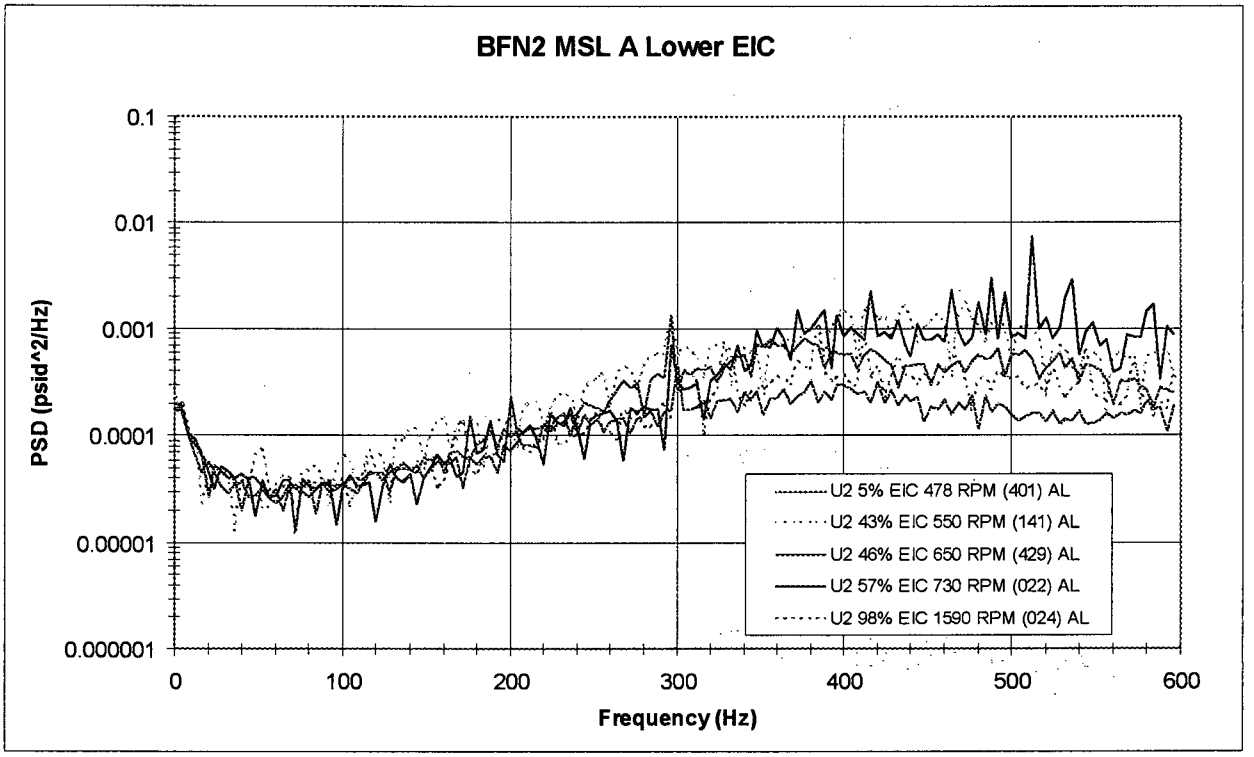
TVA Response to EMCB.154 (Unit 2 only)

Based on observation of raw data signals from Unit 2 MSL strain gages, a strong component of electrical noise can be seen as individual frequency spikes in the PSD plots. These frequency spikes occur at harmonics of the VFD operating frequency which identifies the VFD as the source. Prior to a September 2008 shutdown and startup of Unit 2, insufficient low power EIC data was available to determine if the base amplitude of electrical noise varies significantly with VFD operating frequency and to resolve the behavior of the original low flow data (19% power) above 150 Hz. It was hypothesized that electrical interference from the recirculation pump power cables increased in amplitude at frequencies from 150 to 250 Hz when the VFD was operating at minimum speed.

During September 2008, a planned shutdown on Unit 2 provided the opportunity to collect and evaluate additional MSL strain gage data at reduced power levels. PSD plots of EIC signals up

to 600 Hz for a range of VFD operating frequencies show that the spectral shape varies with recirculation pump speed and VFD frequency, with the maximum for the 150 to 250 Hz range occurring at 550 rpm (18 Hz VFD frequency).

Figures EMCB.154-1 and 2 provide EIC extended frequency plots for MSL A Lower and C Upper at varying recirculation pump speeds (designated by rpm). Recirculation pump speed of 1800 rpm corresponds to 60 Hz VFD frequency. In order to illustrate the base amplitude level, VFD frequency harmonics were filtered as they would be when developing a load definition.



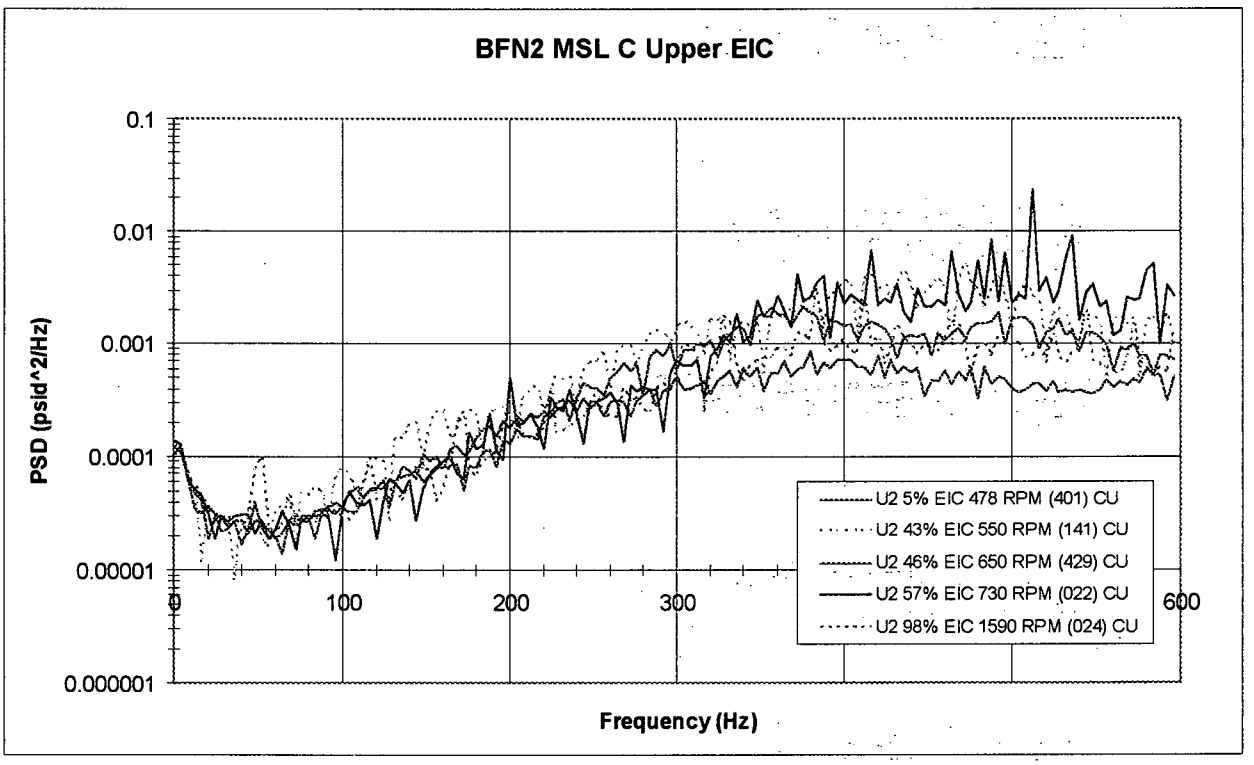


Figure EMCB.154-1: Extended Frequency Response at Varied VFD Frequency

RESPONSES TO ROUND 21 RAI

Two draft RAIs associated with the steam dryer analyses are planned to be issued in Round 21. The response to the two RAIs is provided below.

NRC RAI EMCB.198 (Unit 1 only)

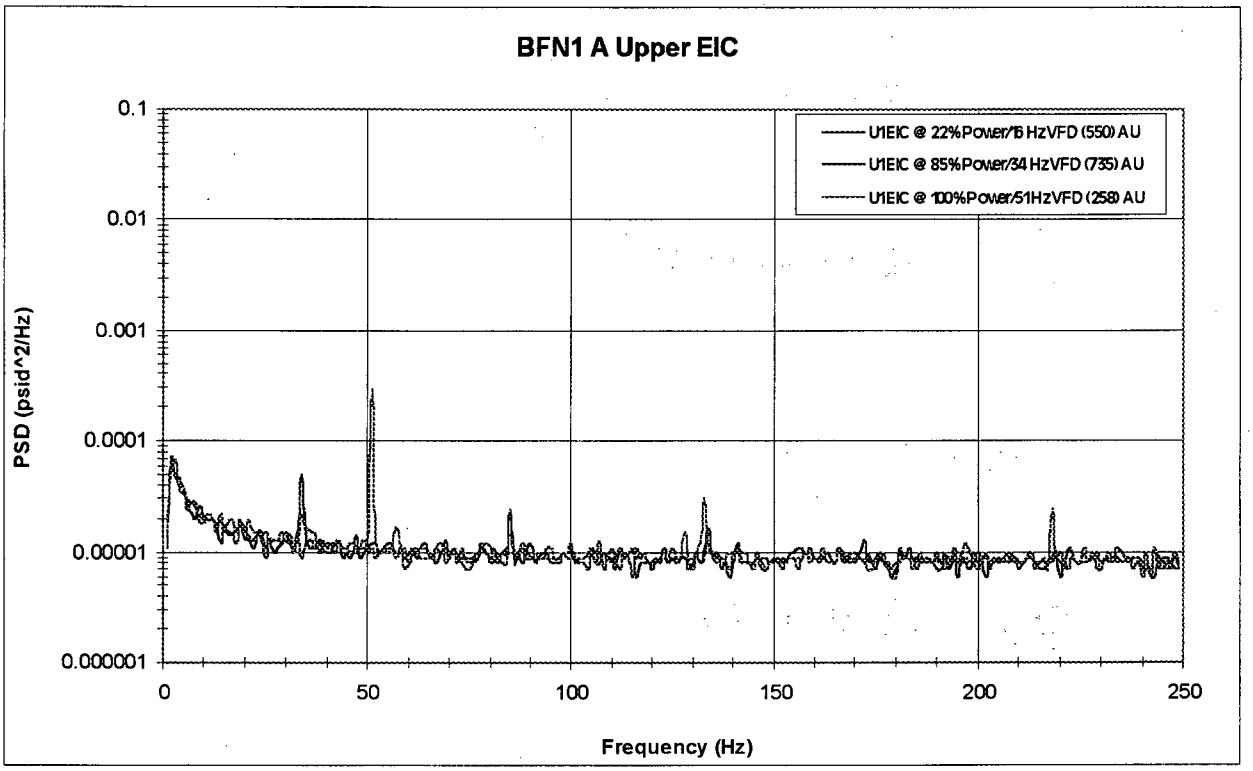
In reference to the September 2, 2008 response for Unit 1 to EMCB-181, explain whether the electrical interference check (EIC) signal at low flow conditions is the same as at the current license thermal power (CLTP) conditions. If so, provide justification, otherwise, provide a comparison of the two signals and confirm that the difference is accounted for in estimating the fluctuating pressure signal [(CLTP-EIS) – (LF-EIS)].

TVA Response to EMCB.198 (Unit 1 only)

During a recent plant shutdown on Unit 1, TVA had the opportunity to collect and evaluate additional EIC signals at reduced power levels that included minimum flow conditions on the recirculation pumps. Figures EMCB.198-1a through 1d provide a comparison of three different EIC signals for each MSL strain gage array. Only mean filtering (0 - 2 Hz) and filtering of alternating current (AC) line noise at 60, 120, 180, and 240 Hz were applied in these plots; VFD frequency filtering was not performed in order to illustrate the associated VFD frequency peaks. These EIC signals consist of:

- 100% power (CLTP) EIC with the VFDs operating at approximately 51 Hz. This EIC signal was taken at approximately the same time (within 10 minutes) as the CLTP signal used in the current stress analyses and is the EIC signal used in the current stress analyses for removal from the CLTP signal.
- 85% power EIC with the VFDs operating at approximately 34 Hz.
- 22% power EIC with the VFDs operating at approximately 16 Hz. This EIC signal is representative of the recirculation pumps operating at minimum flow and will be used in the revised Unit 1 stress analyses for removal from the LF signal.

As can be seen in the comparison plots, the EIC signals at varying power and VFD operating frequencies are similar except for some peaks which are mostly associated with the operating VFD frequency and associated harmonics. Therefore, except for the matching of corresponding operating VFD frequency peaks (which are exclusion filtered after EIC removal), EIC signals taken at different power levels are equivalent and would cancel out in the operation [(CLTP-EIC) - (LF-EIC)]. For the revised Unit 1 stress analyses, the EIC signal removed from the CLTP and LF signals will be at the same operating states.



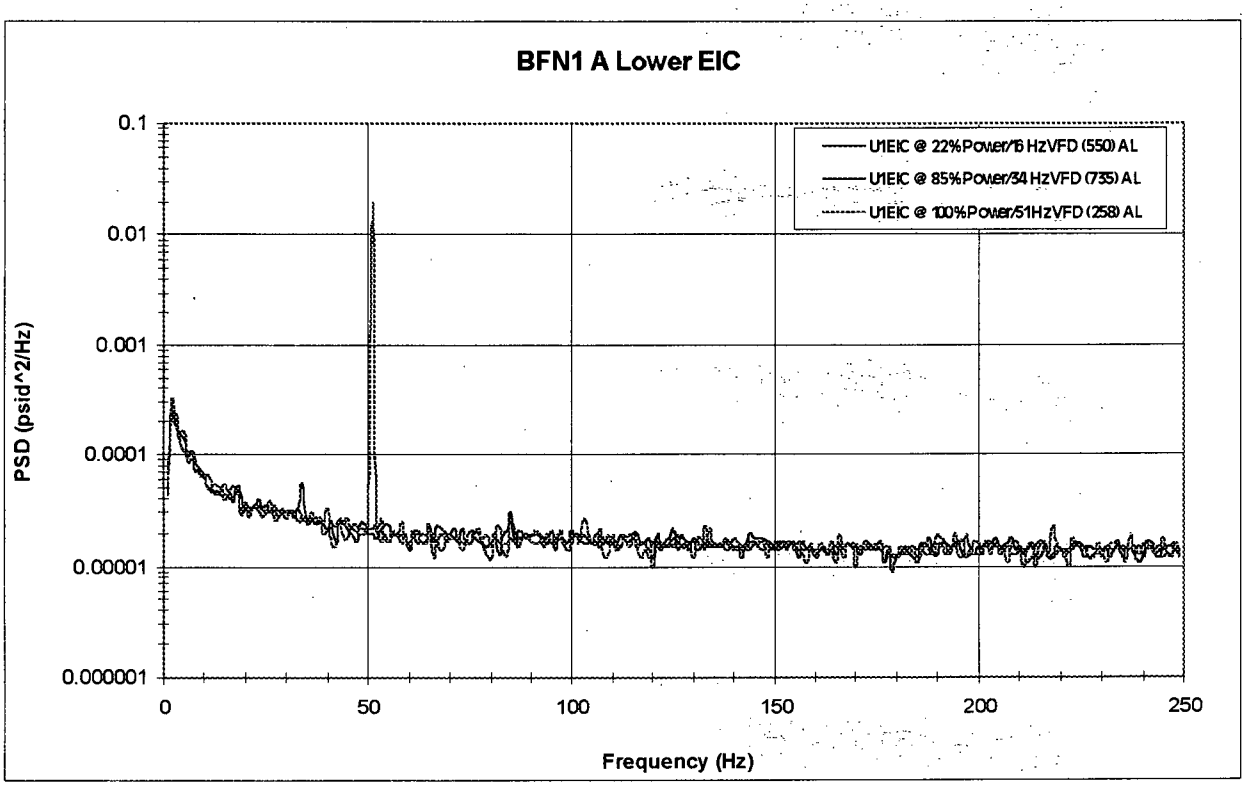
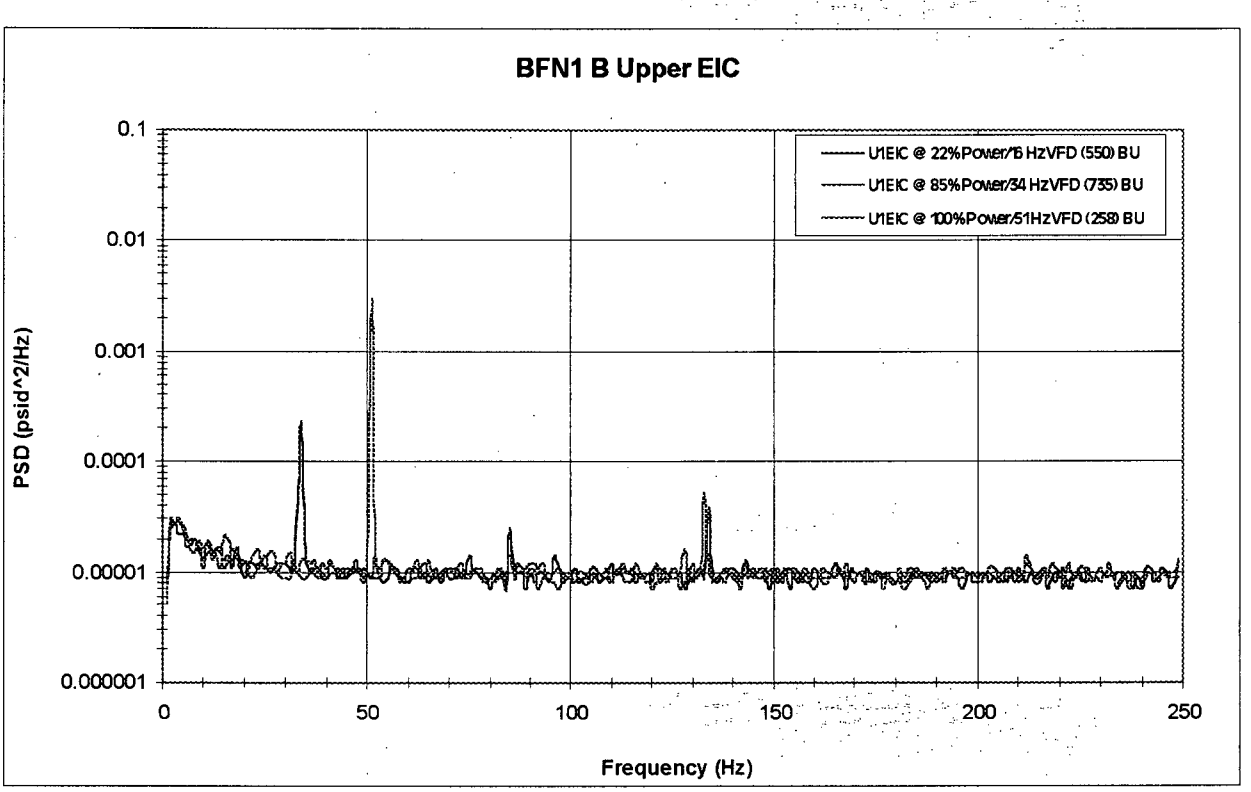


Figure EMCB.198-1a: BFN1 EIC Comparison



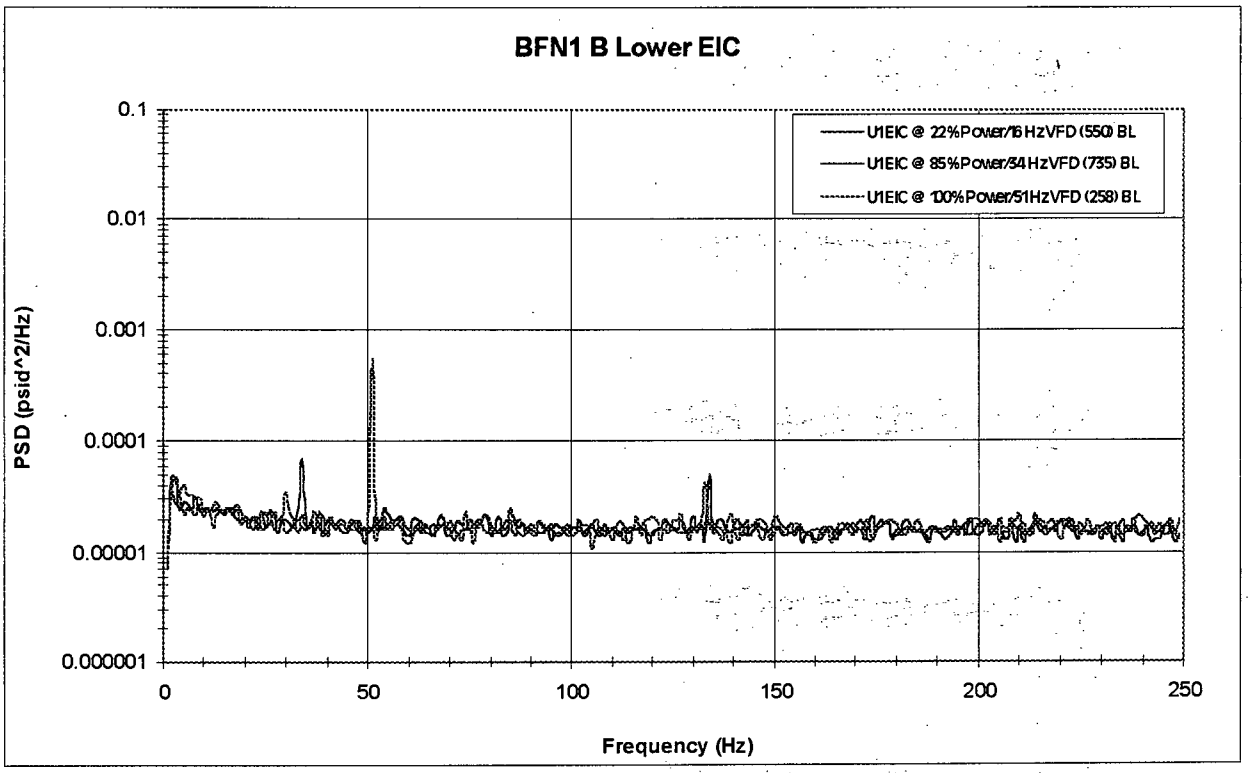
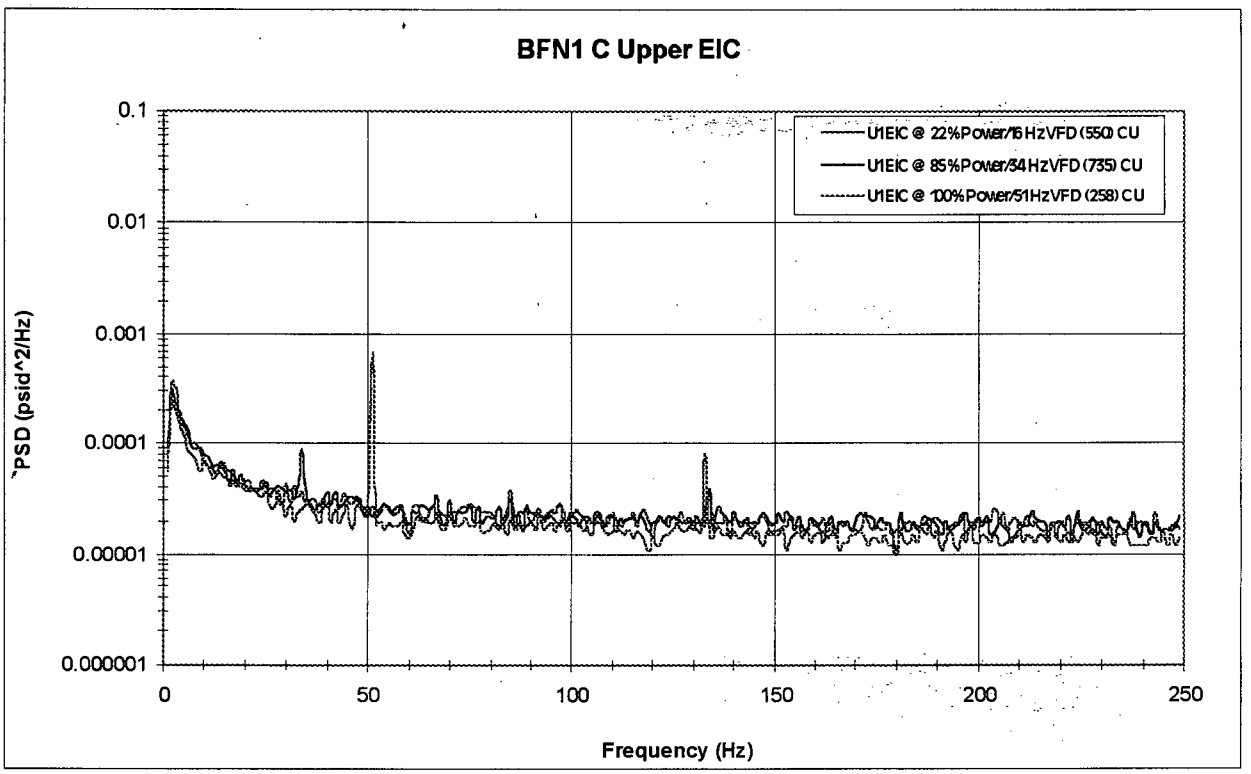


Figure EMCB.198-1b: BFN1 EIC Comparison



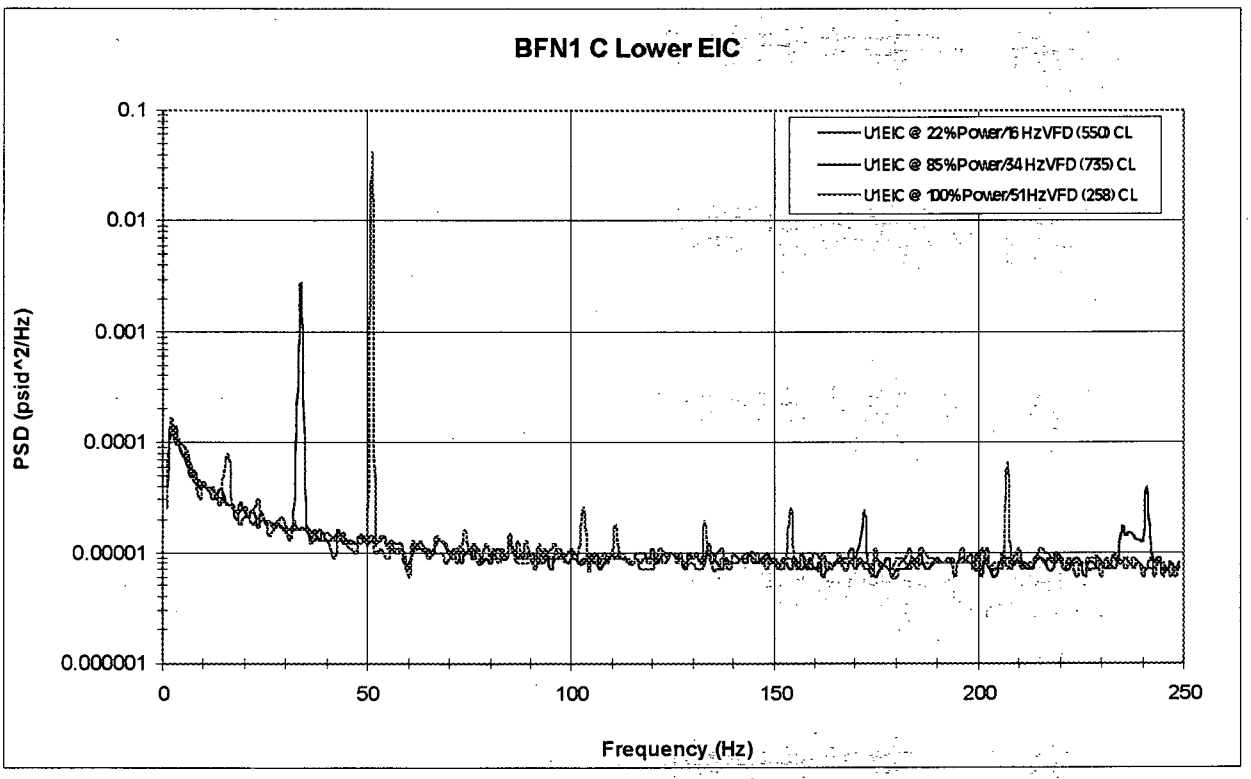
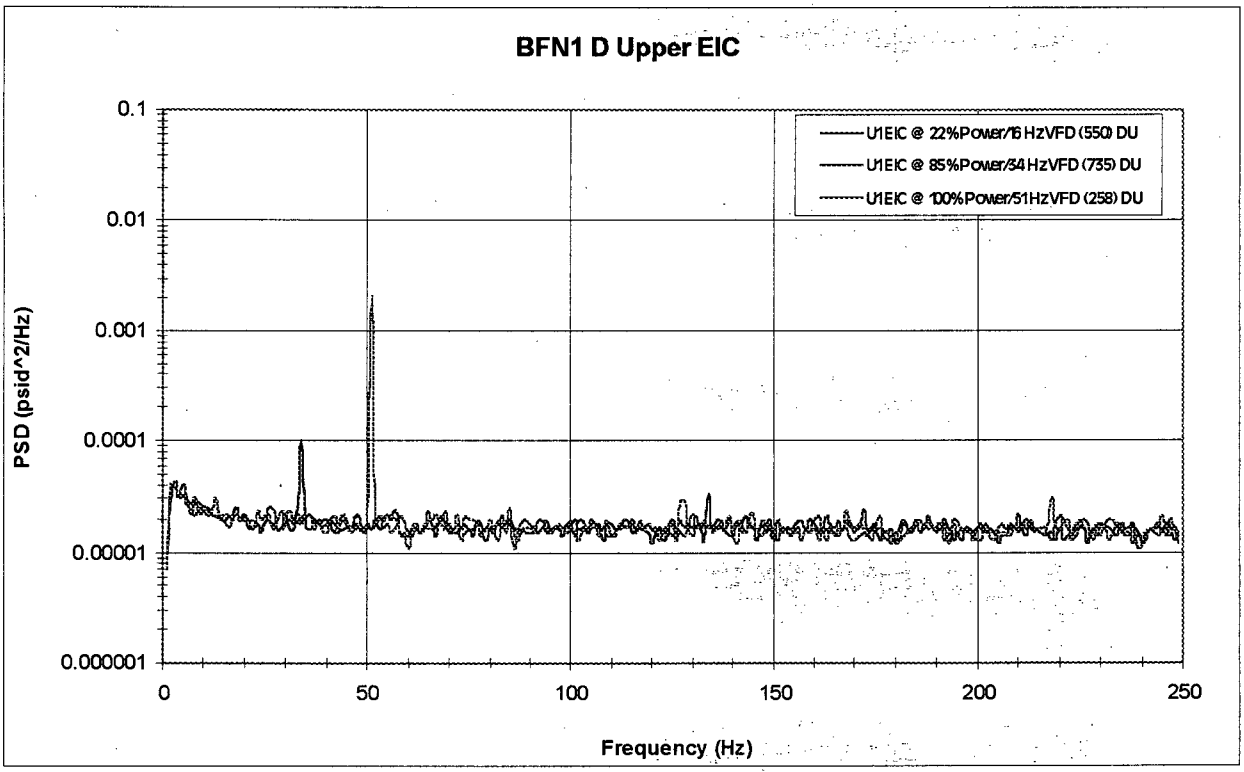


Figure EMCB.198-1c: BFN1 EIC Comparison



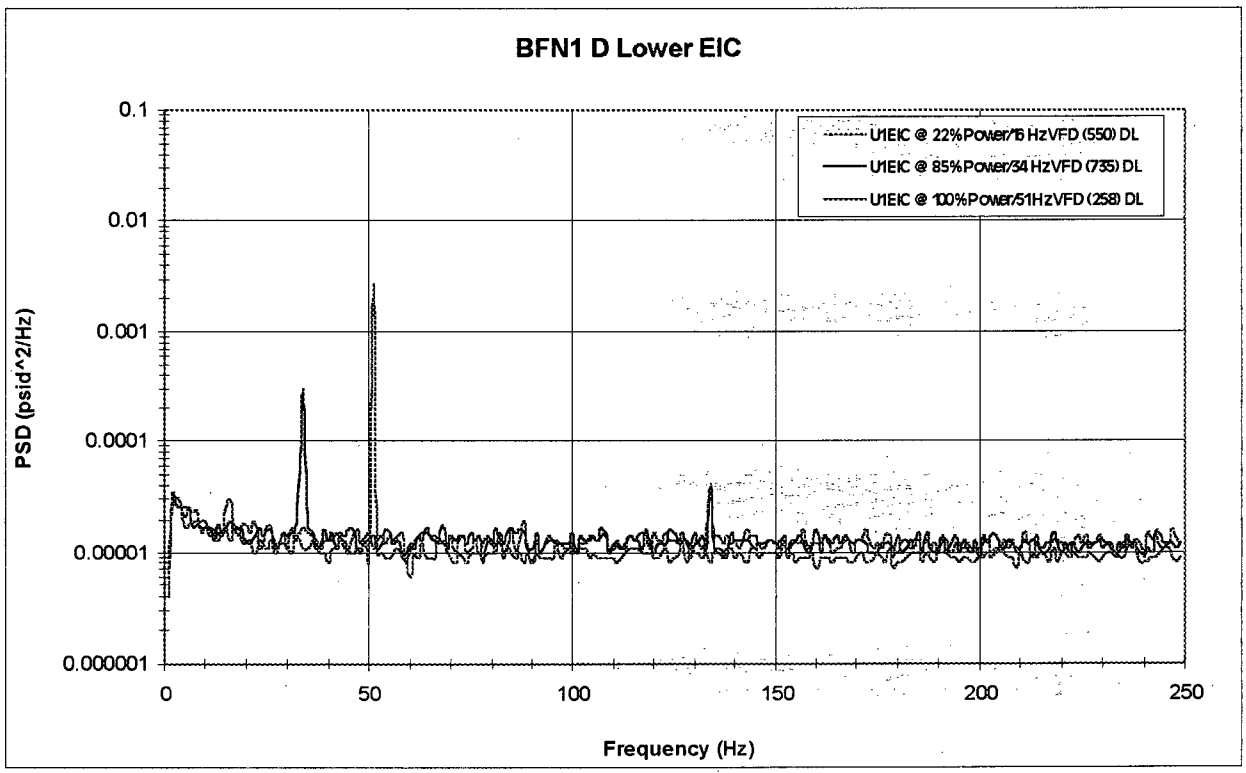


Figure EMCB.198-1d: BFN1 EIC Comparison

NRC RAI EMCB.155 (Unit 2 only)

In the September 2, 2008 response for Unit 2 to EMCB-147, it appears that TVA subtracts the EIC signal from the low flow (LF) signal and treats the difference as mechanical noise (LF-EIC). Then it appears that TVA subtracts the EIC signal and the mechanical noise from the CLTP signal. The resulting signal is the acoustic pressure signal. Explain whether the EIC signal subtracted from the LF signal is the same as the one subtracted from the CLTP signal. If so, please provide justification. Note that in Figures EMCB.147-1a to 147-1d, the power spectral density (psd) for the 19 percent flow rate, in the high frequency range, is higher than that for 30 percent flow rate, which implies that the EIC noise is higher at lower pump/fan speeds.

TVA Response to EMCB.155 (Unit 2 only)

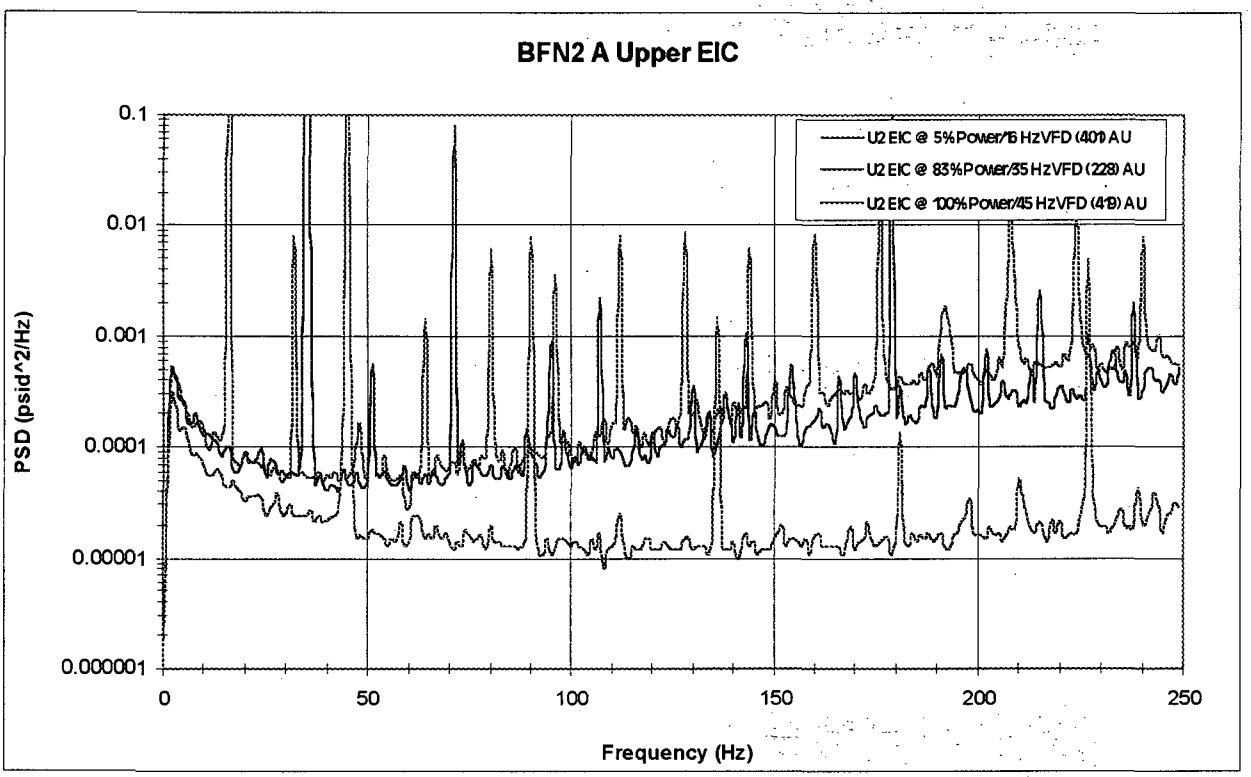
In the current Unit 2 stress analyses, the same EIC signal taken at 100% power is removed from both the CLTP and LF signals as part of the filtering process. During a recent plant shutdown on Unit 2, TVA had the opportunity to collect and evaluate additional EIC signals at reduced power levels that included minimum flow conditions on the recirculation pumps.

Figures EMCB.155-1a through 1d provide comparison of three different EIC signals for each MSL strain gage array except for MSL D Lower. Strain gage failures on MSL D Lower prevent the acquisition of data for this array. Only mean filtering (0 - 2 Hz) and filtering of alternating current (AC) line noise at 60, 120, 180, and 240 Hz were applied in these plots; VFD frequency filtering was not performed in order to illustrate the associated VFD frequency peaks. These EIC signals consist of:

- 100% power (CLTP) EIC with the VFDs operating at approximately 45 Hz. This EIC signal was taken at approximately the same time (within 10 minutes) as the CLTP signal used in the current stress analyses and is the EIC signal used in the current stress analyses for removal from the CLTP signal.
- 83% power EIC with the VFDs operating at approximately 35 Hz.
- 5% power EIC with the VFDs operating at approximately 16 Hz. This EIC signal is representative of the recirculation pumps operating at minimum flow.

As can be seen in the comparison plots, the EIC signals at varying power and VFD operating frequencies vary more than the corresponding EIC signals for Unit 1 (see the response to RAI EMCB.198 in this submittal). This is likely caused by the additional noise that exists due to the close proximity of the MSL strain gage electrical penetration to the recirculation pump power cable penetration. Therefore, for Unit 2, it is necessary to obtain EIC signals at the same time that the corresponding CLTP or LF signal is obtained since EIC signals taken at different times are not the same and would not cancel out in the operation [(CLTP-EIC)-(LF-EIC)].

For Unit 2, EIC removal from either the CLTP or LF signal can be appropriately performed with an EIC signal that has been taken at the same time. For the revised Unit 2 stress analyses, the EIC signal removed from the CLTP signal will continue to be the EIC signal that was taken at the same timeframe as the CLTP signal and the EIC signal removed from the LF signal will be an EIC signal taken at the same time.



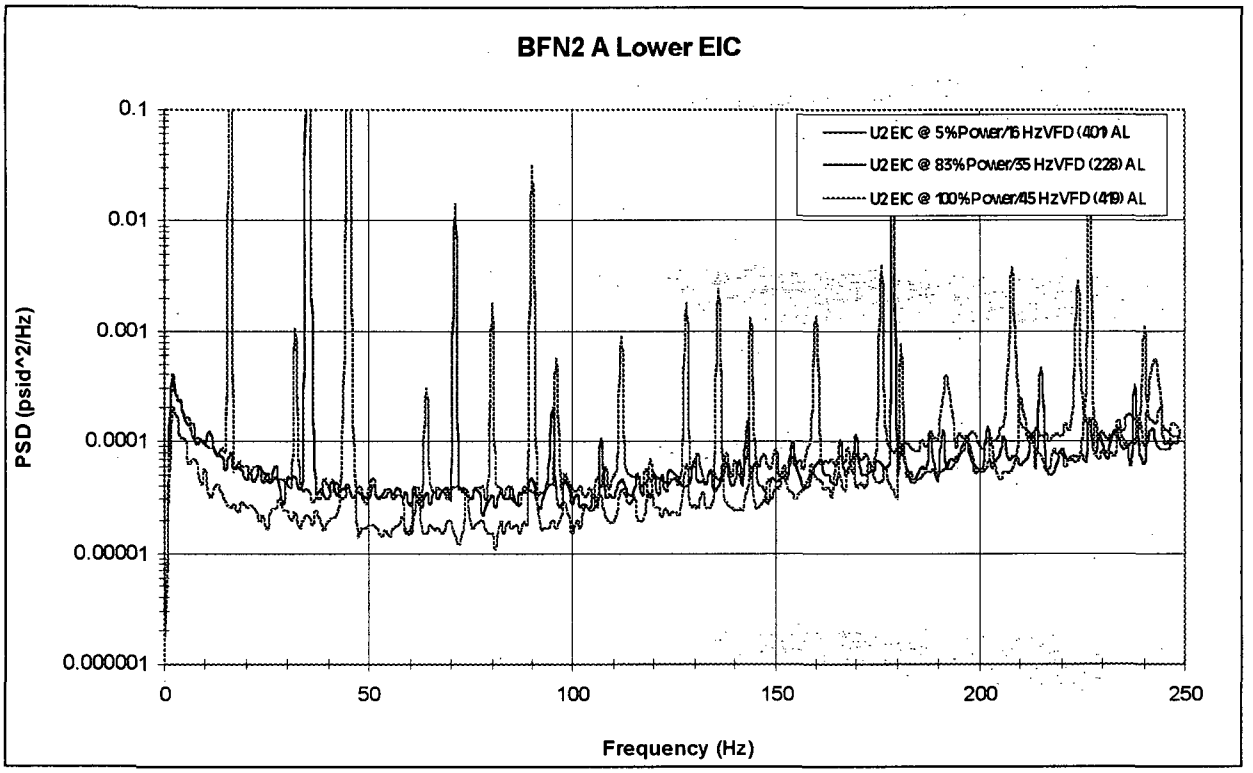
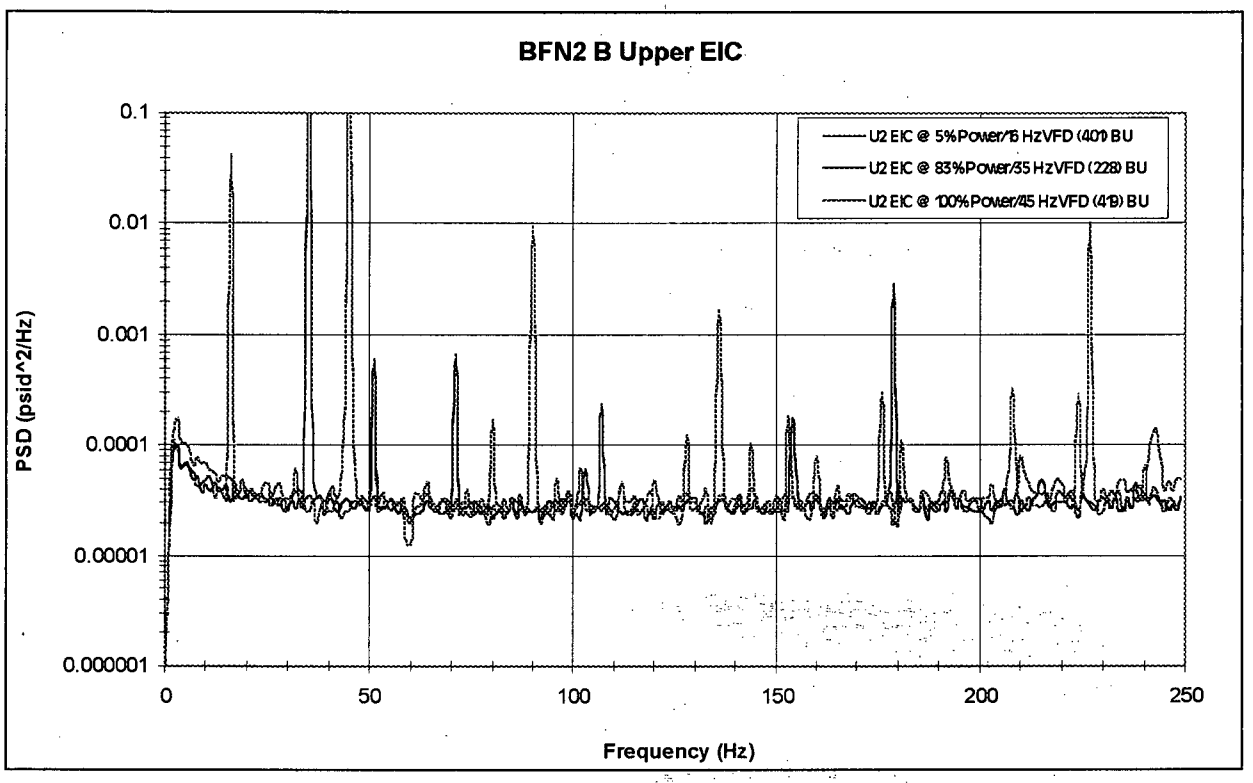


Figure EMCB.198-1a: BFN2 EIC Comparison



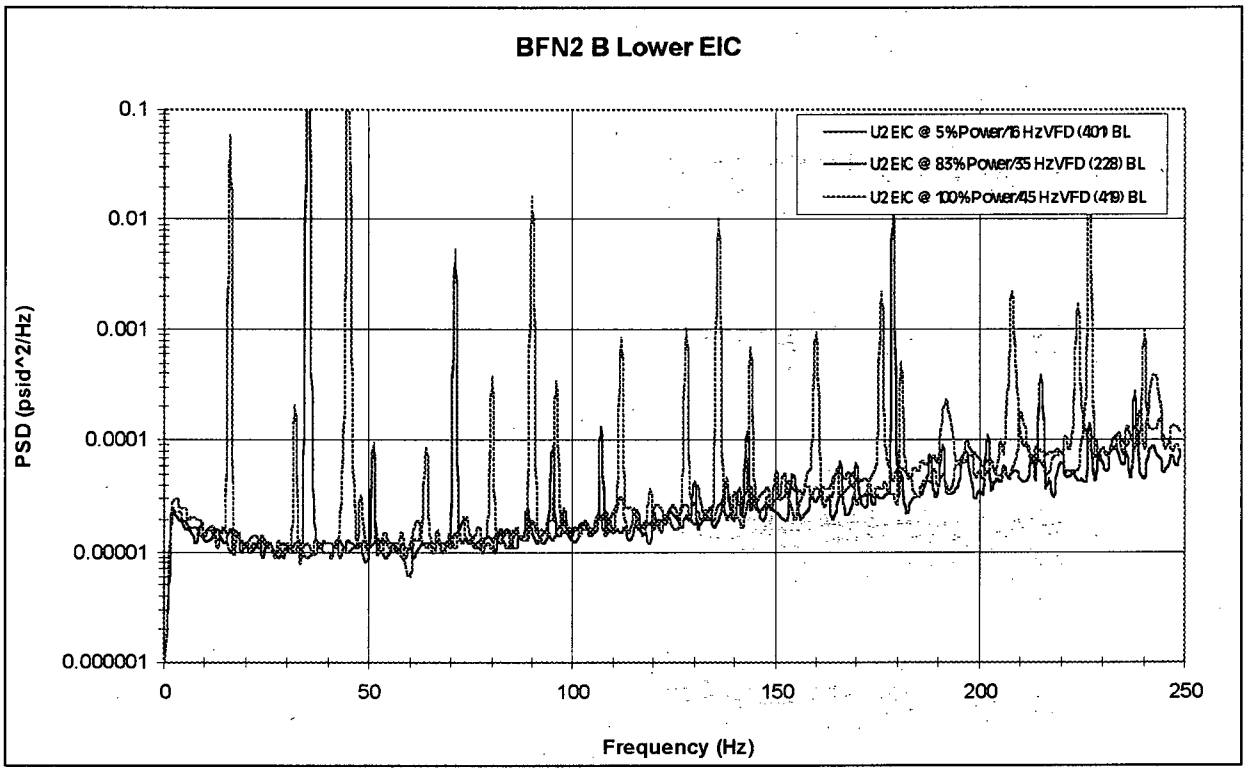
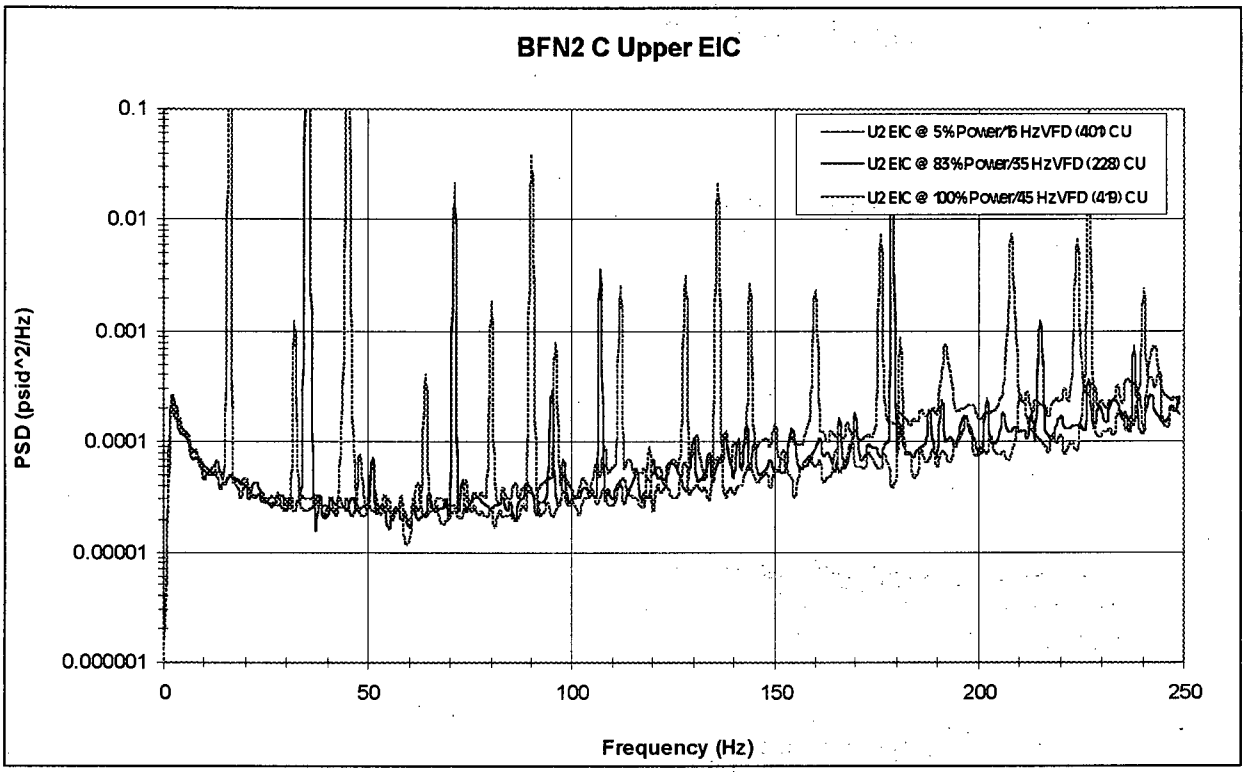


Figure EMCB.198-1b: BFN2 EIC Comparison



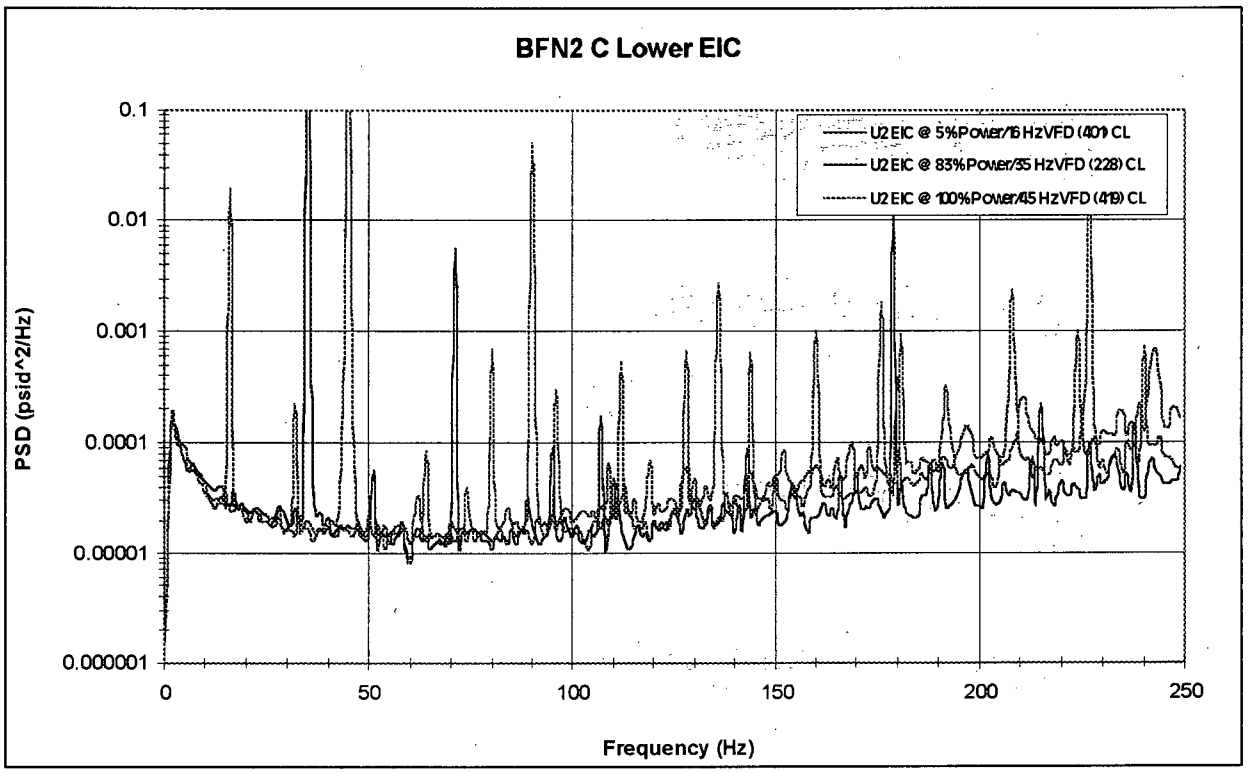


Figure EMCB.198-1c: BFN2 EIC Comparison

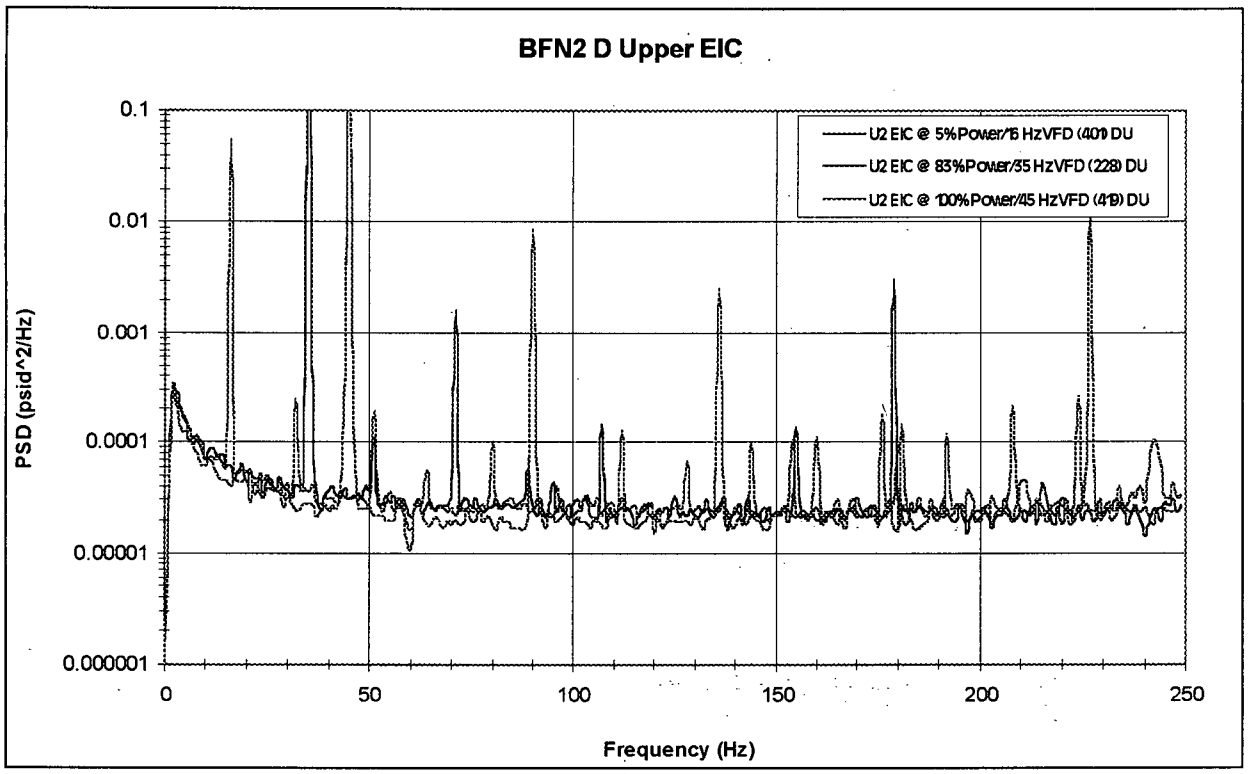


Figure EMCB.198-1d: BFN2 EIC Comparison