

Attachment 10

Peach Bottom Atomic Power Station Units 2 and 3

NRC Docket Nos. 50-277 and 50-278

**WCAP-17626, Rev 1, MSL Strain Gauge Data and Computation of Predicted EPU
Signature**

Processing of Peach Bottom Unit 2 and Unit 3 MSL Strain Gauge Data and Computation of Predicted EPU Signature

WCAP-17626-NP
Revision 1

**Processing of Peach Bottom Unit 2 and Unit 3
MSL Strain Gauge Data and Computation of Predicted EPU
Signature**

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February 2014

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EXECUTIVE SUMMARY

Peach Bottom Atomic Power Stations (PBAPS2 and PBAPS3, herein referred to as “Peach Bottom Unit 2 and Peach Bottom Unit 3”) are implementing an extended power uprate (EPU) to increase plant power to [

] ^{a,c}

To satisfy the requirements of the United States Nuclear Regulatory Commission (NRC) Regulatory Guide 1.20, Revision 3 (Reference 2), an analysis must be performed to demonstrate the structural integrity of the steam dryer at EPU conditions. [

] ^c

[

] ^{a,c}

[

] ^{a,c}

[

] ^a

LIST OF ACRONYMS AND ABBREVIATIONS

AC	alternating current
ACE	[] ^a
ASCII	American Standard Code for Information Interchange
BWR	boiling water reactor
CLTP	current licensed thermal power
DAS	data acquisition system
DS	downstream (for Figures only)
DWT	discrete wavelet transform
EIC	electrical interference check
EPU	extended power uprate
EPU*1.02	102 percent of extended power uprate
FFT	fast Fourier transform
HPCI	high-pressure coolant injection
MSL	main steam line
NRC	Nuclear Regulatory Commission
OEM	original equipment manufacturer
PCF	[] ^a
PBAPS	Peach Bottom Atomic Power Stations
PSD	power spectral density
RRP	reactor recirculation pump
RSD	replacement steam dryer
SIA	Structural Integrity Associates, Inc.
SNR	signal-to-noise ratio
SRV	safety relief valve
SSV	safety spring valve
US	upstream (for Figures only)
VPF	vane passing frequency

Trademark Note:

MATLAB is a registered trademark of The MathWorks, Inc.

1 BACKGROUND AND INTRODUCTION

[

] ^{a,c}

Previous industry experience with boiling water reactors (BWRs) has shown that increasing the steam flow through the MSLs to implement an EPU may lead to amplified acoustic loads on the steam dryer, which may negatively affect the structural integrity of the component. [

] ^c

NRC Regulatory Guide 1.20, Revision 3 (Reference 2), contains requirements for demonstrating the structural integrity of the steam dryer at power levels higher than CLTP. [

] ^{a,c}

[

] ^{a,b,c}

[

] ^{a,b,c}

[

] ^{a,b,c}

[

] ^{a,c}

2 SUMMARY OF PREVIOUS WORK

2.1 ACOUSTIC SCREENING

[

] ^{a,b,c}

Table 2-1 [^{a,c}	
I	
	] ^b

2.2 SUBSCALE TESTING

[

] ^{a,b}

2.3 PLANT DATA RECORDINGS

[

] ^{a,c}

$$\left[\begin{array}{c} \end{array} \right]^{a,c} \tag{2-1}$$

$$\left[\begin{array}{c} \end{array} \right]^{a,c} \tag{2-2}$$

Where,

[

]^{a,c}

]^{a,c}

Figure 2-1 Schematic of MSL [

]^{a,b,c}

[

] ^{a,c}

[

] ^c

2.4 DATA ACQUISITION

[

] ^{a,c}

[

] ^{a,c}

Table 2-2 summarizes the data collected during [

] ^b

Table 2-3 summarizes the data collected during [

] ^b

[

] ^{a,b,c}

[illegible]

b

[illegible][illegible]

3 DATA PROCESSING PLAN AND RESULTS

[

] ^{a,c}

a,c

Figure 3-1 Signal Processing Methodology Flowchart for [] ^{a,c}

3.1 RAW DATA

[

] ^{a,c}

3.2 STRAIN-TO-PRESSURE CONVERSION

The strain to pressure conversion is shown in Box 4 of Figure 3-1. [

] ^{a,c}

[

] ^{a,c}

(3-1)

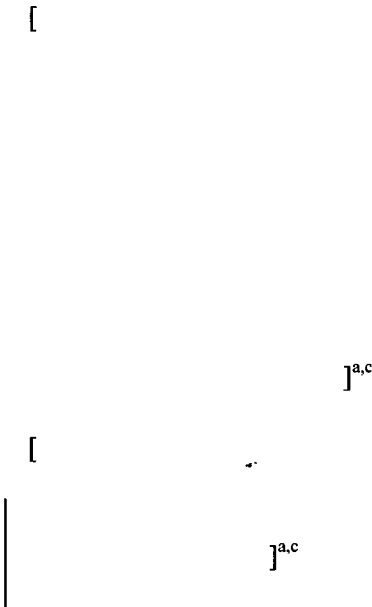
where,

[

] ^{a,c}



Figure 3-2 Pipe Mode Diagram, N= [0, 4]



$$\left[\begin{array}{c} \text{ } \end{array} \right]^{a,c} \quad (3-2)$$

where,

$$\left[\begin{array}{c} \text{ } \end{array} \right]^{a,c}$$

3.3 NARROW-BAND FILTERING

Narrow-band filtering is shown in Boxes 7-10 of Figure 3-1. [

$$\left[\begin{array}{c} \text{ } \end{array} \right]^{a,c}$$

$$\left[\begin{array}{c} \text{ } \end{array} \right]^{a,c}$$

3.4 WAVELET DENOISING

$$\left[\begin{array}{c} \text{ } \end{array} \right]^{a,c}$$

[

]^{a,c}

[

]^c

1. [

]^c

2. [

]^c

3. [

]^c

[

]^c

[

]^c

[

]^c

(3-3)

where,

[

]^c

[

]^c

[

]^{a,c}

[

]^c

3.5 COMPUTATION OF THE PREDICTED EPU*1.02 SIGNAL

[

]^{a,c}

[

]^{a,c}

4 INPUTS TO SIGNAL PROCESSING AND ASSUMPTIONS

4.1 INPUTS

[

] ^{a,c}

[

] ^{a,c}

4.2 ASSUMPTIONS

1. [

] ^{a,c}

2. [

] ^{a,c}

3. [

] ^{a,c}

4. [

] ^{a,c}

5. [

] ^{a,c}

6. The acoustic speed in steam is assumed to be 1484.3 ft/s.

5 DISCUSSION OF RESULTS

5.1 RAW DATA EVALUATION

In fall 2010, [
] ^b

In fall 2011, [
|
] ^{a,b}

[

] ^{a,c}

5.1.1 Unit 2

[

] ^b

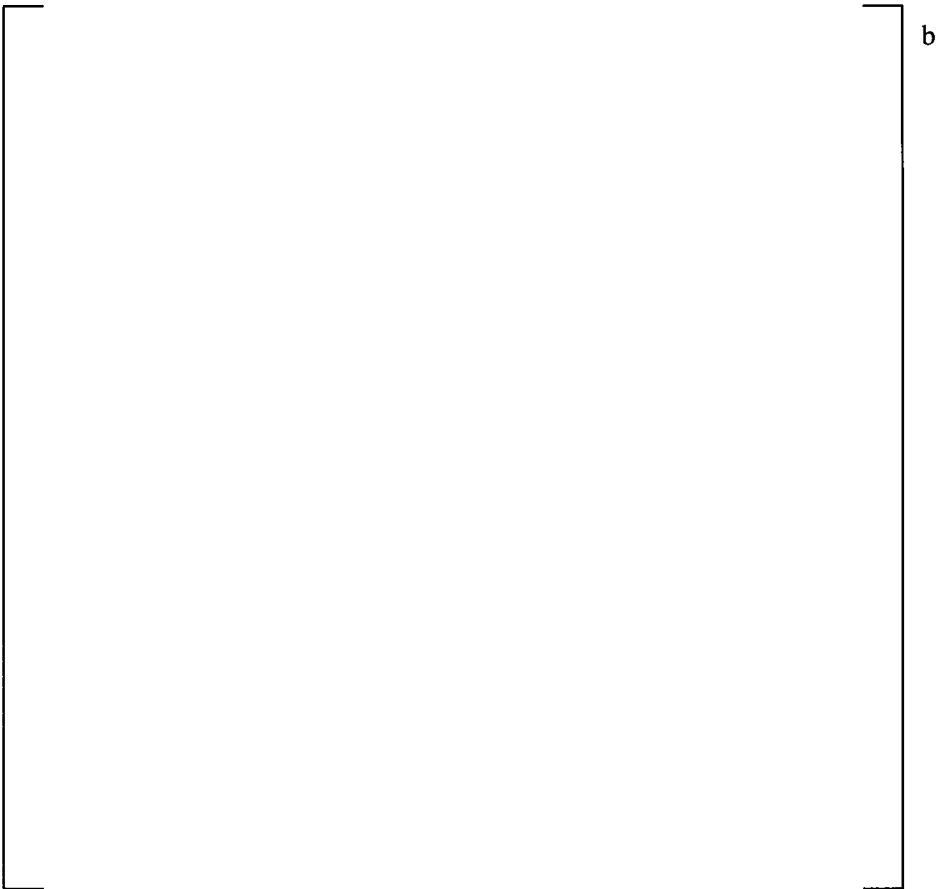


Figure 5-1 [

]^b

5.1.2 Unit 3

[

]^b

5.2 STRAIN-TO-PRESSURE CONVERSION

[

] ^{a,c}

5.2.1 Unit 2

[

] ^{a,b,c}

Table 5-1 Summary of [^{a,c}						
MSL	LOC	Channel				Mean

b

5.2.2 Unit 3

[

] ^{a,c}

[

] ^{a,b}

Table 5-2 Summary of [] ^{a,c}						
MSL	LOC	Channel				Mean

5.3 FILTERING

[

] ^{a,c}

[

] ^{a,b}

5.3.1 Unit 2

[

] ^b

Table 5-3 Peach Bottom Unit 2, Notch Filters, []^b

Filter Order	Low Freq	High Freq	Filter Type	Reason

5.3.2 Unit 3**Table 5-4 Peach Bottom Unit 3, Notch Filters, []^b**

Filter Order	Low Freq	High Freq	Filter Type	Reason

5.4 WAVELET DENOISING

[

] ^{a,c}

5.4.1 Unit 2

Figure 5-2 through Figure 5-9 show the derived MSL pressures at CLTP before and after [

] ^c



Figure 5-2 Unit 2 Raw, Filtered, and Denoised Pressure Data, MSL A Upstream

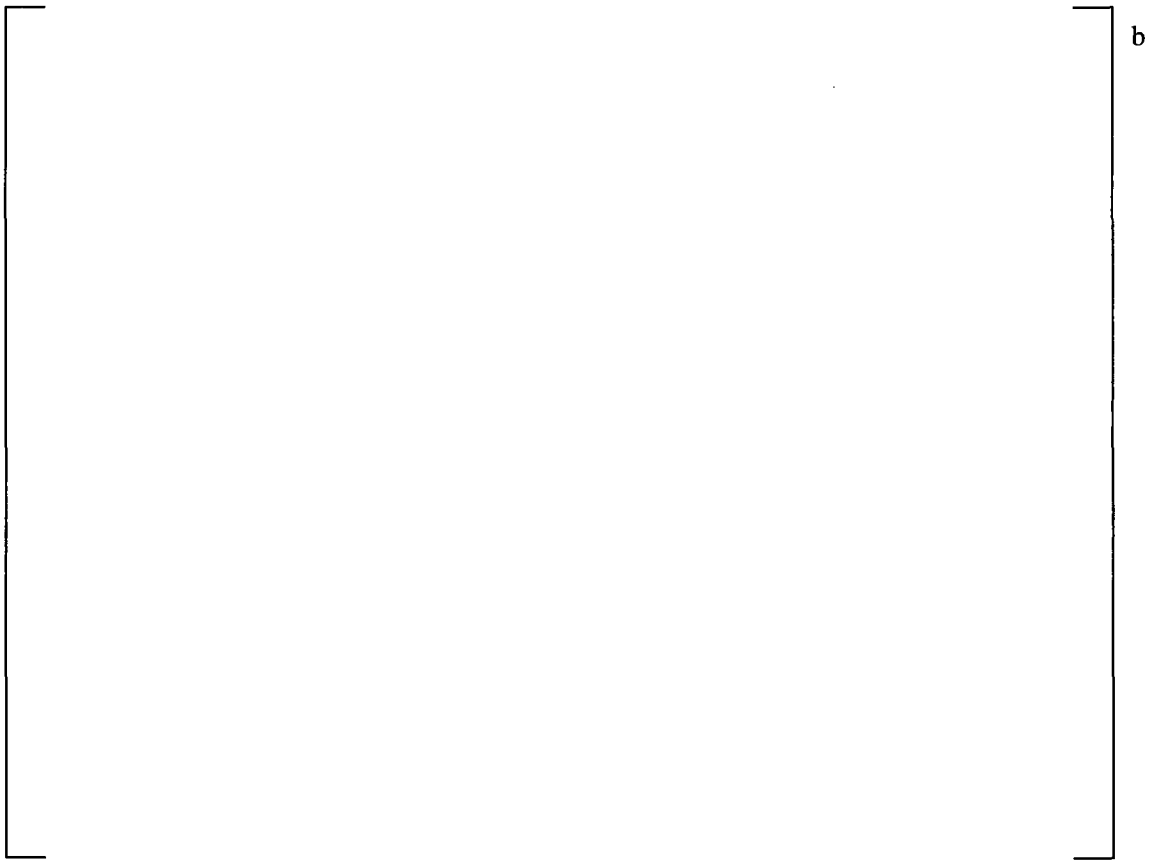


Figure 5-3 Unit 2 Raw, Filtered, and Denoised Pressure Data, MSL A Downstream

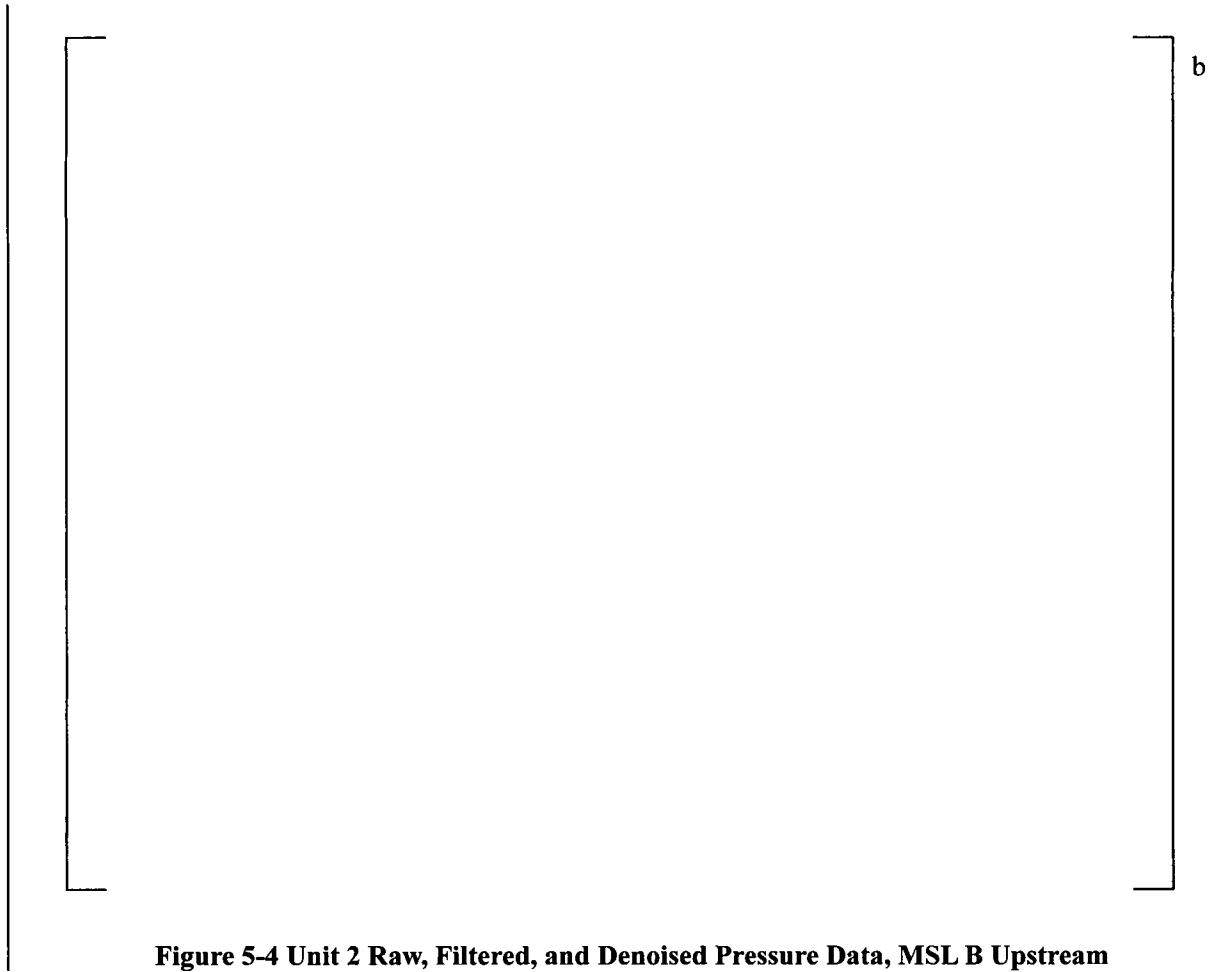




Figure 5-5 Unit 2 Raw, Filtered, and Denoised Pressure Data, MSL B Downstream

b

Figure 5-6 Unit 2 Raw, Filtered, and Denoised Pressure Data, MSL C Upstream



b

Figure 5-7 Unit 2 Raw, Filtered, and Denoised Pressure Data, MSL C Downstream

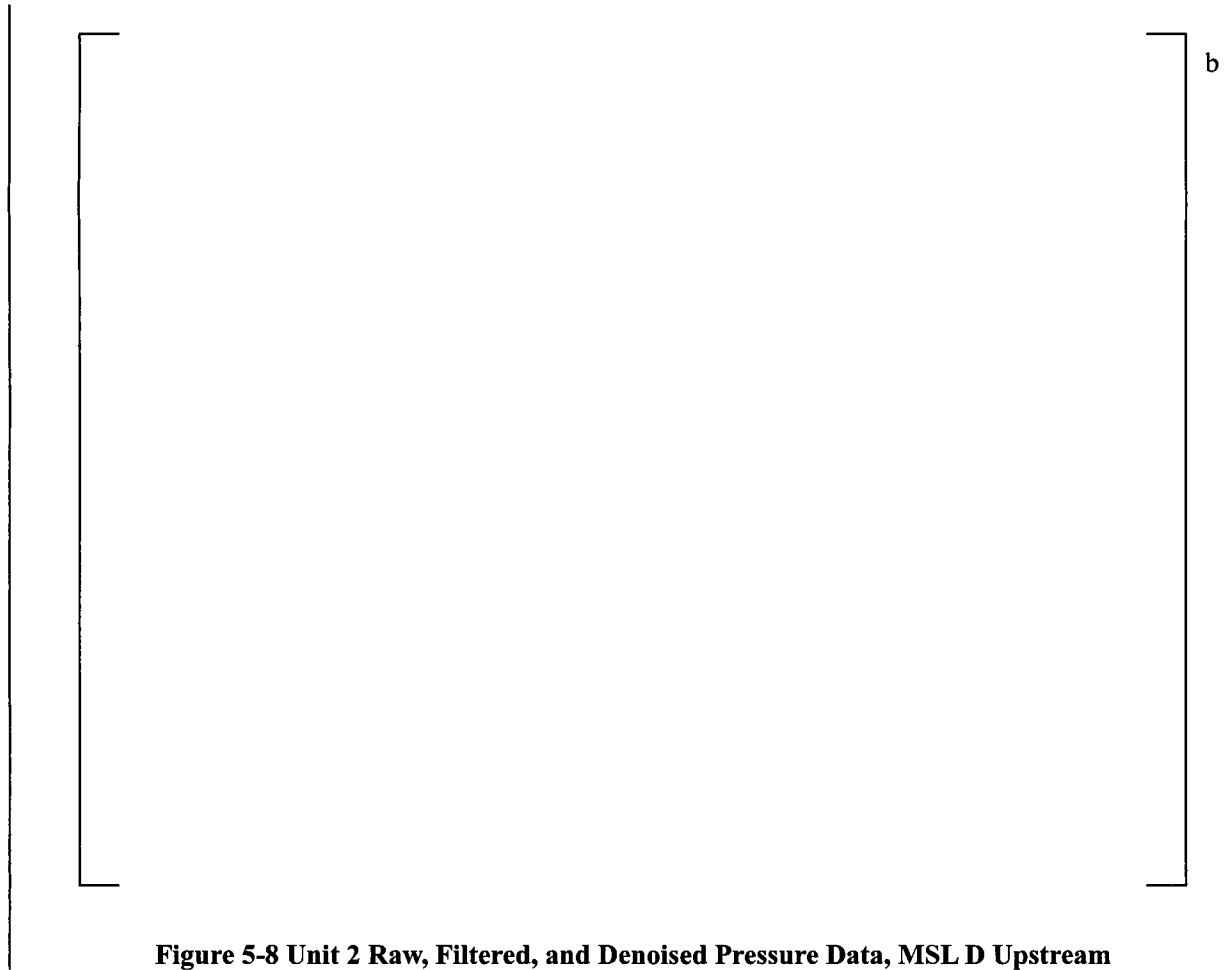


Figure 5-8 Unit 2 Raw, Filtered, and Denoised Pressure Data, MSL D Upstream



Figure 5-9 Unit 2 Raw, Filtered, and Denoised Pressure Data, MSL D Downstream

5.4.2 Unit 3

Figure 5-10 through Figure 5-17 show the derived MSL pressures at CLTP before and after []^c



Figure 5-10 Unit 3 Raw, Filtered, and Denoised Pressure Data, MSL A Upstream



Figure 5-11 Unit 3 Raw, Filtered, and Denoised Pressure Data, MSL A Downstream

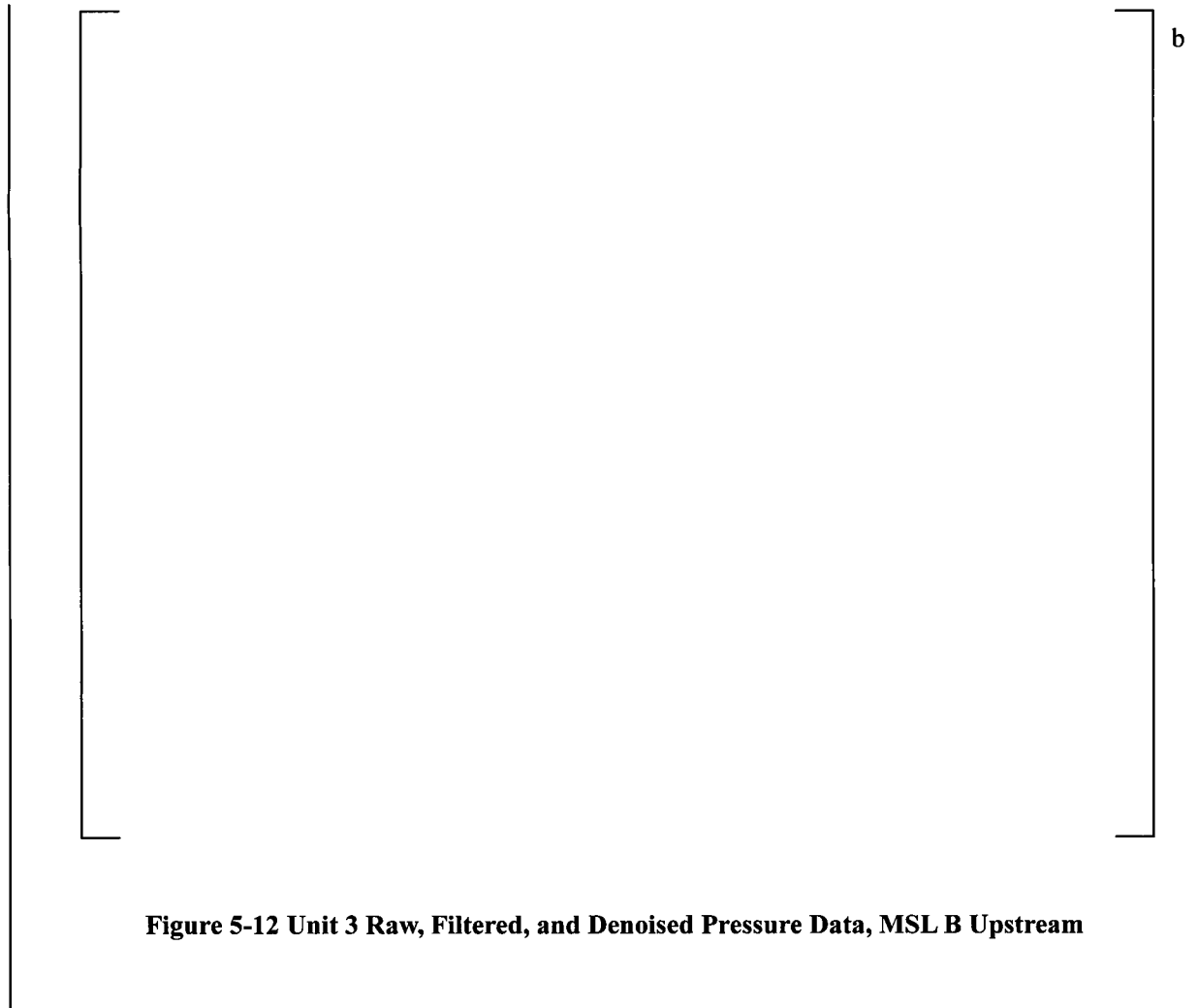


Figure 5-12 Unit 3 Raw, Filtered, and Denoised Pressure Data, MSL B Upstream



Figure 5-13 Unit 3 Raw, Filtered, and Denoised Pressure Data, MSL B Downstream

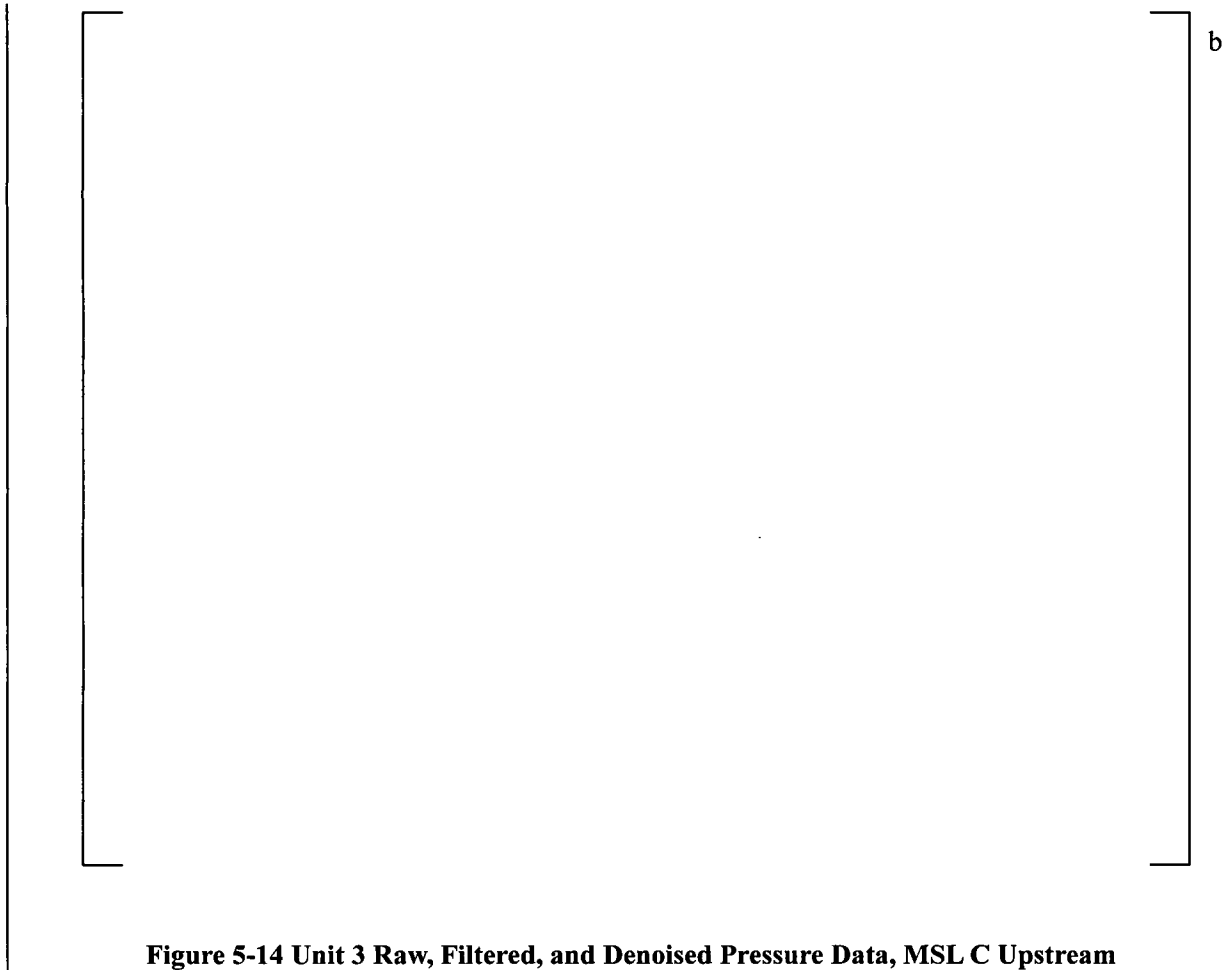




Figure 5-15 Unit 3 Raw, Filtered, and Denoised Pressure Data, MSL C Downstream





Figure 5-17 Unit 3 Raw, Filtered, and Denoised Pressure Data, MSL D Downstream

5.5 EPU*1.02 SIGNAL COMPUTATION

[

] ^{a,c}

5.5.1 Unit 2

| Figure 5-18 through Figure 5-25 show the [

] ^{a,b}



Figure 5-18 Unit 2 CLTP and Predicted EPU*1.02 Signal, MSL A US



Figure 5-19 Unit 2 CLTP and Predicted EPU*1.02 Signal, MSL A DS



Figure 5-20 Unit 2 CLTP and Predicted EPU*1.02 Signal, MSL B US



Figure 5-21 Unit 2 CLTP and Predicted EPU*1.02 Signal, MSL B DS



Figure 5-22 Unit 2 CLTP and Predicted EPU*1.02 Signal, MSL C US



Figure 5-23 Unit 2 CLTP and Predicted EPU*1.02 Signal, MSL C DS

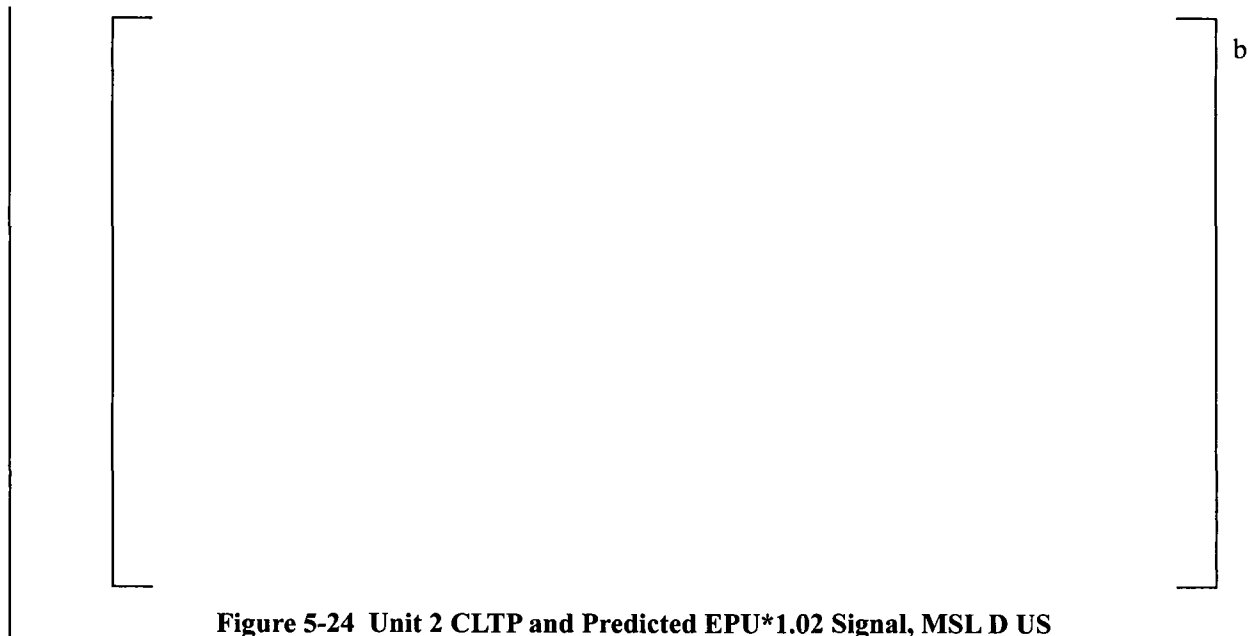


Figure 5-24 Unit 2 CLTP and Predicted EPU*1.02 Signal, MSL D US

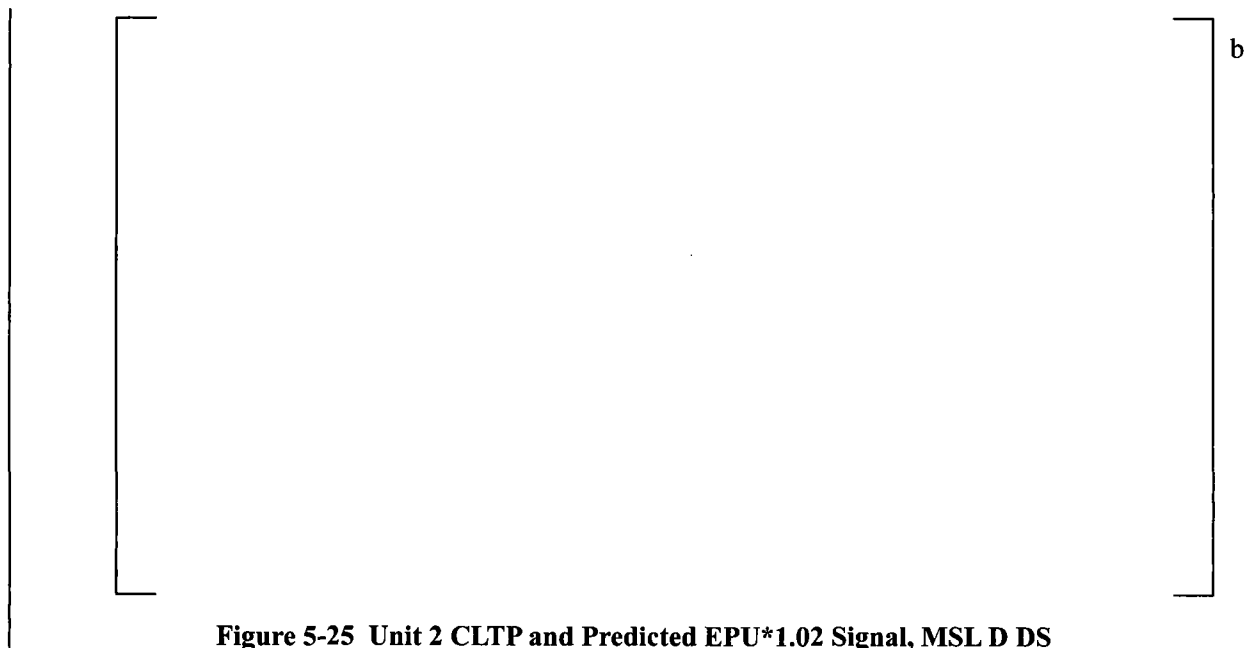


Figure 5-25 Unit 2 CLTP and Predicted EPU*1.02 Signal, MSL D DS

5.5.2 Unit 3

Figure 5-26 through Figure 5-33 show the Unit [

] ^{a,b}



Figure 5-26 Unit 3 CLTP and Predicted EPU*1.02 Signal, MSL A US



Figure 5-27 Unit 3 CLTP and Predicted EPU*1.02 Signal, MSL A DS



Figure 5-28 Unit 3 CLTP and Predicted EPU*1.02 Signal, MSL B US



Figure 5-29 Unit 3 CLTP and Predicted EPU*1.02 Signal, MSL B DS



Figure 5-30 Unit 3 CLTP and Predicted EPU*1.02 Signal, MSL C US



Figure 5-31 Unit 3 CLTP and Predicted EPU*1.02 Signal, MSL C DS



Figure 5-32 Unit 3 CLTP and Predicted EPU*1.02 Signal, MSL D US



Figure 5-33 Unit 3 CLTP and Predicted EPU*1.02 Signal, MSL D DS

6 CONCLUSIONS

[

|

] ^{a,c}

The processing steps that define this methodology and that are described in this document can be summarized as follows:

1. [] ^{a,c}

2. [] ^{a,c}

3. [] ^{a,c}

|

4. [] ^{a,c}

[] ^{a,c}

7 REFERENCES

1. Exelon Technical Requirements Document, "Technical Requirements for the Replacement of Steam Dryers at Peach Bottom Atomic Power Station (PBAPS), LaSalle County Generating Station (LCGS), and Limerick Generating Station (LGS)," Revision 1, February 24, 2012.
2. Regulatory Guide 1.20, Rev. 3, "Comprehensive Vibration Assessment Program for Reactor Internals During Preoperational and Initial Startup Testing," U.S. Nuclear Regulatory Commission, March 2007.
3. BWR Vessel and Internals Project, Guidance for Demonstration of Steam Dryer Integrity for Power Uprate. Electric Power Research Institute, Palo Alto, CA: 2008. BWRVIP-182-A.
4. Westinghouse Report [
] ^{a,b}
5. Westinghouse Letter [
] ^{a,b}
6. Westinghouse Letter [
] ^{a,b}
7. Westinghouse Report [
] ^{a,b}
8. TODI EPU-DIR-T0305A-0, "Exelon Transmittal of Design Information" (Design Inputs for Steam Dryer Analysis), March 1, 2010.
9. Westinghouse Test Plan [
] ^{a,b}
10. Westinghouse Test Plan [
] ^{a,b}
11. Westinghouse Letter [
] ^{a,b}
12. Westinghouse Letter [
] ^{a,b}

13. Calculation Package 1000102.301, Rev. 0, "Peach Bottom Unit 2 Strain Gauge Uncertainty Evaluation and Pressure Conversion Factors," Structural Integrity Associates, Inc., October 26, 2010.
14. Report 1000102.303, Rev. 0, "Peach Bottom Unit 3 Strain Gauge Uncertainty and Pressure Conversion Factors," Structural Integrity Associates, Inc., October 25, 2011.
15. []^{a,b}
16. Letter AMK-11-005, "Peach Bottom Unit 3 Strain Gauge Data Files Transmittal," Structural Integrity Associates, Inc., October 24, 2011.
17. Specification SIS-10-002, "Peach Bottom Units 2 and 3 Main Steam Dynamic Pressure Monitoring Data Acquisition Interface Specification," Structural Integrity Associates, Inc., June 30, 2010.
18. Calculation Package 1000102.302, Rev. 0, "Peach Bottom Unit 2 Strain Gauge Data Reduction," Structural Integrity Associates, Inc., November 22, 2010.
19. Report 1000102.304, Rev. 0, "Peach Bottom Unit 3 Strain Gauge Date Reduction," Structural Integrity Associates, Inc., November 14, 2011.