



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

CNL-15-165

August 20, 2015

10 CFR 50.4

ATTN: Document Control Desk
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555-001

Watts Bar Nuclear Plant, Unit 2
Construction Permit No. CPPR-92
NRC Docket No. 50-391

Subject: **WATTS BAR NUCLEAR PLANT UNIT 2 - SUBMITTAL OF
ELECTROMAGNETIC INTERFERENCE (EMI) SURVEY RESULTS**

- References:
1. TVA Letter to NRC, "Watts Bar Nuclear Plant (WBN) - Resistance Temperature Detector Bypass Elimination Audit Readiness," dated March 24, 1989
 2. TVA Letter to NRC, "Watts Bar Nuclear Plant (WBN) - Unit 2 - Westinghouse Eagle-21 Process Protection System (TAC No. MD6311)," dated February 28, 2008
 3. TVA Letter to NRC, "Watts Bar Nuclear Plant (WBN) Unit 2 - Instrumentation and Controls Staff Information Requests," dated April 15, 2011
 4. NUREG-0847, Supplement No. 23, "Safety Evaluation Report Related to the Operation of Watts Bar Nuclear Plant, Unit 2," dated July 2011

The purpose of this letter is to provide the electromagnetic interference (EMI) survey results as previously committed in References 2 and 3. This EMI survey of the main control room and the auxiliary instrument room was performed to show the field strength of radiated EMI around critical equipment.

The commitments from References 2 and 3 are listed below.

- 1) TVA will perform an electromagnetic interference/radio frequency interference (EMI/RFI) site survey of the Watts Bar Nuclear Plant (WBN) Unit 2 Eagle 21 system during hot functional testing. TVA will submit the results of this survey to the NRC. The submittal will include a description of the methodologies and test equipment that were used to perform the survey, a comparison between on-site and factory EMI/RFI test results, and an assessment of the margin between the measured EMI/RFI spectrum and a conservative threshold above which EMI/RFI problems could occur.
- 2) TVA will perform an EMI survey of the containment high range radiation monitors after they are installed in WBN Unit 2 and submit the results to the NRC within two weeks of the survey being completed.

WBN Unit 2 field strength of radiated EMI during hot functional testing was less than 0.5 volts/meter per the EMI Survey Results.

- 1) The Eagle 21 Process Protection System radiated immunity testing was satisfactorily completed at 10 volts/meter (Reference Westinghouse WCAP-11733 previously provided in Reference 1). Therefore, the margin between the components radiated EMI field strength tested and the measured WBN Unit 2 EMI survey radiated EMI field strength values provides assurance that these components will be able to perform their safety function.
- 2) The Containment High Range Radiation Monitors radiated immunity testing was satisfactorily completed at 10 volts/meter (Reference Sorrento Electronics RM-1000 EMC Test Reports 04509050 and 04038800 previously provided in Reference 3). Therefore, the margin between the components radiated EMI field strength tested and the measured WBN Unit 2 EMI survey radiated EMI field strength values provides assurance that these components will be able to perform their safety function.

Enclosure 1 provides the survey results which were found to be acceptable.. Enclosure 2 provides an evaluation of the survey results.

The delay in submitting this report in accordance with Commitment No. 2 above has been discussed with the NRC staff and has been entered into TVA's corrective action program.

The completion of this survey for the Containment High Range Radiation Monitors is the subject of Supplemental Safety Evaluation Report (SSER) 23, Appendix HH, Open Item No. 79 as described in Reference 4. With the submittal of these survey results, TVA considers Open Item No. 79 and the associated commitments to be closed.

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There are no new regulatory commitments made in this letter. Should you have questions regarding this submittal, please contact Gordon Arent at (423) 365-2004.

Respectfully,

J. W. Shea

Digitally signed by J. W. Shea
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J. W. Shea
Vice President, Nuclear Licensing

Enclosures:

1. Electromagnetic Interference (EMI) Survey Results
2. Analysis of Watts Bar Unit 2 EMI/RFI Survey Results for the Eagle 21 Process Protection System and Containment High Range Radiation Monitors

cc (Enclosures):

U.S. Nuclear Regulatory Commission, Region II
NRC Project Manager - Watts Bar Nuclear Plant, Unit 2
NRC Senior Resident Inspector - Watts Bar Nuclear Plant, Unit 2

Enclosure 1
Watts Bar Nuclear Plant, Unit 2
Electromagnetic Interference (EMI) Survey Results

EMI Survey of WBN U2

August 3

2015

The spectrums for the MCR and the Aux Instrument Room were compared before HFT and during HFT. The spectrums were largely the same before and during. The field strength for these areas is low. The results are compared to existing test limits.

Before and
During HFT

WBN U2 EMI Survey

Main Control Room and Auxiliary Instrument Room

Purpose

The EMI survey of the MCR and the Aux Instrument Room were done to show the field strength of radiated EMI around critical equipment. The test results will be sent to the NRC. This testing was part of the WBN U2 start-up.

Test Equipment

1. EMCWare Software V3.1
2. Agilent E7404 Spectrum Analyzer
3. Lab Ferrite Cable
4. Lab Red BNC Jumper
5. USB to GPIB adapter
6. SAS2/D Wide Band Antenna

Configuration

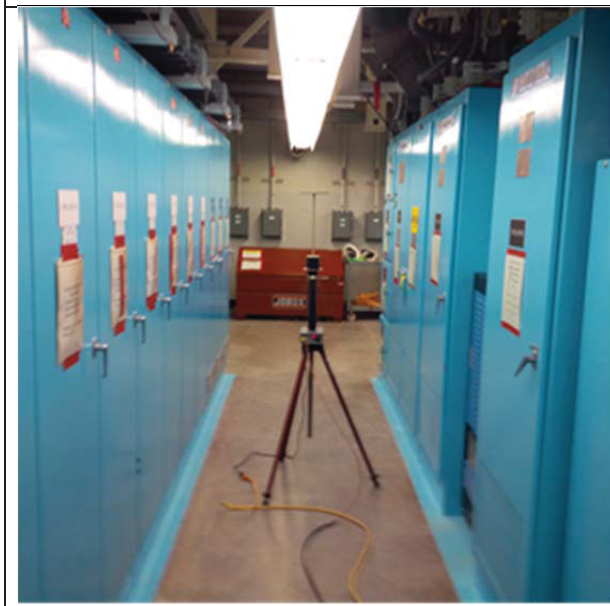
The spectrum analyzer, the antenna and the computer were connected. The antenna was moved to each location for the test.

The software would scan from 10kHz to 1GHz in 2 steps. The antenna outputs would be changed from low to high as appropriate.



WBN U2 EMI Survey

Main Control Room and Auxiliary Instrument Room



WBN U2 EMI Survey

Main Control Room and Auxiliary Instrument Room



Data

The data was taken on a two separate days. The first day was before hot functional testing (HFT) had begun and the second day after HFT had started.

The main control room (MCR) in front of the high range radiation monitors and the auxiliary instrument room in locations by control panels.

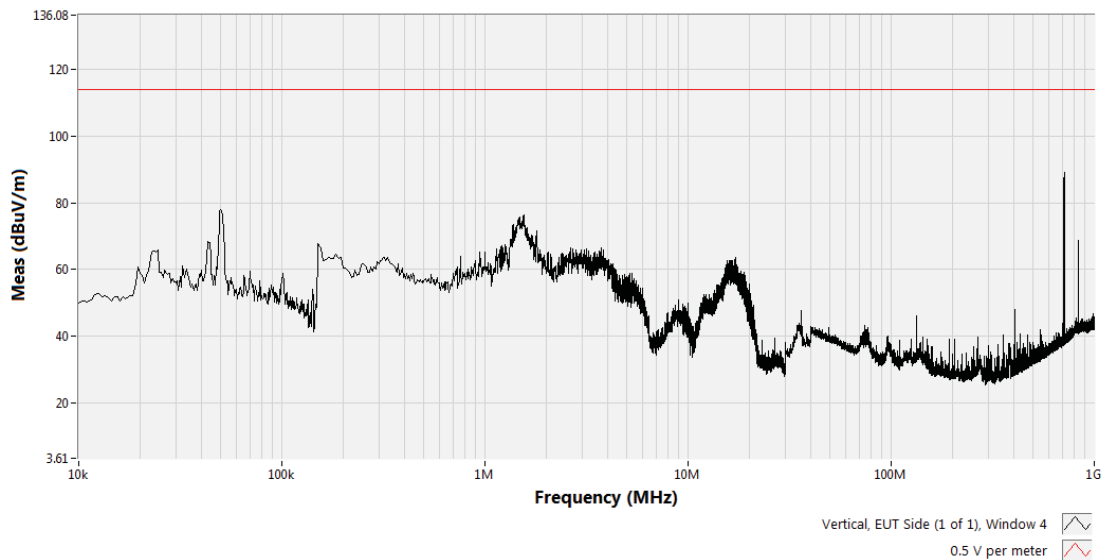
WBN U2 EMI Survey

Main Control Room and Auxiliary Instrument Room

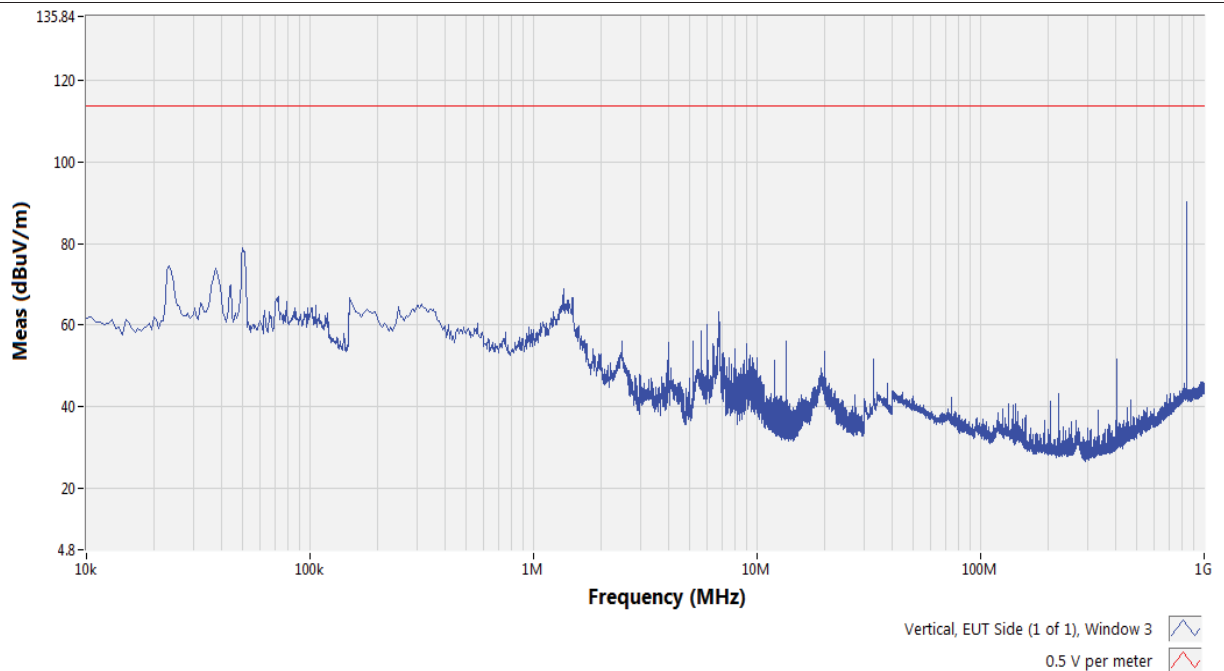
The spectrum graphs have a red line at 0.5V/m for a reference point.

Main Control Room

Here are the spectrums from the MCR before and after HFT.



MCR: Before HFT



MCR: After HFT

WBN U2 EMI Survey

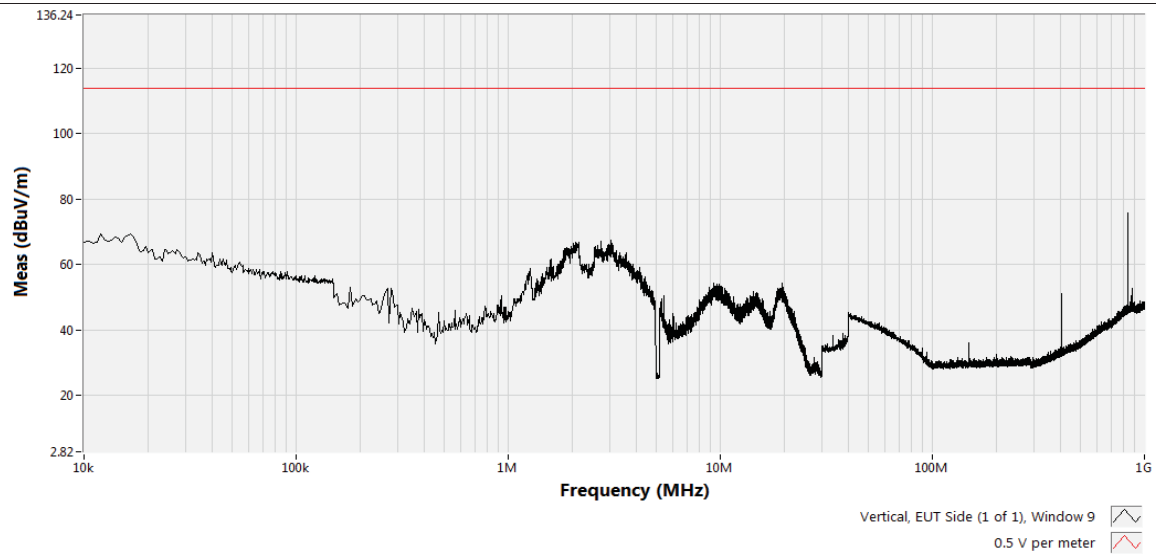
Main Control Room and Auxiliary Instrument Room

Auxiliary Instrument Room

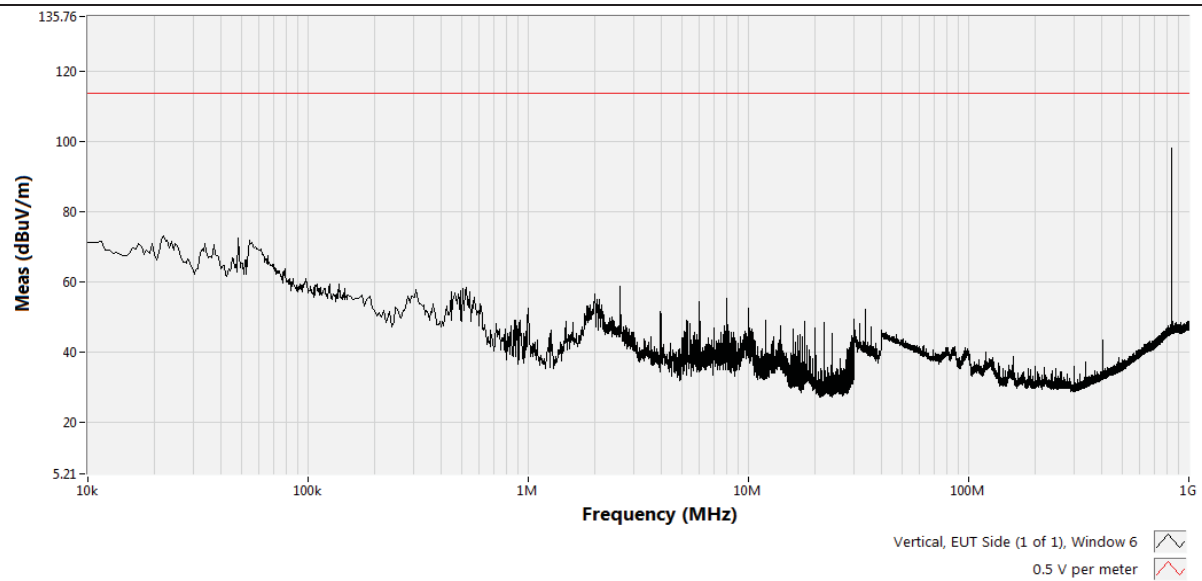
Here are the spectrums from the Aux Instrument Room before and after HFT. The before spectrums are shown on separate graphs. The after spectrums are combined on one graph. This difference is due to software issues.

WBN U2 EMI Survey

Main Control Room and Auxiliary Instrument Room



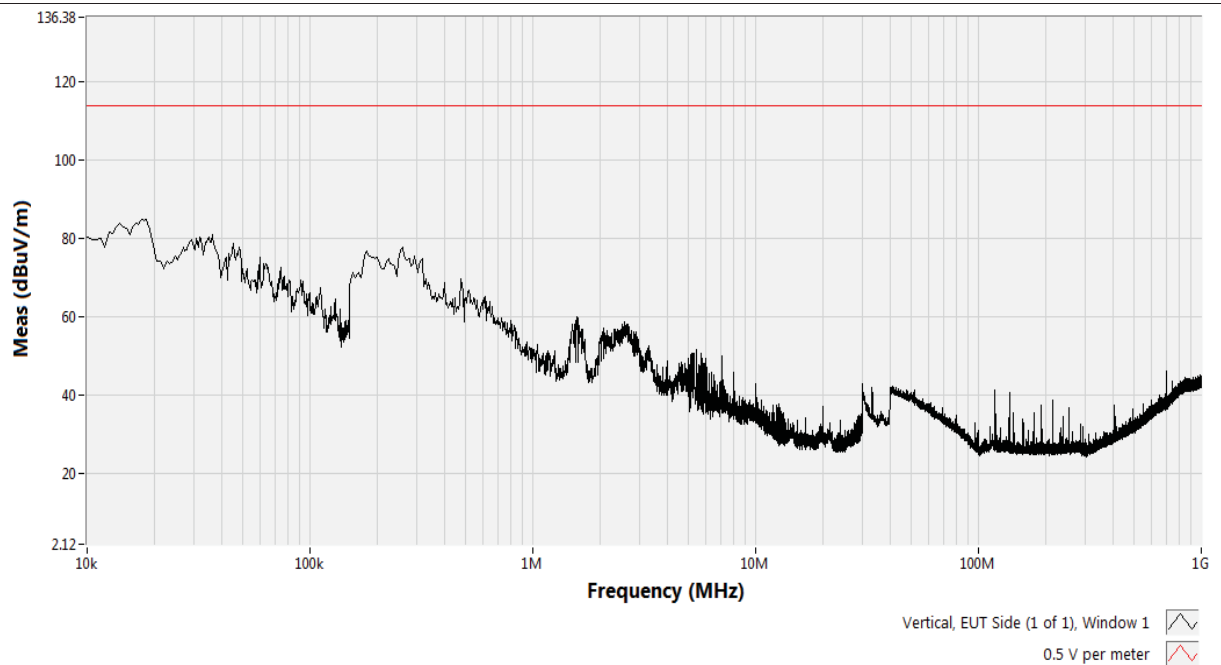
Aux Instrument Room: Before HFT



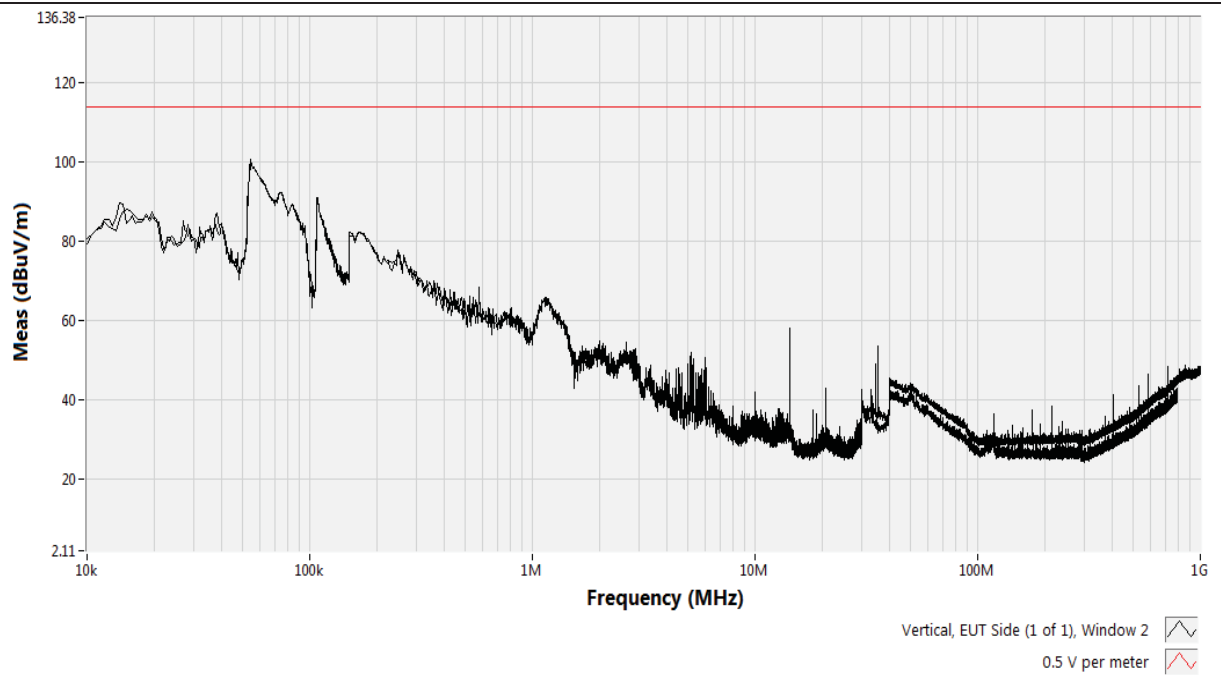
Aux Instrument Room: Before HFT

WBN U2 EMI Survey

Main Control Room and Auxiliary Instrument Room



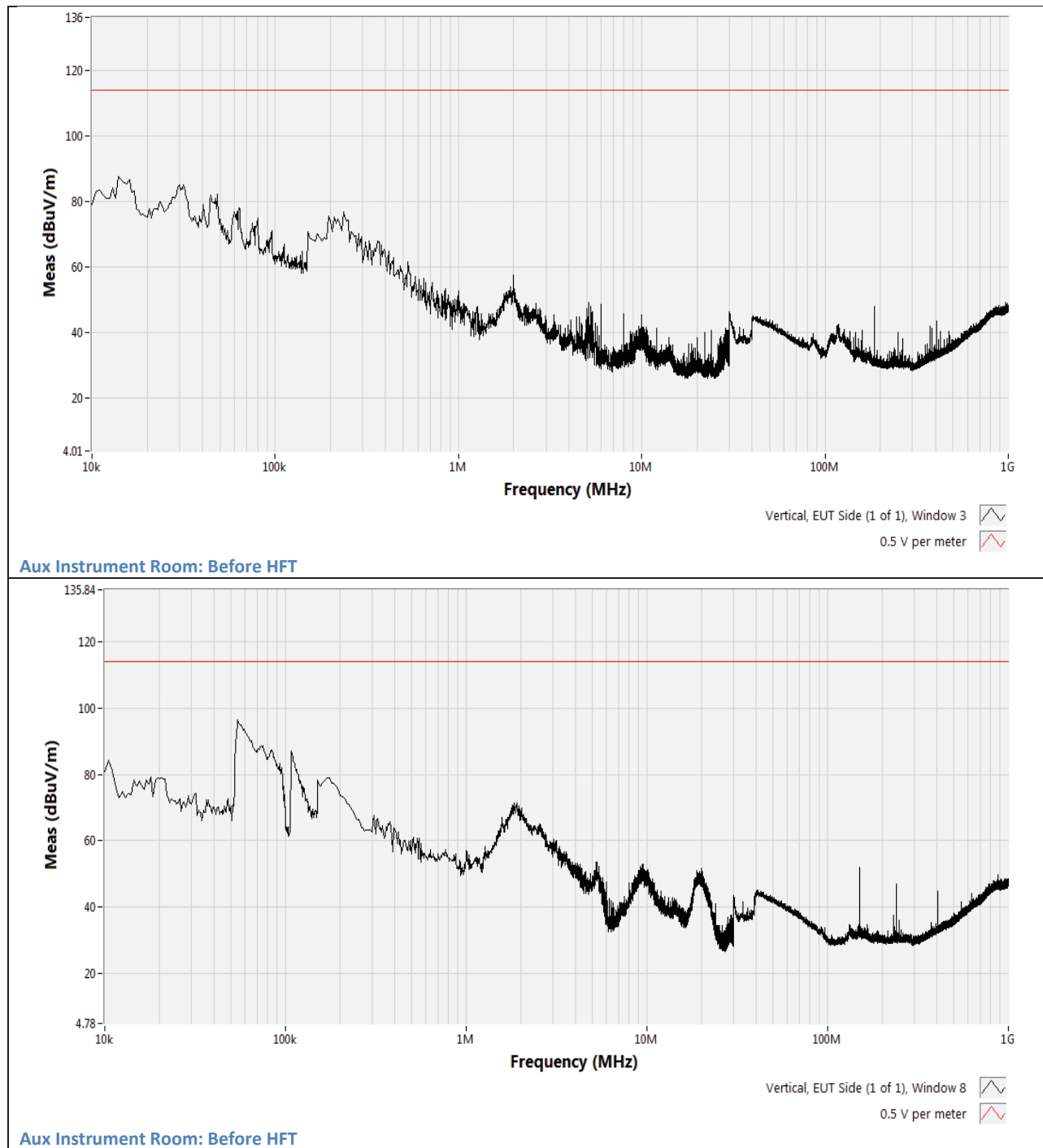
Aux Instrument Room: Before HFT



Aux Instrument Room: Before HFT

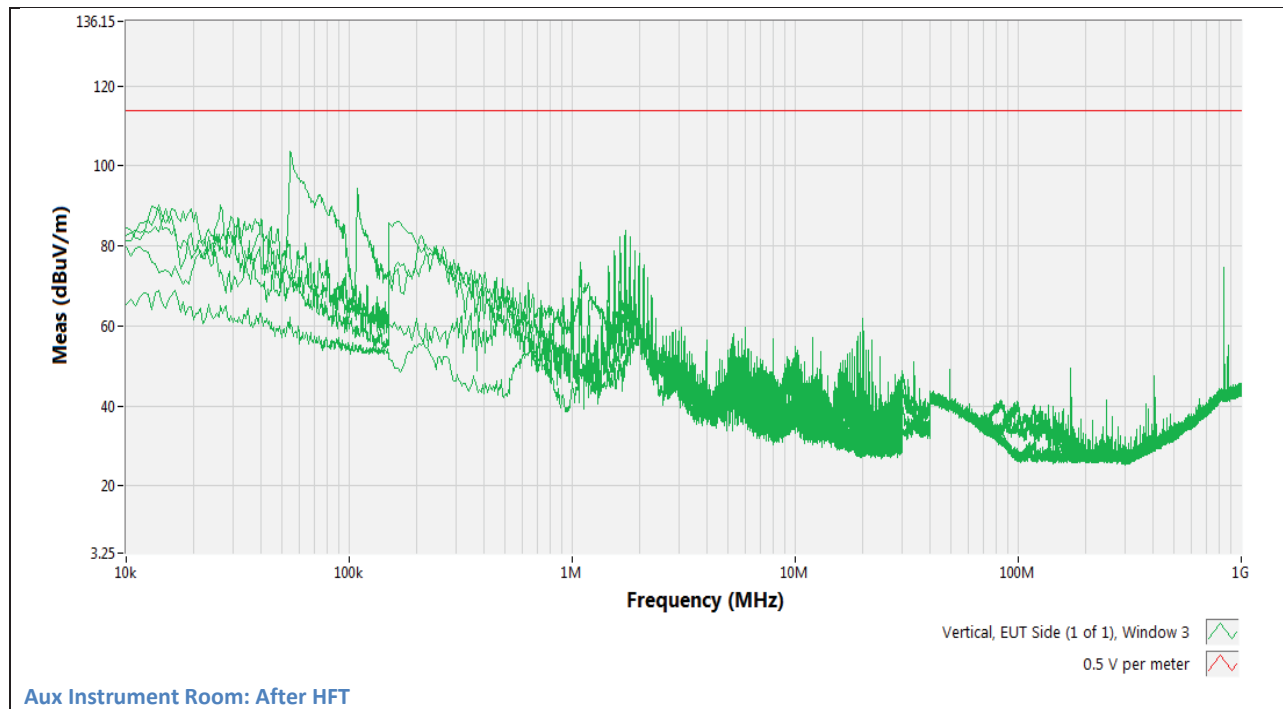
WBN U2 EMI Survey

Main Control Room and Auxiliary Instrument Room



WBN U2 EMI Survey

Main Control Room and Auxiliary Instrument Room



Results

The spectrums show that the field strengths in both before and after HFT in the MCR are:

1. Before –
 - a. All but the cell phone signal is less than 80dBuV/m.
 - b. The cell phone signal is less than 90dBuV/m.
2. After –
 - a. While the spectrum is slightly different the magnitudes are the same.

The spectrums show that the field strengths in both before and after HFT in the Aux Instrument Room are:

1. Before –
 - a. Below about 120kHz the field strength peaks at 100dBuV/m
 - b. Above 120kHz the field strength is below 80dBuV/m for all but the cell phone frequencies.
 - c. The cell phone frequencies are below 100dBuV/m
2. After –
 - a. Below about 120kHz the field strength peaks at 100dBuV/m

WBN U2 EMI Survey

Main Control Room and Auxiliary Instrument Room

- b. Above 120kHz the field strength is below 85dBuV/m
- c. The cell phone frequency is below 80dBuV/m.

Conclusion

The spectrums show that the field strengths in both the MCR and Aux Instrument Room are very low.

The maximum field strength of 100dBuV/m translates to 0.1 V/m at 1 meter.

- Extensive testing was done when the Nextel phones were introduced to the plants. Here are some of the results.
 - The field strength of the Nextel phones was ~5V/m at 1 meter
 - SQN was monitored via ICS during testing with the Nextel phone transmitting on maximum power
 - There were no anomalies
 - Eagle 21 – The antenna of the cell phone was placed between the cards – in near field coupling.
 - The phones were placed next to process control equipment.
 - The phones were placed next to Rod Position equipment.
 - Other equipment was tested without anomaly.
 - The phones were installed at BFN, SQN, and WBN for ~9 years without an EMI incident.
- The present EMI environment is protected.
 - All electronic / electrical equipment introduced to the plant must have the emissions evaluated by engineering before installation.
 - TVA SS E18.14.01 uses EPRI TR102323 / RG 1.180 as a basis.
 - All new 1E and economic instruments have immunity testing performed at 10V/m

There was enough equipment operating before HFT that the spectrums were essentially the same after HFT was begun.

Enclosure 2
Watts Bar Nuclear Plant, Unit 2

**Analysis of Watts Bar Unit 2 EMI/RFI Survey Results for the Eagle 21 Process Protection
System and Containment High Range Radiation Monitors**

Analysis of Watts Bar Unit 2 EMI/RFI Survey Results for the Eagle 21 Process Protection System and Containment High Range Radiation Monitors

1.0 Purpose

The purpose of this evaluation is to analyze the results of the “EMI Survey of WBN U2” dated August 3, 2015 (Reference 8.1) that was performed by TVA’s Corporate EMC Specialist and to assess the acceptability of this EMI Survey to address NRC commitments from References 8.2 and 8.3 for the Eagle 21 Process Protection System and Containment High Range Radiation Monitors respectively.

2.0 Regulatory Commitments

The Watts Bar Unit 2 commitments from References 8.2 and 8.3 are:

- 1) TVA will perform an electromagnetic interference/radio frequency interference (EMI/RFI) site survey of the Watts Bar Nuclear Plant (WBN) Unit 2 Eagle 21 system during hot functional testing. TVA will submit the results of this survey to the NRC. The submittal will include a description of the methodologies and test equipment that were used to perform the survey, a comparison between on-site and factory EMI/RFI test results, and an assessment of the margin between the measured EMI/RFI spectrum and a conservative threshold above which EMI/RFI problems could occur.
- 2) TVA will perform an EMI survey of the containment high range radiation monitors after they are installed in WBN Unit 2 and submit the results to the NRC within two weeks of the survey being completed.

3.0 Radiated EMI Survey Test Equipment

Per Reference 8.1 the EMI survey test equipment consisted of an Agilent E7404 Spectrum Analyzer, a SAS2/D Wide Band Antenna, a computer running EMCWare Software V3.1, and various cables, jumpers and adapters to connect the test equipment (spectrum analyzer, antenna, and computer) together.

4.0 Radiated EMI Survey Methodology

To evaluate the field strength of radiated electromagnetic interference around the Watts Bar Unit 2 Eagle 21 Process Protection System and the Containment High Range Radiation Monitors an EMI survey (Reference 8.1) was completed in the areas adjacent to this critical equipment. Specifically, the test equipment antenna was placed in front of the closed Eagle 21 cabinets in the Unit 2 Auxiliary Instrument Room and the Containment High Range Radiation Monitors in the Main Control Room. Software would scan frequencies from 10 kHz to 1 GHz and monitor the radiated EMI field strength values in these two locations. The Watts Bar Unit 2 EMI surveys were completed before and during hot functional testing. The results of these surveys were generated on spectrum graphs where the measured radiated EMI field strengths could be compared to a reference point of 0.5 Volts/meter (~114 dBuV/m). This reference line of 0.5 Volts/meter (~114 dBuV/m) on the spectrum graphs is well below the acceptance criteria of 10 Volts/meter (140 dBuV/m).

5.0 Acceptance Criteria

- 5.1. The measured radiated EMI field strengths adjacent to the Watts Bar Unit 2 Eagle 21 Process Protection System Panels and Containment High Range Radiation Monitors before Watts Bar Unit 2 hot functional testing shall be less than 10 Volts/meter (140 dBuV/m) per section 8.1 of Reference 8.3.
- 5.2 The measured radiated EMI field strengths adjacent to the Watts Bar Unit 2 Eagle 21 Process Protection System Panels and Containment High Range Radiation Monitors during Watts Bar Unit 2 hot functional testing shall be less than 10 Volts/meter (140 dBuV/m) per section 8.1 of Reference 8.3.

6.0 Analysis

- 6.1 Per the Watts Bar Unit 2 EMI Survey (Reference 8.1), the maximum radiated EMI field strengths measured at the Unit 2 Eagle 21 cabinets in the Auxiliary Instrument Room before and during hot functional testing was 100 dBuV/m (which translates to 0.1 volts/meter). Other plant sources of radiated EMI (Radio System components or new electronic equipment) have maximum radiated EMI field strengths of ≤ 1 volt/meter (120 dBuV/m) for the Radio System components per Reference 8.9 and ≤ 0.01 volt/meter (80 dBuV/m) per section 8.6 of Reference 8.4 for any new electronic equipment. The Eagle 21 Process Protection System radiated immunity testing was satisfactorily completed at 10 volts/meter (Reference 8.5) which is significantly above any radiated EMI field strength value (from the EMI survey, the Radio System, or new electronic equipment). Therefore, the margin between the Unit 2 Eagle 21 Process Protection system tested radiated EMI field strength and the sources of radiated EMI field strength values (from EMI survey, the Radio System, or new electronic equipment) which are all ≤ 1 volt/meter (see Table 1) provides assurance that the Unit 2 Eagle 21 Process Protection System will be able to perform its safety function.
- 6.2 Per the Watts Bar Unit 2 EMI Survey (Reference 8.1), the maximum radiated EMI field strengths measured at the Unit 2 Containment High Range Radiation Monitors in the Main Control Room before and during hot functional testing was 100 dBuV/m (which translates to 0.1 volts/meter). Other plant sources of radiated EMI (Radio System components or new electronic equipment) have maximum radiated EMI field strengths of ≤ 1 volt/meter (120 dBuV/m) for the Radio System components per Reference 8.9 and ≤ 0.01 volt/meter (80 dBuV/m) per section 8.6 of Reference 8.4 for any new electronic equipment. The Containment High Range Radiation Monitors radiated immunity testing was satisfactorily completed at 10 volts/meter (References 8.6, 8.7, and 8.8) which is significantly above any radiated EMI field strength value (from the EMI survey, the Radio System, or new electronic equipment). Therefore, the margin between the Unit 2 Containment High Range Radiation Monitors tested radiated EMI field strength and the sources of radiated EMI field strength values (from EMI survey, the Radio System, or new electronic equipment) which are all ≤ 1 volt/meter (see Table 1)

provides assurance that the Unit 2 Containment High Range Radiation Monitors will be able to perform their safety function.

	Max Radiated EMI Field Strength Values		Reference
	(volts / meter)	(dBuV/m)	
Unit 2 EMI Survey:			
Before HFT	0.1	100	8.1
During HFT	0.1	100	8.1
Other Sources of Radiated EMI:			
Radio System	1	120	8.9
New Electronic Equipment	0.01	80	8.4 (Section 8.6)
Equipment Radiated Immunity Testing:			
Eagle 21	10	140	8.5
Containment High Range Radiation Monitor	10	140	8.6, 8.7, and 8.8

Table 1: Unit 2 Watts Bar Radiated EMI Field Strength Values

7.0 Results and Conclusions


The completion of the Watts Bar Unit 2 EMI Survey (Reference 8.1) and the analysis in the Section 6.0 above, which shows there is significant margin between the components tested radiated EMI field strength values and any radiated EMI field strength values that the components would experience, provides assurance that the Unit 2 Eagle 21 Process Protection System and Containment High Range Radiation Monitors will be able to perform their safety functions. Thus, the NRC commitments (References 8.2 and 8.3) have been addressed.

8.0 References

- 8.1** TVA Report, "EMI Survey of WBN U2," dated August 3, 2015 (B43 150803 001)
- 8.2** TVA Letter to NRC, "Watts Bar Nuclear Plant (WBN) - Unit 2 - Westinghouse Eagle-21 Process Protection System (TAC No. MD6311)," dated February 28, 2008 (T02 080228 001)
- 8.3** TVA Letter to NRC, "Watts Bar Nuclear Plant (WBN) Unit 2 - Instrumentation and Controls Staff Information Requests," dated April 15, 2011 (T02 110415 001)
- 8.4** TVA Standard Specification E18.14.01, Revision 3, "Electromagnetic Interference (EMI) Testing Requirements for Electronic Devices

- 8.5 Westinghouse Test Report, WCAP-11733, "Noise, Fault, Surge, and Radio Frequency Interference Test Report for Westinghouse Eagle 21 Process Protection Upgrade System" dated September 12, 1988 (B26 880912 351)
- 8.6 TVA EMI/RFI Test Review Work Sheet, "Browns Ferry High Radiation Monitor" dated December 8, 2006.
- 8.7 Sorrento Electronics Test Report, 04509050, "RM-1000 EMC Test Report" dated April 22, 2003
- 8.8 Sorrento Electronics Test Report, 04038800, "RM-1000 EMC Test Report, TVA" dated November 11, 1999
- 8.9. TVA EMI/RFI Test Review Work Sheet, "Harris Radio System" dated May 8, 2014 (B43 140508 001)

Prepared: Jeff Kepler /  Date: 8-16-15

Approved: Fred Dimitrew /  Date: 8/17/15

TVA Approval: Steve Hilmes /  Date: 8/18/15