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Addendum to Summary Qualification Report of Hardware Testing for Common Q Applications

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Addendum to Summary Qualification Report of Hardware Testing for Common Q Applications

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LIST OF ACRONYMS AND ABBREVIATIONS

AC	Alternating Current
AI	Analog Input
CAPs	Corrective Action Process
DC	Direct Current
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
EPRI	Electric Power Research Institute
EQ	Equipment Qualification
EQLR	Equipment Qualification Lab Report
ESD	Electrostatic Discharge
EUT	Equipment Under Test
FPD	Flat Panel Display
GOI	Generic Open Item
I/O	Input/Output
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
NRC	United States Nuclear Regulatory Commission
OBE	Operating Basis Earthquake
PCNB	PC Node Box
RFI	Radio Frequency Interference
RG	Regulatory Guide
RH	Relative Humidity
RRS	Required Response Spectra
RTD	Resistance Temperature Detector
SER	Safety Evaluation Report
SSE	Safe Shutdown Earthquake
THD	Total Harmonic Distortion
TRS	Test Response Spectra
TU	Termination Unit
WLL	Washington Laboratories, Ltd.
ZPA	Zero Point Acceleration

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DEFINITIONS

Baseline Common Q Equipment:

Common Q equipment that was referenced in the NRC Safety Evaluation Report, dated February 24, 2003.

Class 1E:

The safety classification of the electric equipment and systems that are essential to emergency reactor shutdown, containment isolation, reactor core cooling, and containment and reactor heat removal or are otherwise essential in preventing significant release of radioactive material to the environment.

Electromagnetic Compatibility (EMC):

The ability of equipment or system to function satisfactorily in its electromagnetic environment without introducing intolerable electromagnetic disturbances to anything in that environment.

Electromagnetic Interference (EMI):

Electromagnetic disturbance which manifests itself in performance degradation, malfunction, or failure of electrical or electronic equipment.

Mild Environment:

An environment expected as a result of normal service conditions and extremes (abnormal) in service conditions where seismic is the only design basis event of consequence.

Operating Basis Earthquake (OBE):

An earthquake that could reasonably be expected to occur at the plant during the operating life of the plant, considering the regional and local geology, and seismology and specific characteristics of local subsurface material. It is that earthquake that produces the vibratory ground motion for which those features of the nuclear power plant, necessary for continued operation without undue risk to the health and safety of the public, are designed to remain functional.

Qualification:

The generation and maintenance of evidence to ensure that the equipment will operate on demand to meet the system performance requirements.

DEFINITIONS (cont.)

Radio Frequency Interference (RFI):

RFI is used interchangeably with EMI. EMI includes the entire electromagnetic spectrum; RFI is more restricted to the radio-frequency band, generally considered to be between 10 kHz and 10 GHz.

Required Response Spectrum (RRS):

The response spectrum issued by the user or agent as part of the equipment specification for seismic qualification purposes. The RRS is a plot of the acceleration versus frequency describing the energy content of the earthquake time history. The RRS constitutes the requirement to be met during qualification activities.

Response Spectrum:

A plot of the maximum response, as a function of oscillator frequency, of any array of single-degree-of-freedom damped oscillators subjected to the same base excitation.

Safe Shutdown Earthquake (SSE):

An earthquake that is based upon an evaluation of the maximum earthquake potential considering the regional and local geology, and seismology and specific characteristic of local subsurface material. It is the earthquake that produces the maximum vibratory ground motion for which certain structures, systems, and components are designed to remain functional. These structures, systems, and components are those necessary to ensure the integrity of the reactor coolant pressure boundary; the capability to shut down the reactor and maintain it in a safe shutdown condition; and the capability to prevent or mitigate the consequences of accidents that could result in potential off-site exposures comparable to the 10 CFR Part 100 guidelines.

Safety-Related:

Equipment that is relied upon to remain functional during and following a design basis event to ensure the integrity of the reactor coolant pressure boundary; the capability to shut down the reactor and maintain it in a safe condition; and the capability to prevent or mitigate consequences of accidents that could result in potential off-site exposures comparable to the 10 CFR Part 100 guidelines.

Seismic Category I:

A classification of structures, systems, and components that shall be designed to withstand the effects of a SSE and maintain the specified design function and integrity.

DEFINITIONS (cont.)

Seismic Category II:

Non-safety related equipment whose function is not required but whose failure could reduce the functioning of adjacent safety-related Seismic Category I equipment to an unacceptable level. This equipment shall be designed to withstand the effects of a SSE and maintain its structural integrity so that such failure shall not occur.

Test Response Spectrum (TRS):

The response spectrum that is developed from the actual time history of the motion of the shake table.

Zero Period Acceleration (ZPA):

The acceleration level of the high frequency, non-amplified portion of the response spectrum. This acceleration corresponds to the maximum peak acceleration of the time history used to derive the spectrum.

REFERENCES

1. Westinghouse Test Report 00000-ICE-37764, Rev. 3, "Summary Qualification Report of Hardware Testing for Common Q Applications," January 2007 (Westinghouse Proprietary).

2. Safety Evaluation by the Office of Nuclear Reactor Regulation CE Nuclear Power LLC Topical Report CENPD-396-P, Rev. 1, "Common Qualified Platform," Project NO. 692, May 2000.

3. EPRI TR-107330, "Generic Requirements Specification for Qualifying a Commercially Available PLC for Safety-Related Application in Nuclear Power Plants," Electrical Power Research Institute, Inc., Palo Alto, CA: December 1996.

4. EPRI TR-102323-R1, "Guidelines for Electromagnetic Interference Testing in Power Plants," Electrical Power Research Institute, Inc., Palo Alto, CA: January 1997.

5. Safety Evaluation by the Office of Nuclear Reactor Regulation CE Nuclear Power Topical Report CENPD-396-P, "Common Qualified Platform," Project NO. 692, February 2003.

6. Westinghouse Topical Report WCAP-16097-P-A, Rev. 0, "Common Qualified Platform Topical Report," May 2003 (Westinghouse Proprietary).

7. Westinghouse Test Report WCAP-16166-P, Supplement 1-E05, Rev. 2, "Equipment Qualification Report for AC160 Platform – PC Node Box/Flat Panel Display System Components," March 2011 (Westinghouse Proprietary).

8. [

   ]a,b,c

9. [

   ]a,b,c

10. Westinghouse Test Report WCAP-16166-P, Supplement 1-E09, Rev. 1, "Equipment Qualification Report for AC160 Platform – AI687 and AI688 Modules and Supporting Components for Use in Common Qualified (Common Q) Post Accident Monitoring System (PAMS)," September 2010 (Westinghouse Proprietary).

11. Institute of Electrical and Electronics Engineers, IEEE Std 344-1987, "IEEE Recommended Practice for Seismic Qualification of Class 1E Equipment for Nuclear Power Generating Stations," June 1987.

12. Institute of Electrical and Electronics Engineers, IEEE Std 323-1983, "IEEE Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Stations," September 1983.

REFERENCES (cont.)

13. U.S. Nuclear Regulatory Commission Regulatory Guide 1.180, Rev. 1, "Guidelines for Evaluating Electromagnetic and Radio-Frequency Interference in Safety-Related Instrumentation and Control Systems," October 2003.

14. U.S. Nuclear Regulatory Commission Regulatory Guide 1.100, Rev. 2, "Seismic Qualification of Electrical and Mechanical Equipment for Nuclear Power Plants," June 1988.

15. Westinghouse Drawing 10042D05, Rev. 2, "Standard Safety Power Input Line Filter Panel Assembly," March 2010 (Westinghouse Proprietary).

16. Westinghouse Process WCAP-17266-P, Rev. 0, "Common Q Platform Generic Change Process," August 2010 (Westinghouse Proprietary).

17. Westinghouse Topical Report WCAP-16097-P, Appendix 5, Rev. 0, "Common Qualified Platform Record of Changes," August 2010 (Westinghouse Proprietary).

18. Westinghouse Design Documentation WNA-DS-01070-GEN, Rev. 5, "Application Restrictions for Generic Common Q Qualification," October 2010 (Westinghouse Proprietary).

19. LTR-EQ-11-79, "Composite Curves of the Qualifying Seismic OBE and SSE Levels for Common Q Hardware Qualified in WCAP-16166-P, Supplements 1-E05, E07, E08, and E09," June 2011 (Westinghouse Proprietary).

1 INTRODUCTION

The objective of this report is to summarize the seismic, environmental, and electromagnetic compatibility (EMC) qualification testing of the Baseline Common Q equipment, and to summarize the equipment qualification (EQ) testing for new Common Q equipment. This report also summarizes the changes to the Common Q Platform since testing, and provides justification that the equipment is still qualified according to the applicable regulatory guides and industry standards.

2 PREVIOUS QUALIFICATION

The previous hardware qualification that was performed to certify various equipment as Class 1E for use in Common Q systems is summarized in 00000-ICE-37764, "Summary Qualification Report of Hardware Testing for Common Q Applications" (Reference 1). The equipment that was qualified consisted of digital processors, input/output (I/O) modules, power supplies, display systems, and miscellaneous support equipment. The qualification efforts described in Reference 1 were a continuation of a previous Common Q qualification program. Based on the previous qualification effort, the United States Nuclear Regulatory Commission (NRC) issued a Safety Evaluation Report (SER), CENPD-396-P, "Common Qualified Platform" (Reference 2) on the Common Q system. This SER contained several Generic Open Items (GOIs) that were related to the Common Q qualification effort. These GOIs are addressed in Reference 1:

- Item 7.1 – Westinghouse addressed this issue by developing and qualifying a new analog input (AI) module (AI685). This AI module meets the requirements of the Electric Power Research Institute (EPRI) TR-107330, "Generic Requirements Specification for Qualifying a Commercially Available PLC for Safety-Related Application in Nuclear Power Plants" (Reference 3).

- Item 7.2 – Westinghouse addressed this issue by designing and qualifying a series of Common Q power supplies. Commercial grade dedication of the Common Q power supplies is addressed elsewhere.

- Item 7.3 – Westinghouse addressed this requirement by dedicating and qualifying a hardware watchdog timer. In addition, Westinghouse qualified the PM646A internal watchdog timer.

- Item 7.5 – Westinghouse addressed this requirement by qualifying the PM646A according to the requirements of EPRI TR-102323-R1, "Guidelines for Electromagnetic Interference Testing in Power Plants" (Reference 4).

- Item 7.6 – Westinghouse addressed this item by performing environmental, seismic, and EMC testing on the complete complement of Common Q equipment.

The NRC staff reviewed the Westinghouse submittal dated August 14, 2002, and concluded that the five GOIs (7.1, 7.2, 7.3, 7.5 and 7.6) are acceptably addressed and should be closed. The staff's evaluation is documented in an SER dated February 24, 2003, CENPD-396-P, "Common Qualified Platform" (Reference 5).

Reference 1 was revised since it was last submitted to the NRC for review and approval. It was revised to correct a typographical error from 12Vdc to 24Vdc. This revision addressed the Westinghouse Corrective Action Process (CAPs) Issue Report 06-286-W001.

3 QUALIFICATION TESTING OF NEW EQUIPMENT

The objective of this qualification testing program is to ensure that the new Common Q Platform equipment, identified in Section 4, meets the required seismic, environmental, and EMC criteria defined in the Common Qualified Platform Topical Report, WCAP-16097-P-A, "Common Qualified Platform Topical Report" (Reference 6). Sections 3 through 10 of this report summarize the EQ findings for the PC Node Box (PCNB) and flat panel displays (FPDs) in WCAP-16166-P, Supplement 1-E05, "Equipment Qualification Report for AC160 Platform – PC Node Box/Flat Panel Display System Components" (Reference 7), the EQ findings for the power supplies in [

]^{a,b,c} (Reference 8), the EQ findings for the fiber optic modems in [

]^{a,b,c}

(Reference 9), and the EQ findings for the AI modules in WCAP-16166-P, Supplement 1-E09, "Equipment Qualification Report for AC160 Platform – AI687 and AI688 Modules and Supporting Components for Use in Common Qualified (Common Q) Post Accident Monitoring System (PAMS)" (Reference 10).

4 EQUIPMENT IDENTIFICATION

This section identifies the Equipment Under Test (EUT) for this qualification program.

4.1 PC NODE BOX/FLAT PANEL DISPLAY

[

]a,b,c

Table 4-1 PC Node Box/Flat Panel Display Equipment Under Test a,b,c

4.2 POWER SUPPLY/INPUT LINE FILTER

[

]a,b,c

Table 4-2 Power Supply Equipment Under Test a,b,c

4.3 FIBER OPTIC MODEM

[

]a,b,c

Table 4-3 Fiber Optic Modem Equipment Under Test a,b,c

4.4 ANALOG INPUT MODULE

[

]a,b,c

Table 4-4 Analog Input Module Equipment Under Test a,b,c

5 QUALIFICATION REGULATIONS AND METHODS

5.1 QUALIFICATION REGULATIONS

The seismic qualification testing performed meets the technical requirements of Institute of Electrical and Electronics Engineers (IEEE) Std 344-1987, "IEEE Recommended Practice for Seismic Qualification of Class 1E Equipment for Nuclear Power Generating Stations" (Reference 11). The environmental qualification performed meets the technical requirements of IEEE Std 323-1983, "IEEE Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Stations" (Reference 12) for equipment located in a mild environment. The electromagnetic interference (EMI)/EMC qualification performed meets selected requirements of NRC Regulatory Guide (RG) 1.180, "Guidelines for Evaluating Electromagnetic and Radio-Frequency Interference in Safety-Related Instrumentation and Control Systems" (Reference 13). The qualification testing is consistent with the methodology defined in Reference 6.

5.2 PC NODE BOX/FLAT PANEL DISPLAY

[

]a,b,c

5.3 POWER SUPPLY

[

]a,b,c

5.4 FIBER OPTIC MODEM

[

]a,b,c

[

]a,b,c

5.5 ANALOG INPUT MODULE

[

]a,b,c

6 EQUIPMENT QUALIFICATION REQUIREMENTS

6.1 SEISMIC

Seismic testing for this program was performed in accordance with NRC RG 1.100, "Seismic Qualification of Electrical and Mechanical Equipment for Nuclear Power Plants" (Reference 14) and IEEE Std 344-1987 (Reference 11), which require that the Class 1E, Seismic Category I equipment must be capable of withstanding the effects of five operating basis earthquake (OBE) events and one safe shutdown earthquake (SSE) event, without loss of functional or physical integrity.

6.1.1 PC Node Box/Flat Panel Display, Power Supply, and Fiber Optic Modem Seismic Qualification

[

]a,b,c

6.1.2 Analog Input Module Seismic Qualification

[

]a,b,c

6.2 ENVIRONMENTAL

[

]a,b,c

Table 6-1 Generic Abnormal Environment Test Conditions

a,b,c

a,b,c

Figure 6-1 Generic Abnormal Environment Test Profile

6.3 ELECTROMAGNETIC COMPATIBILITY

To provide a qualification basis that would satisfy various requirements in the U.S. and for typical new and existing plants around the world, the EUT identified in Section 4 were required to be qualified according to the requirements of RG 1.180 (Reference 13) for emissions and susceptibility. The electrostatic discharge (ESD) susceptibility requirements of EPRI TR-102323-R1 (Reference 4) were also applied.

[

]a,b,c

Table 6-2 Basic Type Test Requirements of RG 1.180 R1 a,b,c

Table 6-2 (cont.) Basic Type Test Requirements of RG 1.180 R1

a,b,c

7 QUALIFICATION TEST RESULTS

7.1 SEISMIC

Seismic testing for this program was performed in accordance with IEEE Standard 344-1987 (Reference 11). The seismic testing was performed on an independent triaxial test table using random multi-frequency acceleration time-history inputs. Both horizontal axes and the vertical axis were excited separately and simultaneously with random multi-frequency inputs. The table drive signal was multi-frequency random input, 30 seconds in duration, with a minimum of 20 seconds of strong motion. The test input was shown to meet all requirements specified in IEEE Standard 344-1987 (Reference 11).

7.1.1 PC Node Box/Flat Panel Display, Power Supply, and Fiber Optic Modem

[

]a,b,c

7.1.2 Analog Input Module

[

]a,b,c

a,b,c

Figure 7-1 Composite OBE TRS at 5% Critical Damping

a,b,c

Figure 7-2 Composite SSE TRS at 5% Critical Damping

a,b,c

Figure 7-3 OBE TRS at 5% Critical Damping

a,b,c

Figure 7-4 SSE TRS at 5% Critical Damping

7.2 ENVIRONMENTAL

Environmental testing was performed at the Westinghouse New Stanton, Pennsylvania test facility. The environmental testing was performed in accordance with the requirements of IEEE Std 323-1983 (Reference 12). The test specimens were energized and loaded as determined by their application and then subjected to the environmental extremes as discussed in Section 6.2.

7.2.1 PC Node Box/Flat Panel Display

[

]a,b,c

7.2.2 Power Supply

[

]a,b,c

7.2.3 Fiber Optic Modem

[

]a,b,c

7.2.4 Analog Input Module

[

]a,b,c

7.3 ELECTROMAGNETIC COMPATIBILITY

EMC testing performed on the equipment identified in Section 4 ensures that the equipment has been designed and manufactured to avoid upset and malfunctions caused by EMI, radio frequency interference (RFI), and surge. The EMI/EMC testing was performed according to the requirements of RG 1.180 (Reference 13) and the ESD requirements of EPRI TR-102323-R1 (Reference 4).

7.3.1 PC Node Box/Flat Panel Display

[

]a,b,c

[

]a,b,c

7.3.2 Power Supply

[

]a,b,c

[

]a,b,c

7.3.3 Fiber Optic Modem

[

]a,b,c

7.3.4 Analog Input Module

[

]a,b,c

[

]a,b,c

Table 7-1 EMC/EMI Test Results

a,b,c

Table 7-1 (cont.) EMC/EMI Test Results

a,b,c

8 QUALIFICATION ANALYSIS

8.1 PC NODE BOX/FLAT PANEL DISPLAY

[

]a,b,c

Table 8-1 PC Node Box/Flat Panel Display Qualified Equipment a,b,c

9 INSTALLATION REQUIREMENTS

The installation requirements for the components identified in Section 4 can be found below. The next revision of WNA-DS-01070-GEN, "Application Restrictions for Generic Common Q Qualification" (Reference 18) will also identify these restrictions.

9.1 PC NODE BOX/FLAT PANEL DISPLAY

[

]a,b,c

9.2 POWER SUPPLY

[

]a,b,c

9.3 FIBER OPTIC MODEM

[

]a,b,c

10 SUMMARY AND CONCLUSION

The qualification program performed on the equipment identified in Section 4 confirms that the equipment is seismically and environmentally qualified for Class 1E applications per the guidance contained in IEEE Std 344-1987 and 323-1983 (References 11 and 12, respectively). The equipment has also demonstrated EMI/EMC compatibility for safety application in nuclear power plants according to the guidance provided in NRC Regulatory Guide 1.180 (Reference 13). The ESD qualification performed meets the requirements of EPRI TR-102323-R1 (Reference 4). The qualification testing was consistent with the methodology defined in Reference 6.

Table 10-1 summarizes the documentation for this EQ program.

Table 10-1 Equipment Qualification Documentation

Equipment	Seismic Procedure/Report	Environmental Procedure/Report	EMC Procedure/Report	Summary Report
PCNB/FPD (Table 4-1)	EQ-TP-35-GEN/ EQLR-159	EQ-TP-33-GEN/ EQLR-161	EQ-TP-60-GEN/ EQ-QR-40	WCAP-16166-P Supplement 1-E05
Power Supply (Table 4-2)	EQ-TP-114-GEN/ EQLR-169A	EQ-TP-117-GEN/ EQLR-169B	EQ-TP-105-GEN/ EQ-QR-57	WCAP-16166-P Supplement 1-E07
Fiber Optic Modem (Table 4-3)	EQ-TP-88/ EQLR-151A	EQ-TP-120/ EQLR-151B	EQ-TP-70/ EQ-QR-63	WCAP-16166-P Supplement 1-E08
Analog Input Module (Table 4-4)	EQ-TP-116/ EQLR-171	EQ-TP-116/ EQLR-171	EQ-TP-119-GEN/ EQ-QR-64-GEN	WCAP-16166-P Supplement 1-E09

11 COMMON Q PLATFORM CHANGES

[

]a,b,c