Project:	TRICON v10 NUCLEAR QUALIFICATION PROJECT

Evaluation of IEEE Std. 323-2003 as Endorsed by USNRC Regulatory Guide 1.209

Document No.: 9600164-545
Appendix C

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1.0 PURPOSE

The Triconex V10 Nuclear Qualification Project was based upon the standards provided in IEEE 323-1974 and IEEE 323-1983. Subsequent to the implementation of the project to these earlier standards, the USNRC provided endorsement to IEEE 323-2003. The purpose of this analysis is to provide an evaluation of the standards provided in IEEE 323-2003 as endorsed by USNRC Regulatory Guide 1.209, and determine the degree of conformance by the Triconex V10 Nuclear Qualification Project.

2.0 SUMMARY

Until recently, the US Nuclear Regulatory Commission had provided endorsement to IEEE Std. 323-1974 as described in Regulatory Guide 1.89. The U.S. Nuclear Regulatory Commission (NRC) issues regulatory guides to describe and make available to the public methods that the NRC staff considers acceptable for use in implementing specific parts of the agency's regulations, techniques that the staff uses in evaluating specific problems or postulated accidents, and data that the staff need in reviewing applications for permits and licenses. The Triconex V10 Nuclear Qualification Project was based on the USNRC's endorsement of IEEE 323-1974. The evaluation contained herein indicates that the Triconex V10 Nuclear Qualification complies with the standards provided in IEEE 323-2003, as endorsed by Regulatory Guide 1.209, dated March 2007.

3.0 EVALUATION

The primary focus of IEEE Std. 323 - 1974, "IEEE Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Stations" (Reference 5.2), is the reliable operation of safety-related equipment under normal, abnormal, design-basis accident, post-design-basis accident, and containment test conditions. Traditionally, computer-based instrumentation and control (I&C) systems are primarily implemented in nuclear power plant locations that are characterized as mild environments that are not affected by design-basis accident conditions. Thus, the design-basis accident element of type testing for qualification does not apply to computer-based I&C systems in mild environments.

Regulatory Guide 1.89 is focused on the environmental qualification of equipment intended for use in harsh environments that are subject to design-basis accidents. Because the NRC has limited the scope of Regulatory Guide 1.89 to equipment intended for application in harsh environments, they had determined that additional guidance was warranted to address qualification for mild environmental conditions, as needed for computer-based technologies.

IEEE revised IEEE Std. 323, in 2003. The main impetus of this revision is to incorporate current practices and lessons learned from the implementation of previous versions of the standard by the nuclear industry. A particular distinction between IEEE Std. 323-2003, "IEEE Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Stations" (Reference 5.3), and IEEE Std. 323-1974 (Reference 5.2), is that the 2003 version acknowledges qualification of equipment in

mild environments and does not require age conditioning to an end-of-installed-life condition for equipment in mild environments, where significant aging mechanisms are not present. Additionally, it recognizes that digital systems and new advanced analog systems may require susceptibility testing for EMI/RFI and power surges, if the environments are significant to the equipment being qualified.

The revision also provides the following: 1) a better definition of harsh environment accident terms, 2) harsh environment test margins have been updated to better identify the parameters that achieve test margin on accident profiles, and 3) recognition that the condition of the equipment for which acceptable performance was demonstrated is the qualified condition, applicable to new license renewal and life extension options. These differences do not affect the Tricon v10 Qualification. Provided in Table 3-1 is a compliance matrix of the provisions of the standard and the V10 Nuclear Qualification Project.

The USNRC has endorsed IEEE Std. 323-2003 in USNRC Regulatory Guide 1.209. The USNRC has acknowledged that the practices in IEEE Std. 323-2003 are sufficient to address qualification for the mild environmental conditions of typical plant locations where safety-related computer-based I&C systems are generally located. However, they have also re-emphasized that commercial MOS devices are very sensitive to ionizing radiation doses, and that radiation hardness levels are on the order of 1E3 Rads.

USNRC Regulatory Guides are comprised of four sections: A. Introduction, B. Discussion, C. Regulatory Position, and D. Implementation. Sections A and B are self explanatory. Section C, Regulatory Position, provides the conditions acceptable to the NRC staff for satisfying the applicable regulations. Section D, Implementation, provides information to applicants and licensees regarding the NRC staff's plans for using the regulatory guide (e.g. applicability to construction permits, standardized designs, etc.). The pertinent section for this evaluation is Section C, Regulatory Position. Provided in Table 3-2 is a compliance matrix of the provisions of the Regulatory Guide and the V10 Nuclear Qualification Project.

Table 3-1 IEEE 323-2003 Compliance Matrix

IEEE 323-2003 Requirements	Triconex V10 Nuclear Qualification Compliance
1. Scope. Description of Standard scope.	No Requirements
2. References	No Requirements
3. Definitions	No Requirements
4. Principles of Qualification (section heading)	No Requirements
4.1 Qualification objective	No Requirements
4.2 Qualified life and qualified condition	Not applicable – harsh environment only.
4.3 Qualification elements a) Equipment specification including definition of the safety function(s) b) Acceptance criteria c) Description of the service conditions, including applicable design basis events and their duration d) Qualification program plan e) Implementation of the plan f) Documentation demonstrating successful qualification, including maintenance activities required to maintain qualification.	Comply. See 9600164-500, Master test Plan.
4.4 Qualification documentation The result of a qualification program shall be documented to demonstrate the equipment's ability to perform its safety function(s) during its qualified life and applicable design basis events. The documentation shall allow verification by competent personnel, other than the qualifier, that the equipment is qualified.	Comply. See 9600164-545, EQ Summary Report.
5.1 Initial qualification (section heading)	No Requirements
5.1.1 Type testing A type test subjects a representative sample of equipment, including interfaces, to a series of tests, simulating the effects of significant aging mechanisms during normal operation.	Not applicable – harsh environment only.
5.1.2 Operating experience Performance data from equipment of similar design that has successfully operated under known service conditions may be used in qualifying other equipment to equal or less severe conditions.	Not applicable. The Tricon-Under-Test (TUT) underwent testing.

Document:	9600164-545	Title:	Appendix C – IEEE 323-2003 Analysis		
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IEEE 323-2003 Requirements	Triconex V10 Nuclear Qualification Compliance
5.1.3 Analysis Qualification by analysis requires a logical assessment or a valid mathematical model of the equipment to be qualified. Analysis alone cannot be used to demonstrate qualification.	Comply. See 9600164-538, Cable Similarity Analysis
5.1.4 Combined methods Equipment may be qualified by combinations of type test, operating experience, and analysis. For example, where type test of a complete assembly is not possible, component testing supplemented by analysis may be used.	Comply. See 9600164-545, EQ Summary Report. TUT is qualified by testing and analysis.
5.2 Extension of qualified life	Not applicable – harsh environment only.
5.3 Condition monitoring	Not applicable – harsh environment only.
6. Qualification program (section heading)	No Requirements
6.1 Equipment specification Documentation shall contain the items specified in 6.1.1, 6.1.2, 6.1.3, 6.1.4, and 6.1.5.	See paragraphs 6.1.1, 6.1.2, 6.1.3, 6.1.4, and 6.1.5.
6.1.1 Identification A technical description of the equipment to be qualified, including applicable performance and qualification standards, shall be provided.	Comply. See 9600164-541, System Description
6.1.2 Interfaces Loadings at interfaces [i.e., physical attachments, mounting, auxiliary components, connectors (electrical and mechanical) to the equipment at the equipment boundary] shall be specified.	Comply. System Drawing 9600164-102.
6.1.3 Qualified life objective	Not applicable – harsh environment only.
6.1.4 Safety function(s) The equipment specification shall identify the equipment's safety function(s) including the required operating times.	Comply. See Appendix A of this report.
6.1.5 Service conditions (section heading)	No Requirements

IEEE 323-2003 Requirements	Triconex V10 Nuclear Qualification Compliance
6.1.5.1 Normal and abnormal service conditions The service conditions for the equipment shall be specified. Examples include, but are not limited to, the following: a) Ambient pressure and temperature b) Relative humidity c) Radiation environment d) Seismic operating basis earthquake (OBE) and non-seismic vibration e) Operating cycles f) Electrical loading and signals g) Condensation, chemical spray, and submergence h) EMI/RFI and power surges	Comply. See 9600164-500, Master test Plan. Item g) not applicable.
6.1.5.2 Design basis event conditions	Not applicable – harsh environment only. See paragraph 6.3.1.10 for seismic requirements.
6.1.5.3 Margin	Not applicable – harsh environment only.
6.2 Qualification program plan A qualification program plan shall define tests, inspections, performance evaluation, acceptance criteria, and required analysis to demonstrate that, when called upon, the equipment can perform its specified safety function(s). The required elements of the program plan are provided in 6.2.1, 6.2.2, 6.2.3, 6.2.4, and 6.2.5.	See sections 6.2.1, 6.2.2, 6.2.3, 6.2.4, and 6.2.5
6.2.1 Aging	Not applicable – harsh environment only.
6.2.1.1 Significant aging mechanisms	Not applicable – harsh environment only.
6.2.1.2 Aging considerations	Not applicable – harsh environment only.
6.2.2 Qualified life objective	Not applicable – harsh environment only.
6.2.3 Margin	Not applicable – harsh environment only.
6.2.4 Maintenance	Not applicable – harsh environment only.
6.2.5 Acceptance criteria The value(s) of performance parameters and other criteria to demonstrate that equipment can perform the safety function(s) shall be identified.	Comply. See 9600164-545, EQ Summary Report
6.3 Qualification program implementation (section heading)	No Requirements

IEEE 323-2003 Requirements	Triconex V10 Nuclear Qualification Compliance
6.3.1 Type testing The type test shall demonstrate that Class 1E equipment performance meets or exceeds the safety function requirements. Type test conditions shall meet or exceed specified service conditions. Appropriate margin shall be added to design basis event parameters (see 6.3.1.3) if not otherwise included in the specified service conditions.	Comply. See 9600164-545, EQ Summary Report Comply. See 9600164-545, EQ Summary Report Not applicable – harsh environment only.
6.3.1.1 Test plan The test plan describes the required tests and shall include the following: a) Identification, description, and quantity of the samples to be tested including significant information— such as manufacturer, model(s), and serial numbers—to uniquely identify the sample b) Equipment safety function(s) to be demonstrated and qualified life objective c) Mounting, connection, and other interface requirements d) Test sequence e) Age conditioning procedure, if required f) Specified service conditions and margins or test levels g) Performance and environmental conditions to be measured, including measurement accuracy h) Operating conditions and measurement sequence in detail, including monitoring requirements i) General acceptance criteria (ultimate acceptance criteria are plant-specific based on application of the equipment) j) Maintenance/replacement during age conditioning, if required k) Provisions for control of modifications during tests l) Required documentation m) Quality assurance requirements	Comply. See 9600164-500, Master Test Plan Comply. See 9600164-500, Master Test Plan. Qualified life objective not applicable. Comply. See 9600164-500, Master Test Plan Comply. See 9600164-500, Master Test Plan Not applicable – harsh environment only. Comply. See 9600164-500, Master Test Plan Comply. See 9600164-500, Master Test Plan Comply. See 9600164-500, Master Test Plan Comply. See 9600164-500, Master Test Plan Not applicable – harsh environment only. Comply. See 9600164-500, Master Test Plan Comply. See 9600164-500, Master Test Plan Comply. See 9600164-500, Master Test Plan
6.3.1.2 Simulated test profiles	Not applicable – harsh environment only.
6.3.1.3 Mounting Equipment shall be mounted in a manner and a position that simulates its expected installation. Any mounting limitations, e.g., orientation, shall be specified in the test report.	Comply. See System Drawing 9600164-102, and EQ Summary Report 9600164-545, Appendix B.
6.3.1.4 Connections Equipment shall be connected (both mechanically and electrically) in a manner that simulates its expected installation.	Comply. See System Drawing 9600164-102

IEEE 323-2003 Requirements	Triconex V10 Nuclear Qualification Compliance
6.3.1.5 Monitoring During testing, both the test environment and the equipment's safety function(s) shall be monitored using equipment that provides resolution for detecting meaningful changes in the parameters.	Comply. See EQ Summary Report 9600164-545.
6.3.1.6 Margin	Not applicable – harsh environment only.
6.3.1.7 Test sequence	Not applicable – harsh environment only.
6.3.1.8 Aging	Not applicable – harsh environment only.
6.3.1.8.1 Natural aging	Not applicable – harsh environment only.
6.3.1.8.2 Age conditioning	Not applicable – harsh environment only.
6.3.1.9 Radiation In the type test, all materials or components, for which radiation causes significant aging, shall be irradiated to simulate the effects of the radiation exposure. A gamma radiation source may be used to simulate the expected effects of the radiation environment.	Comply. See EQ Summary Report 9600164-545. A Co60 source was used.
6.3.1.10 Seismic and non-seismic vibration The equipment shall be qualified for expected seismic events in accordance with IEEE Std 344-1987 following any required aging. Nonseismic vibration, which may produce significant degradation (fatigue, wear) during normal and abnormal use, shall be simulated prior to the seismic tests.	Comply. See EQ Summary Report 9600164-545. Not applicable.
6.3.1.11 Operation under normal and design basis event conditions	Not applicable – harsh environment only.
6.3.1.12 Inspection Upon completion of type testing, the equipment shall be visually inspected, and a description of its physical condition shall be included in the qualification documentation.	Not applicable – harsh environment only.
6.3.2 Operating experience	Not applicable – harsh environment only.
6.3.2.1 Operating history	Not applicable – harsh environment only.
6.3.2.2 Determination of qualification	Not applicable – harsh environment only.

IEEE 323-2003 Requirements	Triconex V10 Nuclear Qualification Compliance
6.3.3 Analysis Qualification by analysis requires a logical assessment, similarity evaluations, or a valid mathematical model to establish that the equipment to be qualified can perform its safety function(s) when subjected to the specified service conditions.	Comply. See 9600164-538, Cable Similarity Analysis
6.3.4 Extrapolation and interpolation Extrapolation and interpolation are analytical techniques that may be used to qualify equipment by extending the application of test data.	See paragraphs 6.3.4.1 thru 6.3.4.6.
6.3.4.1 Material Materials of construction shall either be the same or equivalent.	Comply. See 9600164-538, Cable Similarity Analysis.
6.3.4.2 Size Size may vary if the basic configuration remains the same and dimensions are related by known scale factors. Consideration shall be taken of such factors as thermal effects of different surface areas and seismic effects of different masses and modes.	Comply. See 9600164-538, Cable Similarity Analysis
6.3.4.3 Shape The shape shall be the same or similar (subject to restrictions of size), and any differences shown shall not adversely affect the performance of safety function(s).	Comply. See 9600164-538, Cable Similarity Analysis
6.3.4.4 Stress Operating and environmental stresses on the new equipment shall be equal or less than those experienced on the qualified equipment under normal and abnormal condition.	Comply. See 9600164-538, Cable Similarity Analysis
6.3.4.5 Aging mechanisms	Not applicable – harsh environment only.
6.3.4.6 Function The safety function(s) as evaluated shall be the same (e.g., activate to operate or deactivate to operate).	Comply. See 9600164-538, Cable Similarity Analysis
6.3.5 Extension of qualified life	Not applicable – harsh environment only.
6.3.6 Condition-based qualification	Not Applicable. Tricon was type tested.

IEEE 323-2003 Requirements	Triconex V10 Nuclear Qualification Compliance
6.3.7 Acceptance criteria The equipment being qualified shall demonstrate that it can perform the safety-related function specified in the acceptance criteria. Any failure to meet the acceptance criteria shall be analyzed to determine the modification needed to the equipment or the limitation that shall be imposed on its use.	Comply. See Appendix B of this report.
6.4 Modifications Modifications to the equipment or to the qualification basis made during or after completion of the qualification program shall be evaluated to determine whether additional qualification steps are required.	Comply. See Appendix B of this report.
7.1 Mild environment documentation The documents required to demonstrate the qualification of Class 1E equipment located in a mild environment are the design/purchase specifications, seismic test reports (if applicable), and an evaluation and/or certificate of conformance.	Exceed requirements. See main body of this report.
7.2 Harsh environment documentation	Not applicable – harsh environment only.
Annex A (no information)	No Requirements
Bibliography	No Requirements

Table 3-2 R.G. 1.209 Regulatory Position Compliance Matrix

Regulatory Position	Triconex V10 Nuclear Qualification Compliance
No.1 -For environmental qualification of safety-related computer-based I&C systems, type testing is the preferred method. -Service conditions should be based on actual conditions. -Age conditioning is not applicable because of the absence of significant aging mechanisms on microprocessor-based modules.	The Tricon has been type tested (including radiation) and is qualified to the generic environmental envelope (Figure 4-4) of TR-107330 (Reference 5.1). See the main body of this report.
No. 2 - Testing should be performed with the system functioning, with software and diagnostics that are representative of those used in actual operation, while the system is subjected to the specified environmental service conditions, including abnormal operational occurrences. - Testing should exercise all portions of the safety-related computer-based I&C systems necessary to accomplish the safety-related function or those portions whose operation or failure could impair the safety-related function. - Qualification testing should confirm the response of digital interfaces and verify that the design accommodates the potential impact of environmental effects on the overall response of the system. - Although testing of a safety-related computer-based I&C system as a whole is preferred, type testing an entire system as a unit is not always practical. In those cases, confirmation of the dynamic response to the most limiting environmental and operational conditions for a computer-based I&C system is based on type testing of the individual modules and analysis of the cumulative effects of environmental and operational stress on the entire system.	The Tricon and all modules intended for use in Class 1E systems have been qualified to the generic operational and environmental requirements of TR-107330 (Reference 5.1), including software and diagnostics. Testing has confirmed the response of digital interfaces and that there is no impact from environmental effects. The system was tested as a whole utilizing actual production equipment. A summary of the qualification results are contained in the main body of this report.
No. 3 - Guidelines for conducting electromagnetic susceptibility testing of safety-related I&C systems appear in Regulatory Guide 1.180, Revision 1, and in EPRI TR 102323, Revision 1.	The Tricon V10 Qualification is based on the electromagnetic susceptibility requirements stated in Regulatory Guide 1.180, Revision 1 (Reference 5.4). See the main body of this report.

Regulatory Position	Triconex V10 Nuclear Qualification Compliance
No. 4 - The documented evidence of qualification in a mild environment should be consistent with the guidance given in Section 7.2 selectively based on actual environmental conditions, and the records should be retained at a facility in an auditable and readily accessible form for review and use as necessary.	The Tricon V10 qualification documentation provides evidence that the Class 1E equipment is qualified for its application, meets its specification requirements, and has its periodic surveillance and maintenance intervals established. Data used to demonstrate the qualification of the equipment is pertinent to potential applications and has been organized in a readily understandable and traceable manner that permits independent auditing of the conclusions presented. See the main body of this report and Appendix A.
No. 5 - For safety-related computer-based I&C systems installed in a harsh environment, the regulatory positions of this guide supplement the harsh environment qualification practices endorsed in Regulatory Guide 1.89.	The Tricon is not qualified for harsh environments.

4.0 CONCLUSIONS

A review of IEEE 323-2003 and the regulatory positions contained in Regulatory Guide 1.209 was performed and compared to the Tricon V10 Nuclear Qualification. The evaluation contained herein documents that the Tricon V10 Nuclear Qualification complies with the standards provided in IEEE 323-2003, as endorsed by Regulatory Guide 1.209, dated March 2007.

5.0 REFERENCES

5.1 EPRI TR-107330, Generic Requirements Specification for Qualifying a Commercially Available PLC for Safety-Related Applications in Nuclear Power Plants

5.2 IEEE 323-1974, IEEE Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Stations

5.3 IEEE 323-2003, IEEE Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Stations

5.4 USNRC Regulatory Guide 1.180, Revision 1 - Guidelines for Evaluating Electromagnetic and Radio-Frequency Interference in Safety-Related Instrumentation and Control Systems

5.5 USNRC Regulatory Guide 1.209, Dated March 2007- Guidelines for Environmental Qualification of Safety-Related Computer-Based Instrumentation and Control Systems in Nuclear Power Plants