Project:	TRICON v10 NUCLEAR QUALIFICATION PROJECT

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MASTER TEST PLAN

Document No: 9600164-500

Revision 5

May 10, 2008

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Document:	9600164-500	Title:	Master Test Plan		
Revision:	5	Page:	2 of 48	Date:	05/10/2008

Revision History

Revision	Date	Description	Author
0	06/30/06	Initial issue.	J. Troy Martel, P.E.
1	11/13/06	Updated Firmware Type identification of several modules. Added 10 ohm RTD signal range. Revised test sequence. Moved 7 day test system operation at elevated DC source during Pre-Qualification testing to Performance Proof testing. Emphasis added to P2P and serial communication monitoring. Several editorial changes for document consistency and clarification.	J. Troy Martel, P.E.
2	11/30/06	Revised test sequence. Added 7-day elevated power source test. Revised module quantities in Appendix 1. Revised Appendices 6 and 7 to clarify discrepancies of TR-107330, Table 5-1. Incorporated miscellaneous typographic corrections that do not warrant revision bars.	Frank W. Kloer, P.E.
3	01/10/07	Revised Section 2 to emphasize test scope relative to the previously issued SER and R.G. 1.180, R1. Revised Section 11 to clarify that deviations/limitations will be documented and/or justified in the Compliance and Traceability Matrix. Revised Appendix 5, Section 6 to clarify humidity testing requirements.	Frank W. Kloer, P.E.
4	05/02/07	Revised Figure 2, Sections 5 & 7, and Appendix 9 to reflect the actual location of Performance Proof Testing. Revised Appendix 8, Section 8.0, acceptance criteria for surge testing to reflect EPRI TR-107330 requirements.	Frank W. Kloer, P.E.
5	05/10/08	Revised to incorporate comments from NUPIC audit (Reference ARR 597). Incorporated typographical corrections.	Frank W. Kloer, P.E.

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1. BACKGROUND

In the 1990's most nuclear power utilities began to recognize the growing obsolescence of I&C systems used in process control and safety-related applications. Original equipment vendors either no longer manufactured, maintained stock, or repaired installed equipment. Concurrently, nuclear power utilities observed the many advantages of the digital systems being installed in fossil plants.

EPRI, at the request of its member companies, initiated a research project to investigate if Programmable Logic Controllers (PLC) might be utilized in nuclear power plant process control, safety-related and important-to-safety applications. EPRI commissioned Westinghouse to first analyze the critical characteristics of nuclear plant applications, and secondly to complete a survey of PLC products and establish acceptable application performance, and finally to conduct an in-depth review of four vendors quality and manufacturing practices. In response, Westinghouse authored an EPRI Topical Report in 1994, concluding that the Tricon would perform acceptability in most nuclear power plant applications.

In 1997, EPRI issued TR-107330, which provides an acceptable method for generically qualifying a PLC for safety-related applications in nuclear power plants. After reviewing the technical report, the US Nuclear Regulatory Commission (NRC) issued a favorable Safety Evaluation Report (SER), concluding the methodology acceptable for generically qualifying a PLC for safety-related applications.

Beginning in 1997, Invensys-Triconex (I-T) participated in a subsequent EPRI effort to qualify the Tricon V9.5.3 in accordance with elements of TR-107330. I-T, with the assistance of Foxboro, MPR Associates, Hurst Technologies, Wyle Labs, and others, successfully completed all analysis and testing of the Tricon V9. After reviewing submitted test procedures, test results, analysis reports, and conducting an audit of the Irvine engineering and manufacturing facilities, the NRC issued a favorable SER in December 2001, stating:

> *The staff concludes that the Tricon PLC system meets the requirements of 10 CFR 50.55a(a)(1) and 55a(h). It also meets GDC 1, 2, 4, 13, 20-24, and 29, and IEEE Std 603 for the design of safety-related reactor protection systems, engineered safety features systems, and other plant systems, and the guidelines of RG 1.152 and supporting industry standards for the design of digital systems.*
>
> *On that basis, the staff concludes that, when properly installed and used, the Tricon PLC system is acceptable for safety-related use in nuclear power plants.*

As the leading supplier of digital safety systems, I-T has a responsibility to continue offering new and enhanced products that achieves the evolving demands of the various industries served – Oil and Gas Production, Refining and Petrochemical, Transportation, and Power. The nuclear power industry is no exception.

Since the successful qualification in 2001, I-T has introduced Version 10 of the Tricon, which supports new processors, software and manufacturing techniques. While the V10 product is TUV certified for safety related programmable electronic systems in process control; Fire and Gas; and process emergency shutdown applications; and is now currently in use within the aforementioned industries, I-T believes additional qualification actions are appropriate for the Nuclear industry. Therefore, I-T management has decided to initiate qualification of the Tricon V10 in accordance with

US NRC requirements, while employing lessons learned from the previous successful qualification effort and improving the process– quality, performance, schedule – and project cost.

TR-107330 requirements and Reg. Guide 1.180 provides an NRC endorsed framework for qualifying the Tricon platform for replacement of specific segments of nuclear industry Instrument & Control (I&C) systems classified as "safety-related" (RPS, RTS, ESFAS, QSPDS, LTOP, etc.) and "essential control" applications (SGWLC, Feedwater and Main Turbine Control, etc.) within legacy and new nuclear facilities. Qualification context is the placement of one or more Tricon V10s within the control logic portion of each channel, division, or train of existing safety-related and important-to-safety systems; which emulates control actions that are currently performed using electro-mechanical devices and analog loop controllers. In this type of application, the disruption of existing separation and isolation is minimal, which in turn, minimizes the impact of the replacement on the current licensing basis for these elements.

The technical scope, focus and content of TR-107330 are based on the steps involved in completing a generic qualification effort. Tricon qualification performance requires, in effect, creating a series of steps, which are similar to those used in qualifying any other device for nuclear safety-related service. Steps identified are:

A. Selecting relevant components of the I-T product line that comply with the requirements of TR-107330 and the required functionality of nuclear safety-related applications. The selection process includes selecting the set of Tricon chassis, I/O and communication modules to be qualified.

B. Configuring and producing a Test Specimen Application Program (TSAP). The TSAP is a Tricon application program designed to exercise I/O components, memory, main and communication Processors to aid in the qualification tests and operability testing.

C. Assembling the modules and the TSAP into an integrated test configuration.

D. Develop**ing** a set of qualification tests procedures to be conducted on the Tricon test specimen, including a set of operability and prudency tests to be performed at suitable intervals during the qualification process. These tests are designed to demonstrate acceptable operation during anticipated stresses over plant lifetime.

E. Performing the qualification tests in accordance with approved test procedures and documenting the results. Results documentation includes the qualification envelope, completed test procedures, specific components included in the qualification suite, and specific information for installing and using qualified Tricon components in safety-related and important-to-safety applications.

This Master Test Plan (MTP) addresses paragraphs A through E.

2. SCOPE

The recommendations **requirements** of EPRI TR-107330 (as endorsed and performed in the Triconex Safety Evaluation Report, ADAMS Accession # ML013470433) and RG 1.180, Rev. 1

(Reference ADAMS Accession # ML0433800960) define the requirements for testing to be performed in connection with the Tricon V10 Nuclear Qualification Project.

Qualification testing of Tricon components within an integrated system, configured to encompass a broad range of potential safety-related and important-to-safety applications, accomplishes the major portion of the requirements for qualifying the Tricon platform. Additional analytical information and required documentation are provided, augmenting the qualification assessment. This MTP provides an overview of the I-T Tricon v10 Nuclear Qualification Project, providing a bridge between the specification requirements and the test program results.

Qualification testing demonstrates the acceptability of the Tricon platform; it's hardware and operating software, and the ability of the I-T staff to develop safety-related, important-to-safety and critical applications, which reliably perform in nuclear facility environments, e.g. power plants, research reactors, fuel fabrication, waste handling, etc. The MTP identifies equipment to be tested, tests to be performed, and procedures for conducting the testing. The Nuclear Qualification Quality Plan (9600164-002) provides additional instructions for administering test program activities.

Test results are evaluated against acceptance criteria and summarized in the associated test report. Data recorded during testing establishes configuration and qualification envelope bounds. Data and test results are summarized in the final summary report, which support obligatory evaluations of specific applications within client nuclear power plants.

3. EQUIPMENT TO BE TESTED

In accordance with TR-107330, a representative sample of Tricon components, designated Tricon-Under-Test (TUT), is identified for evaluation and qualification testing and is described in Appendix 1. The TUT assembly is consistent with the technical context of EPRI specification TR-107330. In general, the system consists of a standard Tricon Fault Tolerant Control system configured with a selection of modules, which encompass a variety of safety-related and important-to-safety application scenarios. The typical TUT test system configuration is illustrated by Figures 1A and 1B; System Drawing 9600164-103 represents the actual configuration.

System equipment layout drawings and wiring schedules used in the development of the TUT system design provide additional information. Test plans and procedures provide specific details on hardware mounting and interfaces used in the qualification testing. The Test Specimen Application Program (TSAP) is designed to continuously exercise and verify TUT components during various normal and abnormal environment testing. Detailed configuration information such as serial numbers, software versions, etc. is provided as part of the qualification documentation. The Master Configuration List (MCL) itemizes all hardware and software configuration information.

4. SAFETY FUNCTIONS TO BE DEMONSTRATED

The safety functions to be demonstrated by the test program include:

1. The ability to provide, under normal conditions, acceptable response time, required I/O and memory capability, logic language implementation, redundancy and fault tolerance, failure detection and recovery.

2. The ability to perform safety-related functions under stress conditions, including the ability to:
   - Function before and after exposure to normal accumulated ionizing radiation dose;
   - Function during and after exposure to abnormal temperature and humidity conditions;
   - Function during and/or after exposure to anticipated EMI/RFI conditions;
   - Function during and after exposure to operating basis and design basis seismic events;
   - Function during and after exposure to voltage surges, electrical fast transients and electrostatic discharge;
   - Function under varying input power quality (voltage and frequency) conditions; and
   - Demonstrate class 1E/Non 1E electrical isolation capability of selected modules.

5. TEST REQUIREMENTS

The common test requirements and functional tests necessary to verify proper operation of a Tricon system are contained in Tricon System Test Requirements Specification, 9600121-001. Requirements for conducting nuclear qualification testing activities are found in EPRI TR-107330 specification, sections five and six. These sections reference other sections, which detail further testing criteria.

The EPRI specification provides a generic basis for qualifying the Tricon platform for nuclear safety-related and important-to-safety applications. Where items are not applicable due to unique I-T equipment characteristics, deviations or exceptions are identified in the EPRI TR-107330 Requirements Compliance and Traceability Matrix (CTM). Alternate test methods or criteria are defined in the Test Plan and/or Test Procedures.

As seen on the Master Test Plan flow chart (Figure 2), four categories of tests are conducted to satisfy the requirements of EPRI TR-107330:

(1) **Test Specimen Mfg/Assembly** conducted at the Irvine manufacturing facilities, followed by system setup, checkout and application software validation activities prior to shipping to NTS facilities;

(2) **Pre-Qualification tests** conducted at the NTS facilities prior to qualification testing to determine that the system operates correctly and to provide baseline data on equipment performance;

(3) **Qualification tests** conducted at testing NTS and University of Massachusetts laboratories to demonstrate compliance with specification requirements and suitability of equipment while subject to stress conditions; and

(4) **Performance Proof tests** conducted at the I-T facilities upon conclusion of all testing to confirm satisfactory operation after being subjected to Qualification test conditions. Performance proof tests are merely a repeat of selected pre-qualification baseline tests to identify any changes in equipment performance. Performance Proof testing includes operating

the test system for 7 days with an elevated DC source; this test may be conducted at the I-T facility in Irvine, CA.

Tests to be performed are shown below. Table 1 also lists these tests along with the applicable references and corresponding MPR test procedures.

Pre-Qualification Tests include:

1. System Setup and Checkout Test
2. Operability Test
3. Prudency Test

Qualification Tests include:

1. Radiation Exposure Test (including Operability and Prudency tests)
2. System Setup and Checkout Test (as needed following system disassembly/reassembly)
3. Environmental Test (including Operability and Prudency tests)
4. System Setup and Checkout Test (as needed following system disassembly/reassembly)
5. Seismic Test (including post-seismic Operability test)
6. System Setup and Checkout Test (as needed following system disassembly/reassembly)
7. EMI/RFI Test
8. Electrical Fast Transient
9. Surge Withstand Test
10. Electro-Static Discharge Test
11. Class 1E/Non-1E Electrical Isolation Test

Performance Proof Tests include:

1. System Setup and Checkout Test
2. Seven (7) day Elevated DC Source Test
3. Operability Test (retest)
4. Prudency Test (retest)

Section 5.6 of EPRI TR-107330 includes requirements for Application Software Objects Acceptance (ASOA) testing of the software objects in the Tricon library. The Tricon application development software (TS1131) has received (and continues to receive) extensive testing both internally by I-T and independently by TUV Rheinland. The documentation for this testing provides sufficient objective evidence that the ASOA testing intent described in EPRI TR-107330 has been adequately addressed. The Software Qualification Report provides a complete discussion of the software testing performed by I-T and TUV Rheinland, which satisfy the terms of the initial SER. The ASOA testing is not within the scope of the MTP.

TR-107330 Sections 4.3.7 and 6.3.2 include requirements for Electro-Magnetic Interference and Radio-Frequency Interference (EMI/RFI) testing in accordance with EPRI TR-102323. Subsequently, the NRC propagated Regulatory Guide (RG) 1.180 R1, which provides "Guidelines for Evaluating Electromagnetic and Radio-Frequency Interference in Safety Related Instrumentation and Control Systems". When utilized in their entirety (no intermingling of requirements or specifications), the qualifier may choose either EMI/RFI testing methodology. RG 1.180 endorses Military Standard MIL-STD-461E and the International Electrotechnical Commission (IEC) 61000 series of EMI/RFI test

methods, which includes the guidance covering signal line testing; incorporating portable communication device frequency ranges; and relaxing the operating envelopes (test levels) when experience and confirmatory research warrants.

RG 1.180, R1 provides acceptable suites of EMI/RFI emissions and susceptibility methods from the most recent versions of the military standard and international commercial standards (Ref. U.S. NRC Memorandum Dated December 17, 2004; ADAMS Accession # ML0433800960). EMI/RFI testing practices from military and commercial standards are endorsed to address electromagnetic emissions, EMI/RFI susceptibility, and power surge withstand capability (SWC). Selected EMI/RFI test methods from MIL-STD-461E, "Requirements for the Control of Electromagnetic Interference Characteristics of Subsystems and Equipment," and the IEC 61000 Series are endorsed to evaluate conducted and radiated EMI/RFI phenomena for safety-related I&C systems. The IEC standards include IEC 61000-3, "Electromagnetic Compatibility (EMC) - Part 3: Limits," IEC 61000-4, "Electromagnetic Compatibility (EMC) - Part 4: Testing and Measurement Techniques," and IEC 61000-6, Electromagnetic Compatibility (EMC) - Part 6: Generic Standards." These suites of test methods can be applied as alternative sets (guidance is provided in the Regulatory Position). It also endorses electromagnetic operating envelopes corresponding to the MIL-STD-461E test methods, which were tailored from the MIL-STD-461E test limits to represent the characteristic electromagnetic environment in key locations at nuclear power plants. Comparable operating envelopes for the IEC 61000 test methods are also endorsed. The operating envelopes are presented within the Regulatory Position, along with descriptions of the endorsed MIL-STD-461E and IEC 61000 test methods.

Emissions testing will be conducted to the criteria provided in MIL-STD-461; CE101, CE102, RE101, and RE102. Susceptibility testing will be conducted to the criteria provided in IEC 61000-4-3,**-4, -5,** -6, -8, -9, -10,**-12,** -13, and -16.

6. TEST PLANS AND PROCEDURES

Test Plans have been prepared for various tests or testing categories (Environmental, Seismic, etc.), as listed in Appendices 3-9:

Appendix 3, Pre-Qualification Test Plan
Appendix 4, Radiation Exposure Test Plan
Appendix 5, Environmental Test Plan
Appendix 6, Seismic Test Plan
Appendix 7, EMI/RFI Test Plan
Appendix 8, Surge Withstand, ESD, Electrical Fast Transient & Electrical Isolation Test Plans
Appendix 9, Performance Proof Test Plan

Test Plans join EPRI TR-107330 specifications and RG 1.180 requirements with the associated test procedures. They address general testing approach, objectives, reference to requirements, general testing criteria, service conditions, environmental conditions, sequence of tests, and applicable procedures.

Test Procedures control the detailed sequence of testing activities and document the results. They define equipment set-up, environmental conditions, specific testing steps, performance data collection

requirements, verifications, and measuring equipment used. The Master Configuration List controls the configuration of all test procedures.

Supporting testing software, i.e., the Test Specimen Application Program (TSAP), is identified, verified, validated, and controlled in accordance with the Nuclear Qualification Quality Plan (NQQP) (9600164-002).

7. TEST PROGRAM IMPLEMENTATION

7.1 Test Sequence

Figure 2 diagrams the overall testing process. The general sequence is listed below:

1. Manufacture and assemble standard Tricon platform components.
2. Perform system setup & checkout and conduct software validation procedure.
3. Conduct Pre-Qualification tests and document results (see App. 3).
4. Conduct Radiation Susceptibility test and document results (see App. 4).
5. Conduct Environmental Qualification testing and document results (see App. 5).
6. Perform system setup and checkout, operability, and prudency tests.
7. Conduct Seismic Qualification testing and document results (see App. 6).
8. Perform system setup and checkout, and operability tests.
9. Conduct EMI/RFI testing and document results (see App. 7).
10. Conduct Electrical Fast Transient testing and document results (see App. 8).
11. Conduct Surge Withstand testing and document results (see App. 8).
12. Conduct Electrostatic Discharge testing and document results (see App. 8).
13. Conduct Electrical Isolation testing and document results (see App. 8).
14. Conduct Performance Proof testing and document results (see App. 9)

Details of the individual tests and sequencing are found in Test Plans for the different testing categories (Environmental, Seismic, etc.). System assembly and integration, and software validation will be accomplished at the I-T Irvine facilities. Pre-Qualification testing will be accomplished at the NTS, Boxboro**Boxborough**, MA facility. Qualification and Performance Proof testing will be performed at the I-T facilities in Irvine, CA. Radiation susceptibility testing will be performed at the University of Massachusetts.

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7.2 Methodology

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7.3 Test Personnel and Responsibilities.

All test personnel shall be certified in accordance with an approved quality assurance program.

8. STRESS INFLUENCING FACTORS

Various stress influencing factors are an integral part of the qualification test program. Section 6.3.1 of TR-107330 specification identifies the following key stress mechanisms associated with the Tricon platform validation:

1. Environmental (Abnormal Temperature & Humidity)
2. Seismic
3. Electromagnetic and Radio Frequency Interference (EMI/RFI)
4. Ionizing radiation exposure.
5. Electro-Static Discharge Robustness
6. Electrical Surge Robustness

The specification defines the required parameters and the order in which to perform the stress conditioning procedures. This is factored into the Individual Test Plans (Appendices 3-9) and the test sequencing.

Radiation exposure is addressed in section 4.3.6 of the TR-107330 specification. Ionizing radiation exposure in accordance with the level specified, i.e. 1000 RADS plus 10% margin, is conducted after TUT environmental testing.

9. TEST DEVIATIONS/FAILURES

Deficiencies, including hardware, software and test documentation, identified during qualification testing will be documented, controlled, and dispositioned in accordance with the Nuclear Qualification Quality Plan (9600164-002). MPR Quality Assurance Program procedures for dispositioning Test Deviations may also be invoked.

10. ADDITIONAL CONSIDERATIONS

Qualification testing will be performed at various locations depending upon the particular requirements of a given test. Recognizing that shipping and handling logistics between the various test sites adds special considerations for relocating, transporting, and maintaining test system integrity during the qualification program, a chain-of-custody process is included to assure system integrity.

Once testing begins on the integrated system, configuration and traceability is strictly maintained. The Nuclear Qualification Quality Plan (9600164-002) provides direction for this process.

11. REQUIRED DOCUMENTATION

Section 8 of the TR-107330 specification defines the required documentation to support both the generic qualification and application specific Tricon utilization. In addition to specific test records and reports, other supporting documents such as drawings, equipment data, and engineering reports are required. TUT Description (9600164-541) provides an overview and description of the test specimen and test system.

The NQQP delineates the contents of the Nuclear Qualification Document Package documentation and the EPRI TR-107330 Requirements Compliance and Traceability Matrix (CTM) correlates the specific deliverable documentation that fulfills each TR-107330 requirement. The qualification deviations from the TR-107330 approach and limitations of the SER effort to qualify the Tricon V9.5.3 in accordance with elements of TR-107330 will be acknowledged during the Tricon V10 Nuclear Qualification Project (e.g. test specimen performance, testing beyond known limitations of test equipment, test setup methodology, etc.). All deviations and limitations associated with the Tricon V10 Nuclear Qualification Project will be documented and justified in the Compliance and Traceability Matrix at the completion of the Tricon V10 Nuclear Qualification Project effort.

The primary deliverables for project testing phases are:

11.1 Pre-qualification Test Report (9600164-524)

The Pre-qualification Test Report summarizes the results of the Pre-qualification testing of the TUT in compliance with EPRI TR-107330 requirements. The following documents are attached as appendices to this test report:

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11.2 Qualification Test Reports

Therefore, it is necessary to establish a qualified life for equipment with significant aging mechanisms prior to use in nuclear power plants.

The Qualification Test Reports **will** summarize the results of TUT qualification type testing in compliance with EPRI TR-107330 and RG 1.180 requirements. The TUT is subjected to a series of applied stress test**s**. Each test specifies operability requirements and performance measures to be recorded during the stress application. Successful type testing demonstrates that the TUT can perform the intended safety function(s) for the required operating time before, during, and/or following design basis events. The following documents are attached as appendices to the Qualification Test Report:

11.2.1 Environmental Test Report (9600164-525)

Environmental testing demonstrates sufficient TUT robustness to preclude failures due to abnormal service conditions of temperature and humidity. Environmental Test Report (9600164-525) **will** summarizes the results of TUT environmental testing in accordance with:

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11.2.2 Radiation Susceptibility Test Report (9600164-533)

Radiation Susceptibility testing demonstrates sufficient TUT robustness to preclude failures due to normal service conditions in a mild radiation environment. Radiation Test Report (9600164-533) **will** summarizes the results of TUT radiation susceptibility testing in accordance with:

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11.2.3 Seismic Test Report (9600164-526)

Seismic testing demonstrates the TUT robustness to preclude failure when subjected to the seismic vibration level profile specified in TR-107330. **The** Seismic Test Report (9600164-526) **will** summarizes the results of TUT seismic testing in accordance with:

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11.2.4 EMI/RFI Test Report (9600164-527)

The objective of EMI/RFI testing is to demonstrate the suitability of the I-T Tricon PLC for qualification as a safety-related device with respect to Electromagnetic Interference/Radio Frequency Interference (EMI/RFI) emissions and susceptibility withstand capability. EMI/RFI testing demonstrates sufficient TUT robustness to preclude common-mode failures when exposed to EMI/RFI (radiated and conducted) environments specified in RG 1.180. EMI/RFI Test Report (9600164-527) **will** summarizes the results of TUT EMI/RFI susceptibility testing in accordance with:

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11.2.5 Surge Withstand, ESD and Electrical Fast Transient Test Reports (9600164-528, -522, -521)

The objective of Surge Withstand (SW), Electro-Static Discharge (ESD) and Electrical Fast Transient (EFT) testing is to demonstrate TUT robustness to preclude common-mode failure when subjected to creditable electrical induced events. **The** SW, ESD & EFT Test Reports (9600164-528, -522, **and** -521) **will** summarize the results of TUT SW, ESD and EFT testing in accordance with:

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11.2.6 Class 1E to Non-1E Isolation Test Report (9600164-529)

The objective of Class 1E to Non-1E isolation testing is to demonstrate TUT robustness to preclude common-mode failure when exposed to excessive, but creditable, voltages at various input/output and communication connections. **The** Class 1E to Non-1E Isolation Test Report (9600164-529) **will** summarizes the results of isolation testing in accordance with:

- [a]

11.3 Performance Proof Test Report (9600164-530)

Performance Proof Test Report summarizes the results of performance proof testing of the TUT. Performance proof testing is conducted at the conclusion of all qualification testing at NTS. The report **will** demonstrates the continued acceptable performance of the TUT after exposure to the specified qualification test conditions. The testing involves a final performance test of the TUT in accordance with:

- [a]

11.4 Test Specimen Application Program (TSAP) Verification and Validation Report (9600164-536)

The TSAP Verification and Validation (V&V) Report describes the verification (functional confirmation) and validation (performance confirmation) process, which is utilized during development and integration of TUT application software. The TSAP is a unique application program developed specifically for this qualification project to exercise the functions and features of the TUT under stress conditions found in typical nuclear plant environments. The TSAP V&V Report is based on the guidance provided in:

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11.5 Master Configuration List (9600164-540)

The Master Configuration List (MCL) captures all hardware and software configuration information.

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11.6 Equipment Qualification Summary Report (9600164-545)

The Qualification Summary Report reviews and sums the results of all test reports conducted during each phase of the project. The summary addresses and highlights TUT system description; results of each phase of testing; test procedures developed and utilized; associated data sheets; equipment and test deficiencies; and final acceptability of Tricon equipment and software for use in safety-related and critical control applications within nuclear facilities. The Summary Report includes the EPRI TR-107330 Requirements Compliance and Traceability Matrix (CTM) and the Application Guide.

- EPRI TR-107330, Section 8.6

TABLE 1 – OVERVIEW OF TESTS TO BE PERFORMED

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Test Type & Description	Test Procedure	Test Plan
1.0 PRE-QUALIFICATION TESTS		
1.1 System Setup and Checkout test	9600164-502	App. 3, Pre-qualification test plan
1.2 Operability test	9600164-503	App. 3, Pre-qualification test plan
1.3 Prudency test	9600164-504	App. 3, Pre-qualification test plan
2.0 QUALIFICATION TESTS		
2.1 Radiation susceptibility test	9600164-505	App. 4, Rad. Susc. Test Plan
2.2 System Setup and Checkout test	9600164-502	App. 3, Pre-qualification test plan
2.3 Operability test	9600164-503	App. 3, Pre-qualification test plan
2.4 Prudency test	9600164-504	App. 3, Pre-qualification test plan
2.5 Environmental qualification test	9600164-506	App. 5, Env. Test Plan
2.6 System Setup and Checkout test	9600164-502	App. 3, Pre-qualification test plan
2.7 Operability test	9600164-503	App. 3, Pre-qualification test plan
2.8 Prudency test	9600164-504	App. 3, Pre-qualification test plan
2.9 Seismic qualification test	9600164-507	App. 6, Seismic Test Plan
2.10 Operability test	9600164-504	App. 3, Pre-qualification test plan
2.11 System Setup and Checkout test	9600164-502	App. 3, Pre-qualification test plan
2.12 EMI/RFI tests	9600164-510	App. 7, EMI/RFI Test Plan
2.13 Surge test	9600164-	App. 8, Surge/ESD/Iso Test

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Test Type & Description	Test Procedure	Test Plan	
	508	Plan	
2.14 ESD test	9600164-512	App. 8, Surge/ESD/Iso Test Plan	
2.15 EFT test	9600164-514	App. 8, Surge/ESD/Iso Test Plan	2
2.16 Isolation (1E to non-1E) test	9600164-509	App. 8, Surge/ESD/Iso Test Plan	
3.0 PERFORMANCE PROOF TESTS			
3.1 System Setup and Checkout test	9600164-502	App. 3, Pre-qualification test plan	
3.2 Operability test from 1.3 above	9600164-503	App. 9, Proof Test Plan	
3.3 Prudency test from 1.4 above	9600164-504	App. 9, Proof Test Plan	

FIGURE 1A

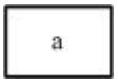

FIGURE 1B

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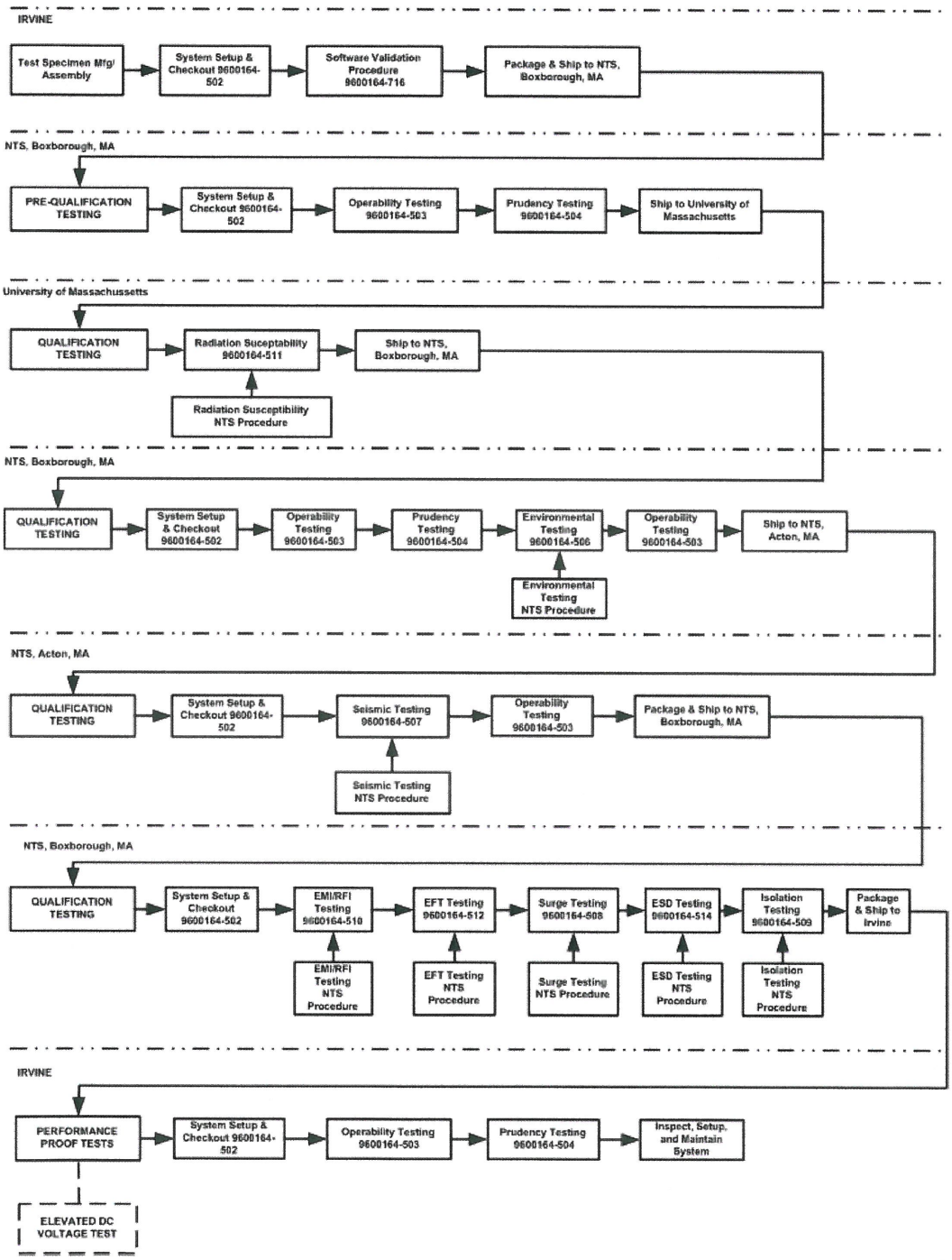
FIGURE 2- MASTER TEST PLAN – FLOW DIAGRAM



APPENDIX 1 – TRICON-UNDER-TEST EQUIPMENT

The equipment under test basically consists of 4 TRICON chassis containing selected functional modules, external termination panels (ETA's) appropriate for the included modules, and necessary connecting cables. A listing of the specific modules and firmware to be qualified is provided below.

Model #	Quantity	Description	Firmware Type
Chassis			
8110	1	Main Chassis	N/A
8111	1	Expansion Chassis	N/A
8112	2	Remote Expansion Chassis	N/A
8405	8	Chassis Mounting Brackets	N/A
Chassis Cable Sets			
9000	1	Triplicated I/O Bus Expansion Cable Set	N/A
9001	1	Triplicated I/O-Comm Bus Expansion Cable Set	N/A
Power Modules			
8310	4	High Density Power Module, 115 V	N/A
8311	2	High Density Power Module, 24 VDC	N/A
8312	2	High Density Power Module, 230 VAC	N/A
Remote Extender Module Sets			
4200	1	Primary RXM, Multi-Mode Fiber Optic Modules (3)	RXMP
4201	1	Remote RXM, Multi-Mode Fiber Optic Modules (3)	RXMS
Main Processor			
3008	3	Enhanced Main Processor III, Motorola MP680, 32 bit, 50 MHz, 16 MB DRAM, 32 KB SRAM, 6 MB Flash PROM	ETSX, IOCCOM
Communication Processors			
4352A	4	Tricon Communication Modules (TCM), Fiber Optic media network ports, RS-232/485 media serial ports.	TCM
TMR Analog Input Modules			
3701	1	Differential, DC Coupled, 32 points, 0-10 VDC	NIAI
3703E	2	Differential, Isolated, 16 points, 0-5/0-10 VDC	EIAI
3721	2	NGAI, Differential, 32 points, 0-5 VDC	AI
TMR Thermocouple Input Modules			
3708E	1	Differential, Isolated, 16 points, J, K, T, E T/Cs	EIAI
TMR Analog Output			
3805E	1	Non-isolated, common return, DC coupled, 8 points, 4-20 mA	EAO

TMR Digital Input Modules			
3501T	1	Non-commoned, isolated, 32 points, 115V AC/DC	EDI
3502E	1	Commoned groups of 8, 32 points, 48V AC/DC	EDI
3503E	1	Commoned groups of 8, 32 points, 24V AC/DC	EDI
TMR Pulse Input Module			
3511	1	Non-commoned, Balanced Differential, AC coupled, 8 points, 16 bit, 1K to 28K Hz	EPI
TMR Digital Output Modules			
3601T	1	Non-commoned, isolated, 16 points, 115 VAC	EDO
3603T	1	Commoned, isolated, 16 points, 120 VDC	TSDO
3623T	1	Supervised, commoned, isolated, 16 points, 120 VDC	TSDO2
3607E	1	Non-commoned, isolated, 16 points, 48 VDC	EDO
3625	2	NGDO, 16 points, 24 VDC	SDO
Non-TMR Digital Output Modules			
3636T	1	Relay Output, N.O., Simplex, 32 points, 155 VAC/DC max.	ERO
Signal Conditioning Components			
1600083-600	1	AD7B34CUSTOM, RTD Signal Converter, 200 ohm Pt., 0 - 600°C	N/A
1600083-200	1	AD7B34CUSTOM, RTD Signal Converter, 200 ohm Pt., 0 - 200°C	N/A
1600024-040	1	AD7B340401, RTD Signal Converter, 100 ohm Pt., 0 - 600°C	N/A
1600024-030	1	AD7B340301, RTD Signal Converter, 100 ohm Pt., 0 - 200°C	N/A
1600024-020	1	AD7B340201, RTD Signal Converter, 100 ohm Pt., 0 - 100°C	N/A
1600024-010	1	AD7B340101, RTD Signal Converter, 100 ohm Pt., -100 to +100°C	N/A
1600082-001	1	AD7B300201, RTD Signal Converter, 0 – 100 mV	N/A
1600081-001	1	AD7B14, RTD Signal Converter, 10 ohm copper, 0 - 120°C	N/A
Passive – Non-Active – Components			
8105	12	Blank I/O Slot Panel	N/A
8107	21	Seismic Balance Module (Inactive)	N/A
External Termination Assemblies			
9790-610	1	10’ cable, 3721 AI, current configurable, 16 pts	N/A
9783-110N	2	10’ cable, 3721 AI, 0 – 5 Vdc, 16 pts	N/A
9764-310N	1	10’ cable, 3721 AI, RTD, 16 pts	N/A

9783-110N	1	10’ cable, 3701 AI, 0 – 10 Vdc, 16 pts	N/A
9795-610N	1	10’ cable, 3701 AI, 0 – 10 Vdc, current configurable, 16 pts	N/A
9790-610N	1	10’ cable, 3703E, Isolated, current configurable, 16 pts	N/A
9783-110N	1	10’ cable, 3703E, Isolated, current configurable, 16 pts	N/A
9860-610N	1	10’ cable, 3805E AO, 4 – 20ma, 8 pts	N/A
9782-110N	1	10’ cable, 3708E TC, Upscale/Downscale, 16 pts	N/A
9794-110N	1	10’ cable, 3511 PI, 8 pts	N/A
9563-810N	2	10’ cable, 3503E DI, 24 V AC/DC, Commoned, 16 pts	N/A
9562-810N	2	10’ cable, 3502E, DI, 48 V AC/DC, Commoned, 16 pts	N/A
9561-110N	1	10’ cable, 3501T DI, 115 V AC/DC, Non-Commoned, 16 pts	N/A
9561-810N	1	10’ cable, 3501T DI, 115 V AC/DC, Commoned, 16 pts	N/A
9662-610N	1	10’ cable, 3625 DO, 24 VDC, Commoned, 16 pts	N/A
9662-810N	1	10’ cable, 3625 DO, 24 VDC, Commoned, 16 pts	N/A
9667-810N	1	10’ cable, 3607E DO, 48 VDC, Commoned, 16 pts	N/A
9663-610N	1	10’ cable, 3601T, DO, 115 VAC, Commoned, 16 pts	N/A
9664-810N	1	10’ cable, 3603T, DO, 120 VDC, Commoned, 16 pts	N/A
9664-810N	1	10’ cable, 3623T, DO, 120 VDC, Commoned, 16 pts	N/A
9668-110N	2	10’ cable, 3636T, RO, Non-Commoned, 16 pts.	N/A

APPENDIX 2 – TEST SPECIMEN APPLICATION PROGRAM (TSAP)

1. GENERAL

The Test Specimen Application Program (TSAP) is a Tricon application program designed to exercise Main and Communication Processors, I/O components, and memory to aid in the pre-qualification; qualification; operability and prudency testing under stress; and performance proof testing. The TSAP Governing regulations for development, content, and implementation are described below.

2. REFERENCES

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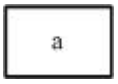

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5. IMPLEMENTATION:

a. Integrate into Test Specimen with the System Setup and Checkout Test per 9600164-502.
b. This application software is only used with this test program and is to be retired upon completion of testing. (The TSAP will not be used in actual nuclear plant applications)

APPENDIX 3 - PRE-QUALIFICATION TEST PLAN

1. GENERAL

Pre-qualification testing will commence upon receipt of the TUT system at NTS, Boxboro**Boxborough** facilities.. Pre-qualification acceptance tests confirm that the TUT is correctly configured, assembled and operational prior to qualification testing. Pre-qualification acceptance tests also provide baseline performance data for comparison to performance data obtained during subsequent qualification testing.

The TUT is assembled from commercial I-T products (Tricon modules & accessories). I-T equipment will be manufactured, tested, and accepted in accordance with normal commercial practices.

A System Setup and Checkout test is then conducted to confirm satisfactory assembly and operation of the integrated system (test specimen). This test checks the basic operation of the system hardware and software, including the TSAP. The TSAP Validation Test Procedure is then conducted to confirm correct execution of the TSAP software in accordance with functional requirements.

Conducting operability and prudency tests procedures benchmarks system operation and establishes baseline performance data on the TUT. The Operability Test is a comprehensive series of tests, which demonstrate the basic functionality of the Tricon in accordance with its published specifications. Mandated tests are defined in EPRI specification 5.3. The Prudency Test is a special type of test that exercises the ability of the Tricon to perform under highly dynamic conditions. Power quality tolerance testing per TR-107330 paragraph 6.4.3 is included in the Operability tests.

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Figure 2 provides an overview of the testing sequence.

2. REFERENCES:

EPRI Specification TR-107330:

a

3. EQUIPMENT

Appendix 1 documents the TUT configuration. During acceptance testing, the TUT is configured as shown on the system drawings.

4. SEQUENCE OF TESTING:

Testing sequence is projected as listed below.

1. System Setup and Checkout test (to confirm correct TUT assembly and operation)
2. Operability test (to establish baseline performance data)
3. Prudency test (to establish baseline performance data)

Specific sequence of test steps will be indicated in the test procedures.

5. PROCEDURES:

The following test procedures will be utilized during pre-qualification testing:

A. System Setup and Checkout Test (9600164-502)
Scope: This procedure verifies the proper assembly and configuration of the test system and confirms the proper functioning of the test system.

B. Operability Test (9600164-503)

a

C. Prudency Test (9600164-504)
Scope: This procedure is designed to demonstrate that the Tricon will perform properly at minimum source power supply voltage and frequency conditions under highly dynamic loading and adverse noise conditions.

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6. SERVICE CONDITIONS AND MARGINS:

Pre-qualification testing is performed in a mild environment. No unique service conditions

a

7. PERFORMANCE AND ENVIRONMENTAL VARIABLES

Performance and environmental variables measured, including required accuracy, are defined in the respective test procedures.

8. ACCEPTANCE CRITERIA

Specific acceptance criteria for individual tests are found in the procedures. Governing source of acceptance criteria are indicated below:

1. System Setup and Checkout Test — EPRI TR-107330 Specification section 5.2
2. Operability Test — EPRI TR-107330 Specification sections 5.3 and 6.4.3
3. Prudency Test — EPRI TR-107330 Specification section 5.4

9. RECORDS:

1. Pre-qualification Test Report (9600164-524)
2. Completed procedures/attachments (9600164-502, 503, 504)
3. System drawings

APPENDIX 4 – RADIATION SUSCEPTIBILITY TEST PLAN

1. GENERAL

Microcircuit devices are sensitive to the effects of ionizing radiation. The cumulative damage of the semiconductor lattice, as measured in rads, causes slow gradual degradation of the device's performance. The effects can vary unpredictably depending on various parameters – radiation flux and total dose, operating voltage and frequency, etc. making a thorough radiation susceptibility evaluation difficult. Therefore, the TUT is subjected to Radiation Susceptibility testing.

Continued operation of the Tricon PLC is required when placed in a mild ionizing radiation environment with a cumulative absorbed dose, plus 10% margin, as defined in sections 4.3.6.1 and 4.3.6.2 of TR-107330. Successfully passing Radiation Susceptibility testing provides assurance that the Tricon does not fail due to mild environment radiation exposure over the anticipated life time of the equipment. Testing is conducted to simulate specified conditions, including margins, which confirm the capability of the TUT to meet its performance specifications of TR-107330.

2. REFERENCES

EPRI specification TR-107330: a

3. EQUIPMENT

Appendix 1 documents the TUT configuration. The test set-up information provided in the Radiation Susceptibility Test Procedure documents the specific TUT mounting methods and interfaces.

4. SEQUENCE OF TESTING

Testing sequence is projected as listed below.

1. Conduct System Setup and Checkout test.
2. Disassemble TUT per Radiation Susceptibility test procedure.
3. Establish radiation exposure conditions (University of Mass).
4. Expose TUT components per Radiation Susceptibility test procedure.
5. Re-assemble TUT per Radiation Susceptibility test procedure.
6. Conduct System Setup and Checkout test.
7. Conduct portions of Operability and Prudency tests per Environmental test procedure.

Specific sequence of test steps are indicated in the test procedures. Normal operating performance data is obtained before and after the Radiation Susceptibility test.

5. PROCEDURES

The following procedures are utilized during radiation testing: a

A. Radiation Susceptibility Test (9600164-511)

a

B. University of Mass Procedure, Radiation Susceptibility Test
Scope: University of Mass personnel to establish the specified radiation conditions in the test chamber and duration of exposure conduct this procedure.

6. SERVICE CONDITIONS AND MARGINS

a

7. PERFORMANCE AND ENVIRONMENTAL VARIABLES

Performance and environmental variables measured, including required accuracy, is defined in the specific test procedures.

8. ACCEPTANCE CRITERIA

1. Successful completion of Operability and Prudency Testing at the conclusion of radiation exposure to levels defined in TR-107330.
2. Paragraphs 4.3.6.1D and 4.3.6.2D of TR-107330 establish acceptance criteria. Radiation Susceptibility operability and prudency test result data is collected and compared to the performance requirements and to the baseline performance data collected during pre-qualification testing.

9. RECORDS

1. Radiation Susceptibility Test Report (9600164-533)
2. Completed procedures/attachments (9600164-505)
2. System Drawings

APPENDIX 5 - ENVIRONMENTAL TEST PLAN

1. GENERAL

The Tricon PLC is required to operate in environmental conditions defined in sections 6.3.3 and 4.3.6 of TR-107330, assuring that the system does not fail due to abnormal conditions of temperature and humidity. Testing is conducted to simulate specified conditions, including margins, which confirm the capability of the TUT to meet its performance specifications. TR-107330, Figure 4-4 defines the environmental profile of varying temperature and humidity to which the TUT is subjected during environmental testing.

Testing is performed at NTS facilities in Boxborough, Massachusetts. NTS personnel establish environmental conditions as specified in the TR-107330 specification. MPR personnel monitor performance of the TUT during application of environmental stresses. The TSAP is loaded and operating during Environmental testing, exercising all TUT components, and supporting automated collection test data collection. This data demonstrates TUT operation in accordance with the applications depicted in the project functional diagrams. Additionally, portions of the Operability and Prudency tests are conducted at specific times during and after the Environmental tests. The test procedure for Environmental testing details the specific sections of the Operability and Prudency tests scheduled and conducted during testing.

2. REFERENCES

EPRI specification TR-107330:
IEEE Std 323-1974

a

3. EQUIPMENT

Appendix 1 documents the TUT configuration. The test set-up information provided in the Environmental Test Procedure documents the specific TUT mounting methods and interfaces. TR-107330, Section 6.3.3 describes equipment arrangement and mounting requirements.

4. SEQUENCE OF TESTING

Testing sequence is projected as listed below.

1. Set-up equipment per Environmental test procedure
2. Conduct System Setup and Checkout test
3. Establish environmental conditions (NTS)
4. Vary temperature and humidity conditions per Figure 4-4 of TR-107330 and section 6 of this appendix
5. Conduct portions of Operability and Prudency tests per Environmental test procedure

Specific sequence of test steps are indicated in the test procedures. Normal operating performance data is obtained before, during, and after the Environmental test.

5. PROCEDURES

The following procedures are utilized during environmental testing:

A. Environmental Test (9600164-506)

a

6. SERVICE CONDITIONS AND MARGINS

7. PERFORMANCE AND ENVIRONMENTAL VARIABLES

Performance and environmental variables measured, including required accuracy, are defined in the specific test procedures.

8. ACCEPTANCE CRITERIA

1. Correct TUT operation during exposure to the temperature/humidity profile illustrated in TR-107330, Figure 4-4 (as modified above in Service Conditions & Margins), as indicated by the normal operating performance data.
2. Sections 5.3 and 6.4.3 of TR-107330 establish acceptance criteria. Environmental operability and prudency test result data is collected and compared to the above performance requirements and to the baseline performance data collected during pre-qualification testing. Comparison results are used to establish the environmental qualification envelope.

9. RECORDS

1. Environmental Test Report (9600164-525)
2. Completed procedures/attachments (9600164-502, 506, 503, 504)
3. System Drawings

APPENDIX 6 - SEISMIC TEST PLAN

1. GENERAL

When utilized in a safety-related application, the Tricon platform is considered a Seismic Category 1 Safety System. The TUT is requred to withstand the SSE vibration following application of five Operating Basis Earthquakes (OBEs). The purpose of Seismic testing is to demonstrate TUT capabilities during OBE and SSE events.

Satisfactory functioning of the TUT and application program will be monitored throughout the OBE and SSE. For modules with electromechanical relays (3636T), specific provisions to monitor relay contact performance during seismic conditions are included in the test procedures.

Seismic Testing conforms to the requirements of IEEE 344-1987. In addition to demonstrating the performance requirements under the specified conditions, a resonance search procedure is conducted in accordance with per paragraph 7.1.4 of IEEE 344-1987. This test plan and supporting procedures demonstrates satisfaction of the requirements of section 6.3.4 of TR-107330.

Testing is performed at NTS facilities in Acton, Massachusetts. NTS personnel provide testing services and establish test conditions as specified in the TR-107330 specification. NTS personnel also document the mounting of the TUT to the seismic test apparatus. MPR personnel conduct performance monitoring of the test specimen during each seismic test. The TSAP is loaded and operating during Seismic testing, exercising all TUT components, and supporting automated test data collection. The resulting data documents TUT operation in accordance with the applications depicted in the project functional diagrams. Data also supports monitoring performance of the module 3636T electromechanical relay contacts during testing. Additionally, Operability testing is conducted at the completion of the Seismic tests.

2. REFERENCES

a

EPRI Specification TR-107330:
IEEE 344-1987

3. EQUIPMENT

Appendix 1 documents the TUT configuration. The test set-up information in the Seismic Test Procedure documents the specific TUT mounting methods and interfaces. The TUT is mounted and tested in the configuration deemed most susceptible to seismic vibration. Connections and interfaces between TUT components and the monitoring equipment are documented in the test procedure. Mounting of the system and test equipment to the seismic test table is in accordance with the requirements of TR-107330 specification paragraph 6.3.4.1.

4. SEQUENCE OF TESTING

Testing sequence is projected as listed below.

1. Set-up equipment per Seismic test procedure (9600164-507)
2. Conduct System Setup and Checkout test (9600164-502)
3. Conduct resonance search to determine equipment resonant frequencies
4. Conduct 5 tri-axial OBEs
5. Visually inspect test specimen for damage after each OBE
6. Conduct tri-axial SSE
7. Visually inspect test specimen for damage after SSE
8. Conduct Operability test

Specific sequence of test steps will be indicated in the test procedures. Normal operating performance data will be obtained before, during, and after each OBE/SSE test.

The EPRI TR (Table 5-1) requires that the Operability and Prudency Tests be performed during Seismic testing. The duration of each OBE/SSE test (approximately 30 seconds) does not support full Operability or Prudency Testing. For this reason it is not practical to perform the Operability and Prudency Tests during the Seismic Tests.

5. PROCEDURES

The following test procedures are utilized for Seismic testing:

A. Seismic Test (9600164-507)

a

6. SERVICE CONDITIONS AND MARGINS

a

7. PERFORMANCE AND ENVIRONMENTAL VARIABLES

Performance and environmental variables to be measured, including required accuracy, will be defined in the specific test procedures.

8. ACCEPTANCE CRITERIA

1. The test specimen shall operate as intended for the specified level of vibration given above, as indicated by the normal operating performance data.
2. All connections shall remain intact.
3. All modules shall remain fully inserted.
4. No functional or non-functional parts shall fall off when subjected to the specified test levels.
5. For the module 3636T with electromechanical relays, the relay contacts shall intentionally change state from energized to de-energized and de-energized to energized during application of the OBE and SSE.
6. For the module 3636T with electromechanical relays, no spurious contact change of state of longer than 2 ms shall occur during application of the OBE and SSE.
7. The operability data collected as part of the Seismic test procedure shall be compared to the performance requirements given in the acceptance criteria of EPRI specification Sections 5.3 and 6.4.3, and to the baseline performance data collected during pre-qualification testing. The results shall be used to make appropriate adjustments to the qualification envelope.

9. RECORDS

1. Seismic Test Report (9600164-526)
2. Completed procedures/attachments (9600164-502, 507)
3. Test response spectrum data
4. System drawings

APPENDIX 7 - EMI/RFI TEST PLAN

1. GENERAL

The purpose of this plan is to establish testing requirements for conducting the EMI/RFI part of the qualification tests on the TUT. Testing demonstrates acceptable performance of the TUT in accordance with EMI/RFI criteria specified in RG 1.180, Rev 1.

Subsequent to the release of TR-107330, which references EPRI TR-102323, in 1997, the NRC approved and issued revision 1 of Regulatory Guide (RG) 1.180 in 2003. This revision endorses Military Standard (MIL-STD)-461E and the International Electrotechnical Commission (IEC) 61000 series of EMI/RFI test methods, cover signal line testing, and relaxing test levels when experience and confirmatory research warrants. Therefore, EMI/RFI susceptibility and emissions withstand capability testing is in accordance with RG 1.180, Rev 1, which supersedes TR-102323.

1. Conducted and Radiated emissions per Section 3.
2. Conducted and Radiated susceptibility per Sections 4.

In the event of unsatisfactory susceptibility test results at the specified levels, testing is performed at 100% of the specified levels, and gradually reduced until the susceptibility limit is found.

Testing is performed at NTS facilities in Boxborough, Massachusetts. NTS personnel conduct the EMI/RFI tests as defined in RG 1.180, Rev 1. MPR personnel conduct performance monitoring of the TUT during application of EMI/RFI test conditions.

a

2. REFERENCES

U. S. NRC Regulatory Guide 1.180, Rev 1-2003
U.S. NRC Memorandum Dated December 17, 2004; ADAMS Accession # ML0433800960
MIL-STD-461E

a

3. EQUIPMENT

4. SEQUENCE OF TESTING

Testing sequence is projected as listed below.

1. Set up equipment per EMI/RFI Test procedure.
2. Conduct System Setup and Checkout test
3. Conduct EMI/RFI Test

The specific sequence of test steps will be indicated in the test procedure. Normal operating performance data will be obtained before, during, and after each individual EMI/RFI test.

a

5. PROCEDURES

The following test procedures will be utilized for this testing:

A. EMI/RFI Test (9600164-510)

6. SERVICE CONDITIONS AND MARGINS

a

a

7. PERFORMANCE AND ENVIRONMENTAL VARIABLES

Performance and environmental variables to be measured, including required accuracy, will be defined in the specific test procedures.

8. ACCEPTANCE CRITERIA

1. Normal operating performance data demonstrates acceptable operation of the TUT modules during and following application of EMI/RFI radiation. When subjected to the specified levels of EMI/RFI:
    a. The main processor continues to function correctly.
    b. The transfer of I/O data is not to be disrupted.
    c. The emissions do not result in discrete I/O changing state.
    d. Analog I/O levels do not vary more than ± 3%.
2. Radiated and conducted emissions meet the above requirements of RG 1.180, Rev. 1.

9. RECORDS

1. EMI/RFI Test Report (9600164-527)
2. Completed procedures/attachments (9600164-502, 510)
3. System drawings

APPENDIX 8 – SURGE, ELECTRICAL FAST TRANSIENT, ELECTROSTATIC DISCHARGE, AND ISOLATION TEST PLAN

1. GENERAL

The purpose of this plan is to define the requirements for Surge **(IEC-61000-4-5, -12)**, Electrical Fast Transients **(IEC-61000-4-4),** and Isolation testing conducted as part of the qualification tests for the TUT. Testing demonstrates Tricon electrical surge, fast electrical transients withstand, and isolation capability as required in the sections 4.6.2 and 4.6.4 of the TR-107330 specification and RG 1.180, R1. Sections 6.3.5 and 6.3.6 of TR-107330 and sections 5.1, 5.2, and 5.3 of RG 1.180, Rev 1 provide the requirements for this testing.

Tests to be conducted under this plan are:

1. Electrical Fast Transients (EFT) Test
2. Surge Withstand (SW) Test
3. Electro-Static Discharge Test
4. Electrical (1E/non-1E) Isolation (EI) Test

a

Testing is performed at NTS facilities in Boxborough, Massachusetts. NTS personnel conduct the SW, EFT and EI tests as defined in Topical Report 107330 and RG 1.180. MPR personnel monitor TUT performance during application of the SW, EFT and EI test conditions.

2. REFERENCES

EPRI Specification TR-107330:
U. S. NRC Regulatory Guide 1.180, Rev 1-2003: Sections 5.1, 5.2, 5.3
EPRI Specification TR-102323, Appendix B, Section 3.5

a

3. EQUIPMENT

4. SEQUENCE OF TESTING

Testing sequence is projected as listed below.

1. Set-up equipment per Conduct Electrical Fast Transient Test
2. Conduct Electrical Fast Transient Test
3. Conduct Surge Withstand Test
4. Electro-Static Discharge Test
5. Conduct Electrical Isolation Test

The specific sequence of test steps is indicated in the test procedures.

5. PROCEDURES

The following test procedures are utilized during this testing:

A. Surge Withstand, Electrical Fast Transisent Test, and Electrostatic Discharge Tests (9600164-508, -514, -512)

a

6. SERVICE CONDITIONS AND MARGINS

a

7. PERFORMANCE AND ENVIRONMENTAL VARIABLES

Performance and environmental variables to be measured, including required accuracy, is defined in the specific test procedures.

8. ACCEPTANCE CRITERIA

1. Applying the EFT and ESD voltages to the specified test points does not damage any other module or device in the test specimen, or cause disruption of the operation of the backplane signals or any other data acquisition signals. Applying the SW voltage to the specified test points does not damage any other module or device in the test specimen, or cause disruption of the operation of the backplane signals or any other data acquisition signals that could result in a loss of the ability to generate a trip. Normal operating performance data demonstrates the acceptable operation of the Tricon backplane and other TUT modules during, and following, the application of SW, EFT, ESD, and EI voltages to a given test point.
2. Applying the Electrical Isolation voltages to the specified test points of the TUT relay output and communication modules does not disrupt the operation of any other module, nor disrupt the operation of the chassis backplane. Normal operation performance demonstrates acceptable operation of the TUT modules and chassis backplane during, and following the application of specified Electrical Isolation voltage to a given test point.
3. Failure of one or more Tricon components (system fault), that does not result in the inability of the TUT to operate as intended, is acceptable. This is demonstrated by normal operating performance of the Tricon following failure of one or more TUT components.

9. RECORDS

1. SW, EFT, ESD, and EI Test Reports (9600164-528, -521, -522, -529)
2. Completed procedures/attachments (9600164-508, -514, -512, -509)
3. System drawings

APPENDIX 9 - PERFORMANCE PROOF TEST PLAN

1. GENERAL

During pre-qualification testing (Appendix 3), acceptable operation of the TUT is confirmed and baseline performance data established for selected operating parameters through performance of the Operability and Prudency tests. Qualification testing (Appendices 4-8) subjects the TUT to specified stresses, confirming operability during adverse conditions. Normal operating performance data, and in some cases Operability test and Prudency test data, is obtained during and/or after each qualification test.

Subsequent to the qualification tests, performance proof testing confirms continuing acceptable performance of the TUT after being subjected to the Environmental, Seismic, and EMI/RFI qualification test conditions. The Operability test and the Prudency test are conducted a final time and results are compared to baseline performance data to identify any changes in the functional characteristics of the TUT. In addition, in accordance with TR-107330, Section 4.6.1, the 24 Vdc source power supplies shall be operated for seven days with the dc source at 30 Vdc.

Performance proof testing is performed at the I-T facilities in Irvine, CA. Invensys-Triconex personnel conduct the testing as defined below.

2. REFERENCES

EPRI Specification TR-107330: a

3. EQUIPMENT

Appendix 1 documents the TUT configuration. Test set-up is defined in the specific procedures referenced below.

4. SEQUENCE OF TESTING

Testing sequence is projected as listed below.

1. Reconfigure test specimen as necessary.
2. Conduct System Setup and Checkout test
3. Conduct Operability test.
4. Conduct Prudency test.
5. Seven day elevated dc source test.

The specific sequence of test steps is indicated in the test procedures.

5. PROCEDURES

The following test procedures, as described in Appendix 3, will be utilized for this testing:

1. System Setup and Checkout Test (9600164-502)
2. Operability Test (9600164-503)
3. Prudency Test (9600164-504)

6. SERVICE CONDITIONS AND MARGINS

a

7. PERFORMANCE AND ENVIRONMENTAL VARIABLES

Performance and environmental variables to be measured, including required accuracy, will be defined in the specific test procedures.

8. ACCEPTANCE CRITERIA

Acceptance criteria are identified in the individual test procedures.

9. RECORDS

1. Performance Proof Test Report (9600164-530)
2. Completed procedures/attachments (9600164-502, 503, 504)
3. System drawings